

Blood and its constitutes

Blood

- **Whole blood** is a suspension of cellular elements in plasma, circulating through the cardiovascular system.
- Blood is the part of **extracellular fluid** within the cardiovascular system.
- Blood is the only **fluid connective tissue**.

Functions of Blood

1. Transport

- ❑ O₂, CO₂, nutrient, hormones, waste product

2. Homoeostasis

- ❑ Regulation of body temperature, ECF pH

3. Protecting against infections

- ❑ White Blood Cells, Antibodies

4. Blood clotting prevent blood loss

Physical Characteristics of Blood

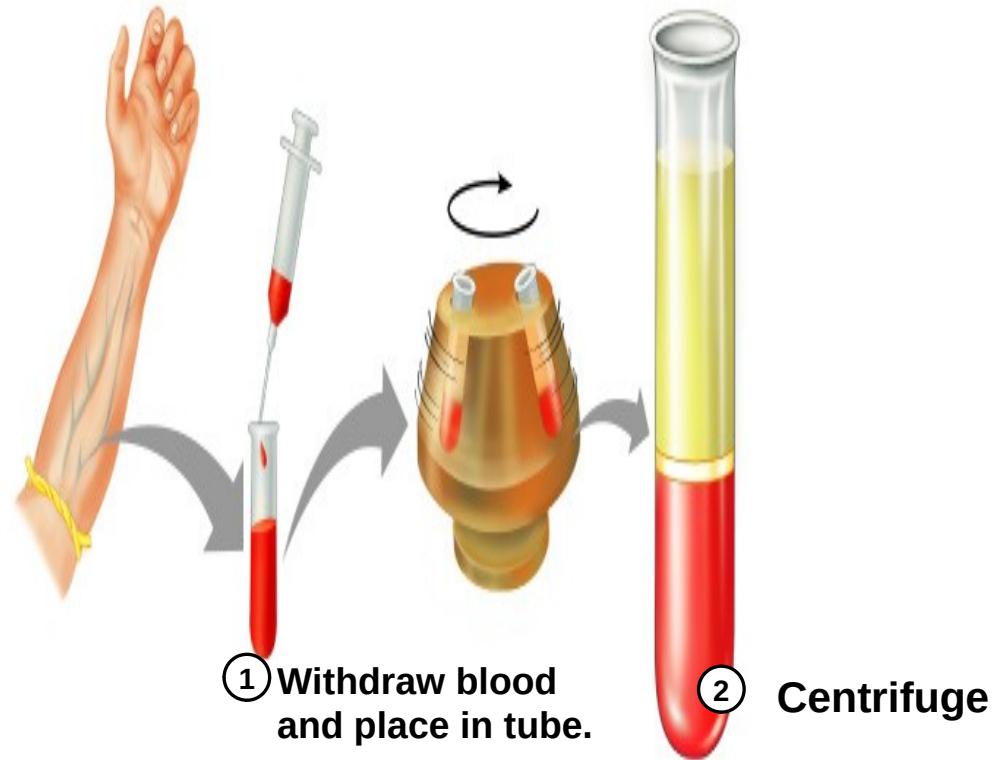
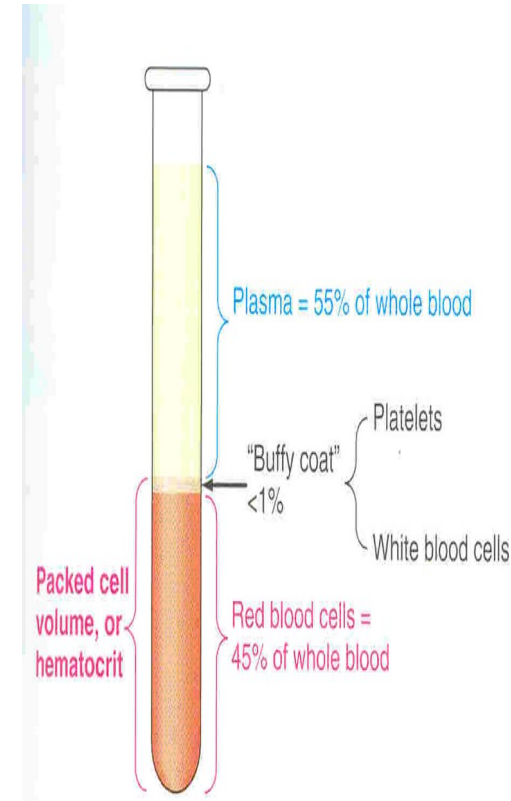
- **Average volume** of blood:
 - 5 - 6 L for males; 4 – 5 L for females
 - **Hypovolemia:** **low** blood volume
 - **Hypervolemia:** **high** blood volume
- It is a viscous fluid, which is heavier and thicker than water.
- The **pH** of blood is **7.35 – 7.45** and its salt content is 0.9%

- **Color:**
 - Bright red (arterial blood, oxygenated)
 - Dark red (venous blood, deoxygenated)
- **Osmolarity** = 295 – 300 mOsm or 0.3 Osm,
 - This value reflects the concentration of solutes in the plasma
- **Temperature** is 38.3°C, slightly higher than “normal” body temperature.
- Blood accounts for approximately 7 – 8 % of body weight.

Composition of Blood

- 2 major components:
 - **Liquid** = **plasma** (55%): About **3 L**
 - **Formed elements** = **Blood cells** (45%): about **2 L**
 - *Erythrocytes*, or **red blood cells** (RBCs),
 - *Leukocytes*, or **white blood cells** (WBCs) and
 - *Thrombocyte*, or **Platelets** - fragments of **megakaryocytes** in marrow.

