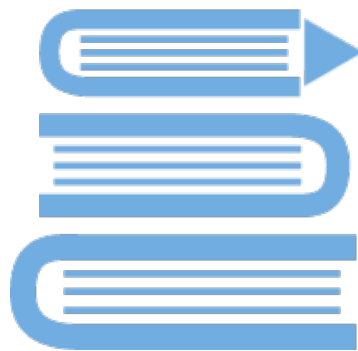


# **ExamLearn.ie**



## **Circulatory System**

# Circulatory System

3.2 Organisation and the Vascular Structures	Learning Outcomes	Can you? (G,O,R)
3.2.2 Organisational complexity of the human - Human Circulatory & Lymphatic Systems	<ol style="list-style-type: none"> <li>1. Understand what is meant by the term Closed Circulation System in humans</li> <li>2. Describe the structure and organisation of the human Closed Circulation System, i.e. strong muscular heart, arteries, arterioles, capillaries, venules, veins</li> <li>3. Identify the two circuits in the human system circulation system (1) pulmonary Circuit, (2) Systemic Circuit</li> <li>4. <b>Draw</b> and label the structure of the heart</li> <li>5. Mark the pathway of blood in a diagram of the heart and through the systemic and pulmonary circuits</li> <li>6. Explain the term Portal System and identify the Hepatic Portal Vein in a diagram</li> <li>7. Explain the role of muscles and valves in the heart and blood vessels</li> <li>8. Explain how the heart supplies blood to the heart wall through the Coronary arteries and Cardiac veins</li> <li>9. Understand and explain Pulse</li> <li>10. Understand and explain Blood Pressure</li> <li>11. Explain the effect of exercise on the circulation system</li> <li>12. Explain the effect of salt, fat and being overweight on the circulation system</li> <li>13. Give a simple explanation of the heart beat and how it is controlled (more detail in sec 3.2.4)</li> <li>14. Describe the structure of the Lymphatic System and describe three functions of the system</li> <li>15. State the four main parts in blood and give the function of each part (more detail for HL in sec 3.2.3)</li> <li>16. Name the four common blood groups and name the two rhesus blood types</li> </ol>	
3.2.3.H Blood Cells extended study	<ol style="list-style-type: none"> <li>1. Describe the structure of red blood cells in detail</li> <li>2. Describe the structure of white blood cells</li> <li>3. Classification of white blood cells as Lymphocytes or monocytes</li> </ol>	
3.2.4.H Heartbeat control	<ol style="list-style-type: none"> <li>1. Know the location of the Pacemaker (SA Node) ( sinoatrial node)</li> <li>2. Know the location of the Pacemaker (AV Node) ( atrioventricular node)</li> <li>3. Understand that the heart has specialised Cardiac Muscle</li> <li>4. Explain the stages in the cardiac Cycle</li> <li>5. Understand the terms Systole and Diastole</li> <li>6. Explain how the AV and SA nodes function in relation to the heart cycle</li> </ol>	

## Mandatory Experiments

- *Dissect and display and identify the dissected parts in a Sheep or Ox heart*
- *Investigate the effect of exercise on pulse rate (or breathing rate)*

## Need for a circulatory system

**Internal transport** in small animals is by diffusion and active transport e.g. amoeba, jellyfish and flatworms

whereas bigger and more complex animals e.g. humans need a vascular system.

**\*\*Open circulatory system** – blood leaves the blood vessels. **\*\* Blood is pumped into open-ended vessels.** The blood then passes into the body cavity where it bathes the cells. Later it goes back to the heart and enters via ostia e.g. insects, spiders, crabs, snails.

**Closed circulatory system** – blood is always enclosed in blood vessels. Tissue fluid bathes the cells and acts as a medium through which substances are exchanged between the blood and the cells e.g. earthworms and vertebrates. The closed circulatory systems are more efficient than open ones because:

- The blood can be pumped around the body faster and therefore exchange of food and oxygen is faster. This allows the animal to be more active.
- It allows the flow of blood to different organs to be increased or decreased.

