

AQA A-Level Biology Revision Notes (Year 2)

Module 7 (Population, Evolution, Inheritance) Revision Notes

What is a species? group of organisms with similar characteristics that can interbreed to produce fertile offspring

What is a population? all the individuals of a particular species in a particular place

What is a community? all the population of different species in a particular place

What is a habitat? the place where an organism lives

What is an ecosystem? a mix of different communities and habitats and how they interact based on abiotic and biotic factors

What is ecological niche? an organisms role/position in an ecosystem – in terms of its interaction with abiotic and biotic factors

Why can 2 different species not occupy the same ecological niche? interspecific competition will take place for the limiting factors/resources (abiotic & biotic factors) – better adapted species will out compete the other = competitive exclusion principle

How to sample plant species over a large area?

- obtain a map of the area
- divide the map into grids
- select a large number of coordinates using a running mean
- select a random set of coordinates using a random number chart
- in each coordinate place a quadrat
- measure abundance of the plant species in each quadrat = frequency or percentage cover
- calculate average for the whole area

How to sample plants species along a path?

- use a transect
- place a tape along the path, count number of plants touching tape (Line Transect)
- or
- place a tape along the path, at regular intervals along the tape place a quadrat, measure abundance within the quadrat (Belt Transect)

How to sample animal species in an area?

- mark-release-recapture technique
- set a trap
- capture the animal species [Sample 1]
- mark them (tag or fluorescent marker – ensure its non-toxic and not harmful)
- release them
- after some time (sufficient time for them to mix with the whole population), replace the trap

- count number in 2nd set [Sample 2] and count the number marked
- estimate population size by: number in sample 1 x number in sample 2
marked in sample 2

Assumptions of Mark-release-recapture technique?

- no births or deaths
- no immigration or emigration
- marked animals mix evenly with population
- mark is not toxic
- mark does not come off
- large population

What are the 3 stages of population growth?

- slow/lag phase: species becomes adapted to new environment
- rapid/log phase: species adapted, abundant resources, doubling with reproduction,
birth rate > death rate
- stationary phase: resources become limited, intraspecific competition occurs,
birth rate = death rate

How are resources/limiting factors grouped?

- abiotic (non-living): light, temperature, water, O₂/CO₂, minerals, pH, living space
- biotic (living): predator, prey, mates, competition, disease

What is competition? when organisms compete for resources (abiotic and biotic)

What are the 2 types of competition?

- intraspecific: occurs between organisms of the same species, only occurs when resources become limited, leads to natural selection and adaptation
- interspecific: occurs between organisms of different species, can happen at any time even if resources are not limited, leads to formation of climax communities

Describe the predator/prey relationship?

- prey increases in number
- more food available for predator
- predator increases in number (more energy available for reproduction & growth)
- predator eats more of the prey
- prey decreases in number
- less food available for predator
- predator decreases in number
- less of the prey are eaten
- prey increases in number [cycle repeats]

What is succession? how an ecosystem changes over time (change in species diversity and habitat diversity) – relies on environment being made less hostile by present species via death and decomposition leading to it being outcompeted and replaced by larger better adapted species

What are the 2 types of succession? primary (occurs on new land) and secondary (occurs on previously colonised land that has become bare e.g. after a forest fire)

Describe Primary Succession?

- new land appears (glacier retreats exposing rock, lava cools, sand dunes)
- pioneer species settle [adapted to surviving in hostile conditions of bare land]
- pioneer species are:
- producers
- have mutualistic NFB
- asexually reproduce (one parent, genetically identical, faster)
- xerophytes
- handle extreme conditions (extreme wind & extreme temperatures on bare land)
- have wind dispersed seeds (spread wide – reduce competition, find favourable environments)
- can anchor to land
- over time – the land erodes and soil forms, pioneer species die and decompose adding humus & nutrients to the soil
- small plants can now grow
- they out compete the pioneer species
- over time – more soil forms, small plants die and decompose adding more humus & nutrients to the soil
- large plants can now grow, they out compete the small plants
- this process continues until the climax community is reached
- the climax community contains the best adapted species to the environment (they are the final community, there will be no more succession after them)

Properties of Succession?

