Composition of the Blood



1) *Plasma*

2) *The Formed Elements*
(blood cells/cell fragments)

General Properties of Whole Blood

- Fraction of body weight **8%**
- Volume
  Female: 4-5 L
  Male: 5-6 L
- temperature **38° C (100.4° F)**
- pH **7.35 - 7.45**
- Viscosity (relative to water)
  Whole blood: 4.5-5.5
  plasma: 2.0
- Osmolarity **280-300 mOsm/L**
- Mean salinity (mainly NaCl) **0.85%**

Hematocrit



RBCs as percent of total blood volume

100%

- Female: **37%-48%**
- male: **45%-52%**

General Properties of Whole Blood (continued)

Hemoglobin

Female:	12-16 g/100 ml
male:	13-18 g/100 ml

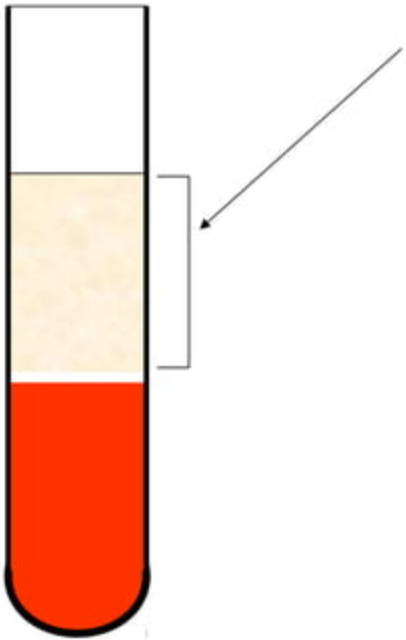
Mean RBC count

Female:	4.8 million/μl
male:	5.4 million/μl

Platelet counts 130,000-360,000/μl

Total WBC counts 4,000-11,000/μl

Plasma



Composition of Plasma

Water	92% by weight
Proteins	Total 6-9 g/100 ml
Albumin	60% of total plasma protein
Globulin	36% of total plasma protein
Fibrinogen	4% of total plasma protein
Enzymes of diagnostic value	trace
Glucose (dextrose)	70-110 mg/100 ml
Amino acid	33-51 mg/100 ml
Lactic acid	6-16 mg/100 ml

Composition of Plasma (continued)

Total lipid	450-850 mg/100 ml
Cholesterol	120-220 mg/100 ml
Fatty acids	190-420 mg/100 ml
High-density lipoprotein (HDL)	30-80 mg/100 ml
Low-density lipoprotein (LDL)	62-185 mg/100 ml
Neutral Fats (triglycerides)	40-150 mg/100 ml
Phospholipids	6-12 mg/100 ml

Composition of Plasma (continued)

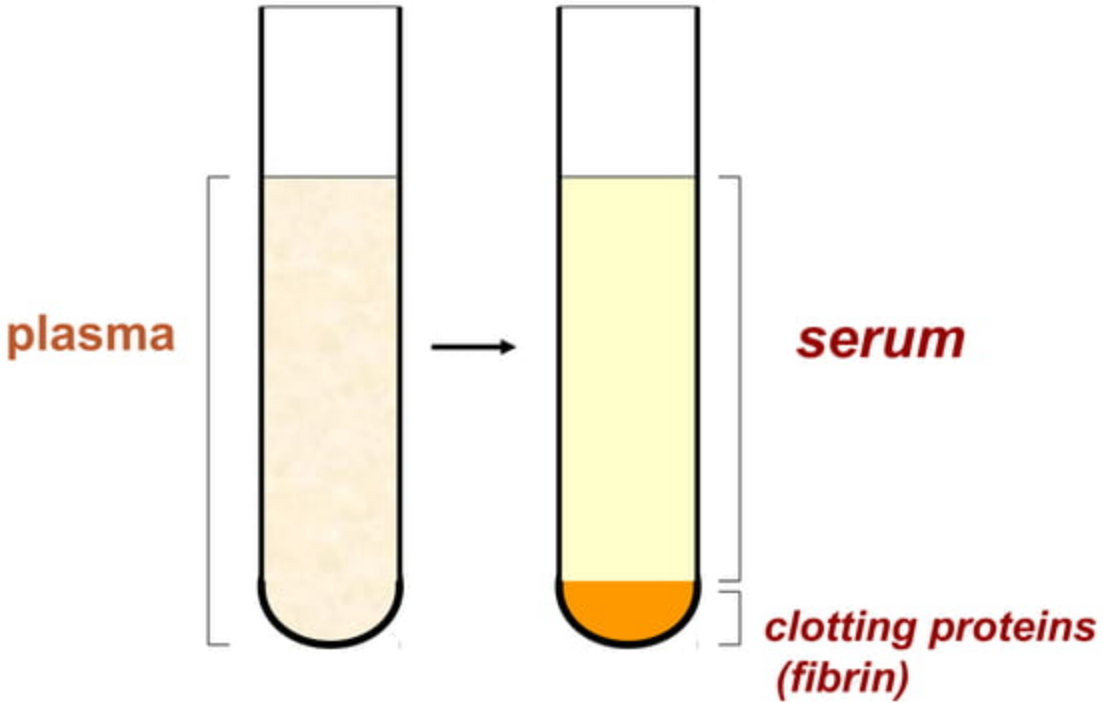
Iron	50-150 µg/100 ml
Vitamins (A, B, C, D, E, K)	Trace amount
Electrolytes	
Sodium	135-145 mEq/L
Potassium	3.5-5.0 mEq/L
Magnesium	1.3-2.1 mEq/L
Calcium	9.2-10.4 mEq/L
Chloride	90-106 mEq/L
Bicarbonate	23.1-26.7 mEq/L
Phosphate	1.4-2.7 mEq/L
Sulfate	0.6-1.2 mEq/L

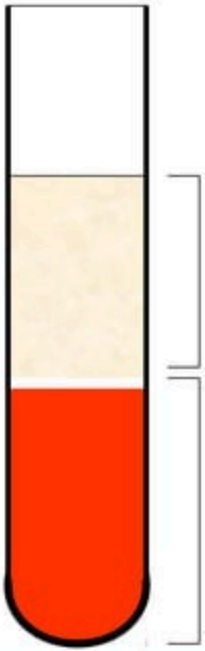
Composition of Plasma (continued)

Nitrogenous Wastes

Ammonia	0.02-0.09 mg/100 ml
Urea	8-25 mg/100 ml
Creatine	0.2-0.8 mg/100 ml
Creatinine	0.6-1.5 mg/100 ml
Uric acid	1.5-8.0 mg/100 ml
Bilirubin	0-1.0 mg/100 ml

Respiratory gases (O_2, CO_2, and N_2)


plasma
serum
clotting proteins
(fibrin)



