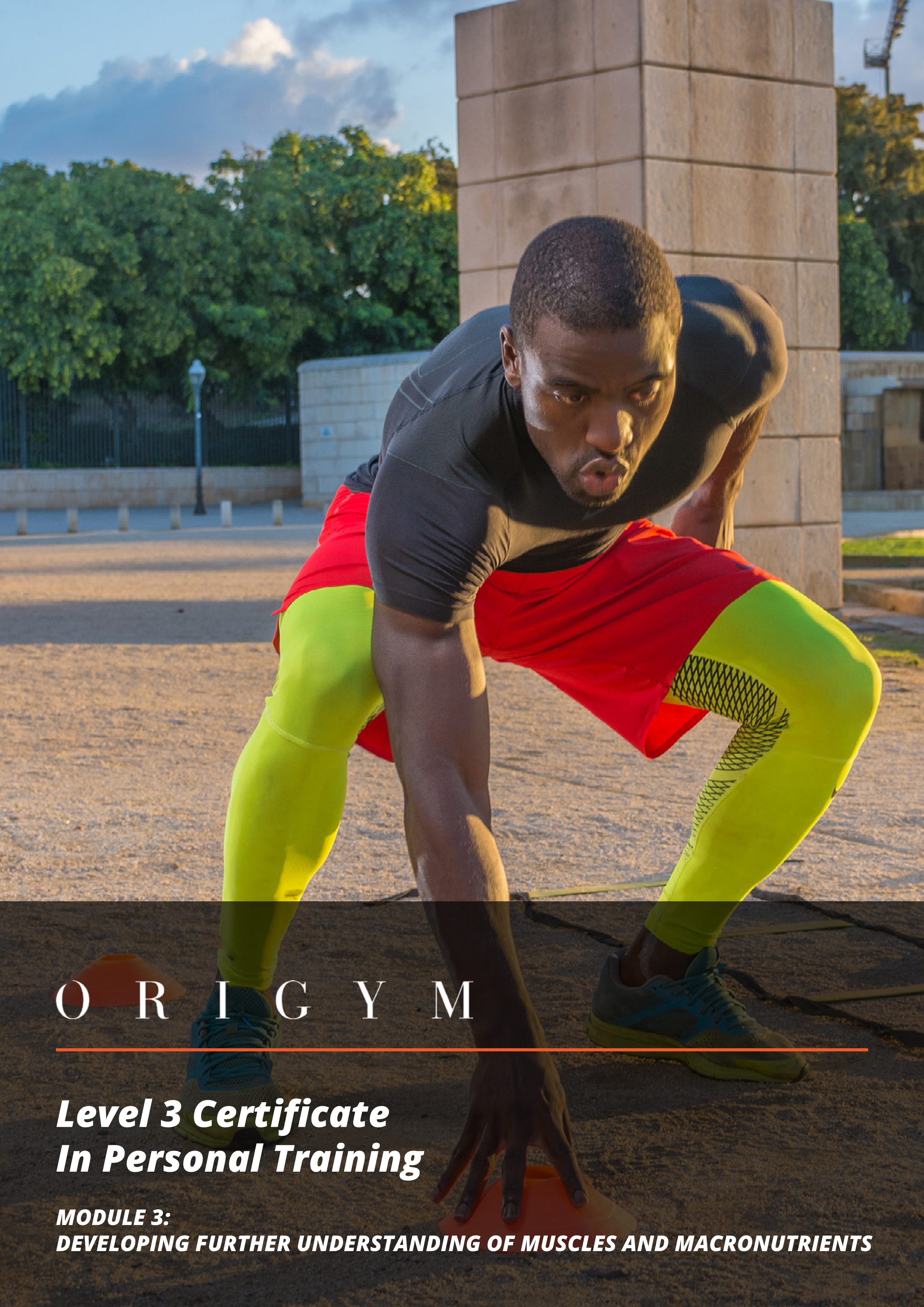

ORIGYM

Level 3 Certificate In Personal Training

MODULE 3:
DEVELOPING FURTHER UNDERSTANDING OF MUSCLES AND MACRONUTRIENTS

CONTENTS

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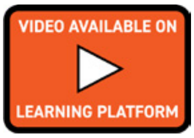


The Nervous System

MODULE 3:
DEVELOPING FURTHER UNDERSTANDING OF MUSCLES AND MACRONUTRIENTS

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 CO2 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 CO2 levels or sweating to reduce body temperature.

There Are Two Main Parts Of The Nervous System:

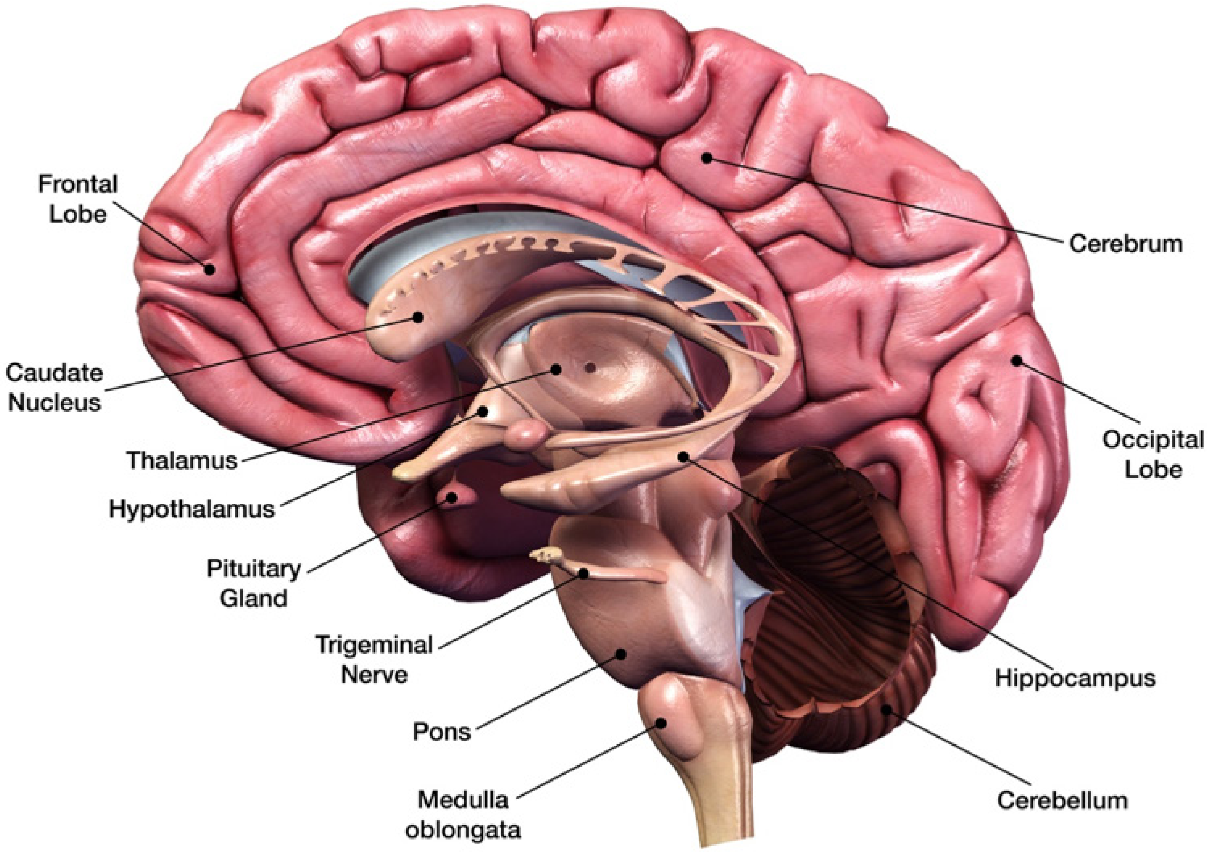
- **The central nervous system or CNS.**
- **The peripheral nervous system or PNS.**

The Brain

The Brain Is Made Up Of <u>Two Hemispheres</u>:

1. **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.

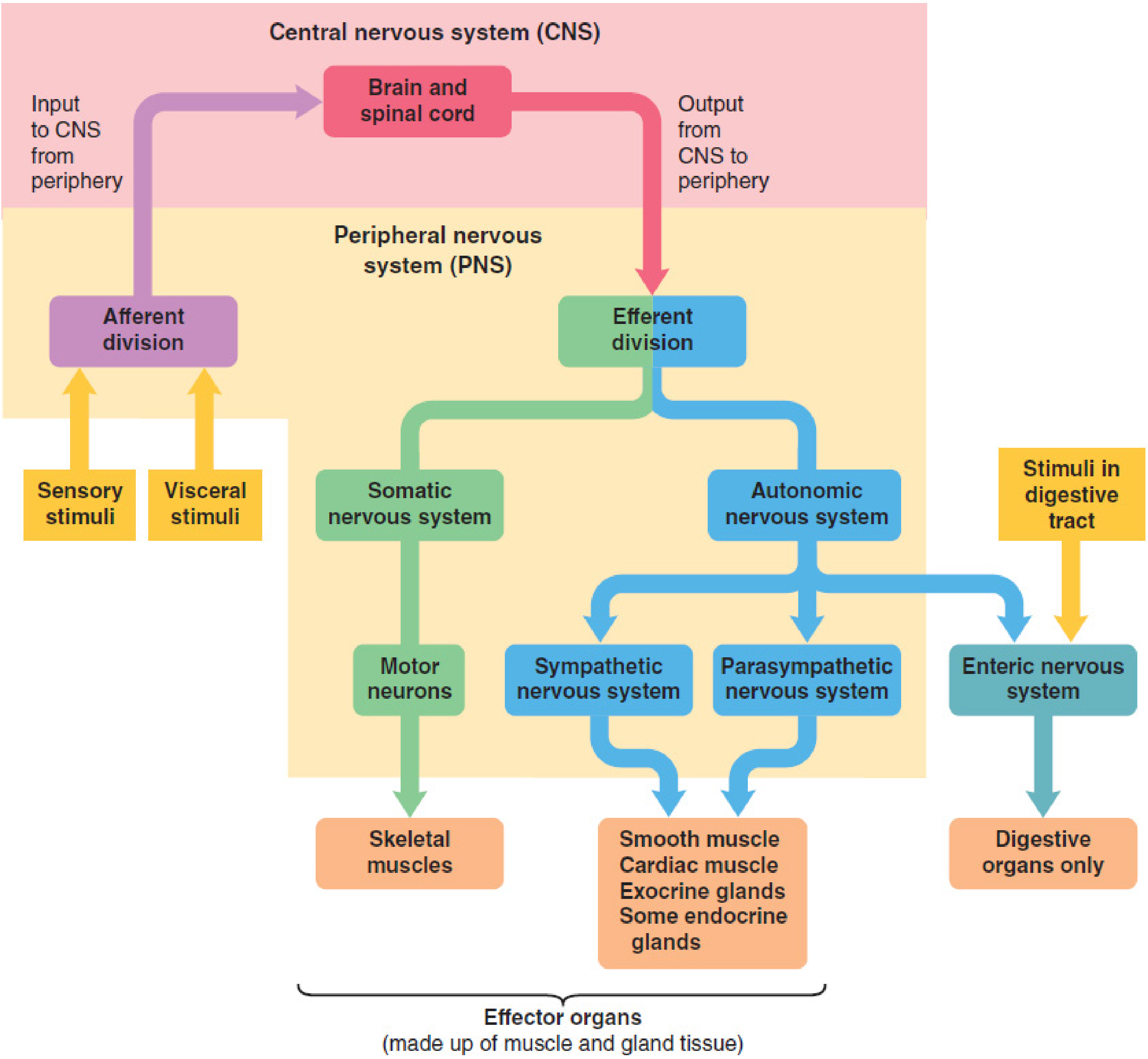
2. **The right side of the brain:** It is responsible for controlling the left side of the body. It also performs tasks that have to do with creativity and the arts.



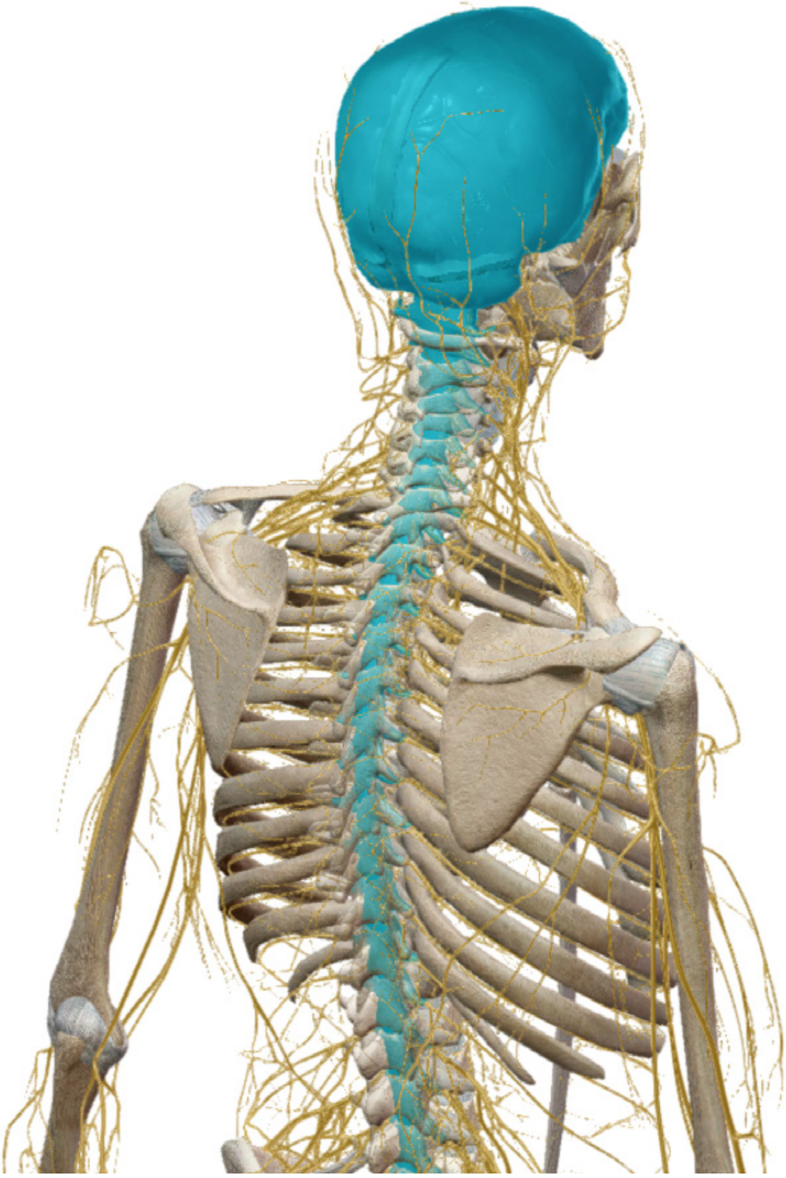
The Brain Has <u>3 Main Parts</u>:

- **Cerebrum:** is the largest part of the brain and is composed of the right and left hemispheres.
- **Cerebellum:** is located under the cerebrum.
- **Brainstem:** 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.

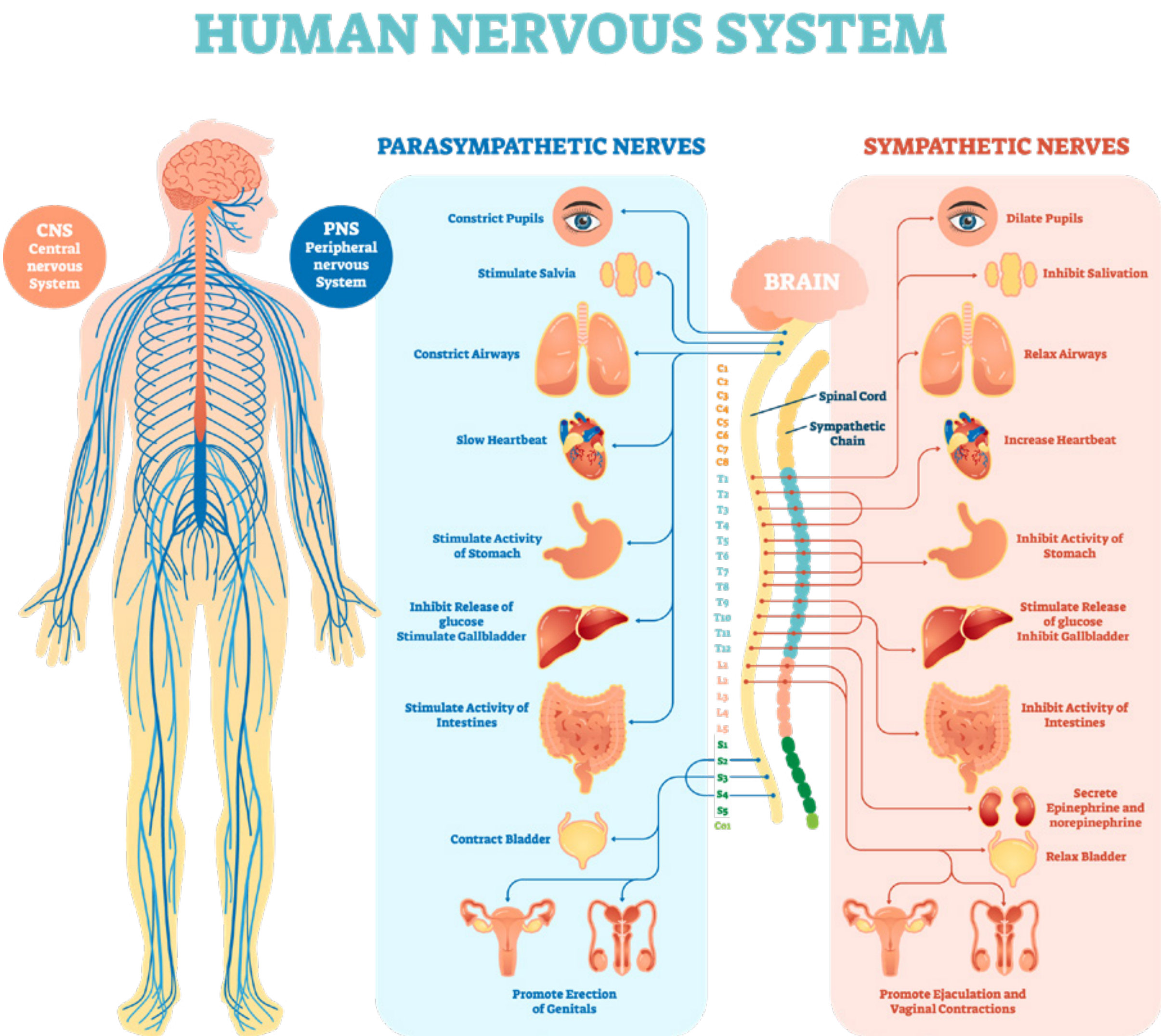
The Peripheral Nervous System

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.

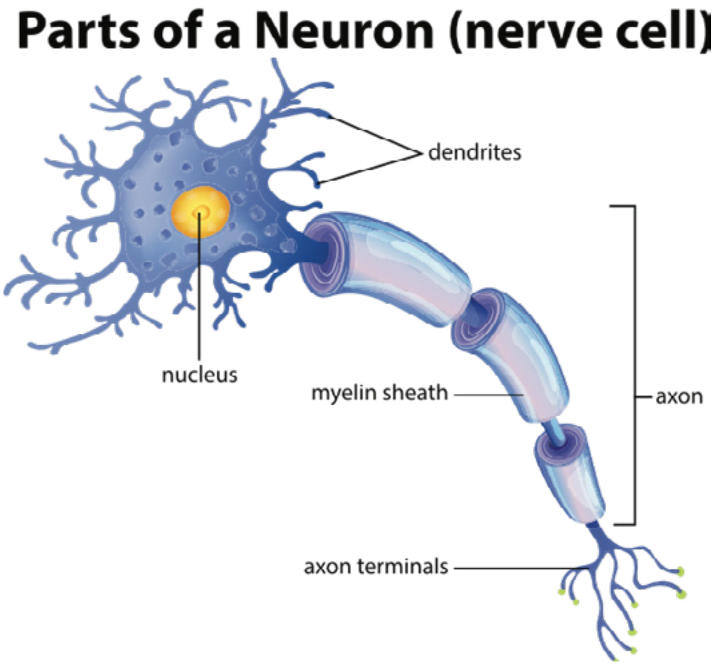
Information is constantly flowing to and from the CNS via the sensory and motor neurons. Both motor and sensory neurons play an important role in muscle contractions.



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 chemicals (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 chemicals that are released from the synaptic left.



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.

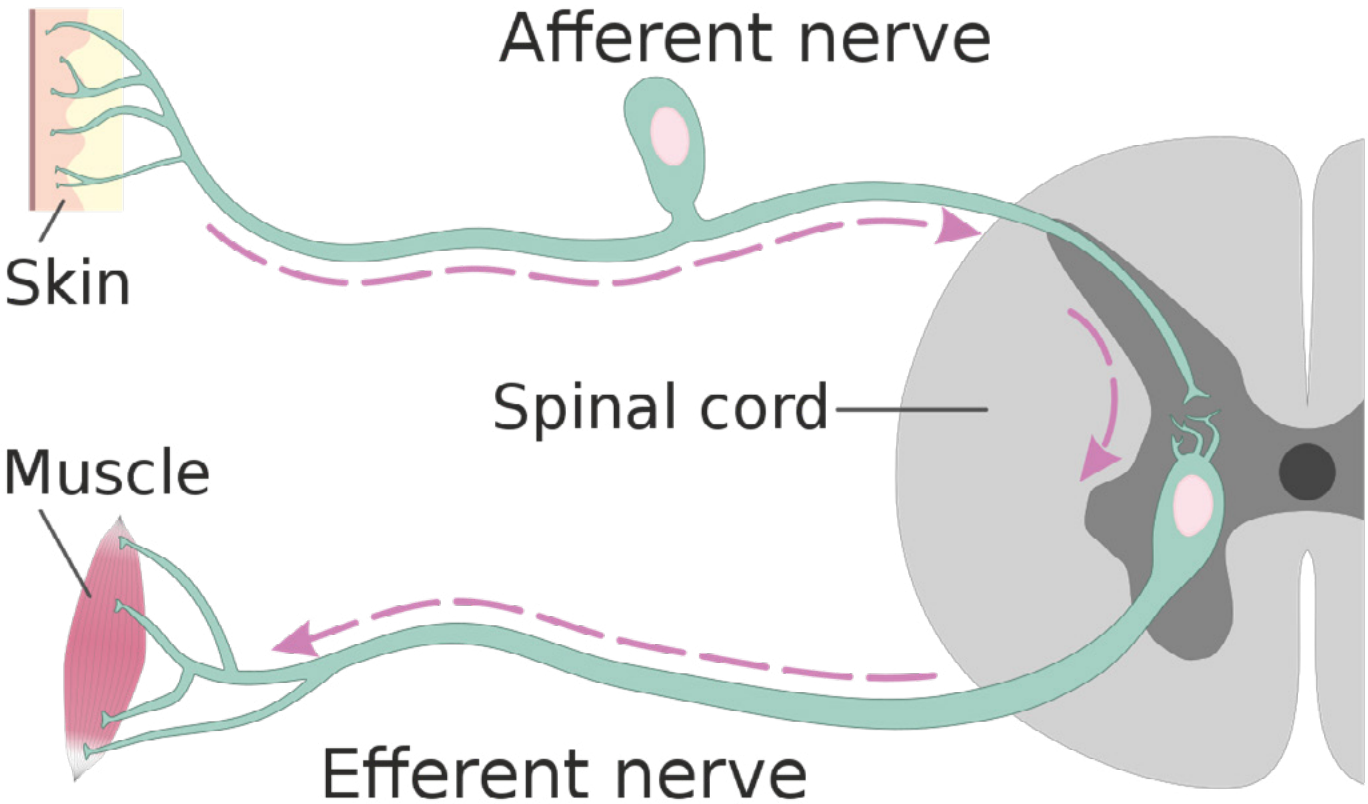
When a neuron is at rest, the outside of its membrane will be positively charged, and the inside is negatively charged. This is known as 'membrane potential'. The high concentration of excess sodium ions outside the neuron membrane cannot enter the cell. Potassium ions line the inside of the cell membrane.

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

Neurontransmitters are stored in small sacs on the end of the dendrites. 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 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

Afferent = Sensory Neurons

Efferent = Motor Neurons

- **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 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.

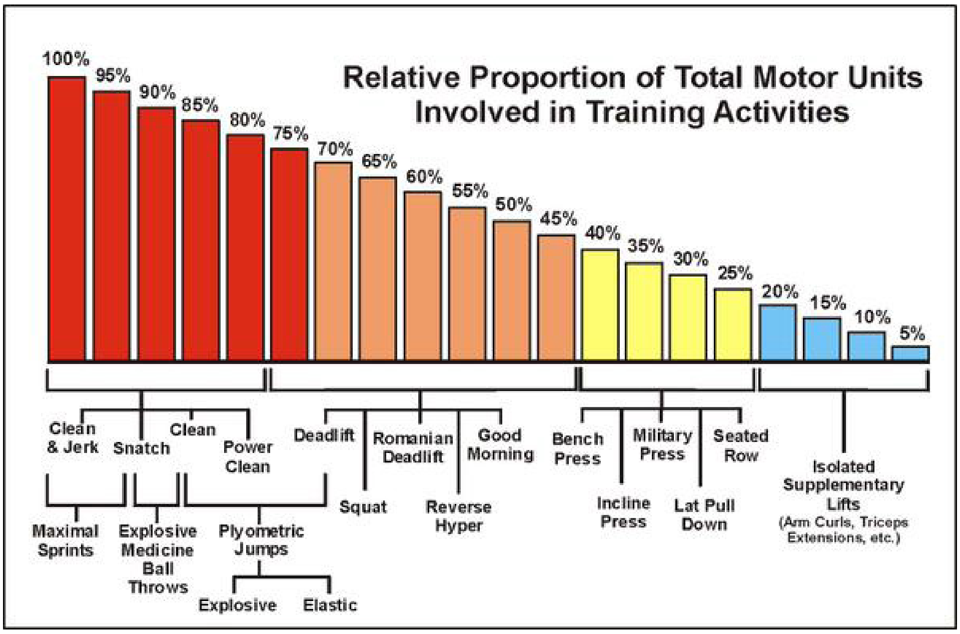
All the muscle fibres innervated by the motor neuron will either work together at the same time or not at all. This is commonly referred to as the "all or nothing" law.

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.

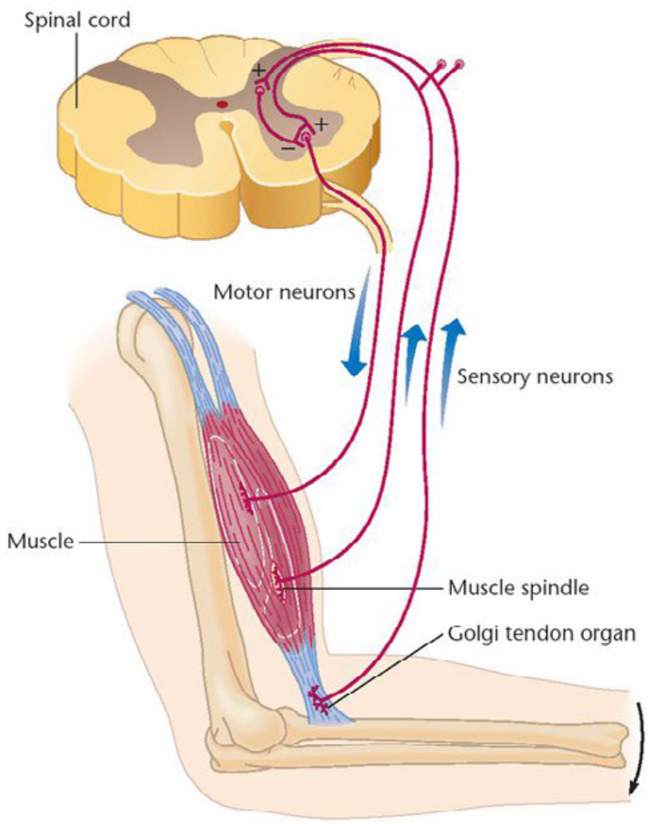
If a muscular task takes an extended period of time, motor units are recruited sequentially or, in other words, one after another. That way, as one motor unit fatigues, another one will take over. In examples of very low-intensity activity, e.g. walking, this sequential recruitment can be almost never-ending 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

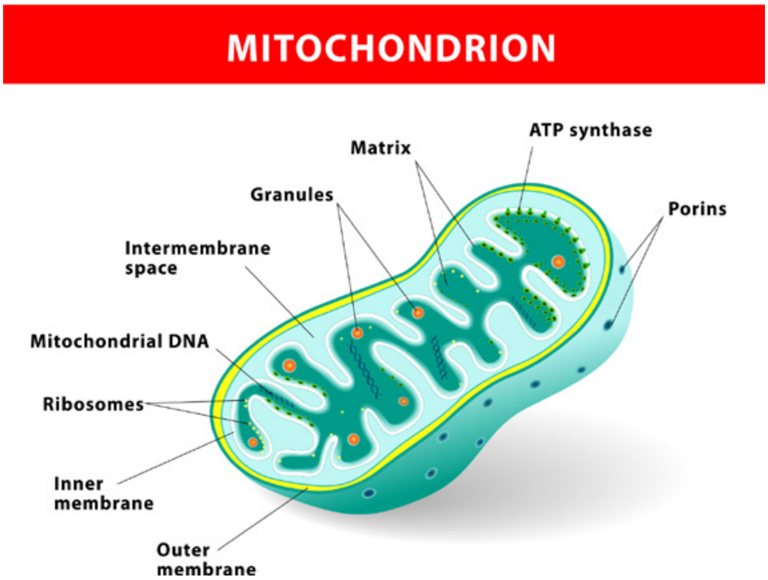
CHRONIC CHANGES

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 coordination
- 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

Connective Tissue

MODULE 3:
DEVELOPING FURTHER UNDERSTANDING OF MUSCLES AND MACRONUTRIENTS

Introduction

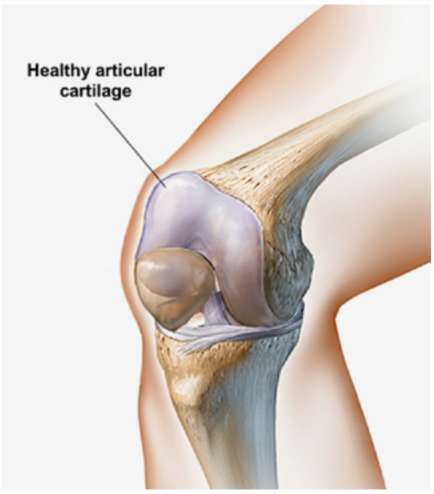
Connective tissue, supports, connects, surrounds, or separates different types of tissues and organs in the body. The bones of the human skeleton form the basic framework for the entire body but need a series of other structures to give the body its shape and functionality.

These structures are:

- Cartilage
- Ligaments
- Tendons

Cartilage

Three types of cartilage found in the body perform separate functions. It is very tough, dense, and fibrous, and these characteristics allow it to withstand great forces of torsion and compression. Despite its strength, it can be worn over time or torn during trauma and has a limited ability to heal itself due to it having no blood vessels of its own therefore a lack of blood supply.



HYALINE (ARTICULAR) CARTILAGE

Found at the end of bones

Characteristics of Hyaline Cartilage

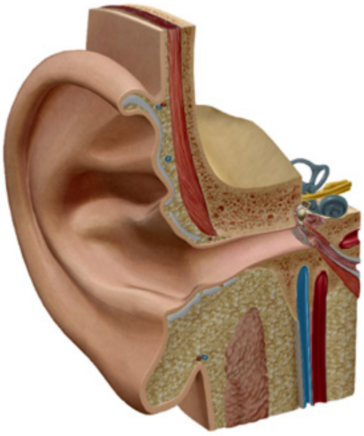
1. The most common type
2. Glossy blue-white in appearance
3. Present in synovial and cartilaginous joints
4. Very tough
5. Smooth and becomes slippery
6. Reduces friction during joint movement

FIBROCARTILAGE

Found in intervertebral discs, joint capsules, and ligaments.

Characteristics of Fibrocartilage

1. The strongest type of cartilage
2. Can act as a shock absorber in joints



ELASTIC CARTILAGE

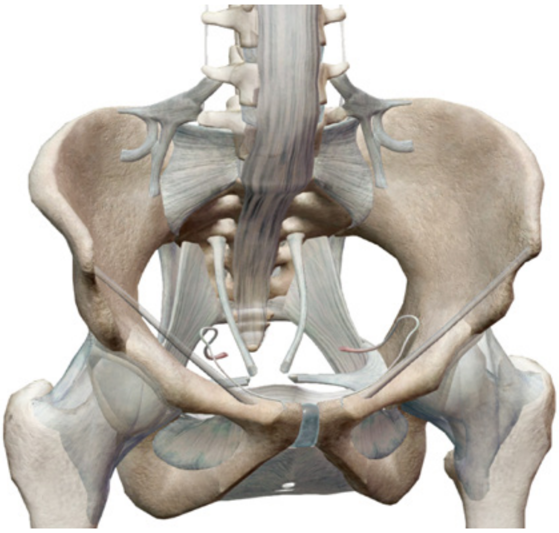
Found in the external ear, epiglottis and larynx.

Characteristics of Elastic Cartilage

1. It has a threadlike network of fibres which contain elastin
2. Elastic properties allow it to return to its original shape
3. Also has collagen fibres to give it strength

LIGAMENTS

Ligaments are white in colour and extremely tough. Their non-elastic fibrous tissue can be either cord-like or strap-like in construction and provide stability to joints. Ligaments help to guide joints through normal movement patterns and also prevent unwanted movement. This means they can endure great tension being placed upon them, although excessive tension can cause damage which is referred to as a tear or sprain.



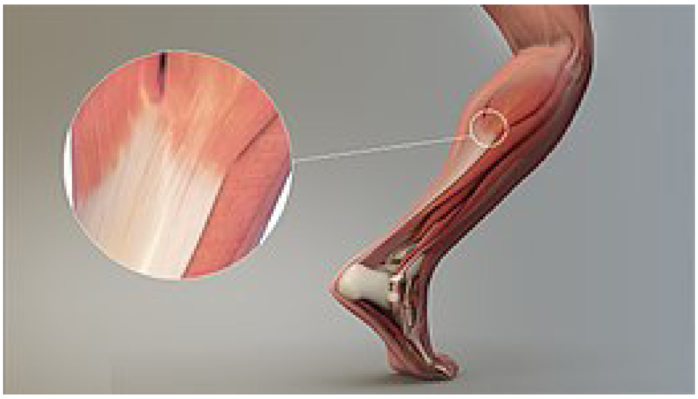
Characteristics of Ligaments

1. Connect bone to bone
2. Provide joint stability
3. Aid joint movement
4. Prevent unwanted movement

TENDONS

Tendons are similar to ligaments in construction. They too can be cord-like or strap-like in construction. Their role is to transmit the forces produced by muscles to allow the bones to act as levers. One tendon can be responsible for the actions of multiple muscles.

Tendons are extremely tough but can be placed under excessive tension which can cause damage, referred to as a tear or strain.



Characteristics of Tendons

1. Connect muscle to bone
2. Enable transmission of force produced by muscles

Blood Supply

Cartilage has a very limited blood supply which means that when damaged it is unlikely to repair. It is common for damaged cartilage to be removed as a surgical procedure.

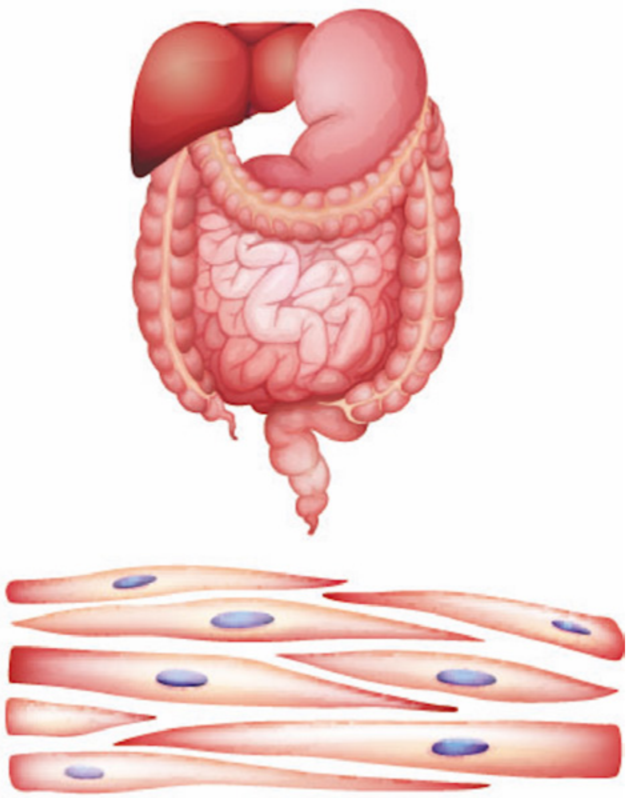
Ligaments have a limited to no blood supply provided from their attachment sites to bone. Therefore the healing time is slow in comparison to **tendons which have a far greater blood supply** gained from the surrounding soft tissues to which they are attached.

