BC Science Connections 10

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Unit 1: DNA is the foundation for the unity and diversity of living things.

Topic 1.2: How is hereditary information passed from one generation to the next?

- Genes pass on inherited traits from parent to offspring.
- Punnett squares show the probability of offspring inheriting specific traits.
- Both alleles are expressed in codominance.
- In incomplete dominance, alleles are neither dominant nor recessive.
- Some inherited traits are due to alleles on the sex chromosomes.

Concept 1: Genes pass on inherited traits from parent to offspring.

- **Genetics:** field of biology that studies heredity, or the passing of traits from parents to offspring
- **Trait:** an inherited characteristic, such as eye colour or hair colour

First Modern Experiments in Genetics

- **Gregor Mendel** discovered how traits are inherited by experimenting with pea plants.

Mendel's Experiments

- Mendel used *true-breeding* pea plants that produce offspring with only one form of a trait.
- Parent plants produced new plants called *offspring* in the *first generation* (F_1).
- Plants from the first generation were allowed to self-fertilize to produce offspring in the *second generation* (F_2).

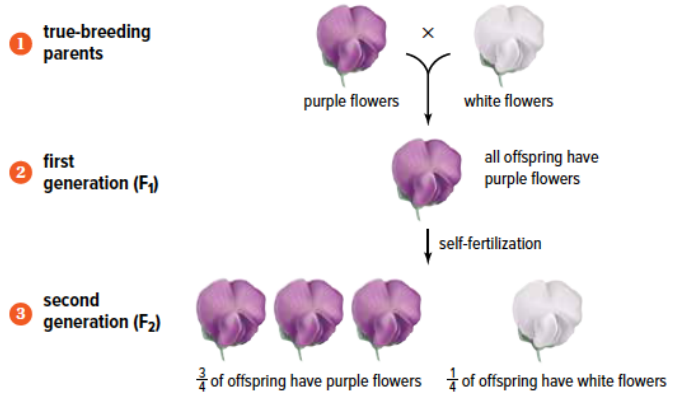

Figure 1.10: These are the results of Mendel's cross involving true-breeding pea plants with purple flowers and true-breeding pea plants with white flowers.

Mendel's Experiments (cont'd)

- When two different true-breeding pea plants are crossed, one trait disappears in the F_1 offspring, but reappears in the F_2 offspring.
- Based on this observation, Mendel proposed:
  - Each plant has two factors for a trait.
  - Each parent gives one factor for each trait.
  - One factor dominates over the other if present.
  - The "factors" Mendel referred to in his conclusions are what we now call alleles.

Homologous Chromosomes and Gametes

- Chromosomes may carry different alleles.
- During gamete formation, pairs of homologous chromosomes separate.
- Each gamete receives one member of each pair, so it receives only one allele of each pair.
- During fertilization when the male and female gametes meet, homologous chromosomes and alleles are paired again.

The Law of Segregation

- **Law of segregation:** states that alleles for a trait separate during meiosis
- Each gamete carries one allele for each trait.
- During fertilization, each gamete contributes an allele for each trait.

Dominant and Recessive Alleles

- Alleles that are **dominant** will always be expressed if present.
- Alleles that are **recessive** will be expressed only if there are two recessive alleles.
- Dominant alleles are represented with a capital letter.
- Recessive alleles are represented with a lower-case letter.

Dominant and Recessive Alleles (cont'd)

