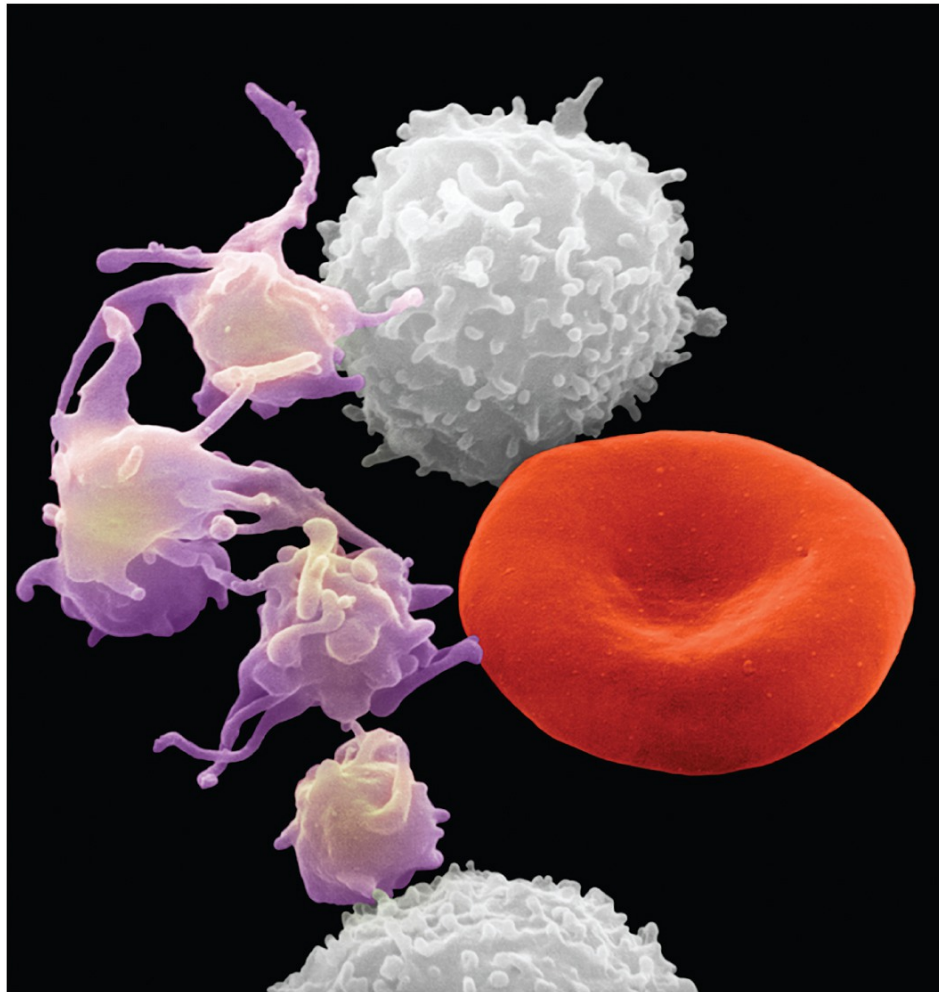


## Chapter 18.5

# Blood Types



## RBC are defined by their antigens.

- Antigens are glycoprotein and glycolipid molecules (transmembrane molecules) on the surface of the RBC plasma membrane (i.e. part of the glycocalyx).
- These molecules are embedded in the plasma membrane of our RBC.
- All human cells, microbes, parasites, and viruses have antigen on their outer surface. Antigen on these cells function as an “identity molecule”.
- Antigen allow our immune system to recognize between **self vs non-self** cells. Our immune system will attack non-self antigen and will not attack our cells with self-antigen.
- Red blood cells have a special group of antigens unique to RBC. These antigens are used to classify RBC into different blood groups (e.g. ABO and Rh blood groups). There are many other RBC antigens but the **ABO and Rh are the most common and therefore the most problematic in medicine.**
- So don't get confused. Keep the rules for the ABO and Rh system separated. Keep antigen focus on antigen type: foreign antigens on pathogens, self-antigens on all our somatic cells, and the RBC antigens for blood cell identification.
- We will look at antigen functions in greater detail when we study the immune system.