The Muscular System

MODULE 3:
DEVELOPING FURTHER UNDERSTANDING OF MUSCLES AND MACRONUTRIENTS

Types Of Muscle Tissue

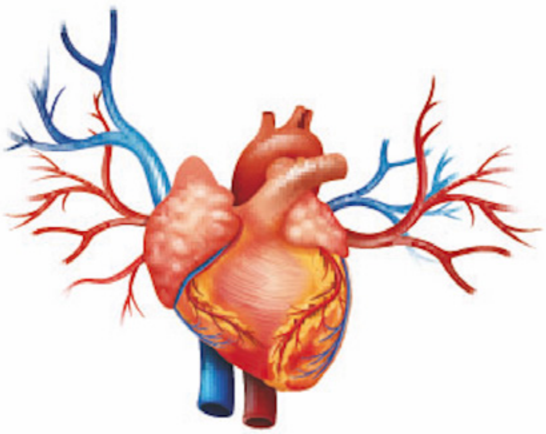
Muscles have the ability to contract, producing movement in the body or maintaining the position of parts of the body. There are three types of muscle tissue:



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.

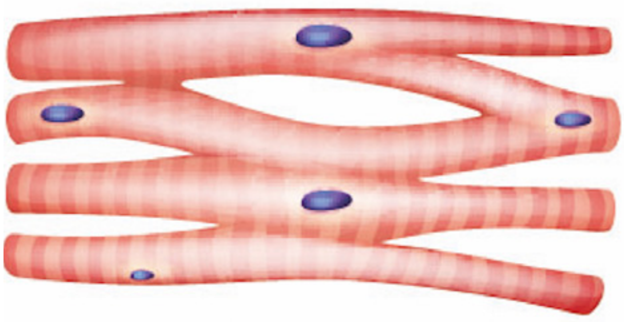
Gastrointestinal Tract
Respiratory Tract
Blood Vessels
Urinary Organs
Reproductive Organs

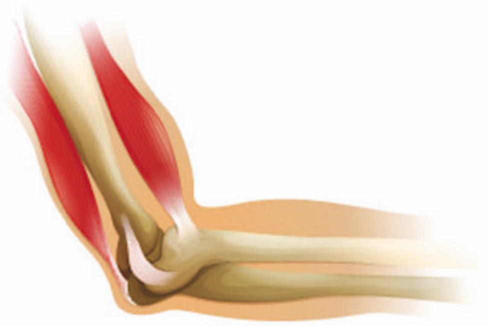


CARDIAC MUSCLE

- Also known as Myocardium.
- Found in the heart.
- Involuntary as it is controlled by the sinoatrial nod.

Myocardium
Coronary Circulation
Conduction System

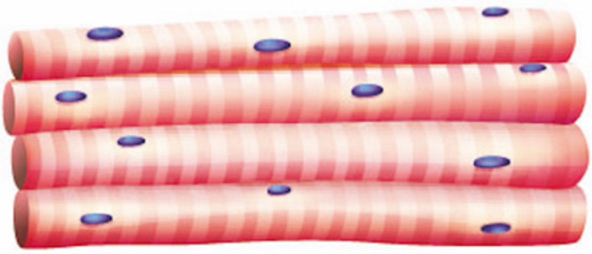




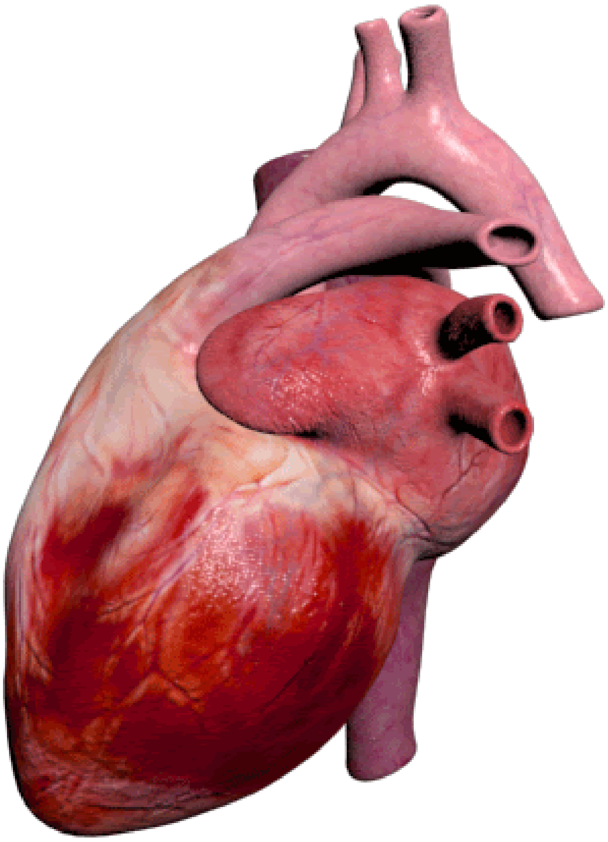
SKELETAL MUSCLE

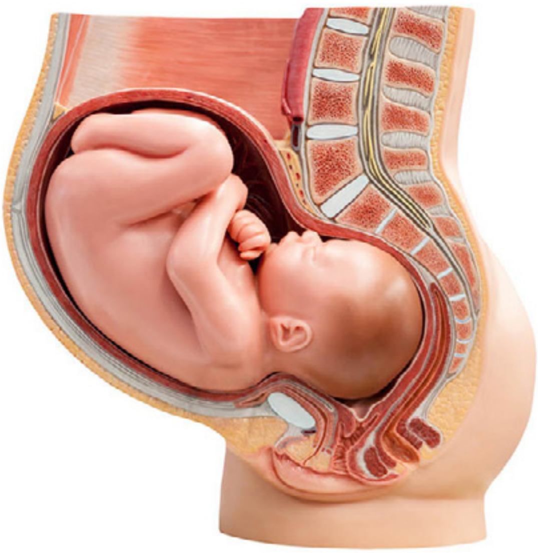
- Represents the majority of muscle in the body.
- Attaches to bone across joints via tendons.
- Produces movements within the body.
- Determines posture by stabilising body position.
- Transports and stores substances within the body.
- Generates heat,
- Voluntary as it is controlled by the somatic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

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.

Respiration

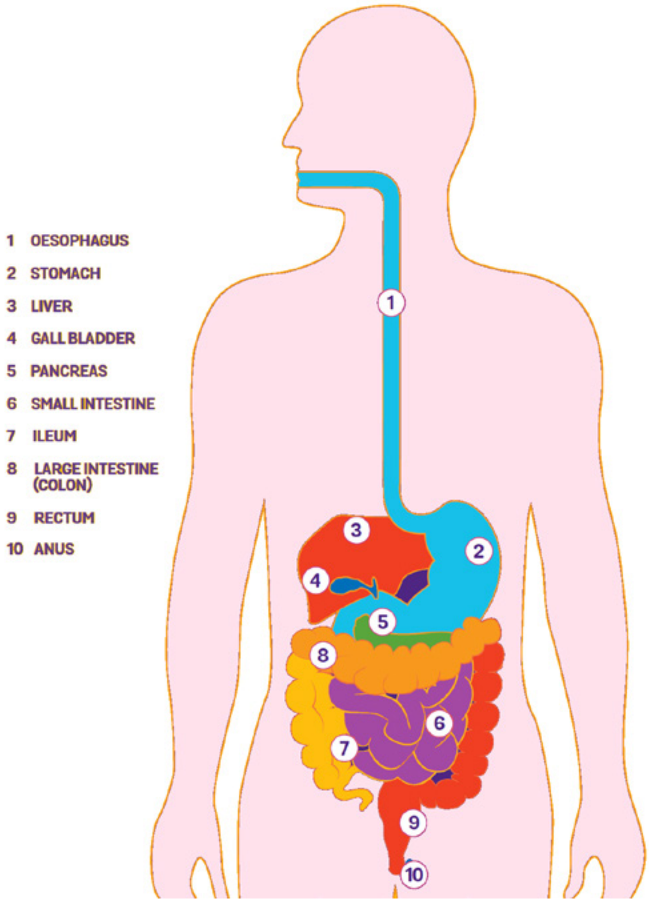
Your diaphragm is the main muscle at work during breathing. Heavier breathing, like what you experience during exercise, may require accessory muscles to help the diaphragm. These can include the abdominal, neck, and back muscles.

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

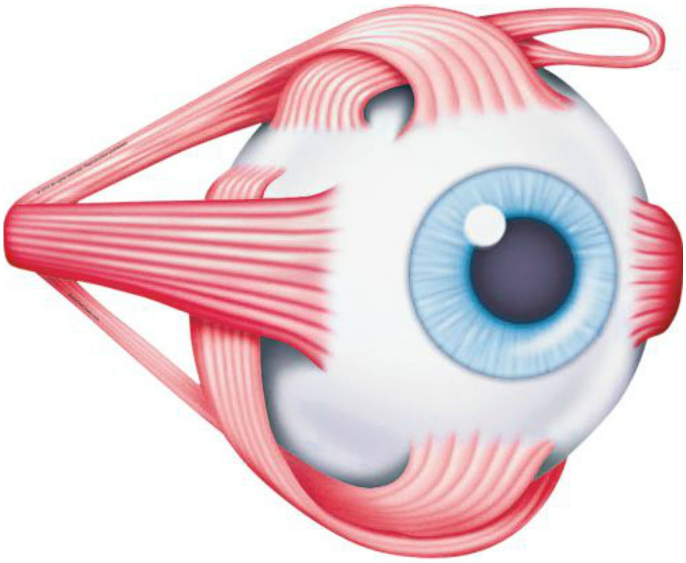
Digestion is controlled by smooth muscles found in your gastrointestinal tract. This comprises the: **Mouth, Oesophagus, Stomach, Small and large intestines, Rectum and Anus**. The digestive system also includes the liver, pancreas and gallbladder. The smooth muscles contract and relax as food passes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

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.**



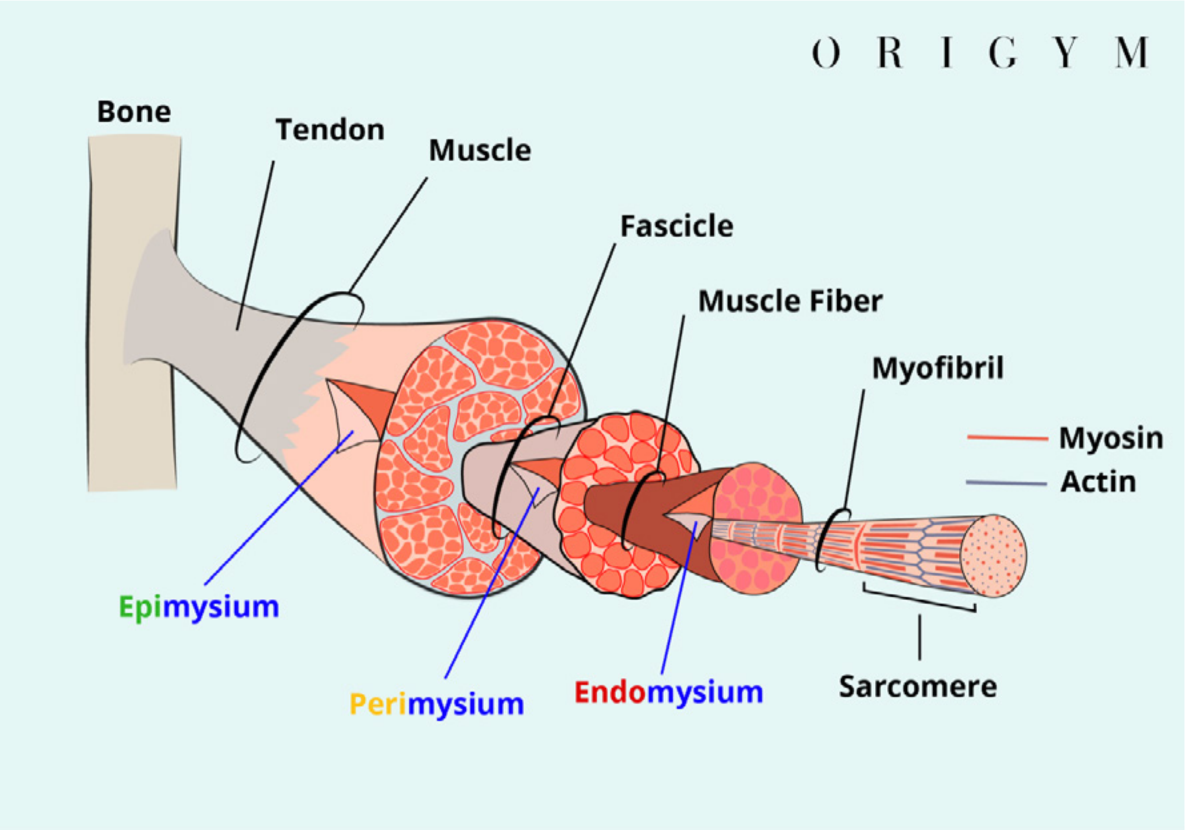
Vision

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.

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.



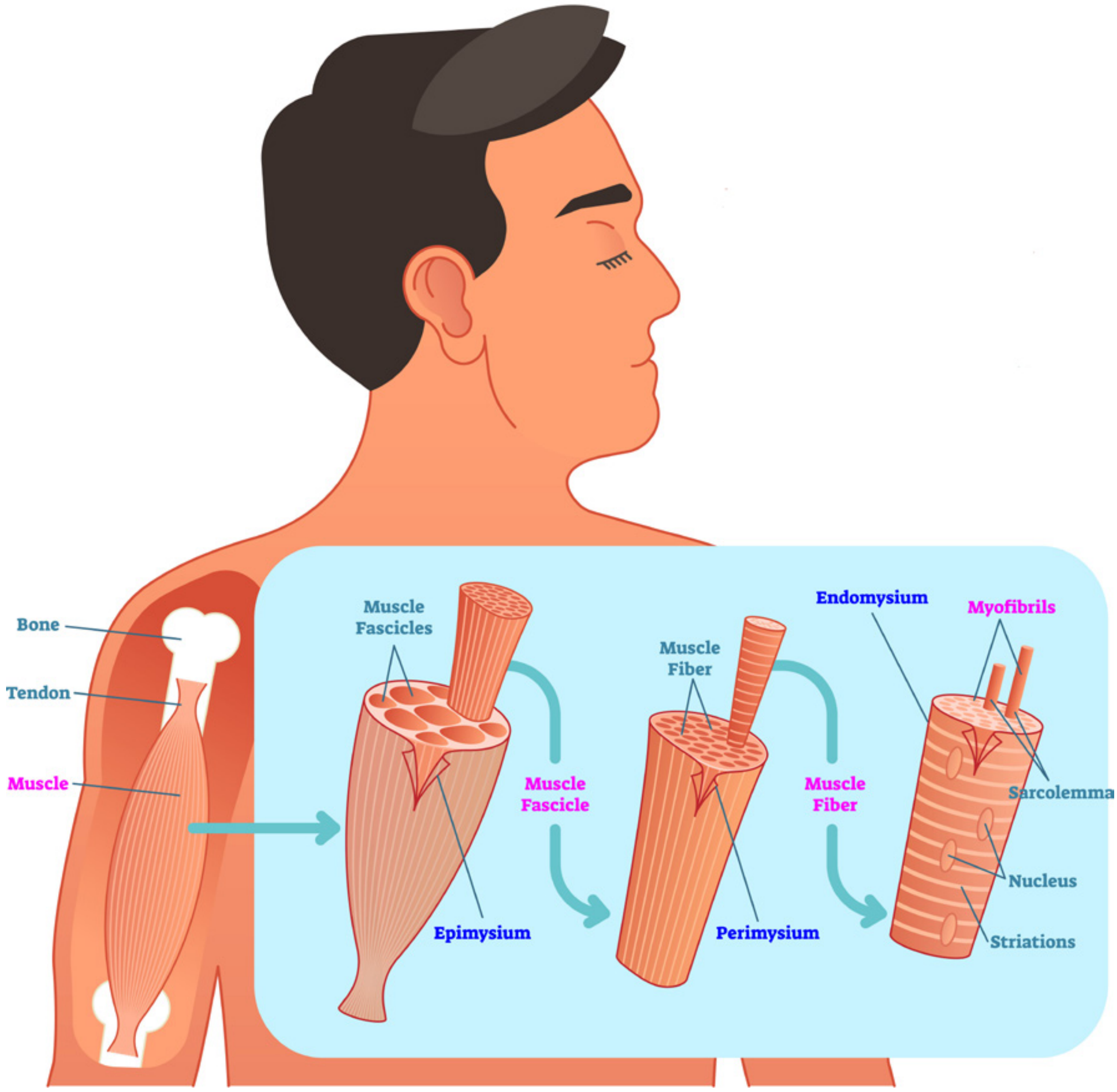
Skeletal Muscle Anatomy

here 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)

1. Muscle = GROUP OF FASICLES = Epimysium
2. Muscle Fascicle = GROUP OF MUSCLE FIBRES = Perimysium
3. Muscle Fibre = GROUP OF MYOFIBRILS = Endomysium
4. Myofibril = GROUPS OF ACTIN AND MYOSIN in a chain = Sarcolemma

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

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Muscle Contraction Overview

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The Sliding Filament Theory

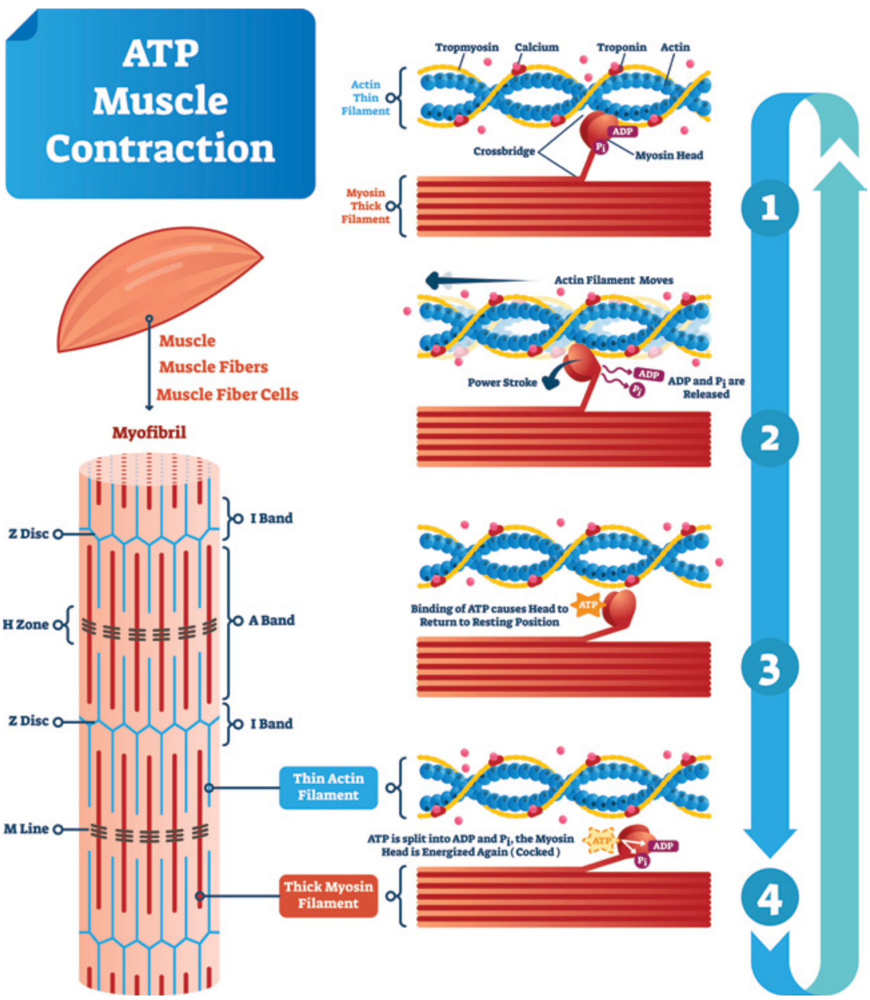
The ability of skeletal muscle to contract is dependent on the movement of **protein myofilaments**:

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.

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In Summary:

The Phases of the Sliding Filament Theory

- Binding - the myosin head attaches to the binding site.
- Power stroke/contraction phase - the myosin head pulls on the actin filament and moves inwards (ADP & Pi Released).
- Recovery - the myosin head detaches from actin and is free to bind with another site.
- Cocking - the myosin head re-energised by ATP splits into ADP and Pi (inorganic phosphate)

Myosin And ATP

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.

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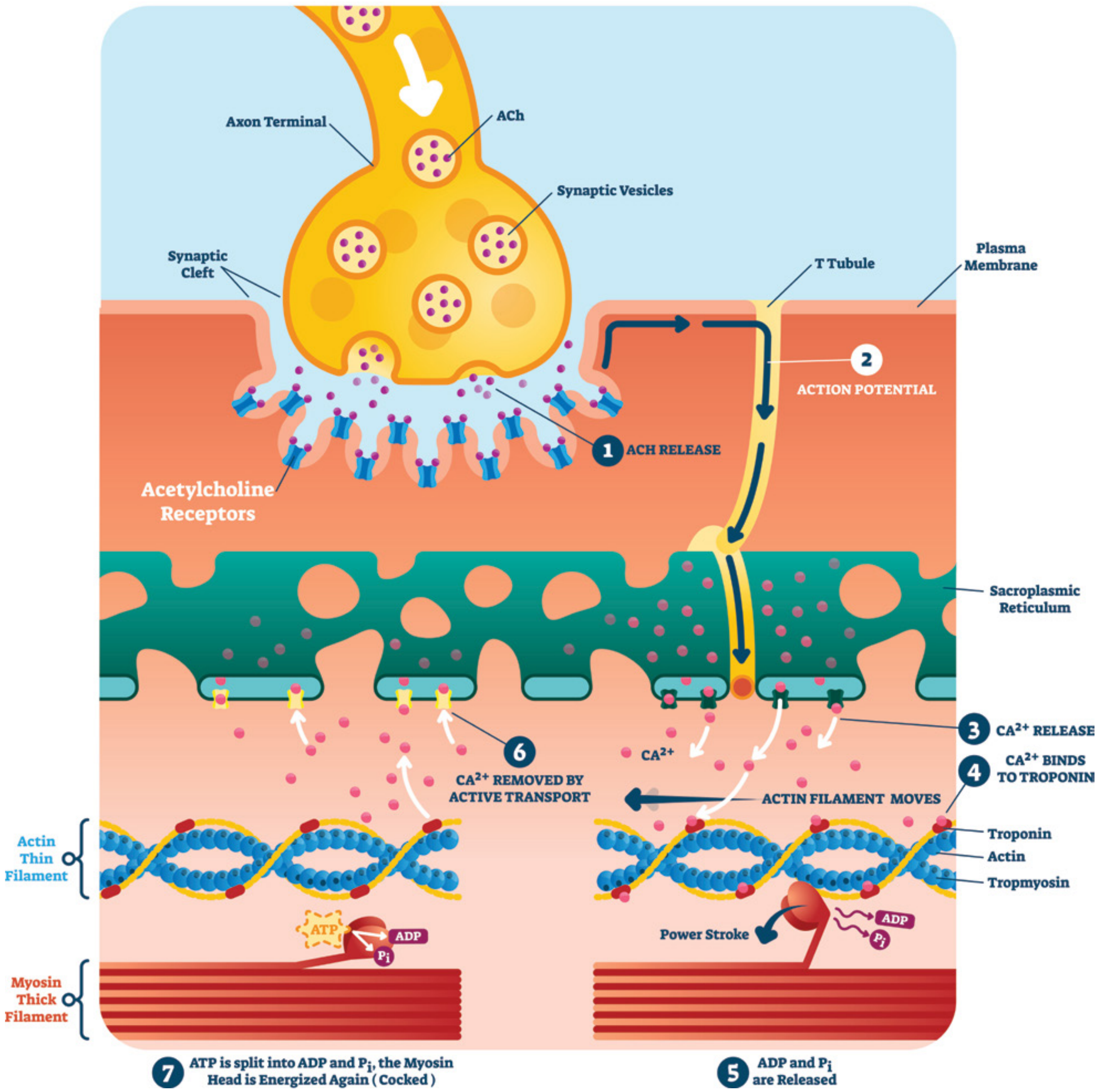
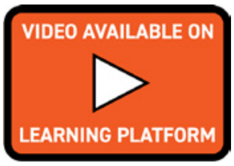
Action Potentials

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.

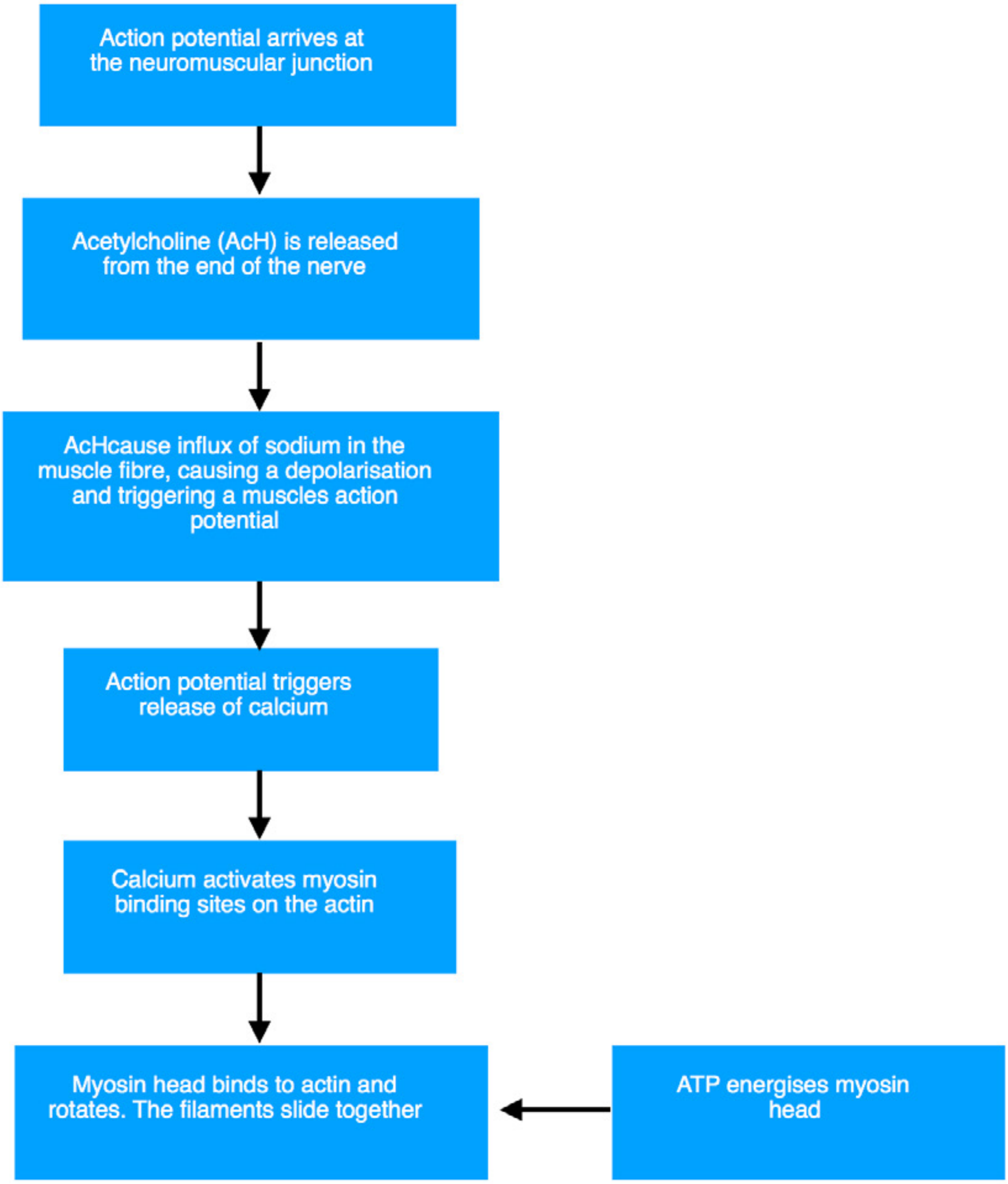
The arrival of an action potential at the neuromuscular junction (where the nerve meets the muscle) causes the release of a neurotransmitter; acetylcholine. Acetylcholine causes sodium to rush through the muscle membrane. This results in a reversal of electrical activity (depolarisation), which if large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



Initiation of a Muscle Action



Summary - Initiation of a Muscle Action



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:

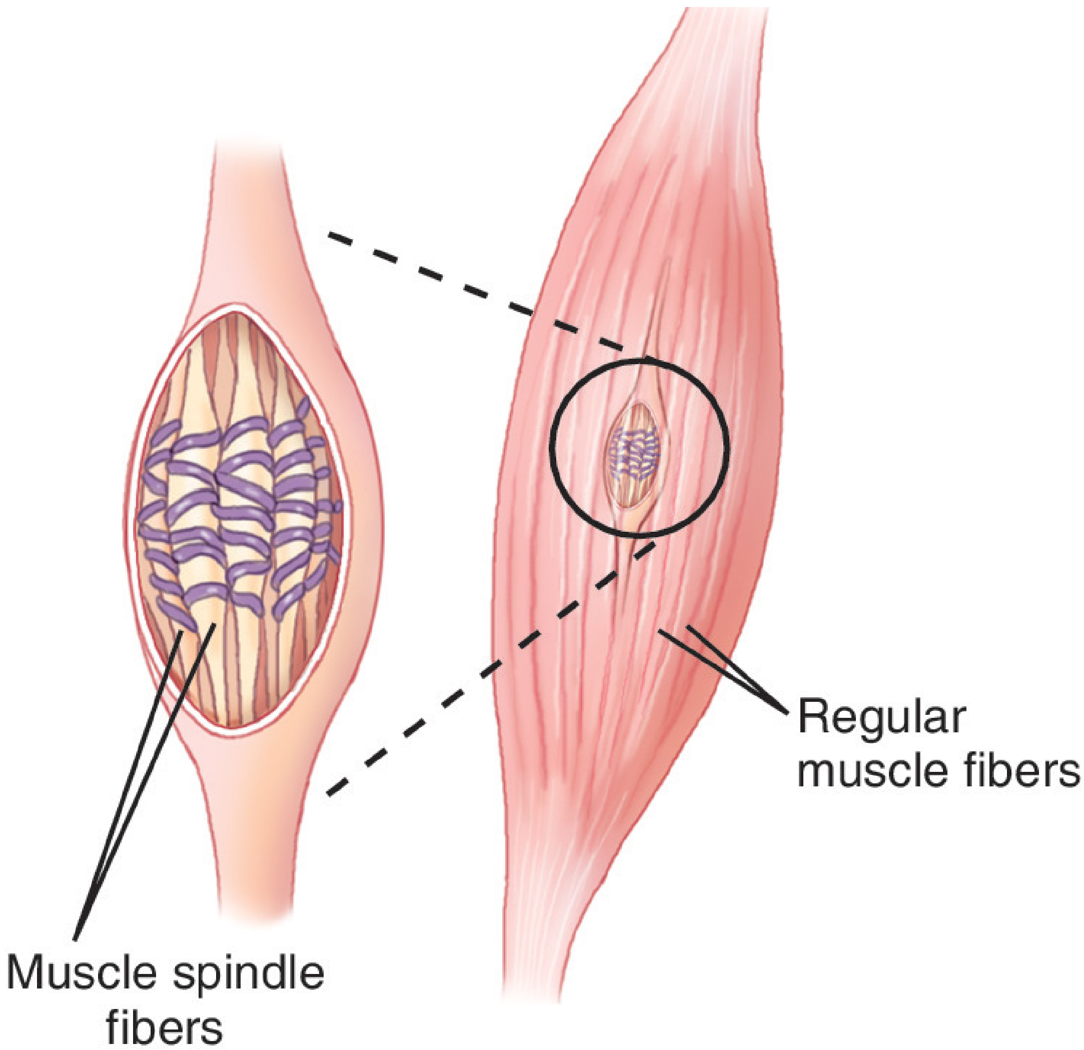
- Muscle spindles
- Golgi Tendon Organs (GTO)

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.

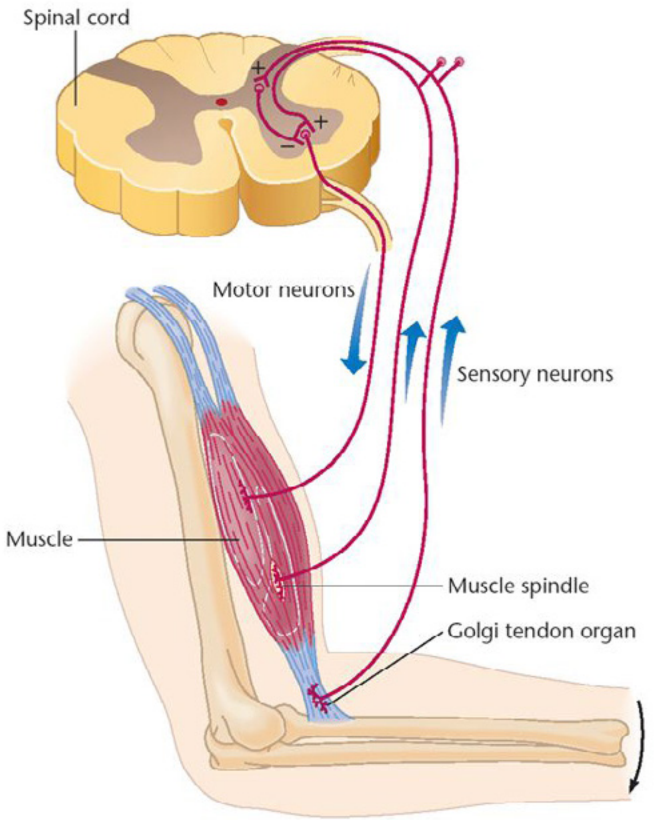
This process is often referred to as the stretch reflex.

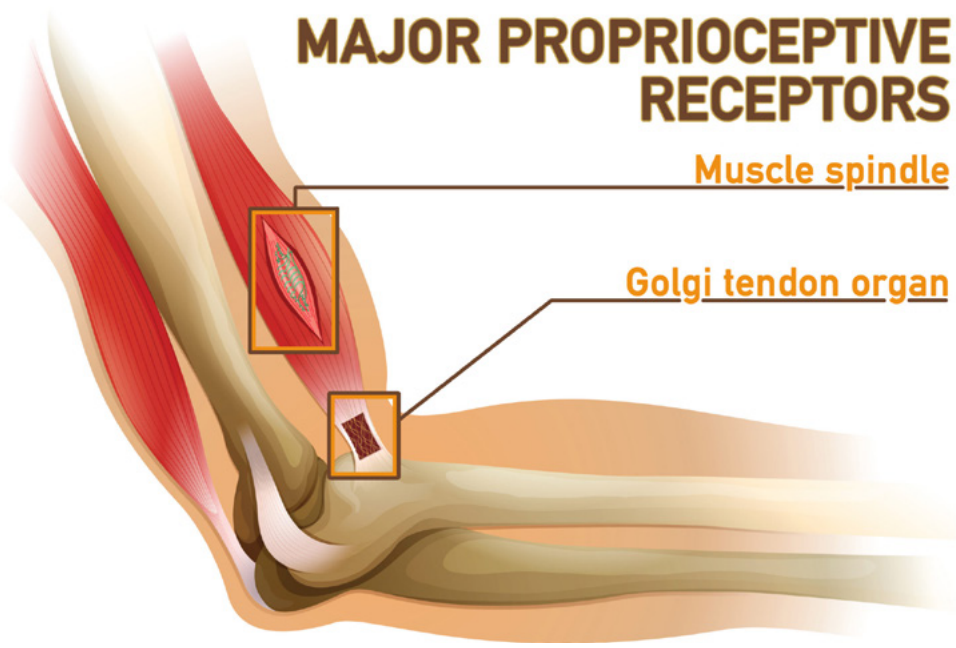


The Golgi Tendon Organ (GTO)

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.





