
بسم الله الرحمن الرحيم

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”قالوا سبحانك لا علم لنا إلا ما علمتنا إنك أنت العليم الحكيم“

صدق الله العظيم

5 - Blood Groups and Blood Transfusion

Objectives;

Intended learning outcomes (ILOs)

After reviewing the PowerPoint presentation and the associated learning resources, the student should be able to:

- ❑ Describe the ABO and Rhesus blood group systems
- ❑ Recognize agglutinogens on the surface of the RBCs
- ❑ Recognize agglutinins in the plasma
- ❑ Describe grouping, cross-matching & typing with anti-sera
- ❑ List precautions taken in preparing blood for transfusion and storage.
- ❑ Define blood transfusion and list its uses
- ❑ Describe the hazards of incompatible blood transfusion reactions.
- ❑ Define hemolytic disease of newborn, describe its pathophysiology and outline its prevention

BLOOD GROUPS

Determined by:

Antigens (glycoprotein) on the surface RBC

The chief blood groups are:

Clinically most significant

- A-B-O System
- Rh (Rhesus) System

The ABO system

- Depends on whether the red cells contain one, both or neither of the two blood antigens:

  A and B.

- Four main ABO groups:

  A, B, AB, O

The ABO system

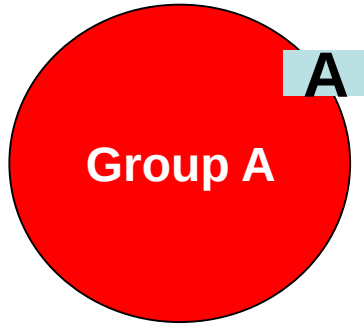
- **Anti-A & Anti-B are:**

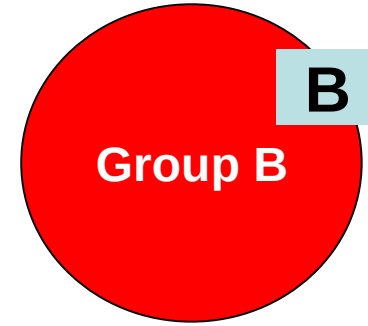
  naturally occurring antibodies.
- Not present at birth, appear few months later
- Triggered by A & B antigens in food and bacteria

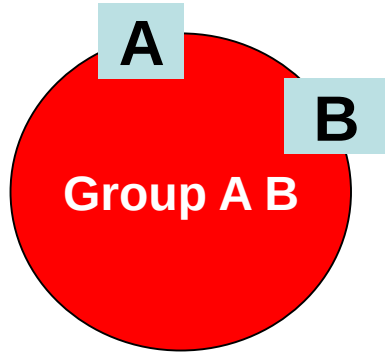
Importance of blood groups

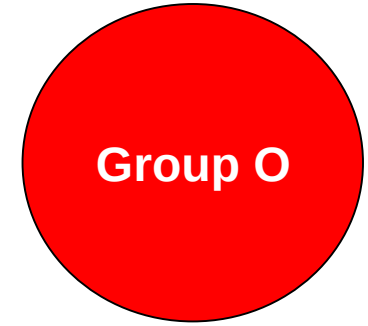
1. Blood Transfusion.
2. Rh incompatibilty between mother and fetus

Antigens (agglutinogens)









Blood Typing

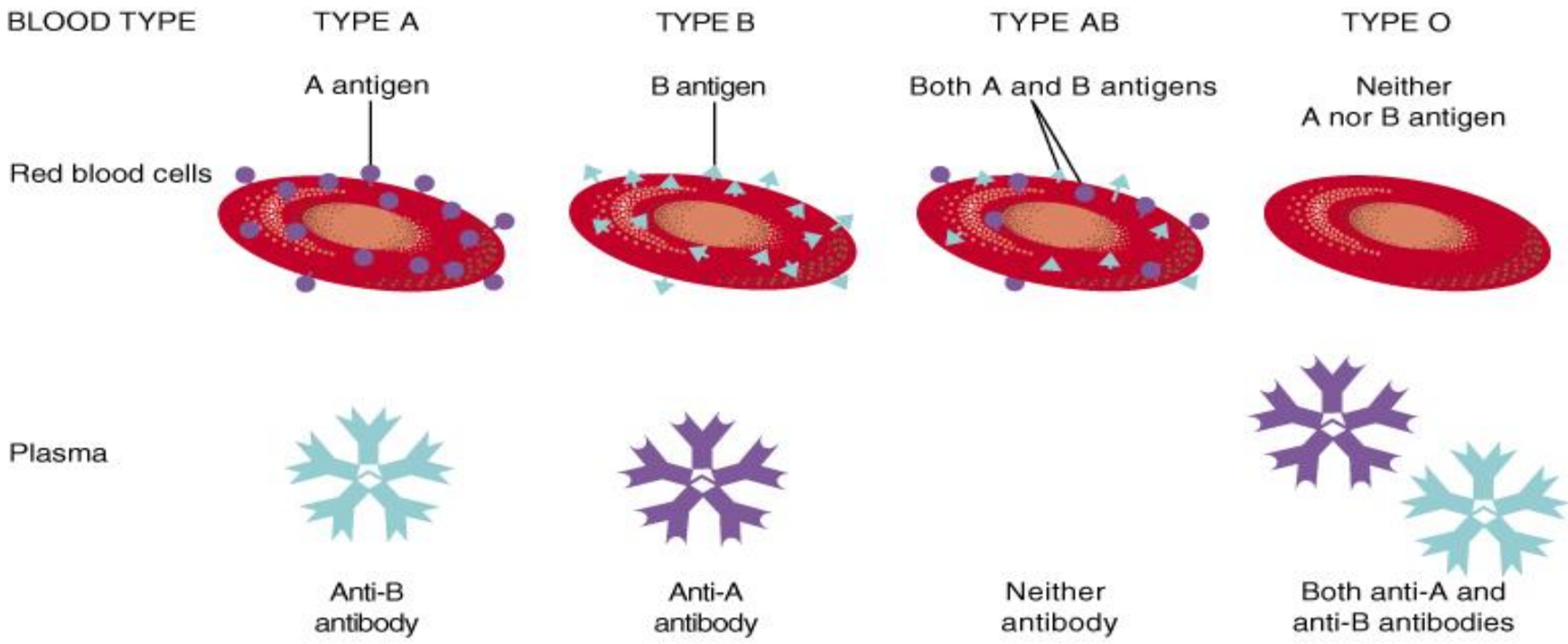
- RBC surfaces are marked by genetically determined antigens (Agglutinogens).
- Blood is typed (grouped) based on surface antigens
- The ABO and Rhesus (Rh) systems of antigens are of major clinical importance as they are associated with transfusion reactions when mismatched