- Purple flower colour = *BB* or *Bb*
- White flower colour = *bb*

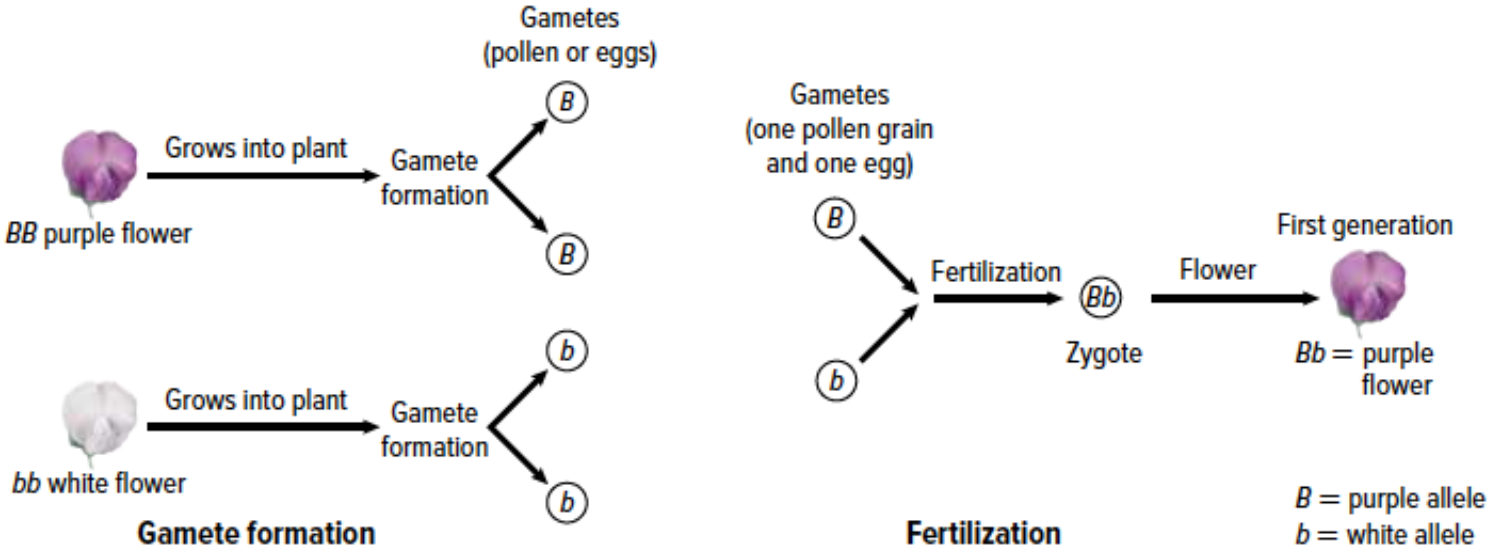

Figure 1.11: These are the results of Mendel's cross involving true-breeding pea plants with purple flowers and pea plants with white flowers.

Genotypes and Phenotypes

- **Phenotype:** the physical description of an organism's trait
- **Genotype:** the specific combination of alleles an organism has for a trait
- **Homozygous:** an organism with two of the same alleles for a particular trait
- **Heterozygous:** an organism with two different alleles for a particular trait

Genotypes and Phenotypes (cont'd)

- There are three possible genotypes:

1) *Homozygous dominant*: two dominant alleles

2) *Homozygous recessive*: two recessive alleles

3) *Heterozygous*: one dominant allele and one recessive allele

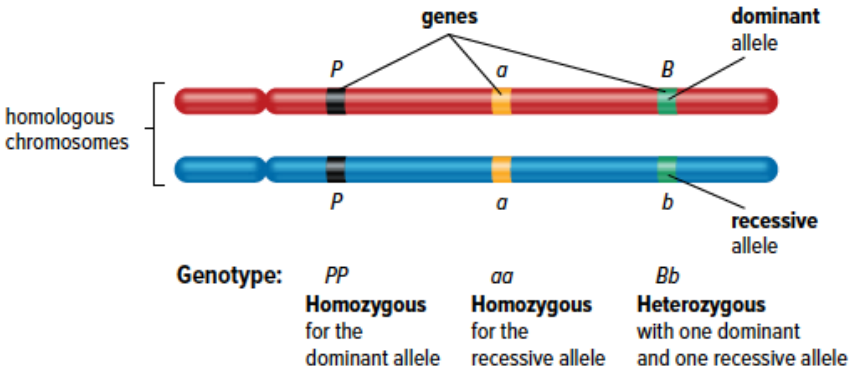

Figure 1.12: Three different genes on homologous chromosomes are indicated. Each example shows one of the three possible combinations (genotypes) of dominant and recessive alleles.

