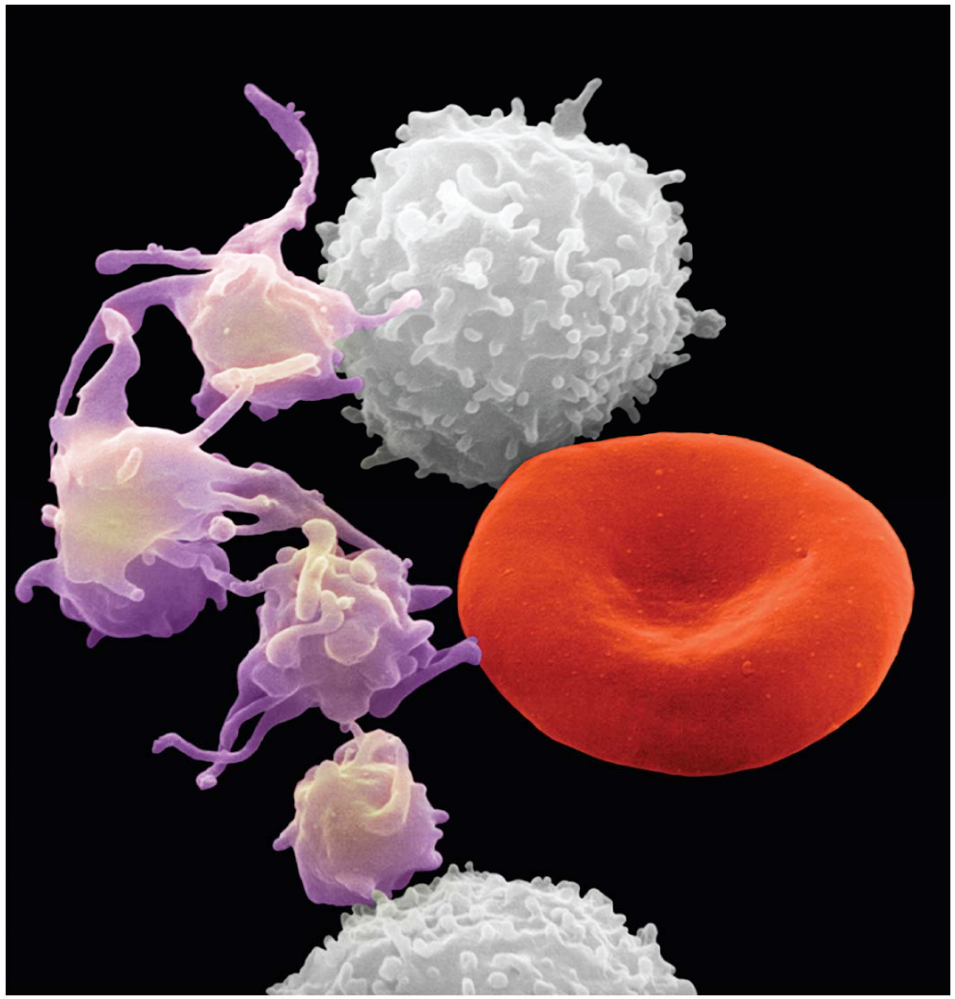
Chapter 19

Blood Types



What is an antigen?

- Antigens are glycoprotein and glycolipid molecules which are part of the plasma membrane (i.e. part of the glycocalyx)

- These molecules maybe imbedded into the plasma membrane of human cells, microbes, parasites, and viruses. A toxin produced by a cell can also act as an antigen to stimulate immune cells

- Antigens are “identity molecules”. Antigens allow your immune system to recognize self vs non-self cells. Our immune system uses antigens to distinguish between self and non-self in order to attack non-self antigen and not our cells with self-antigen.

- We also use a special group of antigens to give identity to our RBCs. (e.g. ABO system & Rh // however there are many different RBC antigens --- but ABO and Rh are the most common and therefore the most problematic)

- Foreign antigens are “masked or covered” by our immune system’s antibodies // this then prevents non-self antigen from harming our tissues but also renders the foreign antigen harmless and tags the pathogen for destruction.

