ORIGYM

# *Level 3 Certificate In Personal Training*

***MODULE 6:***
***UNDERSTANDING THE CARDIOVASCULAR SYSTEM AND DIGESTION AND THE HORMONAL AND METABOLIC EFFECT OF FOOD***

# CONTENTS



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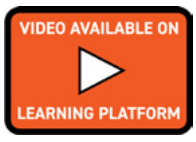



# The Circulatory System

## *MODULE 6: UNDERSTANDING THE CARDIOVASCULAR SYSTEM AND DIGESTION AND THE HORMONAL AND METABOLIC EFFECT OF FOOD*

## Composition of Blood

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

**The circulatory system consists of three main parts:**

1. **The blood**
2. **The cardiac muscle or heart**
3. **The blood vessels**

## The Blood

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

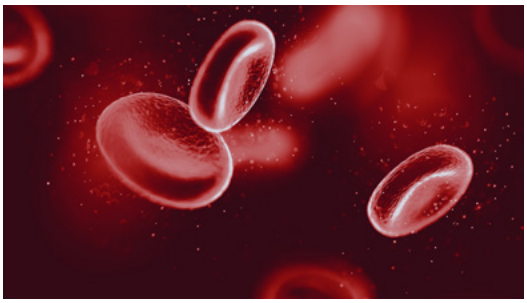
**Blood is made up of four major components:**

1. **Red blood cells (RBCs)**
2. **White blood cells (WBCs)**
3. **Platelets**
4. **Plasma**

## *Red Blood Cells* (*Erythrocytes*)

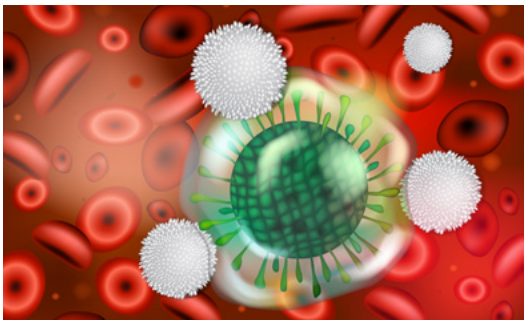
A single drop of blood contains between 240-270 million RBCs so it's safe to say they are pretty prolific. RBCs contain a protein called haemoglobin (Hb) which carries oxygen and carbon dioxide around the circulatory system. RBCs are produced the red bone marrow and are pigmented which is what gives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

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



## *White Blood Cells* (*Leukocytes*)

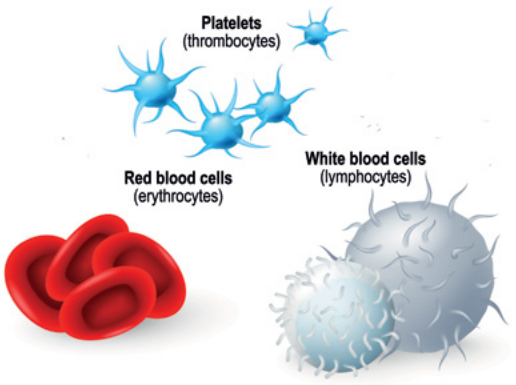
WBCs are clear and contain no haemoglobin. There are fewer of them but they too are produced in the red bone marrow. WBCs are the cells that fight infection and as infections come in various shapes and sizes, so to do WBCs.



## *Platelets* (*Thrombocytes*)

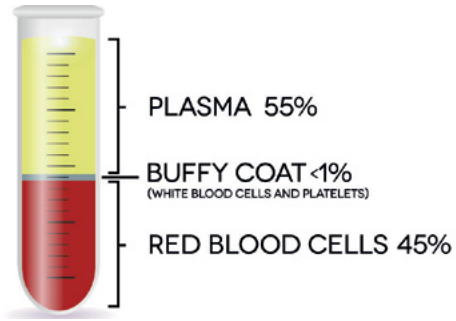
Platelets are responsible for stopping blood loss and are part of the clotting process.

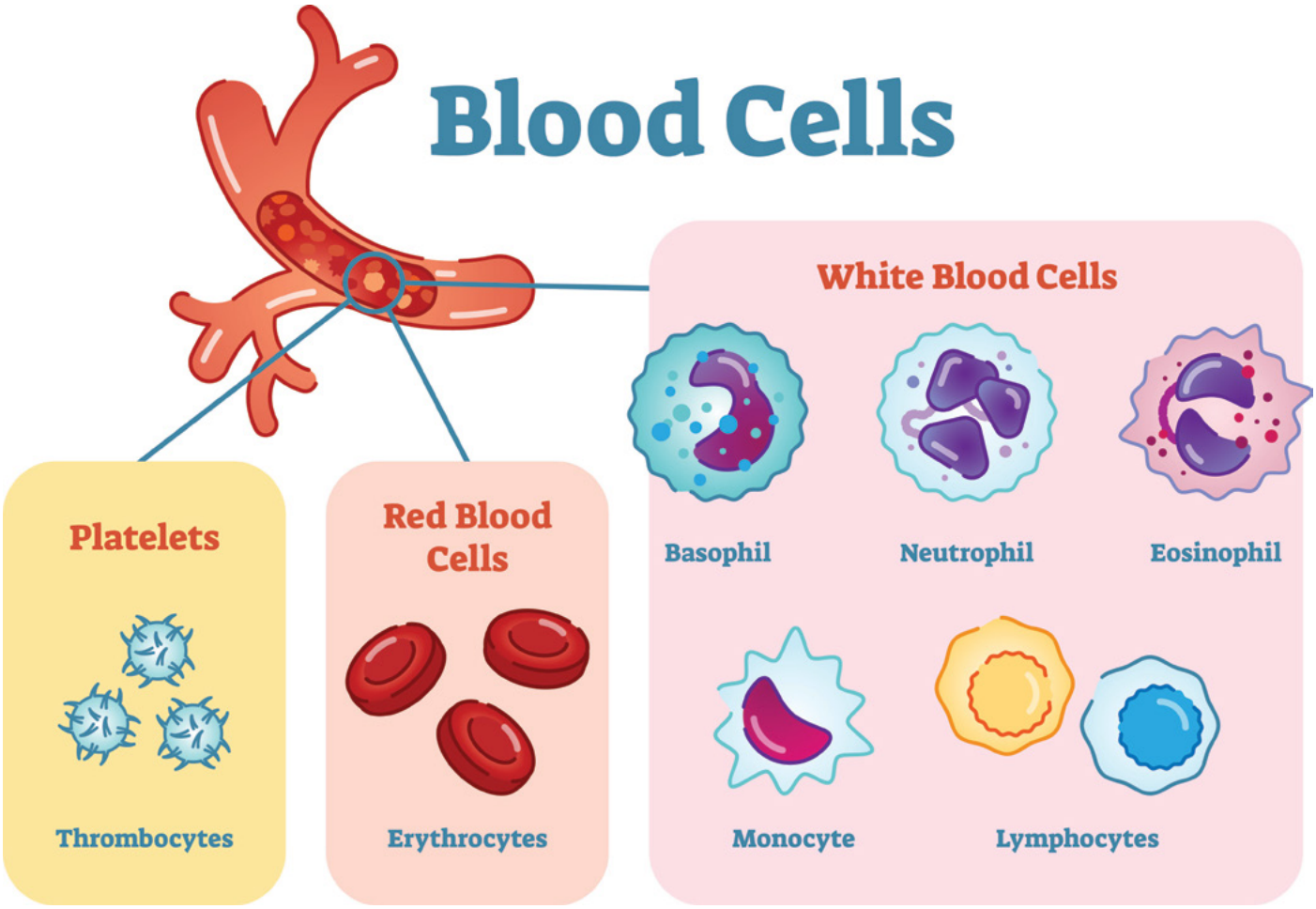
If you cut or otherwise injure yourself, platelets form "plugs" to stop your precious blood escaping. Some medications and diseases can inhibit platelet formation, in particular haemophilia and anticoagulants such as warfarin.



## *Plasma*

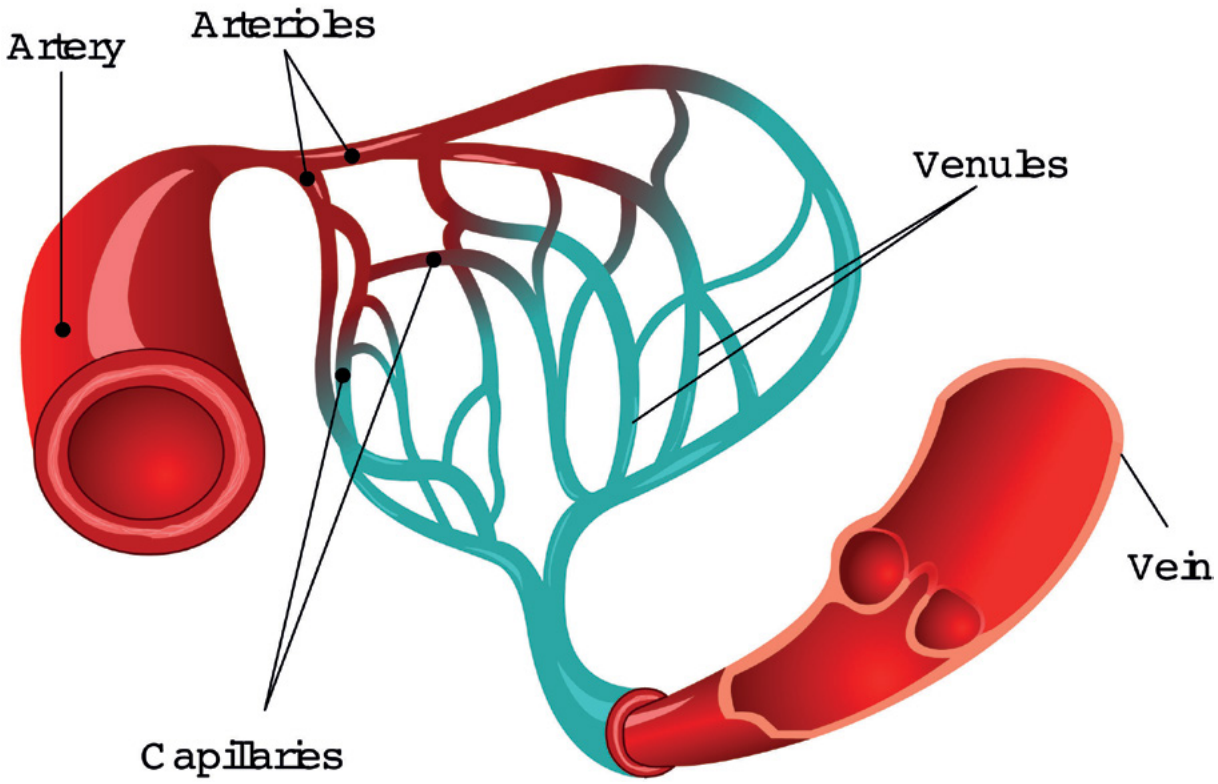
Plasma is the carrier medium in which all the other blood cells are supported and transported. It also contains proteins and other nutrients, electrolytes, gases, enzymes, minerals, vitamins and metabolic waste products. Plasma is 91.5% water and 8.5% solids and solutes.



## Blood vessels

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




**There are three main types of blood vessels:**

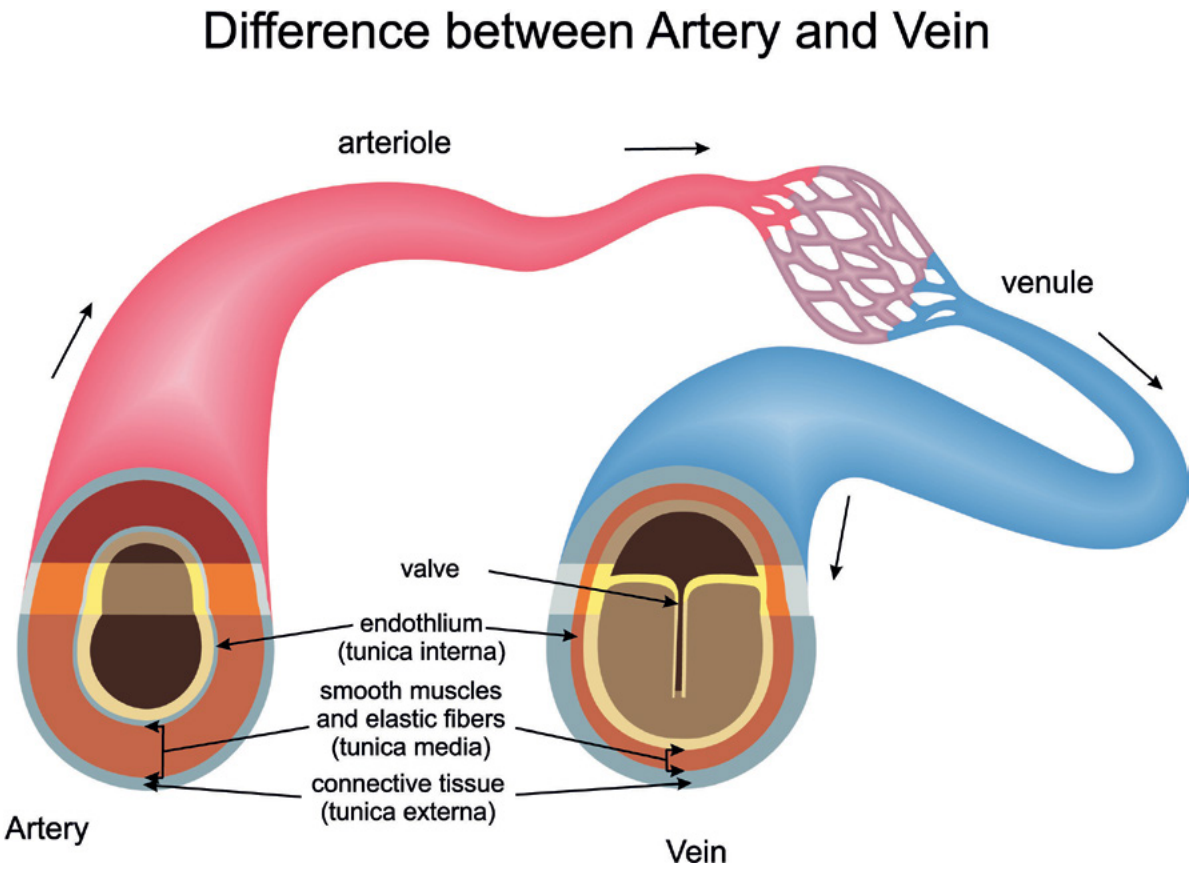
1. **Arteries**
2. **Veins**
3. **Capillaries**

**There are also two sub-categories of blood vessel:**

- **Arterioles: small arteries**
- **Venules: small veins**

## Arteries

Thick and muscular, arteries are under tremendous pressure and their physical characteristics reflect this. They always carry blood away from the heart hence the high pressure within them. The largest artery in the body is the aorta. They are elastic so that they can expand as the heart beats. If you place your fingertips on your radial artery, just below your thumb on the side of your wrist, you can feel the artery expand each time your heart beats. This is called your radial pulse.




## *Veins*

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

## *Capillaries*

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

# Blood Pressure

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

## *Oxygenated blood*

**Lungs > pulmonary vein > heart > aorta > arteries > arterioles > capillaries**

## *Deoxygenated blood*

**Capillaries > venules > veins > vena cava > heart > pulmonary artery > lungs**

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

**There are two measurements associated with blood pressure:**

**Systolic blood pressure:** is the pressure within the arterial system when the heart is beating.

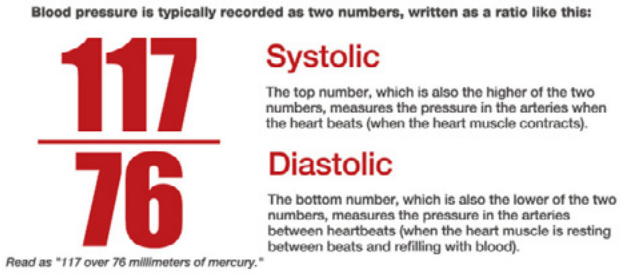
**Diastolic blood pressure:** is the pressure in the arterial system when the heart is refilling.

Subsequently, if you get your blood pressure checked, you will receive two readings: **a higher reading (your systolic blood pressure) and a lower reading (your diastolic blood pressure)**. Blood pressure is normally expressed as one figure over another for example:

## *117 over 76*

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

Mercurial sphygmomanometers are no longer widely used in favour of more machine/computerised devices but the same unit of measure still is.




## Blood Pressure Stages

| Blood Pressure Category | Systolic mm Hg (upper #) | | Diastolic mm Hg (lower #) |
|---|---|---|---|
| Low blood pressure (Hypotension) | less than 80 | or | less than 60 |
| Normal | 80-120 | and | 60-80 |
| Prehypertension | 120-139 | or | 80-89 |
| High Blood Pressure (Hypertension Stage 1) | 140-159 | or | 90-99 |
| High Blood Pressure (Hypertension Stage 2) | 160 or higher | or | 100 or higher |
| High Blood Pressure Crisis (Seek Emergency Care) | higher than 180 | or | higher than 110 |

Source: American Heart Association

## Blood Pressure Categories


*Mercurial Sphygmomanometer*

*Machine Sphygmomanometer*

## Factors That Influence Blood Pressure


**There are 5 factors that influence blood pressure, they are:**

### Cardiac Output

Cardiac output is the volume of blood flow from the heart through the ventricles and is usually measured in litres per minute (L/min). Any factor that causes cardiac output to increase, by elevating heart rate or stroke volume or both, will elevate blood pressure and promote blood flow. Cardiac output is measured by stroke volume multiplied by heart rate.

### Peripheral Vascular Resistance

Peripheral vascular resistance refers to the ability of the vascular system to expand to accommodate increased blood flow. In essence, it is in reference to compliance. An example:

A metal pipe = not compliant

A balloon = compliant

The greater the compliance of a blood vessel, the more effective it is able to expand to accommodate increases in blood flow without increased resistance or blood pressure. Veins are more compliant than arteries and can expand to hold more blood. Atherosclerosis is a vascular disease that causes a reduction in compliance which in turn increases blood pressure.

## The Volume of Circulating Blood

The volume of circulating blood is the amount of blood that is moving through the body at any one time. Increased venous return stretches the walls of the atria which activates baroreceptors from the increased atrial stretching from higher volumes of blood within the atria. The cardiac centre responds by increasing the heart rate.

