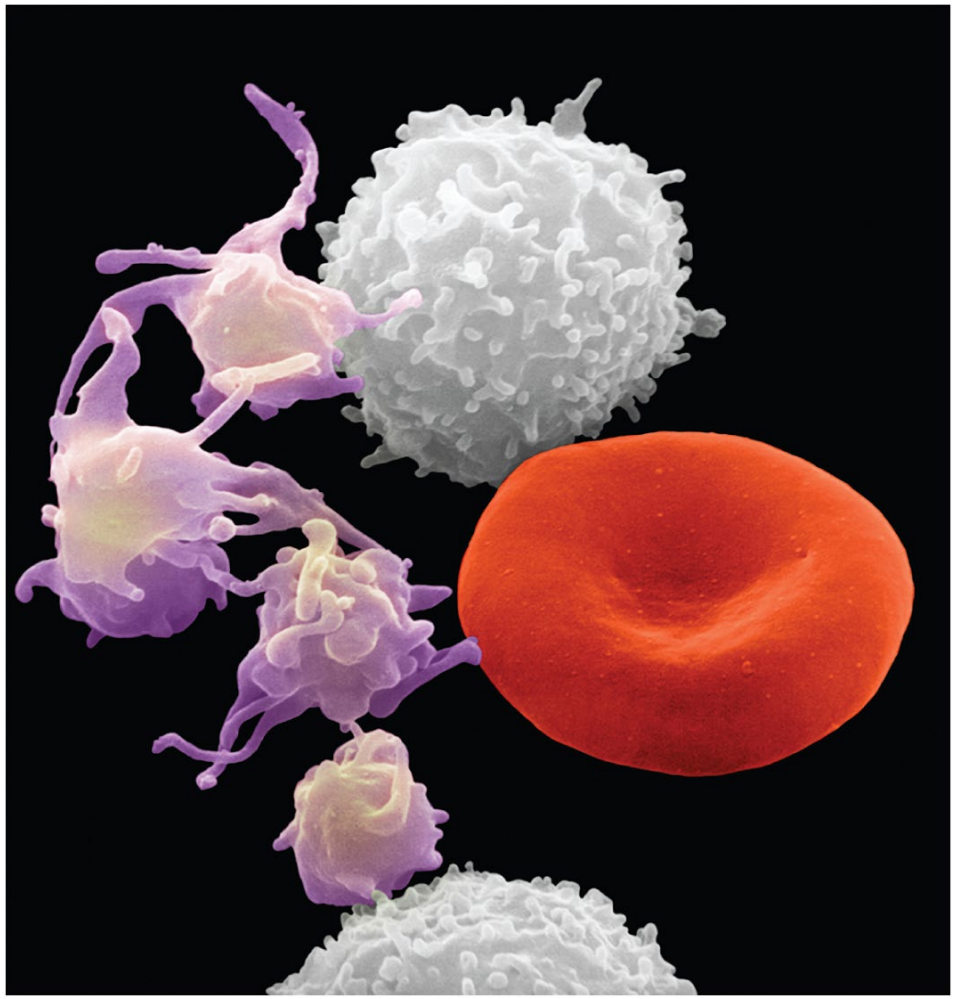
Chapter 18.5

Blood Types



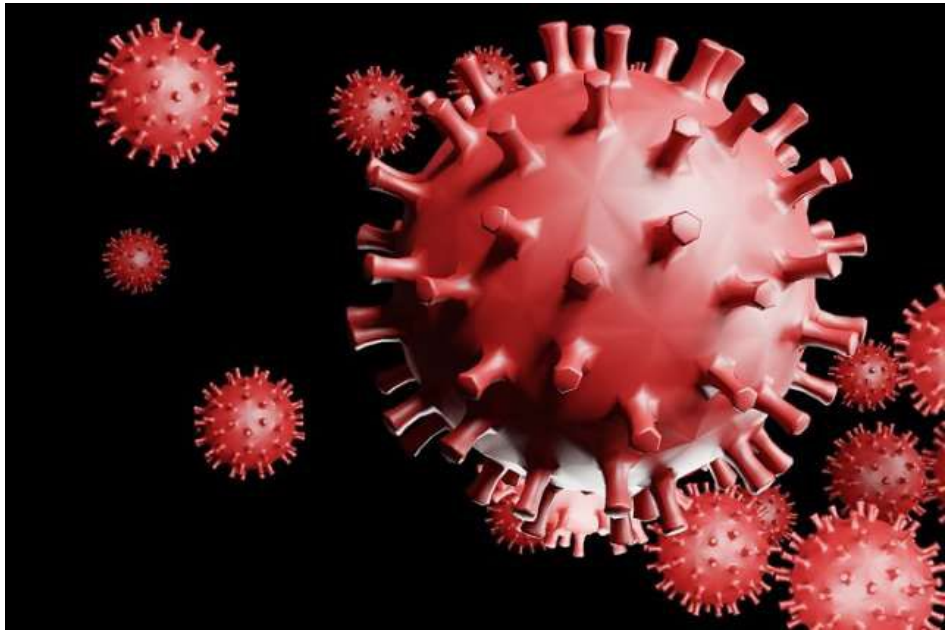
RBC are defined by their antigens.

