Blood Groups and Blood Transfusion

Dr.Ahmed Alsabih

Objectives;

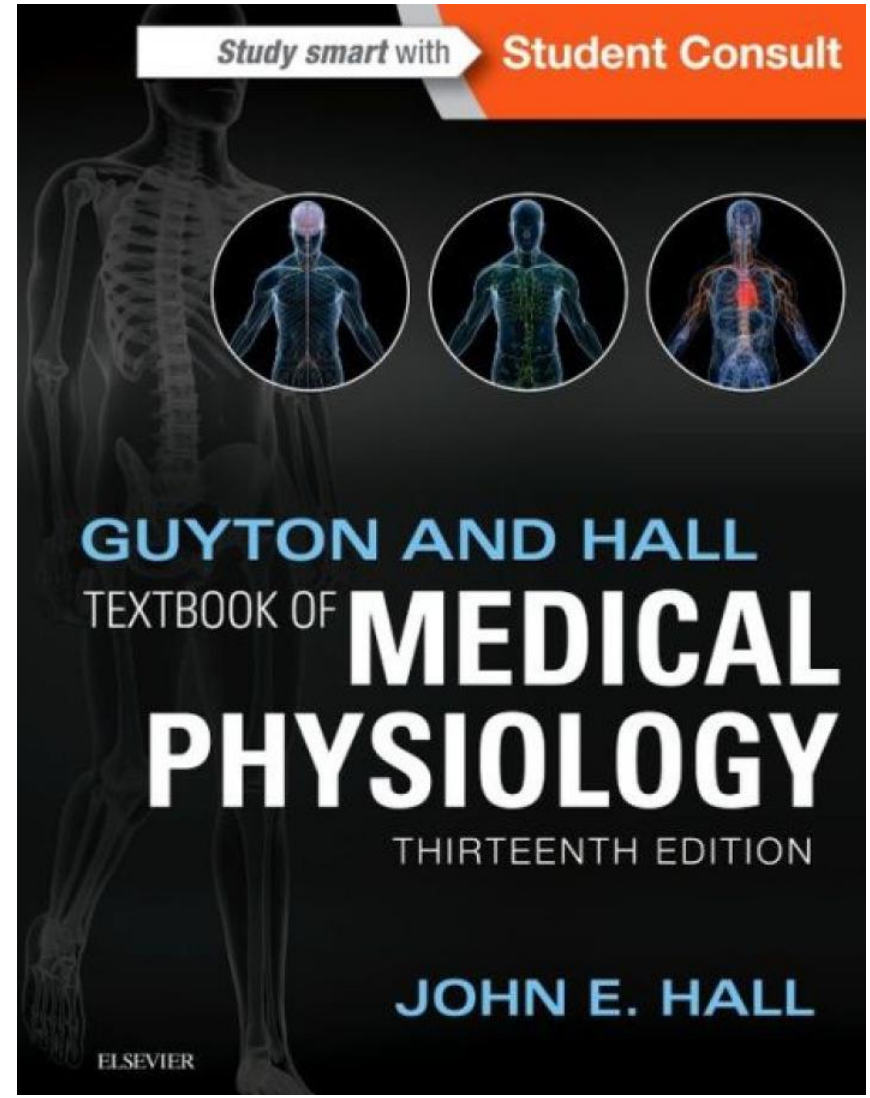
Intended learning outcomes (ILOs)

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 agglutinins in the plasma**
- ❑ **Describe grouping, cross-matching & typing with anti-sera**
- ❑ **List precautions taken in preparing blood for transfusion and storage of blood**
- ❑ **Define autologous transfusion and list its advantages**
- ❑ **Describe transfusion reactions.**
- ❑ **Define hemolytic disease of newborn, describe its pathophysiology and outline its prevention**

Learning Resources

Guyton and Hall, Textbook of Medical Physiology; 13th Edition; Unit VI-Chapter 36.

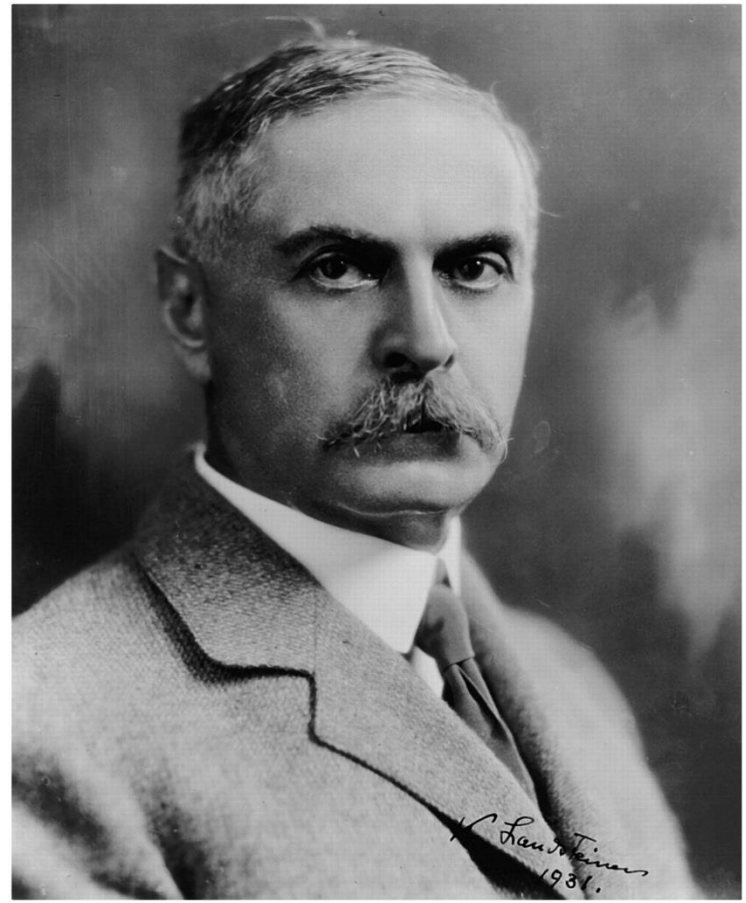


Blood Typing

- RBC surfaces are marked by genetically determined antigens
  - Agglutinogens or isoantigens
- Blood is typed (grouped) based on surface antigens
- At least 30 common antigens and 100s of rare antigens have been found on the surfaces of human blood cells
- The ABO and Rhesus (Rh) systems of antigens are of major clinical importance as they are associated with transfusion reactions when mismatched
- Other antigens are less likely to cause reactions; however, they are of forensic importance (establish parentage).

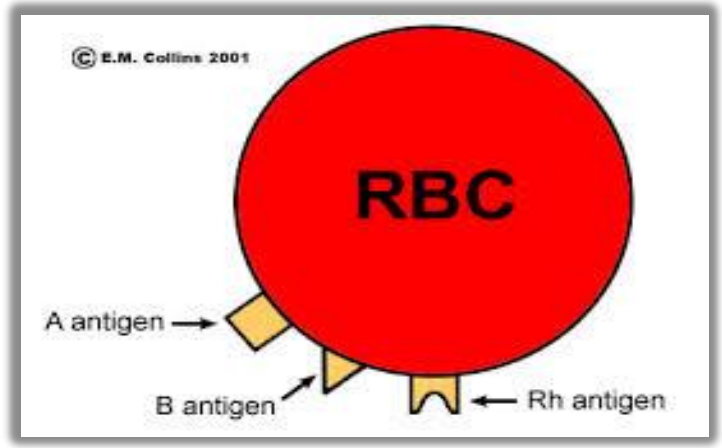
Karl Landsteiner

- 1901: was the first to discover the ABO blood agglutinins & classified blood groups accordingly.
- 1930: awarded the Nobel Prize in Physiology & Medicine for his discovery
- 1937: With Alexander S. Wiener, he identified the Rh factor.



