Immunology Lab 5

ABO Blood Antigens

Samer Alqaraleh,

PhD. Nanobiotechnology

Faculty of Allied Medical Sciences, Mutah university

Immunology, 2nd year students

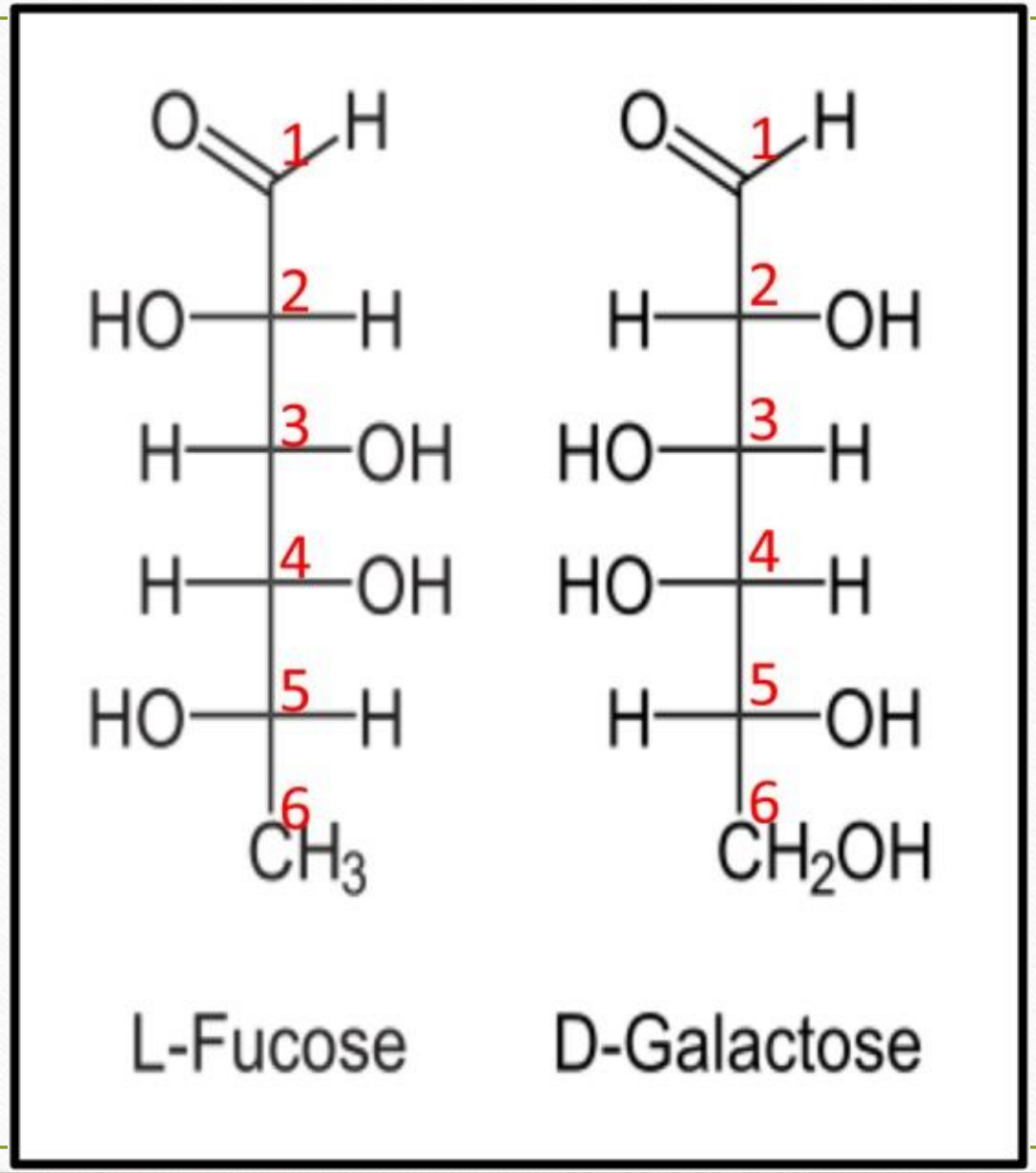
ABO blood antigens

- The ABO antigens are carbohydrates linked to cell surface proteins and lipids that are synthesized by polymorphic glycosyltransferase enzymes.
- Most individuals possess a fucosyltransferase that adds a fucose moiety to a nonterminal sugar residue of the core glycan, and the resulted fucosylated glycan is called the H antigen (O antigen).
- A single gene on chromosome 9 encodes a glycosyltransferase enzyme that may further modify the H antigen.

There are three allelic variants of this enzyme

1. O allele gene product: is devoid of enzymatic activity and can't attach terminal sugars to the H antigen, and express only the H antigen, the precursor of the ABO blood group antigens.
2. A allele– encoded enzyme (N –Acetylgalactosaminyltransferase): transfers a terminal N-acetylgalactosamine moiety onto the H antigen.
3. B allele gene product: transfers a terminal galactose moiety.

The C-6 carbon of l-fucose lacks a hydroxyl group present at the C-6 position of d-galactose. l-Fucose can also be described as 6-deoxy-l-galactose.



