

DR MOHMED ELFAR

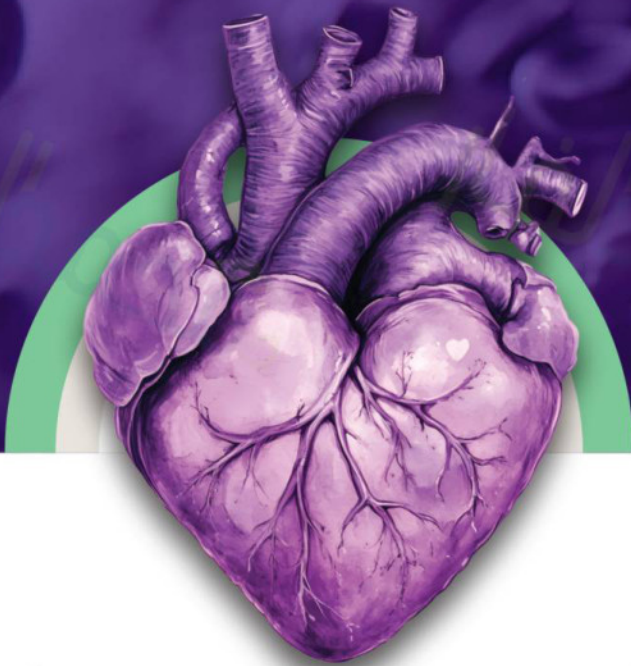
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ALFAR BIOLOGY

BLOOD & CIRCULATORY SYSTEM



BLOOD

CIRCULATORY SYSTEM

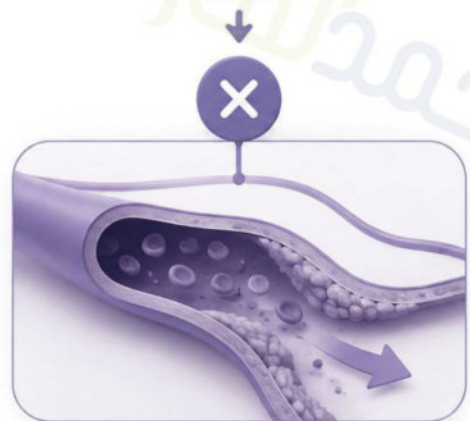
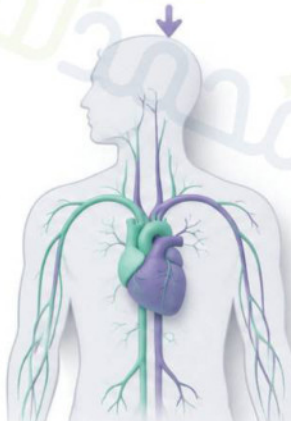
BLOOD & CIRCULATORY SYSTEM

- 1 BLOOD
- 2 VESSELS
- 3 HEART
- 4 DISEASES
- 5 SHOCK

Heart = pump

Blood vessels = routes

Blood = transport fluid.



or the circulating volume falls,
body cells receive less oxygen.

If the pump fails, the
routes become blocked,

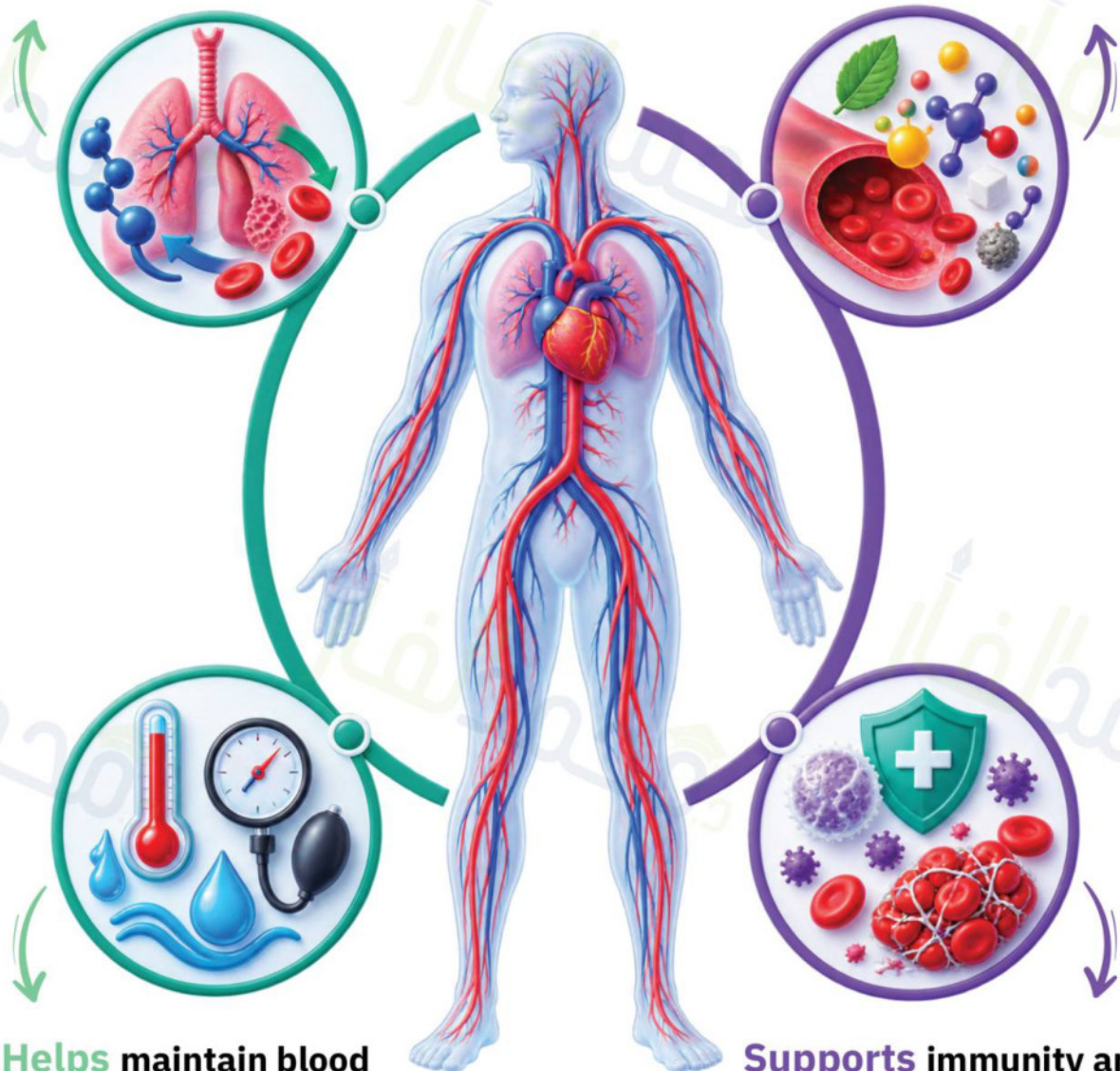
The circulatory system (cardiovascular system or CVS) consists of

- 1 **the heart**
- 2 **blood vessels**
- 3 **blood**

Humans have a closed, double circulatory system.