Genetic Determination of ABO Antigens

Genotypes	Blood Types	Agglutinogens
OO	O	-
OA or AA	A	A
OB or BB	B	B
AB	AB	A and B

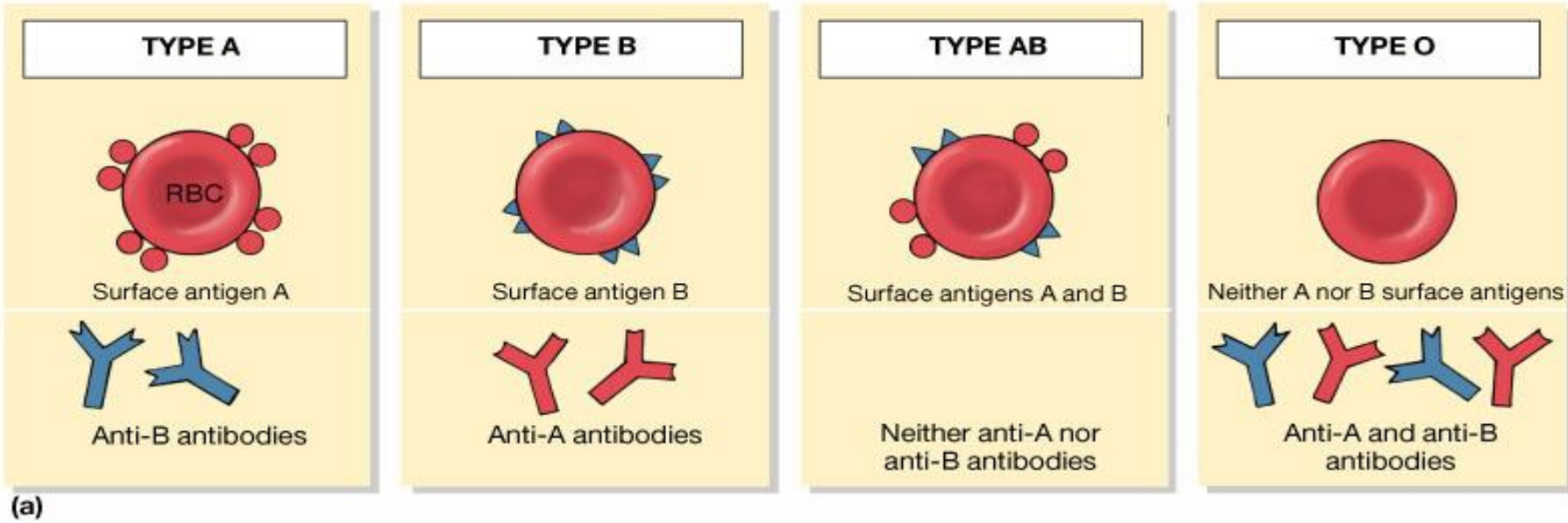
- Two genes (one maternal and one paternal in origin), one on each of the two paired chromosomes number 9, determine the O-A-B blood type.
- These genes can be any one of three types but only one type on each of the two chromosomes number 9: type O, type A, or type B.
- The type O gene is either functionless or almost functionless, so that it causes no significant type O agglutinogen on the cells. Conversely, the type A and type B genes do cause strong agglutinogens on the cells.
- The type A and type B genes are co-dominant. This meant that if a person inherited one type A gene and one type B gene, their red cells would possess both the A and B antigens