Antigen & Antibodies in Blood Types

- blood types and transfusion compatibility is a matter of interactions between antibodies (blood plasma proteins) and antigen (on erythrocytes)
- Karl Landsteiner discovered blood types A, B and O in 1900 // won Nobel Prize for discovery
- blood types are based on interactions between antigens and antibodies
- agglutinogens also called antigens (located on plasma membrane)
- agglutinins also called antibodies (located in plasma circulating in blood, lymph, tissue fluid)

Blood Antigens and Antibodies

- Agglutinogens or antigens
  - complex molecules on surface of cell membrane that are unique to every individual (accept identical twins!)
  - agglutinogens (antigens) on the surface of the RBC is the basis for blood typing
  - Antigens are also used to distinguish self from non-self (foreign cells)
  - foreign antigens are able to generate an immune response

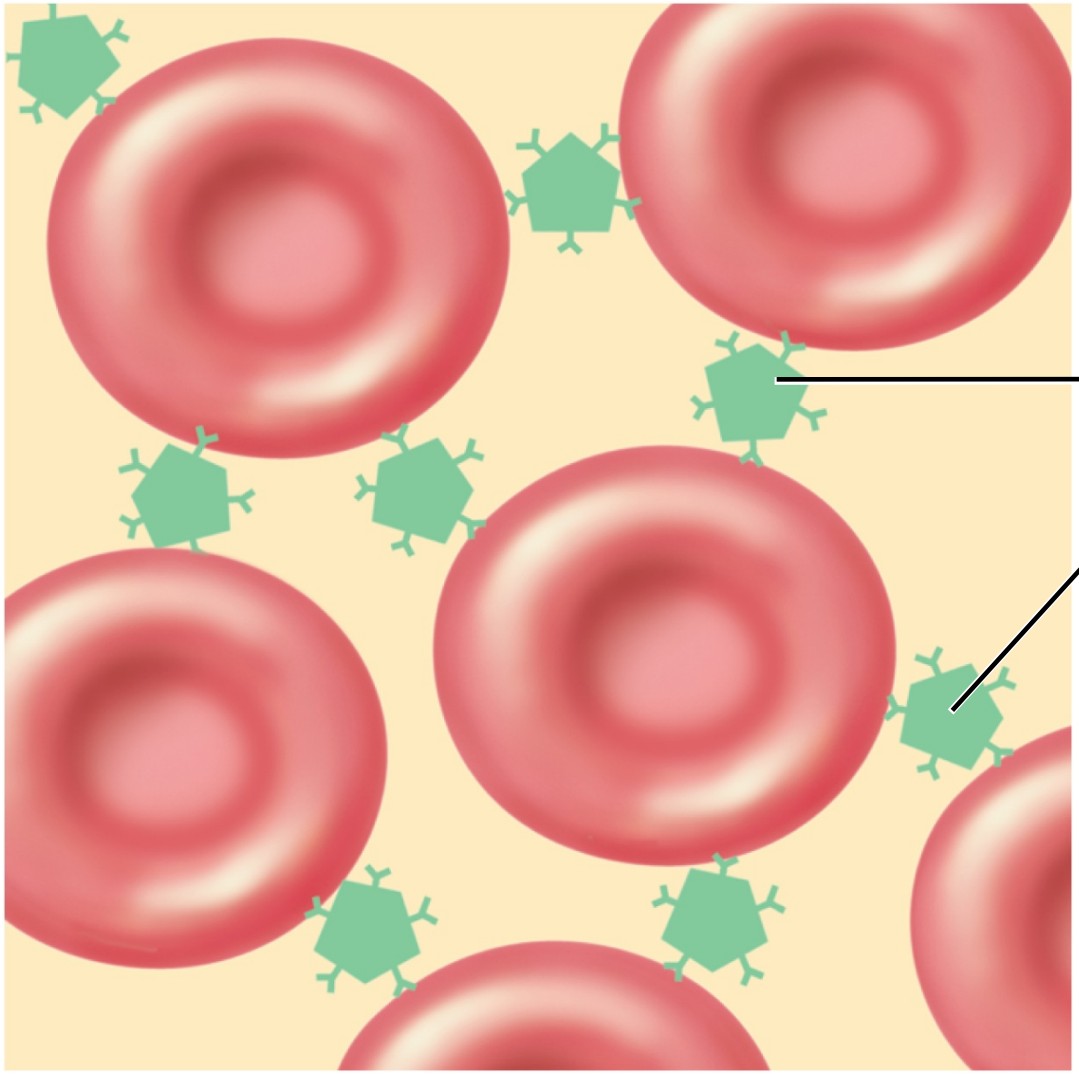
Blood Antigens and Antibodies

- Aglutinin or antibodies associated with blood typing
  - In blood chemistry we make antibodies only if we do not have the antigen on our RBC!
  - Antibody A and antibody B are the two antibodies
  - 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

