ATARNotes

Biology 3/4

ATARNotes October Lecture Series

Presented by:
Sruthy

Overview

About me:

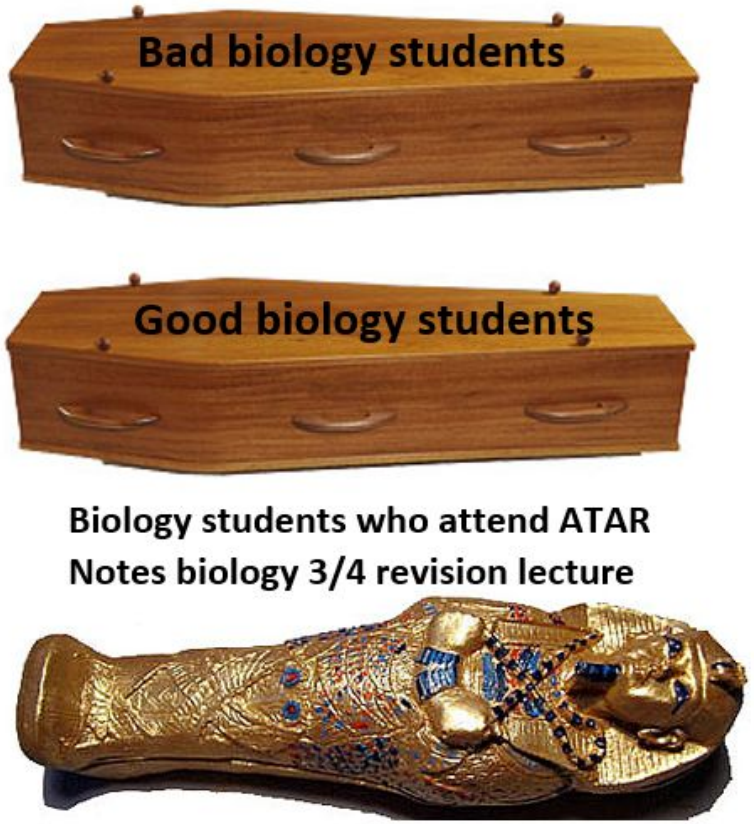
Hi ! I'm Sruthy

- Graduated in 2023 with a 97.30 ATAR
- Raw 50 HHD, 40 Bio, 43 Psych
- I tutor VCE Biology, Psychology and HHD
- Currently doing biomed
- Run a YT channel (Biologue)
- Like to edit videos, sing and listen to music :)

Overview

LECTURE OUTLINE

- Lecture outline:
- Nucleic Acids
- Enzymes
- Photosynthesis & Respiration
- Immunity
- Genetics
- Exam Prep

