Genetics: Mendel’s Laws
Terminology & definitions:

- **Allele:** one of two contrasting genes that determine alternative characteristics in inheritance because they are situated on the same locus in homologous chromosomes.
- **Dominant allele:** an allele that masks or suppressed the expression of the allele partner on the chromosome pair and the dominant characteristic is seen in the homozygous and heterozygous state.
- **Recessive allele:** an allele that is suppressed when the allele partner is dominant. The recessive trait will only be expressed/seen if both alleles for the trait are recessive.
- **Heterozygous:** when two alleles on the same locus are different for a particular characteristic.
- **Homozygous:** when two alleles that control a single trait are alike for a characteristic resulting in true-breeding for a particular characteristic.
- **Gene:** the unit of heredity transmitted in the chromosome which controls the development of the characteristics.
- **Gene mutation:** a change of one or more bases in the nuclear DNA of an organism. If the mutation is favourable, the organism survives but should the mutation be unfavourable, the organism will die.
- **Zygote:** the resulting cell after fertilization has occurred.
- **Gregor Mendel (1822–1884):** an Augustinian monk who enjoyed experimenting with plants and the first known biogeneticist.

Laws / Key Concepts / Diagram

**Mendel’s First Law: The Law of dominance and segregation**

When two individuals with contrasting **homozygous characteristics** are crossed, the individuals of the F₁ hybrid generation will all resemble the parent possessing the dominant characteristic.

Pea plants either grow tall (TT or Tt) or are short plants (tt). Mendel crossed the homozygous tall and homozygous short varieties to prove his theories.

**P**₁  **TT x tt**

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<tr>
<th>gametes</th>
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**F**₁

Genotype: 4:4 Tt heterozygous offspring

Phenotype: 100% Tall
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Note that the $F_1$ offspring show characteristics from both parents but in the phenotype, all are tall.

The plants of the $F_1$ grow and mature (Tt). When they reproduce, half of the gametes will contain the characteristic for tallness and the other half, for shortness (T, T, t, t). The characteristic for shortness is the recessive characteristic and it will appear in the second cross offspring called the $F_2$ generation.

$$P_2 \quad Tt \times Tt$$

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$F_2$

**Genotype:** 1:4 Homozygous Tall, 2:4 Heterozygous Tall, 1:4 Homozygous short

(1 TT : 2 Tt : 1 tt)

**Phenotype:** 75% tall {1 homozygous tall + 2 heterozygous tall} 25% short {1 homozygous short}

Mendel's Second Law: The Law of Independent Assortment

Different pairs of chromosomes segregate independently in a dihybrid cross so that each characteristic separates independently and each gamete randomly receives only one allele from each gene pair. So, if you have blonde hair, you can inherit brown eyes because eye colour is independent of hair colour.

Mendel used peas with a genetic trait for a round seed versus a wrinkled seed AND a yellow versus green colour of the seeds. Independent combinations for the traits round and yellow, round and green, wrinkled and yellow or wrinkled and green will result. (4x4 = 16 combinations)

**X-ample Questions**

**Question 1:**
In humans, the allele for blue (b) eyes is recessive to the allele for brown (B) eyes. A man, heterozygous for brown eyes, marries a woman with blue eyes. Show how the possible genotypes, phenotypes and ratio of individuals with brown and blue eyes in the $F_1$-generation, may be obtained. (8)

(Taken from NSC Examination Paper 1, February 2009 – question 3.3)

**Question 2:**
The ability to curl your tongue to form a tube is passed on from parents to their children.
Study the diagram below, which shows the inheritance of the tongue rolling in a particular family and then answer the questions which follow about the family.
2.1. Using (T) to represent the character for tongue rolling and (t) the character for inability to roll, give the genotypes and phenotypes of individuals A, H and I.

2.2. What were the chances of I and J’s first child being able to roll his tongue? Explain your answer.

2.3. Why is the character for tongue rolling given a capital letter rather than the character for inability to roll the tongue. Use the information from the diagram in your answer.

2.4. You will see on the diagram that L and M have five children, two of whom are tongue rollers. What are the chances of next child being able to roll his/her tongue?

2.5. You will see that P can roll her tongue. What are the chances of her being heterozygous for this condition? Explain the reason for your answer.
X-ercise
The eight items below are based on the pedigree diagram that shows the phenotypes of offspring from wavy-haired parents. Write down the letters A, B, C or D according to the following key:

A - if the statement is TRUE
B - if the statement is FALSE
C - if there is a 25% chance that the statement is TRUE
D - if there is a 50% chance that the statement is TRUE

1. Wavy hair is dominant.
2. Individual 1 is homozygous.
3. If individual 6 married a woman with straight hair, all of the offspring would have straight hair.
4. Individual 4 is homozygous.
5. One of the parents of 2 had the same genotype as 2.
6. If 10 married someone with wavy hair, the first child would have wavy hair.
7. If 1 and 2 had another child, the child would have curly hair.
8. If 3 and 4 had more children than those shown, they might have straight hair.
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Answers to the X-ercise questions:
1. A (True)
2. C (there is a 25% chance that the statement is TRUE)
3. A (True)
4. B (False)
5. D (there is a 50% chance that the statement is TRUE)
6. D (there is a 50% chance that the statement is TRUE)
7. C (there is a 25% chance that the statement is TRUE)
8. D (there is a 50% chance that the statement is TRUE)