- species diversity increases (peaks just before climax – species in climax will out compete others)
- habitat diversity increases
- environment becomes less hostile
- food chains become more complex & biomass increases

Primary succession vs Secondary succession? secondary succession starts from small plants not pioneer species (soil and nutrients already present) and secondary succession is faster (soil, nutrients and seeds already present)

How can conservation be used to prevent succession?

- used to prevent formation of woody forests – either on hill sides (for tourism) and farms (space for crops)
- involves: deforestation, burning trees, grazing, using pesticides

What is Evolution? change in allele frequency in a population

What are the 2 Types of Evolution? Adaptation and Speciation

What is Adaptation? a species adapting to changes in the environment (e.g. new diseases or change in climate) – driven by natural selection, where most of the individuals in the species will have the favourable allele/characteristic for that environment

Process of Adaptation?

- variation in population of species
(genetic diversity/genetic variation/variety in gene pool)
- new alleles arise by random mutation
- environment applies a selection pressure on the population
- those with favourable characteristics/alleles survive, the others die [natural selection]
- the ones that survive will reproduce, passing on their favourable alleles = reproductive success
- if this happens for many generations, then that characteristic will become most common – the favourable alleles will become more frequent [adaptation]

What are the 3 types of selection? stabilising and directional and disruptive

What is stabilising selection?

- when the environment favours those with the most common characteristic – those on the extreme dies out
- the common characteristic increases in proportion
- the range (standard deviation) will reduce

What is directional selection?

- when the environment favours those individuals with characteristics on one of the extremes
- over time this will become the most common characteristic
- normal distribution will shift to that extreme

What is disruptive selection?

- when the environment changes between both extreme conditions
- hence, individuals on both extremes are favoured at different times and increase in number
- those in the middle (average) will decrease in number

What is Speciation? process by which new species arise from existing species

What are the 2 Types of Speciation? Allopatric and Sympatric

What is Allopatric Speciation? speciation driven by geographical isolation

Describe Allopatric Speciation?

- start with a population of species
- variation in the population
- population separated into different groups by geographical isolation
- each group is exposed to different environments/selection pressures
- each group undergoes different directional selections
- therefore each group changes so much in genetic diversity (variety of alleles) that they can no longer interbreed with each other to produce fertile offspring = different species
- changes include different courtship behaviour or incompatible gametes

What is Sympatric Speciation? speciation occurring in the same geographical area (driven by random mutation)

What is inheritance? offspring inheriting a combination of alleles (2 types – paternal/maternal) for each gene which will help determine characteristics

What is a gene? a section of DNA that codes for a protein

What is an allele? a type/form of a gene

What is a dominant allele? an allele that is always expressed if present

What is a recessive allele? an allele that is only expressed if 2 are present

What is genotype? combination of alleles for a particular gene

What is phenotype? expressed/observed characteristic (if discontinuous – only determined by genotype, if continuous – determined by genotype and environment)

What is homozygous? having 2 of the same alleles (homozygous dominant – 2 of the same dominant alleles, homozygous recessive – 2 of the same recessive alleles)

What is heterozygous? having 2 different alleles

What is Monohybrid Inheritance? inheritance dealing with One Characteristic

Examples of Monohybrid Inheritance?

- Dominant/Recessive
- Codominant
- Multiple Allele

- Sex Linkage

What is the Expected Ratio for Monohybrid Dominant/Recessive?

3 Dominant to 1 Recessive

Why are Observed Ratios different from Expected Ratios?

- random fertilisation of gametes
- small sample size
- mutation
- selection

How can 2 parents with a dominant characteristic give birth to a child with a recessive characteristic? if both parents are Heterozygotes (carriers for recessive allele) they have a 25% chance of giving birth to a child who is Homozygous Recessive (has the recessive characteristic)

What is co-dominance? when 2 different dominant alleles are inherited, both will be expressed in the phenotype

What are multiple alleles? when the gene has more than 2 alleles (e.g. blood group)

Alleles for blood group?