Blood Typing

ABO blood group:



A and B antigens are found in:

- Most cells: RBCs, WBCs and platelets

- In secretions: saliva, sweat, semen

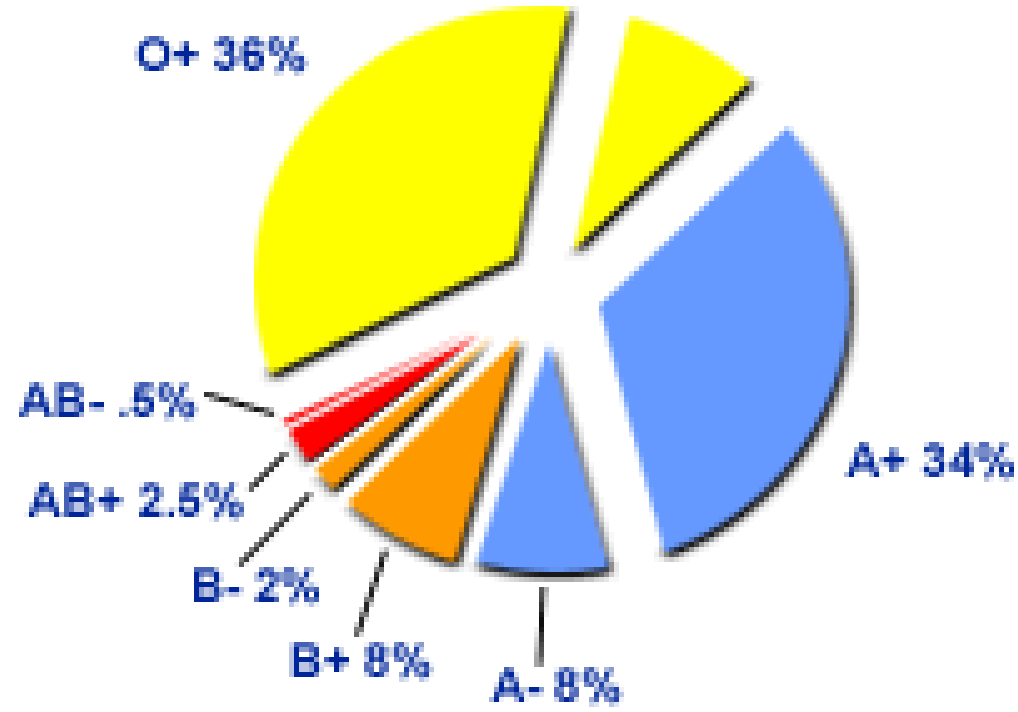
- They are glycoproteins, complex oligosaccharides that differ in their terminal sugar

- **RBCs with A antigen = Type A blood**
- **RBCs with B antigen = Type B blood**
- **RBCs with neither antigens = Type O blood**
- **RBCs with both antigens = Type AB blood**

- **Detection of A and B antigens in dried blood stains is of forensic importance**

ABO Blood Group Frequency

Blood group	% Distribution
O	47%
A	41%
B	9%
AB	3%



Frequency of ABO has ethnic variation

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 Group Inheritance

Mother/Father	OO	AA, AO	BB, BO	AB
OO	O	O, A	O, B	A, B
AA, AO	O, A	O, A	O, A, B, AB	A, B, AB
BB, BO	O, B	O, A, B, AB	O, B	A, B, AB
AB	A, B	A, B, AB	A, B, AB	A, B, AB

The Question of Paternity

- Blood types cannot be used to prove paternity.
- Blood types can disprove paternity.
- Noura blood (type A) and Fahad blood (type B) Have a baby (blood type O) Can Fahad be the father?

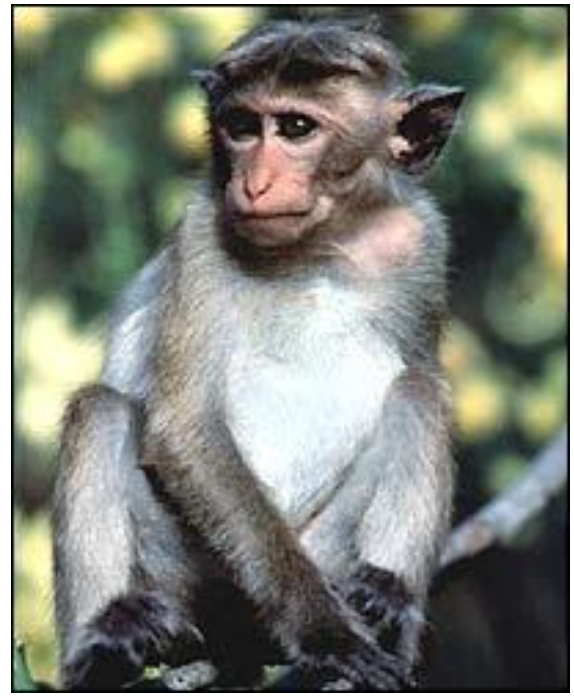
Phenotype	Possible Genotype
Noura: A	AA or AO
Fahad :B	BB or BO
Baby: O	OO

Blood Typing

Rh factor (D):

- There are eight different Rh agglutinogens, three of which (C, D, and E) are common
- Rh factor (antigen) are a complex system of antigens with Mendelian inheritance Cc, Dd, Ee
- Rh factor (antigen) was first discovered in blood of *Rhesus* monkey. Rh factors only detectable on RBCs
- C, D & E antigens (D is the most immunogenic)
  - 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

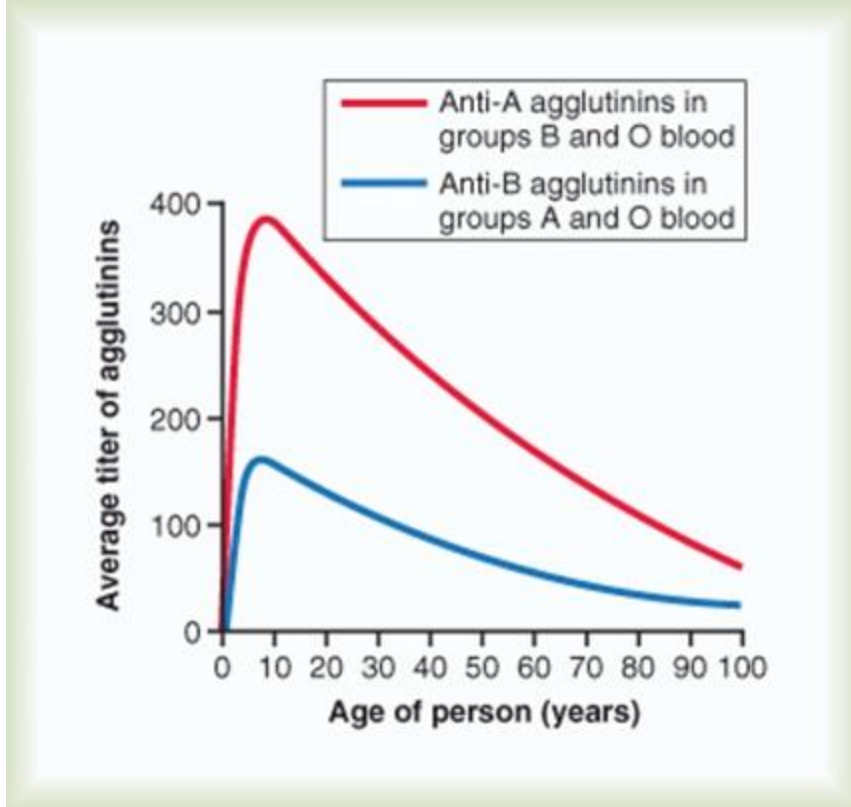
Agglutinins

- Plasma contains isoantibodies or agglutinins (IgM) to the A or B antigens not found in the blood:
  - anti-A antibody reacts with antigen A.
  - anti-B antibody reacts with antigen B.