## Viscosity of Blood

Viscosity of blood is a measure of the blood's thickness. The thickness is influenced by the presence of plasma and other blood proteins. Blood is viscous and is considered 'sticky' to touch. Blood is approximately 5 times thicker than water. When considering blood's viscosity on blood pressure simply think of water flowing through a pipe and then honey flowing through the same pipe. The higher the viscosity the greater the resistance of flow and therefore the likelihood of an increase in blood pressure.

## The Elasticity of Vessel Walls

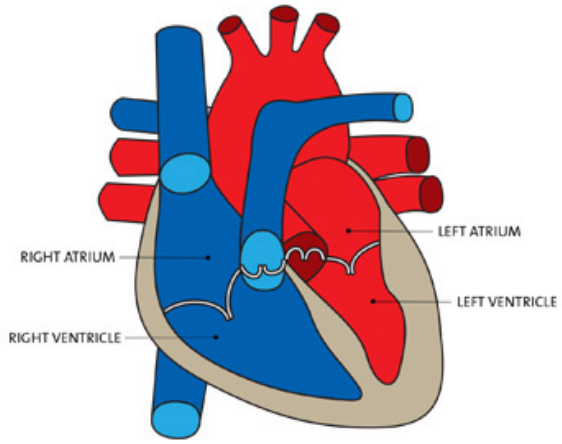
Elasticity refers to the capacity of the vessel's walls to resume its normal shape after it has been stretched and compressed. If artery walls were rigid and unable to expand and return to their original shape, their resistance to blood flow would greatly increase and blood pressure would rise. This requires the heart to pump harder to increase the volume of blood pumped each beat (the stroke volume) and maintain adequate pressure and flow.

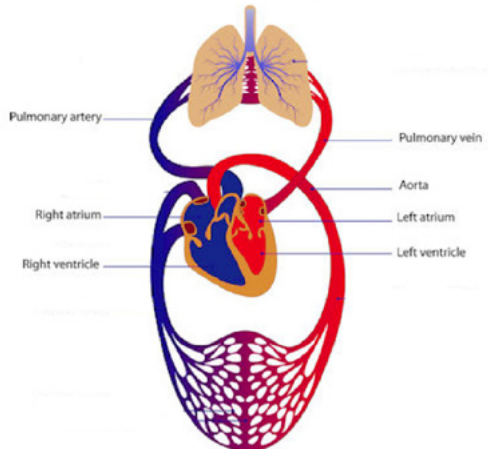
# The Heart

Of all the muscles in the body, the heart is arguably the most important as its sole job is to pump life-giving blood and therefore oxygen around your body. An average heart will beat over 3-billion times in a lifetime and if it stops prematurely or its function is in some way inhibited, major and potentially terminal health issues will ensue.

**In simple terms, the heart is a fist-sized, four-chambered muscular pump located slightly left of centre in your chest behind your sternum.**

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




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

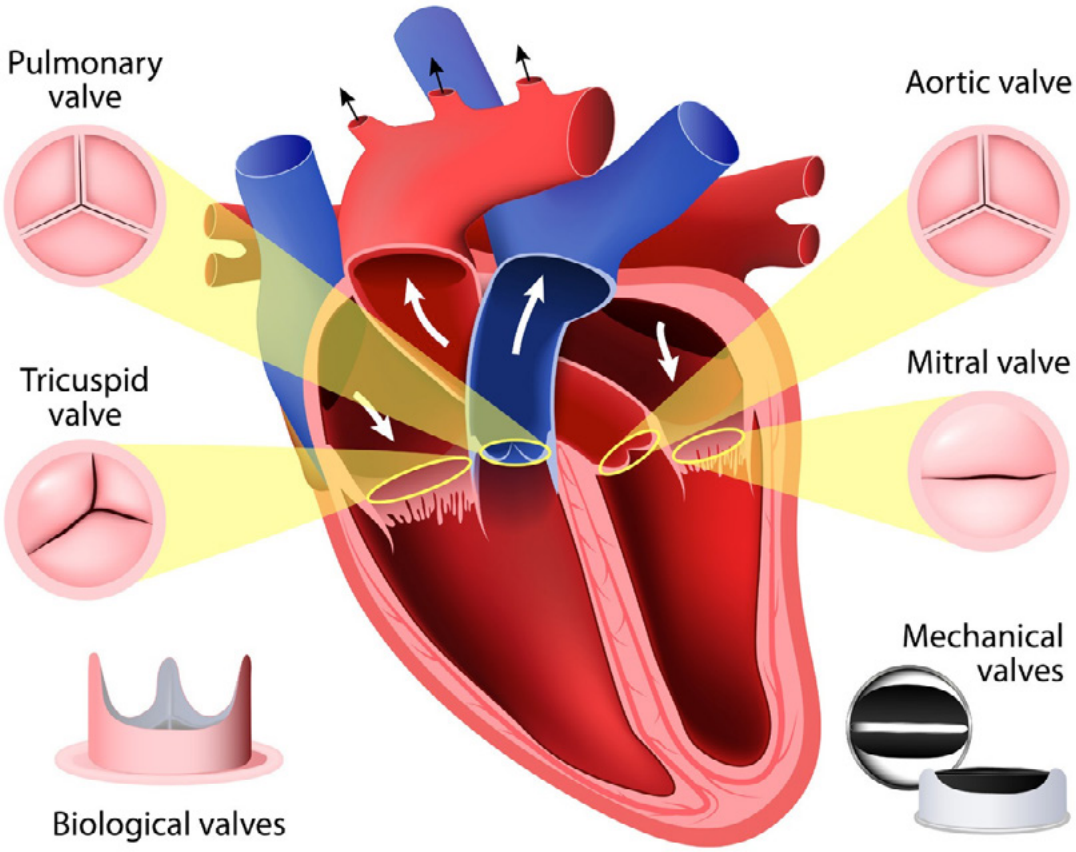
There are **four chambers** in total; two upper chambers called **atria** (the plural of atrium) and two lower chambers called **ventricles**. The atria are the receiving chambers and the **ventricles** are the ejecting chambers. The term atrium comes from the Latin for entranceway and houses often have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

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

## Heart Valves

Blood always flows from atrium to ventricle and there are valves that prevent the backflow of blood. The valves between the atria and the ventricles are called the atrioventricular valves or AV for short. On the left side of the heart between Atria and Ventricle there is a Mitral (Bicuspid) valve and on the right side a Tricuspid valve.

There are also other valves in and around the heart known as the semilunar valves; The Pulmonary and the aortic valve. The pulmonary valve prevents blood flowing back into the heart from the pulmonary artery while the aortic valve stops blood re-entering the heart from the aorta. Most heart valves are tricuspid which means they are made up from three sections, the exception is the Mitral valve.



# The Cardiac Cycle

The conduction system allows the heart to function effectively by causing different compartments of the heart to contract and relax in a coordinated manner. The cardiac cycle is described as all the events associated with one beat. The key elements of the cardiac cycle relate to the contraction and relaxation of the heart's chambers.

A chamber during contraction is referred to as being in 'systole', whereas one which is relaxing is referred to as being in 'diastole'.

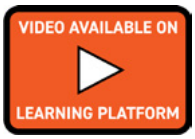
### The following is a brief summary of the key events of the cardiac cycle:

**Relaxation (diastole):** relaxation of the atria allows blood to refill them from the pulmonary veins and vena cava. This precedes, and continues with, the ventricular relaxation which allows blood to flow in from the atria.

**Atrial systole (contraction):** stimulation from the SA node causes the atria to contract and push any remaining blood into the ventricles.

**Ventricular systole (contraction):** the ventricles contract causing a rise in pressure. This closes off the AV valves and directs the blood to be ejected from the heart via the pulmonary artery and aorta.

**Relaxation (diastole):** the atria relax followed by the ventricles until all four chambers are in diastole and the cardiac cycle begins over again.



# The Autonomic System

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

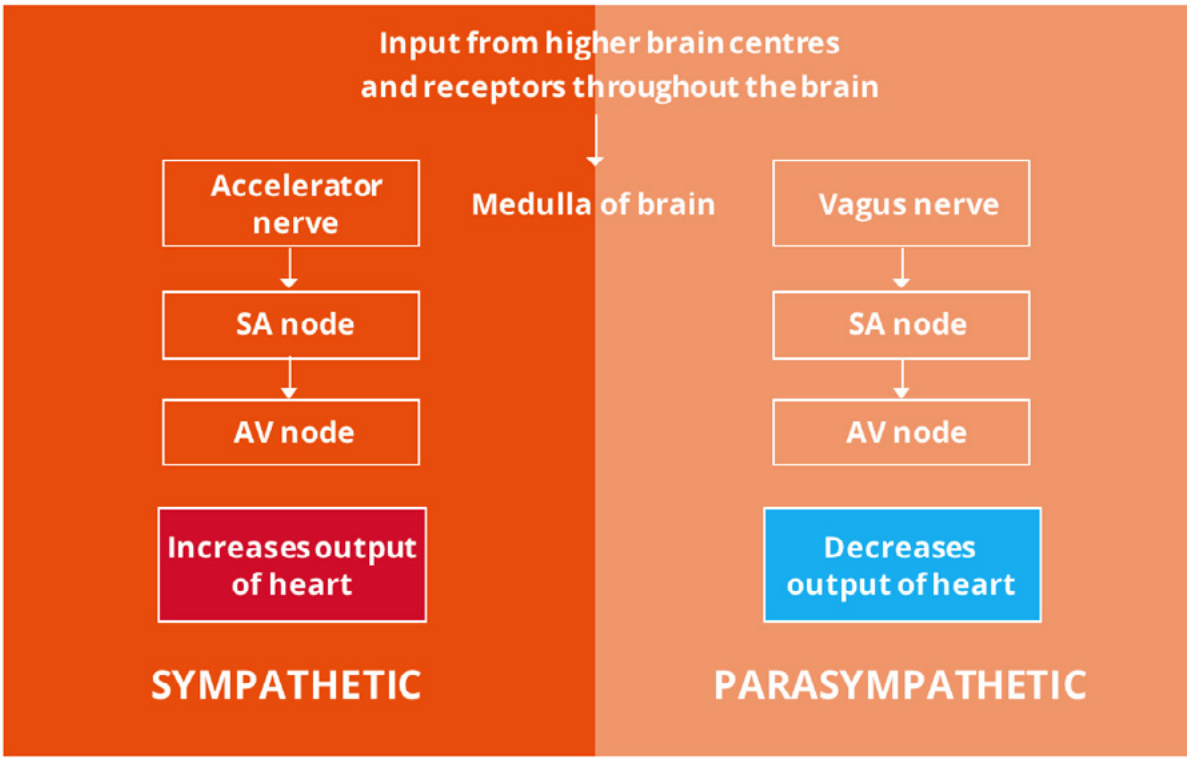
### The activities of the autonomic system can basically be divided into two:

- **Those which prepare the body for activity (The Sympathetic Nervous System)**
- **Those which return the body to rest (The Parasympathetic Nervous System)**

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

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

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



## Heart Control And Rhythm

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

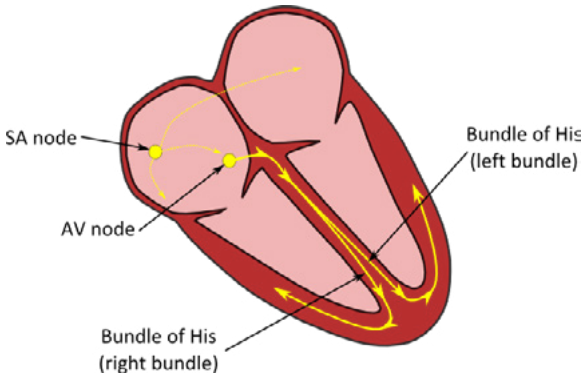
**The average resting heart rate is 72 beats per minute (bpm)** although an exercising heart can beat over 200 times per minute. A resting heart rate above 72 bpm is called **tachycardia** while a resting heart rate of 60 bpm or less is called **bradycardia**. Low resting heart rates are generally seen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

# The Conduction System

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

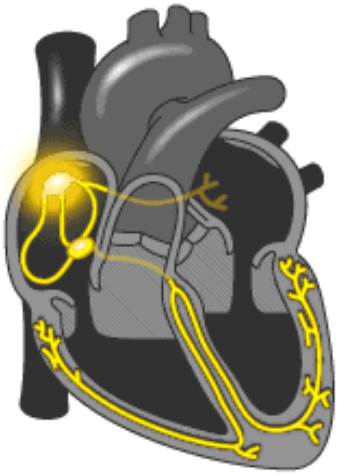
**Central To This Conduction System Are Two Small Bundles Of Fibres Located In The Right Atrium:**

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




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

The flow of action potentials to the ventricles is controlled and directed via **the AV node**. This is located at the base of the right atrium. The function of the AV node is to slow down the action potential and give the atria time to contract. If this did not occur the atria and ventricles would contract almost simultaneously. From here the action potential travels down a specialised nerve bundle (AV node bundle) before branching off into two bundles in the central wall of the heart (the septum). The AV node bundle is the only place where action potentials can cross between the atria and the ventricles. These two branches direct the action potentials to the base of the ventricles, so that an action potential (or contraction) will spread outwards and upward along the outer walls of the ventricles, directing the blood upwards instead of downwards.



# Heart Circulation

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

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

## FROM THE NOSE AND/OR MOUTH:

1. **Pharynx**
2. **Larynx**
3. **Trachea**
4. **Primary bronchi**
5. **Bronchioles**
6. **Alveoli where oxygen is extracted and diffused into the blood via the capillaries**

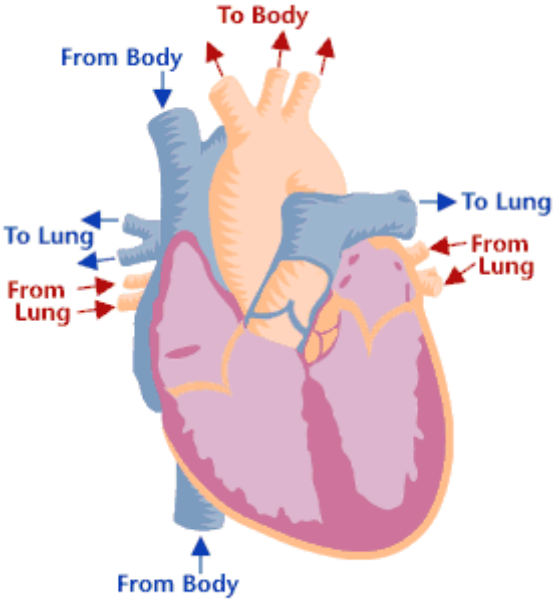
## FROM THE LUNGS:

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

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

## FROM THE BODY:

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

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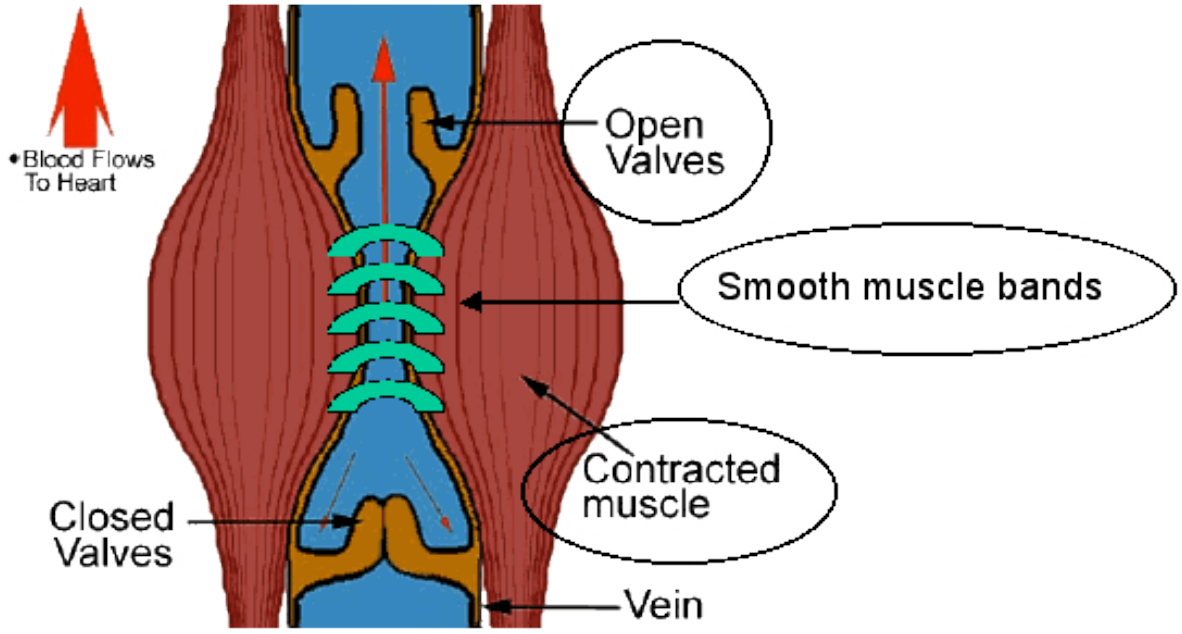
## Venous Return

