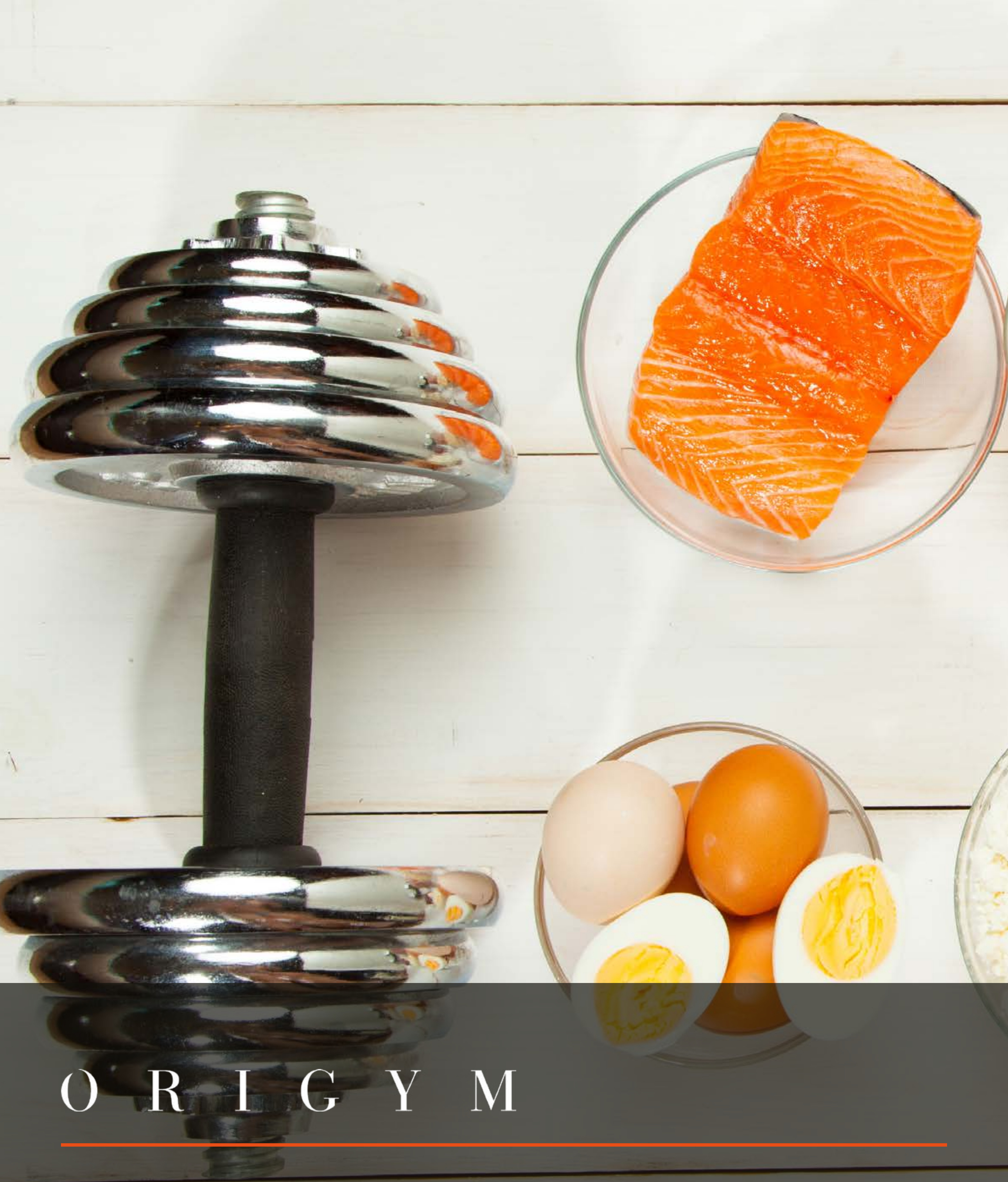

ORIGYM

Level 4 Certificate in Nutrition for Weight Management and Athletic Performance

UNIT 1: THE SYSTEMS THAT MAKE UP THE HUMAN BODY (ANATOMY AND PHYSIOLOGY)

CONTENTS

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VIDEO AVAILABLE ON LEARNING PLATFORM

The Human Body

UNIT 1: THE SYSTEMS THAT MAKE UP THE HUMAN BODY (ANATOMY AND PHYSIOLOGY)

LEARNING OBJECTIVE

- Explain the basic knowledge of human anatomy and physiology.
- Identify the 11 individual systems within the human body.
- Explain the structure and function of an animal cell.
- Describe the different types of human tissue.
- Identify the main organs of the body and understand their role.
- Explain what hunger and appetite is.
- Explain taste and smell and how it is interpreted within the human body.
- Explain how taste relates to nutrition.
- Explain how smell relates to nutrition.

The human body as an organism consists of trillions of cells, these cells are able to perform many functions through access to an external environment. The cells have evolved to make this possible and to specialise in a particular area. A clear organisational structure has been devised to ensure all processes required for life can be carried out.

There are 11 clearly identifiable systems within the human body:

VIDEO AVAILABLE ON LEARNING PLATFORM

- Integumentary system (skin).
- Nervous system.
- Muscular system.
- Skeletal system.
- Circulatory system.
- Respiratory system.
- Endocrine system.
- Digestive system.
- Urinary system.
- Reproductive system.
- Immune and Lymphatic system.

Within the body there are thousands of amazing processes taking place. You must have at least a basic understanding of these processes to properly understand nutrition. From the moment you swallow your food it takes approximately 12 hours to completely digest and whilst this takes place, the following processes are also taking place in the human body:

- The heart will beat over 100,000 times a day.
- The brain will use over one quarter of the oxygen used by the human body.
- An adult will blink on average of 10 times a minute.
- In a single hour the kidney will receive 100 pints of blood.
- Blood will flow through the 300,000 capillaries (tiny blood vessels), found in our lungs.

THE HUMAN CELL

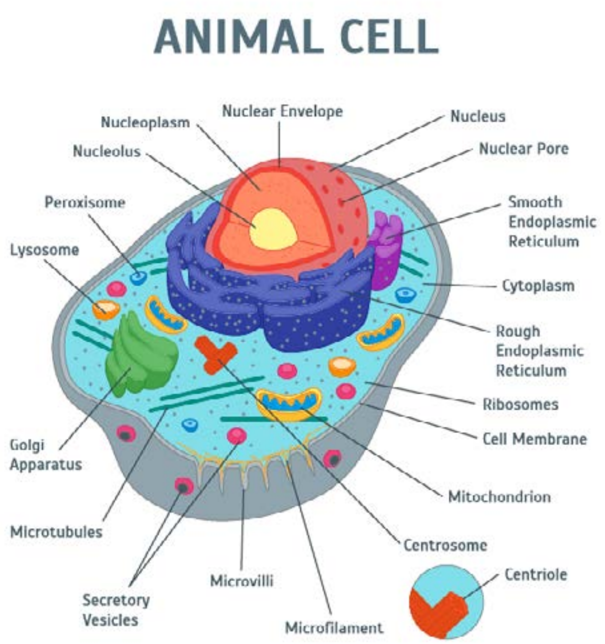
CELLS

The human body is made up of many different types of cells, tissues and organs. These are important as they are the building blocks for the human body. The cell is the basic unit of body structure and all cells need food, water and oxygen to survive. As part of their function, they also produce carbon dioxide and other waste products which need to be removed. The cell is made up of 4 components;

- The cell membrane which helps to hold its shape
- The nucleus which controls the cell's activities
- The cytoplasm which helps transport minerals around the cell
- The chromosomes which contain genes that determine our physical and chemical makeup.

Cells have many functions including the metabolism of food, growth and repair, taking in certain chemicals to make their structure, the removal of waste products, the breakdown of food to use as fuel and to produce new cells.

ANIMAL CELLS



- **NUCLEUS:** DNA, genetic information, provides an appropriate amount of amino acids for protein production.
- **RIBOSOMES:** One of the four main macromolecules essential for life. Made of RNA, (Ribonucleic acid) receives information from the nucleus, and synthesise appropriate protein as required.
- **ENDOPLASMIC RETICULUM (ER):** Create canals in the cytoplasm. There are two types of ER, smooth and rough.
- **ROUGH (ER):** Synthesise protein exportation from the cell.
- **SMOOTH (ER)**: Synthesise lipids.
- **GOLGI COMPLEX:** Folded Membrane sacs that have an entrance and exit through which proteins enter are modified, sorted and then leave.
- **LYSOSOMES:** Exterior of the cell, containing enzymes. Waste management cells, breakdown of protein, lipids nucleic acid, carbohydrates, and expels them as waste.
- **MITOCHONDRIA:** One of the largest Organelles. Two membranes, outer and inner. They take in the nutrients, break them down and produce energy. (ATP)
- **CELL MEMBRANE:** Phospholipids, key building blocks of all cell membranes. Protects the cell, and controls movements in and out.

A cell is the structural and functional unit of life. A typical cell consists of a plasma membrane separating the inner contents, or cytoplasm, from the environment around the cell. The cytosol is the fluid component of the cytoplasm. The cytoplasm includes the cytosol and all the organelles and structures in it. The nucleus is not considered to be part of the cytoplasm. Organelles perform essential cellular functions. The nucleus is the largest organelle, and it contains the cells genetic information encoded in molecules of DNA (deoxyribonucleic acid).

Each cell contains smaller organelles that perform various functions such as metabolism, transportation and secretion of substances. Because some cells perform specific functions, they have specially modified structures. For example, red blood cells are the oxygen carriers in the body. They lack a nucleus to make more space for the oxygen-carrying pigment, haemoglobin. The various structures and organelles in a cell float in a liquid called the cytoplasm.

SIX MAIN FUNCTIONS OF A HUMAN CELL

1. PROVIDE STRUCTURE AND SUPPORT

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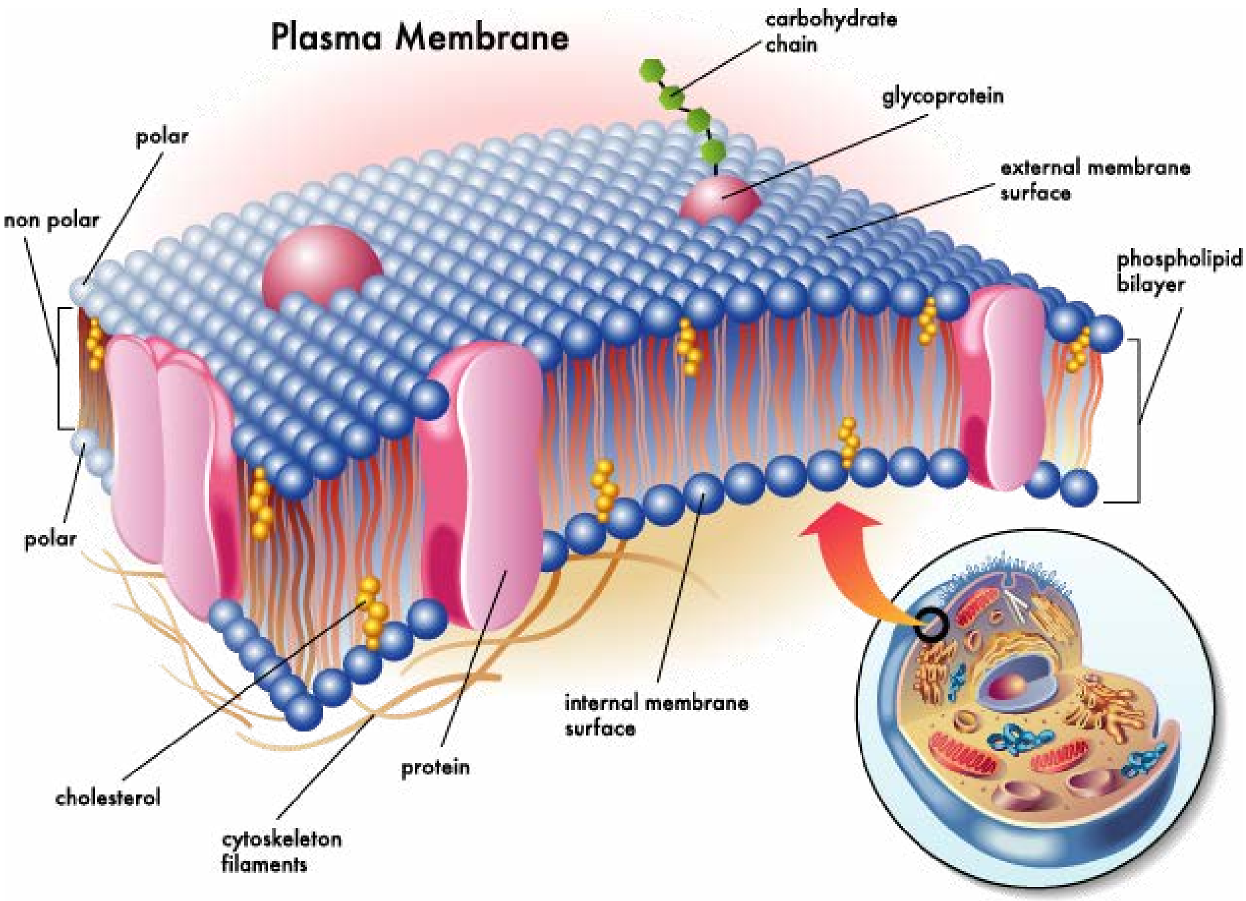
Like a classroom is made of bricks, every organism is made of cells. While some cells such as the collenchyma and sclerenchyma are specifically meant for structural support, all cells generally provide the structural basis of all organisms. For instance, the skin is made up of a number of skin cells. Vascular plants have evolved a special tissue called xylem, which is made of cells that provide structural support.

2. FACILITATE GROWTH THROUGH MITOSIS

In complex organisms, tissues grow by simple multiplication of cells. This takes place through the process of mitosis in which the parent cell breaks down to form two daughter cells identical to it. Mitosis is also the process through which simpler organisms reproduce and give rise to new organisms.



3. ALLOW PASSIVE AND ACTIVE TRANSPORT

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CELLS IMPORT NUTRIENTS TO USE IN THE VARIOUS CHEMICAL PROCESSES THAT GO ON INSIDE THEM. THESE PROCESSES PRODUCE WASTE WHICH A CELL NEEDS TO GET RID OF. SMALL MOLECULES SUCH AS OXYGEN, CARBON DIOXIDE AND ETHANOL GET ACROSS THE CELL MEMBRANE THROUGH THE PROCESS OF SIMPLE DIFFUSION. THIS IS REGULATED WITH A CONCENTRATION GRADIENT ACROSS THE CELL MEMBRANES. THIS IS KNOWN AS PASSIVE TRANSPORT. HOWEVER, LARGER MOLECULES, SUCH AS PROTEINS AND POLYSACCHARIDES, GO IN AND OUT OF A CELL THROUGH THE PROCESS OF ACTIVE TRANSPORT IN WHICH THE CELL USES VESICLES TO EXCRETE OR ABSORB LARGER MOLECULES.

4. PRODUCE ENERGY

An organism's survival depends upon the thousands of chemical reactions that cells carry out relentlessly. For these reactions, cells require energy. Most plants get this energy through the process of photosynthesis, whereas animals get their energy through a mechanism called respiration.

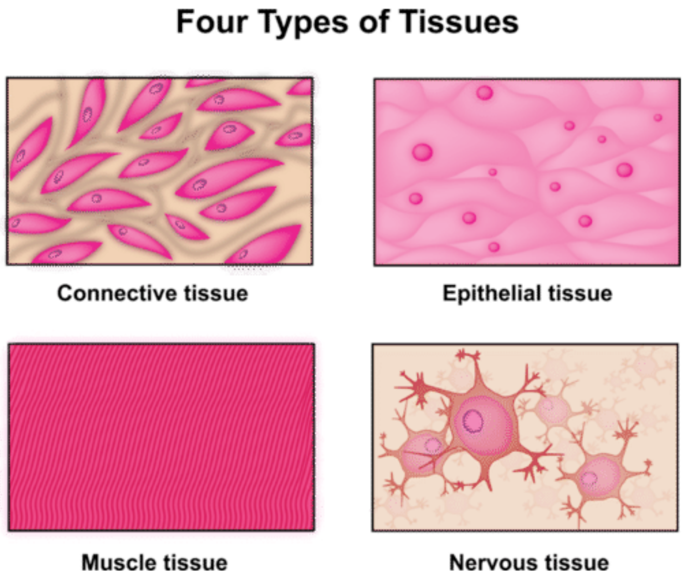
5. CREATE METABOLIC REACTIONS

Metabolism includes all the chemical reactions that take place inside an organism to keep it alive. These reactions can be catabolic or anabolic. The process of energy production by breaking down molecules (glucose) is known as catabolism. Anabolic reactions, on the other hand, use energy to make bigger substances from simpler ones.

6. AIDS IN REPRODUCTION

Reproduction is vital for the survival of a species. A cell helps in reproduction through the processes of mitosis (in more evolved organisms) and meiosis. In mitosis cells simply divide to form new cells. This is termed asexual reproduction. Meiosis takes place in gametes or reproductive cells where there is a mixing of genetic information. This causes daughter cells to be genetically different from the parent cells. Meiosis is a part of sexual reproduction.

FOUR TYPES OF HUMAN TISSUE



THE FUNCTION OF HUMAN TISSUE

A tissue is a group of cells that have similar shape and function. Different types of tissues can be found in different organs. In humans, there are four basic types of tissue: epithelial, connective, muscular, and nervous tissue. There may be various sub-tissues within each of the primary tissues.

1. **EPITHELIAL TISSUE** covers the body surface and forms the lining for most internal cavities. The major function of epithelial tissue includes protection, secretion, absorption and filtration. The skin is an organ made up of epithelial tissue which protects the body from dirt, dust, bacteria and other microbes that may be harmful. Cells of the epithelial tissue have different shapes, cells can be thin, flat to cubic and elongated.

2. **CONNECTIVE TISSUE** is the most abundant and the most widely distributed of the tissues. Connective tissues perform a variety of functions including support and protection. The following connective tissue is found in the human body; ordinary loose connective tissue, fat tissues, dense fibrous tissue, cartilage, bone, blood, and lymph, which are all considered connective tissue.

3. **MUSCLE TISSUE:** There are 3 types: skeletal, smooth and cardiac. Skeletal muscle is a voluntary type of muscle tissue that is used in the contraction of skeletal parts. Smooth muscle is found in the walks of internal organs and blood vessels. It is an involuntary type. The cardiac muscle is found only in the walls of the heart and is involuntary in nature.

4. **NERVE TISSUE** is composed of specialised cells which not only receive stimuli but also conduct impulses to and from all parts of the body. Nerve cells or neurons are long and string-like. In tissues the simplest combination is called a membrane, or a sheet of tissues which cover or line the body surface or divide organs into parts. Examples include the mucous membrane which lines body cavities. Tissues combining to form organs. An organ is a part of the body which performs a definite function. The final units of organisation in the body are called systems. A system is a group of organs each of which contributes its share to the function of the body as a whole. An organ is a part of the body which performs a definite function. The final units of organisation in the body are called systems. A system is a group of organs each of which contributes its share to the function of the body as a whole.

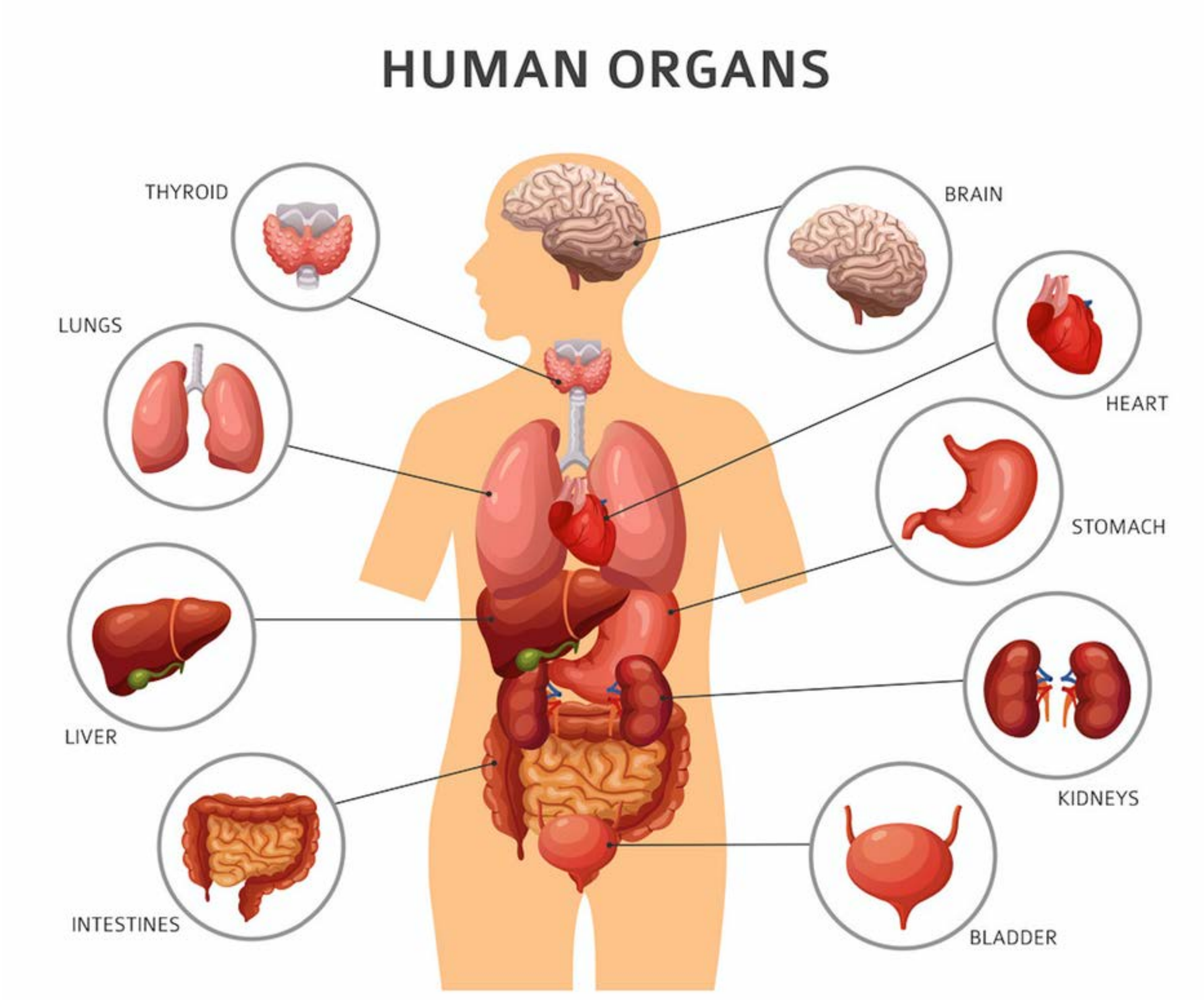
A BASIC CATEGORISATION OF TISSUE TYPES

Tissue Types	Function	Example
Epithelial	Protection	Skin
Connective	Support	Bones
Muscular	Movement	Cardiac Muscle
Nervous	Communication	Brain

ORGAN SYSTEM	FUNCTION	ORGAN, TISSUES AND STRUCTURES INVOLVED
CARDIOVASCULAR	Transports oxygen, carbon dioxide, waste products, nutrients and hormones.	• Heart • Blood • Blood Vessels
LYMPHATIC	Infection and disease defence, transports lymph.	• Lymph • Lymph Nodes • Lymph Vessels
DIGESTIVE	Processes foods and absorbs nutrients, minerals and vitamins and turns it into nutrition for the body.	• Tongue • Oesophagus • Stomach • Liver • Pancreas • Gall bladder • Small intestine • Rectum • Anus
ENDOCRINE	Regulates metabolism, growth and development, tissue function, sexual function, reproduction, sleep and mood.	• Glands
INTEGUMENTARY	Protection from injury and fluid loss, defence against infection and provides temperate control.	• Skin • Hair • Nails
MUSCULOSKELETAL	Movement, support and heat protection.	• Muscles • Joints • Bones
NERVOUS	Collects, transfers and processes information and directs short term change in other organ systems.	• Brains • Spinal Cord • Nerves
REPRODUCTIVE	Produces sex cells and hormones.	• Fallopian Tubes • Uterus • Vagina • Ovaries • Mammary Glands • Testes • Vas Deferens • Seminal Vesicles • Prostate • Penis
RESPIRATORY	Delivers air to sites where gas exchange can occur.	• Mouth • Nose • Pharynx • Larynx • Trachea • Bronchi • Lungs • Diaphragm
URINARY	Removes excess water, salts and waste products from the blood and body and controls the pH	• Kidneys • Ureters • Urinary • Bladder • Urethra
IMMUNE	Defends against microbial pathogens and disease causing agents.	• Leukocytes • Tonsils • Adenoids • Thymus • Spleen

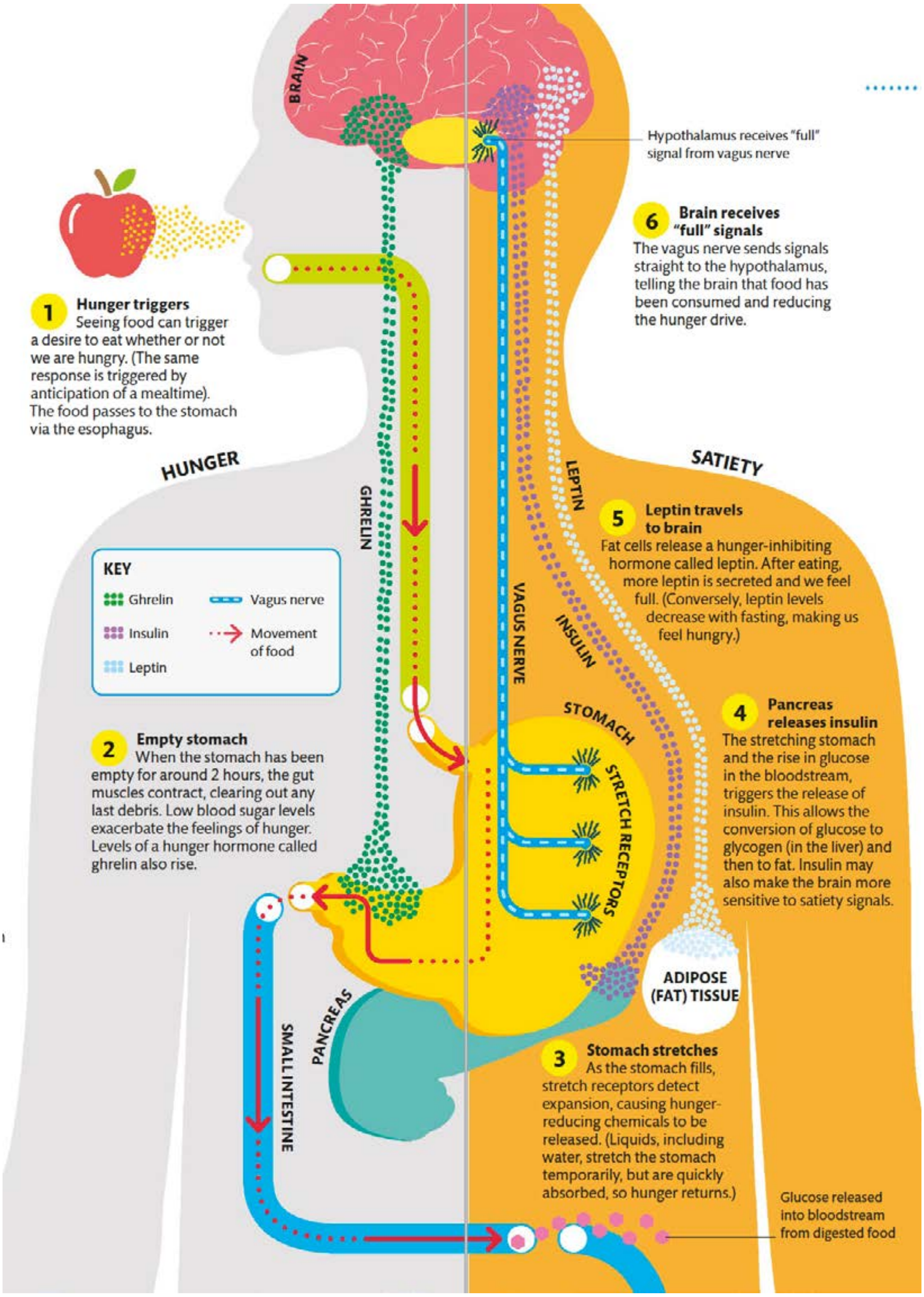
ORGANS

Organs are grouped into organ systems and work together to carry out certain functions. For example, the heart and blood vessels make up the cardiovascular system working together to circulate the blood bringing oxygen and nutrients to cells and taking away carbon dioxide.

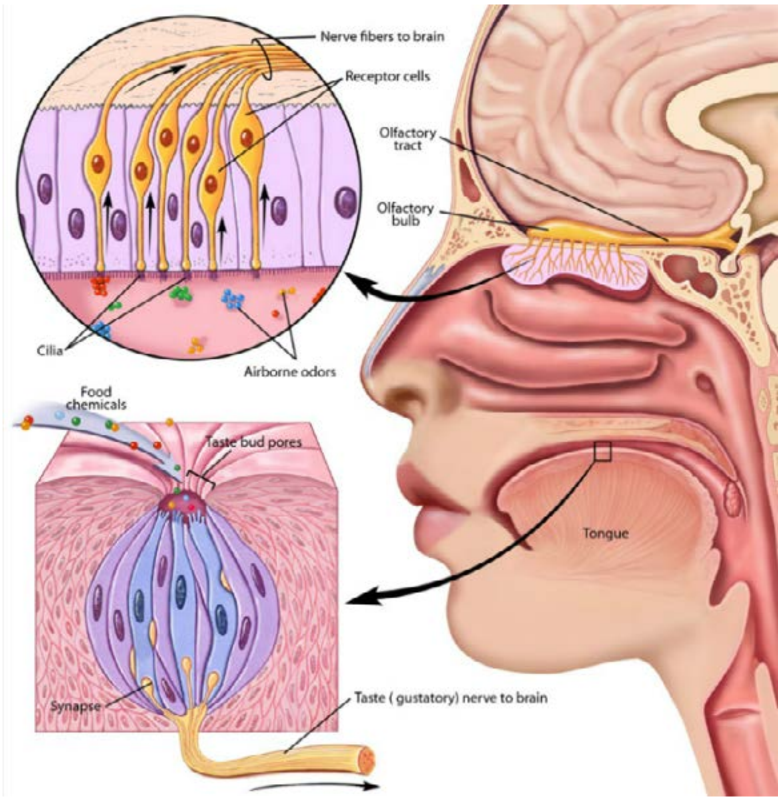


HUNGER AND APPETITE

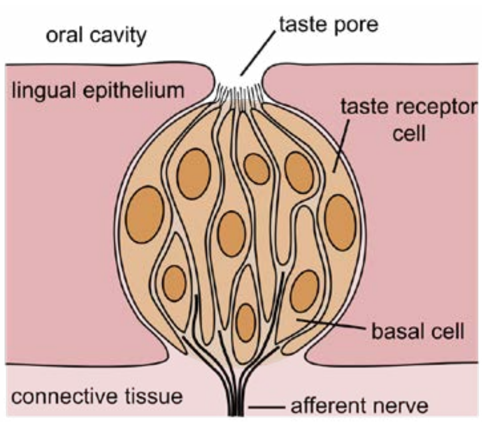
Hunger is vital to our survival, as it ensures that we continue to eat to keep our bodily functions going. Often though we eat not due to a hunger necessity but because we enjoy food and this is known as our appetite. Therefore hunger is the physiological need for food driven by internal (within the body) cues within the body e.g. Low blood sugar. Appetite, however, is driven by seeing or smelling something such as food or something that we link with food.



TASTE AND SMELL



Taste and smell are separate senses with their own receptor organs, yet they are intimately entwined. Tastants, chemicals in foods, are detected by taste buds, which consist of special sensory cells. When stimulated, these cells send signals to specific areas of the brain, which make us conscious of the perception of taste. Similarly, specialised cells in the nose pick up odorants, airborne odour molecules. Odorants stimulate receptor proteins found on hairlike cilia at the tips of the sensory cells, a process that initiates a neural response. Ultimately, messages about taste and smell converge, allowing us to detect the flavours of food.



Just as sound's awareness to changes in air pressure, and sight's awareness to changes in light, taste's and smells are aware of chemical changes in the air and in food. Even though taste and smell are separate senses with their own receptor organs, they are nonetheless intimately entwined. This close relationship is most apparent in how we perceive the flavours of food. As anyone with a head cold can attest, food “tastes” different when the sense of smell is impaired.

Actually, what is really being affected is the flavour of the food or the combination of taste and smell. That's because only the taste, not the food odours, are being detected. The taste itself is focused on distinguishing chemicals that have a sweet, salty, sour, bitter, or umami taste (umami is Japanese for “savoury”).

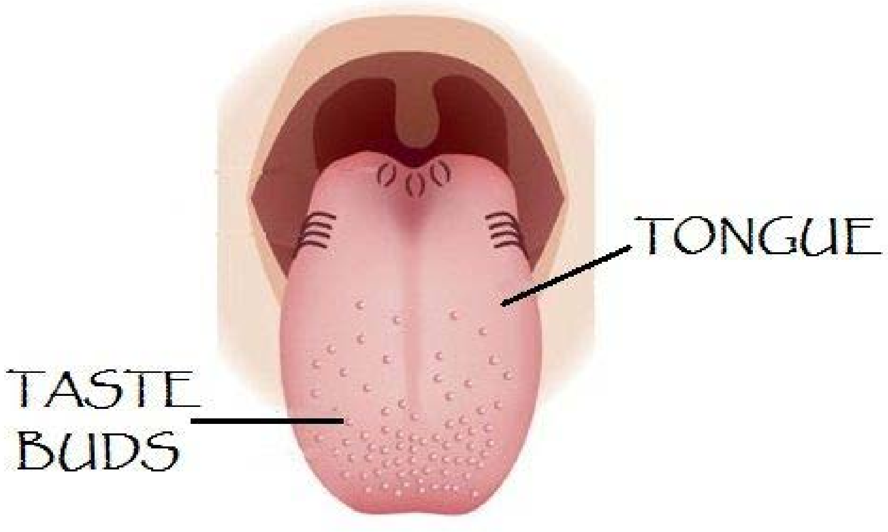
However, interactions between the senses of taste and smell enhance our perceptions of the foods we eat.

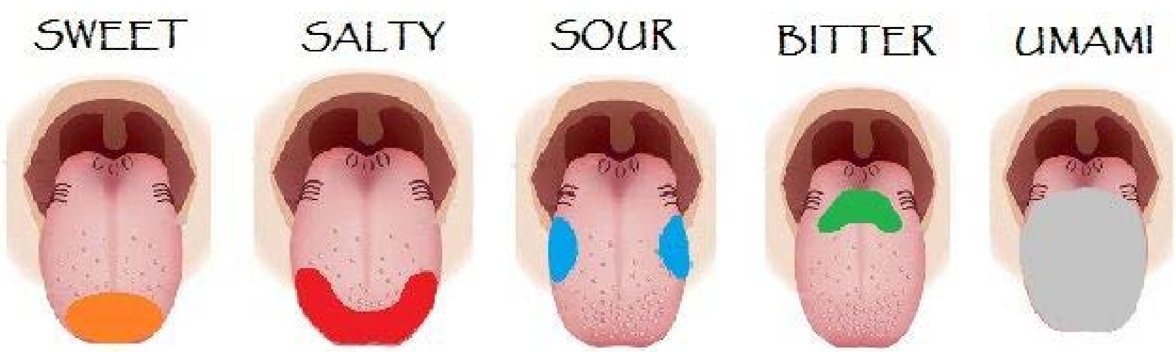
Tastants, chemicals in foods, are detected by taste buds, special structures embedded within small protuberances on the tongue called papillae. Other taste buds are found in the back of the mouth and on the palate. Every person has between 5,000 and 10,000 taste buds. Each taste bud consists of 50 to 100 specialised sensory cells, which are stimulated by tastants such as sugars, salts, or acids.

When the sensory cells are stimulated, they cause signals to be transferred to the ends of nerve fibres, which send impulses along cranial nerves to taste regions in the brain stem. From here, the impulses are relayed to the thalamus and on to a specific area of the cerebral cortex. This makes us conscious of the perception of taste.

Airborne odour molecules, called odorants, are detected by specialised sensory neurons located in a small patch of the mucus membrane lining the roof of the nose. Axons of these sensory cells pass through perforations in the overlying bone and enter two elongated olfactory bulbs lying against the underside of the frontal lobe of the brain.

Odorants stimulate receptor proteins found on hairlike cilia at the tips of the sensory cells, a process that initiates a neural response. An odorant acts on more than one receptor but does so to varying degrees. Similarly, a single receptor interacts with more than one different odorant, though also to varying degrees. Therefore, each odorant has its own pattern of activity, which is set up in the sensory neurons. This pattern of activity is then sent to the olfactory bulb, where other neurons are activated to form a spatial map of the odour. Neural activity created by this stimulation passes to the primary olfactory cortex at the back of the underside, or orbital, part of the frontal lobe. Olfactory information then passes to adjacent parts of the orbital cortex, where the combination of odour and taste information helps create the perception of flavour.





The Brain

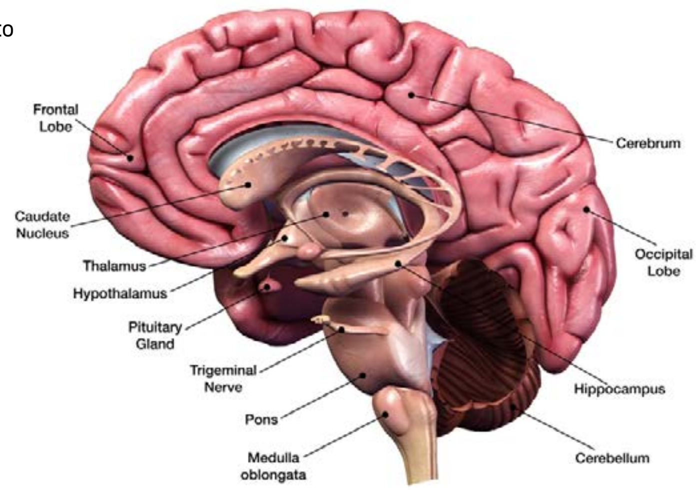
UNIT 1: THE SYSTEMS THAT MAKE UP THE HUMAN BODY (ANATOMY AND PHYSIOLOGY)

The four main elements of the brain are:

CEREBRUM

This is the largest part of the brain and is divided into two hemispheres. It is responsible for:

- Mental activities
- Sensory perception
- Initiation and control of voluntary muscle contraction



CEREBELLUM

Located below the posterior aspect of the cerebrum, the cerebellum is also divided into 2 hemispheres and is responsible for:

- Movement
- Proprioception
- Posture
- Balance

The cerebellum has very close links with the inner ear; within the inner ear fluid-filled canals with receptors monitor the movement of the fluids and convey these messages to the cerebellum. Additional information from touch, pressure, vision and hearing are blended together resulting in motor stimulation to increase or decrease muscular tone, maintaining balance, posture and spatial awareness.

BRAIN STEM:

This links the spinal cord to the brain and is considered a primitive part of the brain. It is made up of the mid-brain (reflex centres), the pons (breathing, eye movement and facial expressions) and the medulla (heart rate, BP, breathing, coughing and sneezing).

DIENCEPHALON:

This is found between the mid-brain and the cerebrum and contains the thalamus, hypothalamus and pineal gland.

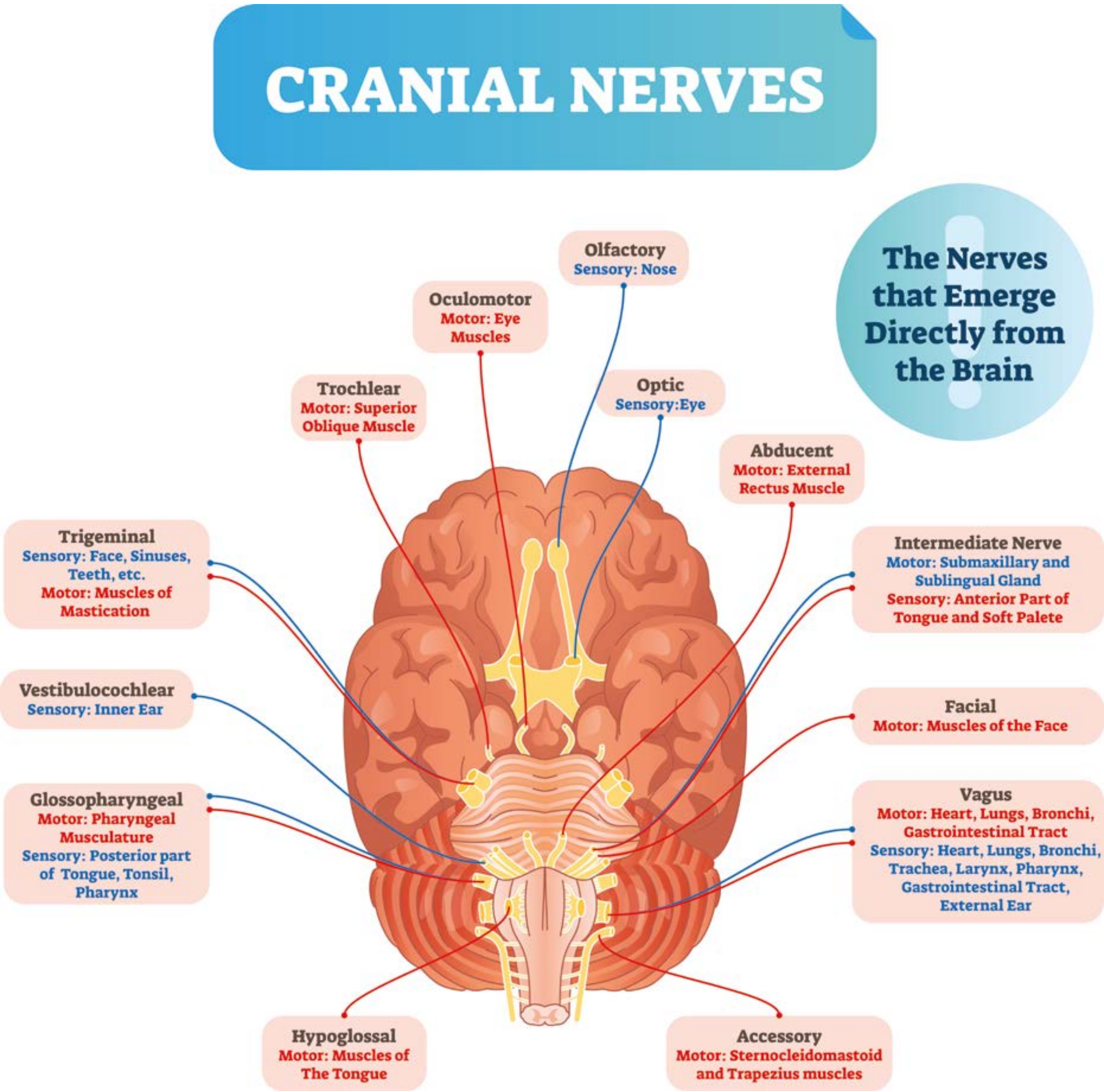
- The thalamus receives signals from the body's various senses and relays that information to the cerebrum for analysis.
- The hypothalamus regulates some of the most important body systems and plays an important role in governing the endocrine system, gland secretion and homeostasis.
- The pineal gland's functions are still not fully understood; however, it is believed to be magnetically sensitive and responsive to external magnetic patterns. It regulates daily and yearly rhythms and converts serotonin to melatonin which is involved in sleep patterns.

THE SPINAL CORD

The spinal cord is protected inside the vertebral column, extends from the brain stem to the first or second lumbar vertebrae, where it fans out across the anterior sacrum and terminates at the end of the coccyx.

It is approximately 45cm in length and the diameter of a finger. It provides the nervous tissue link between the brain and the peripheral nervous system but can act independently of the brain in the form of reflexes.

The spinal cord is formed from grey matter and white matter. The grey matter is largely composed of the myelinated axons and dendrites that pass nerve impulses.

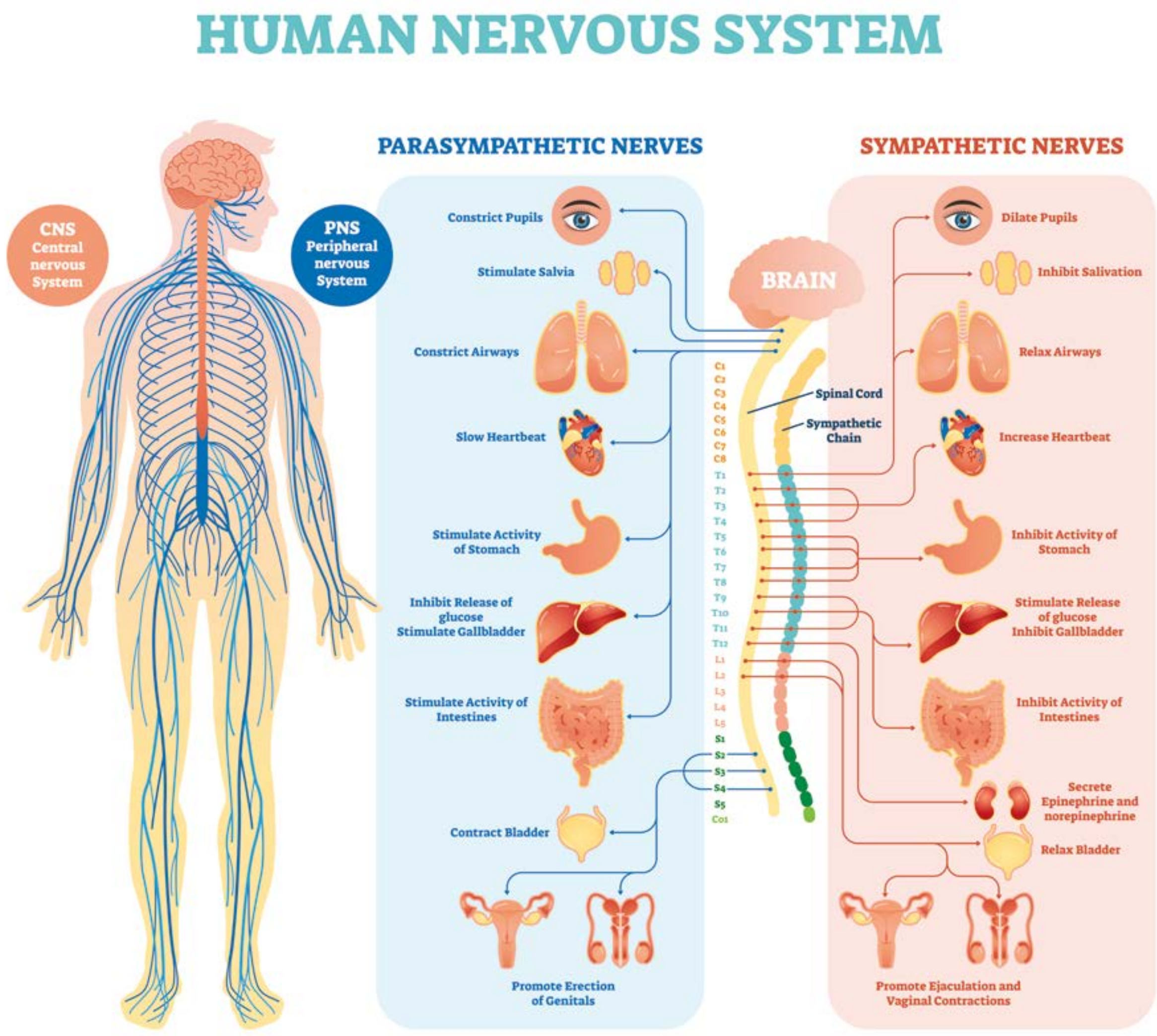


NERVES

The nervous system is comprised of 12 pairs of cranial nerves and 31 pairs of spinal nerves. A group or bundle of nerves supplying a particular area of the body is referred to as a plexus. A plexus will contain both sensory and motor nerves.

There are five plexuses:

- Cervical
- Brachial
- Lumbar
- Sacral
- Coccygeal



THE EFFECTS OF MASSAGE ON THE NERVOUS SYSTEM

The mechanical action on the tissues speeds up the removal of metabolic waste, this combined with the lowering pressure in the muscle tissue and fascia, reduces irritation of nerve endings, hence reducing pain. There will be a balancing effect on the autonomic nervous system (ANS) as the soothing effect on the various nerve endings relaxes muscles, reducing the production of adrenalin, lowering blood pressure and allowing great parasympathetic dominance and relaxation.

The Integumentary System

UNIT 1: THE SYSTEMS THAT MAKE UP THE HUMAN BODY (ANATOMY AND PHYSIOLOGY)

LEARNING OBJECTIVE

- Identify the three layers of the skin.
- Describe the four main functions of the skin.
- Explain how the structure of the skin relates to its main functions.

THE SKIN

The skin is the largest organ of the body forming a versatile, waterproof covering that serves as the first line against injury or invasion by hostile organisms and infectious bacteria. It is referred to as the integumentary system.

STRUCTURE OF THE SKIN

The Skin can be divided into three layers, the epidermis, dermis and the hypodermis.

EPIDERMIS

The epidermis consists of five divisions making up the outer layer of the skin that protects the dermis below. It contains no blood or lymphatic vessels but is pierced by hairs, the follicles of which allow the secretion of sebum onto the skin and sweat ducts. Production of skin cells begins in the deepest layers pushing the cells above them up towards the surface. As the cells move away from the base layers they die, fill with the protein keratin which hardens as the cells reach the surface.

DERMIS

The three divisions of the dermis are much thicker than the epidermis and are mainly formed by connective tissue: elastin and collagen fibres. This very tough tissue supports various structures such as hair follicles, sweat and sebaceous glands, fat cells, nerves, blood and lymphatic vessels.

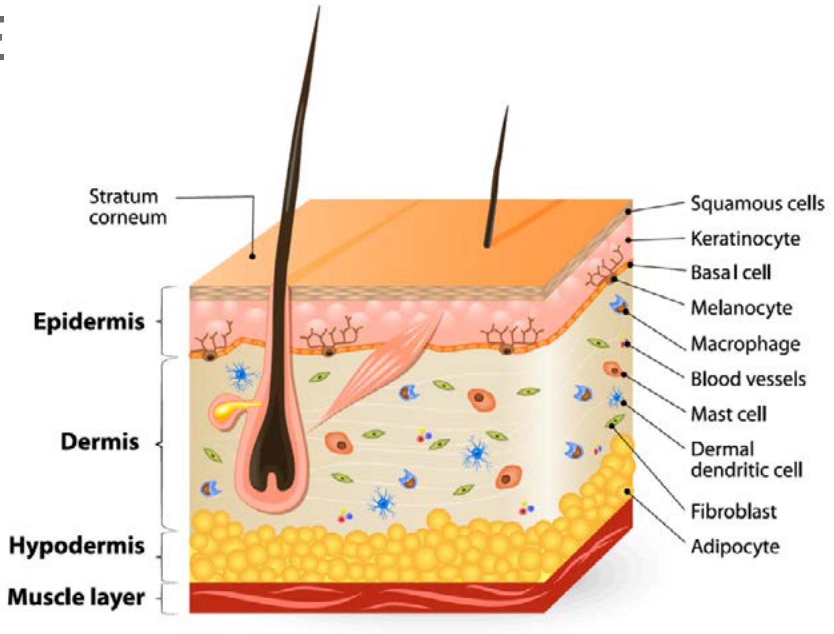
HYPODERMIS

The hypodermis (also called the subcutaneous layer or superficial fascia) is a layer directly below the dermis and serves to connect the skin to the underlying fascia (fibrous tissue) of the bones and muscles. It is not strictly a part of the skin, although the border between the hypodermis and dermis can be difficult to distinguish. The hypodermis consists of well vascularised, loose, areolar connective tissue and adipose tissue, which functions as a mode of fat storage and provides insulation and cushioning for the integument.

MELANOCYTES

These are specialised cells found throughout the deeper layers of the epidermis. These control pigmentation of the skin by increasing their concentrations of melanin in response to UV light. This protects underlying structures by absorbing UV radiation.

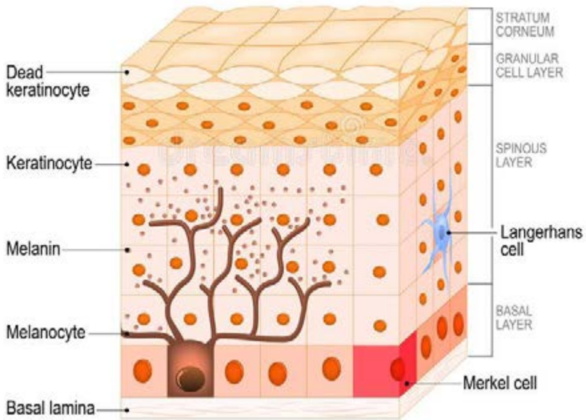
SKIN STRUCTURE



EPIDERMIS

When we think of protecting our bodies from the elements, we may think of putting on a jacket, or shoes and socks. Perhaps you use sunscreen, fortunately, in addition to what we wear. Our skin, the largest organ in our body, serves this crucial purpose with a layer known as the epidermis as our first line of defence. In this lesson, we will take a closer look at this skin layer and gain an understanding of why it is so important to our body.

The epidermis is the outermost layer of our skin. Tough and resilient, protection is its number one job. Think of a parka you may wear in the winter. The inside is lined with soft fleece, providing a layer of warmth. The outside is made of a strong waterproof material that lets nothing through.



It is a similar situation with our own epidermis. Our epidermis is waterproof, which is why we don't swell with liquid each time we bathe. The cellular structure of the epidermis also forms a highly effective barrier against germs.

When skin is healthy and intact, it is difficult for bacteria and viruses to make an entrance. In addition, cells of the epidermis have the miraculous ability to regenerate or grow back, unlike many other cells in the body. When we suffer from a wound, healthy skin heals and replaces damaged cells with ease.

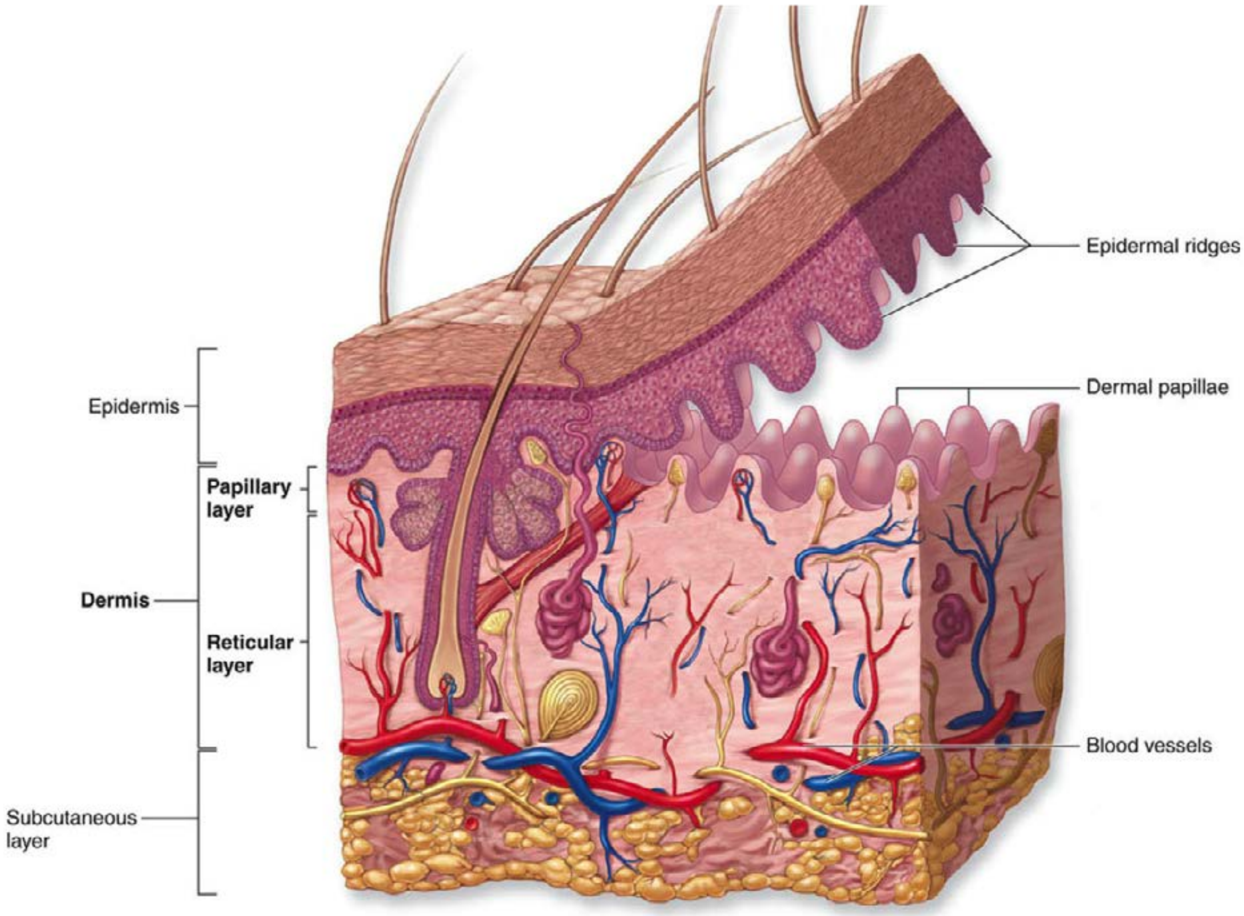
The epidermis is composed of four main strata or layers. The outermost layer is called the stratum corneum. If we were to take a closer look, we find that the stratum corneum is composed almost exclusively of dead cells. It may come as no surprise that we lose skin cells on a regular basis. In fact, the dead cells of the stratum corneum slough off so often that we end up with a completely new outer layer about every 35 days.

And how, you may be wondering, do we have any skin left if we are always losing cells? This is where the stratum basale comes in. Just as its name suggests, it is the base or deepest layer of the epidermis. A cell-producing factory, the basal layer contains stem cells which are constantly dividing to make new ones. These fresh new cells make their way up to the stratum corneum to replace those that have sloughed off. This cycle runs on a continual basis, keeping our epidermis healthy and strong.

DERMIS

The primary role of the dermis is to support the epidermis and enable the skin to thrive. It also plays a number of other roles due to the presence of nerve endings, sweat glands, sebaceous glands hair follicles, and blood vessels.

- **MAKING SWEAT:** There are little pockets called sweat glands in the dermis. They make sweat, which goes through little tubes and comes out of holes called pores. Sweating keeps you cool and helps you get rid of bad stuff your body doesn't need.
- **HELPING YOU FEEL THINGS:** Nerve endings in the dermis help you feel things. They send signals to your brain, so you know how something feels if it hurts (meaning you should stop touching it), is itchy or feels nice when you touch it.
- **GROWING HAIR:** The dermis is where you'll find the root of each tiny little hair on your skin. Each root attaches to a tiny little muscle that tightens and gives you goosebumps when you are cold or are scared.
- **MAKING OIL:** Another type of little pocket, or gland, in your skin makes oil. The oil keeps your skin soft, smooth and waterproof. Sometimes the glands make too much oil and give you pimples. (See Acne: Pimples and Zits).
- **BRINGING BLOOD TO YOUR SKIN:** Blood feeds your skin and takes away bad stuff through little tubes called blood vessels.



SUBCUTANEOUS LAYER

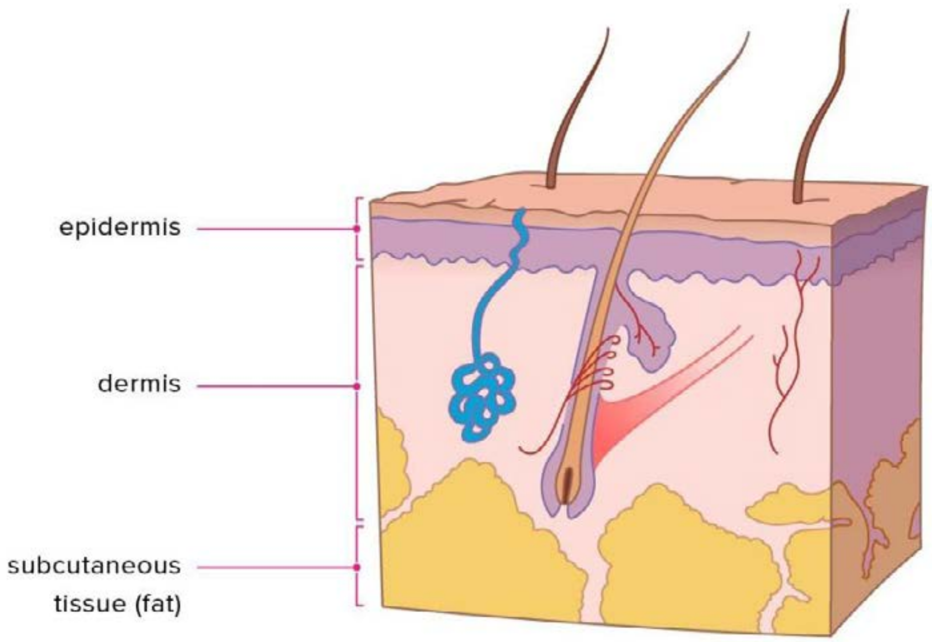
The subcutaneous layer which is also known as the hypodermis is the innermost layer of skin. It's made up of fat and connective tissues that house larger blood vessels and nerves, and it acts as an insulator to help regulate body temperature. The thickness of this subcutaneous layer varies throughout the body and also from person to person. The skin is composed of three layers: the epidermis, the dermis, and subcutaneous tissue.

There are several structures and specialized cells that exist within subcutaneous tissue, including:

- Collagen and elastin fibres (These attach the dermis to muscles and bones).
- Fat cells
- Blood vessels
- Sebaceous glands
- Nerve endings
- Hair follicle roots

The hypodermis is largely composed of adipose tissue(fat tissue), which is made up of adipocytes, or fat cells. The amount of adipose tissue varies throughout the body. It is thickest in the buttocks, the palms of the hands, and the soles of the feet. The size of the adipocytes is determined by an individual's nutritional habits.

Generally speaking, a person that maintains a healthy diet and exercise habits has smaller adipocytes and is less likely to be overweight. The location and thickness of subcutaneous tissue differ by gender. Men tend to accumulate more around the abdomen and the shoulders, while women tend to accumulate it around the thighs, the hips, and the buttocks.



FUNCTIONS OF THE SKIN:

The skin provides the following functions:

- Protection from infection due to the presence of keratin and protection from injury via reflex responses to stimuli.
- Regulation of temperature as sweat gland activity and vasodilation of superficial vessels is stimulated to allow heat loss through convection, conduction and radiation. The need for heat conservation will result in vasoconstriction of superficial vessels. Hair attempts to trap a layer of air next to the skin to slow down convection and involuntary contraction of muscles produces heat.
- Excretion of sweat which is 99% water and 1% salts.
- Sensation as the outermost organ detects the stimuli of temperature, pressure, touch and pain.
- Secretion of sebum to lubricate and protect the skin by making it acidic.
- Formation of chemicals including Vitamin D (for calcium utilisation) and melanin (to protect underlying structures from UV radiation i.e. Sun tan).

CONDITION OF THE SKIN

Your skin condition and the effects of the ageing process will depend upon genetics, the level of UV exposure, diet, exposure to damaging substances such as nicotine and alcohol, hydration levels and your general health.

EFFECTS OF POOR SKIN CONDITION

- Decreased collagen fibres in the connective tissue resulting in reduced elasticity.
- A slower rate of hair and nail growth.
- Reduced sebum levels resulting in poor protection and dry skin.
- Reduced sweat production affecting temperature regulation.
- Reduced cell production leading to thinner skin.
- Reduced tolerance of heat or cold.
- Reduced resistance to infection.

TYPES OF EPITHELIAL CELL

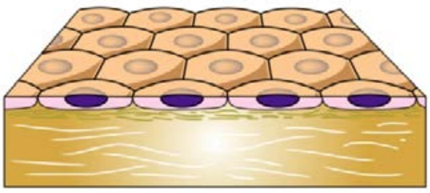
The cells that make up the epithelial layers are usually classified according to their shape. Since most epithelial cells, as a consequence of their locations in the body, are subject to friction, compression, and similar physical wear and tear, they divide rapidly to replace themselves.

SQUAMOUS

- Plate-like or flattened cells.
- Wider than deep.
- Resembling paving slabs.
- Flattened nucleus.

Features

- Cells allow selective diffusion.
- Allow certain substances to pass through, owing to the thinness of the layer.



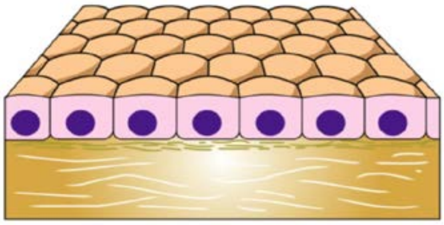
Simple squamous

CUBOIDAL

- Cube or box-shaped cells
- Occasionally hexagonal or polygonal
- Nucleus usually in the cell centre

Features

- Substances absorbed from one side of the layer.
- Can be altered as they pass through the cytoplasm of the cuboidal cells before leaving.



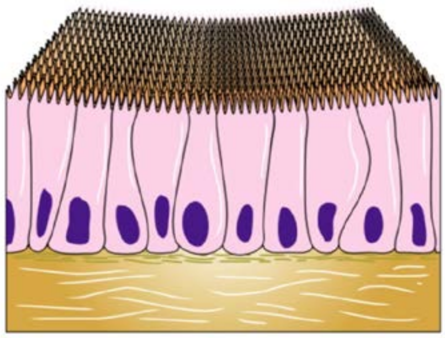
Simple cuboidal

COLUMNAR

- Tall, slim cells, often square, rectangular or polygonal.
- Large oval nucleus near cell base.

Features

- Protect and separate other tissues.
- May be topped with cilia.
- For the movement of fluid outside the cell or microvilli for absorption.



Simple columnar with microvilli

The Cardiovascular System

UNIT 1: THE SYSTEMS THAT MAKE UP THE HUMAN BODY (ANATOMY AND PHYSIOLOGY)

COMPOSITION OF BLOOD

Once oxygen has been inhaled and has diffused into the blood, it has to be moved around your body for use by the cells, tissues and organs. This is the job of the circulatory system. The circulatory system consists of three main parts:

- The blood
- The cardiac muscle or heart
- The blood vessels

THE BLOOD

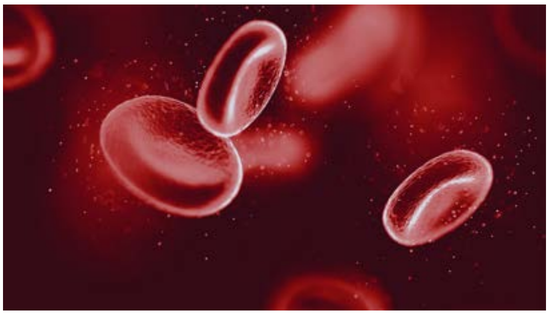
Scientists estimate the volume of blood in a human body to be approximately 7% of body weight. An average adult body with a weight of 150 to 180 pounds will contain approximately 4.7 to 5.5 litres (1.2 to 1.5 gallons) of blood. The body uses blood as a universal transporter for a great many substance, not least oxygen.