- Anti-A and Anti-B antibodies are not present at birth. Two to 8 months after birth, an infant begins to produce agglutinins. A maximum titer is usually reached at 8 to 10 years of age, and this gradually declines throughout the remaining years of life.

- Normal plasma contains no anti-Rh (anti-D) antibodies.

- 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.



LANDSTEINER's LAW:

1. If an agglutinogen is present on red blood cell membrane ,the corresponding agglutinin must be absent in the plasma.
2. If an agglutinogen is absent on red blood cell membrane, then corresponding agglutinin must be present in the plasma.
3. This law is only applicable to ABO blood grouping system.

Agglutinins

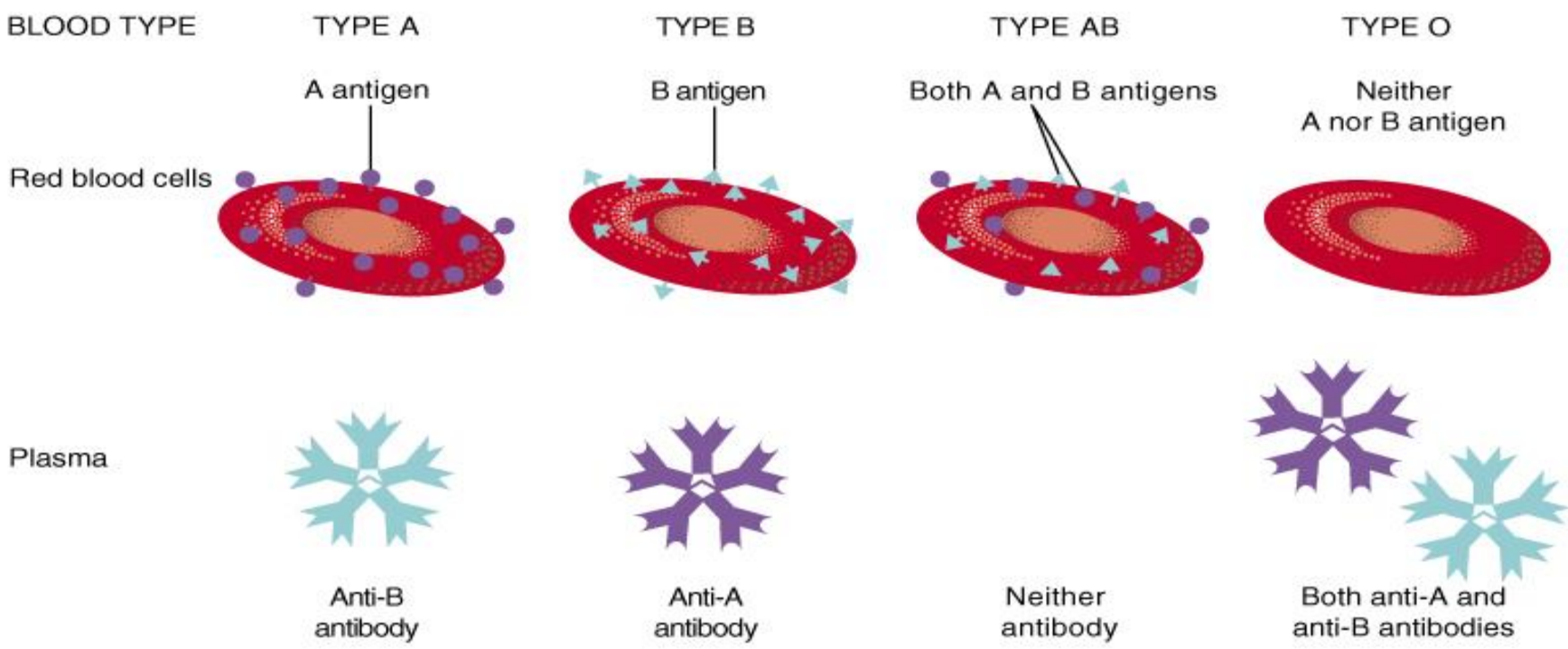
- Anti-Rh antibodies (IgG) develop only in Rh^- blood type and only with exposure to the antigen:
  - transfusion of positive blood.
  - during a pregnancy with a positive blood type fetus.

- Anti-Rh antibodies are not spontaneously formed in Rh^- individuals.
- However, if an Rh^- individual receives Rh^+ blood, anti-Rh antibodies form.
- 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.

Agglutinins

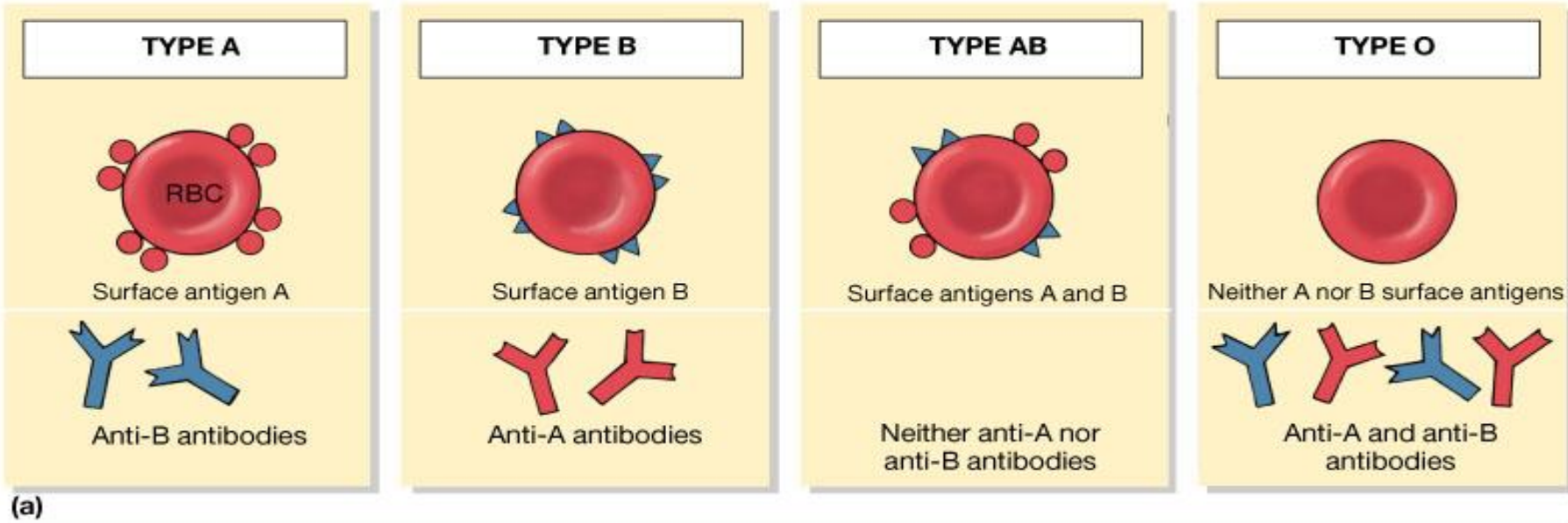
Genotypes	Blood Types	Agglutinogens	Agglutinins
OO	O	-	Anti-A & Anti-B
OA or AA	A	A	Anti-B
OB or BB	B	B	Anti-A
AB	AB	A + B	-