Components of Whole Blood



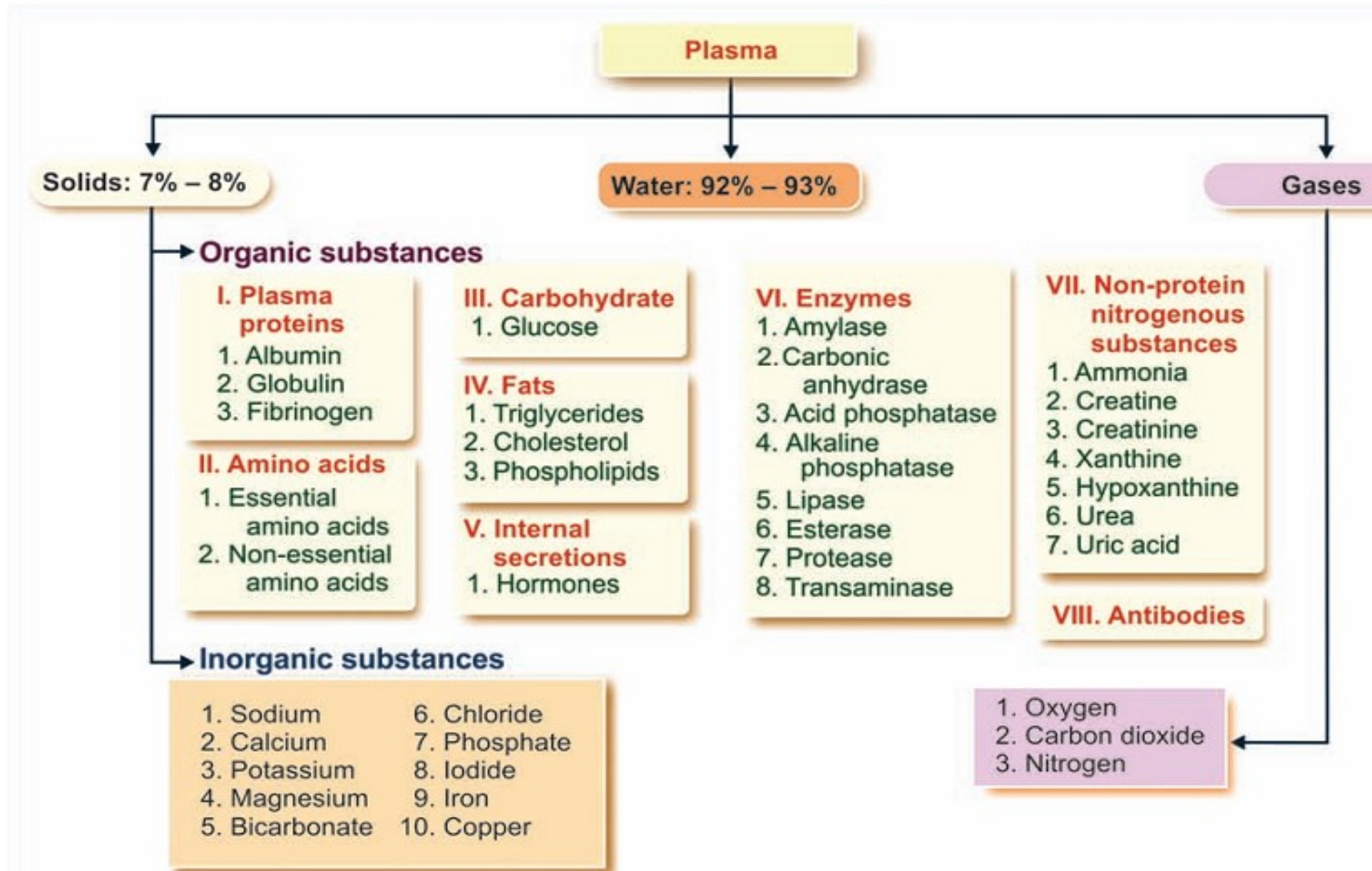
- **Hematocrit:**

- **Males:** $47 \pm 5 \%$
- **Females:** $42 \pm 5 \%$

- **Hemoglobin:**

- **Males:** $14 - 18 \text{ g/dl}$
- **Females:** $13 - 17 \text{ g/dl}$

1. Composition of plasma



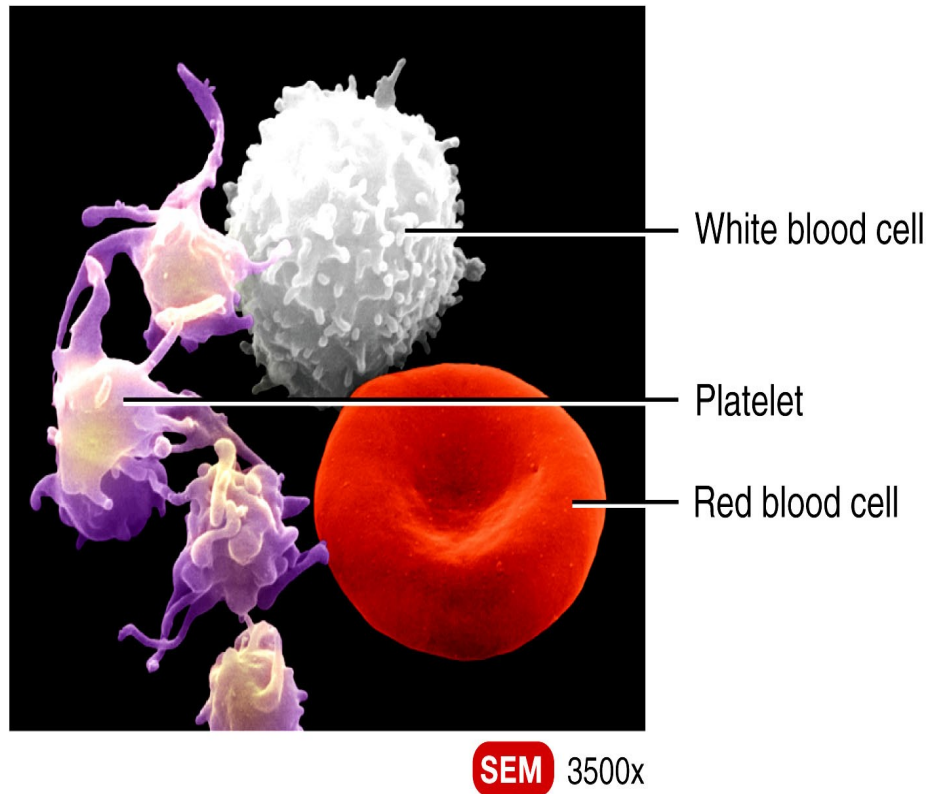
Serum Vs. Plasma

- **Serum** is **blood without fibrinogen** (a clotting factor).
- **Plasma** is **blood which contains all plasma proteins**.
- **In other words**, Serum has more or less similar **composition** to blood plasma except that **its fibrinogen have been removed**.
- **Serum = Plasma – Fibrinogen**

2. Formed Elements

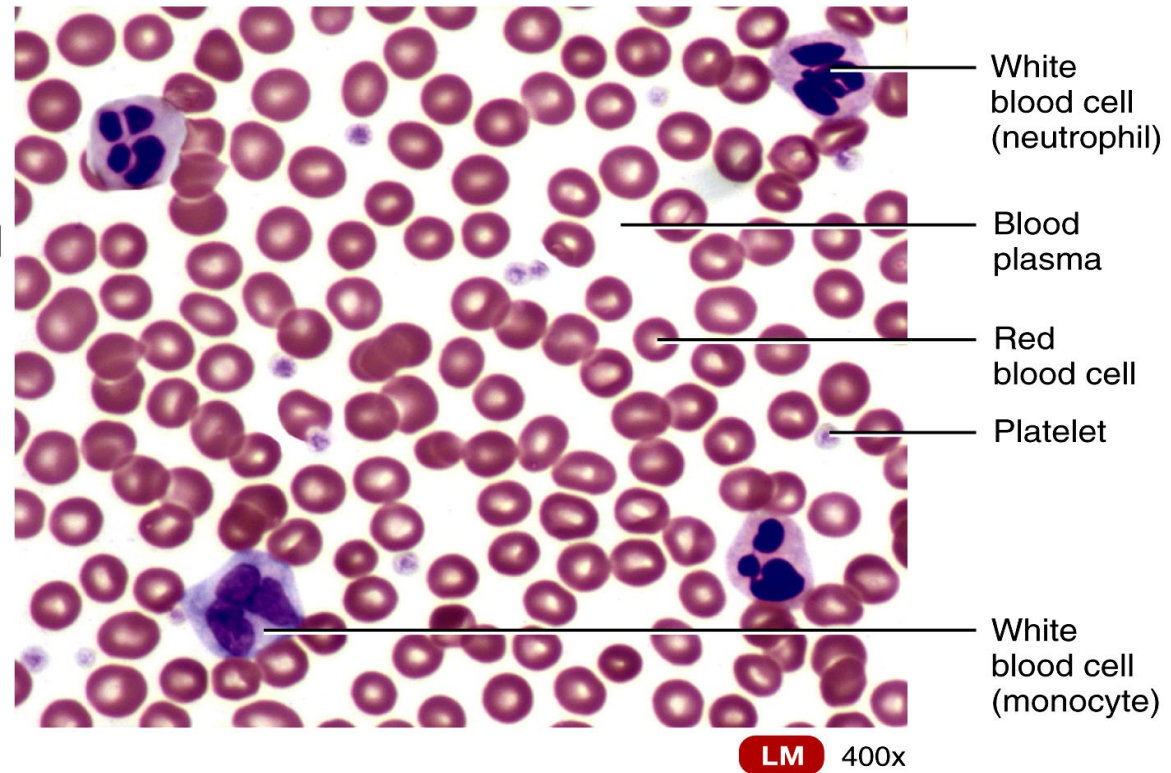
- **Formed elements** comprise **45% of blood**.
- **Erythrocytes, leukocytes, and platelets** make up the formed elements.
- Most formed elements survive in the bloodstream for **only a few days**.

