Blood Groups, Blood Typing and Blood Transfusions

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Learning objectives:

1. Describe different types of blood groups
2. Describe the genotype-phenotype relationships in blood groups.
3. Interpret the plausible blood groups (A-B-O) in children of parents with known blood groups.
4. Describe the role of agglutinogens and agglutinins in blood grouping
5. Describe the antigens and antibodies of the O-A-B blood types/ Interpret the types of agglutinins present in individuals with a specific blood group
6. Describe the process of agglutination

- Experiments with blood transfusions, the transfer of blood or blood components into a person's blood stream, have been carried out for hundreds of years.
- Many patients have died, and it was not until 1901, when the Austrian Karl Landsteiner discovered human blood groups, that blood transfusions became safer.

- Mixing blood from two individuals can lead to blood clumping or agglutination.
- The clumped red cells can crack and cause toxic reactions, can have fatal consequences.
- Karl Landsteiner discovered that blood clumping was an immunological reaction which occurs when the receiver of a blood transfusion has antibodies against the donor blood cells.

- Karl Landsteiner's work made it possible to determine blood groups and thus paved the way for blood transfusions to be carried out safely.
- For this discovery he was awarded the Nobel Prize in Physiology or Medicine in 1930.

Landsteiner's Law

- If an antigen is present on a patient's red blood cells, the corresponding antibody will not be present in the patient's plasma under normal conditions.

What is blood made up of?

- An adult human has about 4–6 liters of blood circulating in the body. Among other things, blood transports oxygen to various parts of the body.
- Blood consists of several types of cells floating around in a fluid called plasma.

- **The red blood cells** contain hemoglobin, a protein that binds oxygen. Red blood cells transport oxygen to, and remove carbon dioxide from, the body tissues.

  The white blood cells fight infection.

  The platelets help the blood to clot, if you get a wound for example.

  The plasma contains salts and various kinds of proteins.