# Antigen & Antibodies in Blood Types

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- Blood transfusion compatibility is dependent upon the interactions between antibodies (in the blood plasma) and antigen (on the RBC)
- Karl Landsteiner discovered blood types A, B and O in 1900 // won Nobel Prize for discovery
- A antigen is on type A RBC / B antigen is on type B RBC / AB antigens is on type AB RBC // if RBC has no antigen then RBC is type O
- Two antibody types in the ABO system: anti A or anti B
- **Agglutinogens** is a another term for antigens (located on plasma membrane)
- **Agglutinins** is another term for antibodies (circulating in plasma, lymph, and tissue fluid)

# Antigens VS Antibodies

## (Agglutinogens VS Agglutins)



BLOOD TYPE

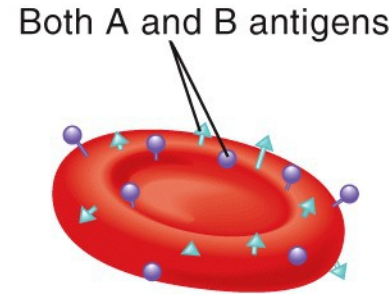
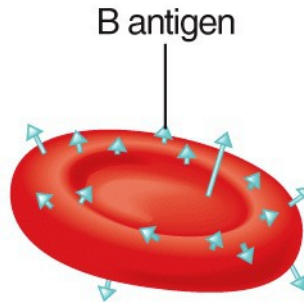
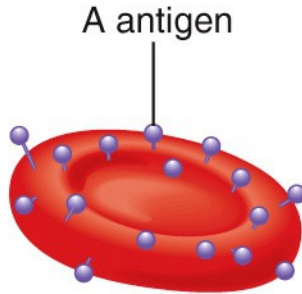
TYPE A

TYPE B

TYPE AB

TYPE O

Red blood cells



Neither  
A nor B antigen



Plasma

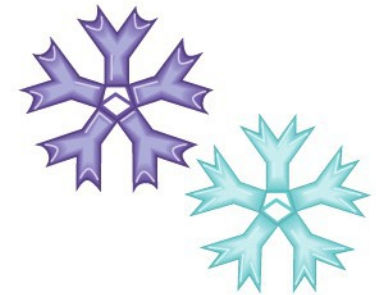


Anti-B  
antibody



Anti-A  
antibody

Neither  
antibody



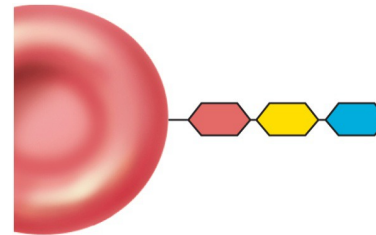
Both anti-A and  
anti-B antibodies

- > How many different antigens?
- > How many blood types?
- > Where is the antigen located?
- > How are antibodies matched to RBC antigen?

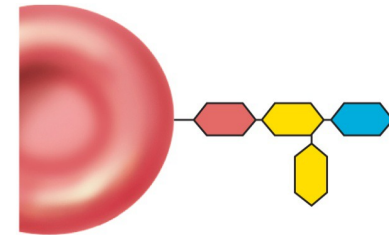
# Agglutinogens VS Agglutinins

- antigens located on outer surface of RBC plasma membrane
  - antigen A or antigen B
  - determined by carbohydrate moieties found on RBC surface
- antibodies located in plasma
  - anti-A and anti-B