ABO Blood Typing

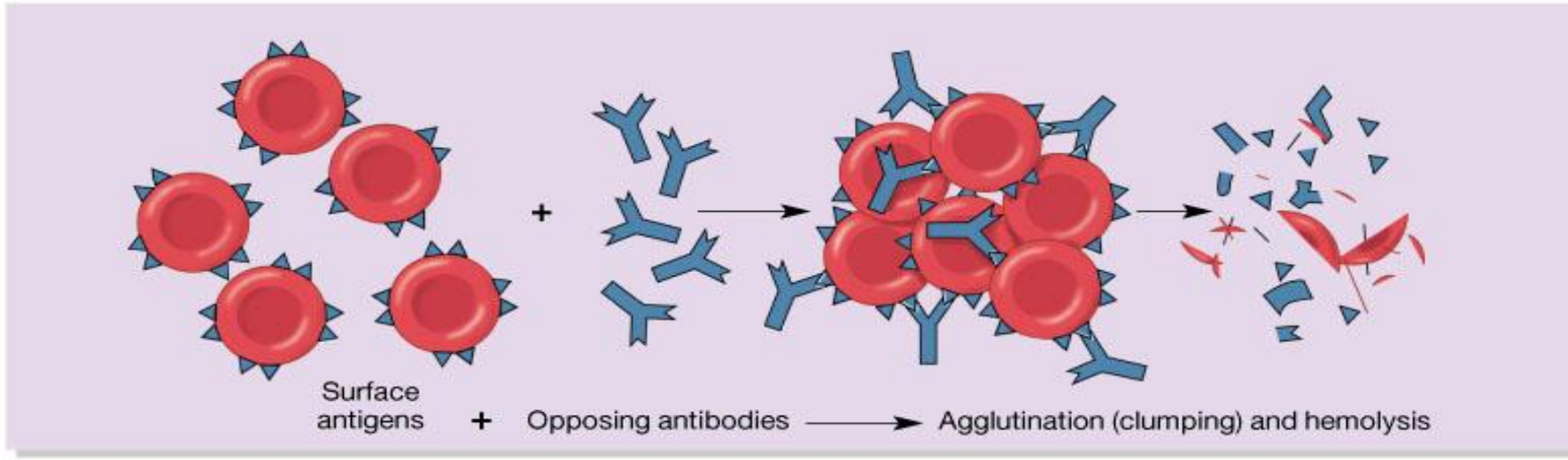


- ***With ABO, person makes antibodies (agglutinens; IgM) against factors (agglutinogens) he/she does NOT have on his/her cells***

Blood Typing and Agglutination



(a)



(b)

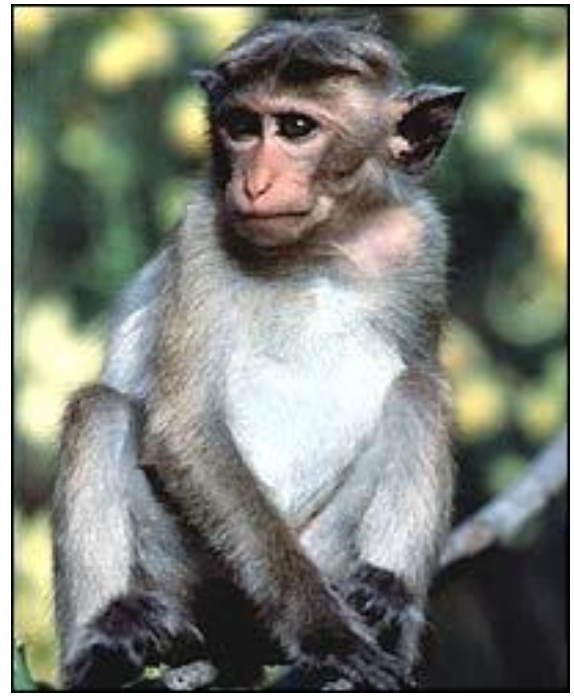
Rh factor (D):

Blood Typing

- **Rh factor (antigen) was first discovered in blood of *Rhesus* monkey. Rh factors only detectable on RBCs**

  - **RBCs with D protein = Rh^+**
  - **RBCs without D protein = Rh^-**

  85% of caucasians, 95% of black Americans, 99% of chinese and nearly 100% of black Africans are Rh+



Locus of alleles responsible of ABO system is on long arm of chromosome 9 while Rh locus is on chromosome 1

Agglutinins

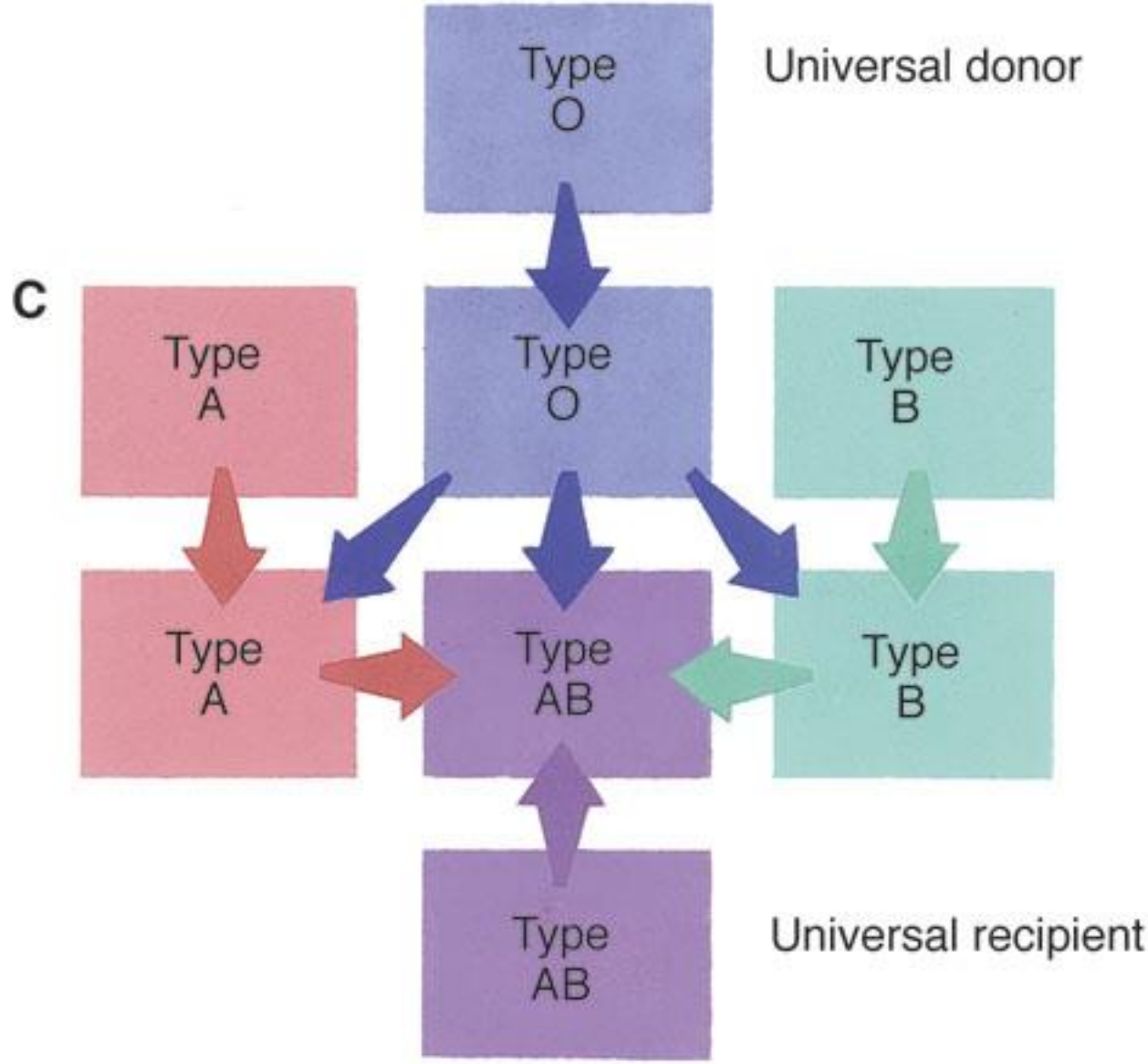
- Anti-Rh antibodies (IgG) develop only in Rh^- blood type and only with exposure to the antigen:
  - transfusion of positive blood.
  - during a pregnancy with a positive blood type fetus.
- Anti-Rh antibodies are not spontaneously formed in Rh^- individuals.
- However, if an Rh^- individual receives Rh^+ blood, anti-Rh antibodies form (Sensitization).
- Anti-Rh agglutinins develop slowly (2-4 months). Once produced they persist for years and can produce serious transfusion reaction during 2^{nd} transfusion.
- This immune response occurs to a much greater extent in some people than in others. With multiple exposures to the Rh factor, an Rh-negative person eventually becomes strongly "sensitized" to Rh factor.