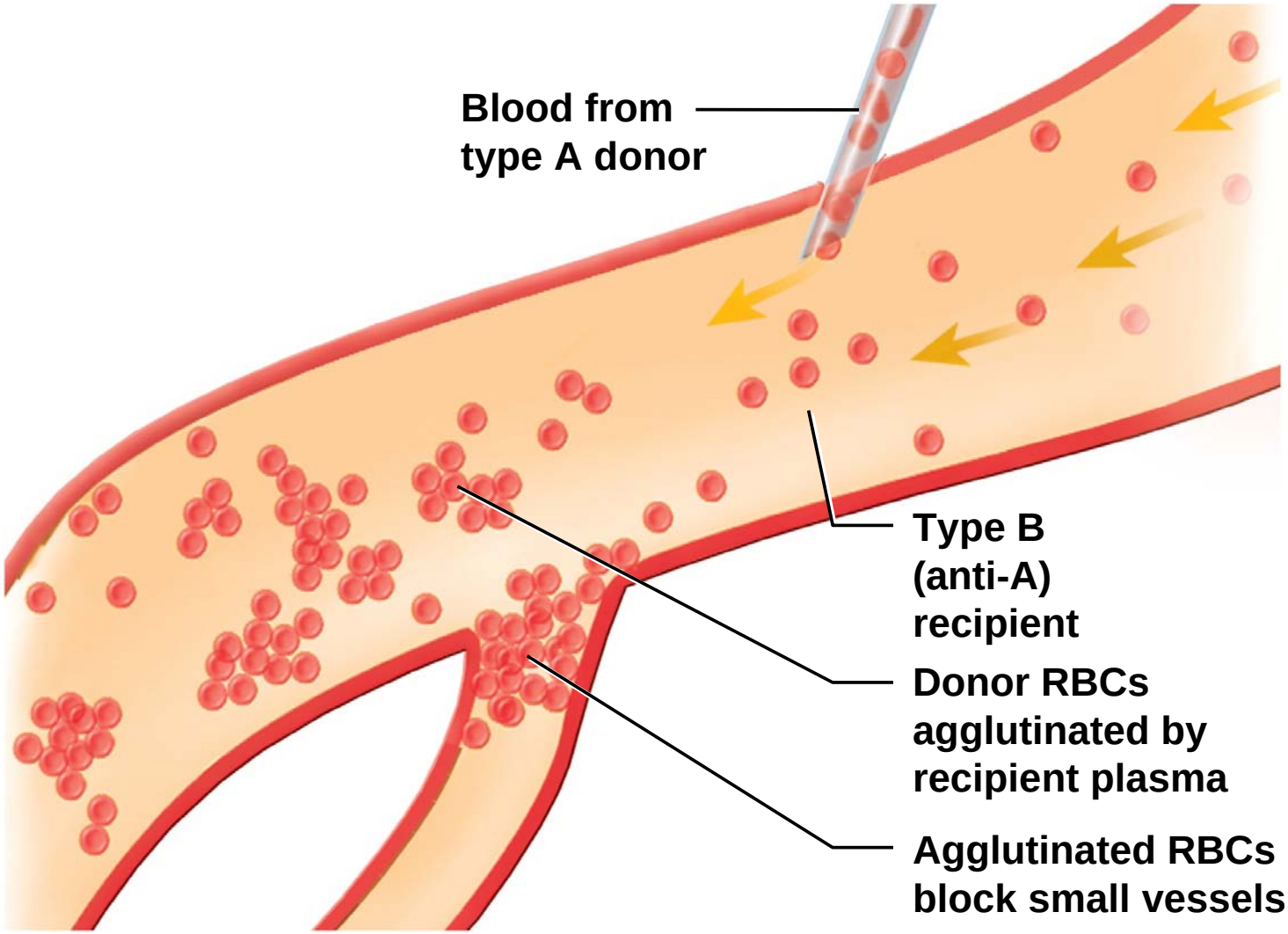
- Agglutination
  - antibody molecule binding to antigens (e.g. A antibody binds to A antigen) // one antibody can bind to several different RBC
  - causes clumping together of red blood cells
  - clumped cells block capillaries // infarctions occur that damage organs // kidneys especially vulnerable to this type of damage
  - each antibody can attach to several foreign antigens on several different RBCs at the same time
  - agglutinated RBCs block small blood vessels, hemolyze, and release their hemoglobin over the next few hours or days
  - Hb blocks kidney tubules and causes acute renal failure

