WJEC (Eduqas) Biology A-level

Topic 2.4 - Sexual Reproduction in Plants

Definitions and Concepts

Aleurone layer - The protein-rich outermost layer of the endosperm that serves as an important enzyme store.

Anther - The pollen-bearing structure of the stamen.

Carpel - The female part of the plant consisting of a stigma, a style and an ovary.

Cotyledons - Embryonic seed leaves that emerge following germination.

Cross-pollination - A type of pollination in which pollen is transferred from an anther of one plant to a stigma of a different plant. This results in plants with greater genetic diversity.

Dehiscence - The splitting of the anther resulting in the release of pollen grains.

Dicotyledons - Plants that produce seeds that contain two cotyledons; they have two primary leaves.

Double fertilisation - Fertilisation of seed plants in which one male gamete fuses with a female gamete to form a diploid zygote and another fuses with two polar nuclei to form a triploid endosperm nucleus.

Endosperm - The food source surrounding the plant embryo.

Endospermic seed - A seed that contains an endosperm when mature, e.g. maize.

Germination - The process by which a plant grows from a seed.

Gibberellin - A plant hormone, which, during germination, induces the synthesis of amylase by aleurone cells, hydrolysing stored nutrients in the endosperm.

Hilum - A scar on the testa as a result of separation from its funicle.

Insect-pollinated flower - A type of flower that relies on insects to transfer pollen grains between flowers.

Micropyle - A pore in the integument of an ovule through which the pollen tube enters the embryo sac. It remains as a pore in the testa.

Non-endospermic seed - A seed that does not contain an endosperm when mature, e.g. broad bean. Cotyledons serve as the food source.

Ovary - Part of the carpel that holds the ovules and following fertilisation, develops into the fruit.

Ovule - The part of the ovary that gives rise to and contains the female germ cell. After fertilisation, the ovule becomes the seed.

Petals - Structures that surround the reproductive parts of a flower. They are often brightly coloured and fragrant to attract insects.

Plumule - The part of a plant embryo that develops into the primary shoot.

Pollen grain - A single granule of pollen that contains the male haploid gamete. Grains are small and produced in large numbers in wind-pollinated plants, whereas they are large and sticky in insect-pollinated plants.

Pollen tube - A hollow tube that grows from a pollen grain to the embryo sac in the ovule after pollination. It delivers two male gametes.

Pollination - The deposition of pollen onto a stigma from an anther.

Radicle - The part of a plant embryo that develops into the root.

Self-pollination - A type of pollination in which pollen is transferred from an anther of a plant to a stigma of the same plant. This results in plants with less genetic diversity.

Stamen - The male part of the plant consisting of an anther and a filament that is involved in the production of male gametes in the form of pollen grains.

Stigma - The sticky structure of the carpel that receives pollen grains.

Tapetum - A specialised layer of cells within the anther that provide nutrients to developing pollen grains.

Testa - The outer covering of a seed, commonly referred to as the seed coat.

Vicia faba - A species of flowering plant, commonly known as the broad bean, that is cultivated for its nutrient-rich seeds.

Wind-pollinated flower - A type of flower that relies on wind to transfer pollen grains between flowers.

2.5 - Inheritance

Allele - A version of a gene.

Autosomal linkage - When two or more genes are positioned on the same autosome. They are unlikely to be separated by crossing over during meiosis so are often inherited together.

Autosome - A chromosome that is not an X or Y chromosome.

Carcinogen - A type of mutagen that causes cancer.

Chi-squared (X^2) test - A statistical test used to determine whether a pattern of inheritance is statistically significant.

Chromosome mutation - A change in the structure or number of chromosomes. This affects many genes.

Codominance - When both alleles for a gene in a heterozygous organism equally contribute to the phenotype.

Degrees of freedom (X^2 test) - The number of categories minus one.

Dihybrid mendelian inheritance - The determination of a trait by the inheritance of two genes.