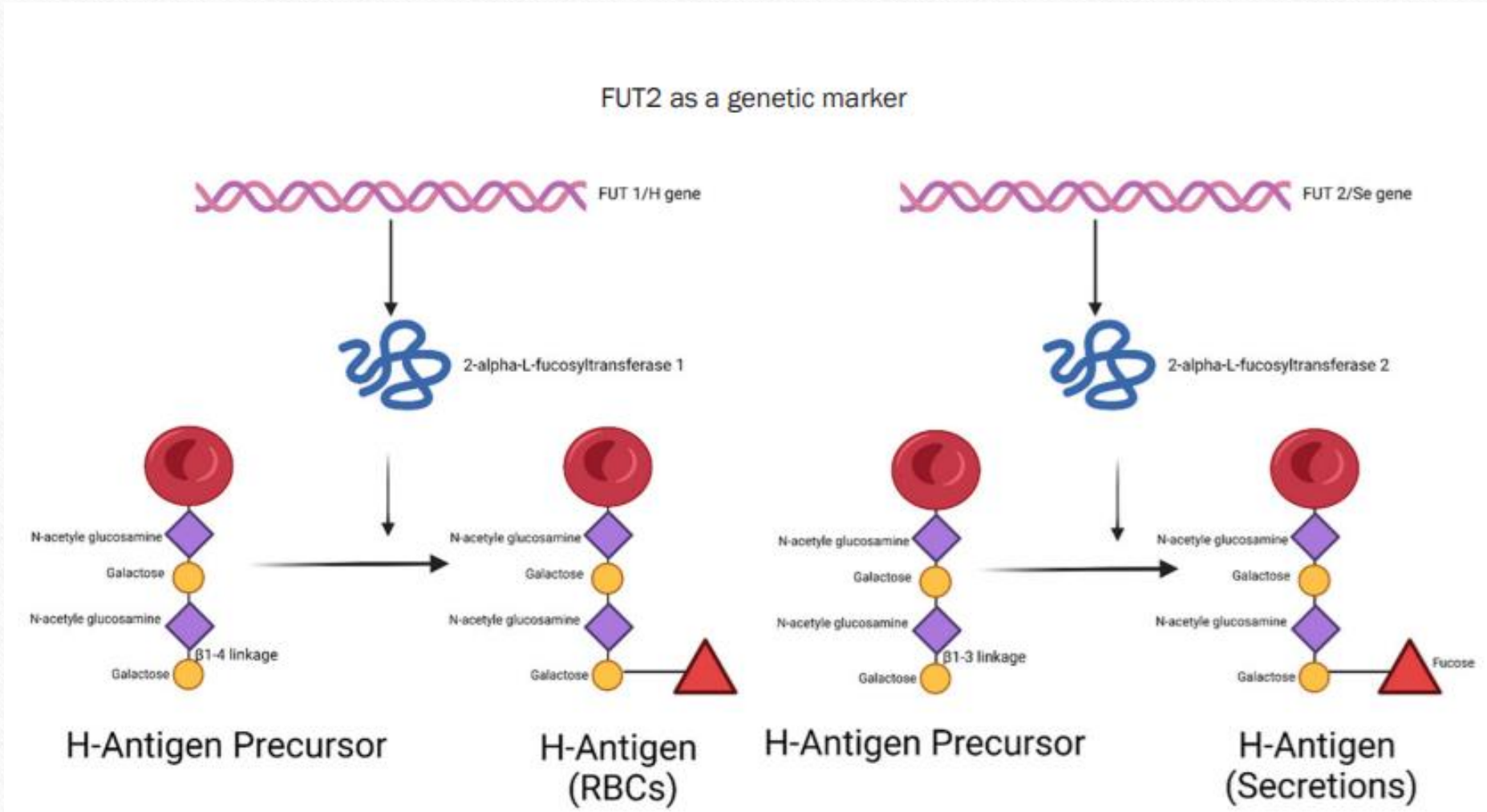
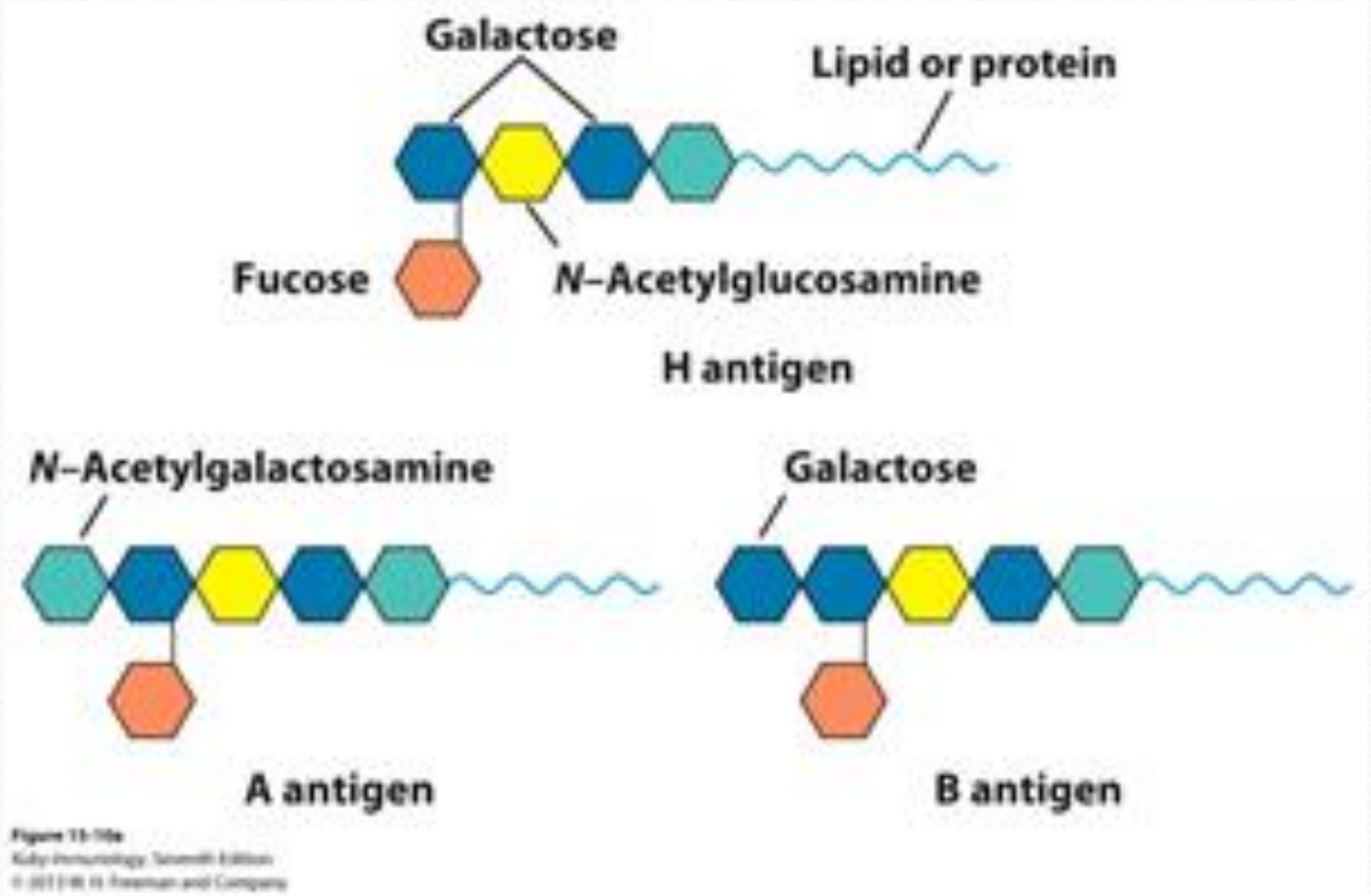
