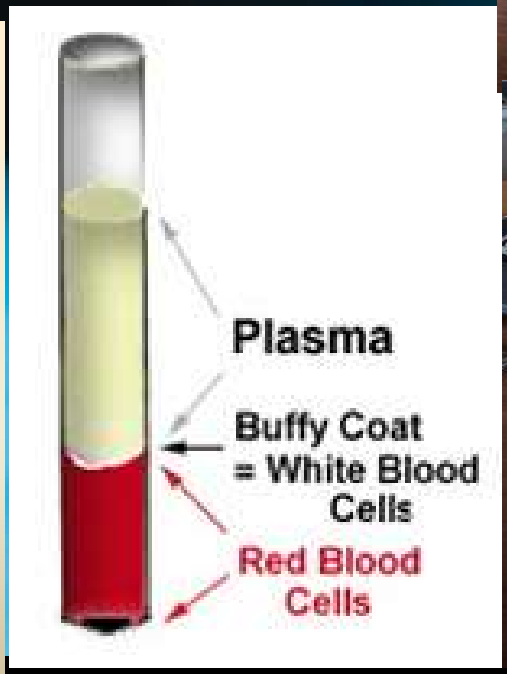
Selected blood test lab

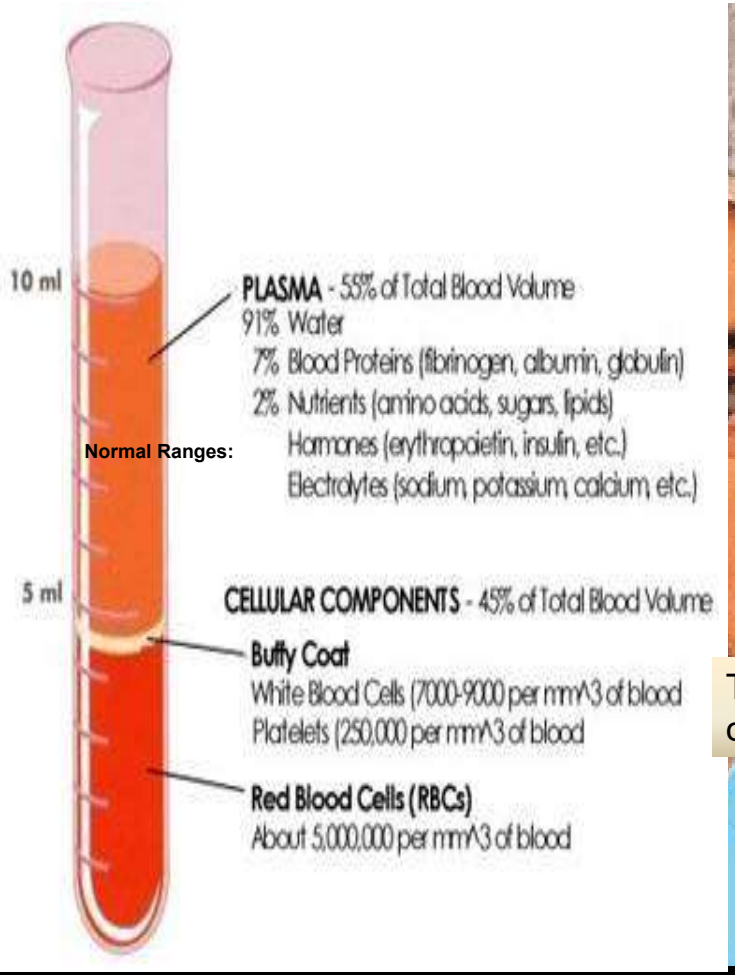
Danil Hammoudi.MD

HEMATOCRIT= PACKED RBC HEIGHT / TOTAL SAMPLE HEIGHT X100

Hematocrit = (Volume of RBCs / Total Blood Volume) × 100

- **The hematocrit (Ht or HCT) or packed cell volume (PCV) or erythrocyte volume fraction (EVF) is the proportion of blood volume that is occupied by red blood cells.**
- It is normally about 47% for men and 42% for women.
- It is considered an integral part of a person's complete blood count results, along with hemoglobin concentration, white blood cell count, and platelet count.





Normal Ranges:

Group	Normal Hematocrit (%)
Men	41–50%
Women	36–44%
Children	36–40%
Newborns	44–64%

The **buffy coat** is the fraction of an anticoagulated blood sample after density gradient centrifugation that contains most of the **white blood cells and platelets**.

Low Hematocrit (Anemia) – Possible Causes:

- **Iron deficiency**
- **Vitamin B12 or folate deficiency**
- **Chronic diseases** (e.g., kidney disease, cancer)
- **Bleeding** (acute or chronic)
- **Bone marrow disorders**

Symptoms:

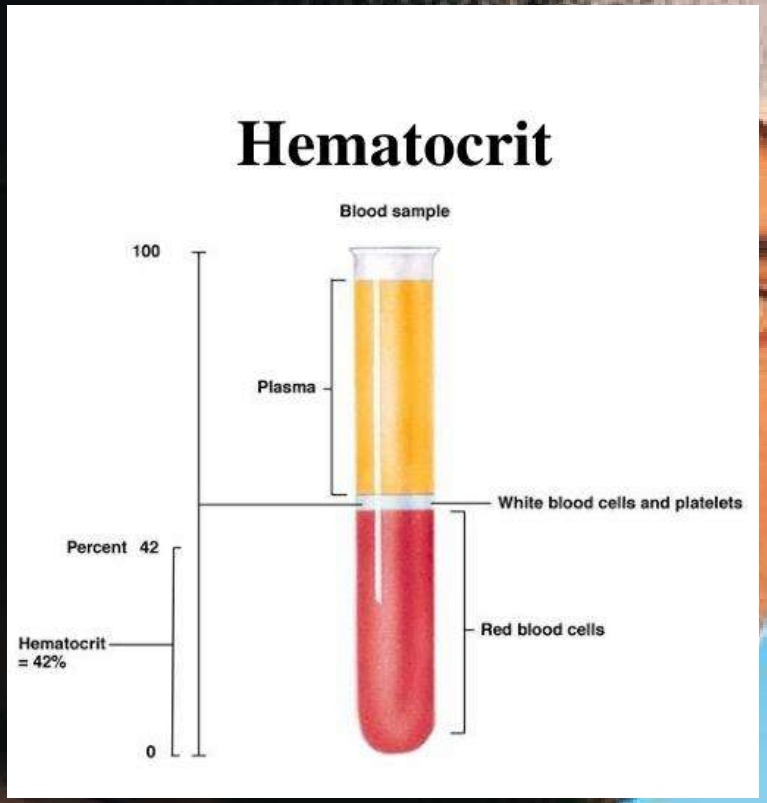
Fatigue,
pallor,
shortness of breath,
weakness

High Hematocrit (Polycythemia) – Possible Causes:

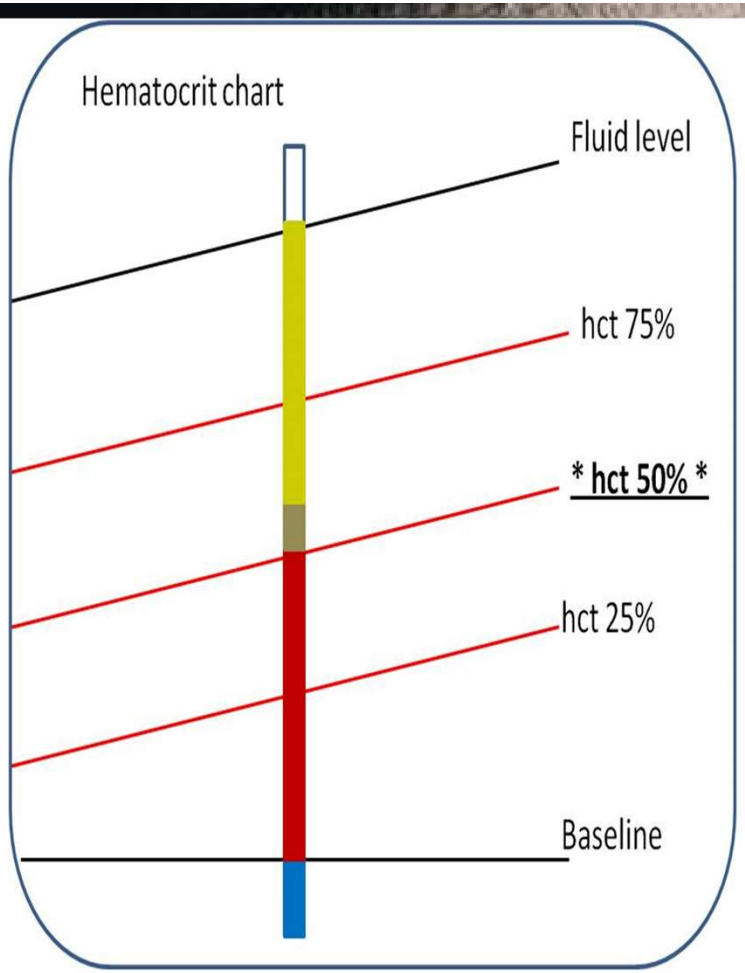
- **Dehydration**
- **Lung disease** (e.g., COPD)
- **Heart disease**
- **Polycythemia vera** (bone marrow disorder)
- **Living at high altitude**
- **Erythropoietin abuse** (e.g., in athletes)

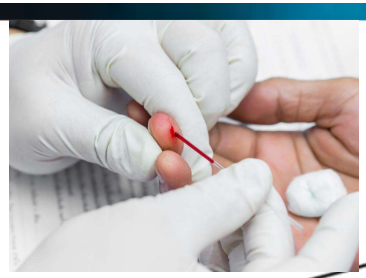
Symptoms:

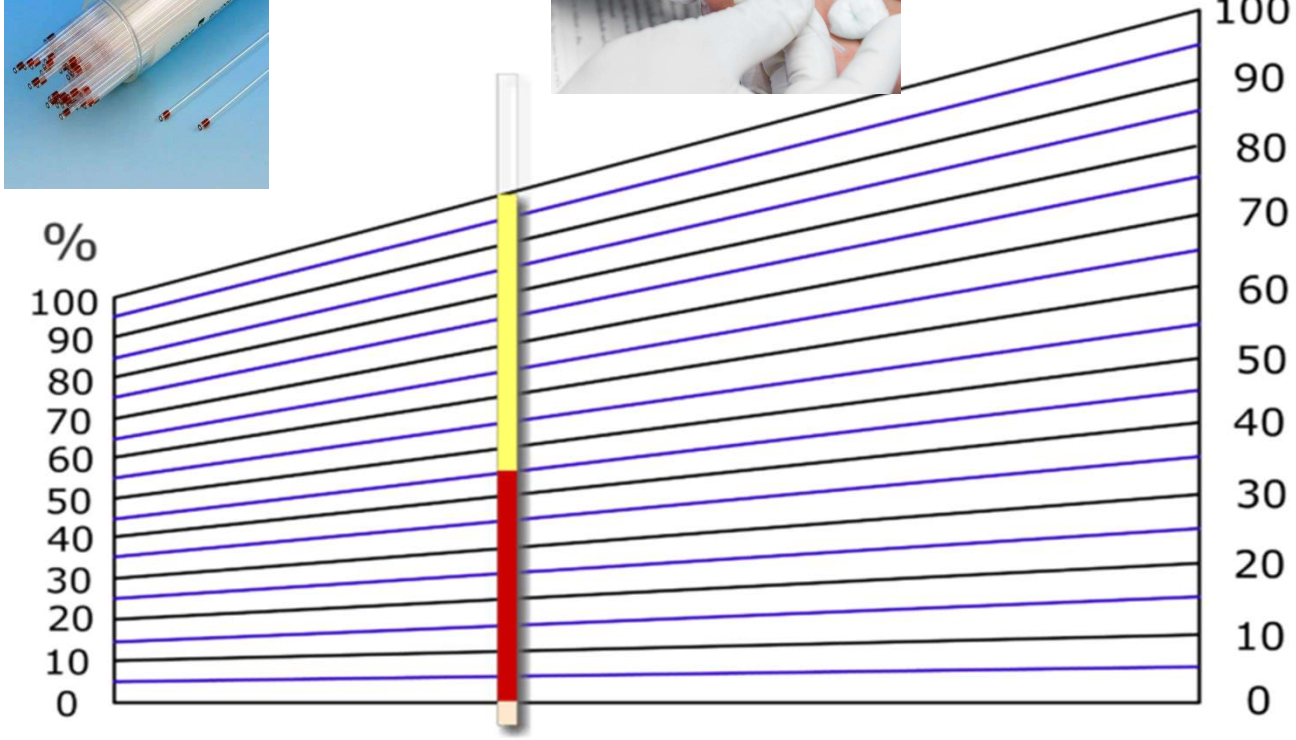
Headache,
dizziness,
blurred vision,
high blood pressure