Agglutination of Erythrocytes

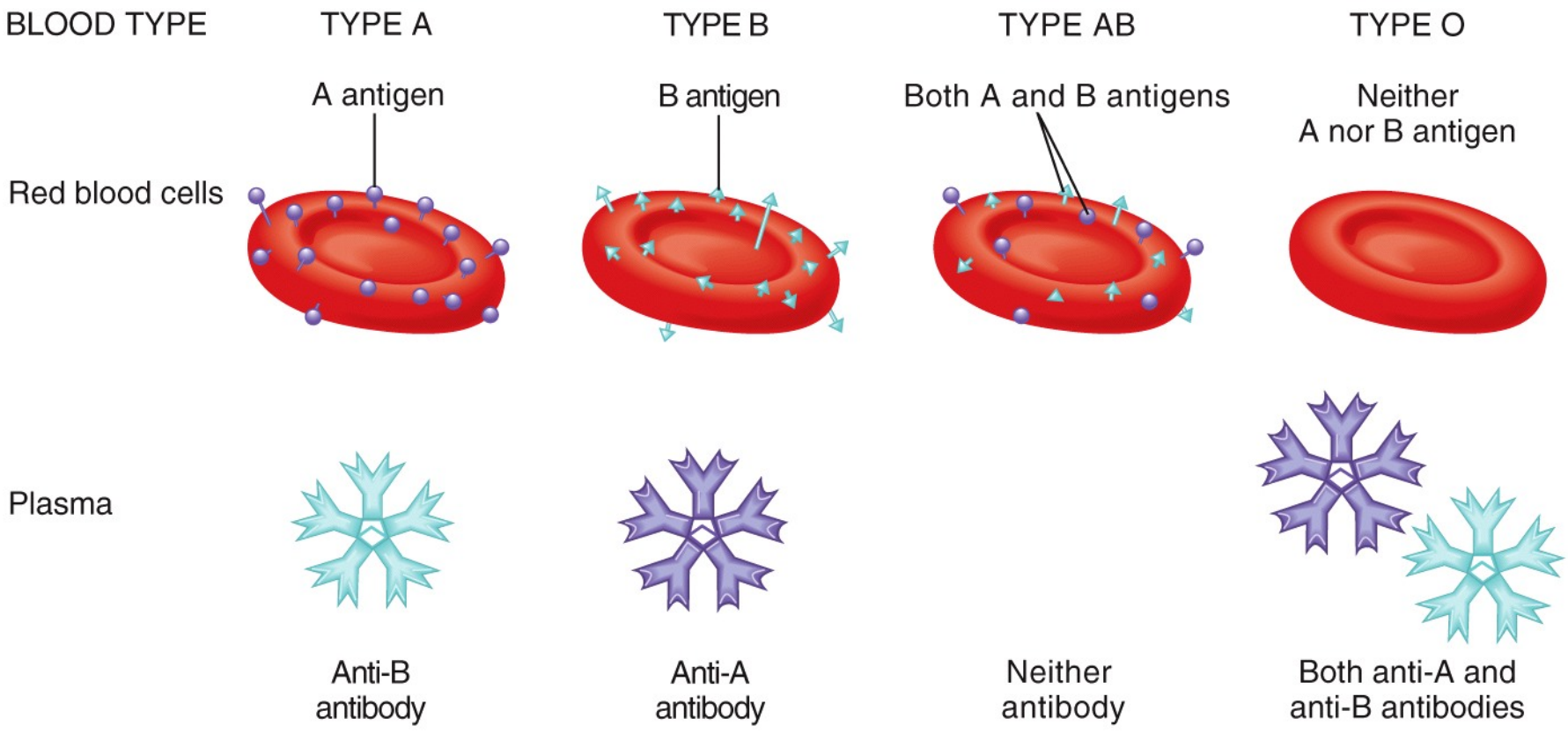


Antibodies
(agglutinins)