Dominant - Describes an allele that is always expressed. Represented by a capital letter.

Down's syndrome - A genetic disorder characterised by delayed development and learning disabilities. Due to non-disjunction, an affected individual possesses three copies of chromosome 21.

Duchenne muscular dystrophy (DMD) - An X-linked recessive condition characterised by muscle degeneration and weakness. It is more common among males because they only inherit one X chromosome.

Epigenetics - The study of changes in gene expression that are not due to alterations in the nucleotide base sequence of DNA.

F_1 generation - The first generation of offspring resulting from the cross of two individuals in the parental generation.

F_2 generation - The second generation of offspring resulting from the cross of two individuals in the F_1 generation.

Gene - A length of DNA on a chromosome that codes for the production of one or more polypeptide chains and functional RNA.

Gene mutation - A change to at least one nucleotide base in DNA or the arrangement of bases. Gene mutations can occur spontaneously during DNA replication and may be beneficial, damaging, or neutral.

Genotype - An organism's genetic composition. Describes all alleles.

Haemophilia - An X-linked recessive condition that results in excessive bleeding and blood that is slow to clot. It is more common among males because they only inherit one X chromosome.

Heterozygous - When someone has two different alleles of a gene e.g. Ff.

Histone modification - The alteration of histones by the addition of methyl, acetyl or phosphate groups. This can increase or decrease gene expression by making the histone more or less accessible to transcription factors.

Homozygous - When someone has two identical alleles of a gene e.g. ff.

Locus - The position of a gene on a chromosome.

Methylation - The transfer of methyl groups to cytosine bases of DNA. Methylation inhibits transcription by making the DNA less accessible to transcriptional factors or preventing transcriptional factors from binding. This deactivates the gene.

Monohybrid mendelian inheritance - The determination of a trait by the inheritance of a single gene.

Mutagen - A chemical, biological or physical agent that increases the rate of gene mutations above normal level.

Non-disjunction - The failure of homologous chromosomes to separate in anaphase I or sister chromatids to separate in anaphase II, resulting in a change in the diploid number of chromosomes.

Oncogene - Mutations of proto-oncogenes that are activated continuously, resulting in uncontrolled cell division.

Phenotype - An organism's observable characteristics. Due to interactions of the genotype and the environment.

Recessive - Describes an allele that is only expressed in the absence of a dominant allele. Represented by a small letter.

Sex chromosome - A chromosome that determines the sex of an organism, e.g. X and Y chromosomes in humans and other mammals.

Sex-linkage - Genes which are usually inherited together on the same sex chromosome (on either the X or Y chromosome in animals) and so expression is sex-dependant. This is often due to many gene loci on the X chromosome having no counterpart on the Y chromosome.

Sickle cell anaemia - A recessive genetic disorder caused by a substitution mutation on chromosome 11. This results in abnormal haemoglobin which distorts red blood cells.

2.6 - Variation and evolution

Allele frequency - The number of times an allele appears at a particular locus in a population, expressed as a proportion or a percentage.

Allopatric speciation - A form of speciation that occurs when two populations become geographically isolated.

Behavioural isolation - The reproductive isolation of two populations due to differences in their behaviour, e.g. different mating rituals.

Continuous variation - A type of variation that cannot be categorised e.g. skin colour, height. It produces a continuous range in which a characteristic can take any value. Multiple genes influence continuous variation and it is often significantly affected by environmental factors.

Discontinuous variation - A type of variation that can be categorised e.g. blood group. A characteristic can only appear in discrete values. One or two genes influence discontinuous variation and environmental factors have little effect.

Evolution - The gradual change in the allele frequencies within a population over time. Occurs due to natural selection.

Founder effect - A type of genetic drift in which a few individuals of a species break off from the population and form a new colony. This results in smaller gene pools and an increased frequency of rare alleles.

Gene pool - All of the different versions of genes (alleles) in the individuals that make up a population.

Genetic drift - Variations in allele frequencies in small populations due to chance.