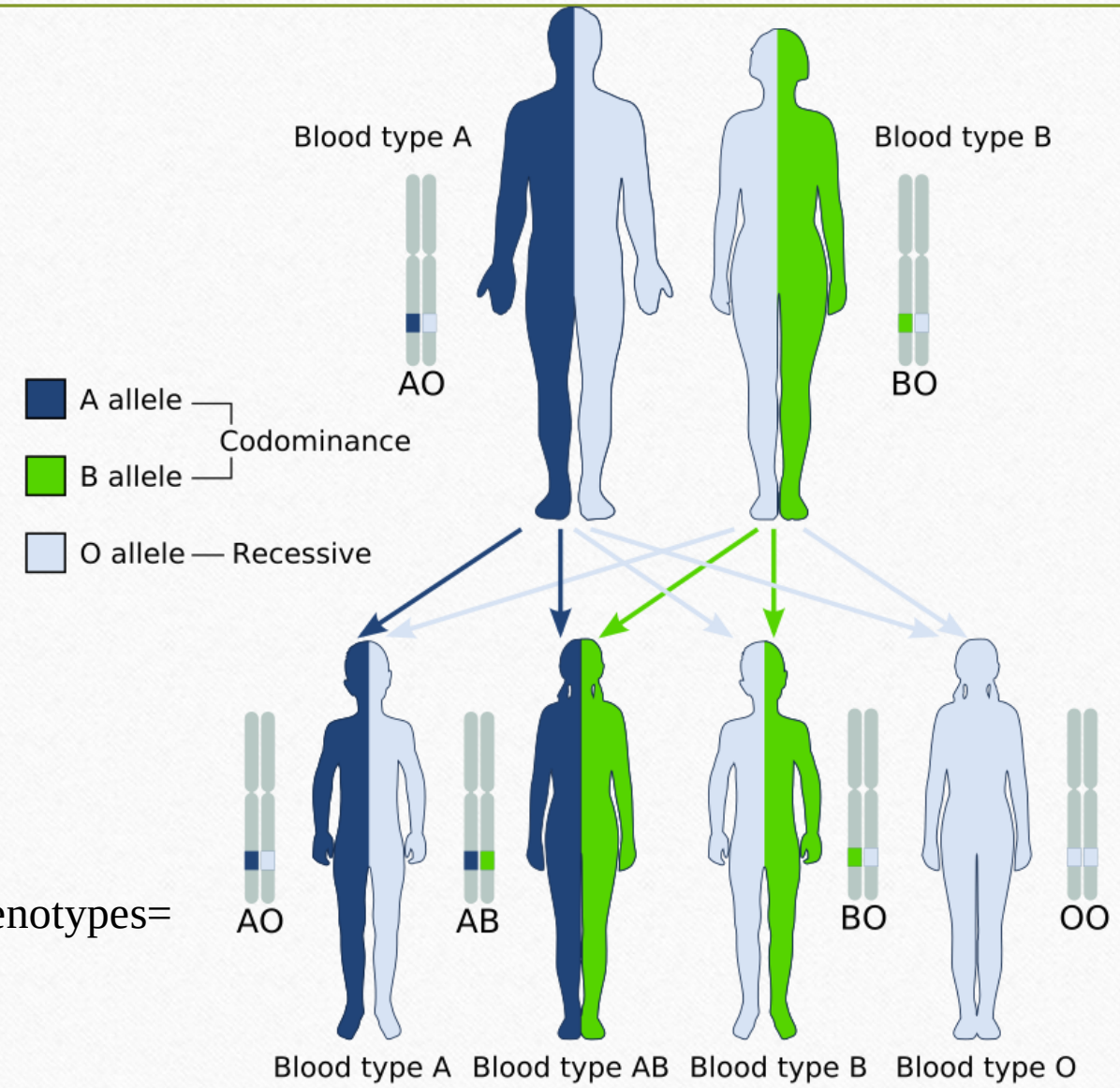


