There are four major blood groups determined by the presence or absence of two antigens (proteins) – A and B – on the surface of red blood cells:

**Group A** – has only the A antigen on red cells (and B antibody in the plasma)

**Group B** – has only the B antigen on red cells (and A antibody in the plasma)

**Group AB** – has both A and B antigens on red cells (but neither A nor B antibody in the plasma)

**Group O** – has neither A nor B antigens on red cells (but both A and B antibody are in the plasma)

Since foreign antigens can trigger a patient’s immune system to attack the transfused blood with antibodies, safe blood transfusions depend on careful blood typing and cross-matching.

There are 3 alleles of the gene that controls blood type: \(I^A\), \(I^B\), \(i\)

The I stands for immunoglobulin, or the type of white blood cell that would be triggered to attack.

\(I^A\) and \(I^B\) are Co-Dominant genes, meaning when inherited together, they are both fully expressed, not blended, as in Incomplete Dominance. “\(i\)” is the recessive form of the allele.

Possible genotypes are as follows:

<table>
<thead>
<tr>
<th>Genotypes</th>
<th>Blood Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>(I^A I^A) or (I^A i)</td>
<td>A</td>
</tr>
<tr>
<td>(I^B I^B) or (I^B i)</td>
<td>B</td>
</tr>
<tr>
<td>(I^A I^B)</td>
<td>AB</td>
</tr>
<tr>
<td>ii</td>
<td>O</td>
</tr>
</tbody>
</table>

**Agglutination**

- Antibody
- Antigen

<table>
<thead>
<tr>
<th>Blood Type</th>
<th>Antigen (RBC membrane)</th>
<th>Antibody (plasma)</th>
<th>Can receive blood from</th>
<th>Can donate blood to</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (40%)</td>
<td>A antigen</td>
<td>Anti-B antibodies</td>
<td>A, O</td>
<td>A, AB</td>
</tr>
<tr>
<td>B (10%)</td>
<td>B antigen</td>
<td>Anti-A antibodies</td>
<td>B, O</td>
<td>B, AB</td>
</tr>
<tr>
<td>AB (4%)</td>
<td>A antigen, B antigen</td>
<td>No antibodies</td>
<td>A, B, AB, O</td>
<td>AB</td>
</tr>
<tr>
<td>O (46%)</td>
<td>No antigen</td>
<td>Both Anti-A and Anti-B antibodies</td>
<td>O</td>
<td>O, A, B, AB</td>
</tr>
</tbody>
</table>
An additional complication in blood typing is that there is a third major antigen called the Rh factor. If you have the Rh antigen as well, we say you are Rh +. No Rh antigen, you are Rh -.
Each of the four A, B, AB, O blood types can come with or without the Rh factor. We will not deal with the Rh factor in the following genetics problems.

**Assignment:**

Show the punnett square and phenotypic ratios for the following crosses:

1) Both the father and mother have type O blood.

\[
\begin{array}{c}
i & i \\
i & i \\
i & i \\
\end{array}
\]

Phenotypic Ratio:

2) The father is type A homozygous, the mother is type B homozygous.

\[
\begin{array}{c}
A & A \\
B & B \\
\end{array}
\begin{array}{c}
B \\
A \\
\end{array}
\]

Phenotypic Ratio:

\[
A : B : AB : O \\
0 : 0 : 4 : 0
\]

3) The father is type A heterozygous, the mother is type B heterozygous.

\[
\begin{array}{c}
i & A \\
i & B \\
i & B \\
\end{array}
\begin{array}{c}
B \\
i \\
A \\
\end{array}
\]

Phenotypic Ratio:

\[
A : B : AB : O \\
1 : 1 : 1 : 1
\]

4) The father has type O blood, the mother has type AB blood.

\[
\begin{array}{c}
ii & A B \\
\end{array}
\begin{array}{c}
i \\
A \\
B \\
\end{array}
\]

Phenotypic Ratio:

\[
A : B : AB : O \\
2 : 2 : 0 : 0
\]
5) Both the father and mother have type AB blood.

\[
\begin{array}{cc}
A & B \\
\hline
A & A \\
A & B \\
B & A \\
B & B \\
\end{array}
\]

Phenotypic Ratio:

6) Alice has type A blood and her husband Mark has type B blood.
   Their first child, Amanda, has type O blood.
   Their second child, Alex, has type AB blood.
   What is Alice’s genotype? _____________
   What is Mark’s genotype? _____________
   Show how you found the answer by completing the Punnett square(s) below:

7) Candace has type B blood. Her husband Dan has type AB blood.
   Is it possible for Candace and Dan to have a child that has O blood? ___________
   Explain why or why not (use a Punnett square to help).

8) Ralph has type B blood and his wife Rachel has type A blood. They are very shocked to hear that their baby has type O blood, and think that a switch might have been made at the hospital. Can this baby be theirs? ___________ Explain why or why not (use a Punnett square to help).