- I^A, I^B, I^O
- I^A gives A antigen on RBC
- I^B gives B antigen on RBC
- I^O gives no antigen on RBC
- I^A, I^B are codominant
- I^O is recessive

Genotypes/Phenotype for blood group?

- A = $I^A I^A, I^A I^O$
- B = $I^B I^B, I^B I^O$
- AB = $I^A I^B$
- O = $I^O I^O$

Can receive blood from whom?

- A = from A & O
- B = from B & O
- AB = from A, B, AB, O
- O = only from O

What is a sex-linked gene? a gene carried on one of the sex chromosomes, normally the X chromosome

What is an inherited disease? inheriting a mutated allele that leads to production of a faulty protein, normally a recessive allele (dominant allele will decrease in frequency by natural selection, recessive allele can be carried by heterozygotes)

What is a sex-linked disease? inheriting a mutated allele carried on one of the sex chromosomes, normally a recessive allele & normally carried on X chromosome

Why do males have increased chance of inheriting a sex linked disease rather than females? males only have 1 X chromosome, females have 2 X chromosomes, females can be carriers, males cannot be carriers

What is Dihybrid Inheritance? inheritance dealing with Two Characteristics

Examples of Dihybrid Inheritance?

- Dominant/Recessive
- Autosomal Linkage
- Epistasis

What is the Expected Ratio for Dihybrid Dominant/Recessive?

- 9 Dominant/Dominant
- 3 Dominant/Recessive
- 3 Recessive/Dominant
- 1 Recessive/Recessive

What is Autosomal Linkage? 2 Genes (characteristics) carried on the same Chromosome

What is Epistasis? interaction between different genes

What are the 3 Types of Epistasis? Dominant and Recessive and Complementary

What is Dominant Epistasis? dominant genotype on one gene inhibits expression of other gene

What is Expected Ratio for Dominant Epistasis?

- 12 Epistasis (inhibited)
- 3 Expressed (dominant)
- 1 Expressed (recessive)

What is Recessive Epistasis? recessive genotype on one gene inhibits expression of other gene

What is Expected Ratio for Recessive Epistasis?

- 9 Expressed (dominant)
- 3 Expressed (recessive)
- 4 Epistasis (inhibited)

What is Complementary Epistasis? dominant genotype required on both genes to achieve final product

What is Expected Ratio for Complementary Epistasis?

- 9 Final Product
- 7 None

What does Hardy-Weinberg Principle calculate? frequency of an allele in a population

What does the HWP assume? that the frequency will not change over time, based on:

- isolated population
- large population
- random mating
- no mutation
- no selection

What is the HWP?

- p = frequency of dominant allele
- q = frequency of recessive allele
- $p + q = 1$ (100%, all the population)
- p^2 = frequency of homozygous dominant
- $2pq$ = frequency of heterozygous
- $p^2 + 2pq$ = frequency of the dominant condition
- q^2 = frequency of homozygous recessive (of recessive condition)
- $p^2 + 2pq + q^2 = 1$

Module 8 (Genes) Revision Notes

What is a Stem Cell?

- a specialised/undifferentiated cell
- potential to form different types of cells

How does a stem cell become a specialised cell?

- differentiation
- 3 changes: cell shape, number of organelles, new content
- occurs by controlling gene expression (some genes are activated, other genes are inhibited)

Stem Cell in Animals/Mammals/Humans?

- Totipotent = Zygote
- Pluripotent = Embryonic Stem Cells
- Multipotent = Bone Marrow Stem Cell
- Unipotent = Tissues

What are Induced Pluripotent Stem Cells (iPS Cells)?

turning unipotent body cells into pluripotent cells (like embryonic stem cells), involves activating certain deactivated genes using transcription factors

Stem Cell Therapy in Humans?

- 2 uses.
- use stem cells to produce tissues/organs for transplant
- use stem cells to treat irreversible diseases e.g. heart disease, type 1 diabetes, paralysis (inject stem cells at site of disorder – will differentiate to become local specialised cells e.g. heart muscle cells, beta cells of pancreas, neurones)

Stem Cell in Plants?