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(a)

Figure 19.02a Tortora - PAP 12/e
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(b)

Figure 19.02b Tortora - PAP 12/e
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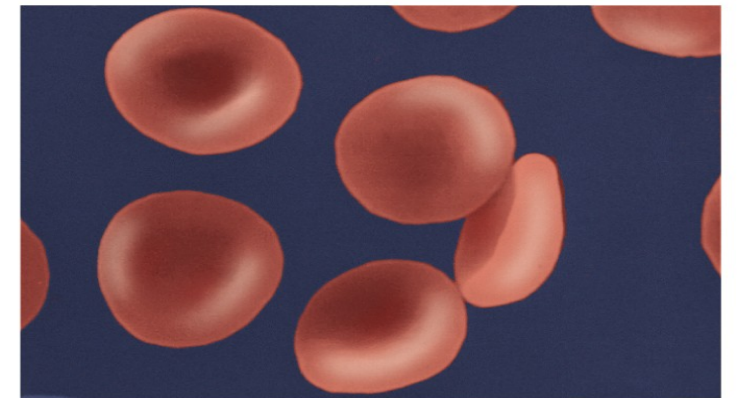
Erythrocytes (RBCs)

- Shape: Biconcave disc
- No nucleus
- Filled with hemoglobin (Hb): 97% of cell contents.
 - Hb functions in gas transport.
 - $\text{Hb} + \text{O}_2 \rightleftharpoons \text{HbO}_2$ (oxyhemoglobin).
- The Most numerous of the formed elements:
 - Females: 4.3 – 5.4 million cells/cubic millimeter
 - Males: 4.6 – 6.2 million cells/cubic millimeter

Function

- O_2 transport
- CO_2 transport
- Buffer

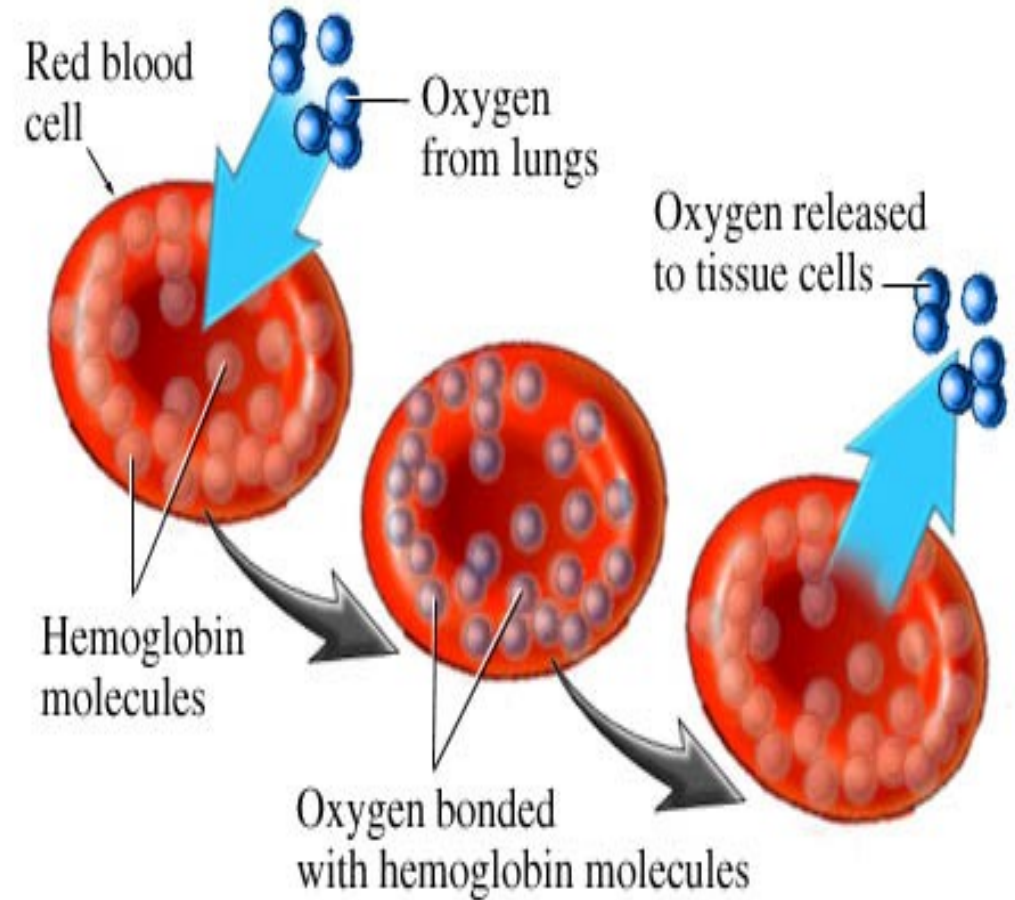
SEM shows biconcave disk shape of RBCs.