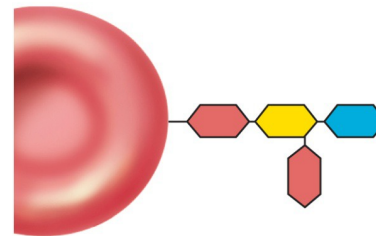
Type O



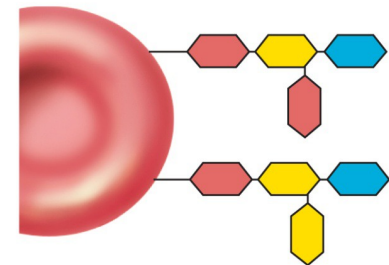
Type B



Type A



Type AB



Key

 Galactose

 Fucose

 N-acetylgalactosamine

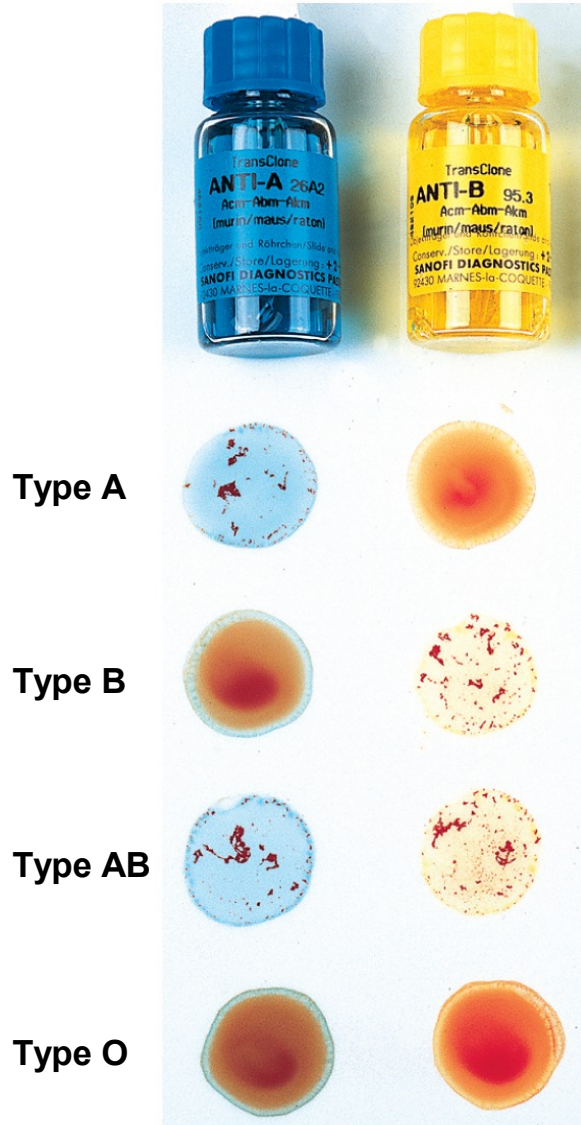


# ABO Group

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- Your ABO blood type is determined by **presence or absence of antigens (agglutinogens) on RBCs**
  - blood type A person has A antigens
  - blood type B person has B antigens
  - blood type AB has both A and B antigens
  - blood type O person has neither antige

# ABO Blood Typing



Use purified antibody (Anti A or Anti B) in a test to determine the RBC blood group.

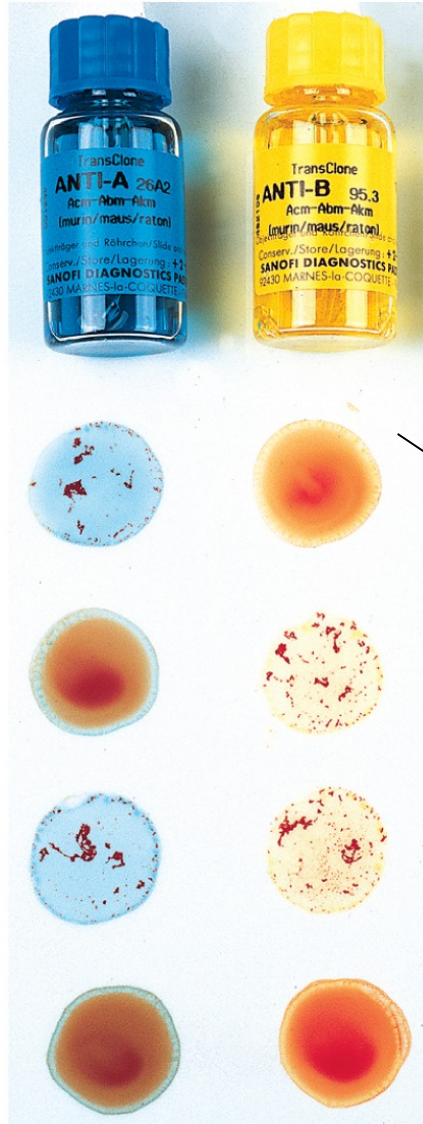
The antibody will only “agglutinate” (clump together) the RBC if the antibody is “matched” to the antigen.

When this occurs the “M class antibodies” will also initiate a process to break apart the RBC. This releases the hemoglobin from the RBC.



# ABO Blood Typing

Aglutinin A  
(antibody A)

