Charting New Horizons in Education

ABO Blood Antigens

5

LAB
Immunology

- Created by; Dr. Mohammad Alzuraiqi

@mzuraiqi

ABO Blood Antigens

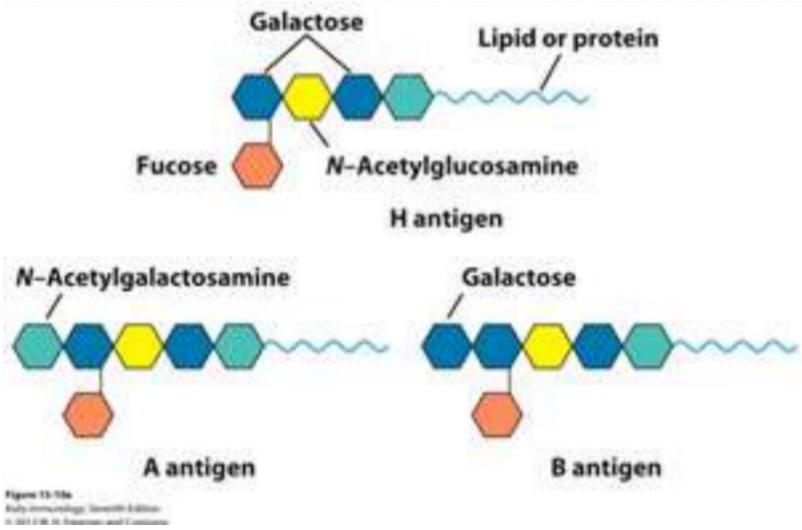
•The **ABO antigens** are **carbohydrates** linked to **cell surface proteins** and **lipids**, synthesized by **polymorphic glycosyltransferase enzymes**.

•**H Antigen (O Antigen):**

- Most individuals possess a **fucosyltransferase** enzyme that adds a **fucose moiety** to a nonterminal sugar residue of the core glycan.
- The resulting **fucosylated glycan** is called the **H antigen (O antigen)**.

•**Genetic Basis:**

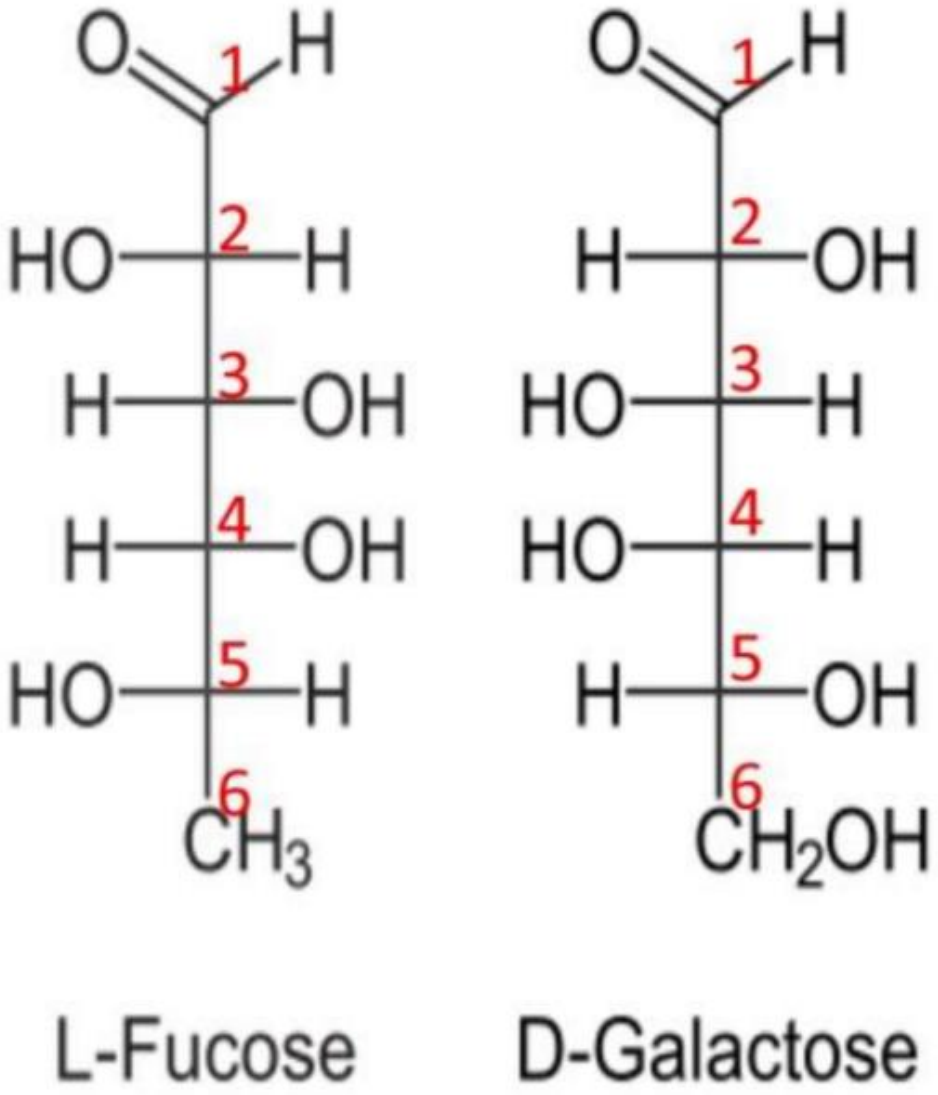
- A single gene on **chromosome 9** encodes a **glycosyltransferase enzyme** that modifies the **H antigen**.
- There are **three allelic variants** of this enzyme:
  - **O allele gene product:**
    - **Devoid of enzymatic activity**.
    - Cannot attach terminal sugars to the **H antigen**.
    - Expresses only the **H antigen**, the precursor of the ABO blood group antigens.
  - **A allele-encoded enzyme (N-acetylgalactosaminyltransferase):** Transfers a terminal **N-acetylgalactosamine moiety** onto the **H antigen**.
  - **B allele gene product:** Transfers a terminal **galactose moiety** onto the **H antigen**