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 on the outer surface of the plasma membrane.

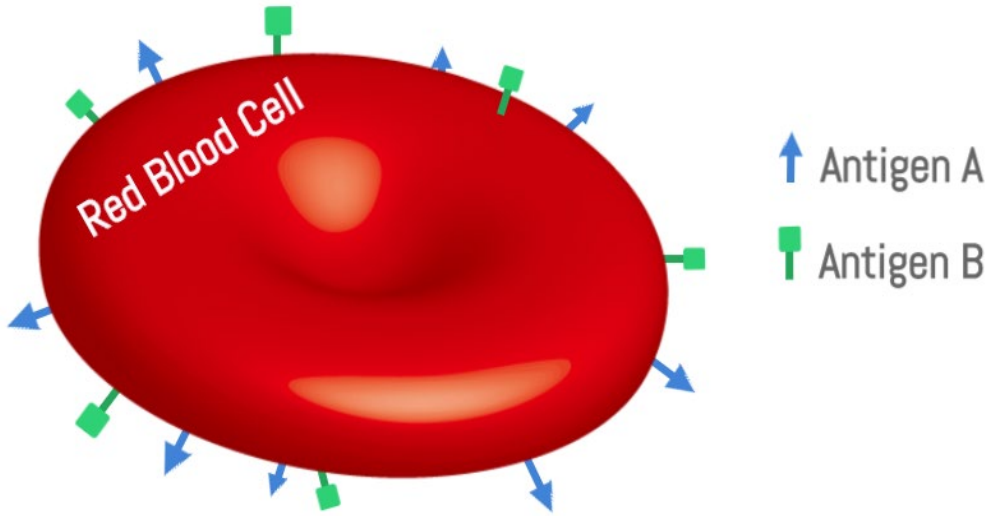
All human cells, microbes, parasites, and viruses have a variety of different types of antigens on their outer surface. Antigen on these cells function as an "identity molecule".

Antigen allow our immune system to recognize between self vs non-self cells. Our immune system will attack non-self antigen but will not attack our cells with self-antigen.



RBC are defined by their antigens.

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 define antigens in greater detail when we study the immune system.