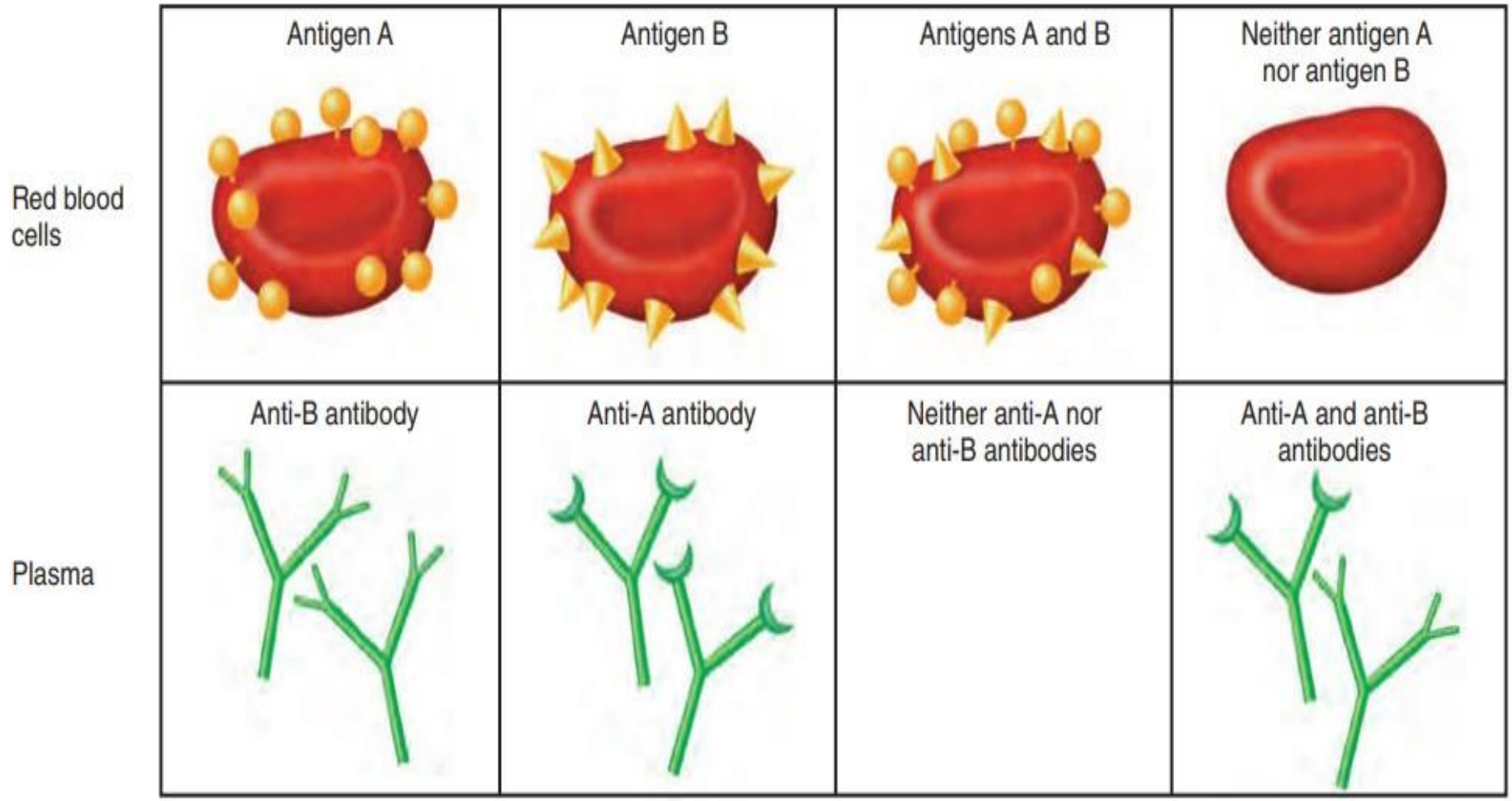
ABO Basics

- Blood group antigens are actually sugars attached to the red blood cell.
- Antigens are “built” onto the red cell.
- Individuals inherit a gene which codes for specific sugar(s) to be added to the red cell.
- The type of sugar added determines the blood group.

What are the different blood groups?

- The differences in human blood are due to the presence or absence of certain protein molecules called antigens and antibodies.
- The antigens are located on the surface of the red blood cells and the antibodies are in the blood plasma.
- Individuals have different types and combinations of these molecules.
- The blood group you belong to depends on what you have inherited from your parents.

- There are more than 20 genetically determined blood group systems known today, but the ABO and Rh systems are the most important ones used for blood transfusions.
- Not all blood groups are compatible with each other.
- Mixing incompatible blood groups leads to blood clumping or agglutination, which is dangerous for individuals.
  - Nobel Laureate Karl Landsteiner was involved in the discovery of both the ABO and Rh blood groups.



Type A

Red blood cells with type A surface antigens and plasma with anti-B antibodies

Type B

Red blood cells with type B surface antigens and plasma with anti-A antibodies

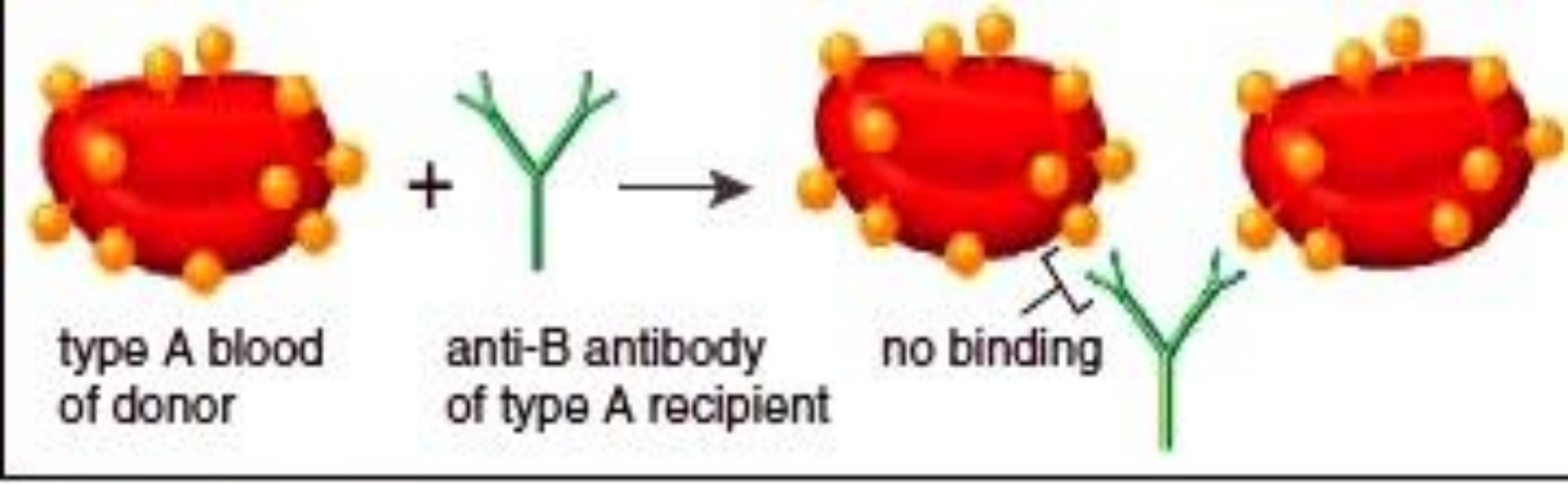
Type AB

Red blood cells with both type A and type B surface antigens and neither anti-A nor anti-B plasma antibodies