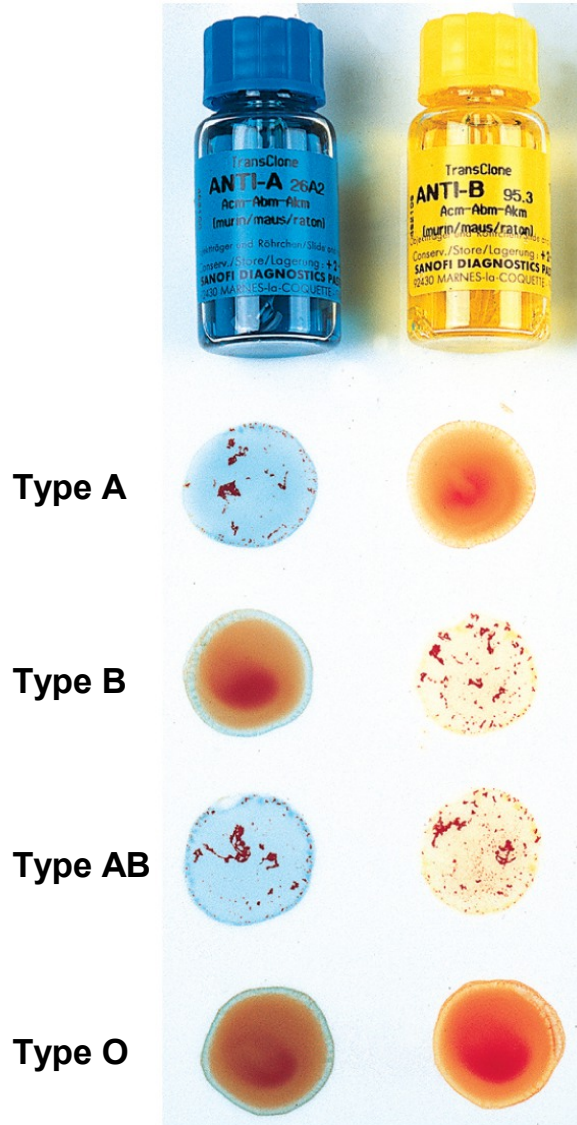


Aglutinin B  
(antibody B)

What is the blood type of these blood samples?



# ABO Blood Typing



# Blood Antigens and Antibodies

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- Agglutinogens (antigens)
  - complex molecules on surface of cell membrane that are unique to every individual (accept identical twins!)
  - special group of agglutinogens (antigens) on the surface of the RBC is the basis for blood typing
  - foreign antigens are able to generate an immune response
  - RBC antigens are A or B.
  - Possible combinations: A, AB, B,
  - Type O = no antigen

# Blood Antigens and Antibodies

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- Agglutinin (antibodies) associated with blood typing
  - In blood chemistry we make antibodies only if we do not have the antigen on our RBC!
  - if RBC has neither A or B agglutinogen then we will have both antibody A and antibody B circulating in our blood
  - mismatch blood transfusions can lead to organ damage and death // agglutinins in the recipient's plasma will bind to donor's RBC