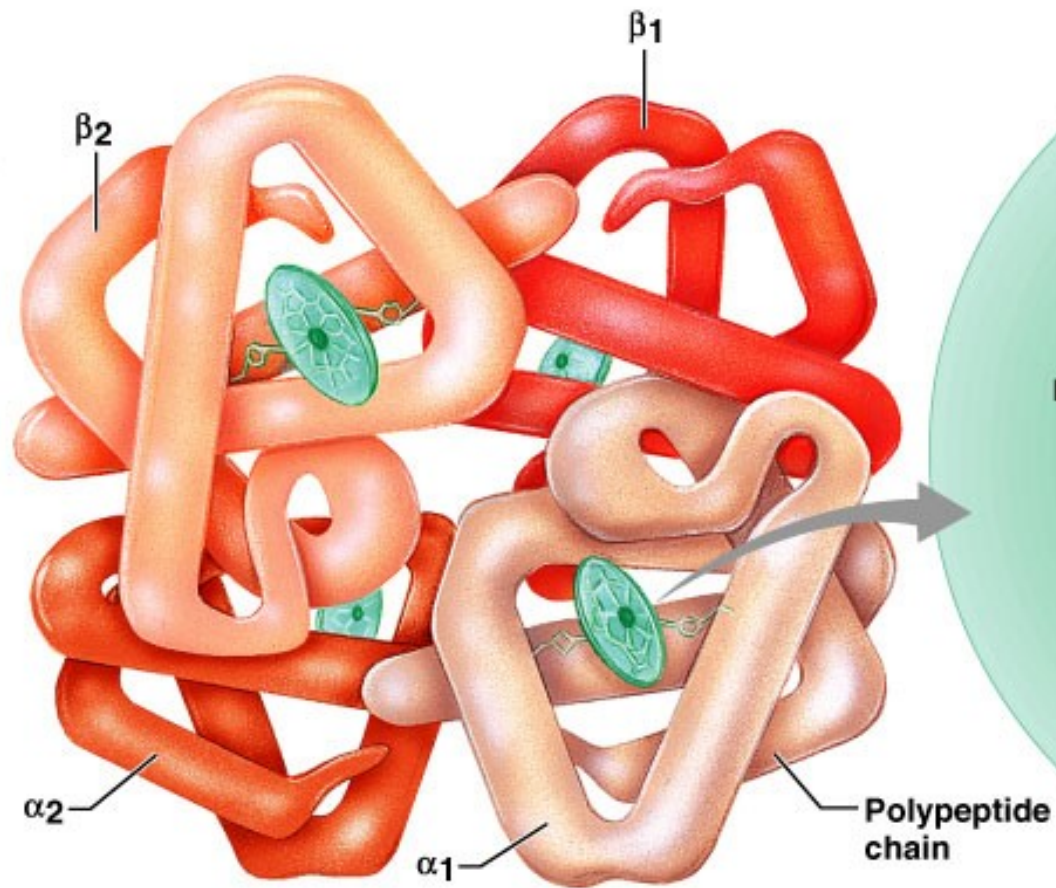
Its diameter is about 7~8 μm

Hemoglobin

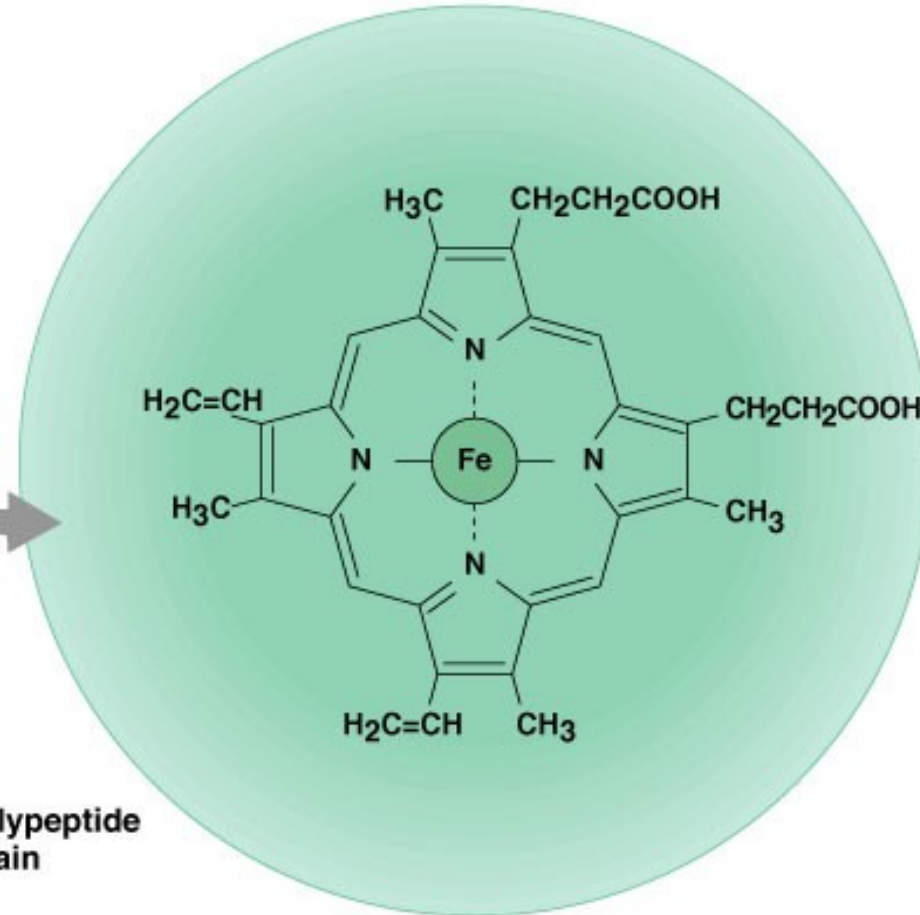
- **Hemoglobin** is the **major protein** present in red blood cells, and is responsible for the **large O₂- carrying capacity of blood**.
- **Oxyhemoglobin**:- hemoglobin bound to oxygen.
- **Deoxyhemoglobin**:- hemoglobin after oxygen diffuses into tissues.
- **Carbaminohemoglobin**:- hemoglobin bound to carbon dioxide.



Hemoglobin



(a) Hemoglobin



(b) Iron-containing heme group

Hematopoiesis

- Hemopoiesis or hematopoiesis is the process of **origin**, **development** and **maturation** of **all the blood cells**.
- **Erythropoiesis** is the process of origin, development and maturation of **erythrocytes**.
- ***Hematopoiesis*** (**blood cell formation**):
 - Occurs in the **red bone marrow**.

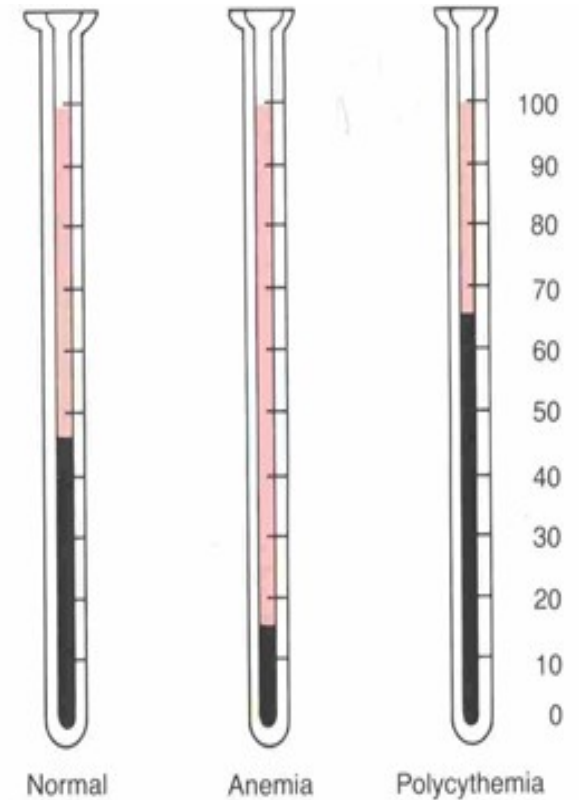
Erythrocyte Disorders

- **Anemia:**

- **Insufficient Erythrocytes or Decreased Hemoglobin Content** as a result blood has **abnormally low oxygen-carrying capacity.**
- It is a **symptom** rather than a disease itself.

- **Polycythemia:**

- Abnormal **excess** circulating erythrocytes.



Hematocrits in the normal person and in patients with anemia and polycythemia

Major Causes of Anemia

- **Dietary deficiencies** of iron (**iron-deficiency** anemia), **vitamin B12**, or **folic acid**,
- **Bone marrow failure** due to **toxic drugs** or **cancer**,
- **Blood loss** from the body (**hemorrhage**),
- **Inadequate secretion of erythropoietin** in **kidney disease**,
- **Excessive destruction of erythrocytes** (for example, **malaria**)

Leukocytes (WBCs)

- Leukocytes, the only blood components that are **complete cells**:
 - **4,000 - 11,000/cubic millimeter**
 - Protect the body from **infectious microorganisms**

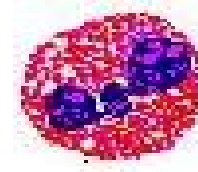
- Two major types of leukocytes:

- ❖ **Granulocytes:**

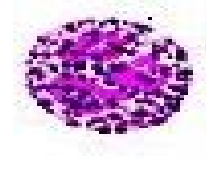
- Neutrophils,
- Eosinophils and
- Basophils.



Neutrophil



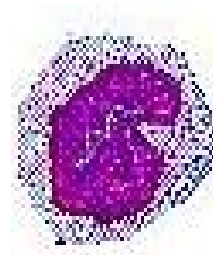
Eosinophil



Basophil

- ❖ **Agranulocytes:**

- Monocytes,
- Lymphocytes.



Monocyte



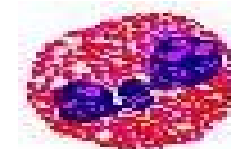
Lymphocyte

Granulocytes

- **Granulocytes:** *Neutrophils*, *Eosinophils*, and *Basophils*.