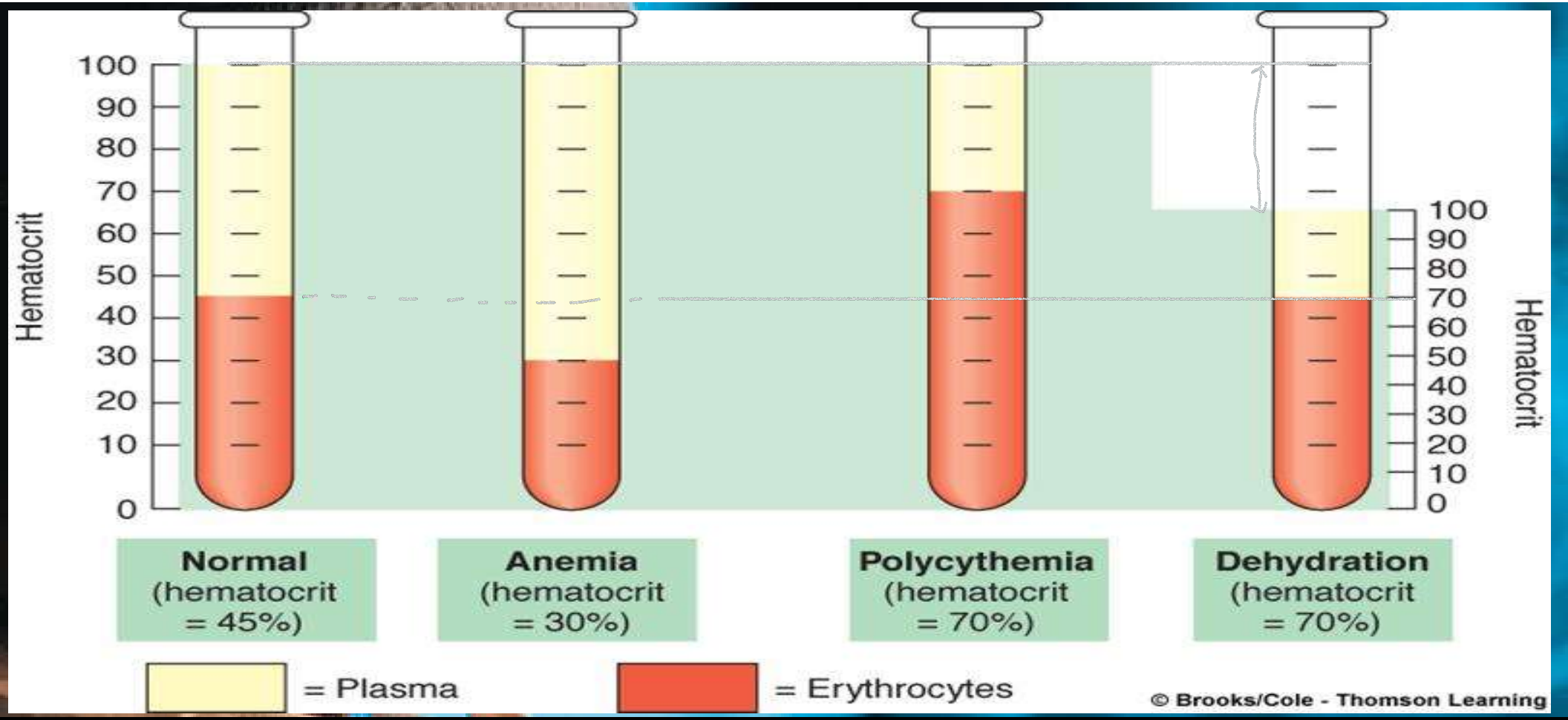


- **Diagnostic Uses of the Buffy Coat**
- Quantitative Buffy Coat (QBC) is a laboratory test to detect infection with malaria or other blood parasites:
- This test is more sensitive than the conventional thick smear and in >90% of cases, the species of parasite can also be identified.
- In cases of extremely low white blood cell count, it may be difficult to perform a manual differential of the various types of white cells, and it may be virtually impossible to obtain an automated differential.
- In such cases the medical technologist may obtain a buffy coat, from which a blood smear is made.
- This smear contains a much higher number of white blood cells than whole blood.


Hematocrit chart
Fluid level
hct 75%
* hct 50% *
hct 25%
Baseline




%
100
90
80
70
60
50
40
30
20
10
0
%
100
90
80
70
60
50
40
30
20
10
0


Hematocrit
100
90
80
70
60
50
40
30
20
10
0
Normal (hematocrit = 45%)
Anemia (hematocrit = 30%)
Polycythemia (hematocrit = 70%)
Dehydration (hematocrit = 70%)
= Plasma
= Erythrocytes
© Brooks/Cole - Thomson Learning

HEMOGLOBIN VERSUS HEMATOCRIT

HEMOGLOBIN	HEMATOCRIT
A red protein responsible for transporting oxygen in the blood of vertebrates	Ratio of the volume of red blood cells to the total volume of blood
Hemoglobin tests measure the amount of hemoglobin per unit volume of blood	Measures the volume of red blood cells with respect to the total blood volume
Normal level for males is 14 to 18 g/dl; that for females is 12 to 16 g/dl	Normal level for men should be 40 to 54%; for women it should be 36 to 48%
Low hemoglobin levels indicate anemia	Hematocrit is the quick method to diagnose anemia

Visit www.PEDIAA.com


https://www.youtube.com/watch?v=fngyZJv8vA4&ab_channel=swicmltvideos

Blood typing

- **blood type =blood group**
- is a classification of blood based on the **presence or absence of inherited antigenic substances on the surface of red blood cells (RBCs).**
- These **antigens** may be :
  - **proteins,**
  - **carbohydrates,**
  - **glycoproteins,**
  - **or glycolipids,**
- depending on the blood group system, and some of these antigens are also present on the surface of other types of cells of various tissues.

- Several of these red blood cell surface antigens, **that stem from one allele (or very closely linked genes), collectively form a blood group system**.

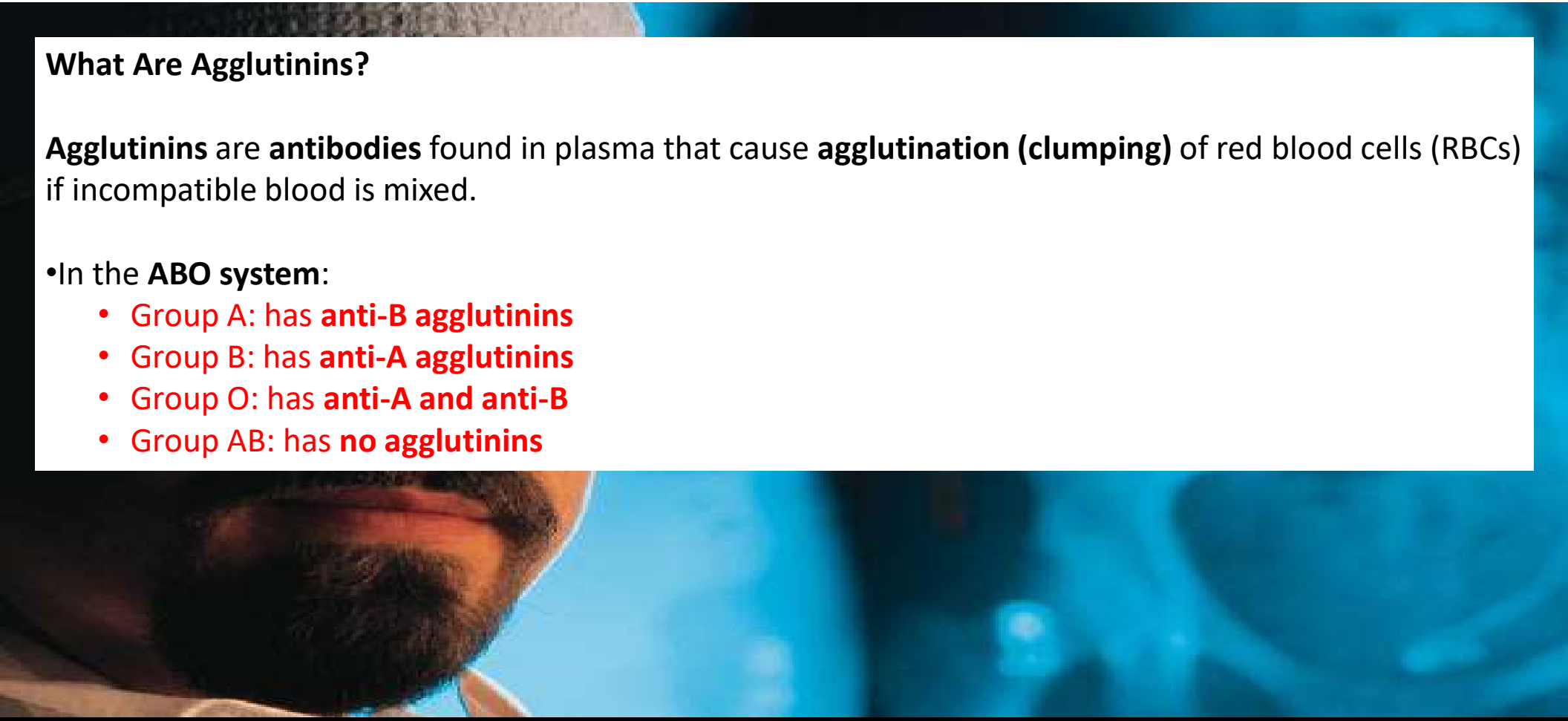
- Blood types are inherited and represent contributions from both parents.
- A total of 30 human blood group systems are now recognized by the International Society of Blood Transfusion (ISBT).