ABO Blood Typing

Blood Type	A	B	AB[1]	O[2]
Agglutinogens (antigen proteins) Present	A	B	A & B	(neither)
Makes Agglutinins (antibodies) Against	B	A	(neither)	A & B
May Receive Blood From:	A, O	B, O	A, B, AB, O	O
May Give Blood To:	A, AB	B, AB	AB	A, B, AB, O
Rh Factor	Present or Absent (A+ or A-)	Present or Absent (B+ or B-)	Present or Absent (AB+ or AB-)	Present or Absent (O+ or O-)

[1] Universal Recipient

[2] Universal Donor



Blood Group	Antigens	Antibodies	Can give blood to	Can receive blood from
AB				
A				
B				
O				

Blood Group	Antigens	Antibodies	Can give blood to	Can receive blood from
AB	A and B	None	AB	AB, A, B, O
A	A	anti-B	A and AB	A and O
B	B	anti-A	B and AB	B and O
O	None	anti-A and anti-B	AB, A, B, O	O

Plasma compatibility table

Recipient	Donor			
	O	A	B	AB
O	OK	OK	OK	OK
A		OK		OK
B			OK	OK
AB				OK

When considering a plasma transfusion, keep in mind that plasma carries antibodies and no antigens. For example *you can't give type O plasma to a type A, B or AB*, because a person with type O blood has A and B antibodies and the recipient would have an immune response. On the other hand an AB donor could give plasma to anyone, since they have no antibodies.

Rh Blood Types

Blood Type	Rh^+	Rh^-
Agglutinogen D (antigen proteins) Present or Absent	Present	Absent
Makes Agglutinins (antibodies) Against Agglutinogen	No	Yes[1]
May *Receive* Blood From:	Rh^+ or Rh^-	Rh^-[2]
May *Give* Blood To Without Reaction[2]:	Rh^+	Rh^+ or Rh^-
Genotype	DD or Dd	dd

[1] Only makes antibodies (agglutinens) after exposure to Rh+ blood cells (via transfusion or during birth process)

[2] Transfusion of Rh^- individual with Rh+ blood results in production of anti-D agglutinens; sensitizes person to Rh factor and may result in anaphylaxis if exposed a second time. *Erythroblastosis fetalis* arises when Rh^- mother has been exposed to Rh^+ blood and is carrying Rh^+ child.

Universal Donor; Suitable for all?

Universal donor:

- **Blood group O, Rh negative.**
- **May be given in emergency to patients with either A, B, AB and Rh negative or positive blood groups.**
- **Antibody concentrations may be high, so may not be suitable if large volume of plasma is required.**

Universal recipient:

- **People with type AB blood are called “universal recipients” since have no antibodies in plasma.**

Blood Transfusion

Indications of blood transfusion:

1. Acute hemorrhage.

2. Sever anemia (if Hb decreased below 7 g/dL).

3. Erythroblastosis fetalis: in this case exchange transfusion is done.

4. To supply a necessary elements e.g. platelets, packed RBCs, and some clotting factors.

Requirements Prior to Blood Transfusion

- *Typing (grouping) of the recipient:* **determining red cell antigens in blood**
  - **ABO typing**
  - **Rh typing**