Antigen & Antibodies in Blood Types

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

Two antibody types in the ABO system: anti A or anti B

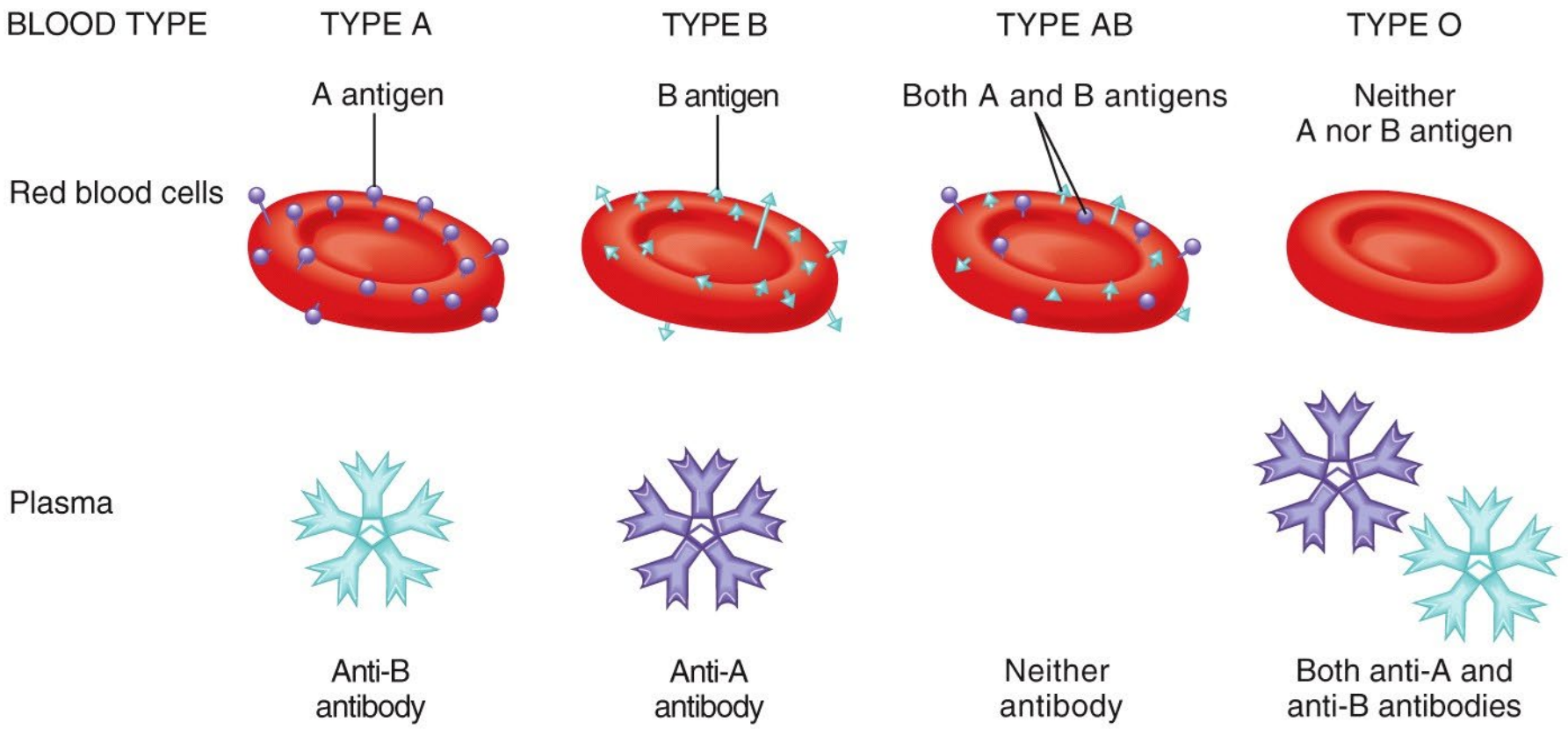
- A antigen is on type A RBC
- B antigen is on type B RBC
- AB antigens are on type AB RBC
- O RBC have no antigen

Agglutinogens is 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)



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

Agglutinogens VS Agglutins

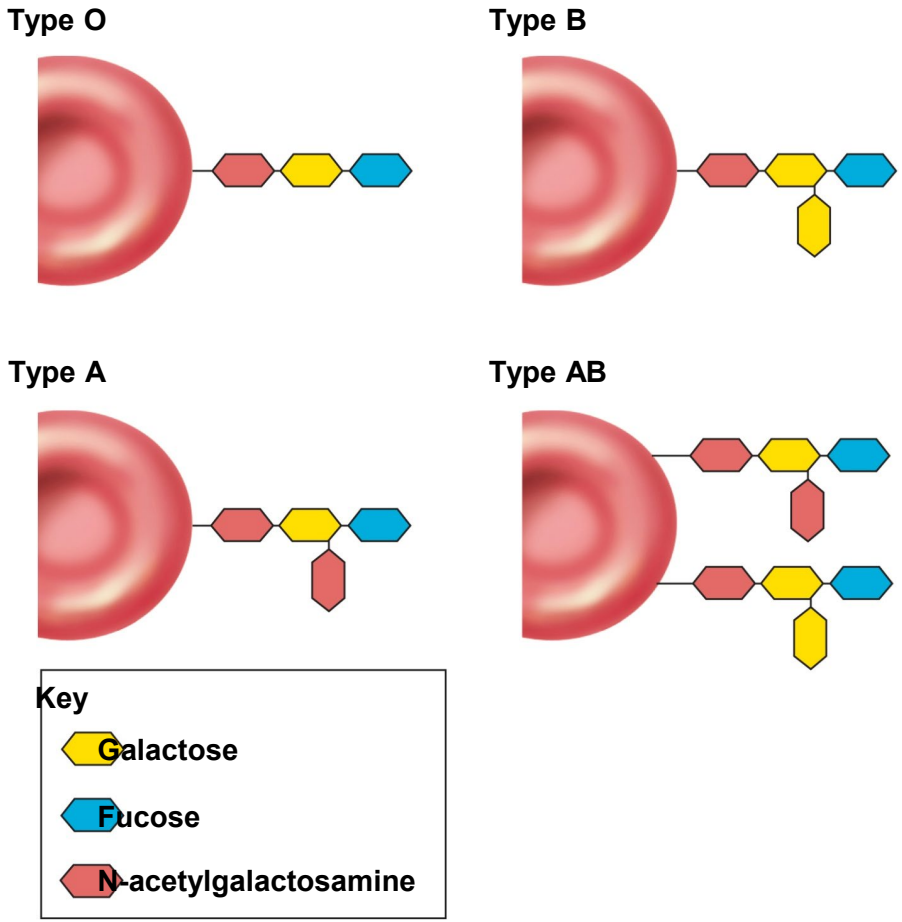
Antigens located on outer surface of RBC plasma membrane

