Transport in animals

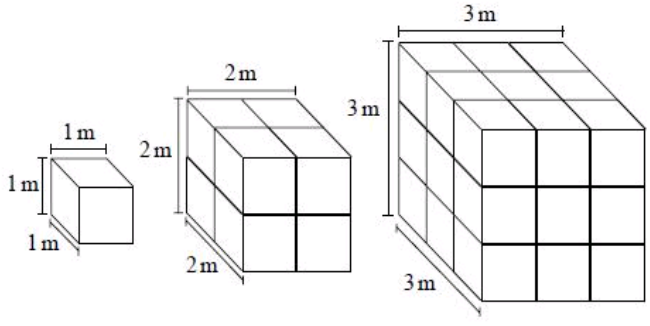
Transport refers to the movement of materials from one part of the organism to another.

Requirements of transport system

1. **Materials to be transported:**
   In animals, they include respiratory gases oxygen and carbon dioxide, nitrogenous excretory products e.g. uric acid, nutrients e.g. glucose, amino acid, etc. In plants, they include oxygen and carbon dioxide.
2. **The medium of transport:**
   The medium of transport in plants and lower animals is water and it is blood in vertebrates and in a few invertebrates like arthropods, annelids (earth worm).
3. **The channels of transport:**
   In most animals, these are blood vessels, in others like earth worms, it is the body cavity (coelom). In higher plants, there is a vascular system or system of xylem and phloem.
4. **Energy:**
   Circulation of blood in animals requires energy supplied from respiration used in pumping of the heart and muscle contractions.

Surface area to volume ratio

A large organism like a mammal which has a low surface area to volume ratio has problems with transport compared to smaller organisms like protozoa. This is because of the large distance over which materials have to cross. The **surface area** to the **volume ratio** gets smaller as the organism gets larger.



surface area	$6m^2$	$24m^2$	$54m^2$
volume	$1m^3$	$8m^3$	$27m^3$
surface area: volume	6:1	3:1	2:1

THE MAMMALIAN HEART

Its function is to pump blood around the body.
The heart is made of tissues called cardiac muscles which have the potential to contract rapidly.
It's divided in to four chambers.
The upper chambers are called atrium / auricle and the lower chambers are each called ventricle.
The heart is divided in to sections i.e. left and right by a muscular septum whose function is to prevent mixing of oxygenated and deoxygenated blood
Movement of blood in the heart is maintained in a single direction i.e. from the auricle to ventricle and then to blood vessels.
Blood flow in one direction in the heart is maintained by the presence of valves.
The auricles receive blood from all parts of the body while the ventricles pump blood to the body e.g. the left atrium receives oxygenated blood from the pulmonary vein and pump it to the left ventricle through the bicuspid valve.
The right atrium receives deoxygenated blood from the rest of the body from the vena cava and pumps it to the right ventricle via the tricuspid valve.
The ventricle walls are more muscular (have thicker walls) than those or the auricles because the auricle pump blood to shorter distance i.e. to the ventricle while the ventricles pump blood longer distances i.e. to body and lungs.
The walls of the left ventricle that pump blood in to the systemic circulation are thicker than those of the right ventricle which pump blood to pulmonary circulation.

Flow of blood through the heart:

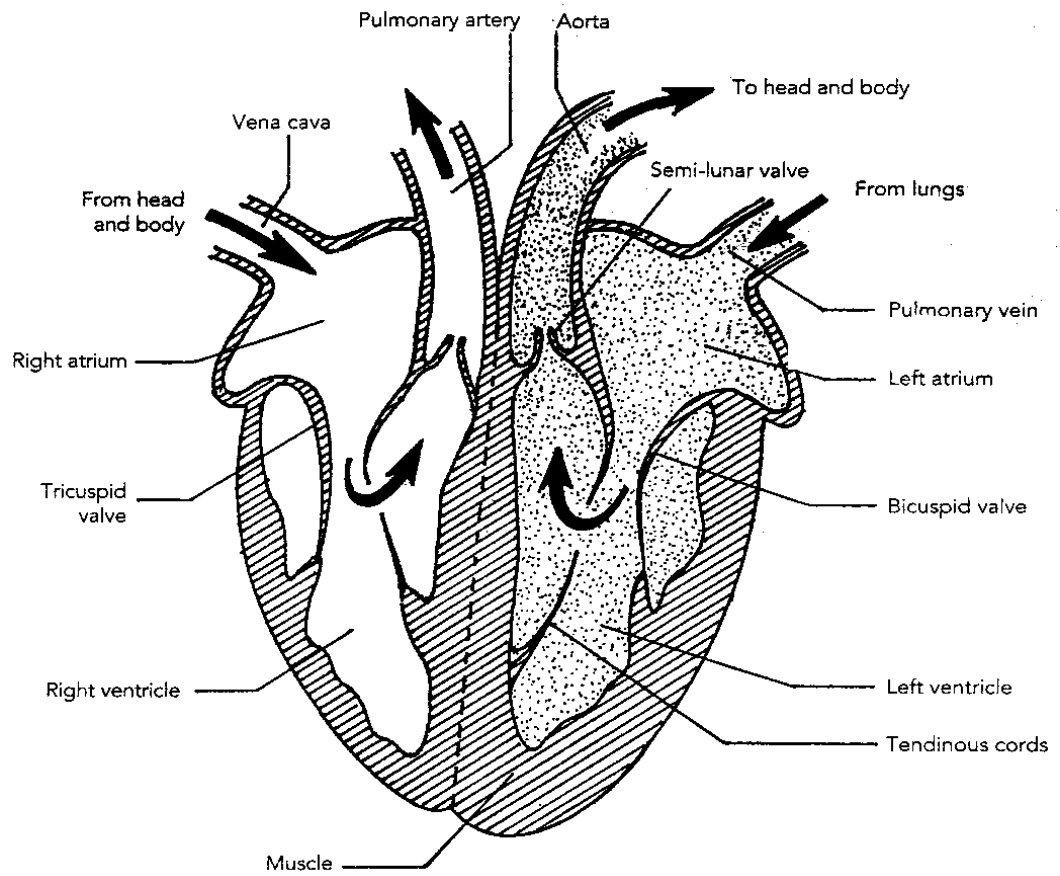
(a) Deoxygenated blood from different parts of the body flows into the heart along the vena cavae. These pour the blood into the right atrium.

(b) This blood passes then to the right ventricle. It is sent to the lungs through the right ventricle. It is sent to the lungs through the pulmonary artery.

(c) Oxygenated blood from the lung returns to the left atrium along the pulmonary veins.

(d) This blood then passes into the left ventricle.

(e) The blood leaves the heart through the aorta to be distributed around the body.



Blood vessels

Blood vessels are tubes, which carry the blood around the body.

There are different types of blood vessels. These include; Arteries, Arterioles, Capillaries, Venules and and veins

- **Arteries** carry blood away from the heart.
- The main artery is the aorta which divide into a numbers of main branches called arteries.
- Arteries branch into smaller vessels called **arterioles.**
- Arterioles split up into tiny blood vessels called capillaries which supply with the entire body tissues with blood. It is from these cappilaries that movement of substances to & from the blood takes place. Capillaries join

together to form larger vessels called venules which join together to form veins. Veins carry blood towards the heart.