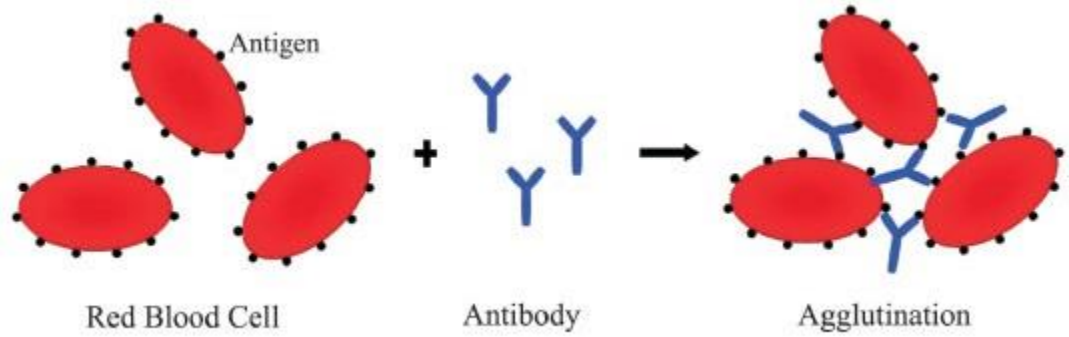
- *Cross-matching:*

  Donor's cells + Recipient's plasma

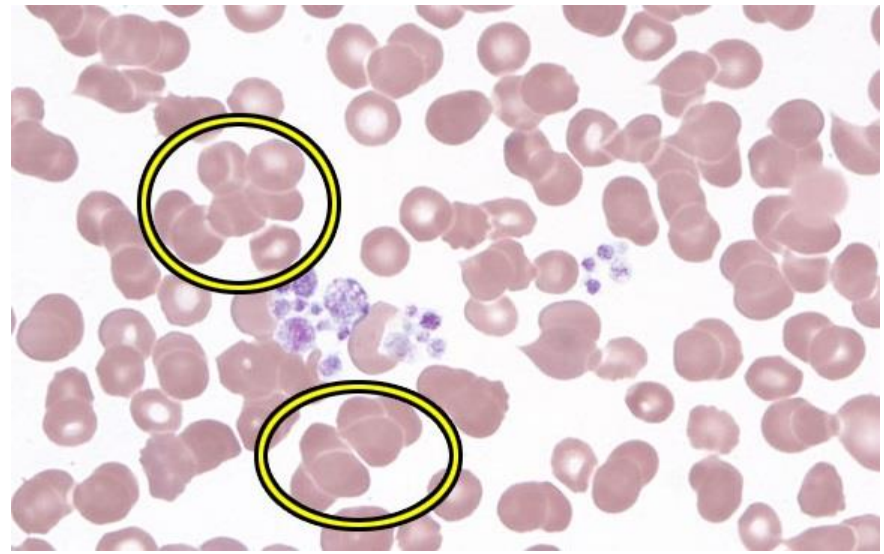
- *Disease Screening:*
  - ***Hepatitis B and C virus***
  - ***Antibody to HIV***
  - ***HIV Antigens***
  - ***Syphilis***
  - ***Cytomegalovirus***

Typing and Cross-Matching Blood

- Typing involves testing blood with known antisera that contain antibodies anti-A, anti-B or anti-Rh.

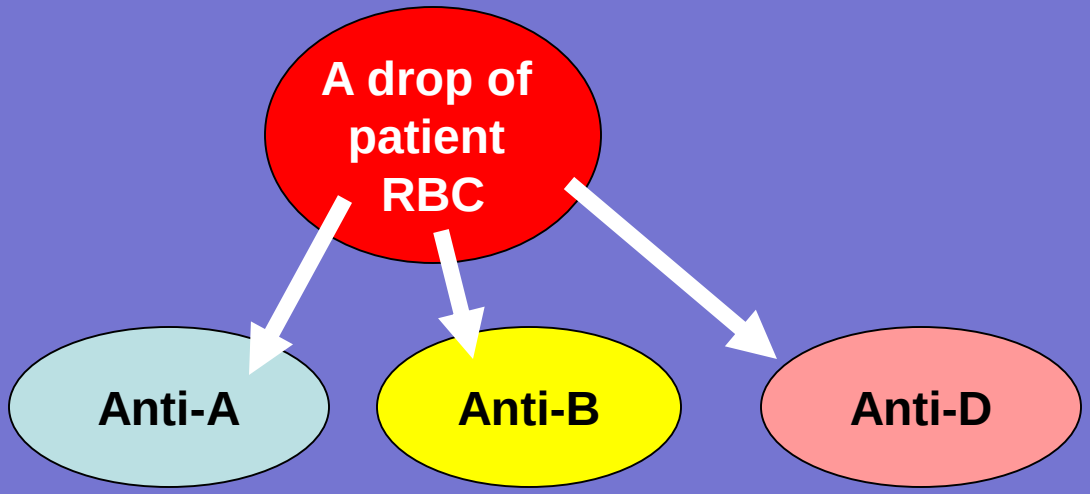


- Mixing of incompatible blood causes agglutination (visible clumping):
  - formation of antigen-antibody complex that sticks cells together (agglutination reaction).
  - Leading to renal obstruction (shutdown) and hemolysis.