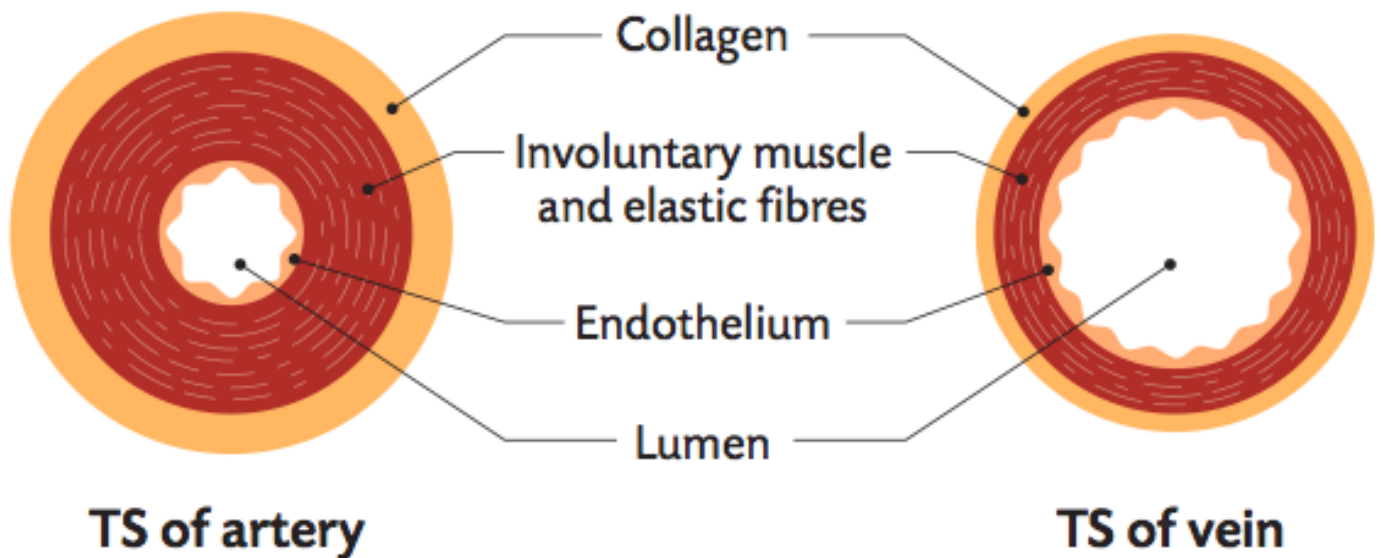
### Human Circulatory System

Double, closed circulatory system. Blood passes through heart twice for every complete circuit of body ('figure of eight'). A **pulmonary system** carries blood to the lungs where it becomes oxygenated and carries it back to the heart. The **systemic system** carries this oxygenated blood to the body and brings deoxygenated blood back to the heart. Advantages of this double system over a single one are (i) it separates the oxygenated from deoxygenated blood and (ii) it ensures that the blood pressure is high enough to reach all parts of the body (iii) allows a rapid and efficient delivery of nutrients.

A single-circulation system can only produce low blood pressure around most of the body. This restricts the activities of the animal e.g. earthworm and fish.

## BLOOD VESSELS

Diagrams of arteries, veins and capillaries



**Differences:**

	<b>Artery</b>	<b>Vein</b>	<b>Capillary</b>
<b>Lumen</b>	Small	Large	Tiny
<b>Wall</b>	Thick wall –outer layer of collagen(connective tissue) and inner layer of smooth muscle and elastic fibres.	Thin wall	1 cell thick (endothelium allows exchange* of materials between blood and cells)
<b>Valves</b>	None (as blood under pressure)	Present (prevent backflow)	None
<b>Direction of blood flow</b>	Transport blood away from heart.	Transport blood to heart.	Link arteries to veins
	Carries oxygenated blood (except pulmonary artery)	Carries deoxygenated blood (except pulmonary vein)	Oxygenated and deoxygenated.
<b>Blood flow</b>	Rapid flow under high pressure.	Slow flow under low pressure – assisted by squeezing action of nearby arteries and muscles.	Slow, pressure falling (allows time for exchange of substances to occur)
<b>Pulse</b>	Blood flows in pulses.	Blood flows at a steady rate.	No pulse.

