DEPARTMENT OF ZOOLOGY

RANIGANJ GIRLS' COLLEGE

SEARSOL, RANIGANJ,

PASCHIM BARDHAMAN

CLASS - IV

CORE COURSE - IV

UNIT - 4

BLOOD GROUPS: RH FACTOR, MN, ABO AND BOMBAY PHENOMENON

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BRIEF CONTENTS

VARIOUS BLOOD GROUP SYSTEM

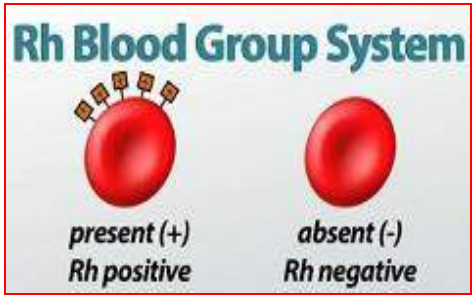
- More than 20 different types of genetically determined blood group systems are known today.
- **CLASSIFICATION OF BLOOD GROUPS:**

- **Major blood grouping system:** Causes major transfusion reactions.
  i. ABO blood group system.
  ii. Rh blood group system.
- **Minor blood grouping system:** Causes minor transfusion reaction
  i. MN blood group system
  ii. P blood group system
- **Familial blood grouping system:** Kell, Daffy, Lewis etc.

RH FACTOR

Rhesus (Rh) factor, an inherited protein antigen

- **DISCOVERY**: In 1937 by Karl Landsteiner and Alexander S. Wiener
- **TYPES OF Rh**: 1. People with Rh factor are Rh^+.
  2. People with no Rh factor are Rh^-.



- **CELLULAR LOCATION**: Rh factor are found on the RBC.
- **CHROMOSOMAL LOCATION**: Rh gene on the chromosome 1.
- **Rh GENES**: Rh antigens are encoded by *RHD* gene and *RHCE* gene.
- Rh blood group system is polymorphic and immunogenic systems.
- **Rh ANTIGENS**: Clinically related Rh antigens are C, c, D, d, E, e.

D > c > E > C > e

Highly → Rarely

Immunogenicity

- Rh(D) antigenic factor is most potent and highly immunogenic.

- **RhD DATA IN INDIA:**

Population	$Rh(D)^-$	$Rh(D)^+$
India	0.6%–8.4%	99.4%–91.6%

- **INHERITANCE:** RhD antigen is heritable as one gene RhD.
- **ANTIBODY AGINST Rh ANTIGEN:**
  - Developed through the exposure to Rh^+ blood.
  - Rh antibodies are commonly IgG.

Table: Punnett square for Rh factor inheritance. Rh positive is dominant

Parent-2 Rh \ Parent-1 Rh	D (Rh+)	d (Rh+)
D	DD (Rh +)	Dd (Rh +)
d	Dd (Rh +)	dd (Rh -)

- **BIOCHEMISTRY OF Rh ANTIGEN:**
  - Nonglycosylated hydrophobic transmembrane protein antigen.
  - Polypeptide is composed of 416 amino acids; MW is 30 – 32 kDa.
- **"GOLDEN BLOOD":** Rare condition, RBC lacking Rh antigens (Rh_{null}).
- **BIOLOGICAL SIGNIFICANCE OF Rh ANTIGEN:**
  - Membrane transport and membrane integrity.
- **CLINICAL SIGNIFICANCE OF Rh ANTIGEN:**
  - Antibodies to Rh antigens involve in hemolytic transfusion reactions.
  - Antibodies to Rh antigens involve in erythroblastosis fetalis.

➢ ERYTHROBLASTOSIS FETALIS: A type of Rh Incompatibility.

- It is the hemolytic disease of the fetus and new born.
- This condition occurs during pregnancy if a woman has Rh^- blood and her baby has Rh^+ blood.
- ***STEPS:***

Rh^+ father

↓

If the Rh^- mother carrying first Rh^+ fetus

↓

Fetal Rh antigens enter the mother's blood during delivery

↓

Mother produce anti Rh antibodies in response to fetal Rh antigens.