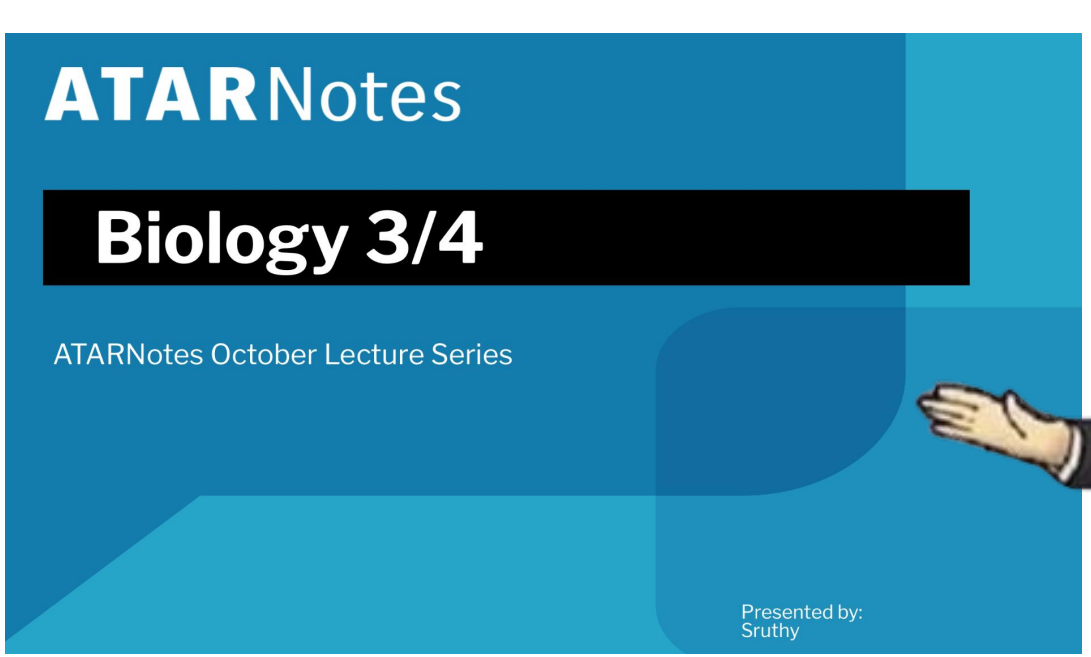


Note: the lecture slides and recording will be available to download, so don't stress if you forget to write something down!

Overview

SOME BIO WISDOM

ATAR Notes Lecturer: *slaps Unit 3/4 Revision Lecture slides* this bad boy can fit so much useful information in it



Overview

DNA + RNA

SIMILARITIES

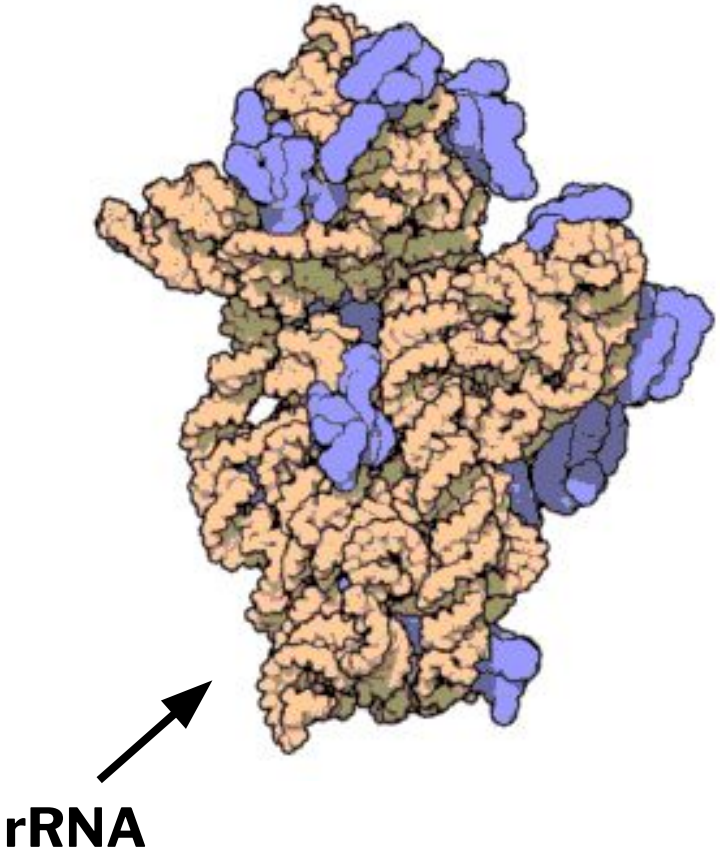
- Phosphate backbone
- Complementary base pairing
- 2 bonds between A + T(U) and 3 between C + G
- Made of nucleotides
- Overall negative charge