Discussion Questions

1. Write a definition for genetics in your own words.
2. Seed shape in pea plants can either be round or wrinkled. The allele for round shape is indicated by *R*. Is round seed shape dominant or recessive?
3. The allele for freckles is indicated by *F*. What is the genotype of a person who is heterozygous for freckles?

Concept 2: Punnett squares show the probability of offspring inheriting specific traits.

- Genetic cross is a deliberate mating between a genetic male and a genetic female.
- *Monohybrid cross* considers one trait.
- *Hybrid* is an offspring that has different traits from its parents.

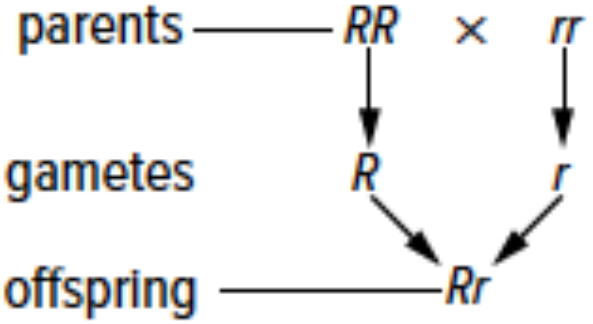

Figure 1.13: A monohybrid cross between a homozygous dominant individual and a homozygous recessive individual. Each parent contributes one type of allele to the offspring. The symbol "×" represents the word *cross*.

Punnett Squares

- A **Punnett square** is a tool used to help determine the *probability* of inheriting traits in a monohybrid cross.
- It shows the genotypes of the parents and the offspring.

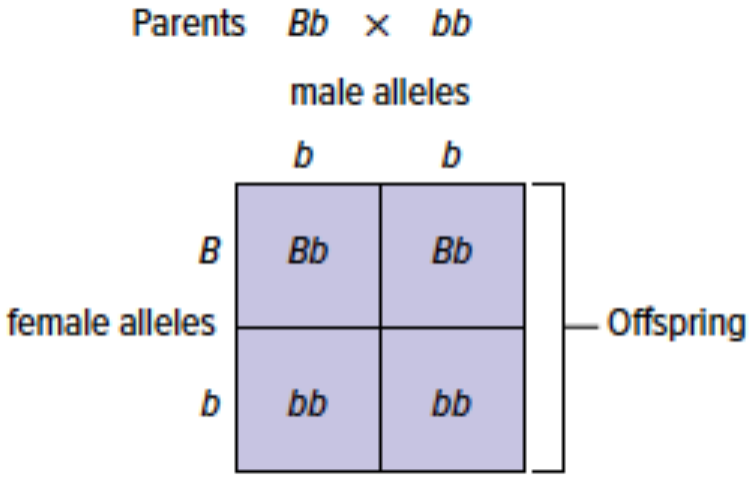

Figure 1.14: In this cross, the female horse can contribute either a *B* allele or a *b* allele to offspring. The male horse can contribute only the *b* allele. The genotypes of the offspring are all possible combinations of alleles that can occur when the gametes combine at fertilization.

Punnett Squares (cont'd)

- *Phenotypic ratio* shows the frequency of the phenotypes in offspring.
  - Example: 3 purple flowers:1 white flower
- *Genotypic ratio* shows the frequency of the genotypes in offspring.
  - Example: 1*BB*:2*Bb*:*1bb*

Discussion Questions

1. A monohybrid cross produces half the offspring with one genotype and half the offspring with another genotype. Express this in the form of a ratio.

2. What do the alleles that are written along the top and beside a Punnett square represent?

Concept 3: Both alleles are expressed in codominance.

- **Codominance:** the condition in which both alleles for a trait are equally expressed in a heterozygote; both alleles are dominant
- Codominant alleles are represented by capital letters with a superscript for each allele
  - Example: $H^R H^W$

Sickle Cell Anemia—Another Example of Codominance

- Sickle cell anemia is a genetic disorder where the red blood cell is C-shaped (sickle shape) and therefore cannot transport oxygen effectively.
- People who are heterozygotes with the sickle cell trait are resistant to the life-threatening disease malaria.