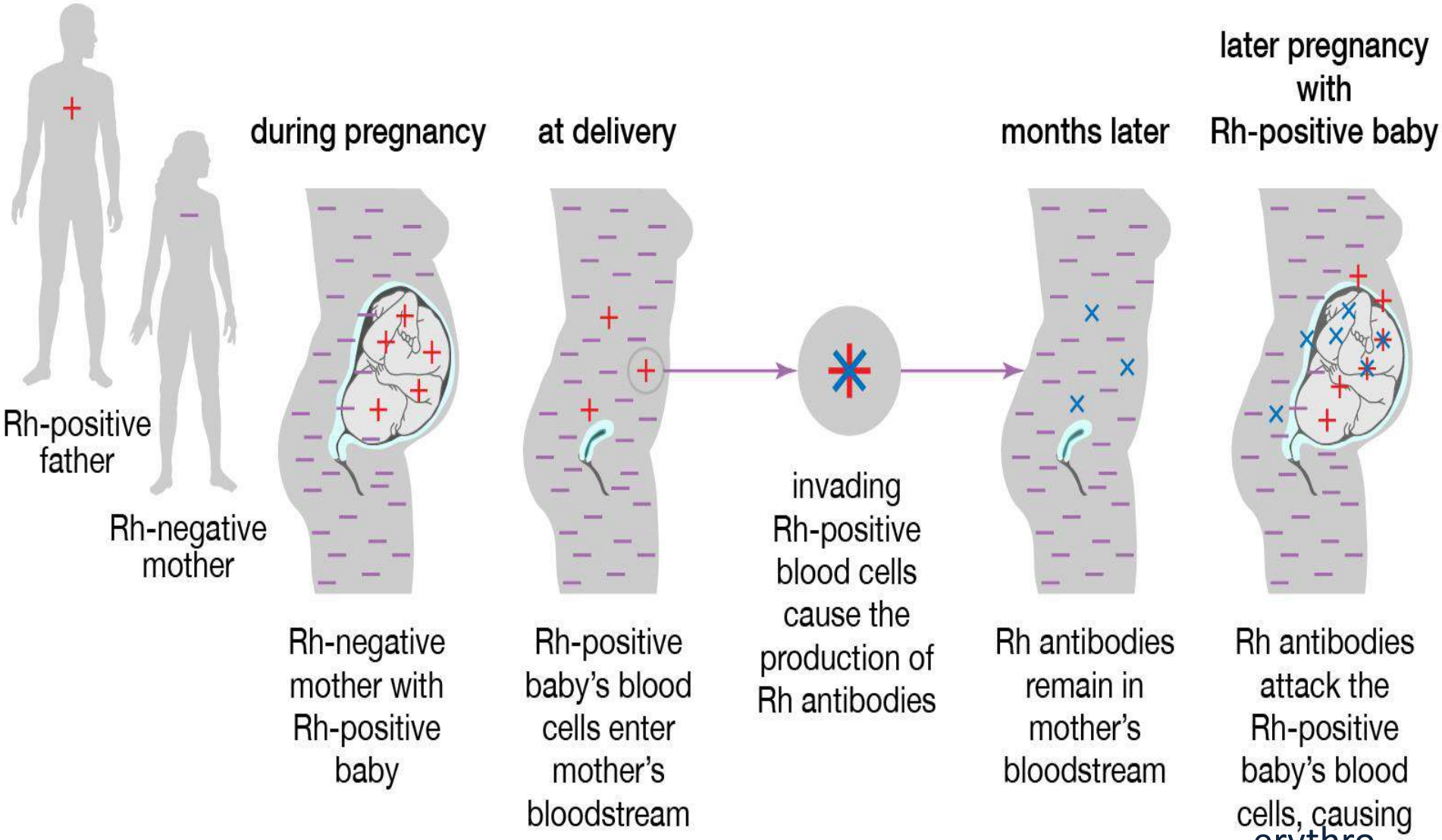
↓

If the woman becomes pregnant with another Rh^+ fetus

↓

Mother's anti-Rh antibodies cross the placenta and damage the fetal RBC

➢ Rh INCOMPATIBILITY IN ERYTHROBLASTOSIS FETALIS

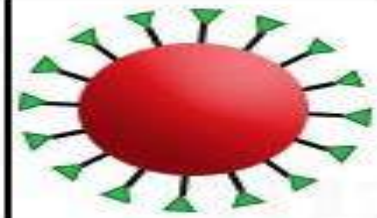
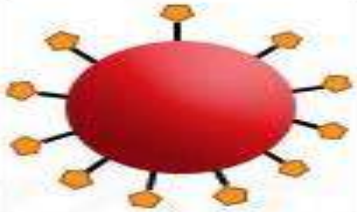
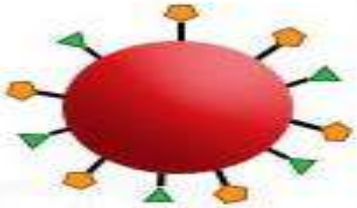
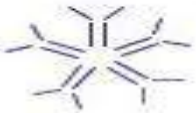


ABO BLOOD GROUP SYSTEM

- **DISCOVERY:** Karl Landsteiner described the ABO system.
  - Karl Landsteiner discovered A, B and O blood groups.
  - Descastello and Sturli discovered AB blood Group.
- **GENETICS:**
  - ABO blood type genes are located on chromosome 9.
  - Each A and B gene consists of 1062 nucleotide base pairs.
  - ABO genes are autosomal. A and B genes are codominant.
  - Multiple alleles encoding the ABO blood group system.
  - ABO gene has 3 allelic forms I^A, I^B and I^O.
  - Allele I^A and I^B are dominant over I^O allele.
  - Three ABO alleles determine 4 blood groups types (A, B, AB and O).