Transfusion Reaction

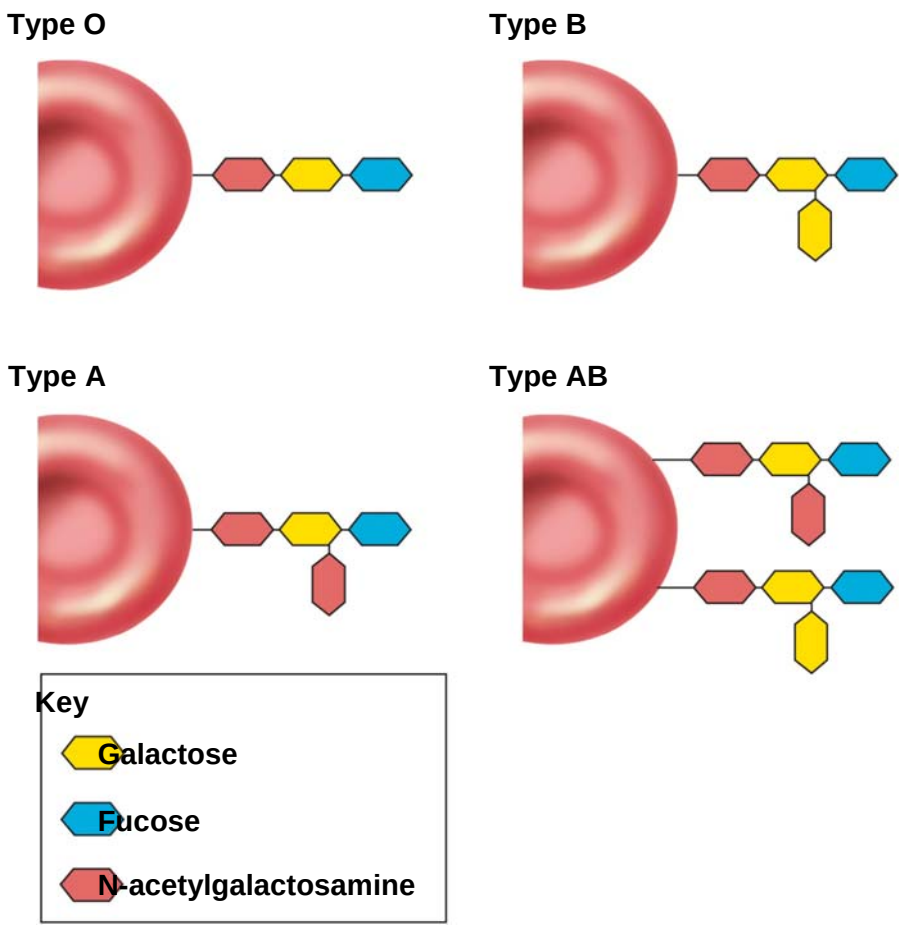


Agglutinogens VS Agglutins



Agglutinogens VS Agglutins

- RBC antigens called agglutinogens
  - called antigen A and B
  - determined by carbohydrate moieties found on RBC surface
- antibodies called agglutinins
  - found in plasma
  - anti-A and anti-B



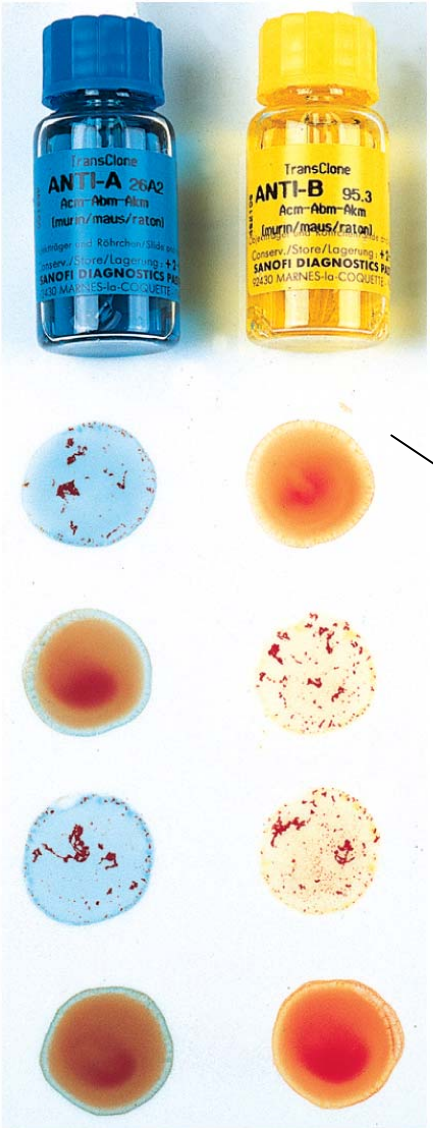
ABO Group

- 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 antigen
    - most common - type O (universal donor)
    - rarest - type AB (universal recipient)

ABO Blood Typing

Aglutinin A

(antibody A)



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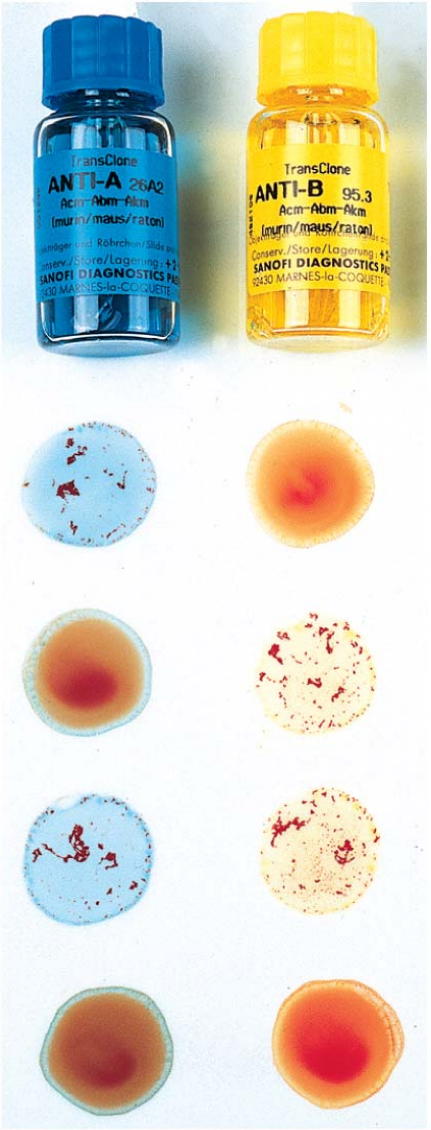
Aglutinin B

(antibody B)

What is the blood type of these blood samples?