Transports oxygen from the lungs to body cells and returns carbon dioxide to the lungs.

Carries nutrients, hormones, heat, and waste products.

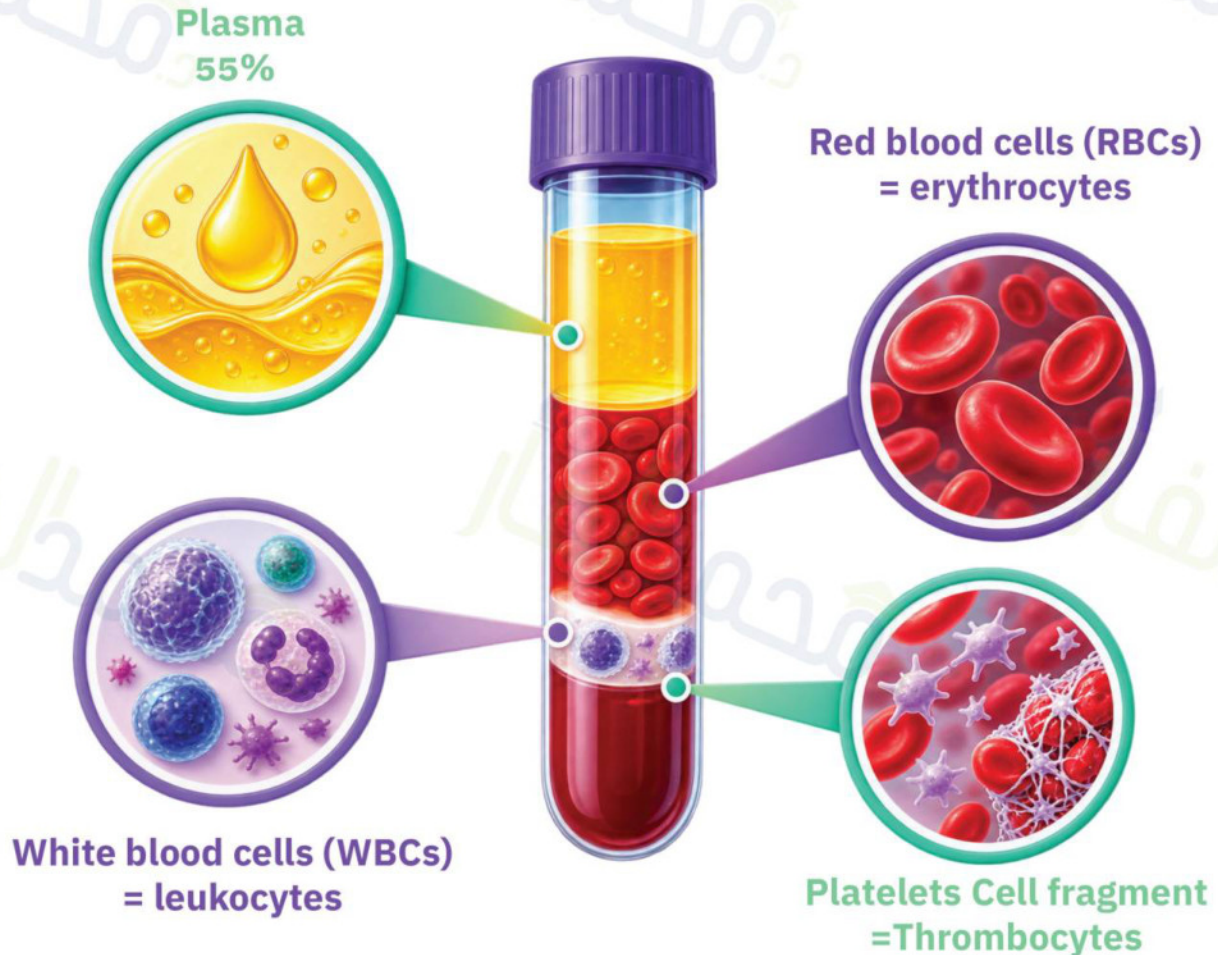


Helps maintain blood pressure, body temperature, fluid balance, and pH.

Supports immunity and prevents excessive blood loss through clotting.

BLOOD

- Blood is a liquid connective tissue made of plasma and formed elements.



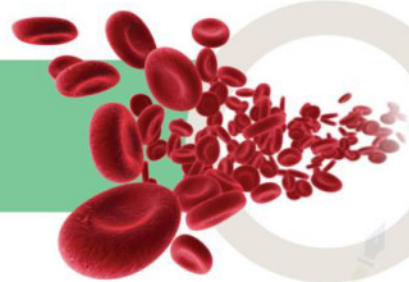
Component	Main role
Plasma 55%	Liquid part; mostly water. Carries proteins, salts, nutrients, hormones, gases, and wastes.
Red blood cells (RBCs) = erythrocytes	Contain hemoglobin and mainly transport oxygen.
White blood cells (WBCs) =leukocytes	Defend the body against infection and abnormal cells. Main WBC types: neutrophils, lymphocytes, monocytes, eosinophils, and basophils.
Platelets Cell fragment = Thrombocytes	Begin the formation of a platelet plug and help stop bleeding.

Red blood cells

- Scientific name: erythrocytes.

The biconcave shape gives RBCs a large surface area and a thin center, allowing gases to diffuse rapidly.

Mature human RBCs have no nucleus or mitochondria, leaving more space for hemoglobin.



- Produced in red bone marrow; average life span is about 120 days.
- Erythropoietin (EPO), mainly from the kidneys, stimulates RBC production when oxygen is low.

Plasma proteins and clotting



Albumin helps keep water inside the circulation by maintaining osmotic pressure.

Globulins include antibodies and transport proteins.

Fibrinogen is converted into fibrin during blood clotting.

Hemostasis occurs in three easy steps:

- The damaged vessel constricts (vasoconstriction).
- Platelets form a temporary platelet plug.
- Clotting proteins produce a fibrin mesh that strengthens the plug.
- **Vitamin K** is needed by the liver to produce several clotting factors.