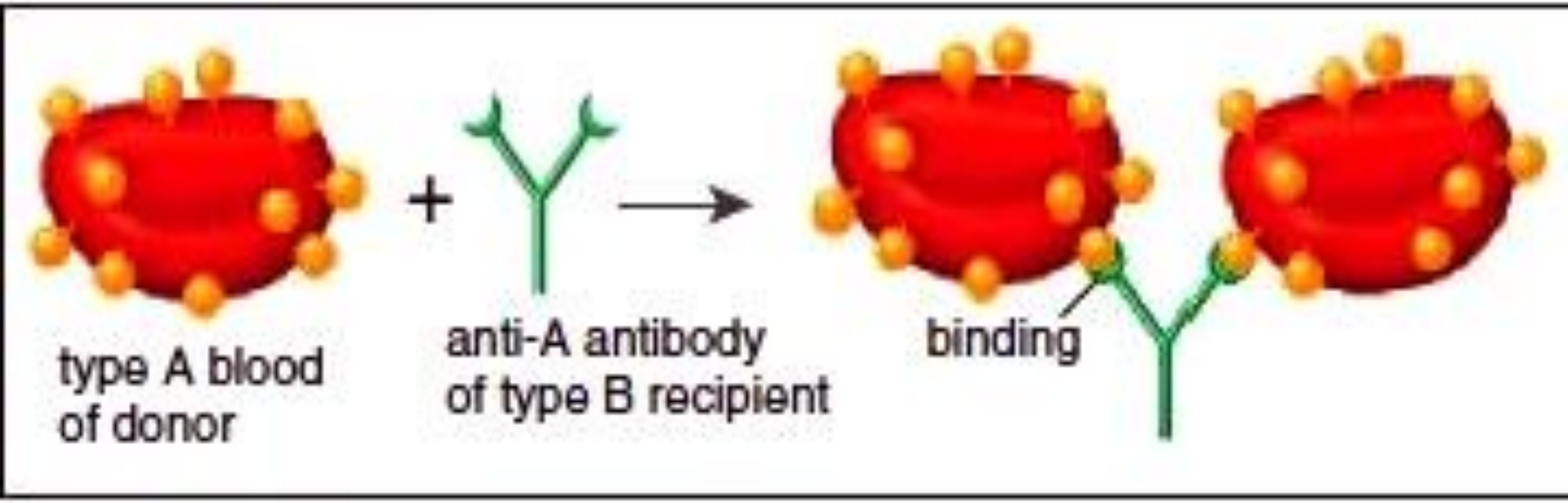
Type O

Red blood cells with neither type A nor type B surface antigens but both anti-A and anti-B plasma antibodies

Figure ABO Blood Groups



a. No agglutination



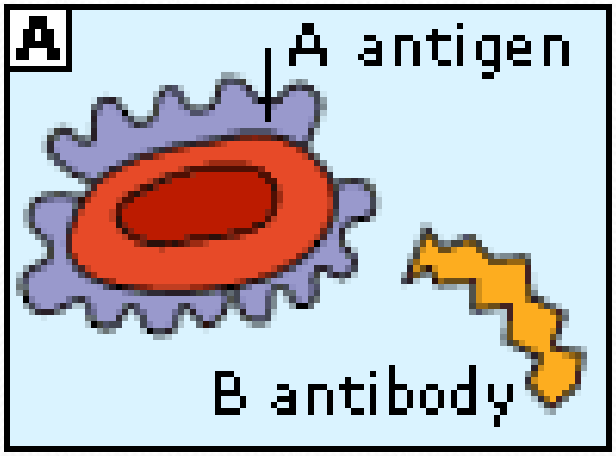
b. Agglutination

ABO blood grouping system

- According to the ABO blood group system there are four different kinds of blood groups: A, B, AB or O