The Formed Elements

(Blood Cells)

Formed elements include:

Erythrocytes (red blood cells, RBCs)

Platelets (cellular fragments)

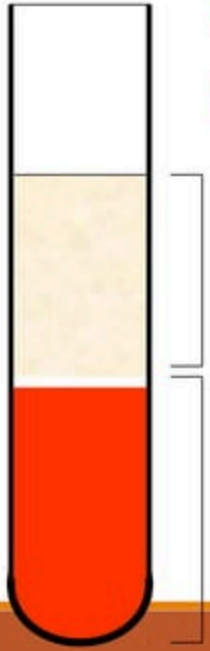
Leukocytes (white blood cells, WBCs)

Granulocytes

- ***Neutrophils***
- ***Eosinophils***
- ***Basophils***

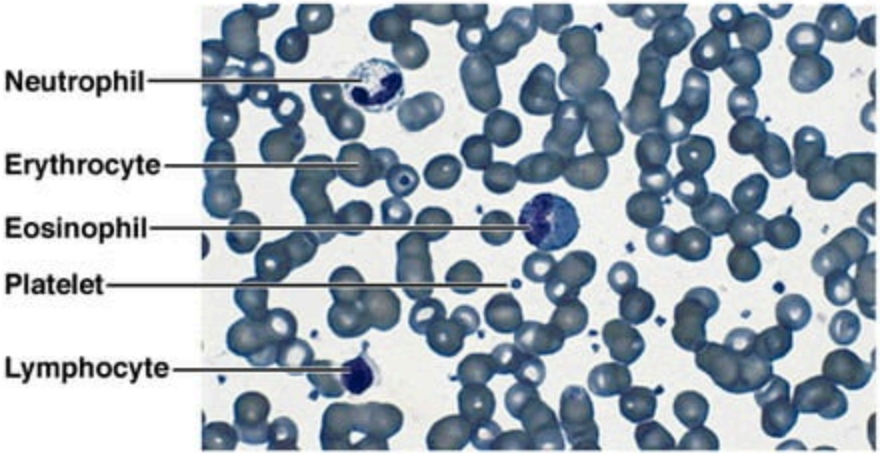
Agranulocytes

- ***Lymphocytes***
- ***Monocytes***

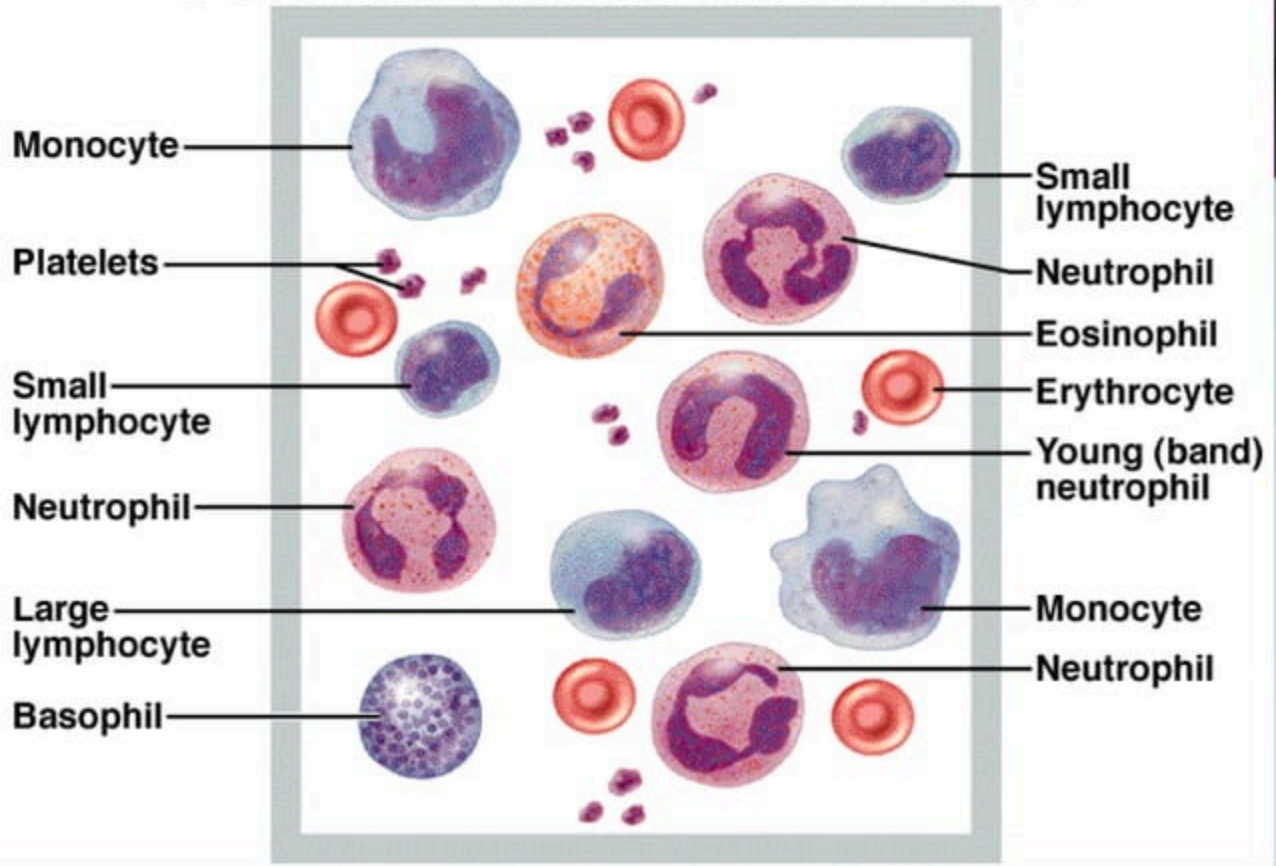




Normal Blood Smear

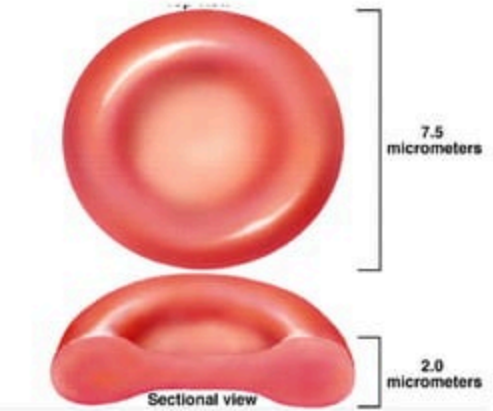


Formed Elements of Blood



Erythrocytes
(red blood cells)