ABO Blood Typing

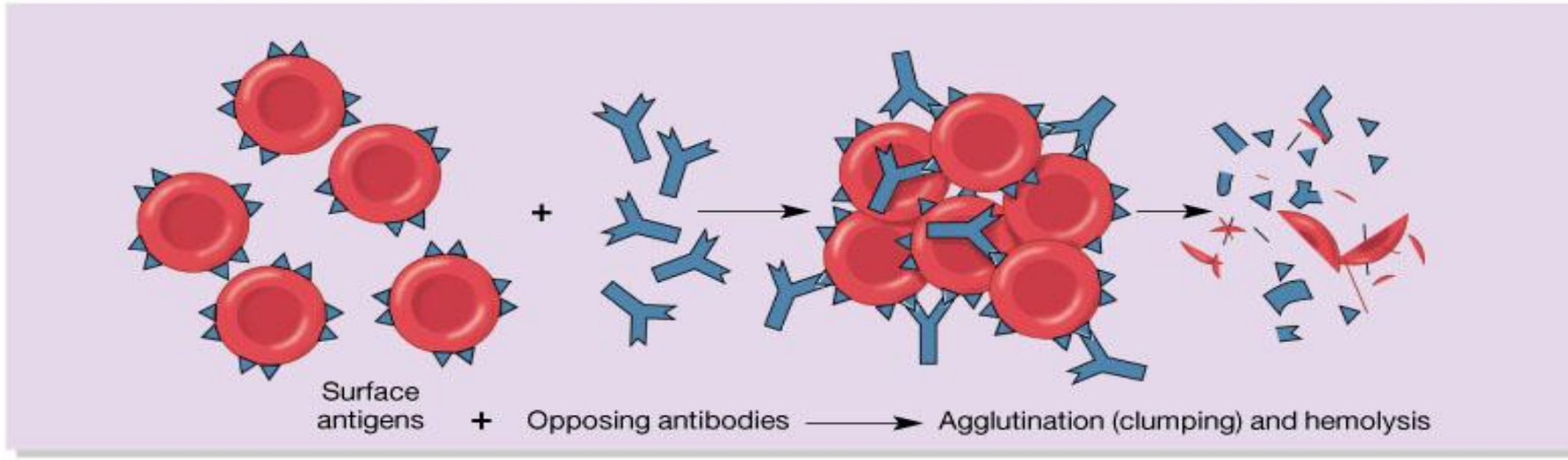


- ***With ABO, person makes antibodies (agglutinens; IgM) against factors (agglutinogens) he/she does NOT have on his/her cells***

Blood Typing and Agglutination



(a)



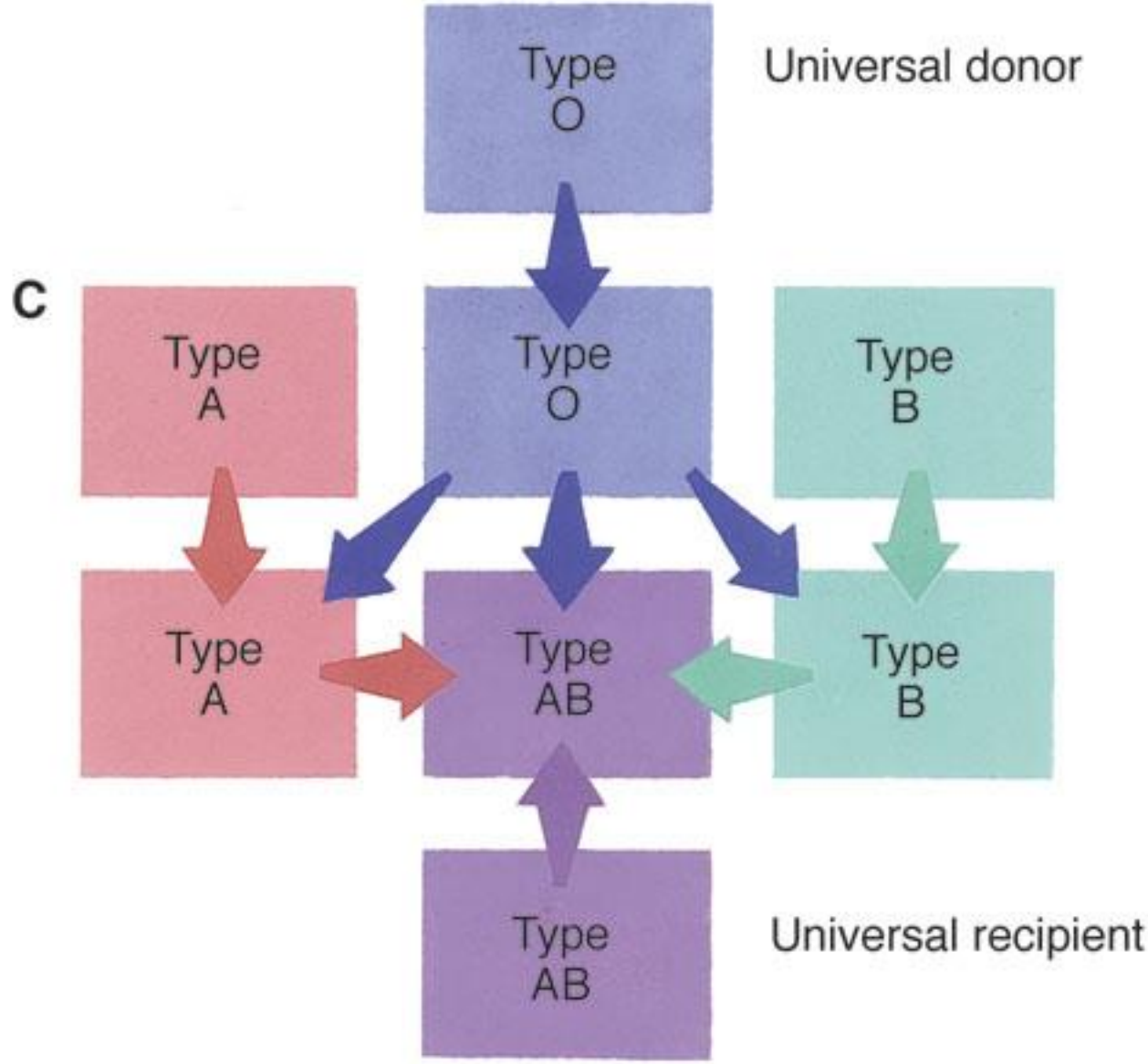
(b)

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

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 blood required.**

Universal recipient:

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

Importance of Blood Groups

- In blood transfusion.
- In preventing hemolytic disease (Rh incompatibility).
- In paternity disputes.
- In medico-legal cases.
- In knowing susceptibility to disease
  - Group O- duodenal cancer
  - Group A- Carcinoma of stomach, pancreas & salivary glands