antigen A or antigen B

determined by carbohydrate moieties found on RBC surface

The antibodies are in plasma

- antibody-A
- antibody-B



ABO Group

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 antibodies (Anti A or Anit B) to determine the RBC blood group.

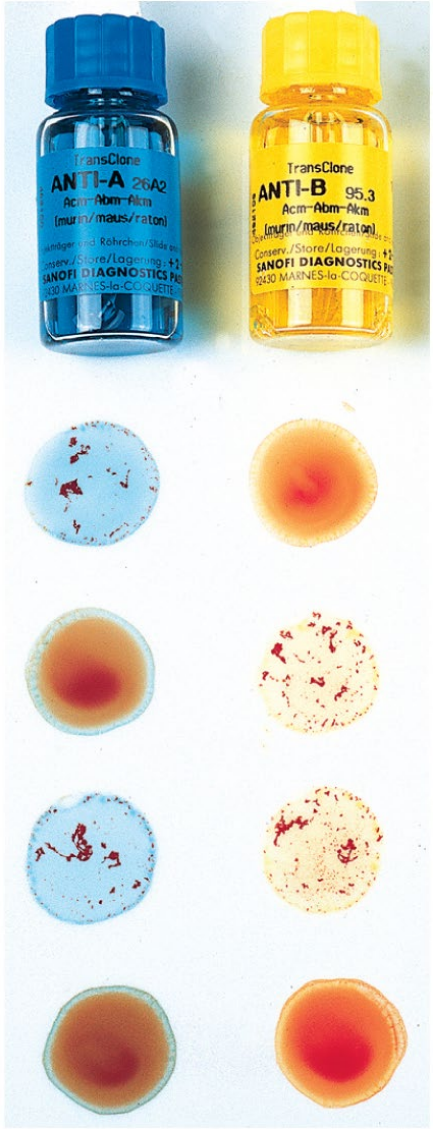
The antibody will “agglutinate” (clump together) the RBC if the antibody is “matched” to the antigen (antibody A to antigen A).

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

Antibodies do not kill cells but render them harmless and tag them for destruction by complement.

Aglutinin A

(antibody A)

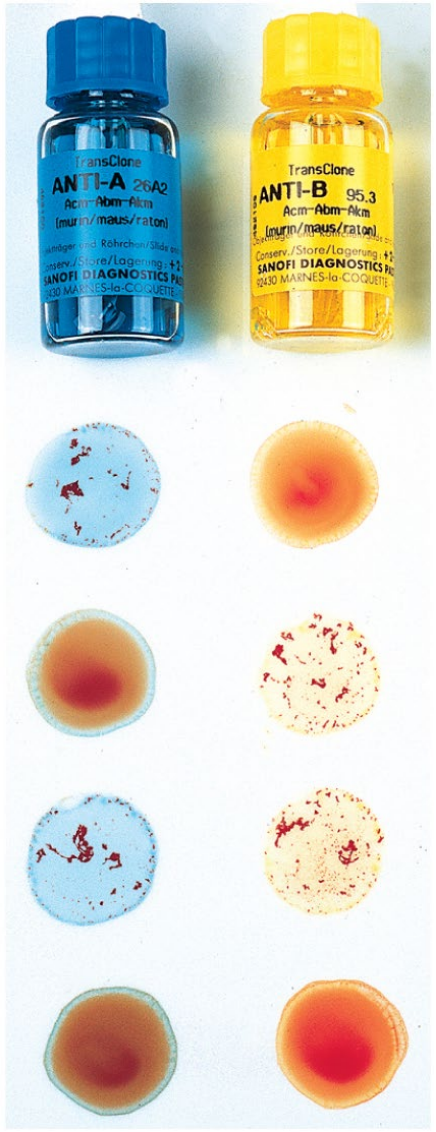


Aglutinin B

(antibody B)

What is the blood type of these blood samples?