- There is a tendency of blood not moving forward due to reduced pressure within veins. The valves within veins stop the flow back of so that its forced in one direction to the heart. Valves open to allow blood flow to next point of the vein and close it. reverses its direction

Illustration of blood vessel network in mammalian body

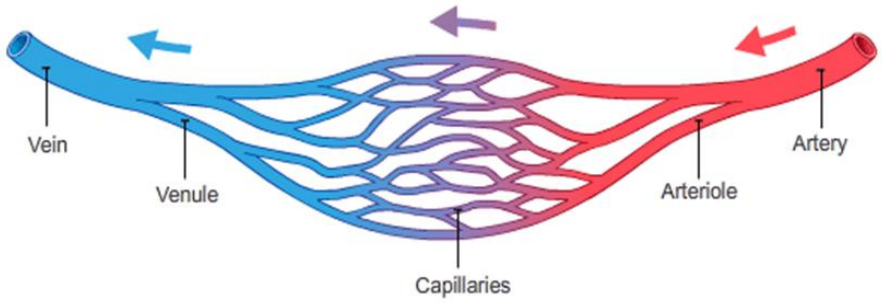
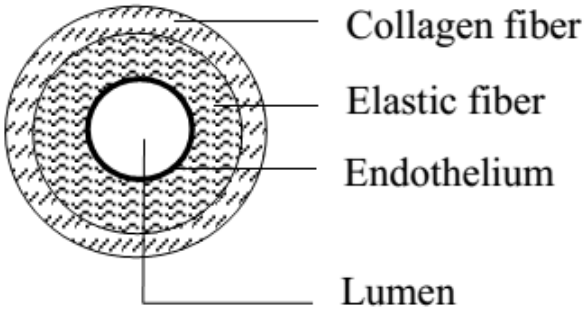
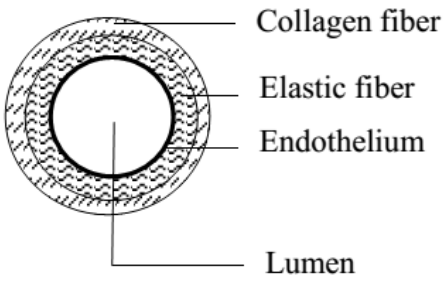


Diagram of an Artery **vein**





Differences between veins and arteries

Veins	**Arteries**
Blood travels to heart	Blood travels away from heart
They have a large lumen relative to their diameter	They a narrower Lumen than veins
They possess thin wall with few elastic fibres	Thick wall with lots of elastic fibres
They have thin muscular walls	They thick muscular layer

Valves present along their entire length to prevent blood back flow	They have no valves except at the bases of aorta and pulmonary artery
Blood travels constantly and there are no pulses	Blood travels in pulses
Carry blood under low pressure	Carry blood under high pressure
Blood moves slowly	Blood moves rapidly
They are not capable of constriction	They are capable of constriction
They transport deoxygenated blood from body tissues to the heart except the pulmonary vein which transports oxygenated blood from the lungs to the heart	They transport oxygenated blood from the heart to the body tissues except the pulmonary artery which transports deoxygenated blood from the heart to the lungs