- In embryo = Zygote/Embryonic Stem Cells
- In adult = Meristem Cells in Stem/Shoot/Root

Uses of Stem Cells from Plants?

- traditionally cuttings were taken from plants (stem/shoot/root) and used to grow genetically identical plants – possible due to presence of meristem cells
- tissue culture (micro propagation) = large scale application of cuttings
- process.
- take cutting from shoot/stem/root (called explant)
- place explant in nutrient rich medium so meristem cells divide by mitosis
- produces a mass of meristem cells (called callus)
- take each meristem cell and grow in plant growth factor medium to promote differentiation and formation of shoot/root
- transfer plant to soil and greenhouse

- then transfer to field

What is Controlling Gene Expression?

- either Activating or Inhibiting a Gene
- activating gene = protein made
- inhibiting gene = protein not made

Example of activating genes?

- using oestrogen
- oestrogen can enter a cell by simple diffusion and bind to receptors on the transcriptional factor
- causes transcriptional factor to change shape
- so transcriptional factor can now enter nucleus and bind to promoters on the DNA to activate transcription
= activated genes (protein to be made)

Example of inhibiting genes?

- using siRNA (small interfering RNA)
- making siRNA = double stranded RNA cut down into small sections, made single stranded, then attaches to an enzyme
- siRNA will bind to complementary sections on mRNA = the enzyme will cut the mRNA so translation cannot occur = gene inhibited (protein not made)

What is Epigenetics?

- Heritable changes in gene function without changes to base sequence of DNA
- Changes may due to lifestyle, stress, diet
- Chromatin (DNA-Histone Complex) is surrounded by an Epigenome (chemical layer)
- Epigenome can either cause the Chromatin to become more condensed or more loose
- Chromatin becoming more condensed means transcription factors cannot reach the DNA and the gene will be inactivated
- Chromatin becoming more loose means transcription factors can reach the DNA and the gene will be activated
- These changes may be brought about by Acetylation or Methylation

How does Methylation and Acetylation affect the Genome?

- Increased Methylation = adding methyl groups, this attracts proteins which condense the DNA-Histone Complex so transcription factors cannot gain access (gene inhibited)
- Decreased Acetylation = removing acetyl groups, increases positive charges on the Histone which increases the attraction to the phosphate groups on DNA which condense the DNA-Histone Complex so transcription factors cannot gain access (gene inhibited)

What is a Gene Mutation?

- a change in the base sequence of DNA
- 2 types = substitution and insertion/deletion
- substitution = replace one base for another, changes one triplet code
can be silent (new triplet code codes for same AA), mis-sense (codes for a different AA, so protein shape changes slightly), non-sense (codes for a stop codon, so polypeptide chain not produced)
- insertion = adding a base, deletion = removing a base
both insertion/deletion causes frameshift, all the triplet codes after the mutation changes, so normal polypeptide chain/protein not produced

What is Cancer?

- formation of a malignant tumour
- due to uncontrolled cell division (mitosis)

Malignant vs Benign Tumour?

Malignant Tumours,

- Rapid Growth (rapidly dividing cells)
- Cells are unspecialised
- Cells can spread (Metastasis)
- Systemic Effects
- Requires Surgery/Chemotherapy/Radiotherapy

What normally controls Cell Division (mitosis)?

- 2 genes: proto-oncogene & tumour-suppressor gene
- both produce proteins to control cell division
- proto-oncogene stimulates cell division
- tumour-suppressor gene inhibits cell division
- proto-oncogene produces growth factor and receptor protein, when the growth factor binds to receptor protein on cells it stimulates DNA replication that leads to cell division
- tumour-suppressor gene produces a protein that inhibits cell division

Cancer?

- caused by mutation of genes that control cell division
- causes of mutation = random or mutagens (chemicals/radiation)
- mutation of proto-oncogene leads to formation of an oncogene = over production of growth factor or receptor proteins permanently active = over stimulation of cell division (uncontrolled cell division)
- mutation of tumour-suppressor gene = loss of protein to inhibit cell division (uncontrolled cell division)

Oestrogen and Cancer?