**\*Exchange of materials facilitated by:**

1. Thin walls (rapid entry/exit of materials)
2. Large surface area/branching – in close contact with all body cells.
3. Narrow tubes – pressure increases, causing leakage of plasma.

**Blood flow in arteries is helped by:**

1. A thick muscle layer – this contracts and pushes blood on
2. Elastic fibres – can expand and recoil to push blood on. Collagen layer prevents over-expansion.

**Relationship between blood vessels:**

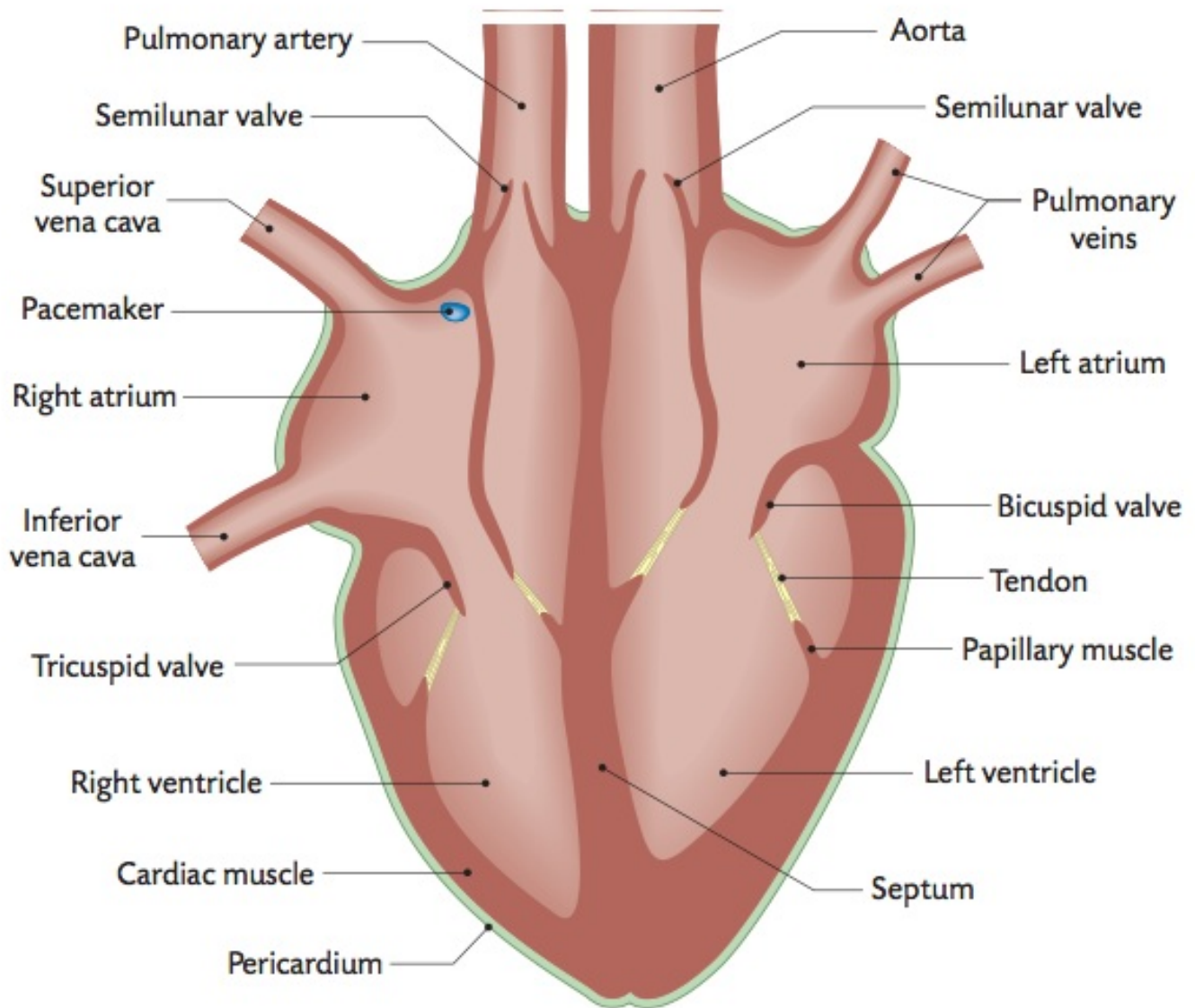
Artery – arteriole – capillary – venule – vein

**Heart**

The heart is located in the thoracic cavity - between the lungs, slightly to the left, above the diaphragm and behind the sternum. It is surrounded by the pericardium. This double membrane is filled with fluid, which allows friction-free movement when the heart is beating.