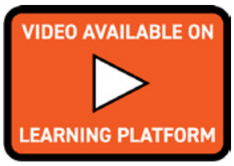
The muscle spindles will be continually activated during human movement as the muscles will be changing lengths in conjunction with the movements being carried out. This is providing a constant stream of valuable information to the CNS about muscle length and where body parts are in space. The spindles 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.

The Stretch Reflex

The stretch reflex is the contraction of a muscle that occurs in response to its stretch. It is not controlled by higher functioning centre i.e. the brain, and is a monosynaptic response that is transmitted to the spinal cord. 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.

Reciprocal Inhibition

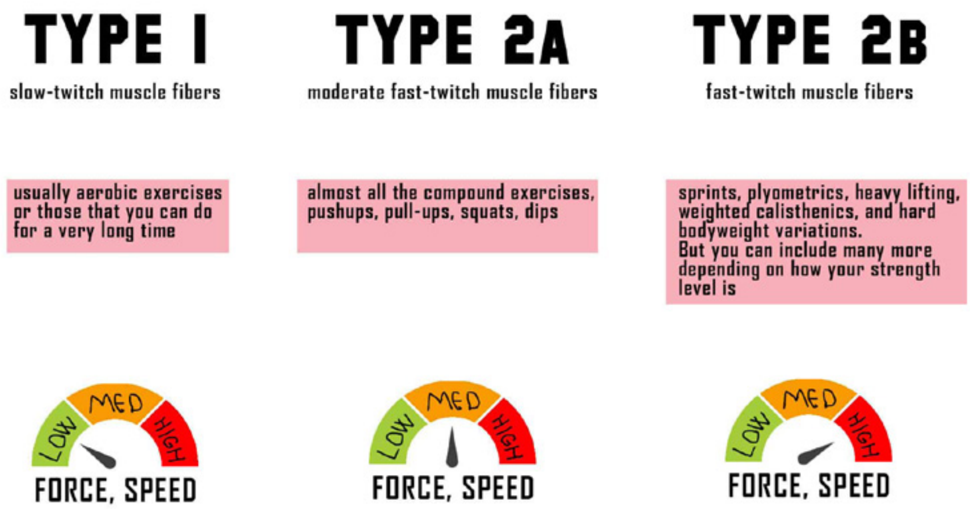
Reciprocal inhibition (RI) is a neuromuscular reflex that inhibits opposing muscles during movement. For example, if you contract your elbow flexors (biceps) then your elbow extensors (triceps) are inhibited. Consider this, when a muscle is causing its primary actions to occur the opposing muscles need to be switched off (relaxed) to allow that movement to take place. 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.



Muscle Fibre Types

MODULE 3:
DEVELOPING FURTHER UNDERSTANDING OF MUSCLES AND MACRONUTRIENTS

Types Of Muscle Fibre



There are several categories of muscle fibre types however there are three main distinct types of skeletal muscle fibres. The fibres are categorised depending on the functions that they perform. Distinct fibre types have been classified according to these following characteristics:

Classification	Structure	Function	Activities
Type 1: Slow twitch (slow oxidative)	• Red coloured • Smallest diameter • Large myoglobin content • Many mitochondria • Many capillaries	• Increased aerobic delivery • Produce less force • Resistant to fatigue • Slow contractions	• Maintenance of posture • Endurance based activity
Type 2A: Fast twitch A (fast oxidative)	• Red/pink colour • Larger diameter • Large myoglobin content • Many mitochondria • Many capillaries	• Requires aerobic delivery • Produce more force • Less resistant to fatigue • Fast contractions	• Walking • Running • Sprinting
Type 2B: Fast twitch B (fast glycolytic)	• White/pale • Largest diameter • Small myoglobin content • Fewer mitochondria • Fewer capillaries	• Anaerobic delivery • Produce most force • Least resistant to fatigue • Fastest contractions	• Throwing • Jumping • Weight lifting

Muscle Fibre Type Considerations

Muscles contain a mixture of muscle fibre types. The activities performed will determine the proportion of each fibre type contained within. Muscles which are used to support the body will contain more type 1 fibres, such as the muscles that support the back and the head.

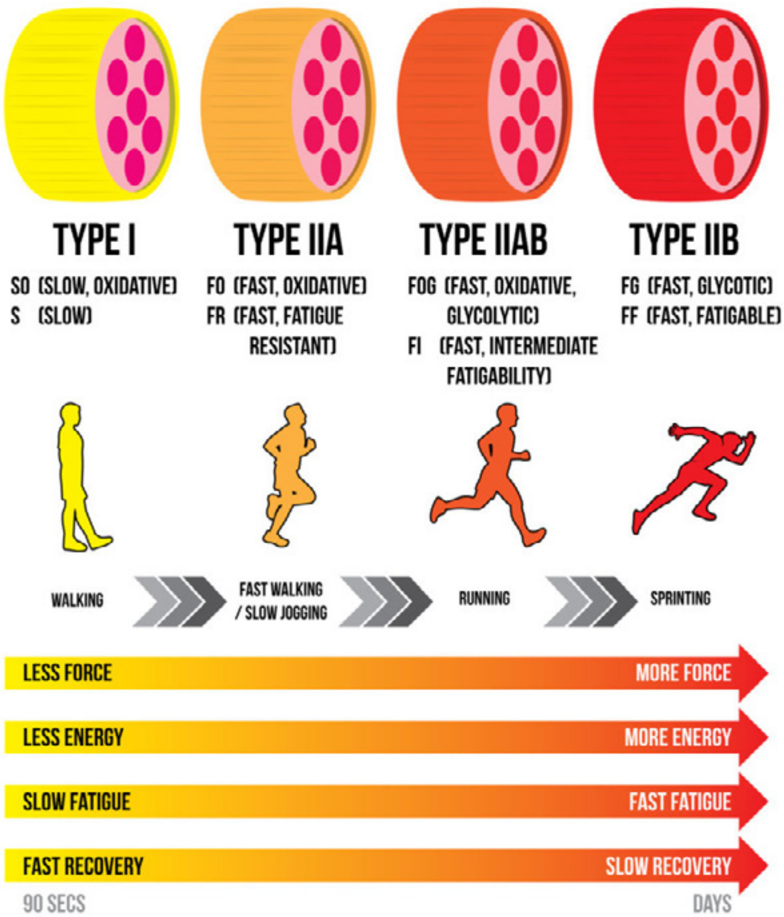
In contrast, the muscles responsible for the force generated by the arms and shoulders will contain more type 2 fibres. The muscles of the legs have a more even distribution of both fibre types as they must generate movement and support the structure of the body parts above.

Each person will have different fibre type combinations and no two persons are the same. The athletic ability of each individual will depend on these fibre combinations, which explains the fact that some people excel at endurance activities and others at power disciplines.

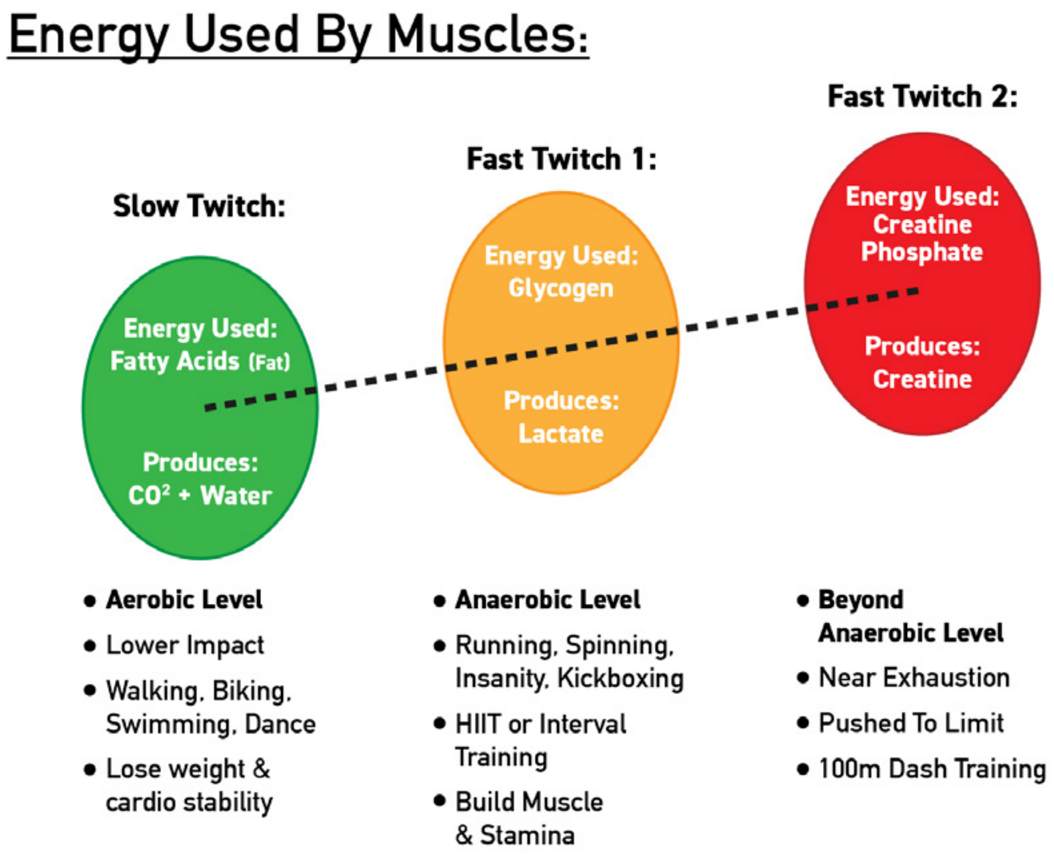
Appropriate training can develop the size and capacity of both muscle fibre types.

It is possible to transform one fibre type to another with an appropriate shift in training. An increase in aerobic exercise will result in a gradual change from type 2B fibres into type 1 fibres. The opposite will occur with an increase in resistance training.

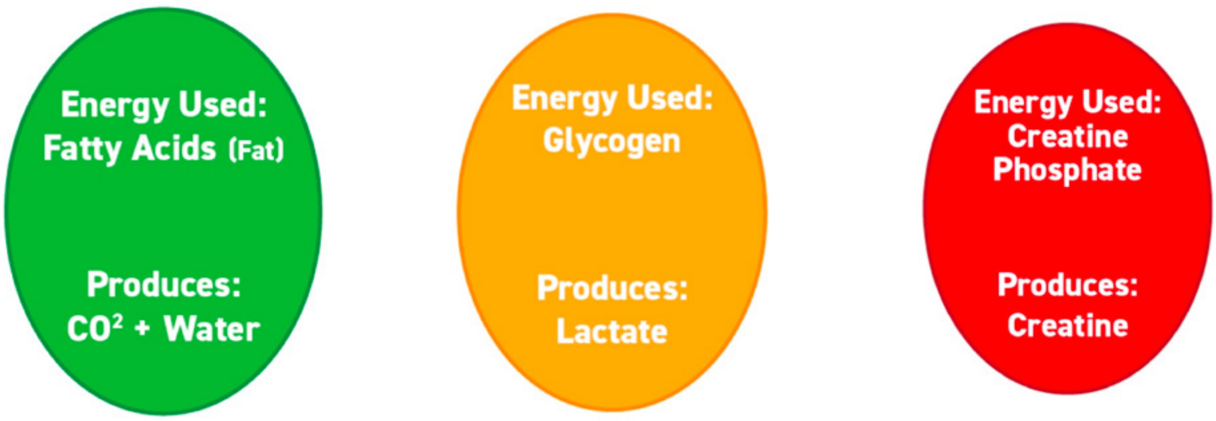
The image below shows an additional variation in muscle fibres:



Energy Consumption



The Interchangeable Names for Muscle Fibres



Type I Muscle Fibres

- Type 1
- Slow Twitch

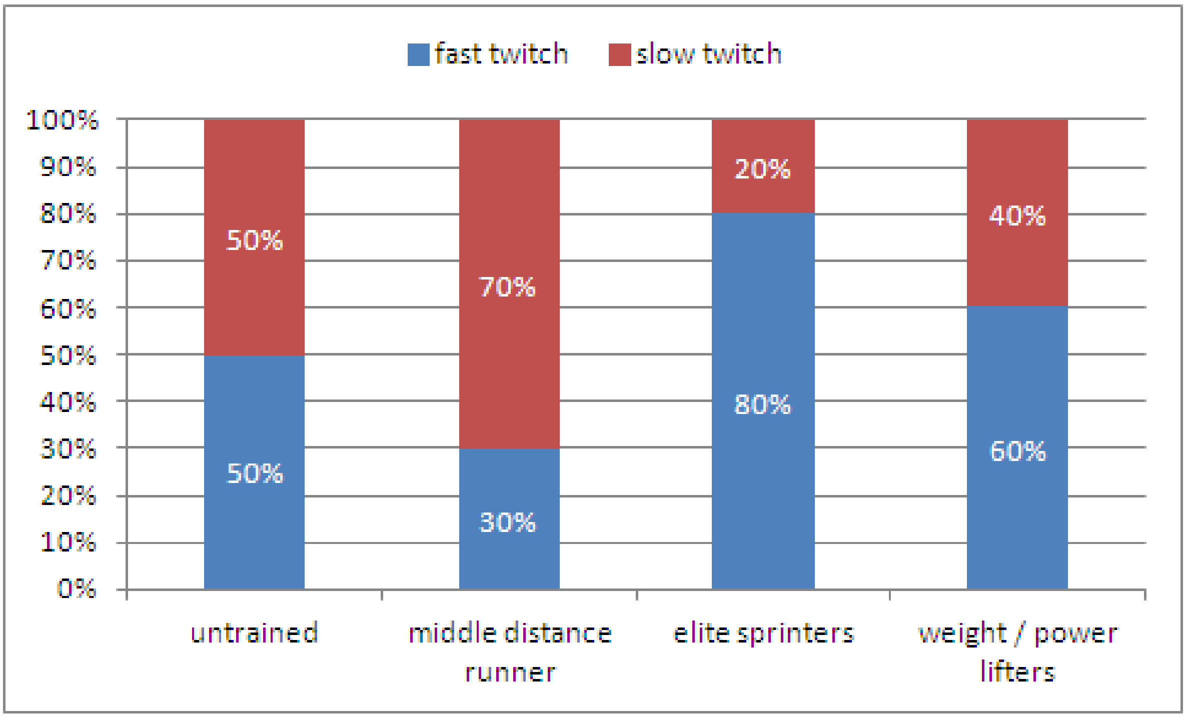
Type IIA Muscle Fibres

- Type 2A
- Fast Twitch 1
- Moderate-Fast Twitch
- Intermediate

Type IIB Muscle Fibres

- Type 2B
- Fast Twitch 2
- Fast Twitch

Effects Of Exercise On Muscle Tissue Type



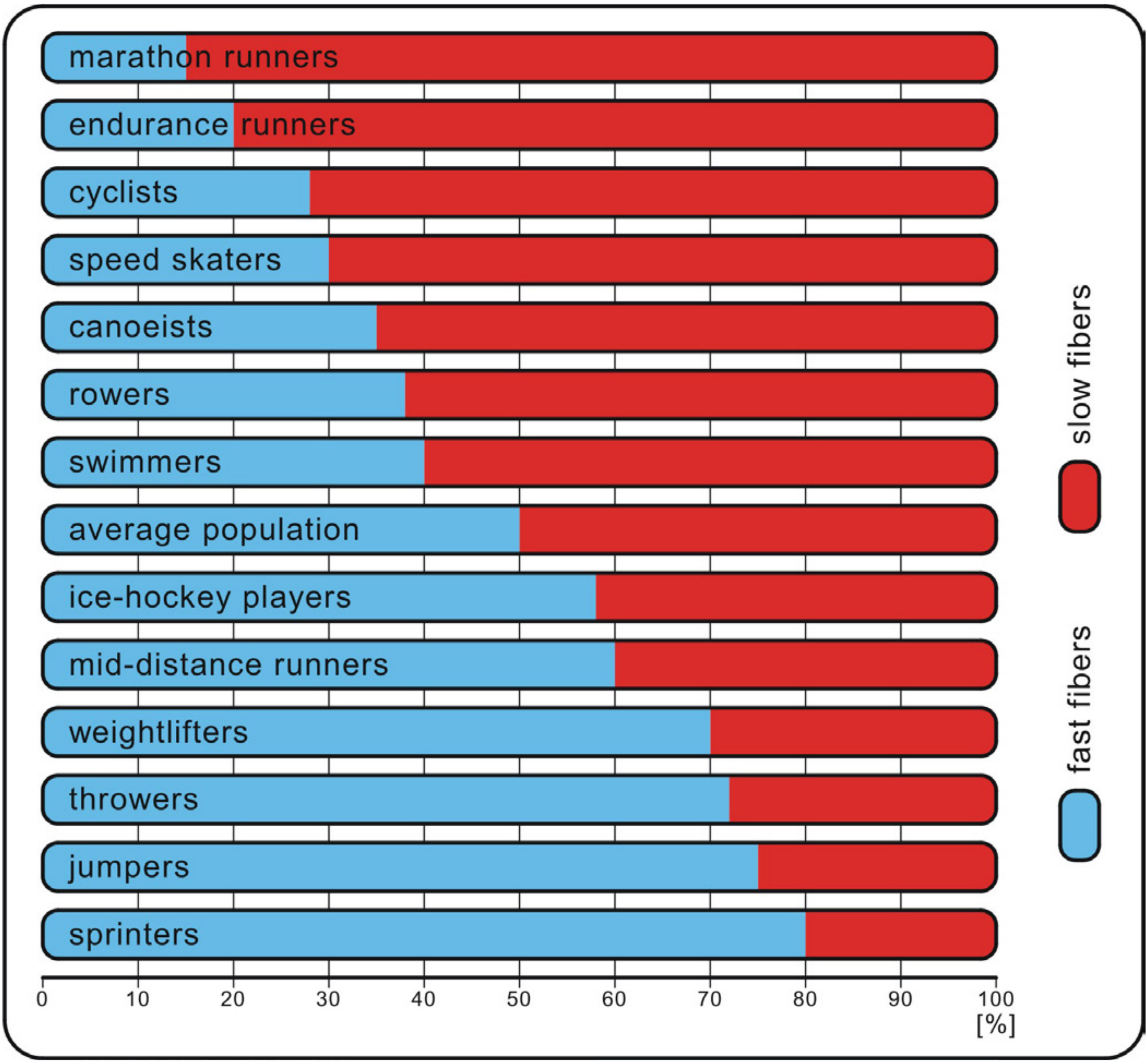
Whilst it is acknowledged that exercise, in general, will have a positive impact on muscle tissue development, certain types of activity have been shown to influence different muscle fibre types. Simply put muscles have three categories of muscle tissue, Type 1 or slow-twitch, Type 2a and Type 2b or fast-twitch. Science is continuing to expand this area of knowledge and other types of muscle tissue have been determined based on function and response.

The most aerobic in nature are the Type 1 (slow-twitch) muscle fibres, which have a greater blood supply and more mitochondria and as a result respond well to aerobic, low to moderate-intensity training.

The opposing fibre type, which is very anaerobic in nature with a reduced blood supply and fewer mitochondria is Type 2b (fast-twitch) muscle fibres. Type 2b fibres respond well to high-intensity exercise with a higher force and power outputs.

The Type 2a (intermediate twitch) fibres have all the characteristics that one would find in other fast-twitch fibre types, but with the added ability to adapt a little more and take on some of the properties of the Type 1 fibre. Type 2a fibres will respond to varying levels of exercise intensity in the direction of the stimulus applied.

Muscle Fibre Types in Sport



Muscles and Muscle Actions

MODULE 3:
DEVELOPING FURTHER UNDERSTANDING OF MUSCLES AND MACRONUTRIENTS

Muscle Anatomy and Voiceover

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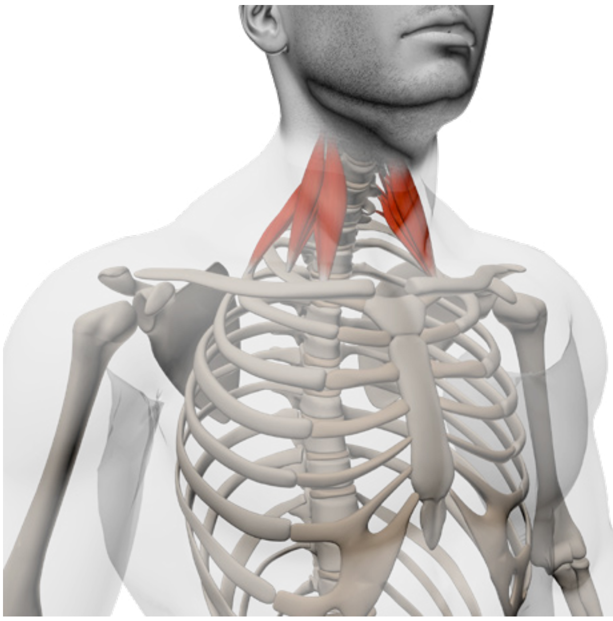
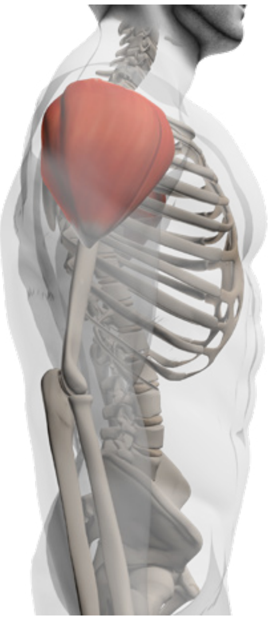
Neck, Shoulder and Arm Muscles



Scalenes

Anterior Deltoid



Middle Deltoid

Posterior Deltoid

Bicep Brachii

Brachialis

Brachioradialis

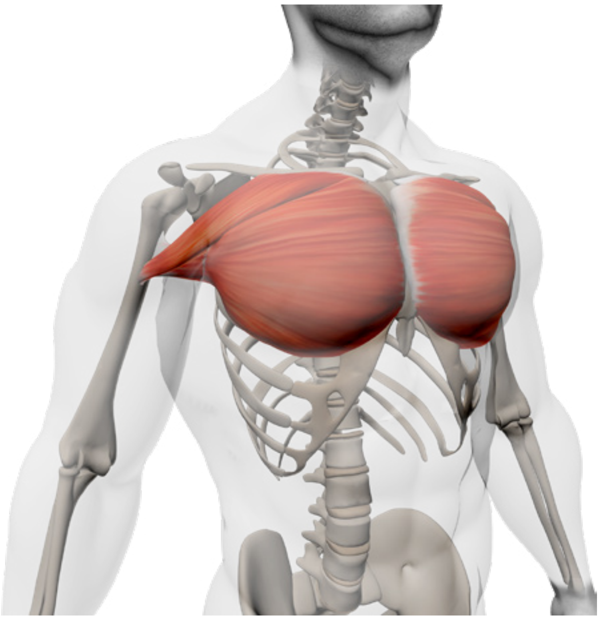
Tricep Brachii

Tricep Brachii Medial Head

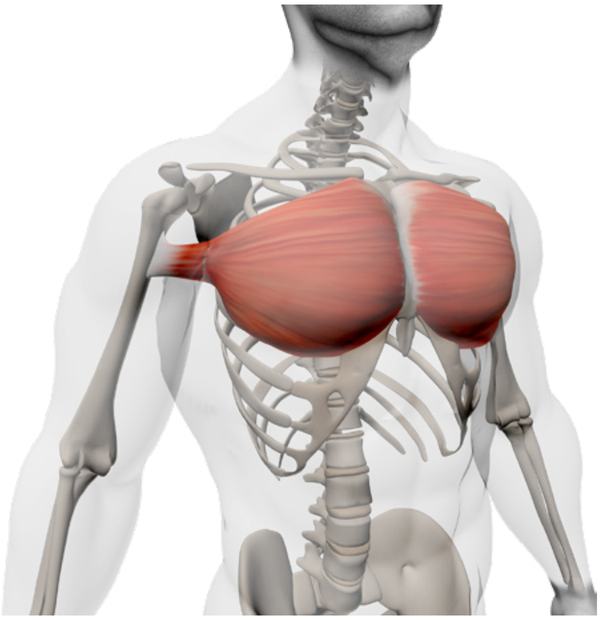
Tricep Brachii Lateral Head

Tricep Brachii Long Head

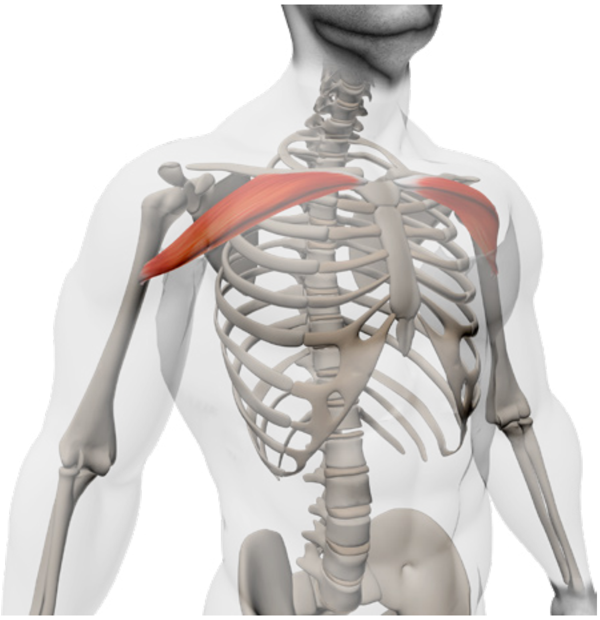
Chest Muscles



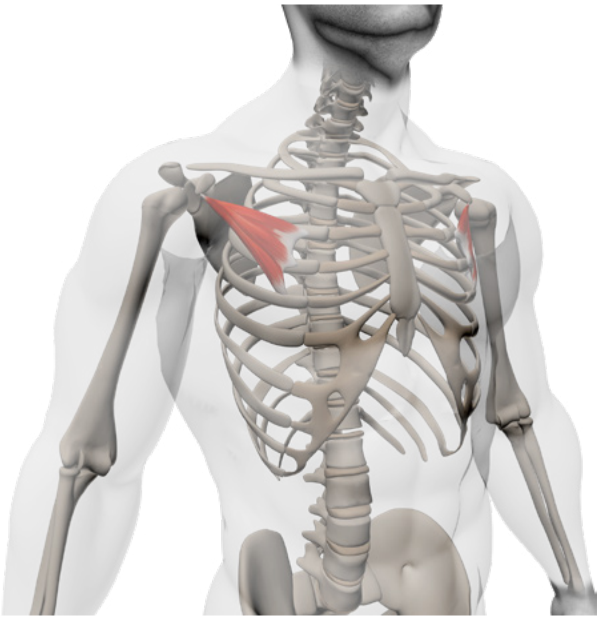
Pectoralis Major



Pectoralis Major (Sternal Head)

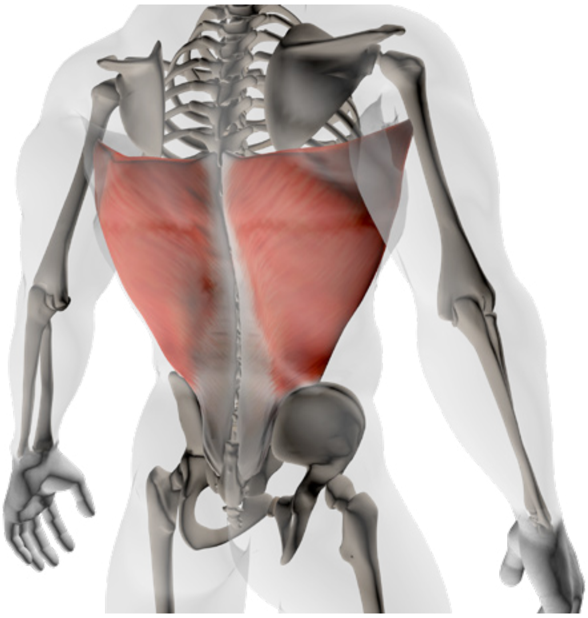


Pectoralis Major (Clavicle Head)



Pectoralis Minor

Back Muscles



Latissimus Dorsi

Rhomboid

Rhomboid Major

Rhomboid Minor

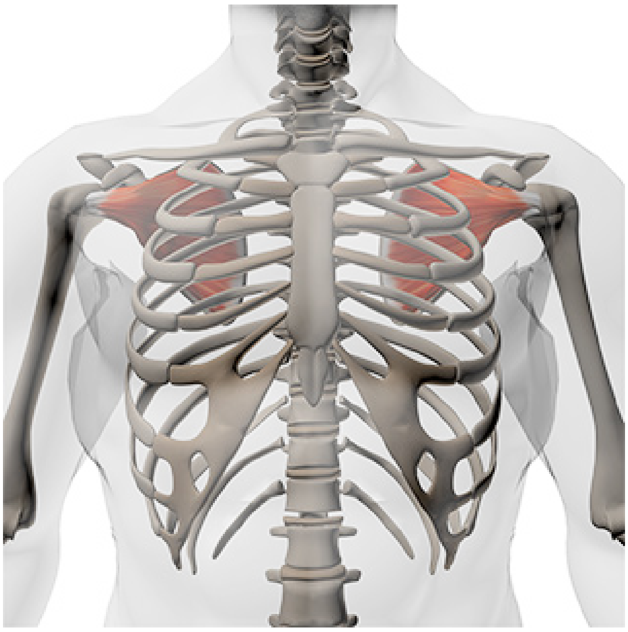
Trapezius

Teres Major

Rotator Cuff Muscles

Supraspinatus

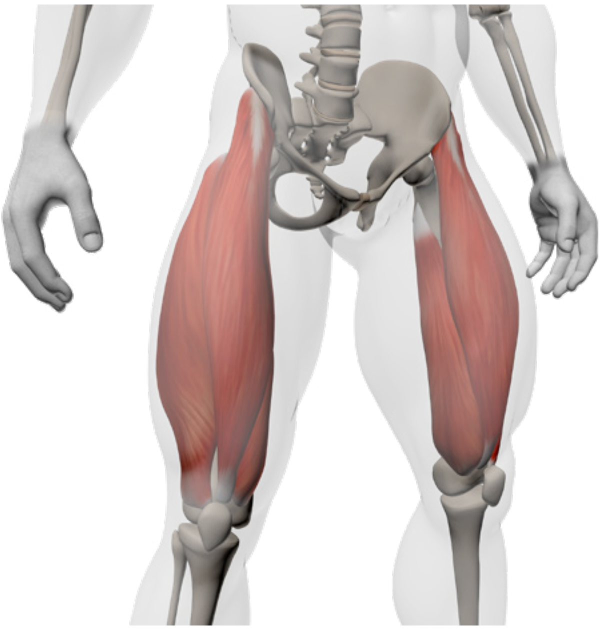
Infraspinatus



Subscapularis

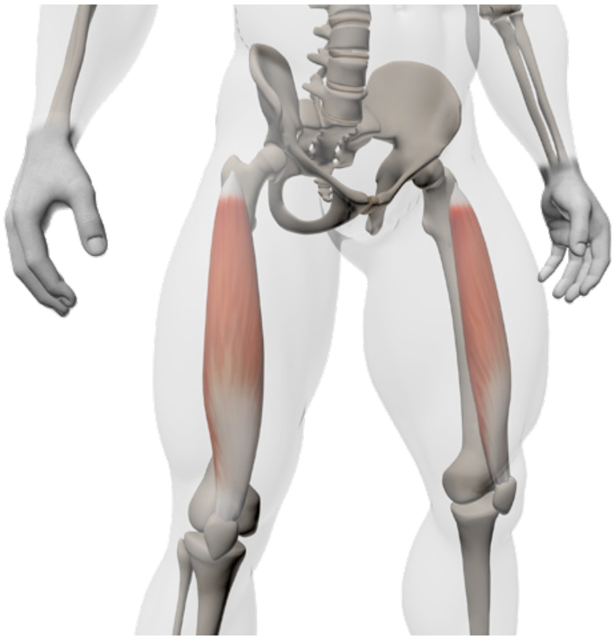
Teres Minor

Quadricep and Caudal Anterior Muscles

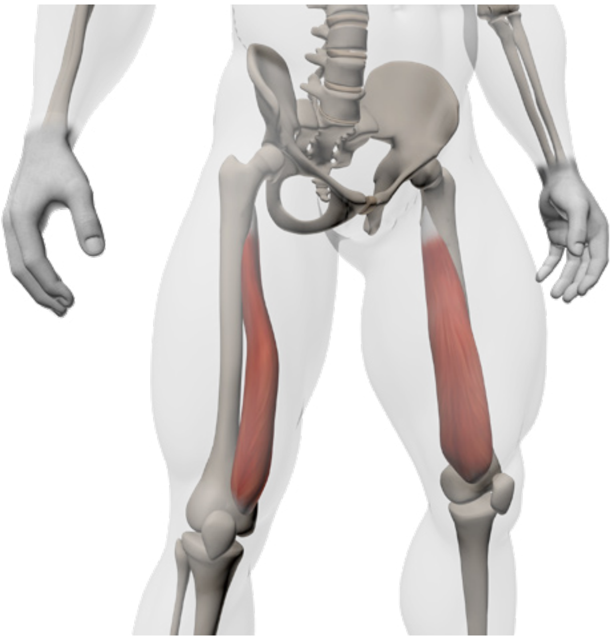


Quadriceps

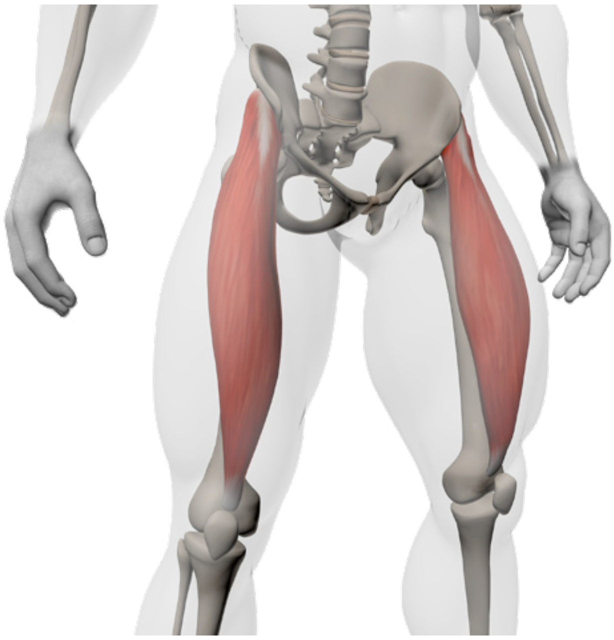
Vastus Lateralis



Vastus Intermedius

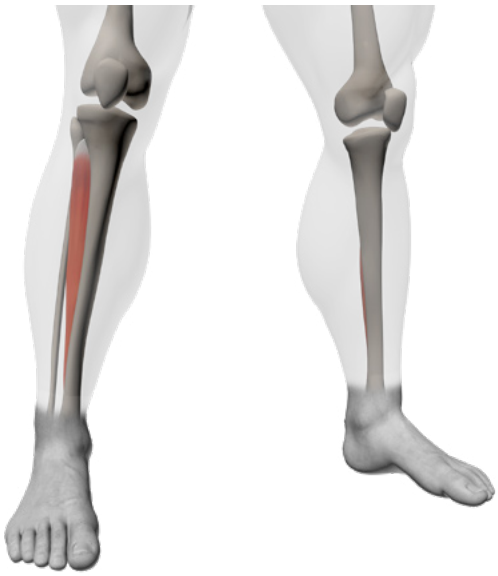


Vastus Medialis



Rectus Femoris

Tibialis Anterior



Tibialis Posterior

Extensor Digitorum Longus

Hamstring and Caudal Posterior Muscles

Hamstring Muscles

Biceps Femoris (Long Head)

Biceps Femoris (Short Head)