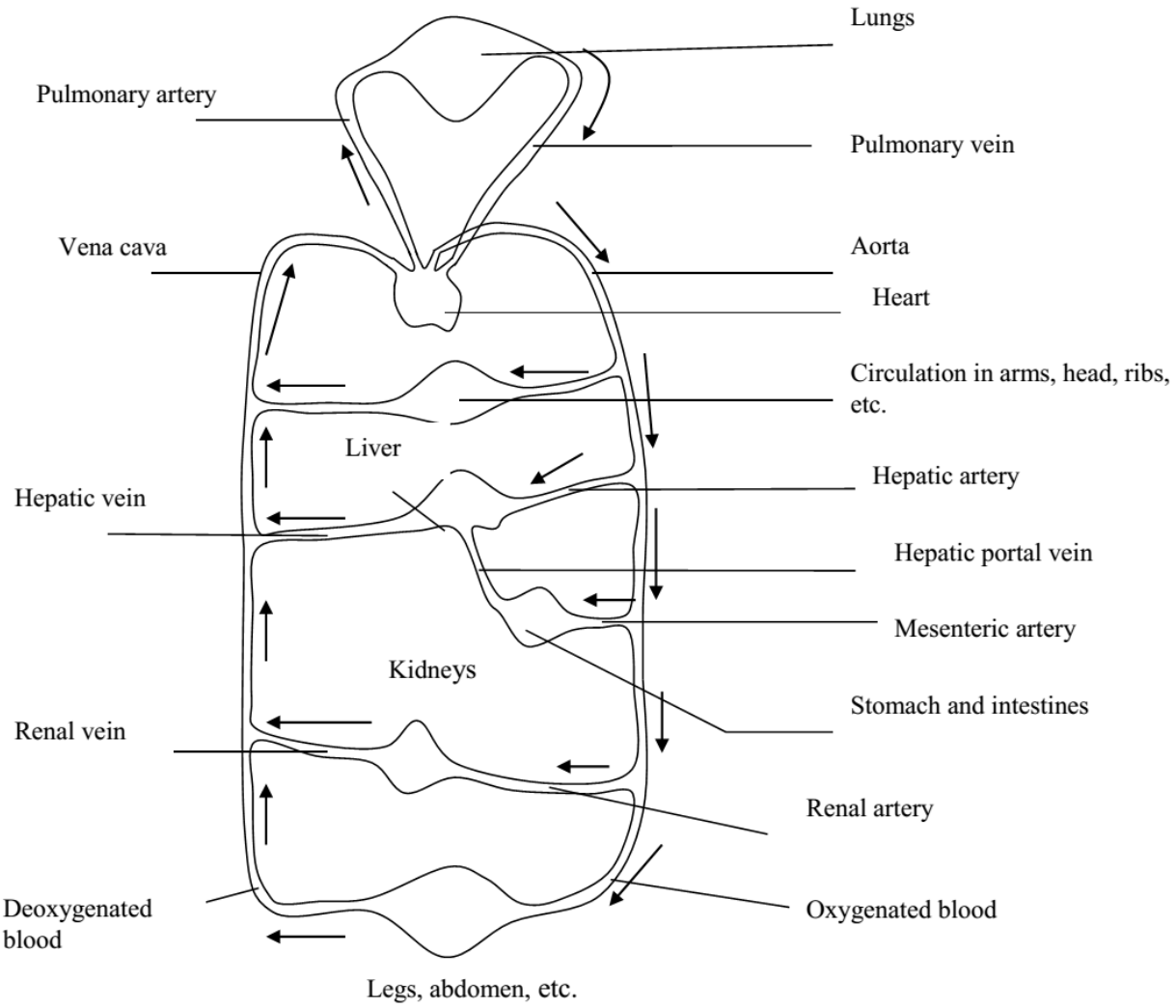
Characteristics of capillaries;

- They are tiny, very thin walled and penetrate deep into every organ
- They are permeable and some blood components and other materials leak through them
- The exchange of materials between blood and tissues take place through their walls
- They do not have muscular walls
- They do not have an elastic tissue
- They have a very large lumen in relative to their diameter
- They are not capable of constriction
- They link arteries to veins through arterioles and venules
- Blood flows slowly and there are no pulses
- They do not have valves

Similarities between Veins, arteries and capillaries

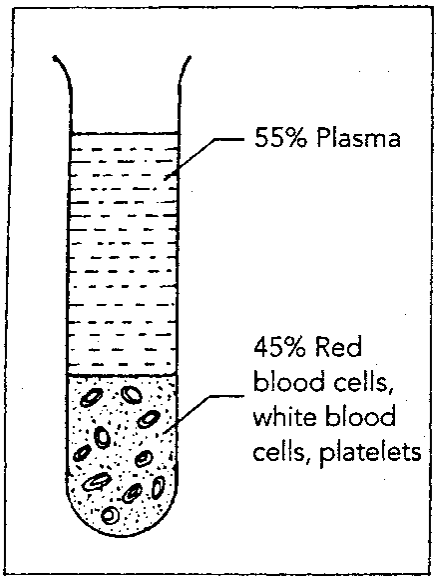
- All are tubular
- All have endothelium/in lining
- All transport blood