Geographical isolation - A physical barrier (such as a river or mountain) separates two populations of the same species.

Hardy-Weinberg principle - A model that predicts that the ratio of dominant and recessive alleles in a population will remain constant between generations if the following five conditions are met: no new mutations; no natural selection; no migration; large population; and random mating. It provides a formula for calculating the frequencies of alleles:

$$p^2 + 2pq + q^2 = 1.0$$

where p is the frequency of the dominant allele and q is the frequency of the recessive allele.

Heritable variation - Genetic differences between individuals.

Hybrid fertility - The formation of fertile hybrid offspring (e.g. wheat) due to hybridisation combined with polyploidy which doubles the chromosome number, enabling meiosis.

Hybrid sterility - The formation of sterile hybrid offspring (e.g. the mule) from the reproduction of individuals of different species; the chromosome sets from each parent differ so are unable to pair up during meiosis.

Interspecific competition - A type of competition that takes place between members of different species.

Intraspecific competition - A type of competition that takes place between members of the same species.

Morphological isolation - The reproductive isolation of two populations due to the incompatibility of their reproductive systems.

Natural selection - The process by which the frequency of beneficial alleles gradually increases in a population's gene pool over time. This theory was developed by Charles Darwin.

Non-heritable variation - Acquired differences in the phenotypes of individuals that cannot be inherited.

Reproductive isolation - The inability of two populations of the same species to interbreed due to behavioural, morphological or seasonal barriers.

Seasonal isolation - The reproductive isolation of two populations due to differences in their breeding seasons.

Selection pressures - Environmental factors that drive evolution by natural selection and limit population sizes e.g. competition, predation and disease. They can change the frequency of alleles in a population.

Speciation - The formation of new species due to the evolution of two reproductively separated populations. Two forms: allopatric and sympatric speciation.

Species - A group of similar organisms that are able to breed with one another to produce living, fertile offspring.

Student's t-test - A statistical test used to determine whether there is a statistically significant difference between the means of two data sets that show normal distribution.

Sympatric speciation - A form of speciation that occurs when two populations within the same area become reproductively isolated.

Variation - The differences between individuals due to genes, the environment or a combination of both.

2.7 - Application of reproduction and genetics

Anopheles gambiae - The vector of malaria, otherwise known as the mosquito. It has rapidly evolved resistance to many insecticides.

Clones - The genetically identical offspring produced as a result of cloning.

Cloning - A method of producing genetically identical offspring by asexual reproduction.

Complementary DNA (cDNA) - A single strand of DNA complementary to the mRNA template strand which is usually synthesised during reverse transcription.

Cystic fibrosis - A genetic disorder characterised by the production of thick, sticky mucus that causes lung infections and scarring.

DNA ladder - A set of DNA fragments of known size (standards) used to estimate the fragment lengths of a molecule run on a gel during electrophoresis.

DNA ligase - An enzyme that joins the sugar-phosphate backbone of two DNA segments.

DNA polymerase - An enzyme that synthesises a double-stranded molecule of DNA from a single template strand using complementary nucleotides.

Drisapersen - An experimental drug which aims to treat DMD by exon skipping. It introduces a 'molecular patch' over the mutated exon, enabling the gene to be read. A shorter, more functional type of dystrophin is synthesised.

Duchenne muscular dystrophy (DMD) - An X-linked recessive condition that is characterised by muscle degeneration and weakness. It is caused by one or more mutations in the dystrophin gene that prevent the production of dystrophin.

Exon - A region of DNA that codes for an amino acid sequence.

Functional mRNA - The final mRNA product that has had introns removed, as well as having undergone other post-transcriptional changes.

Gel electrophoresis - A technique that separates nucleic acid fragments or proteins by size using electric current.

Gene therapy - A therapeutic technique in which a faulty allele is replaced with a functional allele in order to treat or prevent disease.

Genetically modified (GM) organism - An organism that has had its genome altered.