Important blood numbers

Fact	Value to remember
Average adult blood volume	About 5 L, or roughly 7-8% of body weight
Plasma / formed elements	About 55% / 45%
RBC life span	About 120 days
Normal blood pH	7.35-7.45

ABO and Rh Blood Groups

An antigen is a marker on the RBC surface. An antibody is a defensive protein in plasma. If a matching antibody meets its antigen, agglutination (clumping) may occur.

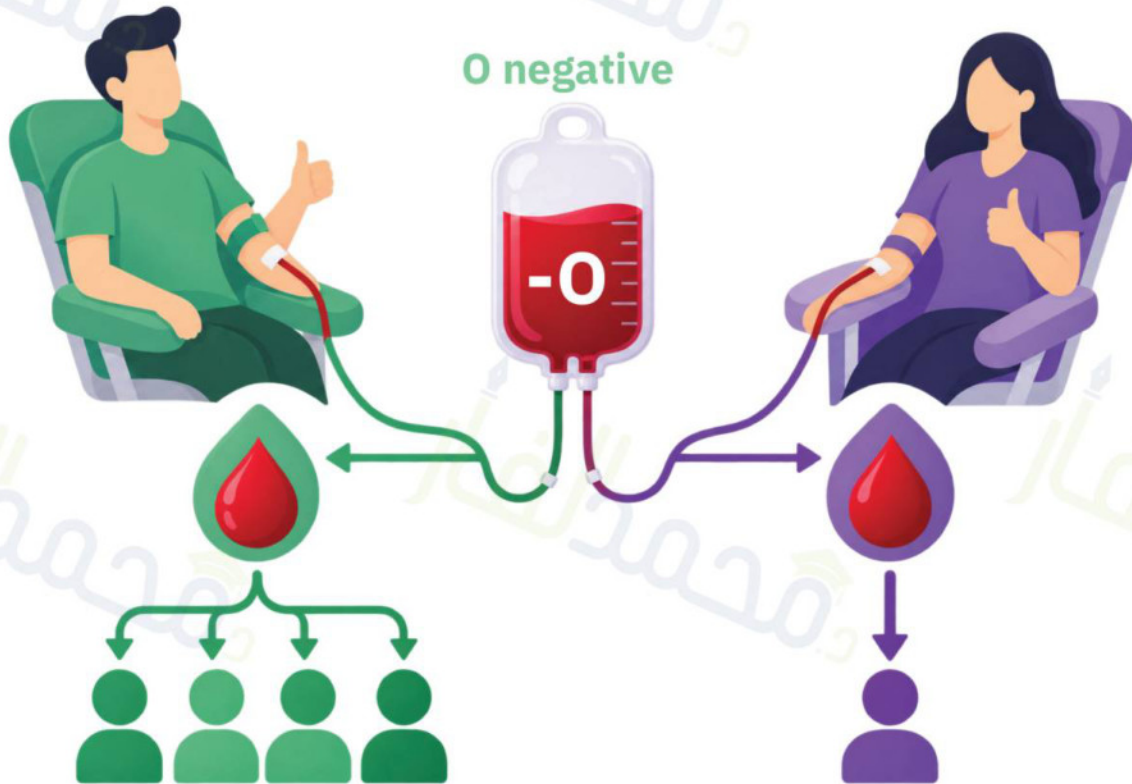
Group	RBC antigens	Plasma antibodies	Possible genotype
A	A	Anti-B	IAIA or IAi
B	B	Anti-A	IBIB or IBi
AB	A and B	None against A or B	IAIB
O	No A or B	Anti-A and Anti-B	Ii

Blood typing rule:

clumping with Anti-A means antigen A is present; clumping with Anti-B means antigen B is present.

RED-CELL TRANSFUSION RULE

O negative is commonly called the universal RBC donor, and AB positive the universal RBC recipient. Crossmatching is still required before transfusion.



Rh blood grouping system

- Rh refers mainly to the D antigen, the second major blood-group system after ABO.
- Rh-positive (Rh+) means the D antigen is present. Rh-negative (Rh-) means it is absent.

Erythroblastosis fetalis

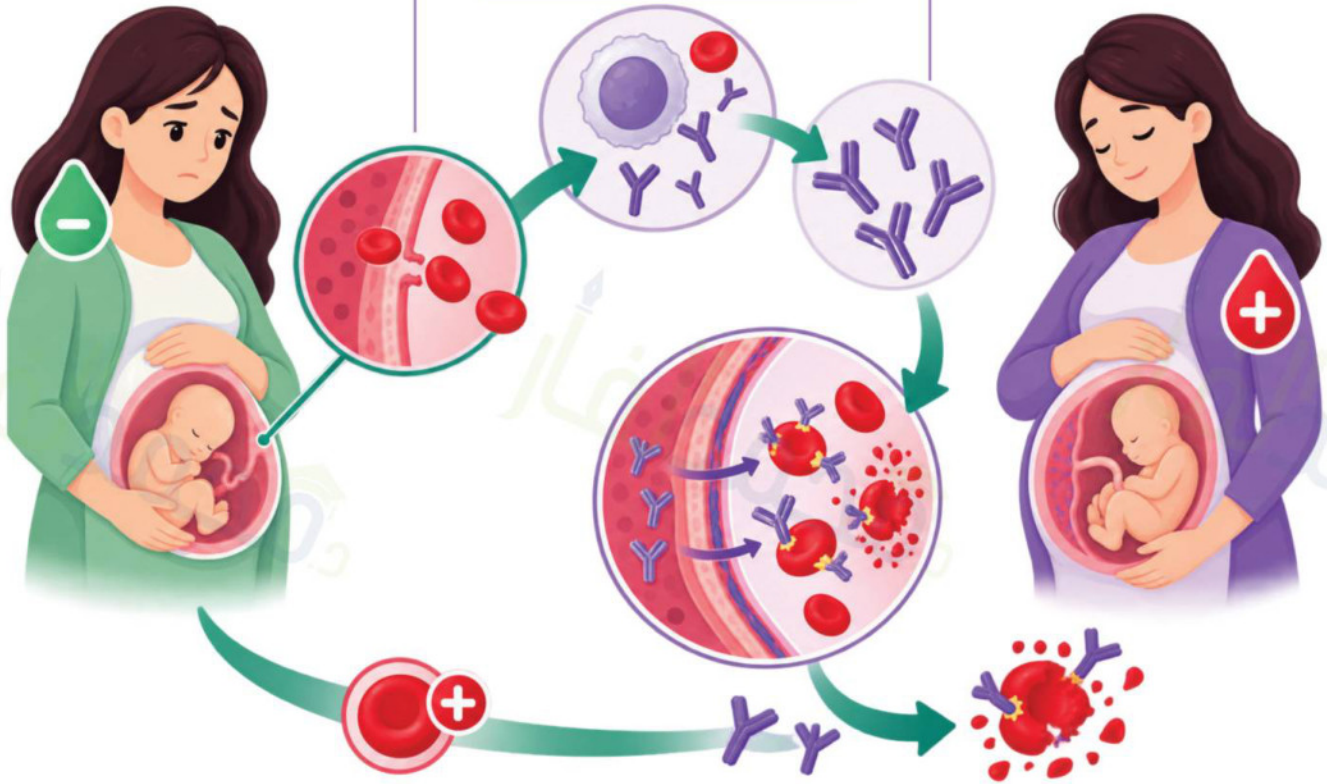
This is also called hemolytic disease of the fetus and newborn.