- **LANDSTEINER'S RULE:** "1. If an antigen is present in the red cells of a blood, the corresponding antibody must be absent from the plasma. 2. If an antigen is absent in the red cells of a blood, the corresponding antibody must be present in the plasma".

➢ABO BLOOD TYPE DEPENDS ON ANTIGENIC DETERMINANT

Allele from parent-1	Allele from parent-2	Genotype of offspring	Blood type of offspring	Antigens on RBC	Antibodies in plasma
I^A	I^A	I^AI^A	A	A	Anti-B (beta)
I^A	I^O	$I^A I^O$	A	A	Anti-B (beta)
I^B	I^B	I^BI^B	B	B	Anti-A (alpha)
I^B	I^O	$I^B I^O$	B	B	Anti-A (alpha)
I^A	I^B	I^AI^B	AB	AB	NIL
I^O	I^O	I^OI^O	O	NIL	Alpha & Beta

	Group A	Group B	Group AB	Group O
Red blood cell type				
Antibodies in Plasma	 Anti-B	 Anti-A	None	 Anti-B and Anti-A
Antigens in Red Blood Cell	 A antigen	 B antigen	 A and B antigens	None

➢ UNIVERSAL DONOR AND RECEIPIENT IN ABO SYSTEM

- Individuals with type O Rh D^- blood are often called universal donors. Type O blood donors can give to A, B and AB.
- Individuals with type AB Rh D^+ blood are called universal recipients. Types A, and O can give to AB.