Genetic counselling - A service that provides information and advice to people affected by or at risk of genetic diseases. This helps individuals and families to make informed decisions.

Genetic engineering - The modification of the genome of an organism by the insertion of a desired gene from another organism. This enables the formation of organisms with beneficial characteristics.

Genetic fingerprinting - A technique used to genetically identify an organism. It has applications in forensics.

Genetic screening - Testing individuals for certain faulty alleles. This can be used to detect disorders such as cystic fibrosis, Huntington's disease and thalassemia.

Genomics - A field of biology that focuses on the evolution, structure, function and mapping of genomes.

Germ line therapy - A type of gene therapy in which a faulty allele is replaced with a functional allele in germ cells or a very early embryo. The effects of this are permanent and can be inherited.

Human Genome Project - An international research project involving thousands of scientists which used Sanger sequencing to successfully map the entire human genome.

Huntington's disease - A genetic disorder characterised by the progressive degeneration of nerve cells in the brain, reducing the affected individual's ability to think, talk and move.

Intron - A non-coding sequence of DNA.

Malaria - A disease caused by the protoctista *Plasmodium* that lives within two hosts, mosquitoes (*Anopheles gambiae*) and humans. It causes recurrent episodes of fever and can be fatal.

Marker gene - An additional gene inserted into a plasmid that is used to aid in the identification of host cells that have taken up the desired gene. Marker genes are easily recognisable e.g. provide antibiotic resistance.

Next-generation sequencing (NGS) - The method of DNA sequencing used in the 100K Genome Project. It is faster, cheaper and more accessible than Sanger sequencing.

Personalised medicine - A form of medical care that enables doctors to provide healthcare customised to an individual's genotype.

Plasmodium sp. - The parasite that causes malaria. It has developed multi-drug resistance.

Polymerase Chain Reaction (PCR) - An *in vitro* technique used to rapidly amplify fragments of DNA.

Post-transcriptional processing - A set of biological processes, including the removal of introns, that modify pre-mRNA to produce functional mRNA following transcription.

Pre-mRNA - The product of transcription before any post-transcriptional regulation.

Primers - Short nucleotide sequences, complementary to one end of each of the DNA fragments.

Recognition sequences - Specific base sequences of DNA that restriction enzymes cut.

Recombinant DNA - A combination of DNA from two different organisms.

Recombinant DNA technology - The process by which segments of DNA are transferred from one organism to another.

Restriction endonucleases - Enzymes that cut DNA molecules at recognition sequences creating sticky ends.

Reverse transcriptase - An enzyme that synthesises DNA from RNA.

Sanger sequencing - The method of DNA sequencing used in the Human Genome Project that involves the formation of DNA fragments of varying lengths. This process takes a long time.

Short tandem repeats (STRs) - Sections of repeated nucleotides within introns that produce variation in individuals.

Somatic cell therapy - A type of gene therapy in which a faulty allele is replaced with a functional allele in affected somatic cells. The effects of this are temporary and cannot be inherited.

Stem cells - Cells that are unspecialised and retain the ability to differentiate into a range of cell types.

Sticky ends - The staggered cut formed by restriction endonucleases in double-stranded DNA.

Taq DNA polymerase - A thermally stable enzyme that synthesises a double-stranded molecule of DNA from a single template strand using complementary nucleotides.

Thalassaemia - A group of genetic disorders that result in reduced haemoglobin production.

Thermocycler - A machine controlled by a computer that varies temperatures at predetermined time intervals.

Tissue engineering - An extension of gene therapy that aims to replace, repair or improve biological function by replacing organs and tissues.

Transformation - The reinsertion of plasmids back into bacterial cells to form transgenic bacteria. This involves mixing the plasmids and bacterial cells.

Vector - A carrier used to transfer a gene from one organism to another e.g. plasmid.

100K Genome Project - A UK Government project that aims to study variation in the human genome amongst 100,000 UK citizens. It uses Next Generation Sequencers (NGS).