Figure 1. Role of FUT1 and FUT2. Fucosyltransferase enzymes H (FUT1) add fucose to the alpha (1, 2) binding of type 2 glycoproteins on RBCs to form H antigen, whereas FUT2 adds fucose to the alpha (1, 2) binding of type 1 glycoprotein chains to make ABH antigens in other body fluids (secretor phenotype).


Galactose
Lipid or protein
Fucose
N–Acetylglucosamine
H antigen
N–Acetylgalactosamine
Galactose
A antigen
B antigen


Blood type A
Blood type B
AO
BO
A allele
B allele
Codominance
O allele — Recessive
Genotypes=
AO
AB
BO
OO
Blood type A
Blood type AB
Blood type B
Blood type O

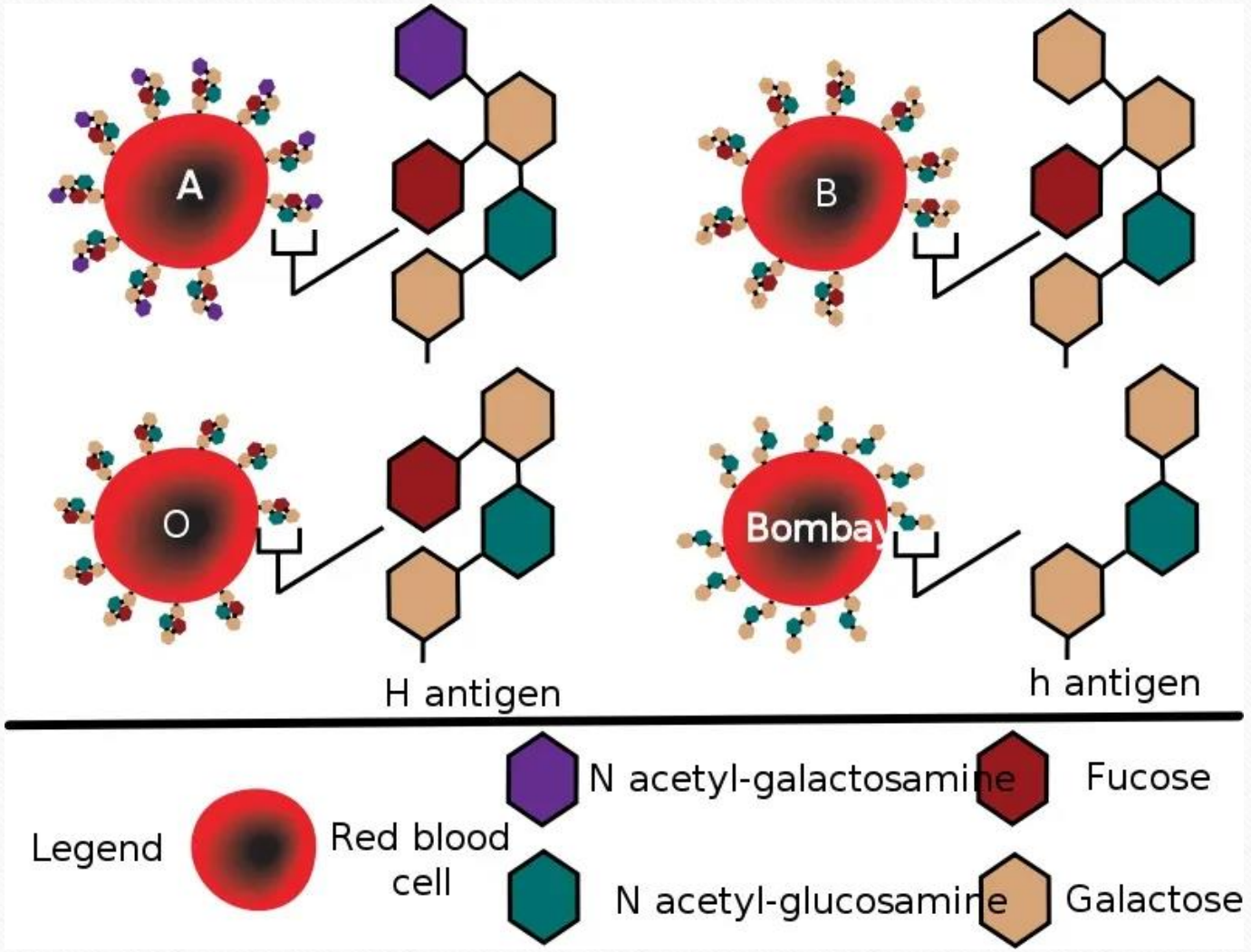


Diagram showing the carbohydrate chains that determine the ABO blood group

- Mutations in the gene encoding the fucosyltransferase that produces the H antigen without fucose are rare.
- People who are homozygous for such a mutation are said to have the **Bombay blood group** (h/h, also known as Oh).
- And cannot produce H, A, or B antigens. And can’t receive type O, A, B, or AB blood.