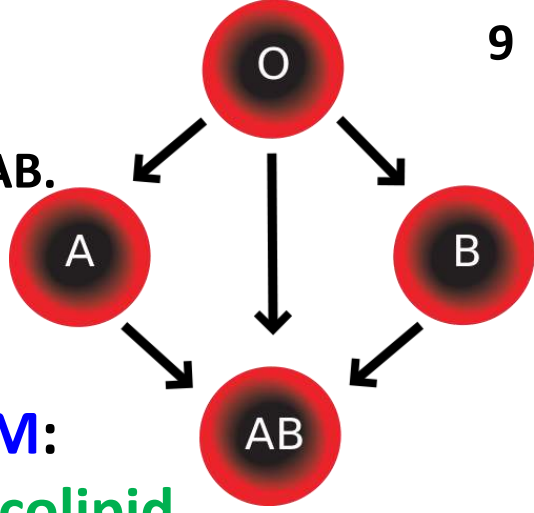
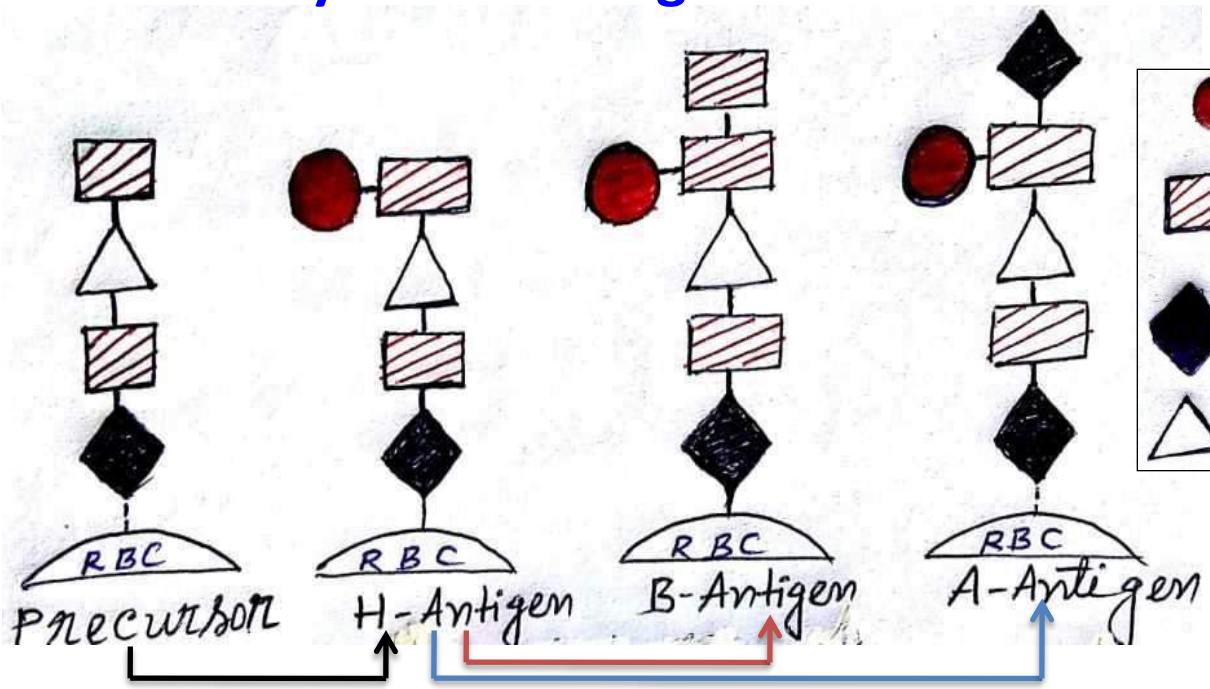