- ***Many pregnant women carry a fetus with a different blood type from their own, and the mother can form antibodies against fetal RBCs.***

- Sometimes these maternal antibodies are **IgG,** a small immunoglobulin, which can cross the placenta and cause hemolysis of fetal RBCs, which in turn can lead to hemolytic disease of the newborn, an illness of low fetal blood counts which ranges from mild to severe

Human 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



What Are Agglutinins?

Agglutinins are **antibodies** found in plasma that cause **agglutination (clumping)** of red blood cells (RBCs) if incompatible blood is mixed.

- In the **ABO system**:
  - Group A: has **anti-B agglutinins**
  - Group B: has **anti-A agglutinins**
  - Group O: has **anti-A and anti-B**
  - Group AB: has **no agglutinins**

ABO BLOOD GROUPS

Blood Group	Antigens on RBCs	Antibodies in Serum	Genotypes
A	**A**	Anti-B	*AA* or *AO*
B	**B**	Anti-A	*BB* or *BO*
AB	**A** and **B**	Neither	*AB*
O	Neither	Anti-A and Anti-B	*OO*

Mother's Blood Type	Father's Blood Type: A	Father's Blood Type: B	Father's Blood Type: AB	Father's Blood Type: O
A	A or O	A, B, AB, or O	A, B, or AB	A or O
B	A, B, AB, or O	B or O	A, B, or AB	B or O
AB	A, B, or AB	A, B, or AB	A, B, or AB	A or B
O	A or O	B or O	A or B	O

Child's Blood Type

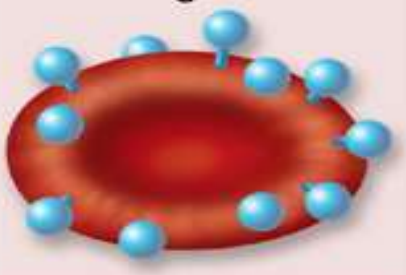
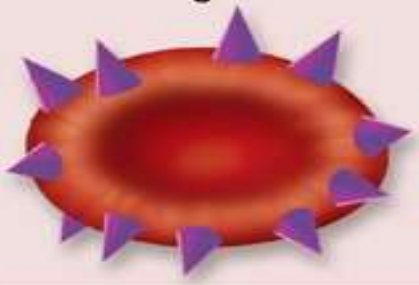
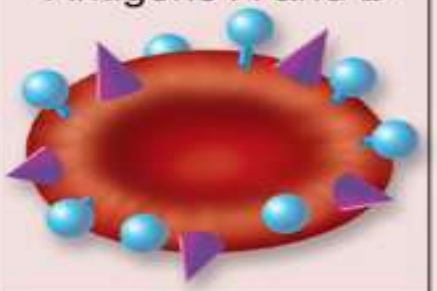
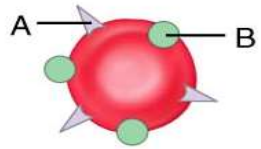
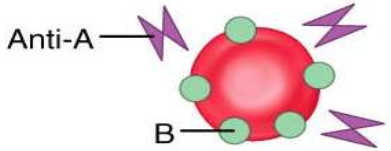
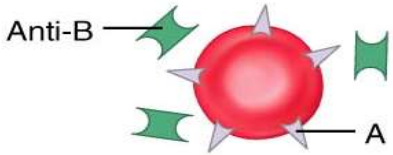
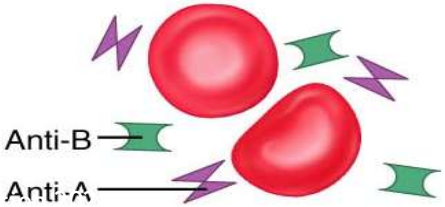
Erythrocytes	Antigen A 	Antigen B 	Antigens A and B 	Neither antigen A nor B 
Plasma	Anti-B antibodies 	Anti-A antibodies 	Neither anti-A nor anti-B antibodies	Both anti-A and anti-B antibodies 
Blood type	**Type A** Erythrocytes with type A surface antigens and plasma with anti-B antibodies	**Type B** Erythrocytes with type B surface antigens and plasma with anti-A antibodies	**Type AB** Erythrocytes with both type A and type B surface antigens, and plasma with neither anti-A nor anti-B antibodies	**Type O** Erythrocytes with neither type A nor type B surface antigens, but plasma with both anti-A and anti-B antibodies

TABLE 17.4 ABO Blood Groups

BLOOD GROUP	FREQUENCY (% U.S. POPULATION) WHITE	BLACK	ASIAN	NATIVE AMERICAN	RBC ANTIGENS (AGGLUTINOGENS)	ILLUSTRATION	PLASMA ANTIBODIES (AGGLUTININS)	BLOOD THAT CAN BE RECEIVED
AB	4	4	5	<1	A B		None	A, B, AB, O (Universal recipient)
B	11	20	27	4	B		Anti-A (a)	B, O
A	40	27	28	16	A		Anti-B (b)	A, O
O	45	49	40	79	None		Anti-A (a) Anti-B (b)	O (Universal donor)

ABO Type Frequencies In U.S.

ABO Type	Per Cent
O	45%
A	40%
B	11%
AB	4%

https://en.wikipedia.org/wiki/Blood_type_distribution_by_country

Interesting

Worldwide ABO Blood Group Frequency Estimates

Blood Group	World Average Frequency
O	~45%
A	~40%
B	~11%
AB	~4%

Europe

Group	Frequency
A	~45%
O	~40%
B	~10%
AB	~5%

Africa

Group	Frequency
O	~50-55%
A	~20-25%
B	~20%
AB	~2-3%

Latin America

Group	Frequency
O	~60-70%
A	~20-30%
B	~5-10%
AB	~1-3%

Asia (e.g., India, China, Japan)

Group	Frequency
B	~25-30%
O	~30-40%
A	~20-30%
AB	~5-10%

Indigenous Peoples (e.g., Native Americans)

Group	Frequency
O	~90-100%
A	Very rare
B	Very rare
AB	Extremely rare

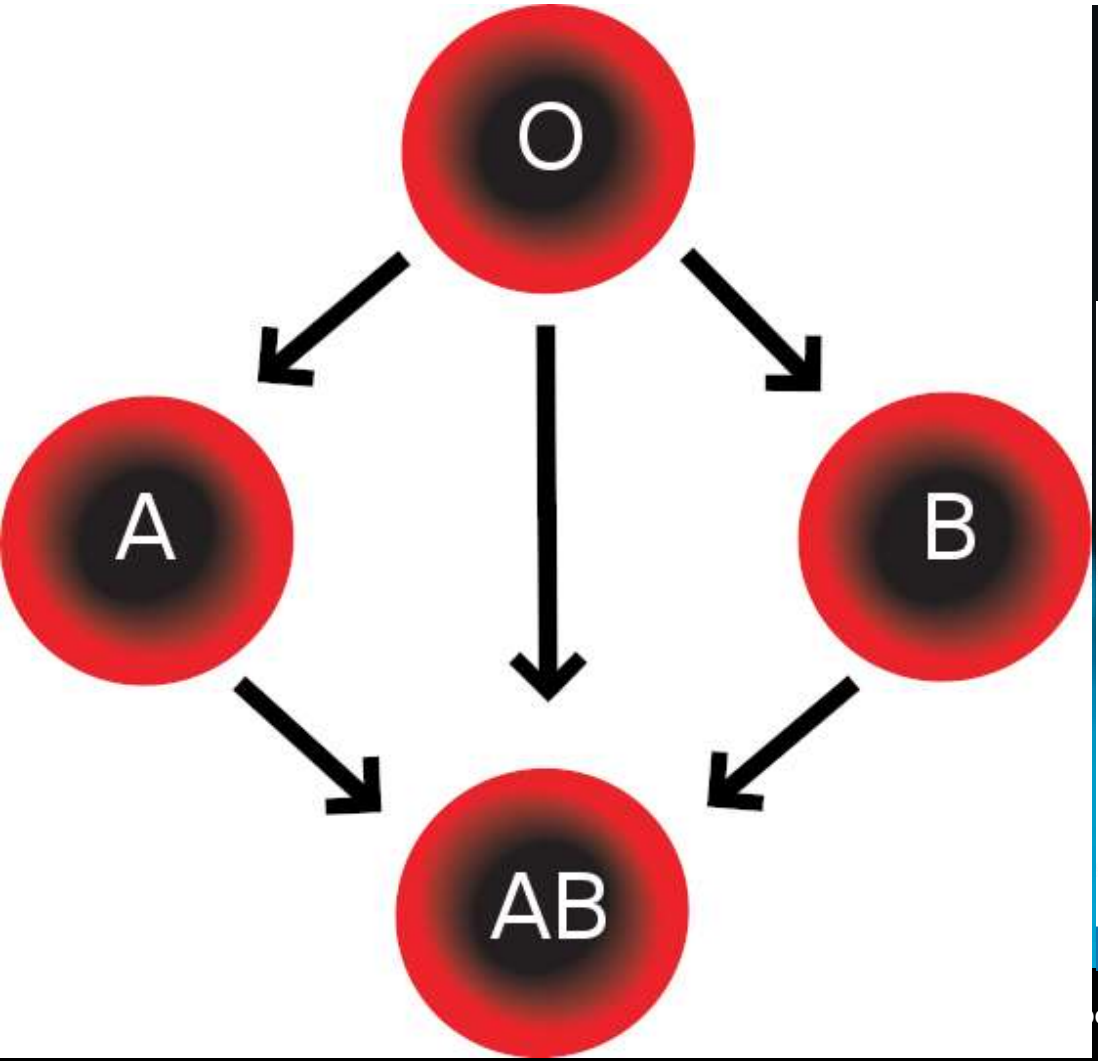
- **O group** is the most common **globally**.
- **B and AB groups** are more frequent in **Asia**.
- **Group O** predominates in **Latin America** and **Indigenous populations**.
- **Group A** is very common in **Europe and North America**.

Blood groups

A	A antigen on RBC surface and B antibody in plasma.	Rh+ blood transfusions into an Rh– individual can result in massive IgG production.
B	B antigen on RBC surface and A antibody in plasma.	
AB	A and B antigens on RBC surface; no antibodies in plasma; "universal recipient."	Incompatible blood transfusions can cause immunologic response, hemolysis, renal failure, shock, and death.
O	Neither A nor B antigen on RBC surface; both antibodies in plasma; "universal donor."	