Diagram - Internal structure of heart:

(and blood flow)



- Atrial walls are thinner than those of the ventricles because they only have to pump blood down into the ventricles. The left ventricle is much thicker than the right ventricle because it pumps blood to the entire body.
- Valves are held in place by tendons ('heart strings'), which are attached to the ventricle wall by projections called papillary muscles. Valves prevent backflow of blood.
- Septum divides heart right and left. It separates oxygenated and deoxygenated blood.
- Cardiac muscle has its own **coronary arteries and veins**. Coronary arteries branch from aorta and coronary veins return blood to right atrium via vena cava. Coronary arteries carry oxygen and food to the heart muscle.

A **portal system** is a blood supply that flows from one organ directly to another organ without passing through the heart

- e.g. hepatic portal vein brings blood (rich in digested food but lacking in oxygen) from the intestine directly to the liver. Portal systems begin and end with capillaries.

## Pulse:

A pulse is caused by the expansion and contraction of an artery as blood is forced through it. When the left ventricle contracts, the pressure of the blood forced into the aorta causes the aorta to expand.

Feel pulse easily in neck or wrist.

Average adult pulse (heart) rate = 72 beats per min. Range: 60-100.

Varicose veins can occur when valves are not working properly allowing the blood to pool. Most often seen in older people - can be painful and can become infected.

**Blood pressure** is the force exerted by the blood on the walls of the arteries due to the contracting of the heart.

It depends on the volume of blood within the system and the space available within the blood vessels

Blood pressure is measured in an artery of the upper arm using a sphygmomanometer. An inflatable cuff is used to measure the pressure required to stop the blood flow at this point. Two pressures are measured: systolic and diastolic pressures of the ventricles (120/80 mm Hg - for a healthy adult). These values normally rise with age. If the lower of the two is above 95 the person is suffering from high blood pressure (hypertension). High blood pressure is often caused by blockages in arterioles or small arteries.

**Atherosclerosis** - hardening/narrowing of blood vessels.

- This is caused by excess cholesterol forming fatty deposits under the inner lining of an artery. An atheroma (raised lump of fatty deposits) in the artery will raise a patient's blood pressure and soon lead to the development of a blood clot (embolus).
- This clot will block the artery completely or break away and block some other smaller blood vessel. This is called thrombosis. This could lead to a **stroke**, if the blood supply to the brain is impaired. **Blockage** in one of the coronary arteries may cause pain (angina). This may lead to a **heart attack**.

## Effects of exercise, diet and smoking on the circulatory system.

### 1. Exercise

Exercise strengthens the heart and improves blood circulation. Aerobic exercises (high oxygen intake over a long period of time) are most beneficial e.g. walking, running, swimming, cycling. Exercise helps to lower blood pressure.

### 2. Diet

- Large amounts of saturated (animal) **fat** raises cholesterol levels and increases risk of heart disease.
- High **salt** intake raises blood pressure. High salt levels mean more water is taken in, increasing blood volume causing blood pressure to rise. Patients with high blood pressure are often given diuretics to decrease blood volume and therefore blood pressure.
- **Obesity** causes high blood pressure and heart attacks.

### 3. Smoking

- **Nicotine** stimulates adrenalin which increases heart rate and blood pressure thus increasing the workload of the heart. This may result in arrhythmia (extra heartbeats).
- **Carbon monoxide** destroys the oxygen-carrying ability of red blood corpuscles. This results in lower energy production by the body.
- Other chemicals in tobacco increase the likelihood of blood clots in blood vessels.

### Treatments for heart disease:

- No smoking and exercise more
- Eat fewer animal fats
- Coronary bypass surgery - coronary vessels are bypassed with blood vessels taken from leg.