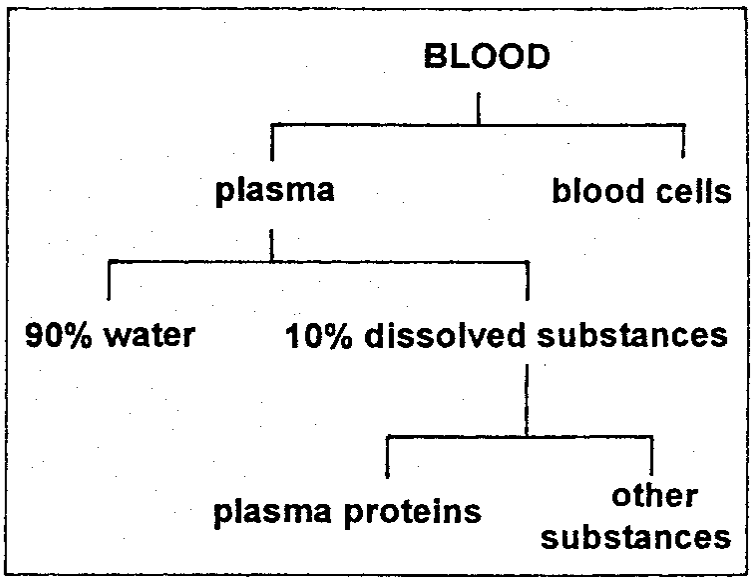
Diagram illustrating the arteries and veins which transport blood to the different organs of the body



Blood

Blood is a fluid in which are found blood cells and cell fragments called platelets. The blood cells and platelets make up for about 45% of blood volume and the plasma about 55%





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Composition of Plasma

PLASMA

Plasma is a yellow liquid containing:

- mineral salts
- blood proteins
- glucose
- amino acids
- fats
- waste products such as urea.

Among the blood proteins there is a substance known as fibrinogen that plays an important role in the clotting of blood.

RED BLOOD CELLS OR RED CORPUSCLES

In humans, there are about five million red blood cells per cubic millimetre of blood. each one of these cells is a flat biconcave disc and is able to

squeeze through small blood vessels by changing its shape. Red blood cells have no nucleus and they contain a reddish pigment called haemoglobin.