- An Rh-negative mother carries an Rh-positive fetus.
- Some fetal RBCs may enter the mother's circulation, often near delivery, and sensitize her immune system.
- The mother forms anti-D antibodies.
- In a later Rh-positive pregnancy, maternal anti-D IgG can cross the placenta and destroy fetal RBCs.

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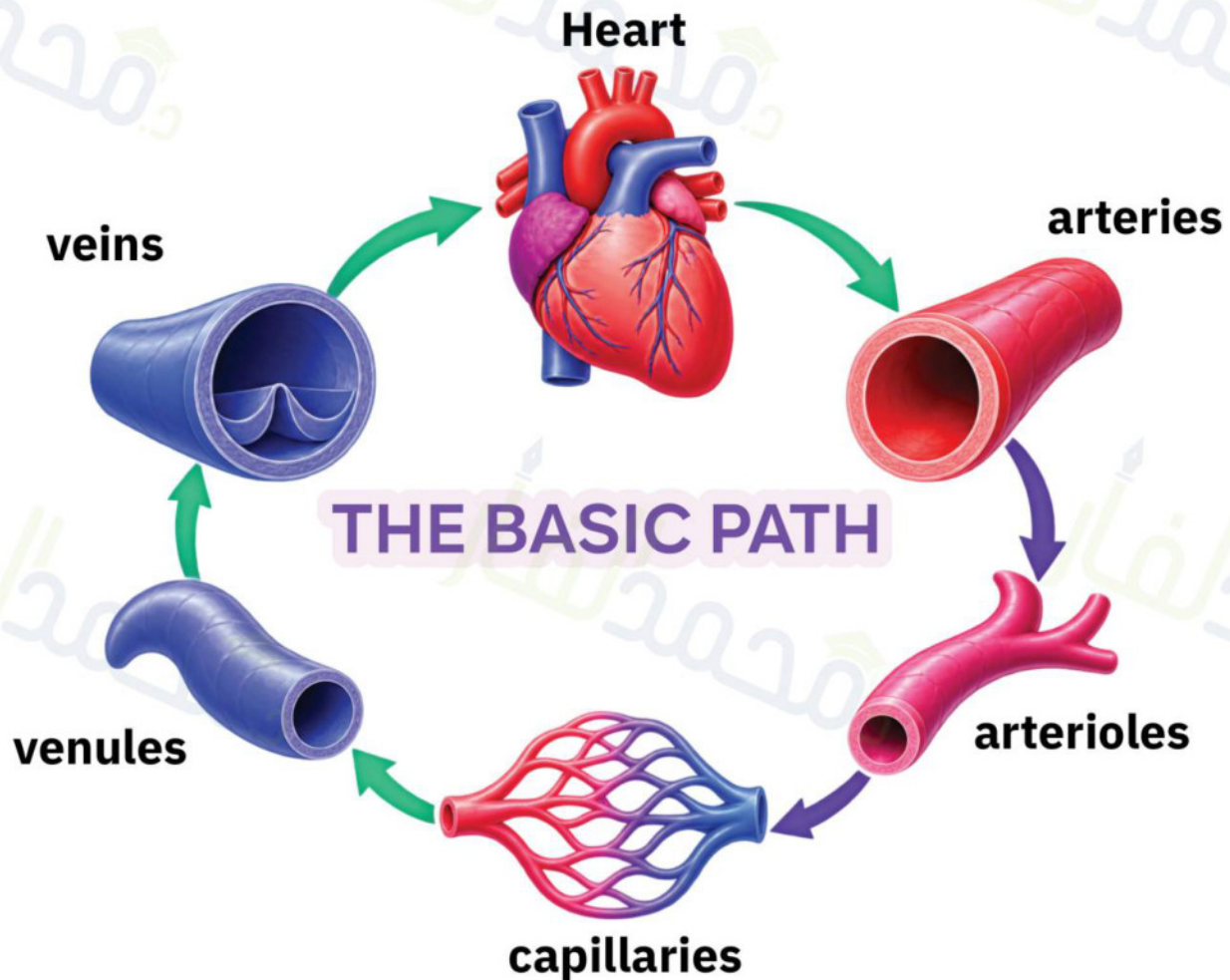
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التي تع



المشكلة ليست أن خلايا دم الأم نفسها تهاجم الجنين؛ الأجسام المضادة Anti-D هي التي تعبر المشيمة وتكسر خلايا دم الجنين.

The first Rh-positive pregnancy is often less affected, but this is not an absolute rule. Anti-D immunoglobulin prevents maternal sensitization.

Blood Vessels



Feature	Arteries	Veins	Capillaries
Direction	Away from the heart	Toward the heart	Connect arterioles to venules
Wall	Thick, elastic, muscular	Thinner and less muscular	One thin endothelial layer
Lumen	Relatively narrow	Wider	Extremely narrow
Pressure	High	Low	Lower than arteries
Valves	Usually absent along arteries	Often present, especially in limbs	Absent
Main job	Distribute blood	Return blood	Exchange gases and materials
Oxygen rule	Usually oxygen-rich	Usually oxygen-poor	Oxygen changes across the network

Lumen _____ الـ

هو الفراغ الداخلى الذي يجري فيه الدم.

الوريد جداره أرق لكن تجويفه غالباً أوسع من الشريان المقابل.

THE RULE AND ITS EXCEPTION

An artery is defined by carrying blood away from the heart, not by oxygen content. The pulmonary artery carries oxygen-poor blood; pulmonary veins carry oxygen-rich blood.

- The aorta is the largest artery and carries blood from the left ventricle to the body.
- The inferior vena cava is the largest vein and returns blood from the lower body to the right atrium.