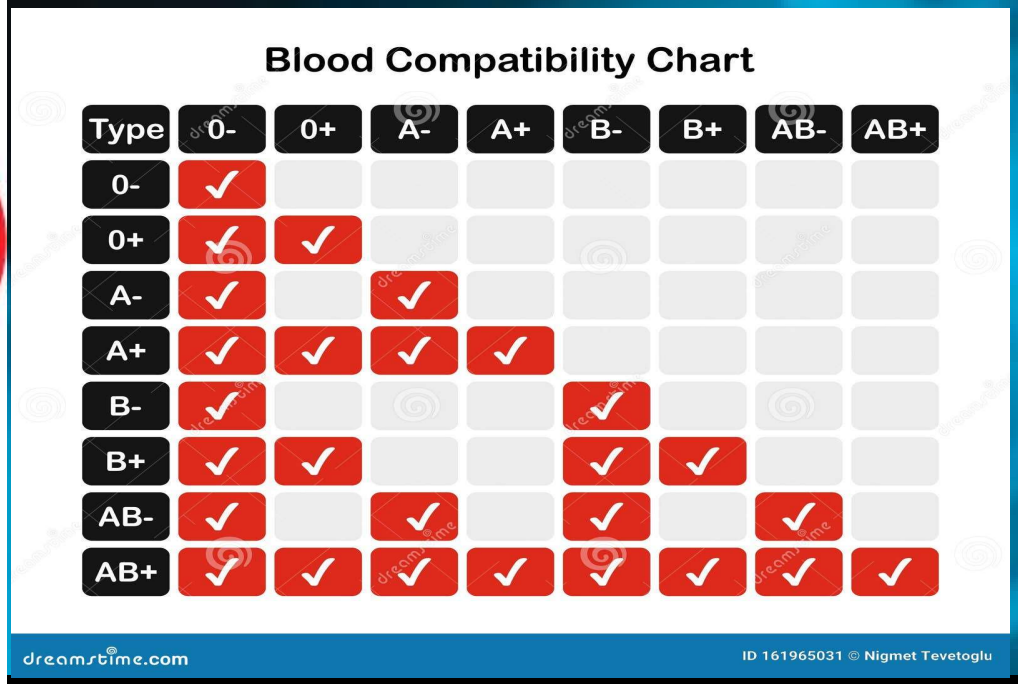
ABO Blood Groups

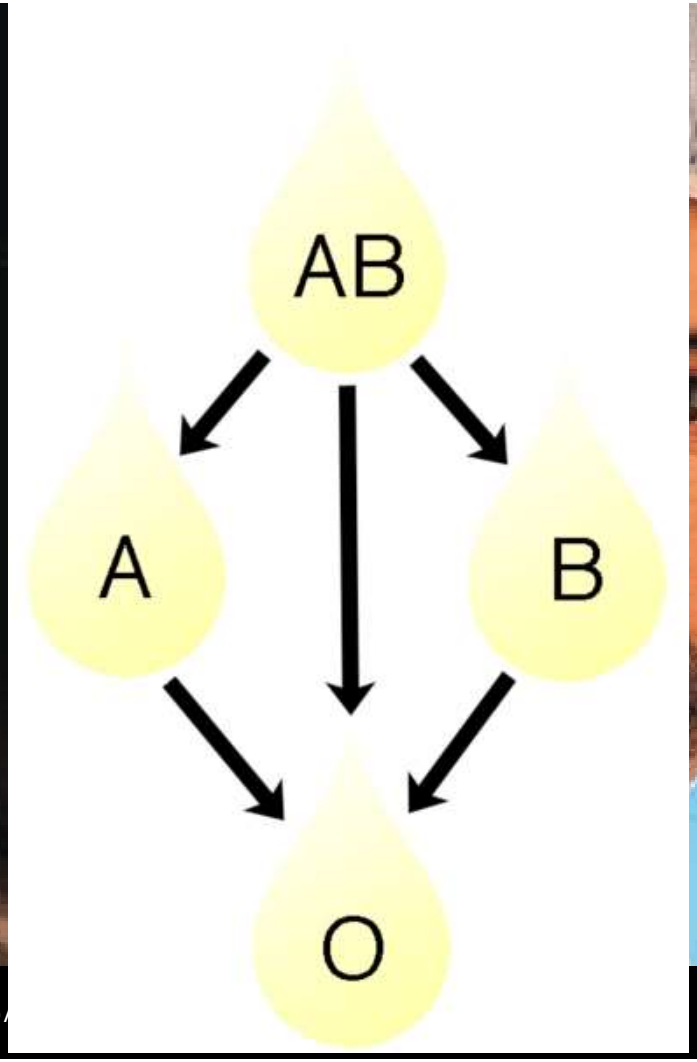
- The ABO blood groups consists of:
  - **Two antigens (A and B) on the surface of the RBCs**
  - **Two antibodies in the plasma (anti-A and anti-B)**
- ABO blood groups may have various types of antigens and preformed antibodies
- Agglutinogens and their corresponding antibodies cannot be mixed without serious hemolytic reactions



RBC Compatibility chart

In addition to donating to the same blood group; type O blood donors can give to A, B and AB; blood donors of types A and B can give to AB.





Plasma compatibility chart

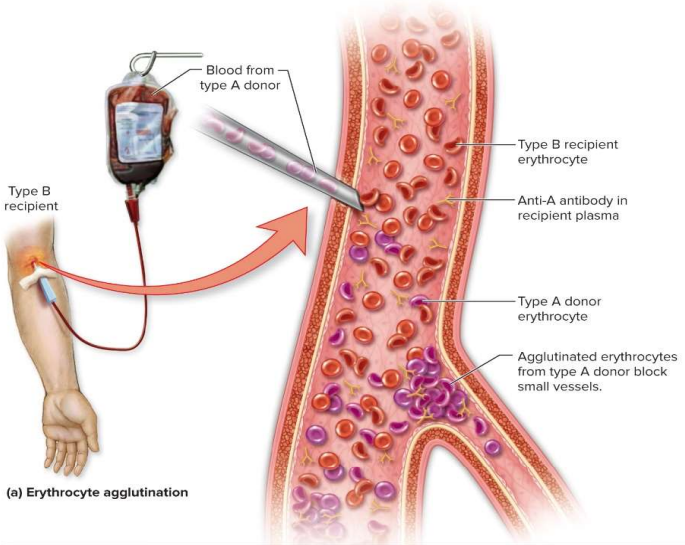
In addition to donating to the same blood group; plasma from type AB can be given to A, B and O; plasma from types A and B can be given to O.

	ABO Blood Types			
Blood type	**Type A**	**Type B**	**Type AB**	**Type O**
Erythrocytes	Surface antigen A	Surface antigen B	Surface antigens A and B	Neither surface antigen A nor B
Plasma	Anti-B antibodies	Anti-A antibodies	Neither anti-A nor anti-B antibodies	Both anti-A and anti-B antibodies

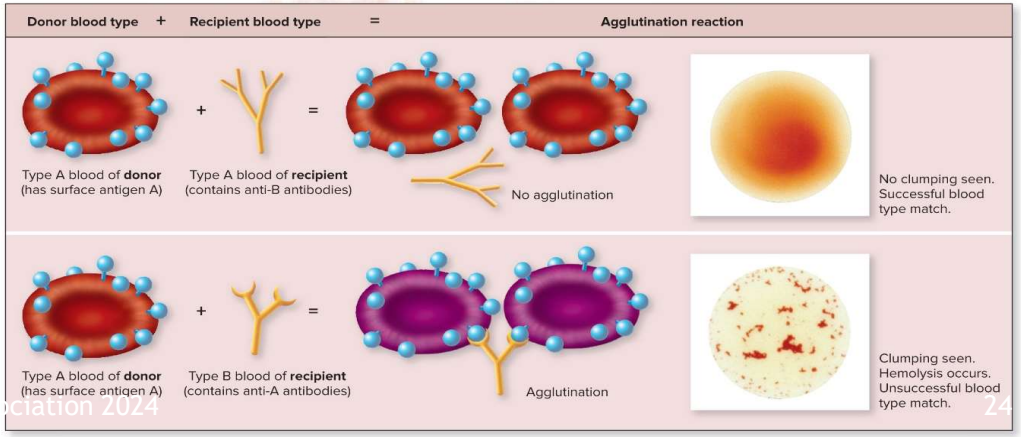
(a)

	Rh Blood Types	
Blood type	**Rh positive**	**Rh negative**
Erythrocytes	Surface antigen D	No surface antigen D
Plasma	No anti-D antibodies	No anti-D antibodies unless exposed to Rh positive blood

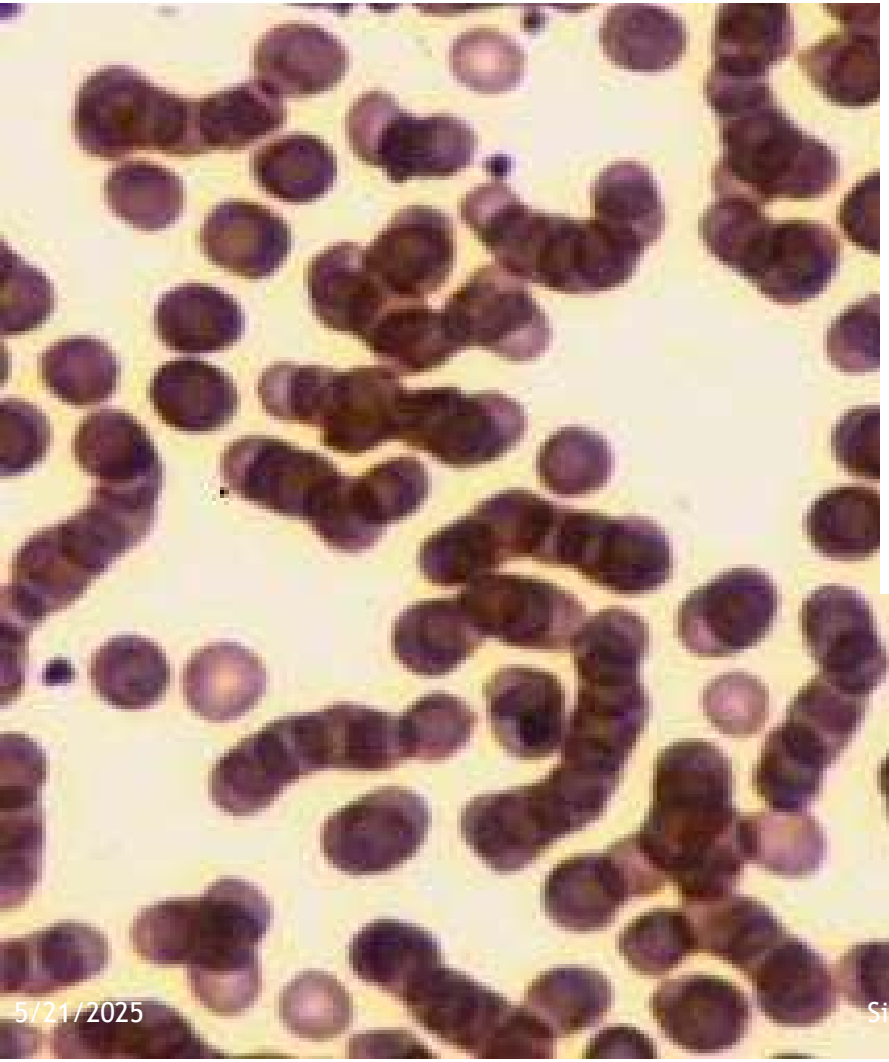
(b)