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

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

## Control Of Blood Flow




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

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

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

# Measuring the Output of the Cardiovascular System

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

***Cardiac Output (Q)* = *the volume of blood pumped from the heart every minute***

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

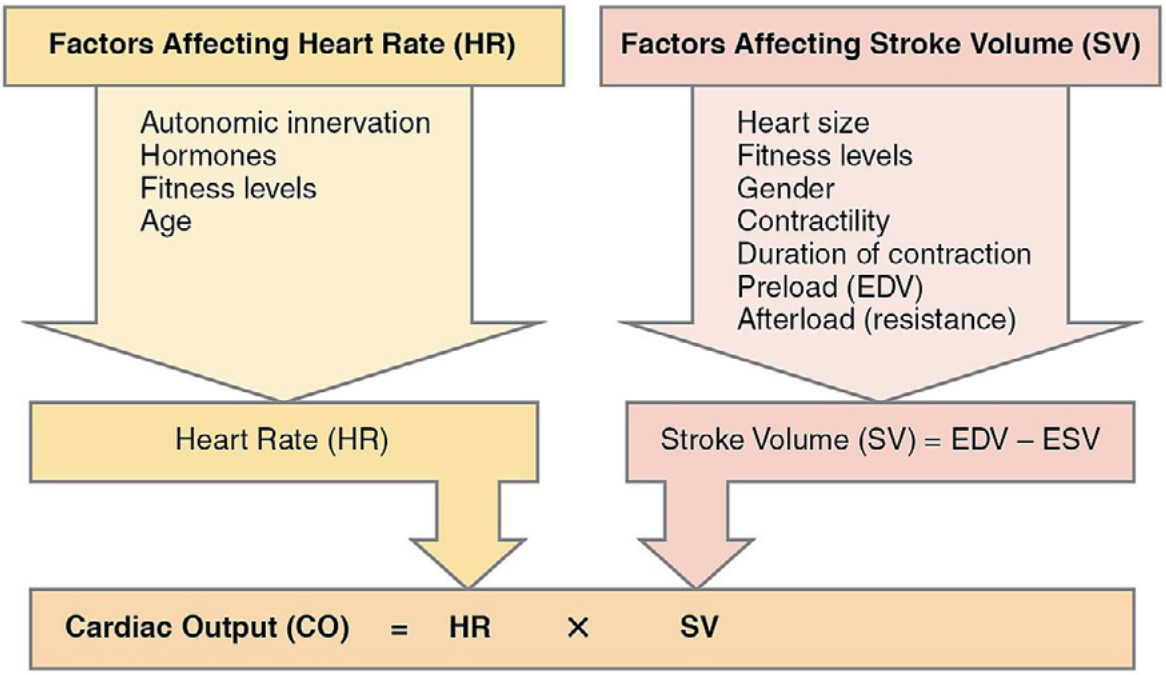
***Heart rate (HR)* = *the number of times the heart beats in a minute.***

***Stroke volume (SV)* = *the amount of blood ejected from the ventricles every beat.***

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

**Q = HR x SV**

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



# Effects of Exercise on Blood Pressure

## *Short Term*

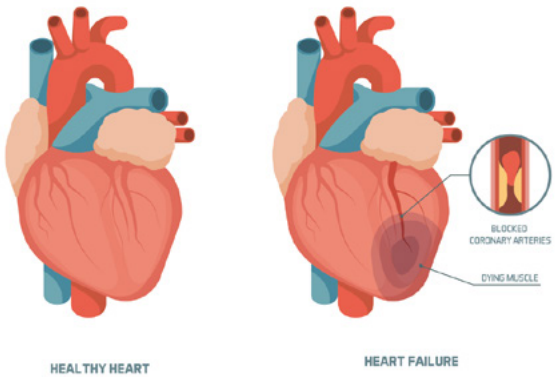
As cardiac output increases with exercise, most forms of exercise will cause systolic blood pressure to increase. This response is linear and an increase in exercise intensity will cause a similar increase in blood pressure. This is not normally of any concern for healthy individuals as blood pressure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

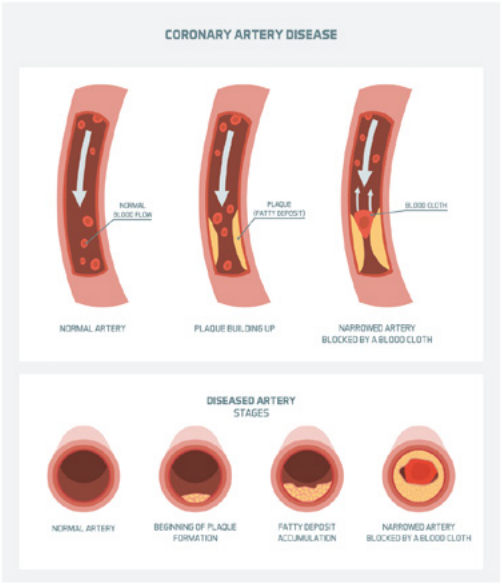
Diastolic blood pressure normally remains relatively unchanged or may even fall slightly when performing low to moderate-intensity aerobic exercise. However, heavy weight training and especially isometric contractions or where the breath is held to increase intra-abdominal pressure using the Valsalva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

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

## *Long Term*

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



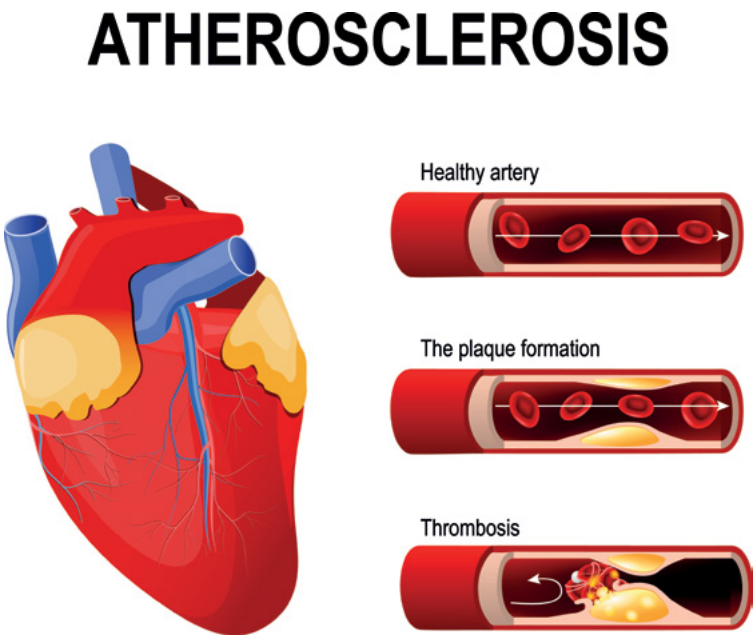



## Disease Effect On Blood Vessels

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

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

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




## Valsalva Effect And Blood Pressure

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

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

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

## Benefits of Endurance/Aerobic Exercise
## on the Cardiovascular System

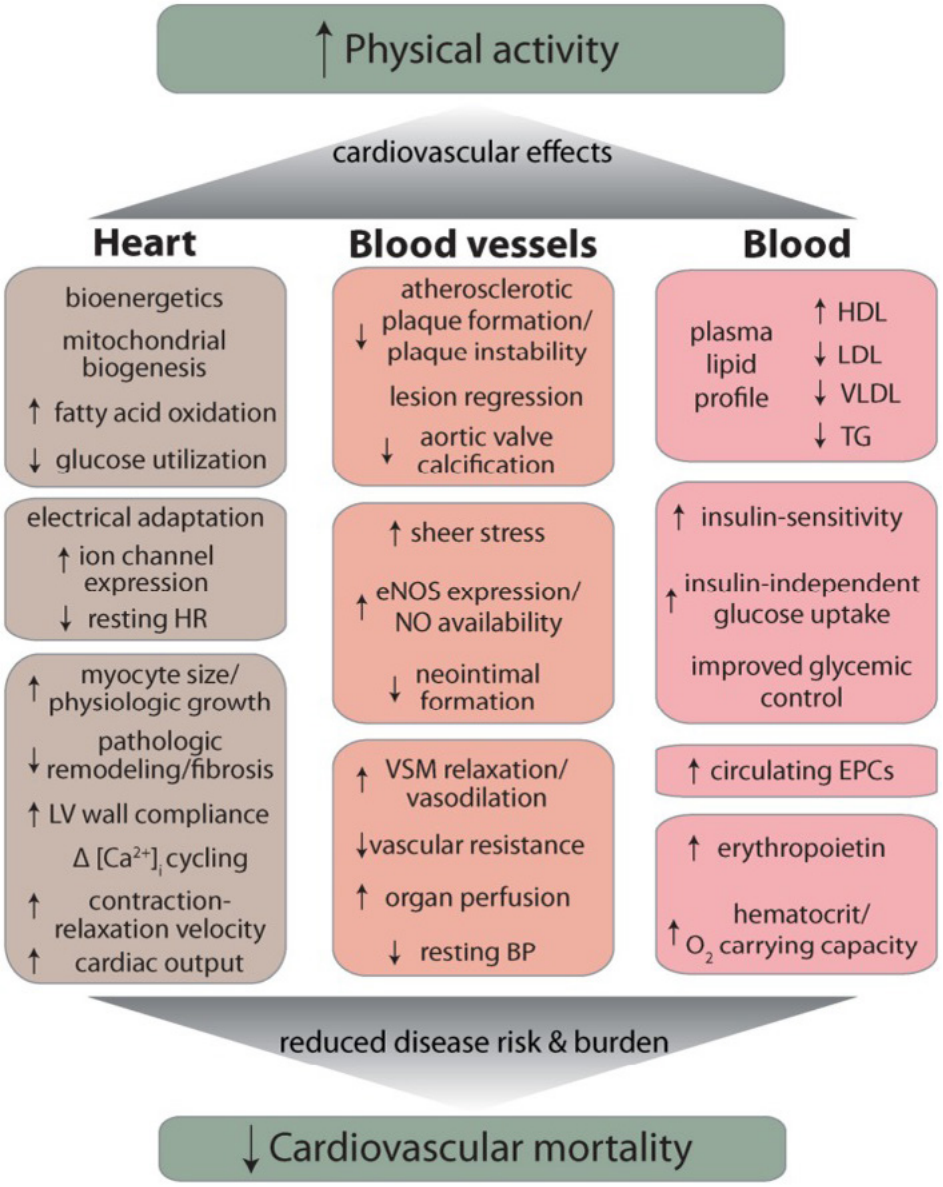
It is no surprise to anyone that aerobic exercise is beneficial to a persons cardiovascular system e.g. their heart, blood and blood vessels. However the detail of how is somewhat less known. When a person takes part in regular aerobic exercise (3-5 x a week) the cardiovascular system responds in the following ways:

- **Increase** in ventricular hypertrophy (Cardiac muscle size/thickness increases)
- **Increase** in stroke volume (Volume of blood in millilitres ejected from the heart (each ventricle) during a contraction.)
- **Increase** in cardiac output (Amount of blood pumped through the circulatory system during 60 seconds)
- **Increase** of capillarization (capillaries around the tissues e.g. muscle supplying the muscle with oxygen)
- **Increased** production of the removal of waste products (removal of carbon dioxide from the blood)
- **Increase** in mitochondria (powerhouses in the cell that produce the energy currency ATP)
- **Decreased** risk of cardiovascular disease
- A normalisation of blood pressure

## The Effect Of Exercise On Circulatory Measures

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

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




Overview of major cardiovascular effects of exercise. Abbreviations: HR, heart rate; LV, left ventricle; eNOS, endothelial nitric oxide synthase; NO, nitric oxide; VSM, vascular smooth muscle; BP, blood pressure; HDL, high density lipoprotein; LDL, low density lipoprotein; VLDL, very low density lipoprotein; TG, triglycerides; EPC, endothelial progenitor cell.

## Risks Associated With Endurance/Aerobic Exercise On The Cardiovascular System

There are inherently fewer risks associated with aerobic exercise on the cardiovascular system however some do exist. Some risks are described below:

If an athlete chronically overloads the muscular chambers of the heart with blood during excessive endurance exercise, some of these chambers and other parts of the heart may become **partially scarred**. This scarring of the heart may lead to **irregular heartbeats (arrhythmias)**. It is possible that some of these arrhythmias, as well as other possible changes in the cardiovascular system stemming from over-exercise, may eventually lead to a heart attack, heart failure, or even cardiac arrest in some people who exercise too much. This is especially true for those who already have an **underlying heart condition**. On occasion perceived risks may also include **Athletic Heart Syndrome** and **Sudden Cardiac Death** stemming from **Left Ventricular Hypertrophy**.

# The Respiratory System

## MODULE 6:
## UNDERSTANDING THE CARDIOVASCULAR SYSTEM AND DIGESTION AND THE HORMONAL AND METABOLIC EFFECT OF FOOD

### Introduction

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

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

There are 3 major parts of the respiratory system:

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

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

## The Anatomy of the Respiratory System

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

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

VIDEO AVAILABLE ON LEARNING PLATFORM

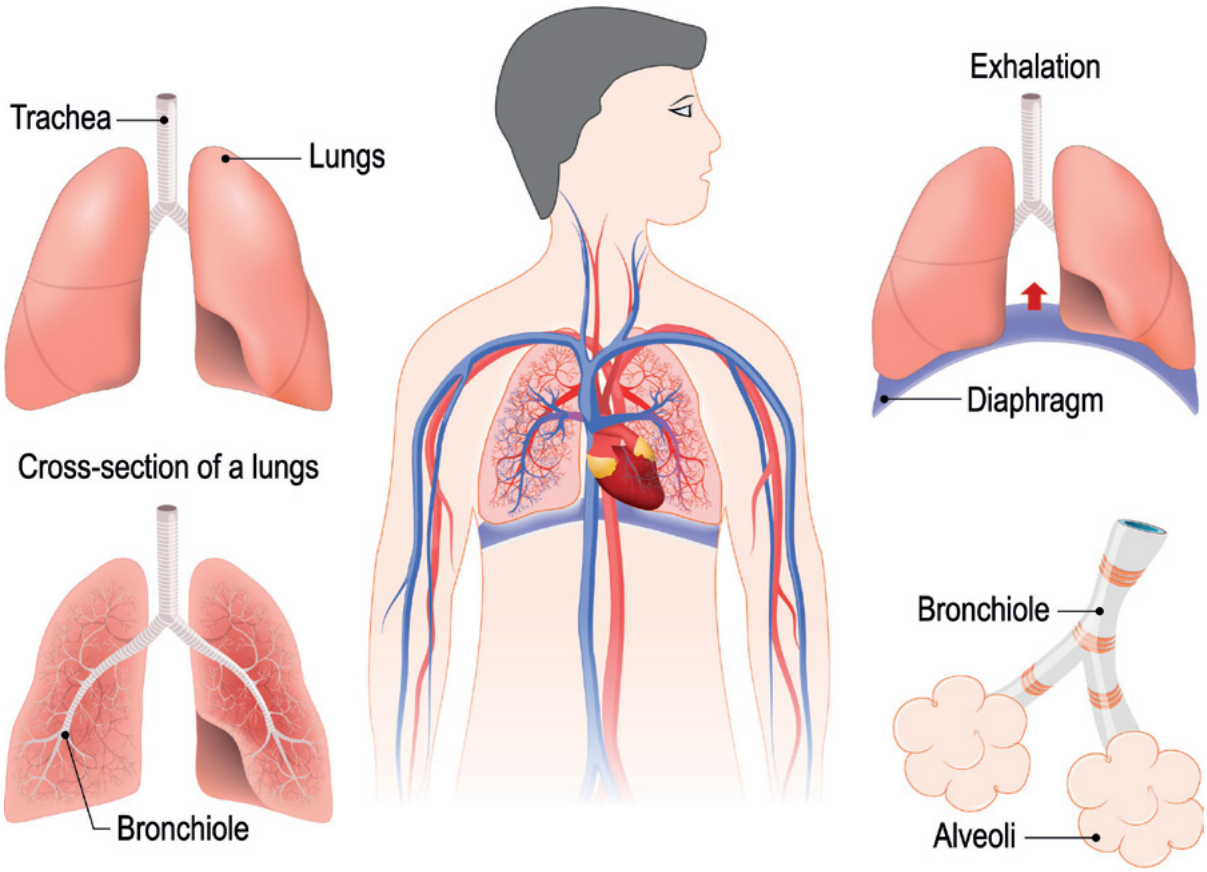
### *The Lungs*

**Location:**

- In the rib cage or thoracic cavity

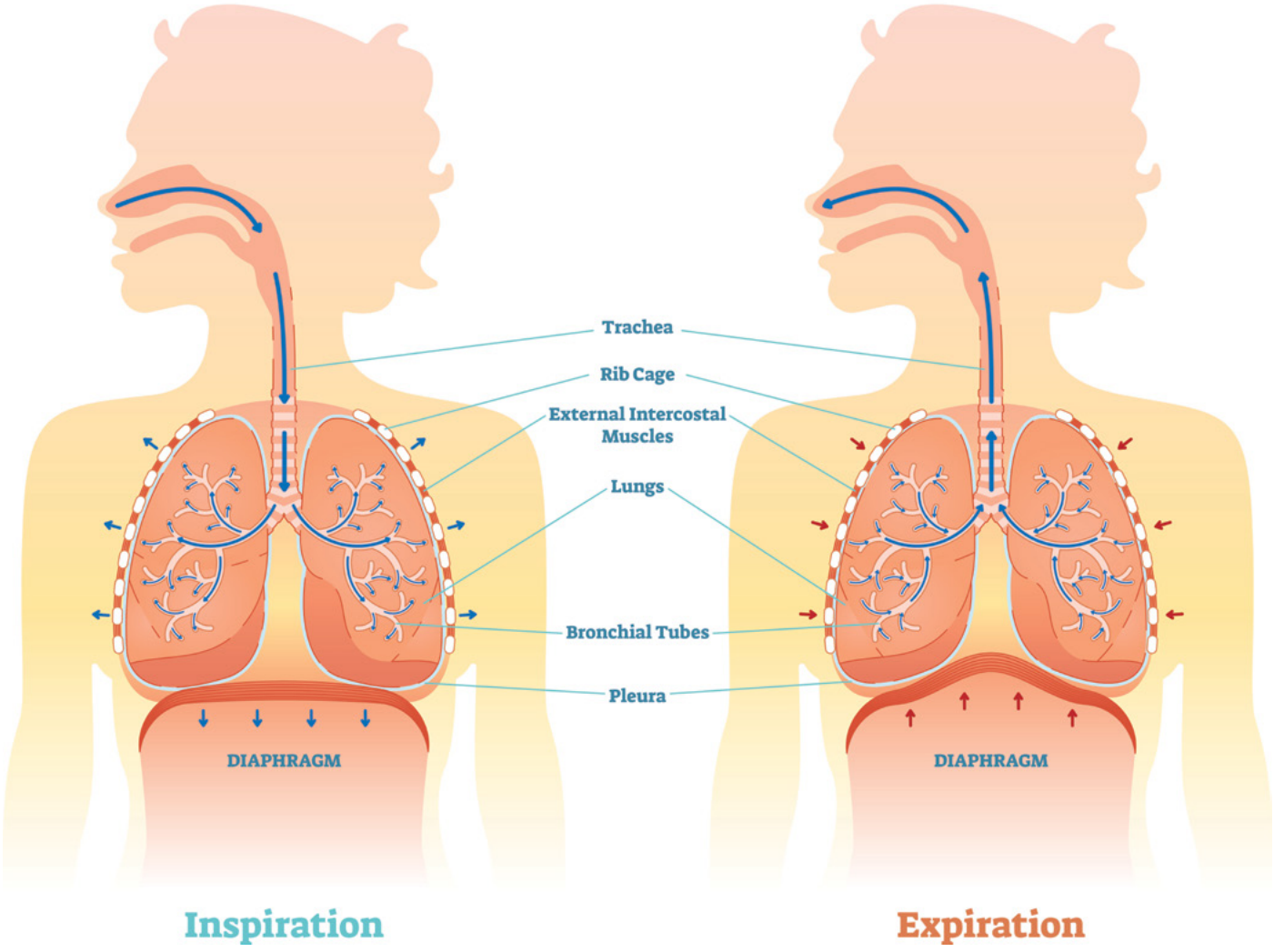
**Function:**

- Remove carbon dioxide
- Take in oxygen



## Essential terminology:

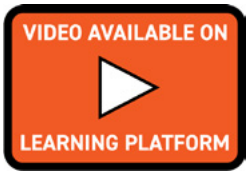
- **Inhalation or inspiration:** Taking air down and into the lungs.
- **Expiration or exhalation:** Expelling the air from the lungs.
- **External respiration:** The exchange of gasses between the lungs and blood.
- **Internal respiration:** The exchange of gasses between the blood and the cells.