ABO Blood Typing

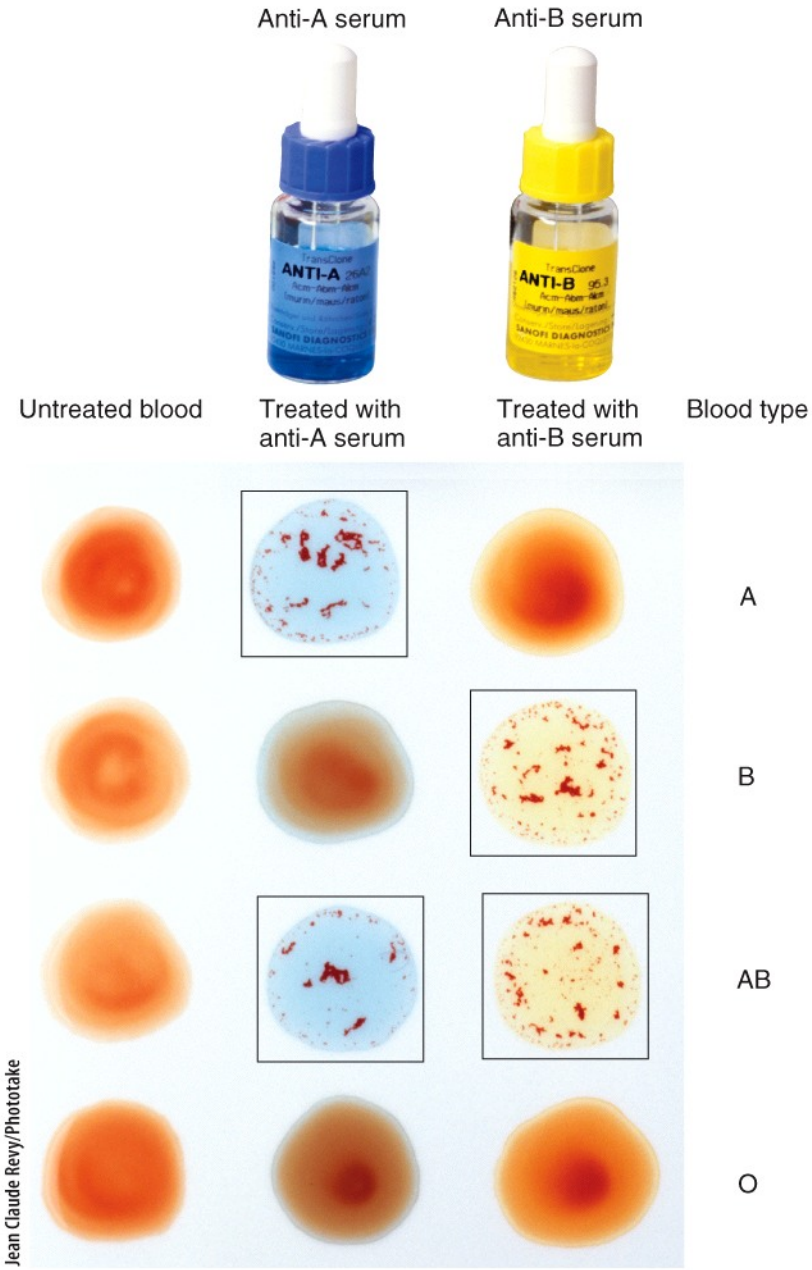


Type A

Type B

Type AB

Type O


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

- antibodies (agglutinins) // anti-A and anti-B
- appear 2-8 months after birth
- maximum concentration at 10 yr.
- antibody-A and/or antibody-B (both or none) are found in plasma
- You will never form plasma antibody to RBC antigen if the antigen is on your RBC!
- You will only make plasma antibody to an RBC antigen if it is not present on the RBC
- These rules only apply to the ABO system (does not apply to Rh factor // different rules apply for Rh factor)

Universal Donors and Recipients

- Universal donor
  - Type O // most common blood type
  - Lack RBC antigens
  - This donor's plasma will have both plasma antibodies (anti-A and anti-B)
  - Minimize affect of antibodies by giving packed cells (minimal plasma volume)

Universal Donors and Recipients

- Universal recipient
  - **Type AB** // rarest blood type
  - Lacks any plasma antibodies
  - No anti A or B

Rh Antigen // Blood Type +

- Rh agglutinogens discovered on rhesus monkey's RBC in 1940 // other "minor" RBC antigen-antibodies discovered
  - Rh D is the most reactive of these groups
  - Patient considered blood type Rh^+ if they have D antigen (agglutinogens) on their RBCs
  - Rh frequencies vary among ethnic groups
  - Note: you may have the AB antigen with the Rh antigen