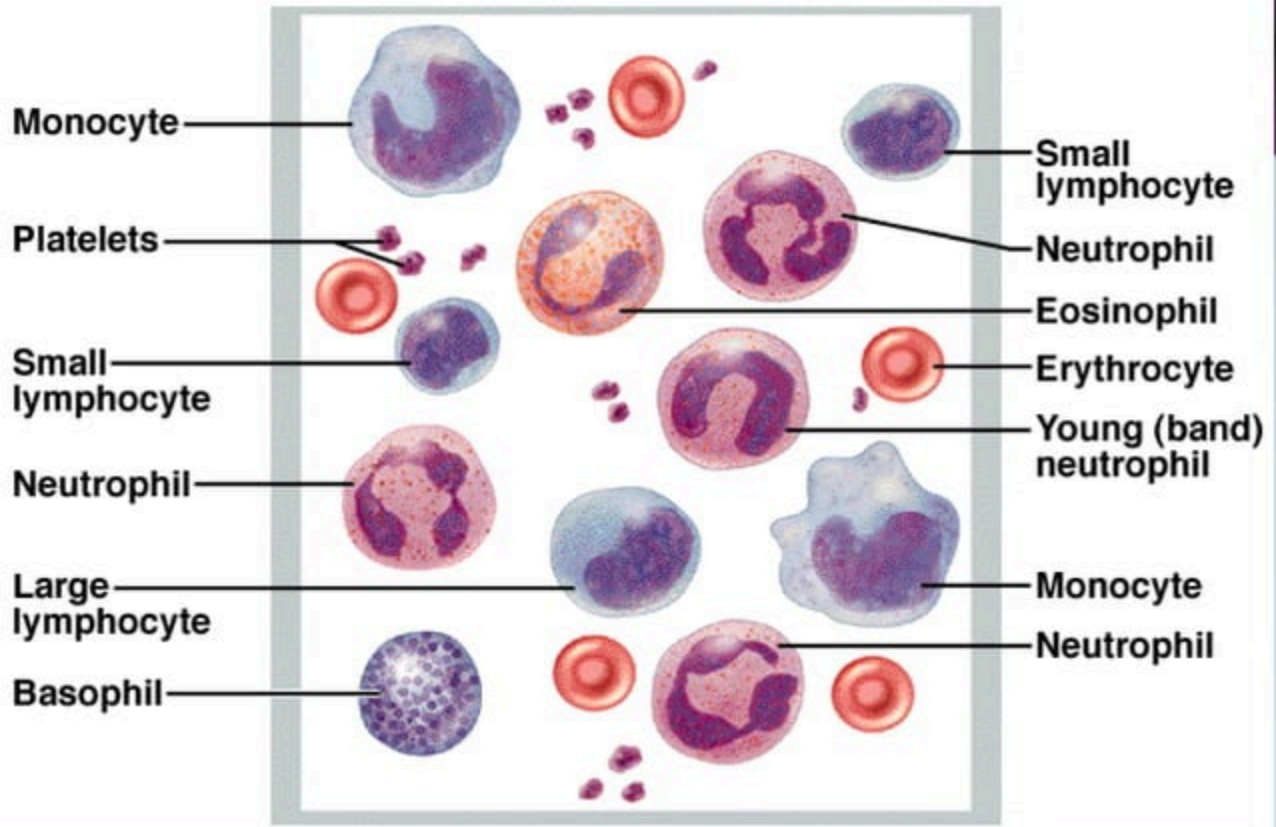
Erythrocytes (Red Blood Cells, RBCs)



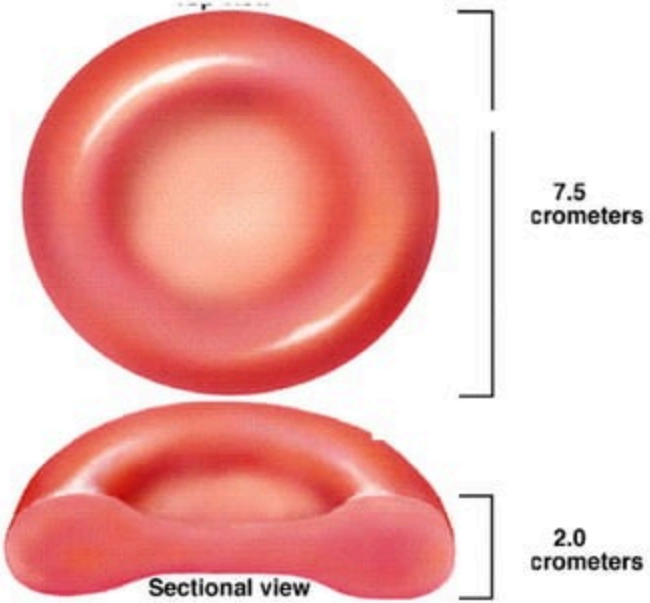
Appearance:

- ***biconcave disc*** shape, which is suited for gas exchange. The shape is flexible so that RBCs can pass though the smallest blood vessels, i.e., capillaries.

Erythrocytes are smaller than Leukocytes.



Erythrocytes (Red Blood Cells, RBCs)



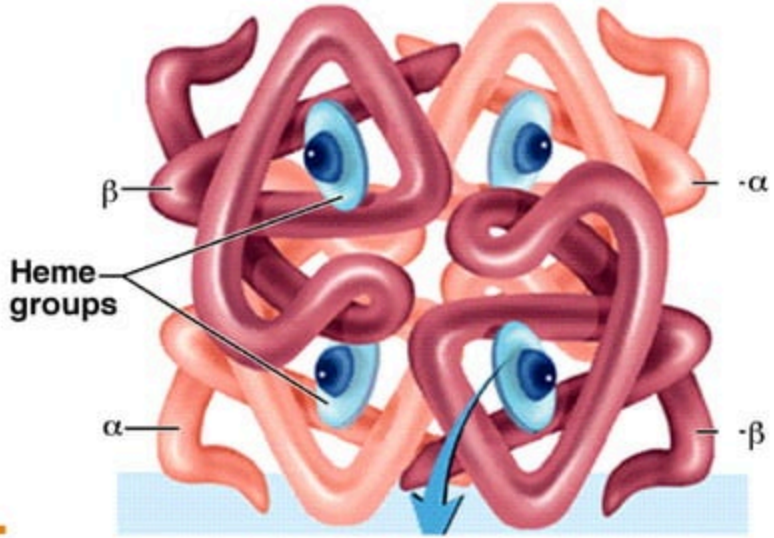
Structure:

-Primary cell content is ***hemoglobin***, the protein that binds oxygen and carbon dioxide.