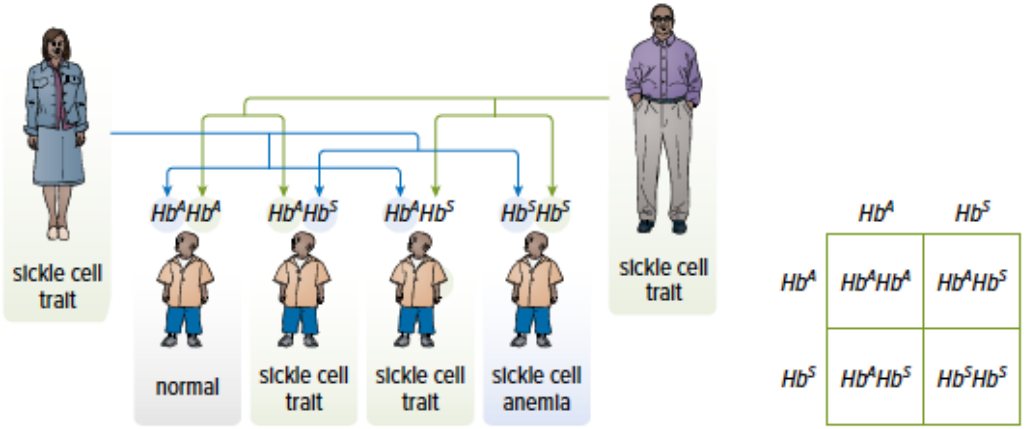

Figure 1.18: When a man and a woman are both heterozygous for the sickle cell gene, there is a one in four chance that they will have a child with sickle cell anemia.

Discussion Questions

1. What is codominance? Give three examples of codominance.

2. Hypothesize why the frequency of the sickle cell allele is much higher in Africa than in other areas of the world.

Concept 4: In incomplete dominance, alleles are neither dominant nor recessive.

- **Incomplete dominance:** a condition in which neither allele for a gene completely conceals the presence of the other; it results in intermediate expression of a trait
- Example: Four o'clock flowers can be red, pink, or white.

Incomplete Dominance

- Use capital letters with superscripts to represent incomplete dominance.

