ABO Blood Typing
A Codominant Example

Multiple Alleles and Codominance
• Inheritance by multiple alleles occurs when more than two alternative alleles exist for a particular gene locus.
• A person’s blood type is an example of a trait determined by multiple alleles.
• Each individual inherits only two alleles for these genes.
• Codominance means that both alleles are equally expressed in a heterozygote.

Phenotypes and Genotypes
• A person can have any one of the alleles:
  • Phenotype - A antigen (blood type A)
    • Genotype - AA or AO
  • Phenotype - B antigen (blood type B)
    • Genotype BB or BO
  • Phenotype - A and B antigens (blood type AB)
    • Genotype AB
  • Phenotype Expression for no antigen (blood type O)
    • Genotype OO

What is an Antigen
• An antigen is a protein that is found on the surface of cells, produced by the DNA that is a marker for a cell in a living thing.
• Antigens trigger an immune response when foreign antigens are detected, resulting in production of an antibody as part of the body's defense against infection and disease.

What Does it Look Like?
• The Image to the right is a virus
• The Image below is the cell
• Since the surface markers don't match, the cell sends a message to get rid of it

What is the Message?
• An antibody is a protein.
• Produced by the DNA because a message (protein) that is sent by the triggering cell (called m-cell lymphocytes).
• Manufactured by other types of white blood cells (called t-cell lymphocytes) to neutralize a foreign antigen that may be found on the surface of an invading cell.
What does it Look Like?

- The globular protein called an antibody is produced to bind with the invading cell antigens and clump all the invading cells together.
- After this happens more white blood cells are “called in” to get rid of the clump of invading cells.

What does all this mean?

- Red blood cells (RBC’s) carrying one or both antigens for the ABO blood group.
- When they come into contact with the “wrong” version of the antigen, they send out the signal for the (WBC’s) to come and help “get rid of” an invading organism.
- So, when RBC’s are exposed to corresponding antibodies, they agglutinate (clump) together.
- Thus, each of us usually have antibodies against those red cell antigens that they lack.

Antigens and Antibodies

<table>
<thead>
<tr>
<th>ABO Blood Type</th>
<th>Antigen A</th>
<th>Antigen B</th>
<th>Antibody Anti-A</th>
<th>Antibody Anti-B</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>YES</td>
<td>NO</td>
<td>NO</td>
<td>YES</td>
</tr>
<tr>
<td>B</td>
<td>NO</td>
<td>YES</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>O</td>
<td>NO</td>
<td>NO</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>AB</td>
<td>YES</td>
<td>YES</td>
<td>NO</td>
<td>NO</td>
</tr>
</tbody>
</table>

Types

- Transfused blood must not contain red cells that the recipient's antibodies can clump.
- The table below shows what types can give and get in the ABO blood groups.

<table>
<thead>
<tr>
<th>ABO Type</th>
<th>A</th>
<th>B</th>
<th>AB</th>
<th>O</th>
</tr>
</thead>
<tbody>
<tr>
<td>Give To?</td>
<td>A, O</td>
<td>B, O</td>
<td>A, B, AB, O</td>
<td>O</td>
</tr>
</tbody>
</table>

Agglutination

- The top image is a picture of RBC’s typically found in people.
- The bottom image is agglutinated blood as the result of antigen and antibody clumping.
Interesting Facts

• Bacteria, viruses and other microorganisms commonly contain antigens, as do pollen, dust mites, mold, food, and other substances.
• Antibodies can thus be protective, but also can be inappropriate or excessively used in the formation of antibodies that may lead to illness.
• When the body forms a type of antibody called IgE (immunoglobulin E), allergic rhinitis, asthma or eczema may result when the patient is again exposed to the substance which caused IgE antibody formation (allergen).

What about Rh?

• Rh is another antigen found on the surface of RBC’s.
• Antigen is named after the rhesus monkey in which it was first discovered.
• This genotype is completely dominant.
  • R - Rh+
  • r - Rh-
• Rh+ people posses the antigen and Rh- people recess the expression of the antigen

More on Rh

• The same rule applies for agglutination of blood.
  • If you are Rh+ then you will agglutinate blood presented that is Rh-
  • If you are Rh- then you will agglutinate blood presented that is Rh+

Importance

• The major importance of the Rh system for human health is to avoid the danger of Rh incompatibility between mother and fetus.
• If the baby is Rh positive (having inherited the trait from its father) and the mother Rh-negative, these red cells will cause her to develop antibodies against the RhD antigen.

Problems

• During birth, there is often a leakage of the baby’s red blood cells into the mother’s circulation.
• The antibodies do not cause problems for that child, but can cross the placenta and attack the red cells of a subsequent Rh+ fetus.
• This destroys the red cells producing anemia and jaundice.
• The disease, called erythroblastosis fetalis may be so severe as to kill the fetus or even the newborn infant.

Solutions?

• The phenomenon has led to an extremely effective preventive measure to avoid Rh sensitization.
• Shortly after each birth of an Rh+ baby, the mother is given an injection of anti-Rh antibodies.
  • The preparation is called Rh immune globulin (RhiG) or Rhogam.
• The anti-Rh antibodies passively acquired antibodies destroy any fetal cells that got into her circulation before they can elicit an active immune response in her for the second child.
What is common?

- People always ask what is common and what is not, in terms of blood type.

<table>
<thead>
<tr>
<th>Types</th>
<th>Distribution</th>
<th>Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>O+</td>
<td>1 person in 3</td>
<td>38.4%</td>
</tr>
<tr>
<td>O-</td>
<td>1 person in 15</td>
<td>7.7%</td>
</tr>
<tr>
<td>A+</td>
<td>1 person in 3</td>
<td>32.5%</td>
</tr>
<tr>
<td>A-</td>
<td>1 person in 16</td>
<td>6.5%</td>
</tr>
<tr>
<td>B+</td>
<td>1 person in 12</td>
<td>9.4%</td>
</tr>
<tr>
<td>B-</td>
<td>1 person in 67</td>
<td>1.7%</td>
</tr>
<tr>
<td>AB+</td>
<td>1 person in 29</td>
<td>3.2%</td>
</tr>
<tr>
<td>AB-</td>
<td>1 person in 167</td>
<td>0.7%</td>
</tr>
</tbody>
</table>

Example Problem

- Human blood type is determined by co-dominant alleles. There are three different alleles, known as A, B, and O.
  - The A and B alleles are co-dominant, and the O allele is recessive. The possible human phenotypes for blood group are type A, type B, type AB, and type O. Type A and B individuals can be either homozygous (AA or BB, respectively), or heterozygous (AO or BO, respectively).
  - A woman with type A blood and a man with type B blood could potentially have offspring with what blood types?