# Mechanics of Breathing

## *Inhalation*

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




## *Diaphragmatic Versus Costal Breathing*

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

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

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

Diaphragmatic breathing is linked to relaxation and is part of yoga, tai chi and can help reduce stress and blood pressure.

Combining diaphragmatic with costal breathing will create the largest possible chest cavity expansion and, therefore, the greatest intake of air.

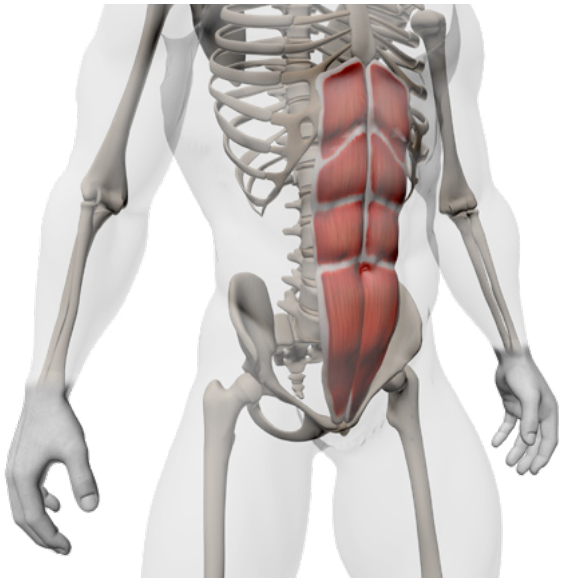
## *Exhalation*

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

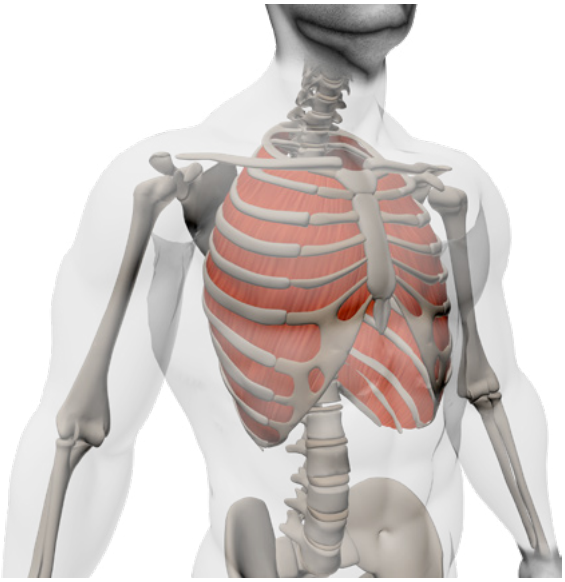
In addition to the action of the diaphragm and intercostals, you can use your rectus abdominus to compress your abdominal cavity to exhale more forcefully e.g. when blowing up a balloon.

## The Muscles used in Breathing

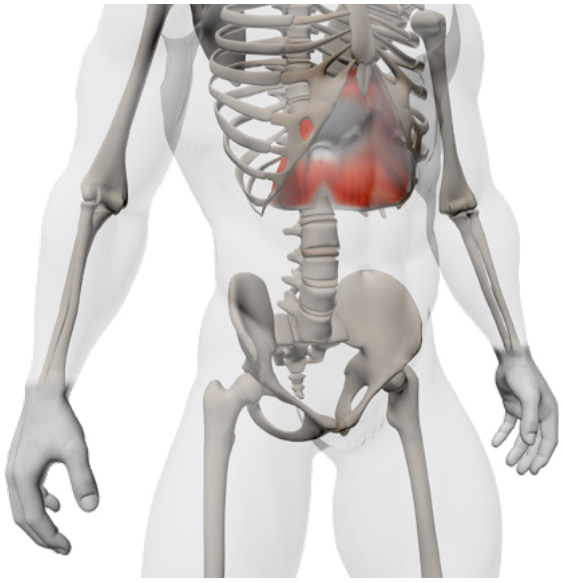
- **Diaphragm**
- **Intercostals**
- **Rectus abdominus**



*Rectus Abdominus*



*Intercostal Muscles*



*Diaphragm*

## Gaseous Exchange

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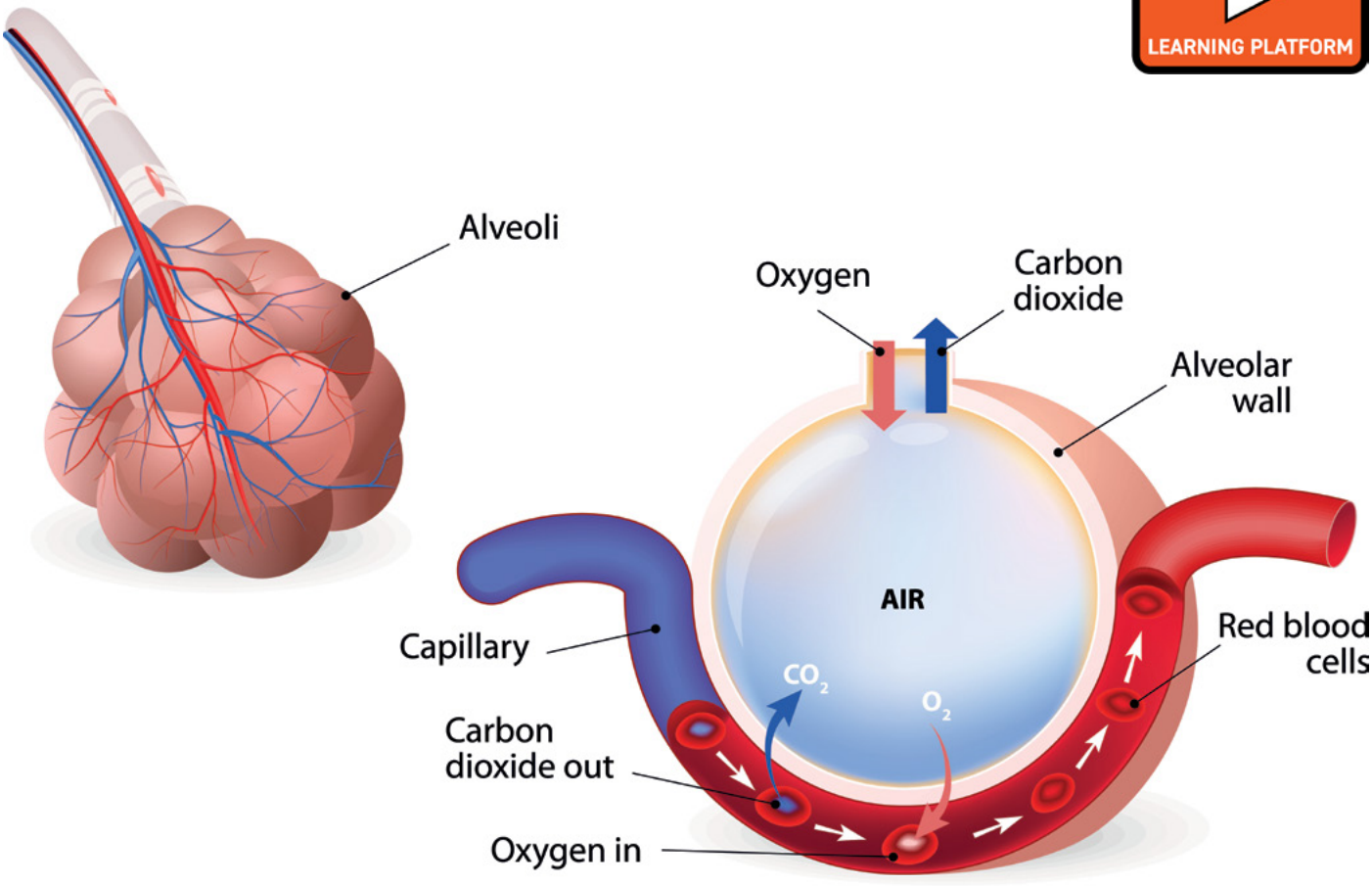


As you breathe in, the air is drawn down into your lungs and ends up in your alveoli which resemble bunches of grapes. The alveoli provide a very large surface area for moving oxygen (O2) into your blood and removing carbon dioxide (CO2) from your blood ready for exhalation. This "swapping" of gasses is called a gaseous exchange and is also known as diffusion. Diffusion can be defined as the movement of gasses from an area of high concentration to an area of low concentration and as this is happening to two gasses simultaneously (O2 and CO2) there is an exchange of equal volumes of gasses.

Diffusion is possible because the alveoli are proliferated with tiny blood vessels called capillaries. Capillaries are one-cell thick so that gasses and other substances can pass through them.

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

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

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

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# The Air We Breathe

## Composition of Air

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

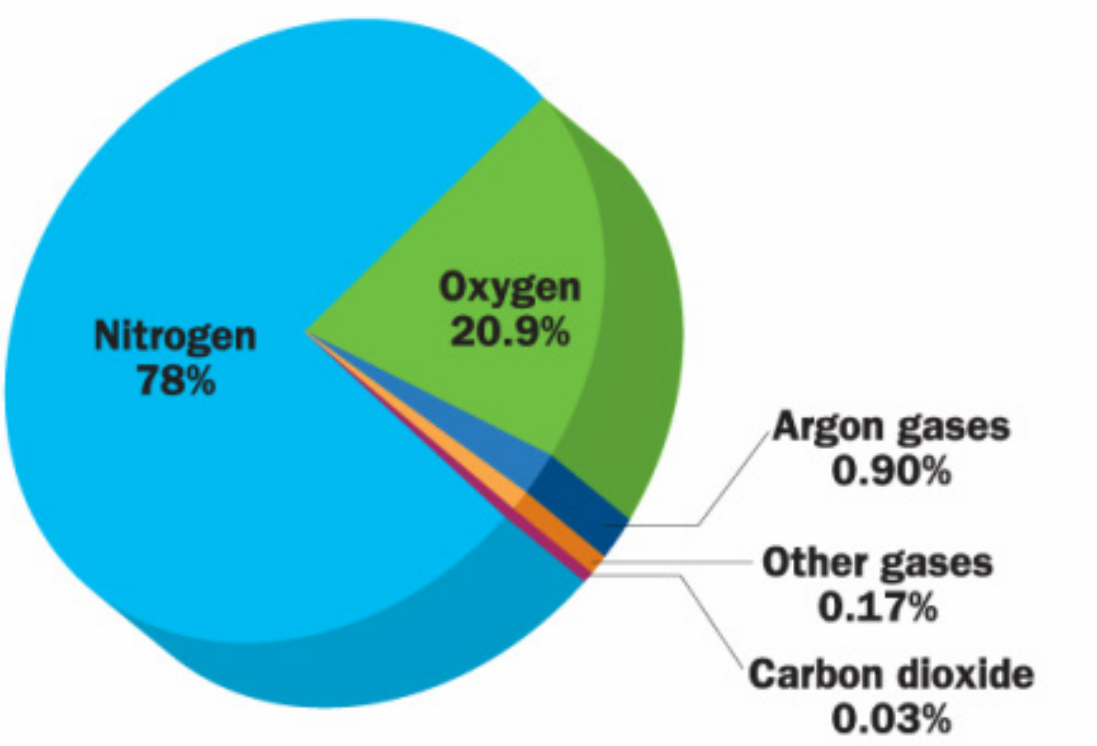
| Gas | Inhaled Air | Exhaled Air | Difference |
|---|---|---|---|
| Nitrogen ($N_2$) | 79% | 79% | No Change |
| Oxygen ($O_2$) | 21% | 17% | 4% decrease |
| Carbon Dioxide ($CO_2$) | <1% | 4% | 4% decrease |

## The Stimulus for Breathing

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

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

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



## Measures Associated with Lung Function

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

### The main measures are:

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

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

$$MV = BR \times TV$$

**For example:**

BR = 12

TV = 500ml

MV = 6000ml/min or 6l/min

| Measure | Acute | Chronic |
|---|---|---|
| Breathing rate | Increases | Decreases |
| Tidal Volume | Increases | Increases |
| Minute Ventilation | Increases | Unchanged or Slightly Increase |

## The Effect of Exercise on Lung Function Measures

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

# *Personal Training Environments And Resources (Including Health and Safety)*

### *MODULE 6:*
### *UNDERSTANDING THE CARDIOVASCULAR SYSTEM AND DIGESTION AND THE HORMONAL AND METABOLIC EFFECT OF FOOD*

## Personal Training Environments and Resources

Personal Trainers may find employment in a variety of locations. Some of the environments in which personal trainers will work in include: health and fitness clubs, recreation centres and gyms, country clubs, yoga and Pilates studios, universities, resorts, the homes of clients, hospitals and in corporate organizations.

## Hours & Timings

A personal trainer's hours and working conditions must be adaptable and flexible; to include work in several different settings alongside their clientele. Depending on where a trainer is working, different skills may be required of them.

For example, if the trainer is working in a hospital environment, they may need to be able to deal with people with emotionally and physically challenging health problems/situations.

## Environment: What Venues?

Most personal trainer's hours and working conditions include work inside, in a gym, a fitness club, or home environment that is open or available to accommodate the client schedules. These public or private facilities are likely to contain different types of training equipment.

The trainer will either work in one or more facilities in which clients are coming to them in order to obtain professional training, or the trainer will go to meet the clients at their homes or other places that are convenient for the client. Some trainers will split up their schedules during the day in order to reach a larger number of clients. They may travel to multiple locations in one day and offer their services from morning to evening, with breaks in between. Trainers will have most of their training sessions scheduled in the evenings and on the weekends, and occasionally during holiday times. During different times of the year, a trainer may find that their schedule is busier than at other times, especially after the Christmas season. Trainers who work both in public facilities and as well as private settings are likely to be affected by busy seasons and changing schedules. A personal trainer's hours and working conditions must have a flexible in order to work with clients wherever and whenever they have time to receive their training sessions.

**There is a wide range of equipment that can be used within the environment, these could be fixed or portable:**

- **Cardio fitness equipment**
- **Core stability equipment**
- **Functional equipment**
- **Strength and resistance training equipment**

When working in environments that are not specifically designed for exercise/physical activity (such as outside or in a person's home), the area must be risk assessed, cleared of any hazards and ensured that there is enough room to safely complete the exercises for the workout. There should be access to a first aid kit, a safe fire escape, adequate heating/ ventilation and access to clean drinking water.

## Looking After Your Body

The work environment and duties of the personal trainer are such that they are vulnerable to sustaining injuries when they are training clients/patients and during any other training-related physical activity. This risk is evident across the various levels of professional personal trainers in the industry. A personal trainer is not only responsible for the safety of themselves during the training session, but also that of their clients/patients. As the nature of the job is very physically demanding, the trainer must also seek to maintain a high level of fitness. The work environment of the personal trainer is fairly flexible. The trainer has the freedom to create the training programs for their clients/ patients, and implement them in the way that they see fit. This aspect of the job can lead to feelings of satisfaction, and it can be very rewarding as they witness the results of their planning and training in the lives of their clients/patients.

The development of training programs can be challenging as the trainer must continually monitor the progress of the client/patient and change the fitness training plan as needed. The work environment may be busy or quieter depending on where the trainer is working and how many clients/patients use the same area of training space. The environment must be risk assessed to be aware of any potential hazards and to ensure these are taken into account and minimised or eliminated where possible.

# Exercise and Physical Activity in Difficult Environments

## Difficult Environments

- **Limited Space:** Best suited to static exercises and inappropriate for travelling moves. Always consider your range of motion and whether you can provide more space by moving obstructions, such as light furniture.
- **High temperatures:** Require you to keep the intensity low and stay hydrated. Try to change the temperature wherever possible, by turning off the heating, opening windows and using a fan.
- **Hard Floors:** Rule the prospect of impact work and jumps; they will also require you to use a mat for floor exercises. Impact work may not be appropriate for some referred clients/patients, regardless of the floor situation.
- **Other people:** Within viewing distance or directly outside can be kept out of sight by using blinds to cover the windows. What's more, you should always try to reduce external distractions e.g. by using an answer machine for the telephone.

# Health and Safety Employer Duties and Employee Responsibilities

Health and safety is of primary importance in the health and fitness industry. Instructors must be legally aware of their organisation's health and safety and duty of care policies and procedures to uphold the health, safety and welfare of their colleagues and those participating in physical activity.

## *Health And Safety At Work Act 1974*

This is a fundamental piece of health and safety legislation. It places general duties on employers, employees, manufacturers and people in control of premises. These general duties form the framework for all health and safety regulations.

## Employer Duties

The employer has a duty of care to ensure that, as far as possible, the health, safety and welfare of employees is protected. Employers must:

- **Provide a Health and Safety Policy Statement for five or more employees**
- **Provide equipment, machinery and an environment that is safe to use**
- **Control use and exposure of substances that may damage health**
- **Provide information, instruction, training and supervision where needed**
- **Take precautions against potential risks**
- **Ensure that visitors and members of the public are not put at unnecessary risk**
- **Report accidents, injuries, diseases and dangerous occurrences**
- **Provide adequate first aid facilities**

### EMPLOYEE RESPONSIBILITIES:

- **Take care of their own health and safety and that of others**
- **Cooperate with the employer to help comply with health and safety legislation**
- **Inform the employer about any work situations that present a serious risk**

# Health and Safety Regulations


## THE MANAGEMENT OF HEALTH AND SAFETY AT WORK REGULATIONS 1999

Identifies in detail what is required from employers to manage health and safety in the workplace.