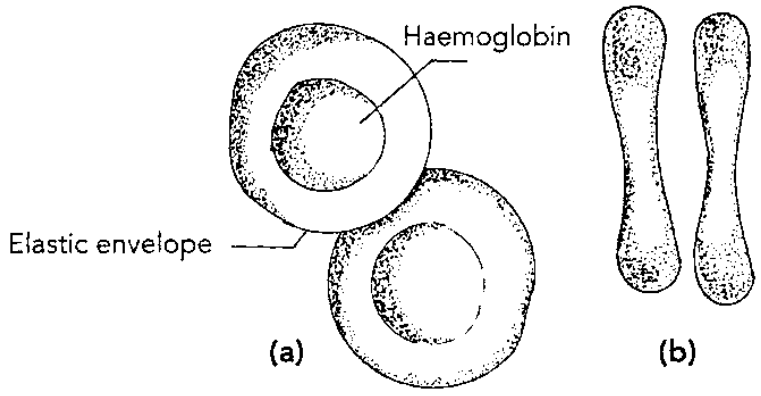


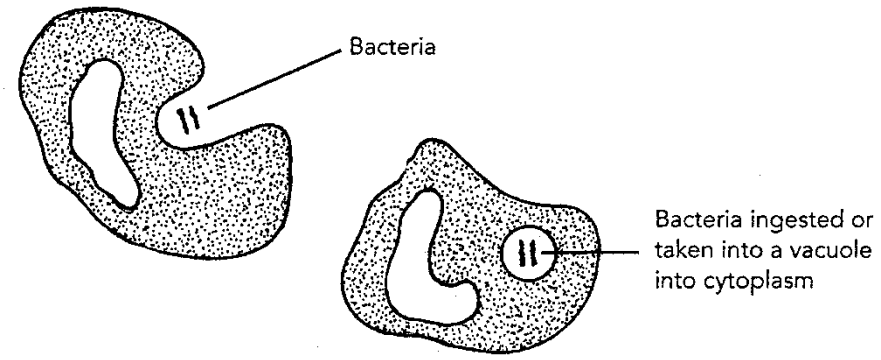
Diagram of Red Blood Cells (a) Front View, (b) Side View

Function: *They carry oxygen and carbon dioxide around the body*

WHITE BLOOD CELLS OR LEUCOCYTES

Leucocytes are much less numerous than red blood cells, the ratio is 1:600. While blood cells are much larger than the red ones. They are colourless. Most of them are irregular in shape and they all possess a nucleus.

Function: *They kill germs getting into the body*



Question: Describe four ways by which antibodies attack disease causing germs

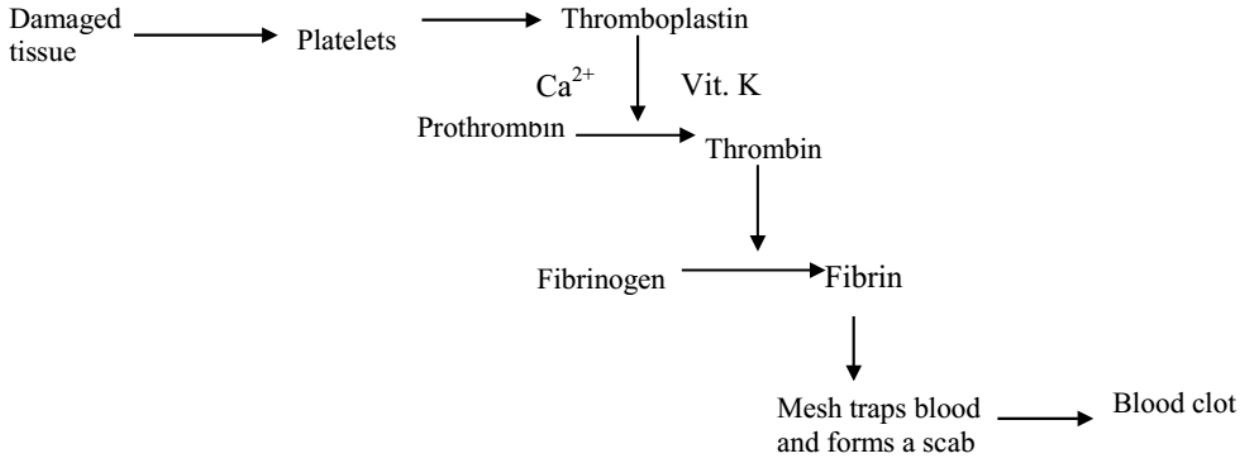
PLATELETS

These are small fragments of cells about one quarter of the size of a white blood cell. Their number is about 250,000 per cubic millimetre of blood.

Function: *They assist in blood clotting*

The Process of Blood Clotting:

When blood is exposed to air as a result of a cut or wound, the platelets in the blood at the damaged tissue stimulate the release of a chemical called **Thromboplastin (thrombokinase)**. In the presence of **calcium ions** and **vitamin K**, **thromboplastin** stimulates the conversion of **prothrombin** to thrombin enzyme. **Thrombin** then catalyzes the conversion of soluble blood protein **fibrinogen** to the insoluble form **fibrin.** Fibrin forms fibers, which form a mesh and trap blood cells and proteins. This mesh dries to form a scab, which is called the blood clot.