Neutrophil



Eosinophil



Basophil

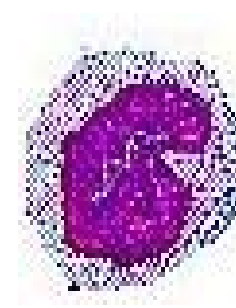
- Contain **cytoplasmic granules** that stain specifically (acidic, basic, or both) with Wright's stain.
- Are **larger** and usually **shorter-lived than RBCs**.
- Have **lobed nuclei**
- Are all **phagocytic cells**.

Lymphocytes

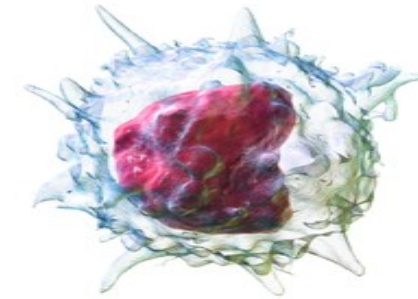


- Account for **25 - 33%** or more of WBCs and:
 - Are found mostly **enmeshed in lymphoid tissue** (some circulate in the blood).
- Most important cells of the **immune system**
- There are two types of lymphocytes: **T - cells** and **B - cells**
 - **T cells** attack foreign cells **directly**.
 - **B cells** give rise to **plasma cells**, which produce **antibodies**.

Monocyte



Monocyte



❖ Its body is large, diameter about 15~30 μm without granule

❖ Function:

- ❑ It contains many nonspecific lipase and displays the **powerful phagocytosis**.
- ❑ As soon as monocytes get into tissue from blood , it change its name called **macrophage** activating **monocyte- macrophage system** to release many cytokins.
- ❑ Cytokins induced by monocyte may modulate other cells growth.

Normal values of different WBCs

WBC	Percentage	Absolute value per cu mm
Neutrophils	50 to 70	3,000 to 6,000
Eosinophils	2 to 4	150 to 450
Basophils	0 to 1	0 to 100
Monocytes	2 to 6	200 to 600
Lymphocytes	20 to 30	1,500 to 2,700

WBCs Vs. RBCs

Feature	WBCs	RBCs
Color	Colorless	Red
Number	Less: 4,000 to 11,000/cu mm	More: 4.5 to 5.5 million/cu mm
Size	Larger Maximum diameter = 18 μ	Smaller Maximum diameter = 7.4 μ
Shape	Irregular	Disk-shaped and biconcave
Nucleus	Present	Absent
Granules	Present in some types	Absent
Types	Many types	Only one type
Lifespan	Shorter $\frac{1}{2}$ to 15 days	Longer 120 days

WBCs Disorders

- **Leukocytosis** :- is the **increase** in total leukocyte (WBC) count **over** $11,000/\text{mm}^3$
- **Leukopenia** :- the **decrease** in the total WBCs count below $4,000/\text{mm}^3$
- **Leukemia** :- is the condition which is characterized by **abnormal** and **uncontrolled increase** in leukocyte count more than $1,000,000/\text{mm}^3$.
 - It is also called **blood cancer**.

Platelets (**Thrombocytes**)

- Platelets are fragments of **megakaryocytes**.
- Platelets function in the **clotting mechanism** by forming a temporary plug that helps **seal breaks in blood vessels**.
- Normal value: ~ **140,000 - 400,000/mm³**
- **Life-span:** Averagely, **7~14 days** in the blood.

Hemostasis

- **Hemostasis:** refers to **stopping** or **arrest of bleeding**.
 - **Blood clotting.**
- **Blood cells involved in **blood clotting processes** are **platelets (Thrombocytes)**.**
- **Platelets are small, **colorless**, and **non-nucleated blood cells** that have a life span of about 10 days.**

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❖ Sequence of responses that stops bleeding

❑ **Three(3) mechanisms reduce blood loss.**

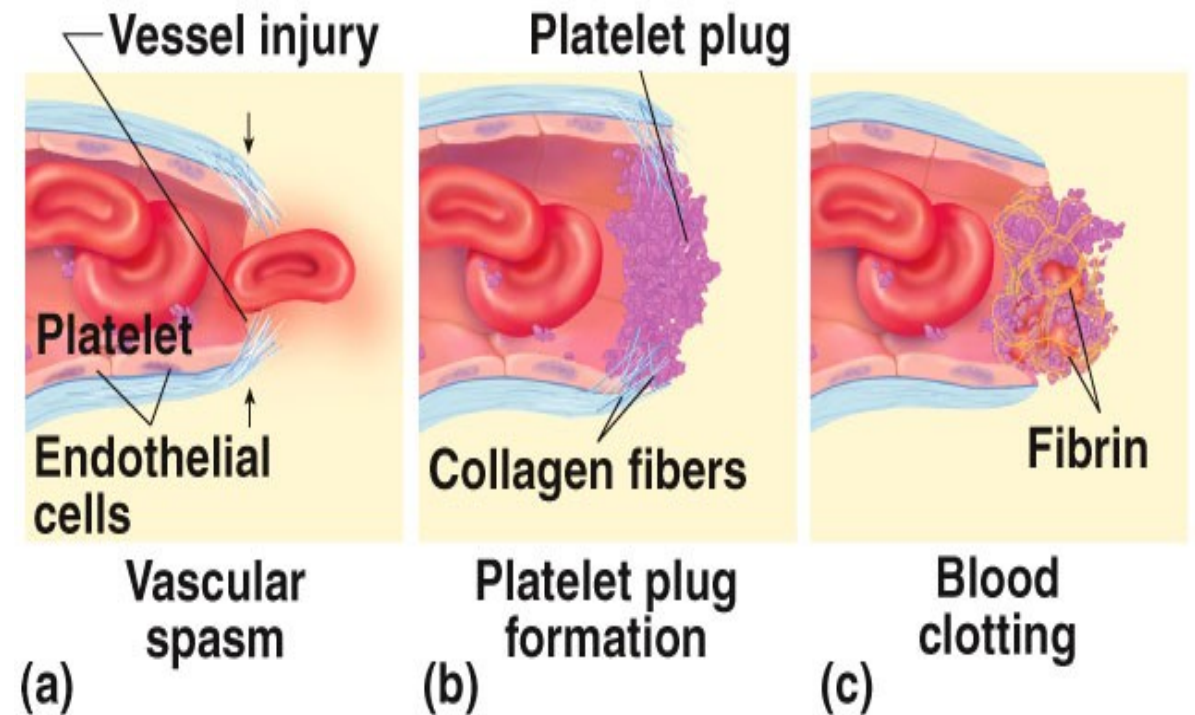
1. Vascular spasm

➤ *Smooth muscle in artery or arteriole walls contracts.*

2. Platelet plug formation

➤ *Platelets stick to parts of damaged blood vessel, become activated and accumulate large numbers.*

3. Blood clotting (coagulation)



Thrombo-embolic conditions in humans

- **Thrombus** : is an **abnormal clot** that develops in a blood vessels.
- **Emboli**: is a **thrombus that is freely flowing through the circulation**.
 - That is , the thrombi detaches , forced by flowing blood and cause the clot to flow through the circulation.
- **Causes:**
 1. **Rough endothelial surfaces of a vessel**
 2. **Slow stagnant flowing blood** in blood vessels can initiate clotting and emboli formation

Human Blood Groups or Blood types

- **Landsteiner**, 1901 (**Austrian scientist**) is the 1st to identify blood groups of humans and he got a Nobel prize for his finding in 1940.

Antigens and Antibodies

- Terms to become familiar with:
 - *Antigens* : a **chemical** that stimulates cells to produce antibodies.
 - *Antibodies* : a **protein** that reacts **against a specific antigen**.
 - *Agglutination* : **clumping** of red blood cells in response to a reaction between an antibody and an antigen.