Blood is made up from four major components:

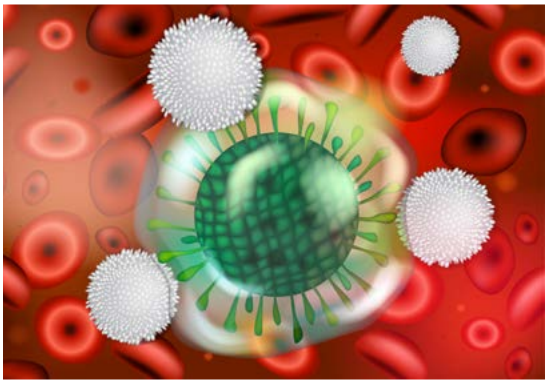
- Red blood cells (RBCs)
- White blood cells (WBCs)
- Platelets
- Plasma

RED BLOOD CELLS (ERYTHROCYTES)

A single drop of blood contains between 240-270 million RBCs so it's safe to say they are pretty prolific. RBCs contain a protein called haemoglobin (Hb) which carries oxygen and carbon dioxide around the circulatory system. RBCs are produced the red bone marrow and are pigmented which is what gives blood its characteristic red colour. RBCs make up approximately 40% of total blood volume.



A sound diet containing adequate iron ensures that there are plenty of RBCs – too few can result in anaemia which is characterised by fatigue and poor exercise performance.

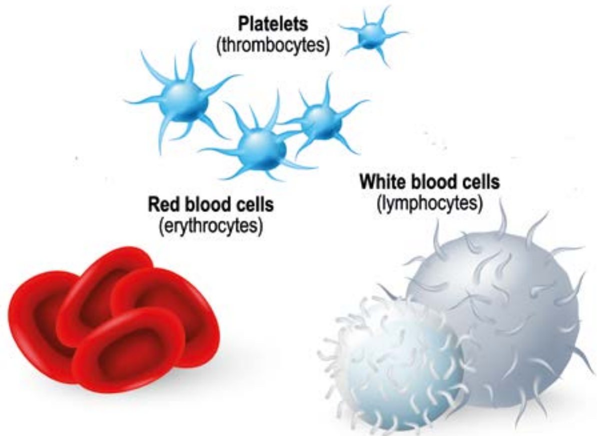


WHITE BLOOD CELLS (LEUKOCYTES)

WBCs are clear and contain no haemoglobin. There are fewer of them but they too are produced in red bone marrow. WBCs are the cells that fight infection and as infections come in various shapes and sizes, so to do WBCs.

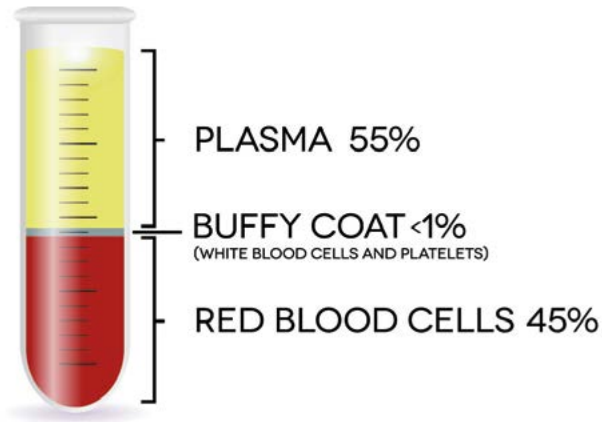
PLATELETS (THROMBOCYTES)

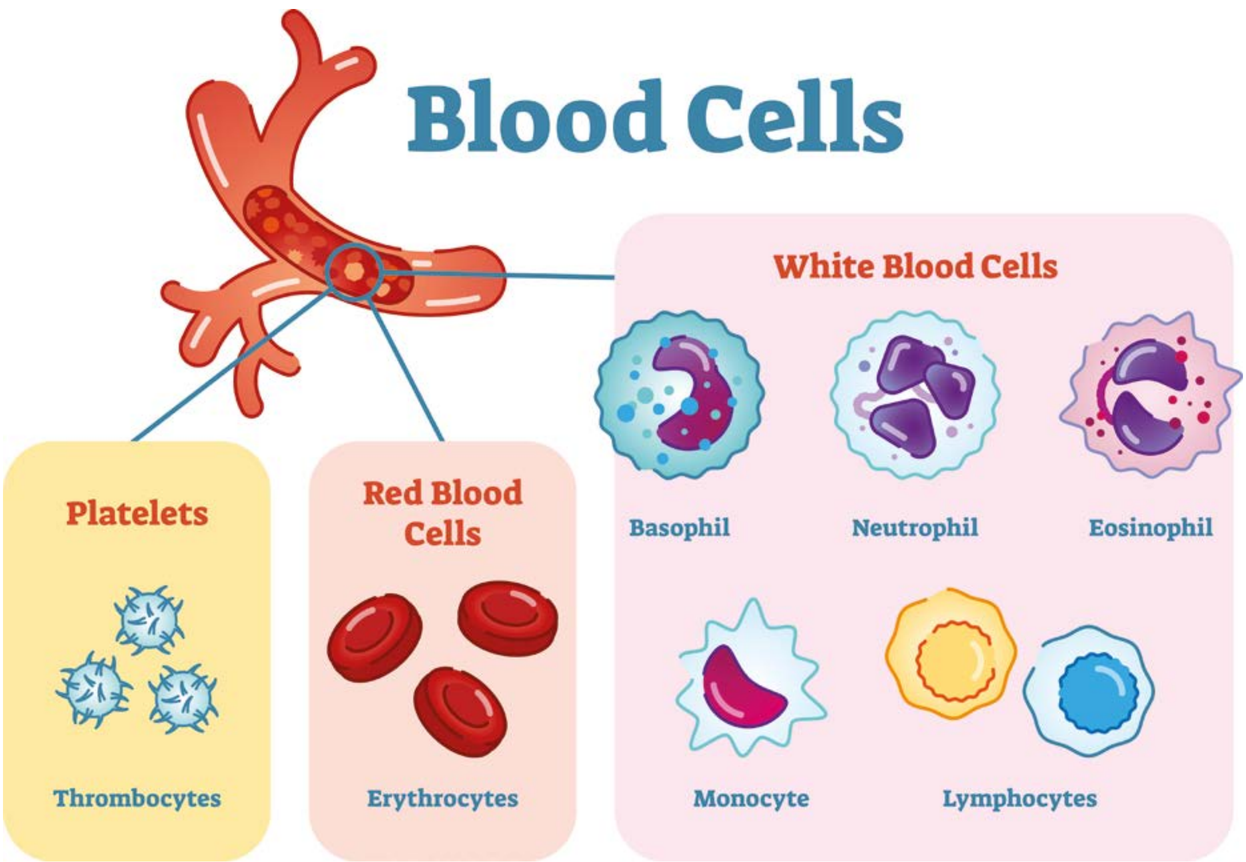
Platelets are responsible for stopping blood loss and are part of the clotting process. If you cut or otherwise injure yourself, platelets form "plugs" to stop your precious blood escaping. Some medications and diseases can inhibit platelet formation, in particular haemophilia and anti-coagulants such as warfarin.



PLASMA

Plasma is the carrier medium in which all the other blood cells are supported and transported. It also contains proteins and other nutrients, electrolytes, gases, enzymes, minerals, vitamins and metabolic waste products. Plasma is 91.5% water and 8.5% solids and solutes.





BLOOD VESSELS

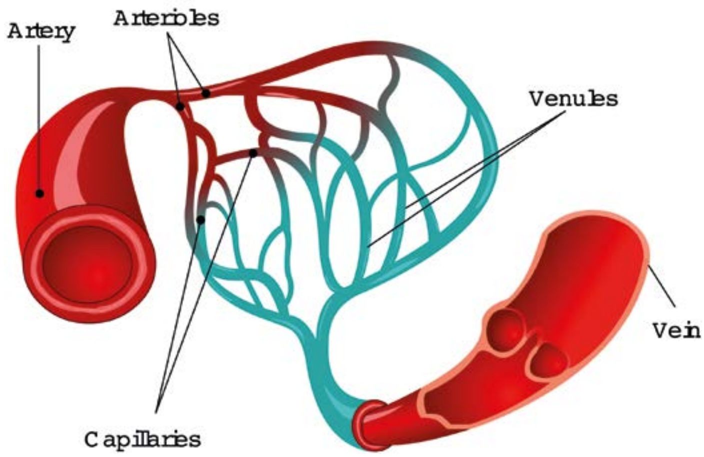
Blood vessels are hollow tubes made from smooth muscle whose function is to transport blood around the body and although there are different types of blood vessel it's important to always remember that they all form a closed, continuous loop and each blood vessel splits to form another type of blood vessel or joins to another blood vessel.

There are three main types of blood vessels:

- Arteries
- Veins
- Capillaries

There are also two sub-categories of blood vessel:

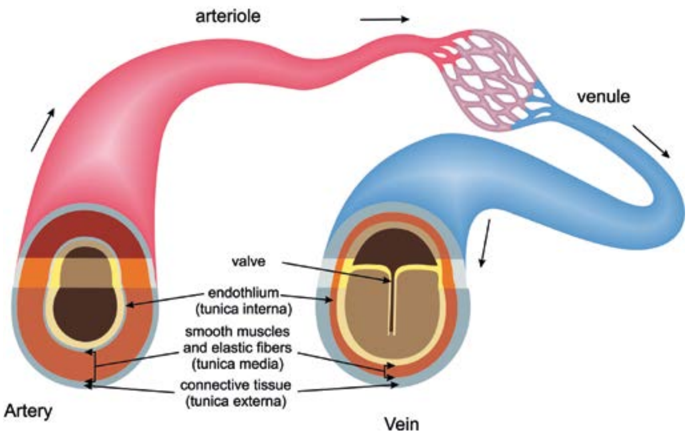
- Arterioles – Small arteries
- Venules – Small veins



ARTERIES

Thick and muscular, arteries are under tremendous pressure and their physical characteristics reflect this. They always carry blood away from the heart hence the high pressure within them.

The largest artery in the body is the aorta. They are elastic so that they can expand as the heart beats. If you place your fingertips on your radial artery, just below your thumb on the side of your wrist, you can feel the artery expand each time your heart beats. This is called your radial pulse.



VEINS

Veins take blood back toward your heart. Under considerably less pressure than arteries, they are not as thick or as muscular. Because they are under less pressure, it is possible that blood could flow backward through a vein so to prevent this, veins have one-way valves to ensure blood does not flow back from whence it came. These one-way valves sometimes go wrong and blood pools within sections of veins. This condition is commonly called varicose veins

CAPILLARIES

One cell thick to allow diffusion, capillaries are semi-permeable to allow various substances pass through them. Capillaries spread through all parts of the body so they can deliver or pick up essential substances. There are more capillaries than any other type of blood vessel and a high density area of capillaries is called a capillary bed. Exercise can cause an increase in the number of capillaries; this is called capillarisation.

BLOOD PRESSURE

The circulatory system is a closed system and as blood enters one area of the body, the same quantity of blood will be leaving another.

OXYGENATED BLOOD:

LUNGS > PULMONARY VEIN > HEART > AORTA > ARTERIES > ARTERIOLES > CAPILLARIES

DE-OXYGENATED BLOOD:

CAPILLARIES > VENULES > VEINS > VENA CAVA > HEART > PULMONARY ARTERY > LUNGS

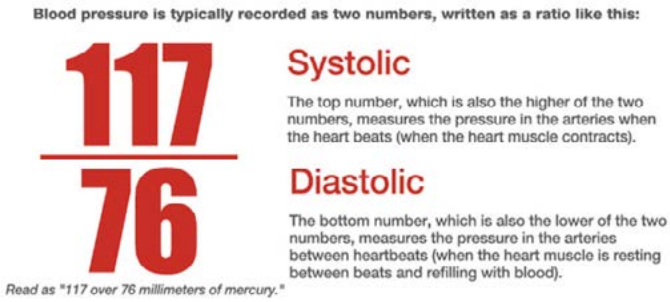
This means that there is pressure within the blood vessels and that pressure varies constantly. While some variance is normal and necessary, blood pressure can become too high or too low. The standard definition of blood pressure is “the measure of the force that blood exerts against the walls of the arteries”.

There are two measurements associated with blood pressure: systolic and diastolic Systolic blood pressure is the pressure within the arterial system when the heart beats. Diastolic blood pressure is the pressure in the arterial system when the heart is refilling. Subsequently, if you get your blood pressure checked, you will receive two readings: a higher reading (your systolic blood pressure) and a lower reading (your diastolic blood pressure). Blood pressure is normally expressed as one figure over another for example:

117 OVER 76

Blood pressure is measured in millimetres of mercury or mmHg. This unit of measure reflects the use of devices called mercurial sphygmomanometers which measured blood pressure against a vertical scale and how high a column of mercury moved during the test.

Mercurial sphygmomanometers are no longer widely used but the same unit of measure still is.



MACHINE SPHYGMOMANOMETER

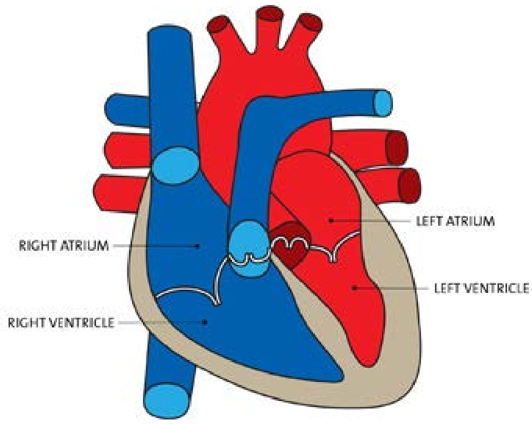
MERCURIAL SPHYGMOMANOMETER

BLOOD PRESSURE CATEGORIES

Blood Pressure Category	SYSTOLIC mm Hg (UPPER #)		DIASTOLIC mm Hg (LOWER #)
Low Blood Pressure (HYPOTENSION)	LESS THAN 80	OR	LESS THAN 60
Normal	80 - 120	AND	60 - 80
Prehypertension	120 - 139	OR	80 - 89
High Blood Pressure (HYPERTENSION STAGE 1)	140 - 159	OR	90 - 99
High Blood Pressure (HYPERTENSION STAGE 2)	160 OR HIGHER	OR	100 OR HIGHER
High Blood Pressure (HYPERTENSION STAGE 3)	HIGHER 10	OR	HIGHER THAN 110

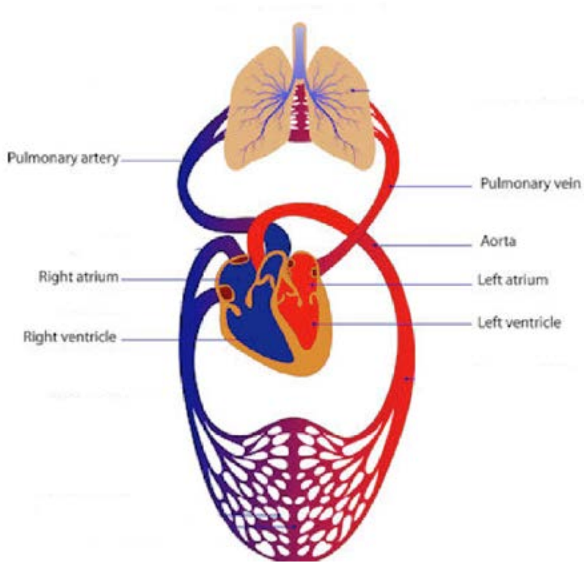
THE HEART

Of all the muscles in the body, the heart is arguably the most important as its sole job is to pump life-giving blood and therefore oxygen around your body. An average heart will beat over 3-billion times in a lifetime and if it stops prematurely or its function is in some way inhibited, major and potentially terminal health issues will ensue. In simple terms, the heart is a fist-sized, four-chambered muscular pump located slightly left of centre in your chest behind your sternum.



The heart is divided into two sides – left and right. Each side functions independently of the other and has a different job. The left-hand side of the heart receives and pumps out oxygenated blood while the right-hand side receives and pumps out de-oxygenated blood.

Remember, when describing the heart, left and right are reversed so imagine you are describing the heart of someone facing you rather than your own heart.



There are four chambers in total; two upper chambers called atria (the plural of atrium) and two lower chambers called ventricles. The atria are the receiving chambers and the ventricles are the ejecting chambers. The term atrium comes from the Latin for entranceway and houses often have atriums which, in more modern language, are called hallways. The ventricles eject or vent blood out of the heart. This is an easy way to remember which chambers are which.

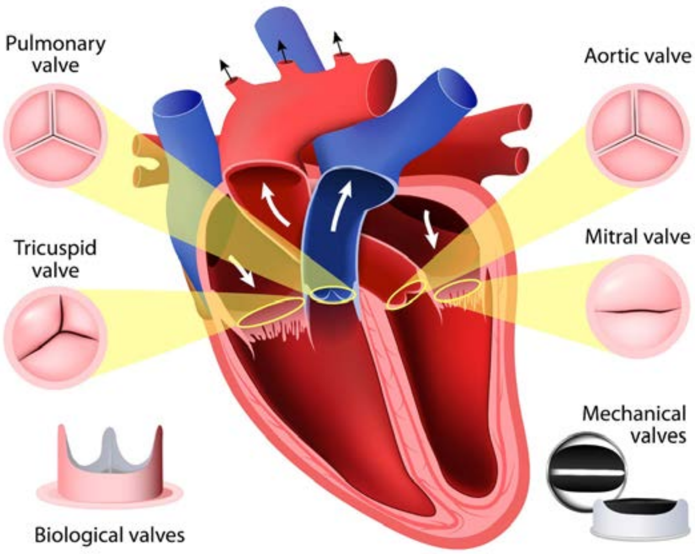
Of the four chambers, the ventricles have to work the hardest and so they are the largest and most powerful with the left ventricle being the biggest as it has to pump blood the furthest. As the ventricle contracts to eject blood, it is said to be in systole whereas when it relaxes (and refills) it is said to be in diastole. In contrast, the atria never have to pump especially hard as they are only pushing blood into the next chamber. Blood enters the atria partly because of gravity and partly because of the pressure in the blood vessels; their contractions are relatively small and therefore their size is also considerably smaller and less muscular than the ventricles for instance.

HEART VALVES

VIDEO AVAILABLE ON LEARNING PLATFORM

Blood always flows from atrium to ventricle and there are valves that prevent the back-flow of blood. The valves between the atria and the ventricles are called the atrioventricular valves or AVs for short.

There are also several other valves in and around the heart; the pulmonary valve prevents blood flowing back into the heart from the pulmonary artery while the aortic valve stops blood re-entering the heart from the aorta. Heart valves are tricuspid which means they are made up from three sections.



THE CARDIAC CYCLE

VIDEO AVAILABLE ON LEARNING PLATFORM

The conduction system allows the heart to function effectively by causing different compartments of the heart to contract and relax in a coordinated manner. The cardiac cycle is described as all the events associated with one beat. The key elements of the cardiac cycle relate to the contraction and relaxation of the heart's chambers. A chamber during contraction is referred to as being in 'systole', whereas one which is relaxing is referred to as being in 'diastole'.

The following is a brief summary of the key events of the cardiac cycle:

- **RELAXATION (DIASTOLE):** Relaxation of the atria allows blood to refill them from the pulmonary veins and vena cava. This precedes, and continues with, the ventricular relaxation which allows blood to flow in from the atria.
- **ATRIAL SYSTOLE (CONTRACTION):** Stimulation from the SA node causes the atria to contract and push any remaining blood into the ventricles.
- **VENTRICULAR SYSTOLE (CONTRACTION):** The ventricles contract causing a rise in pressure. This closes off the AV valves and directs the blood to be ejected from the heart via the pulmonary artery and aorta.
- **RELAXATION (DIASTOLE):** The atria relax followed by the ventricles until all four chambers are in diastole and the cardiac cycle begins over again.

THE AUTONOMIC CYCLE

Whilst the SA node dictates the basic rhythm of the heart beat, the autonomic system is able to exert significant control over the amount of work the heart does. This is primarily directed by the medulla oblongata of the brain. It responds to a variety of different stimuli, such as; input from other brain centres (e.g. The cerebral cortex and the hypothalamus), chemical changes in the blood, variations in blood pressure and movement of the limbs.

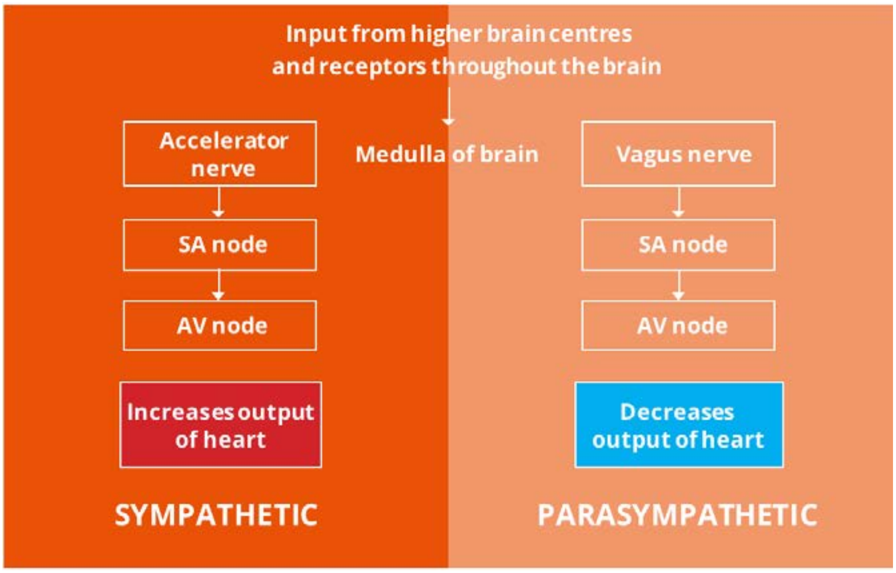
The activities of the autonomic system can basically be divided into two;

- Those which prepare the body for activity (the sympathetic system)
- Those which return the body to rest (the parasympathetic system)

The sympathetic system will increase the output of the heart, whereas the parasympathetic system will decrease the output.

When the need arises (e.g. Starting to run), the autonomic system can increase the volume of work done by the heart via two cardiac accelerator nerves running from the medulla of the brain. These stimulate the SA node to generate action potentials more rapidly, as well as directly causing the myocardium to contract more forcefully (the heart beats quicker and harder).

In contrast, in a resting state, the vagus nerve (also from the medulla) causes the SA node to generate action potentials less rapidly; consequently lowering the heart rate. The SA node will naturally generate between 90 – 100 beats per minute, the influence of the vagus nerve will usually reduce this to approximately 60 – 85 beats per minute. For the trained athlete however, Wilmore and Costill (2004) note that this may drop to less than 30 beats per minute.



HEART CONTROL AND RHYTHM

The speed and power of each heartbeat is controlled by something called the conductive system which ensures the chambers contract in a synchronised rhythm rather than all four chambers contracting at the same time. Your heart's natural "pacemaker" is a bundle of nerves called the sinoatrial node or SAN for short. Along with the atrioventricular node or AV node, your heart will speed up when more blood needs to be pumped around the body e.g. During exercise, and slow down when less blood is needed e.g., While you sleep.

The average resting heart rate is 72 beats per minute (bpm) although an exercising heart can beat over 200 times per minute. A resting heart rate above 72 bpm is called tachycardia while a resting heart rate of 60 bpm or less is called bradycardia. Low resting heart rates are generally seen as an indicator of good circulatory fitness but this is not always the case and unexpected low resting heart rate readings should be investigated

CONTROL OF THE HEART

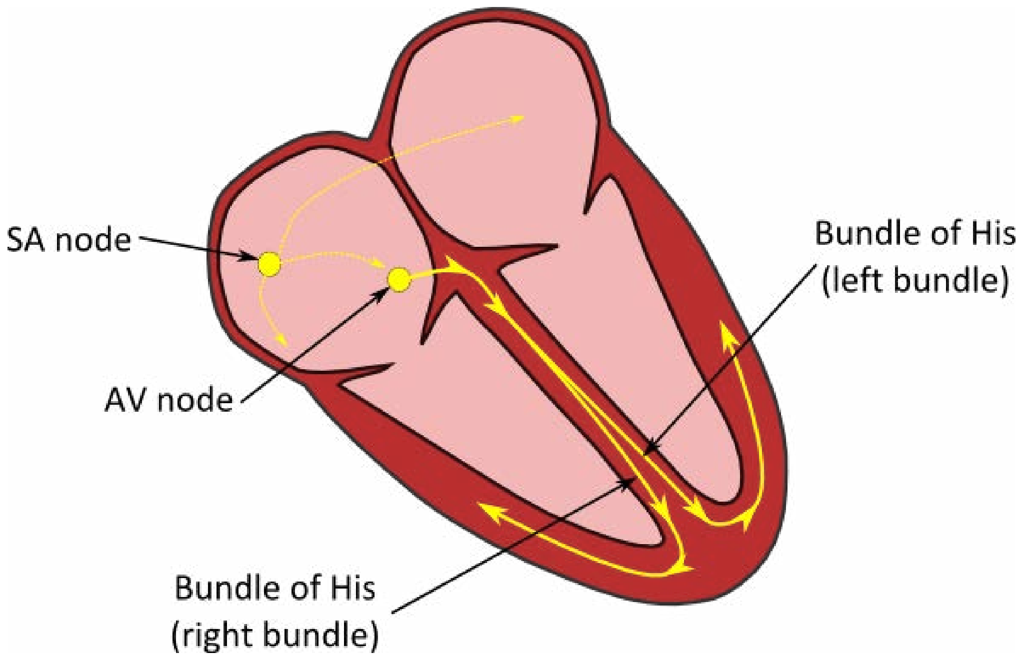
THE CONDUCTION SYSTEM

In order for the heart to work effectively, the various chambers must contract in a systematic and coordinated manner. In order to do this, the heart possesses an elegant 'conduction system'. Basically the course of electrical activity (action potential) is directed through the tissues of the heart in a way that they contract in a particular sequence.

Central to this conduction system are two small bundles of fibres located in the right atrium:

- The sinoatrial (SA) node
- The atrioventricular (AV) node

VIDEO AVAILABLE ON LEARNING PLATFORM



The SA node is a collection of self excitable cells; they require no neural input and are the site where cardiac action potentials begins. From this point, action potentials spread across both atria and so contracting them first.

The flow of action potentials to the ventricles is controlled and directed via the AV node. This is located at the base of the right atrium. The function of the AV node is to slow down the action potential and give the atria time to contract. If this did not occur the atria and ventricles would contract almost simultaneously. From here the action potential travels down a specialised nerve bundle (AV node bundle) before branching off into two bundles in the central wall of the heart (the septum).

The AV node bundle is the only place where action potentials can cross between the atria and the ventricles. These two branches direct the action potentials to the base of the ventricles, so that an action potential (or contraction) will spread outwards and upward along the outer walls of the ventricles, directing the blood upwards instead of downwards.

HEART CIRCULATION

As previously discussed, the two sides of the heart have different jobs. The left side receives and pumps oxygenated blood around the body whereas the right side receives and pumps de-oxygenated blood back to the lungs.
The process of returning de-oxygenated blood back to the heart is called 'venous return'.

Oxygenated blood is bright red in colour whereas de-oxygenated blood tends to have a bluish hue. Air is inhaled and passes through the:

FROM THE NOSE AND/OR MOUTH

- Pharynx.
- Larynx.
- Trachea.
- Primary bronchi.
- Bronchioles.
- Alveoli where oxygen is extracted and diffused into the blood via the capillaries.

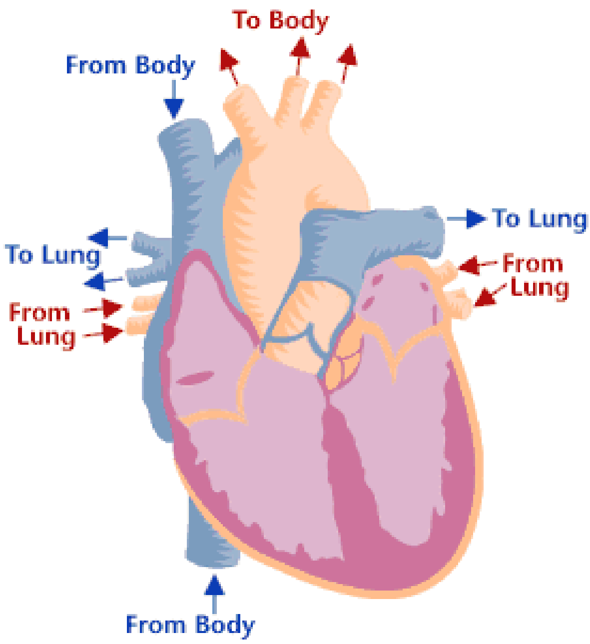
FROM THE LUNGS

- Oxygenated blood enters the left atrium via the pulmonary vein.
- Oxygenated blood flows from the left atrium to the left ventricle.
- Into the aorta to be circulated around the body. This is called systemic circulation.

The oxygen is used by the cells, organs and systems of the body and carbon dioxide is produced.

FROM THE BODY

- De-oxygenated (CO_2 rich) blood is then directed back to the heart via the superior and inferior vena cava where it enters the right atrium.
- Is pumped down into the right ventricle.
- From the right ventricle, the de-oxygenated blood is pumped into the pulmonary artery and sent back to the lungs.
- Its payload of CO_2 diffuses into the alveoli via the capillaries for exhalation and blood is then re-oxygenated. This is called pulmonary circulation.

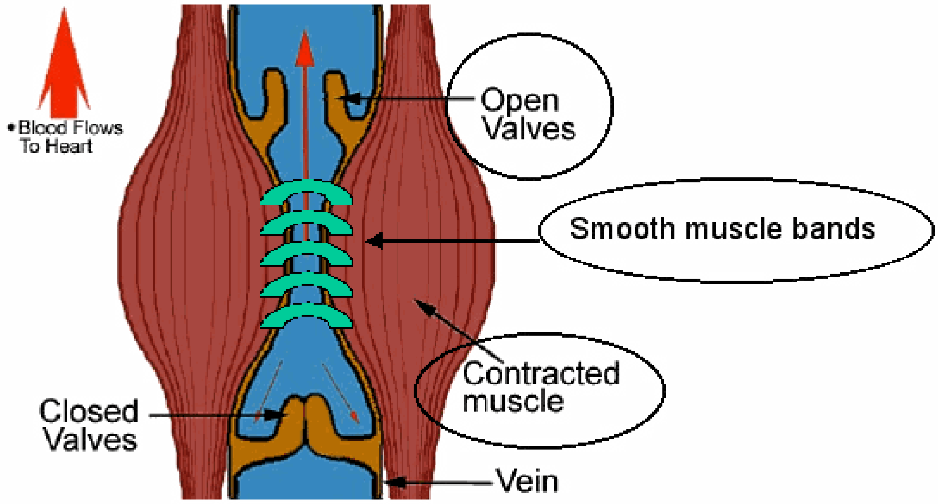


VENOUS RETURN

VENOUS RETURN

The flow of blood back to the heart via veins (often against gravity) is called 'venous return'. The pressure in the veins is relatively low and so several mechanisms combine to ensure that blood circulates in a timely fashion.

- **PERISTALSIS:** Made from smooth muscular tubes, all blood vessels can contract. When they contract they squeeze inward and that helps to push the blood they contain along their length. This is called peristalsis. To understand peristalsis, imagine a snake swallowing an egg; the walls of the snake's digestive tract push inward and, using a wave-like motion, push the egg down the length of the snake's body.
- **SKELETAL MUSCLE PUMP:** As skeletal muscles contract, they push against the walls of the veins which in turn pushes the blood through them.
- **ONE-WAY VALVES:** To prevent the back-flow of blood and aid venous return, veins have valves which prevent blood from flowing the wrong way or from "pooling" in one area.
- **RIGHT ATRIUM:** As the right atrium refills, it creates a slight vacuum effect and pulls blood into it
- **DIAPHRAGM:** As it relaxes and returns to its slightly domed position, the diaphragm creates a vacuum in the abdominal cavity which helps draw blood upward
- **GRAVITY:** Blood from above the heart flows downward to the right atrium via the superior vena cava and is aided by gravity.



CONTROL OF BLOOD FLOW

While every part of your body needs oxygen and therefore blood, some areas need more than others at certain times. For example, if you eat a large meal, your digestive system requires lots of blood and if you exercise, your working muscles and heart/lungs require lots of blood.

To ensure there is enough blood in the areas most in need, your body restricts blood flow to one area and increases it to another using vasoconstriction and vasodilation which basically means blood vessels are narrowed or widened respectively and on-demand.

This vasoconstriction and vasodilation are why it's never a good idea to exercise after a heavy meal and why your muscles can look "pumped up" after a workout. Both vasoconstriction and vasodilation are possible because blood vessels are made from smooth muscular tubes that can contract or relax as required.

MEASURING THE OUTPUT OF THE CARDIOVASCULAR SYSTEM

The work done by the heart is termed cardiac output (Q).

CARDIAC OUTPUT (Q) = THE VOLUME OF BLOOD PUMPED FROM THE HEART EVERY MINUTE

The determinants of cardiac output are heart rate (HR) and stroke volume (SV)

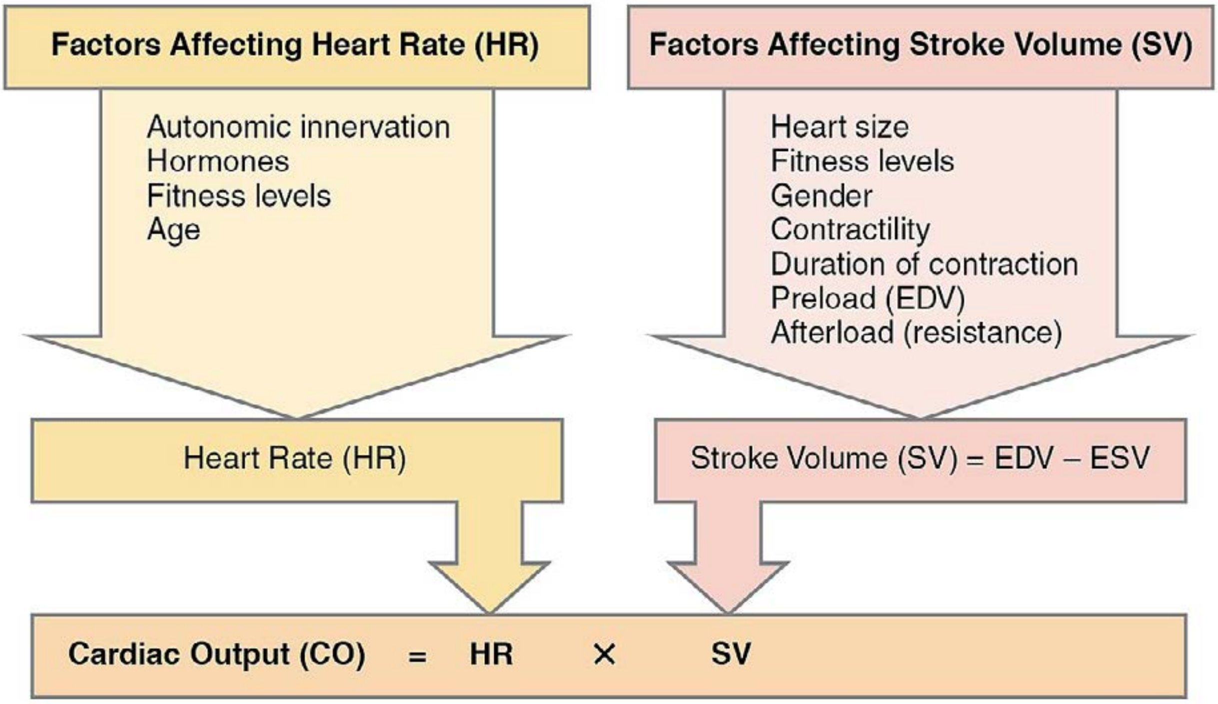
HEART RATE (HR) = THE NUMBER OF TIMES THE HEART BEATS IN A MINUTE.

STROKE VOLUME (SV) = THE AMOUNT OF BLOOD EJECTED FROM THE VENTRICLES EVERY BEAT.

Thus to calculate cardiac output, multiply stroke volume by heart rate.

Q = HR x SV

NB: Practically speaking, however, it is difficult to calculate cardiac output as determining stroke volume can involve some fairly invasive procedures.



THE EFFECT OF EXERCISE

EFFECTS OF EXERCISE ON BLOOD PRESSURE

SHORT TERM

As cardiac output increases with exercise, most forms of exercise will cause systolic blood pressure to increase. This response is linear and an increase in exercise intensity will cause a similar increase in blood pressure. This is not normally of any concern for healthy individuals as blood pressure should return to normal once cardiac output returns to normal. Cardiac output has the greatest effect on systolic blood pressure.

Diastolic blood pressure normally remains relatively unchanged or may even fall slightly when performing low to moderate-intensity aerobic exercise. However, heavy weight training and especially isometric contractions or where the breath is held to increase intra-abdominal pressure using the Valsalva manoeuvre (exhaling against a closed epiglottis can increase diastolic blood pressure in the short term. Again, in healthy individuals, blood pressure should normalise on cessation of exercise.

If an exerciser is hypertensive, care should be taken not to exasperate their health issues by straining so hard that diastolic blood pressure rises excessively. This means that hypertensive exercisers should avoid holding their breath and only exercise to form failure. It is also recommended that hypertensive follow a circuit weight training program rather than use the more traditional multi-set system and avoid overhead and declined exercises.

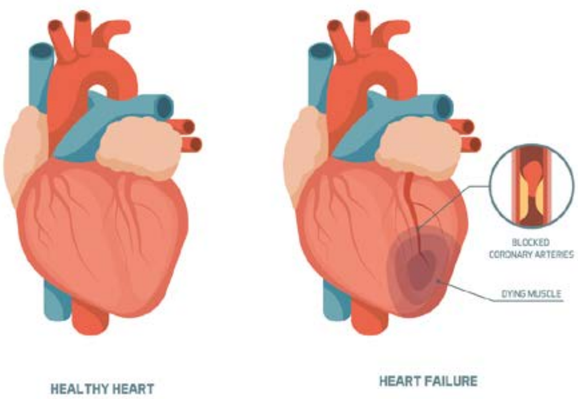
LONG TERM

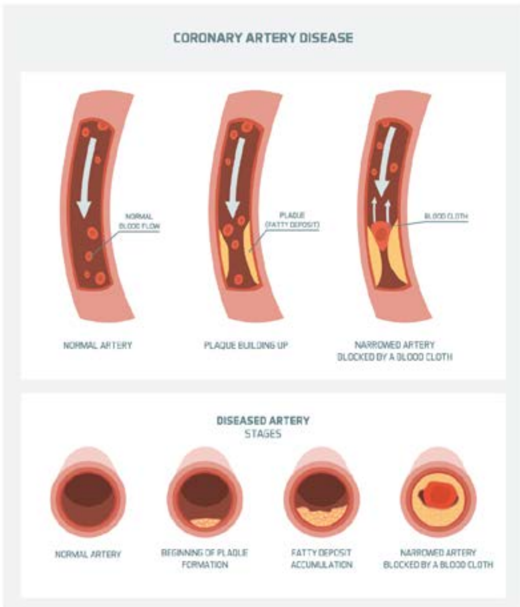
Low to moderate-intensity aerobic exercise has been shown to have a positive effect on cardiovascular health and can help normalise blood pressure in the long term. Regular aerobic exercise can lower systolic and diastolic blood pressure by an average of 10mmHg each.

THE EFFECT OF EXERCISE ON CIRCULATORY MEASURES

Exercise affects the function of your heart and blood vessels, both acutely (as you exercise) and as a result of your body adapting to the exercise (chronically). These changes are caused by increased heart size and strength, increased blood vessel elasticity and increased blood volume.

Each artery is responsible for delivering oxygen to some part of the heart. The heart also must have some mechanism to rid itself of blood that is now low in oxygen after supplying the tissues. This is done via coronary veins that carry the blood away, straight back to the heart. It will then be pumped to the lungs for re-oxygenation before again becoming part of the coronary circulation.





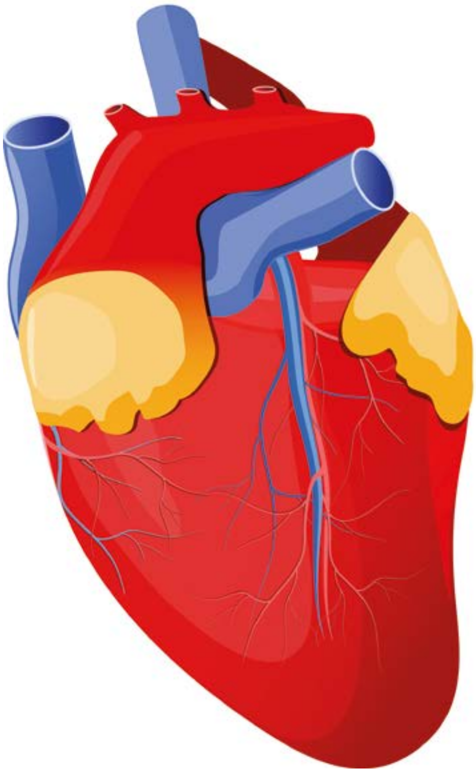
DISEASE AND THE VALSALVA EFFECT

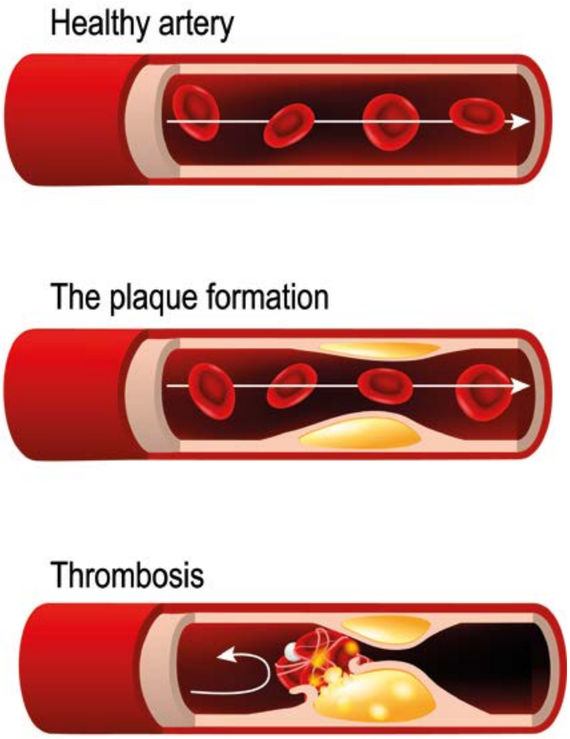
DISEASE EFFECT ON BLOOD VESSELS

Atherosclerosis is a condition where a substance called plaque builds up in the walls of the arteries. This build-up narrows the arteries, making it harder for blood to flow through. If a blood clot forms, it can stop the blood flow.

A heart attack occurs when the blood flow to a part of the heart is blocked by a blood clot. If this clot cuts off the blood flow completely, the part of the heart muscle supplied by that artery begins to die.

An ischemic stroke (the most common type) happens when a blood vessel that feeds the brain gets blocked, usually from a blood clot.





VALSALVA EFFECT AND BLOOD PRESSURE

Although proper breathing during exercise is one of the most important aspects of a safe and effective workout, correct breathing is not intuitive for most of us. Instead of breathing freely and openly during exercise, most people actually do the opposite.

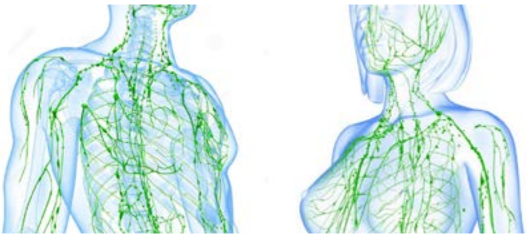
When it comes to weight-training, most of us hold (or force) our breath as a means of handling intensity. Unfortunately, breath-holding obviates our ability to produce high-intensity muscular contractions, and it can actually be dangerous. Breath-holding during exercise increases blood pressure rapidly and this can lead to fainting, painful Exercise- Induced Headaches, or even stroke.

The fancy term for breath-holding is Valsalva. Taking its name from 17th Century Italian Anatomist, Anton Maria Valsalva, the Valsalva Maneuver (or simply, Valsalva) occurs when we attempt to forcibly exhale while keeping the mouth and nose closed.

The Lymphatic System

UNIT 1: THE SYSTEMS THAT MAKE UP THE HUMAN BODY (ANATOMY AND PHYSIOLOGY)

The lymphatic system is part of the vascular system and is often referred to as the secondary circulatory system.



STRUCTURE OF THE LYMPHATIC SYSTEM

The lymphatic system is an open system, beginning in the tissues with blind-ended capillaries and ending at the left and right subclavian veins. It has two main layers of circulation; the superficial circulation located just below the surface of the skin and superficial fascia (60%-70%) and the deep muscular and visceral circulation.

Very similar to the circulatory system, in essence, the lymphatic system is the filtration and overflow component of the CV system. The lymph is formed when the interstitial fluid is collected through lymph capillaries. The interstitial fluid is found in the spaces between cells.

Most tissue fluid travels back into Circulatory system, however excess fluid, bacteria, molecules that are too large will drain into the lymphatic capillaries!

LYMPHATIC CAPILLARIES

These begin in the tissues forming a dense network of large, single-cell thick capillaries. The overlapping cells create one way valves and tissue fluid can easily diffuse into these low pressure, blind-ended tubes.

Once tissue fluid is inside the lymphatic capillaries, it is known as lymph. Lymph is transported from the capillaries which join up to form vessels.

LYMPHATIC VESSELS

AS WITH THE CIRCULATORY SYSTEM, BACK-FLOW OF LYMPH NEEDS TO BE PREVENTED, AND SO THE VESSELS HAVE NON-RETURN VALVES. THE VESSELS CONTINUE TO MERGE FORMING LARGER TRUNKS AND FINALLY TWO MAIN DUCTS; THE RIGHT LYMPHATIC DUCT AND THE THORACIC DUCT, WHERE LYMPH WILL BE RETURNED TO THE BLOOD.

If the excess tissue fluid were not removed and returned to the blood:

- The blood would become gradually more viscous.
- The tissues would become more swollen.

FUNCTIONS OF THE LYMPHATIC SYSTEM

The lymphatic system has three functions:

- The removal of excess fluids from body tissues.
- Absorption of fatty acids and subsequent transport of fat, chyle, to the circulatory system.
- Production of immune cells (such as lymphocytes, monocytes, and antibody-producing cells called plasma cells).

LYMPHATIC NODES

LYMPHATIC NODES

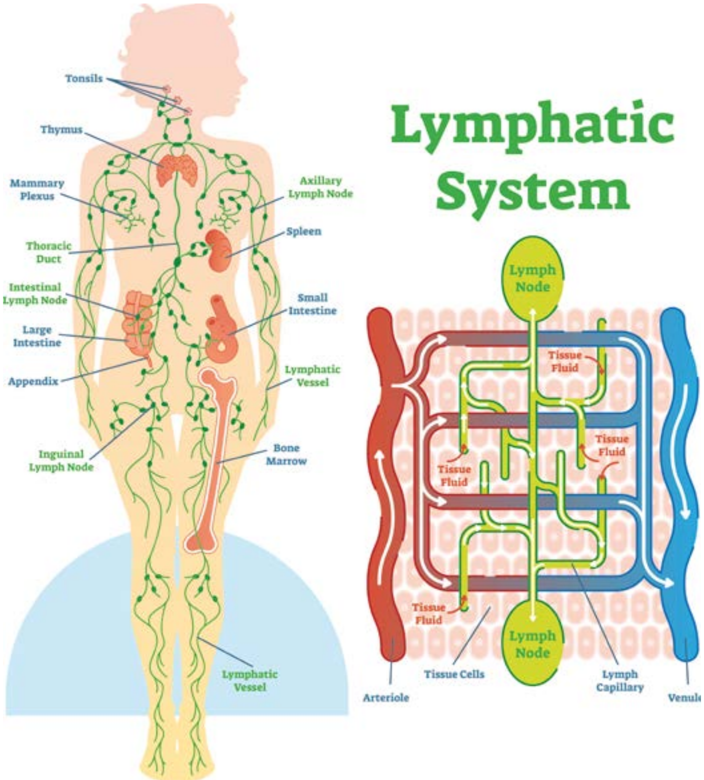
These are small, round, bean-shaped structures of specialised lymphatic tissue surrounded by a capsule, located along with the network of lymphatic vessels through which the lymph will flow. They tend to occur in clusters much like grapes.

Nodes are the production centres for lymphocytes, a variety of white blood cells involved in immunity and the production of antibodies. The lymphocyte's main function is to prevent harmful pathogens (bacteria and viruses) from gaining access to the bloodstream. They also begin detoxifying waste products before they re-enter the blood. Finally, they also circulate the lymph around the body.

Lymphocyte production is stimulated by:

- The presence of harmful pathogens
- An increased flow of lymph through the nodes

In the event of infection, the nodes can increase in size as larger numbers of lymphocytes are produced and become tender.



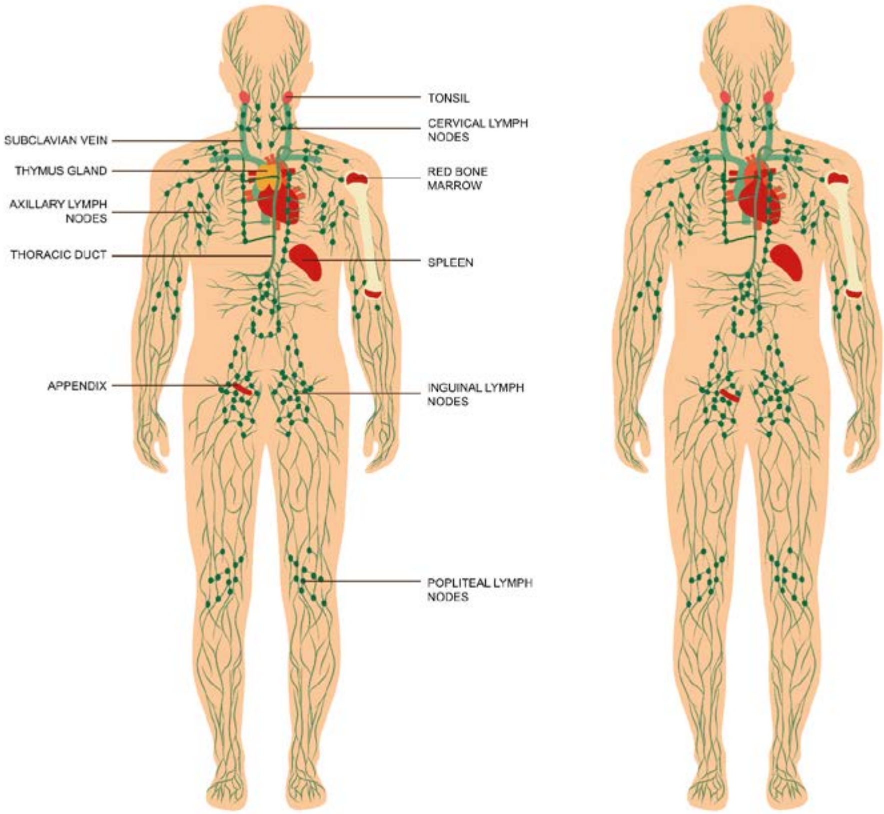
PATH OF LYMPH THROUGH A LYMPH NODE

- Carry lymph to the lymph node from peripheral tissues. The afferent lymphatics penetrate the capsule of the lymph node on the side opposite the hilum.
- The afferent vessels deliver lymph to the subcapsular space, a mesh work of reticular fibres, macrophages, and dendritic cells. Dendritic cells are involved in the initiation of the immune response.
- Lymph next flows into the outer cortex, which contains B cells within germinal centres that resemble those of lymphoid nodules.
- Lymph then flows through lymph sinuses in the deep cortex, which is dominated by T cells.
- Lymph continues into the medullary sinus at the core of the lymph node. This region contains B cells and plasma cells.
- Efferent lymphatics (efferent, to bring out) leave the lymph node at the hilum. These vessels collect lymph from the medullary sinus and carry it toward the venous circulation.

In some parts of the body, the nodes appear in clusters, particularly around the joints. These clusters assist the pumping of lymph through the system as the joints move.

LOCATION OF LYMPH NODE CLUSTERS

- **SUBMANDIBULAR:** Location – Inferior aspect of the jaw.
- **AXILLARY:** Location – In and around the armpit.
- **CUBITAL:** Location - The crook of the elbow.
- **INGUINAL:** Location – Anterior aspect of the groin area.
- **POPLITEAL:** Location – Posterior aspect of the knee.



LYMPH NODULES

Nodules are small, solitary deposits of specialised lymphoid tissue that produce lymphocytes. Differing from nodes, which have lymph fluid flowing through them; nodules are strategically positioned around the body to provide the first line of immune defence where the external environment comes into contact with the body's internal tissues.

Nodules can be found beneath the mucous linings of the:

- Upper respiratory tract.
- Small intestines.
- Urinary tract.

ASSOCIATED ORGANS

The following organs contain lymphoid tissue and support the lymphatic system in providing immunity:

SPLEEN

Located in the upper left abdomen:

- Stores lymphocytes to release as part of the immune response.
- Removes worn-out blood cells.

THYMUS

Located against the trachea above the superior vena cava:

- Prominent in infancy providing immunity
- Aids in lymphocyte maturation
- Programmes T-cells (aggressive white blood cells)

MOVEMENT OF LYMPH THROUGH SYSTEM

Movement of lymph through the system is aided by:

- Peristalsis of smooth muscle walls of the vessels
- Pumping from skeletal muscles
- Suction from the diaphragm
- Non-return valves
- Gravity

EFFECTS OF MASSAGE OF THE LYMPHATIC SYSTEM

Improved drainage of superficial tissues via skin and fascia movement

- The increased removal rate of metabolic wastes from the tissues.
- Improved drainage of deep tissues via compression of muscles influencing tissue pressure.
- Increased speed of lymphatic flow within vessels stimulating lymphocyte production.

System Comparisons
Many aspects of the cardiovascular system are reflected in the lymphatic system:

SYSTEM COMPARISONS

Many aspects of the cardiovascular system are reflected in the lymphatic system.

Comparison of the Cardiovascular and Lymphatic Systems	
Cardiovascular System (Blood)	**Lymphatic Systems**
Blood is responsible for collecting and distributing oxygen, nutrients and hormones to the tissues of the entire body.	Lymph is responsible for collecting and removing waste products left behind in the tissue.
Blood flows in a closed continuous loop throughout the body via the arteries, capillaries, and veins.	Lymph flows in an open circuit from the tissues into lymphatic vessels. Once within these vessels, lymph flows in only one direction.
Blood is sucked. The heart sucks blood from the veins.	Lymph is pumped. Flow within the lymphatic vessels is aided by other body movements such as deep breathing and the action of nearby muscles and peristalsis.
Blood consists of the liquid plasma that transports the red and white blood cells and platelets.	Lymph that has been filtered and is ready to return to the cardiovascular system is a clear or milky fluid.
Blood is visible and damage to blood vessels causes obvious signs such as bleeding or bruising.	Lymph is invisible and damage to the lymphatic system is difficult to detect until swelling occurs.
Blood is filtered by the kidneys. All blood flows through the kidneys where the waste products and excess fluid are removed. Necessary fluids are returned to the cardiovascular circulation.	Lymph is filtered by lymph nodes located throughout the body. These nodes remove some fluid and debris. They also kill pathogens and some cancer cells.

FUNCTIONS OF THE LYMPHATIC SYSTEM

As part of the vascular system it has three main functions:

- Returning tissue fluid to the bloodstream
- Filtering fluid to prevent infection of the blood and tissues
- Absorbing lipids from the small intestine via lacteals

Also playing a vital role in preventing and reducing oedema, maintaining blood viscosity and vascular homeostasis.

CAPILLARY TISSUE EXCHANGE

Blood circulates through the vascular system, travelling in various sized vessels to supply all the tissues of the body with nutrients and oxygen and to remove waste products. Capillary beds in the tissues slow the flow of blood to provide optimum contact time with the fluid that fills the interstitial (tissue) space. Blood pressure pushes plasma from the capillaries into the tissues. This fluid is referred to as interstitial or tissue fluid and it bathes all the cells of the tissues.

It is via the tissue fluid that nutrients and waste products pass between the blood and the cells. The differing concentrations in the two areas allow the exchange to take place (diffusion). The blood is rich in nutrients and oxygen so these diffuse into the tissue fluid where concentrations are very low, but where levels of carbon dioxide and metabolites will be high.

Consequently, carbon dioxide and metabolites will be pulled back into the capillaries where concentrations of the waste product are low.

Most, but not all of the tissue fluid passes back into the circulatory system. Some molecules, however, will be too large to re-enter the blood capillaries or the concentration gradient may not be suitable to allow this to happen. Any remaining fluid will drain into lymphatic capillaries.

The Digestive System

UNIT 1: THE SYSTEMS THAT MAKE UP THE HUMAN BODY (ANATOMY AND PHYSIOLOGY)

The digestive system can be best thought of as the body's food processing plant and is responsible for the digestion and absorption of the food we eat.

The body is unable to use food in its unprocessed state and so the digestive system breaks foods down into substances the body can use.

VIDEO AVAILABLE ON LEARNING PLATFORM

MACRONUTRIENT	END PRODUCT
Carbohydrates	Glucose
Protein	Amino acids
Fats	Fatty acids, glycerol

While digestion and absorption of nutrients is partially a mechanical process, digestion also involves several chemicals called enzymes. The primary digestive enzymes are:

- Lipase
- Amalayse
- Pepsin

DEFINITIONS FOR DIGESTION

- **INGESTION:** The taking in of food into the stomach.
- **PROPULSION:** The movement of food through the hollow tubes of the gastrointestinal tract.
- **DIGESTION:** The breaking down of protein, carbohydrates and fats into smaller units.
- **ABSORPTION:** The movement of nutrients into the blood.
- **ELIMINATION:** The excretion of any waste products out of the body.

THE OUTCOME OF DIGESTED FOOD

- **BLOOD:** Carries simple sugars, amino acids, glycerol and some vitamins and salts to the liver.
- **LIVER:** Stores, processes and delivers nutrients to the body when needed.
- **LYMPH SYSTEM:** Absorbs fatty acids and vitamins to fight infection.
- **THE BODY:** Uses sugars, amino acids, fatty acids and glycerol as building blocks for energy growth and repair.

THE DIGESTIVE SYSTEM

The food we eat passes the length of the digestive system:

- **THE MOUTH:** The first part of the gastrointestinal tract and is equipped with several structures that begin the first processes of digestion. These include salivary glands, teeth and the tongue. It is responsible for the mechanical breakdown of food through mastication (chewing) and the production of saliva, which lubricates food, keeps the mouth healthy and contains enzymes that start the breakdown of carbohydrates.

- **PHARYNX:** A part of the conducting zone of the respiratory system and also a part of the digestive system. It is the part of the throat immediately behind the nasal cavity at the back of the mouth and above the oesophagus and larynx.

- **OESOPHAGUS:** The hollow tube which connects the mouth to the stomach

- **LOWER OESOPHAGEAL SPHINCTER:** These are a group of muscles at the lower end of the oesophagus where it meets the stomach and when it relaxes it lets food pass into the stomach. The ring-like muscle, sphincter stays closed to prevent food flowing back from the stomach.

- **STOMACH:** Is a major organ of the gastrointestinal tract and digestive system. Gastric acid (informally gastric juice), produced in the stomach plays a vital role in the digestive process, and mainly contains hydrochloric acid and sodium chloride. A peptide hormone stimulates the production of gastric juice which activates the digestive enzymes, and gastric acid activates this to the enzyme pepsin which begins the digestion of proteins.

- **SMALL INTESTINE:** Food starts to arrive in the small intestine one hour after it is eaten, and after two hours the stomach has emptied. Most food digestion takes place in the small intestine. When the digested food particles are reduced enough in size and composition, they can be absorbed by the intestinal wall and carried to the bloodstream. It is a primary site for nutrient absorption into the blood

- **LARGE INTESTINE:** Also called the colon. Vitamins, minerals and water are absorbed and waste matter is turned into faeces prior to excretion. It absorbs water from the remaining indigestible food matter and transmits the useless waste material from the body. Sodium, chloride, and water are absorbed through the lining of the colon into blood and lymph, and faeces become less watery.

- **LIVER:** The second largest organ and is an accessory digestive gland which plays a role in the body's metabolism. The liver has many functions some of which are important to digestion. The liver can detoxify many things; synthesise proteins and produce biochemicals needed for digestion. It regulates the storage of glycogen which it can form from glucose. The liver can also synthesise glucose from certain amino acids. Its digestive functions are largely involved with the breaking down of carbohydrates. It produces bile acids which break down fats so that they can be emulsified (mixed with water)

- **GALLBLADDER:** A small organ where the bile produced by the liver is stored, before being released into the small intestine. Bile flows from the liver through the bile ducts and into the gall bladder for storage. Bile acts partly as a surfactant which lowers the surface tension between either two liquids or a solid and a liquid and helps to emulsify the fats.

- **PANCREAS:** Secretes enzymes for the breakdown of protein into amino acids, carbohydrates into glucose and fats into fatty acids and also produces insulin which is necessary for the movement of glucose into the body's cells. It is a major organ functioning as an accessory digestive gland in the digestive system. The pancreas produces and releases important digestive enzymes in the pancreatic juice that it delivers to the duodenum. The pancreas is also the main source of enzymes for the digestion of fats and proteins and carbohydrates. Lipase (fats), Amylase (carbs), and Trypsin (protein).

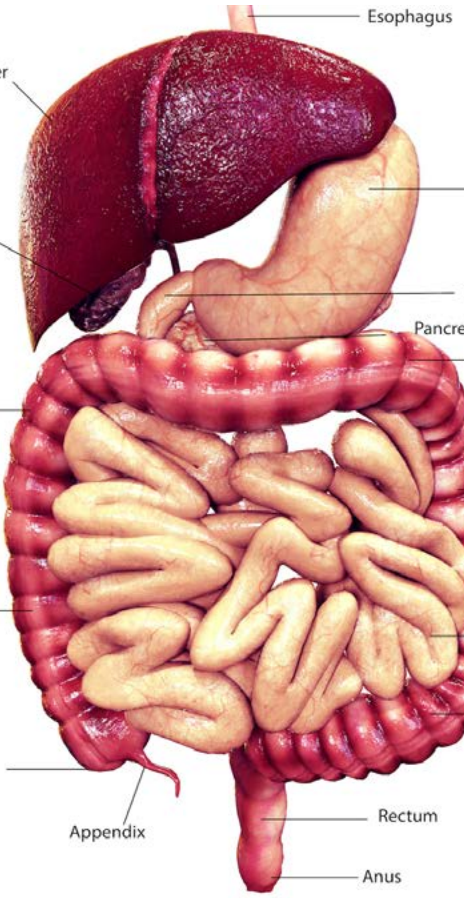
- **RECTUM:** Is around 12cm long. Below it is the anal canal, about 4cm long. In the walls of the anal canal, there are two sets of strong muscles, the internal and external sphincters. During defecation, peristaltic waves in the colon push faeces into the rectum, which triggers the defecation reflex. Contractions push the faeces along, and anal sphincters relax to allow them out of the body through the anus.

THE PASSAGE OF FOOD THROUGH THE DIGESTIVE SYSTEM

Just the thought of food triggers enzymes (substances that control chemical reactions) to be released and saliva to be produced in preparation for eating. Chewing breaks down food into smaller pieces, which makes it easier to swallow and digest. Saliva is produced by the salivary glands and lubricates food for easy passage through the tubes of the digestive system.

After swallowing, food passes down the oesophagus and into the stomach. The movement of food through the hollow tubular organs of the digestive system is called peristalsis. Once in the stomach food is broken down into even smaller units and mixed into a liquid called 'chyme' and digestion is completed. When the chyme is ready, the stomach empties into the first part of the small intestine (long in length, but small in diameter) called the duodenum where absorption begins.

Nutrients are extracted from the chyme by structures called 'villi' and absorbed into the blood for use in the body's cells. Once the chyme has reached the end of the small intestine it passes into the large intestine (large in diameter but shorter in length) where water is absorbed and waste material formed into faeces ready for elimination from the body.



Like your muscles, your digestive system needs some care and attention to keep it in top shape. To prevent common digestive problems, it is essential to eat well and drink plenty of water. Fibre (found in fruit, vegetables and whole grains) is vital for the easy passage of food through the intestines. Without sufficient fibre and water, the propulsion of matter through the hollow tubes of the digestive system can become sluggish. This can result in constipation or less frequent and or more difficult bowel movements, which puts an unnecessary strain on the digestive system. If left unchecked this strain can develop into a condition called 'diverticular disease', where bulges occur in the walls of the large intestine and bacteria builds up resulting in abdominal pain.

To maintain the health of the digestive system, eat plenty of fresh fruit and vegetables, whole grains in preference to refined grains, drink plenty of water, take care with food hygiene and exercise regularly.

The Endocrine System

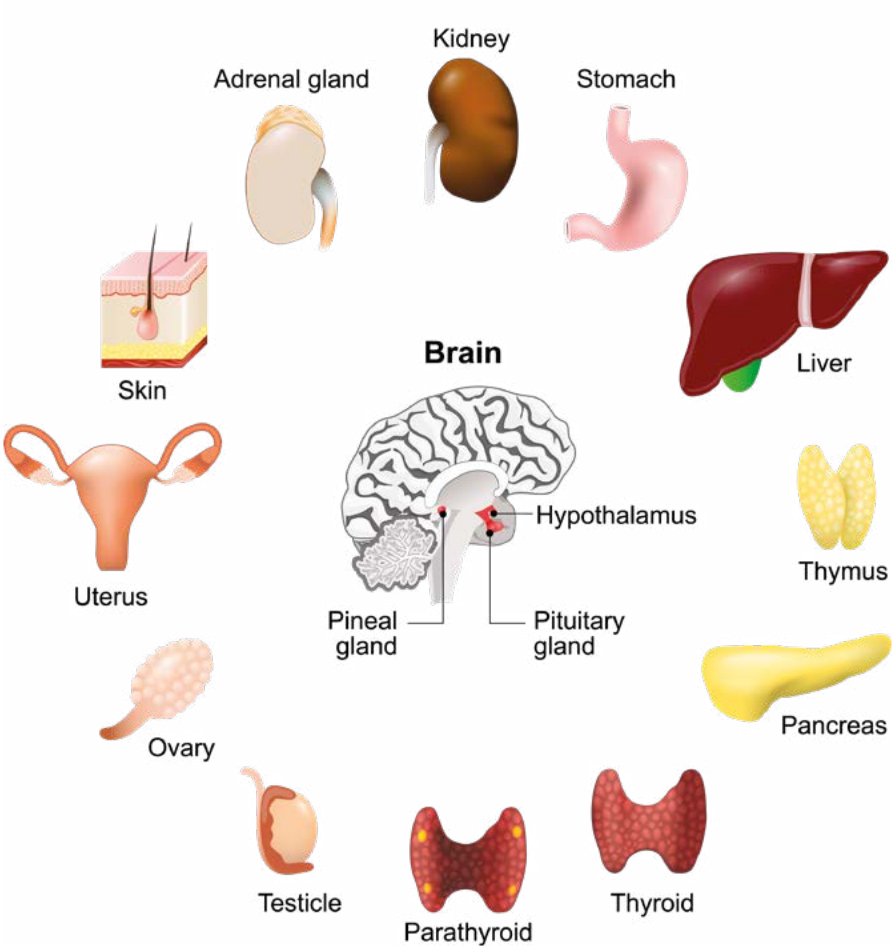
UNIT 1: THE SYSTEMS THAT MAKE UP THE HUMAN BODY (ANATOMY AND PHYSIOLOGY)

The endocrine system is made up of a network of glands. These glands secrete hormones to regulate many bodily functions, including growth and metabolism. Endocrine diseases are common and usually occur when glands produce an incorrect amount of hormones.