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 (all blood is changed) 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**

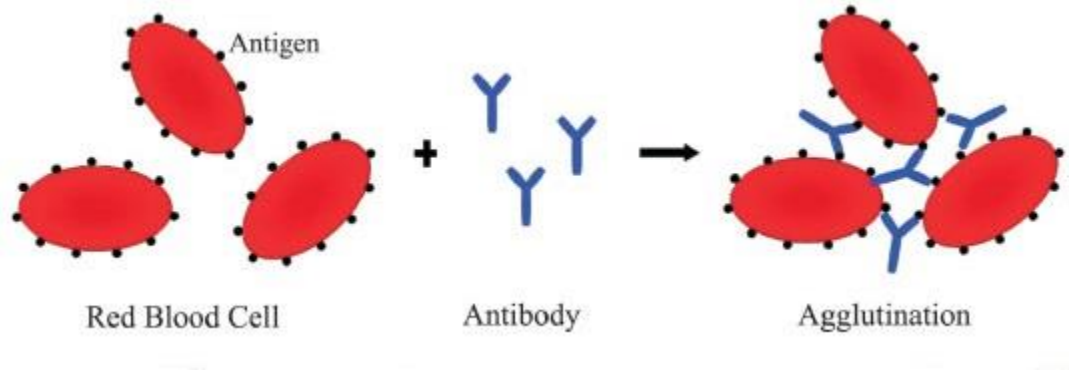
- ***Cross-matching:***

  Donor's cells + Recipient's serum

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

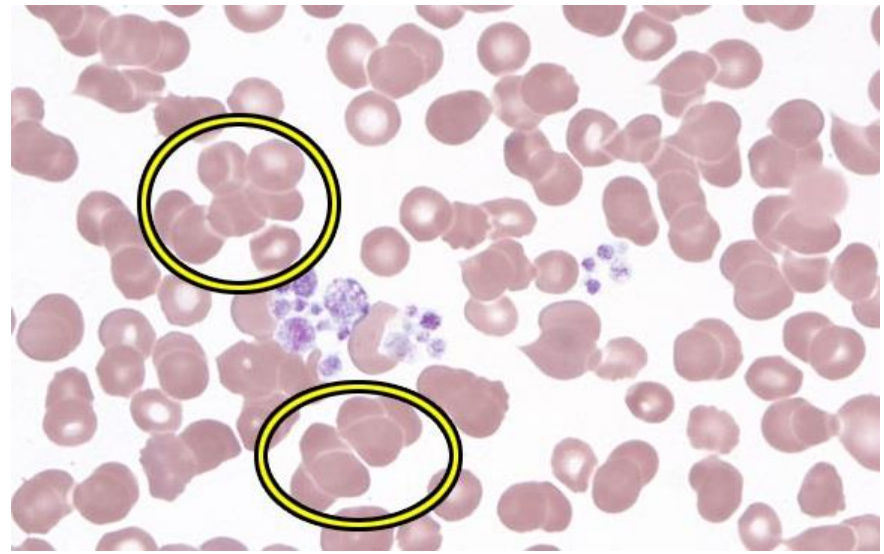
Typing and Cross-Matching Blood

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



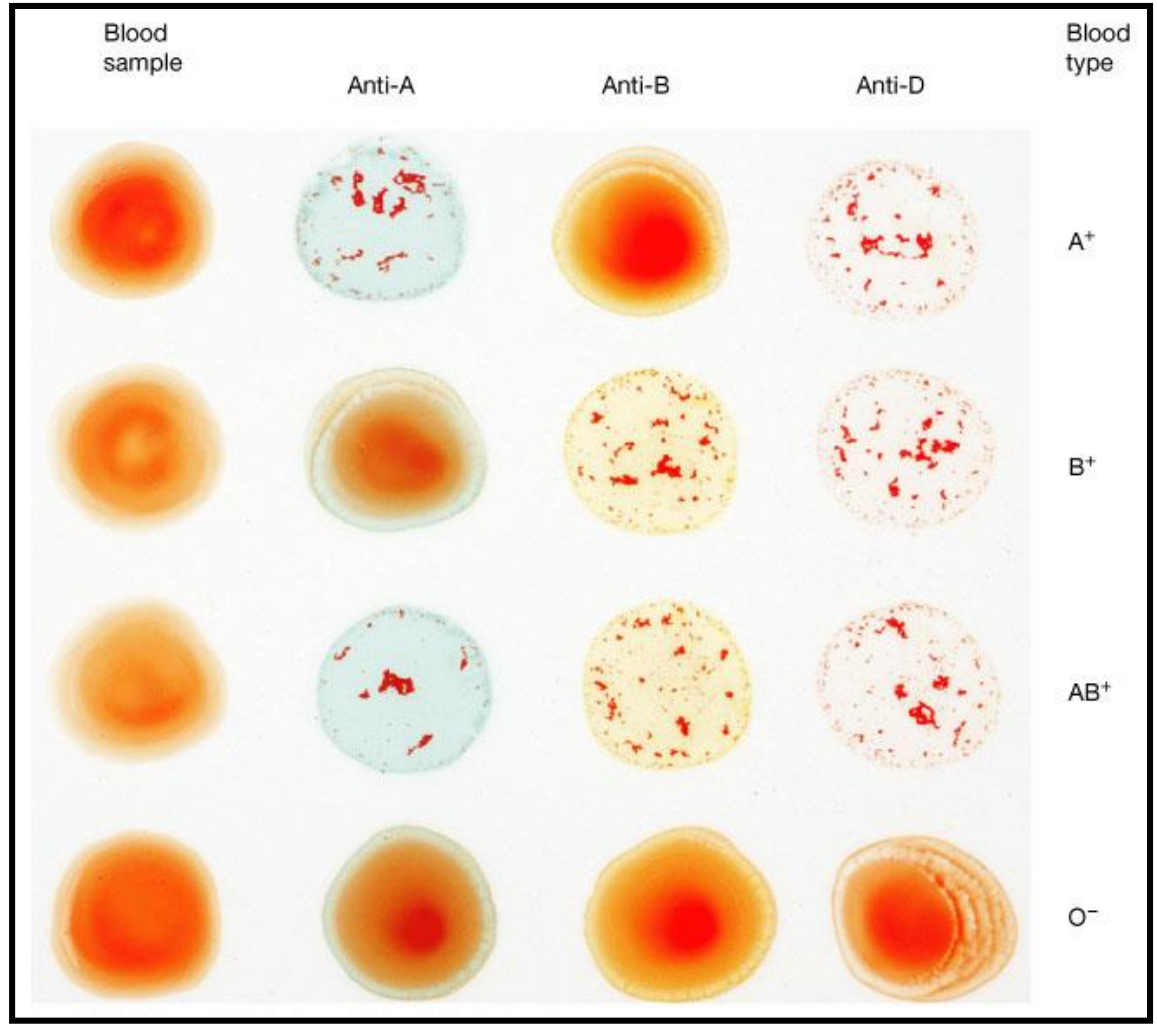
- Cross-matching is mixing of donor cells with recipient's serum.