Types of blood groups

- **RBC membranes** have **glycoprotein antigens** on their external surfaces.
- These antigens are:
 - **Unique** to the individual
 - **Recognized as foreign** if transfused into another individual
 - Promoters of agglutination and are referred to as **agglutinogens**.
- **Presence or absence** of these antigens is used to **classify blood groups**.

- There are several **different** types of **antigens on RBC surfaces**, but the most known and clinically important antigens for blood grouping are:
 - a. The ABO-blood groups, and**
 - b. The Rh-factors.**

- They are important because they can **cause severe agglutination reactions.**
- In the ABO system, blood is classified primarily on the basis of the A and B antigens that present on the **surface of RBC -membranes .**
- Their combinations produce **4-types of blood groups.**

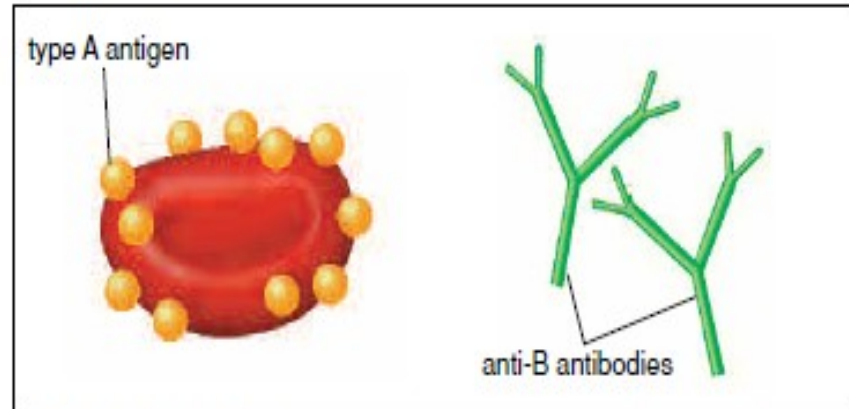
ABO-blood groups

- A person whose **red cells** possess the **antigen-A** (agglutinogen-A) has **anti-B antibody** (agglutinin) in **his serum** and is classified as **blood group A.**
- If **B-antigen** is present in the **Red cell membranes**, **Anti-A antibody** is present in his **serum** and the person is designated as **blood group B.**

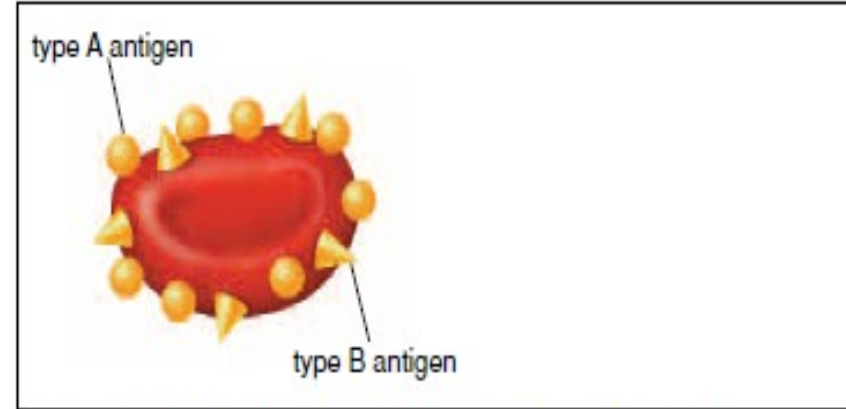
- If both **A and B-antigens** are present on Red cells, then he has **no antibody**, so he is **AB-blood group**.
- If **No antigens** are present on red cells, he is **O blood Type** and has both **anti A and B antibody** in his serum.

Group	Antigen in RBC	Antibody in serum
A	A	Anti-B (β)
B	B	Anti-A (α)
AB	A and B	No antibody
O	No antigen	Anti-A and Anti-B

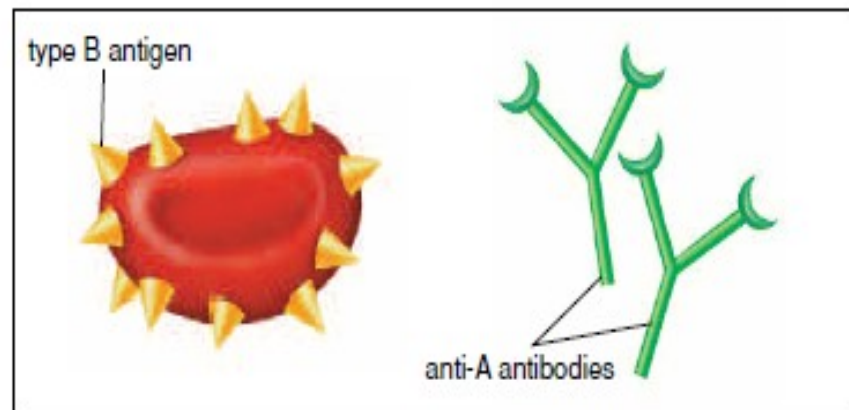
ABO-blood typing



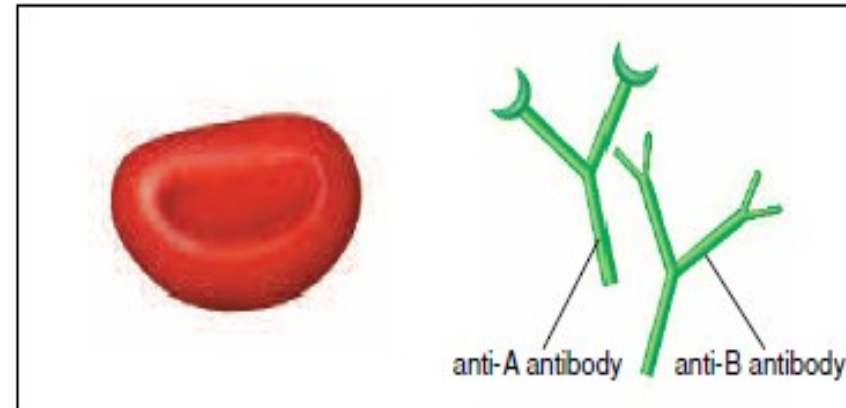
Type A blood. Red blood cells have type A surface antigens. Plasma has anti-B antibodies.



Type AB blood. Red blood cells have type A and type B surface antigens. Plasma has neither anti-A nor anti-B antibodies.



Type B blood. Red blood cells have type B surface antigens. Plasma has anti-A antibodies.



Type O blood. Red blood cells have neither type A nor type B surface antigens. Plasma has both anti-A and anti-B antibodies.