(a) Erythrocyte agglutination

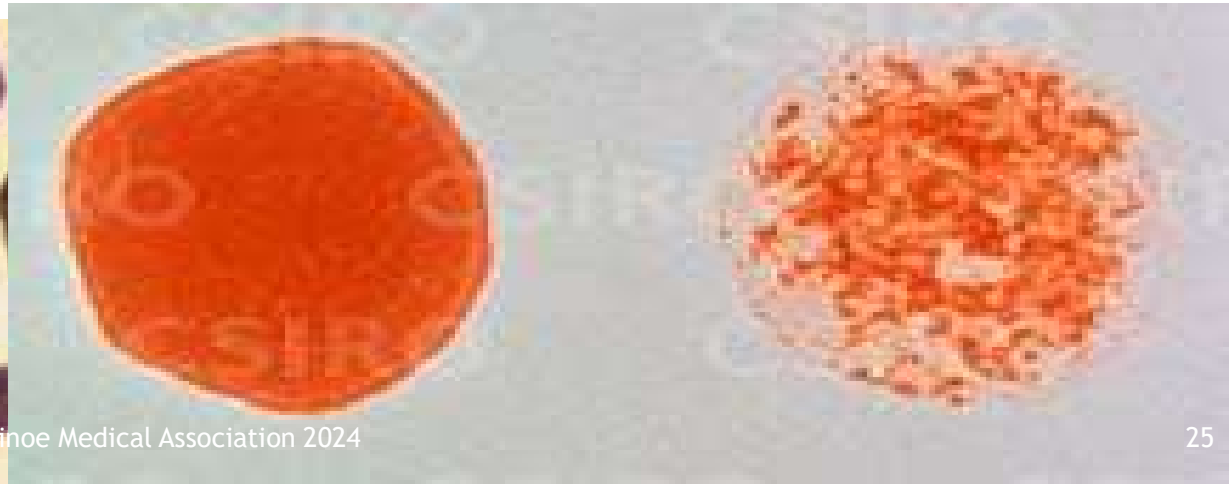


(b) Agglutination test



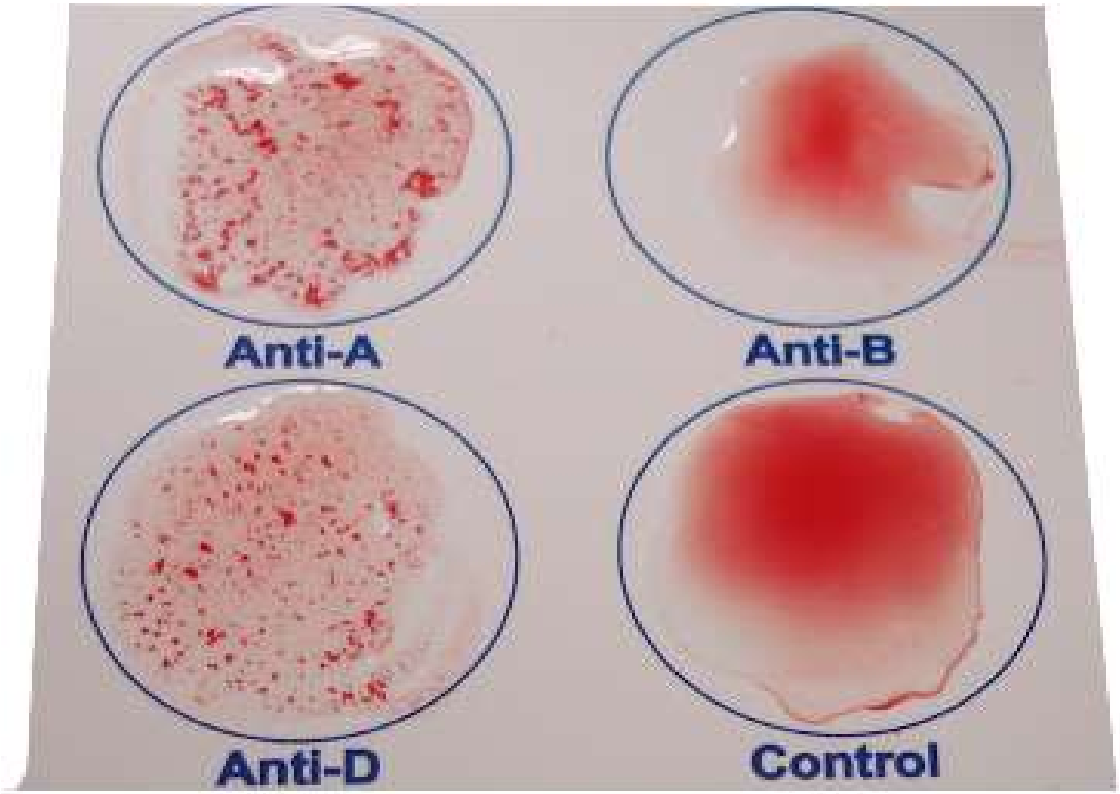
Actual blood sample taken during a demonstration showing red blood cells glued together lacking oxygen.

The same blood cells 30 minutes after the person drank x20 treated water showing blood cells floating free & full of oxygen

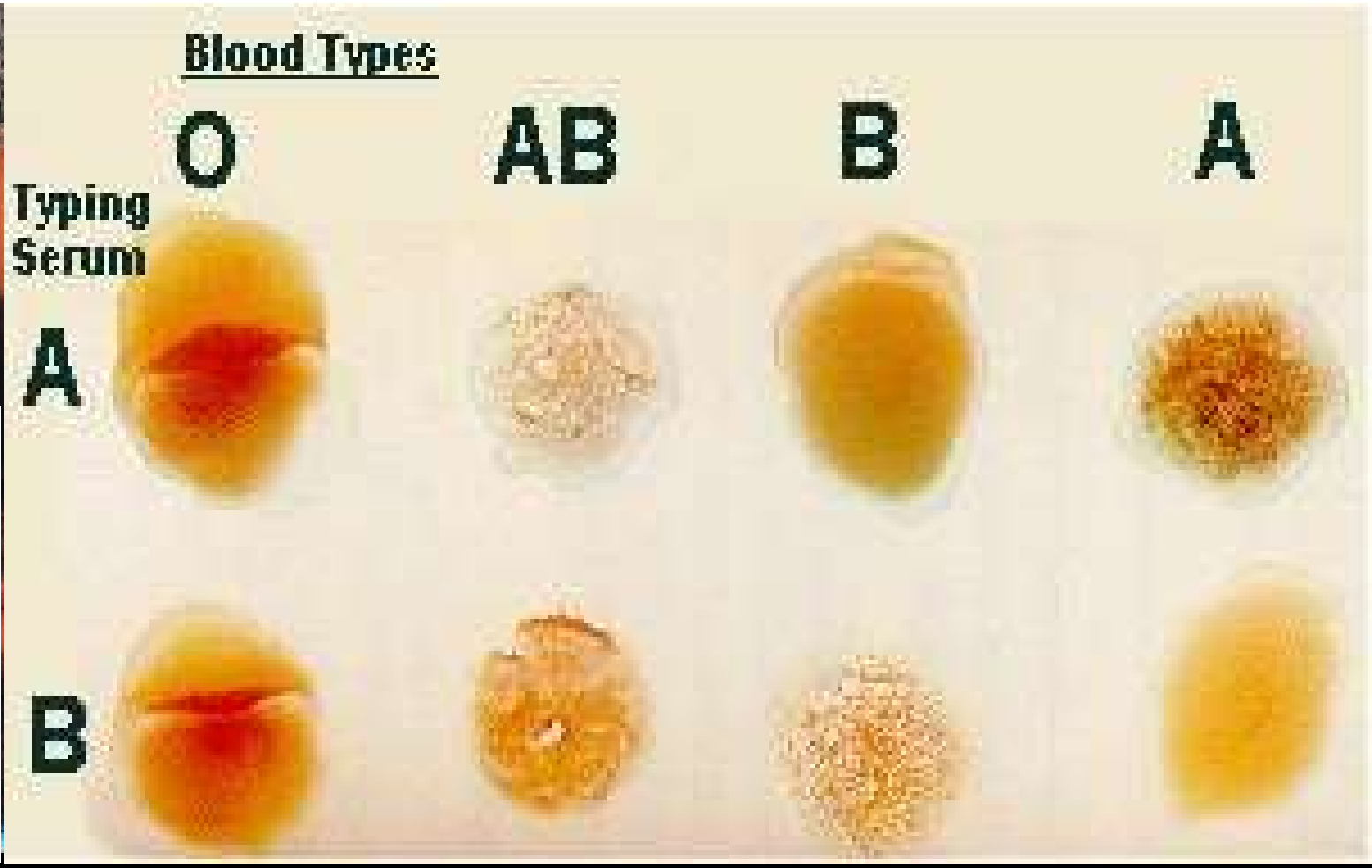


HOW TO READ YOUR RESULTS

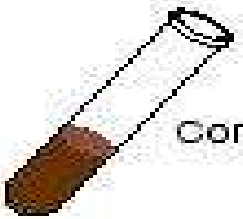
BLOOD TYPE	ANTI-A	ANTI-B	ANTI-D	CONTROL
O-POSITIVE				
O-NEGATIVE				
A-POSITIVE				
A-NEGATIVE				
B-POSITIVE				
B-NEGATIVE				
AB-POSITIVE				
AB-NEGATIVE				
INVALID				



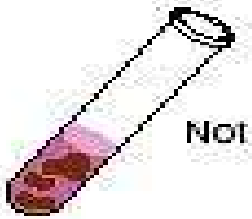

Red-capped tubes contain no additives: SERUM
Glucose= grey
Coagulation=blue
Plasma chemistry =green
Hematology= pink


Blood Types
O
AB
B
A
Typing Serum
A
B

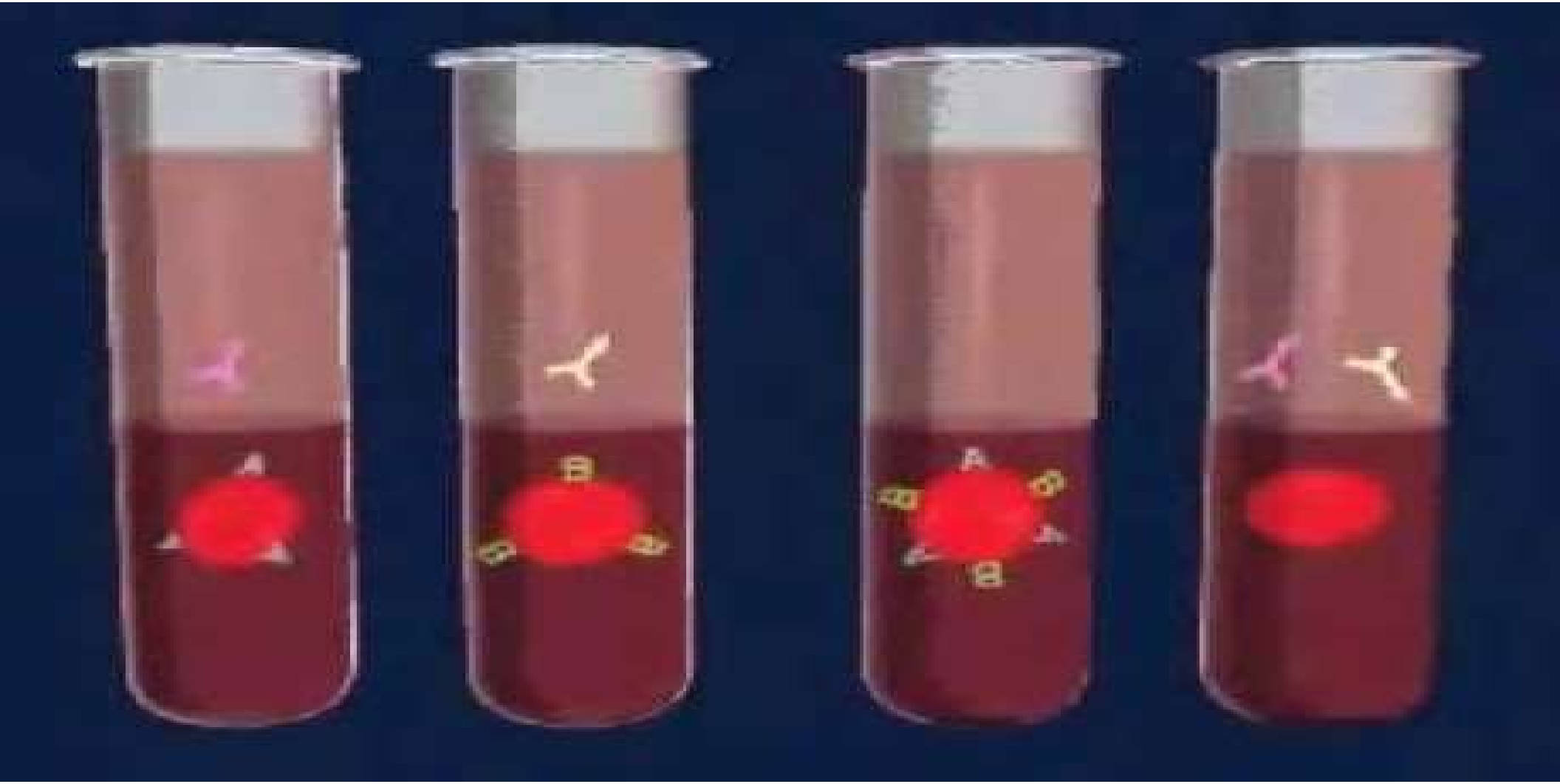
Recipient's blood			Reactions with donor's red blood cells			
ABO antigens	ABO antibodies	ABO blood type	Donor type O cells	Donor type A cells	Donor type B cells	Donor type AB cells
None	Anti-A Anti-B	O				
A	Anti-B	A				
B	Anti-A	B				
A & B	None	AB				