Oestrogen leads to activation of genes – high levels of oestrogen can lead to over activation of Proto-Oncogen forming an Oncogene = Cancer (uncontrolled cell division)

Epigenetics and Cancer?

Main Example = increased methylation of tumour suppressor genes leads to inhibition of tumour suppressor genes leading to cancer (uncontrolled cell division)

What is Genetic Engineering?

- changing the genetic make-up of an organism's DNA by adding or removing a gene
- the DNA becomes Recombinant
- the Organism becomes Genetically Modified (Transgenic)

Why do we Genetically Engineer Animals?

- to give them additional characteristics
- so they can make useful products (proteins)

Examples of genetic engineering in animals?

- additional characteristics.
- add gene for disease resistance
- add gene for growth hormone for growth
- making useful products.
- use to produce anti-thrombin = protein used to make blood clot (people with certain genetic disease may not produce), use milk producing animal to produce, add gene for anti-thrombin next to milk producing gene in animal, therefore anti-thrombin protein will be made in the milk (easily extracted)

Why do we Genetically Engineer Plants?

- to give them additional characteristics
- so they can make useful products (proteins)

Examples of genetic engineering in plants?

- additional characteristics.
- add gene for disease resistance
- add gene for pest resistance
- add gene for pesticide resistance
- add gene to promote growth for high yield
- produce genetically modified tomatoes = prevented from softening therefore remain hardened (easy for storage and transport), involves preventing formation of softening enzyme, a gene is added that is complementary to the the softening enzyme gene, so its mRNA will bind to the mRNA of the softening enzyme preventing translation of the softening enzyme
- making useful products.

- use to make golden rice (rice that contains beta-carotene, a pre-cursor to vitamin A to treat malnutrition deficiency)
- use to make protein raw material for polymers

Why do we Genetically Engineer Bacteria? so they can make useful products (proteins)

Genetically engineering bacteria?

- to make useful proteins e.g, Insulin
- normally used animal sources (problems = limited supply, infection risk, immunorejection)
- involves adding human insulin gene to a plasmid, then inserting this into a bacteria = the bacteria now has the gene/code to produce the human insulin protein

involves 5 steps =

1. Isolation, 2. Insertion, 3. Transformation, 4. Identification, 5. Growth/Cloning

1. Isolation

- either by Reverse Transcriptase or Restriction Enzyme or Gene Machine
- RT = enzyme found in virus, converts RNA into DNA, obtain mRNA for insulin, the RT will convert it into cDNA (single stranded complementary DNA), DNA Nucleotides and DNA Polymerase added to make it double stranded
- RE = enzyme found in bacteria, cuts DNA at certain base sequences (called recognition sites) by breaking bond between sugar and phosphate, can cut straight or staggered, staggered used in GE as it leaves exposed bases called 'sticky ends' [cuts staggered at 6 base pair palindromes, were the 6 bases read forward are identical to 6 bases read backward on both strands]
- GM = build DNA base sequence from know Amino Acid Sequence of the Protein (uses oligosacchairdes)

end result = Isolated Human Insulin Gene

2. Insertion

- cut plasmid using the same RE from isolation stage
- leaves complementary sticky ends
- join human insulin gene with plasmid via the sticky ends
- use DNA Ligase to join the sugar-phosphate backbone

= Recombinant plasmid (carrying human insulin gene)

3. Transformation

- mix recombinant plasmid with bacteria
- add Ca²⁺ ions and heat shock
- bacteria will become permeable and take up the recombinant plasmid

= Genetically Modified Bacteria (carrying recombinant plasmid with human insulin gene)

4. Identification

- identify which of the bacteria have taken up the recombinant plasmid and of these which ones have accepted the new gene (human insulin gene)

step 1 = choose a plasmid that carries an Ampicillin Resistance Gene, so when Ampicillin is added only the bacteria that have taken up the recombinant plasmid will survive (as they will have obtained the ampicillin resistance gene)

step 2 = use gene markers (antibiotic resistant, fluorescent, enzyme) to identify which of the remaining bacteria have accepted the human insulin gene, the human insulin gene will be placed in the middle of these gene markers, if the bacteria accepts the human insulin gene they will reject the gene marker & if the bacteria rejects the human insulin gene they will accept the gene marker