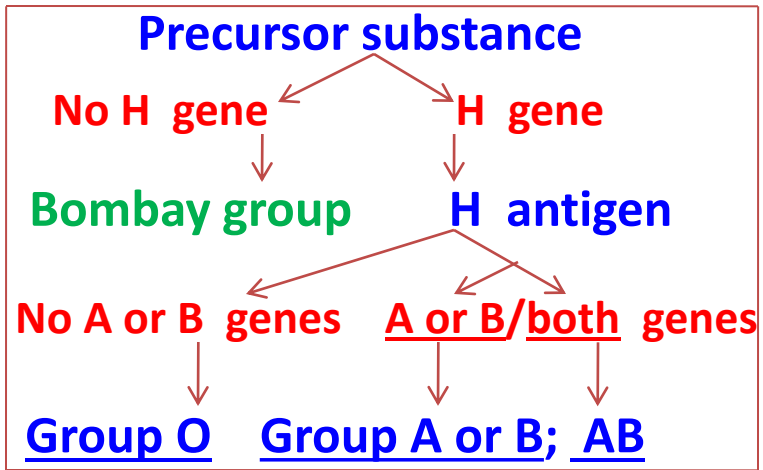
Fig. RBC compatibility chart

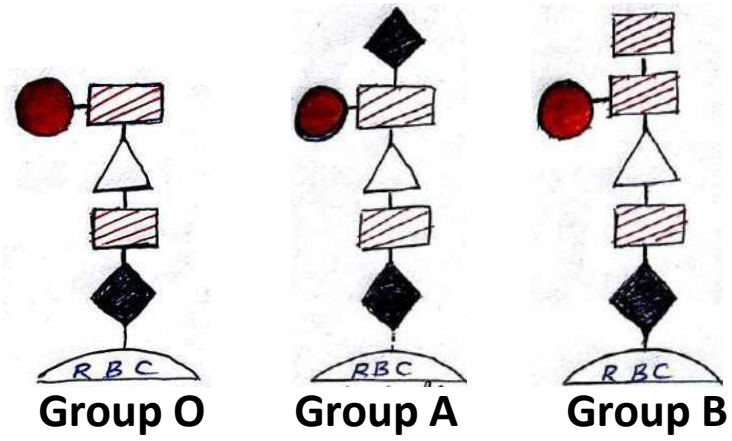
➢ MOLECULAR BASIS OF ABO BLOOD GROUP SYSTEM:

- Chemistry of the antigen: A and B antigens are glycolipid.
- Antigen specificity: It depends on the terminal sugar of H substance.
- Addition of terminal sugar: Blood groups are determined by the addition of terminal sugars to the H substance.
- 'A' antigen from H substance: I^A gene product α-N-Acetylgalactosamyl transferase adds N-acetyl galactosamine to H substance.
- 'B' antigen from H substance: I^B gene product α-Galactosyl transferase adds galactose to H substance.
- 'AB' antigens from H substance: I^A and I^B gene product both adds sugar to different H substances at various sites on RBC surface.
- 'O' (zero) antigen from H substance: Both alleles of I^OI^O individual does not add either sugar, so the H substance remain unmodified.

➢ Biochemistry of ABO antigens:







➢ **SIGNIFICANCE OF ABO SYSTEM:** ABO blood grouping system helps in:--

- Transfusion of blood between donor and recipient.
- Identification of paternity.
- Identification of criminal.
- Prevention of hemolytic diseases.
- Knowing disease susceptibility:

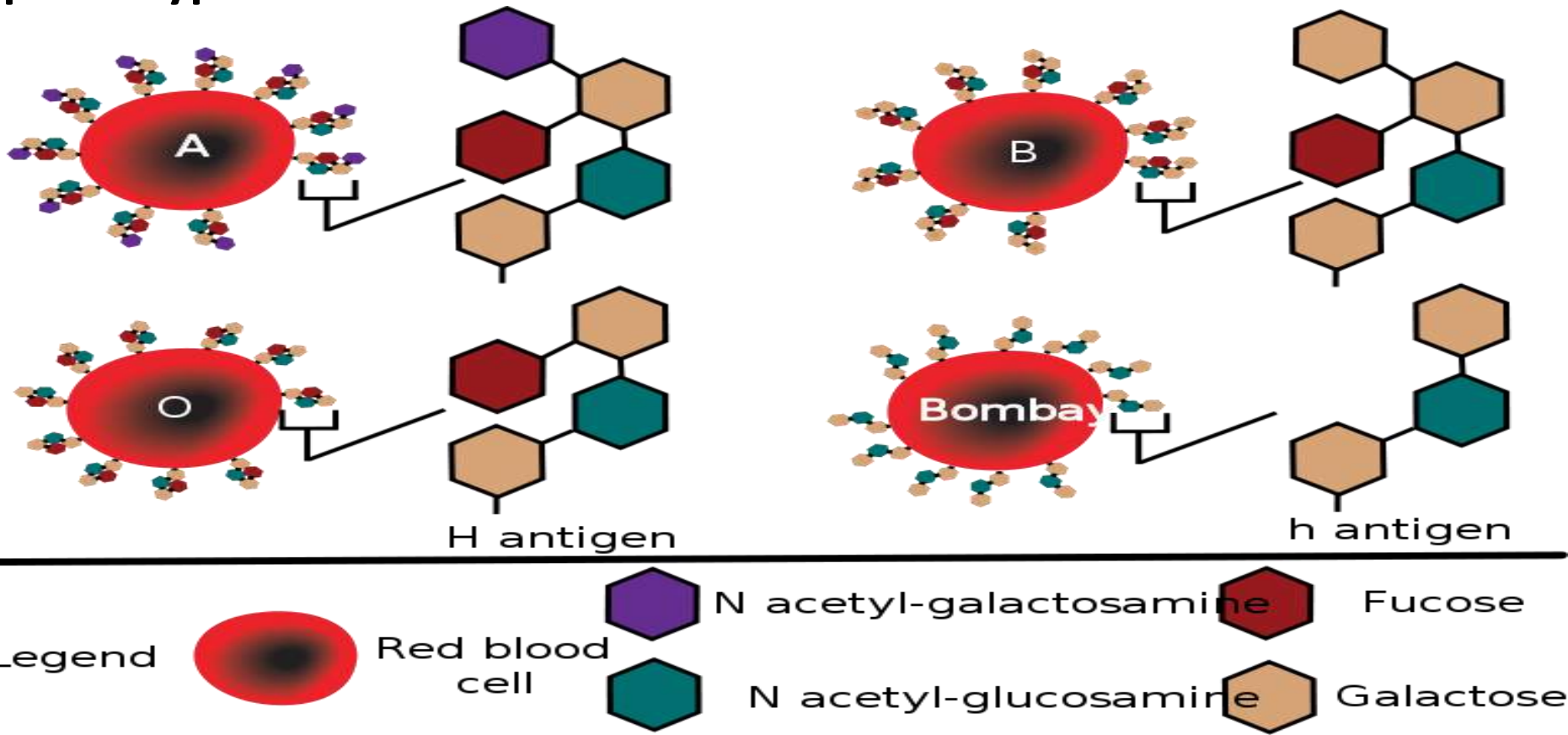
-- A, B and AB groups have greater risk of stomach cancer.

-- 'O' blood group less severely affected by *Plasmodium falciparum*.

-- Peptic ulcer is higher in 'O' group than A, B, AB blood group.

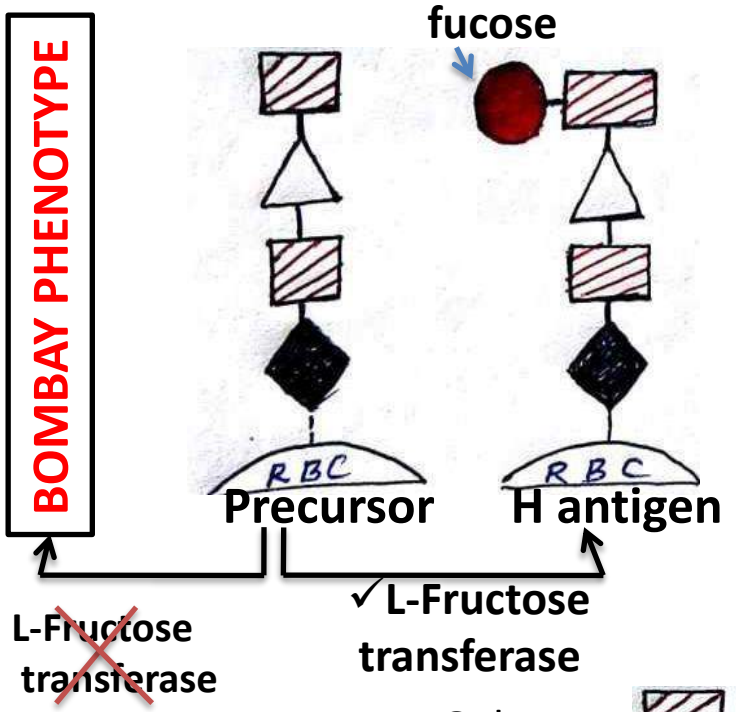
SIGNIFICANCE OF H-ANTIGEN IN THE BLOOD GROUPING SYSTEM

- **H gene is very common (99.9%) and expressed in HH or Hh genotype.**
- **H gene codes fucosyl transferase that adds a fucose to the terminal sugar of a precursor forming H antigen.**
- **H antigen is the foundation upon which A and B antigens are built.**
- **Individuals with hh genotype lack H antigen and showed Bombay phenotype.**