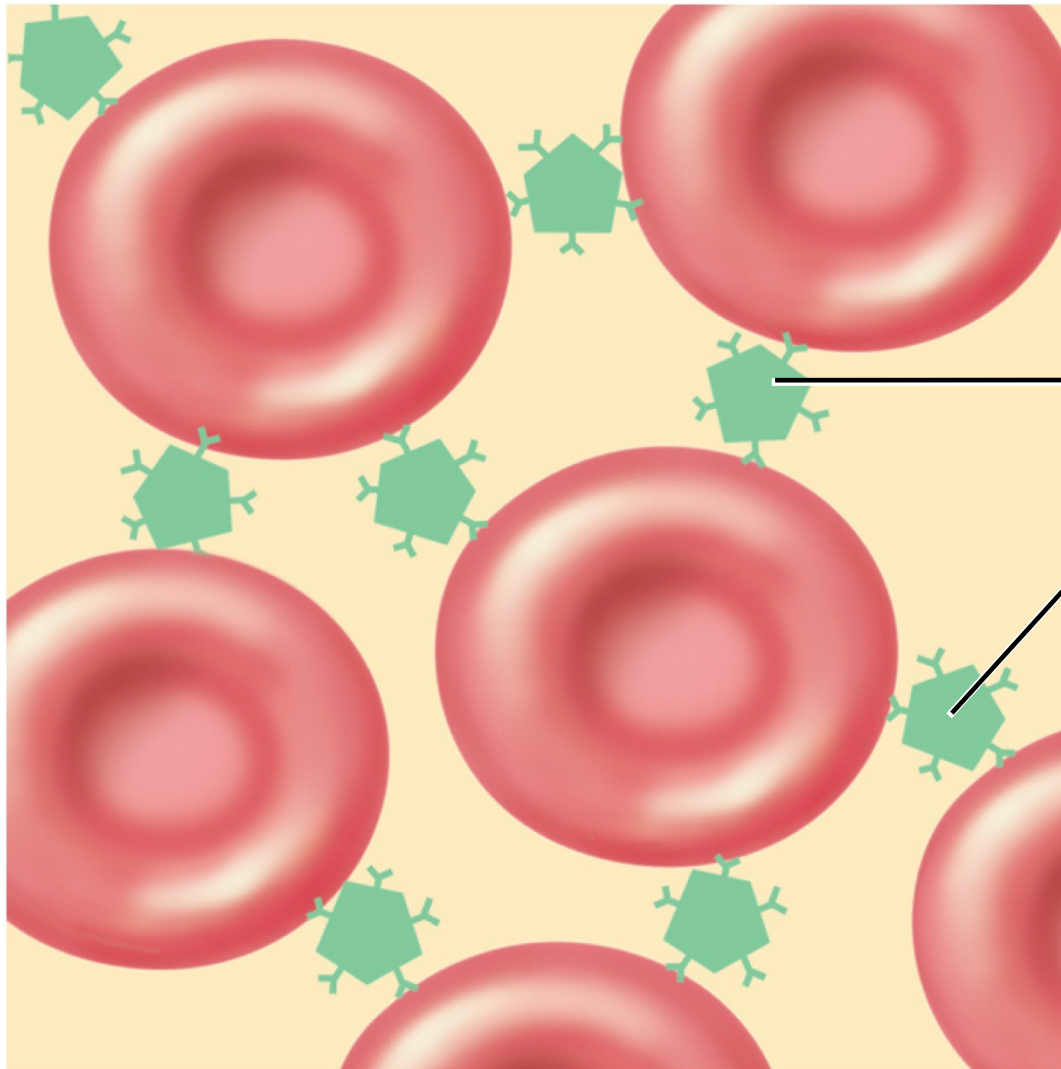
# Blood Antigens and Antibodies

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- **Agglutination**
  - antibody molecule binding to antigens (e.g. A antibody binds to A antigen) // one M class antibody can bind to 10 different RBC
  - causes agglutination of red blood cells
  - clumped cells block capillaries // infraction occur to damage organs // kidneys especially vulnerable to this type of damage
  - agglutinated RBCs block small blood vessels
  - antibodies activate complement to hemolyze RBC and release hemoglobin from RBC over the next few hours or days // causes fever and likely damage to kidney and other organ damage (possible death) // released Hb blocks kidney tubules and causes acute renal failure