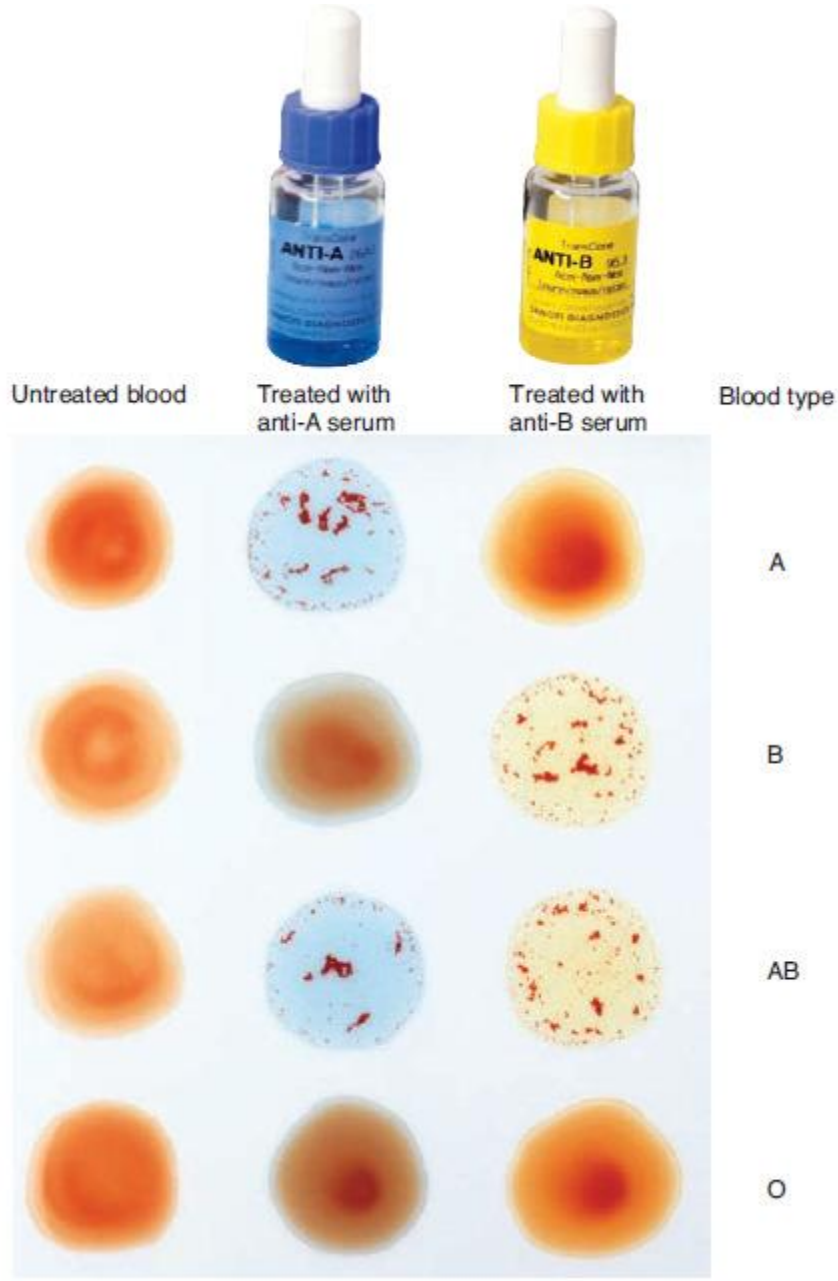
- Mixing of incompatible blood causes agglutination (visible clumping):
  - formation of antigen-antibody complex that sticks cells together (agglutination reaction).



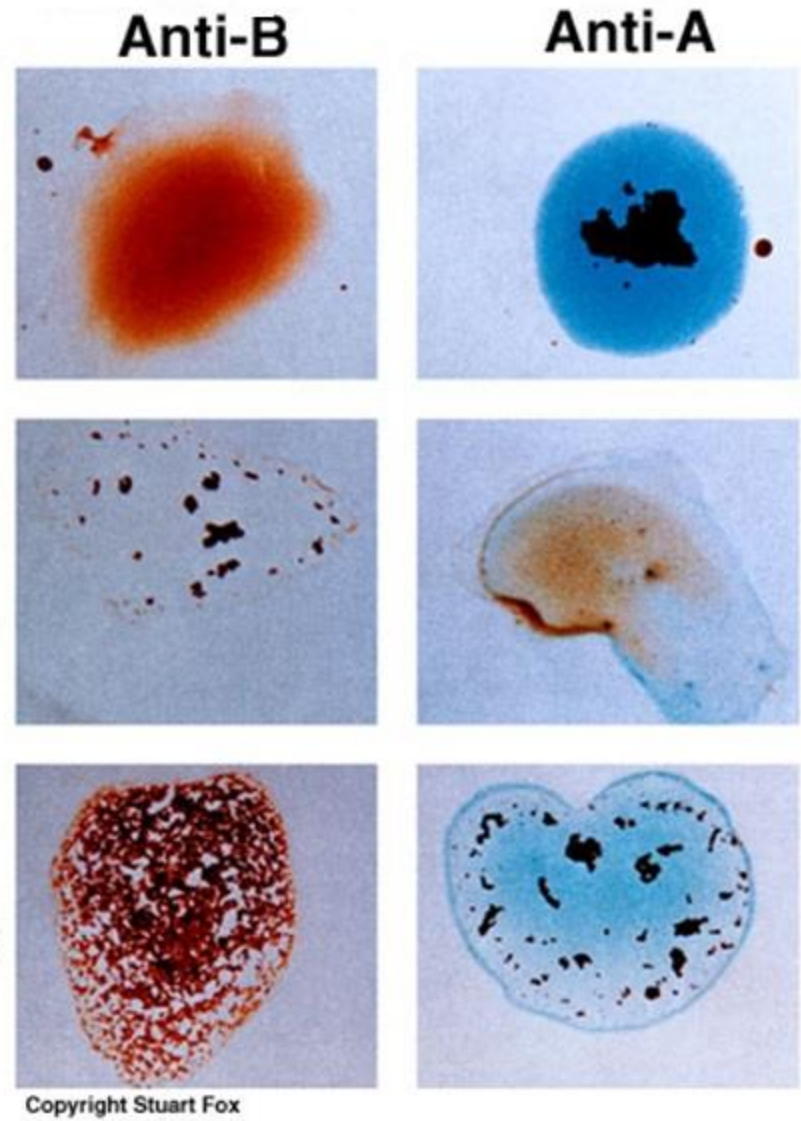
ABO Blood Grouping (Typing) in Laboratory Using Anti-sera