**Risk Assessment:**

- A hazard is anything that can cause harm
- A risk is a chance, whether high or low, that somebody will be harmed
- Each employer must make a suitable and sufficient assessment of risk. How to control risks in a fitness environment will be addressed in more detail later in this section.

## RISK ASSESSMENT CONTROL OF SUBSTANCES HAZARDOUS TO HEALTH (COSHH):

- Requires employers to control substances which are hazardous to health.
- Can be a substance, mixture of products or a process to create substances

## REPORTING OF INJURIES, DISEASES AND DANGEROUS OCCURRENCES REGULATIONS (RIDDOR):

- Includes responsibility of employers and people in control of premises
- Involves the reporting of injuries, diseases and dangerous occurrences
- Requires the reporting of certain incidents to the enforcing authority

## PERSONAL PROTECTIVE EQUIPMENT (PPE):

- Must be appropriate for the task and the risks involved
- Must be maintained and stored correctly
- Must meet European legislation and carry the CE kitemark
- Should fit the wearer correctly
- Must be used in accordance with instructions and training

## Noise At Work

- Ensures that workers' hearing is protected from excessive noise in the workplace
- Hearing protection must be provided in hearing protection zones

## Manual Handling:

- Involves the use of the body to lift, lower, carry, push or pull a workload
- Consideration of the ability of the employee must be considered
- Avoid manual handling where practicable if there is a possibility of injury
- Provision of mechanical equipment where necessary

## First Aid:

- A first-aid needs assessment should be carried out
- Should have a first aid box which holds contents that reflect first aid needs
- People appointed to take charge of first-aid arrangements
- Trained first aider(s)

# Health and Safety Policy Considerations for the Instructor

Instructors must become familiar with health and safety policy and in particular the regulations most relevant to the job.

## *General*

A fitness environment will generally promote health and safety and can be the responsibility of the health and safety manager, or even a duty manager who may be responsible on an operational level.

As the duty of care filters throughout the employees, it will be the job of the fitness instructor to carry out a number of health and safety checks during their hours of work. It will be the duty of the instructor to conduct all safety checks in accordance with company policies and procedure and any failure to do so may result in liability for any incidents or accidents that occur.

Working practices are designed to ensure a high level of health and safety practice and compliance which may include the following considerations:

## *Emergency Action Plan (EAP)*

The purpose of an EAP is to facilitate and organise employer and employee actions during workplace emergencies. For smaller organisations the plan may be communicated verbally and not necessarily written but essentially must demonstrate:

- **What to do in the event of a specified emergency**
- **What to do during the emergency**
- **What to do after the emergency**

## *Qualifications*

Fitness professionals must hold valid and current qualifications for the tasks they are required to perform. These qualifications may differ between regions.

## *Register Of Exercise Professionals (Reps)*

This is a regulating organisation for fitness professionals. It was developed to protect the public from those who do not hold appropriate qualifications and to recognise the skills and qualifications of exercise professionals. Those who hold a qualification which meets REPs approval can apply for membership for which there is an annual fee. REPs levels can vary depending on region and globally there are six levels in total.

## Public Liability Insurance

An essential cover for most types of business and will cover the fitness professional working in a place of employment. Work carried out elsewhere must be covered by an additional policy.

## Competency

Any qualification or job description will describe the tasks which can be performed by the instructor. Any other duties which are not outlined are outside the areas of competency of the fitness professional.

## Health Screening

A common role of the instructor is to carry out a physical activity readiness questionnaire (PAR-Q) with clients before participating in physical activity. This screening process must be carried out by all those wishing to participate in the exercise environment. Any doubts as to the suitability of the client to embark on an exercise programme should be referred to a GP before exercise can begin.

## Risks Of Pre-Exercise Testing And Exercise

Exercise and fitness testing carries the risk of injury and the possible exacerbation of existing conditions brought on by performance. The client should be informed of these risks before deciding whether to undertake such tests or exercise.

## Physical Activity Readiness Questionnaire

- **Informs the instructor of the suitability of the client to begin exercise participation**
- **Raises the awareness of the client to the risks involved in exercise**

## Delivery of PAR-Q

A busy fitness environment will present difficulties in trying to deliver a PAR-Q with clients from time to time. It is not always possible to present a written document or forward the detail of such a document to the instructor before a session is due to start. However, it is a necessary procedure and there are options available to the instructor:

- A written PAR-Q is the preferred format, which gives both the instructor and the client the ideal opportunity to determine activity readiness.
- Verbal questions will present the opportunity for participants to give any information which may prevent them from taking part in an exercise session. This method can be used regularly to determine if there is any change in the wellbeing of clients between sessions and is frequently used in group exercise environments.
- Passive signage such as a PAR-Q poster in the exercise environment will inform participants of their duty to inform the instructor of any health related reason why they may not be able to participate. The instructor should reinforce this with verbal questions before the start of each session.
- Each fitness environment will have their own health screening system and this must be communicated to the instructor(s).

## Additional Information

Instructors may not be responsible for screening of every participant but must be aware of where this information is stored in case of emergency, follow up or changes which need to be made to documents.

# Health Commitment Statement

The health commitment statement will set out the standards that users can reasonably expect from the organisation, facility, staff and each other. It should be drawn to the attention of the user and may be incorporated into membership or screening documents. The purpose of the HCS is to:

- Develop the current PAR-Q to simplify access to activity facilities for users
- Assist the health, medical and fitness industries to work in harmony while supporting initiatives to encourage the nation to be more active
- Bring health and fitness clubs inline with virtually all other sports and active leisure in relation to health matters
- Demonstrate respect for members by placing responsibility where it belongs, with the individual member
- Be consistent with current government policies in encouraging every individual to take responsibility for his or her own health
- Offer the opportunity to clubs to maximise their membership
- Be in keeping with current trends in legislation and case law
- Be consistent with a more modern approach to individual responsibility in medicine and the law
- Provide the opportunity for a uniform approach across the health and fitness industry, producing greater clarity and reducing costs
- Offer a simple solution in plain English, which is accessible to fitness instructors, staff and members
- Remove stress and anxiety from staff in relation to health of members

**The hcs has been designed for users in a gym environment and with all operators in mind, allowing flexibility with its usage, example on learning platform.**

## Duty Of Care

In tort law, a duty of care is a legal obligation to provide and adhere to a reasonable standard of care while performing any acts that could foreseeably harm others. It must be the first element to be established with an action in negligence. A negligent act may be unintentional but nevertheless may still breach a duty of care.

Instructors will have a different and sometimes greater duty of care for the range of clients under their supervision. This can include but not be limited to young people, older adults, pre and post-natal women and vulnerable adults. The acquisition of knowledge without qualification relating to such special populations may allow the instructor to present greater opportunity for access to the exercise environment, however, this does not permit the instructor to provide specialist advice or instruction. Where instructors find themselves frequently working with special population clients, they should seek to obtain the appropriate qualification, otherwise, they could find themselves in breach of their duty of care. It is also important to have the appropriate insurance policy which covers the instruction of such clients.

## Personal Safety

Personal safety depends on your own awareness of any potential risks or threats in the workplace. You can ensure your safety on the job by familiarising yourself with and always following the employers safety policies and procedures.


**The following responsibilities are crucial to your personal safety:**

- Holding appropriate qualifications for any sessions delivered
- Only working with people or groups for which you are qualified to do so
- Holding public liability insurance and employer liability insurance
- Maintaining continuing professional development (CPD)
- Being a member of appropriate regulatory bodies (e.g. Register of Exercise Professionals)
- Adhering to industry codes of conduct
- Following organisational procedures
- Holding a first aid or CPR qualification if working with certain groups (e.g. Exercise Referral)
- Being aware of health and safety policies and responsible behaviour i.e. reporting hazards to the appropriate staff member
- Knowing the duty first aider, the location of the nearest contact phone and first aid kit and the procedure for reporting accidents

## Client Safety

s a fitness instructor, you also have a responsibility to prevent clients/patients putting themselves or being put in danger whilst in your care. You can do this by:

- Screening clients/patients before exercise, using appropriate methods such as the PAR-Q and verbal screening checks
- Referring clients/patients to the GP when necessary i.e. in the case of medical conditions
- Ensuring clients/patients are dressed in appropriate attire (e.g. they are wearing acceptable footwear and are without jewellery)
- Ensuring clients/patients are not chewing gum
- Observing and correcting clients'/patients' technique where necessary to ensure the safe use of equipment

## Environment Safety

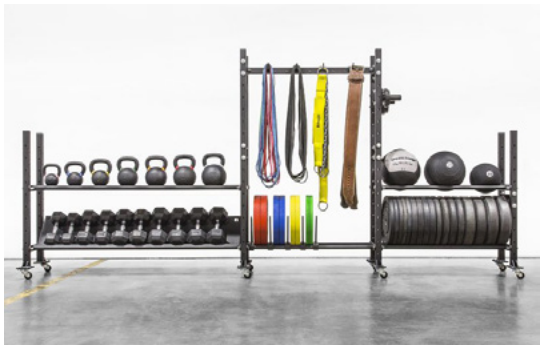
Another factor that will affect the safety of yourself and others is the environment around you. To minimise risk and help ensure environmental safety, the following responsibilities fall under your job role as a fitness instructor:

- Ensuring there is enough space for participants to execute exercises i.e. no overcrowding or risk of collision
- Ensuring there are no trailing wires that may increase risk of trips
- Ensuring floors are dry or signs are positioned to identify wet floors
- Ensuring the environment is prepared for exercise (e.g. making sure equipment is set up correctly and nothing is causing an obstruction)
- Ensuring all equipment is put away in the correct place after use and the environment is left clean and tidy
- Keeping floors clean and swept


## Equipment Safety

Maintenance and correct storage of equipment is extremely important to ensuring a safe gym environment. It will be your responsibility as a gym instructor to:

- Ensure equipment is stored correctly and safely (e.g. steps stacked to an appropriate height, weights put away on the racks, pool equipment stored in baskets)
- Make sure equipment is clean by doing things such as wiping down CV machines and mats after use
- Place 'out of order' signs on any broken or damaged equipment
- Report broken equipment to maintenance personnel



## Vulnerable Groups

**There are certain groups to whom you have a particular duty of care, these groups include:**

- **Children and young people aged 14-16 years old**
- **Older adults**
- **Pre- and post-natal clients**
- **Disabled clients**
- **Clients with medical conditions**
- **Vulnerable adults**

If you do not possess the pre-requisite qualification and training in the adaptation of exercise for these specific groups of people, the client should be informed and given the choice to stay in the session and follow basic recommended guidelines or seek further guidance from an appropriately qualified instructor e.g an exercise referral instructor.

Before taking on any client that falls into a vulnerable group, check that the employer's and your personal insurance policy covers work with special populations.

## Negligence

Duty of care is the obligation to exercise a reasonable level of care towards an individual to avoid injury or damage to property;

One essential priority is screening clients; all clients must be screened using appropriate forms before they can exercise. Clients who answer 'no' to PAR-Q questions can engage in exercise, as long as activities are suitably and personally modified by the instructor.

If planning to work with a vulnerable client group on a long-term basis, additional specialist training and qualifications are required. Clients should be referred to an appropriately qualified instructor should they wish to start a long-term programme.

Negligence is failing to follow responsibilities. Although a negligent act may be unintentional, it shows carelessness and can have serious consequences and reprimands.

**Level 2 gym instructors are not qualified to do the following and would constitute negligence and breach their duty of care:**

- **Act as a specialist instructor**
- **Advertise as a specialist instructor**
- **Instruct clients from specialist groups (one-to-one or in groups) on a regular basis**
- **Plan progressive, long-term programmes for clients with specialist groups**

# Security Procedures

There are a number of security measures which are designed to protect both indoor and outdoor facilities. Security can help to protect staff, users, possessions and the facility itself.

## External Security

A fitness environment may be incorporated within another facility and may not be directly responsible for outdoor security. Those which are will be responsible for the safety of users who drive, park and walk to and from the facility. Security depends not only on the installation of equipment but also the ability to operate it effectively.

### *Video Monitoring System*

CCTV can be used to monitor access and egress from the facility and the land upon which the facility is placed. Car parks, entrances and emergency exits should have camera equipment which is capable of recording and storing this information.

### *Lighting*

Outdoor security lighting can be permanently lit or operated with motion detectors.

### *Security Staff*

The presence of employees often acts as a deterrent to crime. Staff may be issued with secure two-way radios for effective communication in the event of a security breach.

Employment of dedicated security staff from an external organisation may be required for a larger facility.

### *Signage*

The use of signs, posters and stickers in potentially vulnerable areas, windows and doors can also deter criminal behaviour.

# Internal Security

When users enter the facility it is the role of internal security measures to help provide a safe environment.

## *Controlled Access*

Staffed receptions, barriers, swipe cards and coded entry locks provide secure modes of entry. The facility itself will usually determine which combination of methods is most suitable.

## *Electrical Communication*

Radios, pagers and mobile phones allow effective communication between staff, users and emergency services.

## *Alarms*


Intruder alarms are fitted in buildings to protect against unlawful entry. Panic alarms can be installed in areas where one-to-one contact is frequently encountered. These can provide peace of mind for both staff and users in environments such as offices and consultation rooms. Personal alarms may be worn by individuals to attract attention when necessary.

## *Training*

Staff training will inform employees of new equipment, regulation, legislation and changes in industry standards. Specialist agencies such as the police force can provide information on newly identified risks and any community issues which may become relevant.

## *Confidentiality*

A secure workplace will maintain confidentiality regarding all users of the facility. Secure storage and restricted access to confidential information should follow procedures which are communicated to all staff.

## *Prevention*

Criminal and antisocial behaviour can be deterred through effective work methods. Cash handling procedures, transportation of valuable possessions/ information and staff shift rotation can be organised in a manner which eliminates opportunist and organised crime.

The fitness professional has a duty of care to all aspects of the fitness environment in which they work. They must be aware of their responsibilities and encouraged to act accordingly, in the knowledge that the employer will support them in providing a safe and healthy environment.

# How To Control Risks In A Fitness Environment

Essentially a risk assessment is a formal examination of the workplace to find anything that could cause harm to people. It is the aim to make sure that nobody gets hurt or becomes ill at work and this process will determine whether enough precautions have been made or whether more needs to be done.

## *How To Assess Risk*

An individual does not have to be a health and safety expert to carry out a risk assessment. There are five steps to follow:

**1. Identify the hazards:** Slips, trips, falls, chemicals, machinery, electricity, manual handling, noise, lighting, temperature

**2. Decide who might be harmed:** Gym/office staff, members, cleaners, contractors, visitors, people with disabilities. A shared building will have to take others into account

### 3. Evaluate the risks:

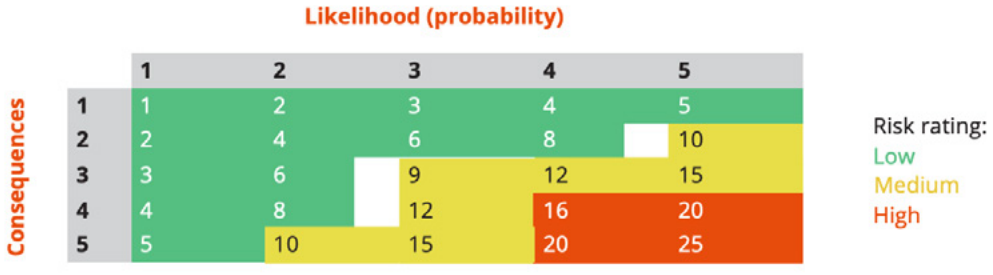
- Decide how likely it is that harm will occur
- Balance the risk against the measures needed to control the risk

### 4. Record your significant findings:

- Record the hazards, how people might be harmed and what is in place to control the risks
- Risks are calculated using a risk assessment severity scale of 1-5 where 1 is low risk
- A 5x5 risk matrix can be used for assessment

### 5. Regularly review your risk assessment:

- Environments and work methods change so it makes sense to review what you are doing and on an ongoing basis




| Likelihood (probability) | Consequences |
|---|---|
| 1. Rare | 1. Minor injury - no 1st aid required |
| 2. Possible (unfortunate) | 2. Minor injury - 1st aid required |
| 3. Possible | 3. Injury requires doctor or hospital |
| 4. Probable | 4. Major injury resulting in disability |
| 5. Almost certain | 5. Fatality |

# Manual Handling

Any job that requires manual handling will carry an associated risk. Lifting an object may seem straightforward but if you add the risk of carrying, climbing, turning or lowering then the risk will increase. Repetitive movements and holding positions can compound the risk further and this series of events can cause damage to all tissues of the body either by trauma (sudden injury) or wear and tear over a period of time.

## Correct Handling Techniques

### *Lifting*

Keep loads close to the body and near to persons' centre of gravity, using diagonal foot positions to provide greater stability. Move loads from waist height where possible and when lifting from the floor, maintain a neutral spine while using the power of the legs.

### *Pushing and pulling*

Pushing is generally easier than pulling. Lean forward when pushing and lean backwards when pulling. It is important to use the arms and legs in unison and avoid twisting where possible.

### *Pivoting*

Handlers are safer when pivoting their shoulders, hips and feet with the load in front of the body. Try to avoid excessive and repetitive twisting actions.

### *Climbing*

When climbing with a load it is important to try and maintain contact with the ladder or stairs at three points (two feet and one hand or two hands and one foot).

In all situations of manual handling large heavy loads, the assistance from another person or mechanical lifting device would be recommended.

# Exercise Risk Assessment

This process will start with the PAR-Q which will highlight the risks of participating in any form of exercise. Once it is established that the client may undertake exercise, it is the job of the instructor to decide which forms of exercise will be appropriate. All exercises involve an element of risk and the instructor must consider these factors when programming for the individual. There is no combination that suits all clients so considering the following factors will serve as a guide to making safe exercise choices:

## *Medical Status*

Avoid any exercise which may aggravate a current condition. Clients may present test results which place them in a special attention category. Previous or present injuries may require the avoidance of exercise for certain muscle groups and past injuries and conditions may reduce performance during exercise.