Simply put, the endocrine system is a network of glands that secrete chemicals called hormones to help your body function properly. Hormones are chemical signals that coordinate a range of bodily functions. The endocrine system works to regulate certain internal processes. (Note: endocrine shouldn't be confused with exocrine. Exocrine glands, such as sweat and salivary glands, secrete externally and internally via ducts. Endocrine glands secrete hormones internally, using the bloodstream).

The endocrine system helps control the following processes and systems:

- Growth and development.
- Homeostasis (the internal balance of body systems).
- Metabolism (body energy levels).
- Reproduction.
- Response to stimuli (stress and/or injury).

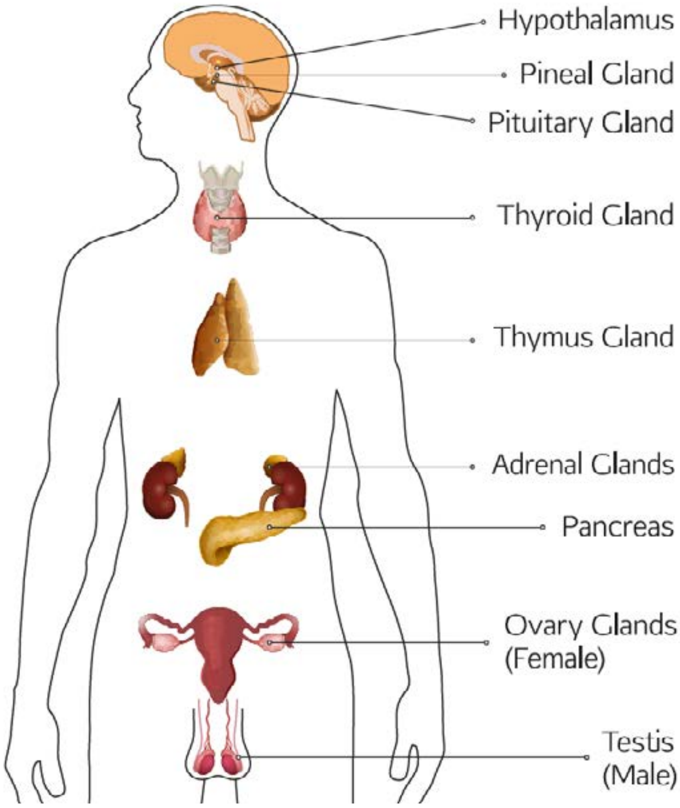


THE ENDOCRINE NETWORK

The endocrine system completes these tasks thı
that produce, store, and secrete hormones.

The glands of the endocrine system are:

- Hypothalamus
- Pineal Gland
- Pituitary Gland
- Thyroid
- Parathyroid
- Thymus
- Adrenal
- Pancreas
- Ovaries
- Testes



These glands produce different types of hormones that evoke a specific response in other cells, tissues, and/or organs located throughout the body. The hormones reach these far away targets using the blood stream. Like the nervous system, the endocrine system is one of your body's main communicators. Instead of using nerves to transmit information, the endocrine system uses blood vessels to deliver hormones to cells.

HORMONES PART 1

Hormones are chemical signals that coordinate a range of bodily functions. Hormones are derived from lipids or proteins. The effect a hormone will have is dependent on the hormone's chemical shape. Each hormone will have a target cell or cells that have specific receptors in their membranes which will only be triggered by the 'right' hormone (i.e. In the same way that locks can only be opened with the right key).

INSULIN, GLUCAGON AND THE CONTROL OF BLOOD GLUCOSE

The principle fuel for vigorous activity is a carbohydrate (specifically glucose). It is also worth noting that glucose is the principle fuel for the brain. Large fluctuations in blood glucose levels can be extremely damaging. Too little will decrease performance and could eventually be fatal, furthermore, too much can damage the vascular system.

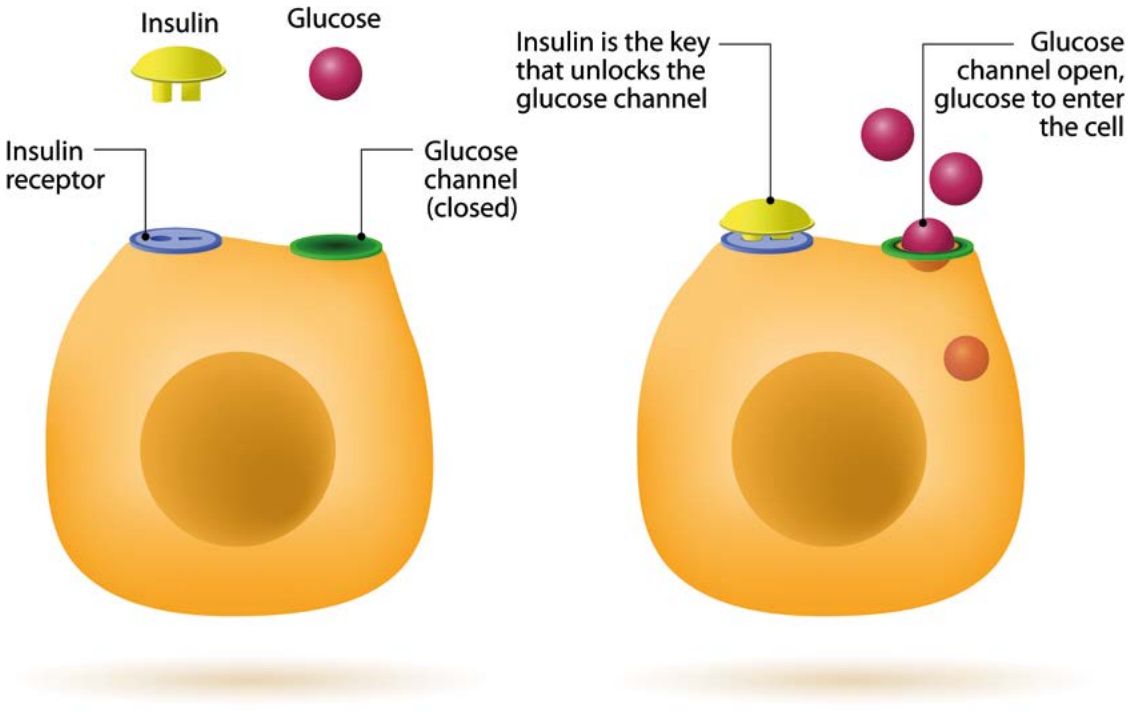
Control of blood glucose levels is primarily directed by the pancreas, which occupies an area posterior to and just below the stomach. As a gland it has multiple functions, however only the production of two hormones; insulin and glucagon are of relevance here.

INSULIN

After consuming a meal, glucose enters the blood at the small intestine causing a rise in blood glucose levels. As this blood is circulated through the pancreas the elevated levels of glucose trigger the release of insulin. The circulating insulin binds with the receptors of its target cells. The cell membrane becomes more permeable to glucose.

Glucose then diffuses out of the bloodstream and into the cell. The net result being, a drop-in blood glucose levels as the glucose is no longer in the bloodstream.

At this point, it is also worth noting that insulin encourages the synthesis (manufacture) of both protein and fat within the body. The extent to which this occurs is determined by the nature of the meal consumed and the existing nutritional status of the individual (McArdle et al. 2001, Tortora and Grabowski, 1996).

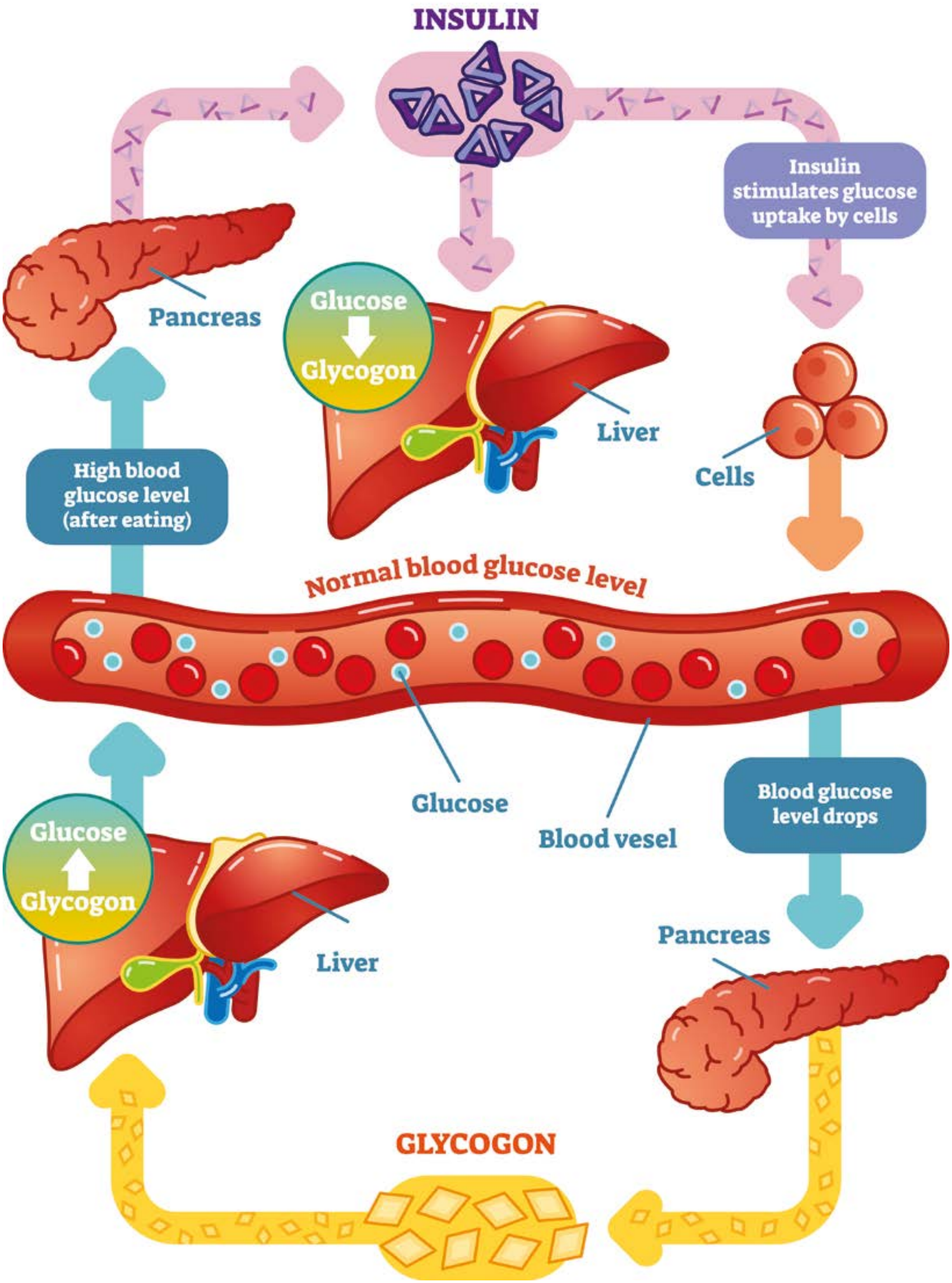


GLUCAGON

Glucagon serves to maintain blood glucose levels, in contrast to insulin, by triggering the release of glycogen stores from the liver (glycogen is the stored form of glucose). In the hours following the last meal, a combination of normal metabolic processes and physical activity will begin to lower blood glucose levels (assuming nothing has been eaten in the meantime). The drop in circulating blood glucose levels triggers the release of glucagon from the pancreas.

Understanding the effects of exercise is helpful because they help underline the interrelationship between insulin and glucagon. As activity levels increase, the body's cells also increase their uptake of insulin. This is the result of an increased sensitivity of the cells to insulin, thus insulin levels will drop during physical activity (Wilmore and Costill, 2004).

Simultaneously glucagon secretion by the pancreas increases, thus a steady supply of blood glucose is maintained.



HORMONES PART 2

TESTOSTERONE AND OESTROGEN

Testosterone is produced in the testes of the male and in small amount in the ovaries and adrenals of the female. Males produce up to ten times more testosterone than females (McArdle et al, 2001). This is primarily responsible for the development of the male secondary sexual characteristics, such as facial and body hair and greater muscle mass.

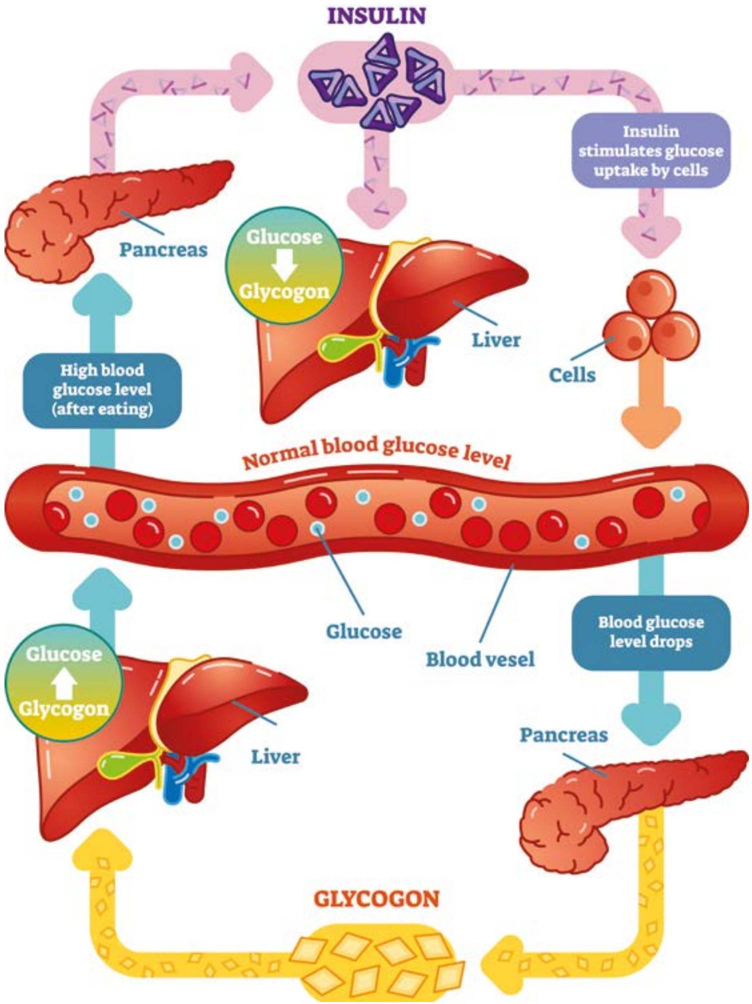
Oestrogen is produced primarily in the ovaries in the female with small amounts produced in the adrenals in males. Women of reproductive age have significantly higher levels of oestrogen than males which gives rise to female secondary sexual characteristics such as breast development and regulation of the menstrual cycle.

For both males and females, however, testosterone plays a fundamental role in the growth and repair of tissue. Raised levels of testosterone are indicative of anabolic training status. Oestrogen has many functions, but in particular has an influence on fat deposition around the hips, buttocks and thighs.

CORTISOL

In contrast to testosterone, cortisol is typically referred to as a catabolic hormone (associated with tissue breakdown).

Under times of stress, such as exercise, cortisol is secreted by the adrenal glands and serves to maintain energy supply through the breakdown of carbohydrates, fats and protein. High levels of cortisol brought about through overtraining, excessive stress, poor sleep and inadequate nutrition can lead to a significant breakdown of muscle tissue, along with other potentially harmful side effects (McArdle et al, 2001).



GROWTH HORMONE

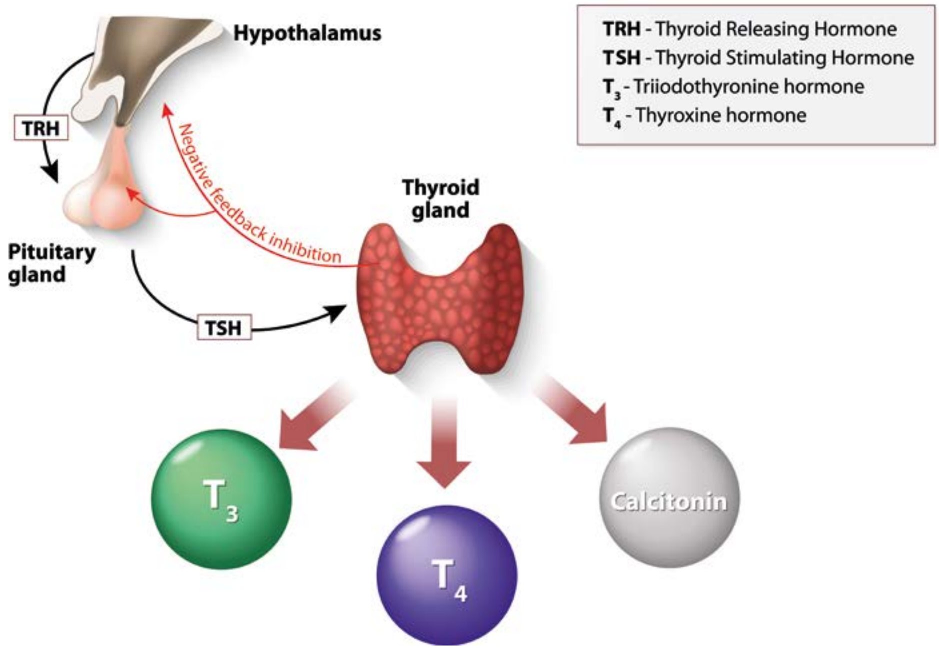
The name of this hormone has particular reference to its primary functions. Growth hormone is released from the pituitary gland in the brain and is regulated by the nearby hypothalamus. Growth hormone is stimulated by several factors including oestrogen, testosterone, deep sleep and vigorous exercise. Growth hormone is primarily an anabolic hormone that is responsible for most of the growth and development during childhood up until puberty when the primary sex hormones take over that control. Growth hormone also increases the development of bone, muscle tissue and protein synthesis, increases fat burning and strengthens the immune system.

THYROID HORMONES

The thyroid gland is located at the base of the neck just below the thyroid cartilage, sometimes called Adam's apple. This gland releases vital hormones that are primarily responsible for human metabolism. The release of thyroid hormones is regulated by the master gland the pituitary.

Thyroid hormones have been shown to be responsible for:

- Carbohydrate, protein and fat metabolism.
- Basal metabolic rate (BMR).
- Protein synthesis.
- Sensitivity to adrenalin.
- Heart rate.
- Breathing rate.
- Body temperature.



Low thyroid function has become a well-recognised disorder leading to:

- Low metabolism.
- Fatigue.
- Depression.
- Sensitivity to cold.
- Weight gain.

The incidence of hypothyroidism today is relatively low with only 3% of the population suffering the condition.

ENDOCRINE GLAND	HORMONE	EXERCISE EFFECT	TARGET ORGAN	MAJOR FUNCTION
HYPOTHALAMUS	Releasing hormones	Increases with anticipation of exercise.	Pituitary gland	Stimulates the pituitary gland to release hormones.
	Inhibiting hormones	Increases with cessation of exercise.	Pituitary gland	Inhibits release of pituitary gland hormones.
ANTERIOR PITUITARY	Growth hormone (GH)	Increases with increasing exercise.	All of the cells in the body	Stimulates growth in all organs/tissues, increases protein synthesis, the mobilisation and use of fat for energy and inhibits carbohydrate metabolism.
	Thyroid stimulating hormone (TSH)	Increases with increasing exercise.	Thyroid gland	Controls the secretion of the hormones released by the thyroid.
	Arenocorticotropic hormone (ACTH)	Increases in response to exercise.	Adrenal Cortex	Controls the secretion of the hormones from the adrenal cortex.
	Endorphins	Increases with long duration exercise.		Blocks pain.
POSTERIOR PITUITARY	Anti diuretic hormone (ADH)	Increases with increasing exercise.	Kidneys	Stimulates water retention by the kidneys.
ADRENAL MEDULLA	Adrenaline (Epinephrine)	Increases with heavy exercise.	Acts on most cells in the body prolonging and intensifying the sympathetic nervous system response to stress.	Mobilises glucose, increases heart rate, heart contractility, oxygen use and blood flow to skeletal muscles.
	Nor Adrenaline (Nor Epinephrine)	Increases with increasing exercise intensity or duration.		Constricts blood vessels and elevates blood pressure.

ENDOCRINE GLAND	HORMONE	EXERCISE EFFECT	TARGET ORGAN	MAJOR FUNCTION
ADRENAL CORTEX	Aldosterone	Increases with exercise.	Kidneys	Regulates electrolyte and fluid balance.
	Cortisol	Increases with heavy exercise.	Most cells in the body	Increases blood sugar levels, aids the metabolism of fats, CHO proteins, suppresses the immune system, has an anti-inflammatory action.
PANCREAS	Insulin	Decreases with increasing exercise.	All the cells in the body.	Controls blood glucose by lowering blood glucose levels.
	Glucagon	Increases with increasing exercise.	All the cells in the body.	Increases blood glucose, stimulates breakdown of glycogen and fat.
KIDNEYS	Renin	Increases as blood pressure lowers.	Adrenal Cortex	Assists in blood pressure control.
GONADS: TESTES	Testosterone	Increases with increasing exercise.	Sex Organs	Development of male sex organs, facial hair and change in voice.
			Muscle	Promotes muscle growth.
OVARIES	Oestrogen		Sex Organs	Development of female sex organs, regulates menstrual cycle.
			Adipose Tissue	Storage of fat.

THE EFFECTS OF EXERCISE

Research has indicated that testosterone and growth hormone levels increase following strength training and moderate to vigorous aerobic exercise. It is also noted that a similar pattern seems to emerge for cortisol (McArdle et al, 2001).

The presence of cortisol in the bloodstream is often taken to be indicative of overtraining. This is perhaps a little simplistic as cortisol is a necessary part of maintaining energy levels during normal exercise activity and may even facilitate recovery and repair during the post-exercise period (McArdle et al, 2001).

Problems may arise however, as a result of extremely intense or prolonged bouts of endurance training, which have been found to lower testosterone levels whilst raising cortisol levels. Under these circumstances, catabolism (breakdown) is likely to outstrip anabolism (build-up) and give rise to symptoms of overtraining (Wilmore and Costill, 2004; McArdle et al., 2001).

ENDOCRINE DISEASES

To ensure that everything runs smoothly (that is, your body functions as it should), certain processes must work properly:

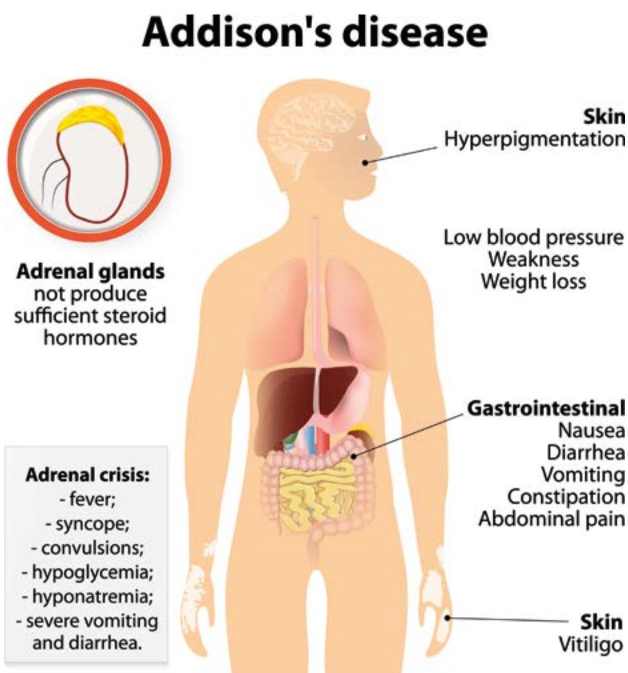
- The endocrine glands must release the correct amount of hormones (if they release too much or too little, it is known as hormone imbalance).
- Your body also needs a strong blood supply to transport the hormones.
- There must be enough receptors (which are where the hormones attach and do their work) at the target tissue.

Those targets must be able to respond appropriately to the hormonal signal. The model here would be like primary hypothyroidism, where the pituitary produces TSH, the TSH is carried via the bloodstream to the thyroid, the thyroid has the appropriate receptors, but for whatever reason, it isn't able to effectively make or secrete thyroid hormone.

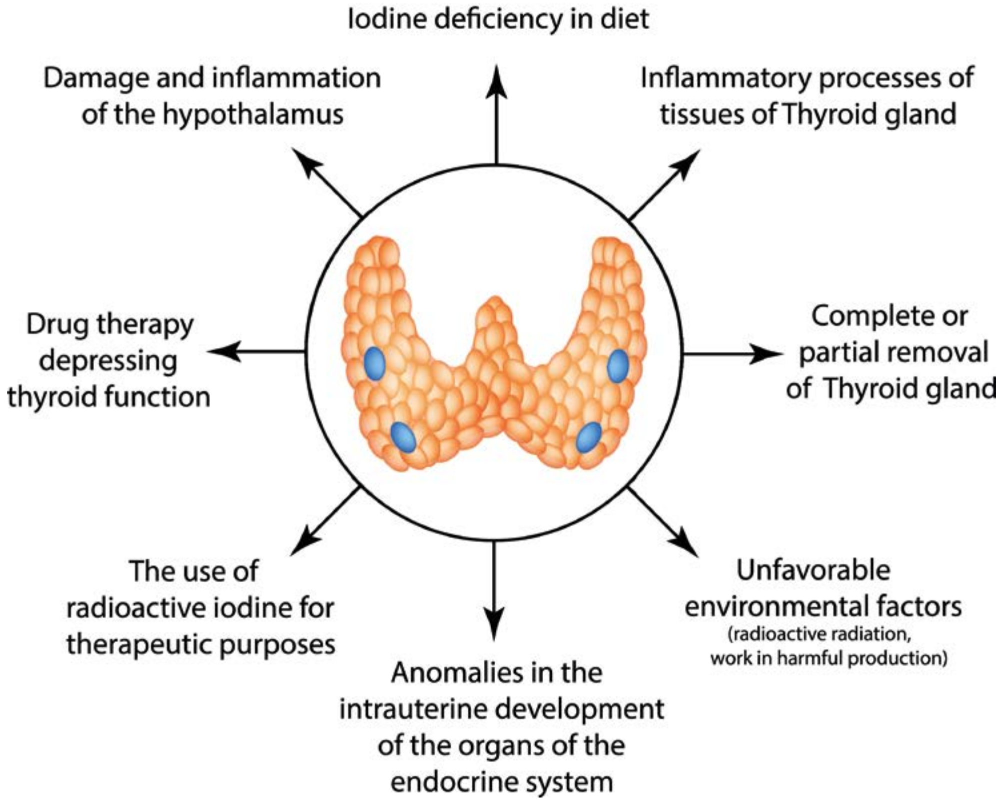
Endocrine diseases are common and happen even when one step in the process doesn't work as it should. If you have an endocrine disease or disorder, you may consult a specialist known as an endocrinologist who will effectively diagnose and help treat your condition.

ENDOCRINE DISORDERS

- Addison's Disease
- Graves' Disease
- Hyperparathyroidism
- Hypothyroidism
- Osteoporosis
- Thyroid Cancer
- Thyroiditis
- Adrenomyeloneuropathy
- Type 1 Diabetes
- Type 2 Diabetes



CAUSES OF HYPOTHYROIDISM



Corticosteroids are a class of steroid hormones that are produced in the adrenal cortex of vertebrates, as well as the synthetic analogues of these hormones. Two main classes of corticosteroids, glucocorticoids and mineralocorticoids, are involved in a wide range of physiologic processes, including stress response, immune response, and regulation of inflammation, carbohydrate metabolism, protein catabolism, blood electrolyte levels, and behaviour.

Catecholamines are derived from the amino acid tyrosine, which is derived from dietary sources as well as the synthesis of phenylalanine. Catecholamines are water-soluble and are 50%-bound to plasma proteins in circulation.

Included among catecholamines are epinephrine (adrenaline), norepinephrine (noradrenaline), and dopamine. Release of the hormones epinephrine and norepinephrine from the adrenal medulla of the adrenal glands is part of the fight-or-flight response.

GROWTH HORMONE (GH)	**Bones, cartilage, muscle, fat, liver, heart.**	**Acts to promote growth of bones and organs.**
THYROID GLAND	**Thyroxine (T4)**	**Acts to regulate the body's metabolic rate.**
	Triiodothyronine (T3)	**Acts to regulate the body's metabolic rate.**
INSULIN	**Muscle, fat tissue**	**Acts to raise blood glucose levels.**
GLUCAGON	**Liver**	**Acts to raise blood glucose levels.**

The Neuroendocrine System

UNIT 1: THE SYSTEMS THAT MAKE UP THE HUMAN BODY (ANATOMY AND PHYSIOLOGY)

THE ENDOCRINE SYSTEM

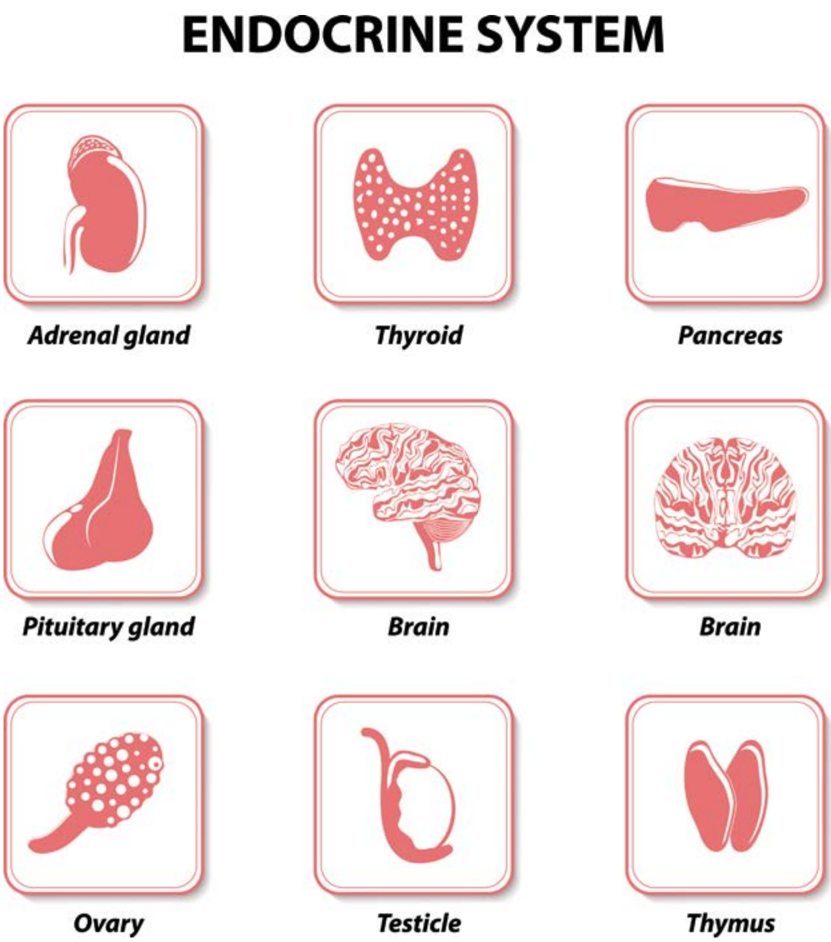
The endocrine system regulates the body by releasing chemical messengers into the blood stream. Chemicals, called hormones, are produced by specialised glands to instruct the cells of the body when hormone levels reach a certain normal amount, the endocrine system helps the body to keep that level of hormone in the blood. The hormones are important for instructing specific cells to produce particular actions in response to a stimulus or imbalance in the body. The glands are responsible to recognise the need for hormone secretion.

The hormones travel in the bloodstream to the cells where they act and bind to the cells to initiate their effects. These processes are tightly regulated by the endocrine system to maintain metabolic balance in the body. They are essential to keeping body functions normal. Such processes include cellular metabolism, sexual development and reproduction, homeostasis of sugar and other nutrients, and regulation of the heart rate, blood pressure, sleep cycles and digestion.

Most hormones are released from glands as a result of positive and negative feedback:

- Positive feedback – increased stimulus from tissues causes increased hormone production.
- Negative feedback – increased stimulus from tissues causes decreased hormone production.

After the action of the hormone, the release of the hormone from the endocrine gland must be regulated by a negative feedback loop to control the process and prevent the continuous and excessive activation of receptors.



HORMONES

GROWTH HORMONE

- The hypothalamus produces GHRH which stimulates the nearby pituitary gland, growth hormone is then produced and secreted from the anterior pituitary.
- Primary function of GH is to stimulate growth in children and adolescents.
- Produced in lower amounts in adulthood. GH release is triggered by quality sleep, intense exercise and acute stress. GH plays an important role in post-exercise recovery by stimulating muscle protein synthesis.

THYROID HORMONES

- Thyroxine (T4) is a pro-hormone produced and secreted by the thyroid gland. T4 is converted to its active form, triiodothyronine (T3) in organs such as the liver and kidneys.
- Approximately 20% of the body's T3 is secreted directly from the thyroid gland. T3 is about 3 times more potent than T4 in affecting the body.
- The primary role of thyroid hormones is the regulation of metabolic rate.
- Other functions include roles in brain development, muscle control, digestion and bone maintenance. Dietary iodine is one nutrient necessary for adequate thyroid hormone production.
- Rich sources of iodine include iodised salt, fish, shellfish and sea vegetables.

PARATHYROID HORMONE

- Secreted from the parathyroid glands at the back of the thyroid gland.
- Its primary role is to regulate calcium levels in the blood.
- Typically, it increases calcium levels by acting on kidneys, bones and the intestines.
- Released with changing blood calcium and magnesium levels.

CORTICOSTEROIDS

- These are steroid hormones produced in the of the adrenal gland which sits on top of the kidneys.
- Corticosteroids are released from the cortex.
- The primary corticosteroid is called cortisol.
- Cortisol has vital functions in energy levels, coping with stress, overall metabolism and regulating immune response.

CATECHOLAMINES

- Catecholamines are hormones produced from the adrenal medulla.
- Catecholamines work in tandem with cortisol as part of the fight-or-flight response.
- Adrenaline and noradrenaline are the main catecholamines.
- Their functions include increasing heart rate, blood pressure and respiration, diverting blood to muscles and stimulating alertness by increasing blood flow to the brain.

THE STRESS RESPONSE

Adrenaline and non-adrenaline are activated during the stress response, ‘fight and flight’. Adrenaline increases the heart rate and non-adrenaline vasoconstricts peripheral vessels to elevate blood pressure. If the stress-evoking event remains unresolved for longer than 15 minutes an adrenocortical response as part of a long-term coping mechanism will be initiated. Increased levels of cortisol over-ride the inhibitory effects on adrenal release, maintaining the stress response.

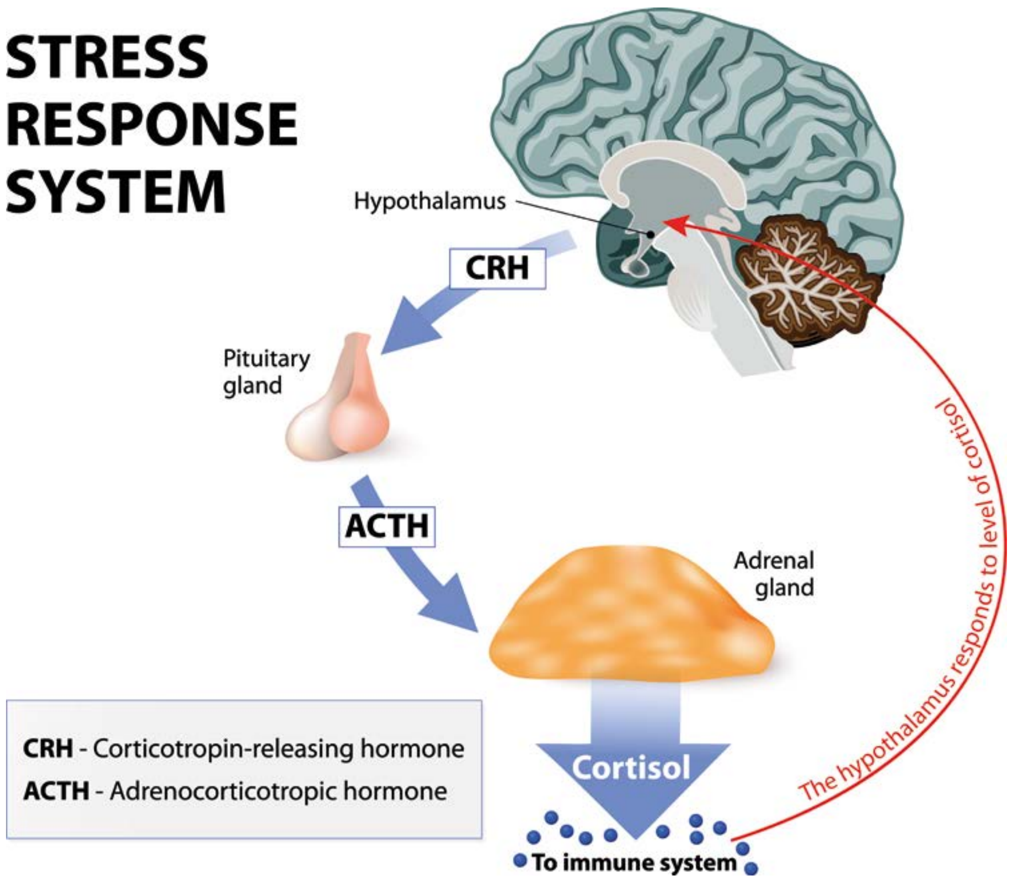
Elevated cortisol levels in the blood can disrupt sleep patterns and slow wound healing due to its anti-inflammatory properties. If high levels persist over a prolonged period of time the immune system becomes depressed, fat storage will increase and changes to the cardiovascular, neural and gastrointestinal function will occur.

Massage encourages vasodilation of peripheral vessels, lowering blood pressure, therefore off-setting the effects of adrenalin and non-adrenalin. This mechanical alteration in physiology allows the feedback loop to begin inhibiting the stress response, in turn reducing blood cortisol levels and regaining homeostatic balance.

STIMULATION OF HORMONE SECRETION

Secretion of hormones can be stimulated in various ways, such as:

- Signals from the nervous system such as ‘fight or flight’, stimulating the release of adrenaline.
- Chemical changes in the blood such as rising acid levels stimulating the kidneys to excrete higher levels of urea.
- Related hormone release such as adrenaline stimulating the release of cortisol in the event of ‘fight or flight’.



HORMONE REGULATION

Most hormones are released from the glands through a mechanism referred to as positive and negative feedback:

- Positive feedback is an increase in output from tissues that will cause an increase in hormone production to meet the tissue's needs.
- Negative feedback is a decrease in output from the tissues resulting in a decrease of hormone production because the tissue's needs have been met.

The regulation of hormone secretion is critical in maintaining homeostasis. Over or under production of hormones is a very common cause of disease.

THE NEUROENDOCRINE SYSTEM

DEFINITIONS

- **ENDOCRINE:** Referring to the endocrine system and slow speed chemical regulation.
- **HOMEOSTASIS:** The physiological process by which the internal systems of the body are maintained at equilibrium despite variations in external conditions.
- **HORMONE:** A substance produced by a gland, transported in the blood, and acting to modify the structure or function of an organ or tissue.
- **NEURO:** Referring to the nervous system and high-speed electrical communication.
- **NEUROENDOCRINE SYSTEM:** The system involved with control of body functions through the interrelationship of the nervous system and endocrine system.
- **NEUROTRANSMITTERS:** Chemical compounds contained in the membranes of the terminal dendrites of a nerve cell.

FUNCTIONS OF THE NEUROENDOCRINE:

The Neuroendocrine system acts to:

- Detects change inside the body.
- Detects change outside the body.
- Produce and conduct electrical messages (nerve impulses) and chemical messages (hormones) to communicate information.
- Control organ and tissue function.
- Maintain homeostasis.
- Initiate movement.

The Nervous System

UNIT 1: THE SYSTEMS THAT MAKE UP THE HUMAN BODY (ANATOMY AND PHYSIOLOGY)

VIDEO AVAILABLE ON LEARNING PLATFORM

The nervous system controls every major function that occurs in your body. In fact, without your nervous system, your muscles and other organs would be all but inert. Without your nervous system, your heart wouldn't beat, your blood wouldn't circulate and your muscles wouldn't contract. It's fair to say that your nervous system is your body's governor.

Because the nervous system and muscular system are so closely linked, symbiotic even, they are collectively called the neuromuscular system; 'neuro' pertaining to the nerves and muscular, obviously, pertaining to your muscles.

ROLES OF THE NERVOUS SYSTEM

- **INPUT:** There are a huge array of sensory nerves spread all throughout your body that are constantly gathering information such as the temperature, level of CO_2 in your blood, degree of stomach distension, weight of the object you are trying to lift or the angle of the hill you are running up.
- **ANALYSIS:** The information gathered by the myriad of sensors around your body has to be interpreted and analysed so that the appropriate response can be generated. While some responses are voluntary, many more are automatic or involuntary and are known as reflexes.
- **OUTPUT:** Finally, having gathered and analysed the incoming information, response or output is initiated e.g. Increasing breathing rate because of elevated CO_2 levels or sweating to reduce body temperature.

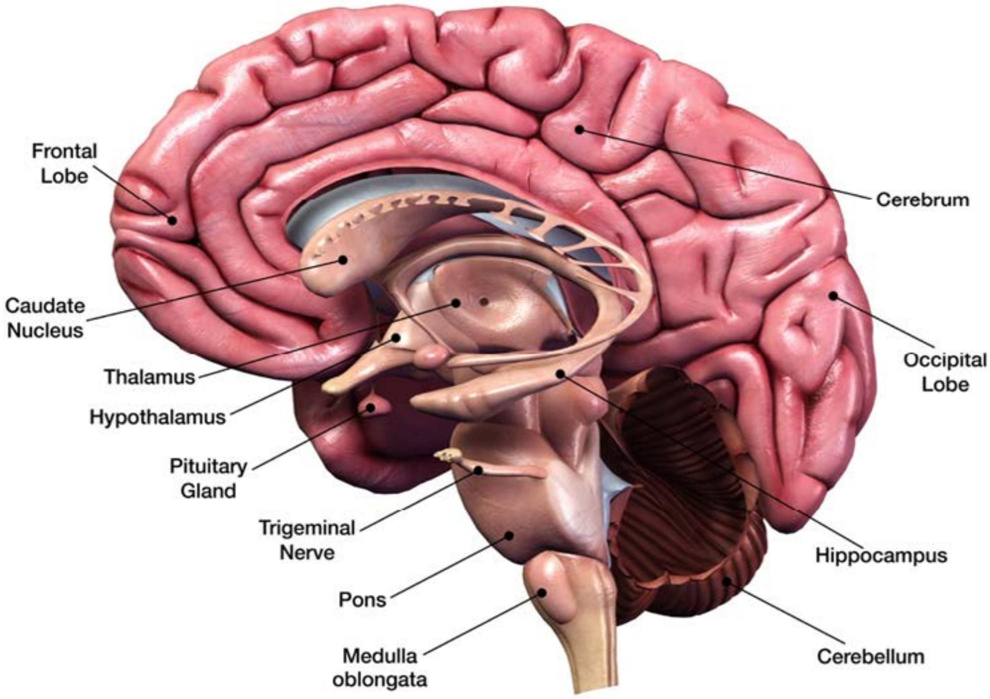
There are two main parts of the nervous system:

- The central nervous system or CNS.
- The peripheral nervous system or PNS.

THE BRAIN

The brain is made up of two hemispheres:

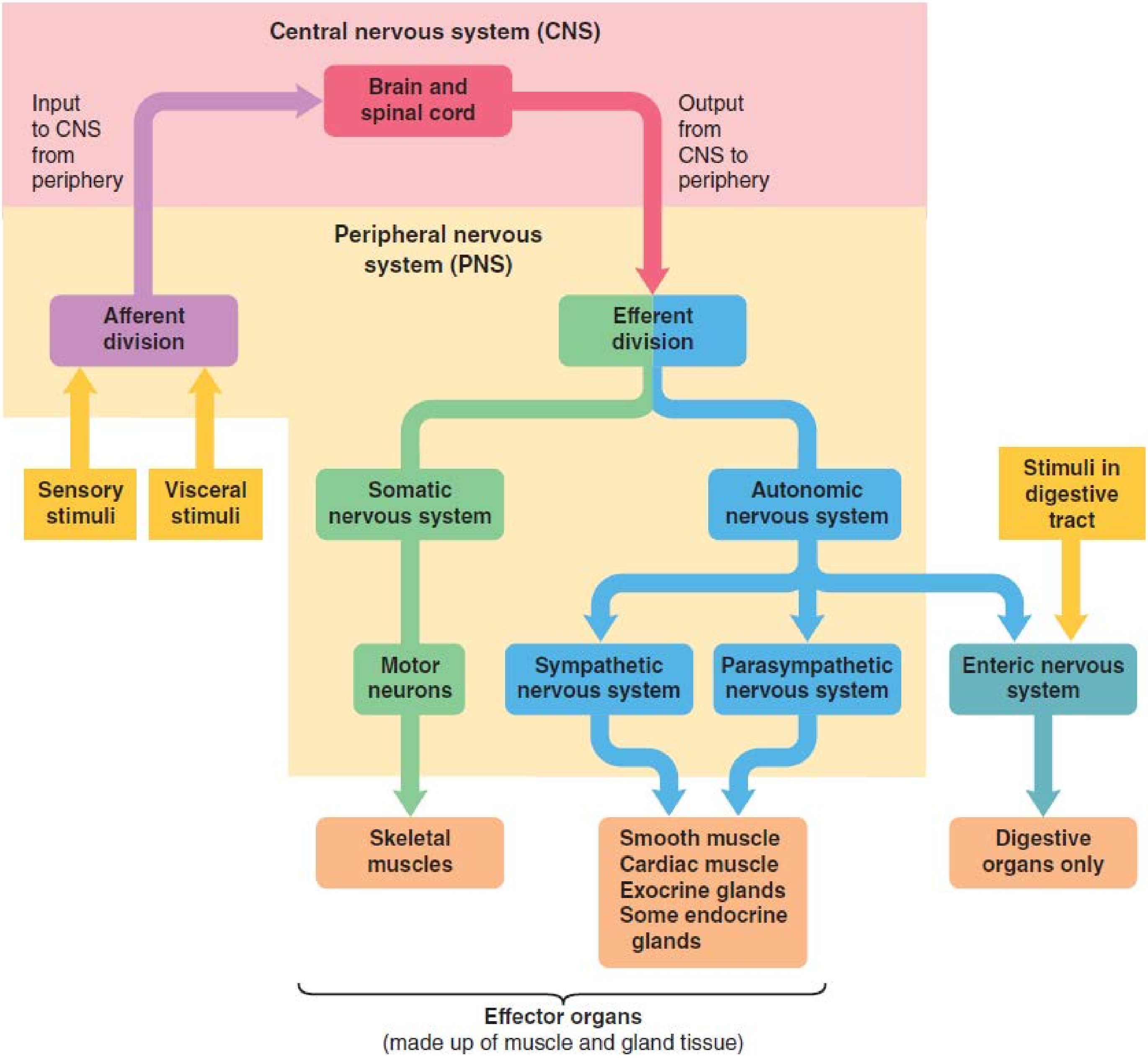
- **THE LEFT SIDE OF THE BRAIN:** It is responsible for controlling the right side of the body. It also performs tasks that have to do with logic, such as in science and mathematics.
- **THE RIGHT SIDE OF THE BRAIN:** It is responsible for controlling the left side of the body. It also performs tasks that have to do with creativity and the arts.



The brain has 3 main parts:

- Cerebrum: is the largest part of the brain and is composed of the right and left hemispheres.
- Cerebellum: is located under the cerebrum.
- Brain stem: acts as a relay centre connecting the cerebrum and cerebellum to the spinal cord.

THE ORGANISATIONAL STRUCTURE OF THE NERVOUS SYSTEM



SUBDIVISIONS OF THE NERVOUS SYSTEM

THE CENTRAL NERVOUS SYSTEM

The central nervous system consists of the brain and spinal cord and is responsible for all conscious and unconscious decision making. The brain has a huge capacity – far greater than any computer – and controls dozens if not hundreds of bodily functions simultaneously.

The brain is made up of two hemispheres, the cerebrum, the cerebellum and several other parts, all of which have very specialist functions. For example, the cerebellum's main job is controlling the actions of your muscles and storing memories. The brain is safely contained within your skull or cranium and is surrounded by a layer of fluid and fat, which protects it from impact.

The spinal cord is responsible for controlling reflex reactions and also provides the means for connecting the brain to the nerves that supply the rest of the body. It comprises of cervical, thoracic, lumbar and sacral segments which are all named after the section of the vertebral column through which they pass.

THE PERIPHERAL NERVOUS SYSTEM

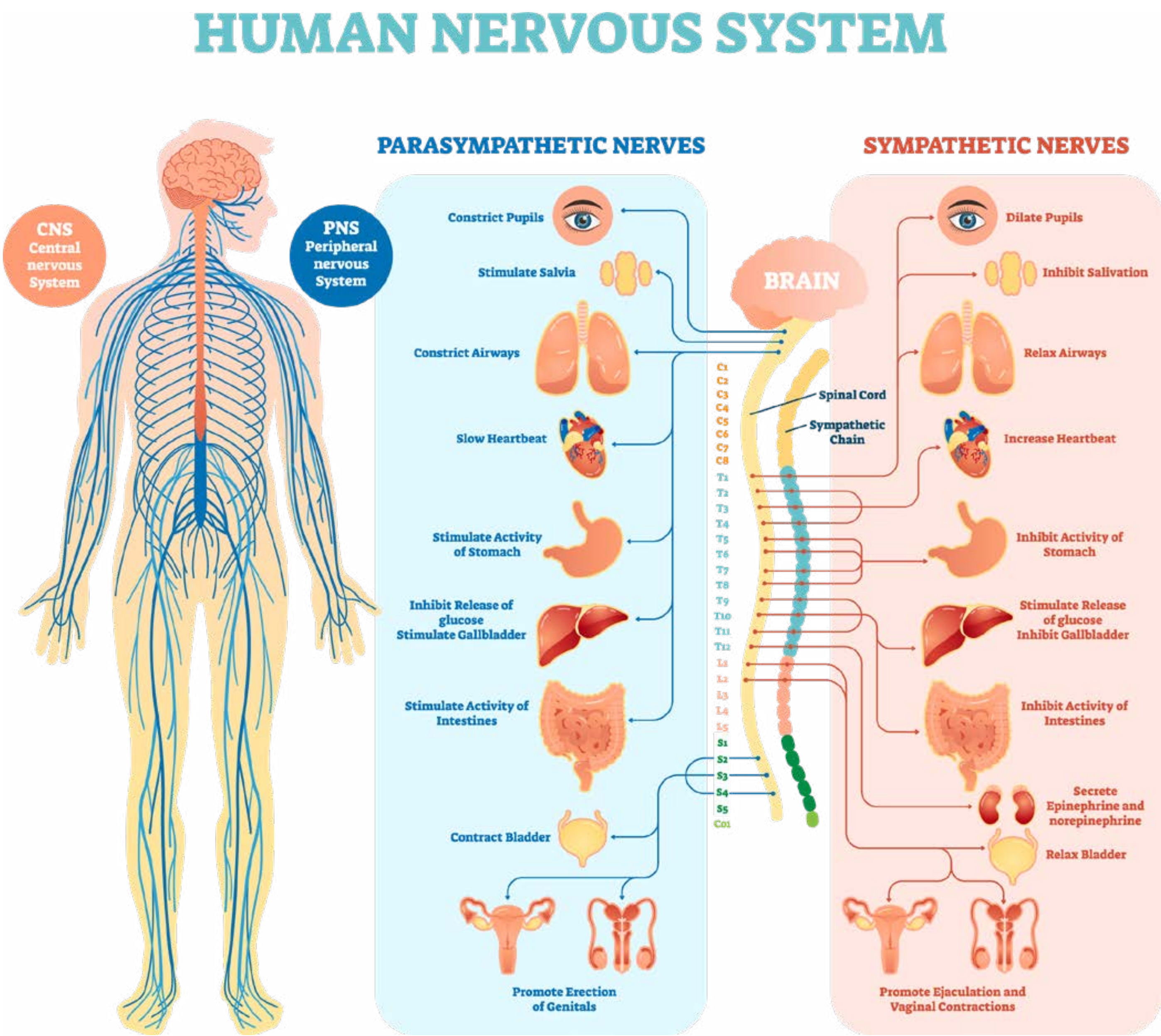
The peripheral nervous system is the name used to describe all of the branches of nerves outside of the central nervous system. The PNS transmits information to and from the CNS and is divided into motor nerves and sensory nerves – also called neurons.

Motor neurons transmit impulses from the CNS to organs, glands and muscles. These impulses will cause the muscles to contract and organs and glands to do their specialist jobs. Motor nerves exit the anterior or front of the spinal cord and essentially "flow away" from the CNS.

In contrast, sensory neurons, which attach to the posterior aspect of the spinal cord, flow toward the CNS and relay information such as the position of the limbs, core temperature, texture, taste and smell.

Information is constantly flowing to and from the CNS via the sensory and motor neurons. Both motor and sensory neurons play an important role in muscle contractions.

SUBDIVISIONS OF THE NERVOUS SYSTEM

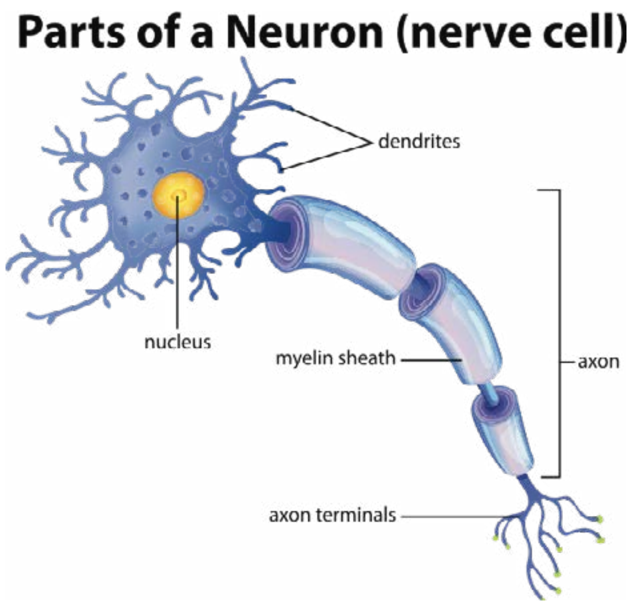


STRUCTURE OF THE NEURON

The basic cellular unit of the nervous system is the nerve cell or neurons. Neurons are designed to transmit information rapidly in response to changes inside and outside the body. They differ in size and shape according to their function and location within the nervous system, but all neurons have different characteristic components:

- **A CELL BODY** which sustains the metabolic activities of the cell and contains the nucleus.
- **THE AXON** that transmits information away from the cell body and is coated with a myelin sheath for protection. Nodes along with the myelin sheath help to speed up the impulses. The sheath and nodes are covered in a protective outer membrane. The axon terminals are specialised to release the neurotransmitters.
- **DENDRITES** are located on the cell body to receive information, or, at the end of the axon to pass information to the next neuron. The pre-synaptic membranes of the dendrites hold chemical (neurotransmitters), that will be released in the synaptic cleft. Once these chemicals come into contact with the post-synaptic membranes of the next neuron, that neuron will be stimulated.
- **THE MYELIN SHEATH** is a protective covering that surrounds fibres called axons, the long thin projections that extend from the main body of a nerve cell or neuron. The main function of myelin is to protect and insulate these axons and enhance their transmission of electrical impulses.
- **NEUROTRANSMITTERS** are packaged into synaptic vesicles that cluster beneath the axon terminal membrane on the presynaptic side of a synapse.

Individual neurons convey information by conducting electrical impulses; however, electrical information does not pass from one neuron to another. Communication between separate neurons occurs chemically in the synaptic cleft between neurons. An impulse will be picked up by the cell body and passed down the axon into the dendrites.



When a neuron is at rest, the outside of its membrane will be positively charged, and the inside is negatively charged. This is known as 'membrane potential'. The high concentration of excess sodium ions outside the neuron membrane cannot enter the cell. Potassium ions line the inside of the cell membrane.

Stimulation of the neuron will result in a brief change in a segment of the neuron, known as depolarisation. As the cell membrane depolarises it becomes very permeable allowing sodium ions to rush into the neuron creating a positive charge on the inside in that segment, while the outside becomes negatively charged. This is called the action potential and as they pass along the nerve, segments will return to their original priority.

NEUROTRANSMITTERS

The membranes of the dendrites have small sacs containing chemicals called neurotransmitters. Once these membranes are stimulated by the action potential the chemicals are released into the synaptic cleft where they will bind with or be absorbed by the post-synaptic membrane.

Neurotransmitters can work in two ways; transmitting the action potential across the synaptic cleft and therefore having a stimulatory effect or slowing or preventing the transmission of the action potential, having an inhibitory effect. The neurotransmitters, like the accelerator and brakes in a car, maintain balance within the nervous system.

TYPES OF NERVES

AFFERENT NEURON

The neurons, which carry sensory impulses towards the CNS are referred to as afferent neurons. The afferent neurons convert external stimuli into an internal electrical impulse. The nerve impulse travels along the afferent nerve fibres to the CNS. The cell body of the afferent neuron is located in the dorsal ganglia of the spinal cord.

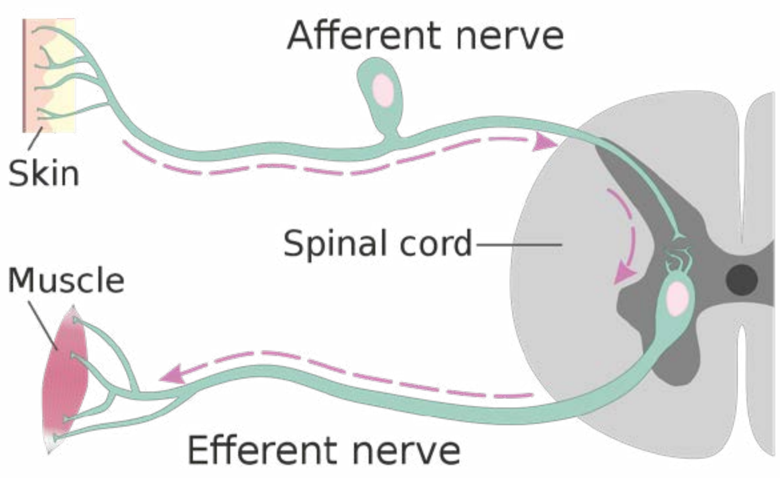
The afferent neurons gather information from sensory perceptions such as light, smell, taste, touch, and hearing, respectively, from the eye, nose, tongue, skin, and ear. The sensory signals of light are gathered from the rod and cone cells in the retina of the eye, and those nerve impulses are carried to the brain by the afferent neurons of the eye. The afferent neurons in the nose are stimulated by different odours, and nerve impulses are sent to the brain. The taste buds in the tongue gather sensory information about different tastes and the nerve impulses are carried to the brain by the afferent nerves of the tongue.

The mechanical stimuli such as touch, pressure, stretch, and temperature are detected by the skin, and the nerve signals are sent to the brain by the afferent neurons. The afferent neurons of the ear are stimulated by different wavelengths within the sensible range to each animal, and the nerve impulses are carried to the brain. All sensory signals are processed in the brain, and the brain coordinates the relevant organs for a specific response.

EFFERENT NEURON

The neurons which carry motor impulses away from the CNS are referred to as efferent neurons. The efferent neurons carry information from the CNS to the effector organs, facilitating muscle contraction and secretion of substances from glands.

The cell body of the efferent neuron is connected to a single large axon, which forms neuromuscular junctions with the effector organs. Two types of motor neurons are found: upper motor neurons and lower motor neurons. There are also three types of efferent neurons known as somatic efferent neurons, general visceral efferent neurons, and special visceral efferent neurons. The two types of somatic efferent neurons are alpha motor neurons and beta motor neurons.



SIMILARITIES BETWEEN AFFERENT AND EFFERENT NERVES

- Afferent and efferent neurons belong to the peripheral nervous system.
- Both neurons help the brain in the coordination of sensory stimuli with their responses.
- Both neurons are composed of a cell body, dendrons, and dendrites.

DIFFERENCE BETWEEN AFFERENT AND EFFERENT

DEFINITION

- **AFFERENT:** Afferent neurons are the neurons that carry sensory impulses towards the CNS.
- **EFFERENT:** Efferent neurons are the neurons that carry motor impulses away from the CNS.

KNOWN AS

- **AFFERENT:** Afferent neurons are also known as sensory neurons.
- **EFFERENT:** Efferent neurons are also known as motor neurons.

FUNCTION

- **AFFERENT:** Afferent neurons carry signal from sensory organs to the CNS.
- **EFFERENT:** Efferent neurons carry signal from the CNS to effector organs and tissues.

AXON

- **AFFERENT:** Afferent neurons consist of a short axon.
- **EFFERENT:** Efferent neurons consist of a long axon.

RECEPTOR

- **AFFERENT:** Afferent neurons consist of a receptor.
- **EFFERENT:** Efferent neurons lack a receptor.

CELL BODY

- **AFFERENT:** Cell body of the afferent neuron is situated in the dorsal root ganglion of the spinal cord and no dendrites are found in it.
- **EFFERENT:** Cell body of the efferent neuron is situated in the ventral root ganglion of the spinal cord and consists of dendrites.

DENDRONS

- **AFFERENT:** Afferent neuron consists of one long dendron.
- **EFFERENT:** Efferent neuron consists of many short dendrons.

FUNCTION

- **AFFERENT:** Afferent neurons carry signals from the outer part of the body into the central nervous system.
- **EFFERENT:** Efferent neurons carry signals from the central nervous system to the outer parts of the body.

MULTIPOLAR/UNIPOLAR

- **AFFERENT:** Afferent neurons are unipolar.
- **EFFERENT:** Efferent neurons are multipolar.

FOUND IN

- **AFFERENT:** Afferent neurons are found in skin, eyes, ears, tongue, and nose.
- **EFFERENT:** Efferent neurons are mainly found in muscles and glands.

MOTOR UNIT AND MUSCLE FIBRE RECRUITMENT

MOTOR UNITS

Muscles are made up of bundles of muscle fibres and these fibres are arranged into groups called motor units. A motor unit consists of anywhere between 10 and 1000 muscle fibres and the motor neuron that innervates or supplies it. The number of fibres present in a motor unit depends on its location and function but, irrespective of where it is located, all muscle fibres within the motor unit are activated by the same, single motor neuron.

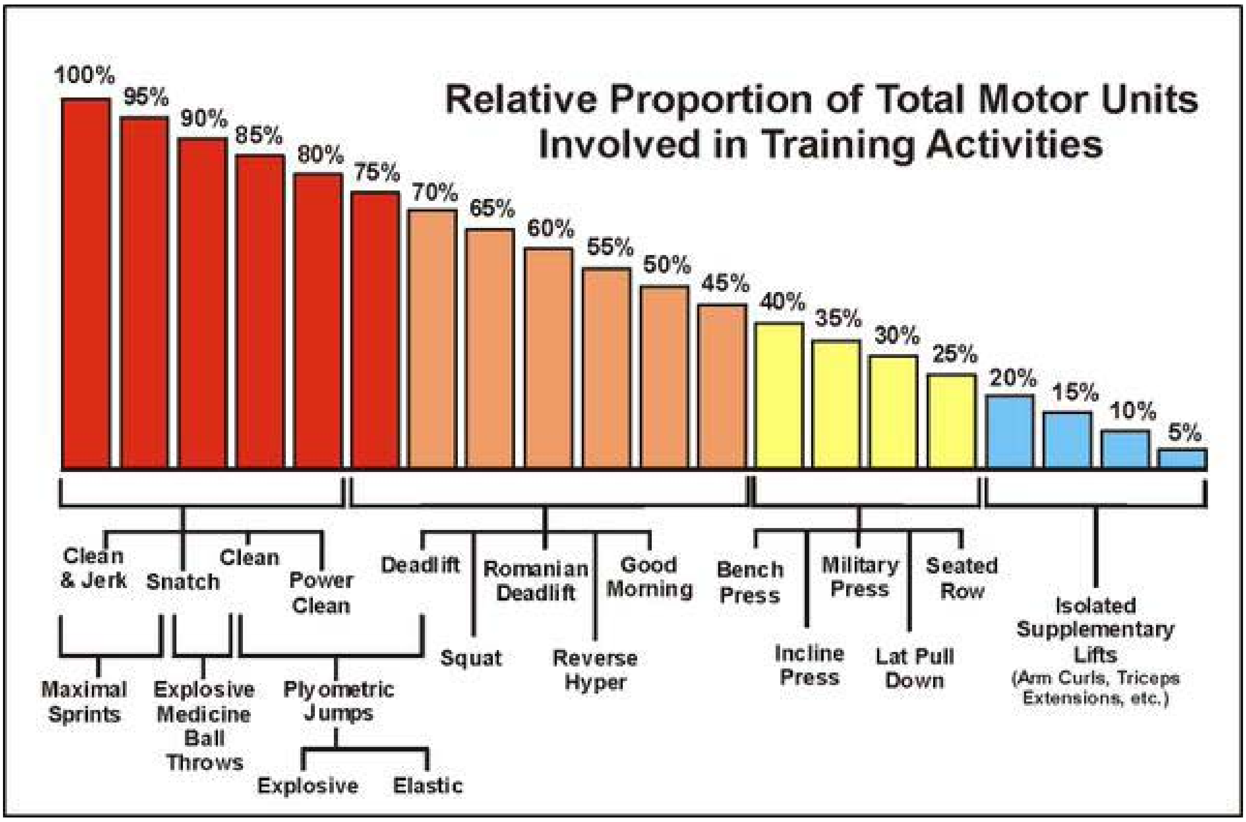
All the muscle fibres innervated by the motor neuron will either work together at the same time or not at all. This is commonly referred to as the "all or nothing" law.

Once sufficient stimulus is received from the motor neuron, all the muscle fibres within the motor unit will contract with 100% of their contractile ability or not at all.

Muscles contain many motor units; the bigger the muscle, the more motor units are likely to be present. The more motor units that are innervated at the same time, the more force will be produced.

If a lot of force is required, i.e. Lifting a heavy weight, a large number of motor units will work together. If, however, a smaller amount of force is needed, fewer motor units will be innervated. At no point do motor units work at anything less than 100% of their contractile ability; force variation is the result of more or fewer motor units being recruited.

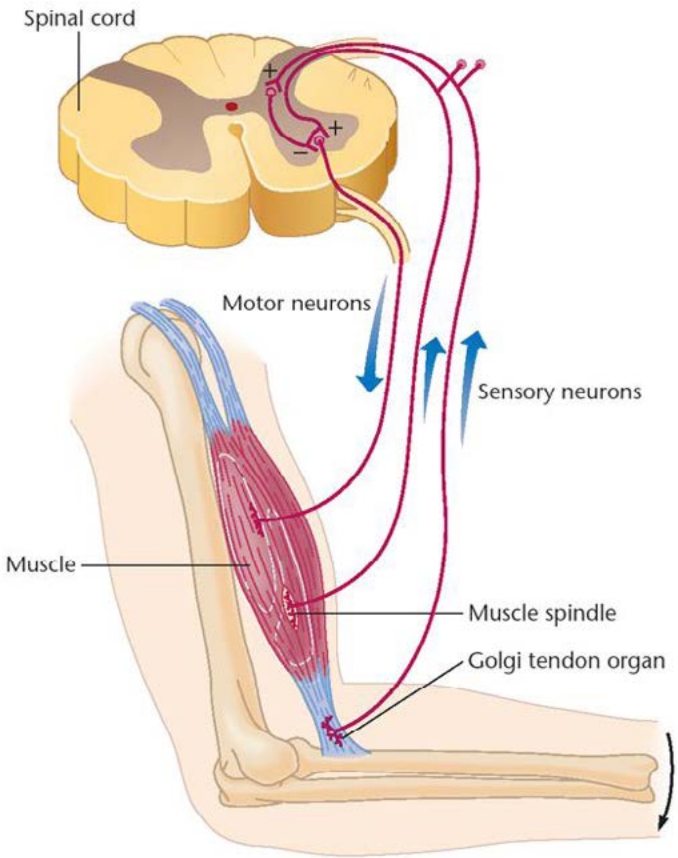
If a muscular task takes an extended period of time, motor units are recruited sequentially or, in other words, one after another. That way, as one motor unit fatigues, another one will take over. In examples of very low-intensity activity, e.g. Walking, this sequential recruitment can be almost never-ending but in more intense activities, e.g. A set of press-ups, work finishes when all motor units are exhausted.