- no nucleus nor mitochondria

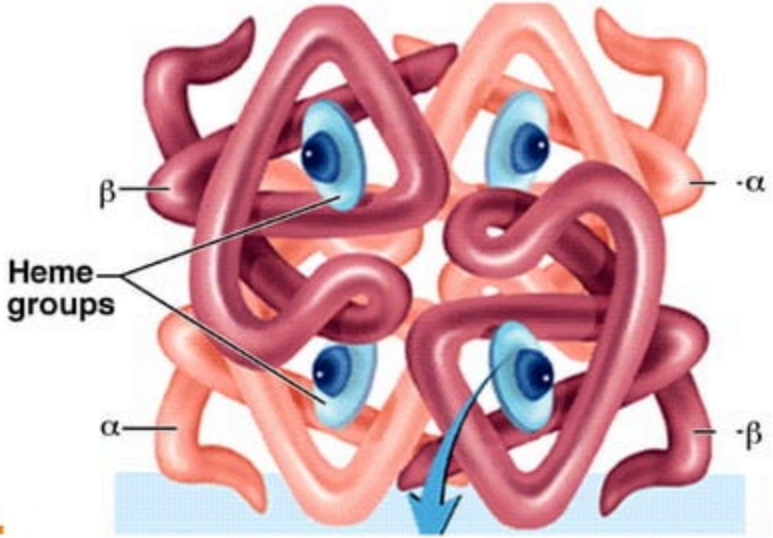
Hemoglobin consists of :

globin and *heme* pigment



Globin

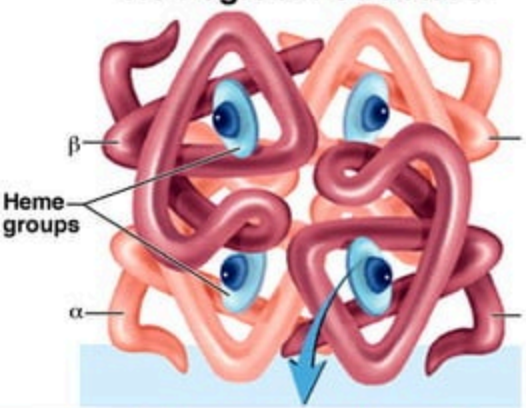
- Consists of two α and two β subunits
- Each subunit binds to a heme group



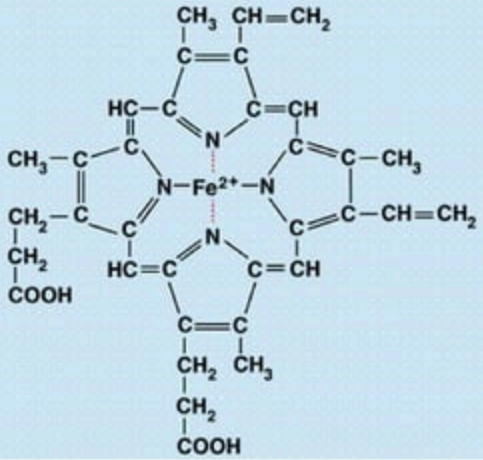
Heme Groups

Each heme group bears an atom of iron, which binds reversibly with one molecule of oxygen

Hemoglobin Structure

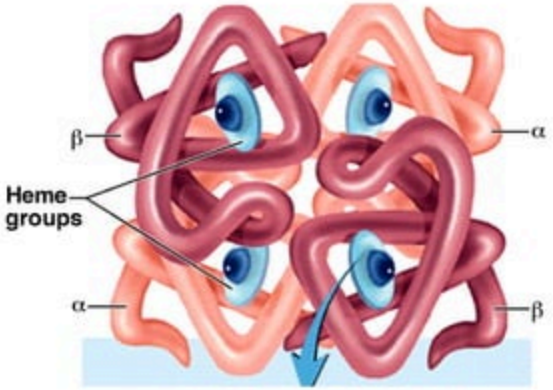


Heme Group Structure



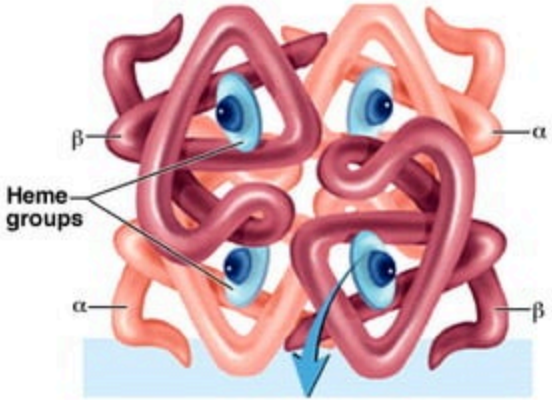
carry four molecules of oxygen

Carbon monoxide competes with oxygen for heme binding with a much higher affinity.



Problem: deoxygenate hemoglobin

Treatment: hyperbaric oxygen chamber



Oxyhemoglobin

- bound with oxygen
- red

Deoxyhemoglobin

- free of oxygen
- dark red.

Carbaminohemoglobin

20% of carbon dioxide in the blood binds to the **globin** part of hemoglobin, which is called ***carbamino-hemoglobin***.

Functions of Erythrocytes

1) Primary Function

Transport oxygen from the lung to tissue cells and carbon dioxide from tissue cells to the lung

2) Buffer blood pH

Production of Erythrocytes

Hematopoiesis

refers to whole blood cell production.

Erythropoiesis

refers specifically to red blood cell production.

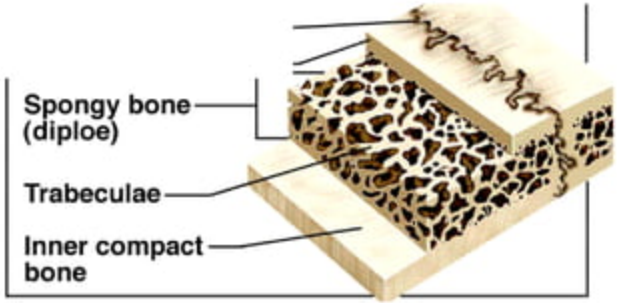
All blood cells, including red and white, are produced in ***red bone marrow***.

On average, one ounce, or 100 billion blood cells, are made each day.