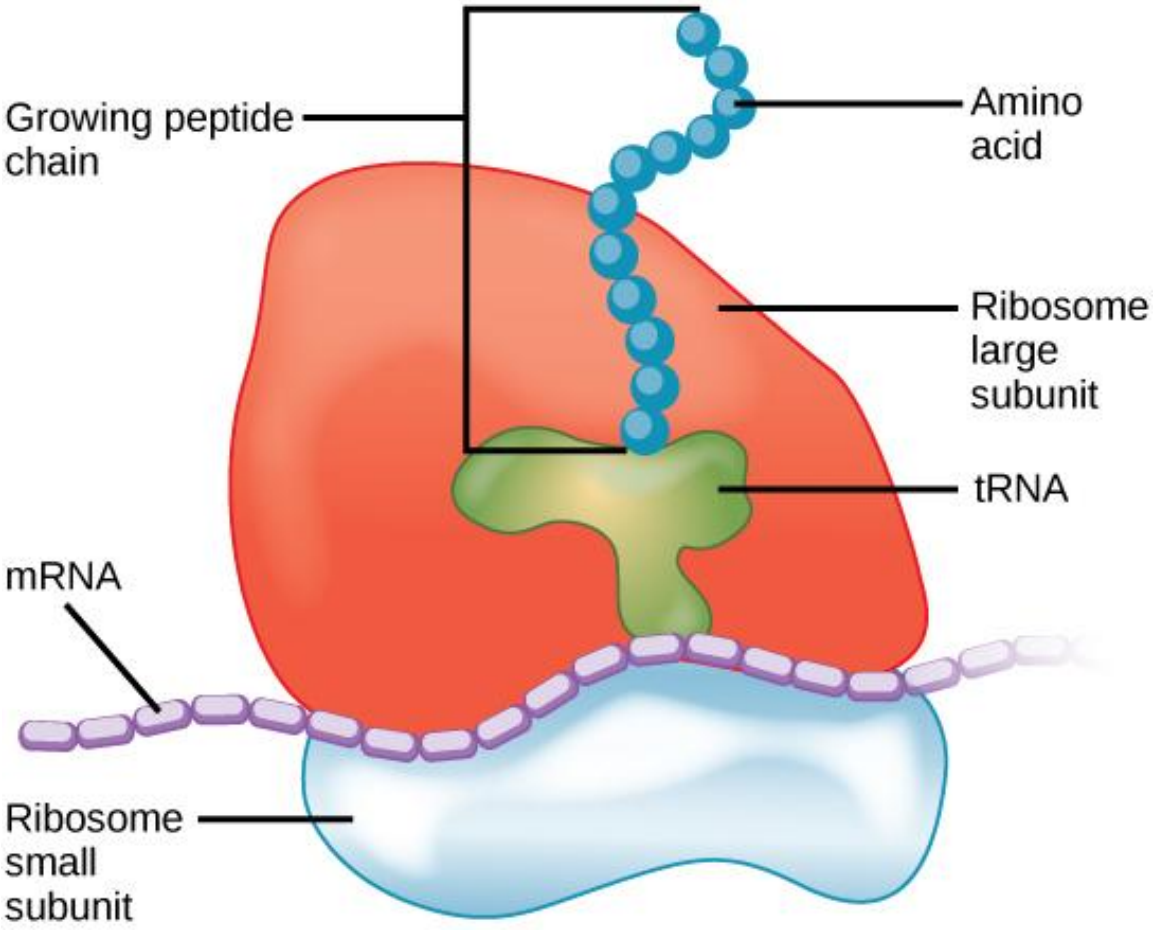
DIFFERENCES

- Pentose sugar molecule
  - Ribose vs Deoxyribose
- DNA double stranded vs RNA single stranded
- DNA thymine, RNA uracil
- DNA stays in the nucleus
  - (besides some in mitochondria and chloroplasts)
- RNA in nucleus and cytoplasm
- DNA long, RNA short

Overview

Types of RNA





Overview

DNA as a Genetic Code

- **Gene:** a segment of DNA that instructs for a certain protein's production
- How does DNA code for specific proteins??
  - It's all in the bases
- **Three** consecutive bases in DNA = a **triplet**
- **DNA triplet** gets transcribed into an **RNA codon** (three consecutive RNA bases)
- **Each RNA codon** gets translated into **one** amino acid in a polypeptide chain
- Therefore, each DNA triplet 'codes' for one amino acid molecule to be inserted into a polypeptide

Overview

Gene Expression: Part 1

- The process of producing mRNA from a DNA template
- **Occurs in the nucleus**

1. **RNA polymerase** (an enzyme) binds to the **promoter region** of the gene to be transcribed on the **template strand** of DNA