## *Occupation*

The physical requirements of a persons' job may identify risks in prescribing certain exercises. In addition, the time of day most suited to exercise will need to be considered. Stress levels, hours of work, length of working day and motivation to exercise before or after work can present a challenge in exercise programming.

## *Lifestyle*

The way in which individuals choose to live their lives can be vastly different. Sleep patterns, social choices, sedentary or active habits are only a few of many lifestyle choices. The effect on energy levels and time available to exercise can affect the exercise diary, levels of intensity and duration of sessions.

## *Nutrition*

Dietary choices can influence our ability to exercise. Calorific intake, eating patterns and choice of food groups can influence how we feel and determine our performance during exercise.

- **Type of exercise**
- **Resistance and intensity**
- **Speed**
- **Balance and proprioception**

## The Exercise Risk Continuum


The risk associated with an exercise can be evaluated by using the following diagram. It is important to understand that there is no right or wrong exercise. An exercise may be

suitable for one client but inappropriate for another. All health factors, fitness levels, client goals, equipment and environment should be considered by the instructor in the decision-making process. The risks of performing an exercise must be weighed up against the benefits when deciding if an exercise is appropriate.

# Emergency Procedures In A Fitness Environment

The fitness environment can be a dangerous one. Such facilities are generally stocked with machines and equipment that has the potential to cause injury. Even when used correctly a gym relies on the vigilance and spacial awareness of all gym users. Often there is a gym etiquette which is difficult to understand for a beginner client or inexperienced member of staff, but in time this often unwritten code of conduct is learned and implemented.

When faced with an emergency, whether caused by equipment which affects an individual, or on a larger scale where the whole facility is at risk, the instructor must become familiar with emergency operating procedures.

## *Types Of Emergency*

There are various threats to the workplace when an unforeseen situation can threaten employees, customers or the public. Emergencies may be natural or manmade and can cause physical and environmental damage.

### THESE CAN INCLUDE:

- **Fire (electrical, chemical)**
- **Floods**
- **Hurricanes/storms (outside environments)**
- **Chemical spills (Cleaning products)**
- **Toxic gas release**
- **Explosions**
- **Civil disturbance**
- **Workplace violence**

## Accidents And Sudden Illness

From time to time a gym user can suffer an accident or illness which may be caused by exercise. Alternatively, it can be an unfortunate coincidence which occurs while on the premises. The instructor has a role to perform in such a situation.

The emergency services should be called when there is a medical emergency whereby someone is seriously ill or injured and their life is at risk.

When contacting the emergency services the following key information should be given:

**C**alm yourself
**A**ssess situation
**L**ocate assistance
**M**ake area safe

**Location** - postcode, telephone number, general area or landmarks
**Incident** - describe what has happened
**Other services required** - e.g. fire brigade, police
**Number of casualties** - number, sex, age
**Extent of injuries** - describe what you see
**Location** - repeat description of location

In the event of an accident that can be dealt with by an appointed first aider on the premises, the contents of a first aid box may be required. The contents should reflect the findings of the first aid needs assessment.

A minimum stock of first aid items may include:

- **1 general guidance leaflet on first aid**
- **20 individually wrapped sterile plasters of assorted sizes**
- **2 sterile eye pads**
- **6 safety pins**
- **2 individually wrapped triangular bandages**
- **2 large sterile individually wrapped unmedicated wound dressings**
- **6 medium-sized sterile individually wrapped unmedicated wound dressings**
- **3 pairs of disposable gloves**

## Other emergencies

It is important for the instructor to follow emergency operating procedures calmly and correctly, as provided by the employer. This is more likely to ensure the safety of everybody on the premises than performing an alternative procedure. Any deviation from the procedures implemented, trained and practised by the employer may result in liability on the part of the instructor as a result of any harm caused during the emergency.

An emergency situation may require the assistance of one or more of the external emergency services, each with a separate role to perform:

- **Police** provide community safety and act to reduce crime against persons and property
- **The fire department** provides fire-fighters to deal with fire and rescue operations
- **Emergency medical service** provides ambulances and staff for medical emergencies

# Safety of Persons in an Emergency Situation

Organisations providing services to the public must take responsibility for all people who enter its premises, otherwise, it may be viewed as discriminatory. The procedures implemented by each facility should account for the safety of all groups and provide full training to the relevant staff. Children, older people and those with disabilities may be particularly vulnerable in an emergency situation.

## GUIDELINES FOR ASSISTING SPECIAL POPULATIONS:

### *Children*

In an emergency, children have special needs and become more dependent on adult guidance and support. Where possible, rehearsal of emergency procedures will prepare them for a potentially frightening experience and assure them that there is a plan to overcome such a situation. In the event of an emergency, the instructor should explain what is happening, listen to any fears a child may express and give concise answers where appropriate. The instructor should remain calm and positive as their behaviour will be interpreted and may be reflected in the actions of a child. Physical contact such as “holding hands” or “guiding direction” may also be appropriate.

### *Older people*

An older adult may have developed impairment in movement, vision, hearing or mental agility and control. This deterioration in physiological and psychological function may result in a loss of independence in an emergency situation. A member of staff can offer physical assistance in evacuation by acting as a “buddy” to ensure their safety.

### *People with disability*

Procedures will vary depending on the needs of a disabled person. Physical assistance may be necessary to aid speed of movement or to overcome obstacles. The maintenance of any specialist equipment, surfaces and wheelchair routes on the premises should be up to date and recorded to avoid failure in the event of an emergency. Staff can attend “assisting disabled people” training courses which will prepare their attitude, communication and assistance skills in order to act appropriately in the event of an emergency.

### *Safeguarding children and vulnerable adults*

It is the duty of all professions to safeguard the welfare of children and vulnerable adults. The vigilance of professionals will help in recognising signs of abuse and the reporting of such findings will maintain and improve the safety of these groups.

### THE FOLLOWING KEY PRINCIPLES SHOULD BE INCLUDED IN ANY ORGANISATIONAL POLICY STATEMENT:

- **Adults must demonstrate proper conduct and personal behaviour at all times**
- **Adults must always respect and champion the rights of every individual who participates in leisure activities**
- **Adults must develop a relationship with children, vulnerable adults and staff based on openness, honesty, mutual trust and respect**

Adults working in the active leisure sector must maintain a high level of competence by attaining qualifications and through a commitment to ongoing training in order to ensure safe and correct practice.

## Policy Content

### THE POLICY OF AN ORGANISATION SHOULD ALSO INCLUDE:

- **A checklist for the recruitment, employment and deployment of staff and volunteers**
- **Procedures to respond to breaches of codes of conduct**
- **Specific codes of conduct for different groups**

# *Prepare self, client and facilities for a gym-based workout*

## *MODULE 6: UNDERSTANDING THE CARDIOVASCULAR SYSTEM AND DIGESTION AND THE HORMONAL AND METABOLIC EFFECT OF FOOD*

Writing and then delivering gym-based workouts is the main role a fitness professional can expect to perform. The client's enjoyment and results, as well as their health and safety, all hinge on the effective delivery and subsequent supervision of an appropriate program of exercise. A successful workout begins with proper preparation.

## Preparing The Instructor

Before the exercise session begins, the instructor should ensure that all resources that will be required for the workout are present and in good working order.

Factors that need to be considered include:

- **The program has been written and is ready for use.**
- **The workout program meets the needs of the client.**
- **The instructor is clean, presentable, and promotes a positive image.**
- **The equipment required is available and in good working order.**
- **Alternatives have been identified in case of last-minute changes to the workout.**
- **The instructor is on time.**

By preparing for the workout in advance, the instructor ensures that the session will go as smoothly as possible and that they will not be "blindsided" by anything other than very unusual events.

# Preparing The Client

Once the instructor and facilities are ready and the client arrives, the following steps should be followed before the commencement of exercise:

## *Welcome the client and explain any emergency procedures*

A warm welcome will help establish rapport and put the client at ease from the outset of the session. Welcoming the client in a friendly but professional manner will set the tone for the rest of the session. If this is the client's first workout in this particular facility or there have been any procedural changes since their last visit, the instructor should clearly explain the location of the emergency phone, first aid kit and duty first aider and detail the procedures that should be followed in the case of a fire or other emergency.

## *Explain the purpose of the session*

Give the client a brief outline of the session and its purpose so they can understand the value of the exercises they will be performing. This also gives them the opportunity to air any concerns regarding the upcoming session and provide any last-minute input.

## *Carry out a verbal PAR-Q*

Prior to starting exercise, ask the client if, since completing their written PAQ-Q, has anything regarding their health changed i.e. do they have any aches or pains that need to be considered, are they feeling unwell in any way, are they still tired from the previous workout. This information should then be used to modify the workout as necessary and, in the case of illness or injury, may necessitate postponing the session. Once this preamble is complete, it is time to move onto the warm-up, main session and cool down.

# Instructional Skills

It's all well and good having a very effective program planned and all the equipment set up in advance but if the instructor is unable to effectively communicate what the client needs to do, the workout can be much less productive than it ought to be. Delivering clear, concise and correct instructions is a skill that all instructors need to develop and practice if they are to be successful. Communicating can be verbal or visual and both types of communication are important to fitness instructors.

## *Verbal Communication*

- Giving instructions
- Providing motivation and praise
- Delivering teaching points
- Providing corrections
- Counting
- Cueing

## *Visual Communication*

- Demonstrations
- Body language
- Teaching position
- Eye contact
- Facial expression
- Physical contact

# Verbal Communication

The ability to verbally communicate clearly and concisely is one of the instructor's most powerful tools. Clearly communicating concepts, ideas, reasoning, instructions and feedback will enhance the whole workout.

**To communicate effectively, the instructor should be mindful of the following:**

- **Terminology:** Instructors must realise that not all clients will be familiar with terms like "neutral spine", "keep your knees soft", "avoid hyperextending your elbows" and "brace your core". Technical terminology, if used at all, must be qualified with a clear initial explanation. Avoid the use of fitness jargon and abbreviation but, instead, use terms that your client will understand. Use the session as an opportunity to teach any relevant terminology to the client but do not try to "blind them with science" by making explanations unnecessarily technical.

- **Motivation:** As the workout progresses, the instructor will need to motivate most if not all clients to work at the appropriate level. This is best done by exuding enthusiasm and confidence and being passionate about what they do. Accompanied by the appropriate intonation and volume, terms like "Well done – only two more reps to go" or "You can do it!" can help the client work through any momentary discomfort. Avoid terms like "Don't stop" as the client can all too easily focus on the negative.

- **Teaching Points:** Teaching points are phrases, keywords and reminders used by the instructor to encourage good exercise technique. Always positive, teaching points remind the client about what to do rather than what NOT to do. For example, when doing press-ups, the instructor may use teaching points like "keep your elbows soft", "long neck", or "keep your elbows soft". Use teaching points to pre-empt technique errors before they happen or correct errors when they do. Avoid overly length or technical teaching points; a teaching point is not a fully-developed instruction but a brief phrase that is easily understood.

- **Correction:** Despite the instructor's best efforts, even the most advanced clients will still make mistakes and need correction. Corrections, like teaching points, should always be positive i.e. tell the client what they need to do, not what they must stop doing. For example, "keep your elbows soft as you press the weight up" is much better than "don't lock your elbows". Correction should be delivered patiently and in such a way that it does not come across like a "telling off" or being judgemental.

- **Cueing and Counting:** Cueing means letting the client know what is about to happen in their workout, for example counting them in as your hand them a weight, letting them know you are about to speed up or slow down the treadmill or warning them that you are about to increase the depth of a partner-assisted stretch. Counting, in contrast, tells the client how their set is progressing and how many reps they have let to do. An instructor should count, coach and encourage during each and every set and avoid just counting reps only.

- **Voice Intonation:** While the words used during an exercise session are important, the way they are spoken are is important too. Voice intonation can reinforce the meaning behind the words and make all the difference to how information is interpreted. For example, saying the word "explode" in a monotonic way will have very little meaning whereas saying the word like it sounds "EXPLODE!!!" as the client drives up and out of the bottom position of a heavy squat is much more emotive and useful. Similarly, when it comes to lowering the intensity and moving into the cool-down stretches, a calmer, more measured voice will aid in relaxation and a better stretching experience.

Often, older people will respond better to a lower level of intonation while younger clients may prefer a more upbeat, energetic tone. Try to vary the volume, speed and general tone of your voice according to the component of the program; mirror the intensity of the workout with your voice.

## Visual Communication

In addition to communicating verbally, instructors must also be familiar with non-verbal forms of communication. In noisy gyms and for reinforcing verbal communication, visual communication is essential.

- **Demonstrations:** To successfully teach an exercise, instructors must be able to do a good demonstration using proper technique. A demonstration should be precise, practiced and ultimately as perfect as possible. Make sure the client is positioned in such a way that they can clearly see the demonstration and do enough reps that they get adequate opportunity to see all the relevant points of the exercise being shown; 5 to 8 is ideal. Make the demo very controlled and emphasises the important aspects including breathing, lower back position etc. Use a lightweight when doing demonstrations so that a) there is no reason for technique not to be perfect, b) to allow for the fact that you are not warmed up or may have to do dozens of demos already, and C) avoid intimidating the client. If you cannot demonstrate an exercise, it can still be taught providing you can give very clear instructions but a demonstration is usually the best option. Once the demonstration is complete, the client should have the opportunity to ask questions before they have ago.

- **Observation:** When the client is performing any exercise, the instructor should adopt a good position from which to observe performance. This often means moving from one position to another to watch the client from a variety of angles. What looks look good exercise technique from the front could actually be very poor technique when viewed from the side so the instructor must not only move but also know the best position from which to spot common technique errors. In addition, the instructor must also end up in the right position at the right time to spot and help the client re-rack the barbell or put down dumbbells.

- **Body language:** Body language is often described as uncensored communication and while it's easy enough to sound motivating and enthusiastic, body language can give out a different message. Avoid slouching, sitting down, crossing your arms or otherwise looking anything other than being an enthusiastic, professional, approachable instructor and remember, body language can be read not just by the client but anyone else who happens to be in the gym.

- **Touching:** It is sometimes necessary to touch a client e.g. when getting them into a correct exercising position when spotting and in the case of Hilton's law (the nerves that innervate the skin also innervate the muscles underneath) however not everyone likes to be touched so it is important that the instructor obtains informed consent before touching the client and can always justify the use of touching. If no justification exists, it is possible that touching is unwarranted, maybe unwelcome and could lead to allegations of misconduct.

# Instructing A New Exercise

One of the main roles of an instructor is introducing clients to new exercises; either on a one-to-one basis or in group inductions. It is very important that this initial instruction is done well as techniques learnt now will potentially influence how client's perform exercises for the foreseeable future and it is much easier to teach someone how to do an exercise properly from the outset than re-teach them once they have developed bad habits. There are several ways to teach a new exercise to a client but the best methods follow a logical pattern, are concise and give both the instructor and the client a framework with which to work. One such instructional method uses the acronym **N.A.S.T.Y.**

**Name the exercise and the muscles involved**
Call the exercise by its correct/accepted name and name the part of the body involved. E.g. "This is the leg extension machine and it mainly works the muscles on the front of your thigh – the quadriceps.

N

**Adjustments**

Show the client how to adjust the machine or their body position for safe and effective exercise performance. Set the machine up for yourself ready for your demo.

A

**Silent demonstration**

Do 5 to 8 reps without saying anything making sure the demo is as clear and precise as possible. Ensure the client is in the best place to see.

S

**Teaching points**
Continue with the demonstration but add relevant teaching points and instructions. Be careful not to over-explain; time may be a limiting factor. However, make sure all important information is conveyed. Use non-technical dialogue so teaching points are easily understood.

T

**You have a go!**
Get the client into position so that they can perform the exercise. Count, coach and encourage them while they exercise.

Y

Some exercises are harder to master than others so make sure you are prepared to regress an exercise if the client is unable to perform a particular exercise properly or safely. It may be necessary to break complex exercises down into their constituent parts so that the client can master one small part of the movement at a time. Remember to only increase exercise intensity when good technique is demonstrated and never sacrifice good technique for heavier weights or more reps. If in doubt, choose easier/less technically demanding exercises that target the same fitness component and introduce more demanding exercises as the client's skill level increases.

NASTY

## Managing Group Inductions

Many organisations induct or introduce groups of new members to the gym simultaneously. This job normally falls to the gym instructor. Inducting a group is more challenging than working with an individual for several reasons:

- **Mixed ability groups mean that advanced and beginner exercisers have to be catered for at the same time**
- **Limited equipment means while some members of the group will be exercising, others will not**
- **In large groups, some people may feel excluded**
- **It is much harder to supervise a group of people that it is to supervise an individual**
- **Time limitations may mean that not all members of the group get to try all exercises**
- **It is very difficult to coach, correct and encourage each member of the group equally**
- **Members of the group may get in each other's way and make it hard to see the instructor's demonstrations**
- **Less outgoing clients may feel uncomfortable asking questions in a group environment**
- **More outgoing clients may try to monopolise the instructor's time and attention**
- **Group inductions make it very difficult for the instructor to offer personalised exercisers commendations**

To manage group inductions effectively and efficiently, instructors may be required to only demonstrate a sample of the exercise equipment available so that the clients have sufficient knowledge to use other machines unsupervised. While not ideal, this is the only real way to deal with large numbers of new members. Secondary, more personalised, inductions should be offered when time permits.

# Spotting

Spotting involves providing hands-on assistance to a client while they are performing a resistance exercise. Spotting is a skill and while good spotting is always well received and beneficial to the client, bad spotting can disrupt a set and be very annoying and even dangerous. Spotting needs to be practised.

## THERE ARE THREE MAIN FUNCTIONS OF SPOTTING:

- **Assisting the client if they are in difficulty**
- **Applying exercise intensifying techniques such as "forced reps"**
- **Reinforcing correct technique**

In general, the greater the potential for injury, the more important spotting becomes. For example, in the bench press where the bar is held over the chest, a failed rep could result in serious injury so spotting is very important. However, for an exercise like triceps cable push-downs, spotting is much less important.

## EXERCISES THAT COMMONLY REQUIRE SPOTTING INCLUDE:

- **Supine exercises such as barbell or dumbbell bench presses**
- **Overhead exercises such as barbell shoulder presses**
- **Squats and lunges where the barbell is supported on the upperback**
- **Any other exercise where a failed rep could result in injury**

Power exercises that are performed at high speed, such as kettlebell swings, cleans or push-presses, should not be spotted as there is a high risk of injury to both the exerciser and the instructor. Some machine exercises can also be spotted however this is generally done to intensify the workout rather than for reasons of safety.