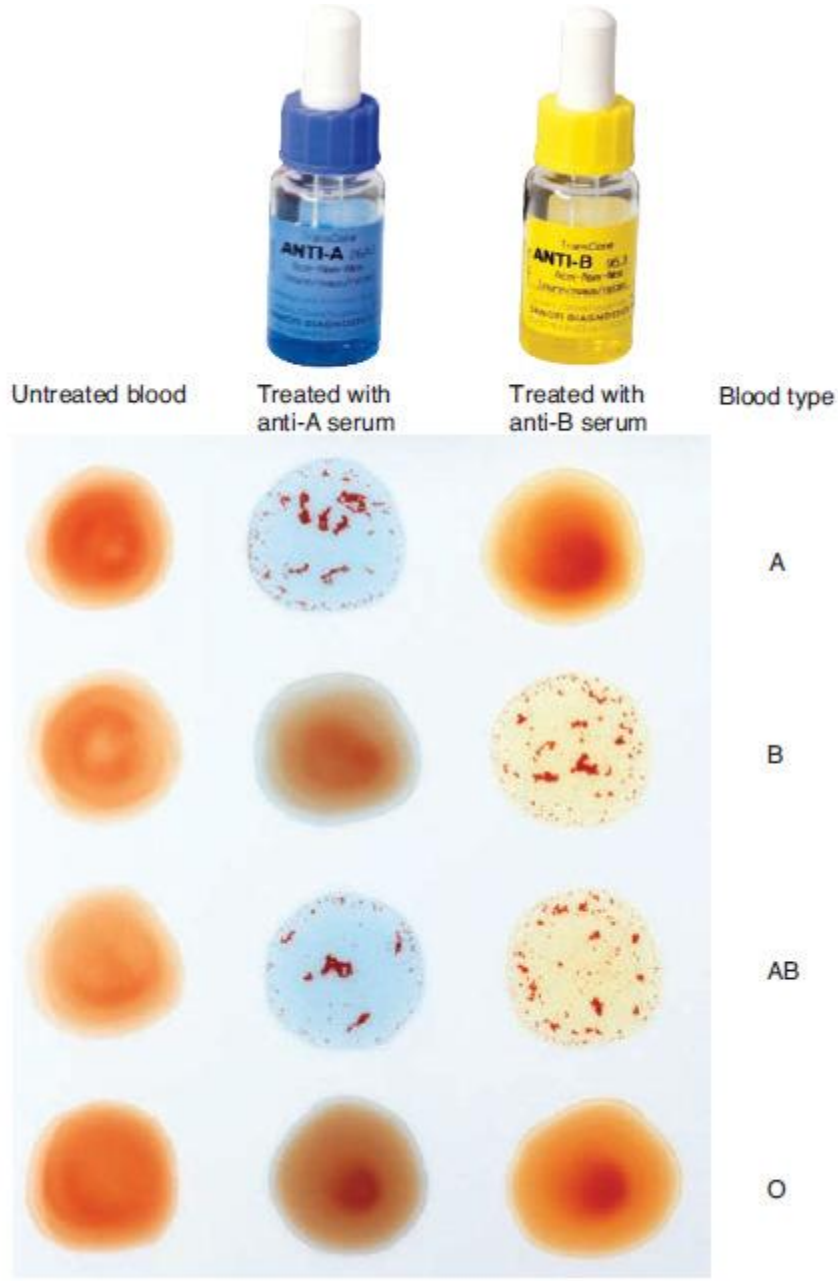


Blood tests before transfusion

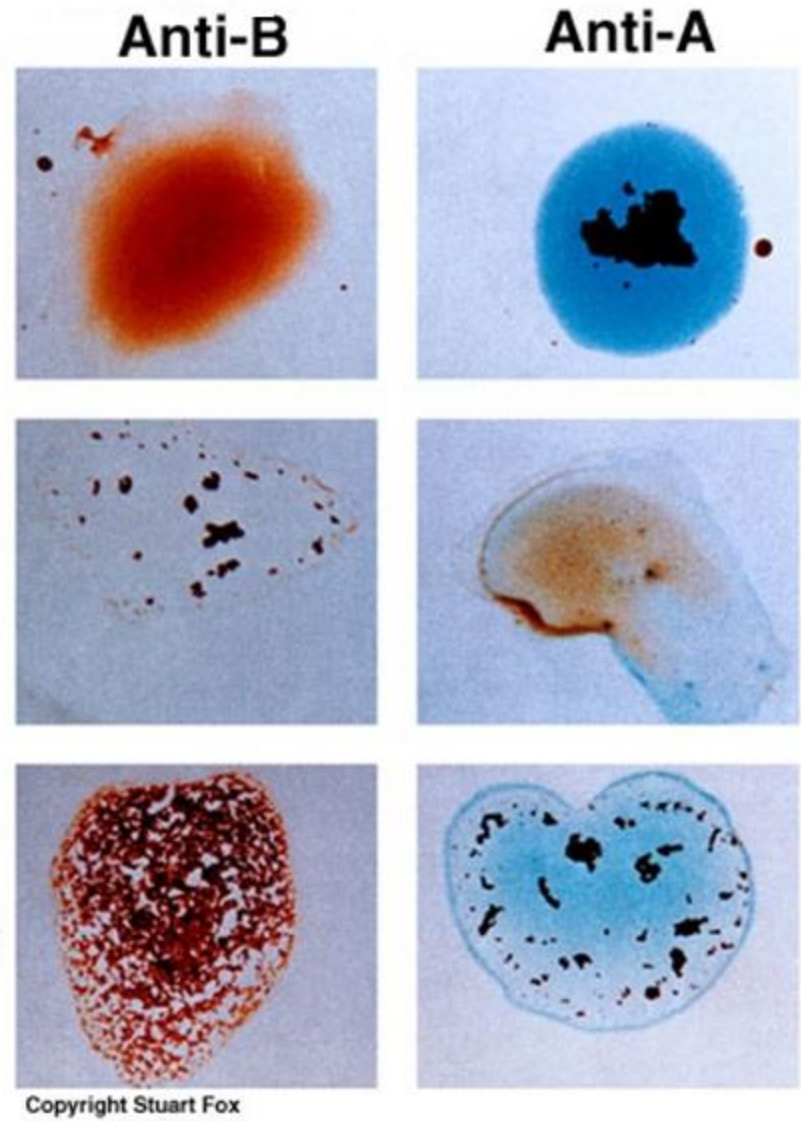
1. Blood group type of patient (recipient)