Blood Groups (Antigens and Antibodies)		
Blood Group	**Antigens**	**Antibodies**
A	A,H	B
B	B,H	A
AB	A,B,H	-
O	H	A,B
Bombay Blood Group	-	A,B,H

Called (O, hh, Oh)

Percentages of the 8 blood groups

AB-negative (0.6 percent)

B-negative (1.5 percent)

AB-positive (3.4 percent)

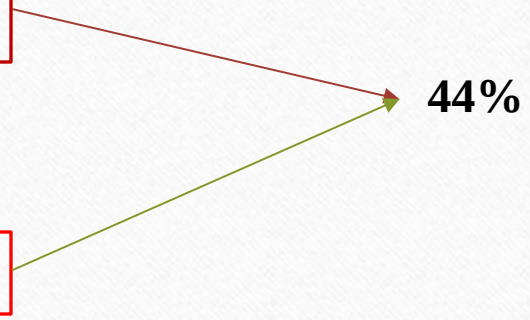
A-negative (6.3 percent)

O-negative (6.6 percent)

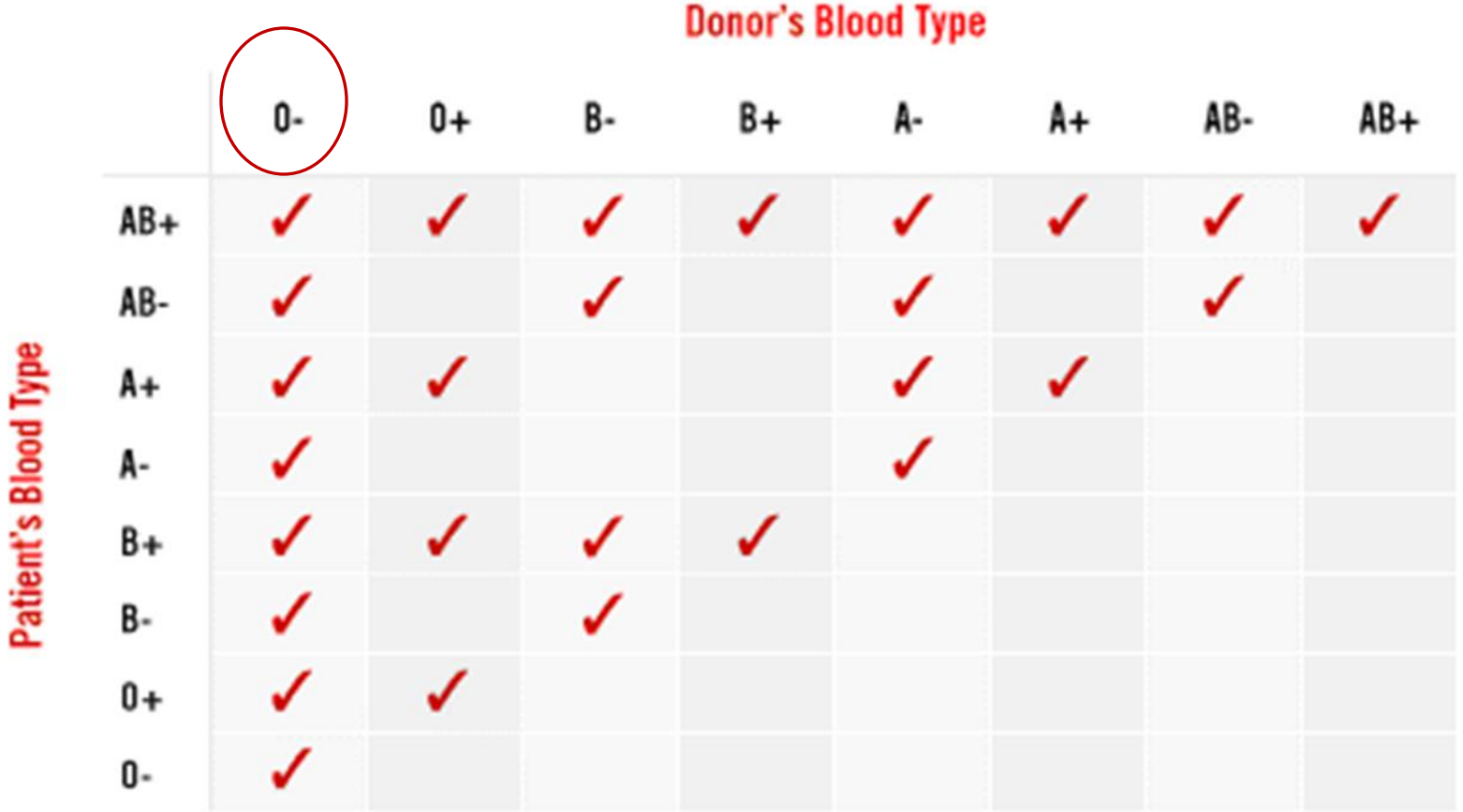
B-positive (8.5 percent)

A-positive (35.7 percent)

O-positive (37.4 percent)

