WJEC (Wales) Biology GCSE

Topic 2.3: DNA and Inheritance

Notes

('Higher Tier only' in **bold**)

DNA

DNA is a double-stranded polymer of nucleotides, wound to form a double helix.

Each strand consists of alternating sugar and phosphate molecules. The two strands are joined by a pair of bases. There are four bases: A (adenine), T (thymine), C (cytosine) and G (guanine). **A pairs with T and C pairs with G.**

A gene is a section of DNA. It codes for a protein.

- **A sequence of three bases in a gene forms a triplet.**
- **Each triplet codes for an amino acid.**
- **Order of amino acids determines the structure and function of the protein formed.**

Genetic profiling

Genetic profiling is a method of comparing DNA:

1. Sample of cells collected
2. DNA extracted from cells
3. DNA sample cut into fragments using enzymes
4. Fragments separated into bands, creating a genetic profile

The patterns of the bands can be compared to view similarities in the DNA sequences.

Genetic profiling can be used for:

- Paternity testing
- Forensics
- Classification
- Detecting genes

Key genetic terms

Term	Definition
Gene	A length of DNA that codes for the production of a particular protein
Allele	A version of a gene
Gamete	Reproductive cells (e.g. egg and sperm cells) that contain a single copy of each chromosome
Dominant	Describes an allele that is always expressed

	Represented with a capital letter e.g. F
Recessive	An allele that is only expressed in the absence of a dominant allele Represented with a small letter e.g. f
Homozygous	Having two identical alleles of a gene e.g. FF or ff
Heterozygous	Having two different alleles of a gene e.g. Ff
Genotype	An organism's genetic composition, describes all alleles
Phenotype	An organism's observable characteristics
F1 generation	First generation in a genetic cross - the offspring produced when two organisms interbreed
F2 generation	Second generation in a genetic cross - the offspring produced when two organisms from the F1 generation are bred together
Selfing	An artificial method of self-pollinating plants

Inheritance

Single gene inheritance

Most characteristics of an organism are determined by multiple genes interacting, however some are determined by a single gene. Monohybrid inheritance is the inheritance of a single gene. A punnett square can be used to illustrate this single gene inheritance.

E.g. PKU is a recessive condition. Two heterozygous parents (Pp) have offspring. Predict the proportion of offspring that will have PKU.

		Female genotype	
		P	**p**
Male genotype	**P**	PP	Pp
	p	Pp	pp

The outcomes are PP, Pp and pp.

As P is dominant, there is a 75% chance that the offspring will not have the PKU phenotype (PP and Pp). However, those offspring that have the 'Pp' genotype are carriers.

There is a 25% chance that the offspring will have PKU (pp).

E.g. Cystic fibrosis is a recessive condition. A female who is homozygous recessive for cystic fibrosis (ff) has a child with a heterozygous male (Ff). Work out the ratio of offspring genotypes.

		Female genotype	
		f	**f**
Male genotype	**F**	Ff	Ff
	f	ff	ff

The outcomes are Ff and ff.

There is a 50% chance of the offspring being a carrier (Ff)
There is a 50% chance of having cystic fibrosis (ff)
∴ ratio of carriers (Ff) to individuals with cystic fibrosis (ff) is 1:1

Sex determination in humans

Sex chromosomes are one of the 23 pairs of chromosomes that determines sex:

- Males have an X and a Y chromosome (genotype XY)
- Females have two X chromosomes (genotype XX)

Meiosis produces gametes with half the number of chromosomes and thus a single sex chromosome. All egg cells contain an X chromosome only whilst male sperm cells may contain an X or a Y chromosome. The baby's gender therefore depends on which sperm cell fertilises the egg.

A punnett square can be used to illustate sex determination:

		Female genotype	
		X	**X**
Male genotype	**X**	XX	XX
	Y	XY	XY

There is a 50% chance of the offspring being a female (XX) or a male (XY)

Genetic engineering

Genetic engineering is the modification of the genome of an organism by the insertion of a desired gene from another organism. It enables the formation of an organism with beneficial characteristics. Genetically engineered organisms are known as GM organisms.

There are both benefits and risks of genetic engineering:

Benefits	Risks
• Increased crop yields for growing population e.g. herbicide-resistance, disease-resistance. • Useful in medicine e.g. insulin-producing bacteria, anti-thrombin in goat milk. • GM crops produce scarce resources e.g. GM golden rice produces beta-carotene (source of vitamin A in the body). • GM crops can produce oils which can be used as biofuels, an alternative to fossil fuels.	• Long-term effects of consumption of GM crops are unknown. • Negative environmental impacts e.g. reduction in biodiversity, impact on food chain, contamination of non-GM crops forming 'superweeds'. • GM seeds are expensive. LEDCs may be unable to afford them or may become dependent on businesses that sell them. • GM plants could become a pest themselves e.g. due to herbicide-resistance.