ABO Blood Grouping

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Human Blood Groups

- RBC membranes have glycoprotein antigens on their external surfaces
- These antigens are:
  - Unique to the individual
  - Recognized as foreign if transfused into another individual
  - Promoters of agglutination and are referred to as agglutinogens
- Presence or absence of these antigens is used to classify blood groups

What are the different blood groups?

•The differences in human blood are due to the presence or absence of certain protein molecules called antigens and antibodies.
•The antigens are located on the surface of the RBCs and the antibodies are in the blood plasma.
•Individuals have different types and combinations of these molecules.

•The blood group you belong to depends on what you have inherited from your parents.

What are the different blood groups?

•There are more than 20 genetically determined blood group systems known today

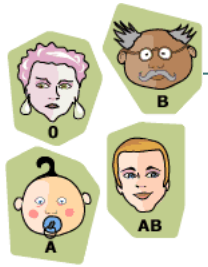
•The **AB0** and **Rhesus (Rh)** systems are the most important ones used for blood transfusions.

•Other blood groups (M, N, Dufy, Kell, and Lewis) are mainly used for legalities.

• Not all blood groups are compatible with each other. Mixing incompatible blood groups leads to blood clumping or agglutination, which is dangerous for individuals.

Landsteiner's Rule

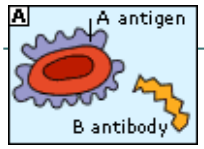
- Individual's will form immune antibodies to ABO blood group antigens they do not possess.
- Substances are present in nature which are so similar to blood group antigens which result in the constant production of antibodies to blood group antigens they do not possess.
- Critical for understanding compatibility between ABO blood groups.



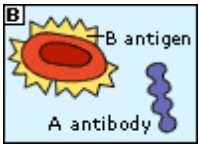
ABO blood grouping system

According to the ABO blood typing system there are four different kinds of blood types: A, B, AB or O (null).

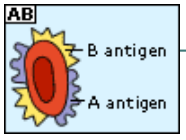
AB0 blood grouping system



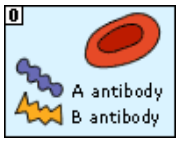
Blood group A
If you belong to the blood group A, you have A antigens on the surface of your RBCs and B antibodies in your blood plasma.



Blood group B
If you belong to the blood group B, you have B antigens on the surface of your RBCs and A antibodies in your blood plasma.



Blood group AB
If you belong to the blood group AB, you have both A and B antigens on the surface of your RBCs and no A or B antibodies at all in your blood plasma.



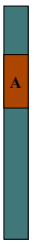
Blood group O
If you belong to the blood group O (null), you have neither A or B antigens on the surface of your RBCs but you have both A and B antibodies in your blood plasma.

ABO inheritance and genetics

- The **ABO gene is autosomal** (the gene is not on either sex chromosomes)
- The **ABO gene** locus is located on the **chromosome 9.**
- **A** and **B** blood groups are **dominant** over the **O** blood group
- **A** and **B** group genes are **co-dominant**
- Each person has **two copies of genes** coding for their ABO blood group (one maternal and one paternal in origin)

AUTOSOMAL CHROMOSOME

Sara



The alleles for Blood group are in the same place on the chromosome 9. However the genes have a different code giving the different blood group

Mustafa

one alleles from Mustafa and one from Sara.

What do co-dominant genes mean?

This meant that if a person **inherited one A group gene and one B group gene** their red cells would **possess both the A and B blood group antigens**.

These alleles were termed A (which produced the A antigen), B (which produced the B antigen) and O (which was "non functional" and produced no A or B antigen)

Genetics

- Two genes inherited, one from each parent.
- Individual who is A or B may be homozygous or heterozygous for the antigen.
- Heterozygous: AO or BO
- Homozygous: AA or BB
- Phenotype is the actual expression of the genotype, ie, group A
- Genotype are the actual inherited genes which can only be determined by family studies, ie, AO.

Example of Determining Genotype

- Mom's phenotype is group A, genotype AO
- Dad's phenotype is group B, genotype BO

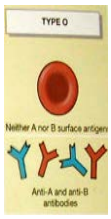
	B	O
A	AB 25%	AO 25% (Group A)
O	BO 25% (Group B)	OO 25% (Group O)

Other Examples

Mom	Dad	Offspring Blood Group
AA	BB	100% AB
BO	OO	50% each of B or O
OO	OO	100% O
OO	AO	50% each of A or O

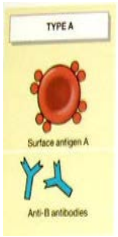
Group O

- Approximately 45% of the population is group O.
- No A or B antigens present, think of as "0" antigens present.
- These individuals form potent anti-A and anti-B antibodies which circulate in the blood plasma at all times.