Rh Blood Type

- Anti-D agglutinins (antibodies) are normally never present in the blood
- Only a Rh negative person may be sensitized (i.e. exposed to the antigen) and only then will that person form the Rh agglutinin
- Rh negative individuals may form anti-D under two mechanisms
  - 1 = Rh^- woman with an Rh^+ fetus
  - 2 = Rh negative person receive transfusion from a Rh^+ blood
  - no problems at time of first transfusion or pregnancy
  - Takes time to develop antibodies // only after Rh negative person exposured will they make antibodies /// so during second exposure there will be antibodies and result in agglutination disease // no problem with first exposure

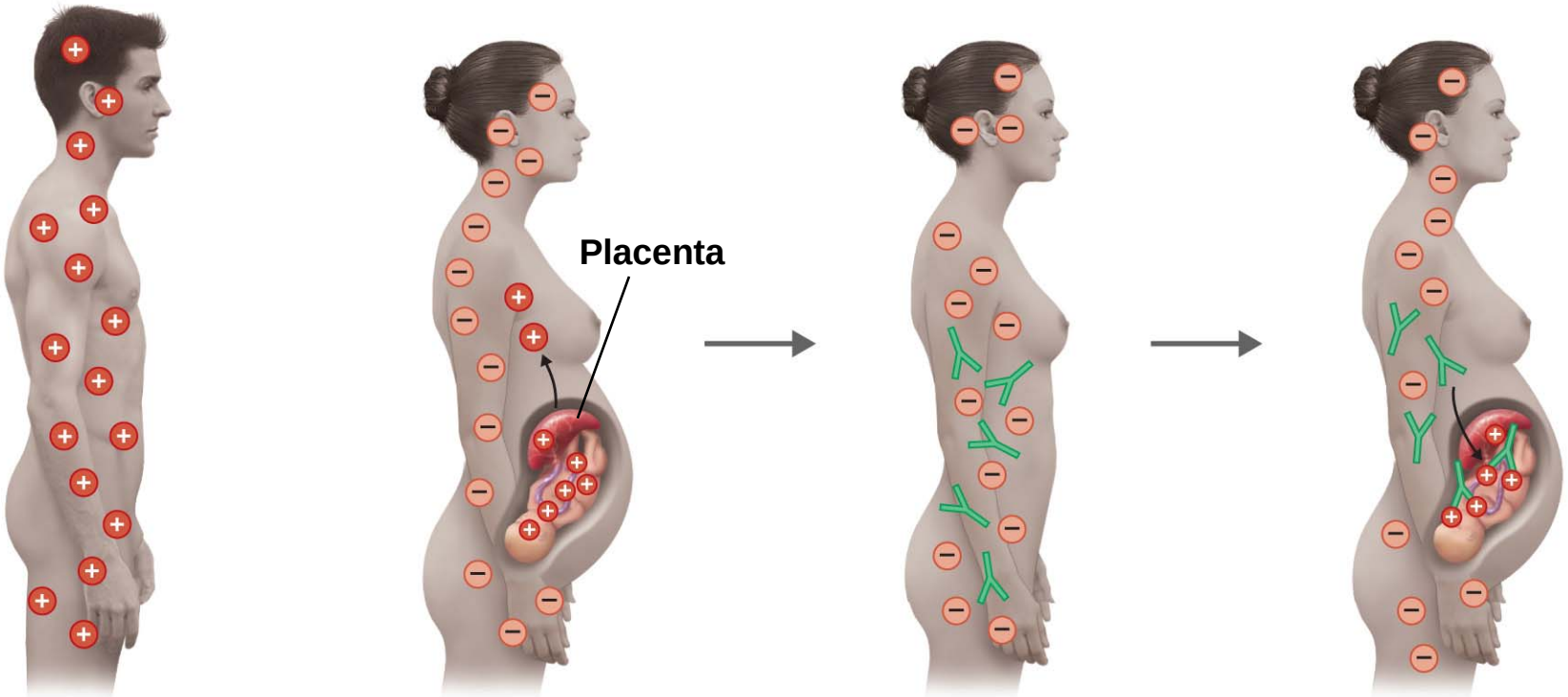
Hemolytic Disease of Newborn

- Occurs when Rh^- woman is sensitized to form Rh-D antibodies then becomes pregnant with second fetus which is Rh+ // now her antibodies will cross placenta and attach fetal Rh- RBCs
  - this may happen because:
    - previously pregnant with Rh^+ fetus
    - received blood transfusion Rh+ RBC
  - now woman has anti-D in plasma
    - Anti-D antibodies can cross placenta
    - forms antigen-antibody complex in fetal blood / hemolyze fetal RBC