- antibiotic resistant = tetracycline resistance gene lost if human insulin gene accepted, so bacteria no longer resistant to tetracycline, add tetracycline by replica plating (on another plate that carries a few of the bacteria from each colony in their same position), the ones that die are the ones that we want, identify on original plate
- fluorescent = fluorescent gene lost if human insulin gene accepted, so identify bacteria showing no fluorescence
- enzyme = enzyme gene lost if human insulin gene accepted, therefore add colourless substrate, where there is no colour change select those bacteria (as enzyme not made to breakdown colourless substrate for colour change)

end result = Genetically Modified Bacteria

5. Growth/Cloning

- grow genetically modified bacteria (carrying human insulin gene)
- they will produce the protein (human insulin)

What is PCR?

- polymerase chain reaction
- used to replicate DNA artificially
- step 1: heat to 95°C, hydrogen bonds break, double strand separates, left with 2 template strands
- step 2: cool to 55°C, primers bind (short single stranded sections of DNA) to start of each template strand, prevents the templates from rejoining and allows DNA Polymerase to bind to build the new strand
- step 3: heat to 72°C, DNA nucleotides attach to complementary bases, DNA Polymerase joins sugar-phosphate backbone of the new strands
= 2 copies of DNA (each made of 1 original strand, 1 new strand)

Polymerase Chain Reaction vs Semi-Conservative Replication?

- PCR can only replicate short DNA fragments, SCR can replicate whole DNA
- PCR use 95°C, SCR uses DNA Helicase
- PCR uses primers, SCR does not require primers

In-vitro vs In-vivo method of DNA Replication?

- In-vitro = PCR
- In-vivo = using bacteria to replicate DNA (add DNA fragment to the plasmid, then replicate the bacteria to make many copies of DNA fragment)
- benefits of in-vitro = more rapid, less complex
- benefits of in-vivo = more accurate (less mutations), less chance of contamination

What is a DNA Probe?

- short single stranded section of DNA
- has a specific base sequence, so it binds to complementary genes
- is radioactively/fluorescently labelled
- if gene is present in DNA, DNA probe will bind to it and show up as radioactivity/fluorescence

What is Genetic Screening?

- analyse an individual's DNA for the presence of a particular gene (e.g. mutated allele)
- use DNA Probes (single stranded section of DNA, complementary to a particular gene, is radioactively labelled)
- obtain individual's DNA, make it single stranded, add the specific DNA Probe for the gene to be screened for, if the gene is present the DNA Probe will bind, will show up as radioactivity on an X-ray film

What is Genetic Fingerprinting?

- used to produce a unique 'fingerprint' of an individual's DNA (produces a specific banding pattern)
- used in forensics and paternity testing
- involves analysing the individual's introns (non-coding DNA)
- introns contain repetitive sequences called variable number tandem repeats (VNTR)
- the number and length of the VNTR are unique for each individual organism

involves 5 steps:

1. Extraction, 2. Digestion, 3. Separation, 4. Hybridisation, 5. Development

1. Extraction

- extracting the individual's DNA

2. Digestion

- cutting the DNA down into fragments
- use Restriction Enzymes that cut just outside the VNTR (leaves the VNTR of the introns)

3. Separation

- separate out the DNA fragments by gel electrophoresis
- add alkali to make the separated fragments single stranded
- transfer the fragments to a nylon membrane by Southern Blotting
- add UV light so the DNA fragments set

4. Hybridisation

- add radioactively labelled DNA Probes complementary to the DNA fragments

5. Development

- add photographic film and take an x-ray to produce the banding pattern picture

What is Genome Sequencing?

- determining base sequence of a genome (full set of DNA)
- uses Whole-Genome Shotgun (WGS) to cut DNA into smaller sections to be sequenced
- Bioinformatics is the science by which the information is collected and analysed
- uses = supports phylogenetic classification, identify genes related to diseases

What is a Proteome?

- full set of proteins produced by a certain genome