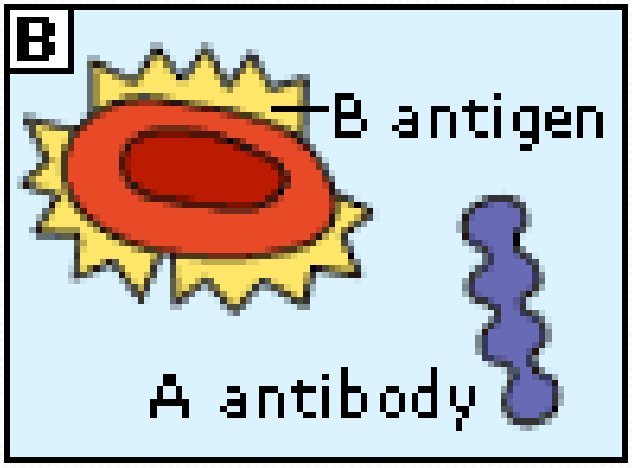
Blood group A

- If you belong to the blood group A, you have A antigens on the surface of your red blood cells and B antibodies in your blood plasma.



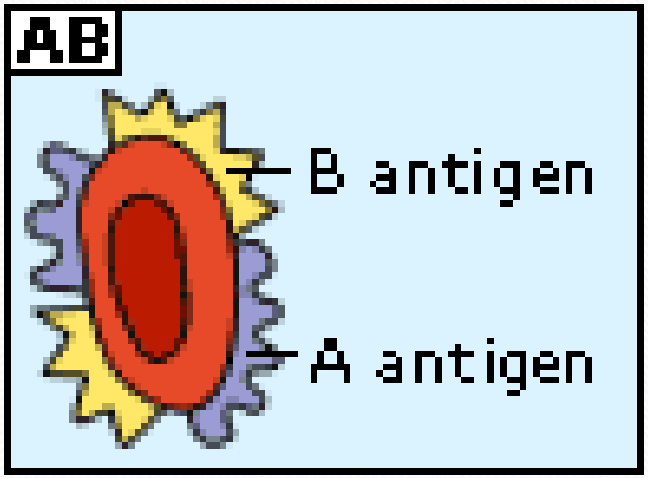
Blood group B

- If you belong to the blood group B, you have B antigens on the surface of your red blood cells and A antibodies in your blood plasma.



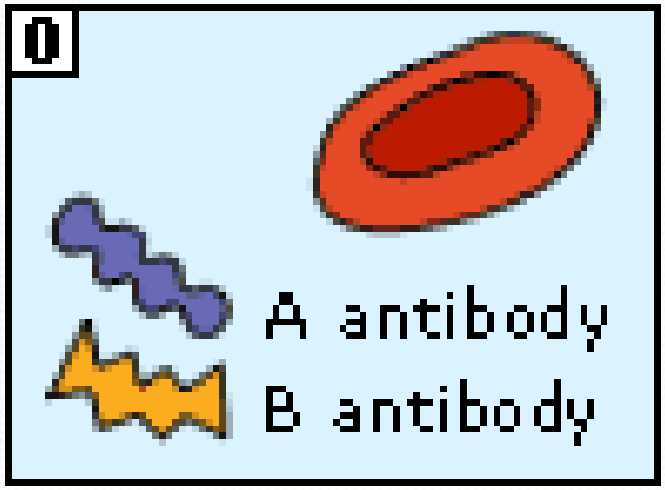
Blood group AB

- If you belong to the blood group AB, you have both A and B antigens on the surface of your red blood cells and no A or B antibodies at all in your blood plasma.



Blood group 0

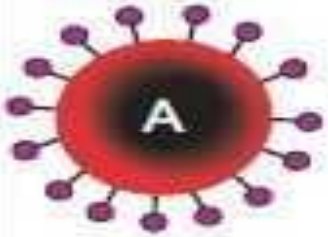
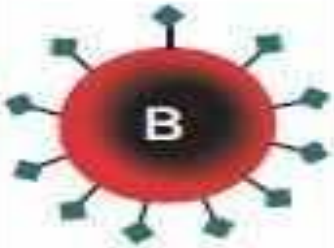
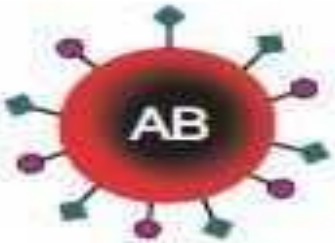
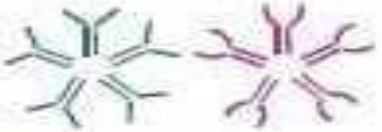
- If you belong to the blood group O (null), you have neither A or B antigens on the surface of your red blood cells, but you have both A and B antibodies in your blood plasma.