Semitendinosus

Semimembranosus

Gastrocnemius

Soleus

Popliteus

Plantaris

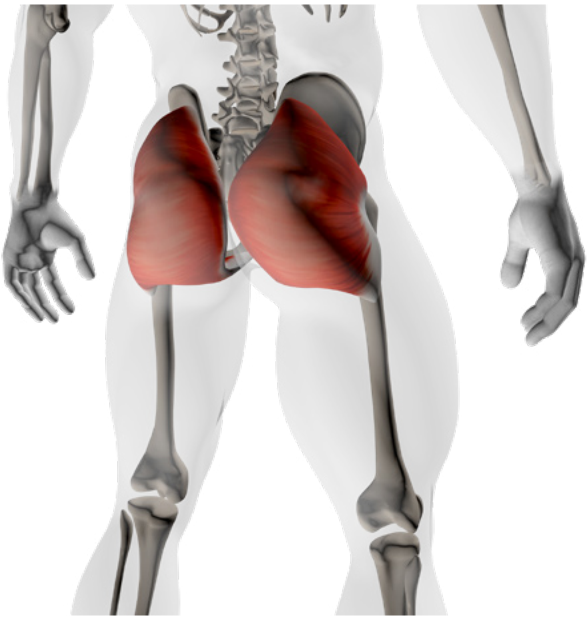
Peroneus Brevis

Peroneus Longus

Flexor Digitorum Longus

Flexor Hallucis Longus

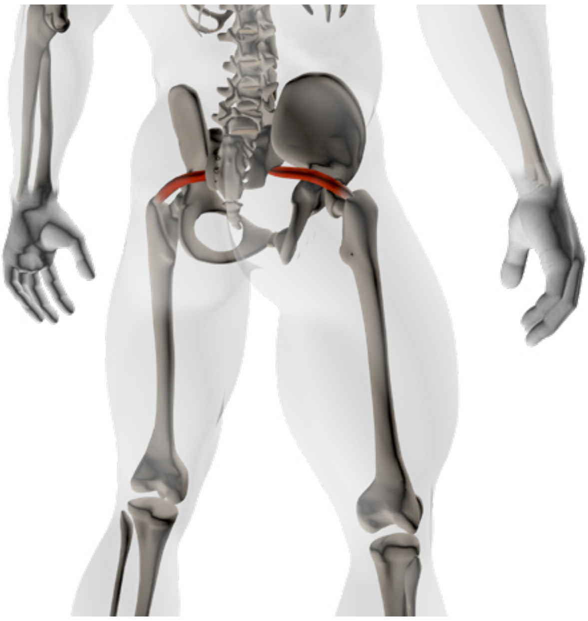
Hip Complex Muscles



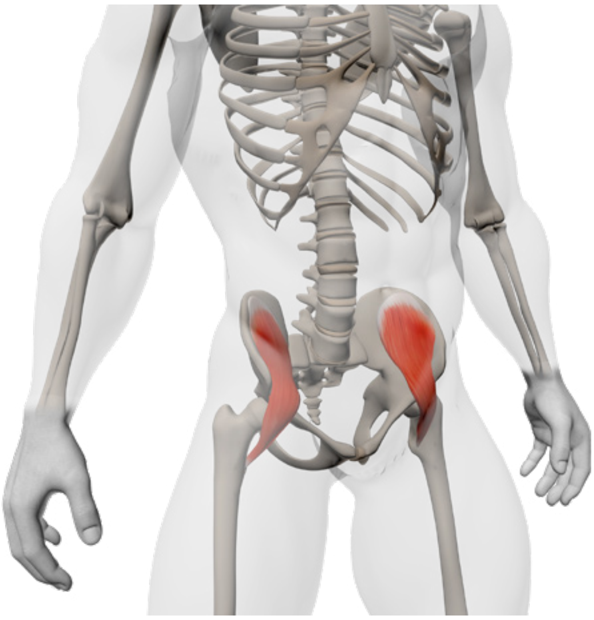
Gluteus Maximus

Gluteus Minimus

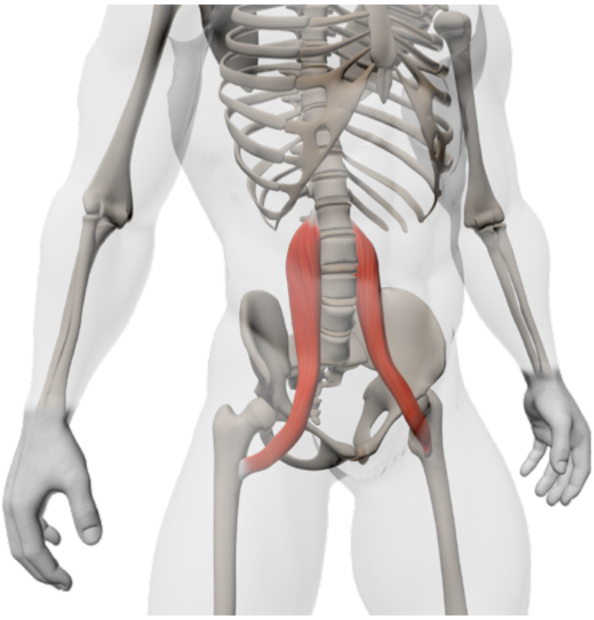
Gluteus Medius



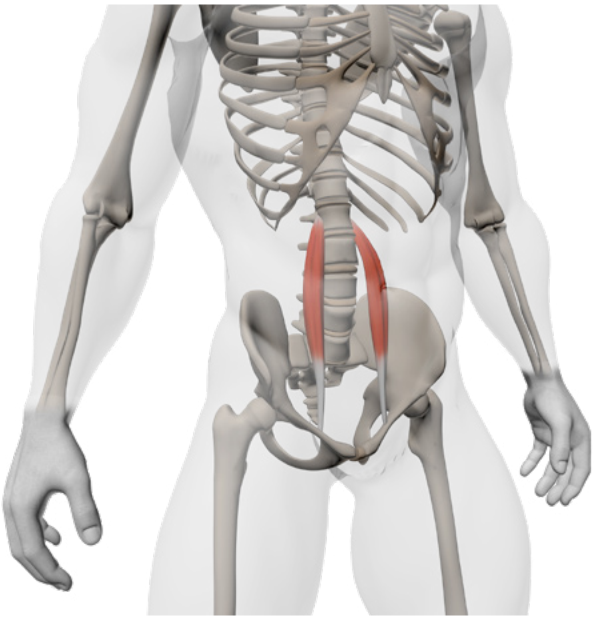
Piriformis



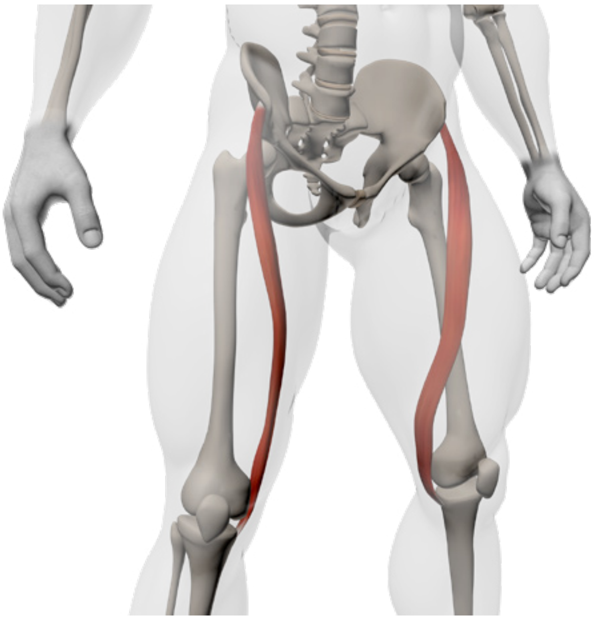
Iliacus



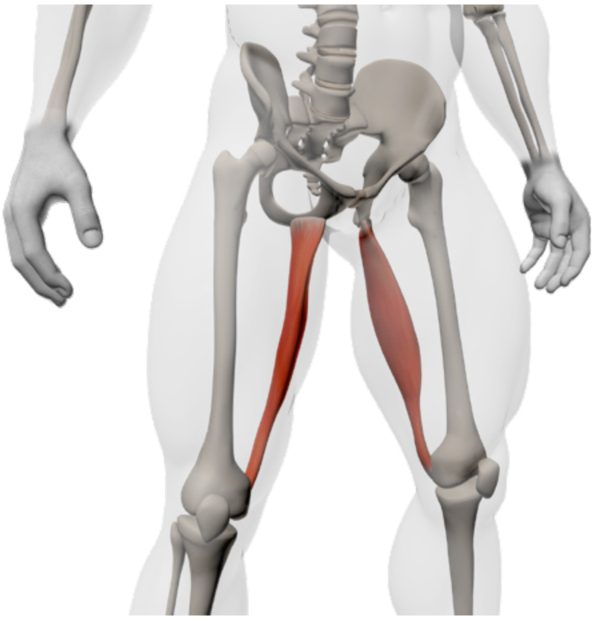
Psoas Major



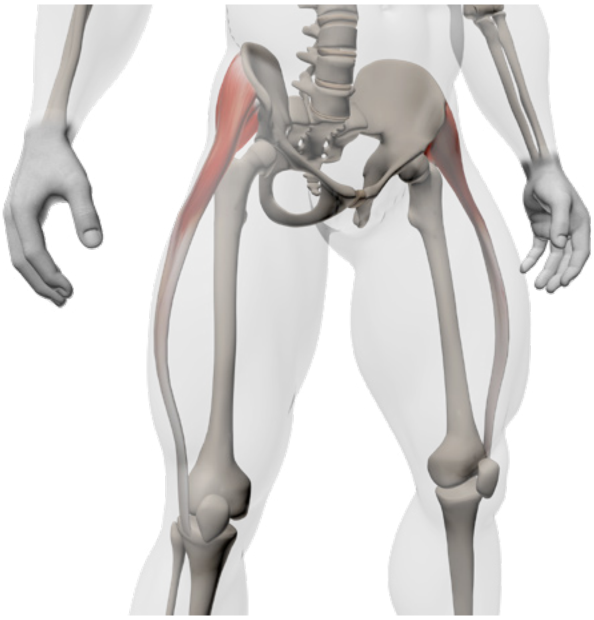
Psoas Minor



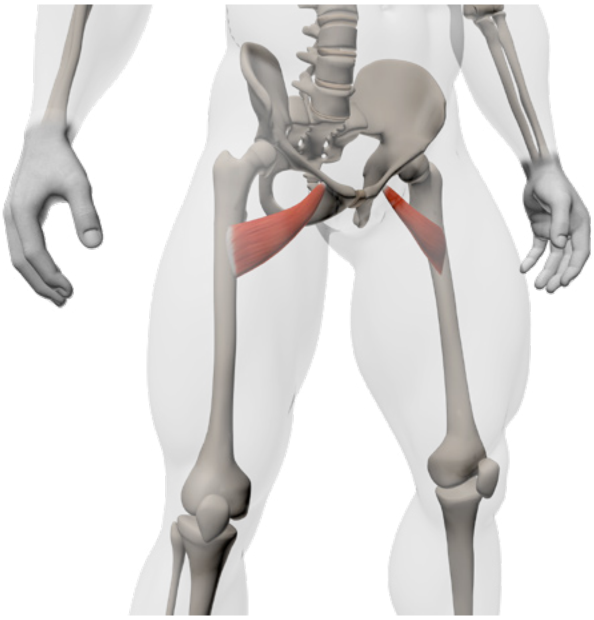
Sartorius



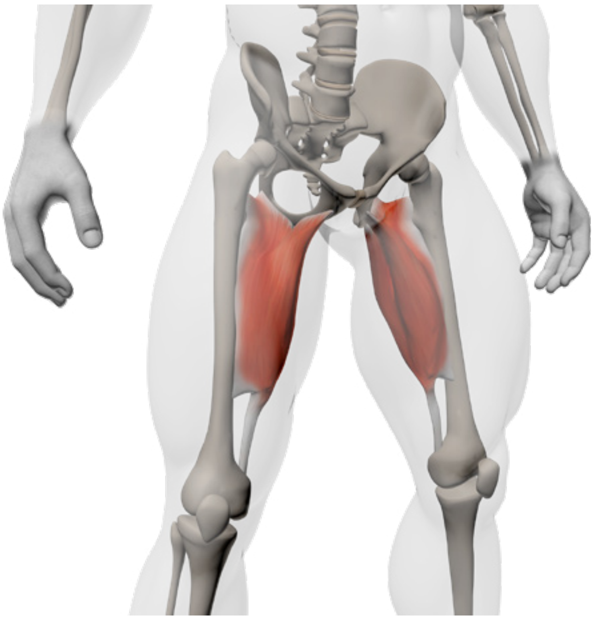
Gracilis



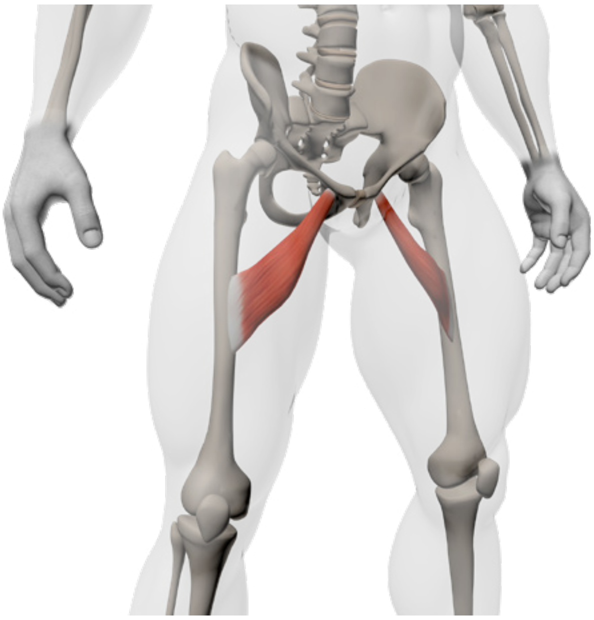
Abductors



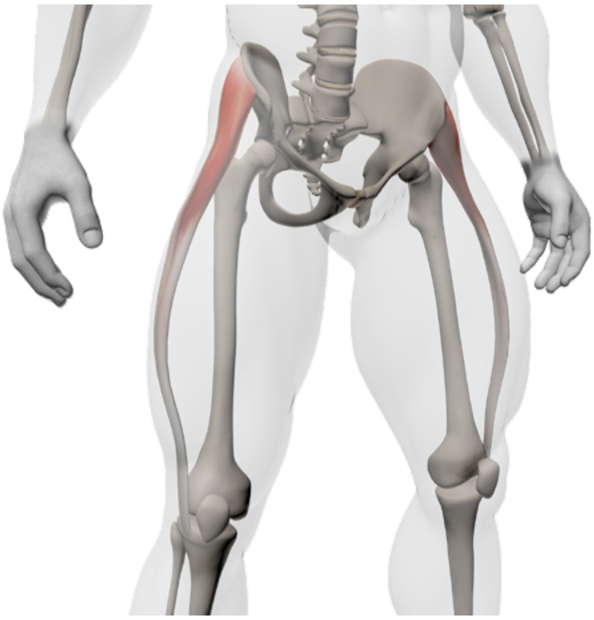
Adductor Brevis



Adductor Magnus



Adductor Longus



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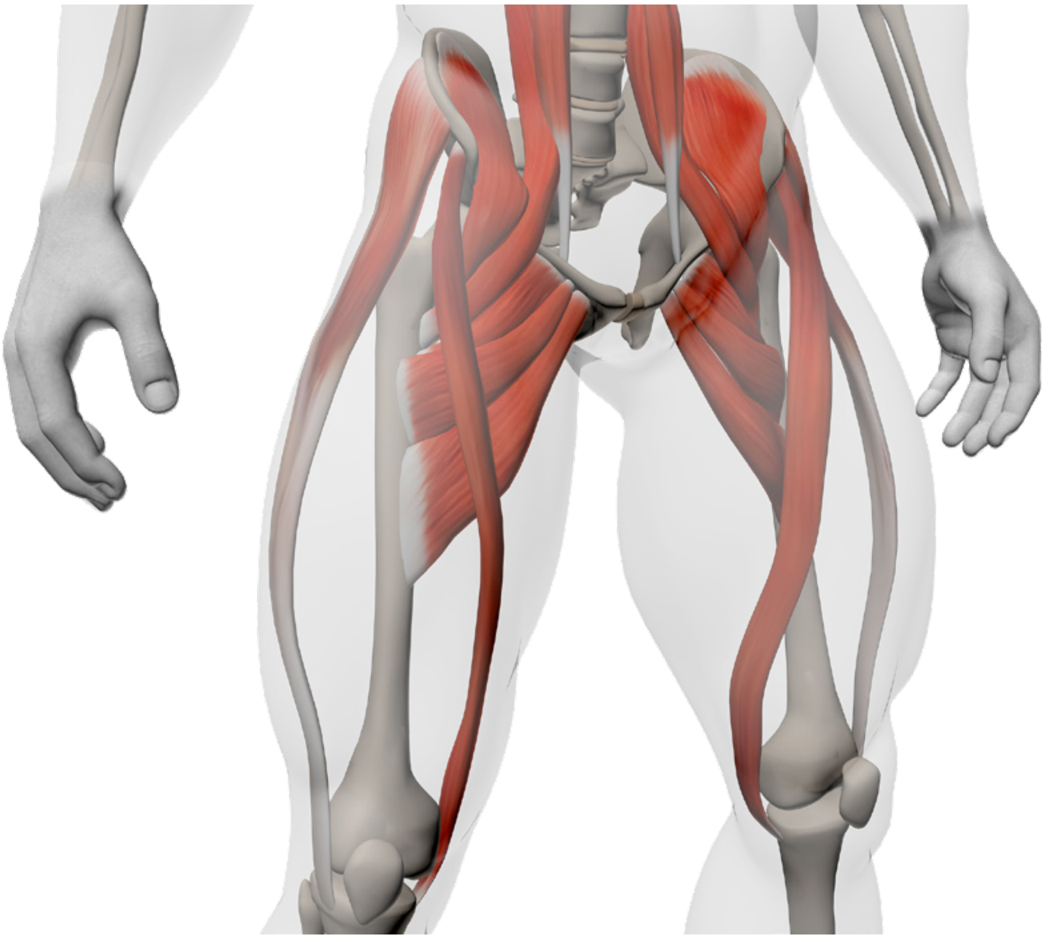
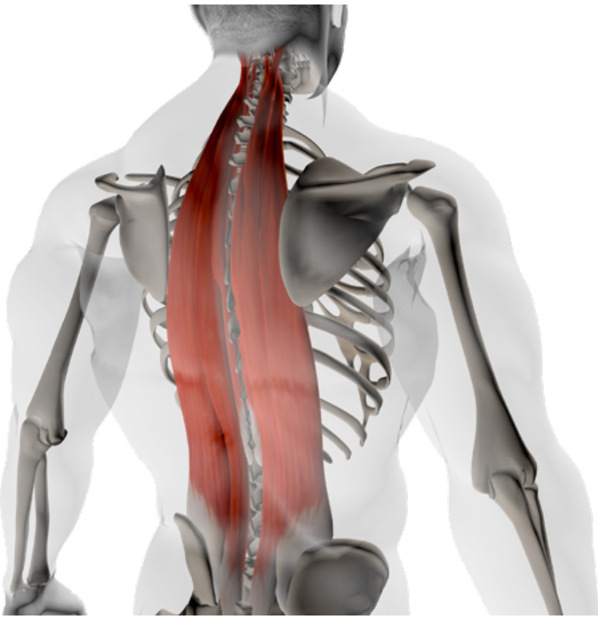
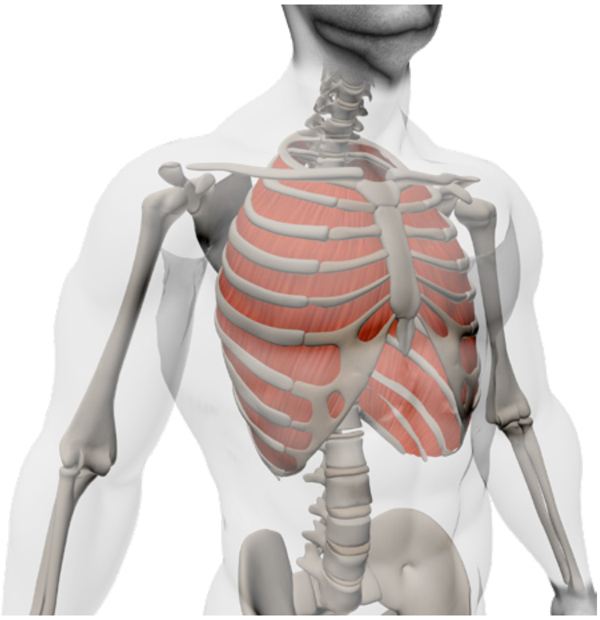


Hip Flexor Muscles

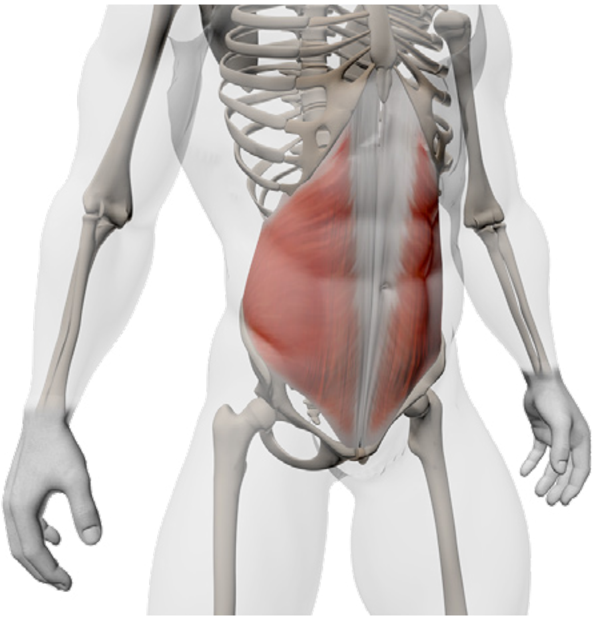
Core and Stabiliser Muscles



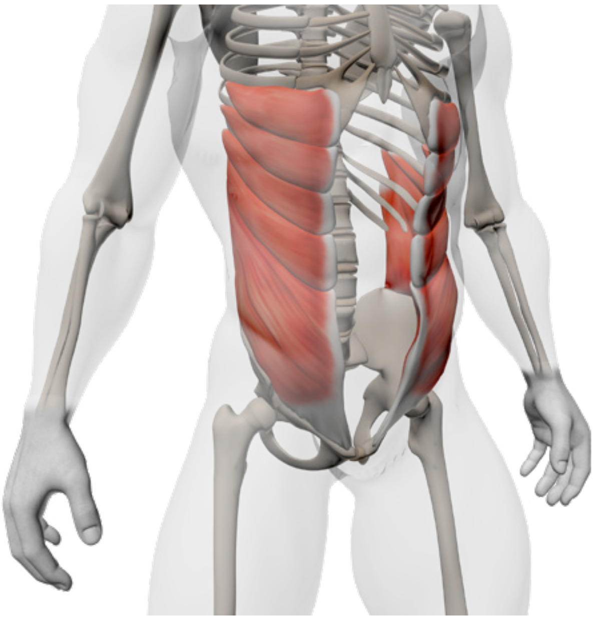
Erector Spinae



Intercostal Muscles

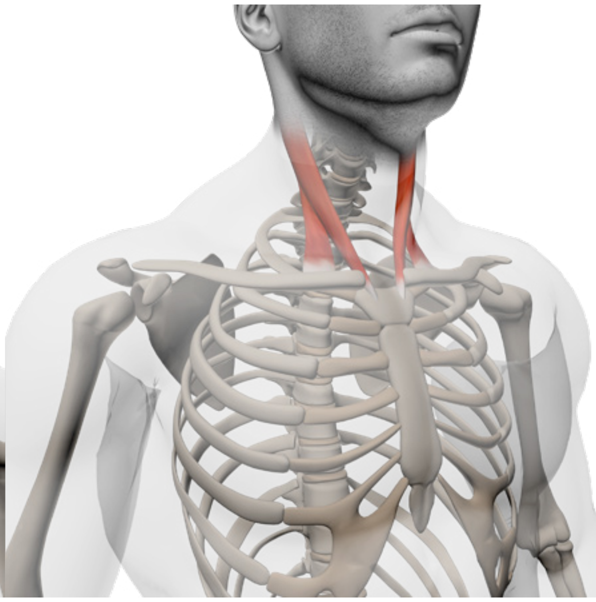


Internal Obliques



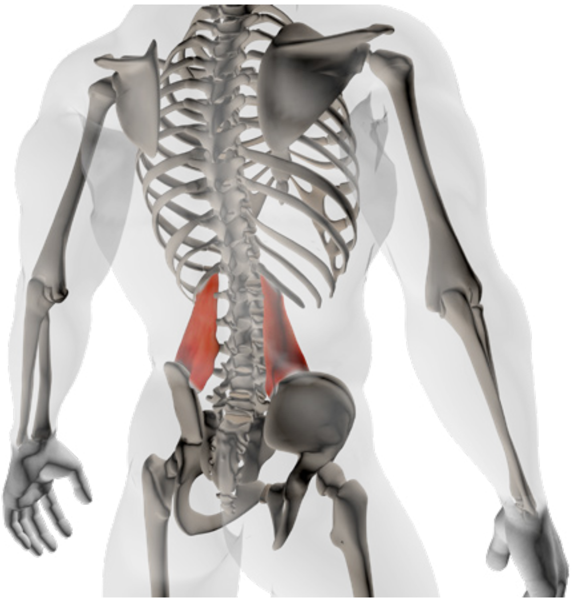
External Obliques

Levator Scapulae

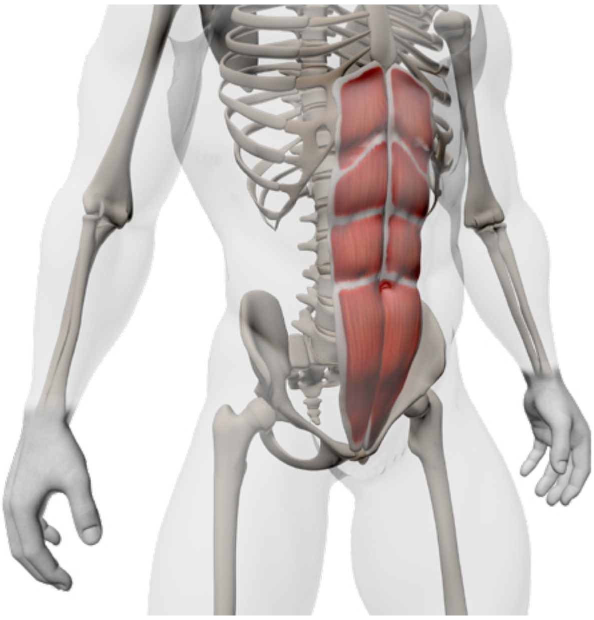


Sternocleidomastoid

Multifidus



Quadratus Lumborum



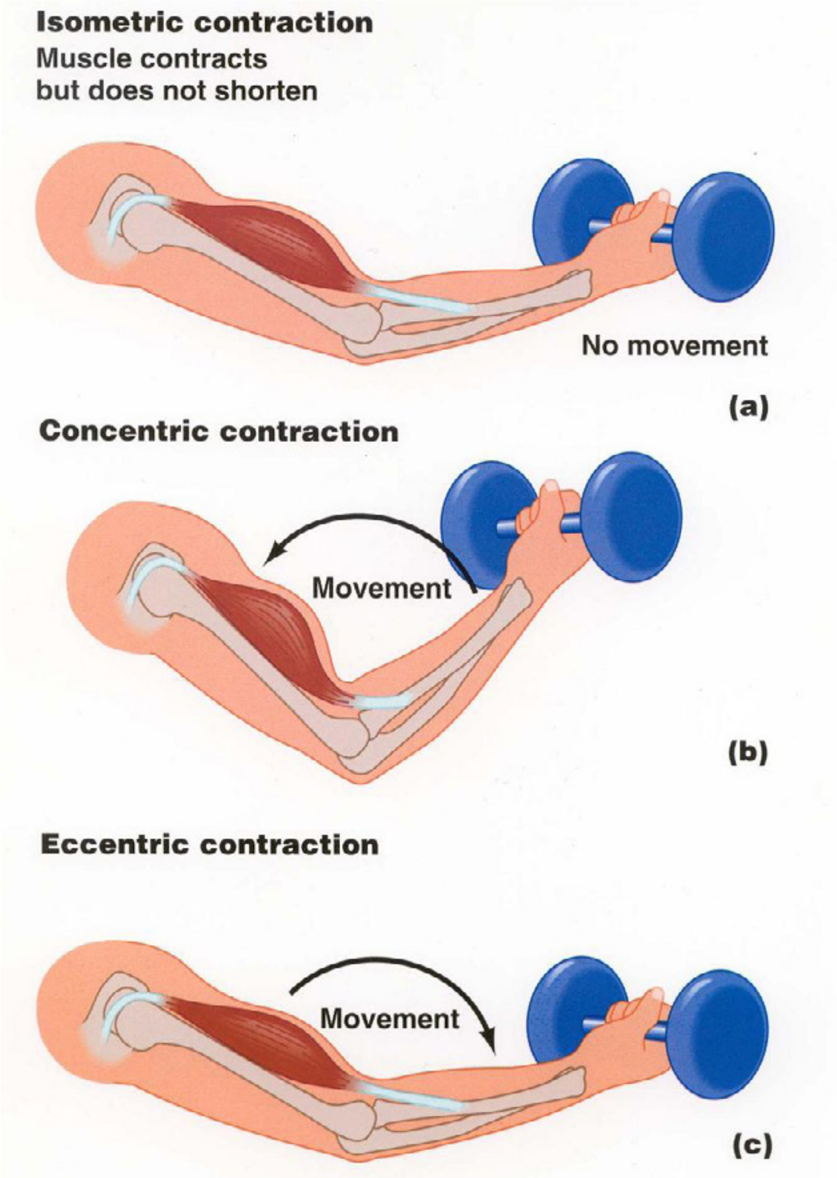
Rectus Abdominus

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 inolving both concentric and eccentric contractions.
- **Isometric:** Muscle stays the same length under contraction.
- **Isokinetic:** Muscle moves at a constant speed during contraction.



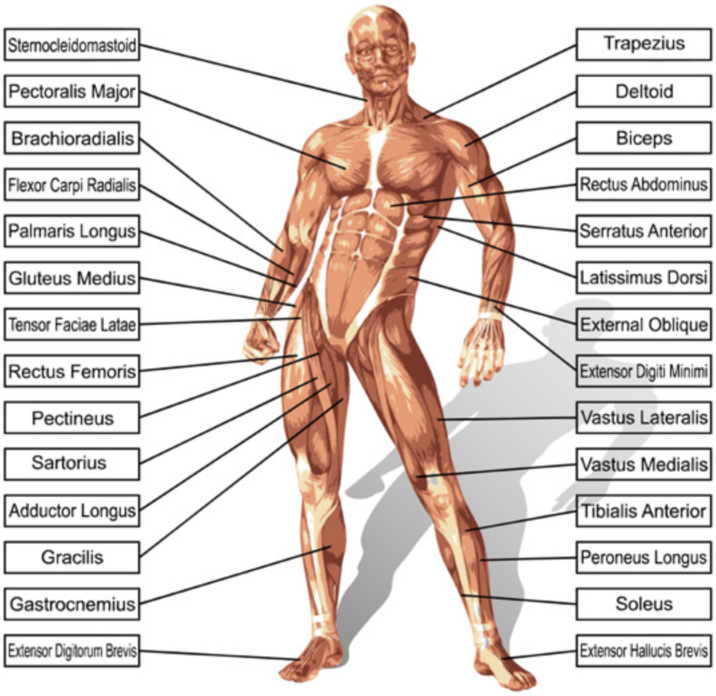
Muscle Roles

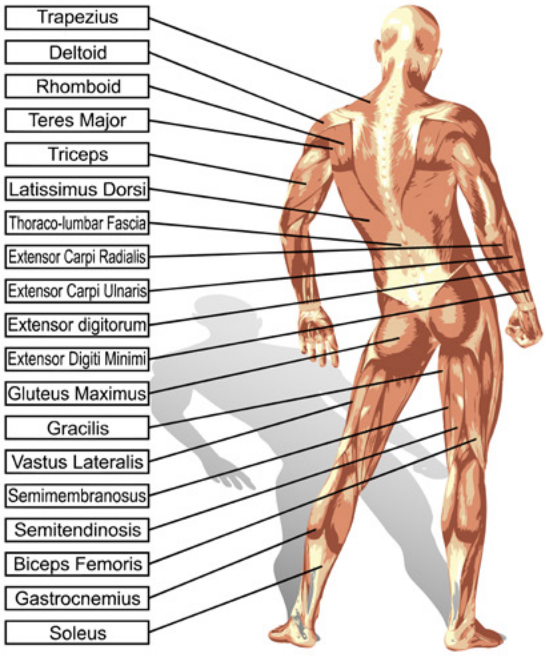
Movement is dependant on coordination of muscle contraction. Each muscle will play a specific role and be categorised as such. It is important to understand that individual muscles can play a different role depending on the movement being performed.