ABO Blood Typing



Blood Antigens and Antibodies

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

Aglutinin (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 aglutinogen 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

Agglutination

Antibody molecule binding to antigens (e.g. A antibody binds to A antigen) // one M class antibody can bind to 10 different RBC

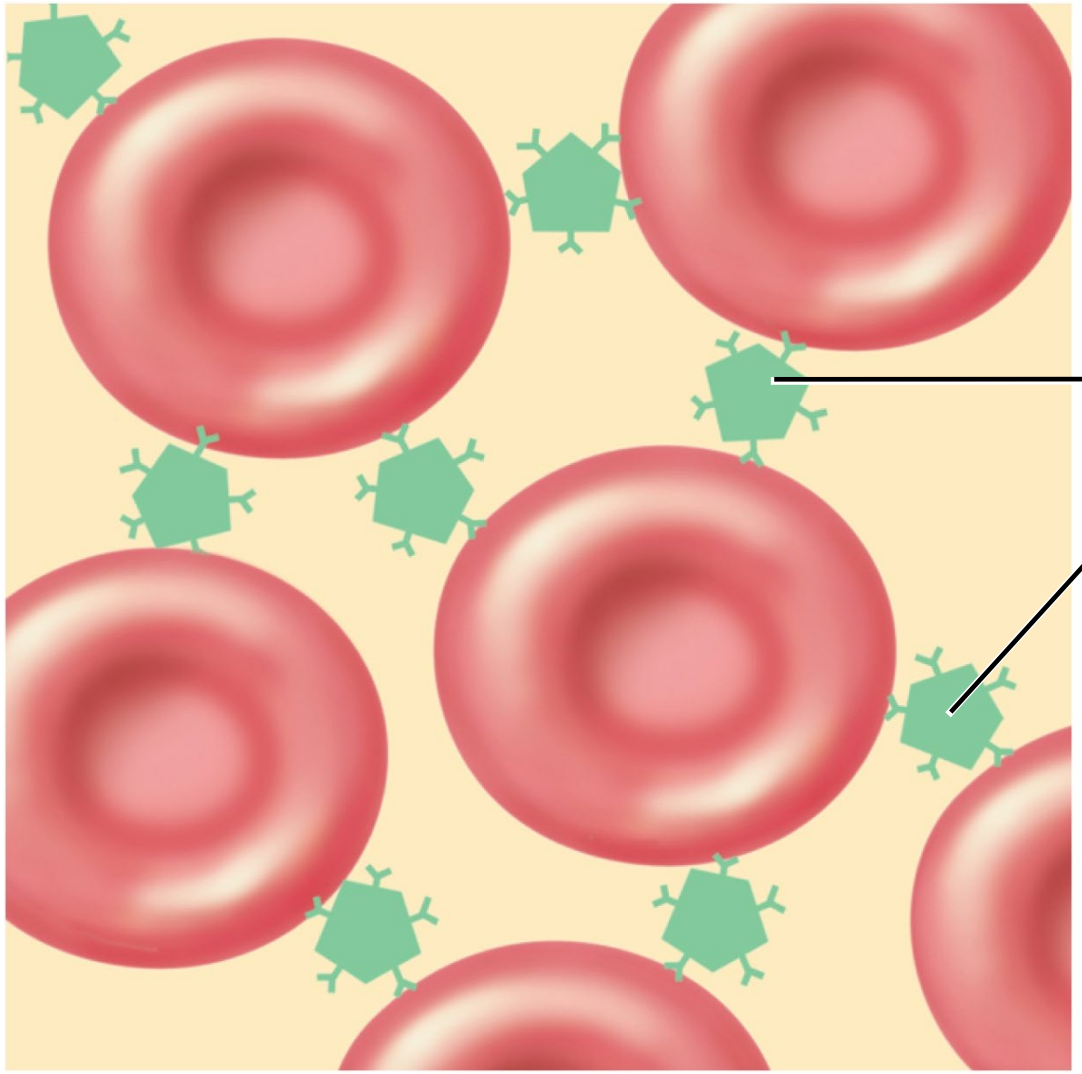
Causes agglutination of red blood cells

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

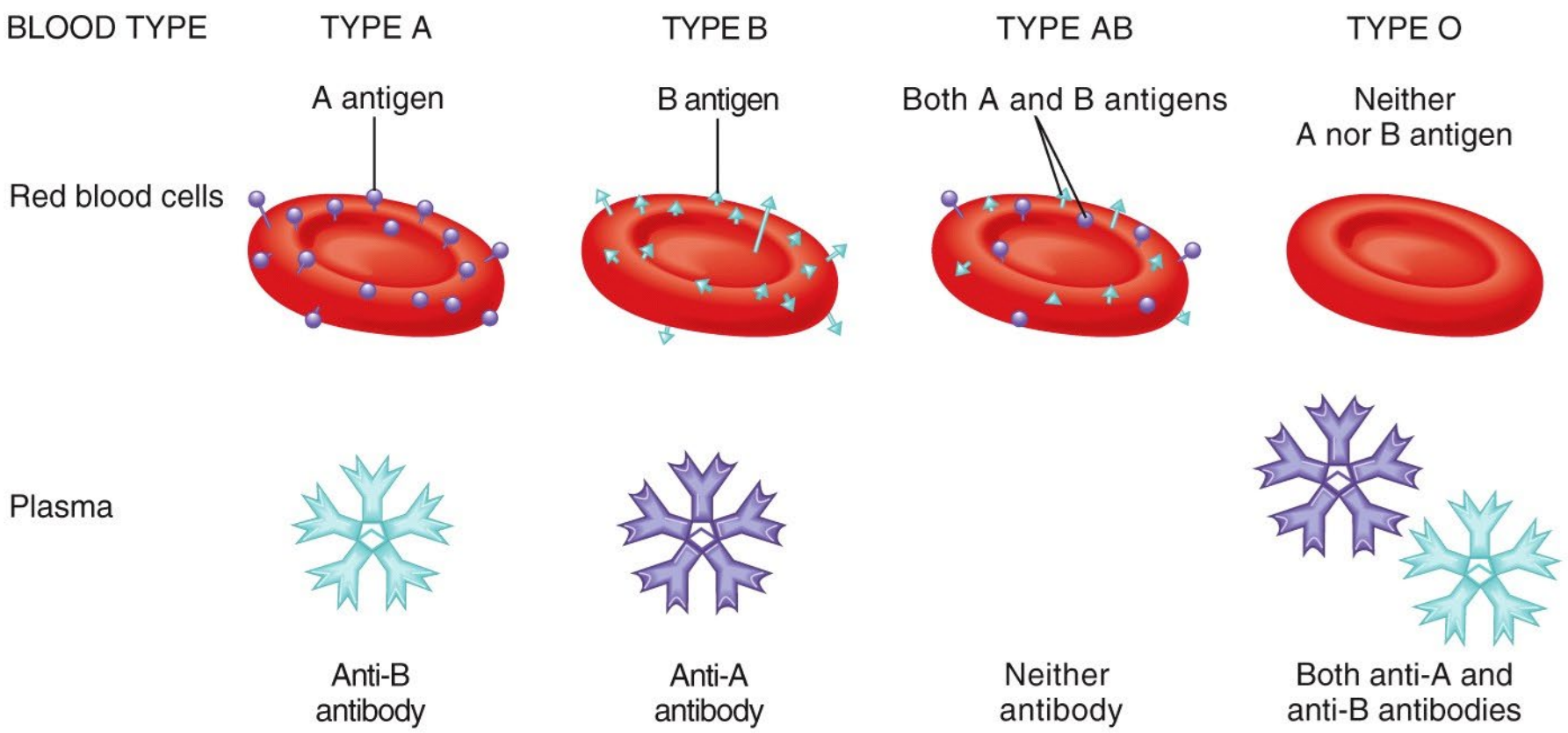
Agglutination of Erythrocytes



Antibodies (agglutinins)

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

Agglutinogens VS Agglutins



Universal Donors

Universal donor

Type O // most common blood type

No antigen on RBC

Donor's plasma will have both plasma antibodies (anti-A and anti-B)

This person may only receive type O blood

To minimize affect of antibodies give packed cells (minimum or no plasma volume)

Universal Recipients

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 Antibodies First Form

- 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 = Antigen D

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

Rh^+ if D antigen (agglutinogens) on RBCs /// Rh- if there is no D antigen on their RBC

Rh frequencies vary among ethnic groups

A Rh+ person will never make D antibodies

–A Rh- 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- person will have circulating D antibodies

–This creates a special problem for women!

Rh Blood Type

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^- woman carries an Rh^+ fetus / at birth fetal blood sensitizes mother.

2 = Rh negative person receive transfusion from a Rh^+ 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+ RBC will there be an agglutination condition

Hemolytic Disease of Newborn

Two conditions may cause this situation

Rh- pregnant woman sensitized by Rh^+ 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+ fetus /// forms antigen-antibody complex in fetal blood / hemolyze fetal RBC

This condition may also occur if women receives blood transfusion Rh+ RBC

Hemolytic Disease of Newborn

How do we to prevention this condition?