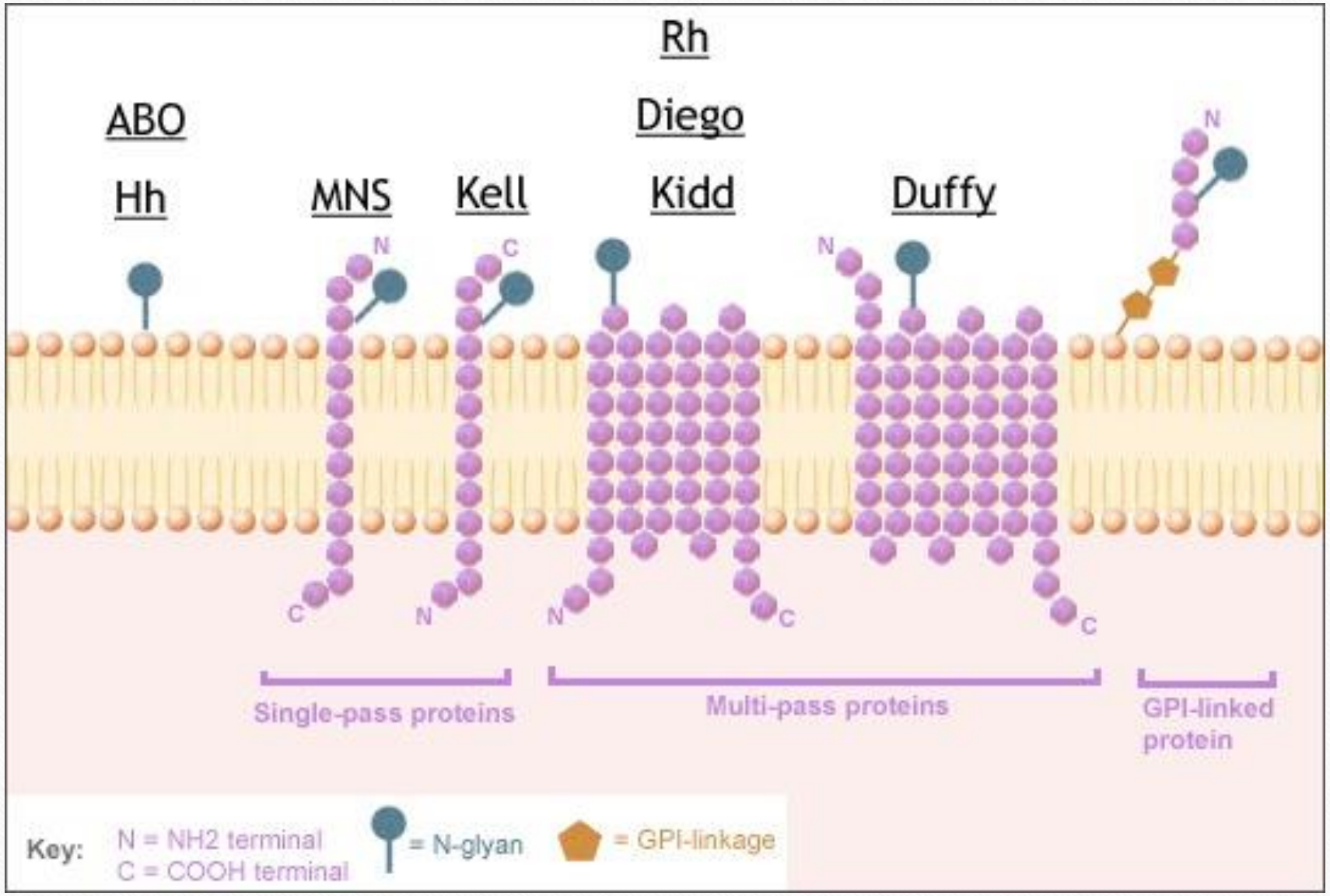


Most Common Transplantation
-Blood Transfusion-



- ✓ O-negative is the **universal blood type**, meaning any other blood type may receive it (see our blood type compatibility chart here).
- ✓ This can quickly deplete the stores of O-negative that blood centers have on the shelves.
- ✓ While 44% of the population is type O, less than 7% is O-negative. So as you can see, the most needed type of blood is also the hardest to collect.
- ✓ AB negative is the rarest of the eight main blood types - just 1% of our donors have it. Despite being rare, demand for AB negative blood is low

Blood grouping System	System symbol	Epitope or carrier, notes	Chromosome
ABO	ABO	Carbohydrate) N-Acetylgalactosamine ,galactose .(A, B and H antigens	9
MNS	MNS	Main antigens M, N, S, s. carried on sugar-bearing proteins called glycophorins.	4
Rh	RH	Protein. C, c, D, E, e antigens (there is no "d" antigen; lowercase "d" indicates the absence of D	1
Kell	KEL	Glycoprotein. K_1 can cause hemolytic disease of the newborn (anti-Kell ,(which can be severe.	7
LI	Li	Polysaccharide	6
Duffy	FY	Protein) chemokine receptor .(Main antigens Fy^a and Fy^b .Individuals lacking Duffy antigens altogether are immune to malaria caused by *Plasmodium vivax* and *Plasmodium knowlesi*.	1


Rh
ABO
Diego
Hh
MNS
Kell
Kidd
Duffy
N
C
N
C
N
C
N
C
N
C
Single-pass proteins
Multi-pass proteins
GPI-linked protein
Key:
N = NH2 terminal
C = COOH terminal
= N-glyan
= GPI-linkage

RH blood antigen

- Rh antigens are non-glycosylated, hydrophobic cell surface proteins found in red blood cell membranes.
- 15% of the population has a deletion or other alteration of the RhD allele.
- Rh status is inherited from our parents, separately from our blood type.
- If you inherit the dominant Rhesus D antigen from one or both of your parents, then you are Rh-positive (85% of us). If you do not inherit the Rhesus D antigen from either parent, then you are Rh-negative (15% of us).