- Look for agglutination

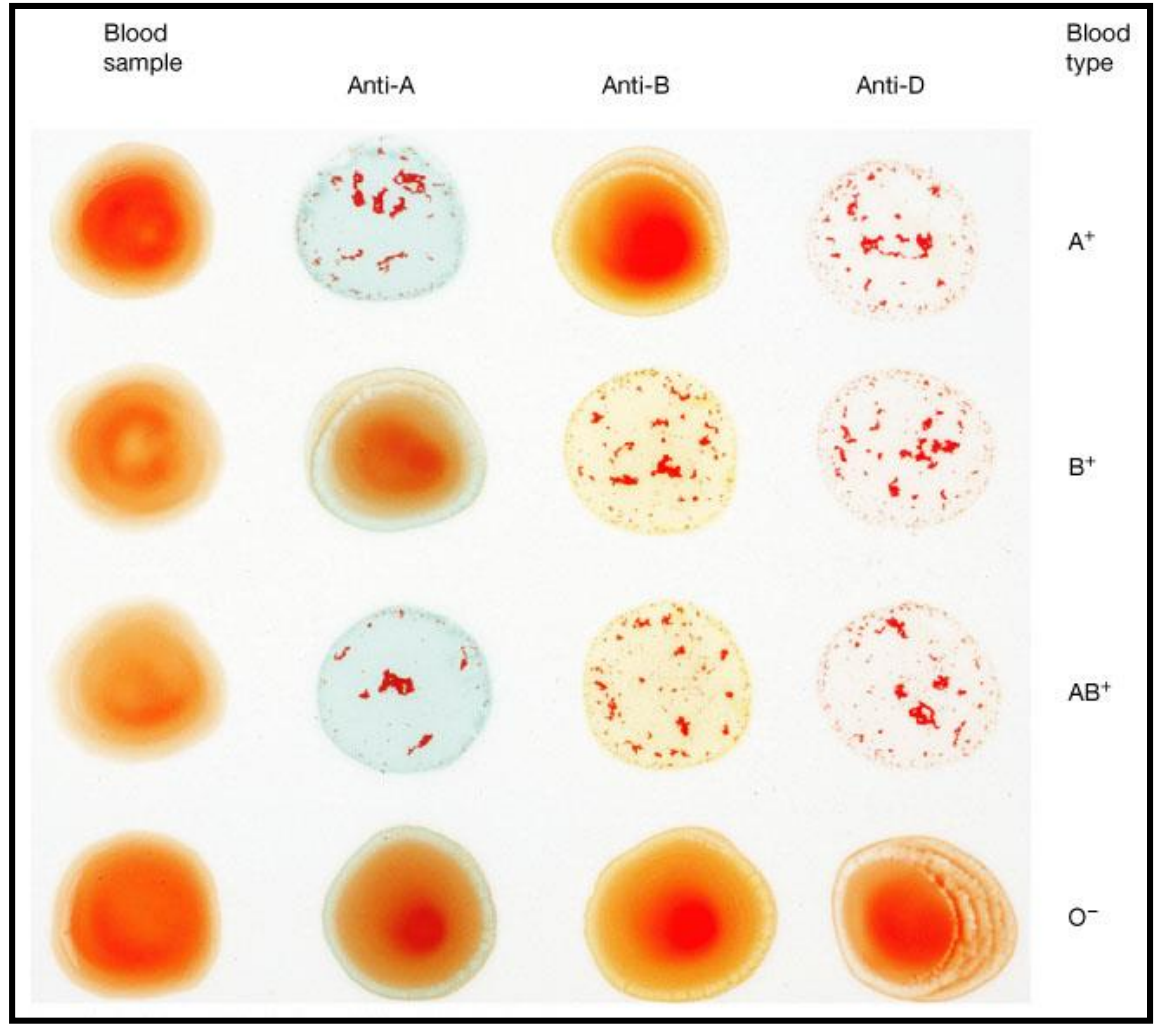

ANTI-A
ANTI-B
Untreated blood
Treated with anti-A serum
Treated with anti-B serum
Blood type
A
B
AB
O