The number of motor units that can be innervated or switched on at the same time varies from person to person and is a trainable characteristic. A beginner might only be able to innervate 50% of his or her total motor units whereas a more advanced exerciser might be able to innervate 70% or more. This helps to explain why two people who have the same amount of muscle can have such different levels of strength.

Beginner exercisers often experience rapid increases in strength not because their muscles get bigger but simply because their nervous systems become more adept at innervating a larger number of motor units simultaneously.

While exercise “teaches” the nervous system to work more efficiently so that more motor units can be innervated simultaneously, in order to protect bones, muscles and connective tissue from injury, it is not possible to recruit all motor units at the same time. This limitation is controlled by the Golgi tendon organ.



RESPONSES OF THE NEUROMUSCULAR SYSTEM TO EXERCISE

Exercise has a profound effect on all the systems of the body, not least the neuromuscular system. Changes can be acute or short term (i.e. During the training session) or chronic or long term (i.e. As a result of several weeks or months of training).

ACUTE CHANGES

During a workout, the following may occur:

- Vasodilation of blood vessels and capillaries to facilitate increased blood flow.
- Blood diverted away from non-essential organs to working muscles.
- Increased temperature.
- Reduced nervous inhibition.

CHRONIC CHANGES

The changes experienced by the neuromuscular system depend on several factors including:

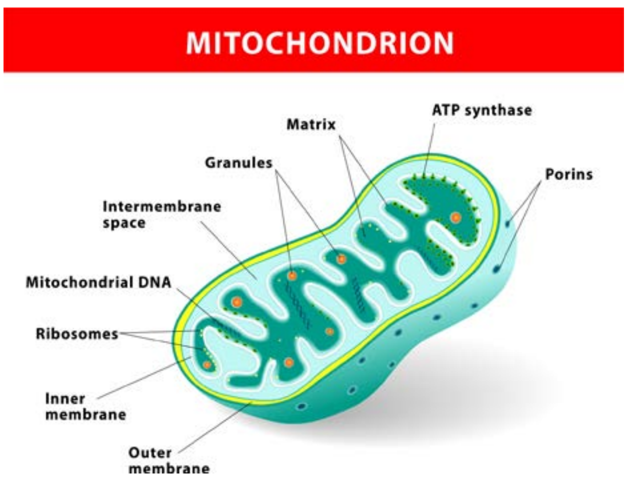
- Exercise frequency.
- Exercise duration.
- Exercise volume.
- Exercise intensity.
- Exercise modality.

LONG TERM ADAPTATIONS TO RESISTANCE TRAINING INCLUDE

- The increased cross-sectional size of muscles (hypertrophy).
- Improved balance and co-ordination.
- Increased strength due to hypertrophy.
- Increased strength due to decreased nervous inhibition.
- Increased glycolytic activity allowing more high-intensity work to be performed.
- Increased size of glycogen stores.

LONG TERM ADAPTATIONS TO AEROBIC EXERCISE INCLUDE

- An increase in the size and number of energy-producing mitochondria.
- An increase in capillarisation surrounding muscle fibres and at the alveoli.
- An increase in aerobic enzyme activity stored glycogen and triglycerides in the muscle fibres.



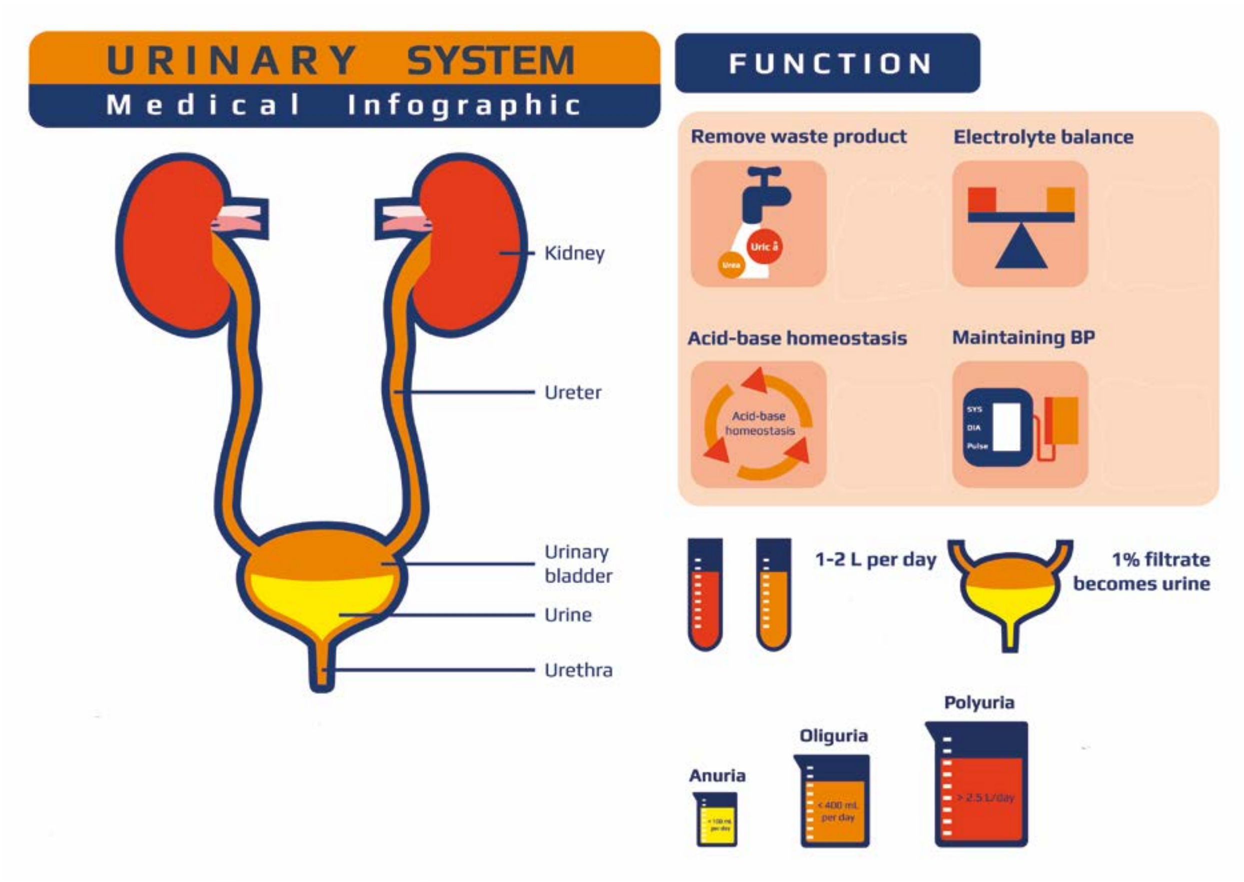
The Urinary System

UNIT 1: THE SYSTEMS THAT MAKE UP THE HUMAN BODY (ANATOMY AND PHYSIOLOGY)

The primary structures of the urinary system are:

- Kidneys
- Ureters
- Bladder
- Urethra

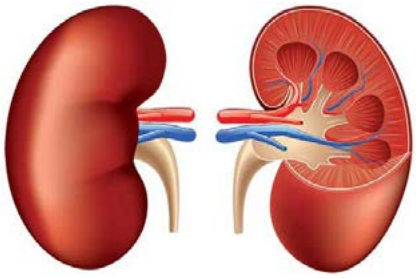
They filter blood and remove waste from the body in the form of urine. The size and position of lower urinary structures vary with male and female anatomy.



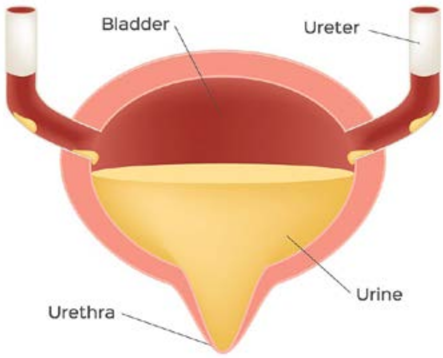
THE FUNCTION OF THE URINARY SYSTEM

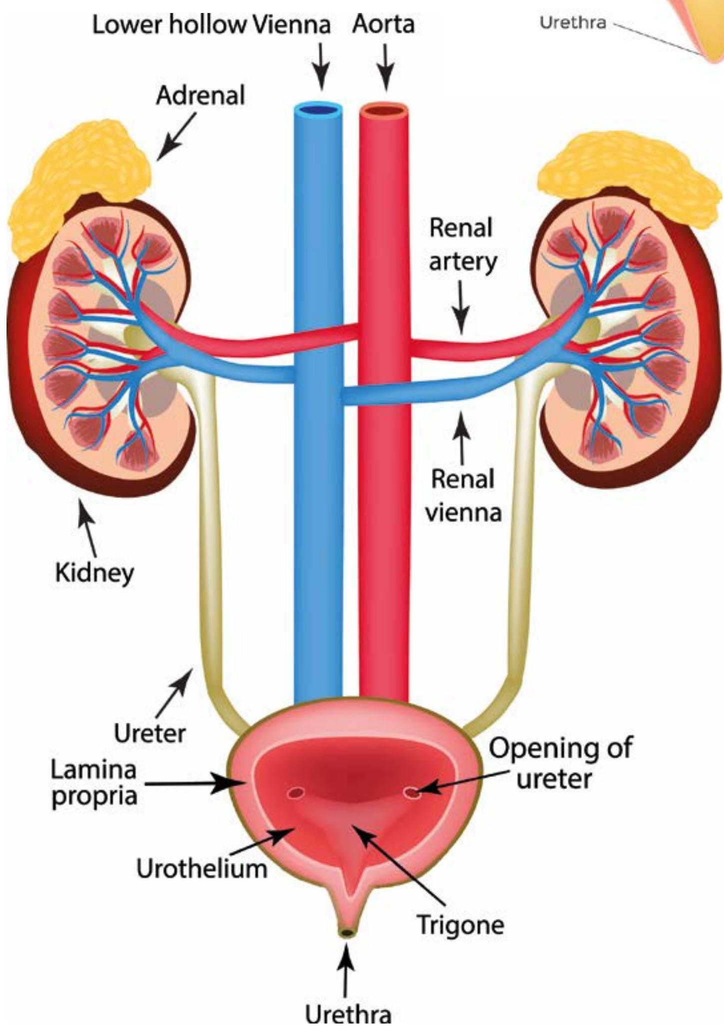
Thousands of metabolic processes in myriad body cells produce hundreds of waste products. The urinary system removes them by filtering and cleansing the blood as it passes through the kidneys. Another vital function is the regulation of the volume, acidity, salinity, concentration, and chemical composition of blood, lymph, and other body fluids. Under hormonal control, the kidneys monitor what they release into the urine to maintain a healthy chemical balance.

The kidneys filter the blood for excess fluid and dissolved solutes. It then selectively returns what is required by the body back into the bloodstream. The remaining fluid and dissolved solutes are passed down the ureter to the bladder ready for excretion.



The bladder is a holding reservoir for urine passed down from the kidneys via the ureter. Upon excretion, urine flows down the urethra. The bladder is estimated to be able to hold a maximum volume of between 500-1000ml.





Anatomical Positional Terminology

UNIT 1: THE SYSTEMS THAT MAKE UP THE HUMAN BODY (ANATOMY AND PHYSIOLOGY)

ANATOMICAL TERMINOLOGY: RELATIVE POSITION

WHERE TO START: THE MIDLINE

THE MIDLINE OF THE BODY

The anatomical position is the reference point describing the relation of body parts to one another. When describing the structures of the body it is important to use terms which encourage precision. Using the anatomical position as a starting point, the following standardised terms are designed to avoid confusion and should be used at all times when discussing anatomical terms.

RELATIVE POSITION: ANTERIOR / POSTERIOR

ANTERIOR

At or near the front of the body (front view).

POSTERIOR

At or near the back of the body (back view).

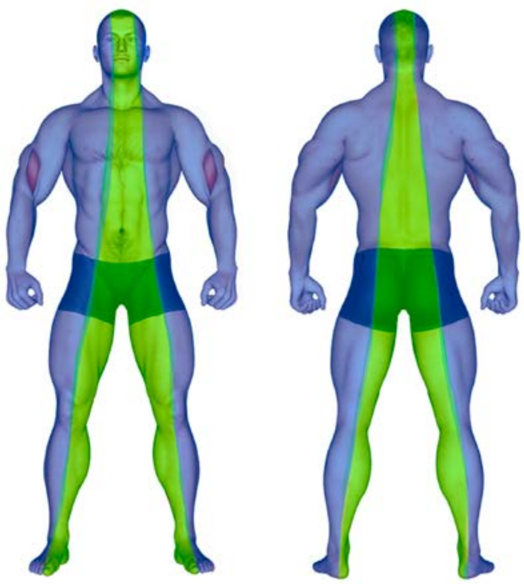
RELATIVE POSITION: MEDIAL / LATERAL

MEDIAL

Nearer to the midline (side view).

LATERAL

Farther from the midline (side view).



RELATIVE POSITION: SUPERIOR / INFERIOR

SUPERIOR

Toward the head/upper part of a structure (bird's-eye view, looking down).

INFERIOR

Away from the head/lower part of a structure (bottom view, looking up).

RELATIVE POSITION: PROXIMAL / DISTAL

PROXIMAL

Nearer to the origination of a structure.

DISTAL

Farther from the origination of a structure

RELATIVE POSITION: SUPERFICIAL / DEEP

SUPERFICIAL

Close to the surface of the body.

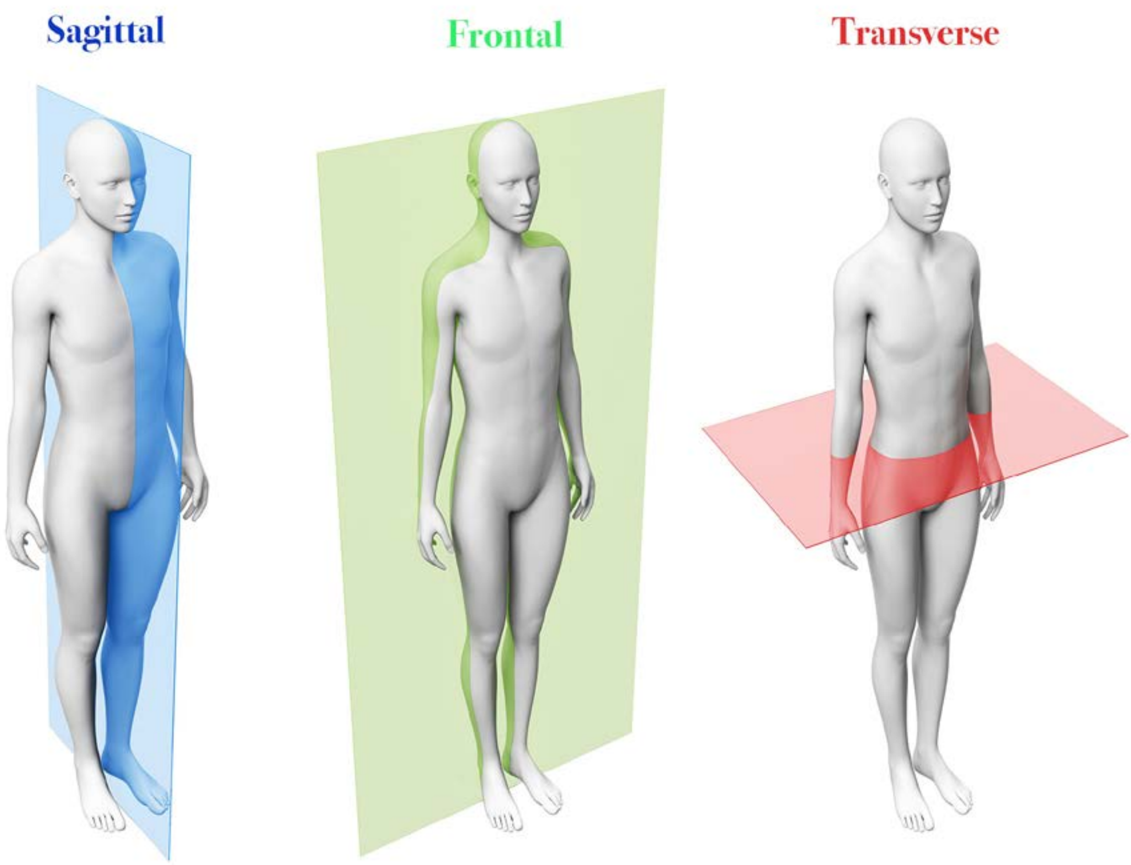
DEEP

Away from the surface of the body.

PLANES OF MOTION

Movements of the human body are often described in terms of the 'plane' in which they pass through. There are three planes of the human body are:

- Sagittal plane.
- Frontal plane.
- Transverse plane.



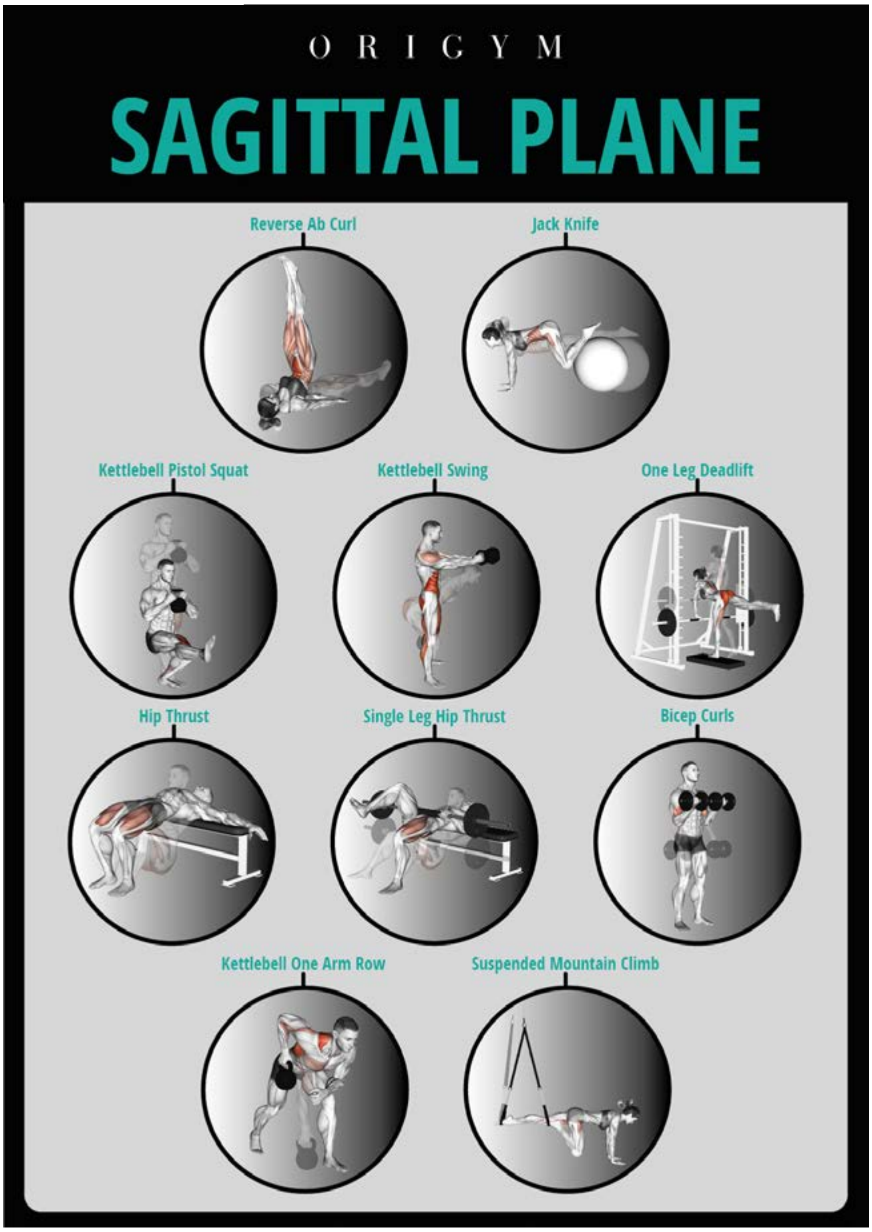
THE SAGITTAL PLANE

- Passes through the body from front to back.
- Dividing the body into left and right portions.

The sagittal plane moves around:

- The medio-lateral axis.

VIDEO AVAILABLE ON LEARNING PLATFORM



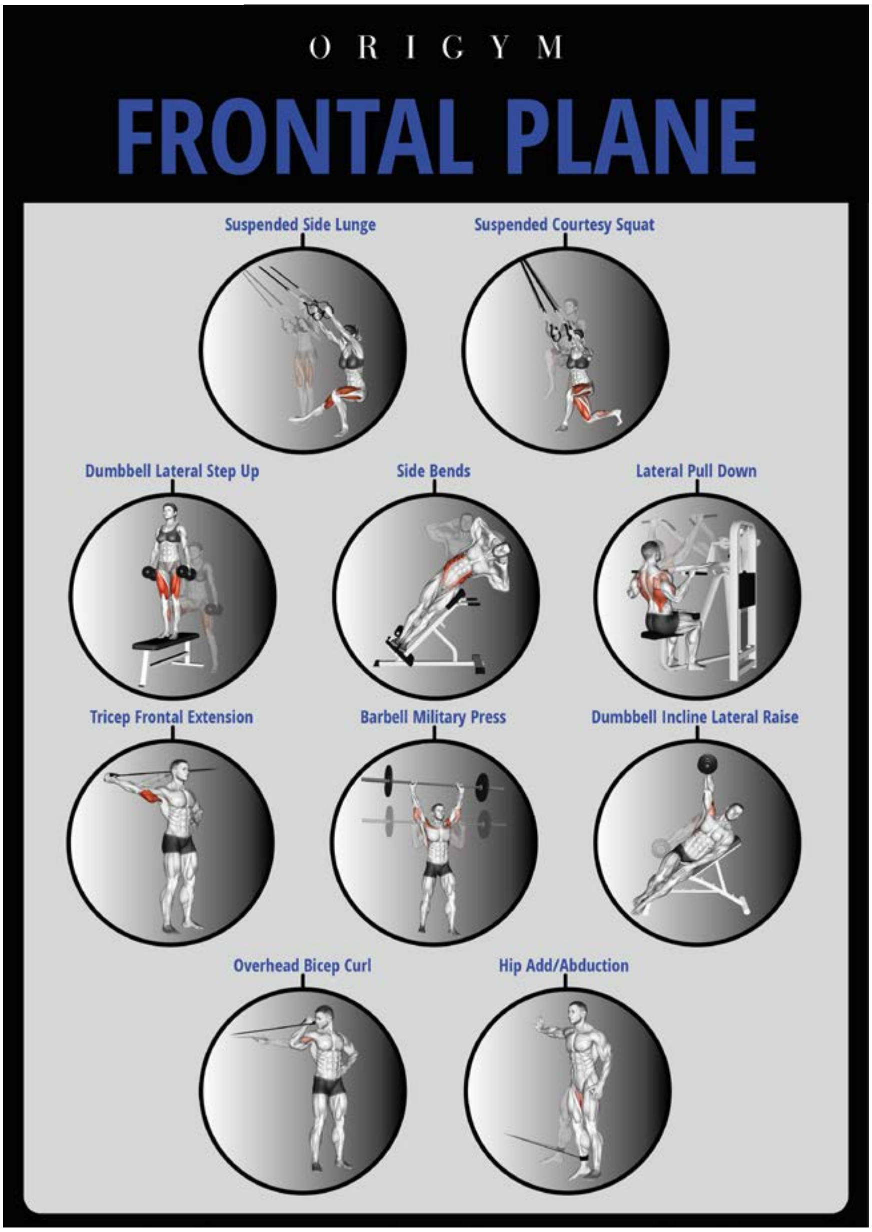
THE FRONTAL PLANE

- Passes through the body from left to right.
- Dividing the body into anterior (front) and posterior (back) portions.

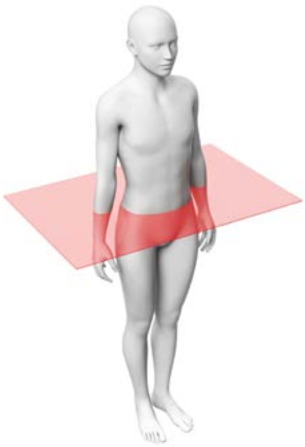
The frontal plane moves around:

- The Anterior-Posterior axis

VIDEO AVAILABLE ON LEARNING PLATFORM



THE TRANVERSE PLANE

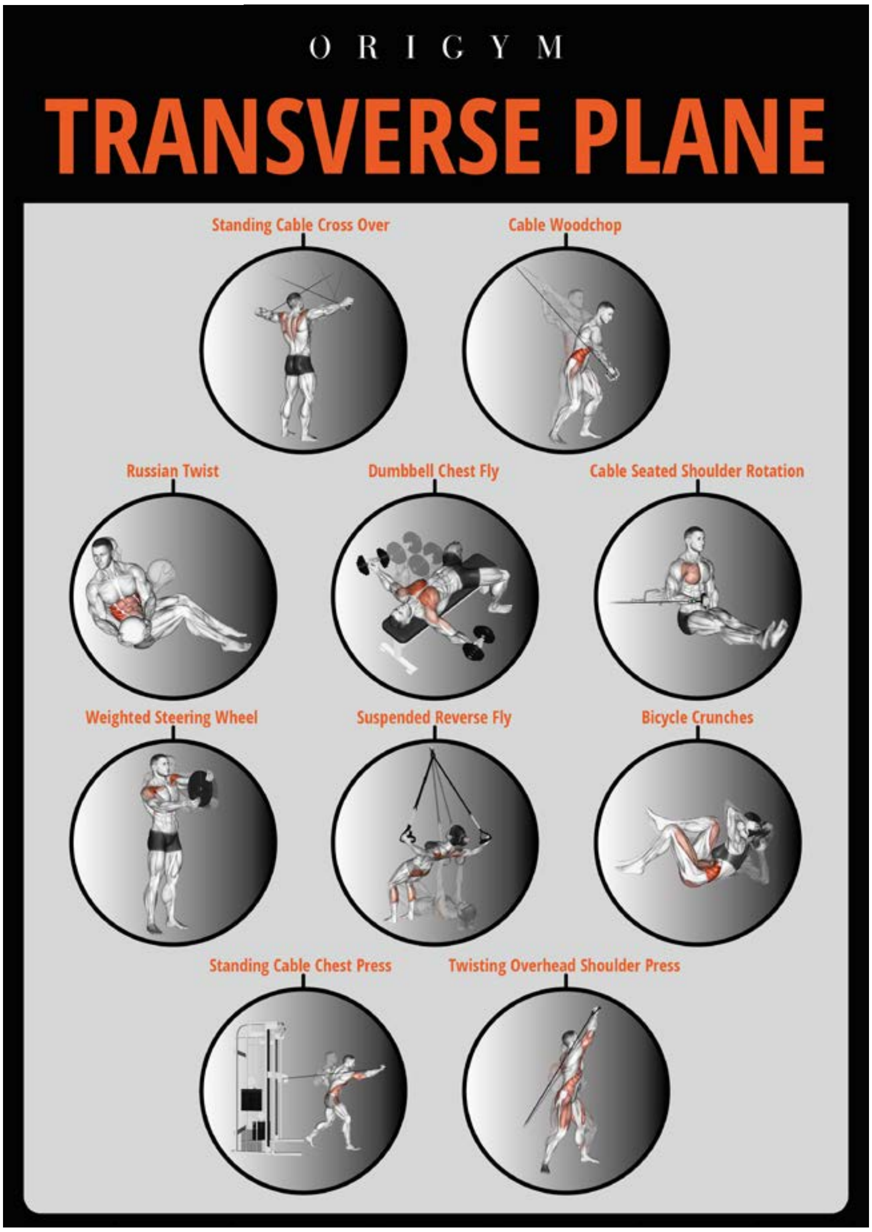


- Passes through the body in a parallel line.
- DIVIDING the body into top and bottom portions.

The transverse plane moves around:

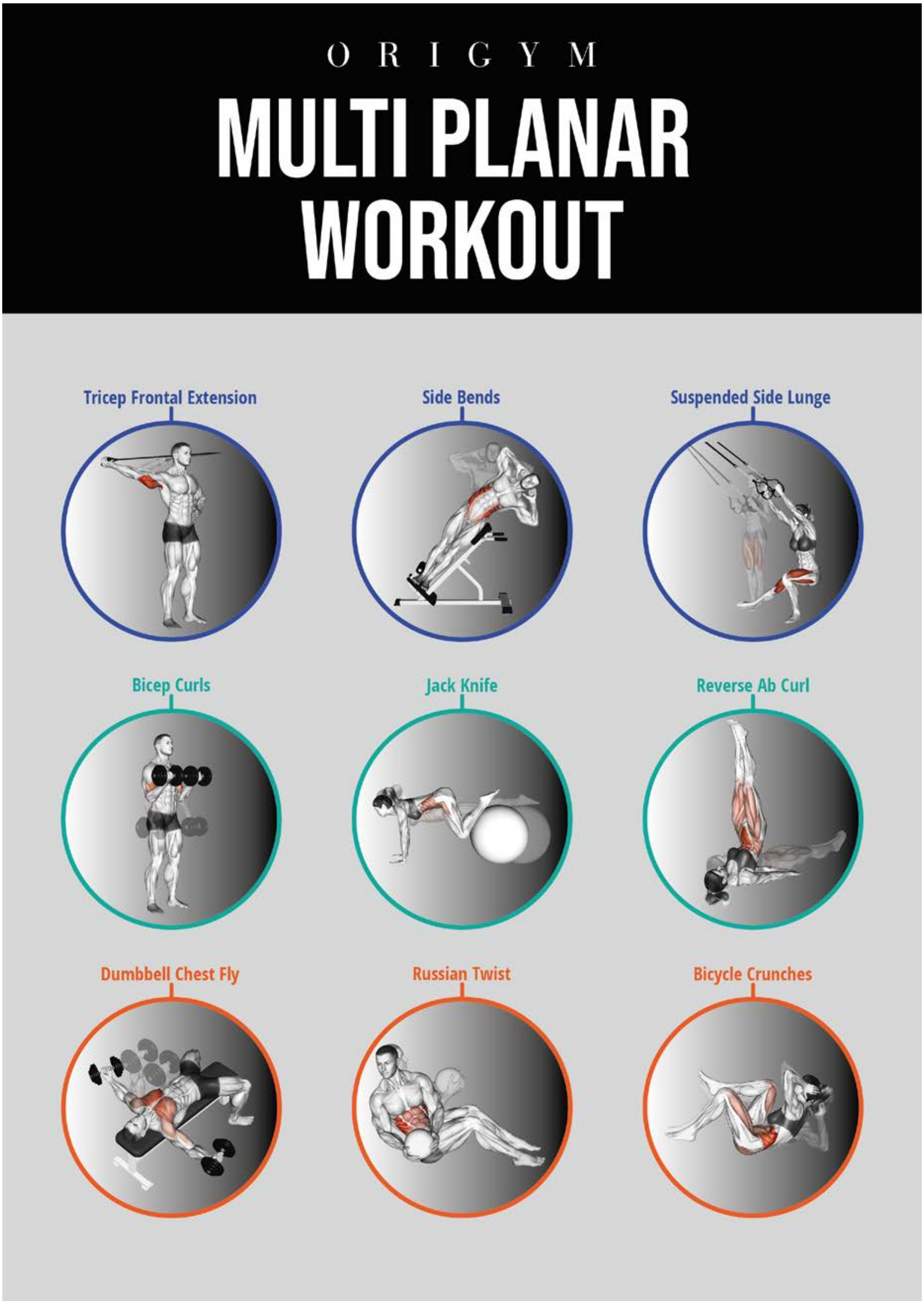
- The longitudinal axis.

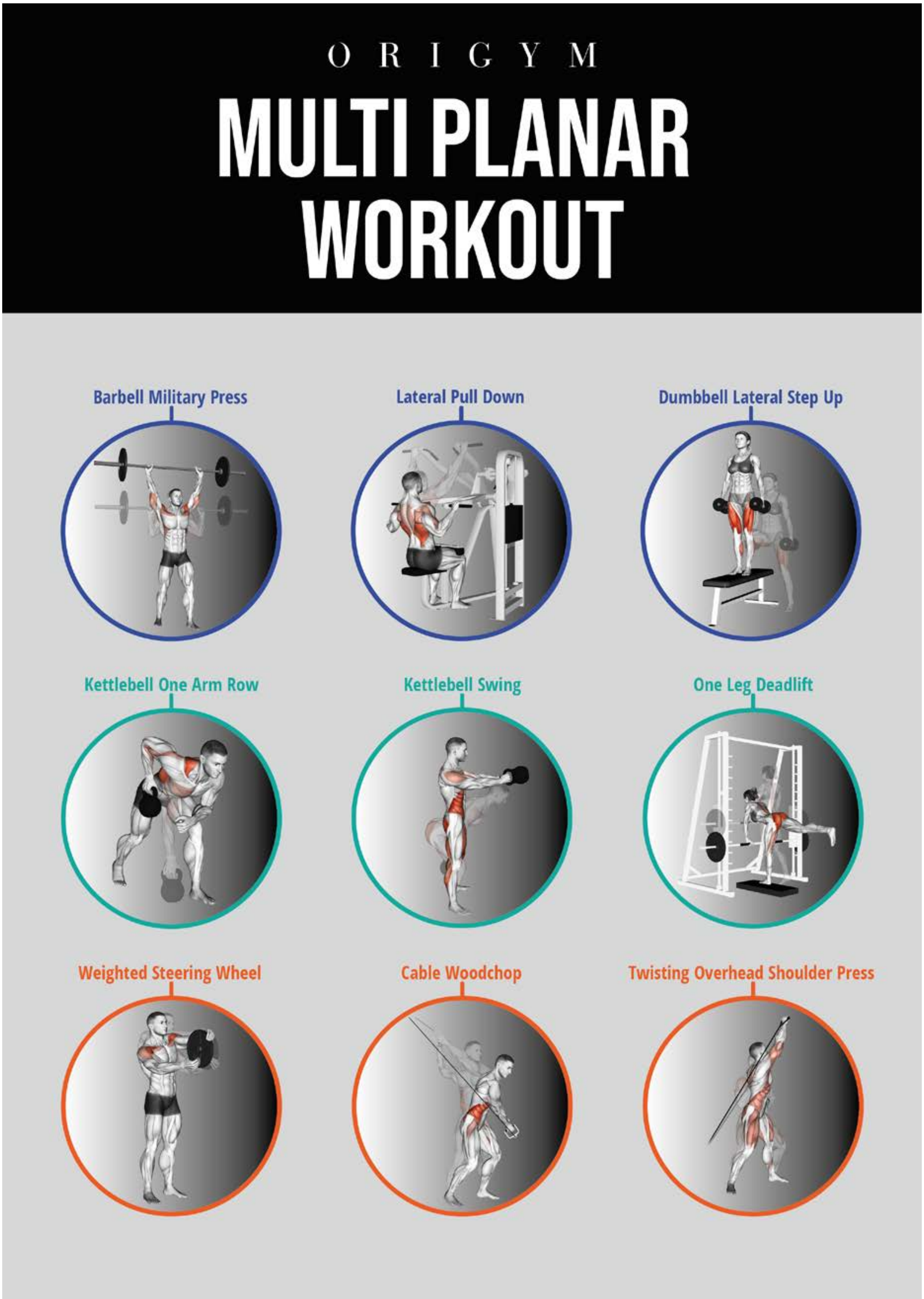
VIDEO AVAILABLE ON LEARNING PLATFORM



MULTI-PLANAR EXERCISES

You can find a downloadable PDF of these posters on the online learning platform.





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DOWNLOADABLE RESOURCE AVAILABLE
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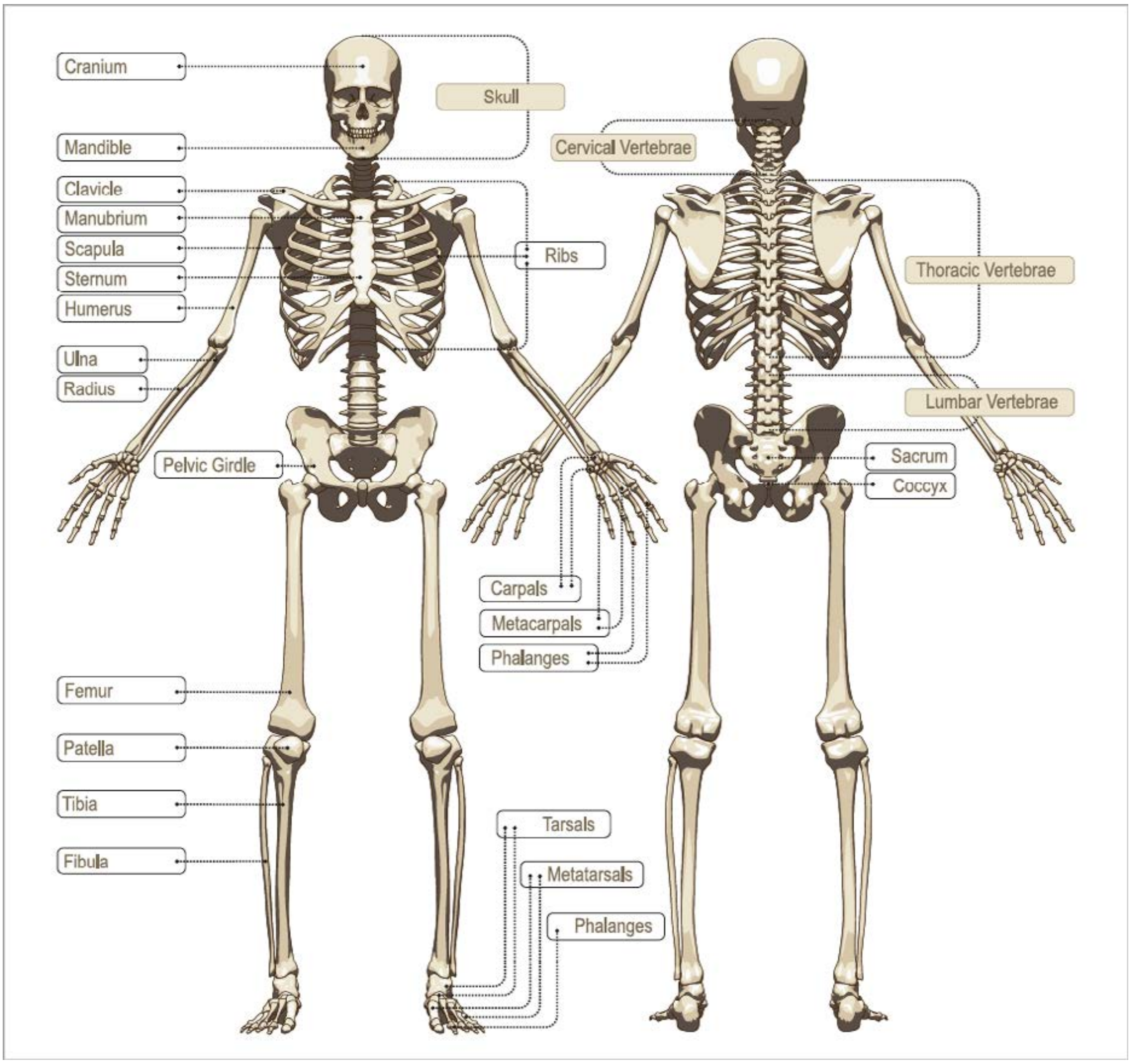
The Skeletal System

SKELETON DIAGRAM



THE AXIAL AND APPENDICULAR SKELETON

The Skeletal System can be divided into 2 parts:

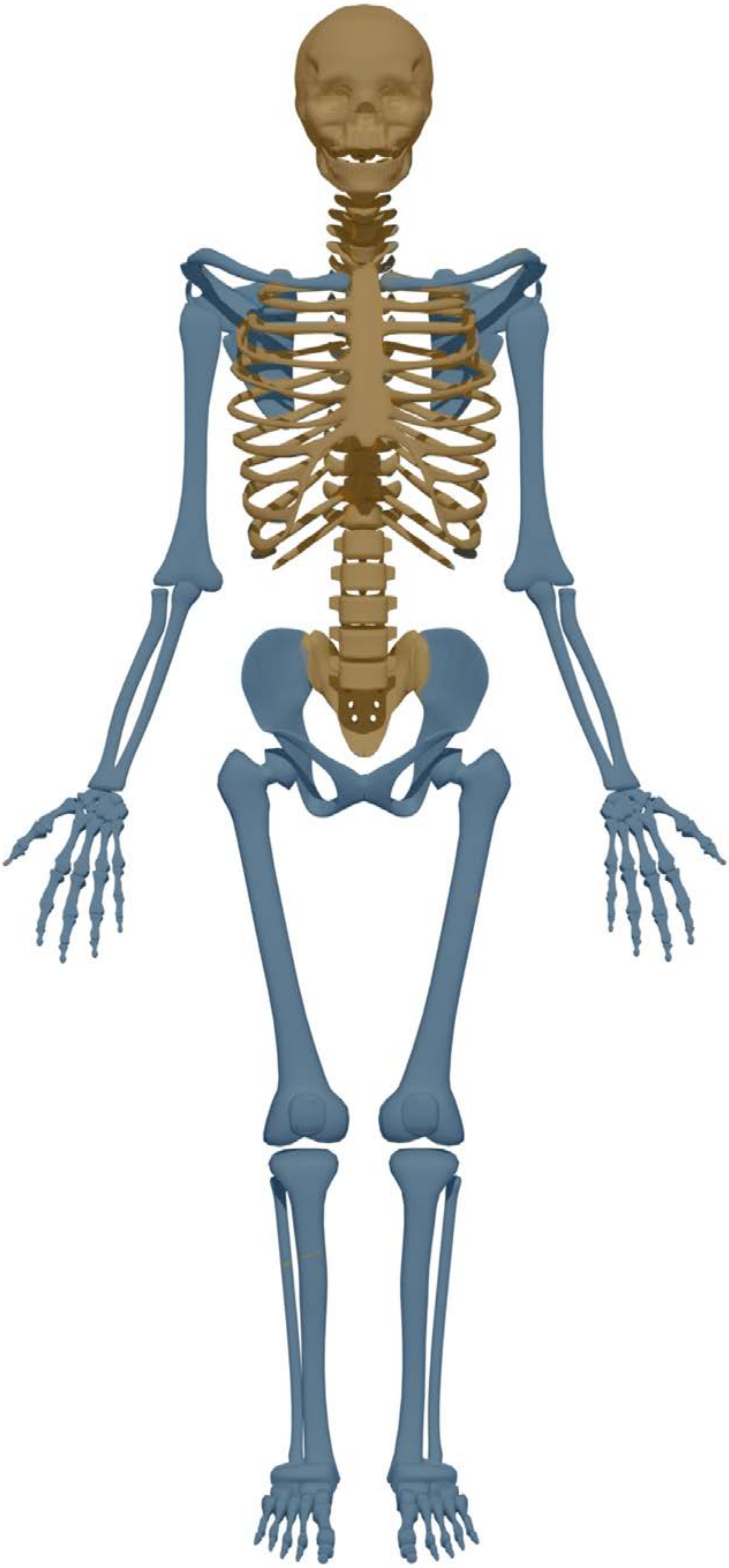
- Axial skeleton: skull, spine, ribs, and sternum.
- Appendicular skeleton: shoulder girdle, upper limbs, pelvic girdle, and lower limbs.

THE AXIAL SKELETON

LOCATION	BONES	NUMBER OF BONES	ADDITIONAL INFORMATION
SKULL	CRANIAL	8	Head
SPINE	CERVICAL	7	Neck
	THORACIC	12	Chest
	LUMBAR	5	Lower Back
	SACRAL	5	Rump (Fused)
	COCCYGEAL	4	Tail (Fused)
CHEST	RIBS (COSTALS)	12 PAIRS	• Originate from the thoracic vertebrae and wrap around the body to form the chest. • The first 7 pairs attach to sternum (true ribs). • The next 3 pairs share cartilaginous attachment to the sternum (false ribs). • The final 2 pairs are free (floating ribs).
CHEST	STERNUM	1	Attachment for true ribs, false ribs and clavicle.

THE APPENDICULAR SKELETON

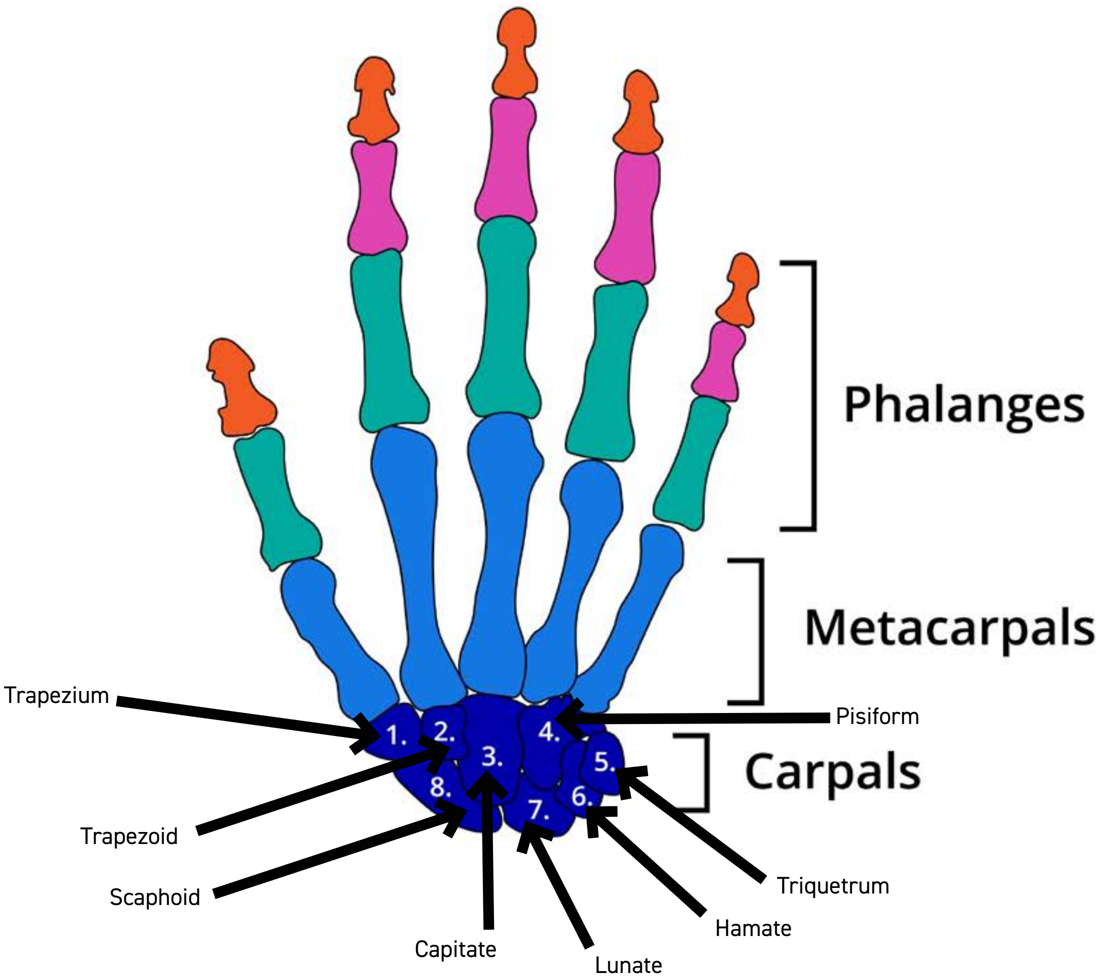
LOCATION	BONES	NUMBER OF BONES	ADDITIONAL INFORMATION
SHOULDER	SCAPULA	2	• Plural = Scapulae. • Triangular bones at the rear (posterior) of the body. • 'S' shaped bones above (superior) the rib cage and at the front (anterior) of the body.
ARM	HUMERUS	2	Upper arm.
	RADIUS	2	Outer and shorter bone of the forearm.
	ULNA	2	Inner and longer bone of the forearm.
HAND	CARPAL	16	2 rows of 4 bones which form the wrist.
	METACARPAL	10	Palm of the hand.
	PHALANGE	28	Finger bones.
PELVIS	ILLIUM	2	Large flat bones of pelvis.
	ISHCHIUM	2	Lower (inferior) rear of the pelvis.
	PUBIS	2	Lower (inferior) front of the pelvis.
LEG	FEMUR	2	Longest bone in the body.
	PATELLA	2	Kneecap.
	TIBIA	2	Larger and inner (medial) bone of the lower leg.
	FIBULA	2	Smaller and outer (lateral) bone of the lower leg.
FOOT	TARSAL	14	Bones of the ankle.
	METATARSAL	10	Bones of the foot.
	PHALANGE	28	Bones of the toes.



SKELETON DIAGRAM: A CLOSER LOOK

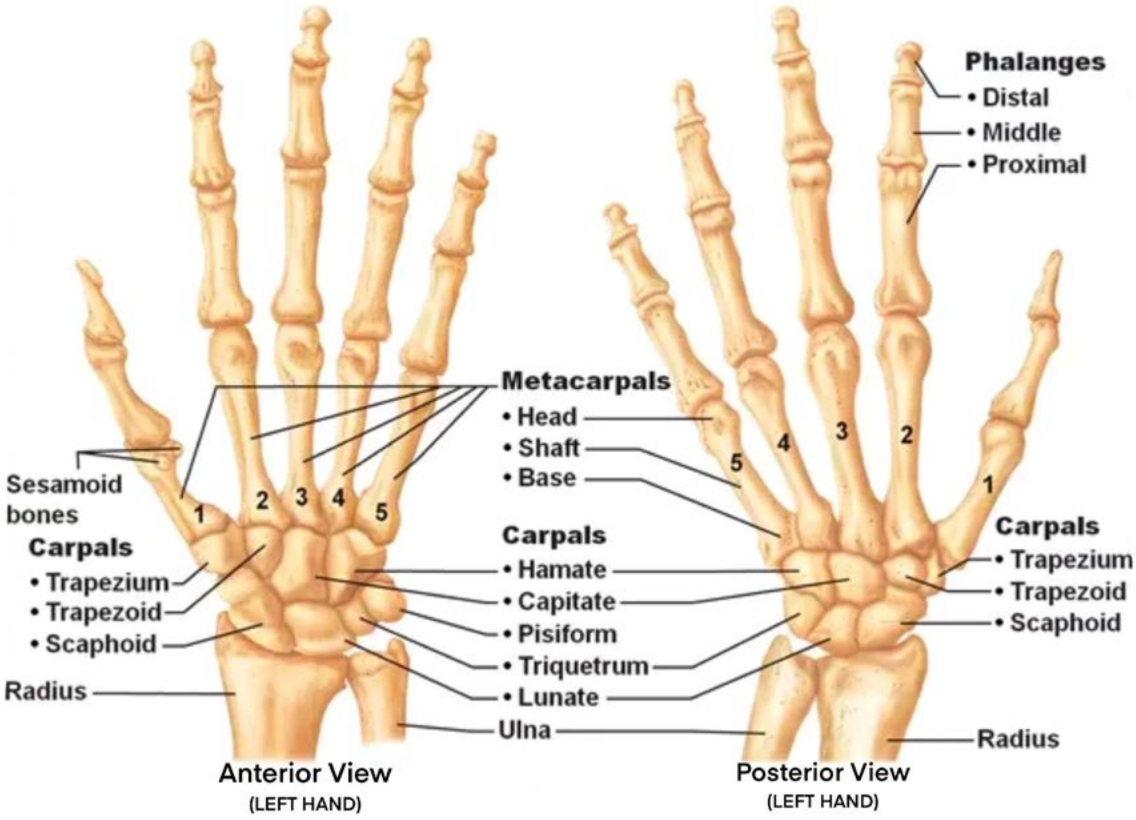
- Distal Phalanges
- Intermediate Phalanges
- Proximal Phalanges
- Metacarpals
- Carpals

1. Trapezium
2. Trapezoid
3. Capitate
4. Hamate
5. Pisiform
6. Triquetrum
7. Lunate
8. Scaphoid

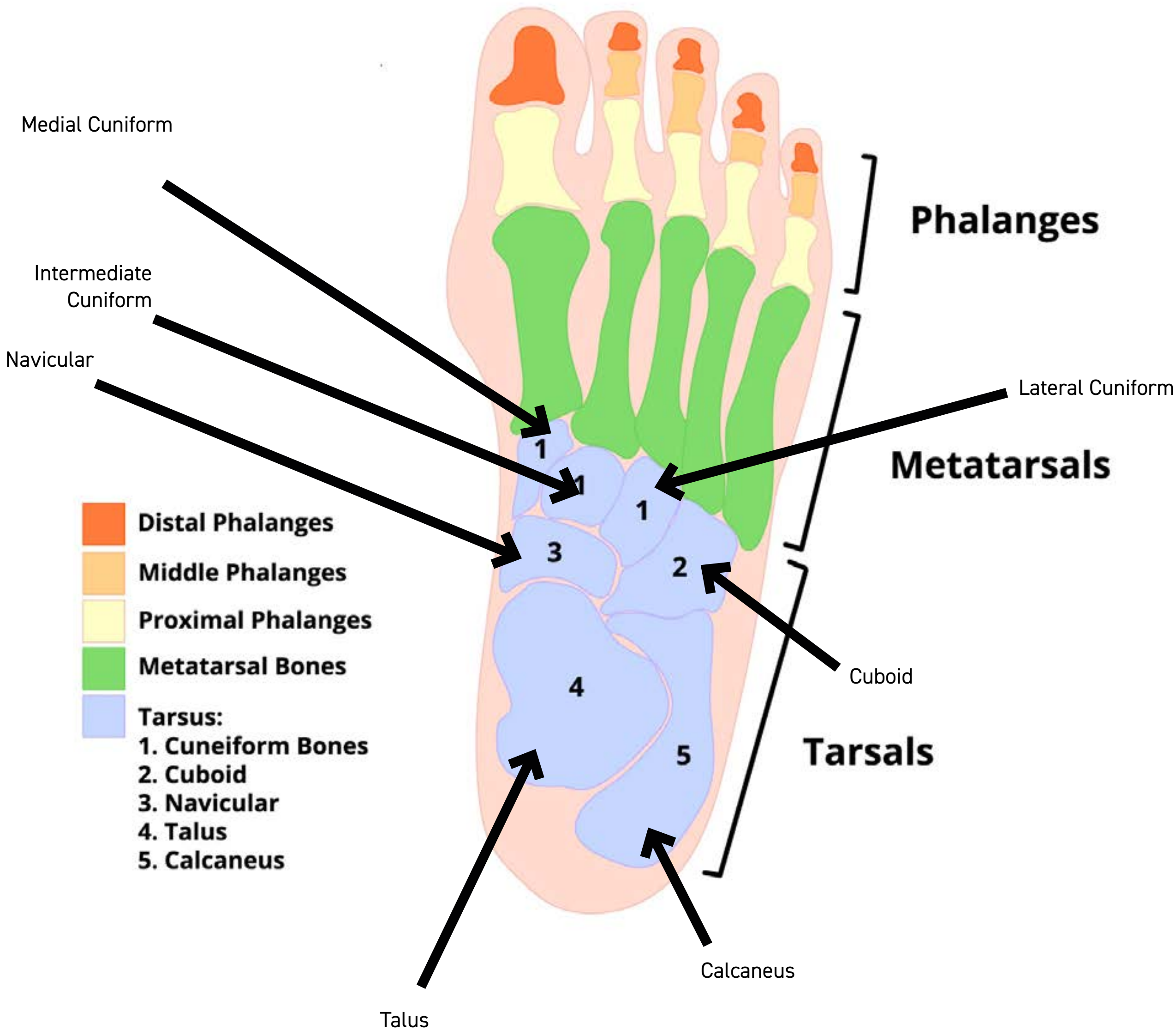


THE HANDS (ANTERIOR AND POSTERIOR)

DOWNLOADABLE RESOURCE AVAILABLE ON LEARNING PLATFORM



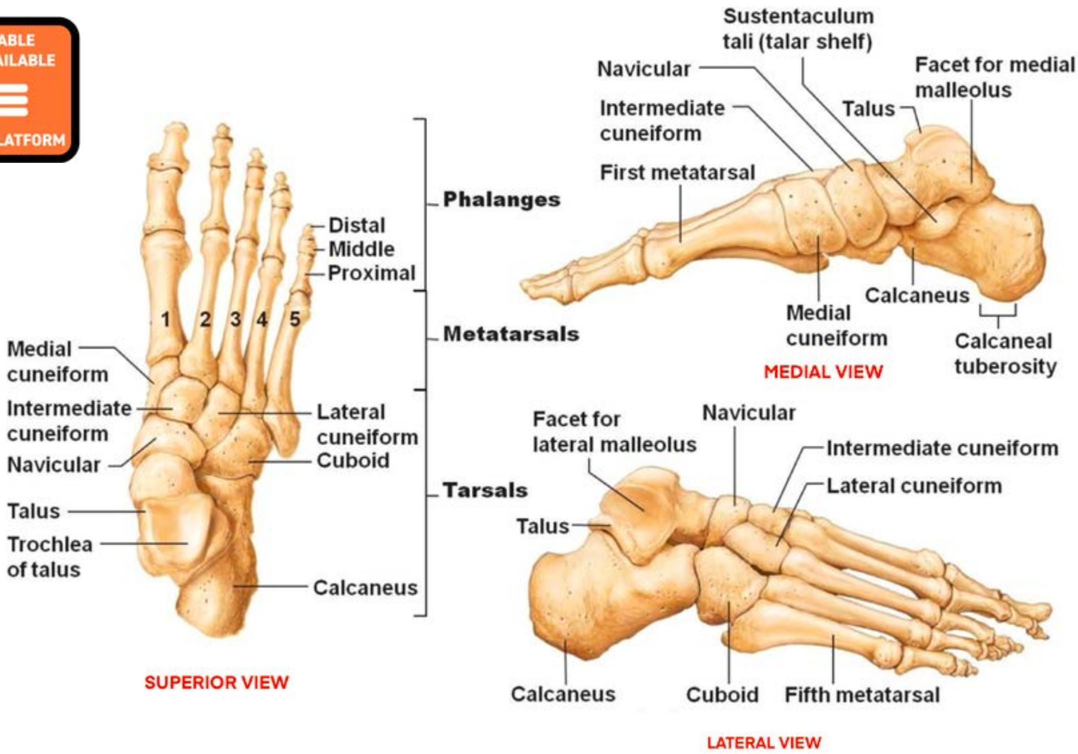
THE FOOT



Medial Cuniform
Intermediate Cuniform
Navicular
Lateral Cuniform
Phalanges
Metatarsals
Tarsals
Cuboid
Calcaneus
Talus
1
1
1
2
3
4
5
Distal Phalanges
Middle Phalanges
Proximal Phalanges
Metatarsal Bones
Tarsus:
1. Cuneiform Bones
2. Cuboid
3. Navicular
4. Talus
5. Calcaneus

THE FOOT (SUPERIOR, MEDIAL AND LATERAL VIEW WITH BONY LANDMARKS)

DOWNLOADABLE RESOURCE AVAILABLE ON LEARNING PLATFORM



FUNCTIONS OF THE SKELETON

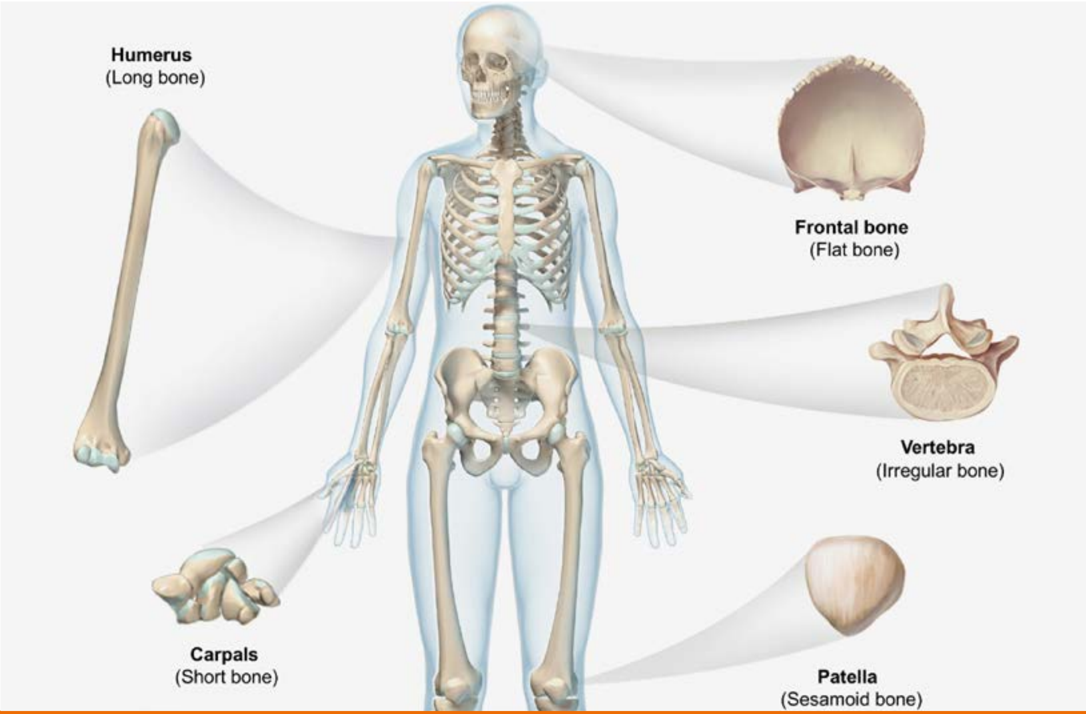
FUNCTIONS	DESCRIPTION
FRAMEWORK	To provide a framework which supports the body and gives it shape.
MOVEMENT OR LOCOMOTION	Bones form joints which acts as levers.
PROTECTION	Helps protect our vital internal organs from being damaged.
SOFT TISSUE ATTACHMENT	Provides surfaces for the attachment of soft tissues.
PRODUCTION	Certain bones produce red blood cells, white blood cells and platelets from bone marrow.
STORAGE	Stores minerals such as calcium and phosphorus to withstand powerful physical stresses. Fats are stored in yellow bone marrow.

BONE CLASSIFICATION

THE CLASSIFICATION OF BONES

- Bone is a calcified connective tissue that forms most of the adult skeleton.
- The skeleton consists of approximately 206 bones.

CLASSIFICATION	DESCRIPTION	EXAMPLES
LONG	• Are longer than they are wide. • Contain mostly compact bone in the shaft (diaphysis). • Contain cancellous bone at each end (epiphysis).	• Humerus • Radius • Ulna • Tibia • Metacarpals • Fibula • Phalanges • Metatarsals
SHORT	• As long as they are wide. Usually consist of mainly cancellous bone. • The above makes them strong and lightweight.	• Carpals • Tarsals
FLAT	• Thin cancellous bone sandwiched between 2 layers of compact bone. • They provide large area's for muscle attachment.	• Cranium • Scapula • Costals • Sternum • Illium
IRREGULAR	• Their many different shapes prevent them from being classifies in any other group.	• Vertebrae
SESAMOID	• 'Seed like'. • Located within tendons at site of tension or friction to protect joint and aid leverage.	• Patella



TYPES OF BONES

FLAT BONES

- Cranial bones
- Scapulae
- Sternum
- Costal bones (ribs)

LONG BONES

- Humerus
- Radius and Ulna
- Femur
- Tibia and Fibula
- Metacarpals and Metatarsals
- Phalanges

SHORT BONES

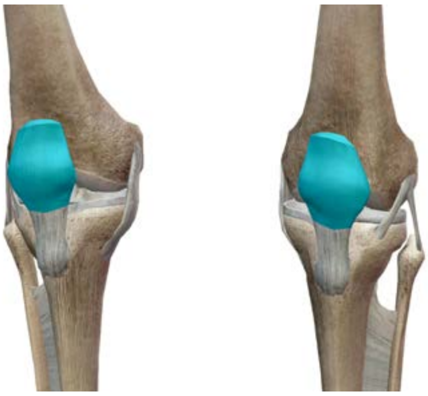
- Carpals
- Tarsals

IRREGULAR BONES

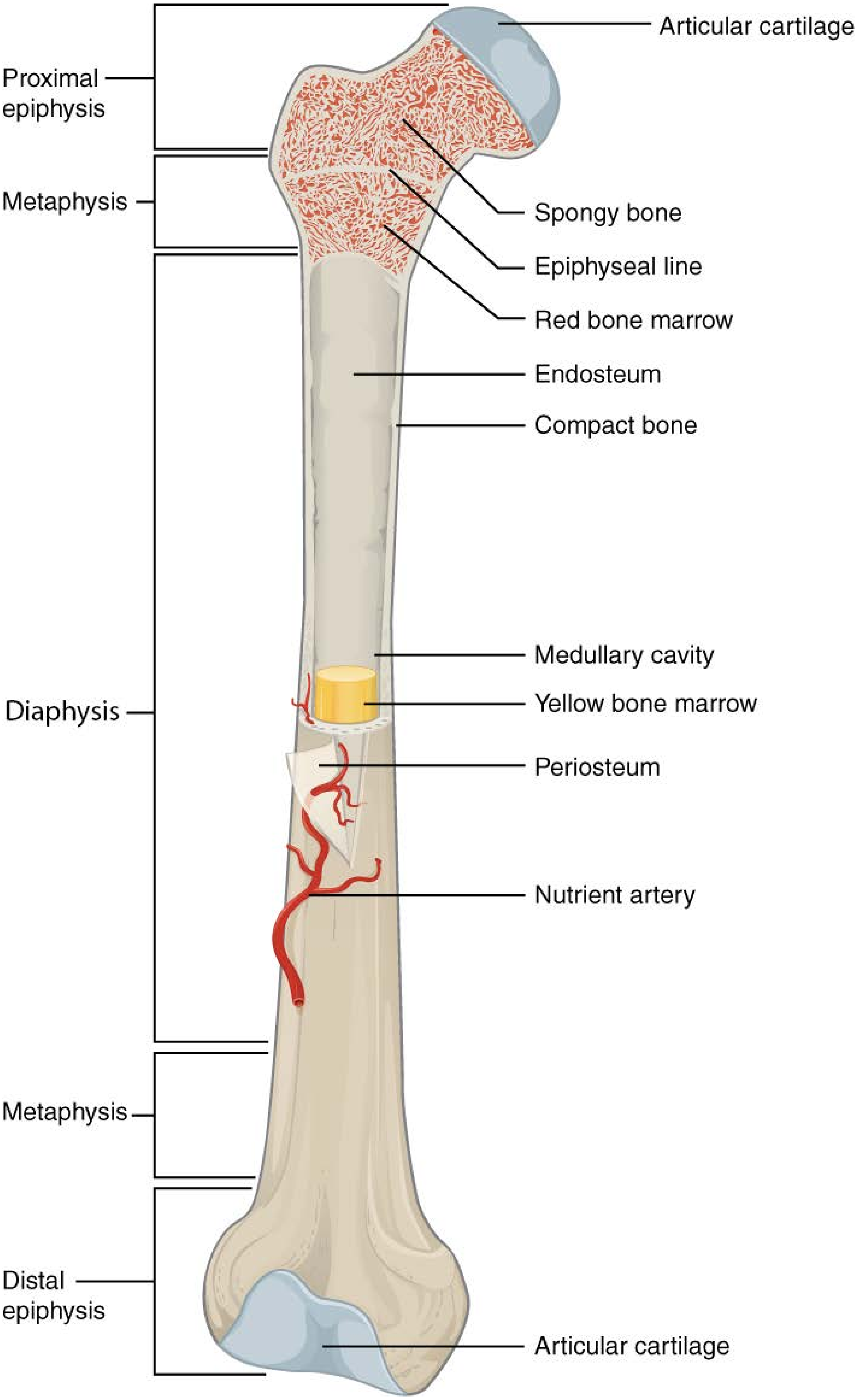
- Vertebrae
- Pelvic bones

SESAMOID

- Patella



ANATOMICAL FEATURES OF A LONG BONE



A closer analysis of a long bone is useful as it helps to highlight many of the properties and functions of the skeletal system.