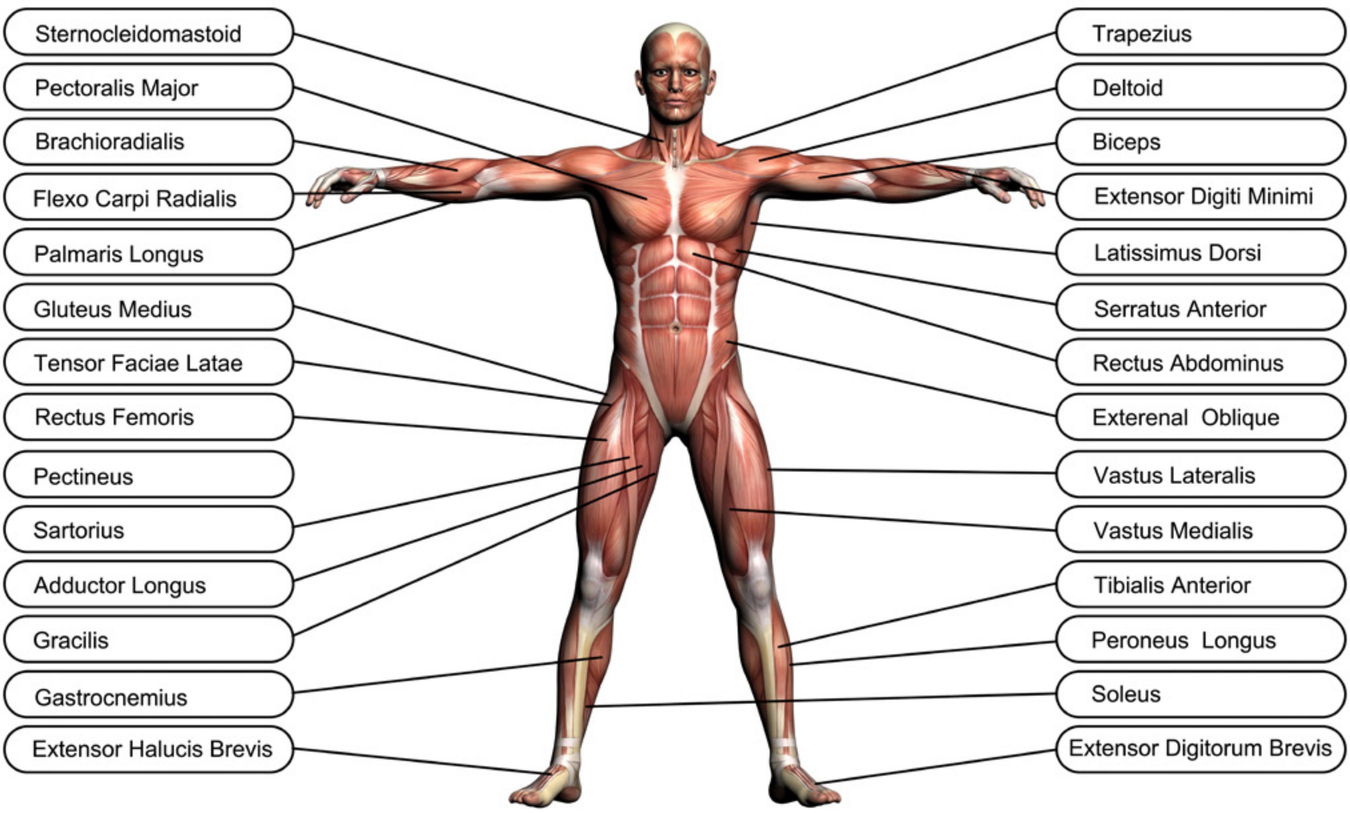
- **Agonist/Prime Mover:** Muscle directly responsible for the desired movement
- **Antagonist:** Muscle that causes the opposite action to the agonist
- **Synergists:** Muscle that assists the prime mover
- **Fixator:** Muscle that stabilises the origin of the prime mover

Muscle Booklet Download

DOWNLOADABLE RESOURCE AVAILABLE ON LEARNING PLATFORM


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


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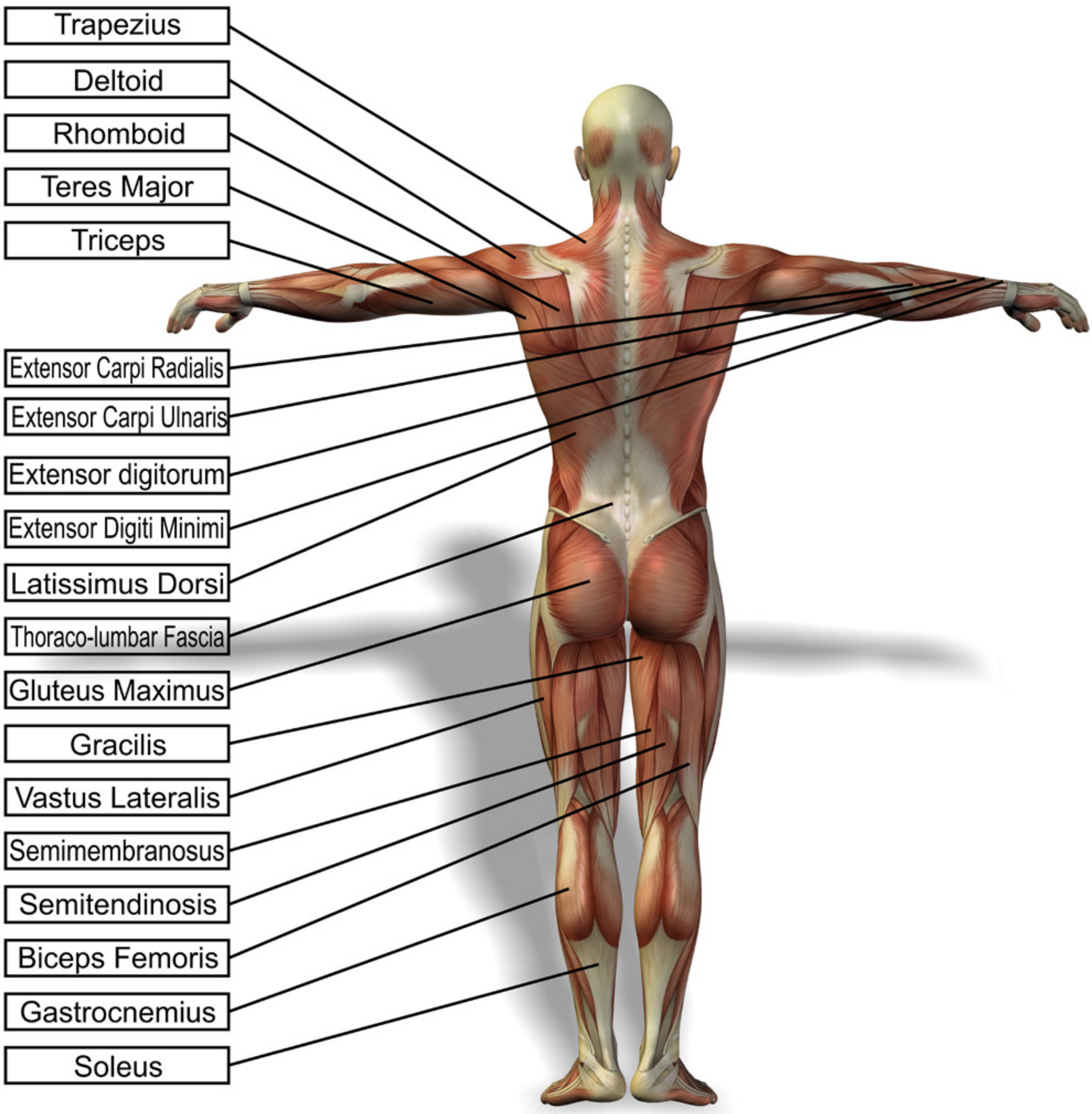
Pectoralis Major
Brachioradialis
Flexo Carpi Radialis
Palmaris Longus
Gluteus Medius
Tensor Faciae Latae
Rectus Femoris
Pectineus
Sartorius
Adductor Longus
Gracilis
Gastrocnemius
Extensor Halucis Brevis
Trapezius
Deltoid
Biceps
Extensor Digiti Minimi
Latissimus Dorsi
Serratus Anterior
Rectus Abdominus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


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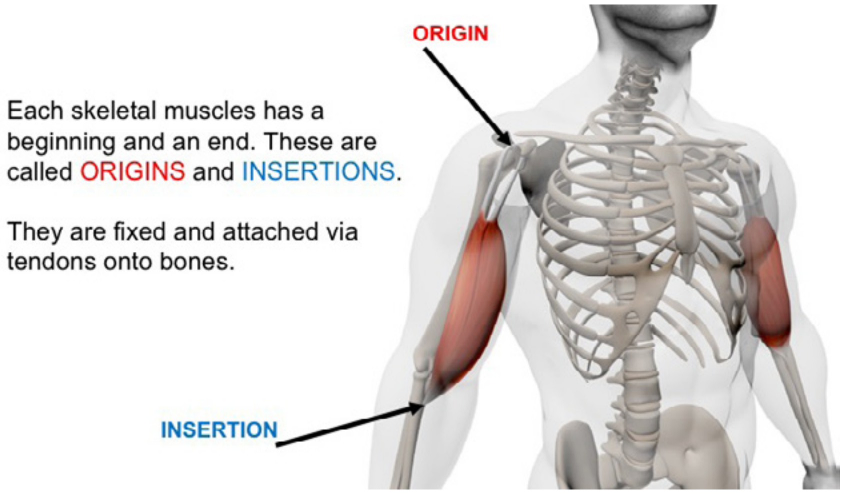
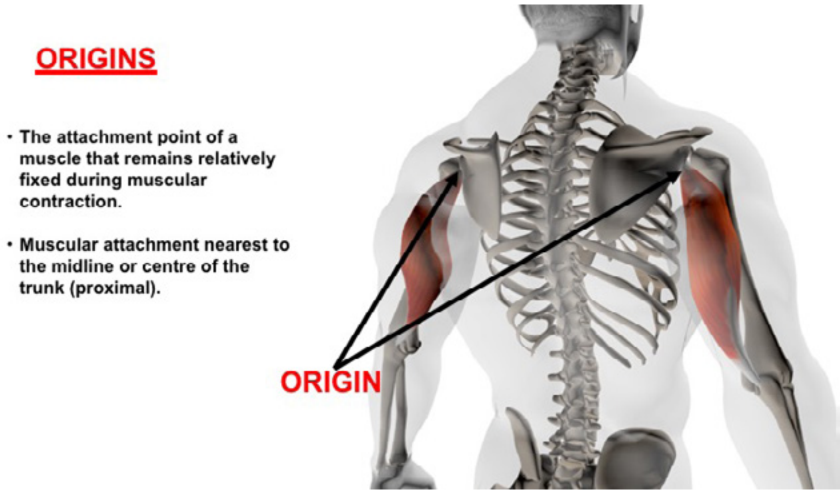
Thoraco-lumbar Fascia
Gluteus Maximus
Gracilis
Vastus Lateralis
Semimembranosus
Semitendinosis
Biceps Femoris
Gastrocnemius
Soleus

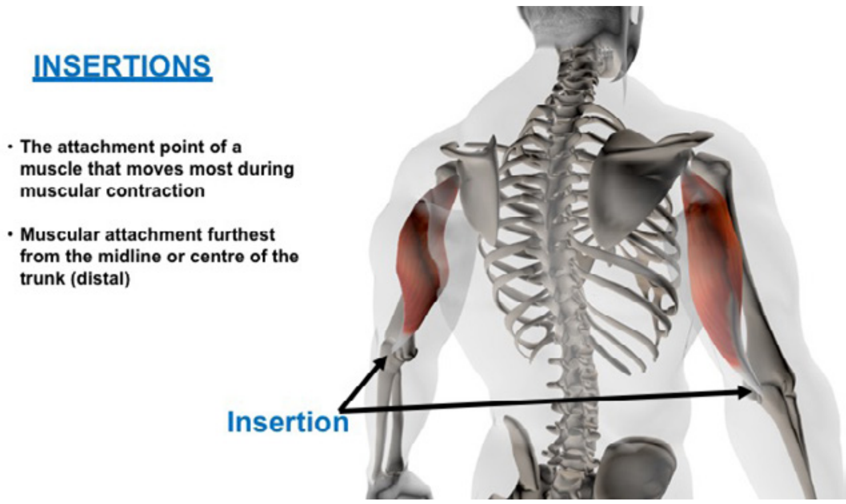
Muscle Origin and Insertions

MODULE 3:
DEVELOPING FURTHER UNDERSTANDING OF MUSCLES AND MACRONUTRIENTS

Introduction

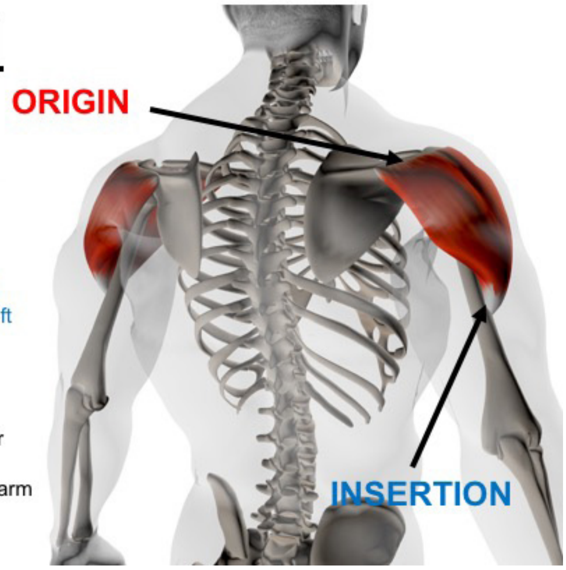






Shoulder Muscles

Posterior Deltoid



Origin:

- Inferior edge of the scapular spine

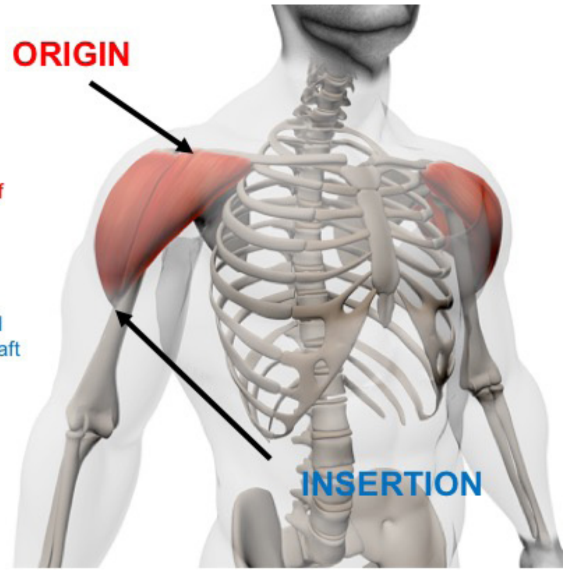
Insertion

- 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

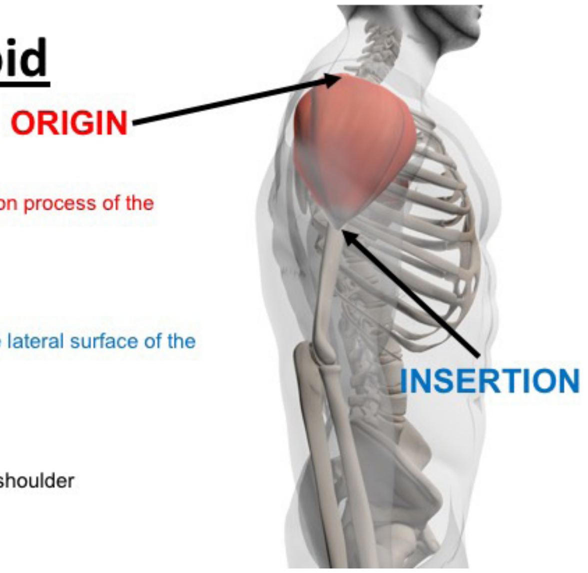
Insertion

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

Actions:

- Flexion of the arm at the shoulder

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

Rotator Cuff Muscles

Supraspinatus

Origin:

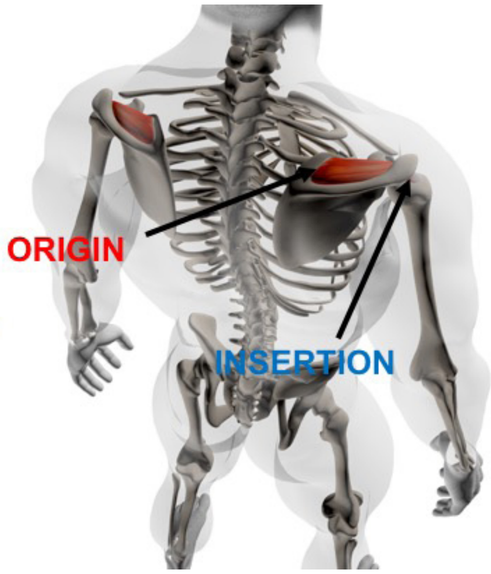
- Superior to spine of scapula

Insertion

- Greater tuberosity of humerus (superior)

Actions:

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



Infraspinatus

Origin:

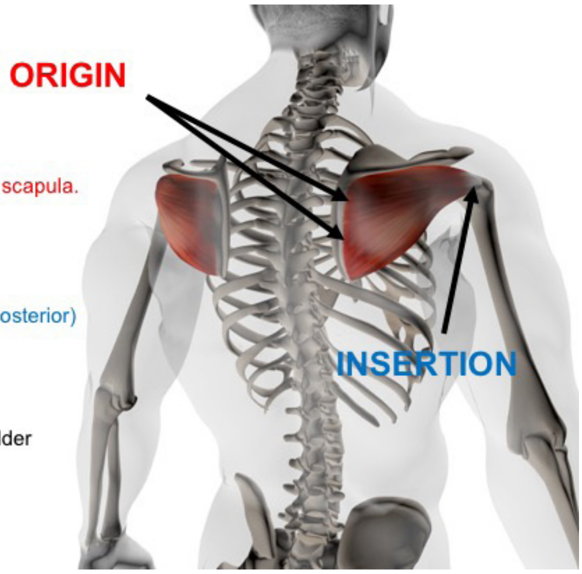
- Posterior surface below spine of scapula.

Insertion

- Greater tuberosity of humerus (posterior)

Actions:

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



Subscapularis

Origin:

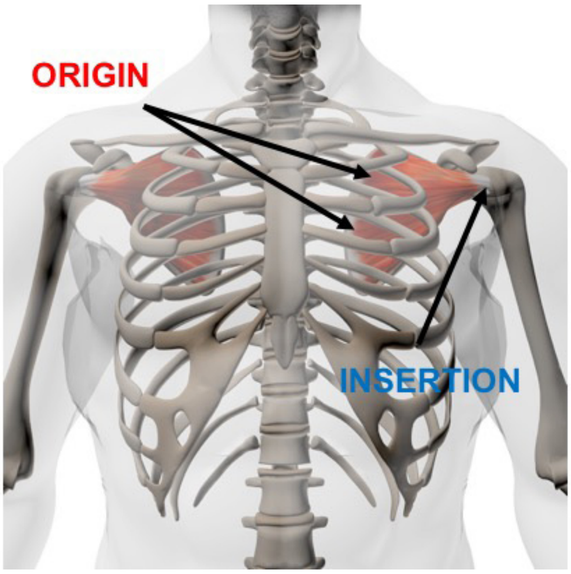
- Anterior surface of scapular

Insertion

- Lesser tuberosity of humerus

Actions:

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



Teres Minor

<u>Origin:</u>

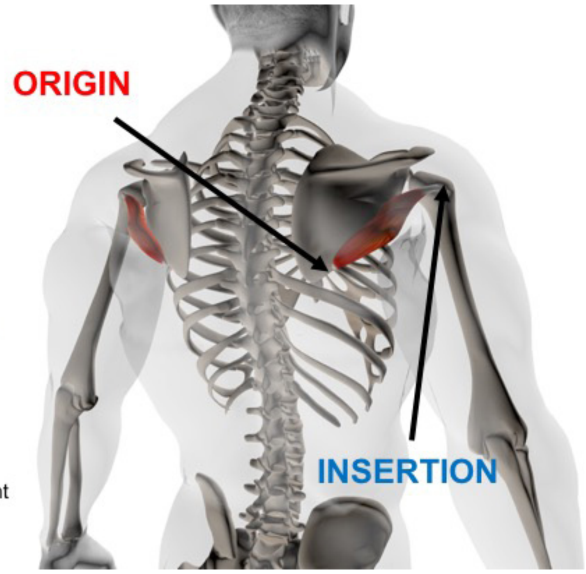
- Lateral border of the scapula

<u>Insertion</u>

- Greater tuberosity of humerus

<u>Actions:</u>

- Lateral rotation
- Stabilisation of the shoulder joint



Chest Muscles

Pectoralis Minor

Origin:

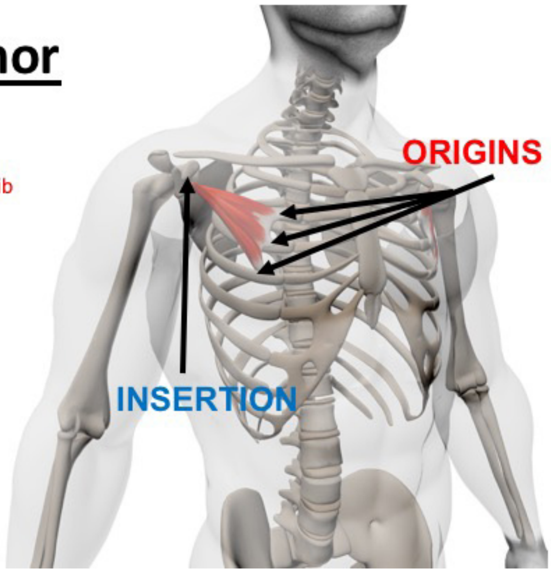
- Anterior surface of the 3rd-5th rib

Insertion

- Coracoid process of scapula

Actions:

- Depression of scapula
- Protraction of scapula



Pectoralis Major

Origin:

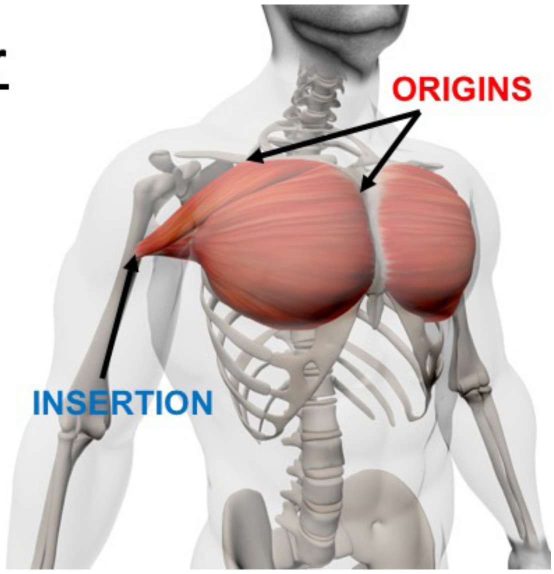
- Clavicle
- Sternum

Insertion

- Humerus

Actions:

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



Serratus Anterior

Origin:

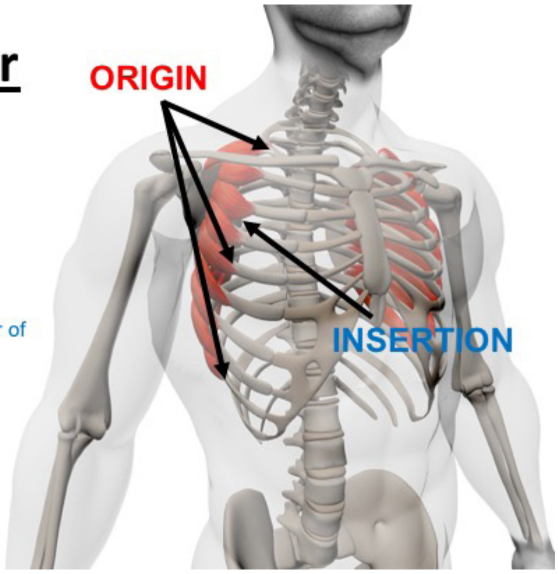
- Surface of upper 8 and 9 ribs

Insertion

- Anterior surface of medial boarder of scapula

Actions:

- Protraction of scapula



Back Muscles

Trapezius

Origin:

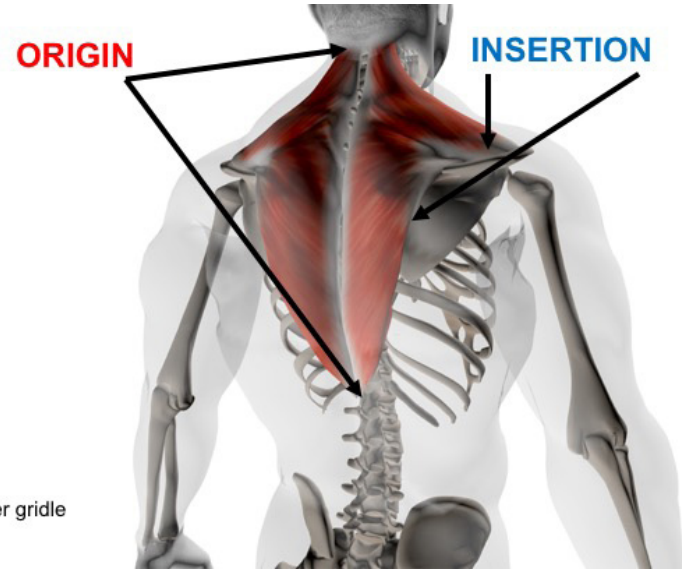
- Base of Skull
- Clavicle
- Thoracic vertebrae

Insertion

- Clavicle
- Scapula

Actions:

- Elevation, retraction
- Depression of shoulder gridle



Rhomboid Major

Origin:

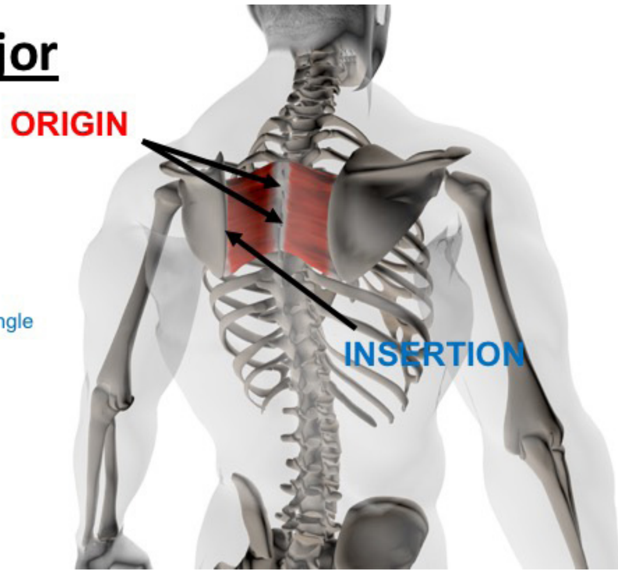
- Spinous process of T2-T5

Insertion

- Medial boarder and inferior angle of scapula

Actions:

- Retraction of scapula
- Elevation of scapula



Rhomboid Minor

Origin:

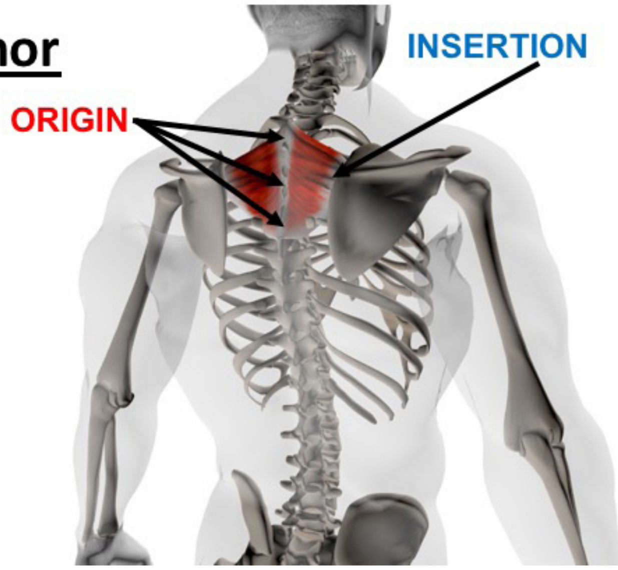
- Spinous process of C7-T1

Insertion

- Medial boarder of scapula

Actions:

- Retraction of scapula
- Elevation of scapula



Latissimus Dorsi

Origin:

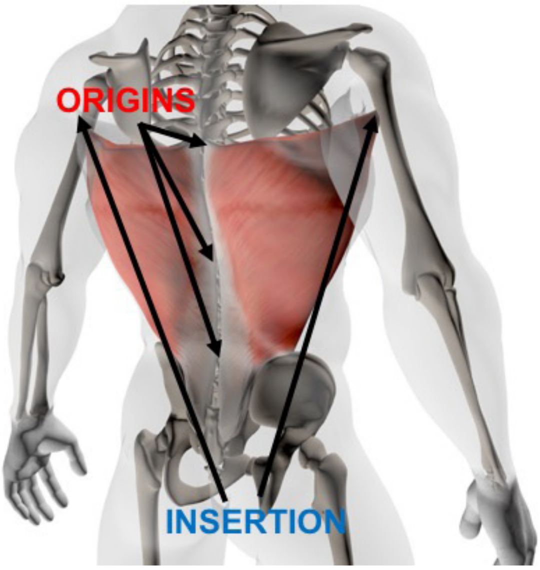
- Lower thoracic vertebrae
- Lumbar vertebrae
- Ilium

Insertion

- Humerus

Actions:

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



Arm Muscles

Biceps Brachii

Origin:

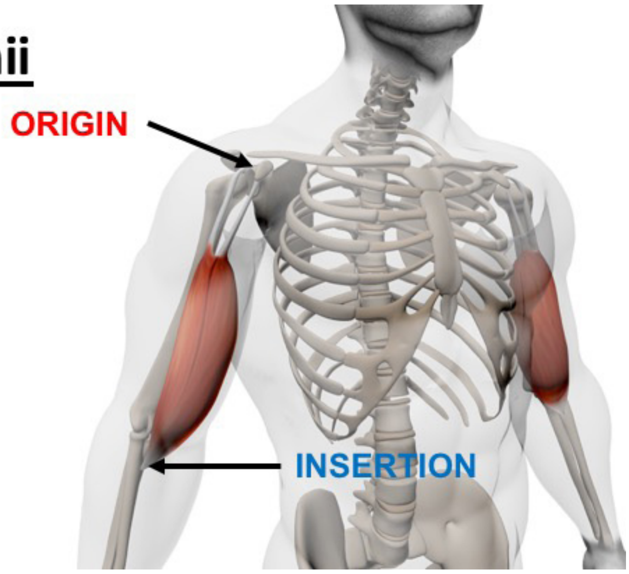
- Scapula

Insertion

- Radius

Actions:

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



Brachioradialis

Origin:

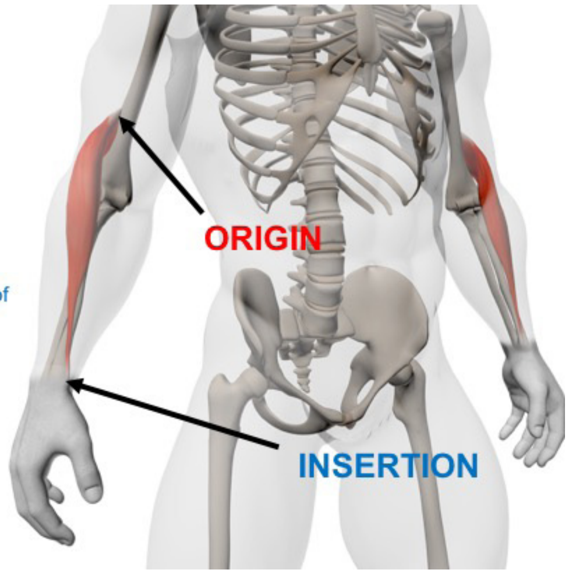
- Laterally at the distal end of humers

Insertion

- Lateral surface of styloid process of radius

Actions:

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



Brachialis

Origin:

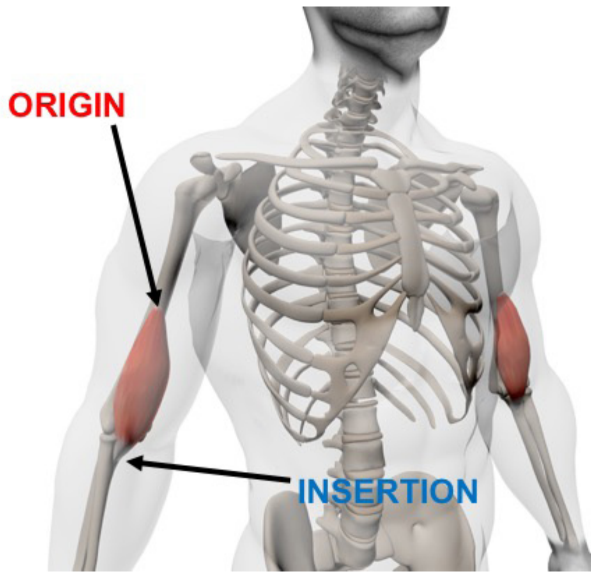
- Humerus

Insertion

- Coronoid process of the ulna

Actions:

- Flexion of the elbow



Triceps Brachii

Origin:

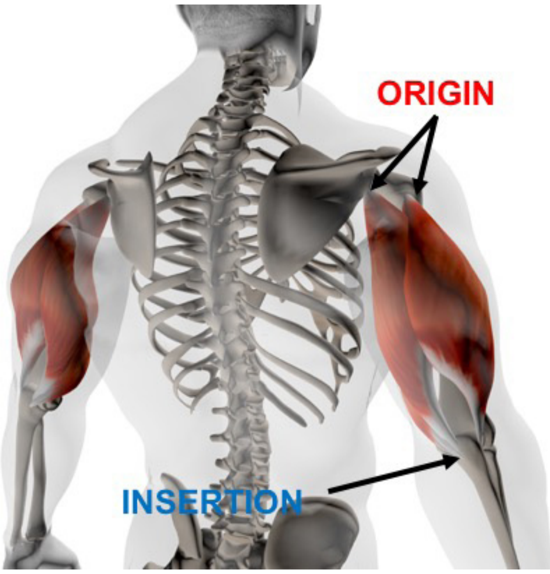
- Humerus
- Scapla

Insertion

- Ulna

Actions:

- Extension of elbow
- Extension of shoulder



Core Muscles

Quadratus Lumborum

Origin:

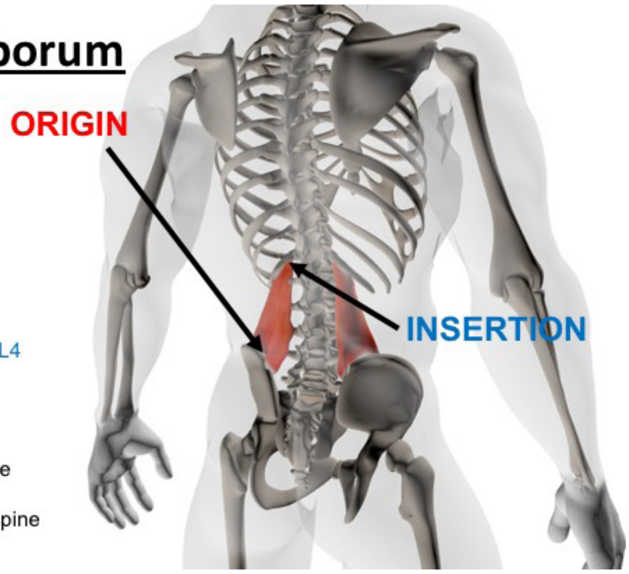
- Iliac Crest

Insertion

- 12th rib
- Transvers process of L1-L4

Actions:

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



Rectus Abdominis

Origin:

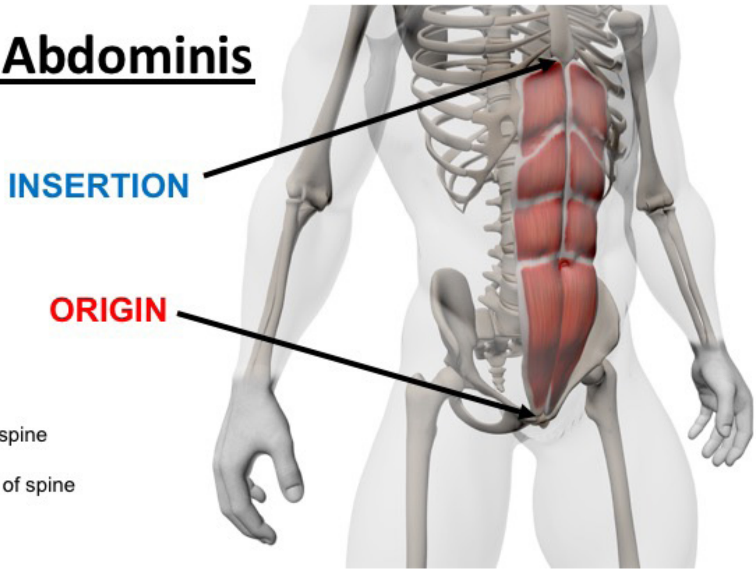
- Pubis

Insertion

- Sternum

Actions:

- Flexion of the spine
- Lateral flexion of spine



External Obliques

Origin:

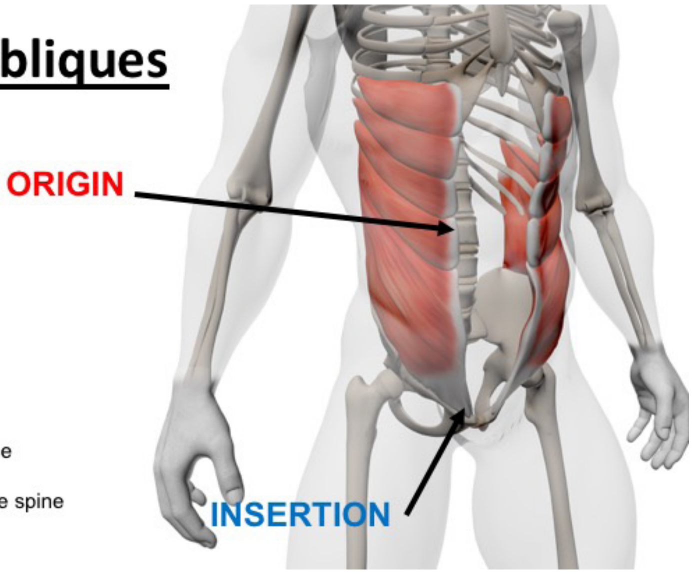
- Ribs

Insertion

- Ilium
- Pubis

Actions:

- Rotation of the spine
- Lateral flexion of the spine



Internal Obliques

Origin:

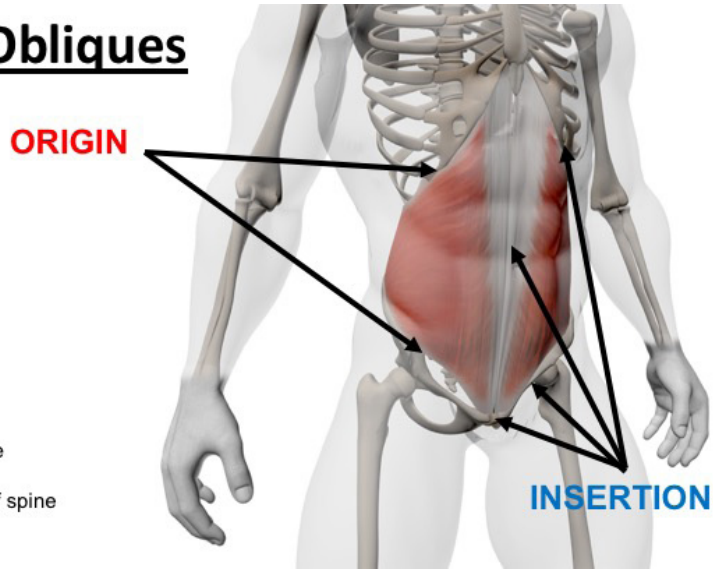
- Ribs
- Ilium

Insertion

- Ilium
- Pubis
- Ribs
- Linea Alba

Actions:

- Rotation of spine
- Lateral flexion of spine



Transversus Abdominis

Origin:

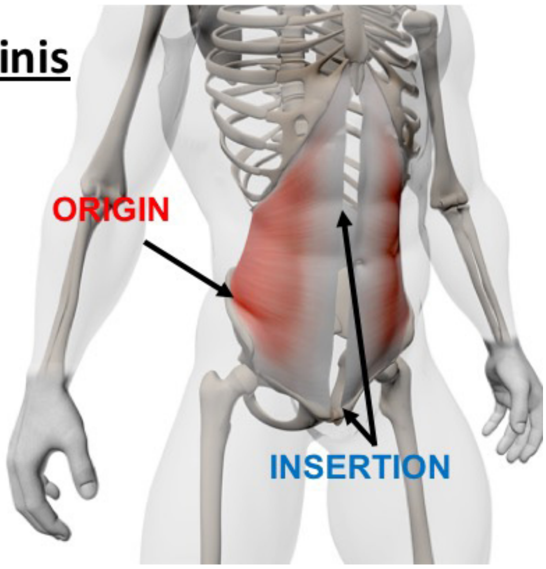
- Iliac crest
- Lumbar fascia

Insertion

- Pubis
- Linea alba

Actions:

- Support internal organs
- Forced expiration



Diaphragm

Origin:

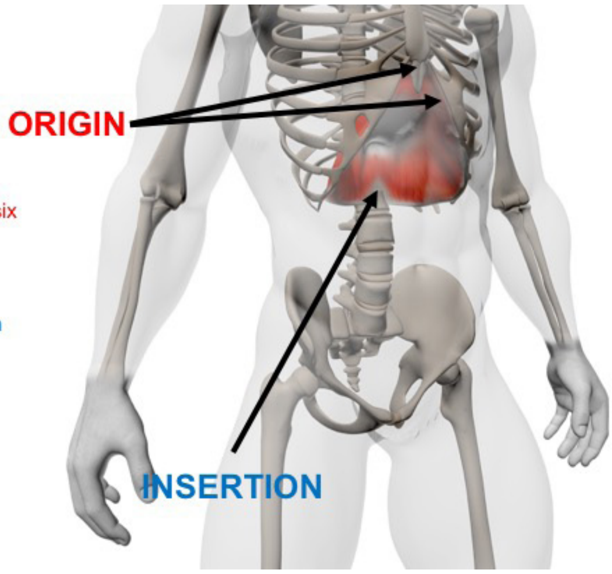
- Xiphoid process
- Inner surface of the lower six costal cartilages

Insertion

- Central aponeurotic tendon

Actions:

- Inspiration
- Forced inspiration



Intercostals

Origin:

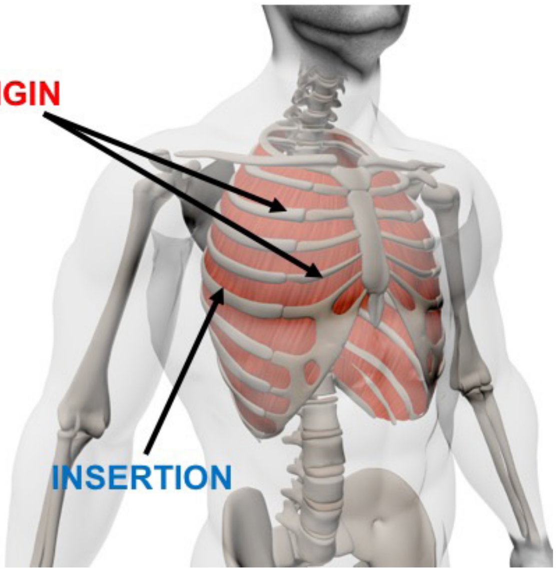
- Ribs
- Costal cartilages

Insertion

- Superior border of next rib below

Actions:

- Elevates ribs
- Aids in respiration



Spinal Muscles

Erector Spinae

Origin:

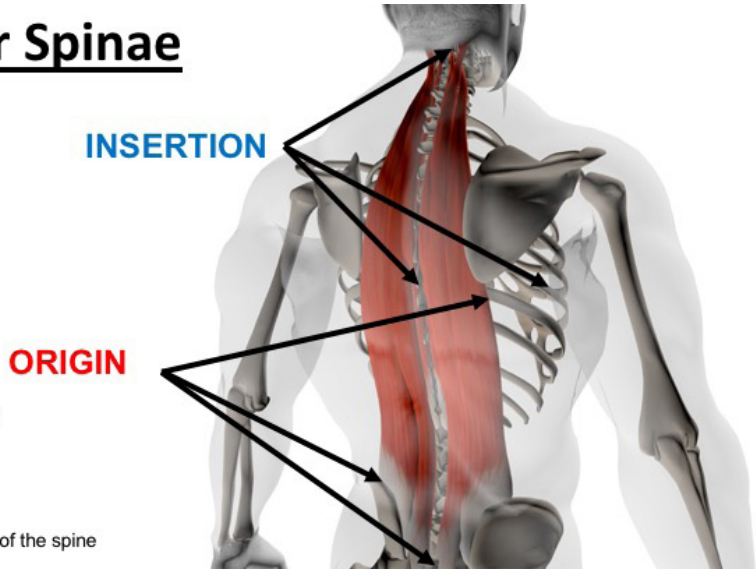
- Sacrum
- Ilium
- Ribs

Insertion

- Ribs
- Vertebrae
- Occipital Bone

Actions:

- Extension
- Lateral flexion of the spine



Multifidus

Origin:

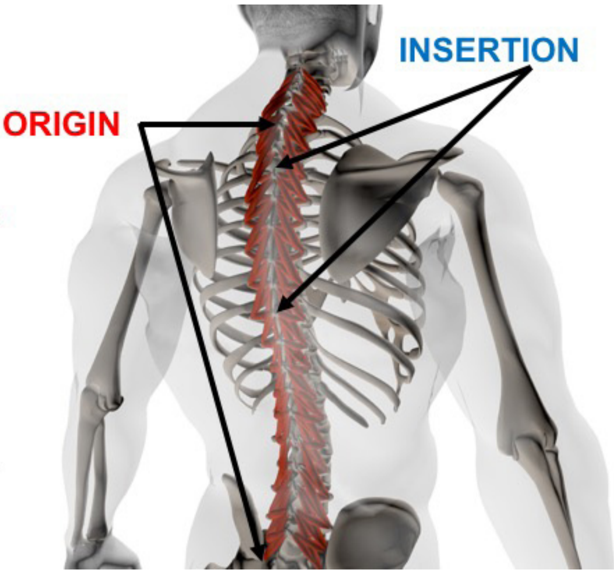
- Posterior superior iliac spine
- Transverse process of lumbar, thoracic and C4-C7 vertebrae

Insertion

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

Actions:

- Extension of vertebrae column
- Rotation of vertebrae column



Longissimus

Origin:

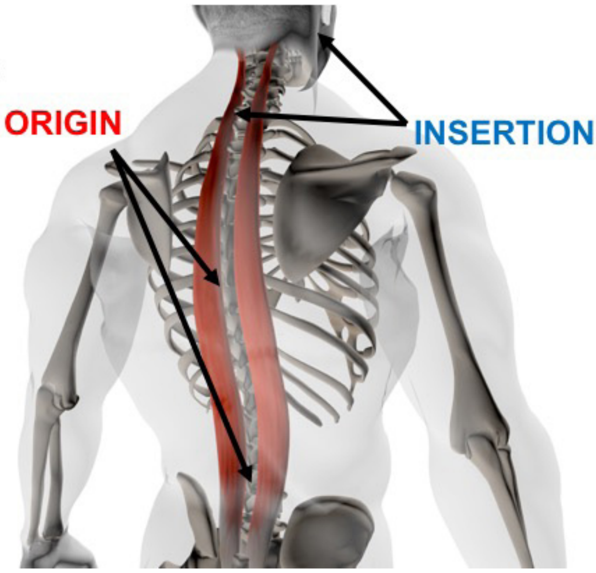
- Transverse process of the lumbar vertebrae
- Transverse process of the thoracic vertebrae

Insertion

- Ribs and transverse process of cervical vertebrae
- Mastoid process

Actions:

- Lateral flexion of neck
- Extension of the vertebrae column



Iliocostalis

Origin:

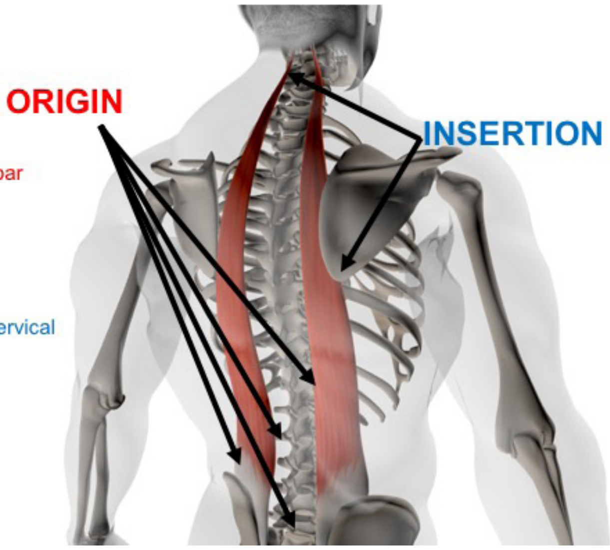
- Sacrum
- Iliac Crest
- Spinous Processes of Lumbar
- Lower thoracic vertebrae

Insertion

- Ribs
- Transverse processes of cervical vertebrae

Actions:

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



Spinalis

Origin:

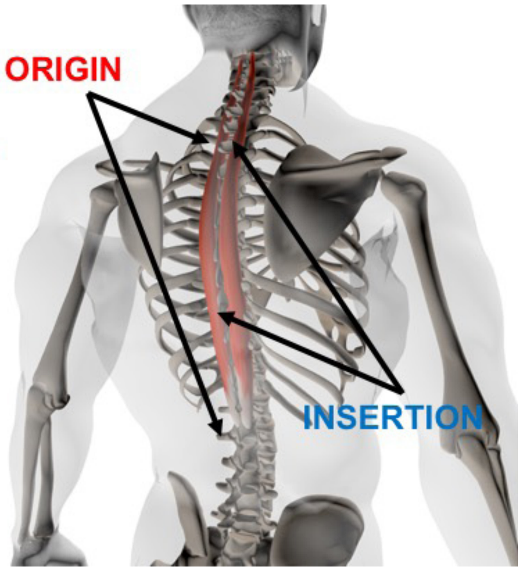
- Spinous processes of lumbar vertebrae
- Spinous processes of thoracic vertebrae

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



Levator scapulae

Origin:

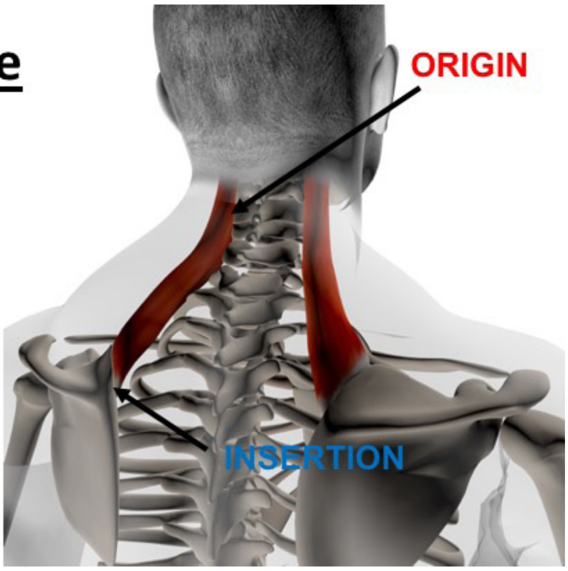
- Transverse process of C1-C4

Insertion

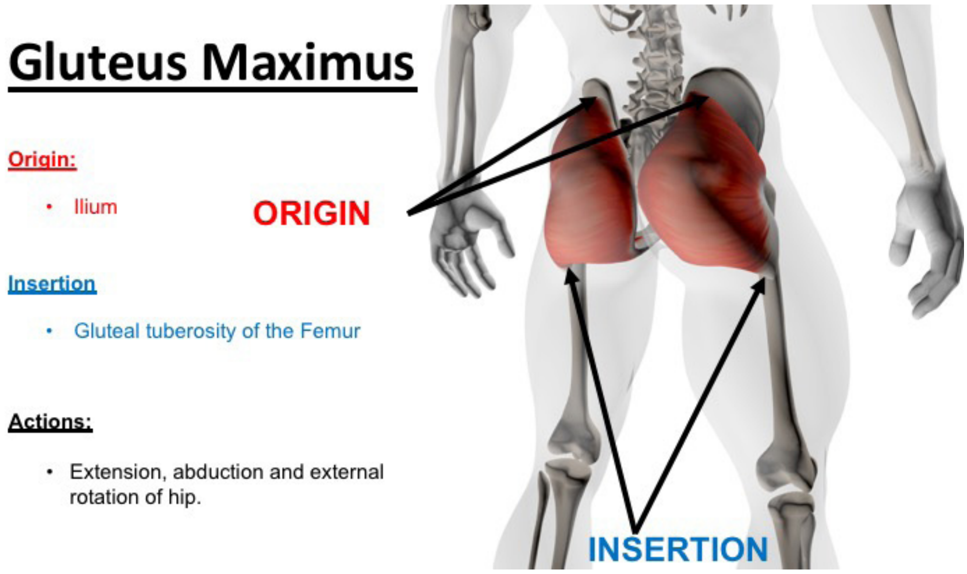
- Superior angle of Scapula

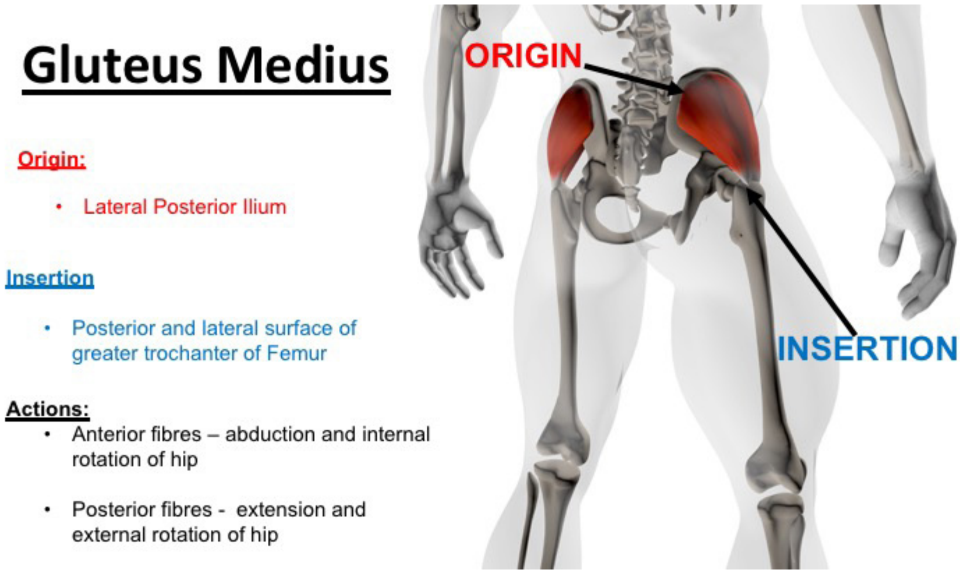
Actions:

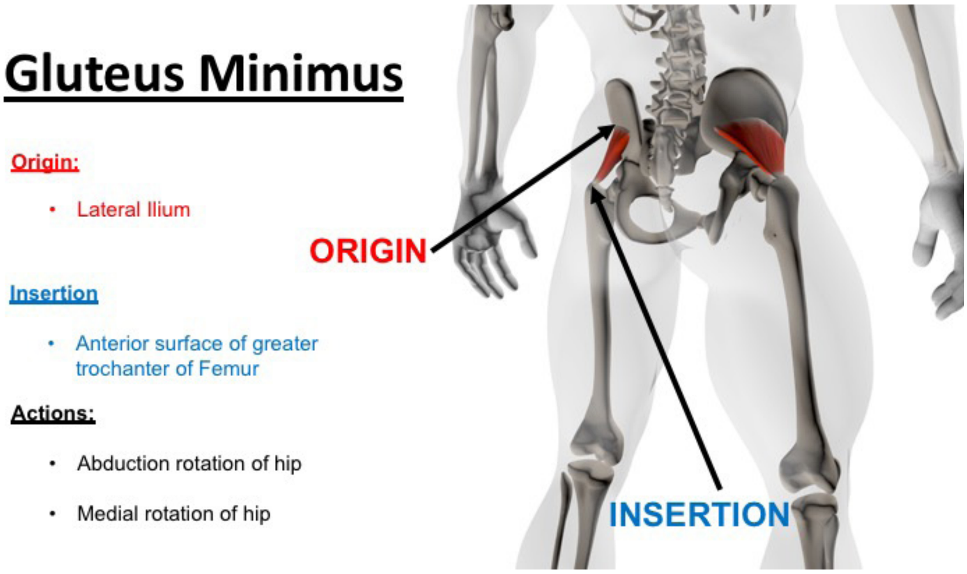
- Elevation of shoulder gridle
- Lateral flexion of the neck



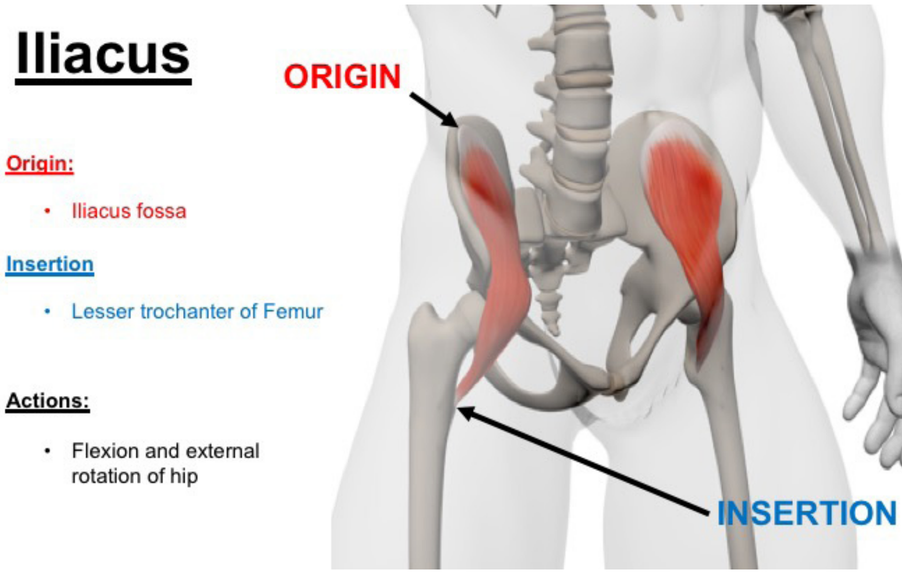
Gluteals

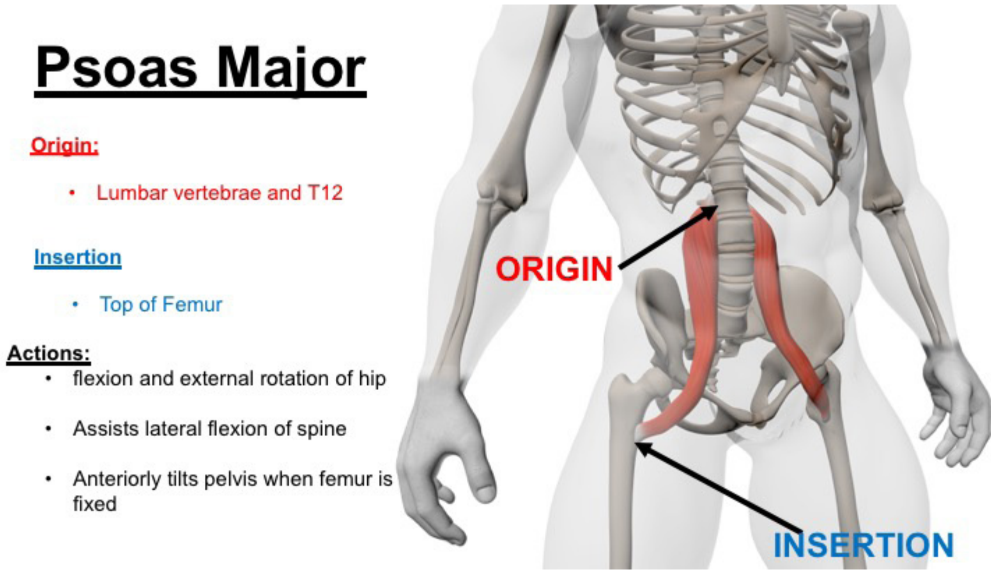

Gluteus Maximus
Origin:
• Ilium
ORIGIN
Insertion
• Gluteal tuberosity of the Femur
Actions:
• Extension, abduction and external rotation of hip.
INSERTION


Gluteus Medius
ORIGIN
Origin:
• Lateral Posterior Ilium
Insertion
• Posterior and lateral surface of greater trochanter of Femur
INSERTION
Actions:
• Anterior fibres – abduction and internal rotation of hip
• Posterior fibres - extension and external rotation of hip


Gluteus Minimus
Origin:
• Lateral Ilium
ORIGIN
Insertion
• Anterior surface of greater trochanter of Femur
Actions:
• Abduction rotation of hip
• Medial rotation of hip
INSERTION

Hip Flexor Muscles





Abductors and Adductors

Piriformis

Origin:

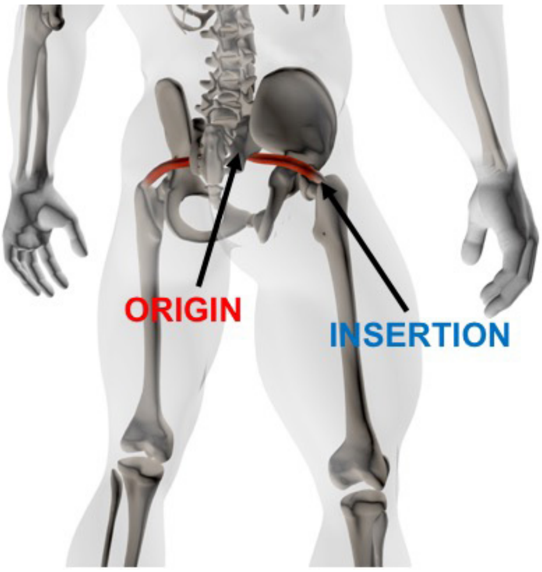
- Anterior sacrum

Insertion

- Upper surface of greater trochanter of Femur

Actions:

- Abduction of the hip
- Lateral rotation of the hip



Tensor Fascia Latae

Origin:

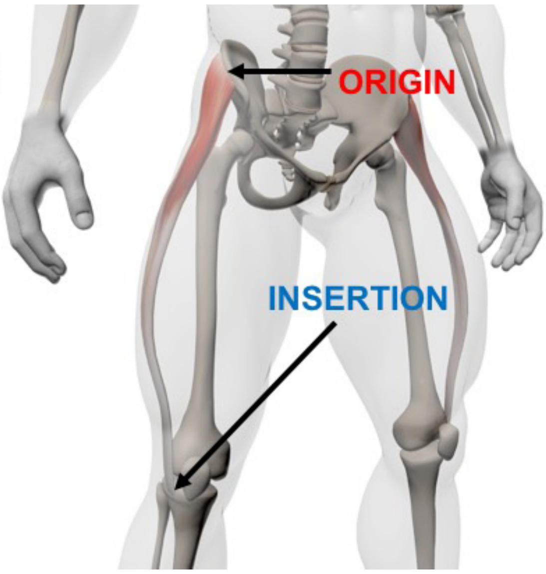
- Anterior Iliac crest

Insertion

- Lateral upper tibia via Iliotibial band (ITB)

Actions:

- Flexion of the hip
- Abduction of the hip



Adductor Magnus

Origin:

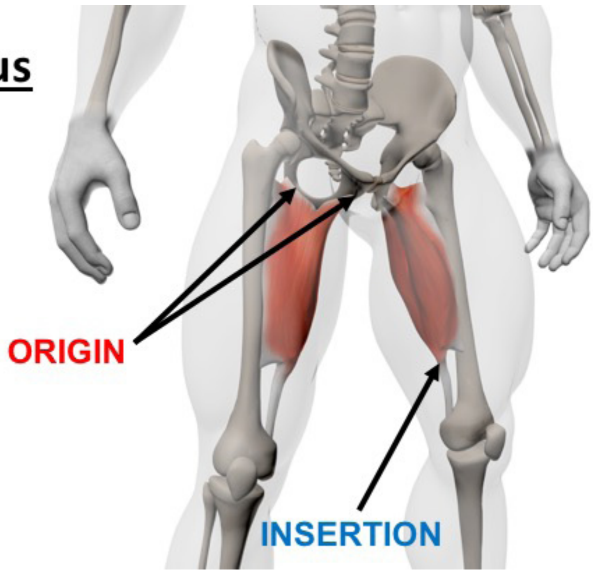
- Pubis
- Ischium

Insertion

- Femur

Actions:

- Adduction of the hip



Adductor Longus

Origin:

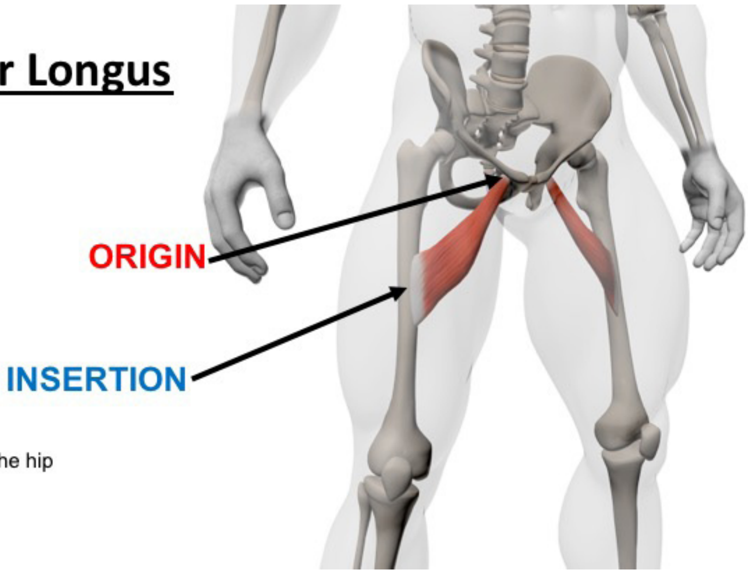
- Pubis

Insertion

- Femur

Actions:

- Adduction of the hip



Adductor Brevis

Origin:

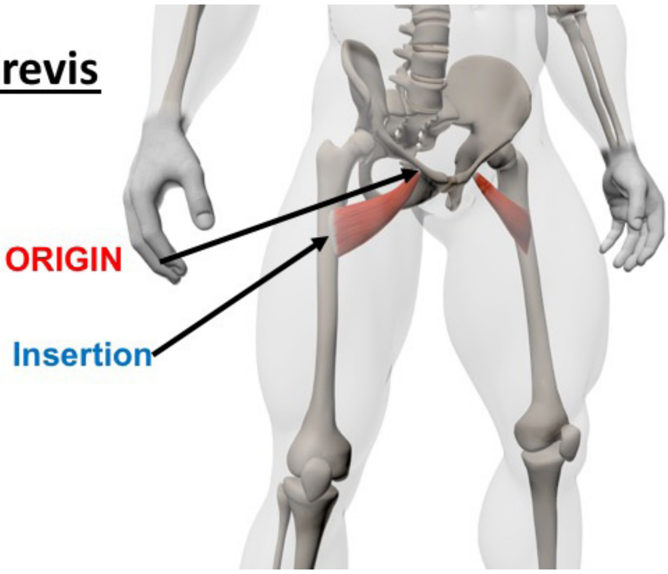
- Pubis

Insertion

- Femur

Actions:

- Adduction of the hip



Pectineus

Origin:

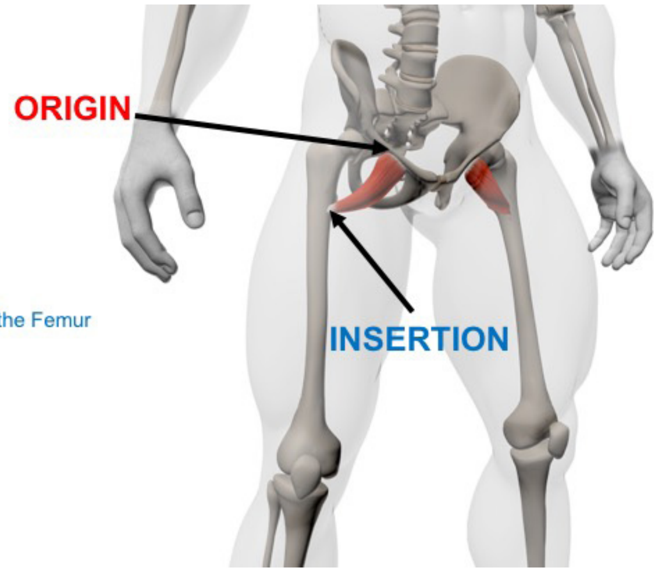
- Anterior Pubis

Insertion

- Lesser trochanter of the Femur

Actions:

- Adduction
- Flexion of the hip



Gracilis

Origin:

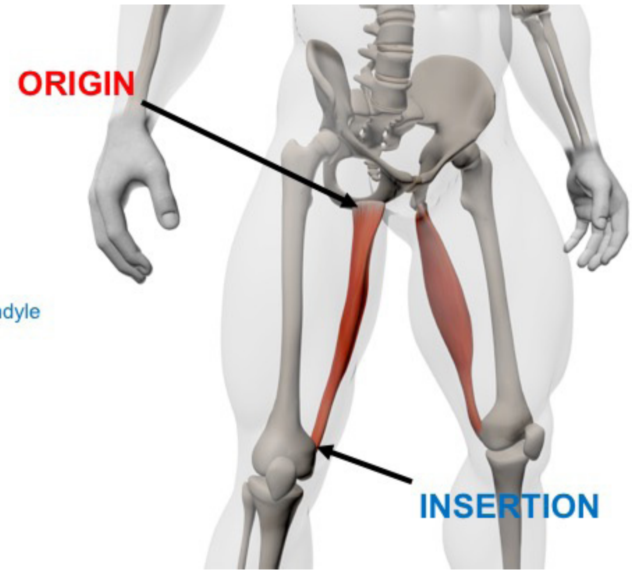
- Ischio-pubic ramus

Insertion

- Medial Tibia below condyle

Actions:

- Adduction
- Flexion of the hip



Sartorius

Origin:

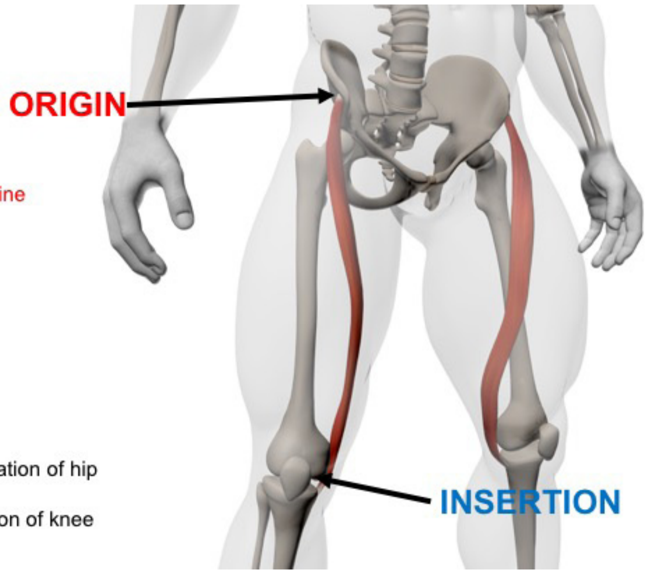
- Anterior Superior Iliac Spine

Insertion

- Medial condyle of Tibia

Actions:

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



Quadricep Muscles

Rectus Femoris

Origin:

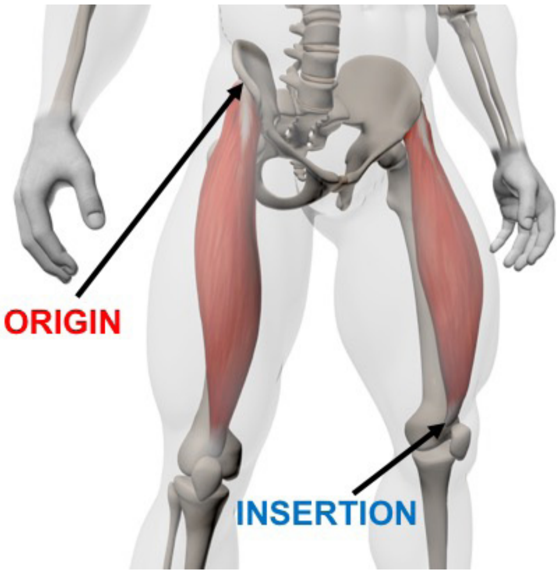
- Anterior Superior Iliac Spine

Insertion

- Tibial Tuberosity via Patella

Actions:

- Flexion of hip
- Extension of knee



Vastus Lateralis

Origin:

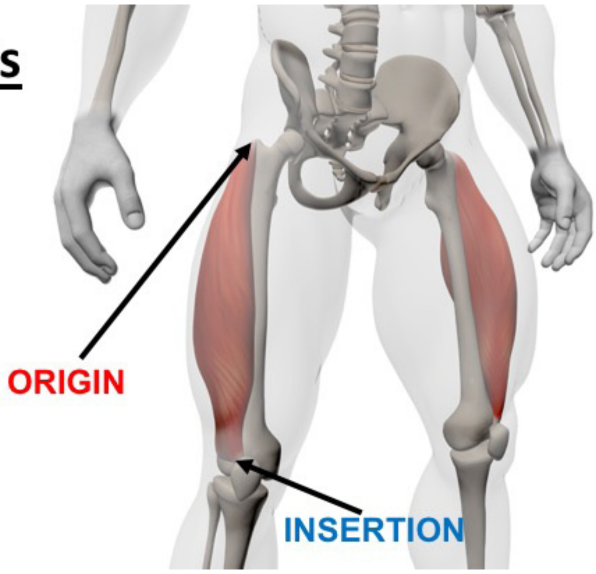
- Lateral Femur and greater trochanter

Insertion

- Tibial Tuberosity via Patella

Actions:

- Extension of knee



Vastus Intermedius

Origin:

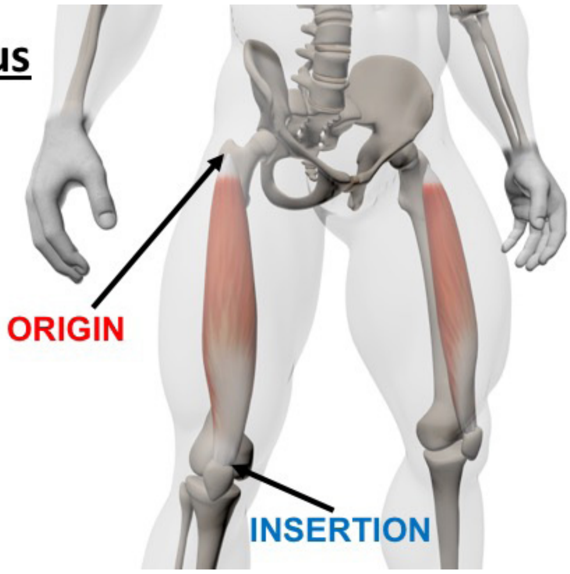
- Anterior Femur

Insertion

- Tibial Tuberosity via Patella

Actions:

- Extension of knee



Vastus Medialis

Origin:

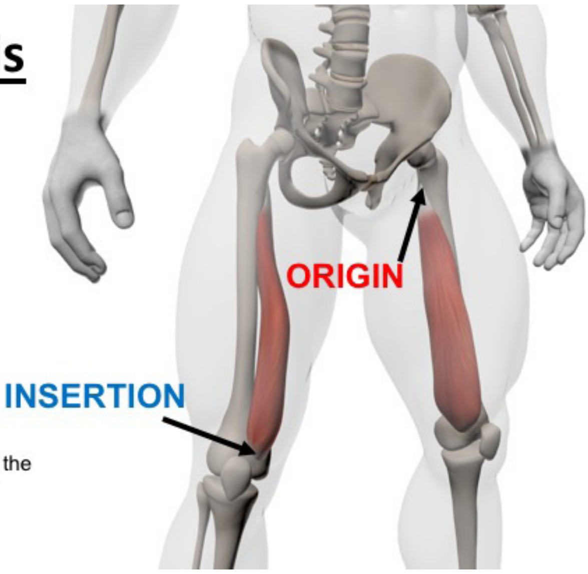
- Medial Femur

Insertion

- Tibial Tuberosity via Patella

Actions:

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



Hamstring Muscles

Biceps Femoris

Origin:

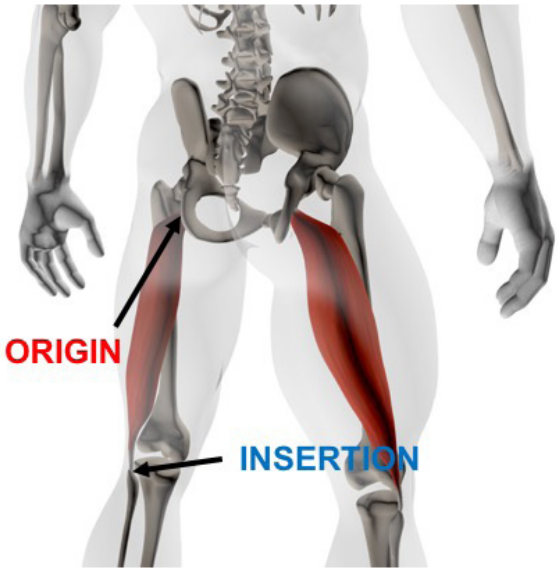
- Ischial Tuberosity
- Posterior Femur

Insertion

- Head of Fibula
- Lateral condyle of Tibia

Actions:

- Extension of hip
- Flexion of the knee



Semitendinosus

Origin:

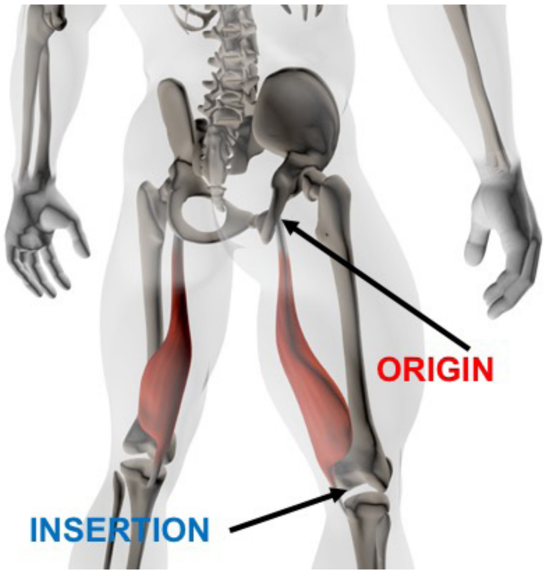
- Ischial Tuberosity

Insertion

- Medial condyle of Tibia

Actions:

- Extension of hip
- Flexion of the knee



Semimembranosus

Origin:

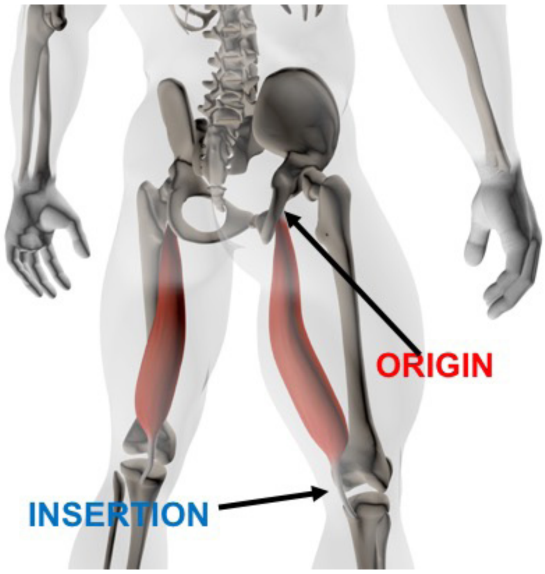
- Ischial Tuberosity

Insertion

- Anterior medial condyle of Tibia

Actions:

- Extension of hip
- Flexion of the knee



Lower Leg Muscles

Gastrocnemius

Origin:

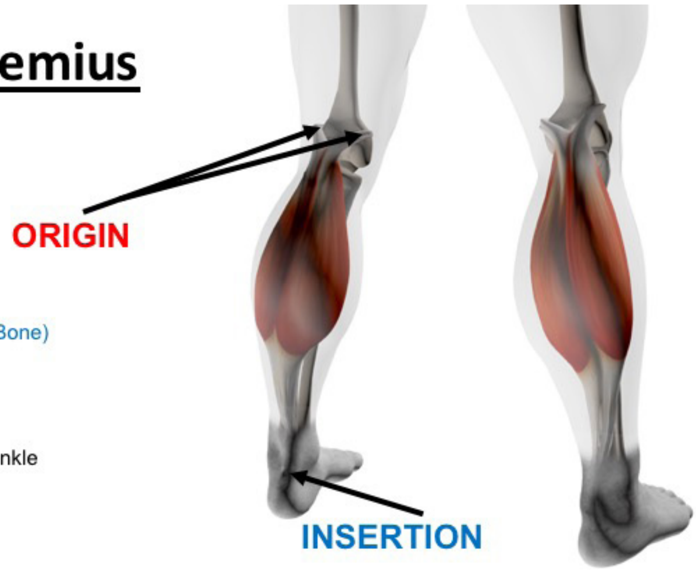
- Femur

Insertion

- Calcaneus (Heel Bone)

Actions:

- Plantarflexion of ankle
- Flexion of knee



Soleus

Origin:

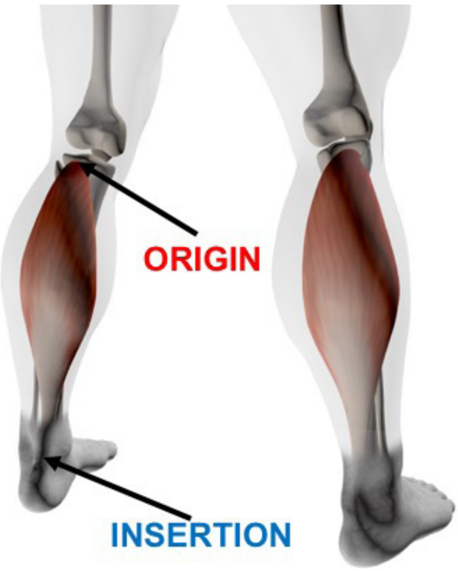
- Tibia

Insertion

- Calcaneus (Heel Bone)

Actions:

- Plantarflexion of ankle



Tibialis Anterior

Origin:

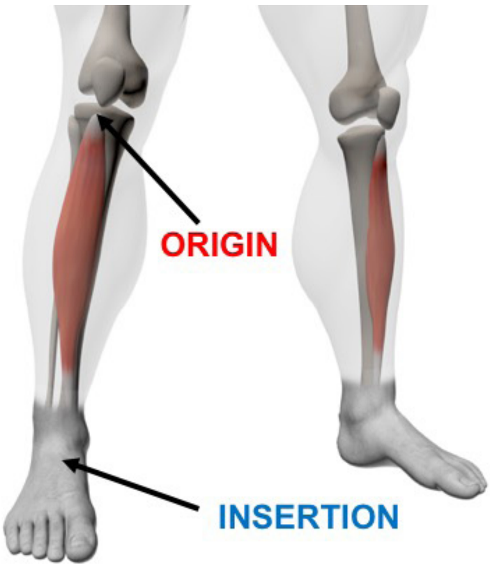
- Tibia

Insertion

- Metatarsals
- Tarsal

Actions:

- Dorsiflexion
- Inversion of ankle



A Muscle Booklet Download is available on the learning platform

Macronutrients: Carbohydrates

MODULE 3:
DEVELOPING FURTHER UNDERSTANDING OF MUSCLES AND MACRONUTRIENTS

Carbohydrates, also known as carbs or simply CHO, are a controversial topic in popular nutrition with a clear divide between the high carb and the low carb camps. In truth, both low and high carb dietary approaches can work – it very much depends on your personal preferences, activity levels, fitness goals, bio-individuality and, of course, your likes and dislikes. Rather than dwell on the high or low carb argument, this section will focus on a general overview of carbohydrate and its role in your body.

What Is A Carbohydrate?

Carbohydrates are plant foods that are made up of sugar molecules called saccharides. Saccharides are found singularly, in pairs and in complicated chains. The structure of a carbohydrate dictates how it is categorised.

Carbohydrates provide four calories of energy per gram or around 16.8 kilojoules and are the preferred source of energy for your brain and higher intensity activities such as weight lifting and sprinting.

On consumption, all digestible carbohydrates are broken down into glucose.

Carbohydrates are found in two forms and have two different roles:

- Simple carbohydrates (sugars) and Complex Carbohydrates (starches). Their role is for energy.
- Non-Starch polysaccharides (fibre): Their role is for digestive health.

The two forms are expanded upon in more detail in the following pages.

Simple Carbohydrates

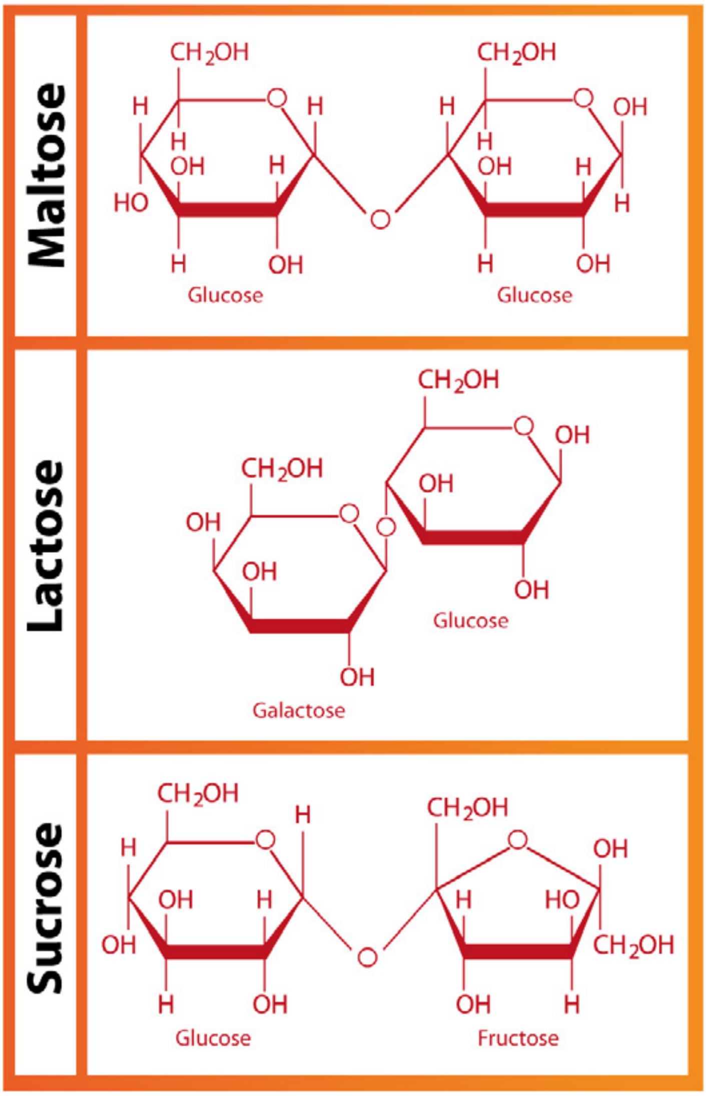
Simple carbohydrates can be found in two forms – **monosaccharides** or **disaccharides.**

Monosaccharides consist of single saccharide molecules.

Disaccharides are pairs of molecules joined together.

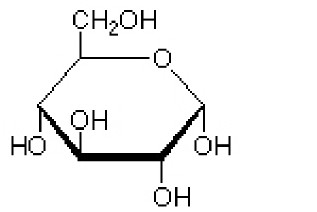
Monosaccharide	Disaccharide
Glucose (Dextrose)	Sucrose
Fructose (Fruit Sugars)	Lactose
Galactose	Maltose

Simple carbohydrates are often referred to as sugars which carry a negative connotation and implies all simple carbohydrates are bad for you. This is not the case!

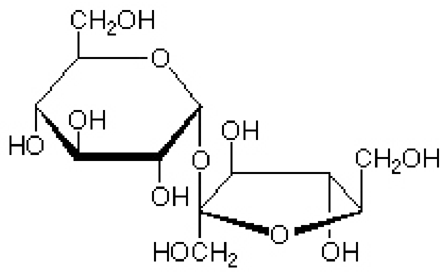


Complex Carbohydrate

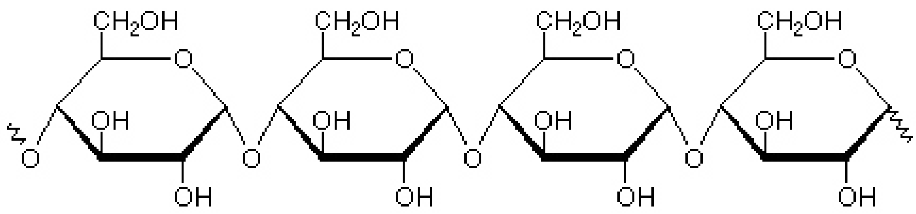
Complex carbohydrates are made from multiple chains of saccharide molecules called polysaccharides – poly meaning many. Polysaccharides are also called starches. Starches make up the greatest percentage of most people's food intake and can be found in bread, rice, pasta, vegetables and grain-based foods. Like simple carbohydrates, complex carbohydrates can be refined or unrefined.



monosaccharide (glucose)



disaccharide (sucrose)

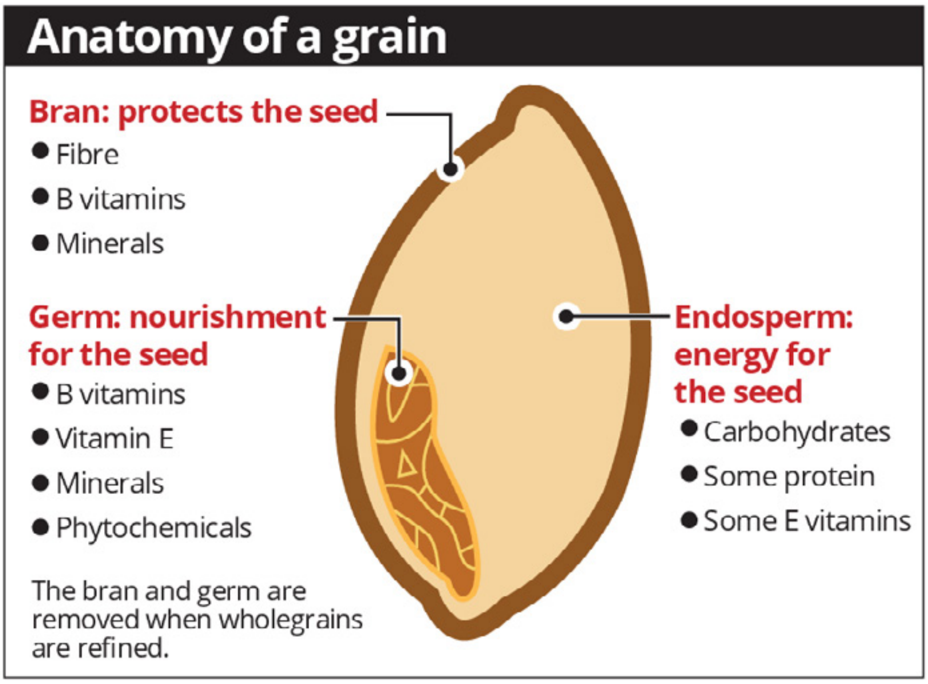


polysaccharide (amylose starch)

Digestible carbohydrates can be further subdivided into two categories:

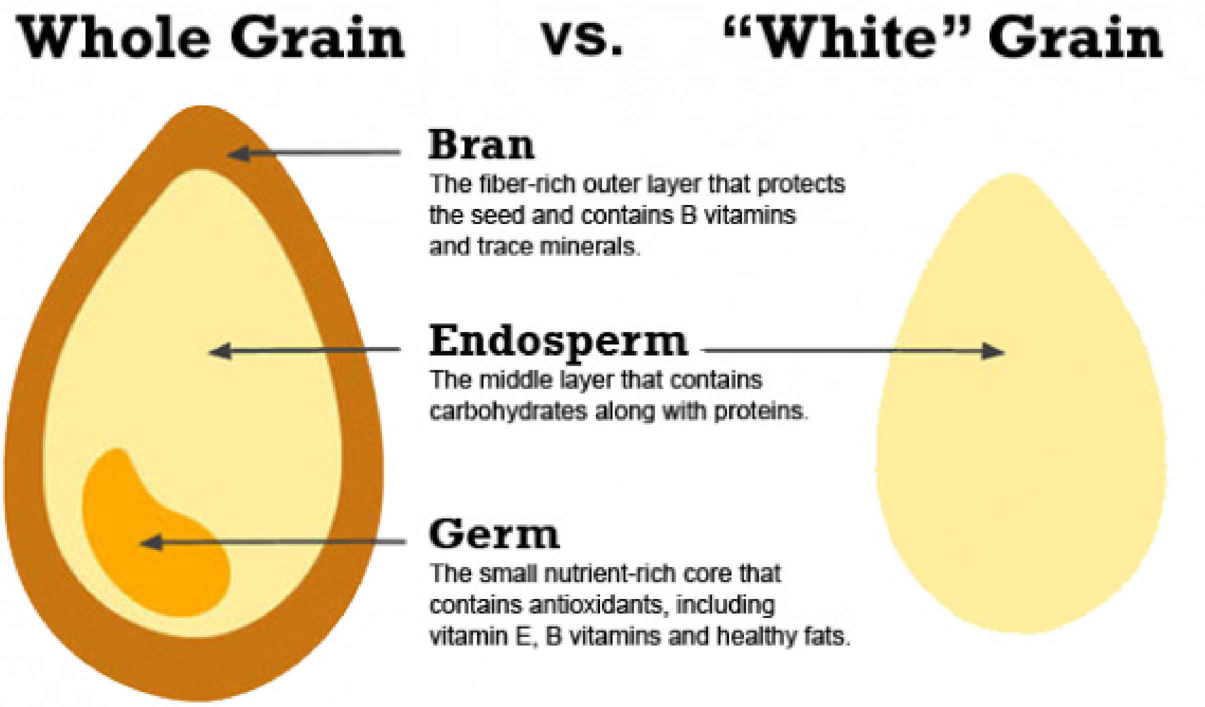
Unrefined and Refined

Unrefined carbohydrates have gone through very little in the way of processing and, subsequently, contain larger amounts of vitamins, minerals and fibre than refined carbohydrates. Examples of unrefined carbs include brown rice, brown pasta, wholemeal bread and fruit. Both simple and complex carbs can be unrefined or refined.



Refined carbohydrates have been through more processing than unrefined carbs and, subsequently, are often stripped of much of their nutritional value. White bread, white rice, white pasta and sugary sweets are good examples of refined carbohydrates.

The energy contained in carbohydrates cannot be released without vitamins and minerals, the most important being the B vitamins. Eating lots of refined carbohydrates, which are devoid of many vitamins, can cause depletion of vitamin and mineral reserves which makes it hard for the body to utilise carbohydrate for fuel. For this reason, heavily refined carbohydrates are often referred to as anti-nutrients or nutrient-robbers as they require vitamins but do not contain any.



In many cases, the list of ingredients in processed and refined foods includes refined sugars. Refined sugars are very sweet, mildly addictive, contain empty calories and help increase sales. They are strongly linked to diabetes and obesity and are best avoided where possible.

Common Refined Sugars and Sweeteners

- Dextrose
- Glucose syrup
- High fructose corn syrup
- Glucose-fructose syrup
- Inverted sugar syrup
- Mannitol
- Xylitol
- Sorbitol
- Maltodextrin

In addition to these caloric sweeteners, there are several low calorie and calorie-free sweeteners in current use including stevia, aspartame, saccharin and acesulfame K.

Low and no-calorie sweeteners are often used in "diet" products but are a very controversial subject as many are linked to things like high blood pressure, seizures, depression, numbness, aching muscles, diarrhoea, headaches, rashes, hyperactivity and even cancers. It is safe to say that switching from sugar to using artificial sweeteners instead is not an automatically healthy option.

In addition to artificial sweeteners, another less-than-healthy but common food additive is the flavour enhancer monosodium glutamate or MSG for short. MSG has mildly addictive qualities and increases appetite so its inclusion is likely to increase the amount of food eaten; good for profit margins but not so good for your waistline.

VARIANTS/INDICATORS OF THE PRESENCE OF MSG INCLUDE:

- Yeast extract
- Hydrolysed protein
- Whey protein isolate
- Soy protein isolate
- Carrageenan
- Some "natural" flavourings

The Glycemic Index

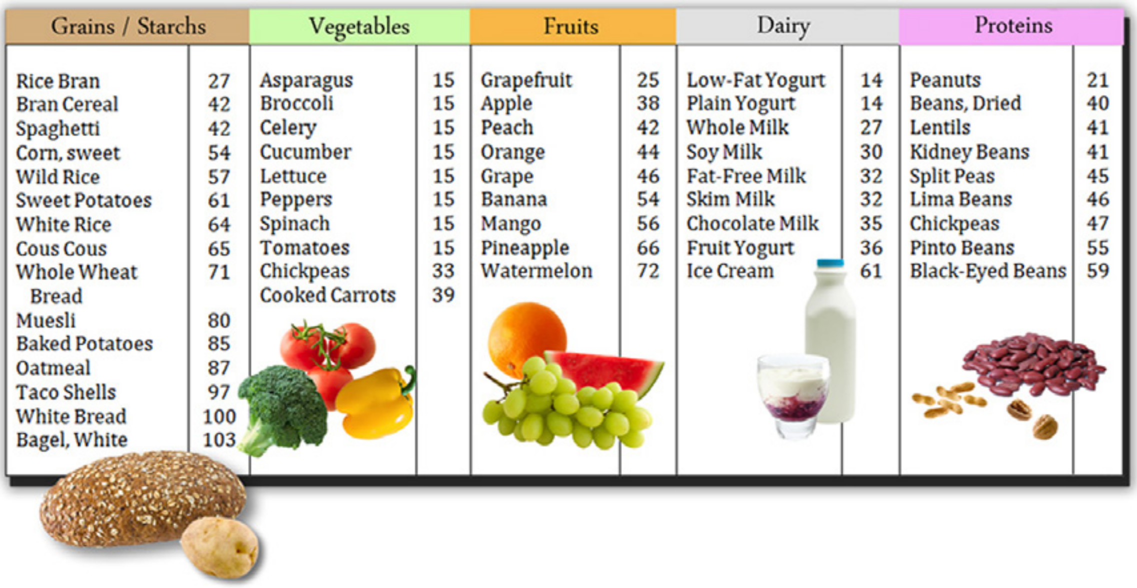
It's clear then, considering refined and unrefined, simple and complex carbohydrates, not all carbohydrates have been created equal and some sources of carbs are definitely healthier than others in terms of nutritional density. It's easy enough to select which carbohydrates contain the least amount of refined sugars and the greatest number of micronutrients but there is yet another way that carbohydrates are classified; The Glycemic Index.

The glycemic index is a scoring system that rates carbohydrates according to the speed at which they are digested and converted into blood glucose.

The glycemic index uses a 1 to 100 scale. Fast-acting carbohydrates score very high on the scale while slower acting carbohydrates get more moderate (medium) to low scores. The glycemic index gives you a good indication of what carbohydrates to eat and when. There are numerous interpretations of what constitutes a low, medium (moderate) or high glycemic index but the chart below is fairly representative of the norm.

Glycemic Index

Low GI (<55), Medium GI (56-69) and High GI (70>)



Grains / Starchs		Vegetables		Fruits		Dairy		Proteins	
Rice Bran	27	Asparagus	15	Grapefruit	25	Low-Fat Yogurt	14	Peanuts	21
Bran Cereal	42	Broccoli	15	Apple	38	Plain Yogurt	14	Beans, Dried	40
Spaghetti	42	Celery	15	Peach	42	Whole Milk	27	Lentils	41
Corn, sweet	54	Cucumber	15	Orange	44	Soy Milk	30	Kidney Beans	41
Wild Rice	57	Lettuce	15	Grape	46	Fat-Free Milk	32	Split Peas	45
Sweet Potatoes	61	Peppers	15	Banana	54	Skim Milk	32	Lima Beans	46
White Rice	64	Spinach	15	Mango	56	Chocolate Milk	35	Chickpeas	47
Cous Cous	65	Tomatoes	15	Pineapple	66	Fruit Yogurt	36	Pinto Beans	55
Whole Wheat Bread	71	Chickpeas	33	Watermelon	72	Ice Cream	61	Black-Eyed Beans	59
Muesli	80	Cooked Carrots	39						
Baked Potatoes	85								
Oatmeal	87								
Taco Shells	97								
White Bread	100								
Bagel, White	103								

High glycemic foods such as sugary cereals, refined grain products and confectionary are quickly digested and converted to usable glucose. This makes them ideal if you need a quick burst of energy during or just before a workout or want to refuel as fast as possible after a workout.

Low glycemic index foods such as beans, apples, most dairy and porridge oats take longer to digest and will release their energy slower. This means that you tend to feel fuller for longer after eating low glycemic index carbohydrates and experience more stable energy levels throughout the day as a result.

As with all of your food choices, try to select the most nutritionally dense form of carbohydrate that you can. Although all carbohydrates provide energy, they are by no means equal in terms of vitamin, mineral and fibre density. Given the choice between a fresh apple and a cookie, the apple should be your food of choice – most of the time anyway.

Fibre

Fibre is part of the carbohydrate group and is present to one degree or another in all grains, fruits, vegetables, pulses, legumes and nuts. Technically a non-starch polysaccharide or NSP for short, the human digestive systems lacks the necessary enzymes to break fibre down and so, as far as we are concerned, fibre is a calorie-free food. Animals that can extract energy from fibre have more than one stomach or have the ability to produce specialised enzymes so they can digest this tough plant-derived starch. For humans, although fibre does not contribute any energy to your daily diet, it provides numerous other health-related benefits.

Types of Fibre

Fibre can be classified as soluble or insoluble. This refers to its interaction with water.

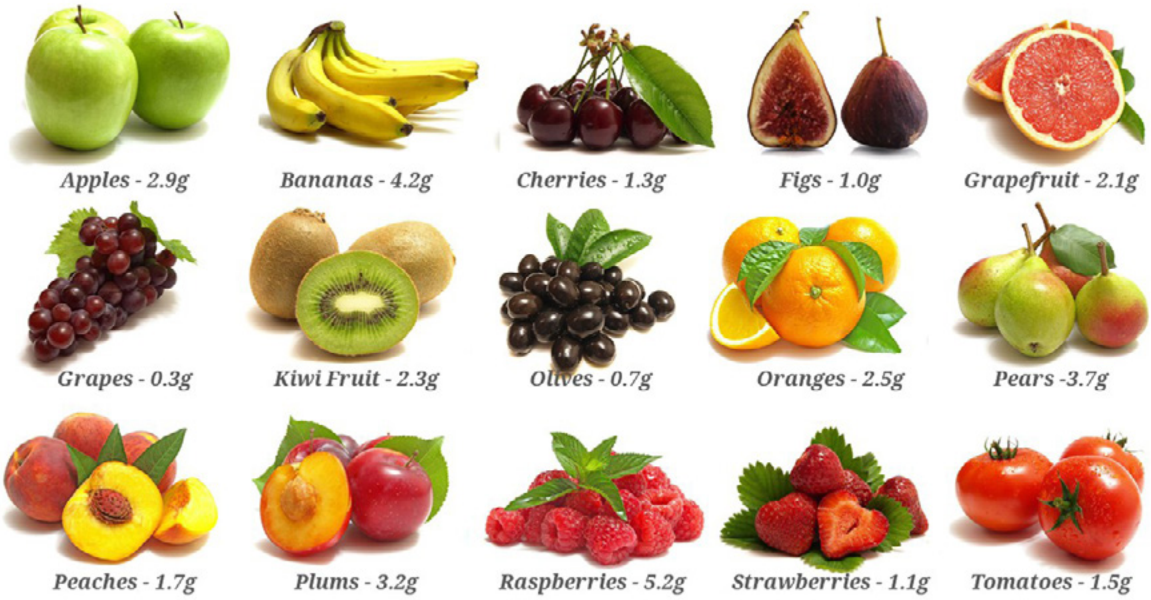
Soluble fibre forms a gel-like substance as it passes through your digestive tract. Like a dry sponge, it soaks up liquid as it passes through your intestines and absorbs small but significant amounts of bile acid, cholesterol and fat in your digestive system. Soluble fibre is found in the soft flesh of fruits, vegetables and grains.

Insoluble fibre is sometimes called roughage and is found in the tough outer husk of grains as well as the skins of vegetables and fruit. Insoluble fibre passes through your digestive system like an old-fashioned bottle brush and gives it a good internal scrubbing.

Fibre Requirements

Despite being calorie and nutrient-free, fibre offers a wide range of health benefits. The RDA (recommended daily allowance) for fibre is around 35 grams per day, split evenly between soluble and insoluble varieties. Your total daily fibre requirement varies according to your age, weight and the amount of food you are eating which is why you may often see a recommended range for fibre consumption of 24 to 35 grams.

As fibre is calorie-free, there is little harm in making sure you hit the upper ranges of this scale. If you are currently eating too little fibre and decide to eat more, increase your daily fibre intake gradually. Going from a low fibre diet to a high fibre diet overnight is like trying to run a marathon on the first day you take up jogging. Increase your fibre intake slowly and gradually over a few weeks to minimise your chances of suffering digestive discomfort.



Lowers cholesterol levels

Soluble fibre found in beans, oats, flaxseed and oat bran may help lower total blood cholesterol levels by lowering low-density lipoprotein (LDLs), or "bad," cholesterol levels.

Studies also have shown that high-fibre foods may have other heart-health benefits, such as reducing blood pressure and inflammation.

Helps control blood sugar levels

In people with diabetes, fibre; particularly soluble fibre, can slow the absorption of sugar and help improve blood sugar levels. A healthy diet that includes insoluble fibre may also reduce the risk of developing type 2 diabetes.

Normalizes bowel movements

Dietary fibre increases the weight and size of your stool and softens it. A bulky stool is easier to pass, decreasing your chance of constipation.

If you have loose, watery stools, fibre may help to solidify the stool because it absorbs water and adds bulk to stool.

Helps maintain bowel health

A high-fibre diet may lower your risk of developing haemorrhoids and small pouches in your colon (diverticular disease). Studies have also found that a high-fibre diet likely lowers the risk of colorectal cancer. Some fibre is fermented in the colon. Researchers are looking at how this may play a role in preventing diseases of the colon.

Aids in achieving a healthy weight

High-fibre foods tend to be more filling than low fibre foods, so you're likely to eat less and stay satisfied longer. And high-fibre foods tend to take longer to eat and to be less "energy-dense," which means they have fewer calories for the same volume of food.

Helps you live longer

Studies suggest that increasing your dietary fibre intake; especially cereal fibre, is associated with a reduced risk of dying from cardiovascular disease and all cancers.

As previously discussed, fibre is calorie-free. This means that foods that contain a lot of fibre such as whole grains, fruits and vegetables are generally lower in calories than less fibrously-dense foods. To put this in perspective, an apple and a typical biscuit both contain around 60 calories. Because much of the mass of the apple is made up from calorie-free fibre and water, compared to sugar and fat in the biscuit, the apple is bigger, far more filling and much more satisfying to eat. Most of us can eat a few biscuits in a single serving but it's pretty unlikely you'll eat the same number of apples! Filling up on fibre is a great way to prevent overeating. Stretch receptors in your stomach send signals to your brain when it is full so you know when to stop eating. This message can take as long as 30 minutes to be sent and received. Fibrous foods cause greater gastric distension than non-fibrous foods. Simply put, this means you feel fuller quicker, which results in your brain getting the "stop eating" signal sooner than usual. This limits your potential for overeating.

In addition to being low in calories, fibrous foods generally take longer to chew and eat and keep you feeling fuller for longer. Fibre is a major gastric inhibitor. This simply means that fibre delays the emptying of your stomachs contents into your small intestine. The longer food stays in your stomach, the longer you feel full.

A real-world example of this phenomenon is Chinese food. It's an old truism that after eating a Chinese meal, 20 minutes later you are hungry again. Why? White rice! White rice is mostly devoid of fibre and subsequently passes out your stomach and into your small intestine very rapidly. This means you can go from feeling full to feeling empty very quickly.

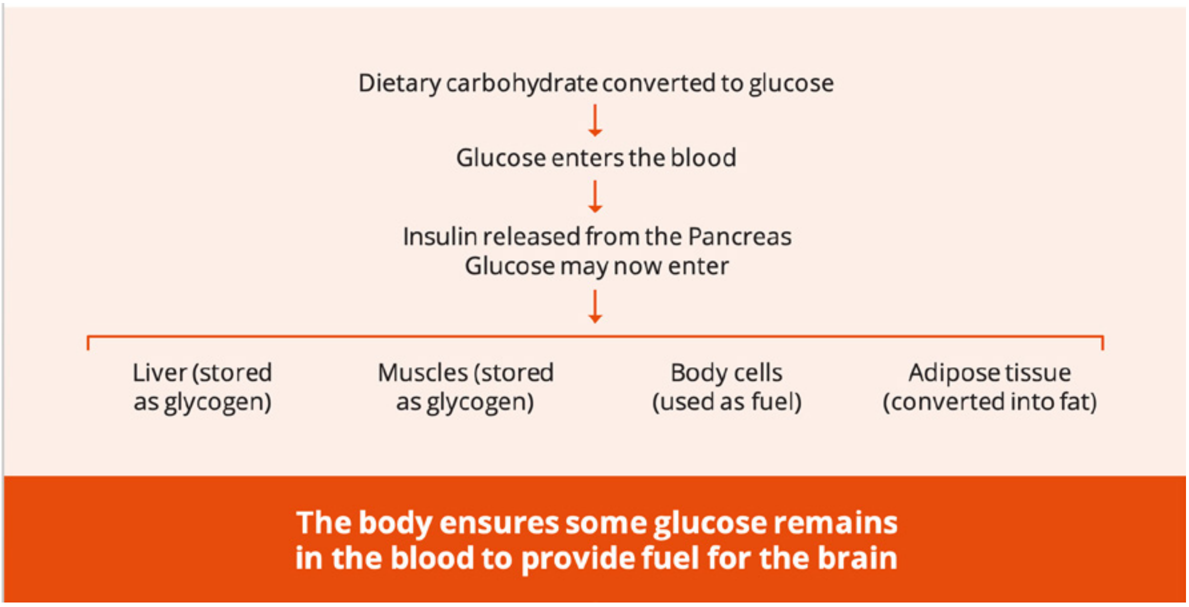
By delaying gastric emptying, fibre also helps to control your blood glucose levels. Large fluctuations in blood glucose trigger corresponding fluctuations in insulin levels. Roller coasting blood glucose levels play havoc with your hunger. A rapid drop in blood glucose can often result in cravings for carbohydrate (one reason never to go grocery shopping on an empty stomach) so by ensuring that your stomach empties slowly, fibre helps ensure that your blood glucose levels remain relatively stable.

The Fate Of Dietary Carbohydrate

Whatever type of carbohydrate you consume; all carbohydrate is broken down by digestive enzymes called pancreatic and salivary amylase and turned into glucose. Your body has a number of different uses for glucose.

Once digested, glucose enters your bloodstream and stimulates your pancreas to release the hormone insulin. Insulin acts like a key to unlock your cells and allows the glucose to enter various tissues. Glucose is stored for later use in the form of glycogen, used for fuel or if there is an excess, converted to fat.

A small amount of glucose also remains in your blood and is the primary fuel for your brain. Glycogen is locked into your liver or muscles. Liver glycogen provides a reservoir of glucose for your brain whereas muscle glycogen provides energy for contractions by the muscles in which it is stored.



Digestive Health

The hollow tubes of your intestines are made of smooth muscle and like the muscles of your chest, arms and legs, benefit from a regular workout. Fibre provides the means to exercise your digestive system. A diet devoid of fibre will result in poor intestinal health in the same way that a lack of exercise will result in a flabby, weak body.

To push food through your digestive system, the smooth muscular tubes that make up your digestive tract must squeeze inward in an action called peristalsis. Picture a snake swallowing an egg and the wave-like undulations as the snake squeezes the egg down the length of its body – that's peristalsis. Low fibre foods do not travel through your hollow digestive tubes very easily. A large amount of pressure is required to push food along.

Imagine trying to get the very last bit of toothpaste out of the tube – it's a real challenge! Fibre adds bulk to your food and, consequently, it passes through your digestive system much more easily and with far less pressure.

Easy food passage and reduced food transit time (the time it takes from ingestion to elimination) has a major impact on digestive health and is strongly linked to a lower incidence of diverticular disease, also known as diverticulitis. This is a painful and serious medical condition where bacteria-filled bulges develop in the walls of your intestines. By consuming adequate fibre, intestinal pressure is kept to a minimum and there is much less likelihood of developing this unpleasant disease.

Getting Enough

While getting enough fibre is very important, supplementation is seldom the best way. Fibre supplements such as bran and psyllium husks do indeed provide fibre but they do not provide any of the other nutritious benefits associated with eating fibrous fruits, vegetables and whole grains; specifically vitamins and minerals. An over-reliance on fibre supplements may actually result in a vitamin and mineral deficiency.