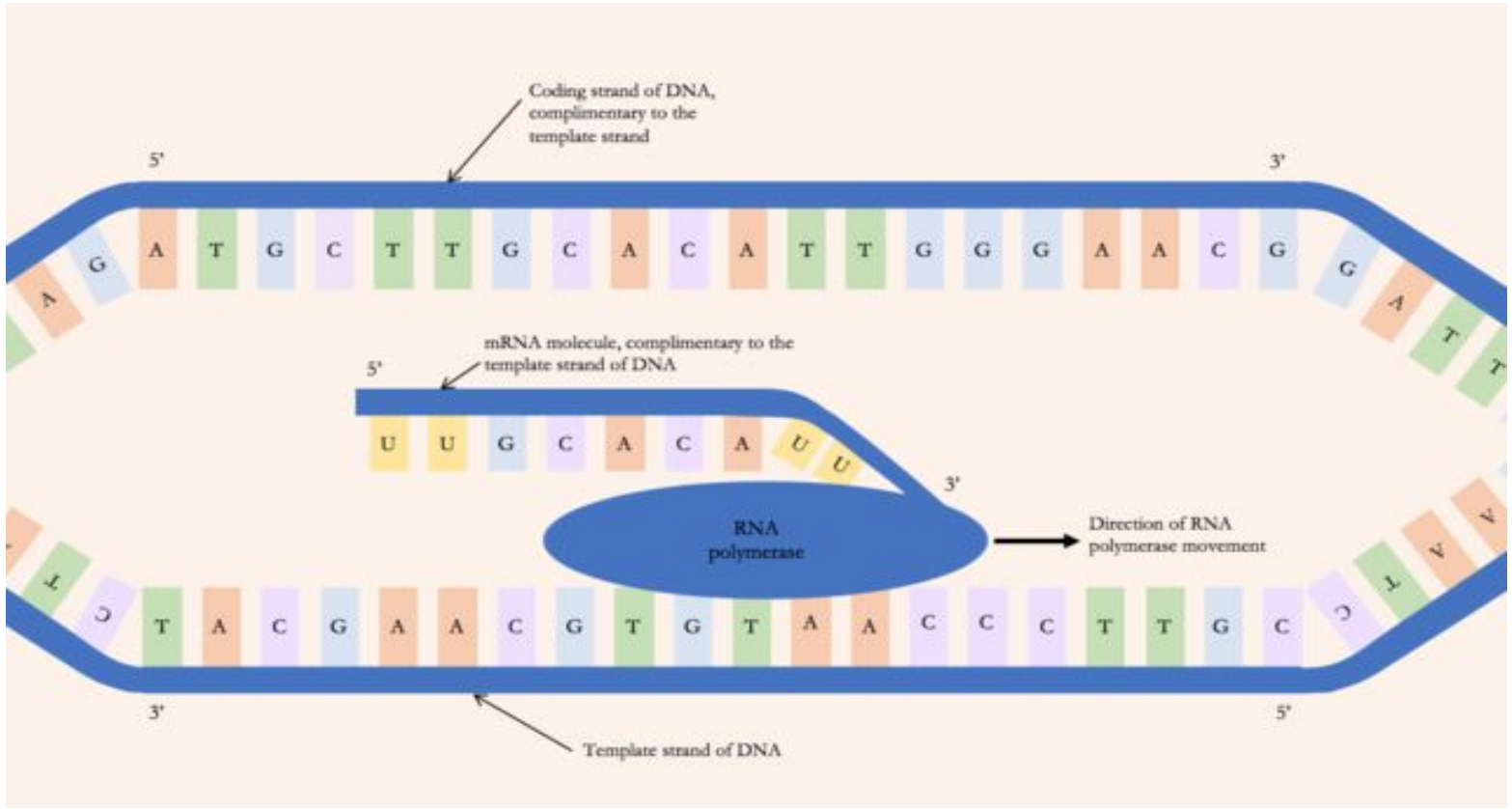
1. The RNA polymerase molecule unwinds the DNA and moves along the template strand '**reading**' it in a **3' to 5'** direction whilst **synthesising RNA** by **joining ribonucleotides in the 5' to 3'** (remember strands are anti-parallel)