## SPOTTERS SHOULD:

- **Be strong enough to safely assist if required**
- **Know the correct way to spot safely and effectively**
- **Be in the right position at the right time to assist**
- **Know how many repetitions are being attempted and when their help is likely to be needed**
- **Be attentive at all times and monitor exercise performance**
- **Understand that for some exercises, such as heavy squats, more than one spotter may be necessary**
- **Be in the optimal position to assist without risking injury to themselves**
- **Maintain neutral spine to minimise risk of injury**
- **Establish and maintain good communication with exerciser**
- **Not end up doing all the work for the client**

Except in the instance of an acute injury or negative-only repetitions, the spotter should never have to lift all of the exercise weight on their own. The assistance should be limited to just enough so the repetition(s) can be completed with the client doing the majority of the work. If the instructor is lifting more weight than the client, the exercise has ceased to be productive and/or the load is too much for the client.

Instructors should also avoid the temptation to spot each and every exercise in a program; some exercises simply do not need to be spotted or cannot be spotted safely. Overly- enthusiastic spotting can be as problematic as not spotting at all.

## Spotting techniques

**Different exercises require different spotting techniques:**

- **Barbell exercises are usually best spotted by gripping the barbell**
- **Dumbbell exercises are best spotted by applying pressure under the elbows**
- **Machine exercises are best spotted by applying pressure to the machine lever arm**

## Monitoring Safety

Monitoring safety is an essential part of a gym instructor's role, whether they are working 1-to-1 with a client or supervising the gym. That means that he/she must be able to stop incorrect and potentially dangerous exercise technique and offer corrections. While it is possible for any exercise to be done incorrectly, the most common incorrectly performed exercises are bodyweight and free weight exercises where movement paths are not guided and it's all too easy to forget about things like spinal position, when focusing on working a seemingly unrelated part of the body.

# Planning Exercise For Health Reasons

While many people exercise for improved sports performance or enhanced appearance, many exercisers work out simply because they want to be healthier and live longer. In this instance, periodisation becomes less important because simply being active will improve health status as well as reducing the risk of developing diseases such as obesity and heart disease.

Research suggests that being physically active reduces all-cause mortality and being hypokinetic (sedentary) is a major risk factor for many medical conditions.

Despite the fact that "exercise is good for everybody's body", a study by the Health Education Authority (HEA), now called The National Institute for Health and Clinical Excellence revealed the following:

- **90% of adults believe that exercise is important however only 40% actually do it**
- **Most adults believe they are active enough to keep fit**
- **80% of adults do not know how much exercise they need to do**
- **70% of men and 80% of women are not active enough to benefit their health**
- **2/3 of women and 1/3 of men find walking briskly uphill for a few minutes very demanding**
- **1/3 of men and 1/2 of women aged 65 to 74 do not have enough strength to lift 50% of their body weight, making everyday tasks like climbing stairs and walking very demanding if not impossible**
- **Amount of exercise necessary to benefit health and fitness**

Health and fitness are two very different things. Health is an absence of disease whereas fitness is more to do with performance and the ability to perform physical work. It is possible to be very healthy but not fit and fit but not especially healthy (for example someone who exercises but smokes heavily) and according to the American College of Sports Medicine (ACSM), the exercise prescription for health and fitness differ significantly.

## *To Reduce Mortality*

**Frequency:** 5-7 times a week

**Intensity:** moderate or 50-70% MHR

**Time:** 30 minutes in total per day

**Type:** any sustained, physically demanding activity using large muscle groups

Simply being physically active for 30 minutes or more a day provides health benefits e.g. gardening or walking for transport or leisure. Research suggests that the time can be cumulative providing eight or more minutes of activity are performed at a time. For general physical activity to have health benefits, the participant should get slightly out of breath and generally feel warm.

## *To Improve Fitness And Reduce Mortality*

**Frequency:** 3-5 times a week

**Intensity:** vigorous 60-90% MHR

**Time:** 20-60 minutes in total per day

**Type:** sustained exercise using large muscle groups e.g. jogging, rowing etc. Examples of activities listed by intensity:

### *Moderate*

- Cycling for pleasure
- Step machine
- Rowing machine
- Walking briskly
- Cricket
- Golf
- Swimming
- Gardening and mowing the lawn
- Badminton
- DIY

### *Vigorous*

- Running at >5mph
- Hockey
- Squash
- Tennis
- Rugby
- Hill-walking
- Stair climbing
- Cross country skiing
- Rock climbing
- Circuit training

## *Benefits*

When trying to "sell" exercise, it is important that instructors are able to explain the myriad of benefits that can be gained from participating in a regular fitness program. While many benefits are physical e.g. weight loss or have a positive health benefit, exercise can also have a positive effect on the mind and may even be socially or spiritually beneficial.

While it cannot be guaranteed that all exercisers will experience all the benefits, it is certain that being physically active will counter the effects of inactivity and can only be a positive undertaking.

# The Endocrine System

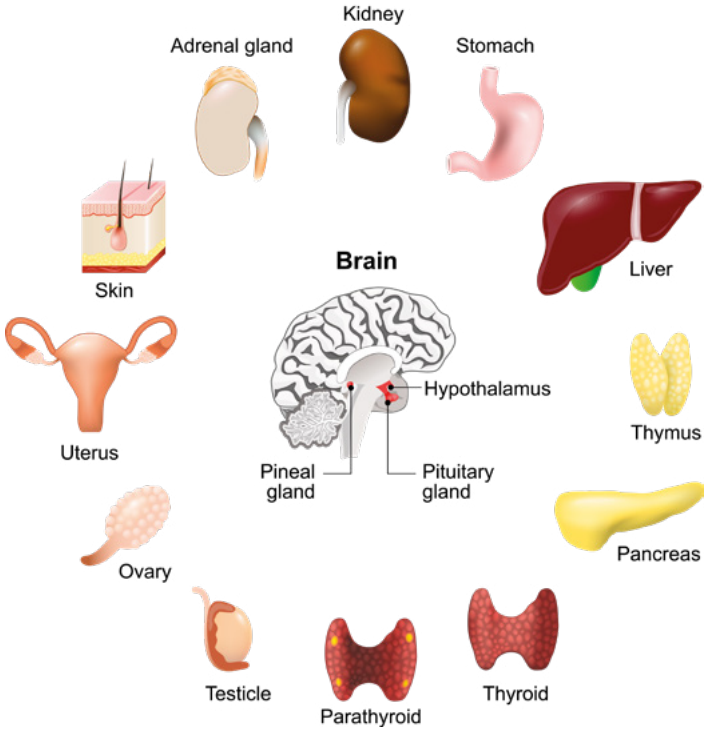
## MODULE 6:
## UNDERSTANDING THE CARDIOVASCULAR SYSTEM AND DIGESTION AND THE HORMONAL AND METABOLIC EFFECT OF FOOD

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

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

**The endocrine system helps control the following processes and systems:**

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

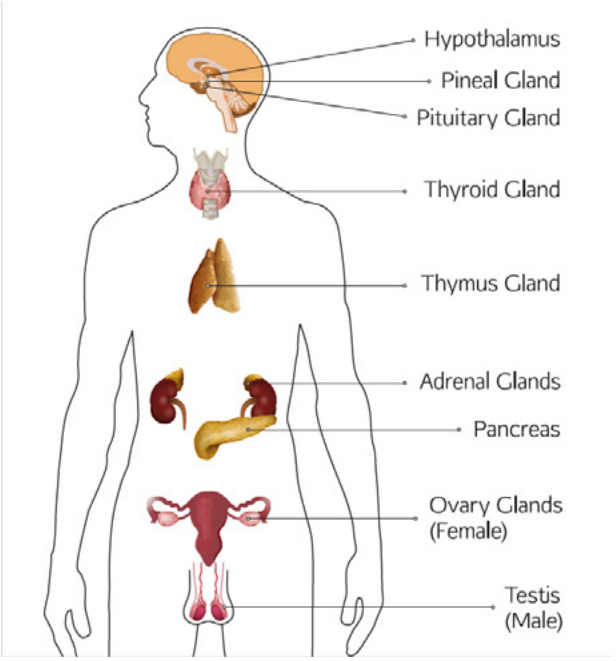


# The Endocrine Network

The endocrine system completes these tasks through its network of glands, which are small but highly important organs that produce, store, and secrete hormones.

**The glands of the endocrine system are:**

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




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

# Hormones Part 1

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

## *Insulin, Glucagon and the Control of Blood Glucose*

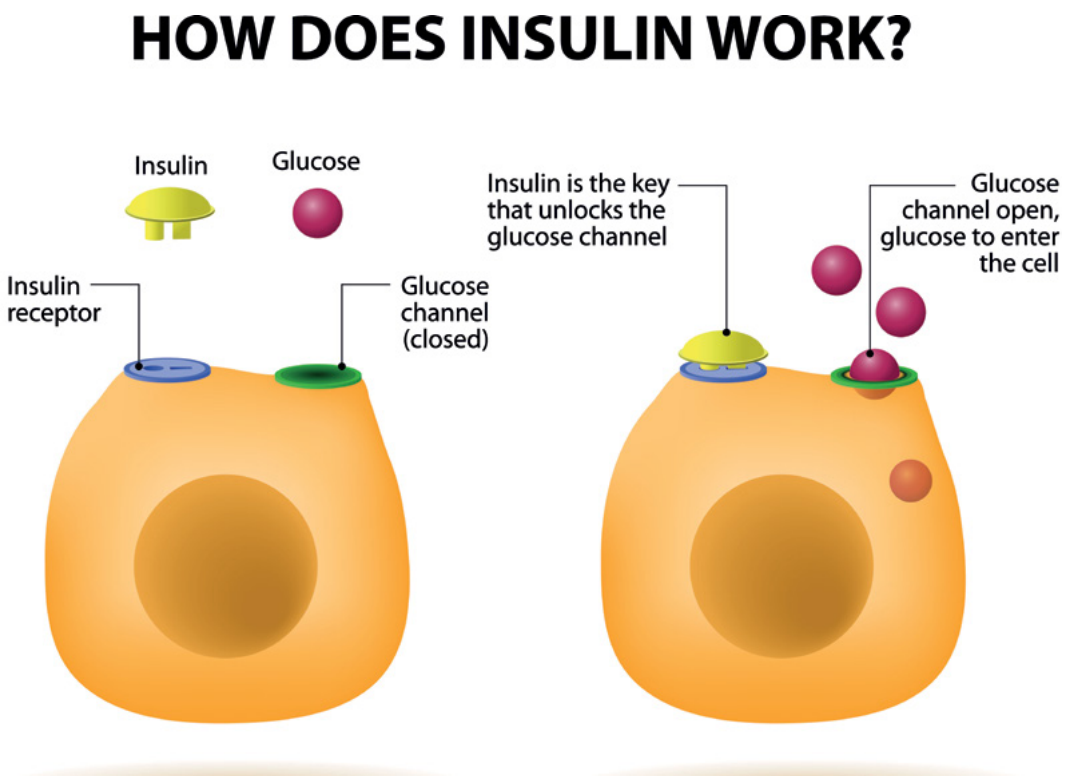
The principle fuel for vigorous activity is a carbohydrate (specifically glucose). It is also worth noting that glucose is the principle fuel for the brain. Large fluctuations in blood glucose levels can be extremely damaging. Too little will decrease performance and could eventually be fatal, furthermore,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