## CARDIAC CYCLE -

The sequence of events which take place during the completion of one heartbeat.

Contraction of the heart is known as **systole** and relaxation of the heart (when the heart is filling with blood) is called **diastole**.

### 1. Blood enters the heart.

The atria and ventricles are both relaxed (diastole). Blood enters the atria. All valves are closed.

### 2. Blood is pumped from atria to ventricles.

Electrical impulses from the pacemaker (SA node) cause the atria to contract (atrial systole). This pumps blood to the ventricles. The tricuspid and bicuspid valves open. The venae cavae and pulmonary veins close to stop blood entering the atria. The semi-lunar valves remain closed.

### 3. Blood leaves the heart.

The atria relax and impulses from the AV node cause the ventricles to contract (ventricular systole). This forces blood out of the heart into the pulmonary artery and the aorta.

The pressure forces open the semilunar valves and closes the cuspid valves (making the 'lub' sound).

The ventricles now relax again. Closing of the semi-lunar valves prevents blood flowing back into the ventricles. This closure causes the 'dub' sound. The cycle now repeats itself - about 70 times per minute for an adult at rest.

- Heart sounds are due to the closing of the valves - "lub dub" phonetically.
- 'lub' = low-pitched, quieter, long-lasting sound. 'hub' = higher-pitched, louder, shorter sound.
- A heart murmur is any abnormal sound associated with the heart. It may indicate damage to one or more of the valves.

### Control of heartbeat.

- Contraction of the heart is preceded by a wave of electrical excitation. It is triggered off by a special node of heart muscle: the sino-atrial node or **pacemaker**, located in the right atrium.
- When impulses through the nerves stimulate the pacemaker a wave of contraction spreads over the two atria. When the wave reaches the junction between the atria and ventricle, it excites **AVN**. The AV node then sends the electrical impulses down the septum. The impulse is passed out to the walls of the ventricles by thin fibres. The impulses from these fibres cause the ventricles to contract.

If electrodes are placed on the heart they can measure the electrical activity of the heart. A record of this activity is called an ECG (electrocardiogram).

While heartbeat is usually controlled by the pacemaker, it can be altered by nervous stimulation from the brain or by hormones.

Patients with heartbeat irregularities use artificial battery-powered pacemakers to regulate the heart beat.