1. When RNA polymerase reaches the end of the gene (**terminator region**), the pre-mRNA molecule will be released

1. The pre-mRNA strand is **complementary to the template strand** and has the **same sequence as the coding strand** (except that T is replaced with U)

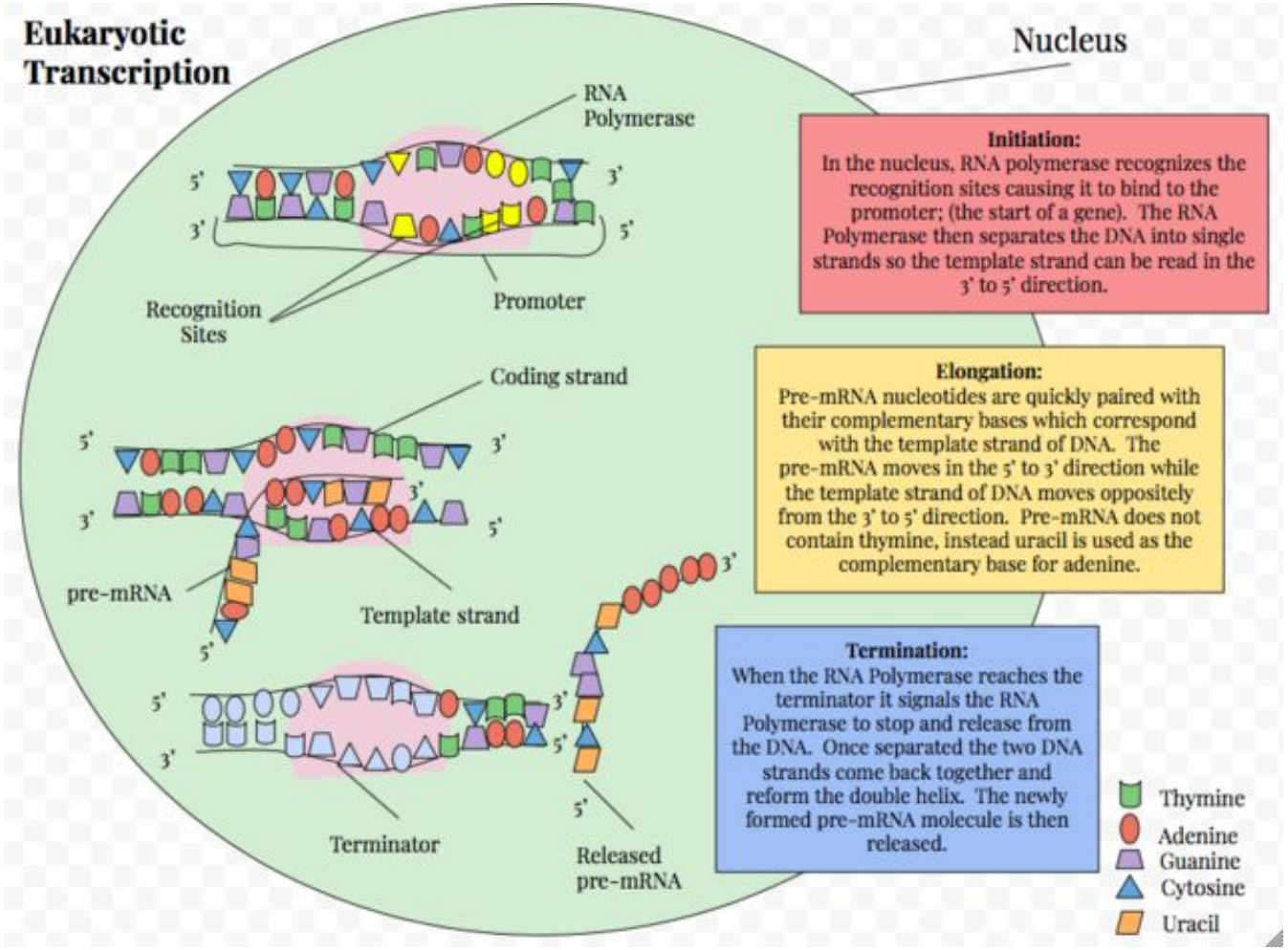
Overview

4. The pre-mRNA strand is **complementary to the template strand** and has the **same sequence as the coding strand** (except that T is replaced with U)