ABO Blood Antigens

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**.



ABO Blood Antigens

Type 2 chains (β1-4 linkage) on **RBCs**, acted on by **FUT1**.
Type 1 chains (β1-3 linkage) in **secretions**, acted on by **FUT2**.

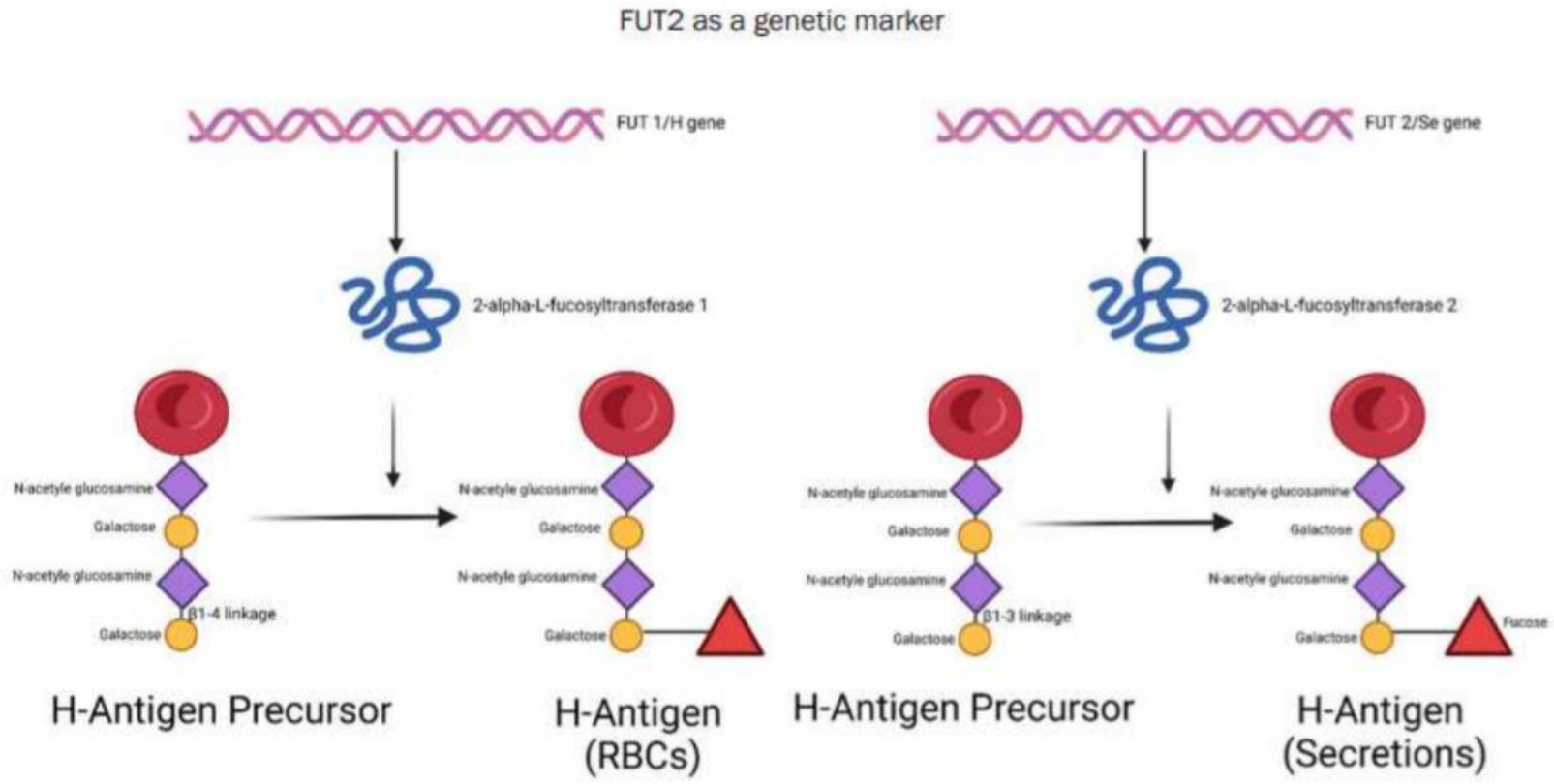
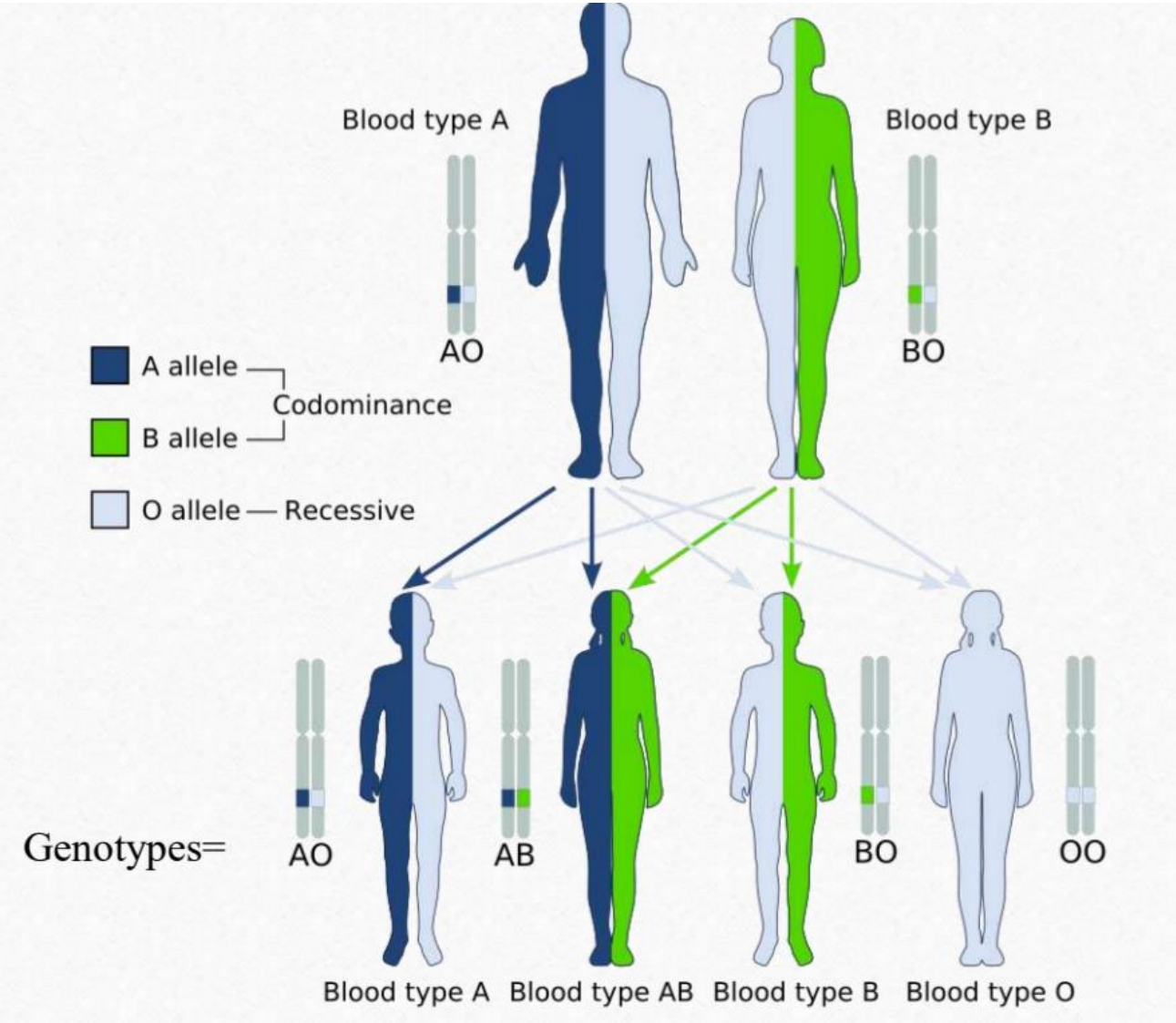


Figure 1. Role of FUT1 and FUT2. Fucosyltransferase enzymes H (FUT1) add fucose to the alpha (1, 2) binding of type 2 glycoproteins on RBCs to form H antigen, whereas FUT2 adds fucose to the alpha (1, 2) binding of type 1 glycoprotein chains to make ABH antigens in other body fluids (secretor phenotype).