Rh System

Rh Antigens and Encoding Genes

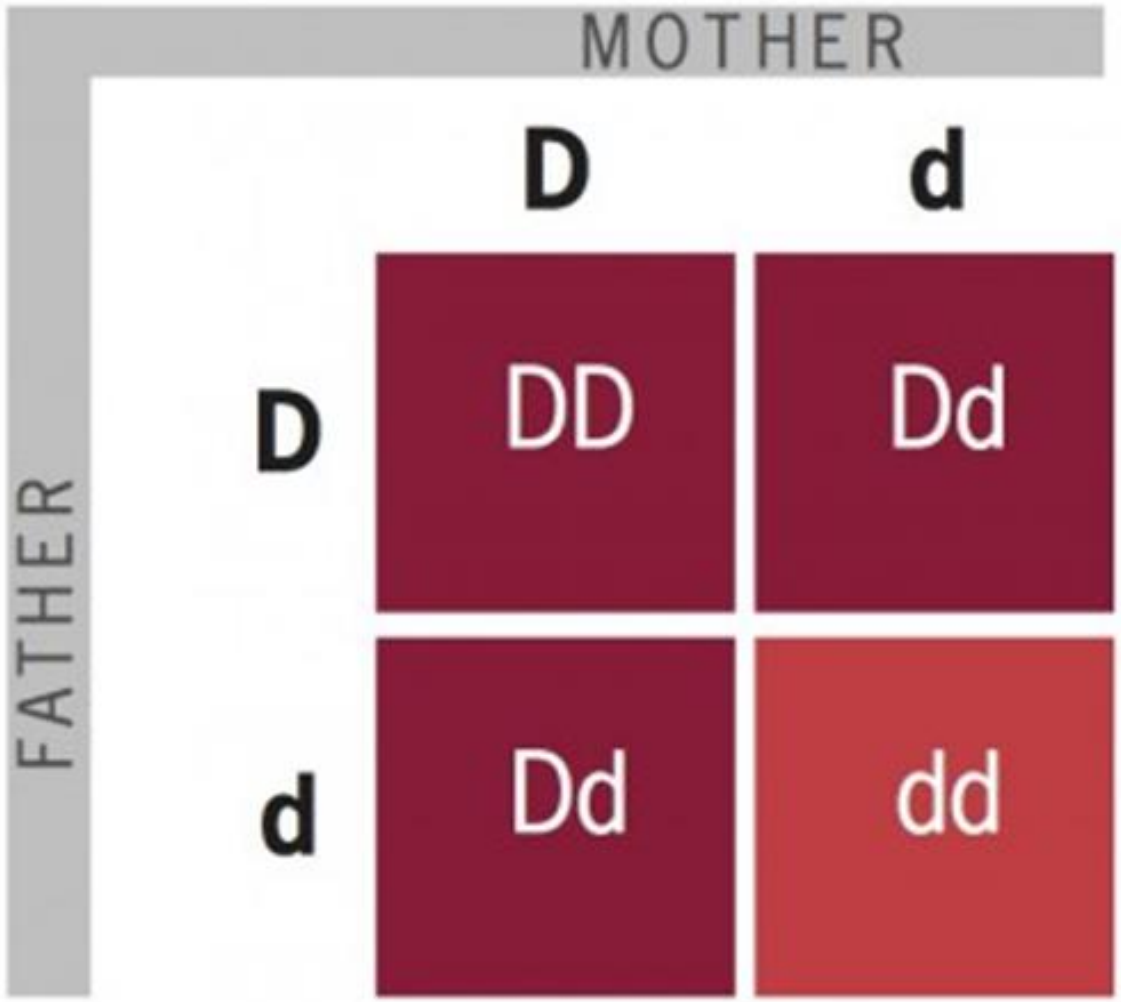
- Subsequently it was confirmed that the RH locus is on chromosome 1 and comprises two highly homologous, very closely linked genes, RHD and RHCE.
- The Rh blood group system consists of 49 defined blood group antigens, among which the five antigens (D, C, c, E, and e) are the most important.
- There is no d antigen. D antigen is the main that its presence or absence mean Rh+ or Rh- respectively.
- The main antigens are D, C, E, c and e, which are encoded by two adjacent gene loci, the RHD gene which encodes the RhD protein with the D antigen and the RHCE gene which encodes the RhCE protein with the C, E, c and e antigens
- The RHCE gene has four main alleles; CE, Ce, ce and cE.
- This concept of D and CcEe genes linked closely and transmitted together is consistent with the Fisher nomenclature.

Examples on antigens in Rh+ and Rh -

D− C+ E+ c− e+ (RhD−)

D+ C+ E− c− e+ (RhD+)

- ✓ Each locus has its own set of alleles which are Dd , Cc , and Ee . The D gene is dominant to the d gene, but Cc and Ee are co-dominant (meaning that all of the inherited alleles lead to expression of the coded antigens).
- ✓ Antibodies to Rh antigens can be involved in hemolytic transfusion reactions and antibodies to the Rh(D) antigens confer significant risk of hemolytic disease of the fetus and newborn.


