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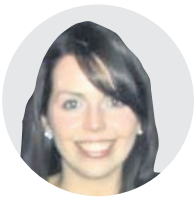
AGRICULTURAL SCIENCE STUDY GUIDE Week 4



Genetic principles with both plant and animal applications

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Genetic principles: plants and animals

This topic will focus on the principles of genetics, referencing Mendel's laws, sex determination, sex linkage and mutations, heritable characteristics and selection for breeding with special attention given to plant and animal applications. These topics are examinable at both Ordinary and Higher levels. Investigations carried out in the area of genetics are examinable at both levels for the practical component of the course. Key terms associated with this topic can be found in the *Pastures New* textbook as well as the *Dictionary of Terms* resource book.

Mitosis

- When a cell is not dividing, it is in a phase called Interphase.
- Cell division is divided into four phases:

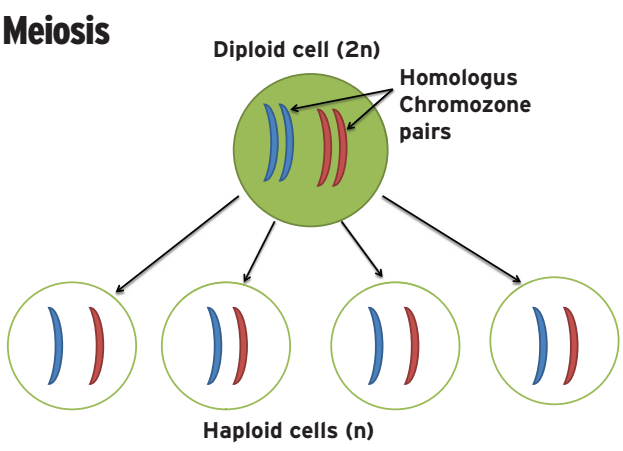
1 **Prophase:** chromosomes are visible and duplicate and spindle fibres form.
2 **Metaphase:** chromosomes position in the middle of the cell and spindle fibres join to centromere of chromosomes.
3 **Anaphase:** spindle fibres contract, separating the duplicated chromosomes to opposite poles of the cell.
4 **Telophase:** chromosomes uncoil to form chromatin, nuclear membrane forms and cytoplasm divides to create two cells.

(The order of the phases can be remembered by the acronym: Passed My Ag Test).

- Two genetically identical daughter cells are produced from a single cell.
- Functions of mitosis:
  - o Growth and repair of cells.
  - o Asexual reproduction in some organisms, eg yeast.

Meiosis

- Meiosis occurs in the ovaries and testes.



- The cells formed are haploid, having half the number of chromosomes of the parent cell.
- A single diploid cell produces four haploid cells.
- Function of meiosis:
  - o To produce gametes for sexual reproduction.

- When fertilisation occurs, a diploid zygote is formed.
- Crossing over can occur during meiosis, resulting in variations in offspring.

> The sex chromosomes determine the sex of an individual

Mendel's laws:

Mendel's first law: The law of segregation.

- At gamete formation, only one allele from a pair of alleles is passed into each gamete.

Mendel's second law: The law of independent assortment.

- At gamete formation, allele pairs separate independently of other allele pairs, and either of a pair of alleles are equally likely to join with either of another pair of alleles, ie all possible combinations of alleles are equally likely to occur.

Sex determination

- Humans have 23 pairs of chromosomes: 22 pairs of autosomes and 1 pair of sex chromosomes (X and Y).
- The sex chromosomes determine the sex of an individual.
- Females possess two X chromosomes (XX).
- Males possess an X and a Y chromosome (XY).
- Males are responsible for sex determination in humans, fruit flies (Drosophila) and other organisms as they possess the two different types of sex chromosomes.
- In birds, the female genotype is ZW and the male genotype is ZZ, meaning the females determine the sex.
- Every time a male and female organism mate, the ratio of male to female offspring is 1:1.

Sex linkage:

- The X chromosome carries some genes that are not present on the Y chromosome.
- Examples: genes which control eye colour and blood clotting.
- Recessive alleles of these genes can cause white eye in fruit flies as well as haemophilia and colour blindness in humans.
- These alleles are expressed when an individual is carrying two recessive alleles for these genes.
- These disorders occur more commonly in males as they possess only one X chromosome which they have inherited from their mother.

Mutations

- Mutations are rare, usually random and can introduce variations in a species through a new allele.
- A mutagen is an agent which can cause a change in the DNA sequence.
- Example of a mutation: Sickle cell anaemia where the gene that controls the production of haemoglobin in red blood cells is mutated.

Heritable characteristics and selection for breeding:

1 Polled condition in cattle:

- Polled cattle are those without horns and this is controlled by genes.
- Aberdeen Angus cattle are naturally polled, the allele for polled is dominant to the allele for horned.
- When a naturally polled animal is mated with a horned breed, all the offspring will be polled.
- This may be a more desirable trait as it is safer on farms, there is also less bruising on beef carcases, and it is also more economical as farmers don't have to get their herd dehorned.

2. Stem height in pea plants:

- This trait is controlled by genes.
- The allele for tall stems is dominant to the allele for dwarf stems.
- It is more advantageous to have plants with tall stems as they are better able to compete for light to carry out photosynthesis.

Plant applications

- **Crossbreeding is used to produce hybrid seed varieties that are hardier, give a higher yield and are disease resistant.**
- **This process involves transferring the pollen from one plant variety to the stigma of another plant of a different variety.**
- **This method can be carried out to produce superior varieties of cereals and vegetables which can then be reproduced asexually using micro-propagation, eg commercial potato plants.**

Animal applications:

Crossbreeding is used in animal production to ensure genetically superior offspring (hybrid vigour).

Example:

- **Purebred Holstein cows have a high milk yield, but the protein and fat content of their milk is low.**
- **Jersey cows have a lower milk yield but a high protein and fat content.**
- **Holstein cattle crossed with Jersey cattle produce offspring with increased milk yield and a high level of protein and fat**

Artificial insemination (AI), embryo transplantation and sexed semen are used on farms as selective breeding methods.

- **AI allows superior bulls to be used to improve the genetic value of a herd.**
- **Embryo transplantation enables the production of large amounts of good-quality offspring.**
- **Semen samples can be analysed, and the sperm divided into those carrying the X chromosome and those carrying the Y chromosome (sexed semen). Dairy farmers may prefer female calves as they can be reared as replacements.**

Experiment
Inheritance of coat and face colour in cattle

- This investigation may be carried out on the farm.
- A Friesian cow is crossed with a Hereford bull.
- Three traits are to be observed in the offspring: coat pattern, coat colour and face colour.
- The allele for solid coat colour (from Hereford) is dominant.
- The allele for black coat colour (from Friesian) is dominant.
- The allele for white face (from Hereford) is dominant.

Result:

- The dominant alleles are expressed for all three traits.
- The offspring produced has a solid black coat colour with a white face, known as a 'black white head' (below).