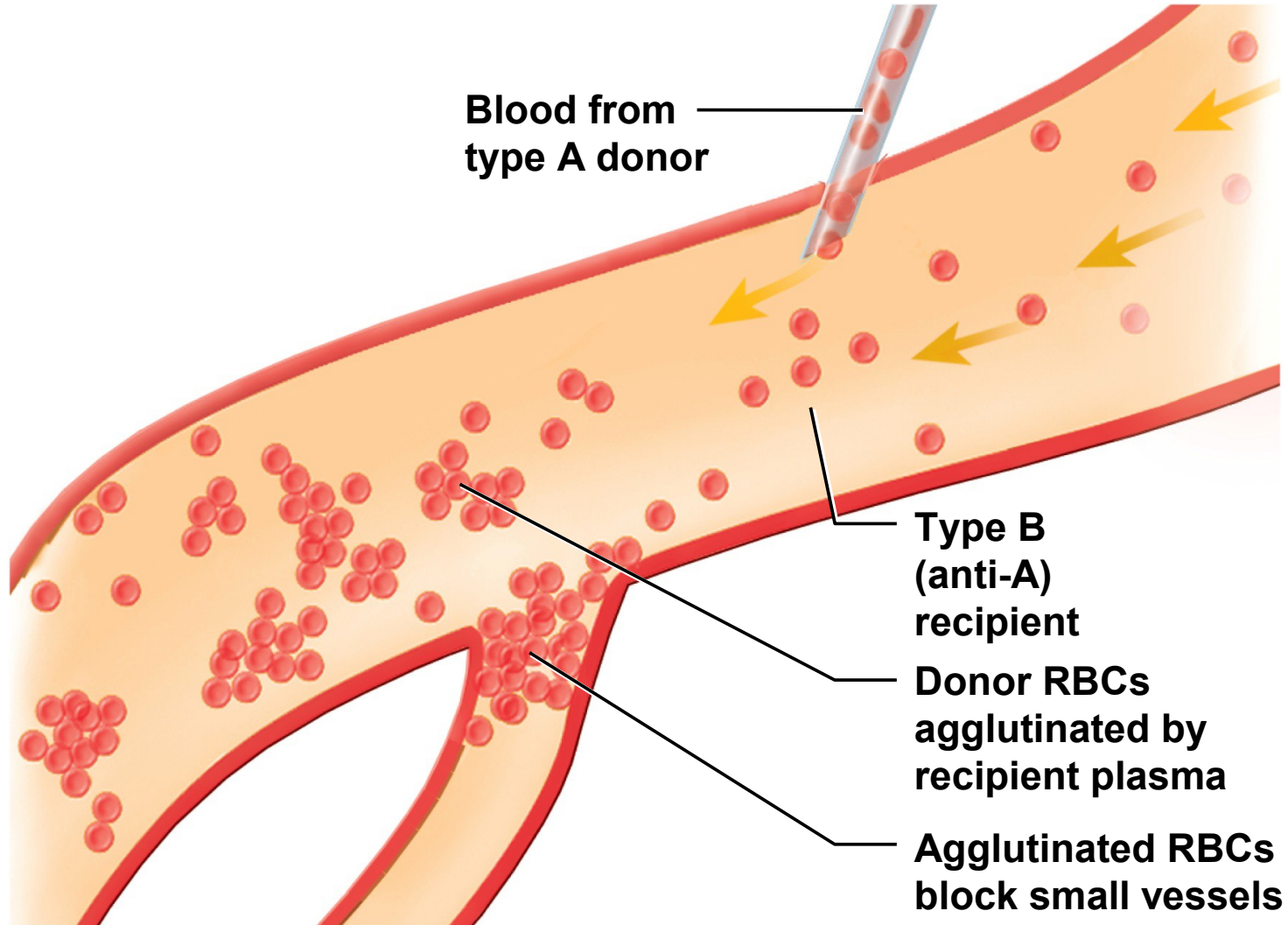
# Agglutination of Erythrocytes



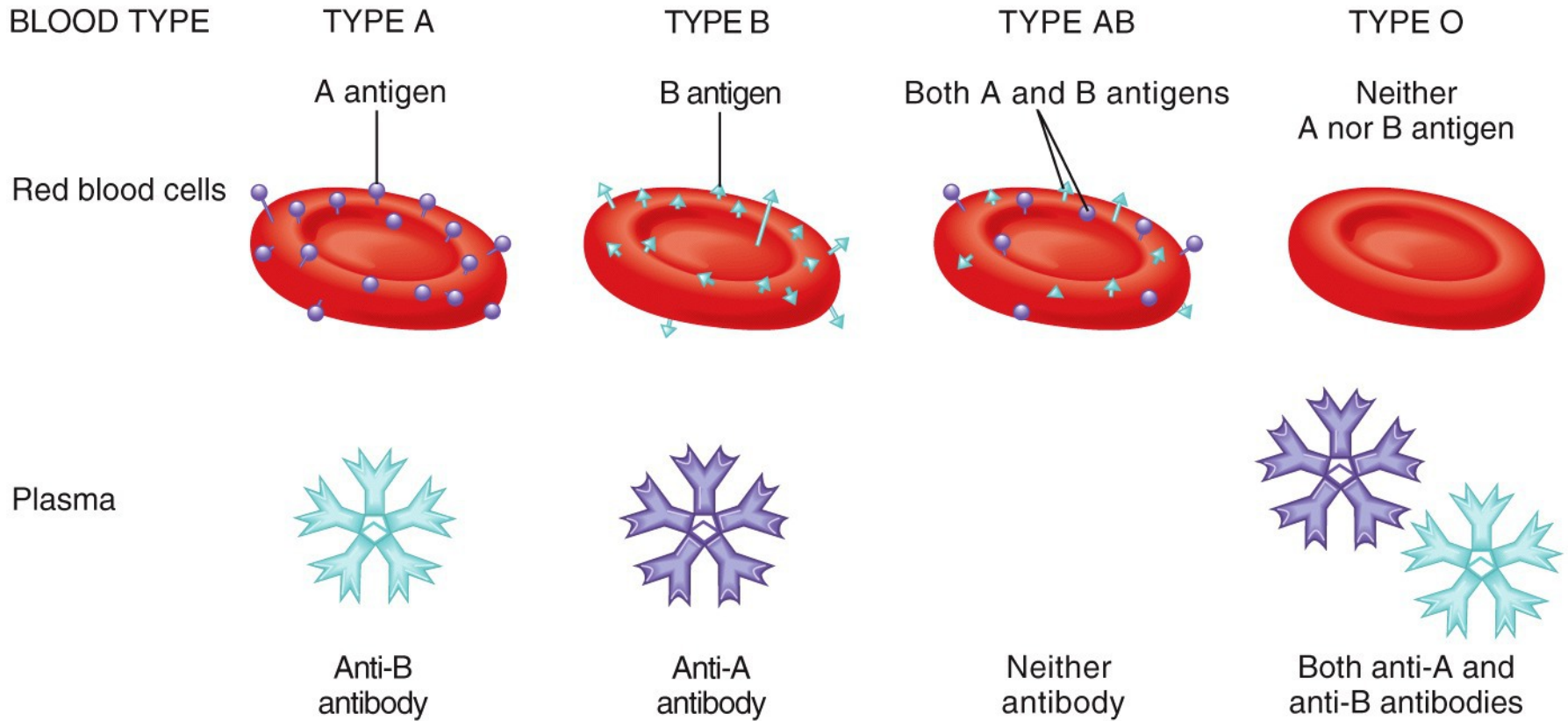
**Antibodies  
(agglutinins)**

An M class antibody complex is made by joining five antibodies together. Each antibody may bind two antigens or clump together 10 RBC

# Transfusion Reaction



# Agglutinogens VS Agglutins





# Universal Donors and Recipients

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- Universal donor
  - Type O // most common blood type
  - No antigen on RBC
  - However, this donor's plasma will have both plasma antibodies (anti-A and anti-B) // may only receive type O blood
  - To minimize affect of antibodies give packed cells (minimum or no plasma volume)