Inheritance



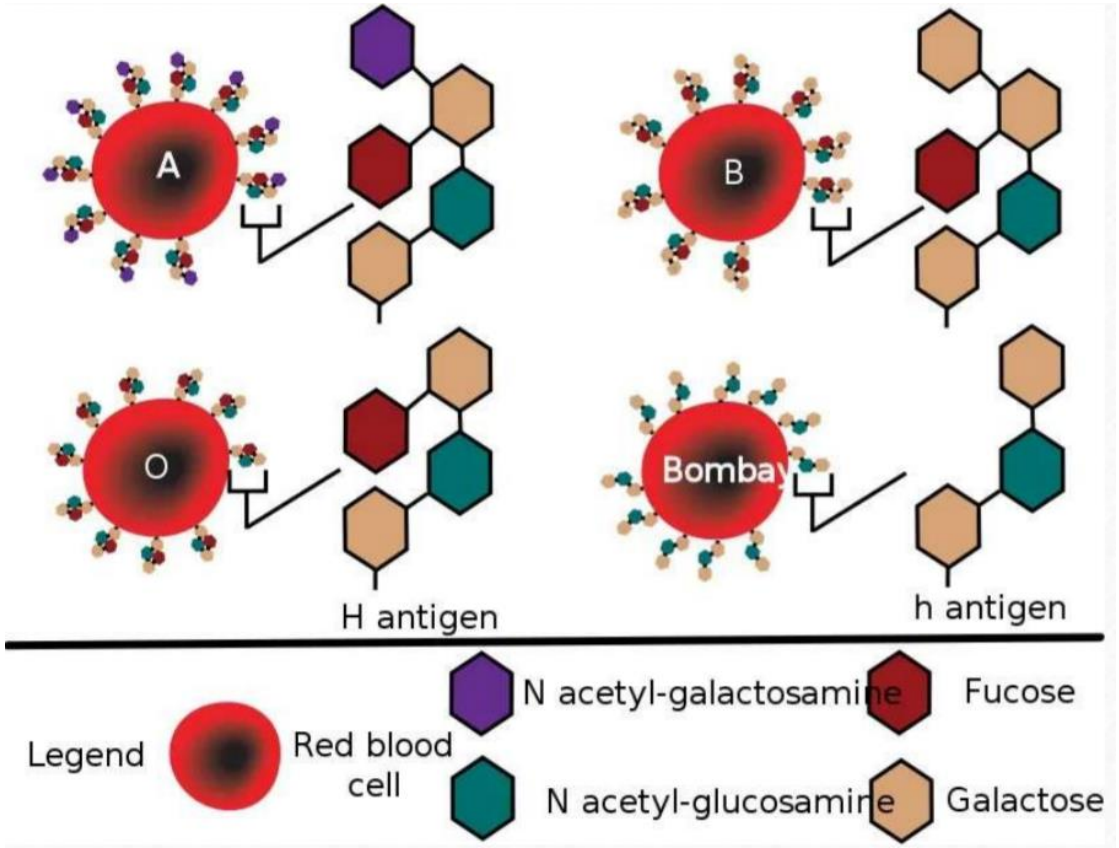
Bombay Blood Group (h/h or Oh)

•**Mutations** in the gene encoding the **fucosyltransferase** that produces the **H antigen** without **fucose** are **rare**.

•Individuals **homozygous** for such a mutation are said to have the **Bombay blood group** (**h/h**, also known as **Oh**).

•Characteristics:

- Cannot produce **H**, **A**, or **B antigens**.
- Cannot receive **type O**, **A**, **B**, or **AB blood**