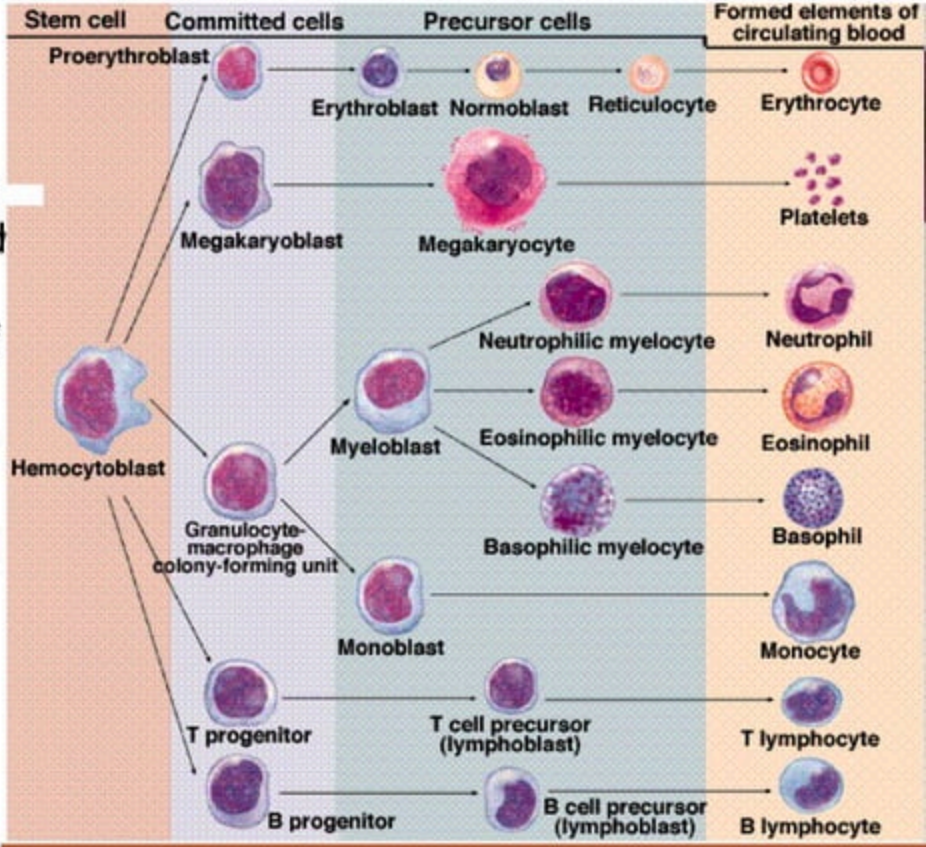


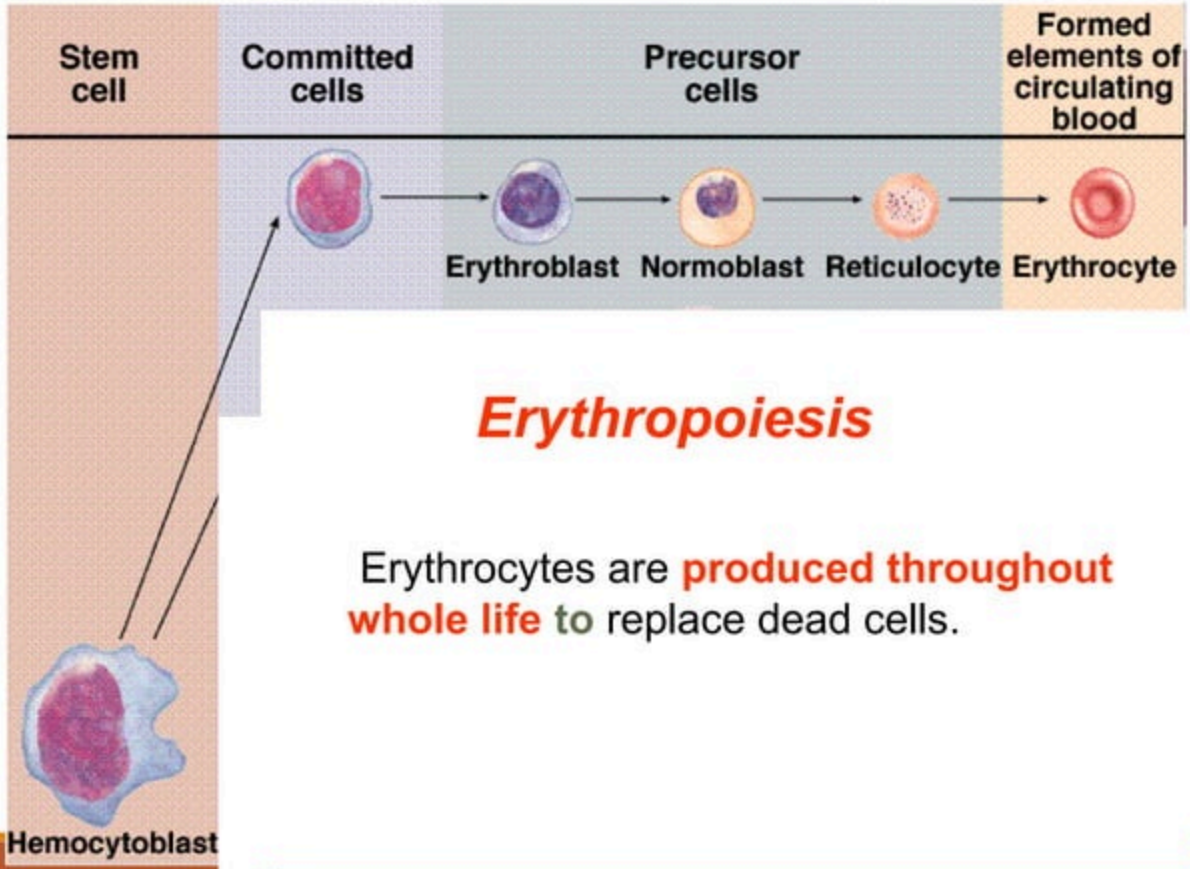
Hematopoiesis

-The **red bone marrow** is a network of reticular connective tissue that borders on wide blood capillaries called blood sinusoids. As hemocytoblasts mature, they migrate through the thin walls of the sinusoids to enter the blood.



All of blood cells including red and white arise from the same type of stem cell, the ***hematopoietic stem cell*** or ***hemocytoblast***





Erythropoiesis

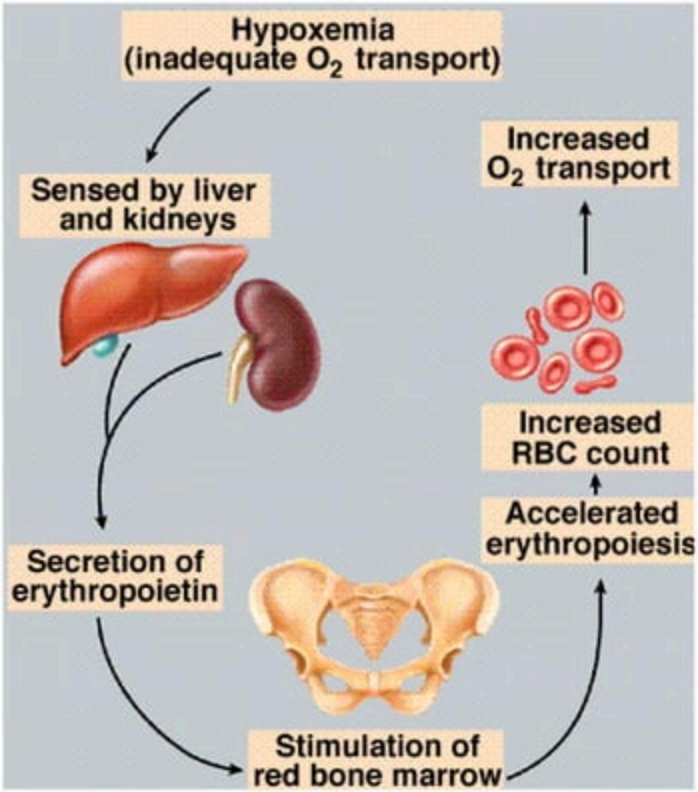
Erythrocytes are **produced throughout whole life to** replace dead cells.