Jugular veins

Blood vessel	Type	Direction
Carotid artery	Artery	Heart → head and brain
Jugular vein	Vein	Head and brain → heart

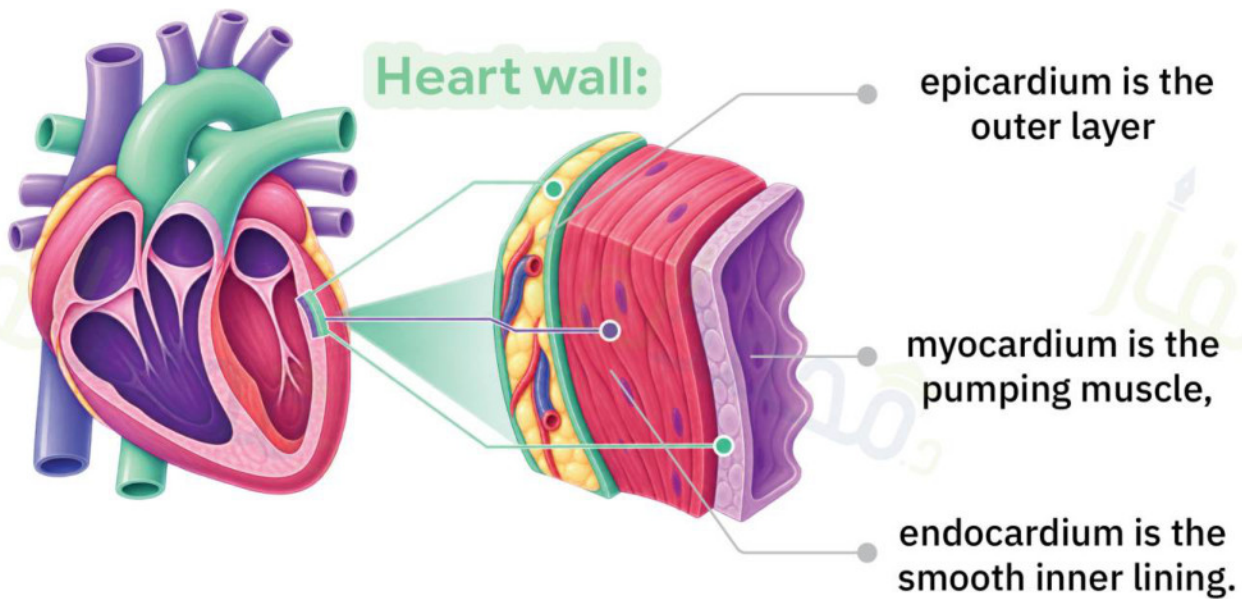
Question ?

How venous blood returns to the heart

- 1 Venous valves reduce backward flow.
- 2 Skeletal-muscle contractions squeeze veins and push blood toward the heart.
- 3 Breathing pressure changes also help venous return.

The Heart

- The heart lies in the thoracic cavity, between the lungs behind the sternum and above the diaphragm.
- It is approximately the size of a fist.
- The pericardium is a protective sac around the heart.



Four chambers

Chamber	Receives or pumps
Right atrium	Receives oxygen-poor blood from the superior vena cava, inferior vena cava, and coronary sinus.
Right ventricle	Pumps oxygen-poor blood to the lungs through the pulmonary artery.
Left atrium	Receives oxygen-rich blood from the pulmonary veins.
Left ventricle	Pumps oxygen-rich blood into the aorta and systemic circulation.

The left-ventricular myocardium is the thickest because it must pump blood through the whole body against greater resistance.

○ NB (One atrium مفرد -Two atria جمع)

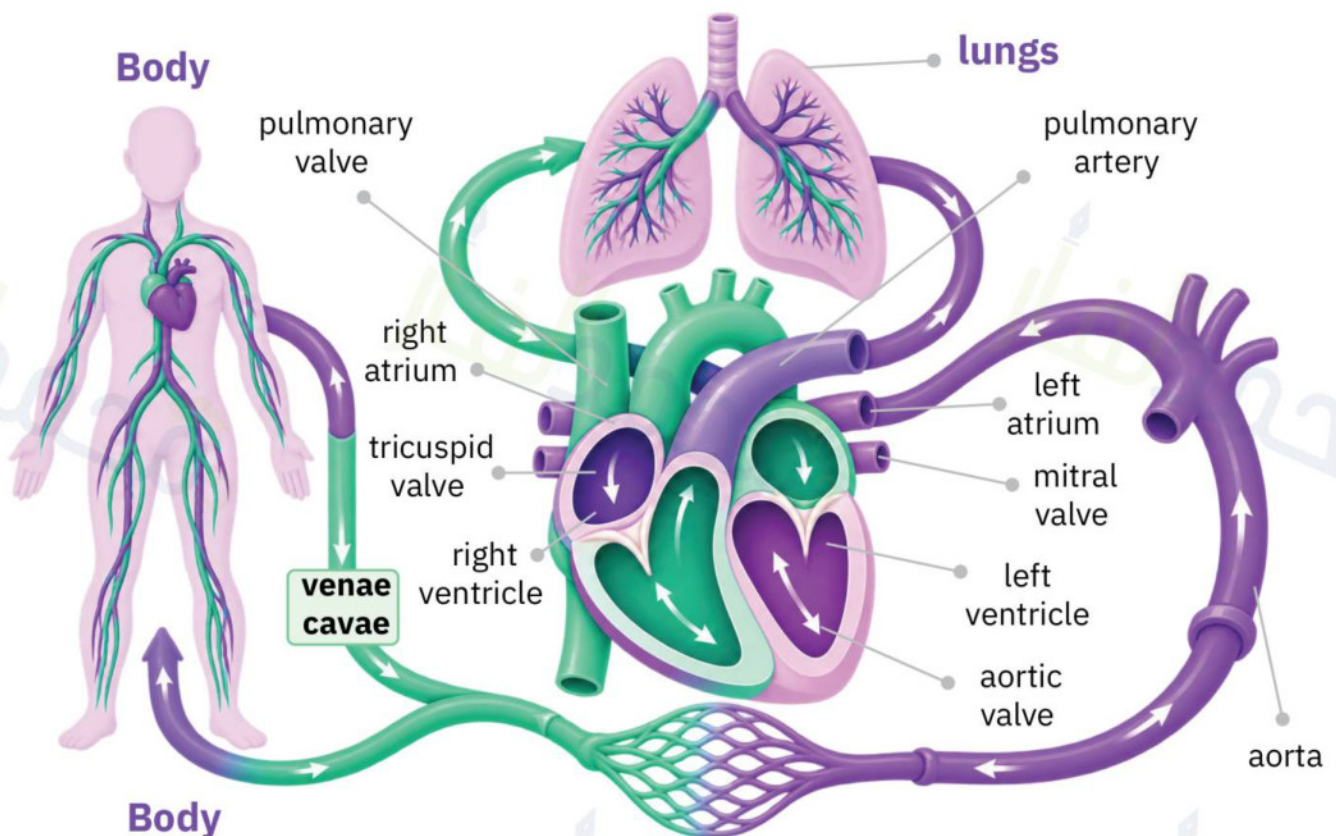
Four valves

Valve	Location
Tricuspid valve	Right atrium -> right ventricle
Pulmonary valve	Right ventricle -> pulmonary artery
Mitral (bicuspid) valve	Left atrium -> left ventricle
Aortic valve	Left ventricle -> aorta