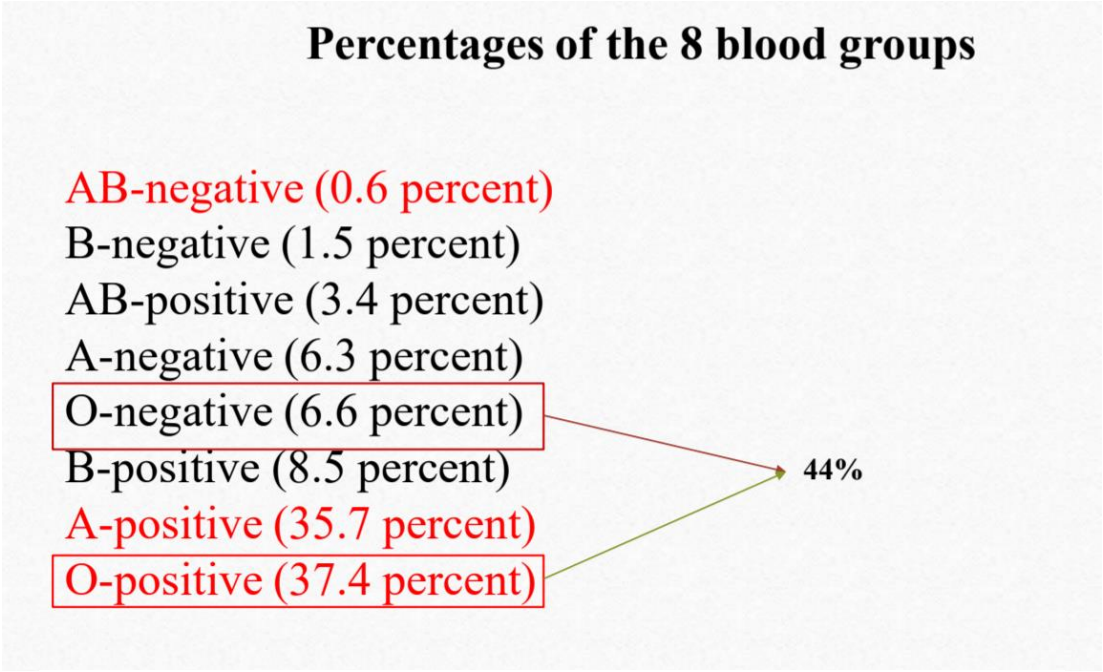


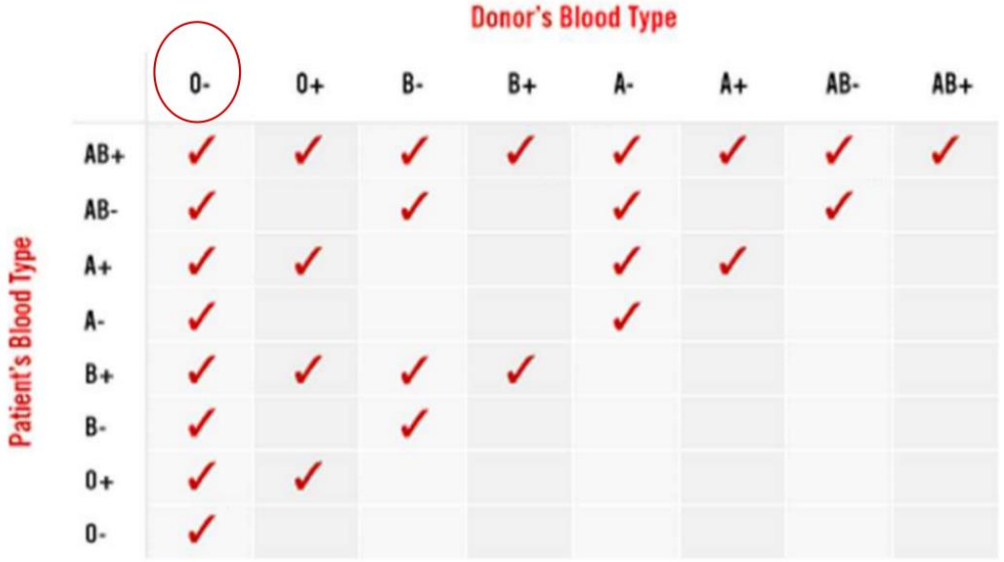
Antigen – antibody

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 Called (O, hh, Oh)	-	A,B,H

Blood Type

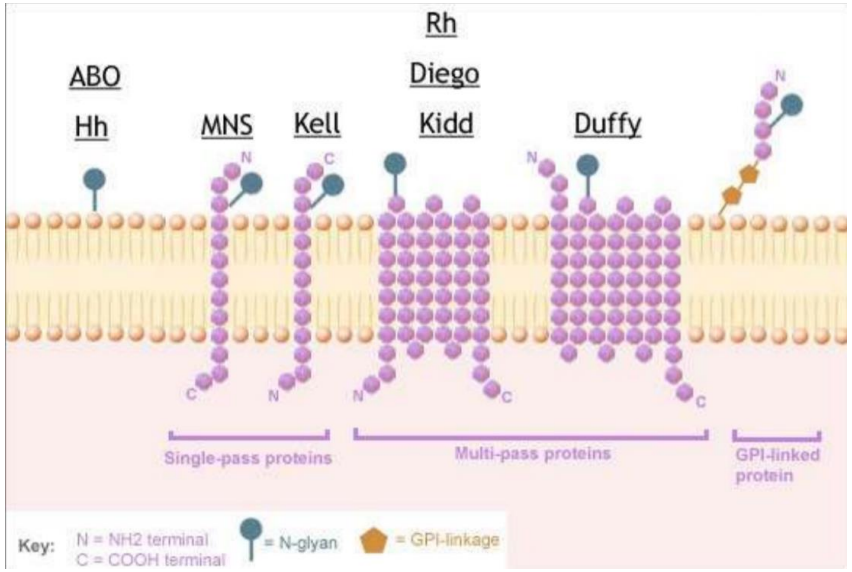
- **O-negative:**
  - Known as the **universal blood type**, meaning any other blood type may receive it.
  - **Challenge:**
    - High demand can quickly deplete the **O-negative stores** at blood centers.
    - While **44% of the population** is type O, less than **7%** is **O-negative**.
    - This makes **O-negative** the most needed yet one of the hardest blood types to collect.
- **AB-negative:**
  - The **rarest** of the eight main blood types, with only **1%** of donors having it.
  - **Demand:**
    - Despite its rarity, the demand for **AB-negative** blood is **low**