Feedback Regulation of Erythropoiesis

- regulated by renal oxygen content.

- ***Erythropoietin***, a glycoprotein hormone, is produced by renal cells in response to a decreased renal blood O2 content.

- Erythropoietin stimulates erythrocyte production in the red bone marrow.



A drop in renal blood oxygen level can result from:

1) reduced numbers of red blood cells due to hemorrhage or excess RBC destruction.

2) reduced availability of oxygen to the blood, as might occur at high altitudes or during pneumonia.

3) increased demands for oxygen (common in those who are engaged in aerobic exercise).

Ways to increase Red Blood Cell Count in Sports

Legal

raise RBC count by training athletes at high altitude

Illegal

use *erythropoietin, androgen,* or their analogs

Dietary Requirements for Erythropoiesis

Iron

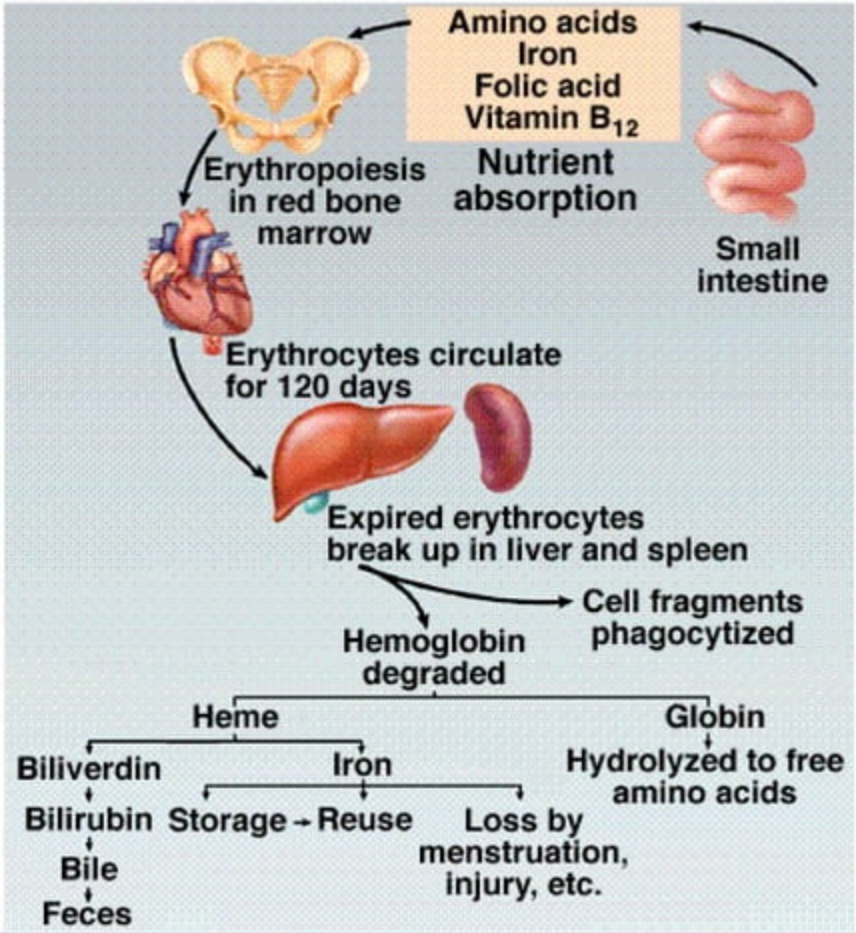
vitamin B12

folic acid

More important to women due to the loss of blood during menstruation

Erythrocyte Life Cycle

The average life span of erythrocytes is 120 days.



Erythrocyte Disorders

Anemia

is a condition in which the blood has an abnormally low oxygen-carrying capacity.

Common causes of anemia include:

1) an insufficient number of red blood cells

2) decreased hemoglobin content

3) abnormal hemoglobin

   Two such examples are ***Thalassemias*** and ***Sickle-cell anemia***, which are caused by genetic defects.

Erythrocyte Disorders - 2

Polycythemia

is an abnormal excess of erythrocytes that increases the viscosity of the blood, causing it to sludge or flow sluggishly.

Common causes of polycythemia include:

1) Bone marrow cancer
2) A response to reduced availability of oxygen as at high altitudes

Human Blood Groups

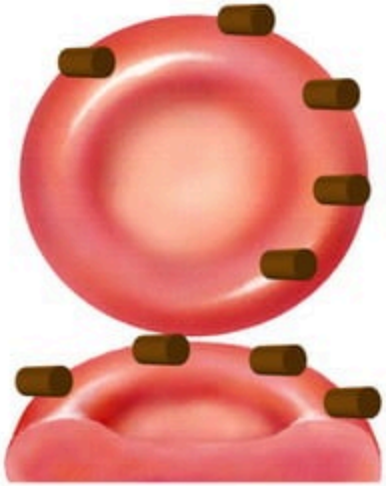
Human Blood Groups

- were learned from tragedies (death) caused by mismatch during transfusion in ancient time.

- ABO blood types were identified in 1900 by Karl Landstein (1930 Nobel laureate).

- Other blood types were identified later.

***Blood type* is determined by**



Agglutinogens

- are specific glycoproteins on red blood cell membranes.
- All RBCs in an individual carry the same specific type of agglutinogens.

ABO Blood Groups

Type A: RBCs carry agglutinogen A.

Type B: RBCs carry agglutinogen B.