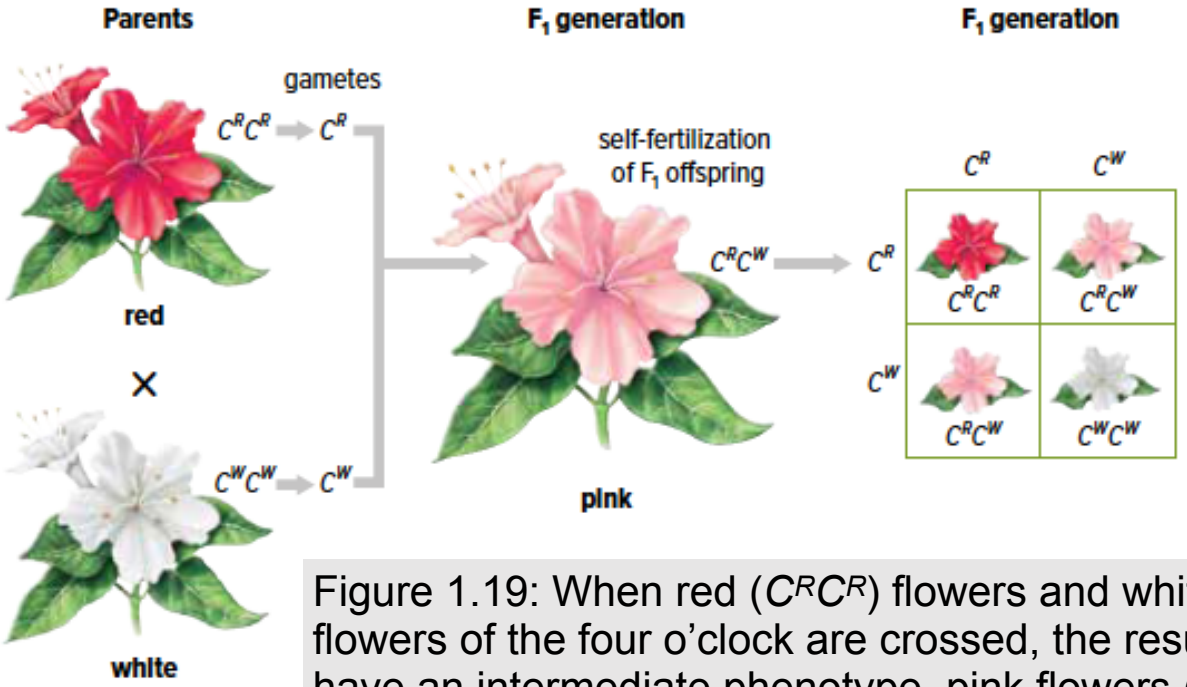

Figure 1.19: When red (C^RC^R) flowers and white (C^WC^W) flowers of the four o'clock are crossed, the resulting offspring have an intermediate phenotype, pink flowers (C^RC^W). In the F_2 generation, all three phenotypes are observed.

Discussion Questions

1. What is the difference between incomplete dominance and codominance?
2. A plant that produces white flowers is crossed with a plant that produces purple flowers. Describe the phenotype of the offspring if the inheritance pattern for flower colour is

a) incomplete dominance

b) codominance

Concept 5: Some inherited traits are due to alleles on the sex chromosomes.

- **Sex-linked trait:** a trait controlled by genes on sex chromosomes
- **X-linked trait:** a trait controlled by genes on the X chromosome
- Males are affected by recessive X-linked traits more often because they have only one X chromosome.

Red-Green Colour Vision Deficiency

- Red-green colour vision deficiency is a recessive X-linked trait.
- *Carrier* is a female that has one recessive allele on one of her X chromosomes.

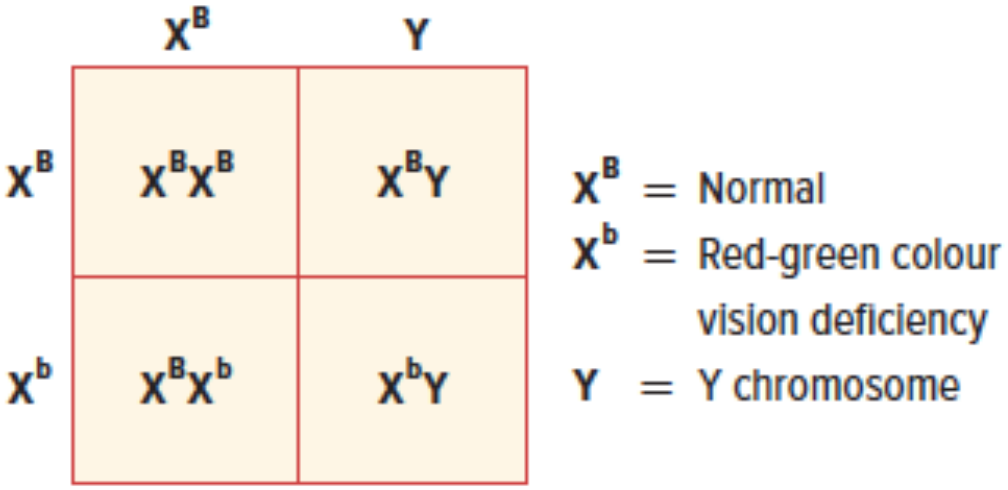

Figure 1.20: The Punnett square shows how the sex-linked trait is inherited.

Discussion Questions

1. What are sex-linked traits?

2. Use vocabulary terms to describe the genotype of a male who is red-green colour vision deficient.

Topic 1.2 Summary: How is hereditary information passed from one generation to the next?

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