Compatible



Not compatible


A
B
A
B

•BLOOD FACTS:

A person with type O blood can donate to anyone (**universal donor**), but can receive blood from a person with type O blood only.

•A person with type AB blood can receive blood from anyone (**universal recipient**), but can donate blood only for others who have type AB blood.

•A person with type A blood can donate blood for people with type A or type AB blood. A person with type A blood can receive blood from a person with type A or type O.

•A person with type B blood can receive blood from a person with type B or type O. A person with type B blood can donate blood for persons with either type B or type AB blood.

•Actually, blood banking is more complicated than this simple description, with test run for other minor compatibility antigens (like the MN antigen system) before transfusions are given.

Blood Groups

- Humans have **30 to 50** varieties of naturally occurring RBC antigens which are grouped into what are called **blood group systems**.
-
- The International Society of Blood Transfusion (ISBT) currently recognizes over 40 blood group systems, including well-known ones like **ABO, Rh (Rhesus), Kell, Duffy, Kidd, and MNS.**
- These systems collectively include more than 300 distinct RBC antigens.
- However, 30 to 50 antigens are considered the most clinically relevant—meaning they are the most likely to elicit an immune response during blood transfusions or pregnancy.
- The antigens of the **ABO and Rh** blood groups cause vigorous transfusion reactions when they are improperly transfused
- **incompatibilities can lead to hemolytic transfusion reactions or hemolytic disease of the fetus and newborn (HDFN)**

Summary Table

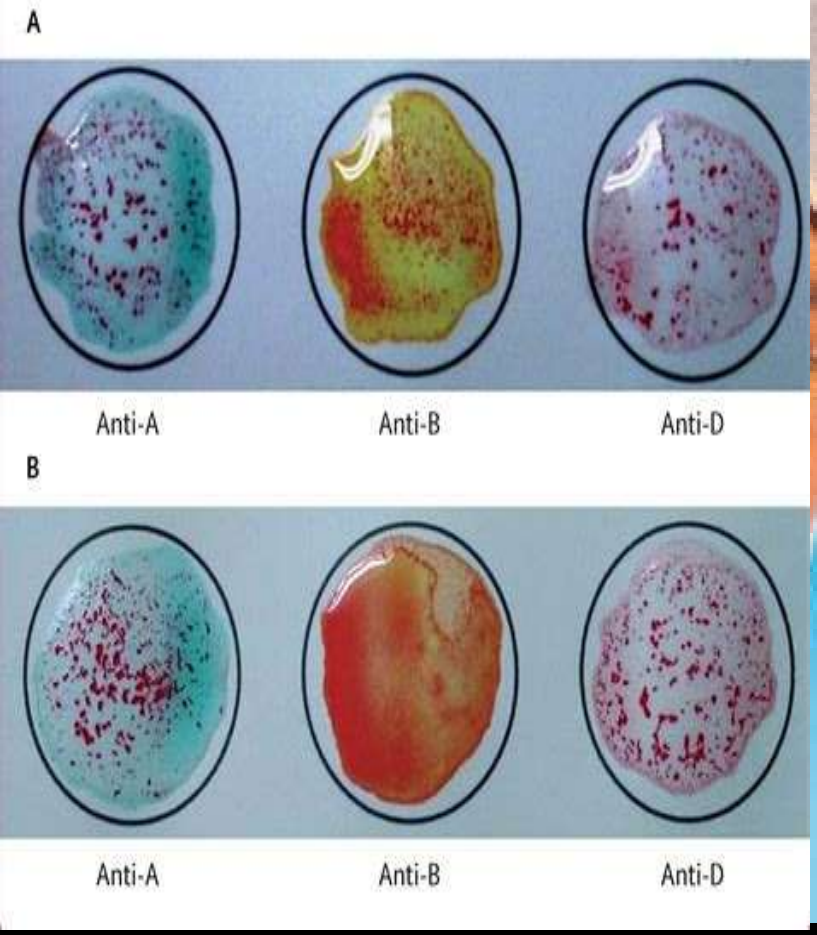
Focus only on the ABO and Rh

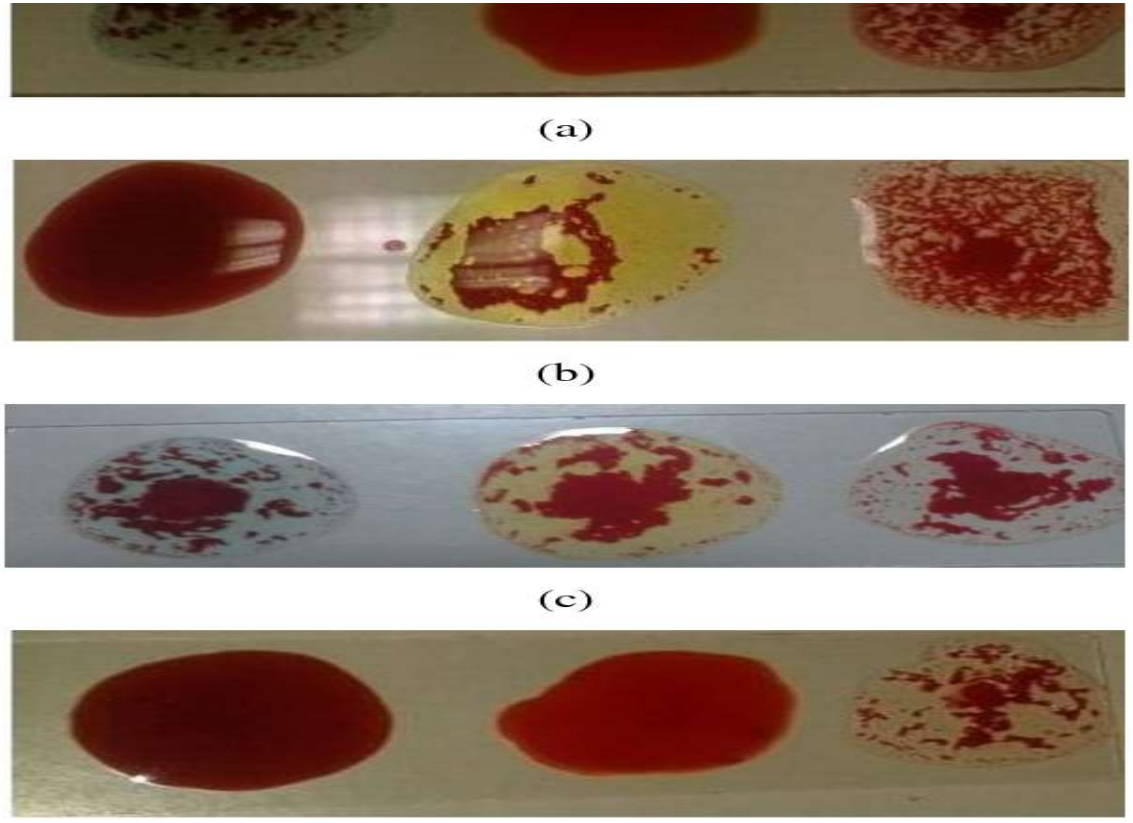
System	Key Antigens	Antibodies	Clinical Significance
ABO	**A, B, O**	**Naturally occurring**	**Severe transfusion reaction**
Rh	**D (and others)**	**Immune-mediated**	**Severe HDFN, transfusion issues**
Kell	K, k	Immune-mediated	HDFN, transfusion
Duffy	Fya, Fyb	Immune-mediated	HDFN, malaria relevance
Kidd	Jka, Jkb	Immune-mediated	Delayed transfusion rxns
MNS	M, N, S, s	Variable	Some HDFN, transfusion rxns
Lutheran	Lua, Lub	Rare	Usually mild reactions
Lewis	Lea, Leb	Usually IgM	Usually benign
P	P1, P	Cold antibodies	Rare hemolysis (cold)

Multiple alleles

ABO blood group s

Blood being tested	Serum: Anti-A	Serum: Anti-B
Type AB (contains agglutinogens A and B; agglutinates with both sera)	RBCs	RBCs
Type A (contains agglutinogen A; agglutinates with anti-A)		
Type B (contains agglutinogen B; agglutinates with anti-B)		
Type O (contains no agglutinogens; does not agglutinate with either serum)		





(a)

(b)

(c)

(d)

Fig.10. (a) Result of A+ (b) Result of B+
(c) Result of AB+(d) Result of O+

The method was tested for 30 slide test images obtained

Rh TYPING: INTRODUCTION

- **It is the second most important typing of blood.**
- **These blood groups were originally discovered in Rhesus monkeys**
- **Rh is another type of agglutinogen.**
- **It is also present on the outer surface of the erythrocytes.**

- **Rh typing determines whether your red blood cells have the Rh (D) antigen.**

- **Rh-positive (Rh^+): You have the Rh antigen on your RBCs.**
- **Rh-negative (Rh^-): You lack the Rh antigen on your RBCs.**

•**Rh^- individuals** should only receive **Rh^- blood** to avoid sensitization.
•**Rh^+ individuals** can receive both Rh^+ and Rh^- blood (though Rh^+ preferred).

Region	Rh^+ (%)	Rh^- (%)
Worldwide Avg	~85%	~15%
Europe (esp. UK)	~83-85%	~15-17%
Africa	~93-99%	~1-7%
Asia	~98-99%	~1-2%
North America	~85%	~15%
South America	~95%	~5%
Indigenous Groups	~99%	<1%

Pregnancy (Hemolytic Disease of the Newborn - HDN):

•If **Rh-negative mother** carries an **Rh-positive fetus**, she can produce **anti-D antibodies**.