Overview

Transcription



Overview

Gene Expression: Part 2

- **Eukaryotic cells** undergo three important types of post transcriptional modifications within the nucleus:

1. Introns are removed and exons are joined together (***splicing***)
   - Introns are non-coding regions
   - Exons are coding regions
   - This means that mature mRNA is shorter than pre-mRNA

2. A methyl guanosine cap is added to the **5' end** of the RNA molecule (***5' capping***)

1. A poly-A tail is added to the **3' end** of the RNA molecule

- Once these modifications have taken place, the RNA molecule is ***mature mRNA*** and will leave the nucleus and move to a ribosome (free or attached to RER)

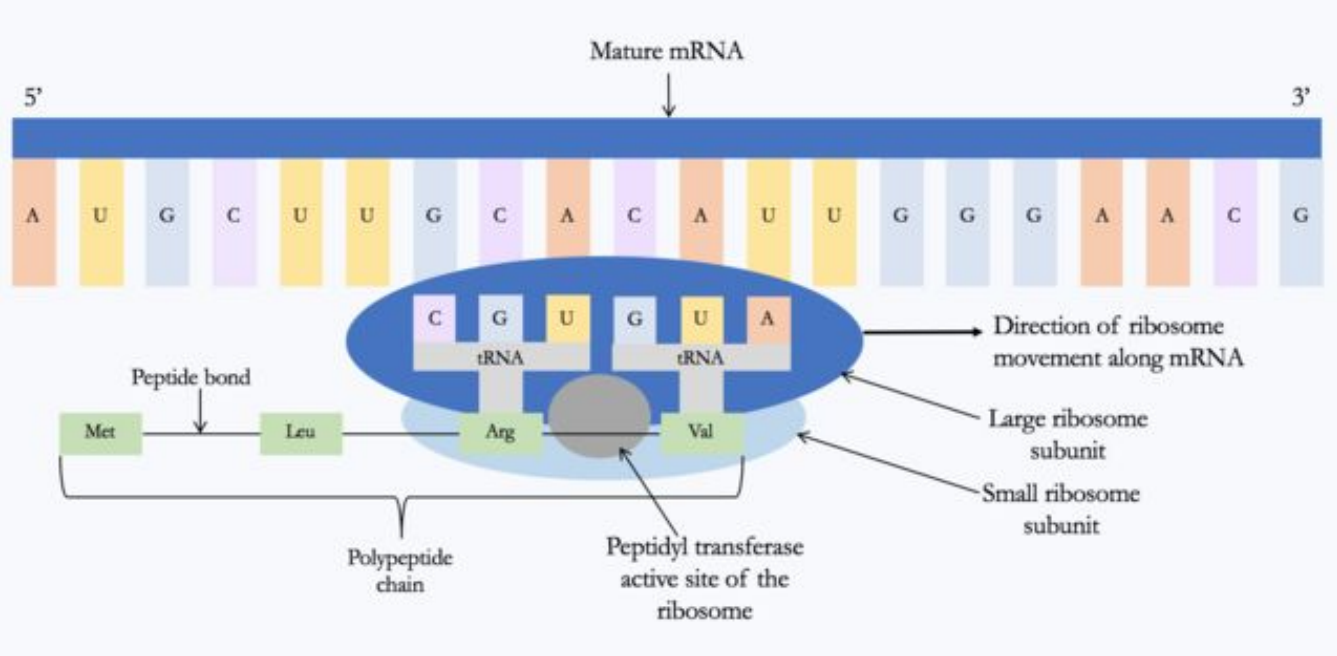
Overview

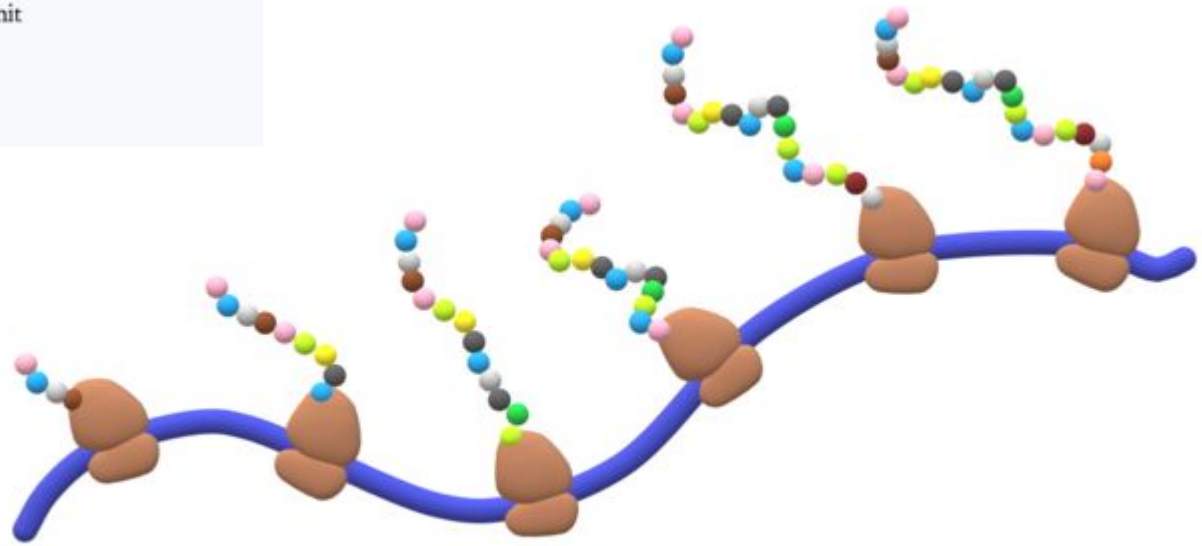
Gene Expression: Part 3

- Protein synthesis: the process by which a ***polypeptide*** molecule is produced from the mRNA code at the ribosome
- How?
  1. Once it leaves the nucleus (via nuclear pore), the mRNA strand will migrate to a **ribosome**
  1. The mRNA will enter the ribosome at the 5' end
  1. The **start codon** AUG instructs for translation to begin, directing for the amino acid methionine to start the polypeptide chain
  1. Each successive codon in the mRNA will pair up with the **anticodon** of a **tRNA** molecule carrying a **specific amino acid** within the ribosome
  1. The process continues with more codons and anticodons pairing, resulting in the amino acids being carried by the tRNA molecules being added to the growing polypeptide chain via **peptide bonding**
  1. Once a **stop codon (UAA,UAG,UGA)** is reached, translation will cease and the ***polypeptide chain*** will be ejected from the ribosome