MOTHER
D
d
FATHER
D
d
DD
Dd
Dd
dd

Rh System

- **Antibodies**

✓ Antibodies directed against all Rh antigens, except d, have been described: anti-D, anti-C, anti-c, anti-E and anti-e.

✓ Rh antigens are restricted to red cells and Rh antibodies result from previous alloimmunization by previous pregnancy or transfusion.

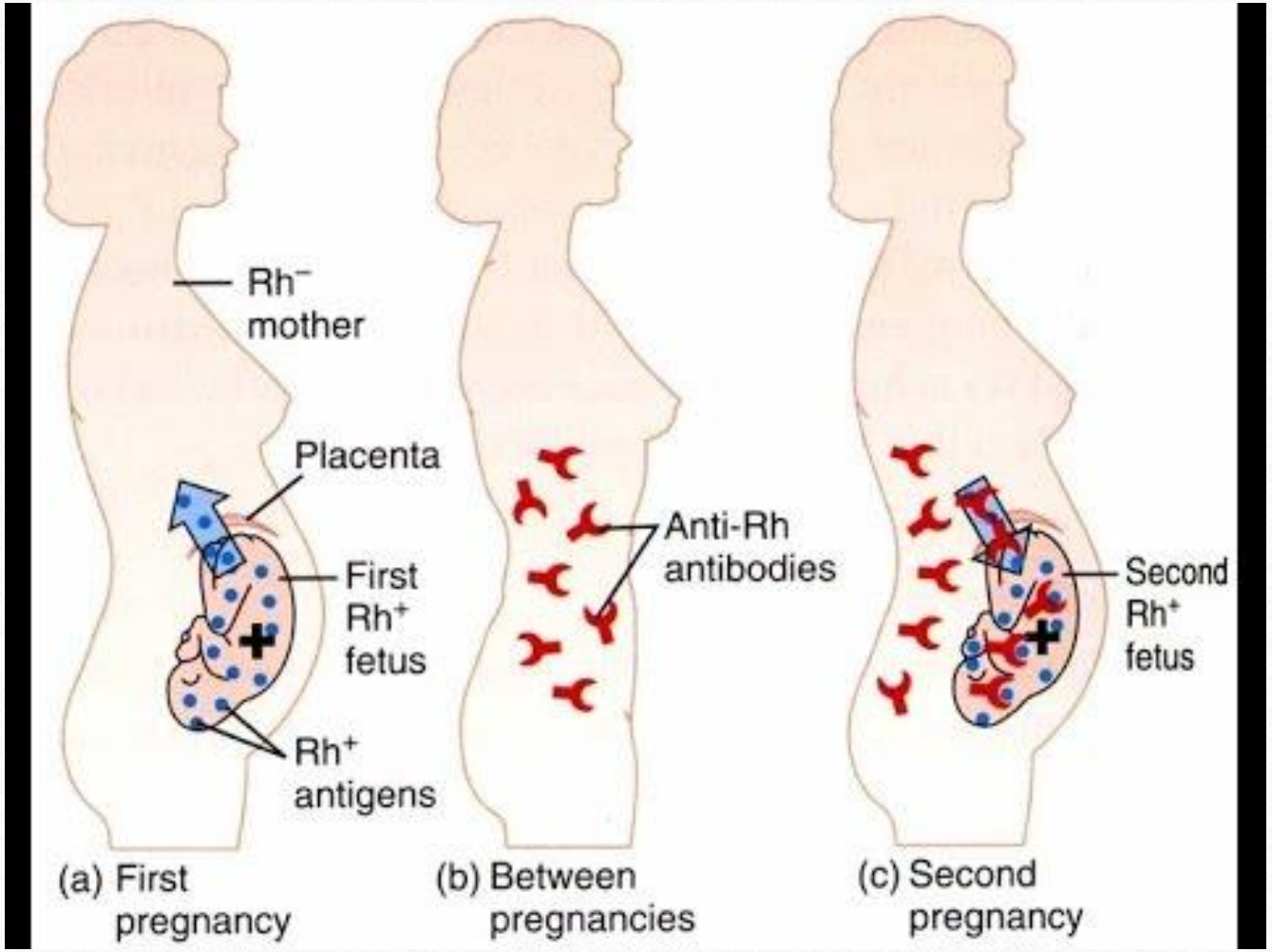
✓ Immune Rh antibodies are predominantly IgG.

…Rh Antibodies

- ✓ Anti-D is clinically the most important antibody.
- ✓ It may cause hemolytic transfusion reactions and was a common cause of fetal death resulting from hemolytic disease of the newborn before the introduction of anti-D prophylaxis.

hemolytic disease of the newborn

- When the condition is caused by the RhD antigen-antibody incompatibility, it is called Rh D Hemolytic disease of the newborn.
- The major clinical significance of anti-Rh antibodies is related to hemolytic reactions associated with pregnancy that are similar to transfusion reactions.
- (**Rh-negative mothers**) carrying an Rh-positive fetus can be sensitized by fetal red blood cells that enter the maternal circulation, usually during childbirth. IgG antibodies are generated in Rh-negative mothers.
- Subsequent pregnancies in which the fetus is Rh positive are at risk because the maternal (anti-Rh D) IgG antibodies can cross the placenta and mediate the destruction of the fetal red blood cells. This causes anemia, dyspnea, jaundice and erythroblastosis fetalis.



Erythroblastosis Fetalis

Kernicterus: is a type of brain damage that can result from high levels of bilirubin in a baby's blood.