Blood grouping System

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 System

•**Rh antigens** are **non-glycosylated**, **hydrophobic cell surface proteins** found in **red blood cell membranes**.

•**Rh Status:**

- **15%** of the population has a deletion or other alteration of the **RhD allele**.
- **Inheritance:**
  - **Rh status** is inherited from our parents, separately from our blood type.
  - If you inherit the **dominant Rhesus D antigen** from one or both parents, you are **Rh-positive** (**85%** of the population).
  - If you do not inherit the **Rhesus D antigen** from either parent, you are **Rh-negative** (**15%** of the population)

Rh System

- **Rh Antigens and Encoding Genes:**
  - The **RH locus** is located on **chromosome 1** and comprises two highly homologous, closely linked genes: **RHD** and **RHCE**.
  - The **Rh blood group system** includes **49 defined blood group antigens**, with the five most important being **D**, **C**, **c**, **E**, and **e**.
  - There is no **d antigen**. The **D antigen** is crucial as its presence or absence determines **Rh+** or **Rh-**, respectively.
- **Main Antigens and Genes:**
  - The main antigens (**D**, **C**, **E**, **c**, and **e**) are encoded by:
    - The **RHD gene**, which encodes the **RhD protein** with the **D antigen**.
    - 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**, being closely linked and transmitted together, aligns with the **Fisher nomenclature**.
- **Examples of Rh Antigens:**
  - **Rh D– C+ E+ c– e+** (RhD−)
  - **D+ C+ E– c– e+** (RhD+)

Rh System

Rh Loci and Alleles:

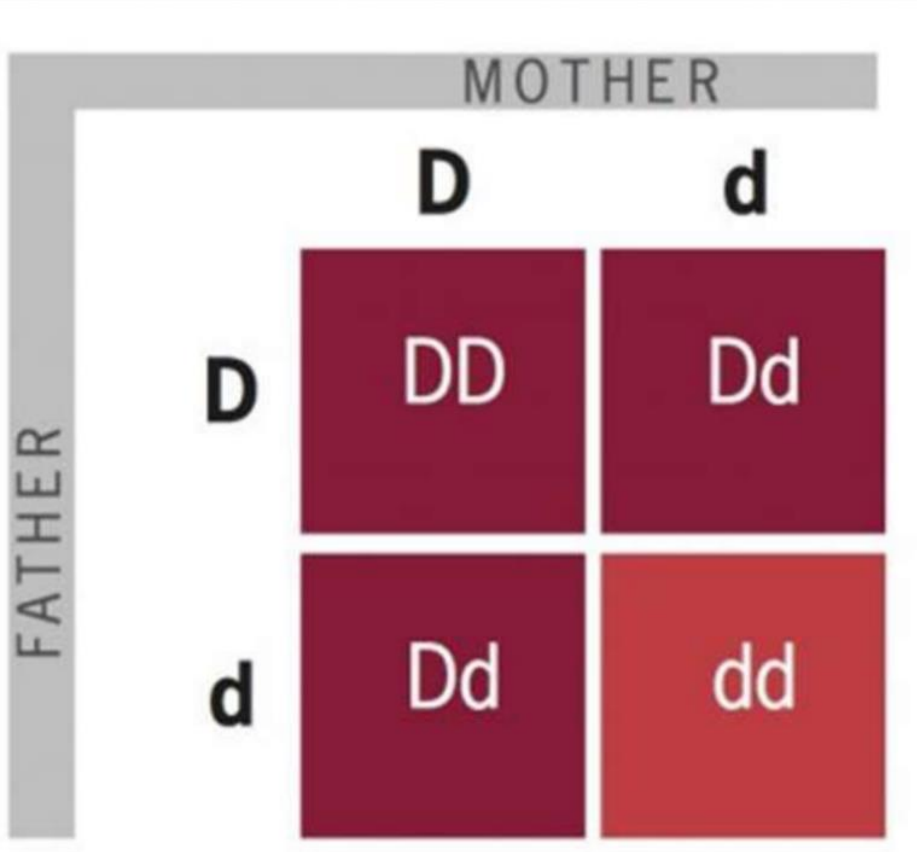
•Each **locus** has its own set of **alleles**: **Dd**, **Cc**, and **Ee**.