Functions of Blood

Blood has many different functions, including:

- transporting oxygen and nutrients to the lungs and tissues
- forming blood clots to prevent excess blood loss
- carrying cells and antibodies that fight infection
- bringing waste products to the kidneys which filter and clean the blood
- regulating body temperature

HOW THE RED CELLS CARRY OXYGEN

Red cells are the body's oxygen carriers. They carry oxygen from the lungs to all the cells of the body.

Carriage of Oxygen by Blood

1. The red cells pick up oxygen as blood passes through the lungs.
2. The oxygen and haemoglobin join to form oxyhaemoglobin. This is bright red.
3. As the blood passes around the body, the haemoglobin breaks down and releases oxygen to the body cells.
4. The red cells return to the lungs for more oxygen.

The table below summarises the other materials carried by the blood.

What it carries	How carried
1. Carbon dioxide from the body to the lungs.	Mainly in plasma (as sodium bicarbonate).
2. Digested food from the gut to the Liver and thereafter to the rest of the body.	In the plasma.
3. Wastes from the liver to the kidneys.	In the plasma.
4. Hormones from glands producing Them to wherever they are needed.	In the plasma.
5. Heat from liver and muscles to the rest of the body so that the temperature of the body is kept Uniform.	Blood.

Protective Function of Blood

White blood cells called phagocytes ingest bacteria. Another type of white blood cells called lymphocytes make chemicals called antibodies. These chemicals destroy bacteria that get into the body by making them stick together or by dissolving them. They also destroy toxins (poisons) produced by the bacteria. There is a different antibody for each kind of bacterium

BLOOD GROUPS

There are 4 main blood groups i.e. A, B, AB, and O

When one has got less blood than necessary, blood transfusion is carried out. The one who gives blood to a patient is called a **donor** and the one receiving is known as a **recipient**. Doctors have to match the blood of the donor to that of the recipient because when incompatibles blood is mixed, the red blood cells stick together (agglutinate) and blood clots. This is a fatal situation and will lead to death.

Agglutination is caused by the presence of proteins called **antigens** on the surface of cells being mixed with specific **antibodies**, which work against them.

Blood groups are determined by the type of antigens one has in blood. This means that one having antigen ***A*** belongs to blood group ***A.*** Those with antigen ***B*** belong to blood group B. Those with antigens ***A*** and ***B*** belong to blood group ***AB*** while those without antigens belong to blood group ***O.***

Each blood produces particular antibodies, which work against particular antigens when introduced into the body. For example, blood group ***A*** produces antibody b. This means that blood group ***A*** is anti (against) blood containing antigen ***B*** (blood group ***B***).

The table below shows the blood groups, the antigens they carry and the antibodies they produce

. **Blood group**	**Antigen present**	**Antibody produced**
A	A	b
B	B	a
AB	A and B	None
O	No antigen	a and b

Table of compatibility

Recipient

Donor	A	B	AB	O
A	√	X	√	X
B	X	√	√	X
AB	X	X	√	X
O	√	√	√	√

Key

X --------- Incompatible

√ --------- Compatible

IMMUNITY AND THE IMMUNE SYSTEM

Immunity is the ability of an organism to resist infection. The immune response is based upon recognition of a foreign particle and the release of chemicals that destroy it. The foreign particle may be an antigen, bacteria, virus or any other pathogen. The substance that destroys these particles can be a white blood cell or antibodies produced by white blood cells.

Types of immunity Active (Antibodies made by the human immune system, long term acting due to memory cells)

	Passive (Given-Antibodies, short term acting)	
Natural	- Response to disease - Rejecting transplant	- Acquired antibodies (via placenta, breast milk)
Artificial (immunization)	- Vaccination (Injection of the antigen in a weakened form)	- Injection of antibodies from an artificial source, e.g. anti-venom against snake bite
Differences	- Antibody in response to antigen - Production of memory cells - Long lasting	- Antibodies provided - No memory cells - Short lasting