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




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

Blood Typing



Transfusion Reactions

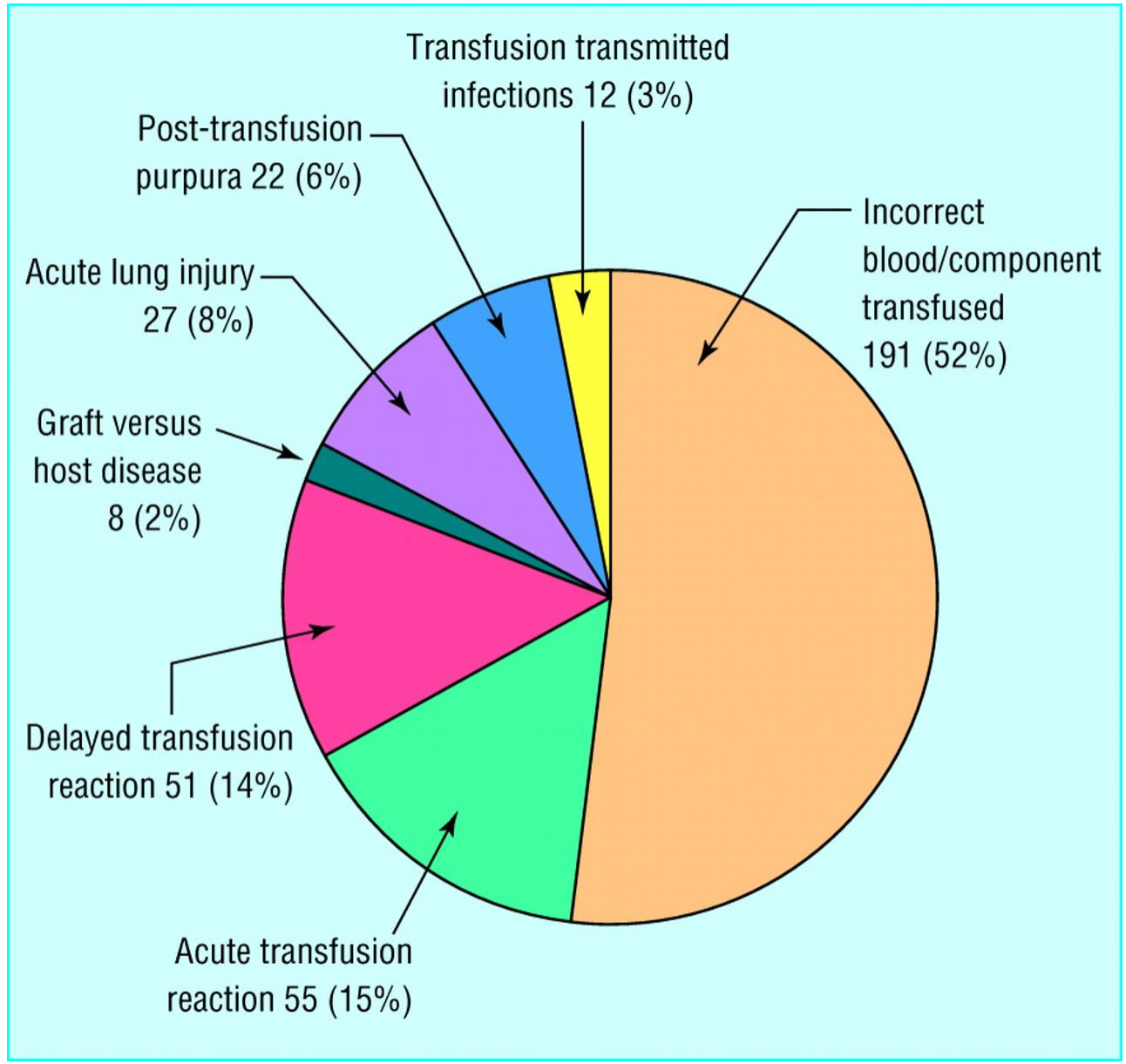
- **Incompatible blood transfusions**
  - **Mixing of incompatible blood causes the formation of antigen-antibody complexes between recipient's plasma antibodies and "foreign proteins; antigens" on donated RBC's (agglutination)**
  - **Donated RBCs become leaky and burst → diminished oxygen-carrying capacity**
  - **Clumped cells impede blood flow**
  - **Ruptured RBCs release free hemoglobin into the bloodstream → circulating hemoglobin precipitates in the kidneys and causes kidney damage and renal failure**

- **Problems are caused by incompatibility between donor's cells and recipient's plasma**
- **Why do donor antibodies not attack recipient RBCs**
- **Donor plasma is too diluted to cause problems**

Symptoms and Signs of Transfusion Reactions

- ❑ Pain at site of infusion
- ❑ Dyspnea
- ❑ Nausea
- ❑ Flushing
- ❑ Hypotension
- ❑ Oliguria or Anuria (renal failure)
- ❑ Chest Pain Back Pain
- ❑ Chills
- ❑ Shock
- ❑ Fever

Serious Hazards of Blood Transfusion



Complications of Blood Transfusion

Table 8.18
Complications of blood transfusion

Immunological	Non-immunological
Alloimmunization	*Transmission of infection*
Incompatibility	Viruses – HAV, HBV, HCV
Red cells	– HIV
Immediate haemolytic transfusion reactions	– CMV, EBV, HTLV-1
Delayed haemolytic transfusion reactions	Parasites – malaria, trypanosomiasis, toxoplasmosis
Leucocytes and platelets	Bacteria
Non-haemolytic (febrile) transfusion reactions	Prion – CJD
Post-transfusion purpura	*Circulatory failure* due to volume overload
Poor survival of transfused platelets and granulocytes	*Iron overload* due to multiple transfusions (see p. 429)
Graft-versus-host disease	*Massive transfusion* of stored blood may cause bleeding and electrolyte changes
Lung injury (TRALI)	*Physical damage* due to freezing or heating
Plasma proteins	*Thrombophlebitis*
Urticarial and anaphylactic reactions	*Air embolism*

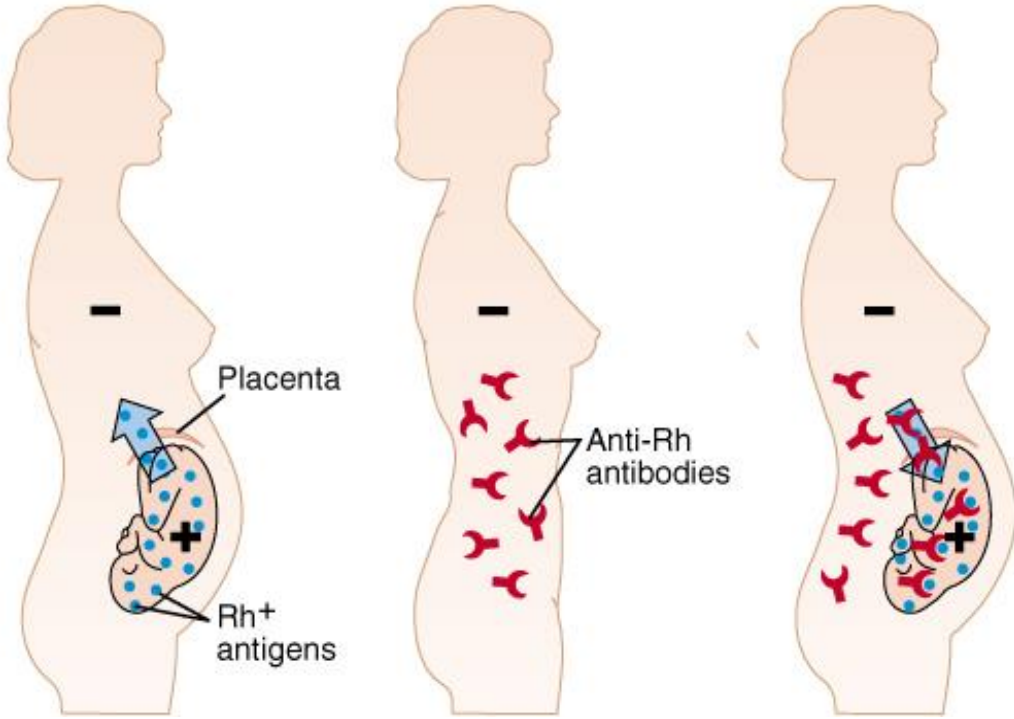
Question

Transfusion reaction occurs between which of the following?