	CAN DONATE TO	CAN RECEIVE FROM
A+	A+, AB+	A+, A-, 0+, 0-
A-	A+, A-, AB+, AB-	A-, 0-
B+	B+, AB+	B+, B-, 0+, 0-
B-	B+, B-, AB+, AB-	B-, 0-
AB+ (Universal receiver)	AB+	ALL THE GROUPS
AB-	AB+, AB-	A-, B-, AB-, 0-
0+	A+, B+, AB+, 0+	0+, 0-
0- (Universal donor)	ALL THE GROUPS	0-

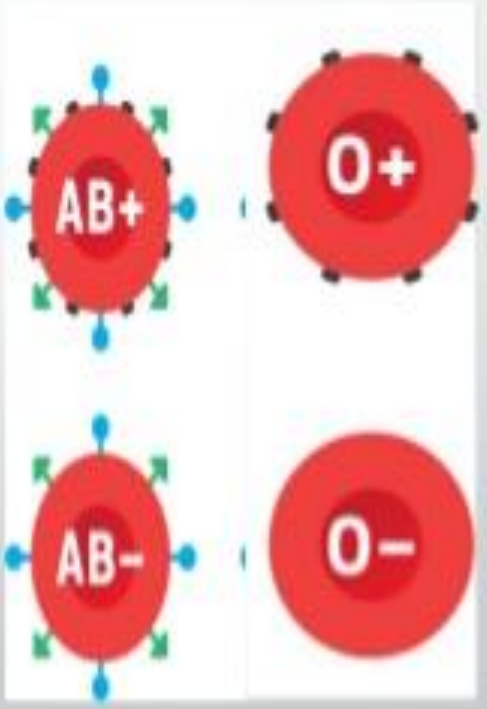
Blood Type	Agglutinogens or antigens	Agglutinins or antibodies in plasma	Can donate blood to type	Can receive blood from type
Type A+	A, Rh	Anti-B	A, AB	A+, A-, O+, O-
Type B-	B	Anti- A, Anti-Rh	B+, B-, AB+, AB-	B-, O-
Type AB+	A,B,Rh	None	AB	A+, A-, O+, O-, B+, B-, AB+, AB-
Type O- (exposed to Rh+ blood)	None	Anti-Rh	A+, A-, O+, O-, B+, B-, AB+, AB-	O-

ABO blood group system

	Group A	Group B	Group AB	Group O
Red blood cell type				
Antibodies in Plasma	 Anti-B	 Anti-A	None	 Anti-A and Anti-B
Antigens in Red Blood Cell	 A antigen	 B antigen	 A and B antigens	None

GROUP OF BLOOD

- **Type AB:**
  (Universal Recipient)
  - RBC's have both A and B antigens.
  - Cen receive from A, B, AB, and O types.
  - Can donate to AB type only.
- **Type O: (Universal Donor)**
  - RBC's have NO antigens.
  - Can receive from O type only.
  - Can donate to A, B, AB and O types.