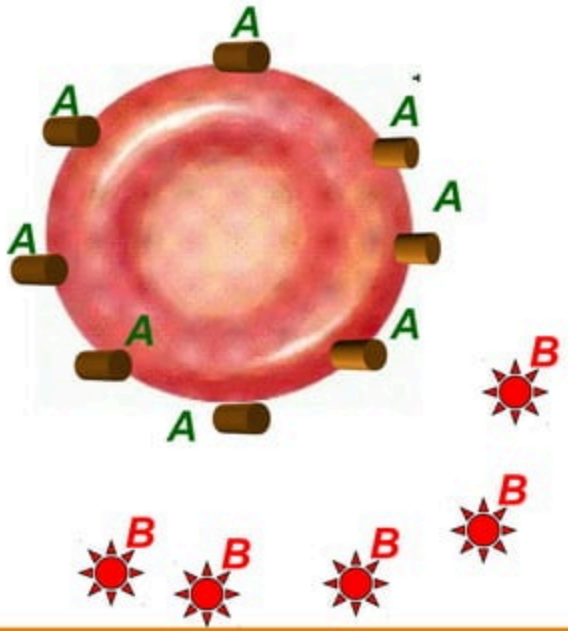
Type O: RBCs carry no A nor B agglutinogens.

Type AB: RBCs carry both A and B agglutinogens.

Type A blood

- RBCs carry type ***A agglutinogens***.

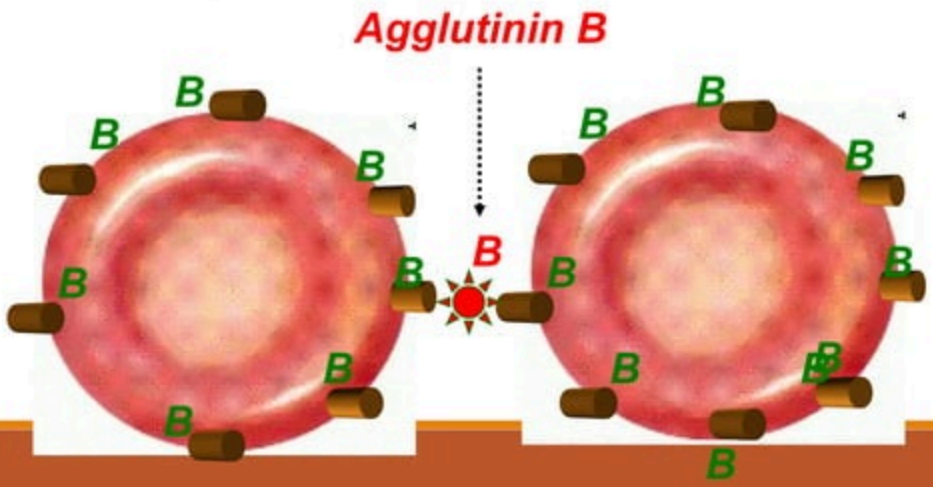
- Plasma contain preformed antibodies, ***Agglutinin B***, against B agglutinogens.



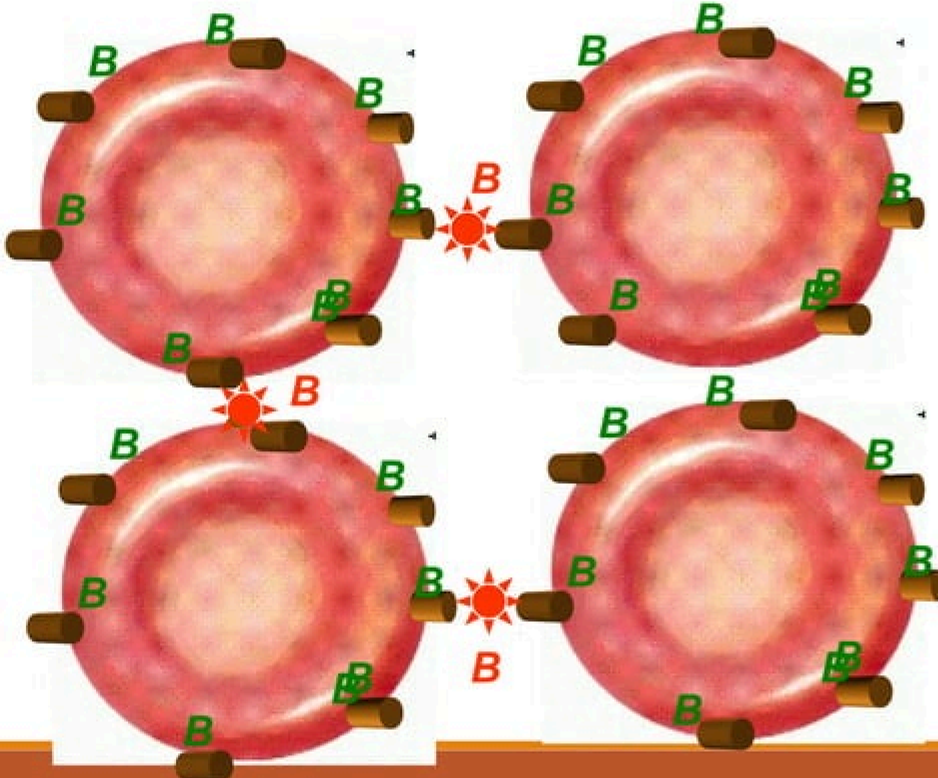


Agglutinins

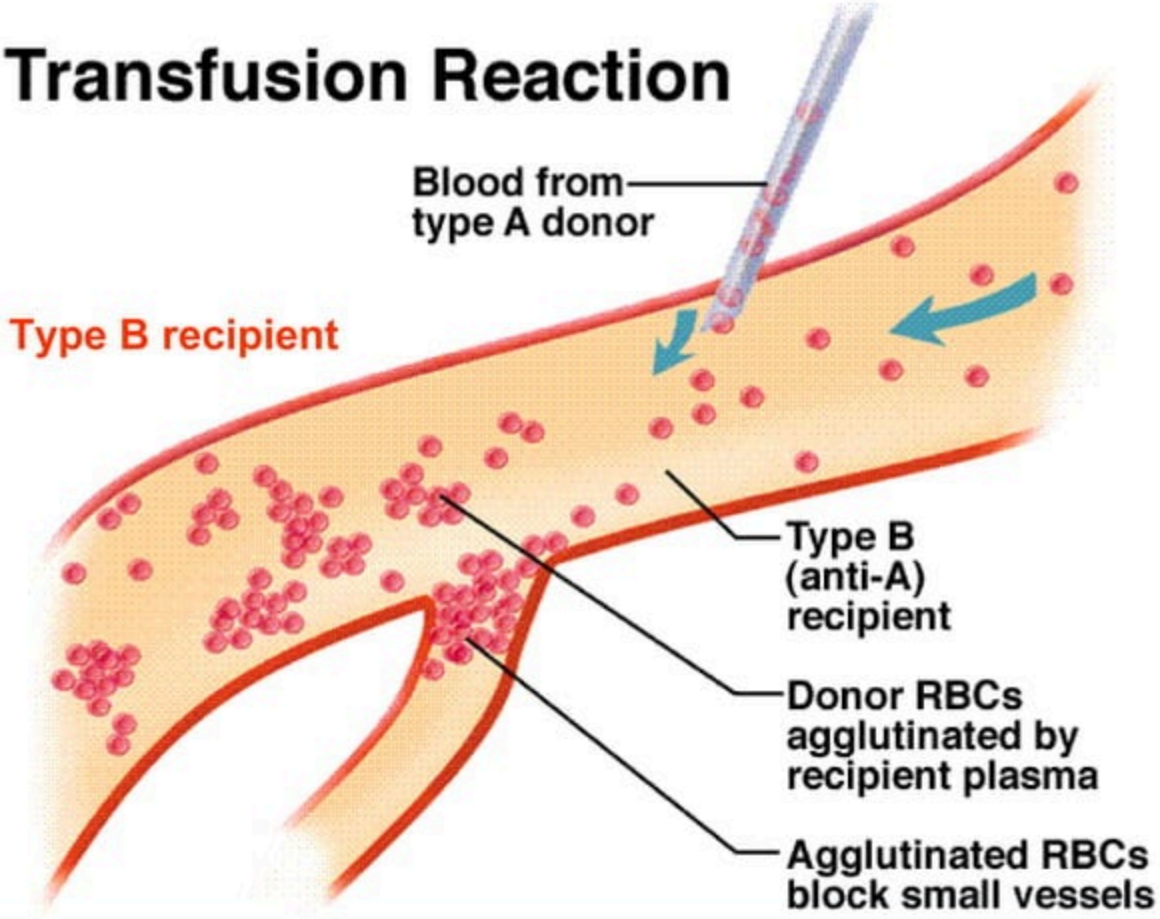
- are preformed antibodies in plasma
- bind to agglutinogens that are not carried by host RBCs
- cause agglutination --- aggregation and lysis of incompatible RBCs.