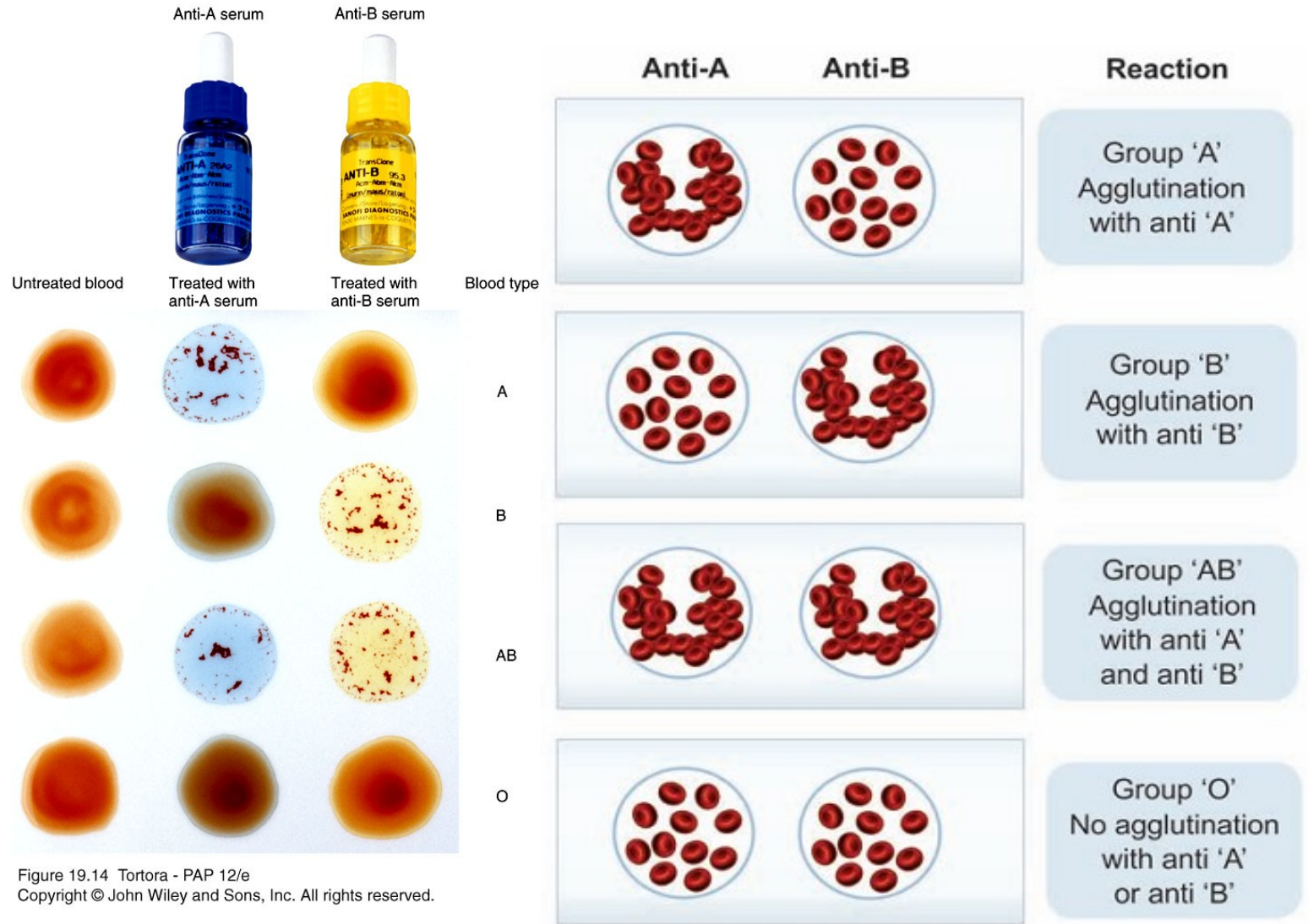
Figure 11.6 Types of blood. In the ABO system, blood type depends on the presence or absence of antigens A and B on the surface of red blood cells. In these drawings, A and B antigens are represented by different shapes on the red blood cells. The possible anti-A and anti-B antibodies in the plasma are shown for each blood type. Notice that an anti-B antibody cannot bind to an A antigen, and vice versa.

Preferred and Permissible blood type for transfusion

Blood Type of Recipient	Preferred Blood Type of Donor	Permissible Blood Type of Donor (In an Extreme Emergency)
A	A	O
B	B	O
AB	AB	A, B, O
O	O	No alternate types

Determination of blood group

- Single drops of blood are mixed with different antisera
- Agglutination with an *antisera* indicates the presence of that *antigen on the RBC*.



Universal donor

- **Blood group “O”** is called **universal donor**, because people with this blood types have **no antigens on their cell-membrane surfaces** and therefore can **not agglutinate if transfused to any blood types**.
- Even though they **lack antigens**, they have **Anti- A & anti-B antibodies in their plasma**.
 - **So, they can receive blood only from persons with blood group “O”.**

Universal recipient

- Blood group **AB** is called universal recipient.
- People with **AB-blood group** can take blood from any **blood types**, because they have **no antibodies** in their blood to cause agglutination reactions.
- **AB can donate blood only to a person with blood AB, not to the others.**

Rh factor

- Rh factor is an antigen present in RBC.
- It was first discovered in **Rhesus monkey** and hence the name 'Rh factor'.
- There are many Rh antigens, (e.g., **C, D, E, c, d, e**),
 - **but the most potent one** (more antigenic) in human **is antigen D**.
- Percentage of Rh positive people is more among black people.

- Thus, people are **classified as Rh+**, if their **red cells possess the Rh-antigen (called D antigen)** or
- **Rh-**, if they **do not posses the D antigen** on their Red cells.
- **Rh- subjects can produce antibodies against that antigen only when they are exposed to Rh+ blood.**

- If Rh⁻ individual receives Rh⁺ blood, **anti-Rh antibodies form.**
- A second exposure to Rh⁺ blood will result in a **typical transfusion reaction.**

Rh Factor and Pregnancy

- **Rh- incompatibility:** Usually causes serious problems

The Incompatibility:

- **Father Rh +** = **Rh +** means he **has D-antigen** on his RBC membrane
- **Mother Rh-** = **No** Rh factor, so it is depicted as **Rh-**

1. Rh+ father X Rh- mother = Rh + fetus

2. During birth through placenta , Rh+ blood (antigens) of the fetus leak (enter) to mothers blood and **sensitizes** her.

3. A second exposure to Rh⁺ leads to **Hemolytic Disease of the Newborn.**

Hemolytic Disease of the Newborn (Erythroblastosis Fetalis)

- May occur in an *Rh- pregnant mother with an Rh+ fetus*
- Rh⁻ mother becomes sensitized when Rh⁺ blood (from a previous pregnancy of an Rh⁺ baby or a Rh⁺ transfusion) causes her body to **synthesis Rh⁺ antibodies**.
- Rh⁺ antibodies of a sensitized Rh⁻ mother **cross the placenta** and **attack** and **destroy** the **RBCs of an Rh⁺ baby**.
- The drugs can prevent the Rh⁻ mother from becoming sensitized.
- Treatment of **hemolytic disease of the newborn** involves **pre-birth transfusions** and **exchange transfusions after birth**.