The best way to get enough fibre in your diet is to eat a wide variety of fruit, vegetables, grains and other natural food. Refined foods such as white bread, white rice, white pasta and processed meals contain very little fibre so, wherever possible, search for foods in their most natural and unprocessed state. Simply following the old advice of eating an apple a day is one way to make sure you are on your way to getting enough essential fibre in your diet.

Whole Sources of Carbohydrates

DOWNLOADABLE RESOURCE AVAILABLE ON LEARNING PLATFORM

Below is a table that shows various food products and where they are found relative to the eatwell plate.

The listed foods all have the highest amount of carbohydrates per 100g of product. Therefore they should be called 'whole' sources of carbohydrates.

Whole Sources of Carbohydrates	Amount per 100g	Additional Information
Carrots (Baby)	6g	N/A
Carrots (Tinned)	4.4g	Tinned in water
Banana	20.3g	N/A
Strawberries (Fresh)	6g	N/A
Strawberries (Frozen)	6g	N/A
Mango (Fresh)	13.6g	N/A
Mango (Dried)	74.7g	N/A
Flour (Plain)	73.5g	N/A
Flour (Wholemeal)	59.4g	N/A
Bread (White)	46.4g	Warburtons 'Toastie'
Bread (Wholemeal)	37.8g	Hovis "Wholemeal'
Potatoes (Maris Piper)	17.5g	N/A
Potatoes (New/Baby)	14.9g	N/A
Rice (Basmati)	32.3g	N/A
Rice (Brown)	36.9g	N/A
Pasta (White)	35.7g	Fusili
Pasta (Brown)	32.9g	Fusili
Baked Beans	12.5g	Heinz
Lentils	9.4g	Red Split
Milk **	4.8g per 100ml	Semi-Skimmed/2%/Green
Natural Yoghurt (Plain) **	6.8g	N/A
Digestive Biscuit	63.6g	N/A

* Colours are representative of their location within the eat-well plate.
** Whilst the highlighted dairy products do not contain starch, they do contain fast acting sugars in greater amounts than the other macronutrients.

ORIGYM

As we now know, foods such as pasta and bread, are defined as processed food because it has been changed from its natural wheat form. When choosing more natural carbohydrates opt for foods such as rice or potatoes as the carb source on your plate.

Macronutrients: Proteins

MODULE 3:
DEVELOPING FURTHER UNDERSTANDING OF MUSCLES AND MACRONUTRIENTS

Protein is an organic compound that serves many functions in the body. Protein contains four-calories or 16.8 kilojoules of energy per gram, protein is a vital nutrient that makes up a large amount of your body's tissues including your hair, skin, nails, and bones and, of course, your muscles. It is also an important factor in controlling homeostasis and can, under certain circumstances, be used for fuel.

The word protein is derived from the Greek word for primary or first – proto and is made up of smaller units called amino acids. Amino acids can be thought of as the protein alphabet although, unlike the 26 letters in the English alphabet, there are only 20 amino acids. When digested, protein is broken down into these amino acids which are then re-ordered and re-built back into useable proteins for use in the body.

Peptides

Animal and plant amino acids are joined together to make substances called peptides. This process results in chains of amino acids of varying length. When the chain of amino acids is long or complex enough, it forms a protein. To be considered a protein, the polypeptide chain must contain 100 or more amino acids.

Peptides		
2 Amino Acids	Dipeptide	Di meaning 2
3 Amino Acids	Tripeptide	Tri meaning 3
4 - 9 Amino Acids	Oligopeptide	Oligo meaning Few
10+ Amino Acids	Polypeptide	Poly meaning Many

Amino Acids

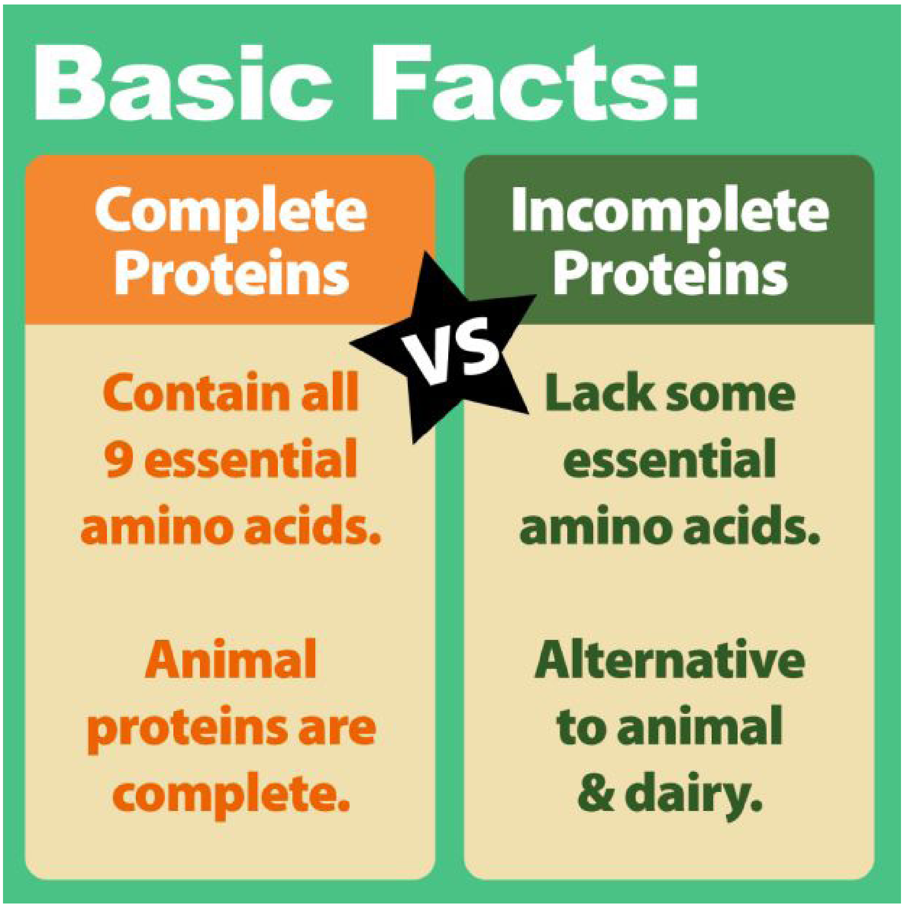
Of the 20 amino acids, nine are classified as essential while eleven are classified as non-essential or conditionally essential. The nine essential amino acids must be present in the food you eat while the remaining eleven non-essential amino acids are synthesised by your liver providing that the essential amino acids are present in your diet. Non-essential amino acids are also present in some foods and consumption of these foods will "spare" the essential amino acids.

- **Essential (9)**
- **Non-Essential (11)**

Essential	Conditionally Non-Essential	Non-Essential
Histidine	Arginine	Alanine
Isoleucine	Cystine	Asparagine
Leucine	Glutamine	Aspartate
Lysine	Glycine	Glutamate
Methionine	Proline	Serine
Phenylalanine	Tyrosine	
Threonine		
Tryptophan		
Valine		

*Leucine, isoleucine and valine are collectively called the branch chain amino acids and make up approximately 35% of the amino acids found in muscle tissue. For this reason, BCAA supplements are very popular as it is hypothesised that consuming BCAAs can help repair muscle tissue from exercise-induced muscle damage and may reduce muscle soreness. Whether this is true or not, BCAA supplements are popular with many athletes.

Complete And Incomplete Proteins



Foods that contain adequate amounts of all the essential amino acids are classed as complete. Complete proteins include eggs, meat, fish, dairy produce, poultry, soy and quinoa. A diet rich in these foods means that you have all the amino acids necessary to synthesise the non-essential amino acids.

Many plants contain a variety of amino acids but are often deficient in some of the essentials and are therefore classed as incomplete proteins. Because they are lacking one or more of the essential amino acids most plant foods are considered to be carbohydrates rather than proteins. Examples include vegetables, seeds, nuts, beans and grains.

Complete Proteins	Incomplete Proteins
Eggs	Cereals
Dairy Foods	Grains
Poultry	Nuts
Fish	Beans
Meat	Lentils
Seafoods	Seeds
Buckwheat	Vegetables
Quinoa	

Complementary Proteins

Like pieces of a jigsaw, you can slot incomplete proteins together to make a fully-fledged protein. This is important for vegetarians and for people who want to consume non-animal protein sources.

It's simply a matter of making sure that, between them, the incomplete proteins supply all of the essential amino acids in sufficient amounts. A protein made up in this way is called a complementary protein and provides a convenient way to obtain adequate dietary protein without having to eat any animal-protein foods. There are a number of food combinations you can use to form a complementary protein.

- **Grains and pulses**
- **Vegetables and nuts**
- **Vegetables and seeds**
- **Grains and dairy**
- **Nuts and seeds**
- **Nuts and pulses**
- **Seeds and pulses**

With a little culinary imagination it is possible to turn any of the incomplete proteins listed into a healthy source of complete protein, or, at the very least put some peanut butter on your toast or some nuts in your vegetable stir fry! However, it's worth noting that complementary proteins do not need to be consumed in the same meal to be effective. In fact, recent research suggests that a viable complete protein can be created from two complementary proteins consumed in the same 24-hour period. Foods that are considered to be complementary proteins will also contain insignificant amounts of carbohydrate which must be considered when calculating energy intake.

Whole Sources of Protein

DOWNLOADABLE RESOURCE AVAILABLE ON LEARNING PLATFORM

Below is a table that shows various food products and where they are found relative to the Eatwell plate.

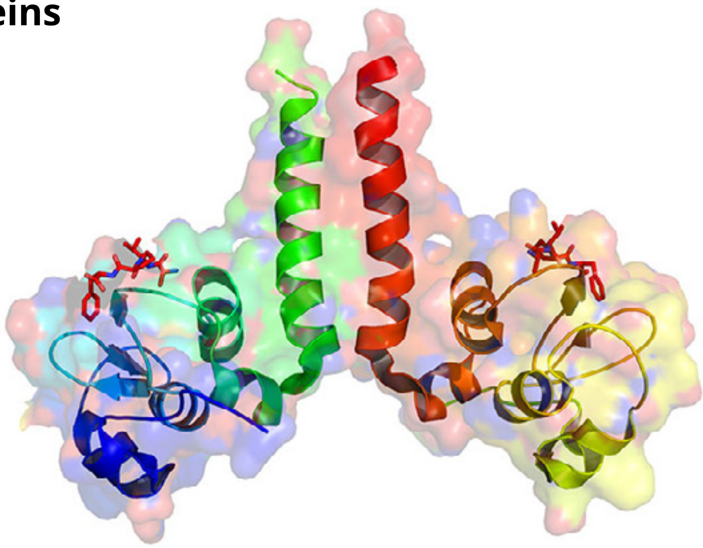
The listed foods all have the highest amount of protein per 100g of product. Therefore they should be called 'whole' sources of protein.

Whole Sources of Protein	Amount per 100g	Additional Information
Tuna (Tinned)	22g	N/A
Salmon	23.8g	N/A
Egg White	11g	N/A
Turkey (Breast)	29g	N/A
Turkey (Leg)	28g	More fat content will reduce overall protein percentage
Chicken (Breast)	31g	N/A
Chicken (Thigh)	24g	More fat content will reduce overall protein percentage
Beef (15% Fat Mince)	19.7g	N/A
Beef (Sirloin)	27g	N/A
Pork (4% Mince)	32g	N/A
Pork (Tenderloin)	26g	N/A
Tofu	8g	N/A
Tempeh (Soy)	19g	N/A
Seitan (Wheat Gluten)	75g	Not recommended for those with a gluten intolerance
Spirinula	57g	Is not a traditional vegetarian product but suitable for all
Quorn (Mycoprotein)	11g	Doesn't have all 9 EAA in the highest amounts but it is combated when combined with lentils
Quark (Soft Cheese)	11g	N/A
Skyr (Plain)	10g	N/A
Greek Yoghurt (0% Fage)	11g	N/A
Grated Cheddar (50% Less Fat)	29.4g	Sample taken from Tesco
Protein Bar	38.9g	Sample in Grenade - 'carb Killa-Brownie' flavour

* Colours are representative of their location within the eat-well plate.

ORIGYM

Functions of Proteins



In addition to dietary protein, there are three other types of protein which are categorised according to their function in the body:

- **Dietary Protein:** As discussed in this chapter.
- **Structural proteins** form the framework of many-body components including collagen which is present in bone and connective tissue and keratin which is present in the skin. Muscle tissue, hair and nails are other examples of structural proteins.
- **Homoeostatic proteins** are an integral part of the synthesis of hormones, enzymes and blood cells. These substances regulate various bodily functions and include insulin and adrenalin and infection-fighting white blood cells (WBCs).
- **Fuel proteins** are not the body's preferred source of energy but are a viable source of energy when glycogen (stored glucose) levels start to run low and an alternative source of energy is required e.g. during periods of starvation or during long-duration endurance events. Amino acids can be converted to glucose, fatty acids or a substance called ketones to produce adenosine triphosphate (ATP).

Necessary Terminology

Catabolism

Catabolism describes the breaking down larger structures into smaller ones in the body; specifically protein. Exercise, ageing and illness all cause catabolism and some degree of catabolism is happening all of the time inside your body. As cells are broken down, they are built back up using recycled and fresh amino acids. In the case of exercise-induced catabolism, tissue, muscle specifically, is built back bigger and stronger but in the case of age-related catabolism, the repair process is eventually outpaced by the breakdown process and the result is the ageing process.

Anabolism

The process of building within the body, i.e. renewing skin cells or building muscle, is called anabolism; anabolism primarily occurs during periods of rest and recovery. Characterised by tissue growth, repair and renewal, the process of anabolism requires adequate dietary protein otherwise both health and performance may suffer. Anabolism always follows catabolism – providing there are enough amino acids available to fuel the process.

Rating Protein

Protein foods are rated in terms of quality using a number of different scales. The various scales evaluate the digestibility of a protein and the availability of essential amino acids.

The greater the amount of the consumed protein that can be utilised by your body, the higher the score will be. Most animal origin proteins such as eggs, meat, fish as well as soya score very highly whereas incomplete proteins score much lower.

The most well-known scale for protein quality is the Biological Value scale or BV for short however other scales include Net Protein Utilisation or NPU, Protein Efficiency Ratio or PER and the Protein Digestibility Corrected Amino Acid Score or PDCAAS. Each rating method is slightly different and uses a variety of criteria for scoring a protein, hence the variance in the chart below.

Protein Quality Ratings

The chart below shows four different rating methods scientists use to evaluate the quality of several proteins. The higher the number shown in the columns, the better your body uses the protein.

B.V. (Biological Value): is the proportion of absorbed protein that is retained in the body for maintenance and/or growth. The highest score of 100 was given for the best protein at the time, egg. However, whey protein came along and proved even better than an egg.

N.P.U (Net Protein Utilisation): is the proportion of protein intake that is retained (calculated as BV times Digestibility).

P.E.R. (Protein Efficiency Ratio): is the gain in body weight divided by the weight of the protein consumed.

P.D.C.A.A.S (Protein Digestibility Corrected Amino Acid Score): is based on the amino acid requirements of humans. A protein scoring a 1.0 indicates it meets all the essential amino acid requirements of humans according to the Food Agriculture Organisation and World Health Organisation. However, it does not take into account surplus essential amino acids some proteins have that could compensate for lower levels in another protein like beans.

Whey protein tops the list as the best quality protein due to its specific amino acid array. Lower quality vegetable proteins are at the bottom of the list due to low levels of one or more essential amino acids. However, one protein is not superior to others in all ways. Each has distinct advantages and disadvantages.

Source	B.V	N.P.U	P.E.R	P.D.C.A.A.S
Whey Protein	104	92	3.6	1.0
Whole Egg	100	94	3.8	1.0
Beef	80	73	2.0	0.92
Casein (milk)	77	76	2.9	1.0
Soy	74	61	2.1	0.99
Rice	59	57	2.0	0.26
Beans	49	39	1.4	0.68

Protein Requirements

Protein requirements vary from one person to another; it depends how big you are and how active you are. Because the food pyramid and Eat Well Plate nutrition models place an emphasis on carbohydrate over protein, it's not unlikely that a significant percentage of the exercising population is actually consuming too little protein. This can adversely affect the potential benefits of exercise. By contrast, eating too much protein can result in increases in body fat.

Protein should feature as a major part of most meals and daily intake then fine-tuned to ensure protein needs are being met. The table below outlines the American College of Sports Medicine's (ACSM) recommendations for protein consumption which is widely accepted as being appropriate in the majority of cases.

Activity Type	Ideal Daily Intake Gram per Kg of Body Weight
Sedentary person / Low Intensity Activity	0.75
Recreational adult exerciser	0.8 - 1.5
Endurance Training (moderate/heavy)	1.2 - 1.4
Strength and Power Training	1.4 - 1.8
Growing Teenage Athlete	1.5 - 2
Exerciser on a Weight (fat) loss program	1.6 - 2
Exerciser on a weight (muscle) gain program	1.8 - 2

Protein Recommendations

It's clear then that all proteins were not created equal. However, it's not just the quality of the protein you should consider but also the actual food quality as well.

As the old adage goes; "If you put junk in you'll get junk out" so it pays to try and consume the best quality protein foods you can. Lean organic meats and poultry, free-range eggs, organic milk and raw nuts are all good sources of protein that will provide amino acids and other essential nutrients.

Not-so-good protein choices include burgers, sausages, meat pies, UHT dairy, roasted nuts, non-organic pulses, reformed meats such as luncheon meat and battery farmed eggs. Reformed and processed meats often contain as little as 6% actual meat, a figure allowable by law, and much of their weight consists of water, fillers such as wheat, sugar and bone meal.

More information will be discussed during the "Calculating Protein Requirements" section.

Macronutrients: Fats

MODULE 3:
DEVELOPING FURTHER UNDERSTANDING OF MUSCLES AND MACRONUTRIENTS

Weighing in at 9 calories or 37.8 kilojoules per gram, dietary fats are much maligned and often misunderstood. The media frequently vilifies them and food marketers take advantage of our "fat-phobia" by actively promoting low-fat products. While dieticians usually suggest cutting reducing your fat intake, proponents of Palaeolithic and low carbohydrate diets insist that fat is good and should be well represented in your daily diet. Who is right and who is wrong is a book in the making so the intention of this section is to discuss how your body uses fat and the different types of fat you will find in your diet.

Fat plays an important role in many physiological functions:

FAT PLAYS AN IMPORTANT ROLE IN MANY PHYSIOLOGICAL FUNCTIONS:

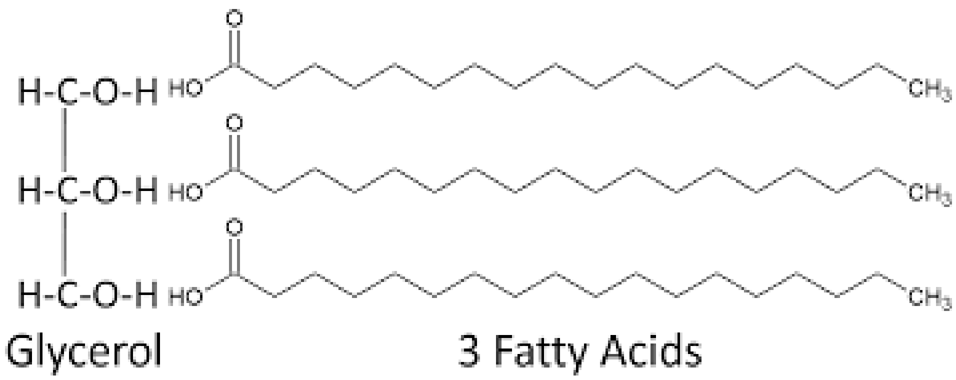
- **The formation of virtually all cell membranes**
- **The formation of myelin sheaths within the nervous system**
- **Constitutes the majority of the CNS and spinal cord**
- **Provides a means for storing energy – i.e. adipose tissue**
- **The synthesis of steroid hormones**
- **Assists in the regulation of enzymes**
- **Provides insulation through subcutaneous adipose tissue**
- **Provides protection to the internal organs and brain**
- **Facilitates the transportation, storage and usage of vitamins A, D, E and K**
- **Provides primary fuel source at low levels of intensity**

Types Of Dietary Fats

Fats, also known as lipids, come in four main types – saturated, monounsaturated, polyunsaturated and trans fats. They are broken down into fatty acids when digested and each fat has a very specific chemical structure which dictates its role in your body.

TRIGLYCERIDES

In nature, fatty acids usually occur in threes. These three-fatty acid units are called triglycerides because the three fatty acids are attached to a carbohydrate "backbone" called glycerol.



SATURATED FATS

Often considered the "bad boy" of dietary fats, saturated fats are comprised of chains of carbon atoms that are packed or saturated with hydrogen. This makes them, with the exception of palm oil and coconut oil, solid at room temperature and chemically inert.

Saturated fats do not react very much to heat, light or oxygen which makes them ideal for cooking. Foods such as butter, animal produce, eggs and dairy contain large amounts of saturated fat.

Your body likes to use saturated fats for energy during aerobic activity, as stored energy for later use within your adipose tissue, protection of vital organs, cell membrane integrity, transport and storage of fat-soluble vitamins and is also essential for protein utilisation.

Common Sources of Saturated Fat	
Animal	**Non-Animal**
Meat	Coconut Oil
Poultry	Palm Oil
Dairy	
Eggs	

Despite their negative reputation, research has revealed that saturated fat should be included in all healthy diets and is, in fact, a vital nutrient.

SATURATED FAT HAS SEVERAL IMPORTANT FUNCTIONS:

- **Enhancement of immune system function**
- **Provides energy and structural integrity to cells**
- **Enhances liver function and provides protection against alcohol**
- **It is anti-microbial and anti-viral**

The worst thing that can be said about saturated fats is they have a high propensity to being converted to body fat is consumed in large quantities and with high levels of carbohydrate. For this reason, many people reduce their saturated fat intake in an effort to create a calorific deficit and lose weight.

MONOUNSATURATED FAT

Monounsaturated fat is missing some hydrogen and, as a result, a double bond is formed in the carbon chain. The double bond causes a bend in the carbon chain and, in chemistry, shape dictates function. This means that a monounsaturated fat behaves differently to saturated fat.

Monounsaturated fats are moderately reactive and more susceptible to changes caused by heat, light and oxygen. Liquid at room temperature, monounsaturated fats are linked to cardiovascular health and feature heavily in the olive oil-rich Mediterranean diet.

Other sources of monounsaturated fats include nuts and nut derived oils and butters, beef, avocados and numerous seeds. The relative chemical instability of monounsaturated fats means that, while they can be heated and used for cooking, overheating them can make them less healthful. To avoid turning your good monounsaturated into less healthy trans fats (discussed later) do not overheat olive oil or nut oil when cooking. You can tell when you have overheated an oil when it begins to smoke.

For cooking, choose oils that have a high “smoke point”. Olive oil, for example, has a smoke point of around 200 degrees centigrade compared to flaxseed oil that will smoke at around 100 degrees centigrade.

Sources of Monounsaturated Fat	
Olives and Olive Oil	Rapeseed Oil
Lard	Avocados
Beef	Most Nuts
Peanuts, Peanut Oil and Butter	Most Seeds

POLYUNSATURATED FATS

Polyunsaturated fats contain two or more double bonds in their carbon chains. This characteristic makes them highly reactive when exposed to heat, light or oxygen.

Examples of polyunsaturated fats include oily fish, sunflower seeds, sesame seeds, walnuts, soya beans and any oils subsequently extracted from these sources.

The inherent reactivity seen in polyunsaturated fats means that exposing an otherwise healthy polyunsaturated fat to high temperatures is likely to result in the formation of trans fats. Polyunsaturated fats are not ideal oils for cooking and more stable saturated and monounsaturated fats are the better choice. Consume the majority of your polyunsaturated fats in a raw state to maximize their healthfulness.

Polyunsaturated fats, many of which are considered essential for health hence their common moniker "essential fatty acids" or EFAs for short, can be subcategorised as omega-three or omega-six fatty acids. Omega, the final letter in the Greek alphabet, refers to the position in the chain at which the last double bend is located i.e. three from the end or six from the end. These extremely healthful fats are responsible for a wide range of functions within your body including the formation of cellular hormone-like substances called prostaglandins, the regulation of inflammation, mental function and development and skin, hair and immune system health.

Many people take cod liver oil to help "lubricate their joints" but, in actuality, cod liver oil is an effective anti-inflammatory agent and helps reduce joint pain rather than increasing lubrication!

Sources of Polyunsaturated Fat	
Oily Fish	Sunflower Seeds and Oil
Flax Oil	Safflower Oil
Walnuts	Pumpkin Seeds
NB: All oils need to be cold pressed and unprocessed	
An ideal ratio of Omega 3 and 6 fatty acids is 1:1 or 1:2	

EFAs have been shown to reduce blood clotting, lower triglyceride levels, lower total cholesterol levels, raise good HDL cholesterol levels and reduce overall heart disease risk.

TRANS FATS

Hydrogenation And Trans Fats

Trans fats occur in nature and, when consumed in relatively small amounts, do not present any real problems for your health. However, many man-made foods and modern food preparation methods result in an abundance of trans fats being formed and consumed.

Overconsumption of trans fats is strongly linked to immune system dysfunction, bone and tendon weakness, sterility, coronary heart disease, high cholesterol and triglyceride levels, inability to lactate, learning difficulties and low birth weight babies.

In food manufacturing, large amounts of unsaturated oils are heated and then, after a catalyst (nickel usually) is added, hydrogen is pumped in under high pressure. This causes the normally "bent" fatty acid chain to straighten and therefore take on the properties of saturated fat but the arrangement of the hydrogen atoms means that trans fats do not behave like "real" saturated fats. Trans fats "block" healthy mono and polyunsaturated fats from entering cells resulting impairment of cellular function which may lead to poor health.

- Normal placement of hydrogen atoms: as seen in mono or polyunsaturated fat
- Diagonal placement of hydrogen atoms: as seen in a trans fat

You can minimise your consumption of trans fats by not overeating mono and polyunsaturated fats, cutting down on processed and takeaway foods, using saturated fats for high-temperature cooking and avoiding food products that contain hydrogenated or partially hydrogenated vegetable oils. It is also a good idea to keep your mono and polyunsaturated oils in dark glass air-tight containers, buying extra-virgin cold-pressed oils and consider using butter instead of margarine as many margarine type spreads contain hydrogenated vegetable oils. Check the label to be sure.

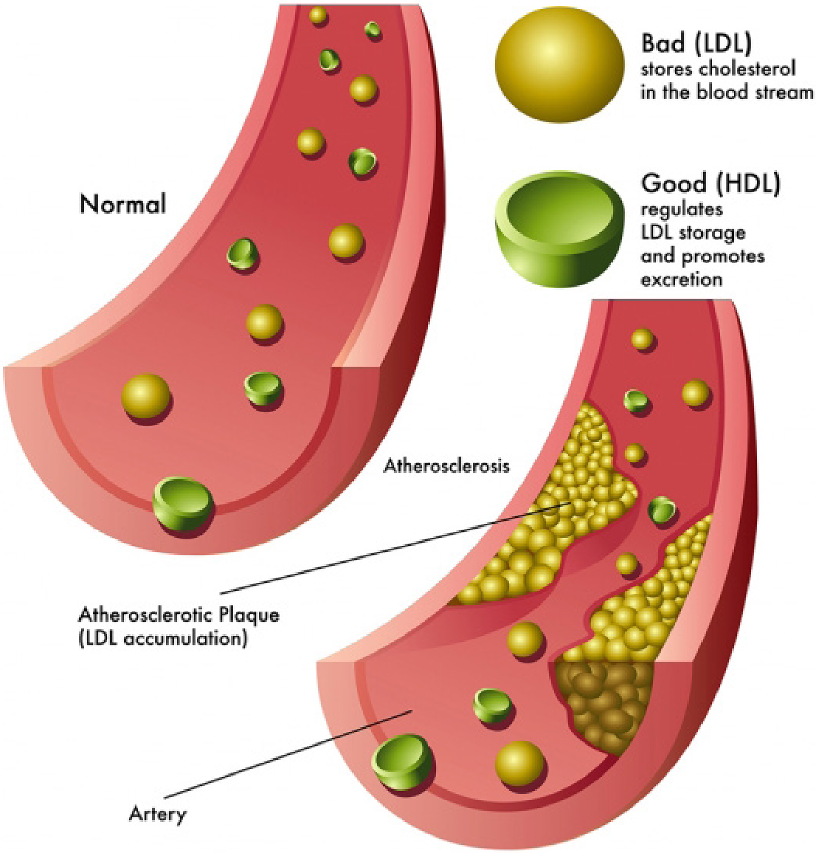
Common Sources of Trans Fats

- **Most margarines and vegetable oil spreads**
- **Biscuits**
- **Cakes**
- **Take-away foods**
- **Pies**
- **Pastries**
- **Pre-prepared foods**
- **Many "low-fat" foods**
- **Ice cream**

Fats – maybe not as bad for us as we are often lead to believe.

Many of the health problems associated with fats are due to the fact they can make you fat. Being over-fat presents a much greater health risk than fats alone ever could. Your body needs a certain amount to fat for health and eliminating fat from your diet can lead to a host of medical problems. By being more "fat aware" you can make sure you consume the fats that are best for you while avoiding those that can cause you harm.

Cholesterol



Cholesterol is a lipid molecule that effectively contains no calories and does not represent a source of energy despite being present in many foods.

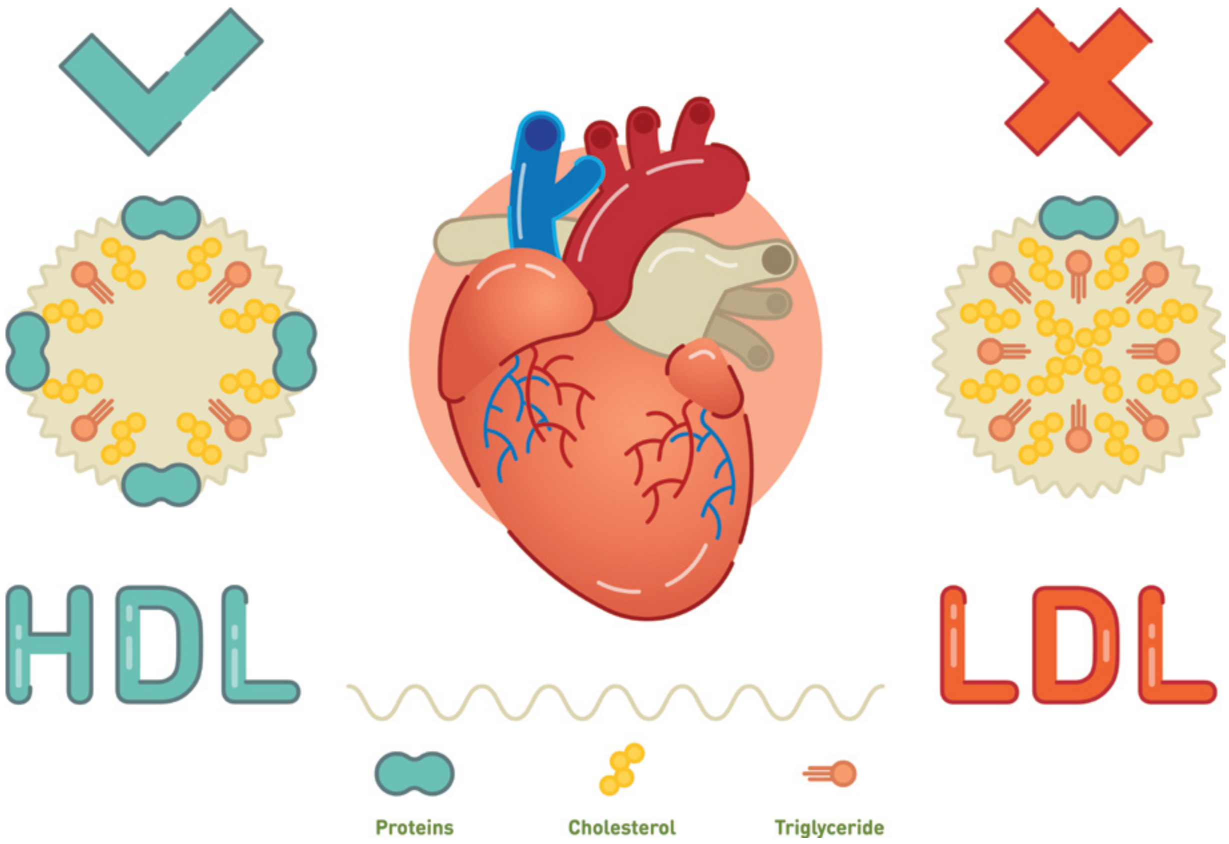
However, and despite often being labelled as unhealthy, cholesterol has several important functions:

- **A vital part of cell membranes.**
- **Essential in the production of steroid hormones.**
- **Necessary for the production of bile acid.**
- **Vital for the synthesis of vitamin D.**

Although cholesterol is present in a number of foods, most notably eggs and seafood, cholesterol is so important for body health and function that it is synthesised by the liver. In fact, 70-80% of the body's supply of cholesterol is made by the liver and if dietary cholesterol intake should be insufficient, the liver will increase production to meet any shortfall. Typically, the body needs between 1000 to 1500mg of cholesterol per day.

Because cholesterol is a lipid, it is not soluble in water and, therefore, will not mix with blood plasma which is predominately water. Therefore the body uses protein-based transporters called lipoproteins to carry cholesterol around the body.

THERE ARE THREE KEY LIPOPROTEINS:



Very low-density lipoproteins (VLDLs): manufactured by the liver, VLDLs contain both triglycerides and cholesterol and are responsible for transporting triglycerides into adipose (fat) cells.

Low-density lipoproteins (LDLs): formed from VLDs that have deposited their triglyceride payloads into the adipose cells, LDLs transport cholesterol throughout the body to the cells where it is needed.

High-density lipoproteins (HDLs): synthesised by the liver, HDLs “mop up” excess cholesterol from the tissues and blood and transport it back to the liver.

Measuring serum cholesterol and triglyceride levels have become a key risk indicator and pathology marker for cardiovascular disease. Elevated triglyceride, LDLs and cholesterol and a 25% lower HDL reading have all been identified as multipliers for the risk of developing heart disease. The upper desirable limit for serum cholesterol in the UK is 5.2mmol/L (millimoles of cholesterol per litre of blood plasma) and levels exceeding this will usually result in lifestyle changes (increase exercise, lose weight, cut down on fat intake, give up smoking, reduce stress etc.) and the possible use of cholesterol-lowering drugs called statins.

However, and controversially, several prominent experts suggest that lowering cholesterol using statins is like running the police out of an area of high crime as cholesterol levels often increase because of overconsumption of trans fats and the cholesterol is necessary for repairing the damage done by this harmful lipid.

Whole Sources of Fat

DOWNLOADABLE RESOURCE AVAILABLE ON LEARNING PLATFORM

Below is a table that shows various food products and where they are found relative to the eatwell plate.

The listed foods all have the highest amount of fat per 100g of product. Therefore they should be called 'whole' sources of fat.

Whole Sources of Fat	Amount per 100g	Additional Information
Avocado	19.5g	N/A
Peanuts	49.5g	Plain - no salt, no roast
Cashew Nuts	45.7g	N/A
Almonds	51.7g	N/A
Egg (Yolk)	27g	N/A
Beef (20% Fat Mince) **	19.8g	N/A
Pork (Belly) **	20.2g	N/A
Sunflower Seeds	47.5g	Used for Vegetarian Protein Sources
Pumpkin Seeds	45.6g	Used for Vegetarian Protein Sources
Sesame Seeds	56.4g	Used for Vegetarian Protein Sources
Mackerel	20.1g	Whilst also a source of protein this food has a greater amount of fats per 100g
Single Cream	19.1g	N/A
Greek Style Yoghurt	9.5g	N/A
Cheddar Cheese	34.9g	N/A
Red Leicester	33.6g	N/A
Olive Oil	91.3g	Per 100ml
Sunflower Oil	100g	Per 100ml
Rapeseed/Canola Oil	91.7g	Per 100ml
Walnut Oil	100g	Per 100ml
Lurpak	78g	Spreadable Variety
Lower Fat Spreadable	42g	"I can't believe it's not butter"
Dark Chocolate	46g	Lindt 85% cocoa

* Colours are representative of their location within the eat-well plate.
** The eat-well plate advises lower fat meats as protein sources however, this is only advisory and these food groups will still belong here in their raw form.

ORIGYM

The following pages will explain the differences between the types of fat that are within our diet.