Mix *Type A plasma* with *Type B RBCs*



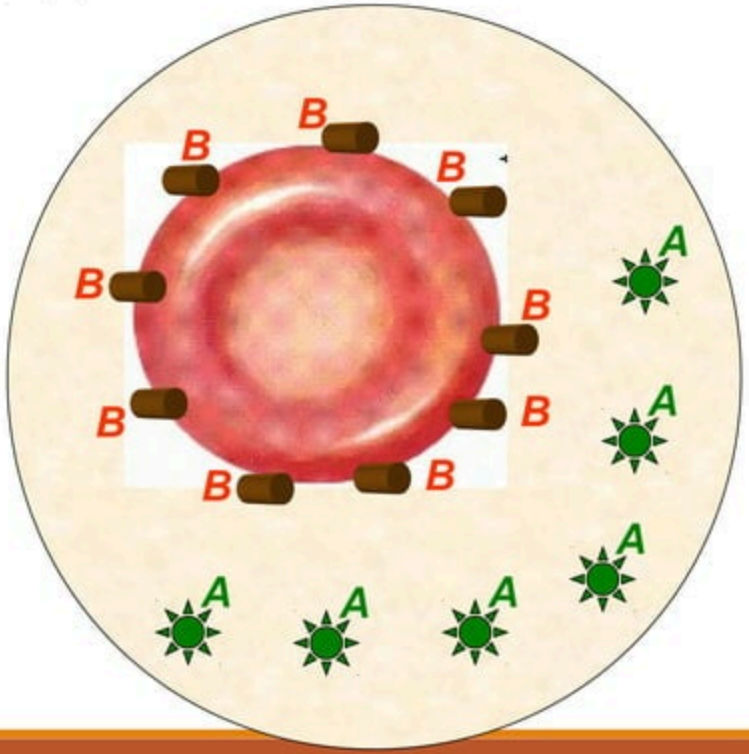
Transfusion Reaction



Type B blood

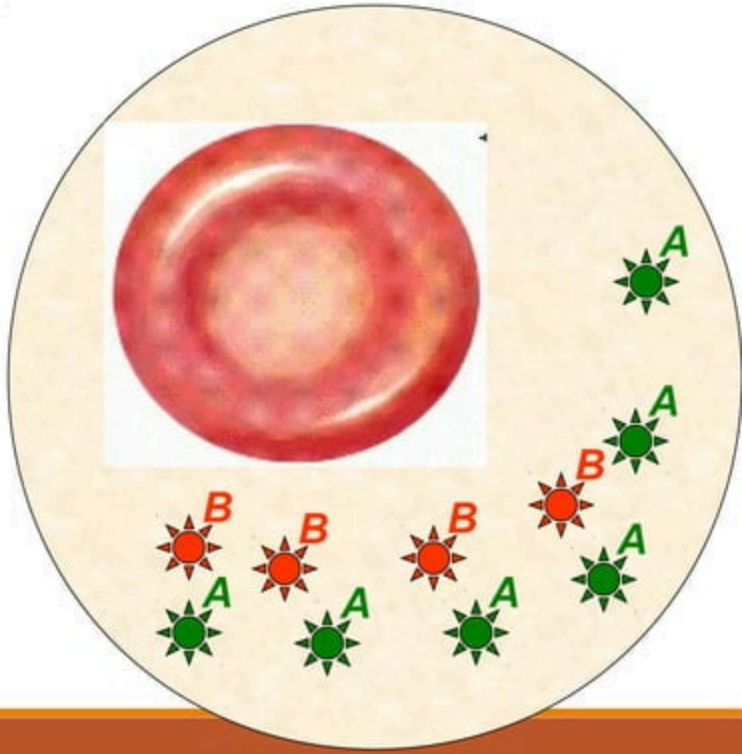
-RBCs carry type ***B agglutinogens***.

- Plasma contain agglutinin against ***A agglutinogens***.



Type O blood

- RBCs carry neither type A nor type B agglutinogens.
- Plasma contain agglutinin against both ***A*** and ***B*** ***agglutinogens.***
- The person can accept only type O blood transfusion.



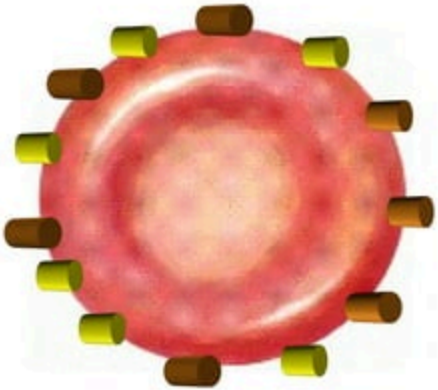
Type AB blood

Agglutinogen(s) ?

Agglutinin(s) ?

Type AB blood

Agglutinogen(s): **A and B**



Agglutinin(s) ? **No A nor B**

Summary of ABO Blood Groups

Blood Type	Agglutinogen (on RBC)	Agglutinin (in Plasma)
A	A	B
B	B	A
O		A & B
AB	A & B	