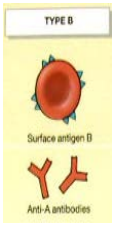
Group A

- Approximately 40% of the population is group A.
- No B antigens present.
- These individuals form potent anti-B antibodies which circulate in the blood plasma at all times.



Group B

- Approximately 11% of the population is group B.
- No A antigens present.
- These individuals form potent anti-A antibodies which circulate in the blood plasma at all times.



Group AB

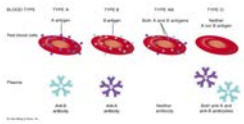
- Approximately 4% of the population is group AB.
- Both A and B antigens present.
- These individuals possess no ABO antibodies.
- NOTE: This slide is in error as it only illustrates presence of one antigen not 2.

Summary

Blood Group	Antigens on cell	Antibodies in plasma	Transfuse with group
A	A	Anti-B	A or O
B	B	Anti-A	B or O
AB	A and B	none	AB, A, B or O
O	None	Anti-A & B	O

ABO Blood Types

Group	O	A	B	AB	Rh
White	45	40	11	4	85
African Am.	49	27	20	4	95
Korean	32	28	30	10	100
Japanese	31	38	21	10	100
Chinese	42	27	25	6	100
Native Am.	79	16	4	1	100



The Rhesus (Rh) System

Well, it gets more complicated here, because there's another antigen to be considered - the **Rh antigen**.

Some of us have it, some of us don't.

If it is present, the blood is RhD positive, if not it's RhD negative.

So, for example, some people in group A will have it, and will therefore be classed as A+ (or A positive).

While the ones that don't, are A- (or A negative).

And so it goes for groups B, AB and O.

The Rhesus (Rh) System (Cont.)

• **Rh antigens** are **transmembrane proteins** with loops exposed at the surface of red blood cells.

• They appear to be used for the transport of carbon dioxide and/or ammonia across the plasma membrane.

• They are named for the **rhesus monkey** in which they were first discovered.

• RBCs that are "Rh positive" express the antigen designated **D**.

• 85% of the population is RhD positive, the other 15% of the population is running around with RhD negative blood.

Rh (D) Antigen (continued)

- Unlike the ABO blood group system, individuals who lack the D antigen do not naturally make it.
- Production of antibody to D requires exposure to the antigen.
- The D antigen is very immunogenic, ie, individuals exposed to it will very likely make an antibody to it.
- For this reason all individuals are typed for D, if negative must receive Rh (D) negative blood.

Rh (D) Antigen (continued)

- However, if an Rh^- individual receives Rh^+ blood, anti-Rh antibodies form
- A second exposure to Rh^+ blood will result in a typical transfusion reaction
- The most important patient population to consider is females of child-bearing age.
- If immunized to Rh (D) antigen the antibody can cross the placenta and destroy Rh (D) positive fetal cells resulting in death.
- This is why Rh negative women are given Rhogam after birth of Rh positive baby.

Rh Blood Group and Rh Incompatibility

A person with Rh- blood does not have Rh antibodies naturally in the blood plasma

Blood Type	Genotype	Alleles Produced
Rh positive	RR	R
	Rr	R or r
Rh negative	rr	r

Do you know which blood group you belong to?

According to above blood grouping systems, you can belong to either of following 8 blood groups:

A Rh+	B Rh+	AB Rh+	O Rh+
A Rh-	B Rh-	AB Rh-	O Rh-

Why group A blood must never be given to a group B person?

Giving someone blood from the wrong ABO group could be fatal.

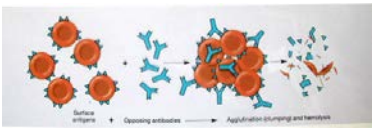
The anti-A antibodies in group B attack group A cells and vice versa.

- Blood group O negative is a different story.