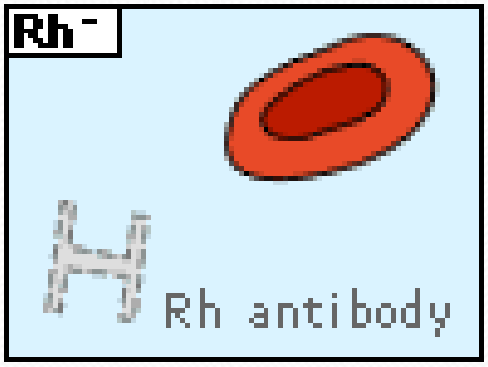


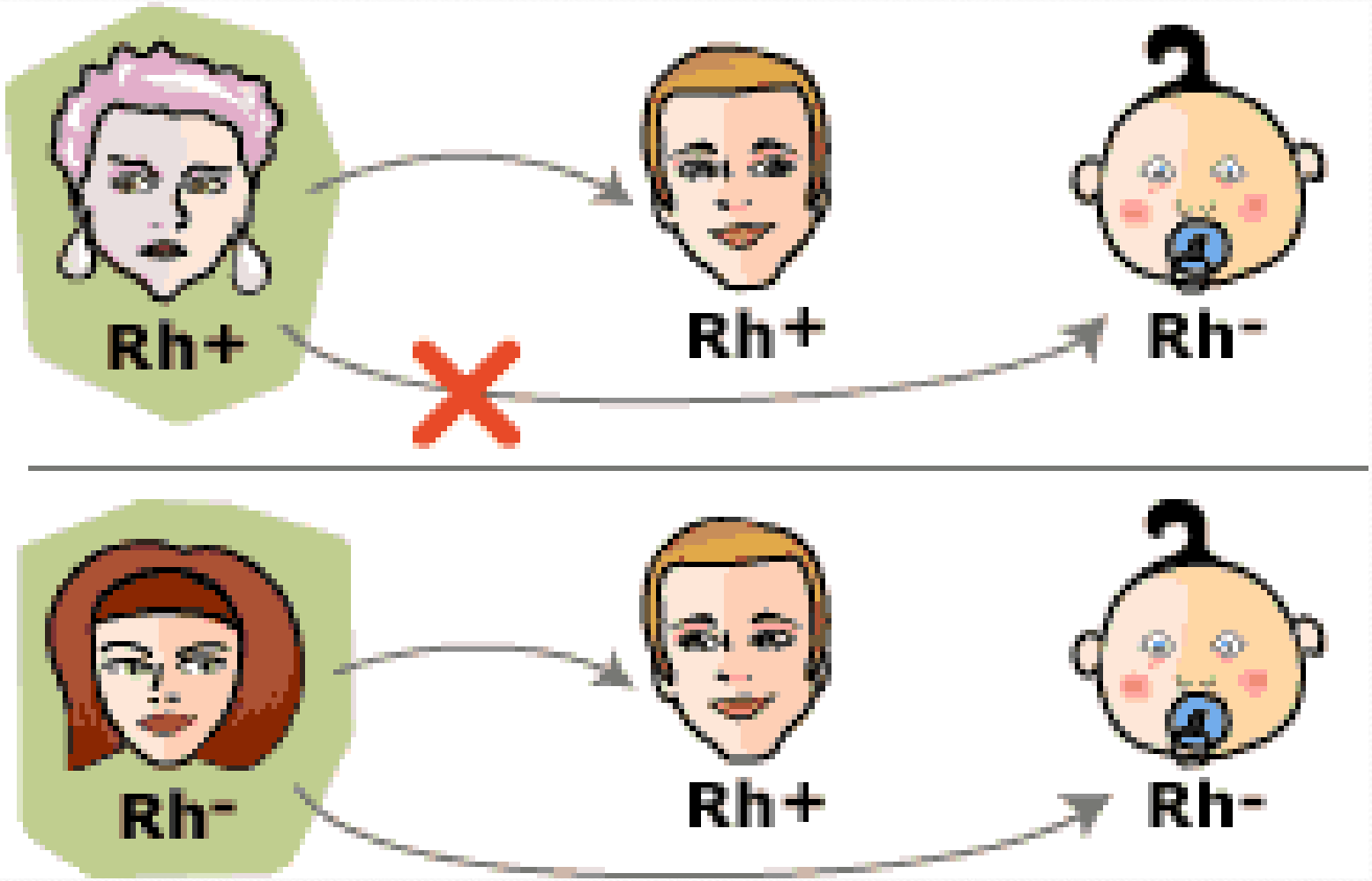
Rh factor blood grouping system

- Many people also have a so-called Rh factor on the red blood cell's surface.
- This is also an antigen and those who have it are called Rh+.
- Those who haven't are called Rh-.
- A person with Rh- blood does not have Rh antibodies naturally in the blood plasma (as one can have A or B antibodies, for instance).

Cont.

- But a person with Rh- blood can *develop* Rh antibodies in the blood plasma if he or she receives blood from a person with Rh+ blood, whose Rh antigens can trigger the production of Rh antibodies.
- A person with Rh+ blood can receive blood from a person with Rh- blood without any problems.




Rh+
Rh+
Rh-
Rh-
Rh+
Rh-

ABO INHERITANCE

T2

Dad = *A/O* and Mom = *B/O*		Mom	
		B	*O*
Dad	*A*	A/B	A/O
	O	O/B	O/O

Blood group notation

- According to above blood grouping systems, you can belong to either of following 8 blood groups:
- Rh+B (B+) Rh-B (B-)
- Rh+AB (AB+) Rh-AB (AB-)
- Rh+o (O+) Rh-o (O-)
- Rh+A (A+) Rh-A (A-)
- Do you know which blood group you belong to?

Major ABO Blood Group

Forward blood grouping using anti-sera and red blood cells

ABO Group	Antigen Present	Antigen Missing	Antibody Present
A	A	B	Anti-B
B	B	A	Anti-A
O	None	A and B	Anti-A&B
AB	A and B	None	None

If an antigen (Ag) is present on a patients red blood cells the corresponding antibody (Ab) will NOT be present in the patients plasma, under 'normal conditions'.

Blood typing – how do you find out to which blood group someone belongs?

- **1.**
  You mix the blood with three different reagents including either of the three different antibodies, A, B or Rh antibodies.