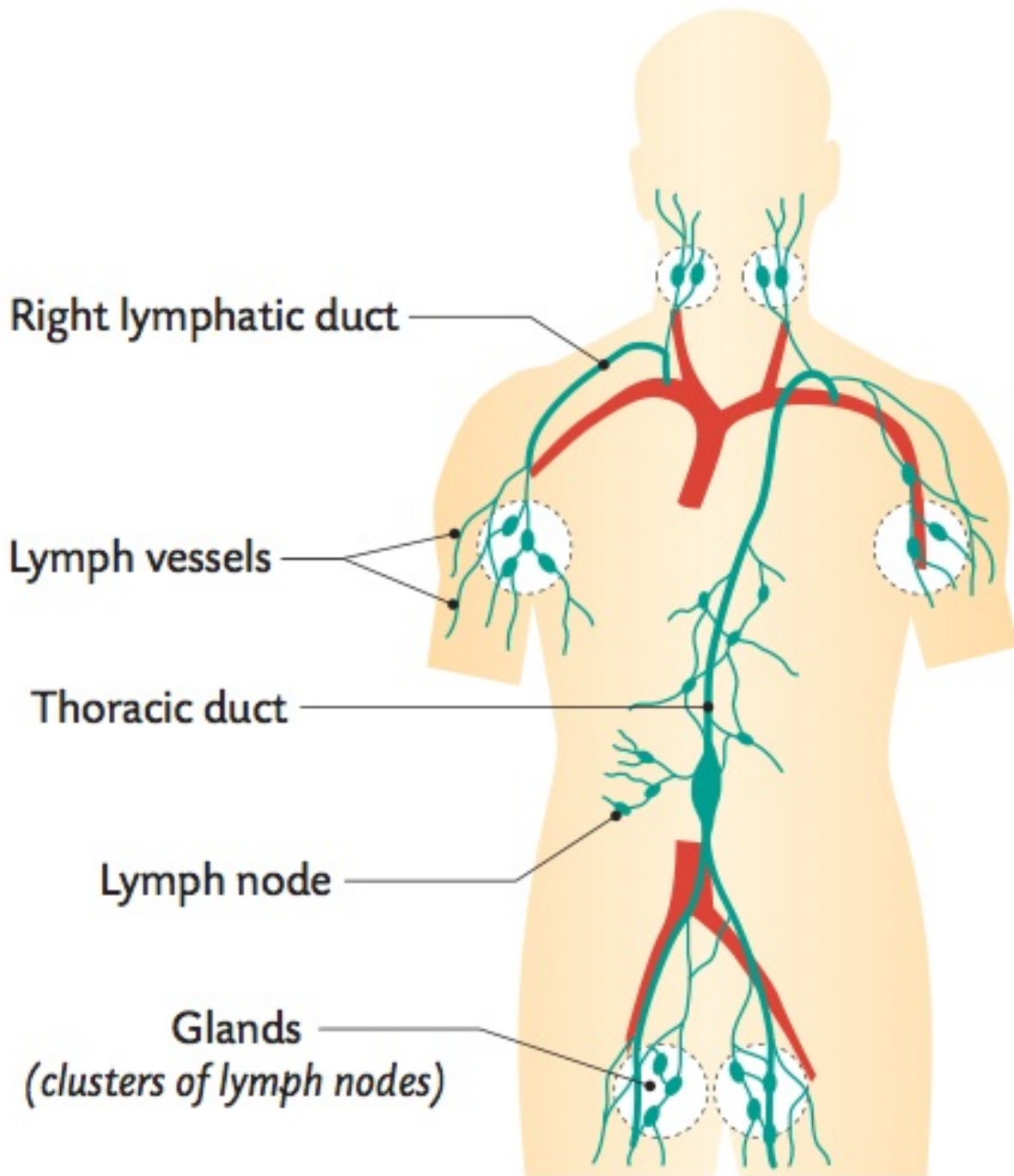
Factors that increase the rate of heartbeat include exercise, temperature, emotions and shock. Factors that decrease it are relaxation, sleep and alcohol.

## Lymphatic system

A secondary transport system that returns excess tissue fluid to the blood circulatory system.

Consists of lymph, lymph vessels, lymph nodes, spleen, tonsils, adenoids, lacteals and thymus.

Diagram of lymphatic system -



**Tissue fluid** - liquid that is forced out of the capillary arterioles (due to high blood pressure). Contains no RBC and no plasma proteins.

**Lymph** = a clear, tissue fluid with lymphocytes, protein and lipids.

The cells take up the nutrients and oxygen from and excrete their waste (carbon dioxide, urea) into the tissue fluid. Most of the tissue (intercellular) fluid reenters the capillaries (venules) by osmosis. Approx. 1-2% is returned in separate vessels called lymphatics .

Valves ensure that the lymph flows in one direction only. Muscles squeeze the lymph through the tubes. The lymph capillaries, which unite to form two main vessels, right lymphatic duct (which drains upper right side of body) and the thoracic duct (which drains rest of body and returns the fluid to the blood in the subclavian veins).

**Lymph nodes** are swellings, found especially in groin and armpits.

**Functions of lymphatic system:**

### 1. Drainage

To **collect excess tissue fluid** from intercellular spaces and return it to the blood (keeping the volume of the blood constant).



## 2. Defend against infection

- Filters out germs and then phagocytes engulf and destroy them.
- Stores **lymphocytes** , which produce antibodies.

## 3. Transport

To absorb and transport **fatty acids and glycerol** via lacteals from the small intestine to skin or other organs for storage.

To transport hormones from endocrine glands into bloodstream.