# Universal Donors and Recipients

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- Universal recipient
  - Type AB // rarest blood type
  - Host does not have any plasma antibodies on their RBC
  - No anti-A or anti-B // may receive any ABO type RBC

# When Do Plasma Antibodies Form

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- appear in plasma 2-8 months after birth
- maximum concentration at 10 yr.
- You will never form antibodies matched to the antigen on your RBC
- You will only make plasma antibody that are not present on your RBC
- These rules apply to the ABO system
- Different rules apply for Rh factor antigen and Rh antibodies

# Rh Antigen = Blood Type +

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- Rh agglutinogens (antigens) discovered on rhesus monkey's RBC in 1940 // other "minor" RBC antigen-antibodies have been discovered
  - after the ABO system the Rh D is the most problematic of these RBC antigens /// patient considered blood type Rh<sup>+</sup> if they have D antigen (agglutinogens) on their RBCs and Rh<sup>-</sup> if there is no D antigen on their RBC /// Rh frequencies vary among ethnic groups
  - A Rh<sup>+</sup> person will never make D antibodies
  - *A Rh<sup>-</sup> person will also not have D antibodies, however. This person maybe sensitized by D antigen from a transfusion or during child birth. // Now the Rh<sup>-</sup> person will have circulating D antibodies*
  - *This creates a special problem for women!*

# Rh Blood Type

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- Rule 1 = Anti-D agglutinins (antibodies) are never present in the blood at birth. This is true both for Rh+ and Rh- individuals.
- Rule 2 = Only an Rh negative person may be sensitized after birth by being exposed to a RBC with the Rh antigen.
- Exposure to RBC with Rh antigen will cause the Rh negative person to make Rh antibodies in their plasma. Now, if more RBC with Rh antigen enters their blood the Rh antibodies will attack these cells.
- Rh negative individuals may be sensitized to form anti-D antibodies in these two situations:
  - 1 = Rh<sup>-</sup> woman carries an Rh<sup>+</sup> fetus / at birth fetal blood sensitizes mother.
  - 2 = Rh negative person receive transfusion from a Rh<sup>+</sup> donor
  - There is no problem at time of this first exposure /// It takes time to develop antibodies // only after Rh negative person has time to make antibodies and there is a second exposure to Rh<sup>+</sup> RBC will there be an agglutination condition

# Hemolytic Disease of Newborn

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- Two conditions may cause this situation
  - Rh- pregnant woman sensitized by Rh<sup>+</sup> fetus blood cells during delivery of fetus // She will now have D antibodies circulating
  - D antibodies may cross placenta // potential problem if future pregnancy has a Rh<sup>+</sup> fetus /// forms antigen-antibody complex in fetal blood / hemolyze fetal RBC
  - This condition may also occur if women receives blood transfusion Rh<sup>+</sup> RBC

# Hemolytic Disease of Newborn

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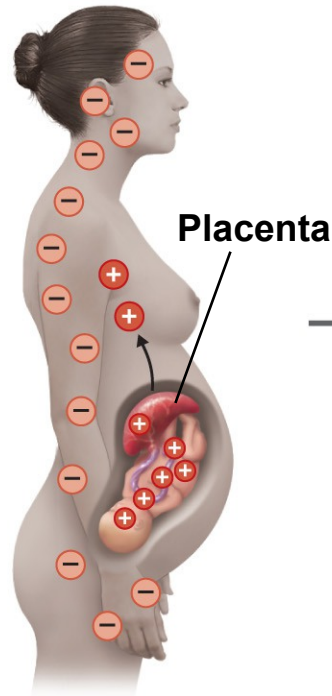
- How do we to prevention this condtion?
  - RhoGAM // given to pregnant Rh<sup>-</sup> women right before delivery
  - RhoGAM binds any fetal Rh antigen that may mix with maternal blood
  - Rh<sup>+</sup> RBC can not sensitize (expose) mother to antigen ( RhoGam binds to antigen and covers the Rh antigen so it is not able to sensitize mother during delivery)
  - Mother will not make Anti-D antibodies



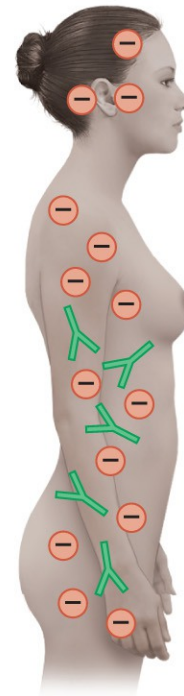
# Hemolytic disease of the newborn.



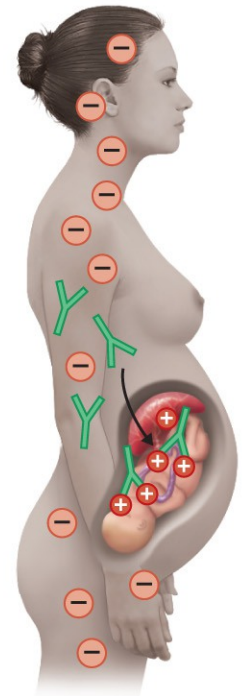
**1** Rh<sup>+</sup> father.