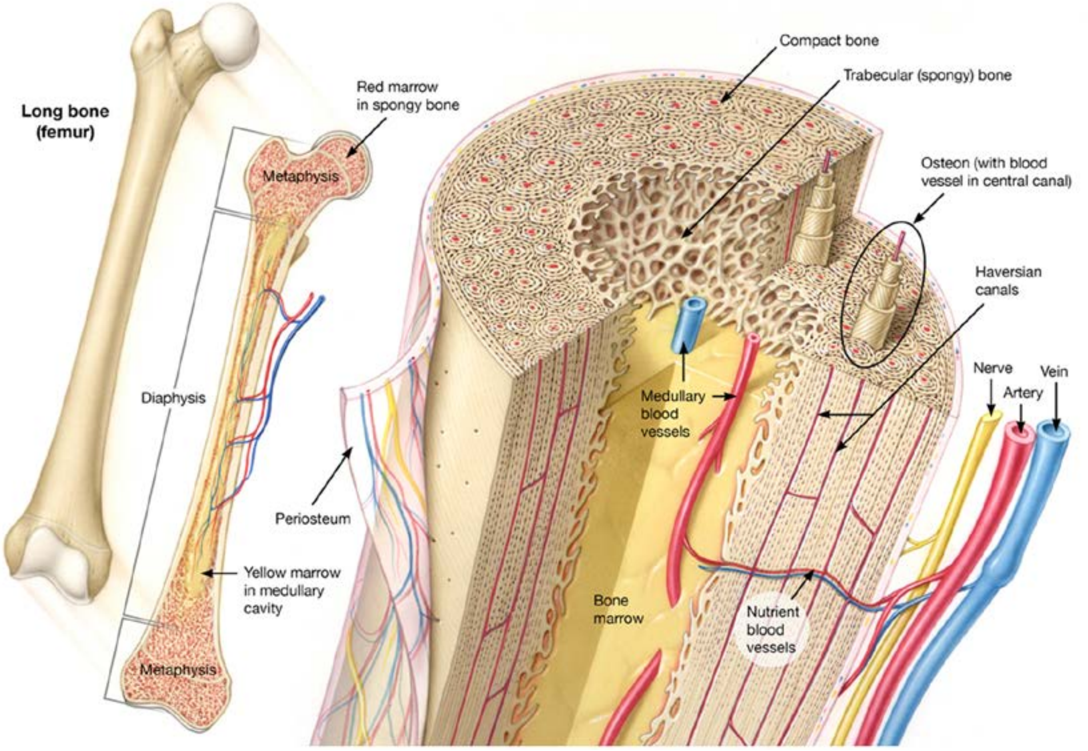
- **EPIPHYSIS (EPIPHYSES):** The bone ends, which are mainly comprised of cancellous bone, and house much of the red marrow involved in red blood cell production. They are also one of the primary sites for bone growth, and during growth, periods can be quite vulnerable to breakage.
- **DIAPHYSIS:** The shaft portion of a long bone, and in comparison to the bone ends is predominantly compact bone (although the inside of the shaft is hollow). The principal role of the diaphysis is to support.
- **EPIPHYSEAL LINE (PLATES):** Are part of the region connecting the diaphysis to the epiphysis. It is a layer of subdividing cartilaginous cells where growth in length of the diaphysis occurs. Cartilaginous cells, which are arranged like columns of coins multiply here. They move towards the diaphysis, becoming more calcified as they go. Osteoblasts continue and complete the process of bone formation.
- **ARTICULAR (HYALINE) CARTILAGE:** The ends of articulating bones are covered with articular or hyaline cartilage. It is a hard, white shiny tissue which, along with synovial fluid, helps reduce friction in freely moveable (synovial joints). The cartilage is necessary for smooth joint action.

NB: When adults finish growing the plates will harden and 'close', no further growth will take place. If the plates are damaged before growth has finished, then this may result in a shorter bone.

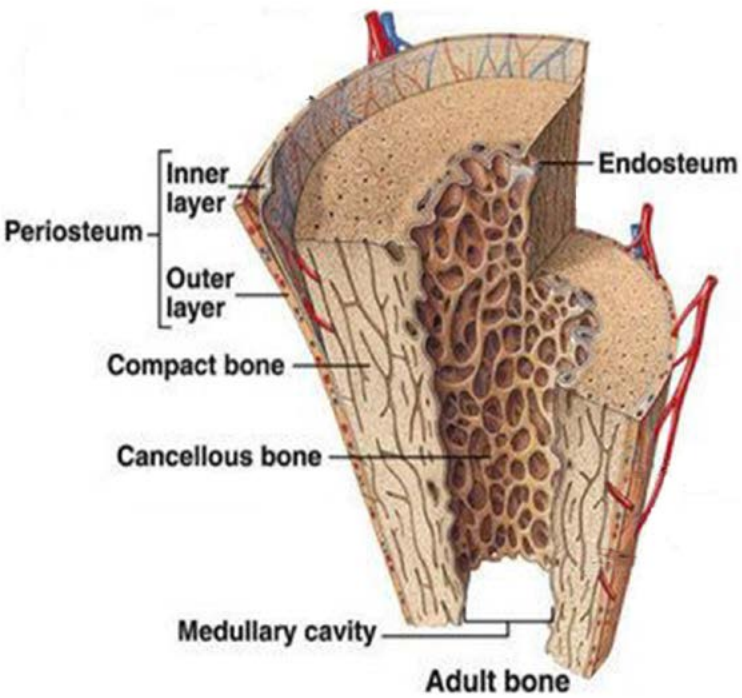
TYPES OF BONE TISSUE

- **COMPACT BONE (CORTICAL BONE):** Is hard and heavy and therefore a dense material, especially in comparison to the cancellous bone to which it surrounds. It is the hard outer structure of the skeleton. It is comprised of units called lamellae. These lamellae are sheets of collagen aligned in parallel patterns. It is these sheets that give the bone its strength. The bony matrix is compactly filled leaving only very small spaces for lacunae that are filled with osteocytes. Compact bone is supplied with oxygen and nutrients through a blood supply within structures called Haversian canals or osteons.
- **CANCELLOUS BONE (SPONGY BONE):** This bone is the less dense and softer of the two types. It makes up the ends of bones and is surrounded by compact bone. Cancellous bone is a highly vascularised and porous tissue and is where blood cells are created.

A CLOSER LOOK AT A LONG BONE



- **PERIOSTEUM:** This forms a tough fibrous membrane which coats the bone. It contains nerves, blood vessels and bone producing cells. Its inner surface provides the materials for nutrition repair and facilitates growth in the diameter of the bone. It also provides the point of attachment for tendons.
- **MEDULLARY CAVITY:** This is the space within the centre of the diaphysis. This contains fatty yellow marrow which is predominantly composed of adipose tissue which is a useful energy reserve.
- **ENDOSTEUM:** Is essentially connective tissue deep within the bone. It is a thin vascular membrane that lines the inner surface of the bone that forms the medullary cavity.



BONE FORMATION

Most of the skeleton begins as cartilage, very strong fibres of collagen which are gradually replaced by compact or cancellous bone. This can be living or non-living material in a human being, both of which contribute to the evolving cycle of bone formation. A number of cells play important roles in this process:

OSTEOBLASTS: BONE FORMING CELLS

OSTEOCLASTS: BONE DESTROYING CELLS

OSTEOCYTES: OSTEOBLASTS WHICH HAVE MATURED INTO BONE CELLS

THE PROCESS OF OSSIFICATION

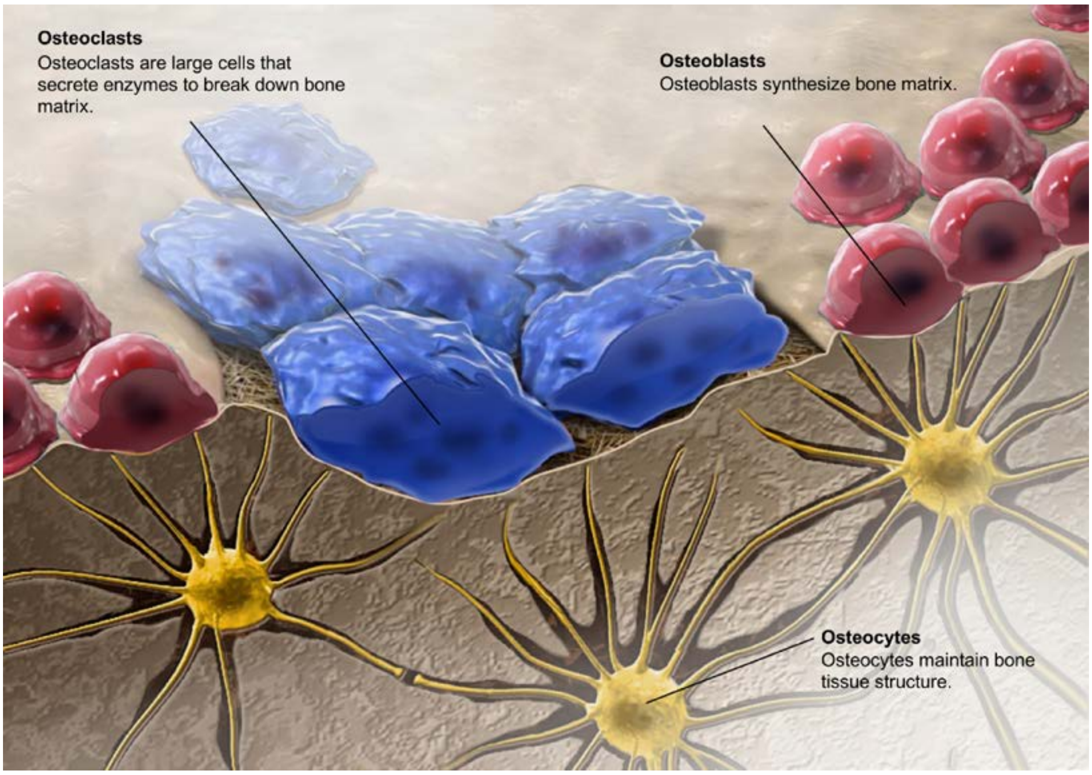
Ossification is the creation of new bone tissue from either cartilage or stress and injury. This process starts from birth and can be complete between the ages of 18-30.

As above there are 3 main osteo-cells used in this process, they are;

- Osteoblasts - B for 'building cells' they deposit the minerals into the bone tissue
- Osteoclasts - CL for clearing old tissue, by occupying cracks in the bone and dissolving surrounding damaged tissue.
- Osteocytes - Mature osteoblasts that have created its own site within the bone tissue to maintain the structure.

(See image below for a clearer depiction of this)

As bone tissue nearly always starts from cartilage (strong collagen fibres), the presence of minerals and salts is required to convert it to human skeletal tissue, one of the main minerals being calcium. The growth and lengthening of long bones continue throughout this time. Lengthening or elongation is achieved by the expansion of epiphyseal growth plates at each end of the diaphysis (see long bone diagram on the previous slide). These plates expand allowing new cells to form and increase the length of the shaft at both ends. The process stops when the thickness of the 14 epiphyseal plates decreases which occurs at different rates for different bones.



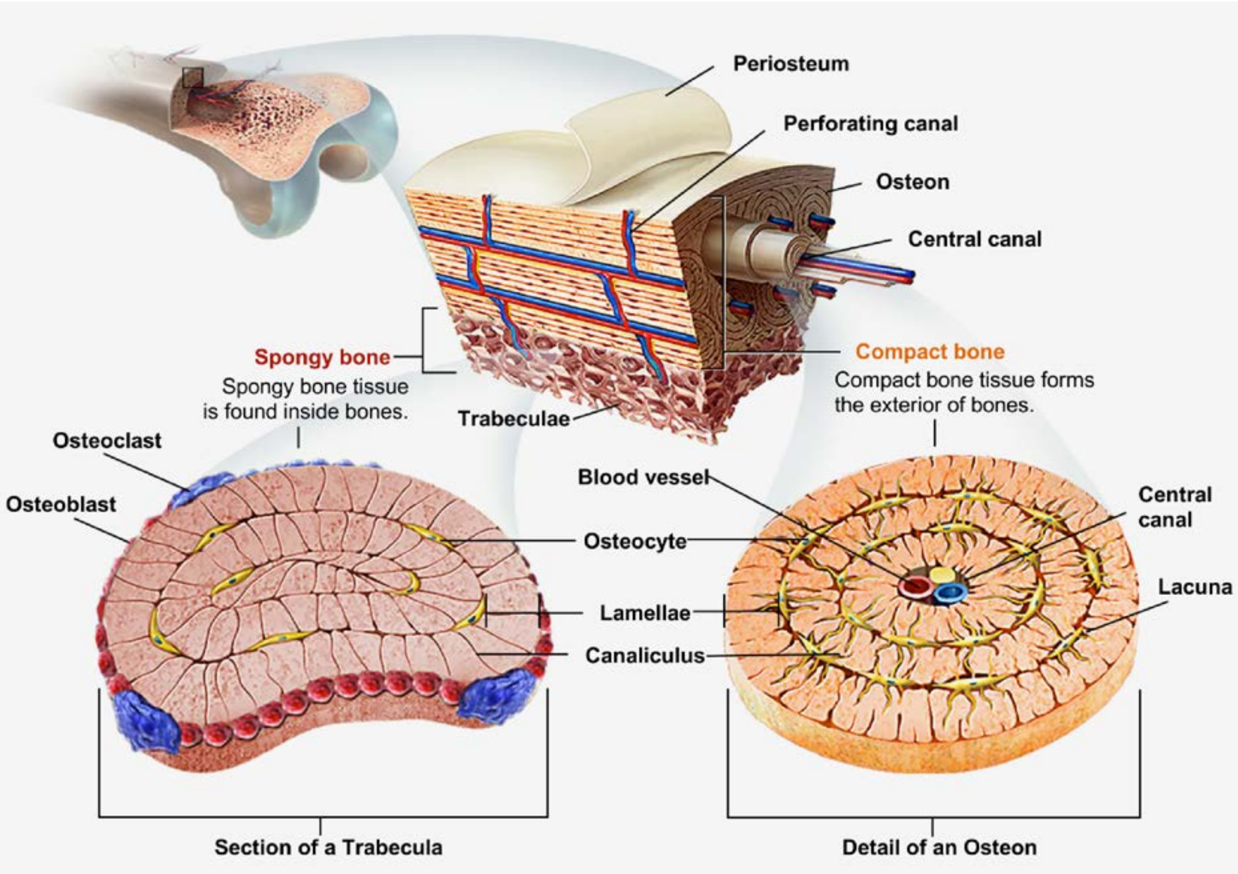
Any stress from physical activity, be it from impact or from tendons pulling on the bone itself, this will create 'microfractures' and begin the process of bone growth and repair.

The 4 stages of Bone Growth and Repair:

- **HEMATOMA FORMATION:** Blood vessels in the broken bone tear and haemorrhage, resulting in the formation of clotted blood, or a hematoma, at the site of the break. The severed blood vessels at the broken ends of the bone are sealed by the clotting process. Bone cells deprived of nutrients begin to die.
- **BONE GENERATION:** Within days of the fracture, capillaries grow into the hematoma, while phagocytic cells begin to clear away the dead cells. Though fragments of the blood clot may remain, fibroblasts and osteoblasts enter the area and begin to reform bone. Fibroblasts produce collagen fibres that connect the broken bone ends, while osteoblasts start to form spongy bone. The repair tissue between the broken bone ends, the fibrocartilaginous callus is composed of both hyaline and fibrocartilage. Some bone spicules may also appear at this point.
- **BONY CALLUS FORMATION:** The fibrocartilaginous callus is converted into a bony callus of spongy bone. It takes about two months for the broken bone ends to be firmly joined together after the fracture. This is similar to the endochondral formation of bone, when cartilage becomes ossified; osteoblasts, osteoclasts, and bone matrix are present.
- **BONE REMODELLING:** The bony callus is then remodelled by osteoclasts and osteoblasts, with excess material on the exterior of the bone and within the medullary cavity being removed. Compact bone is added to create bone tissue that is similar to the original, unbroken bone. This remodelling can take many months; the bone may remain uneven for years.

BONE PHYSIOLOGY

Bone consists of a mixture of water, protein and mineral salts, the latter of which constitutes roughly 50% of the structure. Bone strength is the result of a combination of the hardness of these minerals combined with the tensile properties of collagen (derived from protein). Too little of one (e.g. Collagen) and the bone will shatter like an eggshell, too little of the other (e.g. Mineral salts) and bone will bend like a piece of rubber.



HORMONAL REGULATION OF BONE

Bone formation, in the pre-puberty years, is predominantly regulated by human growth hormone (HGH) produced by the pituitary gland (located in the brain). At puberty, however, testosterone produced by the male testes and oestrogen produced by the female ovaries begin to exert a greater influence. In women, oestrogen promotes the growth of the skeleton and development of the unique female skeletal characteristics (i.e. The broader pelvis). Whereas testosterone, causes males to have larger more robust skeletons (McArdle et al, 2001).

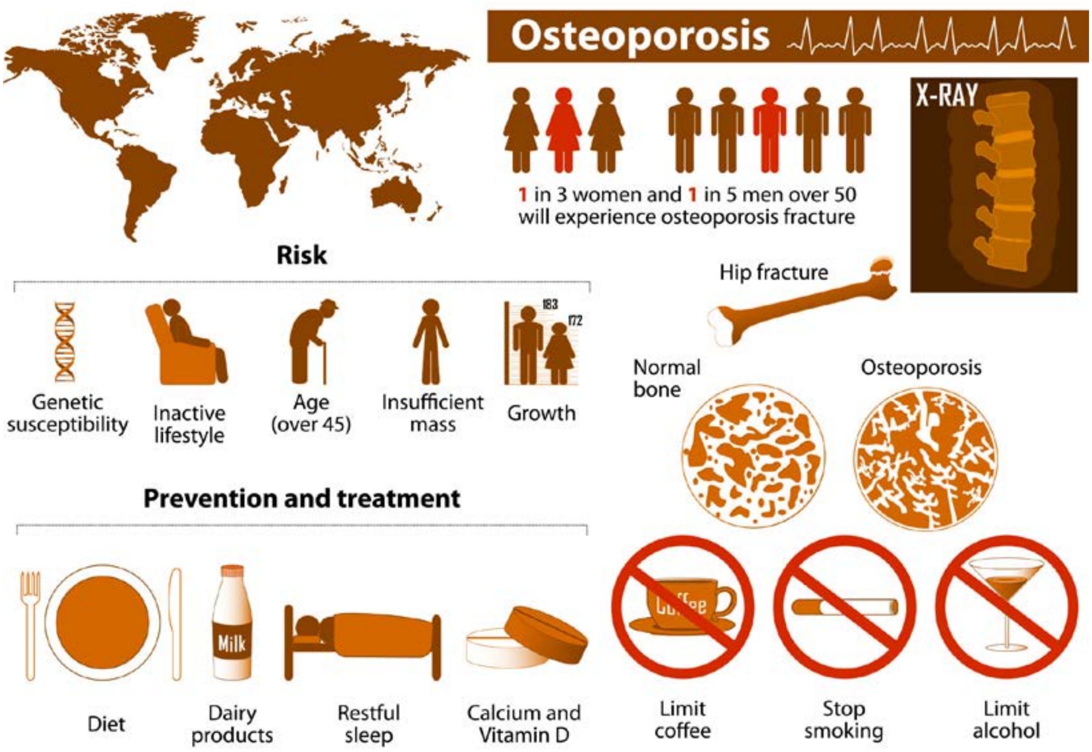
Additional aspects of bone growth are discussed below with respect to the structure of a long bone.

THE SKELETAL SYSTEM AND CALCIUM REGULATION

Although calcium provides the skeletal system with rigidity it is also involved in a number of other important functions:

- Muscular contraction.
- Transmission of nervous impulses.
- Regulating fluid balance (McArdle et al.,1996; Jones and Round,1991).

Too much or too little calcium in the body can affect the functions above. Therefore bones act as calcium reservoirs which can either take up or release calcium depending on the needs of the body (Jones and Rounds, 1990; Tortora and Grabowski, 1996). When calcium is lacking within the body it will be withdrawn from the bones. This is why diets that are chronically low in calcium tend to increase the risk of osteoporosis.



OSTEOPOROSIS

(BRITTLE BONE DISEASE)

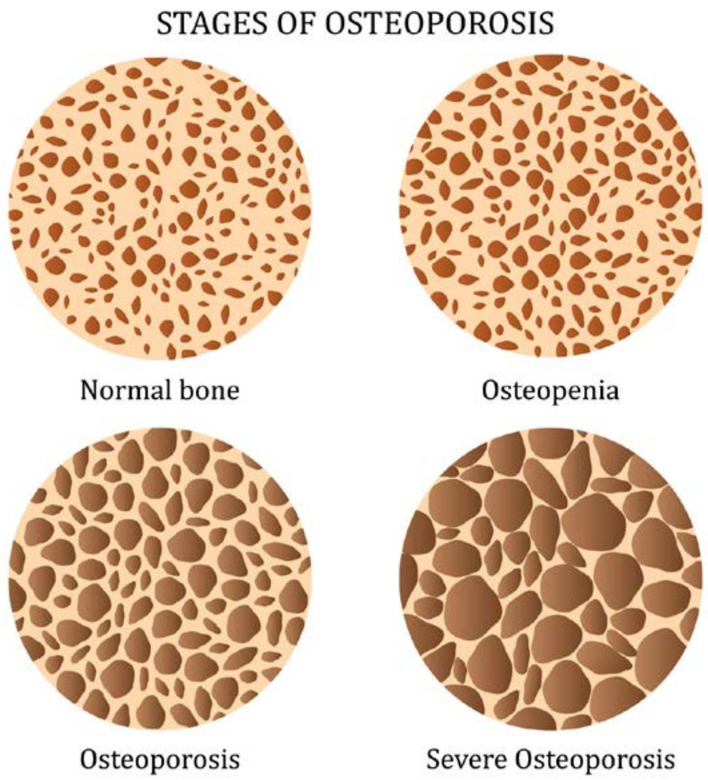
Bone remodelling is a delicate balance of osteoblast and osteoclast activity. An imbalance of this activity is what causes Osteoporosis. Essentially osteoblast activity decreases causing a drop in bone growth. This leads to a gradual loss in bone density and ultimately gives rise to a skeletal system that is unable to withstand the forces placed on it.

The condition may give rise from a number of causes; however one of the biggest is the drop in oestrogen levels associated with the menopause. This makes women significantly more likely to develop the condition than men. In men, a proportion of circulating testosterone is converted into oestrogen and this is thought to provide men with significant protection against loss of bone mass.

Low calorific intake and/or overtraining can also increase the risk of osteoporosis in females due to the depletion of body fat stores which are one of the primary sources of oestrogen. Poor quality diets which are lacking in minerals and vitamins or have an imbalance of the two also increase the risks by limiting the availability of calcium (Tortora and Grabowski, 1996).

The list below provides a summary of some of the risk factors associated with osteoporosis:

- Female sex – due to drop in oestrogen levels (particularly at the menopause).
- Calcium deficiency – through poor diet.
- Lack of exercise.
- Smoking – causes a drop in oestrogen.
- Family history.
- Certain drugs, such as alcohol.
- Low body fat.
- Overtraining.
- (Mcardle et al., 2001; Tortora and Grabowski, 1996; National Institutes of Health Osteoporosis and Related Bone Disease).



FACTORS AFFECTING BONE FORMATION

Bone development is influenced by:

- Nutrition.
- Hormonal excretions.
- Exposure to sunlight.
- Physical exercise.

Bone health may be influenced by many factors from maternal nutrition, through toddler and pre-school years, with calcium intake playing an important role. Calcium can only reach its full bone building potential if the body has enough vitamin D. Calcium helps build and maintain bones while vitamin D helps the body absorb calcium effectively. We can get most of our vitamin D from exposure to sunlight.

Hormones are made in glands and travel around the body via the bloodstream. They are important in the balance between formation and re-absorption of bone.

Physical activity causes new bone tissue to form. The stress placed on bones during weight-bearing activity has a direct influence on bone strength.

The Muscular System

UNIT 1: THE SYSTEMS THAT MAKE UP THE HUMAN BODY (ANATOMY AND PHYSIOLOGY)

MUSCLE TISSUE

TYPES OF MUSCLE TISSUE

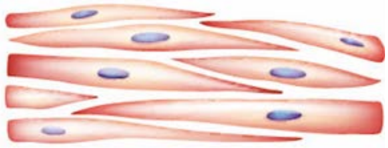
Muscles have the ability to contract, producing movement in the body or maintaining the position of parts of the body.

There are three types of muscle tissue:

SMOOTH MUSCLE

- The most diverse type of muscle in the body.
- Found in internal organs e.g. Digestive and circulatory systems.
- Involuntary as it is controlled by the autonomous nervous system.

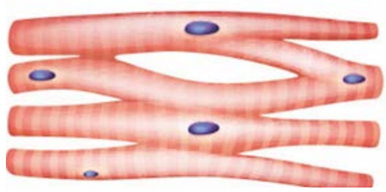
Gastrointestinal Tract
Respiratory Tract
Blood Vessels
Urinary Organs
Reproductive Organs



CARDIAC MUSCLE

- Also known as myocardium.
- Found in the heart.
- Involuntary as it is controlled by the sinoatrial node.

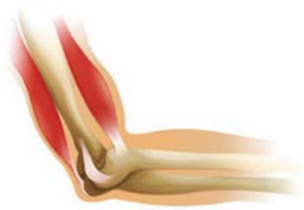
Myocardium
Coronary Circulation
Conduction System

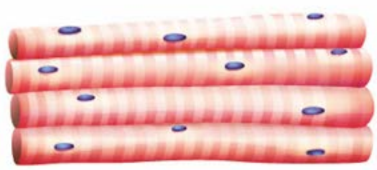


SKELETAL MUSCLE

- Represents the majority of muscle in the body.
- Attaches to bone across joints via tendons.
- Produces movements within the body.
- Determines posture by stabilising body position.
- Transports and stores substances within the body.
- Generates heat.
- Voluntary as it is controlled by the somatic nervous system.

Head/Neck
Shoulder Girdle
Thorax/Abdomen
Pelvis/Hip
Upper Limbs
Lower Limbs





FUNCTIONS OF THE MUSCULAR SYSTEM

MOBILITY

Your skeletal muscles are responsible for the movements you make. Skeletal muscles are attached to your bones and partly controlled by the Central Nervous System. You use your skeletal muscles whenever you move. Fast-twitch skeletal muscles cause short bursts of speed and strength. Slow-twitch muscles function better for longer movements.

RESPIRATION

Your diaphragm is the main muscle at work during breathing. Heavier breathing, like what you experience during exercise, may require accessory muscles to help the diaphragm. These can include the abdominal, neck, and back muscles.

CHILDBIRTH

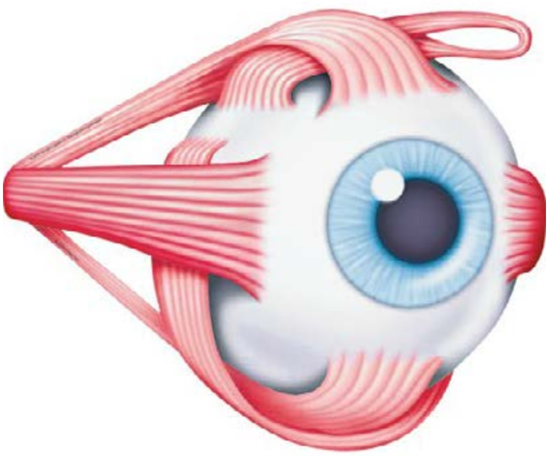
Smooth muscles are found in the uterus. During pregnancy, these muscles grow and stretch as the baby grows. When a woman goes into labour, the smooth muscles of the uterus contract and relax to help push the baby through the vagina.

URINATION

Smooth and skeletal muscles make up the urinary system. The urinary system includes the: Kidneys, Bladder, Ureters, Urethra, Penis or Vagina and Prostate. All the muscles in your urinary system work together so you can urinate. The dome of your bladder is made of smooth muscles. You can release urine when those muscles tighten. When they relax, you can hold in your urine.

DIGESTION

Digestion is controlled by smooth muscles found in your gastrointestinal tract. This comprises the: Mouth, Oesophagus, Stomach, Small and large intestines, Rectum and Anus. The digestive system also includes the liver, pancreas and gallbladder. The smooth muscles contract and relax as food passes through your body during digestion. These muscles also help push food out of your body through defecation, or vomiting when you're sick.



VISION

Your eye sockets are made up of six skeletal muscles that help you move your eyes. And the internal muscles of your eyes are made up of smooth muscles. All these muscles work together to help you see. If you damage these muscles, you may impair your vision.

STABILITY

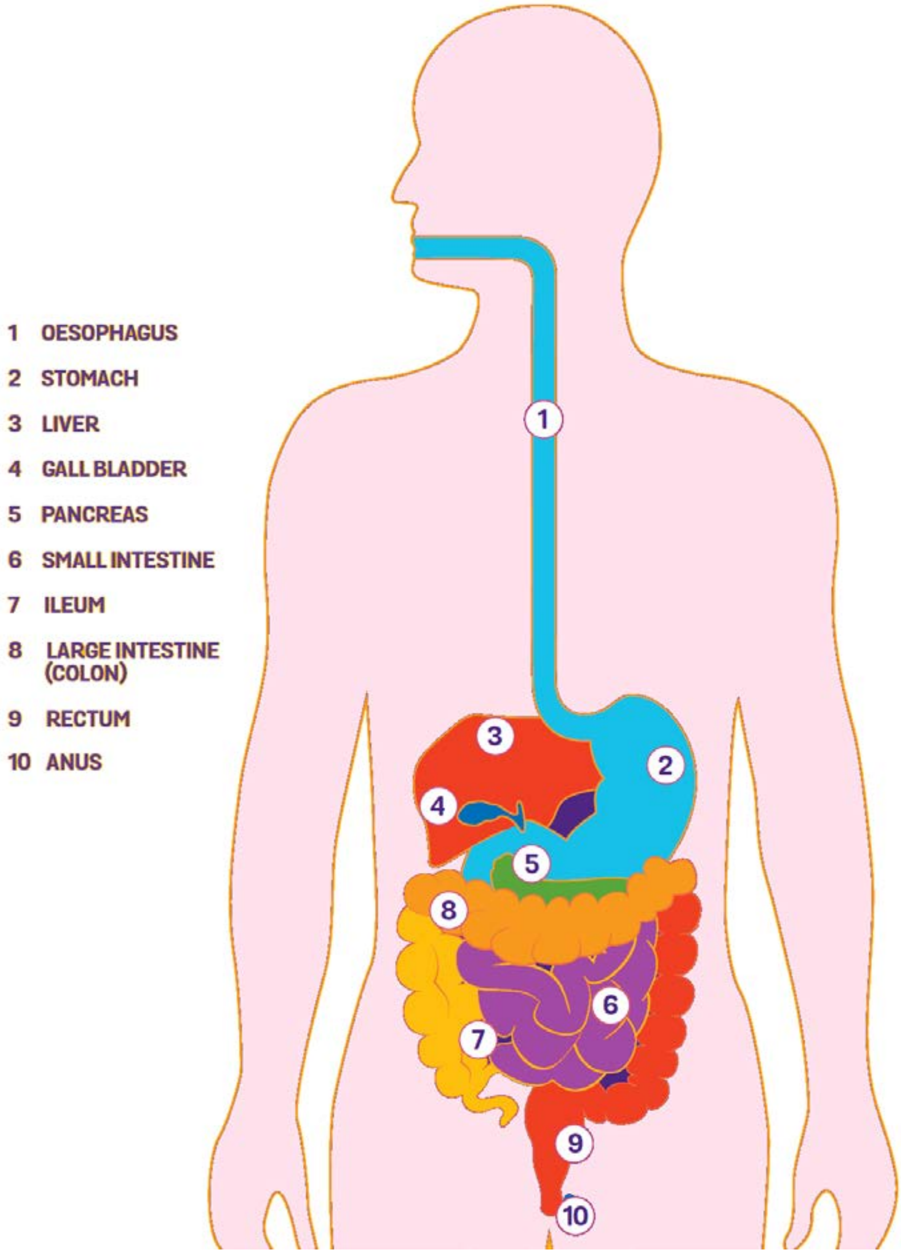
The skeletal muscles in your core help protect your spine and help with stability. Your core muscle group includes the abdominal, back, and pelvic muscles. This group is also known as the trunk. The stronger the core, the better you can stabilise your body. The muscles in your legs also help steady you.

POSTURE

Your skeletal muscles also control posture. Flexibility and strength are keys to maintaining proper posture. Stiff neck muscles, weak back muscles, or tight hip muscles can throw off your alignment. Poor posture can affect parts of your body and lead to joint pain and weaker muscles. These parts include the: Shoulders, Spine, Hips and Knees.

CIRCULATION

The involuntary cardiac and smooth muscles help your heartbeat and blood flow through your body by producing electrical impulses. The cardiac muscle (myocardium) is found in the walls of the heart. It's controlled by the autonomic nervous system responsible for most bodily functions. The myocardium also has one central nucleus like a smooth muscle. Your blood vessels are made up of smooth muscles and also controlled by the autonomic nervous system.

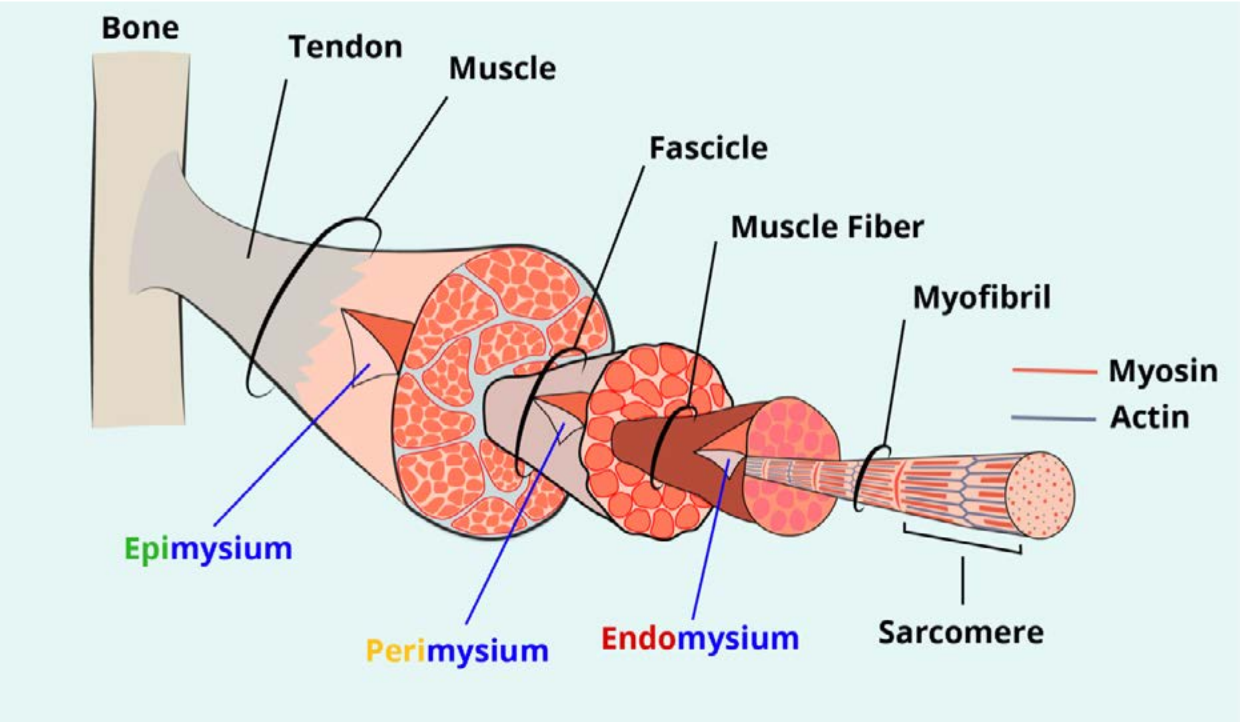


PROPERTIES

PROPERTIES OF SKELETAL MUSCLE

There are four main properties of muscle tissue:

- **ELASTICITY:** Returns to the original length after a stretch.
- **CONTRACTILITY:** Develops tension in order to perform a contraction.
- **ELECTRICAL EXCITABILITY:** Can respond to a stimulus.
- **EXTENSIBILITY:** Ability to be stretched or to increase in length.



SKELETAL MUSCLE ANATOMY

There are no exact figures to determine the number of muscles in the human body, although they make up approximately 40% of body weight. They comprise of 70% water, 23% protein and 7% minerals.

Myofilaments are the rigid protein filaments (actin and myosin) within myofibrils and are responsible for the creation of tension during contraction. Many myofibrils are grouped together to form a muscle fibre which is surrounded by endomysium. The number of muscle fibres varies according to the location and function of each muscle. The greater the demands of the muscle, the more fibres will be required. Each group of fibres is held together by perimysium to form a fascicle which means 'cluster' or 'bundle'.

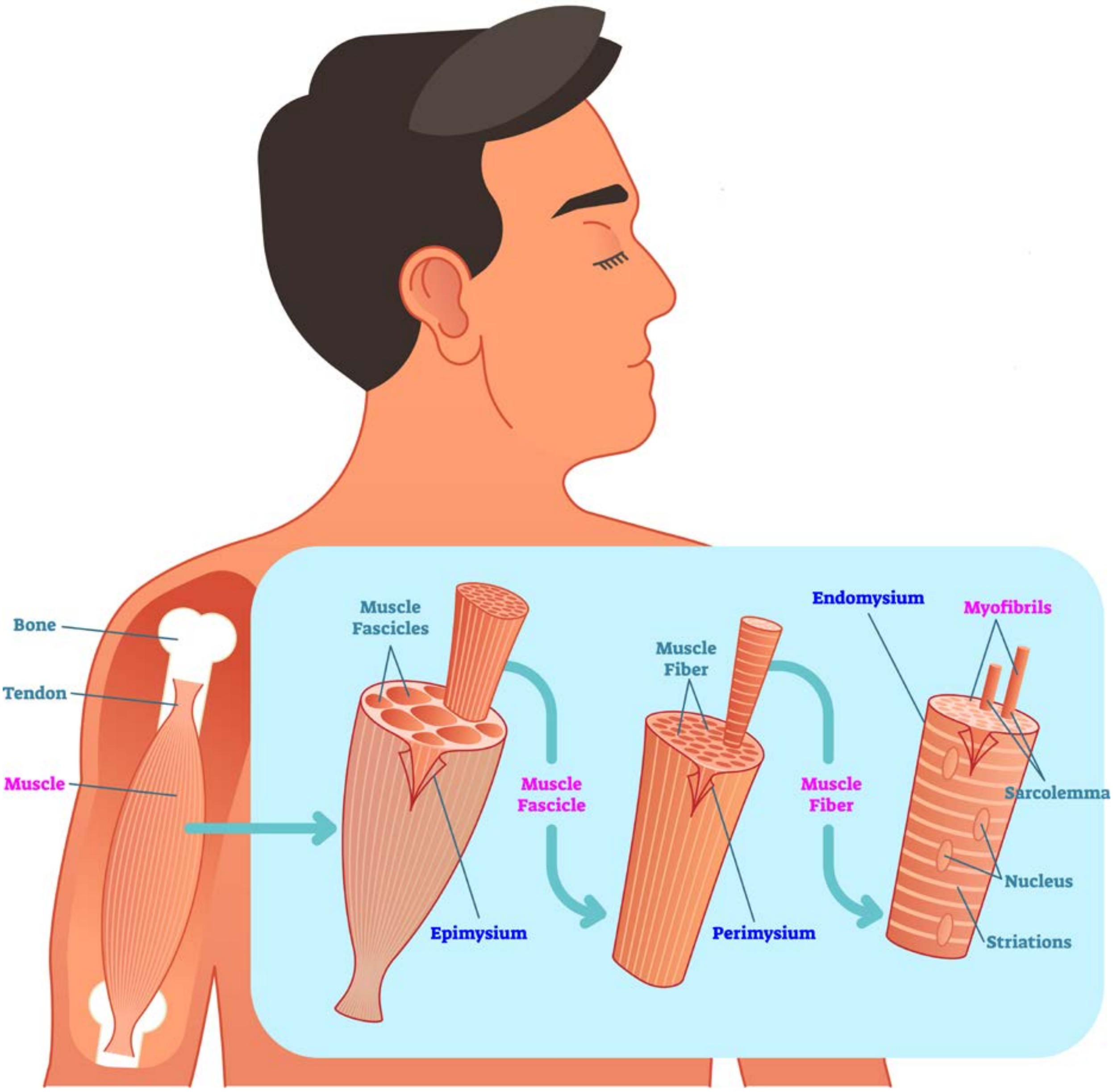
Finally, the many fasciculi are covered by a fascia of epimysium to form the muscle. Connective tissue is continuous throughout the length of a muscle and these layers come together to form tendons. The tendons attach to the periosteum sheath which surrounds the bone.

CONNECTIVE TISSUE

(Area) = (INSIDE THE AREA) = (Around the area)

- **Muscle = GROUP OF FASICLES = Epimysium**
- **Muscle Fascicle = GROUP OF MUSCLE FIBRES = Perimysium**
- **Muscle Fibre = GROUP OF MYOFIBRILS = Endomysium**
- **Myofibril = GROUPS OF ACTIN AND MYOSIN in a chain = Sarcolemma**

NB: Sarcolemma is not connective tissue however it is continuous around myofibrils



MUSCLE CONTRACTION OVERVIEW

VIDEO AVAILABLE ON LEARNING PLATFORM

THE SLIDING FILAMENT THEORY

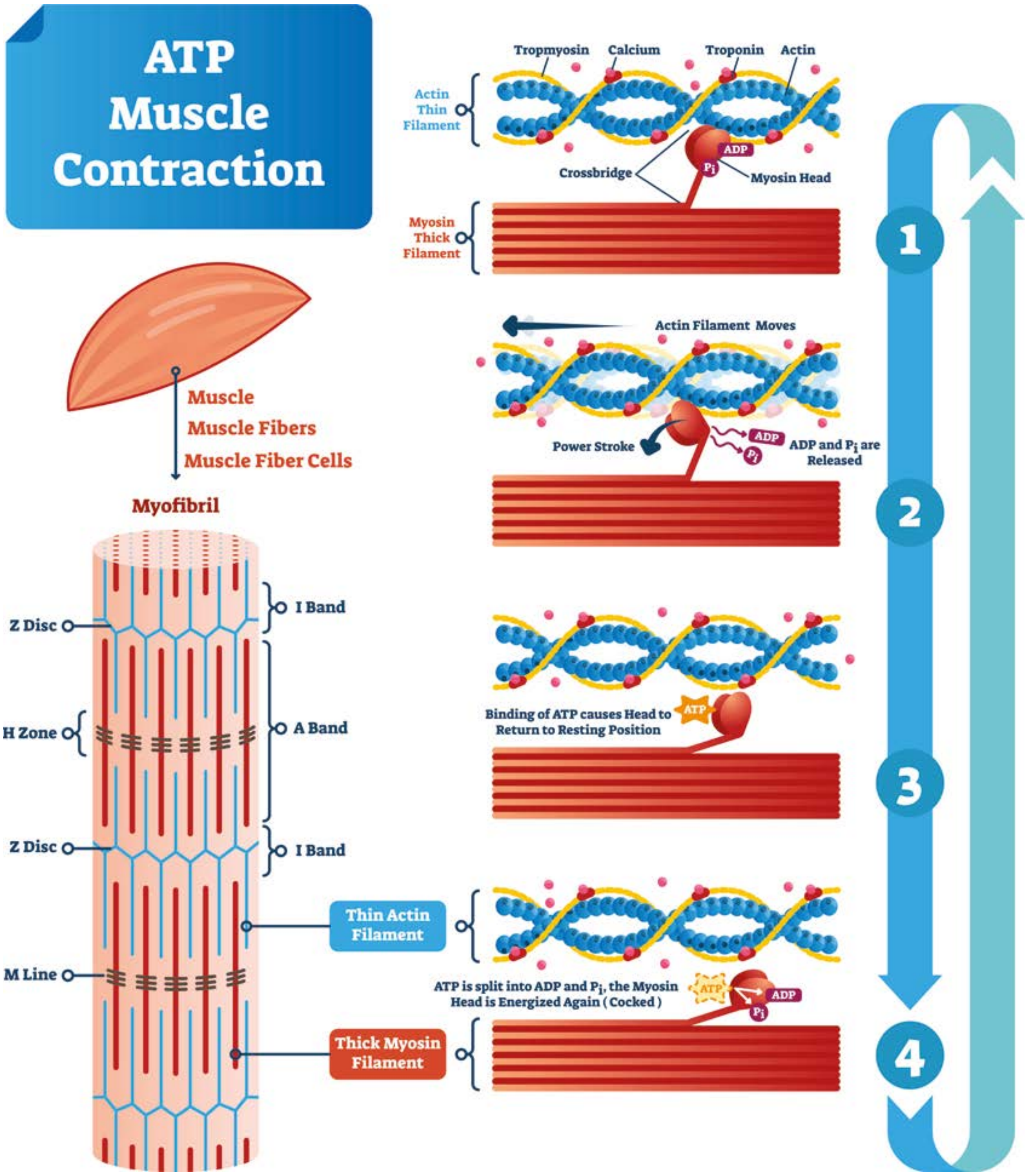
The ability of skeletal muscle to contract is dependent on the movement of protein myofilaments:

ACTIN - THIN PROTEIN STRAND

MYOSIN - THICK PROTEIN STRAND

These rigid protein strands do not actually contract or decrease in size, but simply slide over each other to reduce the size of the space they occupy which is called a sarcomere, (this underlying principle of muscle movement was popularised as The Sliding Filament Theory in 1954).

There are many myofilaments in each sarcomere. The heads of the myosin, known as cross-bridges attach to a binding site and pull on the actin, causing them to slide inwards causing an overlap in the centre of the sarcomere. This is known as the contraction phase or 'power stroke'. The myosin cross-bridges then detach from the actin in the 'recovery stroke'. At this point, the myosin is free to attach to the next binding site and repeat the process.



FORCE GENERATION

You must look at the fine structure of a muscle fibre to understand how a muscle generates force. Beneath the endomysium, there are even smaller rows of fibres: myofibrils. It is within these myofibrils that the structures which are responsible for force production are located; Myosin and Actin.

MYOSIN AND ACTIN & THE SLIDING FILAMENT MECHANISM

Responsible for force generation are two contractile proteins called myosin and actin, often referred to as thick and thin filaments respectively. These are arranged in a series of partitions called sarcomeres that run the length of the myofibril. Sprouting from the myosin filament is a series of 'hook-like' bulges referred to as myosin heads. During the "stroke phase" and indeed a muscular contraction, these heads attach themselves to the actin filament and rotate. The result of this is that the thinner actin filaments are drawn inwards drawing the ends of the sarcomeres together. This process is referred to as the sliding filament mechanism.

MYOSIN AND ATP

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The power to drive the myosin head is provided by adenosine triphosphate (ATP). The ATP molecule primes the myosin for activity by binding with the head. When the conditions are right, the myosin head will bind with the actin and rotate.

ACTIN AND CALCIUM

Although the ATP has primed the myosin the binding to actin would not be successful without the presence of calcium. During muscular relaxation, the myosin-binding sites on the actin are blocked by a combination of other molecules (troponin and tropomyosin). These must be cleared before myosin can be attached.

Surrounding the myofibrils is a network of tubes called the sarcoplasmic reticulum (SR) that act as calcium reservoirs. The release of calcium is through stimulation of the sarcoplasmic reticulum from an action potential. This causes calcium to be flushed into the fluid surrounding the myosin and actin, the sarcoplasm. The calcium causes the molecule that is blocking the myosin binding site to move away, allowing the now 'primed' myosin head to bind with the actin and rotate.

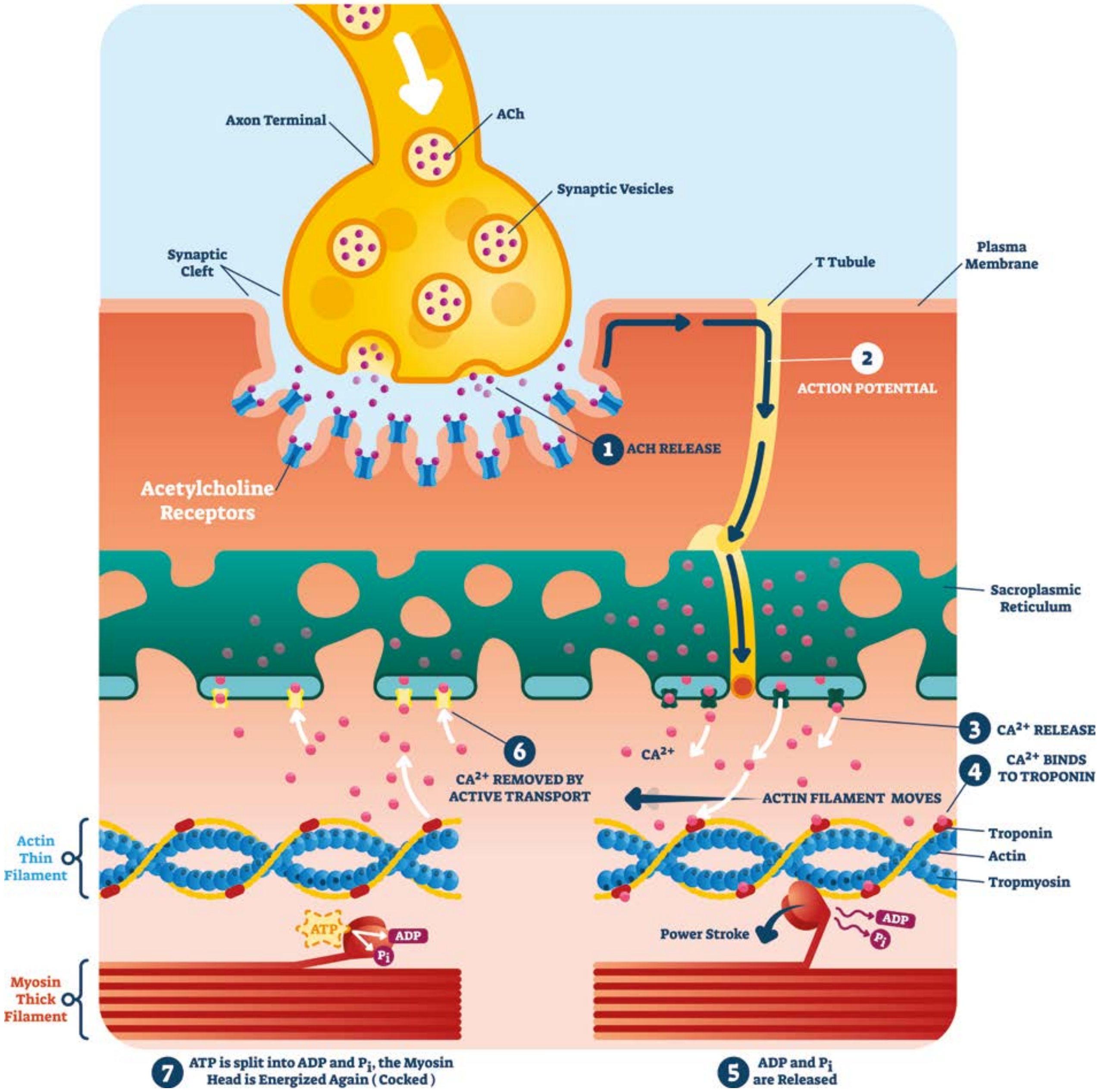
Without the influx of calcium into the muscle fibre, the sliding filament mechanism could not take place. Therefore the question arises as to what triggers the sarcoplasmic reticulum to flood the myofibril with calcium. To understand this process, it is necessary to take a look at the point at which nervous impulses reach the muscle.

ACTION POTENTIALS

VIDEO AVAILABLE ON LEARNING PLATFORM

The stimulus for the release of calcium is the spread of electrical activity (the action potential) along the length of the muscles. During rest, muscle membranes are negatively charged interiorly and a positively charged exteriorly. The difference between the two serves as a form of potential energy, rather like that stored in a battery (Tortora & Grabowski, 1996). This is achieved through a combination of selective permeability of the cell membrane and the presence of sodium pumps.

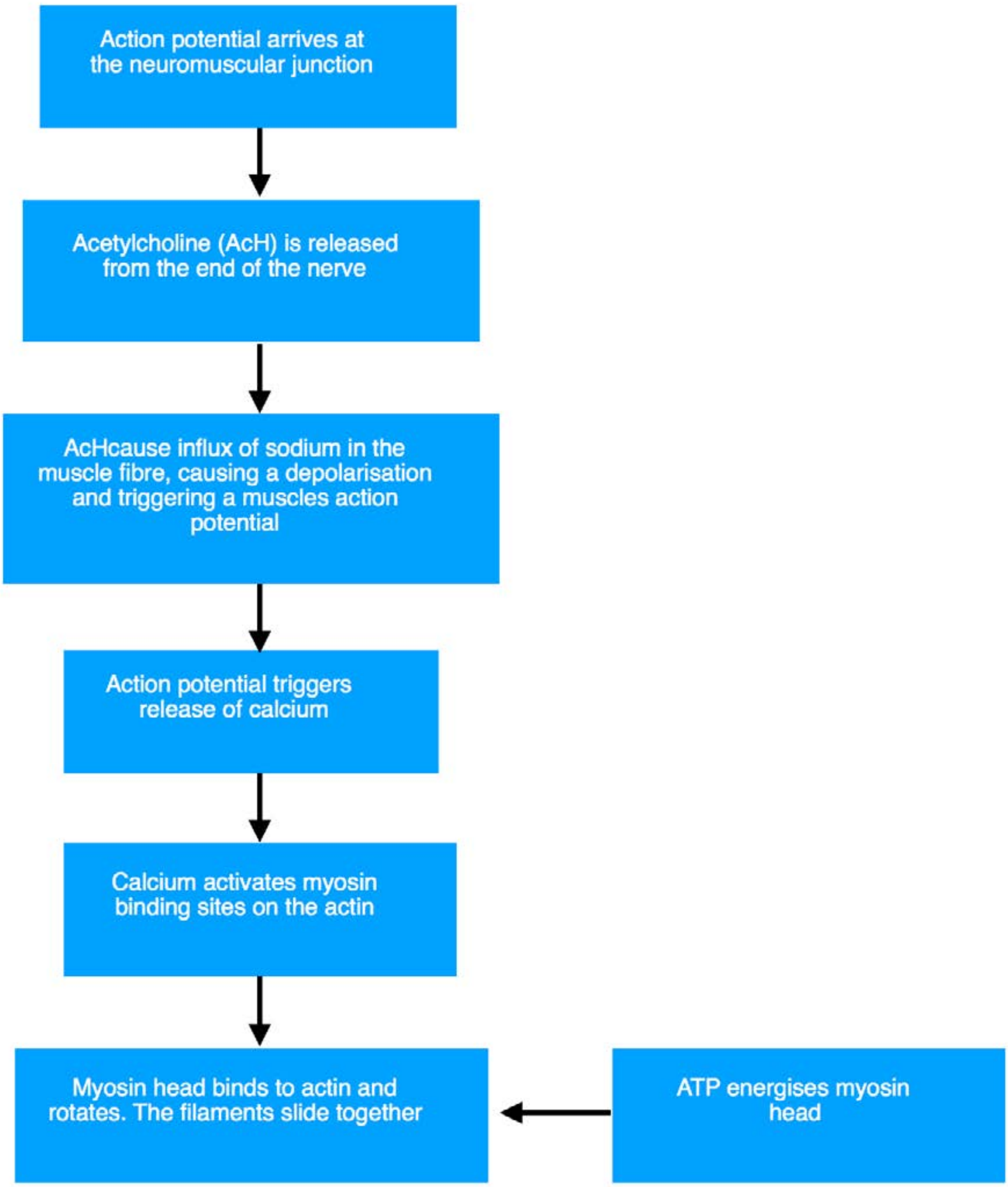
The pumps actively remove positively charged sodium ions from the cell. The arrival of an action potential at the neuromuscular junction (where the nerve meets the muscle) causes the release of a neurotransmitter; acetylcholine. Acetylcholine causes sodium to rush through the muscle membrane. This results in a reversal of electrical activity (depolarisation), which if large enough, will cascade along the muscle fibre as an action potential, there by triggering a release of calcium and beginning the sliding filament mechanism.


Axon Terminal
ACh
Synaptic Vesicles
Synaptic Cleft
T Tubule
Plasma Membrane
2 ACTION POTENTIAL
1 ACH RELEASE
Acetylcholine Receptors
Sacroplasmic Reticulum
3 CA2+ RELEASE
CA2+
6 CA2+ REMOVED BY ACTIVE TRANSPORT
4 CA2+ BINDS TO TROPONIN
ACTIN FILAMENT MOVES
Actin Thin Filament
Troponin
Actin
Tropmyosin
ATP
ADP
Pi
Power Stroke
ADP
Pi
Myosin Thick Filament
7 ATP is split into ADP and Pi, the Myosin Head is Energized Again (Cocked)
5 ADP and Pi are Released

INITIATION OF A MUSCLE ACTION

VIDEO AVAILABLE ON LEARNING PLATFORM

SUMMARY



MUSCLE CONTROL

CONTROL OF MUSCULAR ACTIVITY

The fundamentals of muscular contraction exploration gives a better understanding of how muscles generate force. However, questions still remain regarding the mechanisms of how muscular activity is controlled. The following section takes a closer look at the muscular control systems.

MOTOR UNITS AND THE 'ALL OR NOTHING' LAW

Muscles are divided up into motor units; a single motor unit consists of one motor neuron (nerve) and the muscle fibres it innervates. As was discussed earlier if the stimulus is strong enough to trigger an action potential then it will spread through the whole length of the muscle fibre. More specifically it will spread through all the muscle fibres supplied by a single nerve. Conversely, there will be no action potential and no muscle contraction if the stimulus is not strong enough.

Motor units cannot, therefore, vary the amount of force they generate, they either contract maximally or not at all – hence the 'all or nothing' law.

Control of muscular force is achieved through a combination of:

- Adjusting the number of motor units recruited (i.e. The greater the number the greater the force)
- Increasing the frequency of their discharge.

It is worth noting that co-ordinating motor unit activity is fundamental to optimising force generation and therefore, improving exercise performance (McArdle et al., 2001).

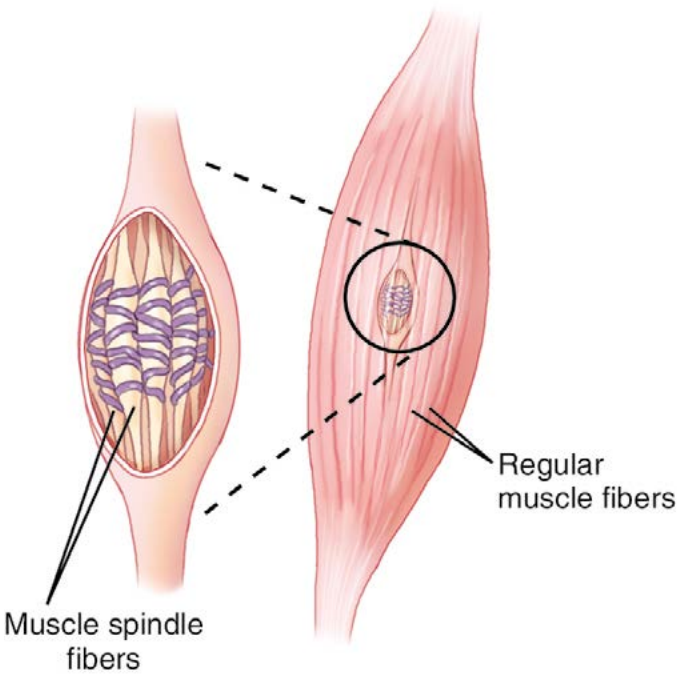
MUSCLE PROPRIOCEPTORS

The muscles have two small neural sensors that help to provide feedback and respond to changes within the muscle itself:

- Muscle spindles
- Golgi Tendon Organs (GTO)

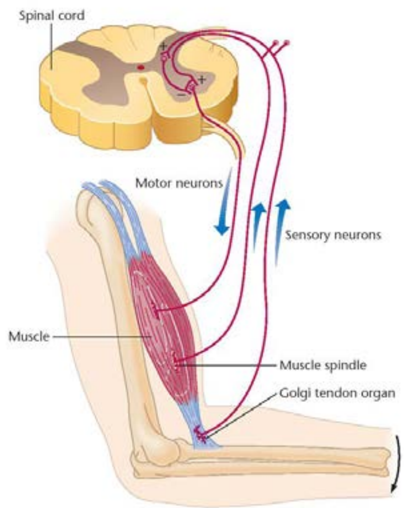
MUSCLE SPINDLES

Muscle spindles are located deep within the muscle fibres. The spindle is a small sensory unit wrapped tightly around the individual muscle fibres like a coiled spring. When the muscle changes length, depending on whether the muscle is lengthening or shortening the 'coils' of the muscle spindle are either pulled apart (lengthening) or pushed together (shortening). This change in muscular length and a resulting change in the muscle spindle stimulates neural firing to the central nervous system at the spinal level. The resulting outcome of a lengthened muscle and muscle spindle is a stimulus to contract that same muscle. The degree of contraction that occurs will depend on the degree of change in muscle length and the rate at which the change in length occurs. As a general rule the greater the range of motion and the faster the muscle lengthens the greater the resulting contraction will be. This process is often referred to as the stretch reflex.



THE GOLGI TENDON ORGAN (GTO)

The Golgi Tendon Organ (GTO) has an influence on the muscle but is actually located in the tendon and is such its namesake. The tendon is inelastic and so the GTO cannot detect changes in muscle length. However, when a muscle contracts it pulls on the tendon that is attached to the bone creating tension within the tendon. The GTO is ideally located to measure the amount of tension created by a muscle. When the GTO is activated a signal is sent to the spine which brings about an inhibiting effect on the same muscle. This relaxation response, a result of GTO firing, is called the inverse stretch reflex.

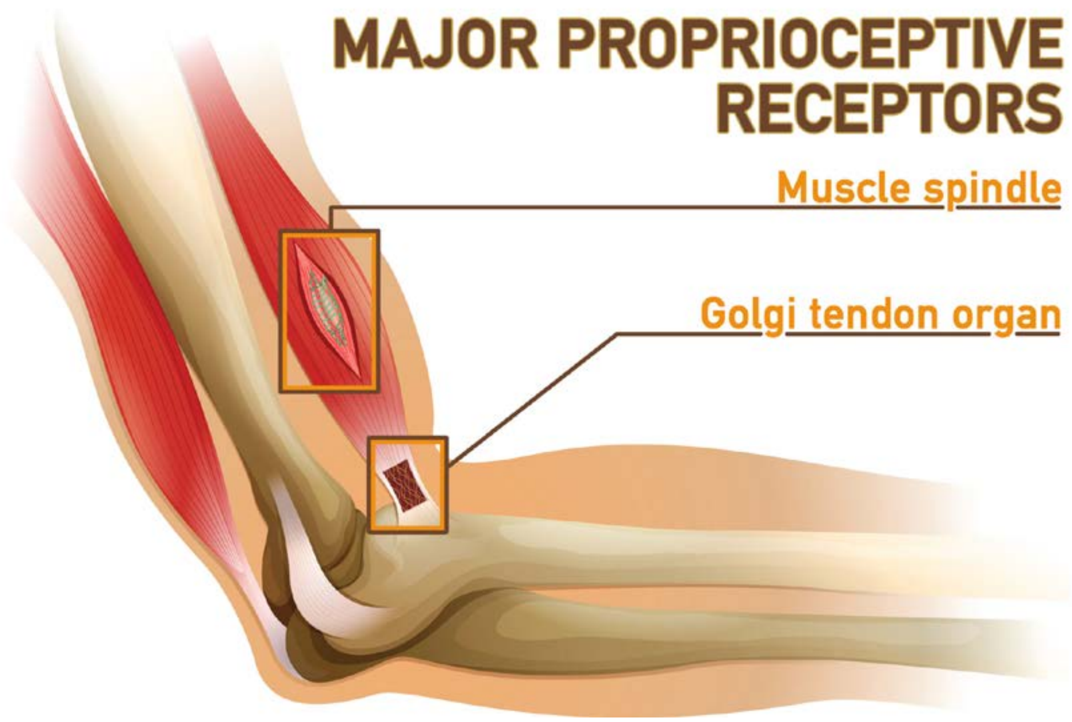


The muscle spindles will be continually activated during human movement as the muscles will be changing lengths in conjunction with the movements being carried out. This is providing a constant stream of valuable information to the CNS about muscle length and where body parts are in space. The spindles also bring about the muscular contraction that assists with the movements being performed. The GTO responds just after the muscular contraction has engaged by inhibiting the muscular contraction to allow the opposite action to be performed. GTOs and muscle spindles can be thought of as the on and off switches for muscle activity during exercise and movement.

Consider this, when a muscle is causing its primary actions to occur the opposing muscles need to be switched off (relaxed) to allow that movement to take place. Opposing muscle inhibition is called reciprocal inhibition (RI). RI is a necessary part of normal movement.

However, it can also play a part in creating muscular imbalance. A very tight muscle group will send a continuous RI signal to the opposing muscle which can lead to them becoming inhibited in their function.

Exercise and training have been shown to increase the neural side of the muscular response with improvements in the stretch reflex and the net response from the inverse stretch reflex. Training methods such as plyometrics, have been designed particularly to develop the stretch-shortening cycle with effective results. Not only does the muscle learn to develop more force through this type of training, but timing and co-ordination of movement at speed also improves as the muscle spindles in supporting muscle tissue are also trained to respond better.