Valves open and close because of pressure differences. Their main function is to prevent backflow.

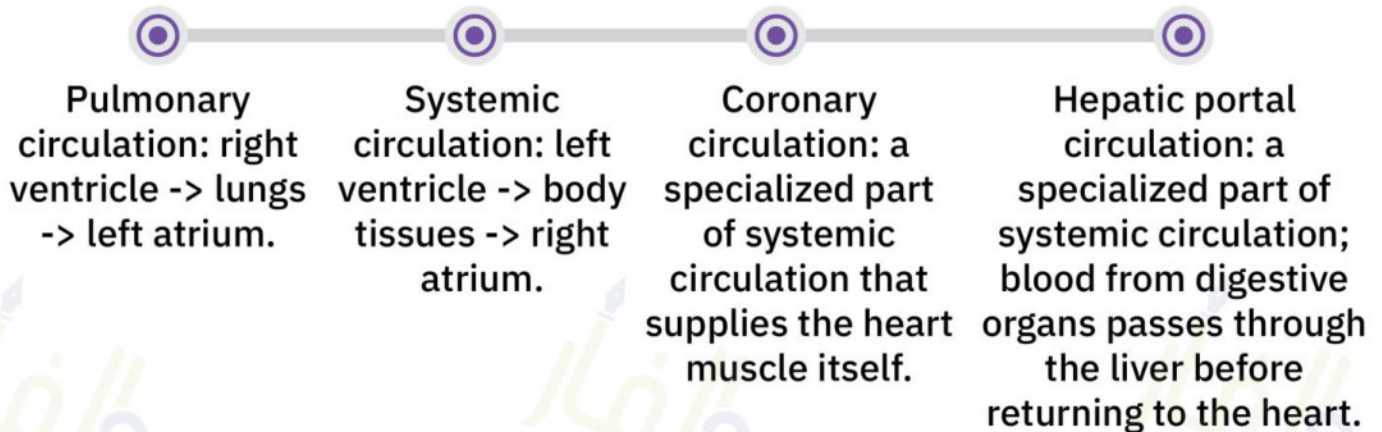
Papillary muscles are connected to the tricuspid and mitral valves by strong cords called chordae tendineae. During ventricular contraction, they prevent the valves from turning backward into the atria.

Follow one drop of blood

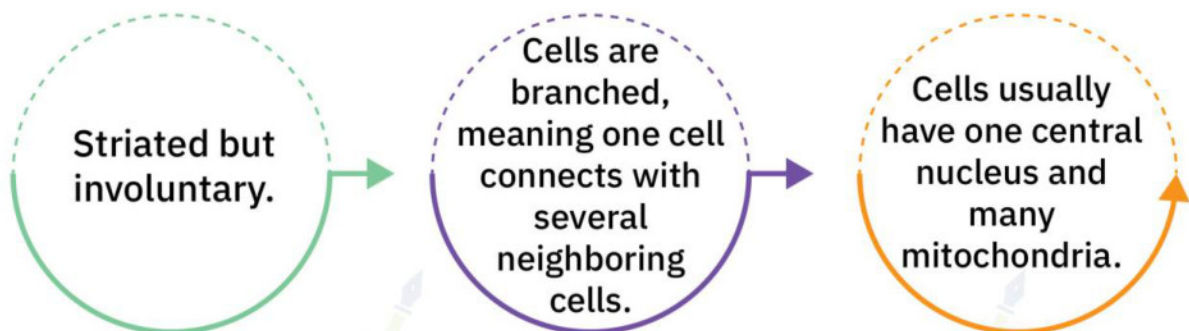


Types of circulation

- Humans have double circulation because blood moves through two separate loops: pulmonary circulation and systemic circulation.



Cardiac muscle



The Heartbeat: Electricity and ECG

- The heart is myogenic: it can start its own rhythmic electrical impulses.
- Nerves adjust the rate but do not normally start every heartbeat.

SA node starts the impulse and makes the atria contract. It is the natural pacemaker.

AV node briefly delays the impulse so the ventricles have time to fill.

The Bundle of His, bundle branches, and Purkinje fibers spread the impulse through the ventricles, causing ventricular contraction.

The SA node is located in the upper wall of the right atrium, near the opening of the superior vena cava.

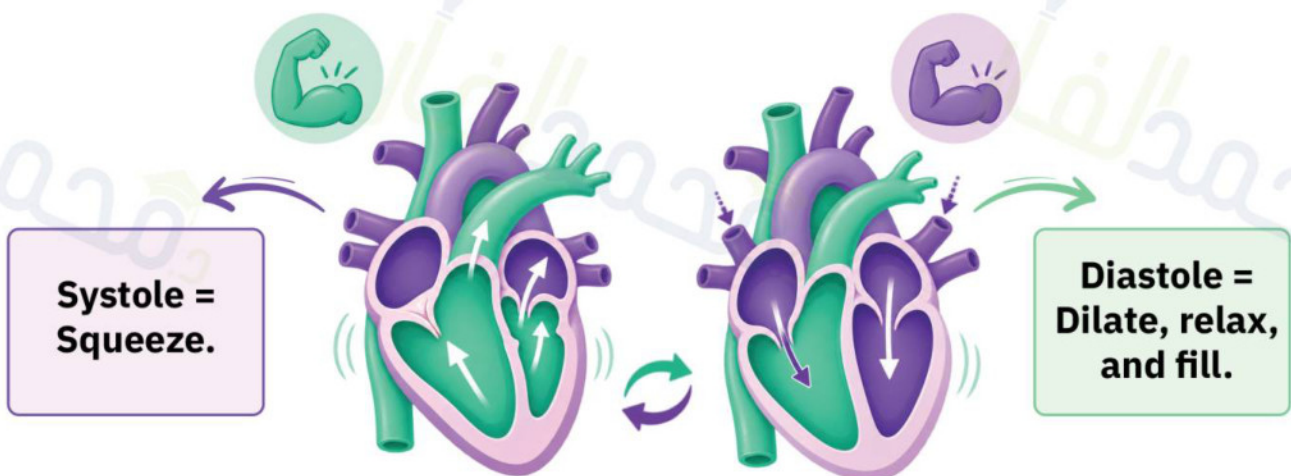
ECG

- An electrocardiogram (ECG) records the electrical activity of the heart from electrodes placed on the skin.
- Sympathetic stimulation increases heart rate and force. Parasympathetic stimulation, mainly through the vagus nerve, decreases heart rate.