Hemolytic Disease of Newborn

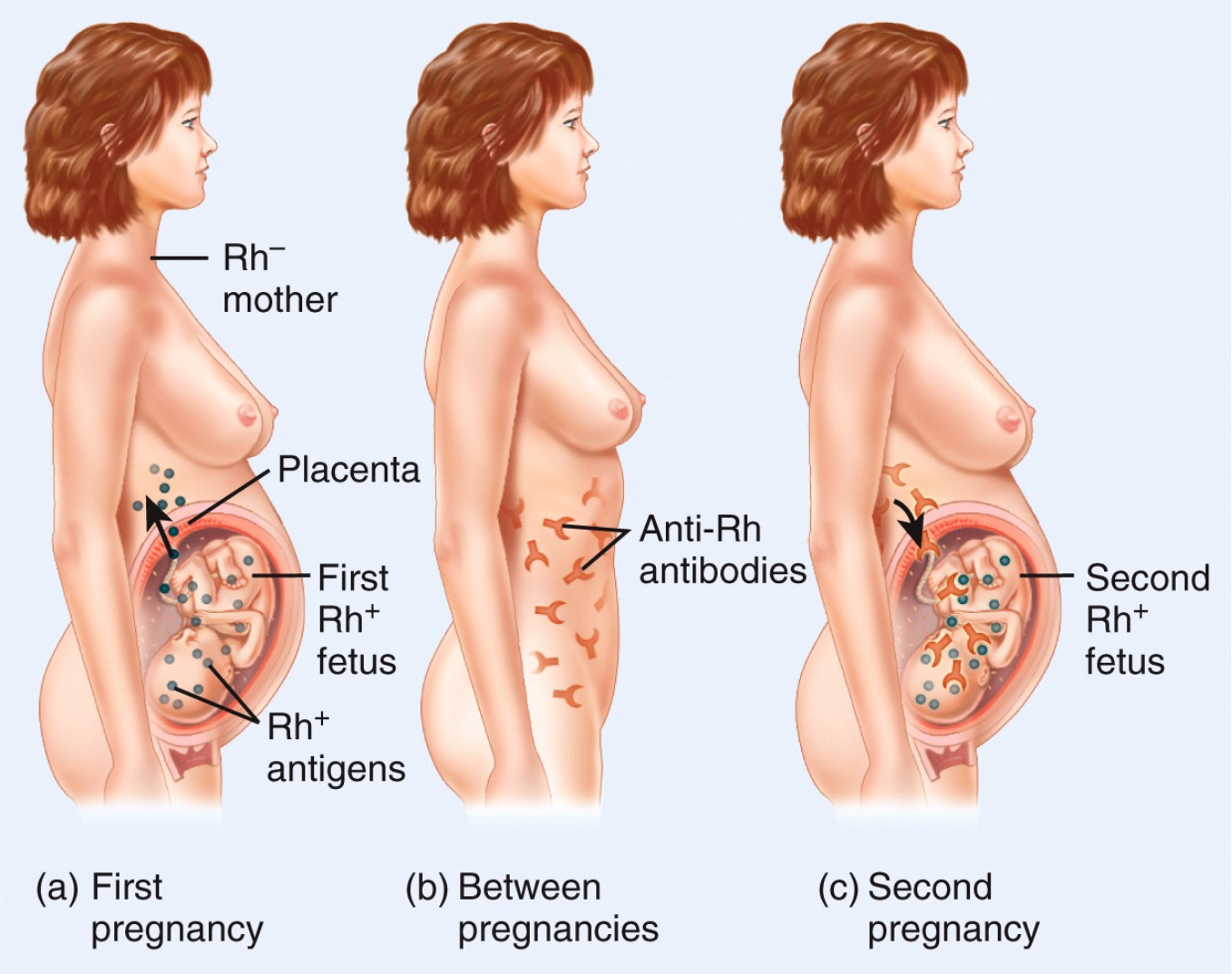
- How to prevention
  - RhoGAM // given to pregnant Rh^- women before delivery
  - RhoGAM binds fetal agglutinogens // so Rh+ RBC can not sensitize or exposed mother to antigen (now masked by RhoGam) during delivery
  - Mother now will not make Anti-D antibodies

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

Antibodies Matched to Non-Self Antigen

- This is the humoral adaptive immunity response
- Antibodies are produced by plasma cells against foreign cells
  - Antibodies are proteins (gamma globulins)
  - Activated plasma cells secrete antibodies matched to specific foreign molecules (i.e. toxins) or cells (e.g. bacteria, virus, parasites)
  - This is the humoral part of our immune system response to foreign matter // these antibodies bind to pathogens not inside of our cells!
  - Binding to antigens results in making the antigen either harmless or marking them for destruction
  - forms <u>antigen-antibody complexes</u>