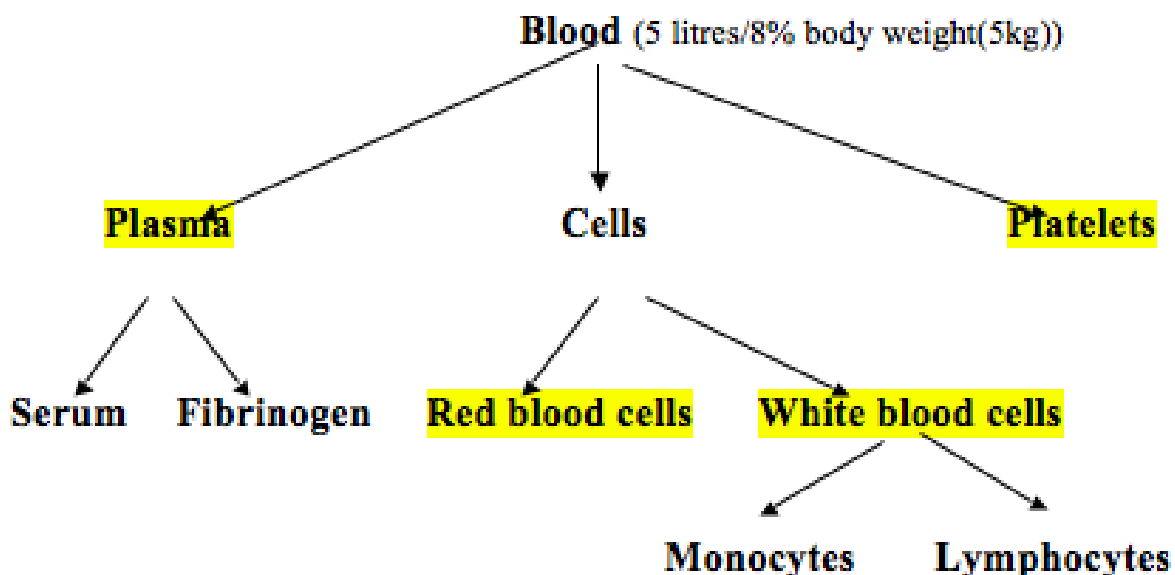
4. To help hearing and balance by carrying vibrations in the inner ear.

Lymphatic system	Blood system
Open circulatory system	Closed <u>c.s.</u>
No pump	Heart
No RBCs and proteins	Has both
Colourless fluid	Red
Nodes	None

**Oedema** is the swelling of the body (usually lower legs and feet) due to too much tissue fluid. It may be due to a failing circulation system or an unusual blood composition (too much water and salt or too little protein) due to a kidney complaint.

**Elephantiasis** is due to eggs from a parasitic roundworm getting in by mosquito bites. The young worms grow and block the lymph vessels giving an elephantiasis appearance of limbs. Treatment is by removal of worm, drainage of fluid and surgical repair of damaged vessels if necessary.

## Composition of blood tissue:



**PLASMA** is a straw-yellow liquid, pH of about 7.4, containing:

90 % water, 10% dissolved substances

- proteins e.g. antibodies, hormones, fibrinogen
- nutrients e.g. amino acids, glucose, vitamins and minerals
- gases e.g. oxygen and carbon dioxide
- wastes e.g. urea.

**Function:**

(a) **Transport** medium for **blood cells** and **dissolved substances**.

(b) **Transport heat** from organs such as liver. Helps to maintain a constant body temperature

**Serum** is plasma minus fibrinogen. It is sometimes used in injections to give someone resistance to disease (contains antibodies).

**RED BLOOD CELLS** – aka erythrocytes (5 million per mm<sup>3</sup>)

Biconcave discs, 7-8µm in diameter, elastic membrane. Contain haemoglobin (red pigment made from protein), no mitochondria (can therefore transport oxygen). Life span = about 4 months (no nuclei). Made in red bone marrow of e.g. ribs, vertebrae, femur.

Dead red blood cells are broken down in the liver. The iron is stored in liver and recycled to make haemoglobin and the pigments bilirubin & biliverdin form bile.

**Function:**

**Transport of oxygen** (haemoglobin + oxygen = oxyhaemoglobin).

**Anaemia** results from a lack of haemoglobin (or RBCs). The person lacks energy and can look pale. Causes are menstruation and lack of iron in diet. Iron-rich foods = red meat, liver, kidneys, chicken, eggs, sardines, nuts, prunes, apricots, bananas and green veg.

**WHITE BLOOD CELLS** aka leucocytes ≈ 8000/mm<sup>3</sup>

Larger flattened discs, have no definite shape. Made in red bone marrow.