Systole, Diastole, and Blood Pressure

Point	Systole	Diastole
Meaning	Contraction and ejection	Relaxation and filling
Ventricles	Contract and pump blood out	Relax and fill with blood
AV valves	Closed	Open during filling
Semilunar valves	Open during ejection	Closed
Blood-pressure number	Systolic: top number	Diastolic: bottom number

MEMORY KEY



- S1 (lub) is mainly produced when the mitral and tricuspid valves close at the start of ventricular systole. S2 (dub) occurs when the aortic and pulmonary valves close at the start of ventricular diastole.

1. Resting Adult Heart Rate

هو عدد ضربات القلب في الدقيقة أثناء الراحة.

Heart rate = number of heartbeats per minute

الطبيعي للبالغ أثناء الراحة: 60-100 beats/min

نستخدم 70 beats/min كرقم تقريبي في المسائل.

2. Stroke Volume

هو كمية الدم التي يدفعها أحد البطينين في ضربة قلب واحدة.

Stroke volume = the amount of blood pumped by one ventricle in one heartbeat

القيمة التقريبية أثناء الراحة: 70 mL per beat

يعني البطين الأيسر مثلاً يدفع حوالي 70 mL من الدم مع كل ضربة.

3. Cardiac Output

هو كمية الدم التي يدفعها أحد البطينين خلال دقيقة واحدة.

Cardiac output = the amount of blood pumped by one ventricle per minute

ويُحسب كالتالي:

Cardiac output = Heart rate $\times$ Stroke volume

مثال Example

70 L/min $\approx$ 4900 mL/min $\times$ 70 mL/beat = 70 beats/min

يعني القلب يضخ حوالي 5 liters of blood per minute أثناء الراحة.

4. Blood Pressure

هو الضغط الذي يسببه الدم على جدران الشرايين.

Blood pressure = the force exerted by blood against the walls of arteries

القيمة المشهورة:

120/80 mmHg

Systolic pressure = 120 :الضغط أثناء انقباض البطينين.

Diastolic pressure = 80 :الضغط أثناء ارتخاء البطينين.

mmHg

تعني millimeters of mercury، وهي وحدة قياس ضغط الدم.

5. Heartbeats per Day

هو العدد التقريبي لضربات القلب خلال 24 ساعة.
إذا كان القلب ينبض حوالي 70 مرة في الدقيقة:

$$\text{minutes} \times 24 \text{ hours} = 100,800 \text{ beats/day } 60 \times 70$$

لذلك نقول تقريبًا:

The heart beats about 100,000 times per day.



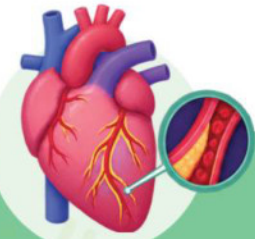
Common Diseases and Disorders

Heart and vessel disorders



Atherosclerosis

fatty, plaques develop in arterial walls and narrow the lumen.



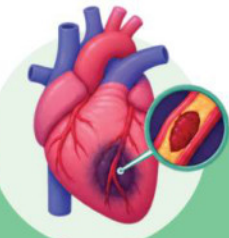
Coronary artery disease:

narrowing or blockage of the arteries that supply the heart muscle.



Angina pectoris:

temporary myocardial ischemia causing chest discomfort without permanent death of heart-muscle cells.



Myocardial infarction (heart attack):

prolonged ischemia causes death of part of the heart muscle.



Troponin:

a protein inside cardiac-muscle cells. When these cells are injured, troponin enters the blood, so doctors measure it when myocardial infarction is suspected.



Heart failure:

the heart has not stopped, but it cannot pump enough blood efficiently.



Hypertension:

persistently high blood pressure; important risk factors include obesity, smoking, increasing age, and kidney disease.



Stroke

sudden damage to brain tissue because a cerebral blood vessel is blocked or ruptures.

VALVE AND RHYTHM DISORDERS

Stenosis

a valve cannot open fully, so blood has difficulty moving forward.

Regurgitation

a valve cannot close fully, so some blood leaks backward.

Arrhythmia

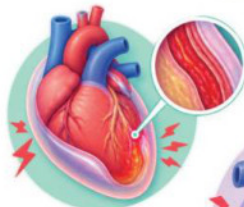
an abnormal heart rhythm caused by a problem in impulse formation or conduction.

○ Bradycardia: an unusually slow heart rate.

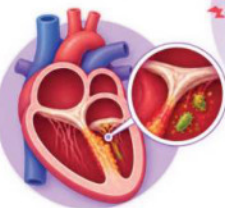
○ Tachycardia: an unusually fast heart rate.

INFLAMMATION AND INFECTION

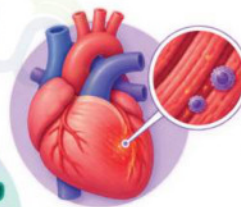
Pericarditis = inflammation of the sac around the heart.



Myocarditis = inflammation of the heart muscle.



Endocarditis = inflammation or infection of the inner lining and often the valves.



Rheumatic heart disease may damage valves after rheumatic fever.



Blood disorders

Iron-deficiency anemia:

too little iron leads to reduced hemoglobin and lower oxygen-carrying capacity.

Sickle cell disease:

abnormal hemoglobin causes RBCs to become rigid and sickle-shaped, which may block small vessels.

Leukemia

cancer of blood-forming tissues that produces abnormal white blood cells.

Thrombocytopenia

a low platelet count, increasing the tendency to bleed.

Hemophilia

an inherited deficiency of a clotting factor, causing prolonged bleeding.

Thalassemia

an inherited disorder that reduces normal hemoglobin production.

Cytopenia means an abnormally low number of blood cells.