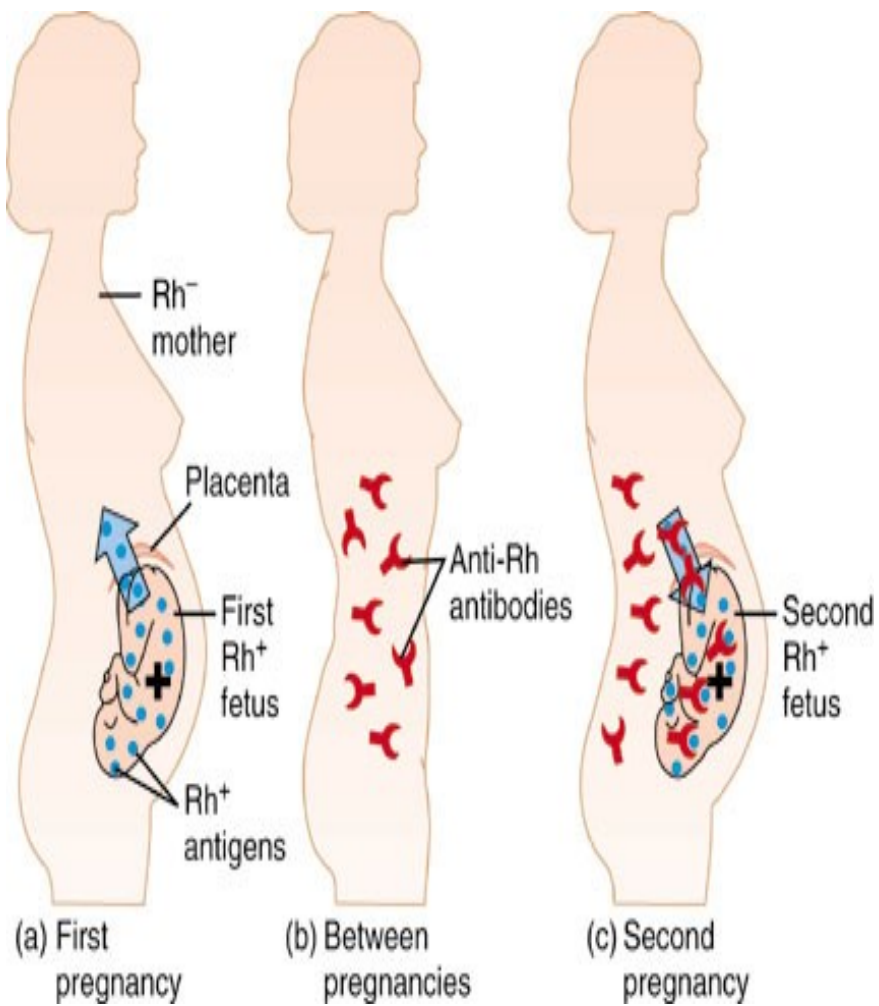
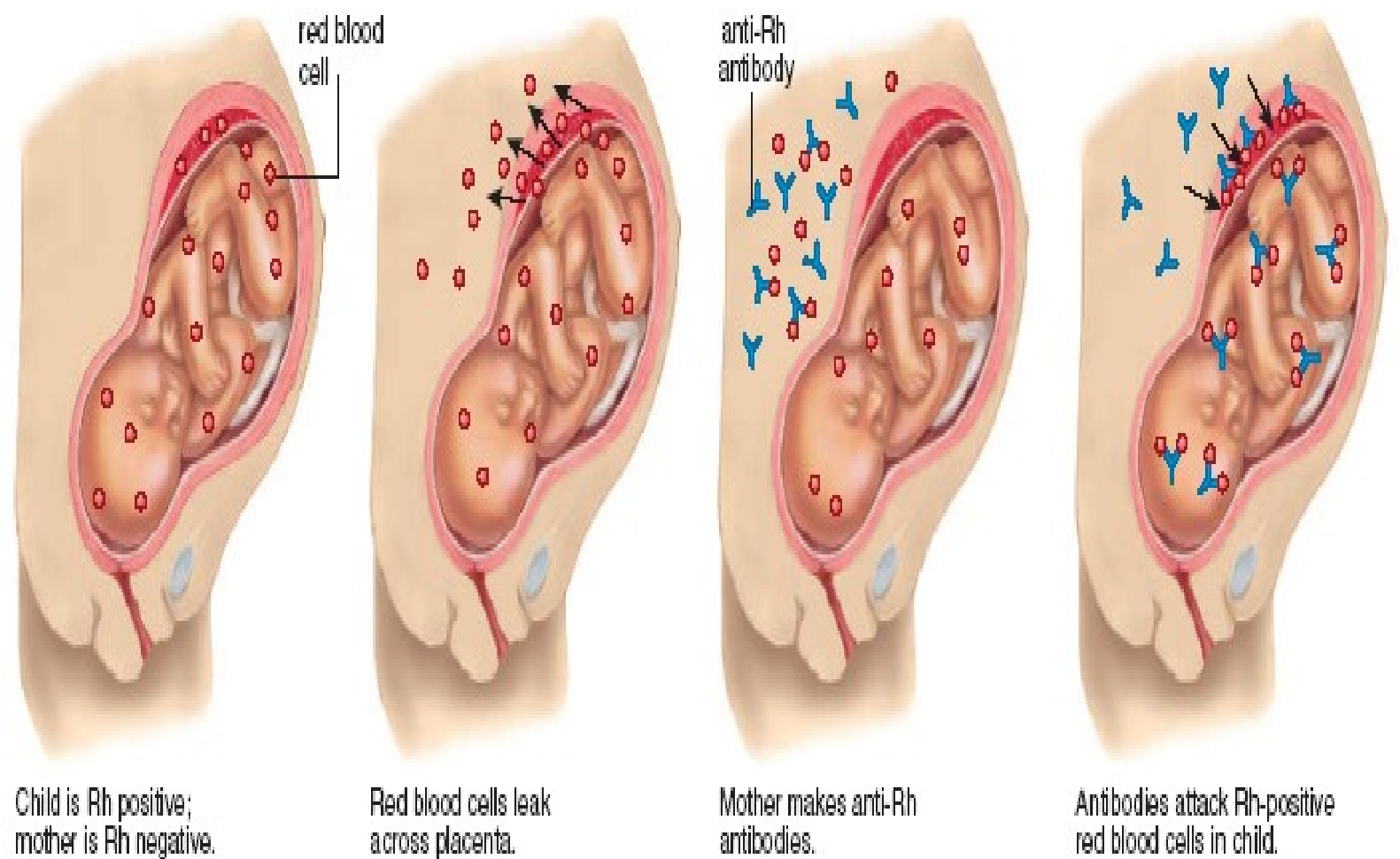


Figure 6.11 Hemolytic disease of the newborn.

Due to a pregnancy in which the child is Rh⁺, an Rh⁻ mother can begin to produce antibodies against Rh⁺ red blood cells. In another pregnancy, these antibodies can cross the placenta and cause hemolysis of an Rh⁺ child's red blood cells.

Blood transfusion

- Blood transfusion is the **process of transferring blood or blood components** from one person (the donor) into the bloodstream of another person (the recipient).
- Transfusion of **whole blood** or its parts is supplied in order to:
 - **Restore blood volume**
 - **Improve O₂ transport to tissues**
 - **Correct bleeding abnormalities** etc.

- Transfusion is done as a **life-saving procedure** to replace blood cells or blood products lost through bleeding.
- Blood transfusion is essential in the following conditions:
 - **Anemia**
 - **Hemorrhage, Trauma**
 - **Burns** and
 - **Surgery.**

EXCHANGE TRANSFUSION

- Exchange transfusion is the procedure which involves **removal** of patient's blood completely and **replacement** with fresh blood or plasma of the donor.
- It is otherwise known as **replacement transfusion**.
- It is an important life-saving procedure carried out in conditions such as:
 - ❖ **Severe jaundice,**
 - ❖ **Sickle cell anemia, Leukemia**
 - ❖ **Erythroblastosis fetalis, etc.**

Principle of Transfusion

- Identification of blood group must be taken **before** transfusion.
- Cross-match test must be done **before** transfusion.
- The same types of blood group for transfusion should be firstly considered.
- The different types of blood group for transfusion should be done very **careful, small amount** and **slow import** and if condition is better, changes in the same types of blood group for transfusion.

Cross matching

- Cross matching is a condition where:
 - **RBC's of the donor** are mixed with
 - **Serum (or antibodies) of the recipient** to check for compatibility reactions.
- So, Cross matching before transfusion **eliminates the possibility of any error in blood group of the donor.**
- **Cross-matching** = **Recipient's serum + Donor's RBC.**

- Hazards of blood transfusion should also be considered and carefully guarded:
 1. **Mismatched (incompatible) blood reactions**
 2. **Cross infections AIDS, malaria, hepatitis etc.,**
 3. **Volume overload, causing myocardial damage etc.**

Transfusion Reactions

- **Transfusion reactions** occur when *mismatched blood is infused*.
- Donor's cells are attacked by the recipient's plasma agglutinins causing:
 - Diminished oxygen-carrying capacity
 - Clumped cells that impede blood flow
 - Ruptured RBCs that release free hemoglobin into the bloodstream.