**Function** : defence against disease.

Two types are:

- **Monocytes** - comprise 5%WBC \*\*. \*\* Size15-20µm. Nucleus (kidney-shaped). Life span: 6-9 days.

**Function** : They engulf foreign matter by phagocytosis. Some, called macrophages, can leave blood vessels and engulf damaged/dead cells as well as antigens in the tissues.

- **Lymphocytes** - comprise 25% of WBC. Size 8-10µm. Large, round nucleus. Some mature and all are stored in the lymphatic system. Life span: 3months – 10 years.

**Function:** Produce **antibodies** to fight disease. This inactivates and immobilises the pathogen.

## Leukaemia

Is a form of cancer in which white blood cells are produced too rapidly and are immature. Cause is unknown but often linked to radiation exposure. They crowd out other blood cells and may cause anaemia, increased risk of infection and reduced ability to clot blood. Treatment is by drugs and radiation.

**PLATELETS** – aka thrombocytes (300,000/mm<sup>3</sup>) 2µm

Tiny fragments of cells. No definite shape and no nuclei. Made in bone marrow. Live for about a week.

**Function:**

- Blood clotting (prevents blood loss and entry of pathogens)

**Deep vein thrombosis (DVT)** – blood clot deep in vein, usually in leg. Can lead to pulmonary embolism which can be life threatening.

	<b>Red blood cells</b>	<b>White blood cells</b>	<b>Platelets</b>
<b>Shape</b>			
<b>Size</b>			
<b>Nucleus</b>			
<b>Frequency</b>			
<b>Function</b>			
<b>Site of production</b>			

## Blood clotting:

When a blood vessel is cut:

1. The vessel narrows to reduce blood flow.
2. Platelets stick to the damaged cells to form a temporary clot.
3. A permanent clot is made when fibrin forms a mesh of strands at the site of the damaged cells. Blood cells are trapped in the mesh and later it hardens as a scab.

Blood clotting prevents further loss of blood and the entry of pathogenic micro-organisms.

In **haemophilia**, the platelets cannot make one of the clotting chemicals (usually factor VII) and so their blood will not clot easily if they cut themselves. They get regular injections of factor VII. Also their blood vessels are inclined to leak or burst under skin, leading to painful swelling, particularly in joints.

**Thrombosis** - a blood clot forms inside a blood vessel and may block it e.g. stroke or heart attack.

## Blood Groups - ABO system:

Two antigens, A and B, can be present on the surface of red blood cells.

<b>Blood group</b>	<b>O</b>	<b>A</b>	<b>B</b>	<b>AB</b>
<b>Antigens</b>	Neither	A	B	A and B
<b>Antibodies (in plasma)</b>	A and B	B	A	neither
<b>Occurrence (Ireland)</b>	55%	31%	11%	3%

The immune system will not produce antibodies against its own antigens but will produce antibodies against the other antigens. When blood transfusions are given it is important that the recipient's blood matches that of the donor. If bloods are not the same clumping of donor's RBCs occurs. This may block a blood vessel with fatal consequences. In addition, haemoglobin leaks from the agglutinated cells and may eventually cause kidney failure.

**Universal donor** = Blood group O (no antigens). Can be given to all other groups.

**Universal recipient** = Blood group AB (no antibodies)

## Rhesus factor:

Rhesus<sup>+</sup> or Rhesus<sup>-</sup>

Grouping is determined by the presence or absence of a rhesus protein (first discovered in rhesus monkeys and then in humans).

- In Ireland about 85 % are rhesus positive and 15% rhesus negative. Important in prenatal life.
- The mother will recognise these rhesus antigens as 'foreign' and produce antibodies against them. Usually there is no danger to the baby during the first pregnancy, though the mother is now sensitised to rhesus antigen.
- These antibodies will destroy the baby's red blood cells in subsequent Rh<sup>+</sup> babies because antibodies pass into baby. This may cause the baby to be anaemic, brain damaged or stillborn. To prevent this happening the mother may be injected with Rh antibodies immediately after birth of first child. These will destroy the baby's RBC before they cause a natural build-up of anti Rh antibodies in her blood.