•On future pregnancies, these antibodies can **attack fetal RBCs**, causing **erythroblastosis fetalis**.
✅ **Prevention**: Rh^- mothers get **Rho(D) immune globulin (RhoGAM)** around 28 weeks and after delivery if baby is Rh^+.

Rhesus [Rh] Blood Groups

- **There are eight different Rh agglutinogens, three of which (C, D, and E) are common**
- Presence of the Rh agglutinogens on RBCs is indicated as Rh^+
- Anti-Rh antibodies are not spontaneously formed in Rh^- individuals
- However, if an Rh^- individual receives Rh^+ blood, anti-Rh antibodies form
- A second exposure to Rh^+ blood will result in a typical transfusion reaction

Rh or D Agglutinins

- **Anti-D agglutinins or antibodies do not occur naturally.**
- **They are produced by the Immune systems as and when it is exposed to the D antigens.**
- **So these Anti D agglutinins are found only in some of the Rh Negative people.**
- **Those who have been exposed to the Rh or D antigen**
- **Unlike ABO antibodies, anti-D agglutinins are produced only after exposure to Rh^+ red cells, such as:**
- **Blood transfusion (Rh^- person gets Rh^+ blood)**
- **Pregnancy (Rh^- mother carries an Rh^+ fetus)**

The Rh System & D Antigen

•The **D antigen** is the **main antigen in the Rh system**.

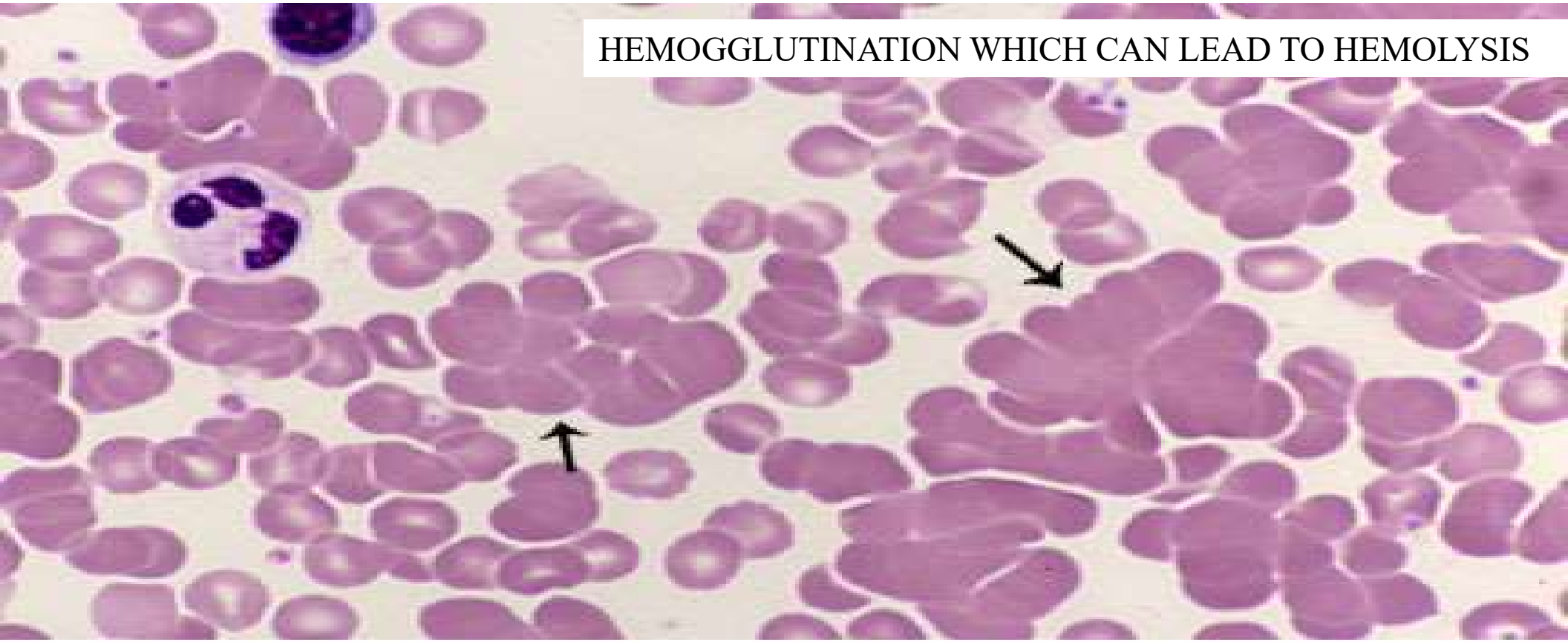
•If you **have the D antigen** → you are **Rh-positive (Rh^+)**.
•If you **lack the D antigen** → you are **Rh-negative (Rh^-)**.

Rh Typing Test Procedure:

1.Blood is mixed with **anti-D serum**.

2.If **agglutination (clumping)** occurs → **Rh-positive**.
3.No agglutination → **Rh-negative**.

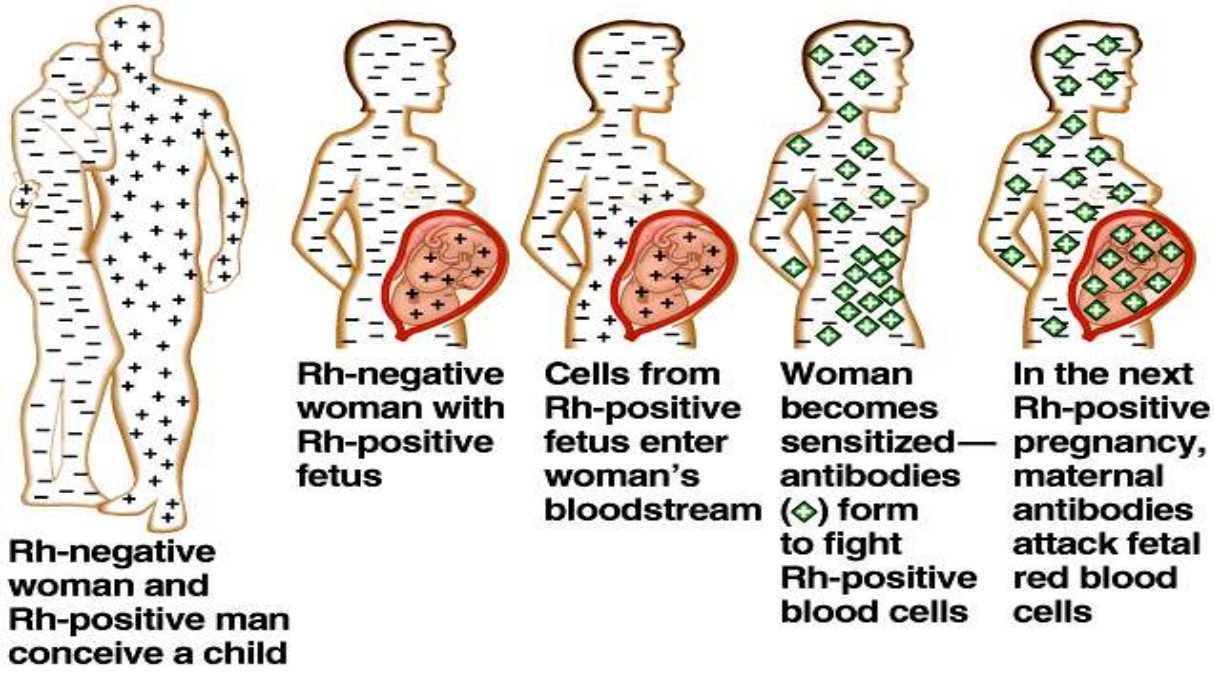
HEMOGGLUTINATION WHICH CAN LEAD TO HEMOLYSIS



CRITOCAPS CARD

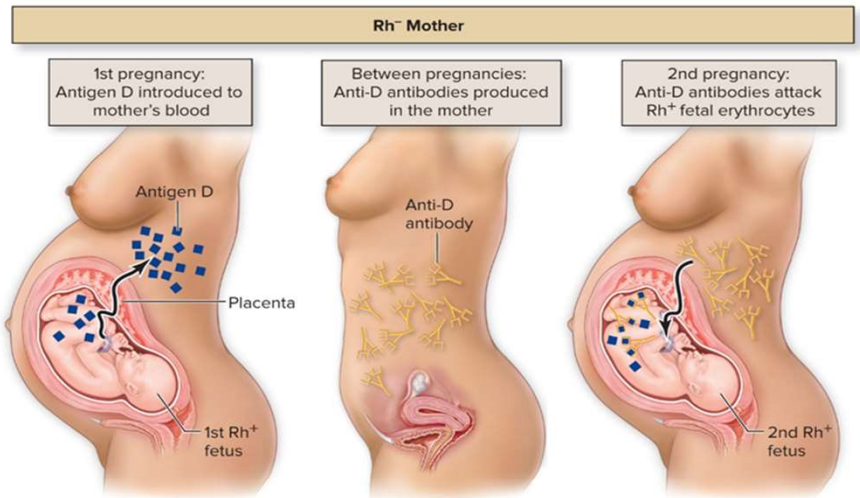
HOW TO READ YOUR RESULTS

BLOOD TYPE	ANTI-A	ANTI-B	ANTI-D	CONTROL
O-POSITIVE	●	●	◔	●
O-NEGATIVE	●	●	●	●
A-POSITIVE	◔	●	◔	●
A-NEGATIVE	◔	●	●	●
B-POSITIVE	●	◔	◔	●
B-NEGATIVE	●	◔	●	●
AB-POSITIVE	◔	◔	◔	●
AB-NEGATIVE	◔	◔	●	●
INVALID	◔	◔	◔	◔



The disease, called **erythroblastosis fetalis** or **hemolytic disease of the newborn**, may be so severe as to kill the fetus or even the newborn infant.

It is an example of an antibody-mediated cytotoxicity disorder.



	Mother Rh Blood Types		Fetus Rh Blood Types	
	Pregnancy #1	Pregnancy #2	Pregnancy #1	Pregnancy #2
Blood type	Rh negative	Rh negative	Rh positive	Rh positive
Erythrocytes	No antigen D	No antigen D	Antigen D	Antigen D
Plasma	No anti-D antibodies	Anti-D antibodies (due to prior exposure)	No anti-D antibodies	No anti-D antibodies Anti-D antibodies from mother cross placenta and attack fetal erythrocytes causing **hemolytic disease of the newborn**

Mother	Fetus	Risk
Rh^-	Rh^+	Mother may develop **anti-D** agglutinins if fetal blood enters her circulation.

If this happens in the **first pregnancy**, it usually doesn't affect the fetus.

But in **subsequent pregnancies**, maternal **anti-D** antibodies can **cross the placenta** and attack fetal RBCs → **hemolytic disease of the newborn (HDN)**.

Prevention

•Give **Rho(D) immune globulin (RhoGAM)** to Rh^- mothers at 28 weeks & after delivery (if baby is Rh^+).

•RhoGAM **neutralizes fetal Rh^+ cells** before the mother can form anti-D agglutinins.