Blood Typing

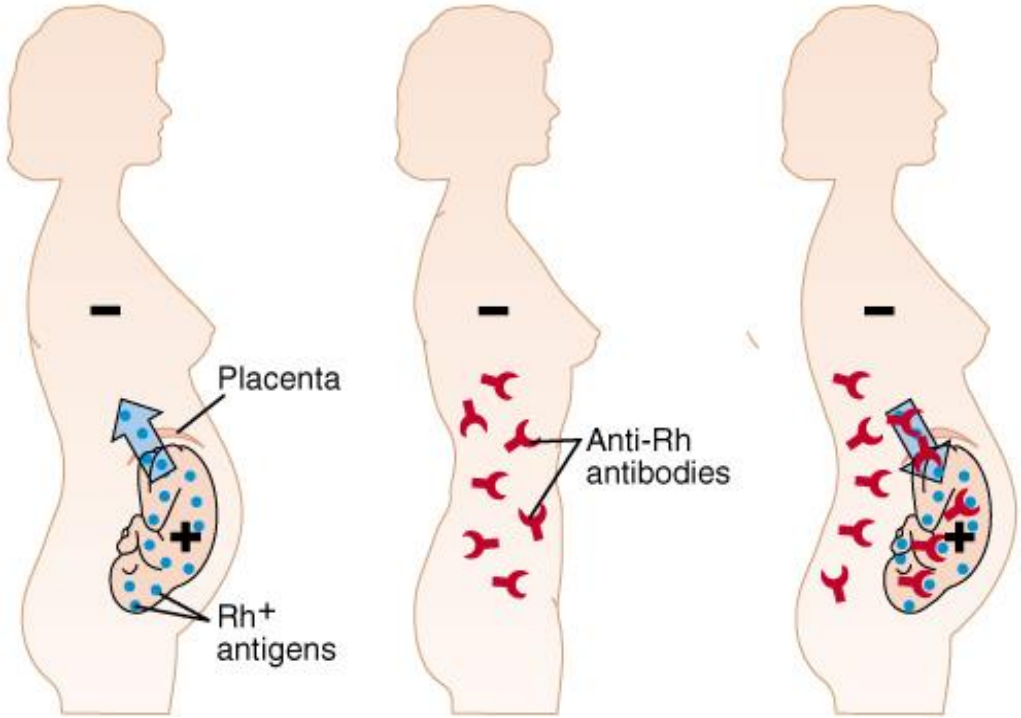


ABO Blood Grouping (Typing) in Laboratory Using Anti-sera

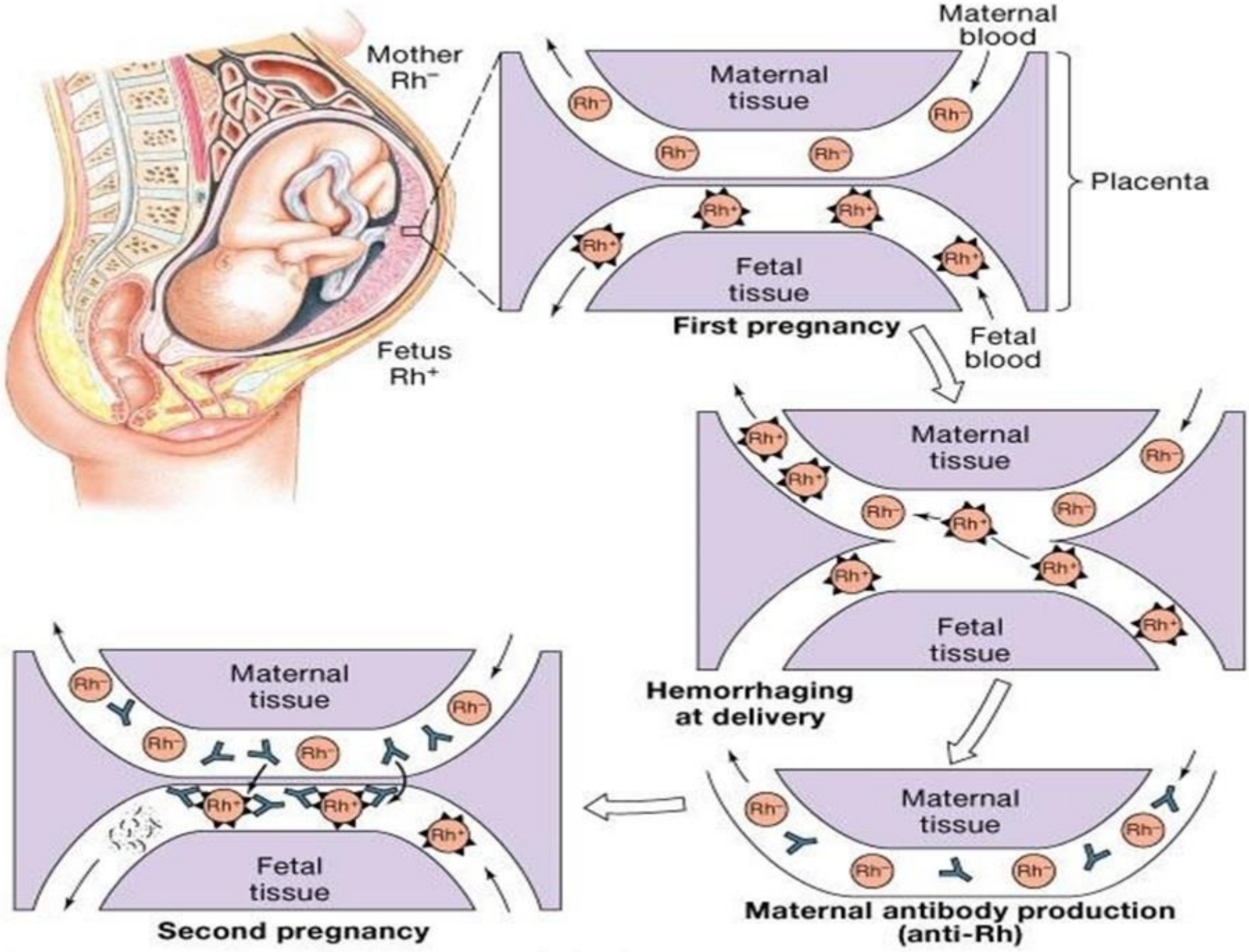
Group	Anti-A	Anti-B
A	Agglutination	Nil
B	Nil	Agglutination
AB	Agglutination	Agglutination
O	Nil	Nil



Hemolytic Disease of Newborn



- During birth, there is often a leakage of the baby's red blood cells into the mother's circulation. But the first pregnancy passes without any problems. ??
- If the baby is Rh-positive (having inherited the trait from its father) and the mother Rh-negative, these red cells will cause her to develop antibodies (IgG class) against the RhD antigen.
- In 2nd child, hemolytic disease of the newborn may develop causing hemolysis of the fetal RBCs → anemia and jaundice.


Mother
Rh⁻
Fetus
Rh⁺
Maternal blood
Maternal tissue
Fetal tissue
Placenta
First pregnancy
Fetal blood
Hemorrhaging at delivery
Maternal antibody production (anti-Rh)
Second pregnancy

Hemolytic Disease of Newborn

- **Hemolytic anemia:**
  - **If severe:**
    treated with exchange transfusion: Replace baby blood with Rh-ve RBC (several times)

- **Kernicterus (mental retardation due to bilirubin deposition in the brain).**

- **Hydrops fetalis (death in utero)**

Prevention of Hemolytic Disease of Newborn

Rh immune globulin (RhIg) or Rhogam or anti-D:

- **Shortly after each birth of an Rh-positive baby, the mother is given an injection of anti-Rh antibodies.**

- **These antibodies destroy any Rh+ fetal cells that got into the maternal circulation before they can stimulate an active immune response in the mother.**

- **The routine administration of such treatment to Rh - ve mothers after the delivery of Rh+ve baby has reduced the incidence of disease by >90%.**

Treatment **Phototherapy or exchange blood transfusion.**

Fetal Incompatibility

- Most anti-A or anti-B antibodies are of the IgM class and these do not cross the placenta.
- Thus, an Rh^-/type O mother carrying an Rh^+/type A, B, or AB foetus is resistant to sensitization to the Rh antigen.
- Her anti-A and anti-B antibodies destroy any fetal cells that enter her blood before they can stimulate anti-Rh antibodies in her.

Thank You