- **2.**
  Then you look at what has happened. In which mixtures has agglutination occurred? The agglutination indicates that the blood has reacted with a certain antibody and therefore is not compatible with blood containing that kind of antibody. If the blood does not agglutinate, it indicates that the blood does not have the antigens binding the special antibody in the reagent.

- **3.**
  If you know which antigens are in the person's blood, it's easy to figure out which blood group he or she belongs to!

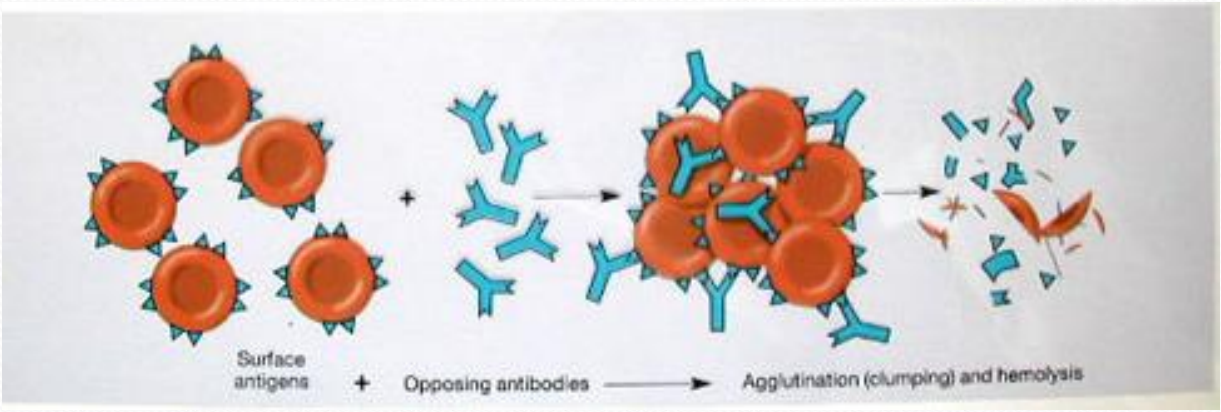
What happens when blood clumps or agglutinates?

- For a blood transfusion to be successful, ABo and Rh blood groups must be compatible between the donor blood and the patient blood.
- If they are not, the red blood cells from the donated blood will clump or agglutinate.
- The agglutinated red cells can clog blood vessels and stop the circulation of the blood to various parts of the body.
- The agglutinated red blood cells also crack, and its contents leak out in the body.
- The red blood cells contain hemoglobin which becomes toxic when outside the cell.
- This can have fatal consequences for the patient.

- The A antigen and the A antibodies can bind to each other in the same way that the B antigens can bind to the B antibodies.
- This is what would happen if, for instance, a B blood person receives blood from an A blood person.
- The red blood cells will be linked together, like bunches of grapes, by the antibodies.
- As mentioned earlier, this clumping could lead to death.

Hemolysis

- If an individual is transfused with an incompatible blood group destruction of the red blood cells will occur.
- This may result in the death of the recipient.



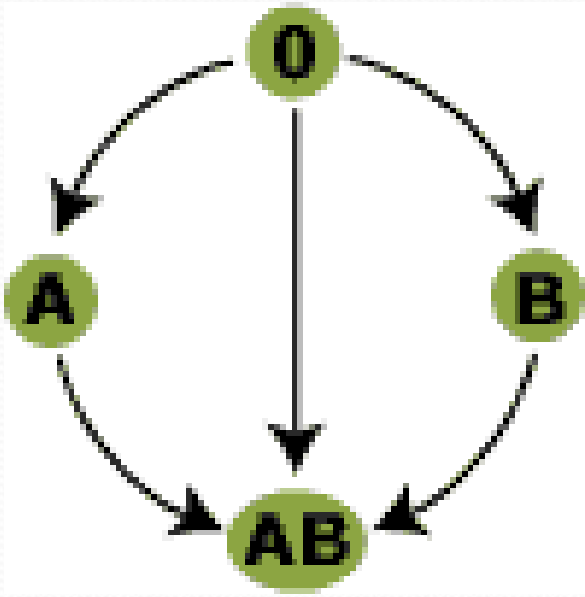
Blood transfusions – who can receive blood from whom?

- Of course you can always give A blood to persons with blood group A, B blood to a person with blood group B and so on.
- But in some cases, you can receive blood with another type of blood group,or donate blood to a person with another kind of blood group.