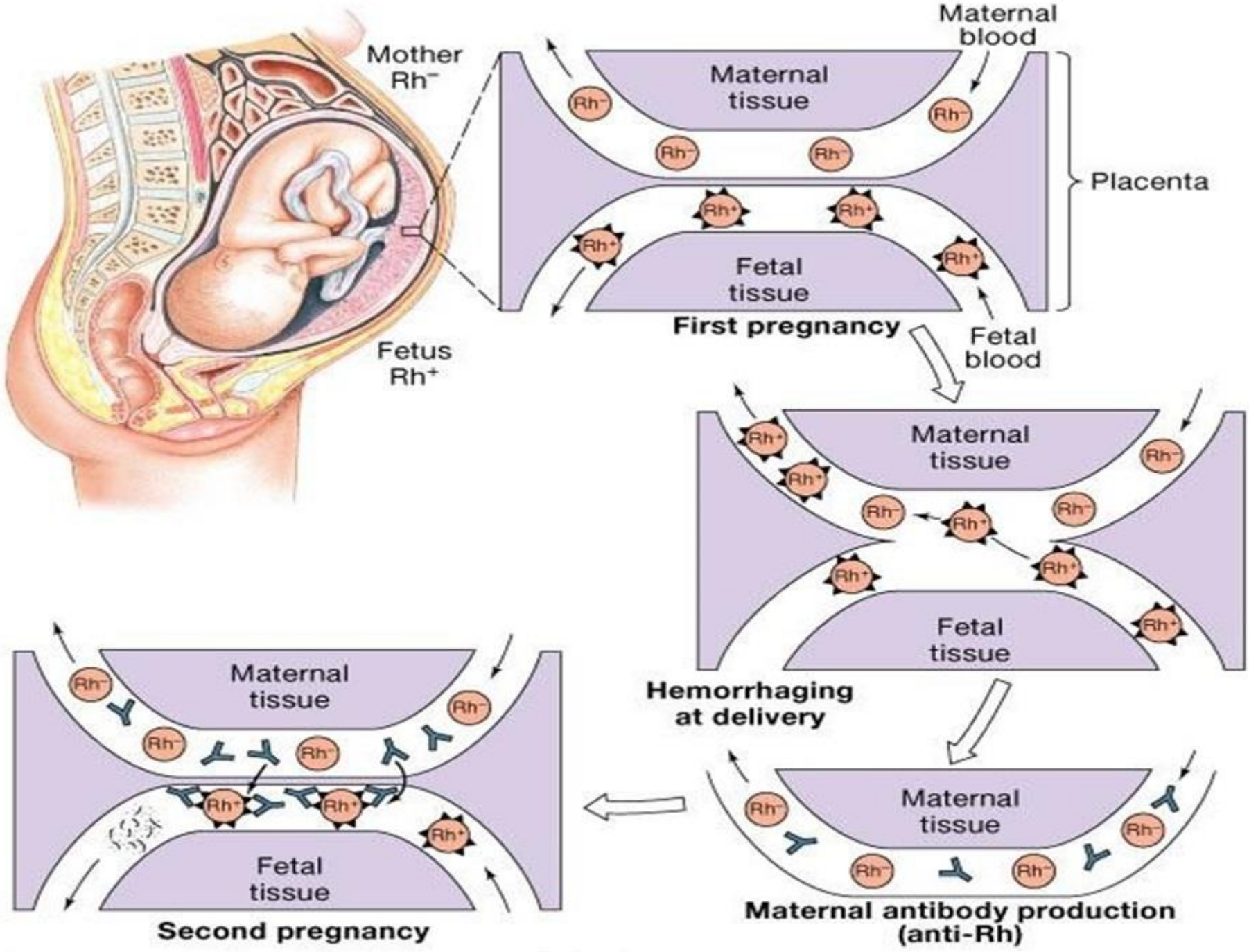
- **Donor's plasma agglutinins against the red cell antigens of the recipient**
- **Donor's red cell antigens against plasma agglutinins of the recepient**
- **Both**

Explain

Hemolytic Disease of Newborn

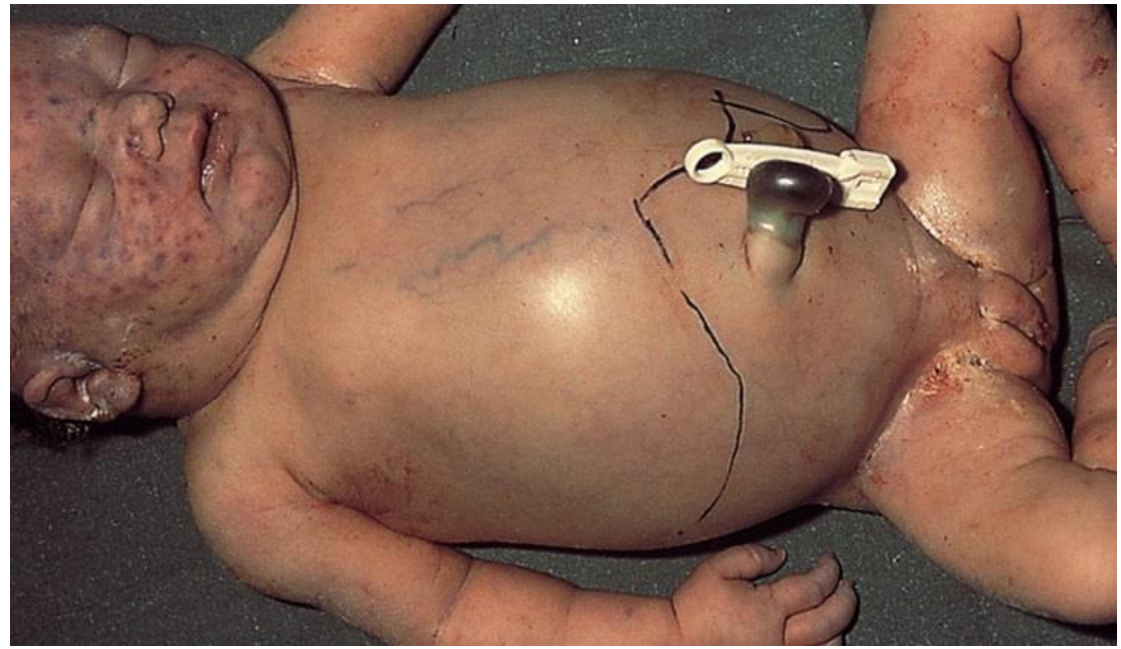


- During birth, there is often a leakage of the baby's red blood cells into the mother's circulation.
- If the baby is Rh-positive (having inherited the trait from its father) and the mother Rh-negative, these red cells will cause her to develop antibodies (IgG class) against the RhD antigen unless she receives an anti-D injection soon after first delivery or abortion.
- Anti-D binds to fetal red blood cells and remove them from body before she reacts
- 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)



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

- **Kernicterus (yellow, jaundice baby)**

Prevalence of Disease

1st Pregnancy: 0%
2nd Pregnancy: 3
3rd Pregnancy: 10%

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.

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%.**

- **Fetal Rh typing from amniocenthesis, and treatment with small dose of Rh immune serum will prevent sensitization during pregnancy.**

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 agglutinins in the plasma**
- ❑ **Describe grouping, cross-matching & typing with anti-sera**
- ❑ **List precautions taken in preparing blood for transfusion and storage of blood**
- ❑ **Define autologous transfusion and list its advantages**
- ❑ **Describe transfusion reactions.**
- ❑ **Define hemolytic disease of newborn, describe its pathophysiology and outline its prevention**

Thank You