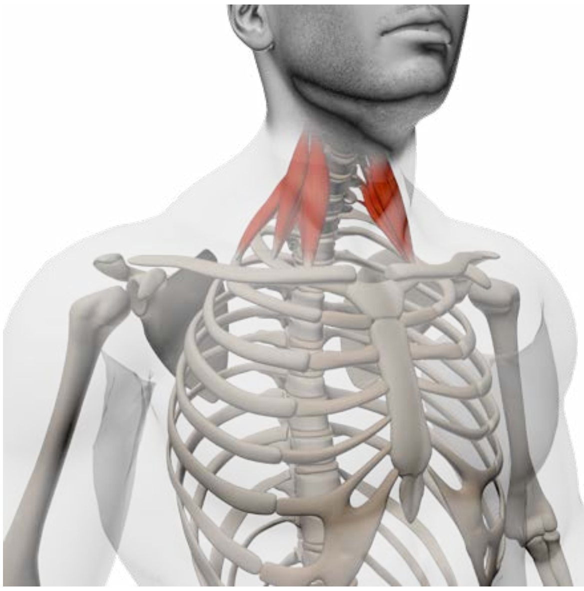
Muscles and Muscle Actions

UNIT 1: THE SYSTEMS THAT MAKE UP THE HUMAN BODY (ANATOMY AND PHYSIOLOGY)

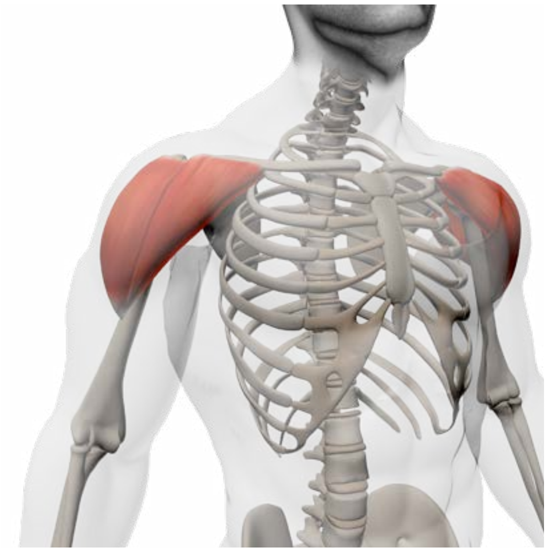
MUSCLE ANATOMY AND VOICEOVER

VIDEO AVAILABLE ON LEARNING PLATFORM

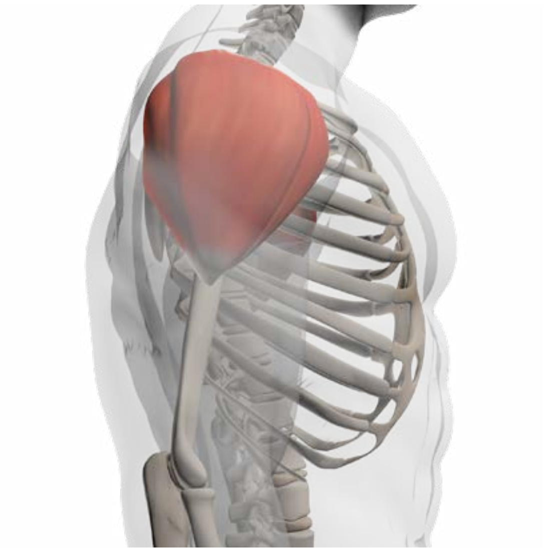
NECK, SHOULDER AND ARM MUSCLES



SCALENES



ANTERIOR DELTOID



MIDDLE DELTOID

POSTERIOR DELTOID

BICEP BRACHII

BRACHIALIS

BRACHIORADIALIS

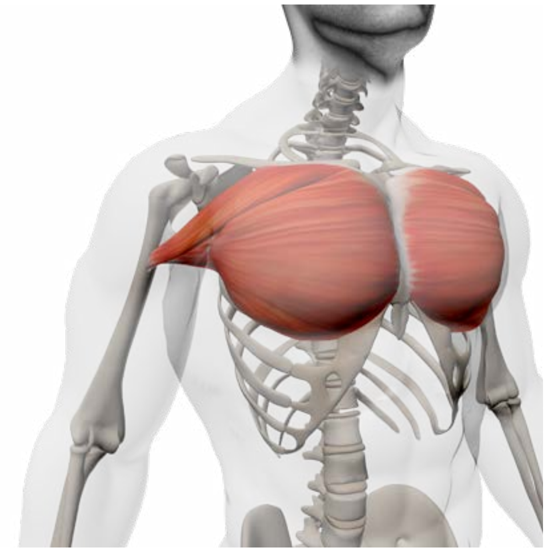
TRICEP BRACHII

TRICEP BRACHII MEDIAL HEAD

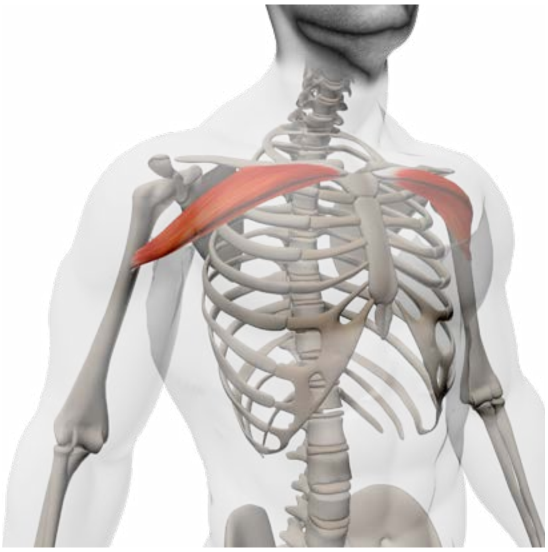
TRICEP BRACHII LATERAL HEAD

TRICEP BRACHII LONG HEAD

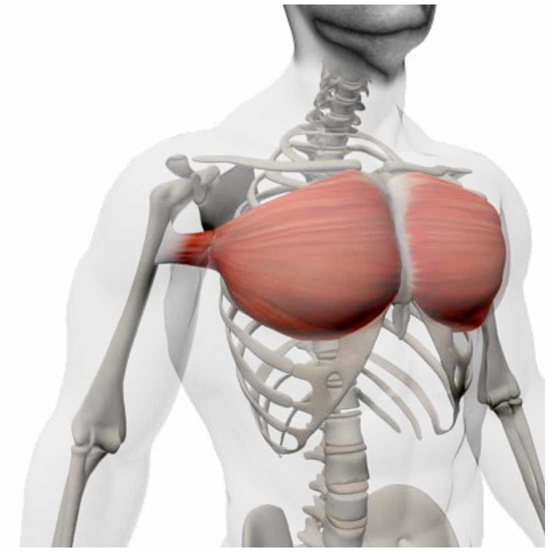
CHEST MUSCLES



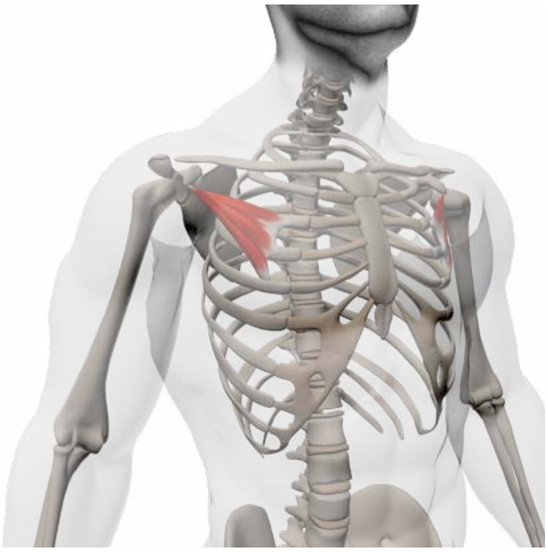
PECTORALIS MAJOR



PECTORALIS MAJOR (CLAVICLE HEAD)

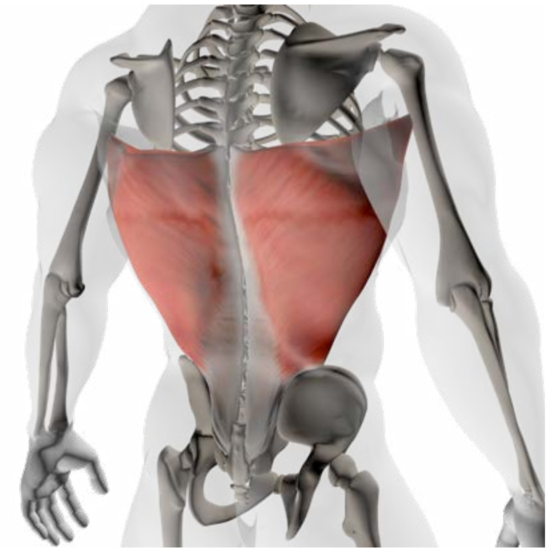


PECTORALIS MAJOR (STERNAL HEAD)



PECTORALIS MINOR

BACK MUSCLES



LATISSIMUS DORSI

RHOMBOID

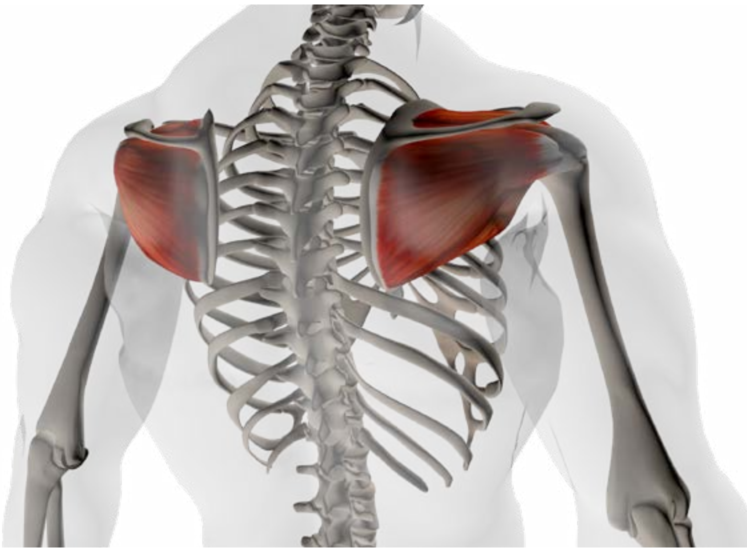
RHOMBOID MAJOR

RHOMBOID MINOR

TRAPEZIUS

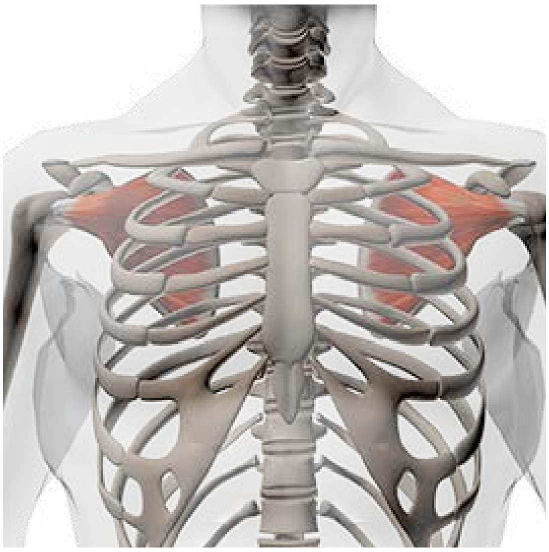
TERES MAJOR

BACK MUSCLES



SUPRASPINATUS

INFRASPINATUS



SUBSCAPULARIS

TERES MINOR

QUADRICEP AND CAUDAL ANTERIOR MUSCLES

VASTUS LATERALIS

VASTUS INTERMEDIUS

VASTUS MEDIALIS

RECTUS FEMORIS

TIBIALIS ANTERIOR

TIBIALIS POSTERIOR

EXTENSOR DIGITORUM LONGUS

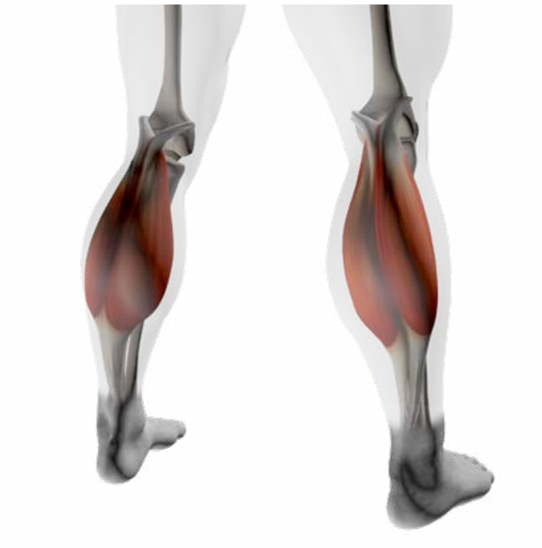
HAMSTRING AND CAUDAL POSTERIOR MUSCLES

BICEPS FEMORIS (LONG HEAD)

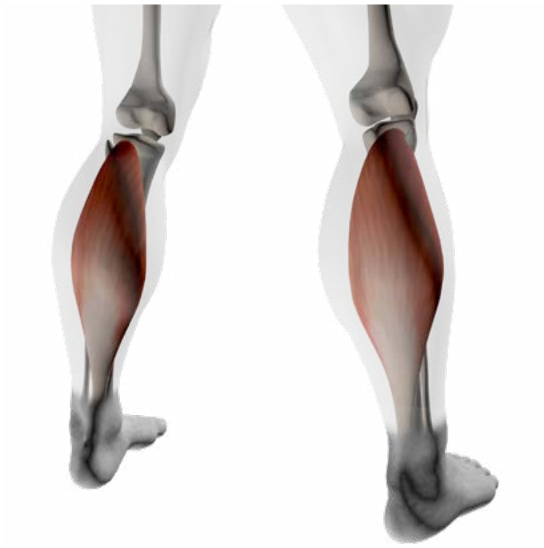
BICEPS FEMORIS (SHORT HEAD)

SEMITENDINOSUS

SEMIMEMBRANOSUS



GASTROCNEMIUS



SOLEUS

POPLITEUS

PLANTARIS

PERONEUS BREVIS

PERONEUS LONGUS

FLEXOR DIGITORUM LONGUS

FLEXOR HALLUCIS LONGUS

HIP COMPLEX MUSCLES

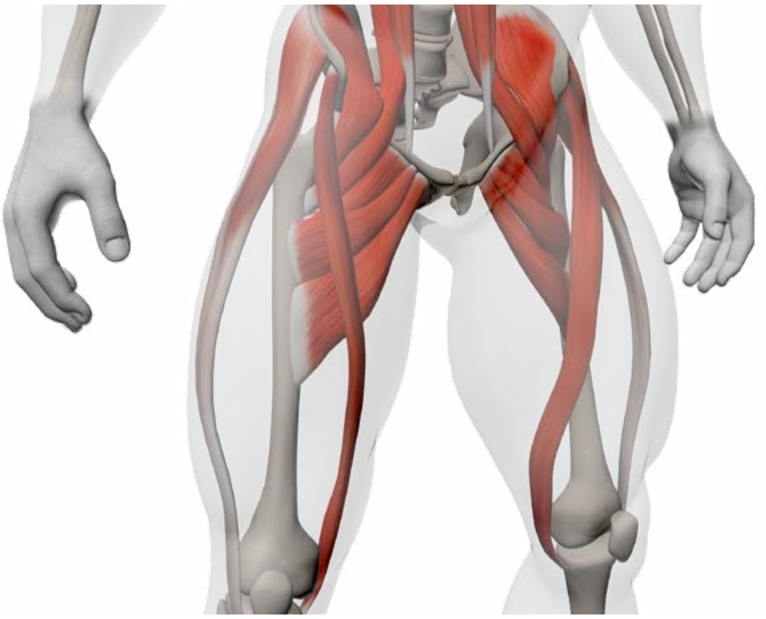
GLUTEUS MAXIMUS

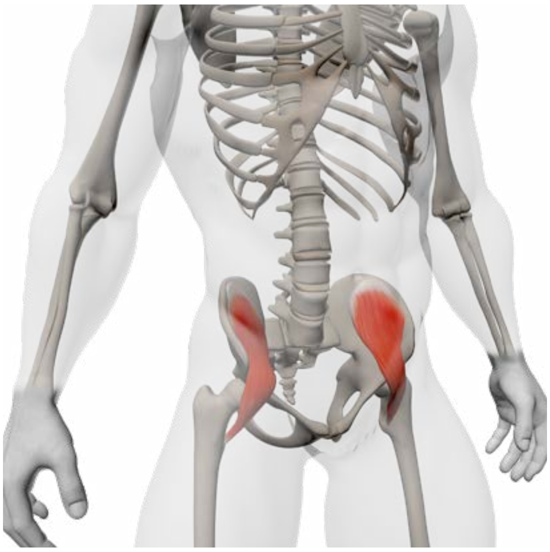
GLUTEUS MEDIUS

GLUTEUS MINIMUS

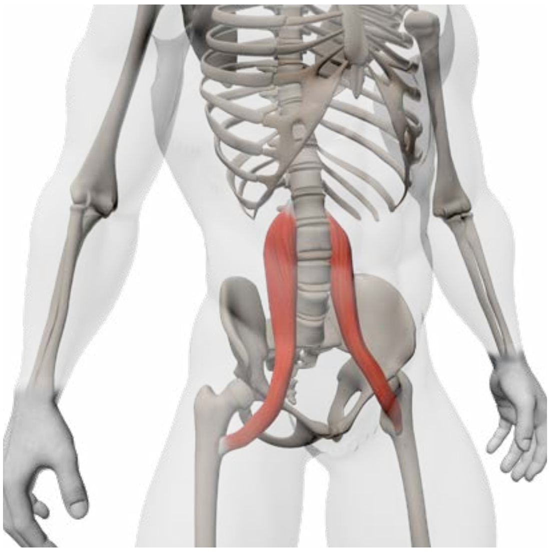
PIRIFORMIS

HIP FLEXOR MUSCLES

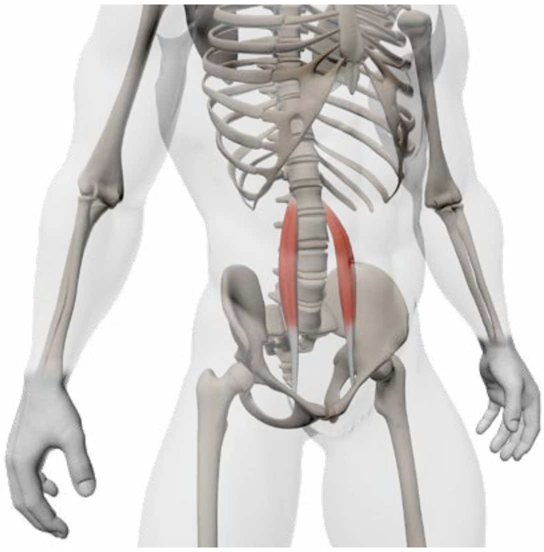




ILIACUS

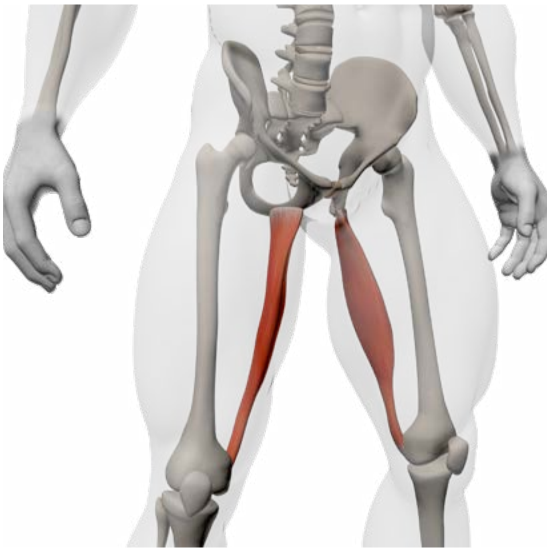


PSOAS MAJOR



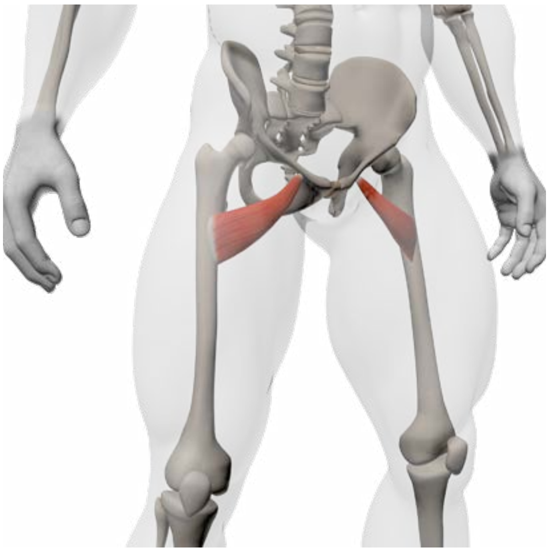
PSOAS MINOR

SARTORIUS



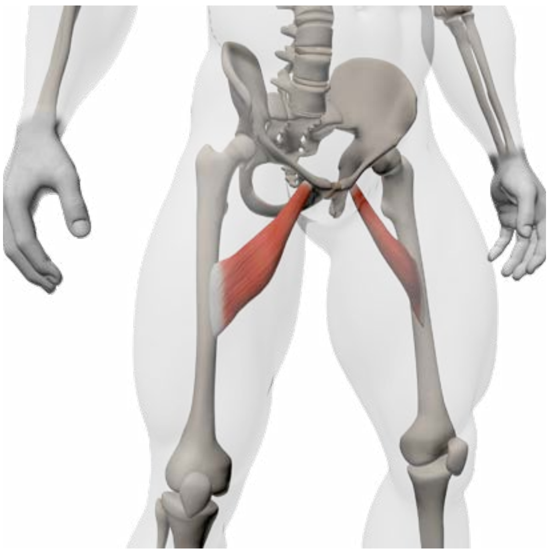
GRACILIS

ABDUCTORS



ADDUCTOR BREVIS

ADDUCTOR MAGNUS

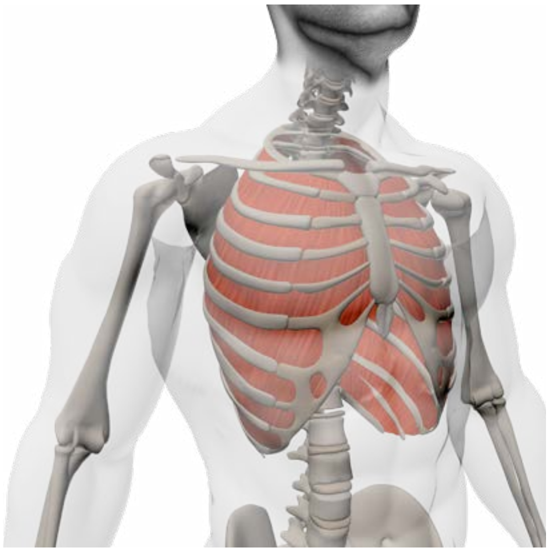


ADDUCTOR LONGUS

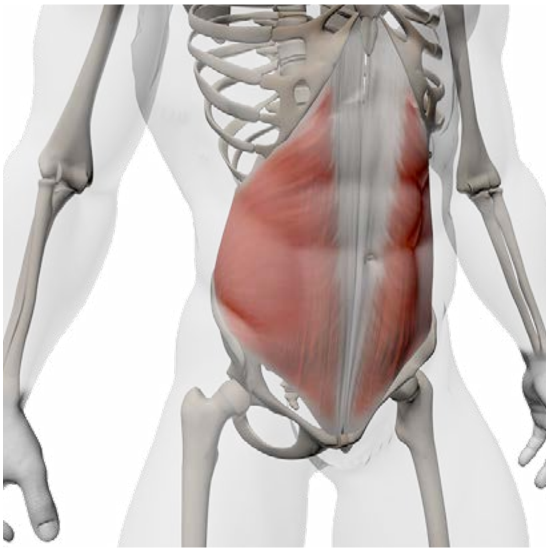
TENSOR FASCIA LATAE

CORE AND STABILISER MUSCLES

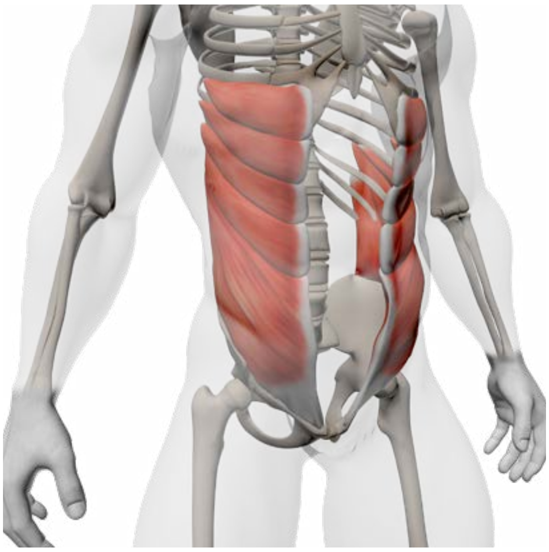
ERECTOR SPINAE



INTERCOSTAL MUSCLES

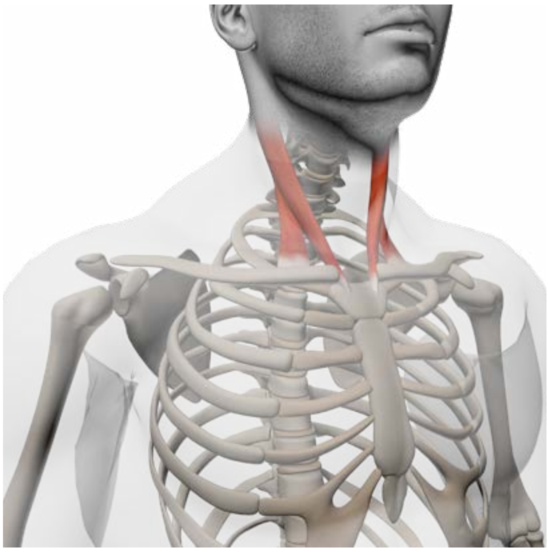


INTERNAL OBLIQUES



EXTERNAL OBLIQUES

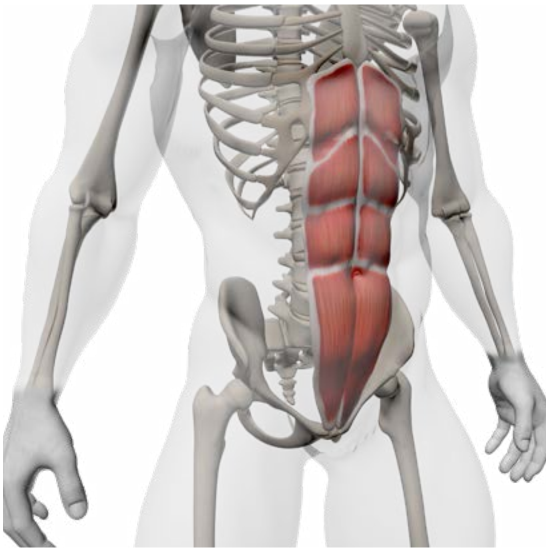
LEVATOR SCAPULAE



STERNOCLEIDOMASTOID

MULTIFIDUS

QUADRATUS LUMBORUM



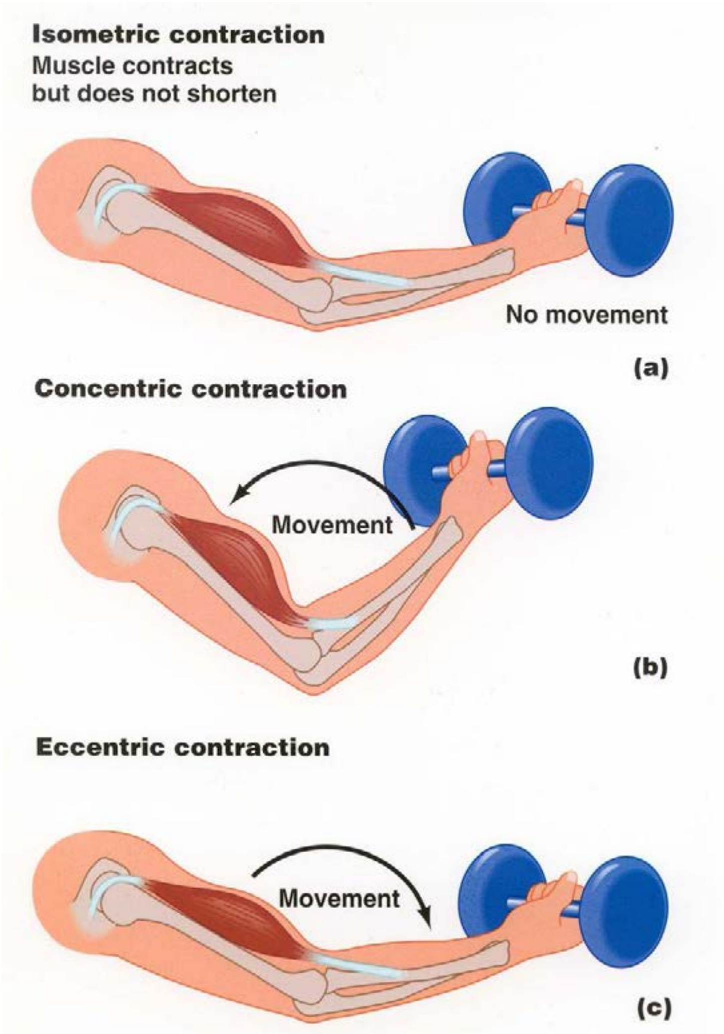
RECTUS ABDOMINUS

SERRATUS ANTERIOR

MUSCLE CONTRACTION TYPES

Muscles can perform different kinds of contractions. They can lengthen, shorten and remain stationary as well as generating forces to move at differing speeds:

- **CONCENTRIC:** Muscle shortens under contraction.
- **ECCENTRIC:** Muscle lengthens under contraction.
- **ISOTONIC:** Movements involving both concentric and eccentric contractions.
- **ISOMETRIC:** Muscle stays the same length under contraction.
- **ISOKINETIC:** Muscle moves at a constant speed during contraction.



MUSCLE ROLES:

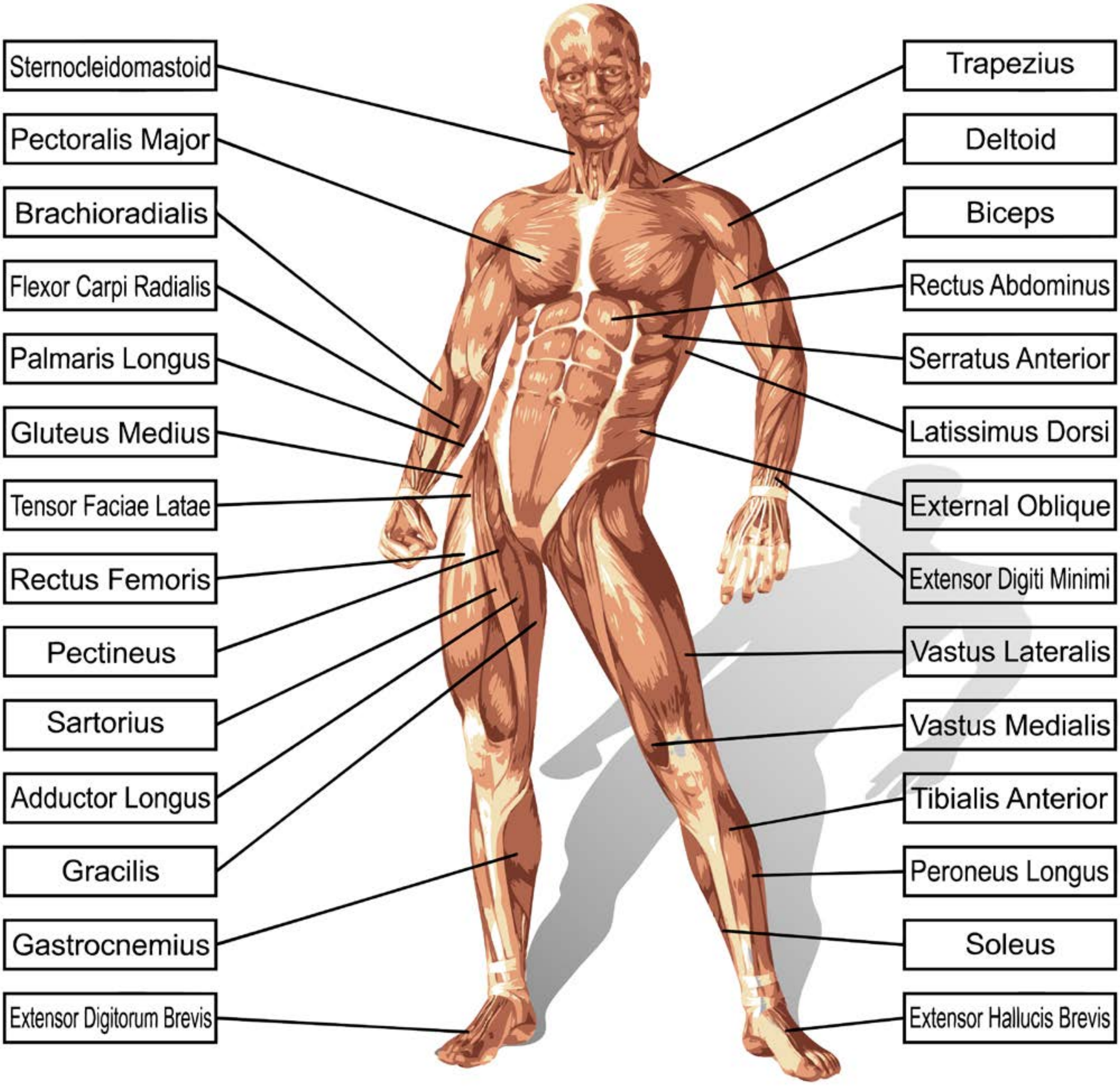
Moving is dependent on coordination of muscle contraction. Each muscle will play a specific role and be categorised as such. It is important to understand that individual muscles can play a different role depending on the movement being performed:

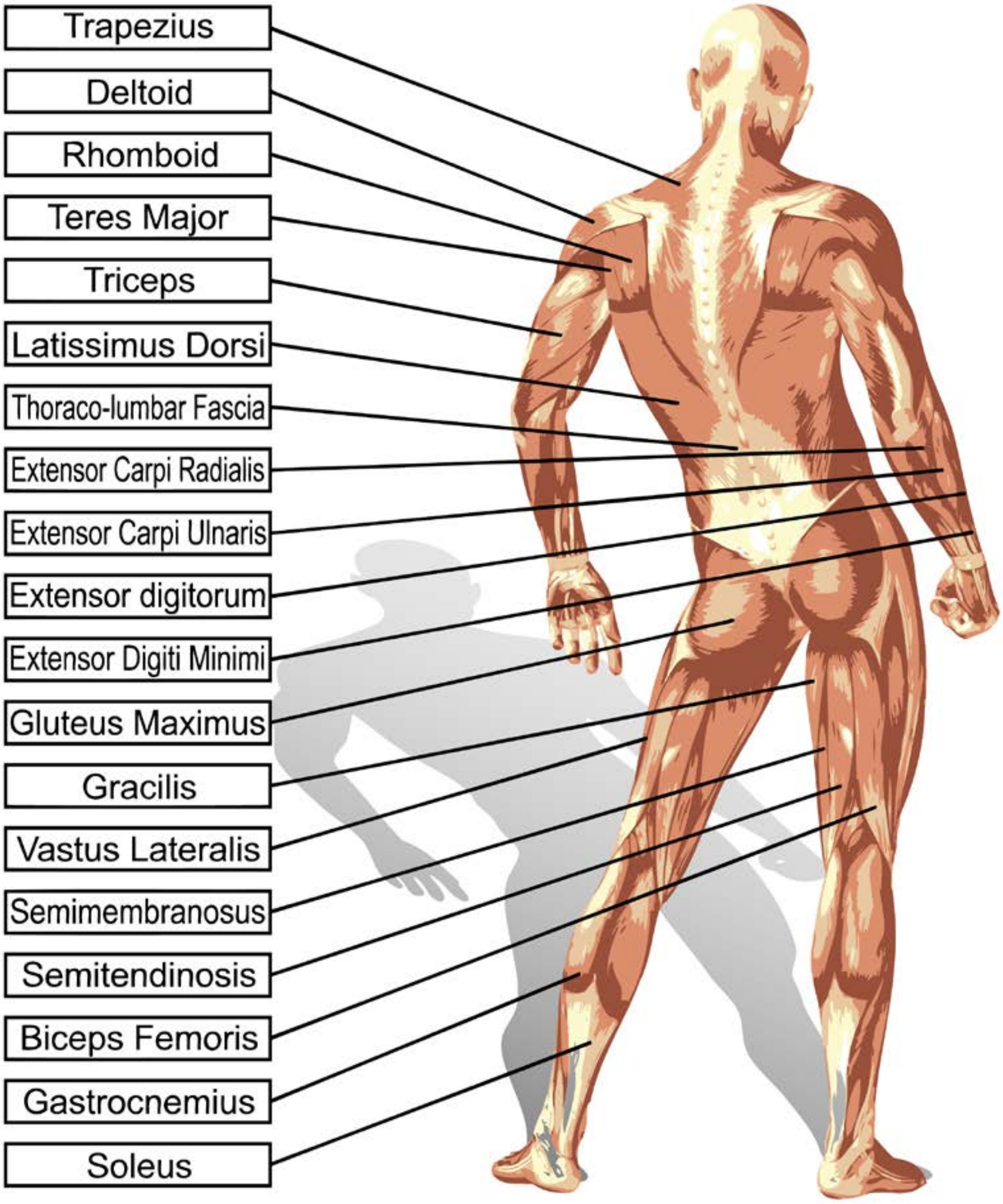
- **AGONIST/PRIME MOVER:** Muscle directly responsible for the desired movement.
- **ANTAGONIST:** Muscle that causes the opposite action to the agonist.
- **SYNERGIST:** Muscle that assists the prime mover.
- **FIXATOR:** Muscle that stabilises the origin of the prime mover.

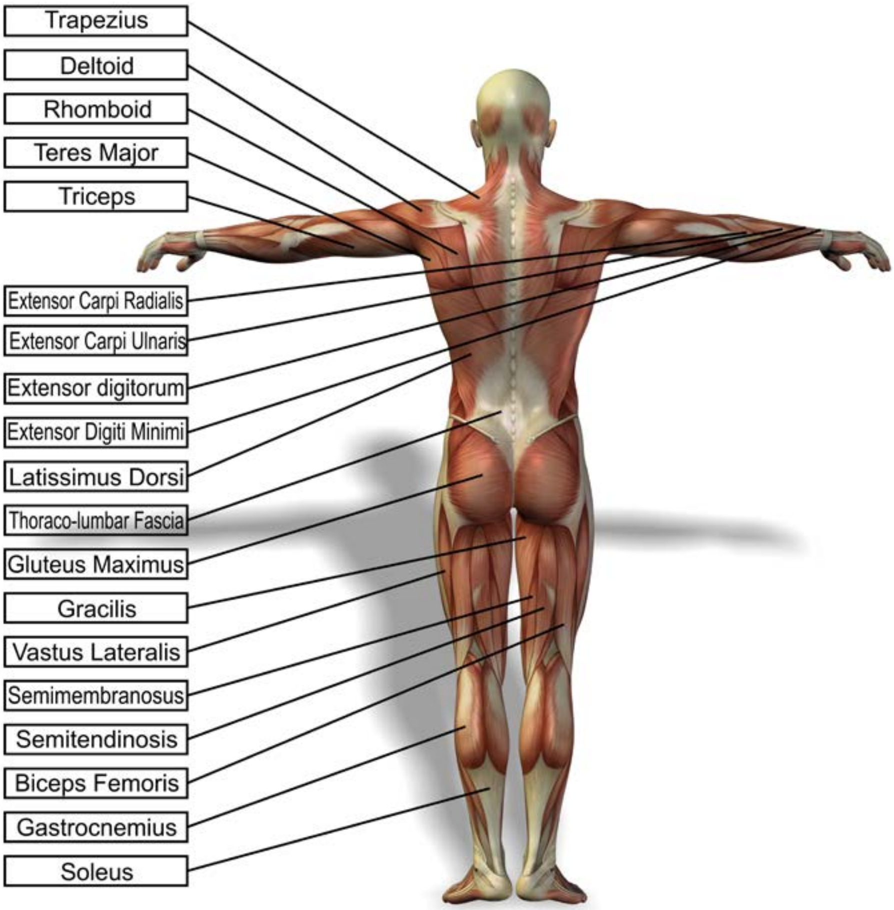
VIDEO AVAILABLE ON LEARNING PLATFORM

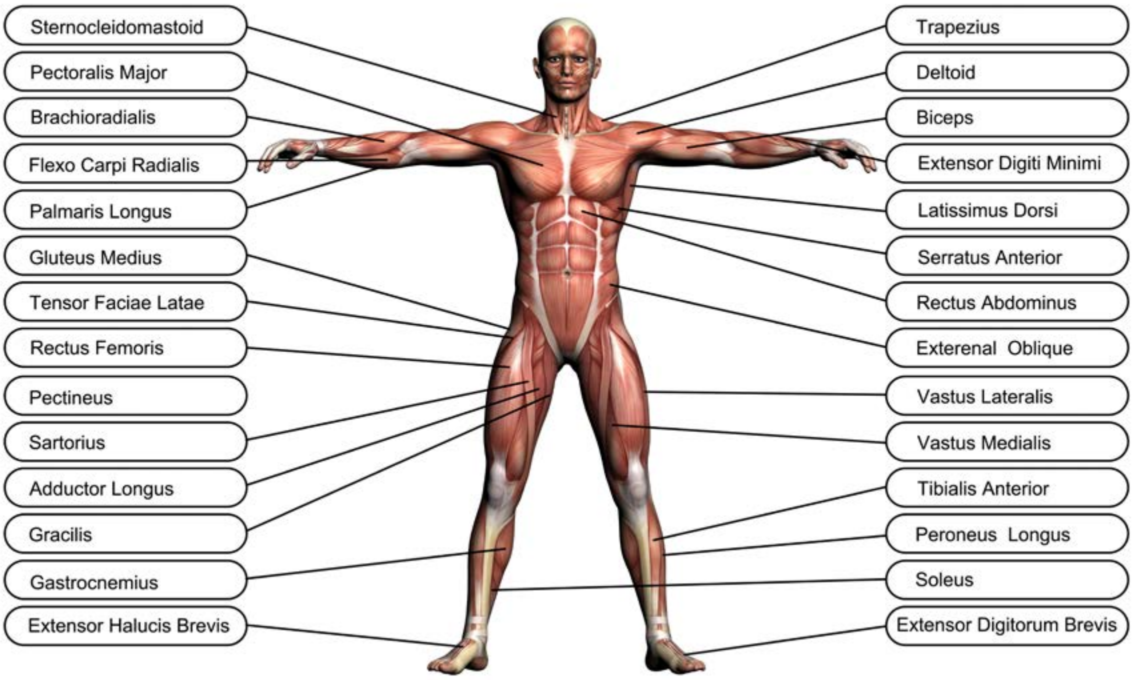
MUSCLE ANATOMY DIAGRAM

A Muscle Booklet is available on the online platform to go alongside these resources and aid with your studying of muscles.




Trapezius
Deltoid
Rhomboid
Teres Major
Triceps
Latissimus Dorsi
Thoraco-lumbar Fascia
Extensor Carpi Radialis
Extensor Carpi Ulnaris
Extensor digitorum
Extensor Digiti Minimi
Gluteus Maximus
Gracilis
Vastus Lateralis
Semimembranosus
Semitendinosis
Biceps Femoris
Gastrocnemius
Soleus


Trapezius
Deltoid
Rhomboid
Teres Major
Triceps
Extensor Carpi Radialis
Extensor Carpi Ulnaris
Extensor digitorum
Extensor Digiti Minimi
Latissimus Dorsi
Thoraco-lumbar Fascia
Gluteus Maximus
Gracilis
Vastus Lateralis
Semimembranosus
Semitendinosis
Biceps Femoris
Gastrocnemius
Soleus

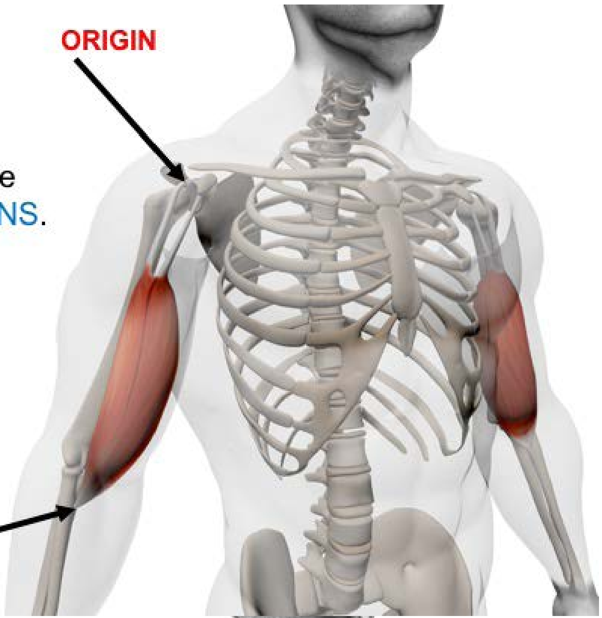

Sternocleidomastoid
Pectoralis Major
Brachioradialis
Flexo Carpi Radialis
Palmaris Longus
Gluteus Medius
Tensor Faciae Latae
Rectus Femoris
Pectineus
Sartorius
Adductor Longus
Gracilis
Gastrocnemius
Extensor Halucis Brevis
Trapezius
Deltoid
Biceps
Extensor Digiti Minimi
Latissimus Dorsi
Serratus Anterior
Rectus Abdominus
Exterenal Oblique
Vastus Lateralis
Vastus Medialis
Tibialis Anterior
Peroneus Longus
Soleus
Extensor Digitorum Brevis

Muscle Origin and Insertions

UNIT 1: THE SYSTEMS THAT MAKE UP THE HUMAN BODY (ANATOMY AND PHYSIOLOGY)

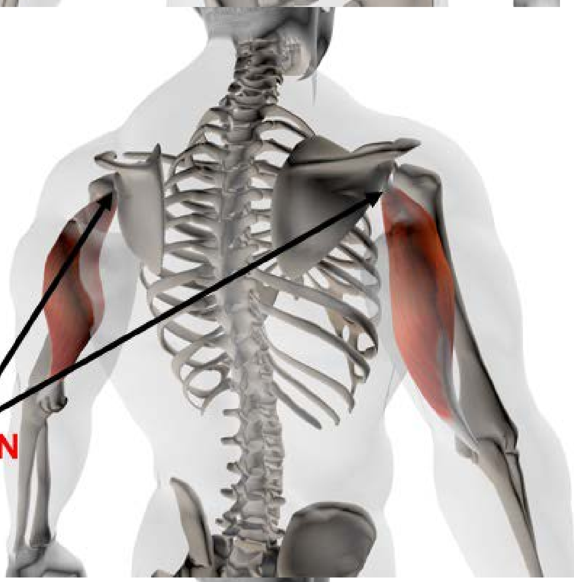
Each skeletal muscles has a beginning and an end. These are called ORIGINS and INSERTIONS.

They are fixed and attached via tendons onto bones.



ORIGINS

- The attachment point of a muscle that remains relatively fixed during muscular contraction.
- Muscular attachment nearest to the midline or centre of the trunk (proximal).

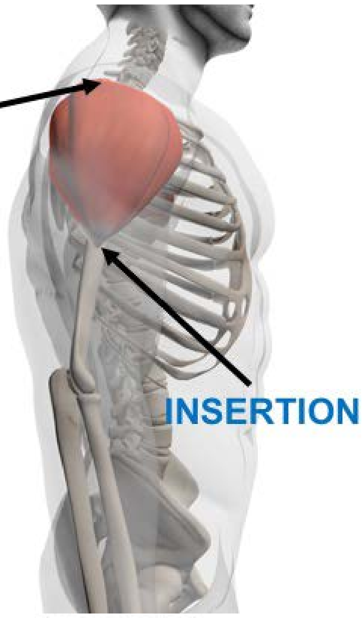


INSERTIONS

- The attachment point of a muscle that moves most during muscular contraction
- Muscular attachment furthest from the midline or centre of the trunk (distal)

SHOULDER MUSCLES

Middle Deltoid



Origin:

- Lateral border of the acromion process of the scapula

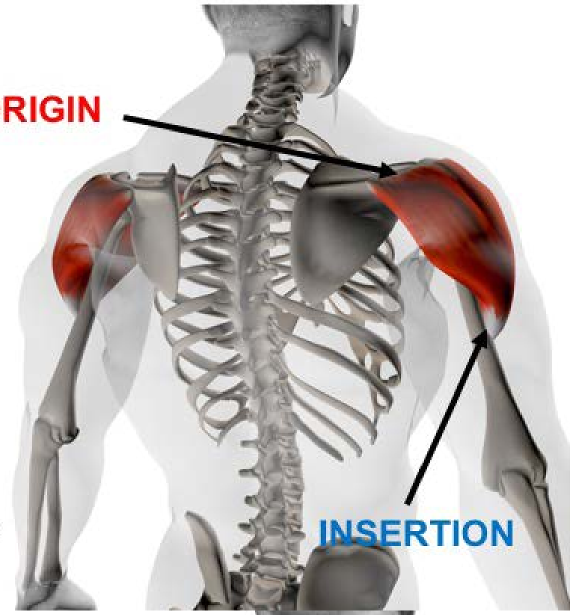
Insertion

- The deltoid tuberosity on the lateral surface of the proximal humeral shaft

Actions:

- Abduction of the arm at the shoulder

Posterior Deltoid



Origin:

- Inferior edge of the scapular spine

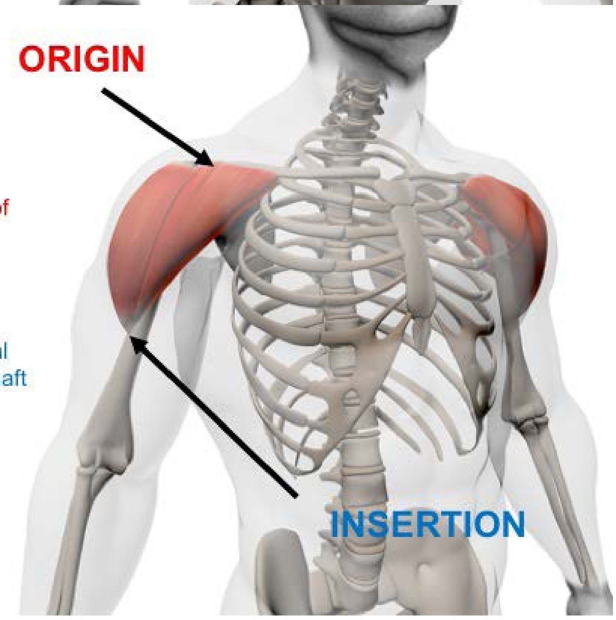
Insertion

- The deltoid tuberosity on the lateral surface of the proximal humeral shaft

Actions:

- Extension of the arm at the shoulder
- Assists with external rotation of the arm at the shoulder

Anterior Deltoid



Origin:

- Anterior border of the lateral third of the clavicle

Insertion

- The deltoid tuberosity on the lateral surface of the proximal humeral shaft

Actions:

- Flexion of the arm at the shoulder

ROTATOR CUFF MUSCLES

Infraspinatus

Origin:

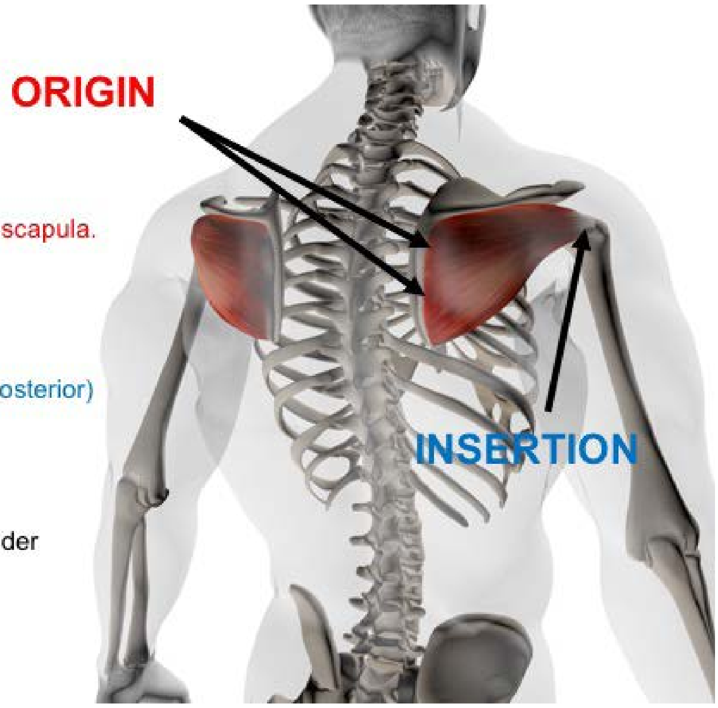
- Posterior surface below spine of scapula.

Insertion

- Greater tuberosity of humerus (posterior)

Actions:

- Horizontal extension of the shoulder
- Lateral rotation of the shoulder
- Stabilisation of the shoulder



Subscapularis

Origin:

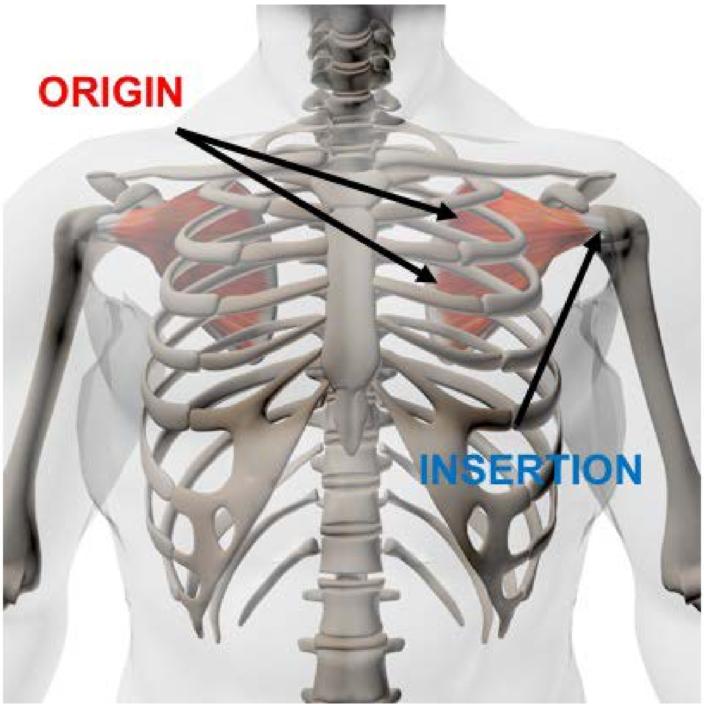
- Anterior surface of scapular

Insertion

- Lesser tuberosity of humerus

Actions:

- Medial rotation of the shoulder
- Adduction of the shoulder
- Extension of the shoulder
- Stabilisation of the shoulder



Supraspinatus

Origin:

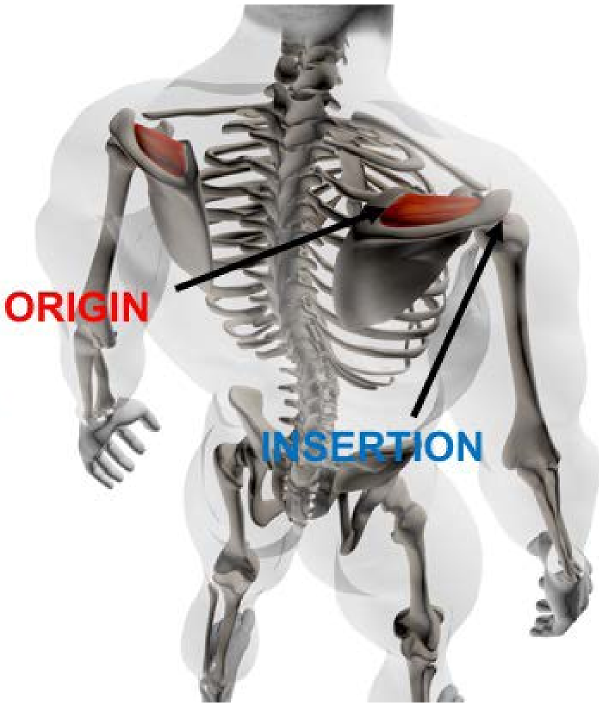
- Superior to spine of scapula

Insertion

- Greater tuberosity of humerus (superior)

Actions:

- Abduction
- Flexion of shoulder joint
- Stabilisation of shoulder joint



Teres Minor

Origin:

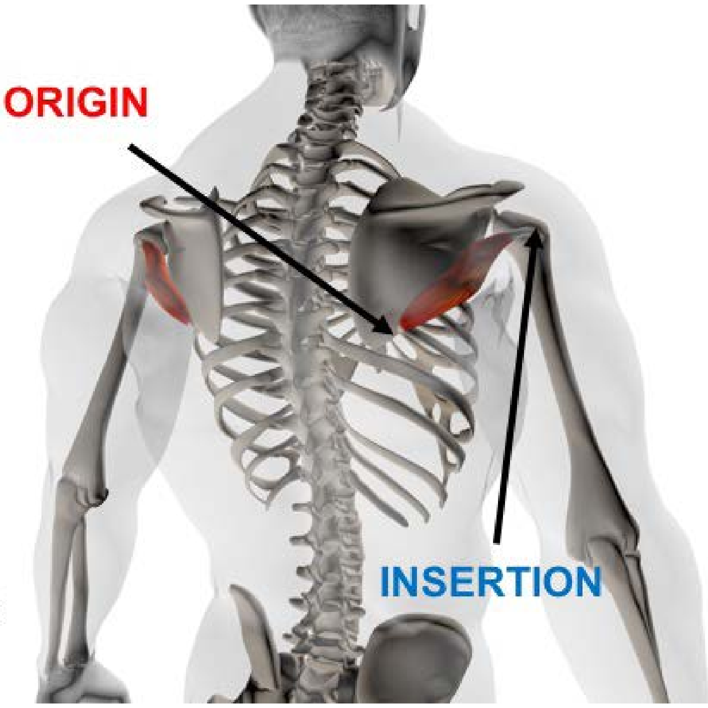
- Lateral border of the scapula

Insertion

- Greater tuberosity of humerus

Actions:

- Lateral rotation
- Stabilisation of the shoulder joint



CHEST MUSCLES

Pectoralis Minor

Origin:

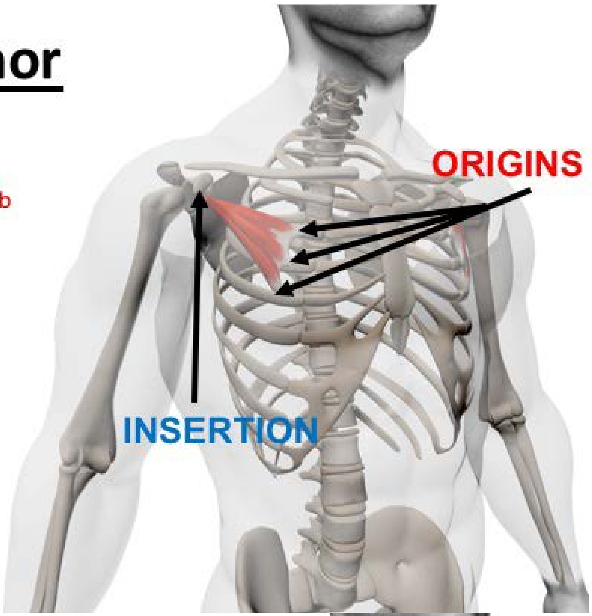
- Anterior surface of the 3rd-5th rib

Insertion

- Coracoid process of scapula

Actions:

- Depression of scapula
- Protraction of scapula



Serratus Anterior

Origin:

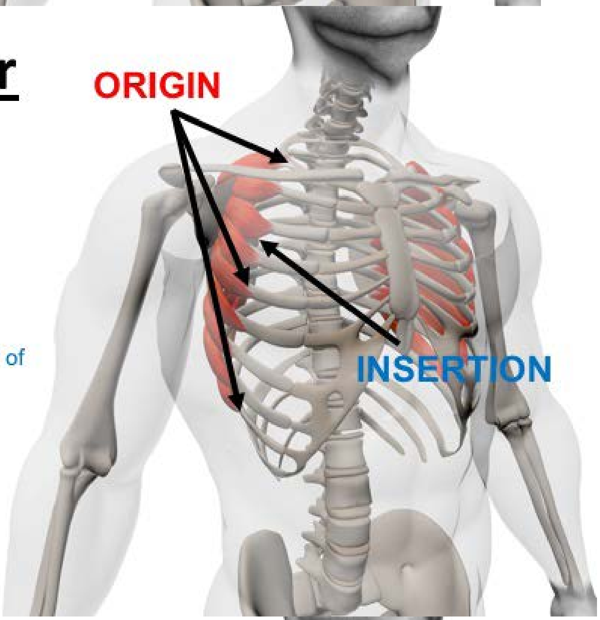
- Surface of upper 8 and 9 ribs

Insertion

- Anterior surface of medial boarder of scapula

Actions:

- Protraction of scapula



Pectoralis Major

Origin:

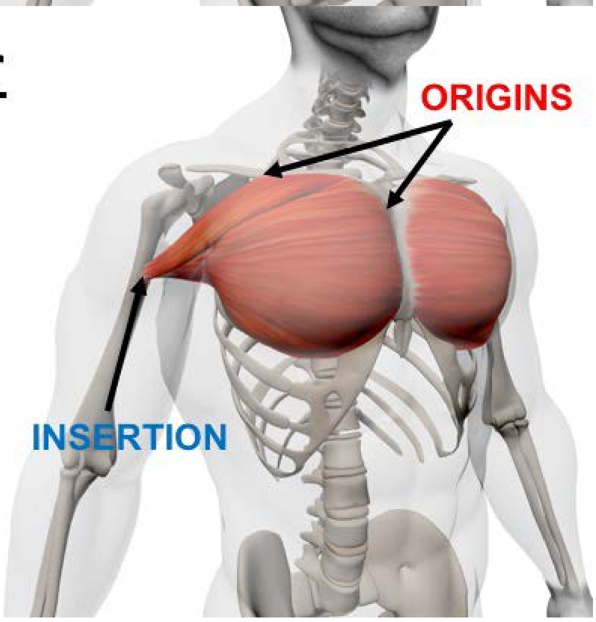
- Clavicle
- Sternum

Insertion

- Humerus

Actions:

- Horizontal flexion of shoulder
- Adduction of shoulder
- Medial rotation of the shoulder



BACK MUSCLES

Rhomboid Major

Origin:

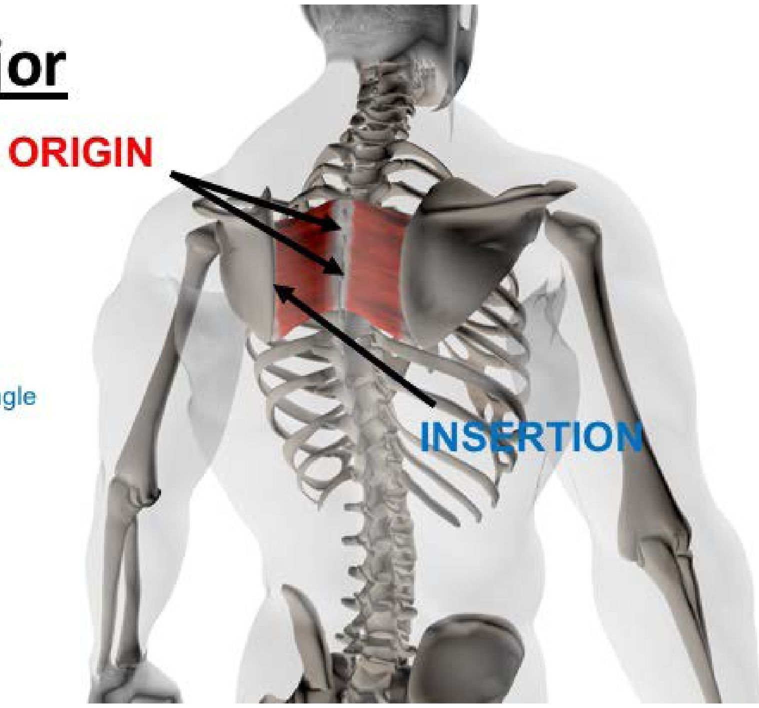
- Spinous process of T2-T5

Insertion

- Medial boarder and inferior angle of scapula

Actions:

- Retraction of scapula
- Elevation of scapula



Trapezius

Origin:

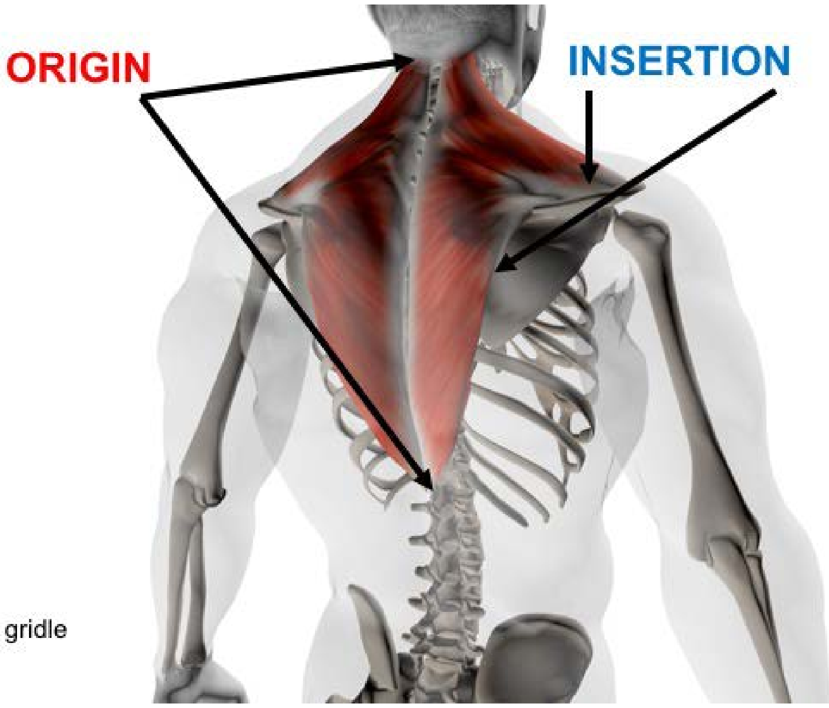
- Base of Skull
- Clavicle
- Thoracic vertebrae

Insertion

- Clavicle
- Scapula

Actions:

- Elevation, retraction
- Depression of shoulder gridle



Rhomboid Minor

Origin:

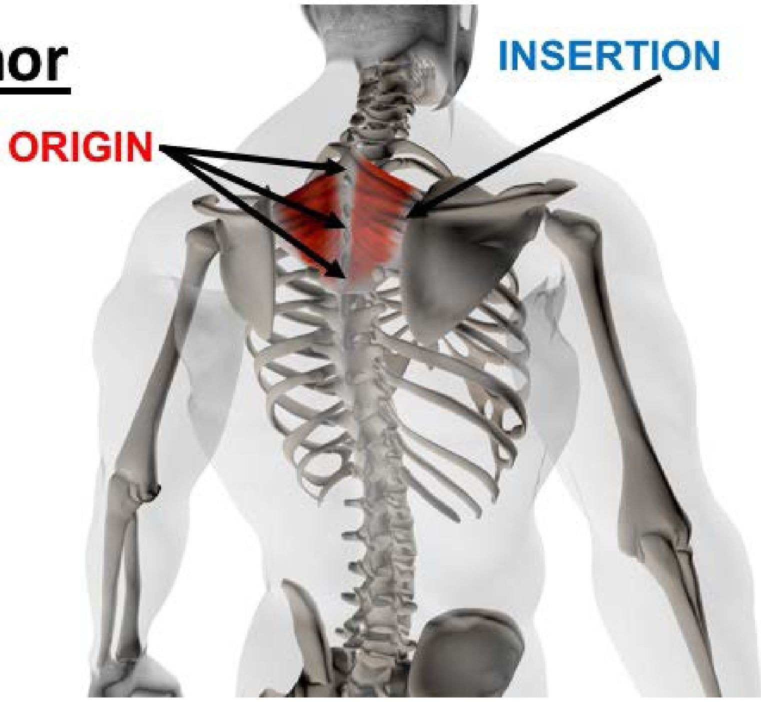
- Spinous process of C7-T1

Insertion

- Medial boarder of scapula

Actions:

- Retraction of scapula
- Elevation of scapula



Latissimus Dorsi

Origin:

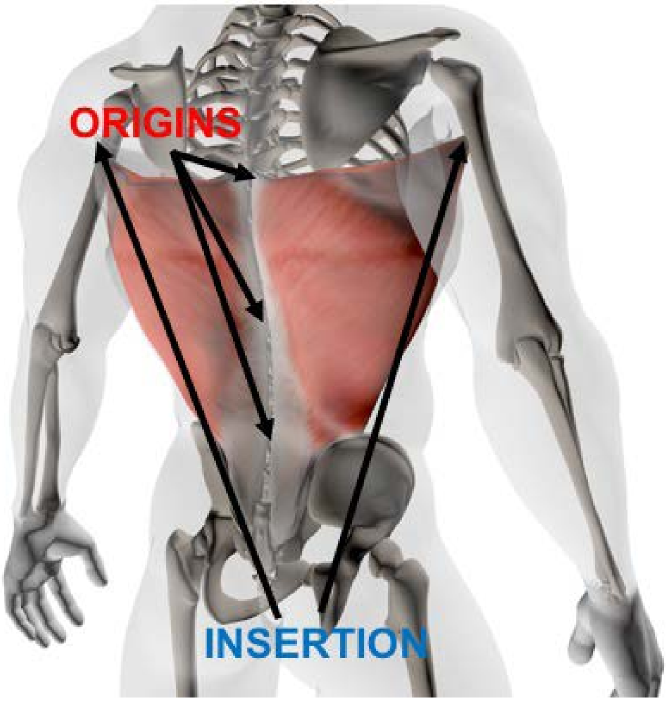
- Lower thoracic vertebrae
- Lumbar vertebrae
- Ilium

Insertion

- Humerus

Actions:

- Adduction of the shoulder
- Extension of the shoulder
- Medial rotation of the shoulder



ARM MUSCLES

Brachialis

Origin:

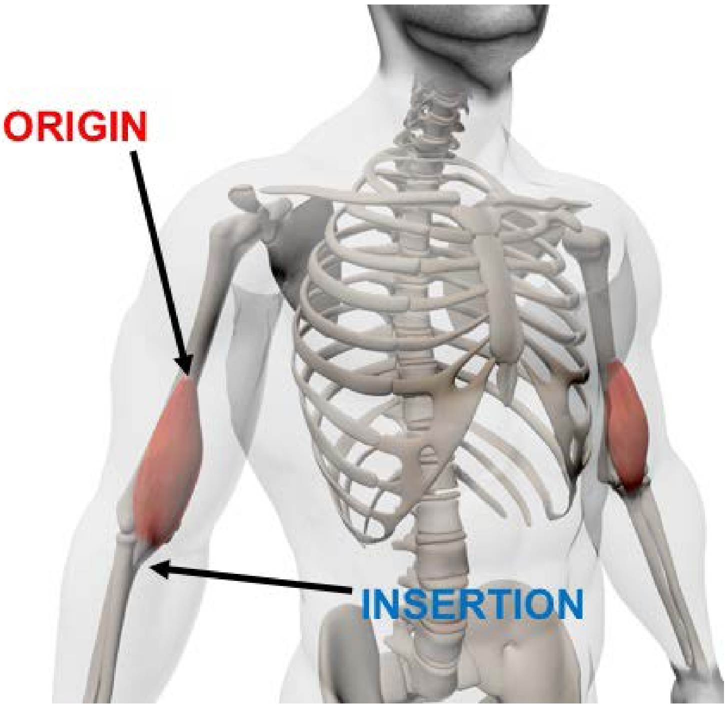
- Humerus

Insertion

- Coronoid process of the ulna

Actions:

- Flexion of the elbow



Brachioradialis

Origin:

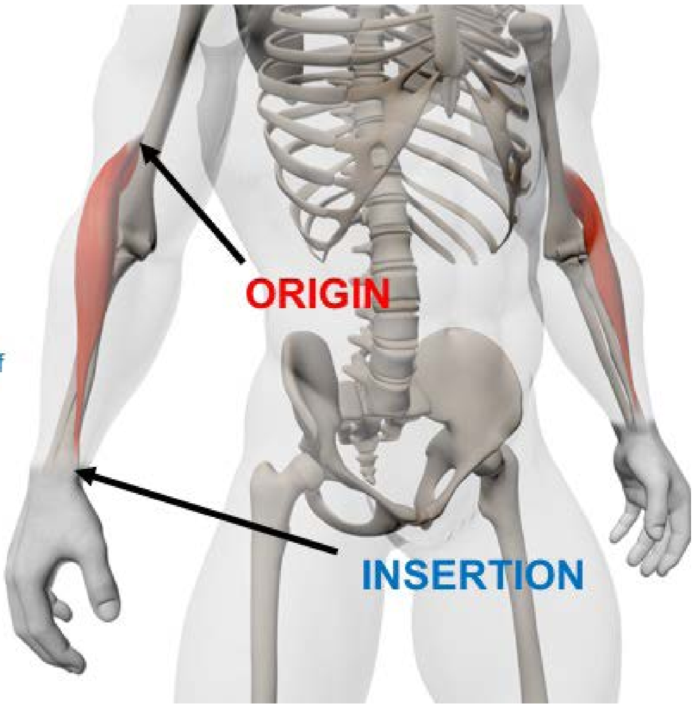
- Laterally at the distal end of humers

Insertion

- Lateral surface of styloid process of radius

Actions:

- Flexion of elbow
- Pronation from supination to neutral
- Supination from pronation to neutral



Triceps Brachii

Origin:

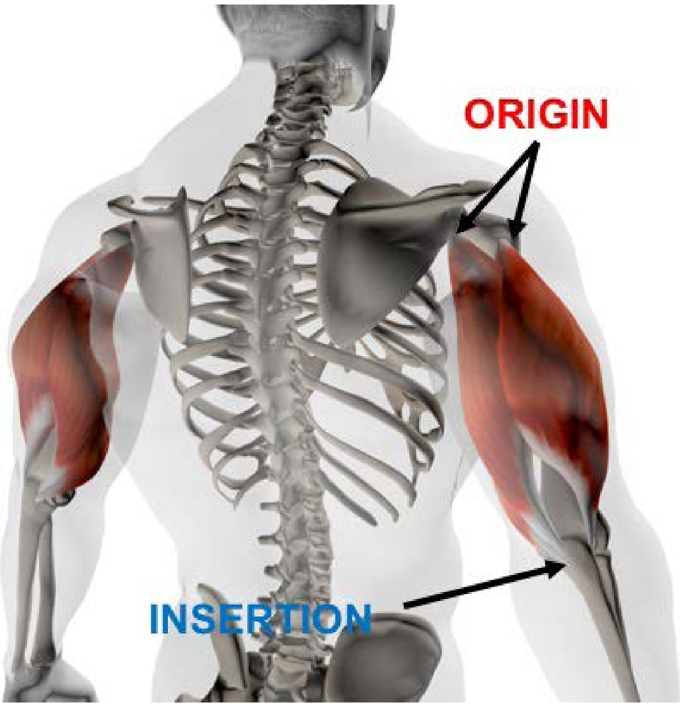
- Humerus
- Scapla

Insertion

- Ulna

Actions:

- Extension of elbow
- Extension of shoulder



Biceps Brachii

Origin:

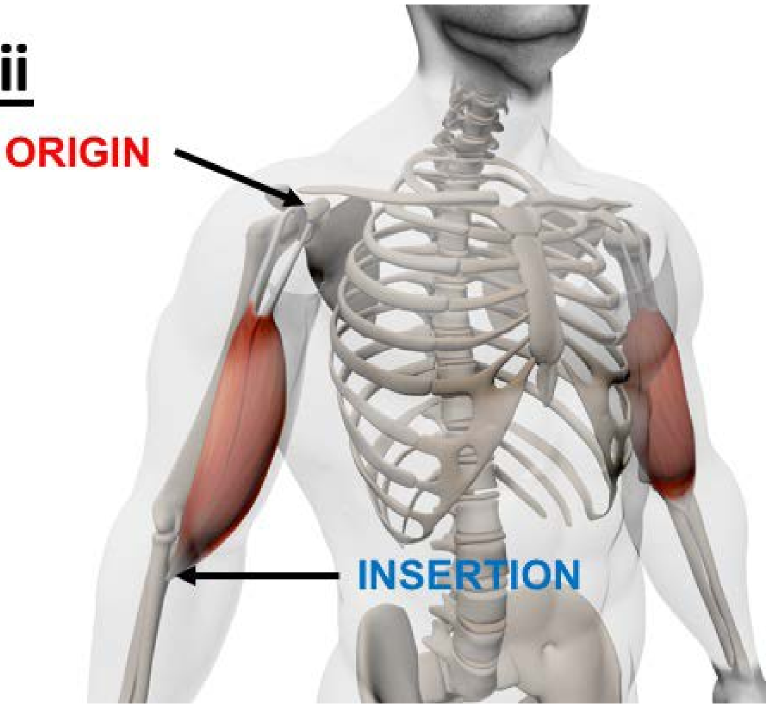
- Scapula

Insertion

- Radius

Actions:

- Flexion of elbow
- Flexion of shoulder
- Supination of forearm



CORE MUSCLES

Rectus Abdominis

Origin:

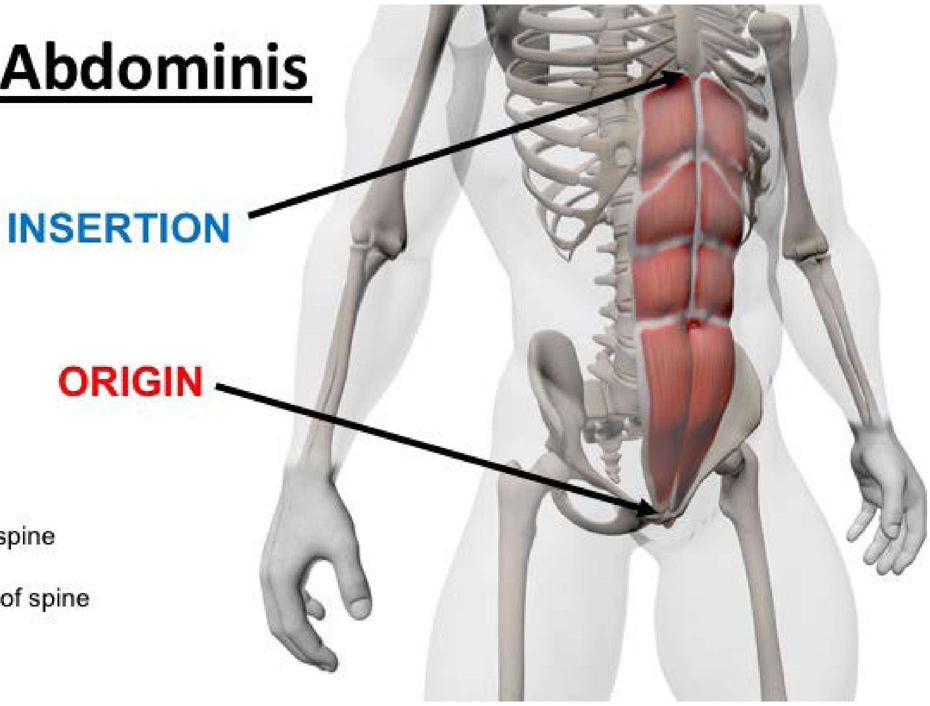
- Pubis

Insertion

- Sternum

Actions:

- Flexion of the spine
- Lateral flexion of spine



Internal Obliques

Origin:

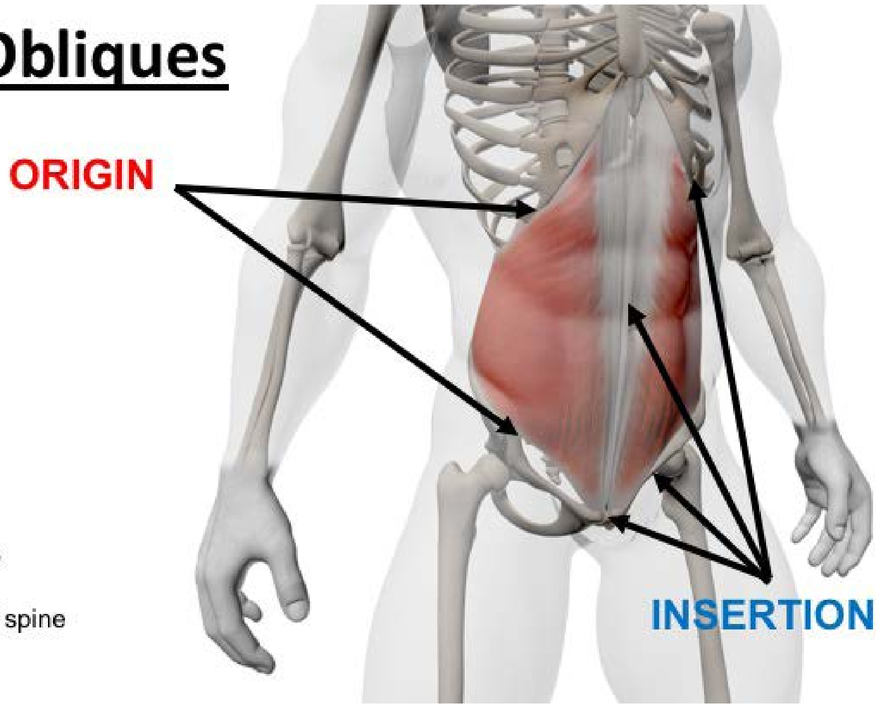
- Ribs
- Ilium

Insertion

- Ilium
- Pubis
- Ribs
- Linea Alba

Actions:

- Rotation of spine
- Lateral flexion of spine



Transversus Abdominis

Origin:

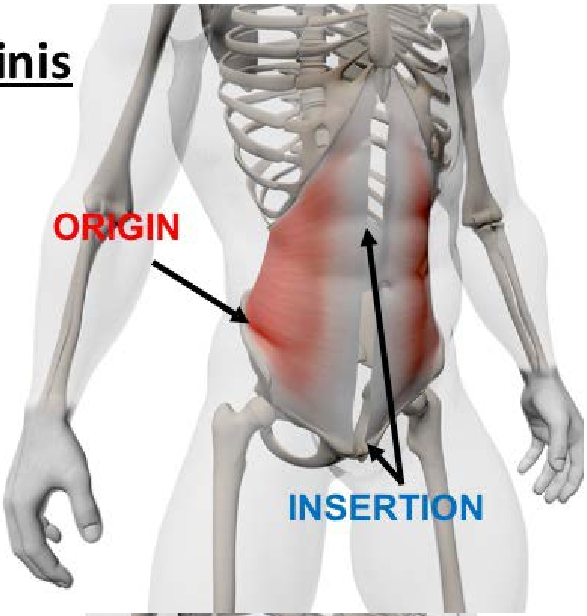
- Iliac crest
- Lumbar fascia

Insertion

- Pubis
- Linea alba

Actions:

- Support internal organs
- Forced expiration



Diaphragm

Origin:

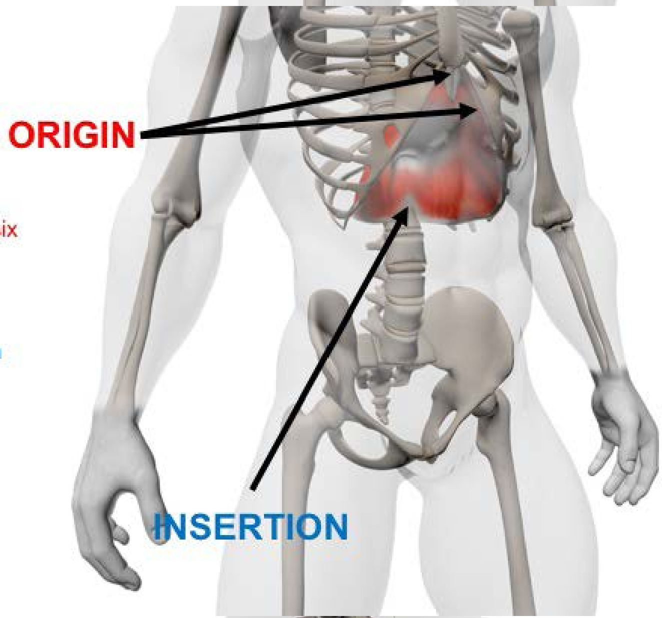
- Xiphoid process
- Inner surface of the lower six costal cartilages

Insertion

- Central aponeurotic tendon

Actions:

- Inspiration
- Forced inspiration



Quadratus Lumborum

Origin:

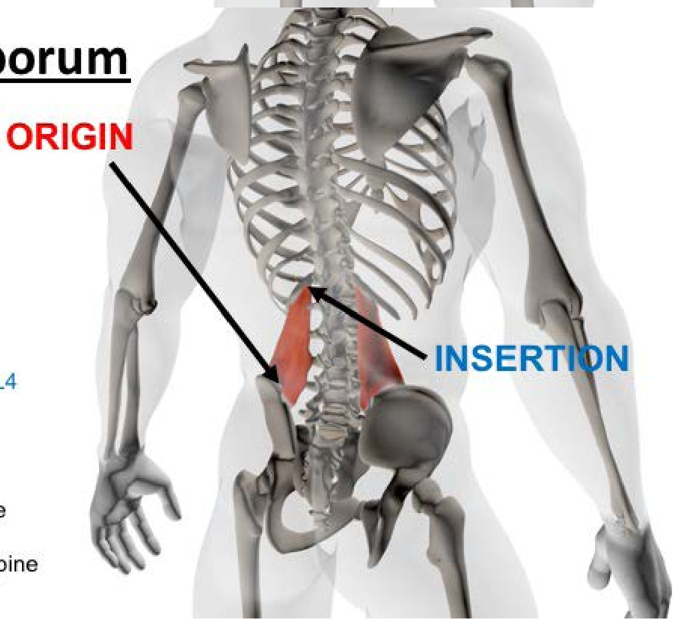
- Iliac Crest

Insertion

- 12th rib
- Transvers process of L1-L4

Actions:

- Lateral flexion of the spine
- Lateral extension of the spine



Intercostals

Origin:

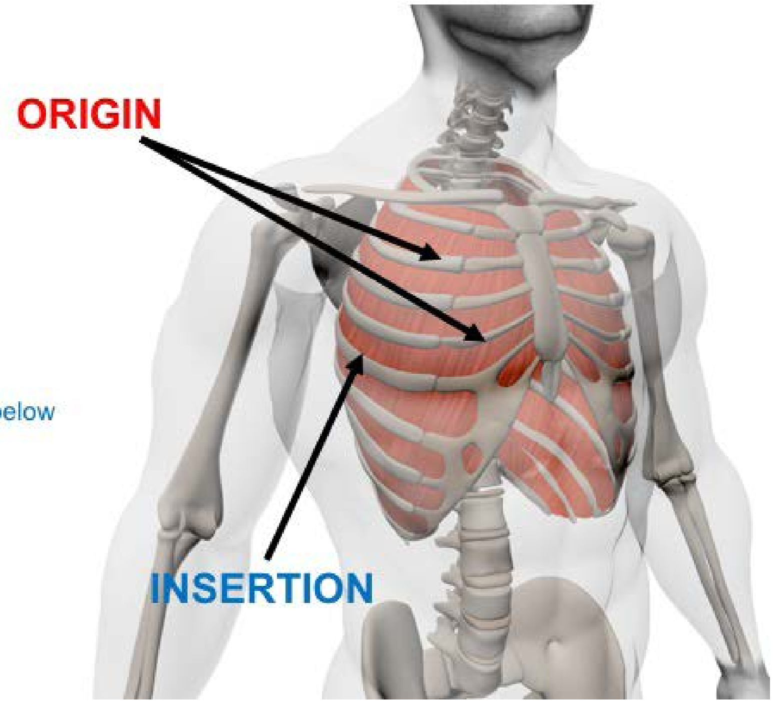
- Ribs
- Costal cartilages

Insertion

- Superior border of next rib below

Actions:

- Elevates ribs
- Aids in respiration



External Obliques

Origin:

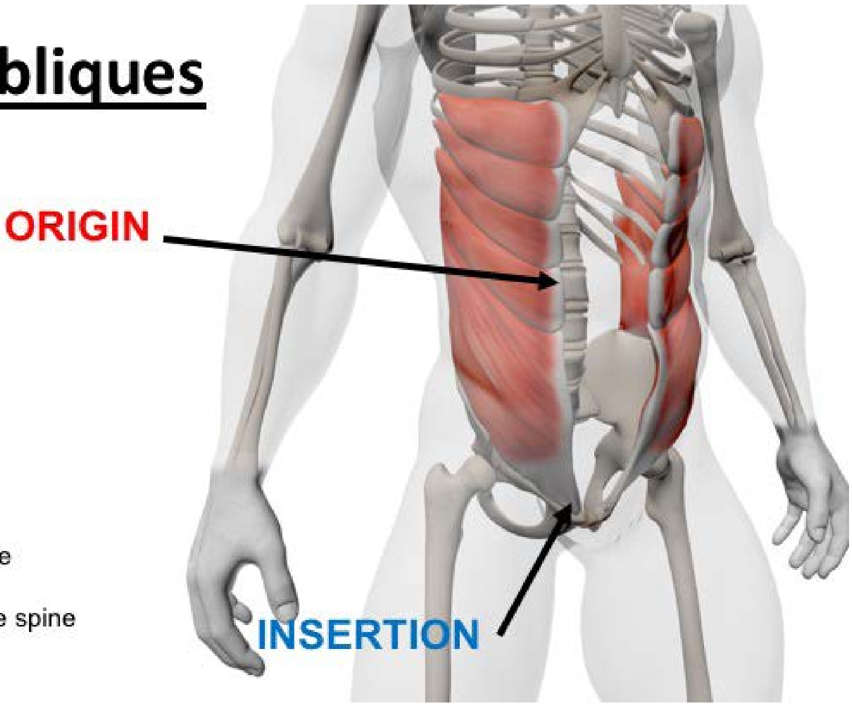
- Ribs

Insertion

- Ilium
- Pubis

Actions:

- Rotation of the spine
- Lateral flexion of the spine



SPINAL MUSCLES

Spinalis

Origin:

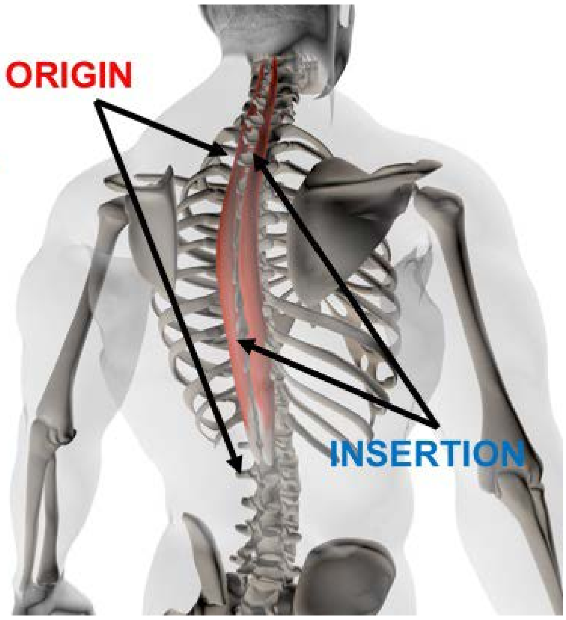
- Spinous processes of lumbar vertebrae
- Spinous processes of thoracic vertebrae

Insertion

- Spinous process of the upper thoracic vertebrae
- Spinous process of the upper cervical vertebrae

Actions:

- Lateral flexion of the neck
- Extension of the vertebrae column



Iliocostalis

Origin:

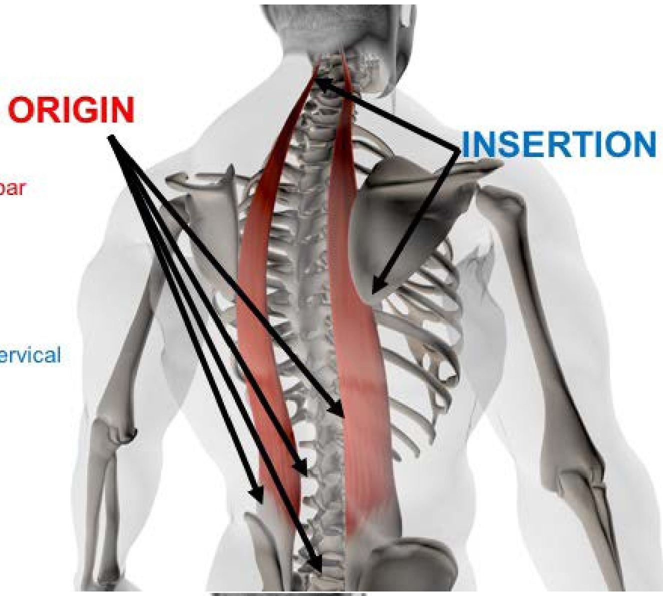
- Sacrum
- Iliac Crest
- Spinous Processes of Lumbar
- Lower thoracic vertebrae

Insertion

- Ribs
- Transverse processes of cervical vertebrae

Actions:

- Lateral flexion of the neck
- Extension of the vertebral column



Longissimus

Origin:

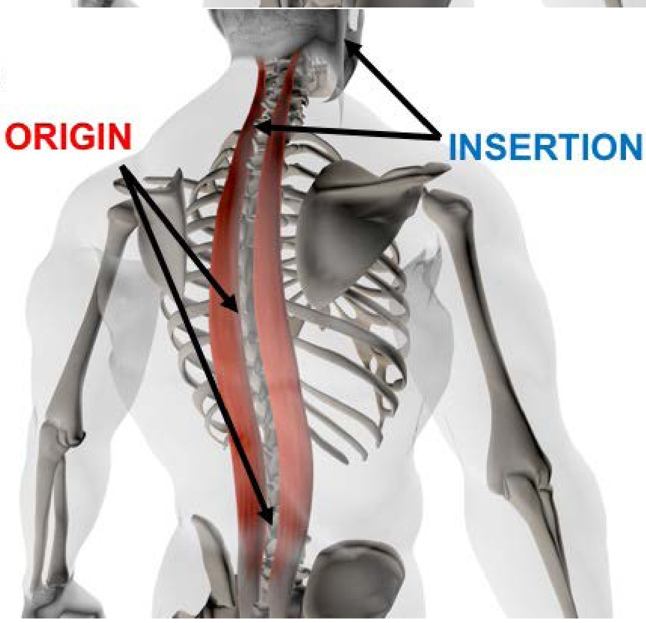
- Transverse process of the lumbar vertebrae
- Transverse process of the thoracic vertebrae

Insertion

- Ribs and transverse process of cervical vertebrae
- Mastoid process

Actions:

- Lateral flexion of neck
- Extension of the vertebrae column



Levator scapulae

Origin:

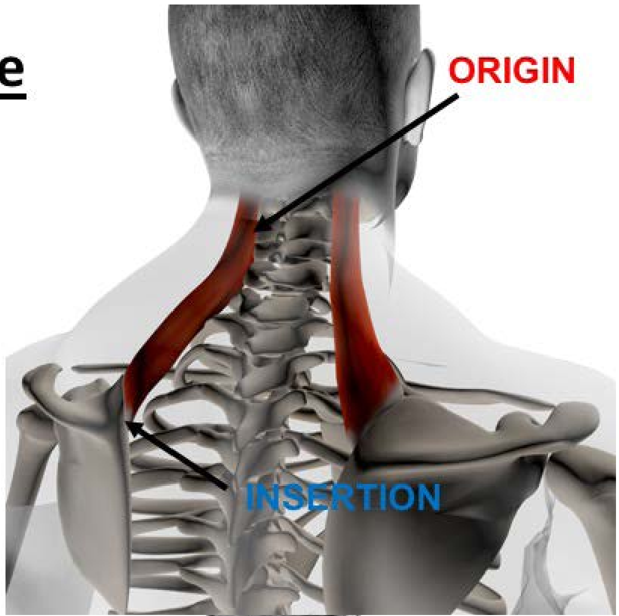
- Transverse process of C1-C4

Insertion

- Superior angle of Scapula

Actions:

- Elevation of shoulder gridle
- Lateral flexion of the neck



Erector Spinae

Origin:

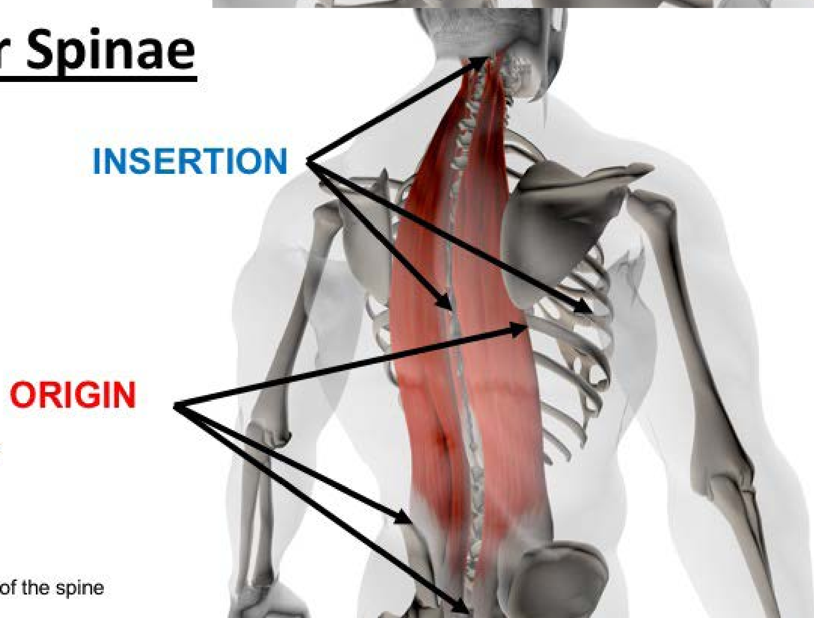
- Sacrum
- Ilium
- Ribs

Insertion

- Ribs
- Vertebrae
- Occipital Bone

Actions:

- Extension
- Lateral flexion of the spine



Multifidus

Origin:

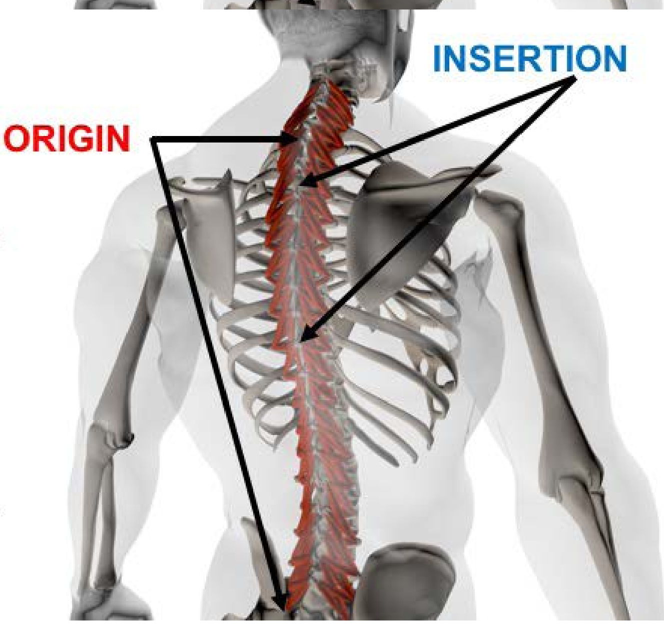
- Posterior superior iliac spine
- Transverse process of lumbar, thoracic and C4-C7 vertebrae

Insertion

- Spinous process of 2nd –4th vertebrae above each origin

Actions:

- Extension of vertebrae column
- Rotation of vertebrae column



GLUTEALS MUSCLES

Gluteus Maximus

Origin:

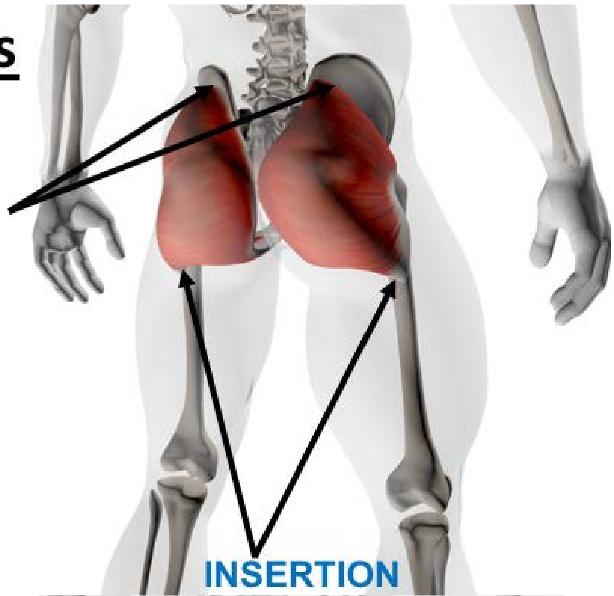
- Ilium

Insertion

- Gluteal tuberosity of the Femur

Actions:

- Extension, abduction and external rotation of hip.



Gluteus Medius

Origin:

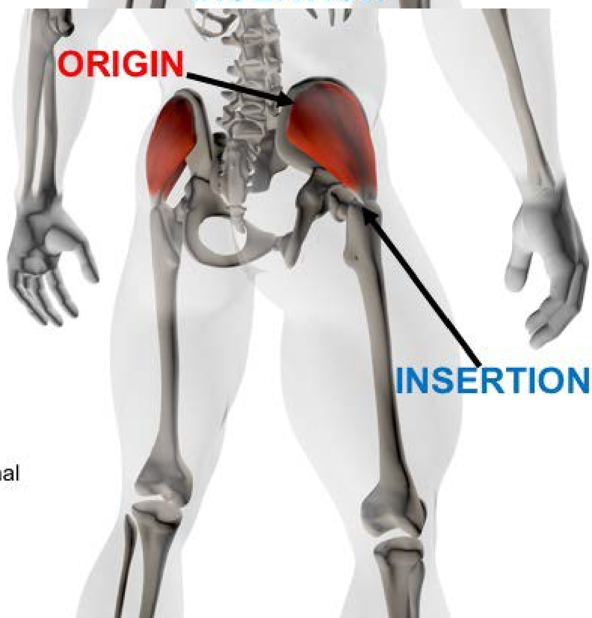
- Lateral Posterior Ilium

Insertion

- Posterior and lateral surface of greater trochanter of Femur

Actions:

- Anterior fibres – abduction and internal rotation of hip
- Posterior fibres - extension and external rotation of hip



Gluteus Minimus

Origin:

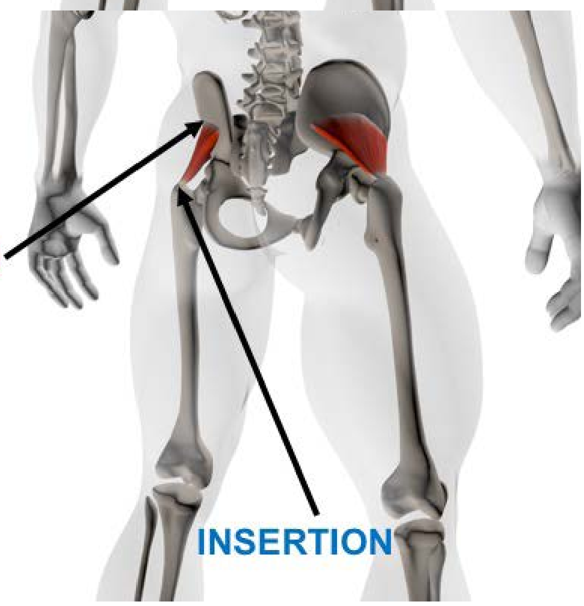
- Lateral Ilium

Insertion

- Anterior surface of greater trochanter of Femur

Actions:

- Abduction rotation of hip
- Medial rotation of hip



HIP FLEXOR MUSCLES

Psoas Major

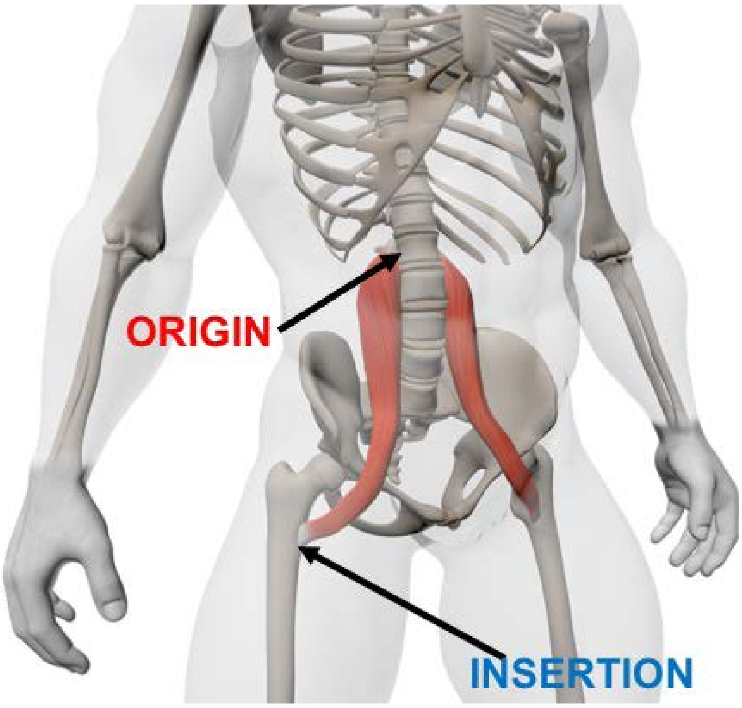
Origin:

- Lumbar vertebrae and T12

Insertion

- Top of Femur

Actions:
- flexion and external rotation of hip
- Assists lateral flexion of spine
- Anteriorly tilts pelvis when femur is fixed



Iliacus

Origin:

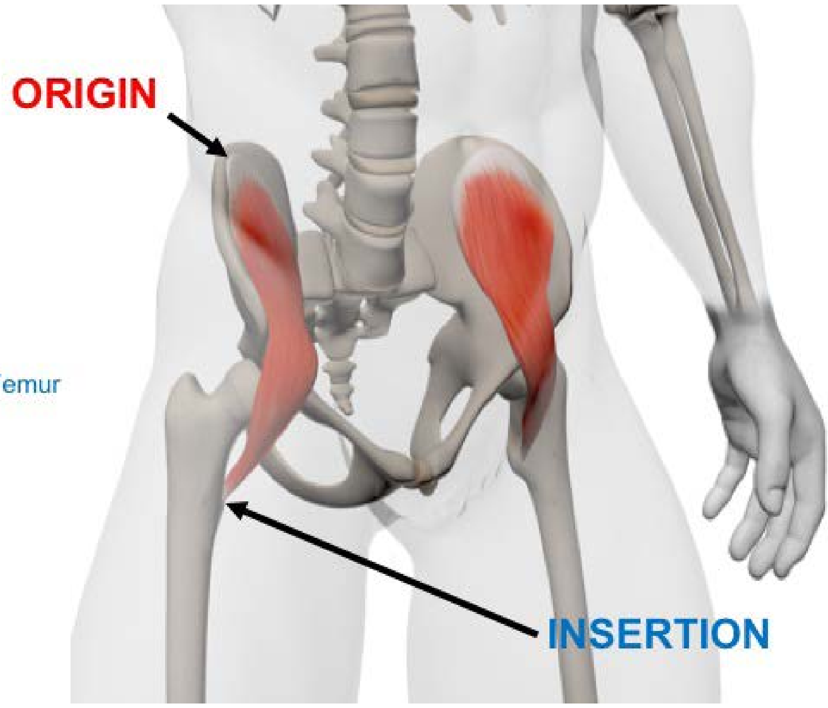
- Iliacus fossa

Insertion

- Lesser trochanter of Femur

Actions:

- Flexion and external rotation of hip



ABDUCTORS AND ADDUCTORS

Piriformis

Origin:

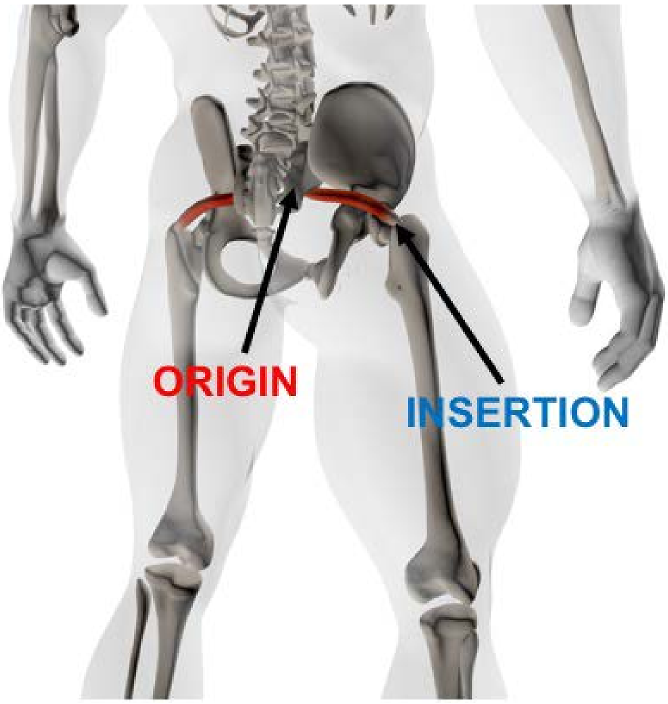
- Anterior sacrum

Insertion

- Upper surface of greater trochanter of Femur

Actions:

- Abduction of the hip
- Lateral rotation of the hip



Pectineus

Origin:

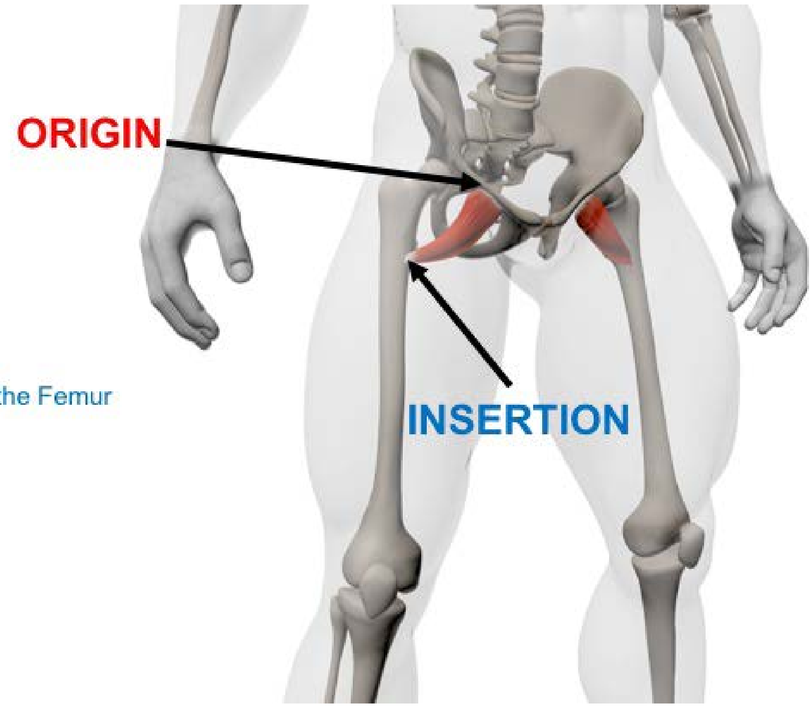
- Anterior Pubis

Insertion

- Lesser trochanter of the Femur

Actions:

- Adduction
- Flexion of the hip



Sartorius

Origin:

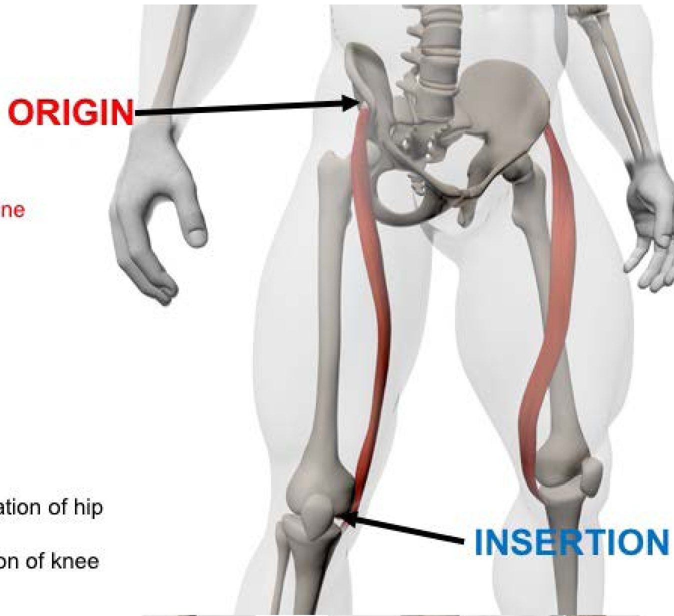
- Anterior Superior Iliac Spine

Insertion

- Medial condyle of Tibia

Actions:

- Flexion
- Abduction and lateral rotation of hip
- Flexion and medial rotation of knee



Adductor Longus

Origin:

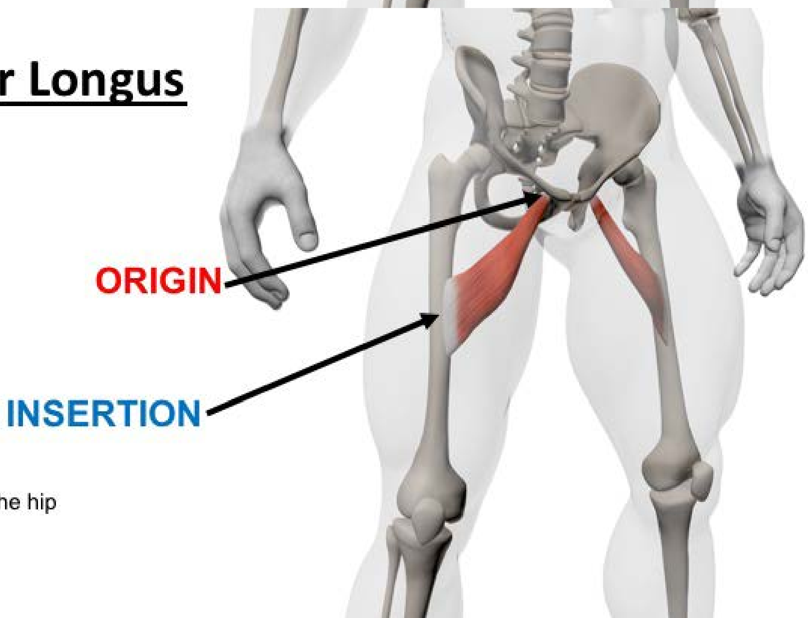
- Pubis

Insertion

- Femur

Actions:

- Adduction of the hip



Adductor Magnus

Origin:

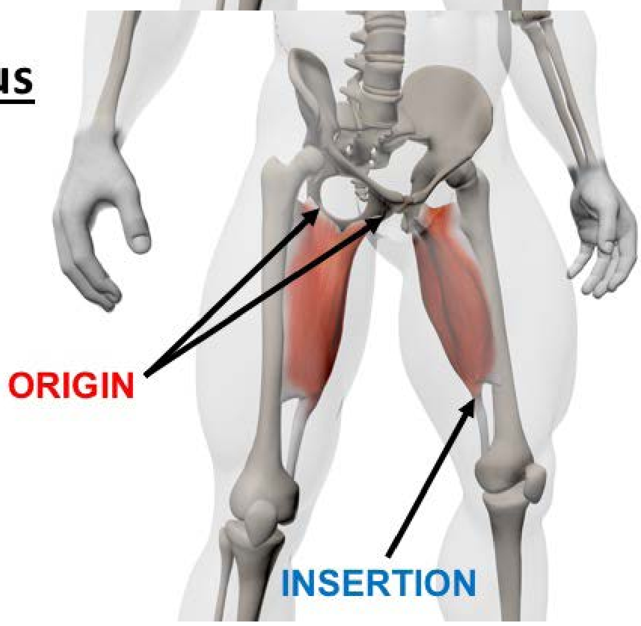
- Pubis
- Ischium

Insertion

- Femur

Actions:

- Adduction of the hip



Adductor Brevis

Origin:

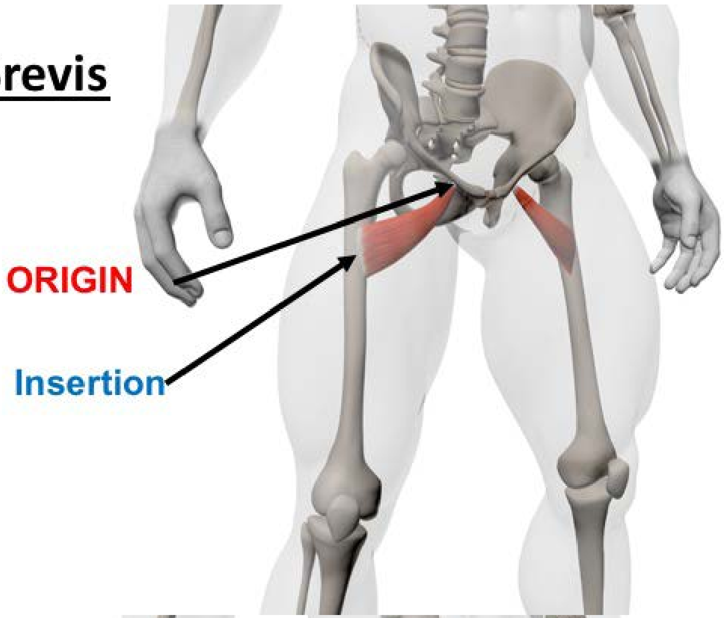
- Pubis

Insertion

- Femur

Actions:

- Adduction of the hip



Gracilis

Origin:

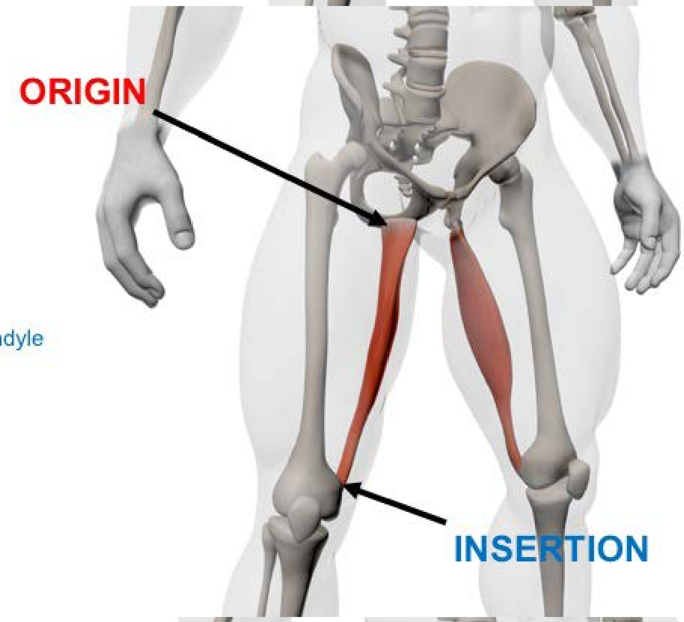
- Ischio-pubic ramus

Insertion

- Medial Tibia below condyle

Actions:

- Adduction
- Flexion of the hip



Tensor Fascia Latae

Origin:

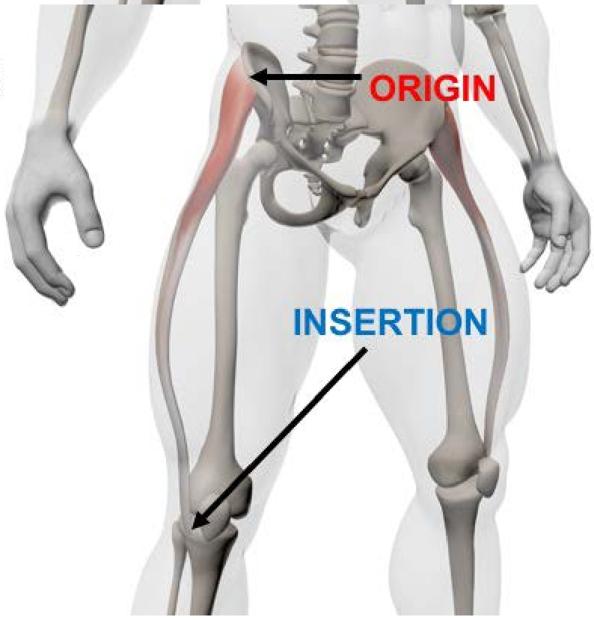
- Anterior Iliac crest

Insertion

- Lateral upper tibia via Iliotibial band (ITB)

Actions:

- Flexion of the hip
- Abduction of the hip



QUADRICEP MUSCLES

Vastus Lateralis

Origin:

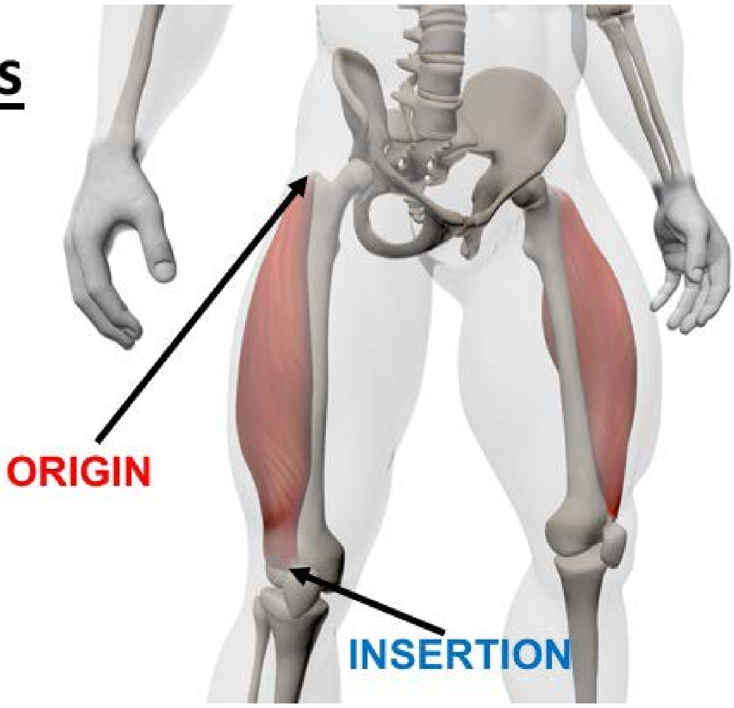
- Lateral Femur and greater trochanter

Insertion

- Tibial Tuberosity via Patella

Actions:

- Extension of knee



Vastus Intermedius

Origin:

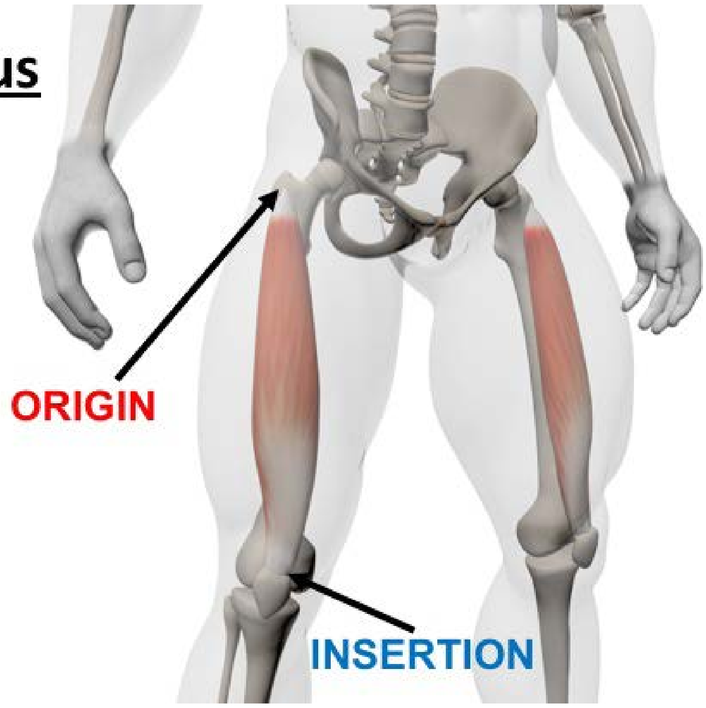
- Anterior Femur

Insertion

- Tibial Tuberosity via Patella

Actions:

- Extension of knee



Vastus Medialis

Origin:

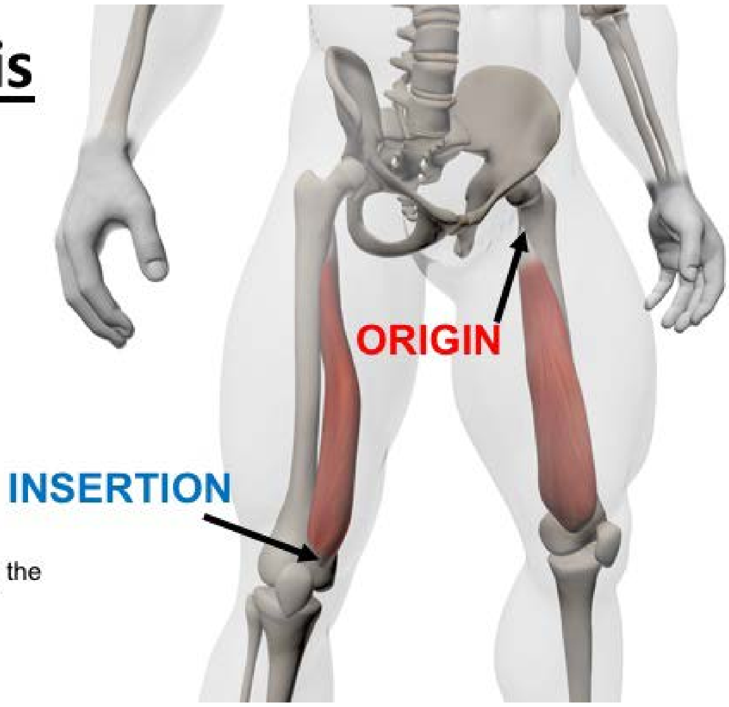
- Medial Femur

Insertion

- Tibial Tuberosity via Patella

Actions:

- Extension of knee (especially the last 20 degrees of motion)



Rectus Femoris

Origin:

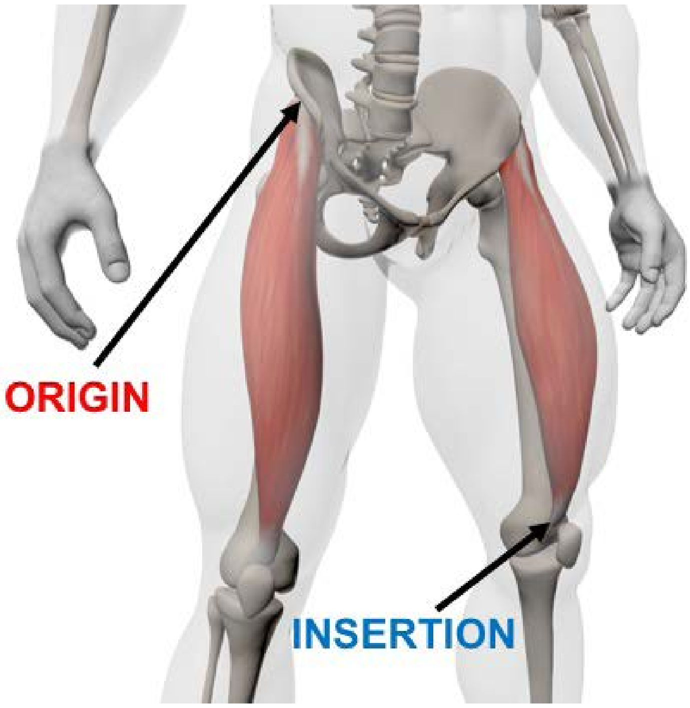
- Anterior Superior Iliac Spine

Insertion

- Tibial Tuberosity via Patella

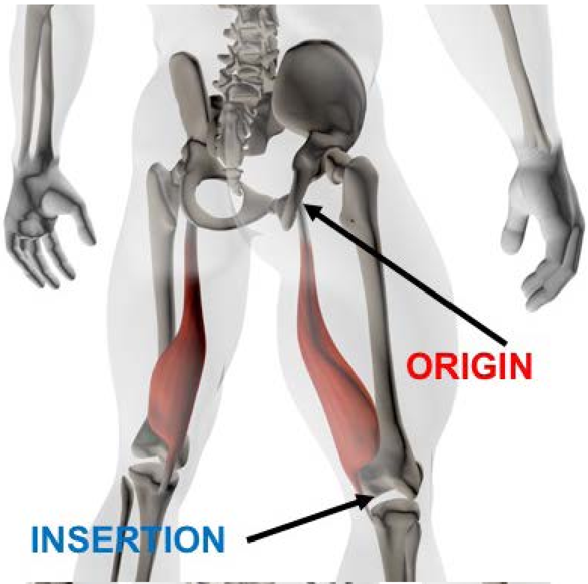
Actions:

- Flexion of hip
- Extension of knee



HAMSTRING MUSCLES

Semitendinosus



Origin:

- Ischial Tuberosity

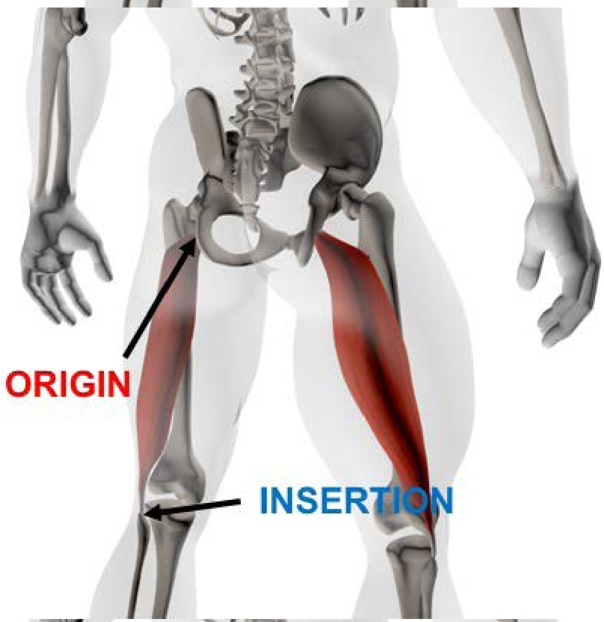
Insertion

- Medial condyle of Tibia

Actions:

- Extension of hip
- Flexion of the knee

Biceps Femoris



Origin:

- Ischial Tuberosity
- Posterior Femur

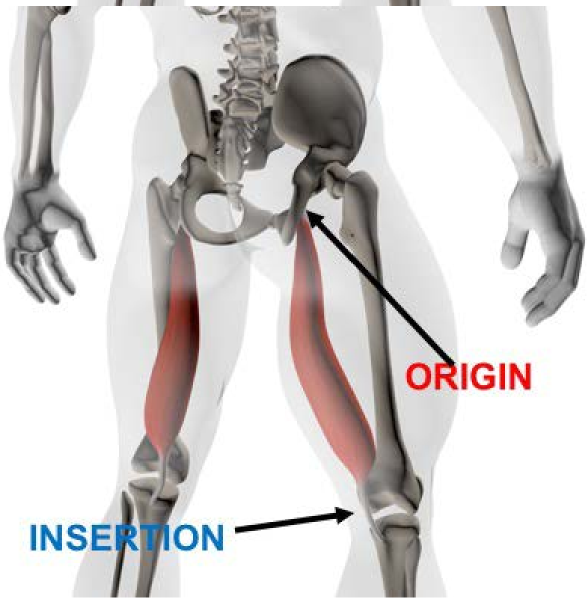
Insertion

- Head of Fibula
- Lateral condyle of Tibia

Actions:

- Extension of hip
- Flexion of the knee

Semimembranosus



Origin:

- Ischial Tuberosity

Insertion

- Anterior medial condyle of Tibia

Actions:

- Extension of hip
- Flexion of the knee

LOWER LEG MUSCLES

Soleus

Origin:

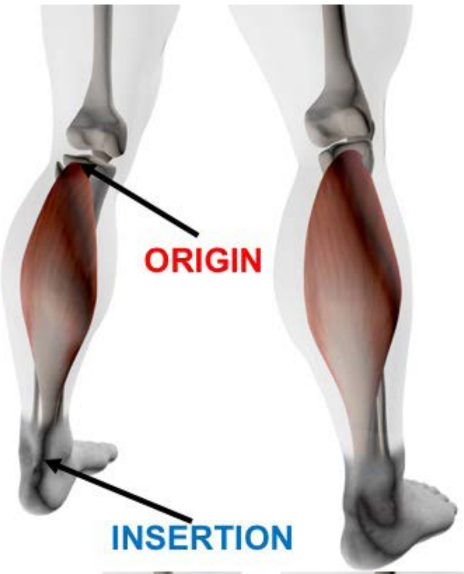
- Tibia

Insertion

- Calcaneus (Heel Bone)

Actions:

- Plantarflexion of ankle



Gastrocnemius

Origin:

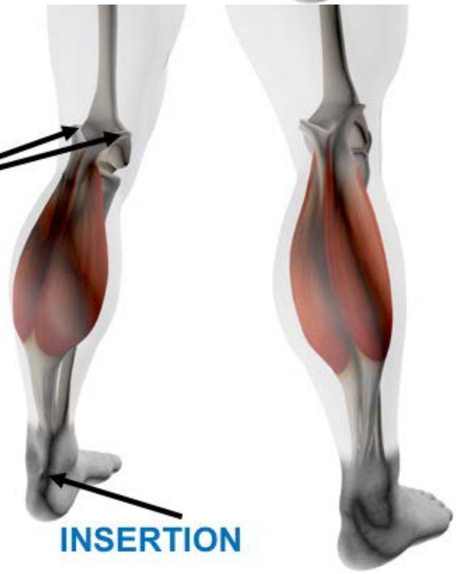
- Femur

Insertion

- Calcaneus (Heel Bone)

Actions:

- Plantarflexion of ankle
- Flexion of knee



Tibialis Anterior

Origin:

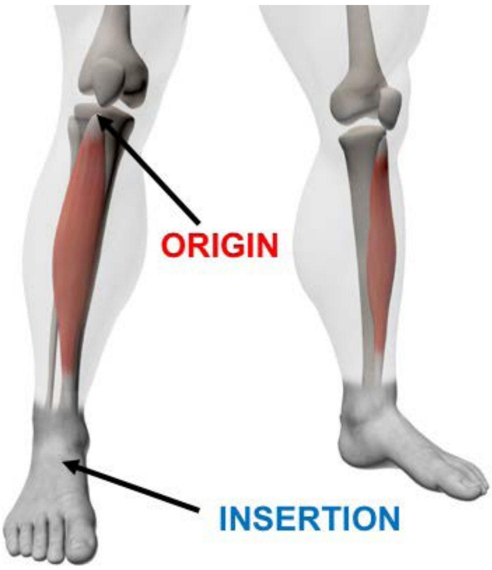
- Tibia

Insertion

- Metatarsals
- Tarsal

Actions:

- Dorsiflexion
- Inversion of ankle



The Respiratory System

UNIT 1: THE SYSTEMS THAT MAKE UP THE HUMAN BODY (ANATOMY AND PHYSIOLOGY)

The respiratory system is responsible for taking oxygen into the body and removing the waste product of aerobic respiration – carbon dioxide. And while you have limited control over breathing, i.e. You can choose to hold your breath, ultimately breathing is controlled by your autonomic or involuntary nervous system.