**2** Rh<sup>-</sup> mother carrying her first Rh<sup>+</sup> fetus. Rh antigens from the developing fetus can enter the mother's blood during delivery.

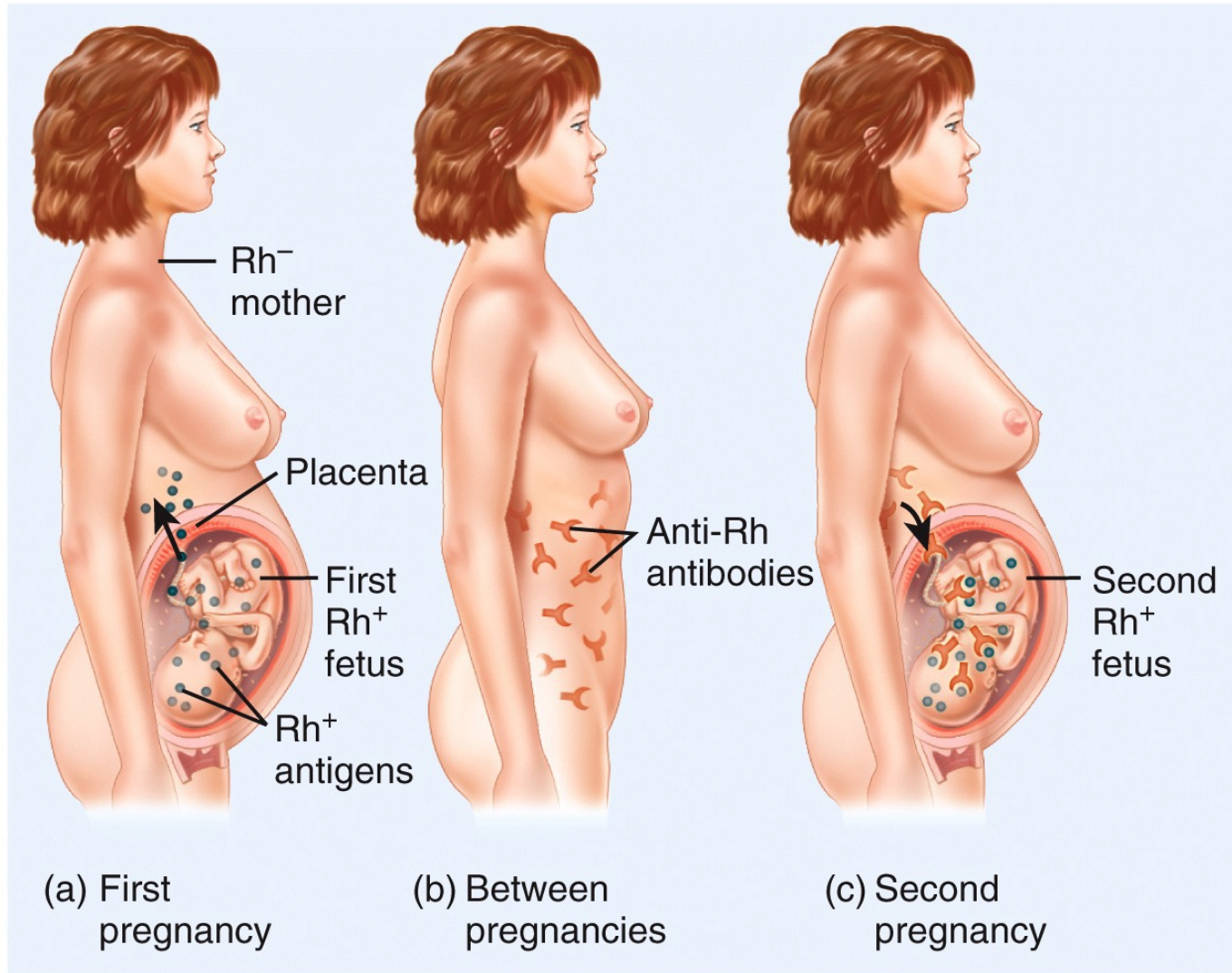


**3** In response to the fetal Rh antigens, the mother will produce anti-Rh antibodies.



**4** If the woman becomes pregnant with another Rh<sup>+</sup> fetus, her anti-Rh antibodies will cross the placenta and damage fetal red blood cells.

# Hemolytic Disease of Newborn



- Rh antibodies attack fetal blood causing severe anemia and toxic brain syndrome // erythroblastosis fetalis