Decreased component	Medical term
Red blood cells	Erythrocytopenia (Erythropenia)
Hemoglobin or oxygen-carrying capacity	Anemia
White blood cells	Leukopenia
Neutrophils	Neutropenia
Lymphocytes	Lymphocytopenia (Lymphopenia)
Monocytes	Monocytopenia
Basophils	Basopenia
Platelets	Thrombocytopenia

Notebook :

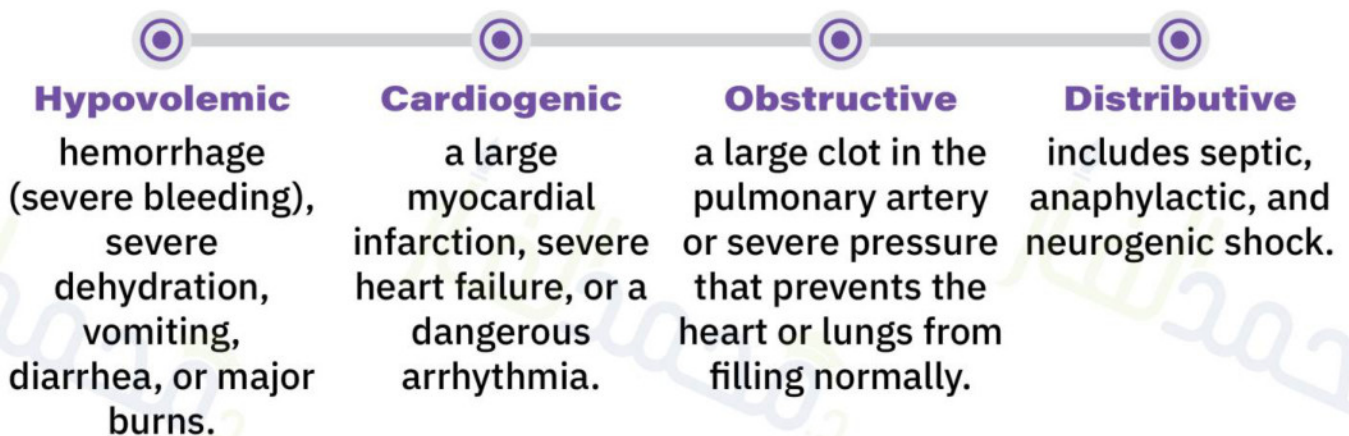
- Erythrocytopenia means a low RBC count, while anemia mainly means reduced hemoglobin or oxygen-carrying capacity.

CIRCULATORY SHOCK

DEFINITION

- Shock is failure of the circulation to deliver enough blood and oxygen to tissues.
- It causes cellular hypoxia and may progress to organ dysfunction.

Type	Main problem
Hypovolemic shock	Too little circulating volume: the tank is empty.
Cardiogenic shock	The heart cannot pump effectively: the pump fails.
Obstructive shock	A physical obstruction blocks filling or blood flow.
Distributive shock	Widespread vasodilation makes the vascular space too large.



Septic shock

- a severe, dysregulated response to infection causes marked vasodilation and poor tissue perfusion.

Anaphylactic shock

- a severe allergic reaction causes vasodilation, fluid leakage, and possible airway narrowing.

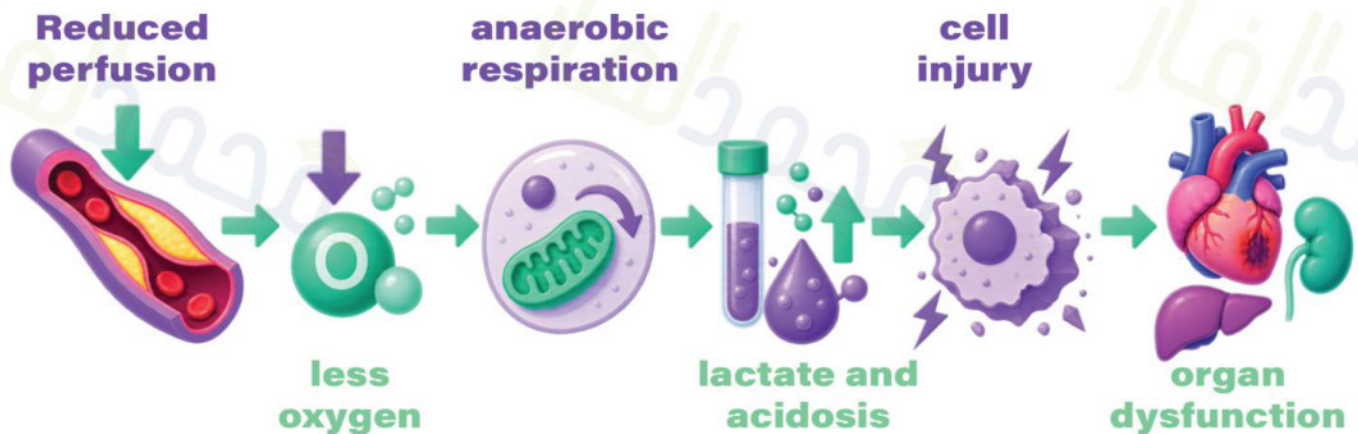
Neurogenic shock

- loss of sympathetic vascular tone causes vasodilation; unlike many other types, bradycardia may occur.

Question ?

What happens in shock?

MECHANISM



Common warning signs

rapid weak pulse, confusion, reduced urine output, pale or cold skin, and low blood pressure.

- Early distributive shock may cause warm skin because of vasodilation.
- Hemorrhage lowers blood volume, venous return, cardiac output, and eventually blood pressure.

Fast Revision

1

atria receive blood; ventricles pump blood out.

2

The left ventricle has the thickest myocardium.

3

Valves prevent backflow and keep blood moving in one direction.

4

The SA node is the natural pacemaker.

5

Systole means contraction; diastole means relaxation and filling.

6

Ventricular systole closes AV valves and opens semilunar valves during ejection.

7

Capillaries are the main exchange vessels.

8

Arteries carry blood away; veins return blood to the heart.

9

Pulmonary arteries carry oxygen-poor blood; pulmonary veins carry oxygen-rich blood.

10

Jugular veins drain the head and neck;

11

carotid arteries supply the head and neck.

12

The superior vena cava returns blood from the upper body; the inferior vena cava returns blood from the lower body.

13

Coronary arteries supply the myocardium itself.

14

The aorta is the largest artery; the inferior vena cava is commonly taught as the largest vein.

15

Shock means inadequate tissue perfusion, not simply a low blood-pressure reading.