RhoGAM // given to pregnant Rh^- women before delivery

RhoGAM binds any fetal Rh antigen that may mix with maternal blood during delivery

Fetal Rh+ RBC can not sensitize Rh- mother to D antigen because RhoGam binds to the D antigen, so it is not able to sensitize mother during delivery

Mother will not make Anti-D antibodies // therefore, a future pregnancy with a Rh+ baby will not be attacked by mother's anti-D antibodies.

RhoGAM

In pregnancy, RhoGAM is a treatment for Rh-negative individuals to prevent Rh sensitization, a condition that can harm a future Rh-positive baby. Rh sensitization can happen when the blood of an Rh-negative mother mixes with the Rh-positive blood of her baby, causing the mother's immune system to produce antibodies.

RhoGAM (also called Rh immunoglobulin or RhIg) is a solution containing anti-D antibodies. It works by neutralizing any Rh-positive fetal red blood cells that enter the mother's bloodstream during pregnancy.
•The shot "masks" the foreign blood cells from the mother's immune system.
•This prevents her body from identifying them as an invader and producing its own antibodies against them.
•The treatment is effective only for the current pregnancy.

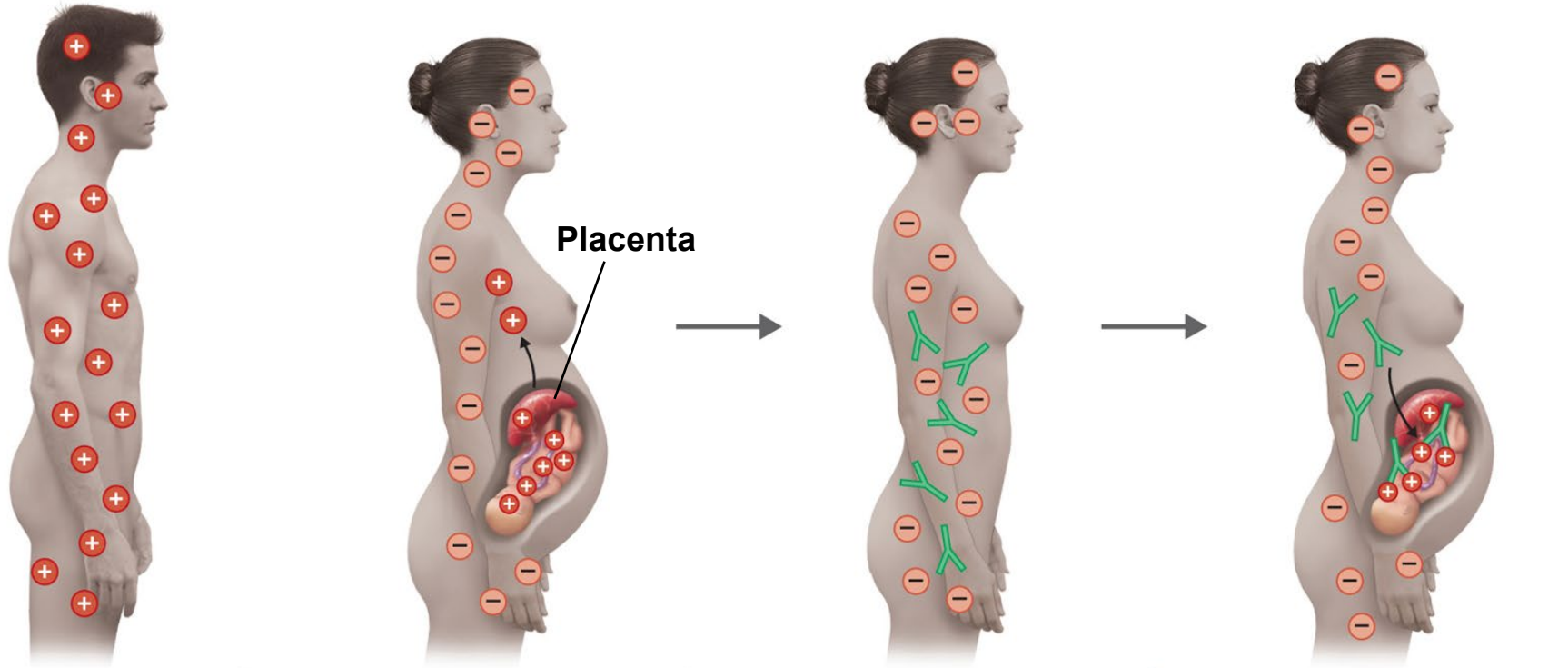
A pregnant person needs RhoGAM if they have Rh-negative blood and their baby is or could be Rh-positive. A blood test early in pregnancy determines a person's Rh status. An Rh factor mismatch occurs when an Rh-negative mother is carrying an Rh-positive baby.