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

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

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

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

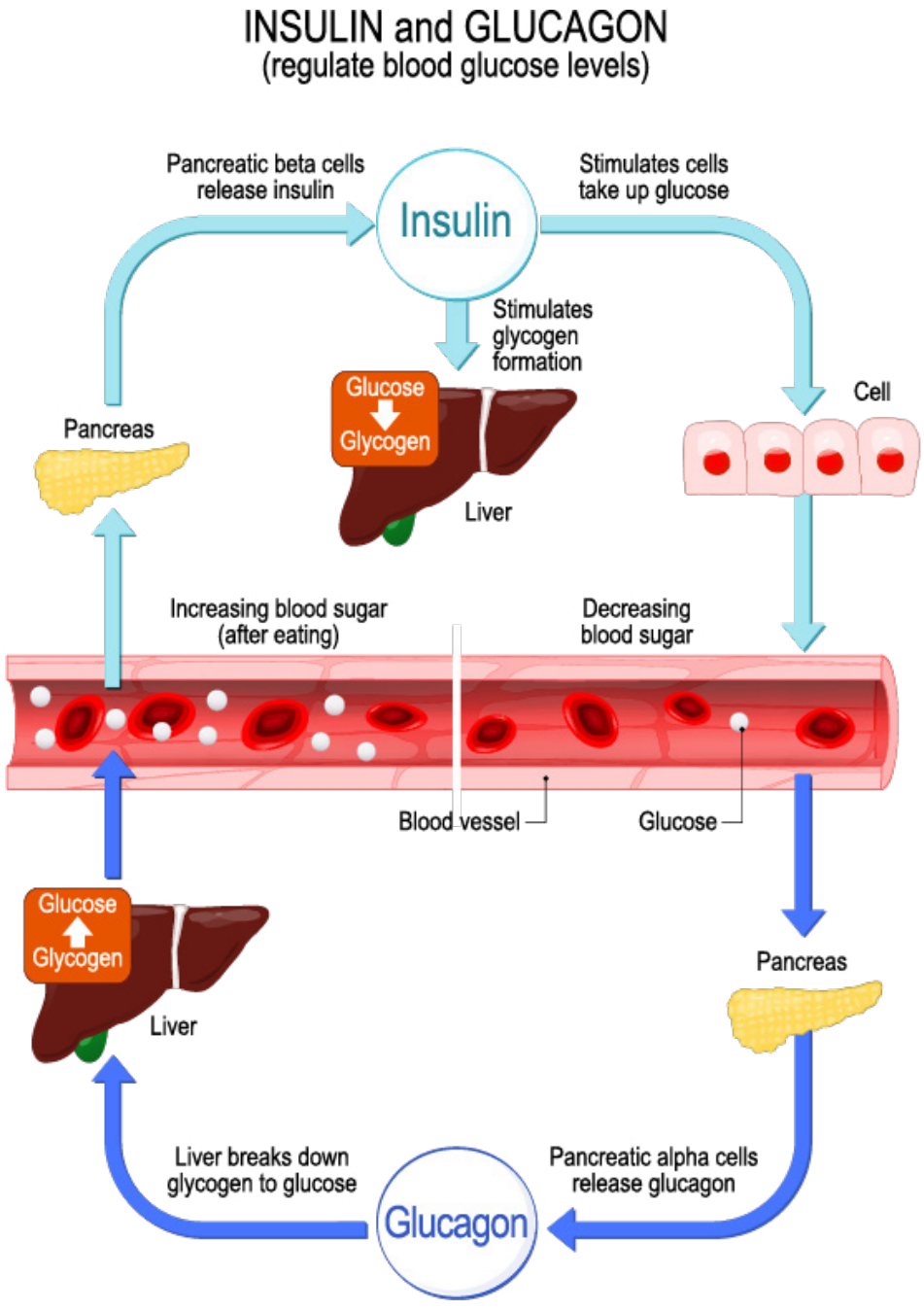


## *Glucagon*

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

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

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



# Hormones Part 2

## *Testosterone and Oestrogen*

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

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

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

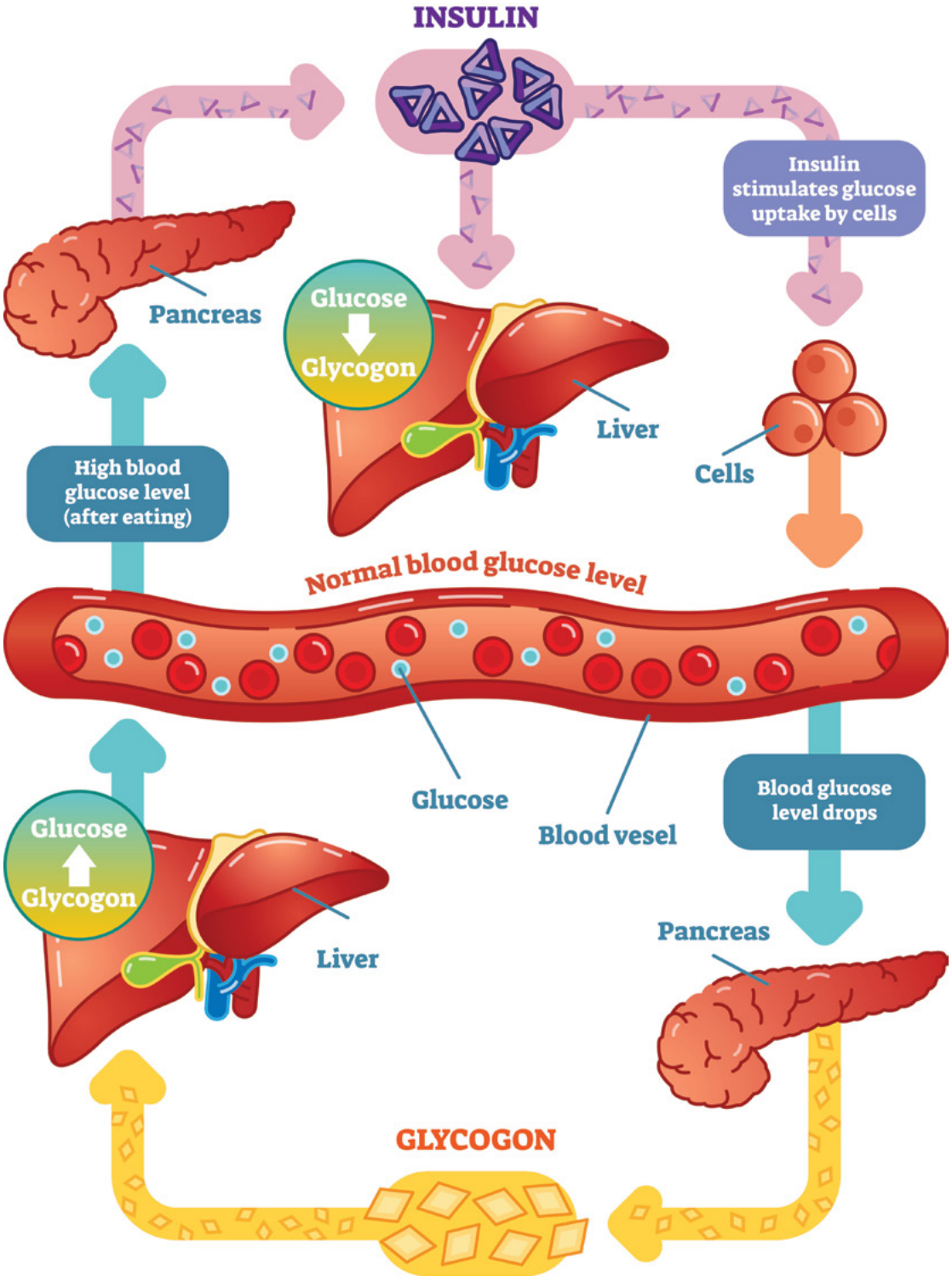
## *Cortisol*

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

## *Growth Hormone*

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

# Insulin and Glucagon

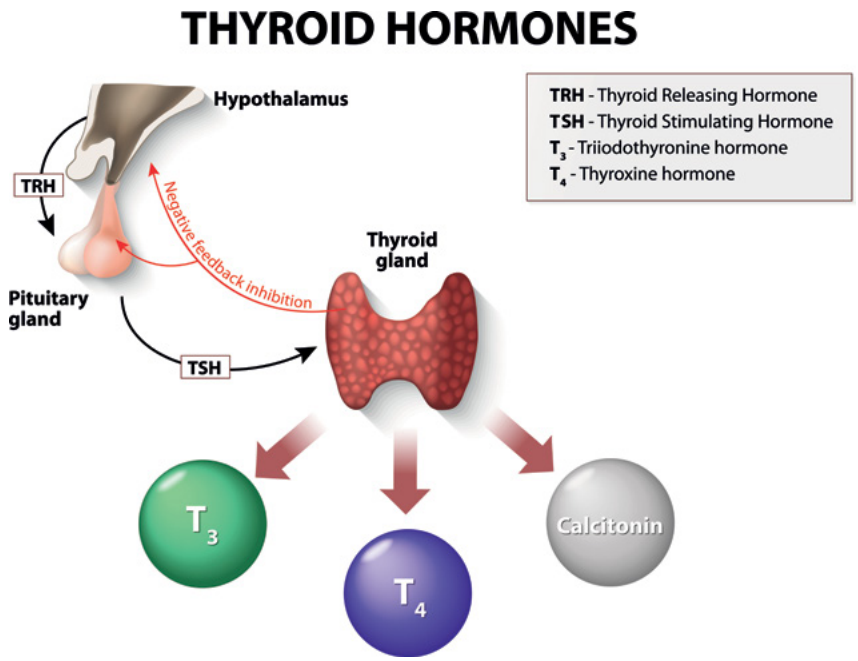


## *Thyroid Hormones*

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

**Thyroid hormones have been shown to be responsible for:**

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




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

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

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

## Hormones Function Table

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| Endocrine Gland | Hormone | Exercise effect | Target organ | Major function |
|---|---|---|---|---|
| Hypothalamus | Releasing hormones | Increases with anticipation of exercise | Pituitary gland | Stimulates the pituitary gland to release hormones |
| | Inhibiting hormones | Increases with cessation of exercise | Pituitary gland | Inhibits release of pituitary gland hormones. |
| Anterior Pituitary | Growth Hormone (GH) | Increases with increasing exercise | All cells of the body | Stimulates growth in all organs/ tissues, increases protein synthesis, the mobilisation and use of fat for energy and inhibits carbohydrate metabolism |
| | Thyroid stimulating hormone (TSH) | Increases with increasing exercise | Thyroid gland | Controls the secretion of the hormones released by the thyroid |
| | Adrenocorti cotropic Hormone (ACTH) | Increases in response to exercise | Adrenal Cortex | Controls the secretion of hormones from the adrenal cortex |
| | Endorphins | Increases with long duration exercise | | Blocks pain |
| Posterior Pituitary | Anti diuretic hormone (ADH) | Increases with increasing exercise | Kidneys | Stimulates water retention by the kidneys |

| Endocrine Gland | Hormone | Exercise effect | Target organ | Major function |
|---|---|---|---|---|
| Adrenal Medulla | Adrenaline (Epinephrine) | Increases with heavy exercise | Acts on most cells in the body prolonging and intensifying the sympathetic nervous system response to stress | Mobilises glucose, increases heart rate, heart contractility, oxygen use and blood flow to skeletal muscles<br><br>Constricts blood vessels and elevates blood pressure. |
| | Nor adrenaline<br><br>(Nor epinephrine) | Increases with increasing exercise intensity or duration | Acts on most cells in the body prolonging and intensifying the sympathetic nervous system response to stress | Mobilises glucose, increases heart rate, heart contractility, oxygen use and blood flow to skeletal muscles<br><br>Constricts blood vessels and elevates blood pressure. |
| Adrenal Cortex | Aldosterone | Increases with exercise | Kidneys | Regulates electrolyte and fluid balance. |
| | Cortisol | Increases with heavy exercise | Most cells in the body | Increases blood sugar levels, aids the metabolism of fats, CHO and proteins, suppresses the immune system, has an anti-inflammatory action. |

| Endocrine Gland | Hormone | Exercise effect | Target organ | Major function |
|---|---|---|---|---|
| Pancreas | Insulin | Decreases with increasing exercise | All cells in the body | Controls blood glucose by lowering blood glucose levels |
| | Glucagon | Increases with increasing exercise | All cells in the body | Increases blood glucose, stimulates breakdown of glycogen and fat |
| Kidneys | Renin | Increases as blood pressure lowers | Adrenal Cortex | Assists in blood pressure control |
| Gonads:<br>Testes | Testosterone | Increases with increasing exercise | Sex organs | Development of male sex organs, facial hair and change in voice |
| | | | Muscle | Promotes muscle growth |
| Ovaries | Oestrogen | | Sex organs | Development of female sex organs, regulates menstrual cycle |
| | | | Adipose tissue | Storage of fat |

## The Effects Of Exercise


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

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

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

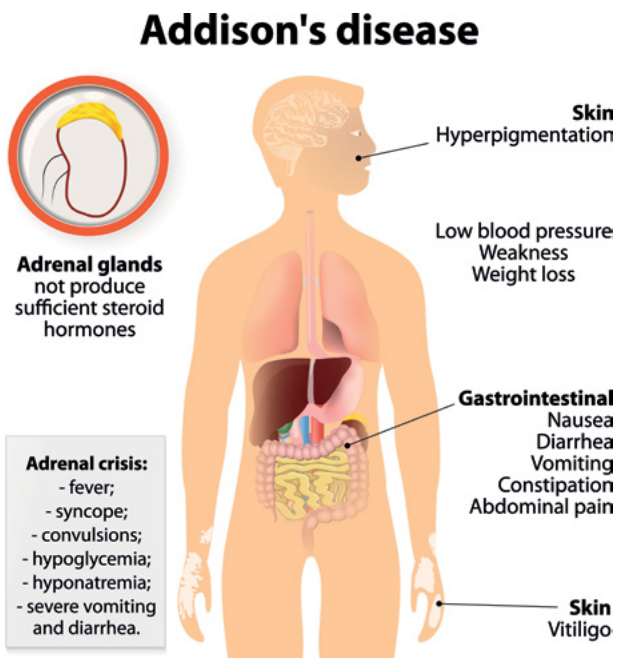
## Endocrine Diseases

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

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

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

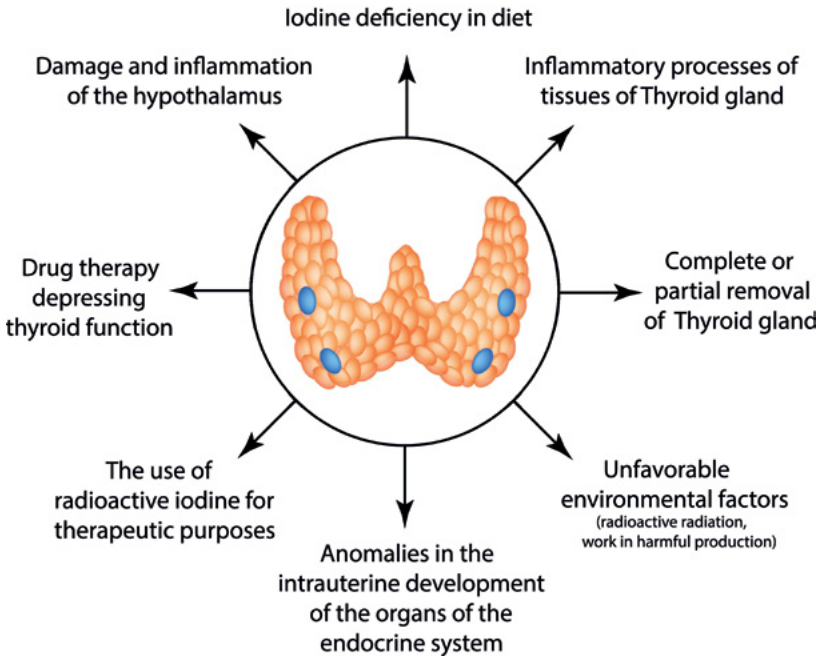
Endocrine diseases are common and happen even when one step in the process doesn't work as it should. If you have an endocrine disease or disorder, you may consult a specialist known as an endocrinologist who will effectively diagnose and help treat your condition.




### *Endocrine Disorders*

- **Addison's Disease**
- **Graves' Disease**
- **Hyperparathyroidism**
- **Hypothyroidism**
- **Osteoporosis**

# CAUSES OF HYPOTHYROIDISM




- **Thyroid Cancer**
- **Thyroiditis**
- **Adrenomyeloneuropathy**
- **Type 1 Diabetes**
- **Type 2 Diabetes**

| | | |
|---|---|---|
| Growth Hormone (GH) | Bones, cartilage, muscle, fat, liver, heart. | Acts to promote growth of bones and organs |
| Thyroid gland | Thyroxine (T4) | Acts to regulate the body's metabolic rate (Not as active as T3) |
| | Triiodothyronine (T3) | Acts to regulate the body's metabolic rate (More biologically active than T4) |
| Insulin | Muscle, fat tissue | Acts to lower blood glucose levels by channelling glucose from the blood into the cells of the body. |
| Glucagon | Liver | Acts to raise blood glucose levels by releasing stored glucose (in the form of glycogen) from the liver |

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

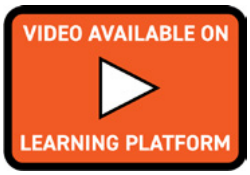
Catecholamines are derived from the amino acid tyrosine, which is derived from dietary sources as well as the synthesis of phenylalanine. Catecholamines are water-soluble and are 50%-bound to plasma proteins in circulation.

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

# Digestion

## *MODULE 6: UNDERSTANDING THE CARDIOVASCULAR SYSTEM AND DIGESTION AND THE HORMONAL AND METABOLIC EFFECT OF FOOD*

### Digestion




The digestive system can be best thought of as the body's food processing plant and is responsible for the digestion and absorption of the food we eat. The body is unable to use food in its unprocessed state and so the digestive system breaks foods down into substances the body can use.

| Macronutrient | End product |
|---|---|
| Carbohydrates | Glucose |
| Protein | Amino acids |
| Fats | Fatty acids, glycerol |

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

- **Lipase**
- **Amalayse**
- **Pepsin**

# The Digestive System

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

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

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

**Oesophagus:** the hollow tube which connects the mouth to the stomach.

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

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

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

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

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

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

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

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

## Definitions for Digestion

**Ingestion:** the taking in of food into the stomach.

**Propulsion:** the movement of food through the hollow tubes of the gastrointestinal tract.

**Digestion:** the breaking down of protein, carbohydrates and fats into smaller units.

**Absorption:** the movement of nutrients into the blood.

**Elimination:** the excretion of any waste products out of the body.

## The Outcome of Digested Food

**Blood:** carries simple sugars, amino acids, glycerol and some vitamins and salts to the liver.

**Liver:** stores, processes and delivers nutrients to the body when needed.

**Lymph system:** absorbs fatty acids and vitamins to fight infection.

**The body:** uses sugars, amino acids, fatty acids and glycerol as building blocks for energy growth and repair.

# The Passage of Food Through the Digestive System

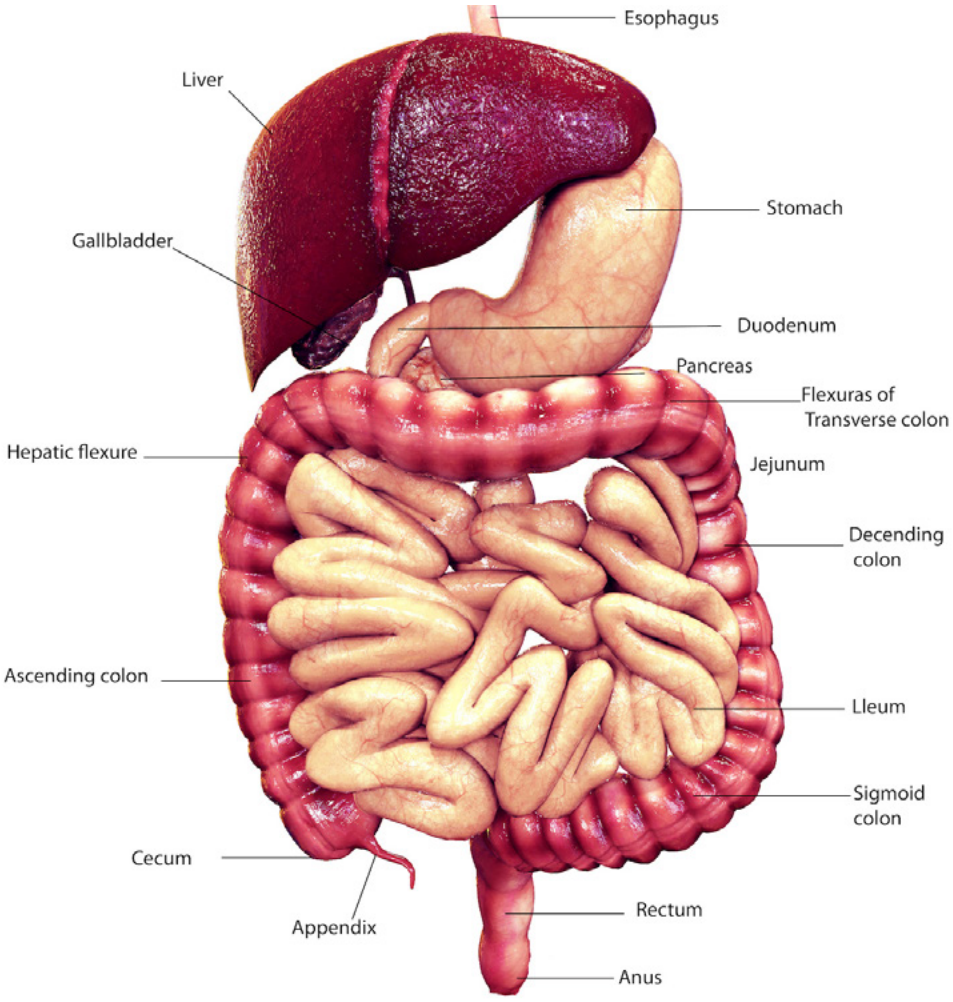
Just the thought of food triggers enzymes (substances that control chemical reactions) to be released and saliva to be produced in preparation for eating. Chewing breaks down food into smaller pieces, which makes it easier to swallow and digest. Saliva is produced by the salivary glands and lubricates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

After swallowing, food passes down the oesophagus and into the stomach. The movement of food through the hollow tubular organs of the digestive system is called peristalsis. Once in the stomach food is broken down into even smaller units and mixed into a liquid called 'chyme' and digestion is completed. When the chyme is ready, the stomach empties into the first part of the small intestine (long in length, but small in diameter) called the duodenum where absorption begins. Nutrients are extracted from the chyme by structures called 'villi' and absorbed into the blood for use in the body's cells.

Once the chyme has reached the end of the small intestine it passes into the large intestine (large in diameter but shorter in length) where water is absorbed and waste material formed into faeces ready for elimination from the body.

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

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



# Food Quality

## MODULE 6:
## UNDERSTANDING THE CARDIOVASCULAR SYSTEM AND DIGESTION AND THE HORMONAL AND METABOLIC EFFECT OF FOOD

Eating a balanced diet is one thing and managing intake quantities is another but another important factor that must be considered is the quality of food.

Beyond the refinement processes that often strip food of much its nutritional value, the farming, handling, manufacturing and preparation of food from seed to eating can adversely affect food quality.

Modern farming methods and even common cooking methods can have an adverse effect on the nutritional and therefore healthful qualities of the food we eat.

Consider the cycle of food quality described below:


Nutritionally, many seemingly healthy foods are considerably less nutritionally dense than they were as few as 50-years ago because of intensive farming methods, breeding to increase profitability, the routine use of artificial fertilizers, pesticides, herbicides and fungicides and antibiotics and growth hormones.

Thankfully, there is an alternative: Organic farming.

Organic farming began in the 1940s in response to the mass-food production methods that developed as a result of World War II and has, in the last few decades, become a very marketable force in the food industry.

Organic food producers are bound by strict legislation that helps ensure a higher level of farming which leads to more nutritionally-dense and therefore healthier food.

Several studies have demonstrated that food grown organically contains far more essential nutrients than traditionally-farmed foods but none of the harmful artificial substances used in regular farming.

**The soil association, the regulatory body governing organic food production, stipulates that organic food must:**

- **Contain minimal additives**
- **Use no pesticides, fungicides or herbicides in the production**
- **Contain no genetically modified ingredients**
- **Involve no non-essential or routine antibiotic treatment on animals**
- **Ensure animal welfare is paramount**


While it is irrefutably true that organic food is more nutritious than non-organic food, this health benefit comes at a price and unscrupulous food manufacturers often attempt to "dupe" unwary consumers into buying organic "junk food" by making them believe that anything organic must be healthy.

While organic fruit, meat, vegetables, nuts, seeds and grains are undoubtedly healthy, organic cookies, cakes, ice creams, sugary breakfast cereals or processed meals are still far from healthy and should be consumed in moderation if at all.