- The **D gene** is **dominant** to the **d gene**.
- **Cc** and **Ee** are **codominant**, meaning all inherited alleles lead to the expression of the coded antigens.

Clinical Relevance of Rh Antigens:

•**Antibodies** to **Rh antigens** can be involved in **hemolytic transfusion reactions**.

•Antibodies to the **Rh(D) antigen** pose a significant risk of **hemolytic disease of the fetus and newborn**



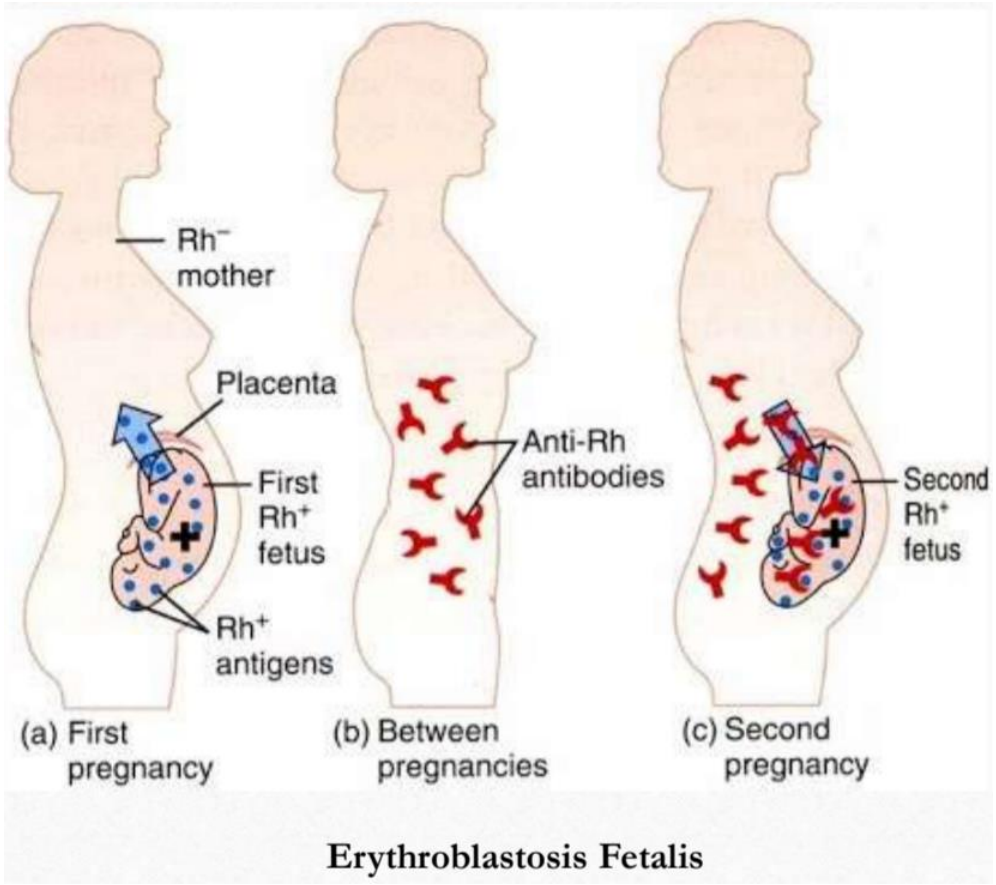
Rh System: Antibodies

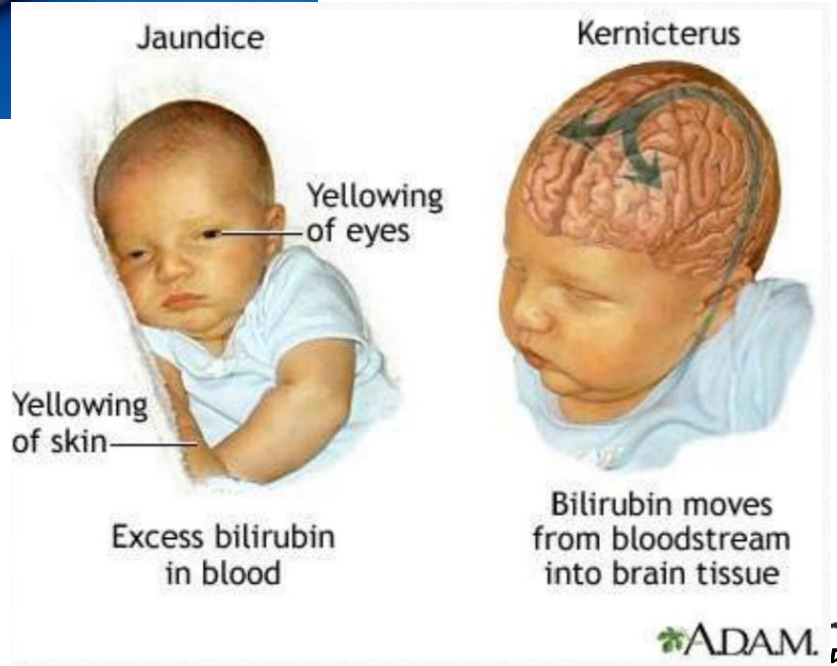
- **Antibodies to Rh Antigens:**
  - Antibodies directed against all **Rh antigens** (except **d**) have been described: **anti-D**, **anti-C**, **anti-c**, **anti-E**, and **anti-e**.
  - **Rh antigens** are restricted to **red blood cells**.
  - **Rh antibodies** result from previous **alloimmunization** through pregnancy or transfusion.
  - **Immune Rh antibodies** are predominantly **IgG**.
- **Rh Antibodies (Anti-D):**
  - **Anti-D** is the **most clinically important antibody**.
  - It can cause **hemolytic transfusion reactions**.
  - Prior to the introduction of **anti-D prophylaxis**, **anti-D** was a common cause of **fetal death** due to **hemolytic disease of the newborn**

Hemolytic Disease of the Newborn

- **Rh D Hemolytic Disease:**
  - When the condition is caused by **RhD antigen-antibody incompatibility**, it is referred to as **Rh D Hemolytic Disease of the Newborn**.
- **Clinical Significance of Anti-Rh Antibodies:**
  - The major clinical significance of **anti-Rh antibodies** is related to **hemolytic reactions** during pregnancy, similar to **transfusion reactions**.
  - **Rh-negative mothers** carrying an **Rh-positive fetus** can become sensitized by fetal **red blood cells** entering the maternal circulation, usually during **childbirth**.
  - **IgG antibodies** are generated in **Rh-negative mothers**.
- **Risk in Subsequent Pregnancies:**
  - If the fetus is **Rh-positive** in subsequent pregnancies, the maternal **anti-Rh D IgG antibodies** can cross the **placenta** and mediate the destruction of fetal **red blood cells**.
  - This leads to **anemia**, **dyspnea**, **jaundice**, and **erythroblastosis fetalis**.
- **Kernicterus:**