BOMBAY PHENOMENON

- **INTRODUCTION:** H antigen is a building block in the ABO blood group system. The lack of H antigen is known as "Bombay phenotype".
- **DISCOVERY: Dr. Y. M. Bhende and Bhatia et. al. in 1952.**
- **NORMAL INDIVIDUAL: H antigen *present* on RBC surface.**
- **BOMBAY INDIVIDUAL: H antigen *absent* on RBC surface.**
- **INCIDENCE: 1 in 7600 in Bombay.**
- **BOMBAY GENOTYPE: hh or H null.**
- **MOLECULAR BASIS: Allele 'h' does not produce the L-Fructose transferase necessary for the addition of a fucose to the terminal sugar of a precursor.**



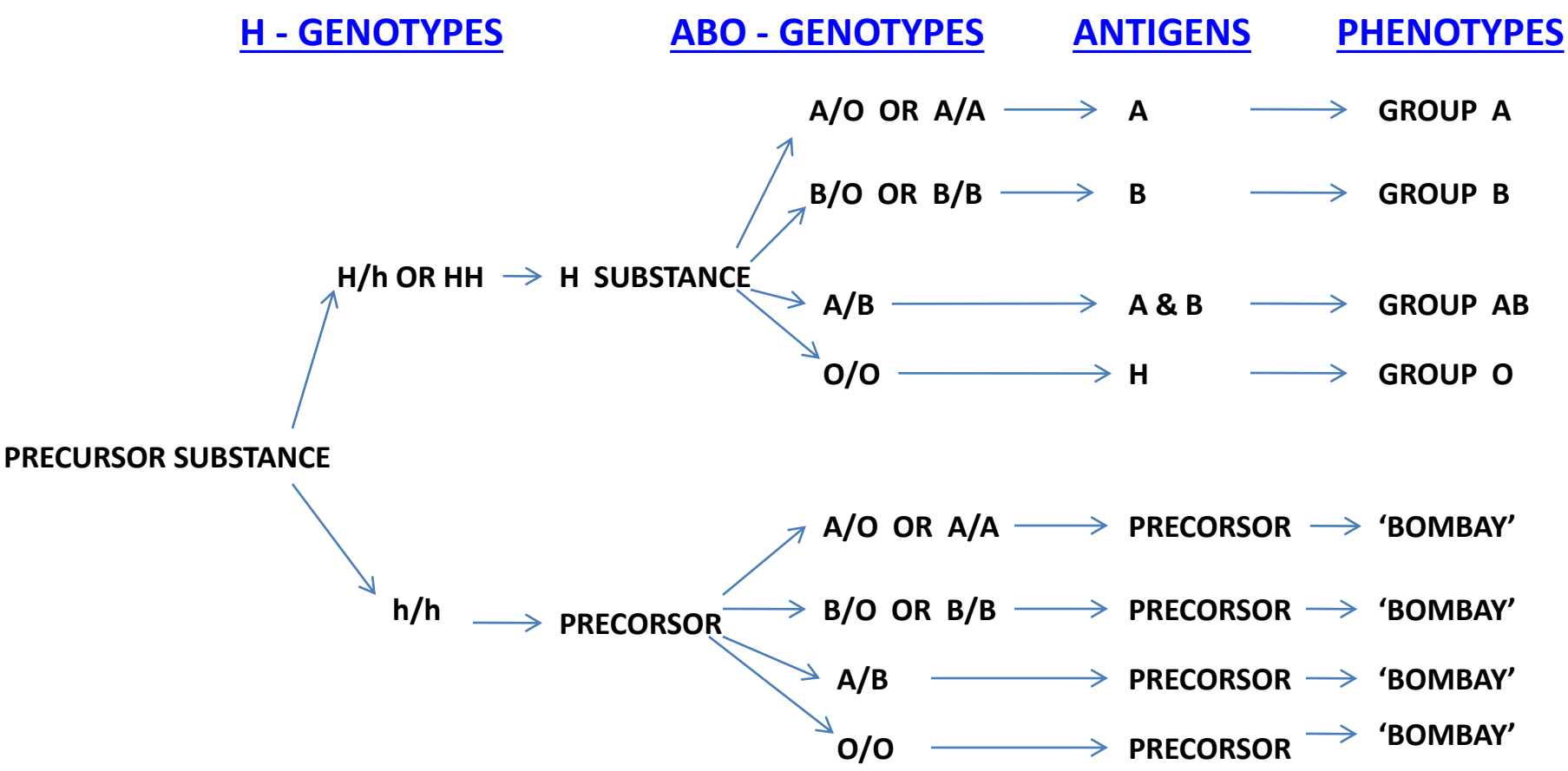
- **BOMBAY PHENOTYPE:**
- **Individuals lack H antigen or substance H.**
- **Phenotypic expression is like O blood type.**