The cells of the human body require a constant stream of oxygen to stay alive. The respiratory system provides oxygen to the body's cells while removing carbon dioxide, a waste product that can be lethal if allowed to accumulate.

There are 3 major parts of the respiratory system:

VIDEO AVAILABLE ON LEARNING PLATFORM

- The airway.
- The lungs.
- The muscles of respiration.

The airway, which includes the nose, mouth, pharynx, larynx, trachea, bronchi, and bronchioles, carries air between the lungs and the body's exterior. The lungs act as the functional units of the respiratory system by passing oxygen into the body and carbon dioxide out of the body. Finally, the muscles of respiration, including the diaphragm and intercostal muscles, work together to act as a pump, pushing air into and out of the lungs during breathing.

THE ANATOMY OF THE RESPIRATORY SYSTEM

VIDEO AVAILABLE ON LEARNING PLATFORM

- Nose or mouth
- Pharynx
- Larynx
- Trachea
- Primary bronchi
- Bronchioles
- Alveoli
- Capillaries

Carbon dioxide exits the body through the same structures but in reverse.

THE LUNGS

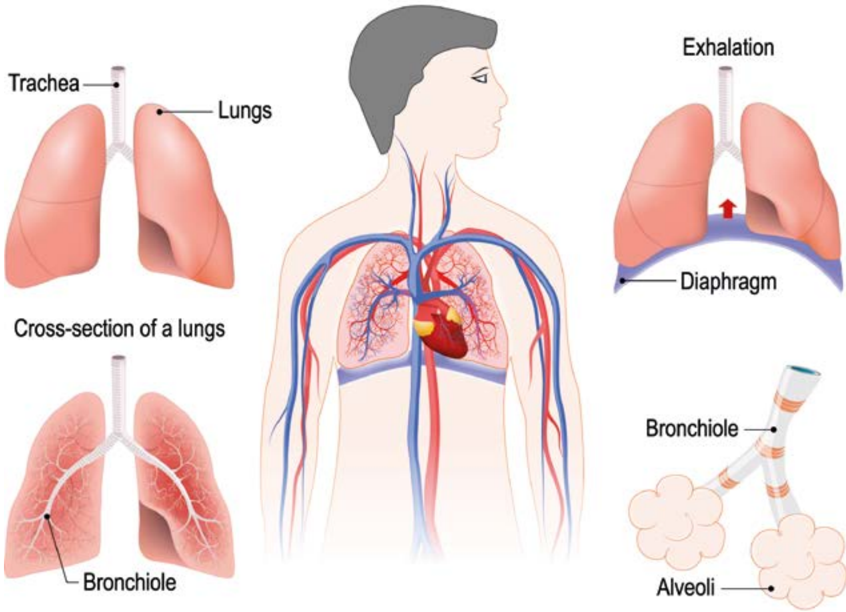
VIDEO AVAILABLE ON LEARNING PLATFORM

Location:

- In the rib cage or thoracic cavity.

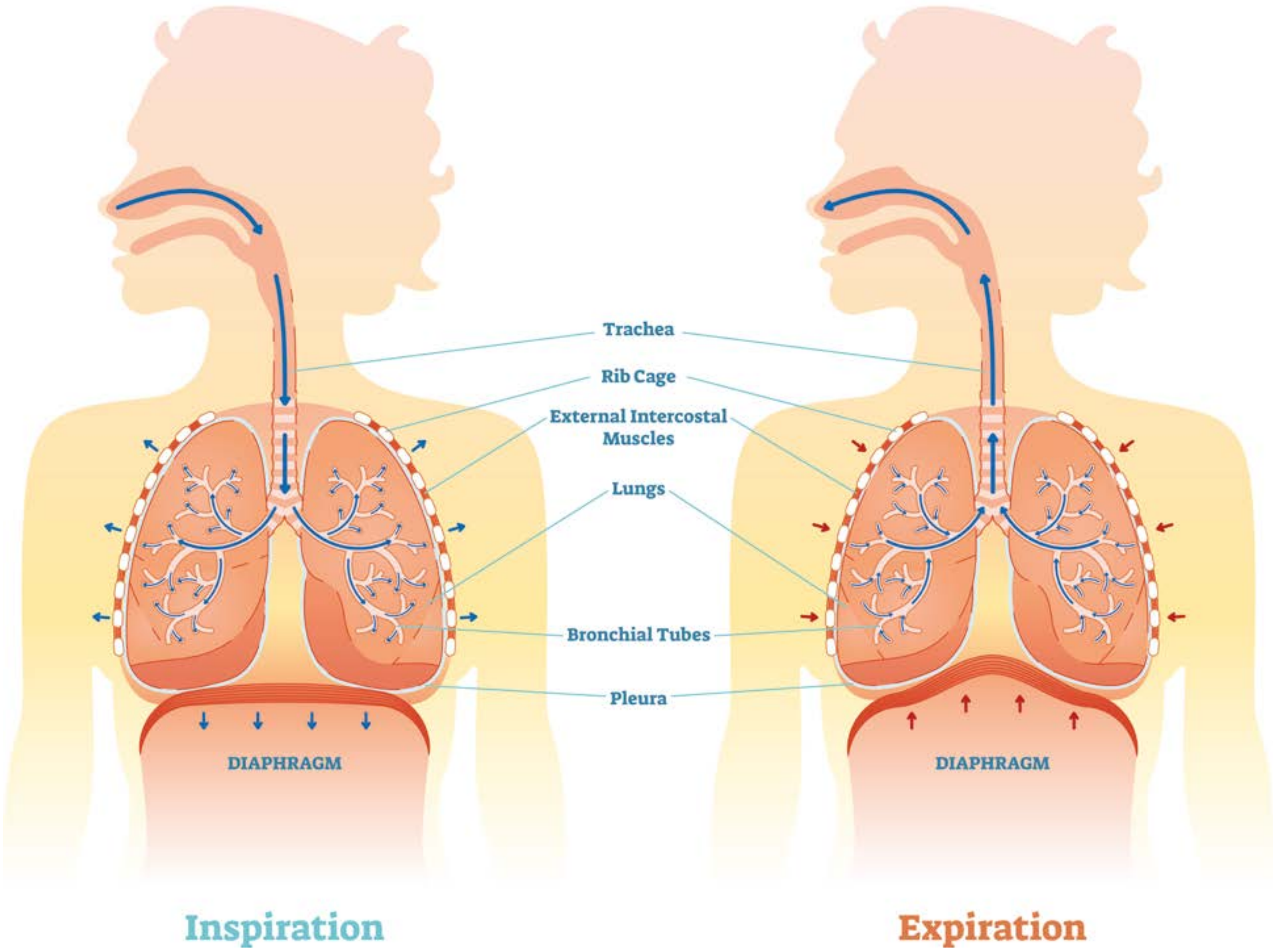
Function:

- Take in oxygen.
- Remove carbon dioxide.



ESSENTIAL TERMINOLOGY

- **INHALATION OR INSPIRATION:** Taking air down and into the lungs.
- **EXPIRATION OR EXHALATION:** Expelling the air from the lungs.
- **EXTERNAL RESPIRATION:** The exchange of gasses between the lungs and blood.
- **INTERNAL RESPIRATION:** The exchange of gasses between the blood and the cells.



MECHANICS OF BREATHING

INHALATION

To draw air into your body, your diaphragm, a dome-shaped muscle across the bottom of your ribs, contracts and depresses. At the same time, your intercostal muscles, which are located between your ribs, contract and pull your ribs upward and outward. This increases the volume of your chest cavity which in turn, creates a vacuum. Air is then drawn into your lungs until the pressure inside your lungs is equal to the pressure outside.

DIAPHRAGMATIC VERSUS COSTAL BREATHING

When you are at rest and oxygen demands are low, your primary breathing muscle should be your diaphragm. Diaphragmatic breathing is characterised by abdominal distension and very little chest expansion. To experience this, lie on your back and place one hand on your abdomen and the other on your chest. Now breathe normally but ensure only your lower hand moves.

VIDEO AVAILABLE ON LEARNING PLATFORM

To increase your oxygen intake, for example when exercising, more costal breathing is necessary so that sufficient air can be taken into the lungs.

Again, lying on your back, inhale but this time make sure the hand resting on your chest also moves.

Diaphragmatic breathing is linked to relaxation and is part of yoga, tai chi and can help reduce stress and blood pressure. Combining diaphragmatic with costal breathing will create the largest possible chest cavity expansion and, therefore, the greatest intake of air.

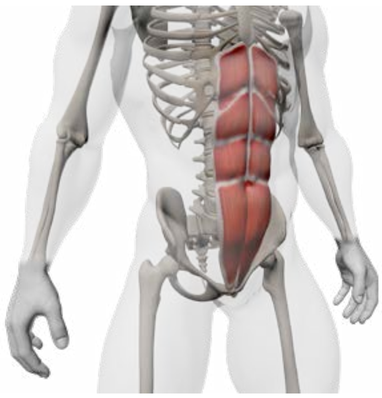
EXHALATION

To drive air out of your lungs, the diaphragm relaxes and so does the intercostals. This causes the ribcage to deflate which pushes the air out of your lungs. Although you can push most of the air out of your lungs, some always remains which is called your Residual Volume (RV).

In addition to the action of the diaphragm and intercostals, you can use your rectus abdominus to compress your abdominal cavity to exhale more forcefully e.g. When blowing up a balloon.

THE MUSCLES USED IN BREATHING

- Diaphragm.
- Intercostals.
- Rectus abdominus.



RECTUS ABDOMINUS

INTERCOSTAL MUSCLES

DIAPHRAGM

GASEOUS EXCHANGE

As you breathe in, the air is drawn down into your lungs and ends up in your alveoli which resemble bunches of grapes. The alveoli provide a very large surface area for moving oxygen (O2) into your blood and removing carbon dioxide (CO2) from your blood ready for exhalation. This “swapping” of gasses is called a gaseous exchange and is also known as diffusion.

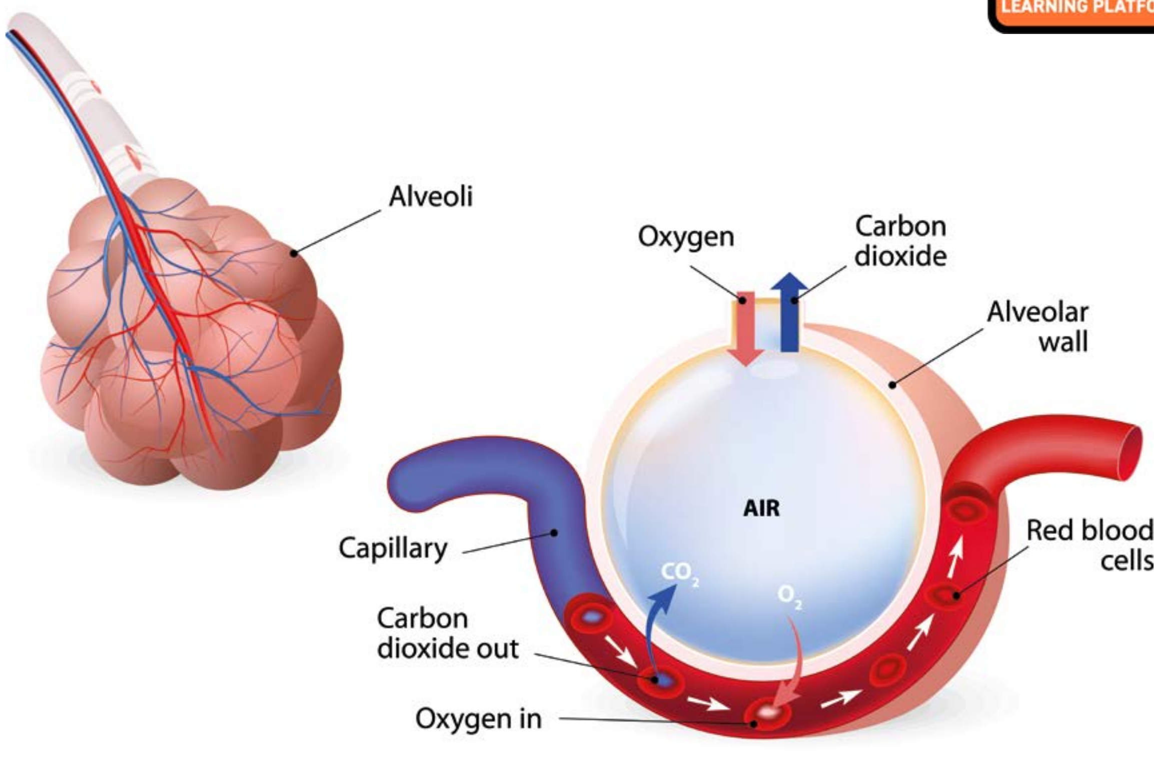
Diffusion can be defined as the movement of gasses from an area of high concentration to an area of low concentration and as this is happening to two gasses simultaneously (O2 and CO2) there is an exchange of equal volumes of gasses. Diffusion is possible because the alveoli are proliferated with tiny blood vessels called capillaries. Capillaries are one-cell thick so that gasses and other substances can pass through them.

As air is inhaled and reaches the alveoli, O2 is extracted from the air and passed through the capillaries and into the blood. The O2 binds to a substance called haemoglobin (essentially your red blood cells and known as Hb for short) and is then transported around the body and used as required.

Conversely, CO2 from the blood diffuses into the alveoli via the capillaries and is exhaled.

CO2 is also carried by Hb although when haemoglobin is carrying oxygen it is called oxy-haemoglobin and when it is carrying CO2 it is carboxy-haemoglobin.

VIDEO AVAILABLE ON
LEARNING PLATFORM



THE AIR WE BREATHE

COMPOSITION OF AIR

Air is comprised of several gasses, some of which are very important and some of which are less so. Oxygen is essential for human life but nitrogen, which makes up a large percentage of the air we breathe, is inert. Inhaled air has a different composition to exhaled air because some of the oxygen is used in aerobic respiration.

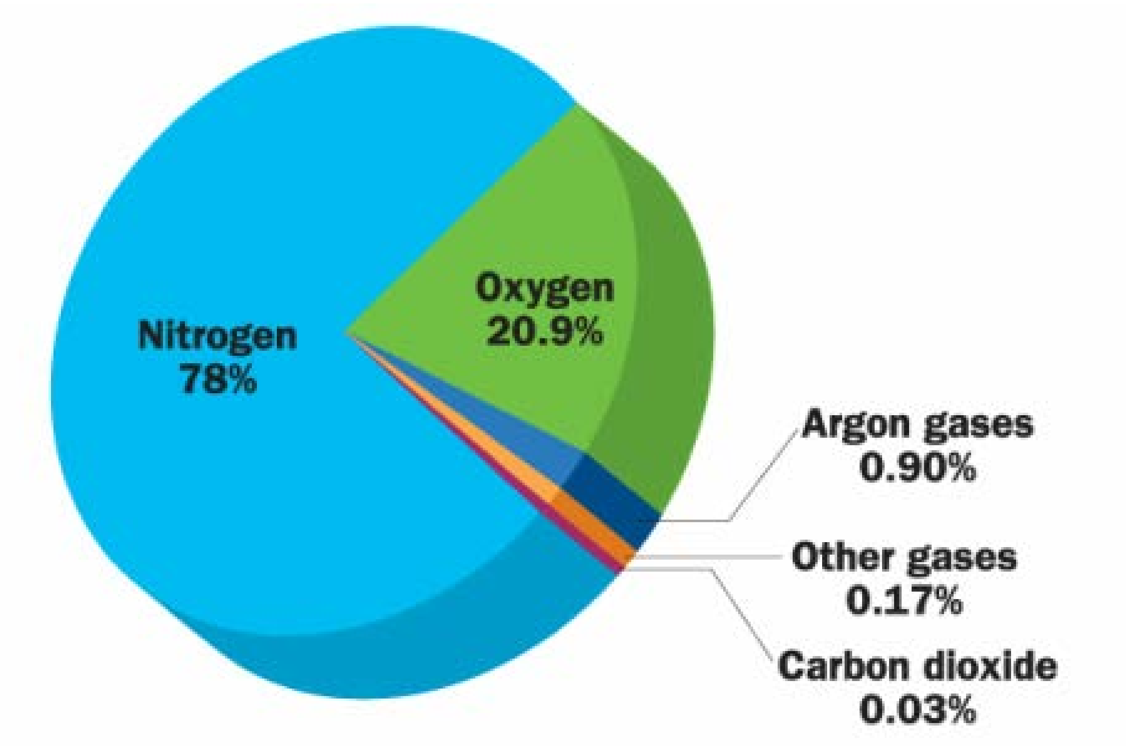
GAS	INHALED AIR	EXHALED AIR	DIFFERENCE
Nitrogen ($N2$)	79%	79%	No change
Oxygen ($O2$)	21%	17%	4% decrease
Carbon Dioxide ($CO2$)	<1%	4%	4% decrease

THE STIMULUS FOR BREATHING

While you can voluntarily control the depth and speed of your breathing up to a point, the majority of the time, breathing is controlled by your autonomic nervous system which means it is involuntary.

When blood CO2 levels reach 4%, breathing will occur. This is why you can only hold your breath for so long and why, even underwater, you will attempt to breathe if deprived of oxygen for long enough.

When you exercise, CO2 levels increase quickly and so breathing rate increases significantly to prevent CO2 levels exceeding 4%. In contrast, at rest and especially during sleep, CO2 levels are very low and subsequently so too is the breathing rate.



LUNG FUNCTION

MEASURES ASSOCIATED WITH LUNG FUNCTION

Many aspects of lung function can be measured through the use of spirometry tests. These measures can be affected by several factors including gender, age, general health, body type and illnesses such as asthma. Spirometry tests involve blowing into measuring devices that analyse and record volume, velocity and/or duration of airflow.

The main measures are:

- Breathing rate (BR): The number of breaths taken per minute
- Tidal volume (TV): The amount of air inhaled and exhaled in one breath
- Minute ventilation (MV): The total amount of air exhaled and exhaled in one minute

Therefore minute ventilation (MV) which is measured in millilitres per minute (ml/Min) or litres per minute (l/Min) equals breathing rate (BR) multiplied by tidal volume (TV).

MV = BR x TV

For example:

BR = 12
TV = 500ml
MV = 6000ml/Min or 6l/Min

MEASURE	ACUTE	CHRONIC
Breathing rate	Increases	Decreases
Tidal volume	Increases	Increases
Minute ventilation	Increases	Unchanged or slightly increases

THE EFFECT OF EXERCISE ON LUNG FUNCTION MEASURES

Exercise affects the function of your lungs, both acutely (as you exercise) and as a result of your body adapting to the exercise (chronically). These changes are caused by increased capillarisation at the alveoli, increased haemoglobin density in the blood and improved respiratory muscle strength and endurance.

Energy Systems

UNIT 1: THE SYSTEMS THAT MAKE UP THE HUMAN BODY (ANATOMY AND PHYSIOLOGY)

The human body is, at its most basic level, a machine and like any machine, it needs a supply of energy work. As a car needs petrol or a light bulb needs electricity, your body needs a substance called Adenosine Triphosphate which is known as ATP for short.

ATP is the universal fuel for everything that happens in your body; from lifting weights to running to reading to sleeping – ATP is what powers your body.

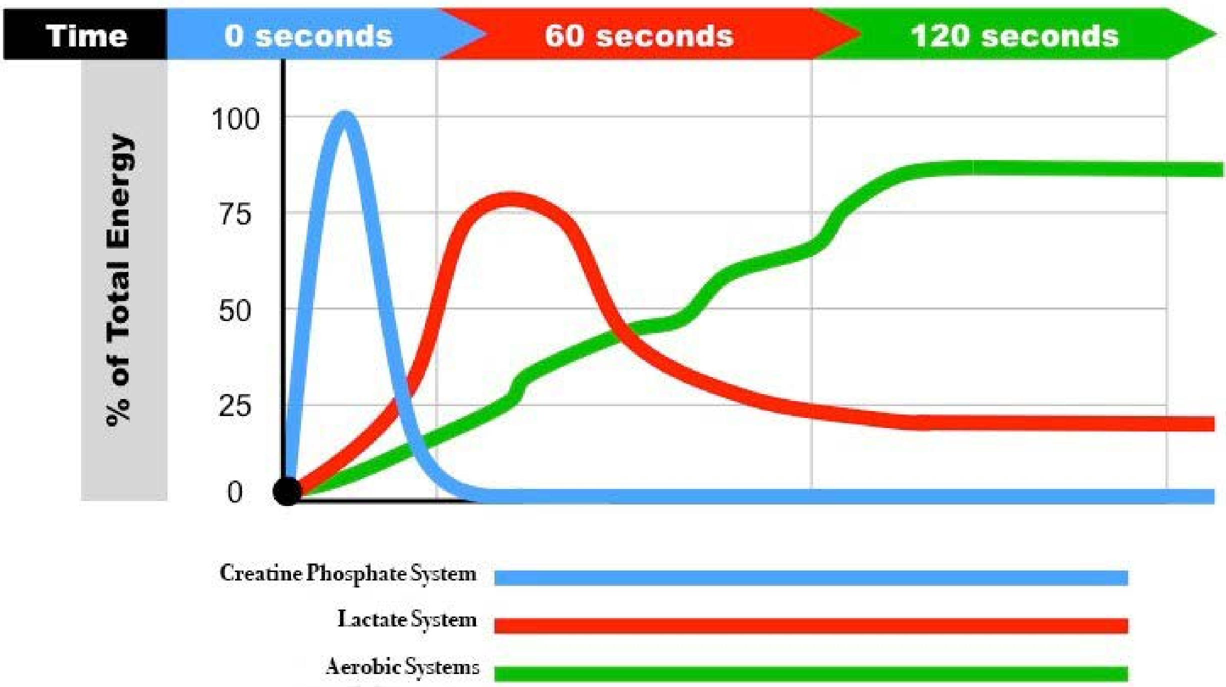
ATP is made up of one adenosine molecule and three phosphate molecules. These molecules are held together by high energy bonds which, when broken, release energy for us to use. The result of this reaction is ADP (adenosine diphosphate) + energy +one lone molecule of phosphate.

We only have a very limited supply of ATP stored in our bodies; about enough for 1-2 seconds of activity, however, humans convert food into ATP to ensure that we always have plenty of energy. In addition to food, ATP can be manufactured from fat stored around your body and the carbohydrate reserves in your muscles and liver called glycogen.

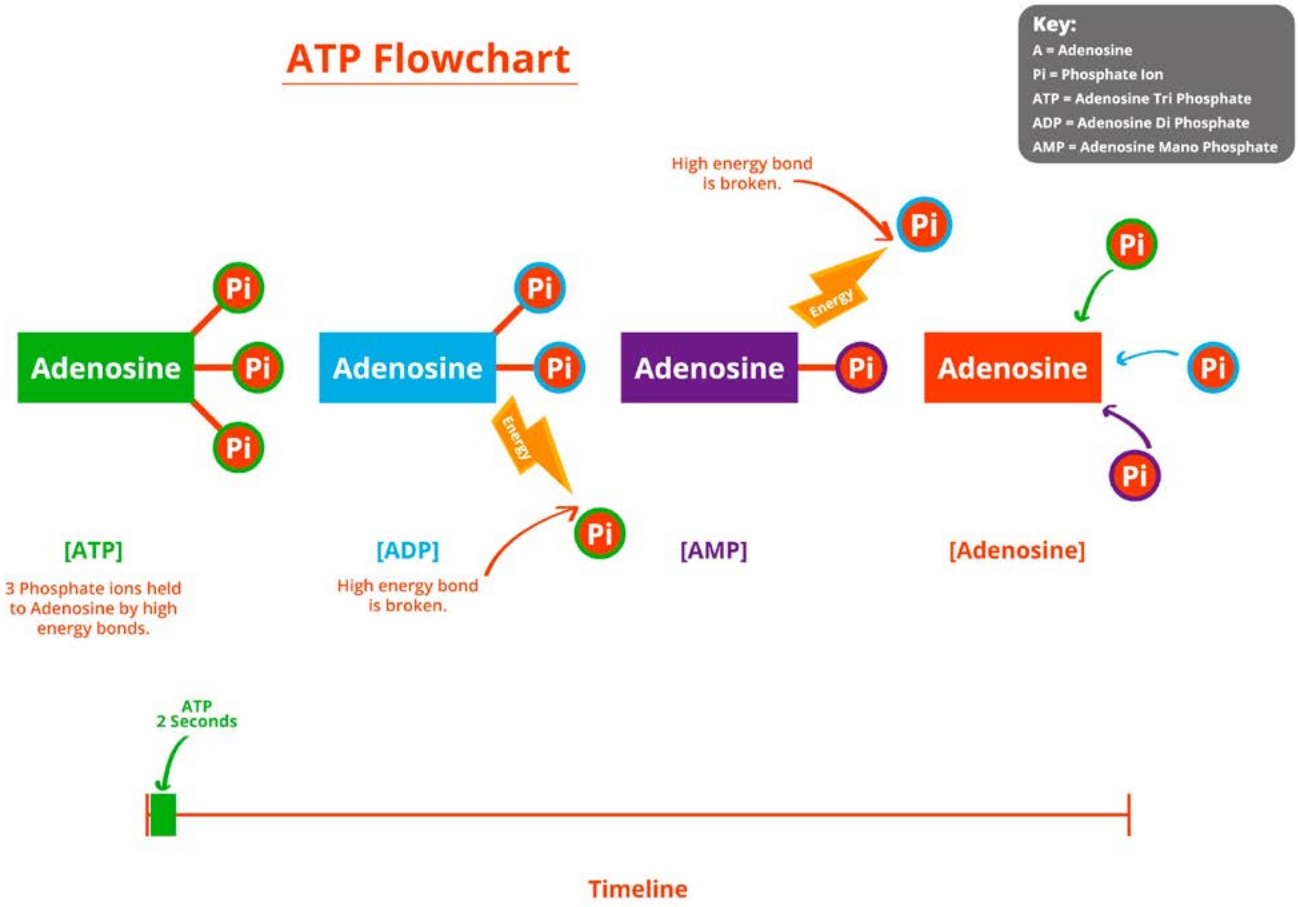
Food + O2 + digestion = energy (ATP) + muscular contractions + CO_2 + H_2O + heat

Humans use three primary systems for creating ATP or regenerating ADP back into ATP for use by the body. There are two anaerobic energy systems that operate without oxygen and one that requires an abundance of oxygen. The three energy systems are:

- Creatine phosphate system: also known as the CP system, the phosphocreatine system or the anaerobic lactate system.
- Lactate system: also known as the lactic acid system or the anaerobic glycolysis system.
- Aerobic system: also known as the oxidative system.



THE BREAKDOWN OF ATP TO RELEASE ENERGY

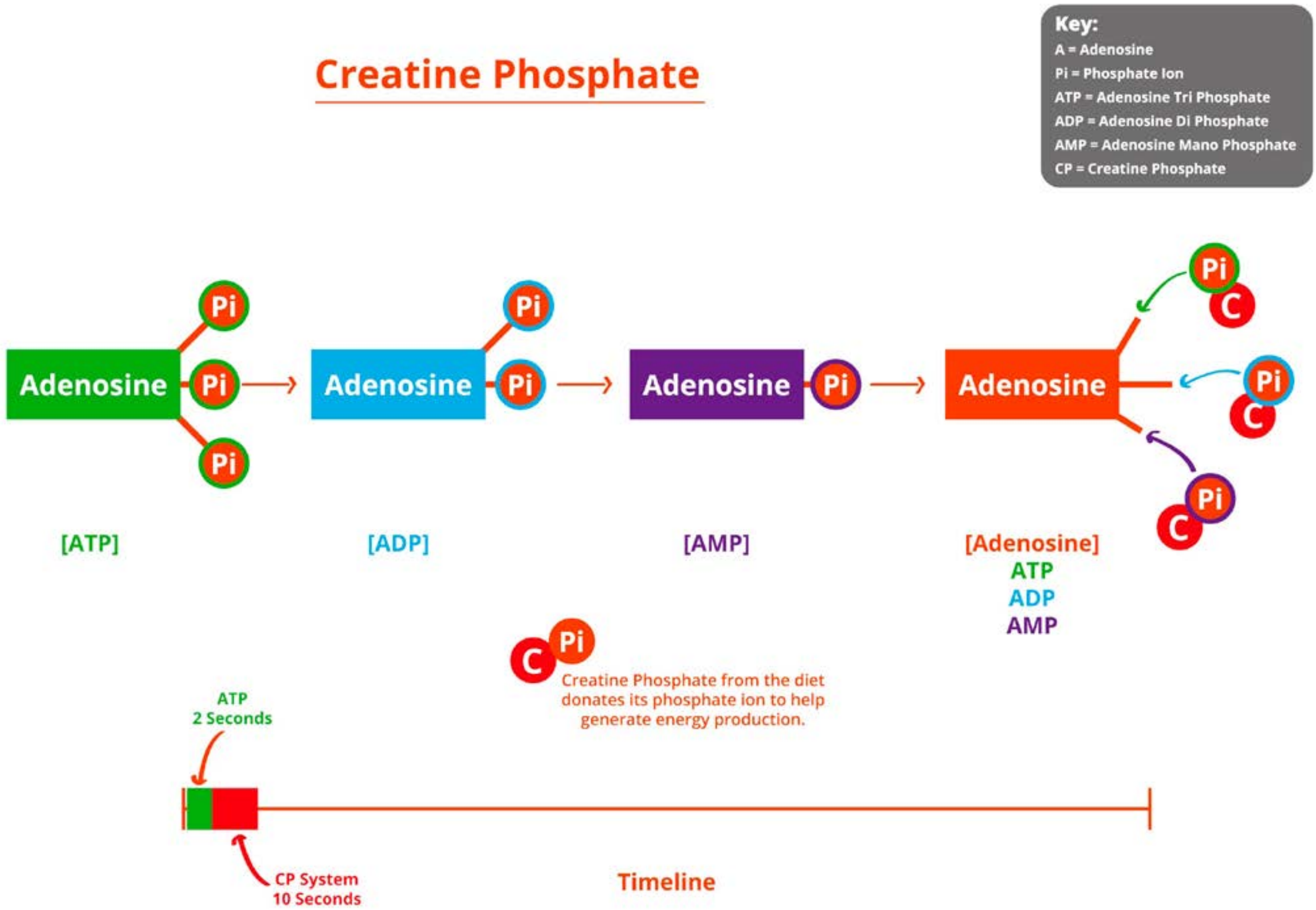


CREATINE PHOSPHATE SYSTEMS

CP TRAINING ADAPTATIONS

There is little doubt that activities emphasising the CP system, such as heavy weight lifting and sprinting have a significant training effect; namely increased muscle mass and a pre-domination of fast-twitch muscle fibres (Jones and Round, 1991) As well as a significant increase in muscular stores of anaerobic fuel sources i.e. ATP, creatine phosphate and glycogen.

Debate continues, however, as to whether this form of training improves the ability of enzymes within these muscles to generate greater amounts of ATP. To date, there is little research to support this idea. In summary, the principle adaptations associated with training the PC system would appear to be increased muscle size (fast-twitch) and improved activation of the muscle by the nervous system.

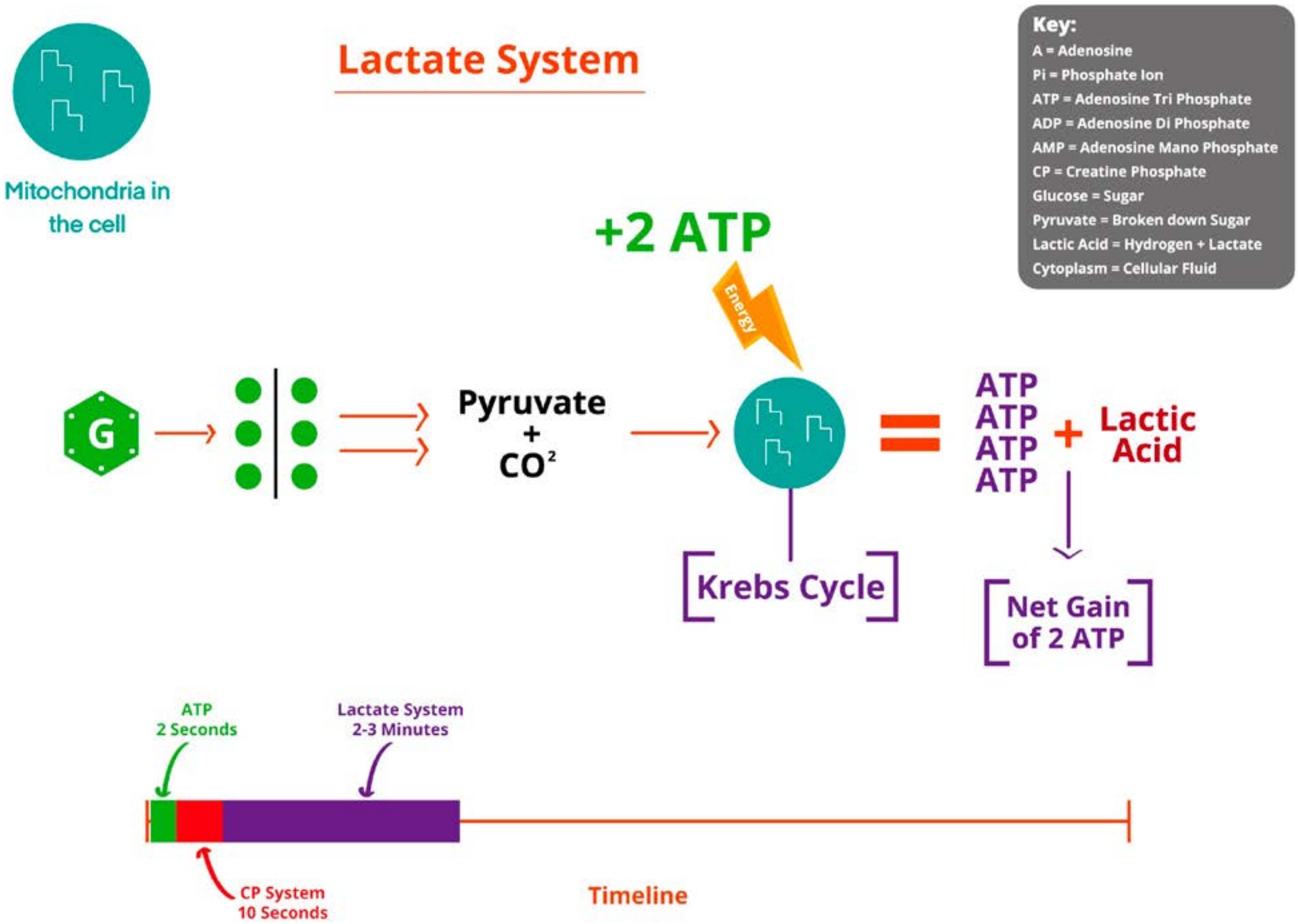


LACTATE SYSTEM

TRAINING AND THE LACTATE SYSTEM

Changes in this system are related to improvements in the cardio-respiratory system and are difficult to describe. Muscles that receive and utilise more oxygen, for example, are going to produce less lactic acid at any given exercise intensity.

It would also appear that regular anaerobic training improves tolerance to the build-up of fatiguing waste products. As of yet, however, researchers can only speculate as to whether this is due to physiological adaptations or is simply the result of motivational changes.



AEROBIC SYSTEM

(OXIDATIVE SYSTEM)

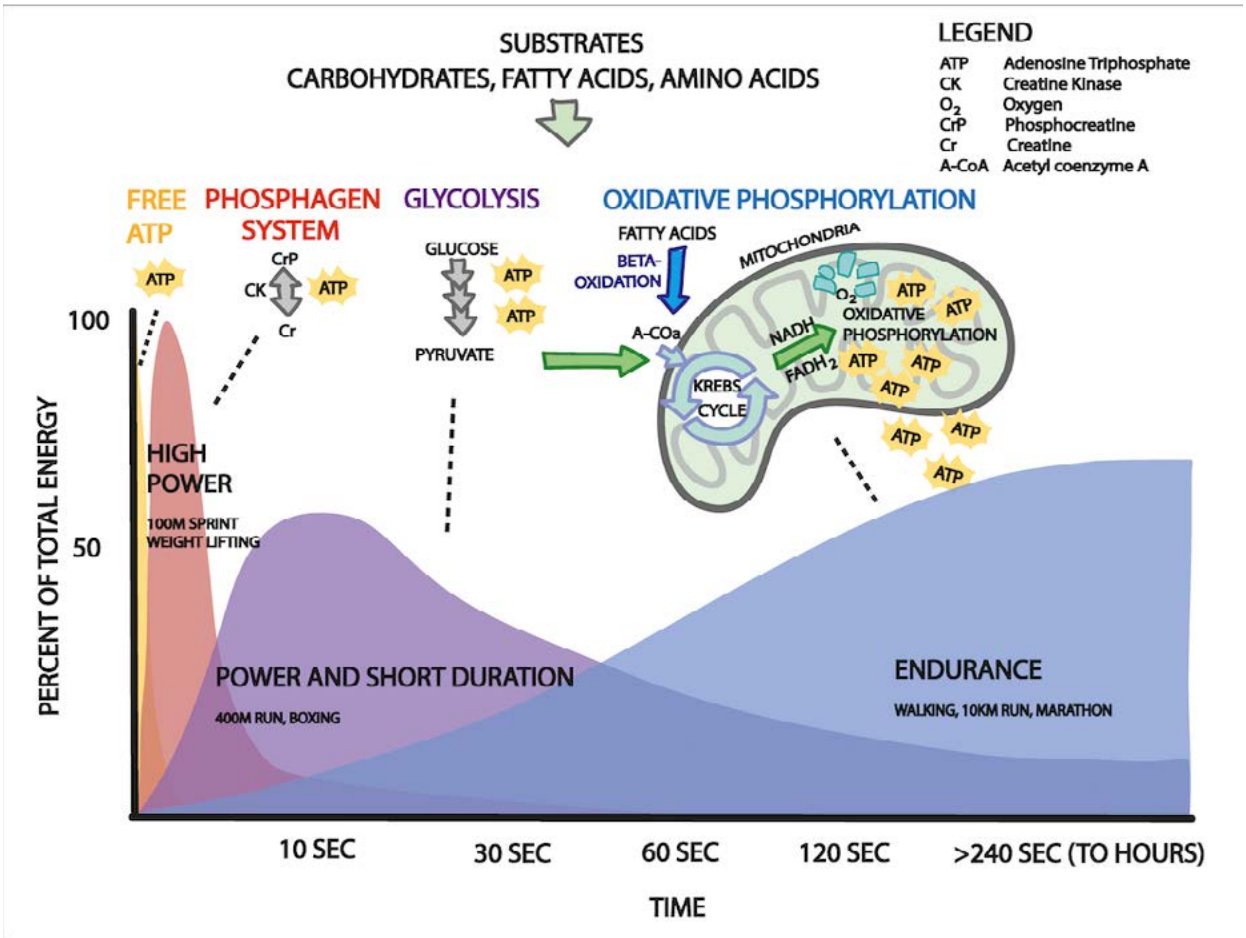
Meaning “with oxygen”, the aerobic or oxidative system produces ATP from the complete breakdown of carbohydrate and fat. The lower the intensity, the more fat is used and the higher the intensity, the more carbohydrate is used. Because both fat and carbohydrate are “burnt” to produce ATP, it is often said that fat burns in the flame of carbohydrate. The aerobic system can only provide meaningful amounts of ATP when oxygen is abundant i.e. At low to moderate levels of intensity such as while at rest or while walking or jogging.

- Carbon dioxide
- Water
- Heat

Different fuel sources produce different amounts of energy. The complete breakdown of one carbohydrate-derived glucose molecule yields 262 kcal (a thousandth of a calorie) while the complete breakdown of one fat-derived molecule of fatty acid will yield 3360 kcals.

However, and despite fat providing much more energy per molecule, carbohydrate is the preferred source of ATP in the body because it is released much more quickly.

All ATP, irrespective of which of the three energy systems is responsible, is produced in cells called mitochondria. Aerobic energy production occurs in the organelles of the mitochondria while anaerobic energy production occurs in the cytoplasm surrounding the mitochondria. Mitochondria are best thought of as cellular power stations and the larger or greater the number of mitochondria present, the higher the potential for energy production.



OXYGEN UPTAKE

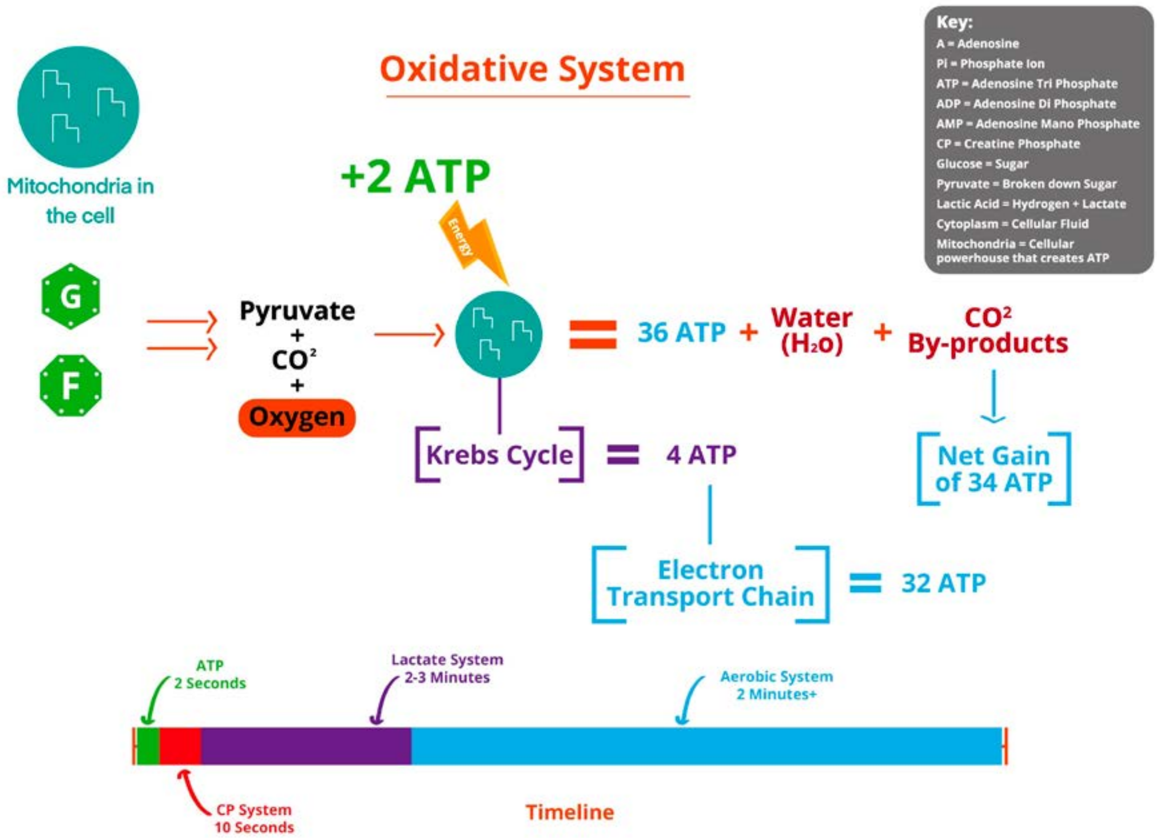
During aerobic activity and during the recovery from anaerobic activity, the cells of the body require oxygen. The aerobic system is essentially the "go-to" energy system as once the anaerobic activity has stopped, the aerobic system is always the system to which your body returns. The use of oxygen by the cells is called oxygen (or O2) uptake or consumption.

At rest, oxygen consumption is approximately 3.5 millilitres per kilogram of body weight per minute (ml/kg/Min). This value is also known as one metabolic equivalent or one MET for short. As activity intensity increases, so do does oxygen uptake which is mirrored by an increase in heart and breathing rate.

The maximum amount of oxygen that a person can take in, transport and utilise during exercise is called the VO2 Max and is a commonly assessed measure used to identify an exerciser's fitness level as well as predict their performance. The greater the potential for oxygen uptake, the higher the VO2 Max, the higher the fitness level of the test subject would be.

However, the person with the highest VO2 Max score may not necessarily be the winner of an event or race as things like strategy, lactic acid tolerance, mental toughness, recovery, nutritional status and motivational state all play a part in physical performance.

THE PHYSIOLOGY OF THE AEROBIC (OXIDATIVE) SYSTEM

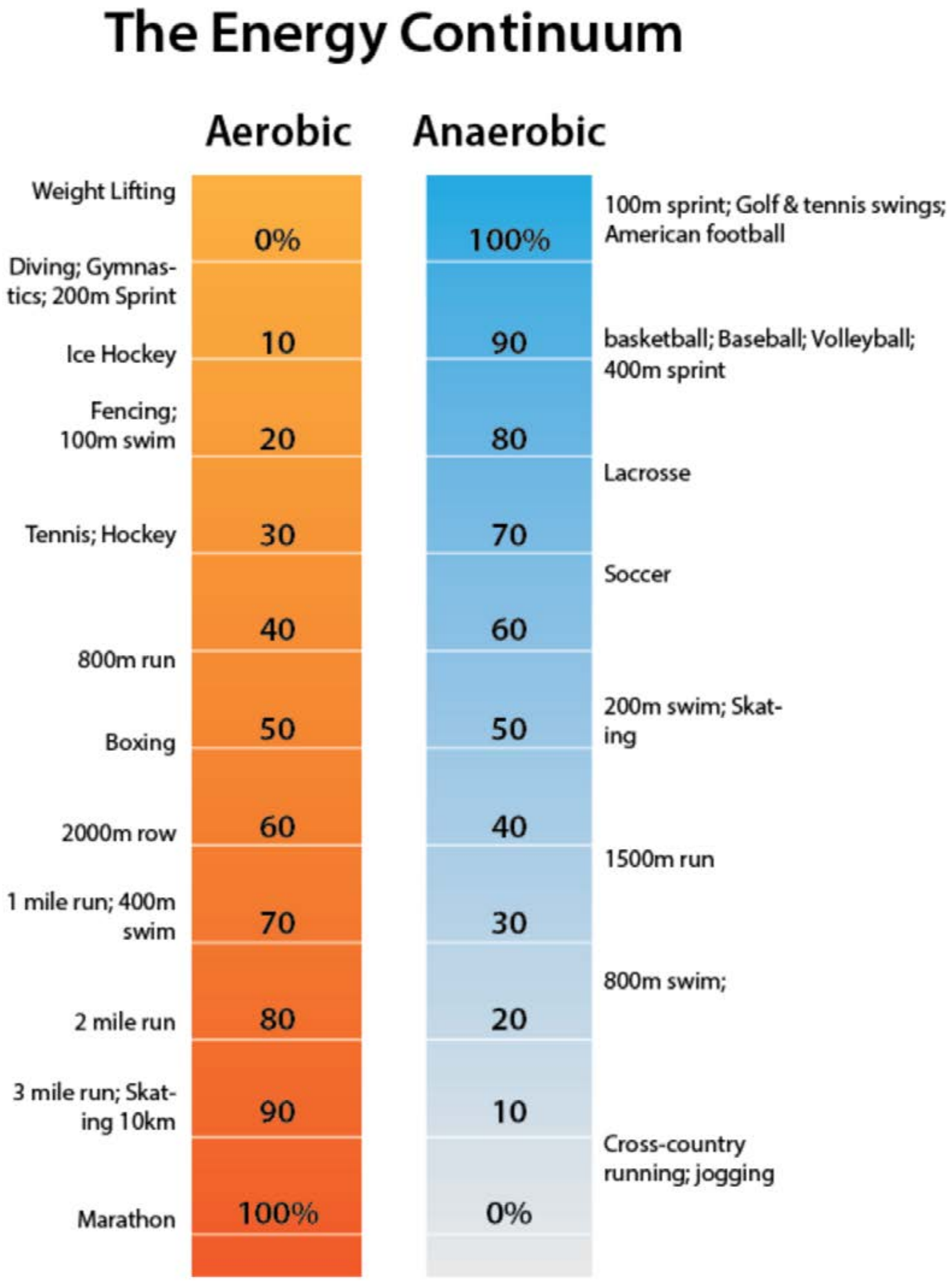


INTERACTION BETWEEN ENERGY SYSTEMS:

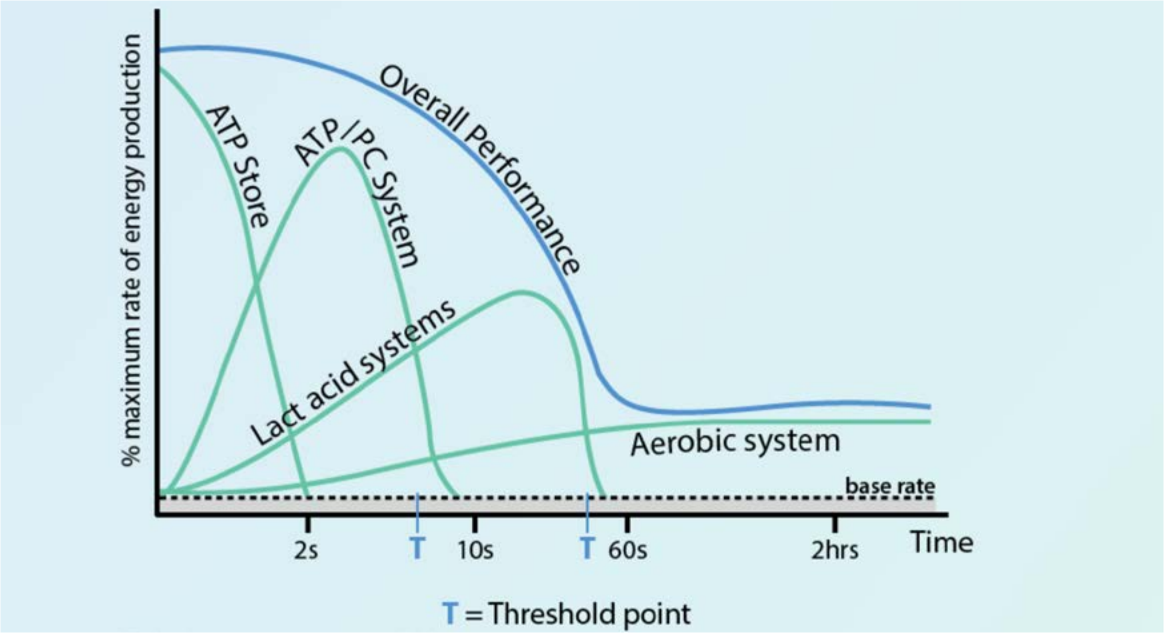
Although the energy systems are presented separately here, it is important to underline that there is considerable overlap between them. In fact, at any one time, all three systems could be providing the body with energy. However, the relative contribution of each is determined by the intensity of the activity.

THE ENERGY CONTINUUM:

While it should be remembered that at no point do we use one of the three energy systems in isolation, it is possible to identify which system is most dominant in any given activity. This is useful when designing sports-specific exercise programs for athletes.



ENERGY SYSTEM	FUEL	BY - PRODUCT	LASTS
ATP	N/A	N/A	Up to 3 seconds
CP System	Creatine Phosphate	N/A	Up to 10 seconds
Lactate System	Carbohydrates (Glycogen/Glucose)	Lactic Acid	Up to 3 minutes
Aerobic (Oxidative) System	Carbohydrates (Glycogen/Glucose) Fats Protein	Carbon Dioxide Water	From 3 minutes



IN SUMMARY

- The energy systems work together to replenish ATP.
- The 3 energy systems are the ATP-PC, Anaerobic Glycolysis and Aerobic.
- The energy systems all work together at the same time to keep replenishing ATP. At no point, will only one energy system will be used, but there is often a predominant system.
- The predominant energy system used during exercise will depend on the intensity and duration of the activity and the individual's levels of fitness.
- ATP-PC system is predominantly used during maximum intensity activities lasting no longer than 10 seconds.
- Anaerobic Glycolysis system is predominantly used for high-intensity activities lasting approximately 1 minute
- The aerobic system is predominantly used during medium to low-intensity activity.
- The predominant energy system being used at rest is the aerobic system.
- The predominant energy system used during exercise will depend on the intensity and duration of the activity and the individual's levels of fitness.
- ATP-PC system is predominantly used during maximum intensity activities lasting no longer than 10 seconds.
- Anaerobic Glycolysis system is predominantly used for high intensity activities lasting approximately 1 minute.
- The aerobic system is predominantly used during medium to low intensity activity.
- The predominant energy system being used at rest is the aerobic system.

TRAINING ADAPTATIONS

Energy Systems and Training Adaptations
Provided the right training stimulus is used, the energy systems show a variety of differing adaptations which ultimately equate to improvements in exercise performance. Many of these adaptations are not fully understood, even today, so for the purpose of simplicity only the principle ones will be discussed below.
Aerobic Training Adaptations

It was discussed earlier that the main limit on aerobic energy production is the ability to take in, transport and utilise oxygen (these will be referred to as pulmonary, cardiovascular and muscular changes respectively). Aerobic training has been shown to enhance all three of these areas:

Pulmonary Changes
Evidence suggests that the principle adaptations associated with the pulmonary system are improvements in the efficiency of the respiratory muscles. This is indicated by an increase in maximal breathing rate and tidal volume (breathing quicker and deeper at maximal intensities). It is also suggested that more efficient respiratory muscles are likely to use less oxygen, produce fewer waste products and thus potentially increase oxygen availability to other working muscles (McArdle et al, 2001).

Cardiovascular Changes
There are a number of training adaptations associated with the cardiovascular system. Firstly, the heart of a trained individual shows significant hypertrophy and improvements in coronary blood flow, thus allowing a greater capacity for work.
The most significant coronary adaptation appears to be an increased stroke volume. This is indicated by a lower resting heart rate and a greater cardiac output at maximal heart rates. These improvements are complimented by an increase in blood plasma volume which may also contribute to the increased stroke volume, and oxygen transport (McArdle et al, 2001).
The larger cardiac output of the heart facilitates a greater flow of blood to the working tissues. However, changes in the control of blood distribution, increased arterial diameter and capillary density also serve to maximise blood flow to the muscles.

Muscular Changes
Improved blood supply to the active muscles is matched by a greater ability of these muscles to extract and utilise oxygen from the blood. In this respect, one of the key adaptations within the muscles is an increase in size and number of mitochondria. Mitochondria are the structures within the muscle cells, where aerobic ATP production takes place, thus bigger and more numerous mitochondria mean greater ATP production.
Furthermore, within the mitochondria, there are significant increases in the volume of aerobic enzymes, which increases the muscles ability to metabolise (breakdown) fat and carbohydrate.

ENERGY SYSTEM DOWNLOADABLE FLOWCHARTS

The Reproductive System

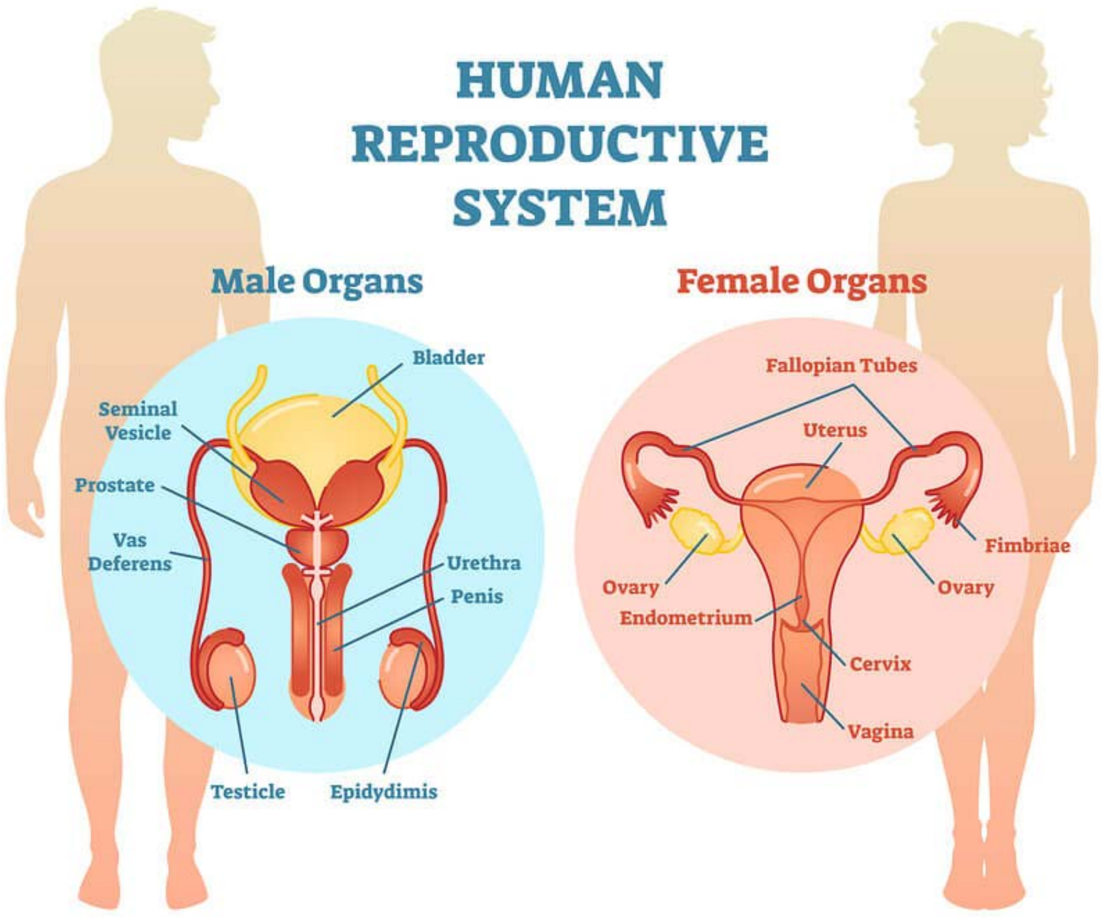
UNIT 1: THE SYSTEMS THAT MAKE UP THE HUMAN BODY (ANATOMY AND PHYSIOLOGY)

FUNCTIONS OF THE HUMAN REPRODUCTIVE SYSTEM

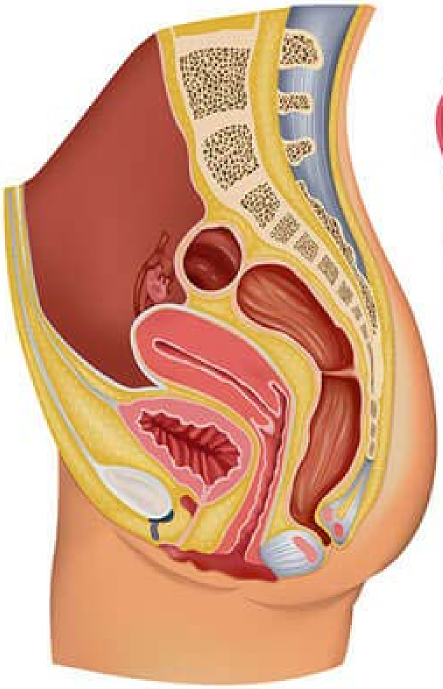
The human reproductive system is how humans reproduce and bear live offspring. The essential features of the human reproductive system are:

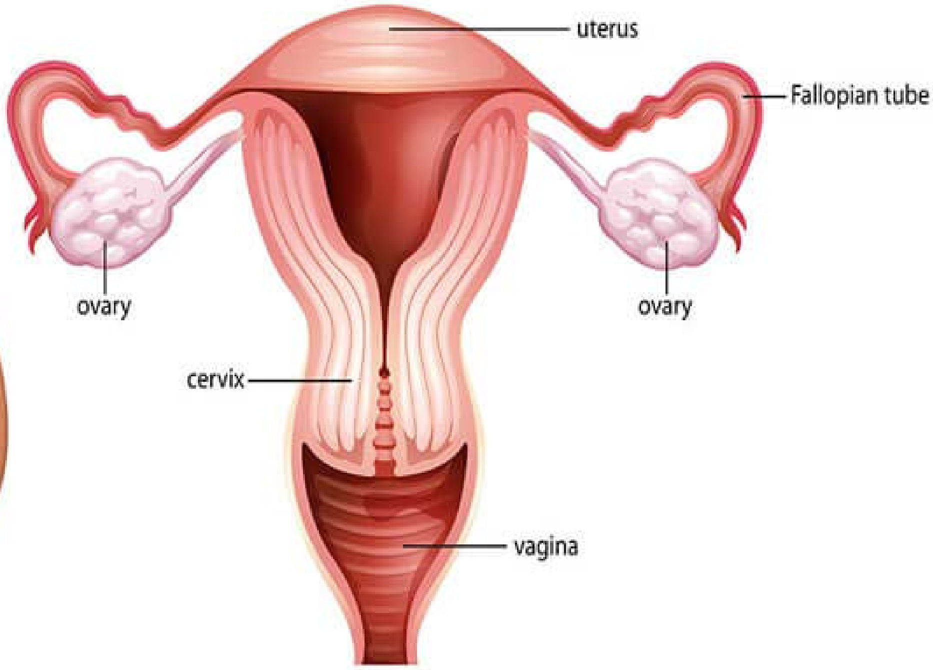
- Liberation of eggs (ovum) at specific times in the reproductive cycle
- Internal fertilization of the egg by sperm cells (spermatoza)
- Transport of the fertilised egg to the womb (uterus)
- Implantation of the blastocyst, the early embryo developed from fertilised egg, imbedded in the lining of the womb.
- Formation of the placenta and the maintenance of the unborn child during gestation.
- Expulsion of the placenta and birth of the child
- Care of the child through suckling (breast milk)
- Eventual return of the maternal organs to their original (near original) state.

For this biological process to be carried out, certain organs and structures are required in both the male and the female.



THE FEMALE REPRODUCTIVE SYSTEM





THE STRUCTURE

The source of the ova (the female germ cells) is the female ovary. In females, the two ovaries are situated in the pelvic cavity. The female reproductive tracts comprise of the: fallopian tubes, the uterus, the vagina, and associated structures.

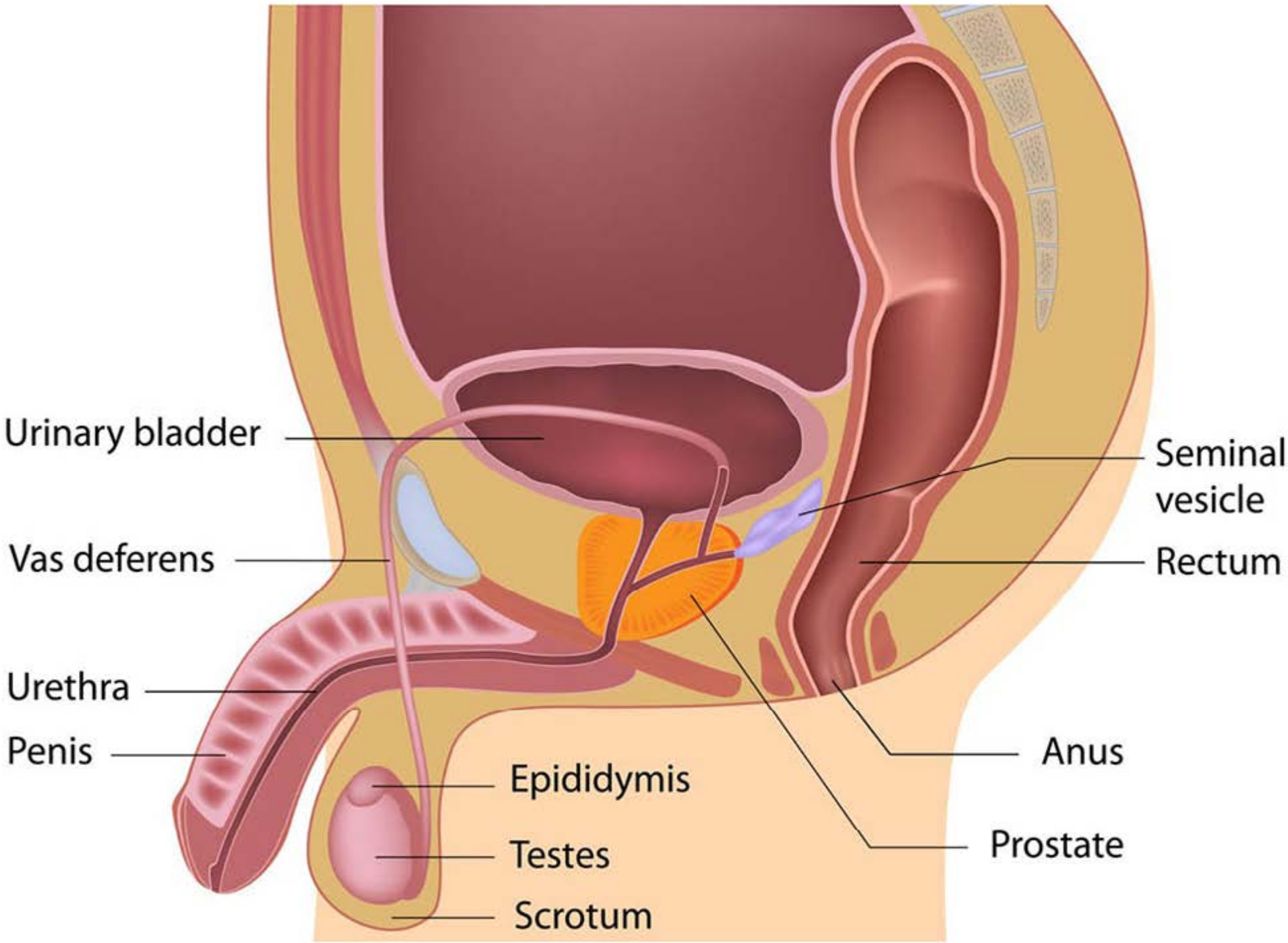
The function of the fallopian tube is to convey an egg (ovum), which is fertilised in the tube, to the uterus, where gestation (development before birth) takes place.

The uterus is located between the bladder and the rectum. It is an organ that is muscular and pear-shaped. It functions to both house and nourishes a fertilised egg through to a foetus.

The cervix is the lowest part of the uterus and attaches the uterus to the vagina creating a passage between the two. The cervix is approximately 4cm (1.6 inches) in length.

The vagina is part of the birth canal and in humans, it also functions as a canal for the expulsion of menstrual products.

THE MALE REPRODUCTIVE SYSTEM



THE STRUCTURE

The source of spermatozoa (the male germ cells) is the testes. In males, the two testes are enveloped in a sac of skin, the scrotum, lying below and outside the abdomen. The male structure comprises of the penis, sperm channels (epididymis, ductus deferens, and ejaculatory ducts), and other related structures and glands in males.

The function of the male ducts is to convey spermatozoa from the testis, to store them, and, when ejaculation occurs, to eject them with secretions from the male glands through the penis.

COPULATION

SEXUAL INTERCOURSE

During sexual intercourse (copulation) an erect penis is inserted into a vagina. Spermatozoa contained in the semen (seminal fluid) is ejaculated into the female genital tract. The spermatozoa pass through the vagina through the uterus and fallopian tubes to fertilise the egg. Females exhibit a periodical cycle of approximately 28 days dispensing eggs which starts at puberty and ends at menopause.

HORMONES

Besides producing the germ cells (eggs and spermatoza), or gametes, the ovaries and testes are the sources of hormones that cause full development of secondary sexual characteristics and also the proper functioning of the reproductive tracts.

The two main sex hormones are: oestrogen (female) and testosterone (male).