  - A type of **brain damage** that can result from **high levels of bilirubin** in a baby's blood

Hemolytic Disease of the Newborn





MCQ

A woman who is Rh- has a first child with a man who is Rh+ (heterozygous). What, if any, are the likely consequences if the woman has a second child with the same man?

a) No problem expected
b) The second child is at risk of developing myasthenia gravis
c) The mother will develop hemolytic anemia
d) The second child has at least a 50% chance of developing hemolytic anemia of the newborn
e) The second child has a 100% chance of developing hemolytic anemia of the newborn

Answer:
d) The second child has at least a 50% chance of developing hemolytic anemia of the newborn

MCQ

A woman who is Rh+ has a first child with a man who is Rh- What, if any, are the likely consequences if the woman has a second child with the same man?

a) No problem expected
b) The second child is at risk to develop myasthenia gravis
c) The mother will develop hemolytic anemia
d) The second child has at least a 50% chance of developing hemolytic anemia of the newborn
e) The second child has a 100% chance of developing hemolytic anemia of the newborn

Answer: A

MCQ

Hemolytic disease of the newborn due to RhD incompatibility depends on:

a) Transplacental passage of anti-RhD IgG antibodies
b) Transplacental passage of anti-RhD IgM antibodies
c) Production of cytotoxic antibodies by the baby
d) The first pregnancy of the RhD+ mother with an RhD- fetus
e) Transplacental passage of anti-RhD IgA antibodies

Answer:
a) Transplacental passage of anti-RhD IgG antibodies

MCQ

Serum from an AB, Rh-negative patient mixed with red blood cells from a patient with _____ and result in _____?

a) Type A, no agglutination
b) Type B, agglutination
c) Type O, agglutination
d) Type AB, agglutination
e) Type A, agglutination

Answer: A

MCQ

Serum from an A, Rh-negative patient mixed with red blood cells from a patient with _____ and results in _____?

a) Type A, no agglutination
b) Type B, no agglutination
c) Type O, agglutination
d) Type AB, no agglutination
e) Type A, agglutination

Answer:
a) Type A, no agglutination

«Wherever the art of medicine is loved,
there is also a love of humanity.»

- Hippocrates-

Charting New Horizons in Education