- **Preventive Measures**:
  - To prevent Rh incompatibility, Rh-negative pregnant women are typically given Rh immunoglobulin (RhIg or Rho(D) immune globulin), such as RhoGAM,
  - during pregnancy and after delivery if the baby is Rh-positive.
  - **This injection prevents the mother's immune system from developing antibodies against Rh-positive blood cells.**

- **Testing**:
  - During pregnancy, the mother's Rh status is determined through blood tests.
  - If she is Rh-negative, the father's Rh status may also be tested.
  - **If the father is Rh-positive, there is a potential for Rh incompatibility.**
  - Additional monitoring and preventive measures will be taken to ensure the health and safety of both the mother and the baby.

How Rh incompatibility can affect pregnancy:

1.Rh Incompatibility:

- This occurs when an Rh-negative mother is pregnant with an Rh-positive baby.
- If the baby's Rh-positive blood cells enter the mother's bloodstream, her immune system may recognize these cells as foreign and produce antibodies against them.
- This can happen during :
  - pregnancy,
  - delivery,
  - due to a miscarriage
  - abortion
  - trauma.

2. Sensitization and Hemolytic Disease of the Newborn (HDN):

- If the mother becomes sensitized (produces antibodies against Rh-positive blood cells), **these antibodies can cross the placenta in subsequent pregnancies and attack the red blood cells of an Rh-positive fetus.**
- This can lead to hemolytic disease of the newborn (HDN), which can cause serious health issues like
  - anemia,
  - jaundice,
  - heart failure,
  - death in severe cases.

Erythroblastosis fetalis, also known as hemolytic disease of the newborn (HDN),

- severe condition in fetuses and newborns resulting from the destruction of the baby's red blood cells by maternal antibodies.
- **This usually occurs due to Rh incompatibility between the mother and the fetus.**

Causes

1.Rh Incompatibility:

1. When an Rh-negative mother is pregnant with an Rh-positive baby, she can become sensitized to Rh-positive blood cells, usually during a previous
   - **pregnancy,**
   - **delivery,**
   - **miscarriage,**
   - **abortion,**
   - **medical procedures.**
2. If the mother has been sensitized, her immune system produces antibodies against Rh-positive blood cells.
3. These antibodies can cross the placenta and attack the red blood cells of an Rh-positive fetus in subsequent pregnancies.

2.ABO Incompatibility:

1. Although less common and generally less severe than Rh incompatibility, ABO incompatibility can also cause erythroblastosis fetalis.
2. This occurs when the mother's blood type is O, and the baby's blood type is A or B.
3. The mother can produce antibodies against the A or B antigens on the baby's red blood cells.

Symptoms

In the fetus:

•**Anemia**: Due to the destruction of red blood cells.

•**Hydrops fetalis**: Severe swelling (edema) in the fetus, which can be life-threatening.

•**Enlarged liver and spleen**: As these organs work harder to produce more red blood cells.

In the newborn:

•**Severe anemia**: Which can lead to heart failure and other complications.

•**Jaundice**: High levels of bilirubin (a byproduct of red blood cell breakdown) can cause yellowing of the skin and eyes.

•**Kernicterus**: A type of brain damage caused by very high levels of bilirubin.

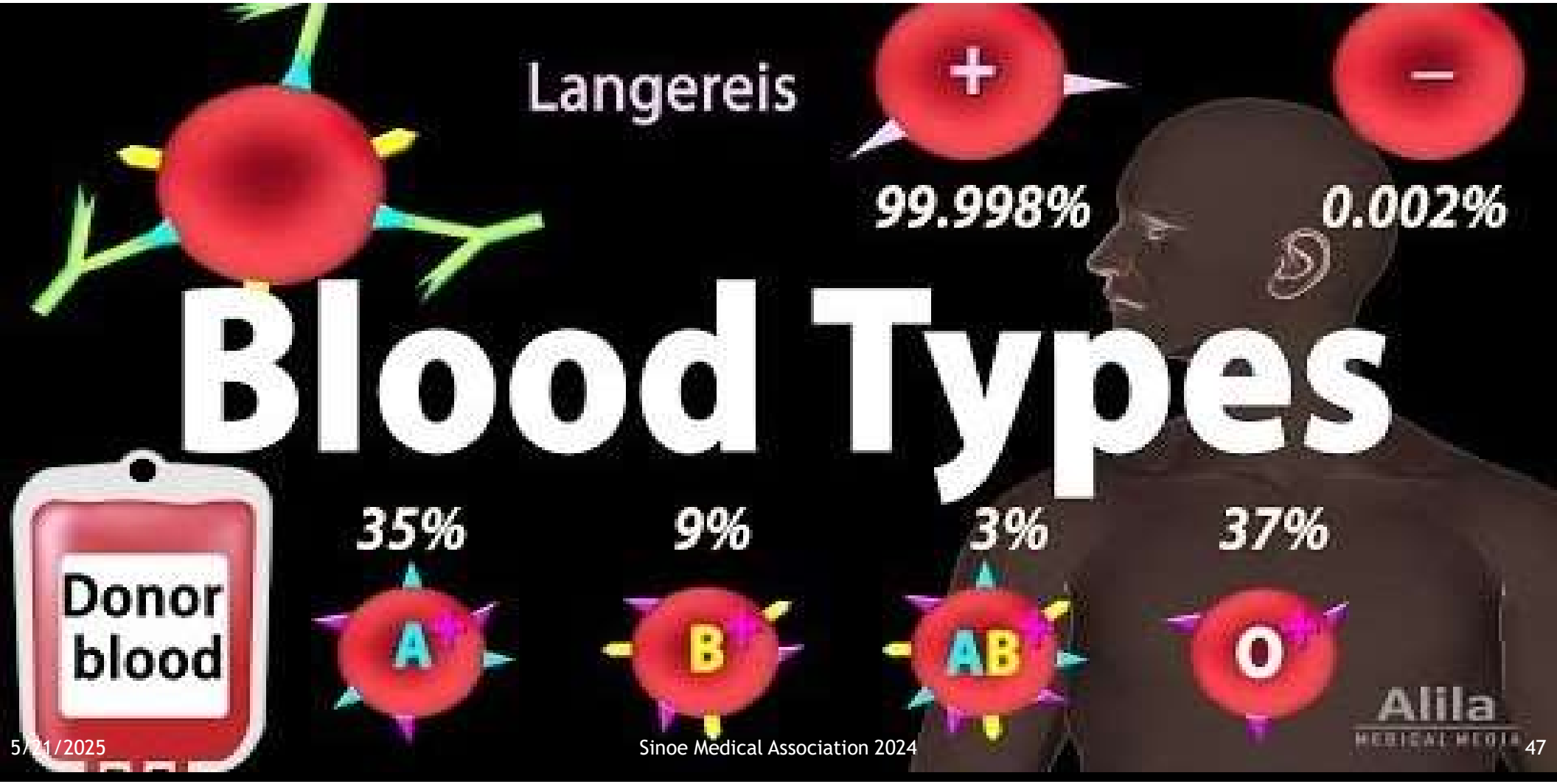
Diagnosis

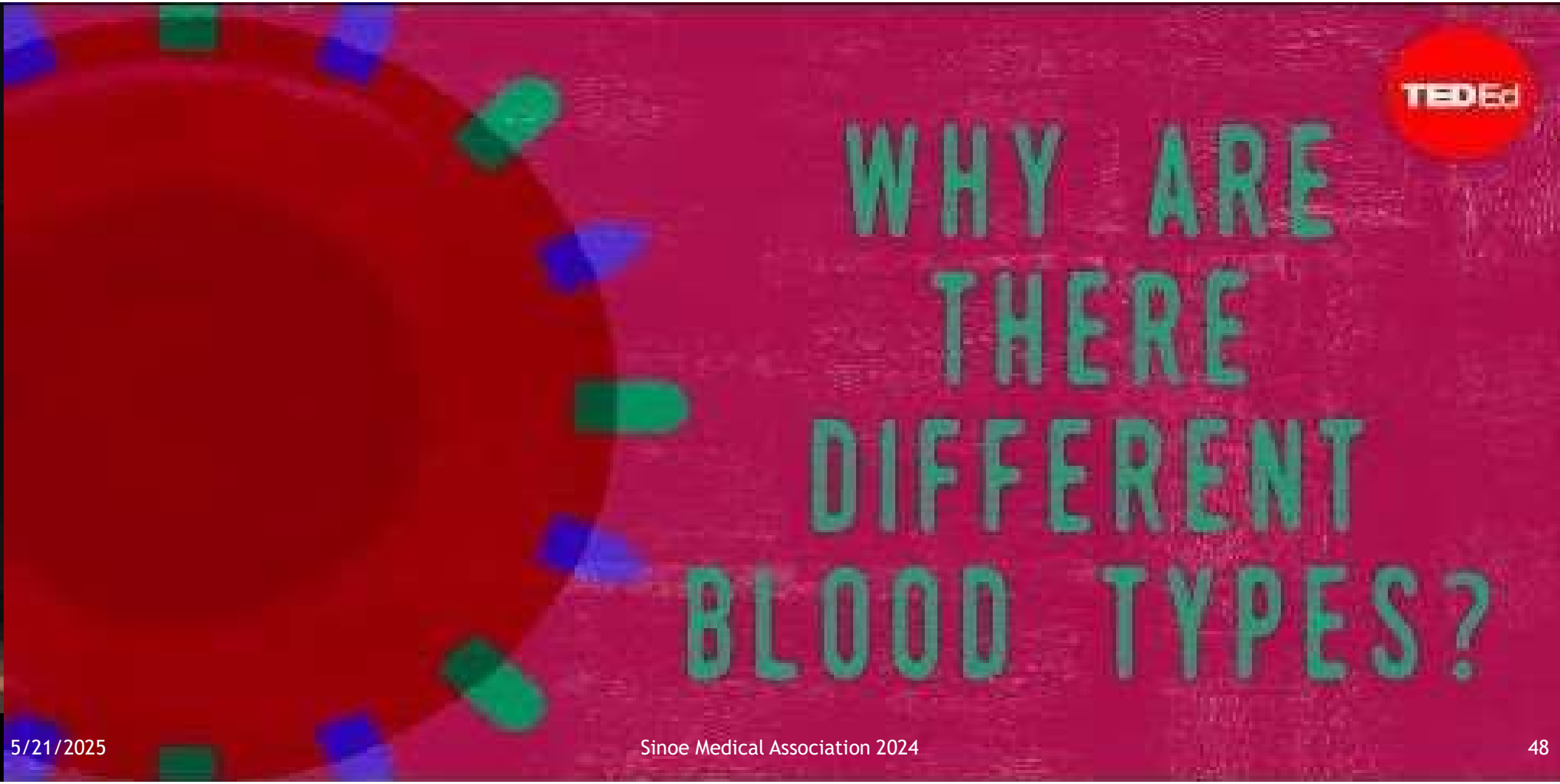
•**Prenatal Testing**:

- Blood tests to determine the mother's and father's Rh status.
- Antibody screening to check if the mother has been sensitized.
- Ultrasound and Doppler studies to monitor the fetus for signs of anemia or hydrops fetalis.
- Amniocentesis or cordocentesis may be performed to assess the severity of the condition.

•**Postnatal Testing**:

- Blood tests on the newborn to check for anemia, bilirubin levels, and the presence of maternal antibodies.


Langereis
+
−
99.998%
0.002%
Blood Types
Donor blood
35%
9%
3%
37%
A
B
AB
O
Alila
MEDICAL MEDIA


TED-Ed
WHY ARE THERE DIFFERENT BLOOD TYPES?