Incomplete Dominance

**Incomplete dominance:** is condition in which neither allele for a gene completely conceals the presence of the other; it results in intermediate expression of a trait.

**Homozygous dominant** will produce the dominant characteristic. **Homozygous recessive** will produce the recessive characteristic. **Heterozygous** combination will produce a new phenotype, a combination of the dominant and recessive characteristics.

When representing incomplete dominance, upper case and lower case letters are not used. The trait letter is used as a capital and a superscript letter is used to represent the characteristic of that trait.

Flower colour \((C)\), characteristic red \((C^R)\), characteristic \((C^W)\).

Lower case letters are only used to represent recessive characteristics, seen neither is recessive, only capital letters are used.

**Figure 6.1:** when red \((C^R C^R)\) flowers and white \((C^W C^W)\) flowers of the snapdragon are crossed, the resulting offspring have an intermediate phenotype, pink flowers \((C^R C^W)\). In the \(F_2\) generation, all three phenotypes are observed.
Co-dominance

Co-dominance: is the condition in which both alleles for a trait are equally expressed in a heterozygote; both alleles are dominant.

The roan cow is an excellent representation of a co-dominance situation. From a distance the cow looks pink in colour. After a close examination the fur is made up both red and white fur. The homozygous pairing for red creates red fur and the homozygous pairing for white creates white fur. When there is a heterozygous mix, the red and white allele is expressed, both fur colours are expressed.

Sickle Cell Anemia

Sickle cell anemia is a human example of co-dominance. It is caused by a gene that directs the synthesis for hemoglobin. The proteins causes a change in the red blood cell, causing a ‘C’ shaped cell and inhibits its oxygen carrying capacity.

Hemoglobin (Hb) and the allele for a normal cell is (A), and the sickle cell anemia is (S). The genotype for a normal cell would be Hb^A Hb^A and for sickle cell anemia Hb^S Hb^S.

A heterozygous mix Hb^A Hb^S, creates individuals with the sickle cell trait. An individual expresses both normal cells and sickle cells. This is advantageous to individuals, it gives an individual a resistance to malaria, transmitted by a parasite through mosquito bites.
Figure 6.4: When a man and woman are heterozygous for the sickle cell gene, there is a one in four chance that they will have a child with sickle cell anemia.

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**Multiple Alleles**

The traits that we have been studying have been controlled by one gene with two alleles (dominant and recessive). In some cases there situations where there are more then two alleles for the one gene, *Multiple alleles*.

**Human Blood Groups**

A single gene determines blood types, *ABO*. It determines the antigen protein that is attached to the red blood cell, if any. A person’s body will produce an immune response to any foreign protein markers.
The different combinations of the three alleles (IA, IB, i) can lead to four different phenotypes. Type A blood is created by the following combinations; (IAIA) Homozygous type A, or (IAi) heterozygous type A. Type B blood is created by the following combinations; (IBIB) Homozygous type B, or (IBi) heterozygous type B. Type AB blood is created being heterozygous (IAIB). Type O blood is created by a combination of (ii) homozygous recessive.

Figure 6.5: Different combinations of the three I alleles result in four different blood types; type A, type B, type AB, and type O.

Rabbit Coat Colour

Rabbit coat colour is determined by multiple alleles. There are four alleles which can combine to create four fur colours. A hierarchy is established, expressing the following dominance, agouti, chinchilla, Himalayan, and albino; (C>Ch>Ch>c).
List all possible combinations:

<table>
<thead>
<tr>
<th>Breed</th>
<th>Genotypes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agouti</td>
<td>CC, CC&lt;sup&gt;ch&lt;/sup&gt;, CC&lt;sup&gt;h&lt;/sup&gt;, Cc</td>
</tr>
<tr>
<td>Chinchilla</td>
<td>C&lt;sup&gt;ch&lt;/sup&gt;C&lt;sup&gt;ch&lt;/sup&gt;, C&lt;sup&gt;ch&lt;/sup&gt;C&lt;sup&gt;h&lt;/sup&gt;, C&lt;sup&gt;ch&lt;/sup&gt;c</td>
</tr>
<tr>
<td>Himalayan</td>
<td>C&lt;sup&gt;h&lt;/sup&gt;C&lt;sup&gt;h&lt;/sup&gt;, C&lt;sup&gt;h&lt;/sup&gt;c</td>
</tr>
<tr>
<td>Albino</td>
<td>cc</td>
</tr>
</tbody>
</table>

Figure 6.6: Rabbits have multiple alleles for coat colour, with four possible phenotypes.

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Environmental Effects on Complex Patterns of Inheritance

Environmental factors may also affect the expression of traits. Genes can be influenced by temperature like in the Himalayan rabbit. The face, ears, tails and feet can be cooler than the abdomen of the rabbit, therefore may express a different colour.

Figure 6.8: The dark ears, nose, feet, and tails of Himalayan rabbits are thought to be created by lower body temperature in these areas.
Polygenic Inheritance

*Continuous variation:* is a range of variation one trait resulting from the activity of many genes. Examples of this can found in humans; heights and skin colour. The variations in phenotypes vary gradually from one extreme to another.

*Polygenic trait:* is a trait that is controlled by more than one gene. The dominant genes will contribute, but recessive genes have no impact. For skin colour, the more dominant alleles a person has, the darker their skin will be.

Figure 6.9: This graph shows possible shades of skin colour from three of the sets of alleles that determine this trait.

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