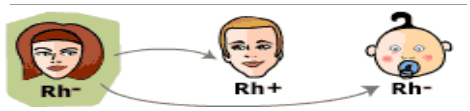
Transfusion Reactions

- Transfusion reactions occur when mismatched blood is infused
- Donor's cells are attacked by the recipient's plasma agglutinins causing:
  - Diminished oxygen-carrying capacity
  - Clumped cells that impede blood flow
  - Ruptured RBCs that release free hemoglobin into the bloodstream
- Circulating hemoglobin precipitates in the kidneys and causes renal failure

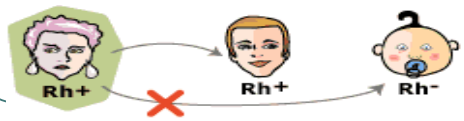
Hemolysis



- A person with Rh- blood can *develop* Rh antibodies in the blood plasma if he or she receives blood from a person with Rh+ blood, whose Rh antigens can trigger the production of Rh antibodies.



- A person with Rh+ blood can receive blood from a person with Rh- blood without any problems.



Why is an Rh incompatibility so dangerous when ABO incompatibility is not during pregnancy?

• Most anti-A or anti-B antibodies are of the IgM class (large molecules) and these do **not** cross the placenta.

•In fact, an **Rh⁻/type O** mother carrying an **Rh⁺/ type A, B, or AB** foetus is resistant to sensitisation to the Rh antigen.

•Her anti-A and anti-B antibodies destroy any foetal cells that enter her blood before they can elicit anti-Rh antibodies in her.

Rh incompatibility during pregnancy (cont.)

•This phenomenon has led to an effective preventive measure to avoid Rh sensitisation.

•Shortly after each birth of an Rh⁺ baby, the mother is given an injection of anti-Rh antibodies (or **Rhogam)**.

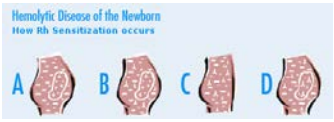
•These passively acquired antibodies destroy any foetal cells that got into her circulation before they can elicit an active immune response in her.

Hemolytic Disease of the Newborn

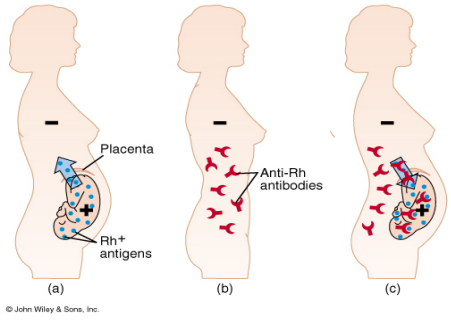
- May occur in an Rh- mom pregnanet with an Rh+ fetus
- Hemolytic disease of the newborn – Rh⁺ antibodies of a sensitized Rh⁻ mother cross the placenta and attack and destroy the RBCs of an Rh⁺ baby
- Rh⁻ mother becomes sensitized when Rh⁺ blood (from a previous pregnancy of an Rh⁺ baby or a Rh⁺ transfusion) causes her body to synthesis Rh⁺ antibodies
- The drug RhoGAM can prevent the Rh⁻ mother from becoming sensitized
- Treatment of hemolytic disease of the newborn involves pre-birth transfusions and exchange transfusions after birth

Hemolytic Disease of the Neborn – How it Occurs

- A child is Rh pos
- B during pregnancy fetal Rh pos rbc's escape into maternal circulation
- C Mother produces antibodies to Rh (D) antigen
- D Second pregnancy with Rh (D) pos child results in destruction of fetal D pos rbcs



Hemolytic Disease of Newborns (HDN) or Erythroblastosis Fetalis



Possible Blood group Genotypes

Parent Allele	A	B	O
A			
B			
O			

Possible Blood group Genotypes

Parent Allele ↓ / →	A	B	O
A	AA	AB	AO
B	AB	BB	BO
O	AO	BO	OO

TABLE 17.4 ABO Blood Groups

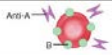
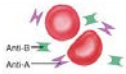
Blood Group	Frequency (% U.S. Population) White	Black	Asian	Native American	RBC Antigens (Agglutinogens)	Illustration	Plasma Antibodies (Agglutinins)	Blood That Can Be Received
AB	4	4	5	<1	A B		None	A, B, AB, O Universal recipient
B	11	20	27	4	B		Anti-A (a)	B, O
A	40	27	28	16	A		Anti-B (b)	A, O
O	45	49	40	79	None		Anti-A (a) Anti-B (b)	O Universal donor

Table 17.4

Blood Typing

Blood type being tested	RBC agglutinogens	Serum Reaction	
		Anti-A	Anti-B
AB	A and B	+	+
B	B	–	+
A	A	+	–
O	None	–	–