For Rh-negative pregnant individuals, the standard protocol includes multiple shots:

•**Routine dose during pregnancy:** Typically given around 26 to 28 weeks of gestation. This anticipates potential small exposures to the baby's blood as the pregnancy progresses.

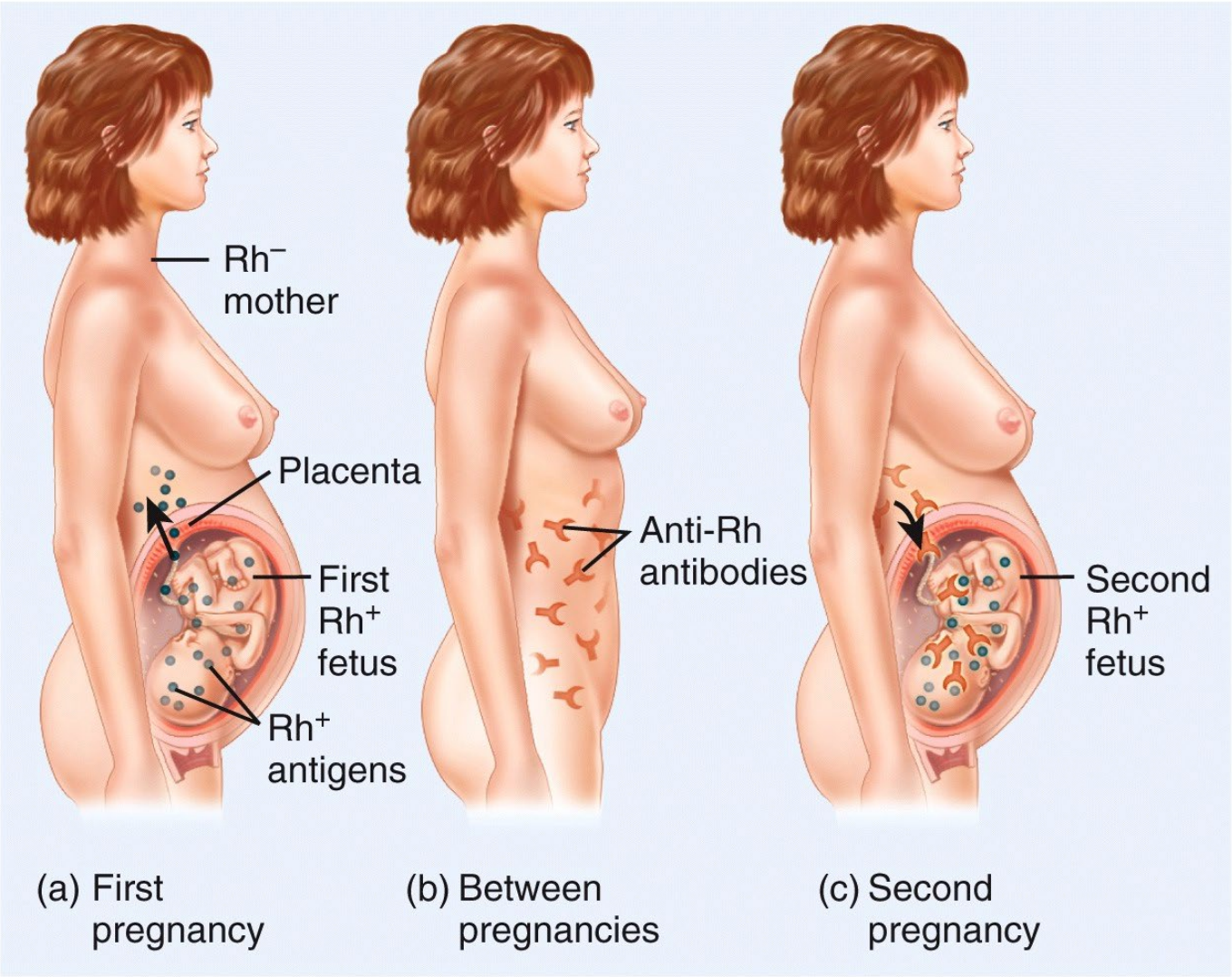
•**Routine dose after delivery:** Given within 72 hours after birth if the baby is found to be Rh-positive. This protects against the larger mixing of blood that can happen during delivery.

Hemolytic disease of the newborn.



1. Rh^+ father.
2. Rh^- mother carrying her first Rh^+ 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^+ 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