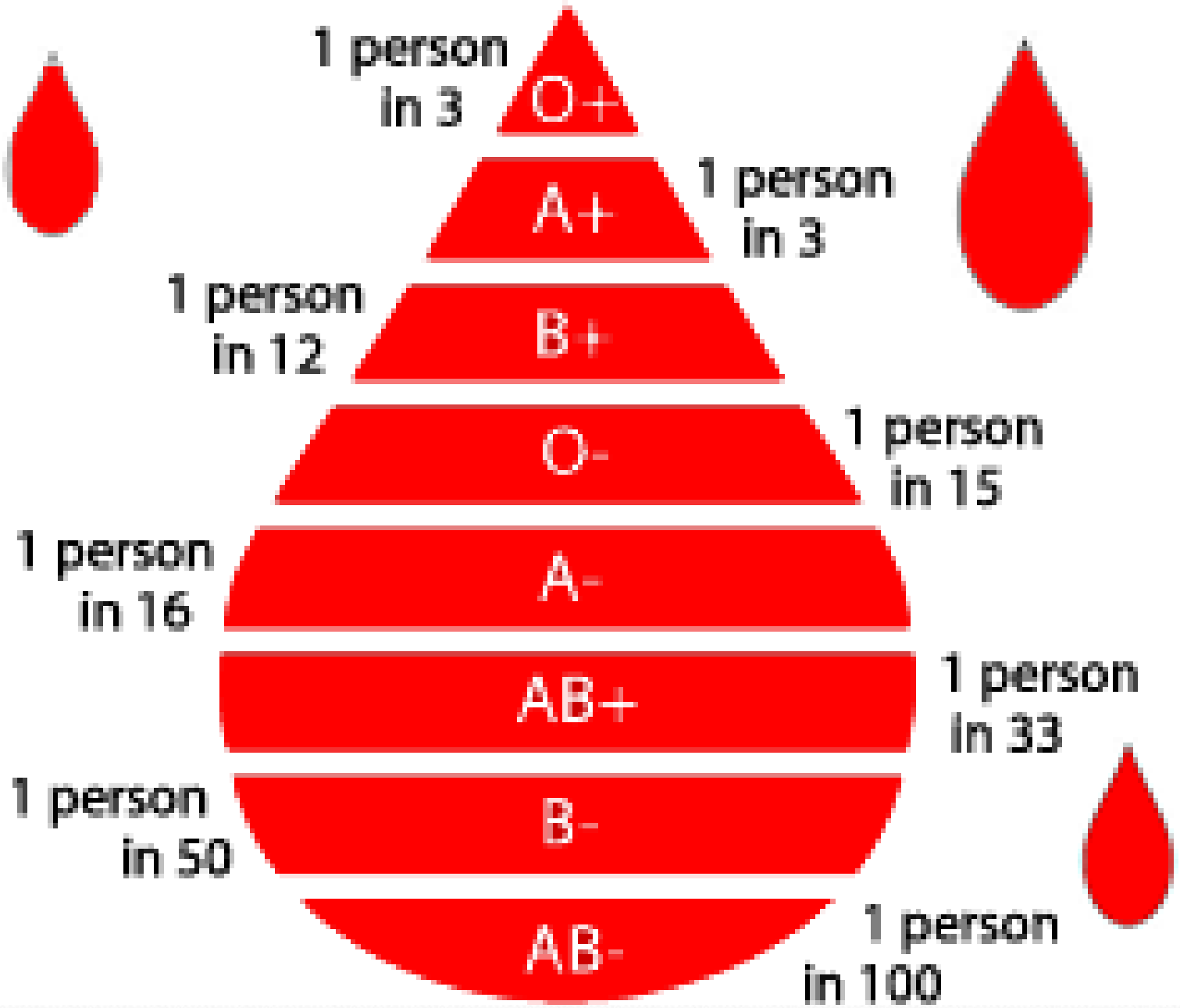
Cont.

- The transfusion will work if a person who is going to receive blood has a blood group that doesn't have any *antibodies against the donor blood's antigens*.
- But if a person who is going to receive blood has antibodies matching the donor blood's antigens, the red blood cells in the *donated blood* will clump.

Cont.



- People with blood group O Rh - are called "universal donors" and people with blood group AB Rh+ are called "universal receivers."


1 person in 3
O+
A+
1 person in 3
1 person in 12
B+
O-
1 person in 15
1 person in 16
A-
AB+
1 person in 33
1 person in 50
B-
AB-
1 person in 100

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

If You Have	*You Can Receive*			
O+	O+	O–		
O–	O–			
A+	A+	A–	O+	O–
A–	A–	O–		
B+	B+	B–	O+	O–
B–	B–	O–		
AB+	AB+	AB–	O+	O–
	A+	A–	B+	B–
AB–	AB–	O–	A–	B–