- **PRESENCE OF ANTIBODIES:** Serum anti H, anti A, anti B are present.
- **PRESENCE OF ANTIGENS:** H, A, B o
- **INCOMPATIBILITY:** Bombay group is not compatible with any ABO blood groups.
- **COMPATIBILITY:** Compatible only the individuals with Bombay phenotype.
- **TRANSFUSION REACTION:**

Bombay individuals can not receive blood from ABO blood group. They receive blood only from the people with Bombay phenotype.

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

INHERITANCE OF ABO AND BOMBAY PHENOTYPE



MN-BLOOD GROUP

- **DISCOVERY:** MN blood group system was discovered by Land Steiner and Levine.
- **GENES:** Antigens M and N are encoded by polymorphic genes GYPA (Glycophorin A) and GYPB (Glycophorin B).
- **CHROMOSOMAL LOCATION:** MN blood group system is under the control of an autosomal locus found on chromosome 4.
- **CELLULAR LOCATION:** Present on the surface of red blood cells.
- **ALLELES:** MN blood group in humans is under the control of a pair of codominant alleles, L^M and L^N.
- **ANTIGEN TYPE:** M and N antigens are antithetical and polymorphic.
- **ANTIGENIC DETERMINANT:** Blood type is due to a glycoprotein present on the surface of the RBC which behaves as a negative antigen.
- **BIOCHEMISTRY OF MN ANTIGENS:** They are transmembrane glycophorins, single-pass glycoproteins that mostly contain sialic acid.
- **ANTIGEN SPECIFICITY:** Amino acid sequence determines the specificity of MN antigens.
- **ANTIBODIES AGAINST MN ANTIGEN:** Anti-M and anti-N antibodies are usually IgM
- **TRANSFUSION REACTION:** Anti MN antibodies are rarely associated with transfusion reaction.
- **ANTIGEN-ANTIBODY REACTION:** Antibodies to the M and N antigens rarely cause incompatibility reactions.

❑ MN BLOOD GROUP SYSTEM:

Genotype	Phenotype	Antigen present on RBC
$L^M L^N$	MN	M and N
$L^M L^M$	M	M
$L^N L^N$	N	N

❑ PATERNITY TEST TABLE

Antigen type of child	Antigen type of mother	Antigen type to which father can not belong
M	M	N
M	MN	N
N	N	M
N	MN	M
MN	M	M
MN	N	N

➢ SIGNIFICANCE OF MN GROUP:

- Medicolegal use in paternity test.
- Disease susceptibility: In low fat diet, lowering of plasma LDL cholesterol was greatest in NN and least in MN.
- Physiological signifiance: Glycophorins A and B acts as receptors for cytokines,bacteria, and viruses.

“Stay home Stay safe”

Thank You