Overview

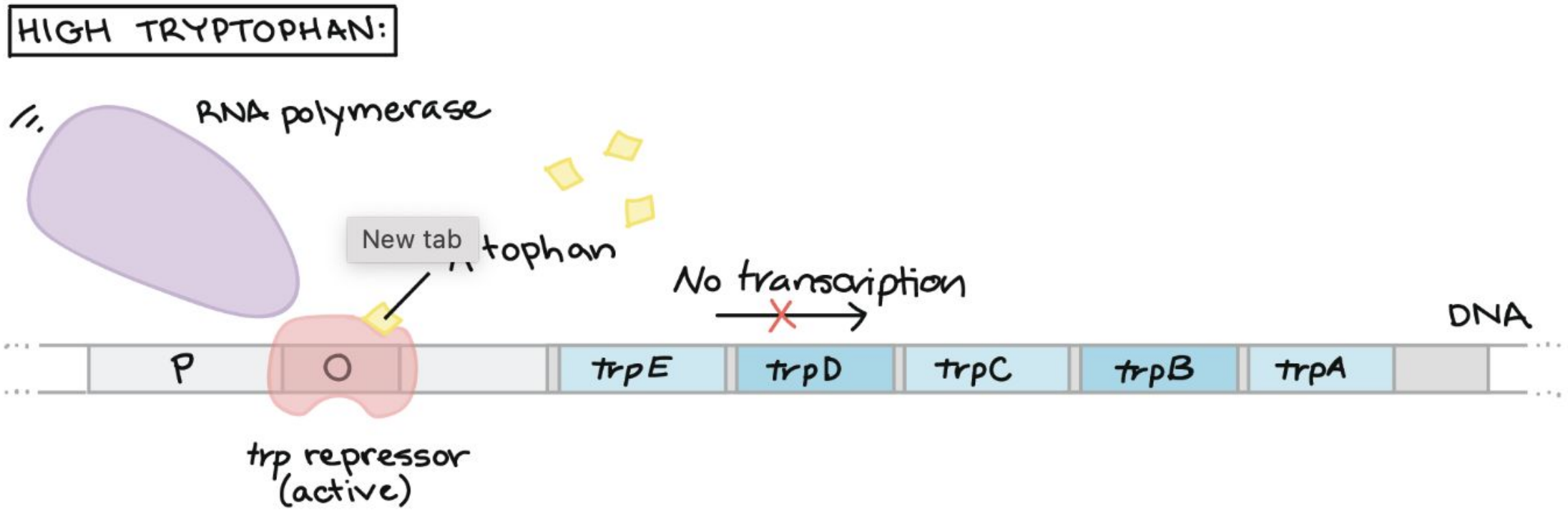
Translation





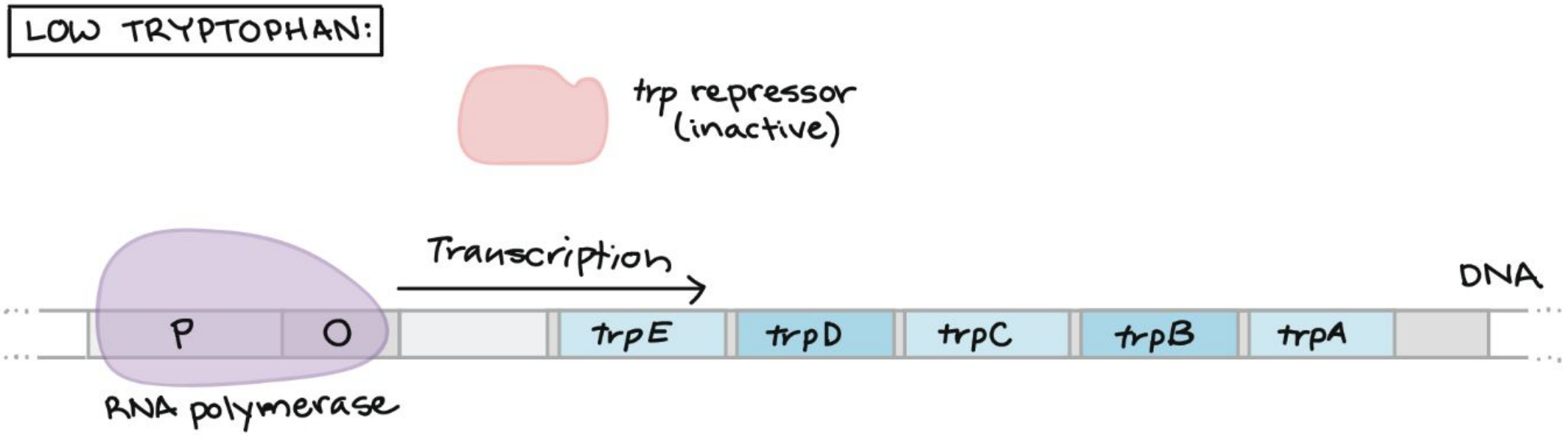
Overview

Repression- trp operon



Overview

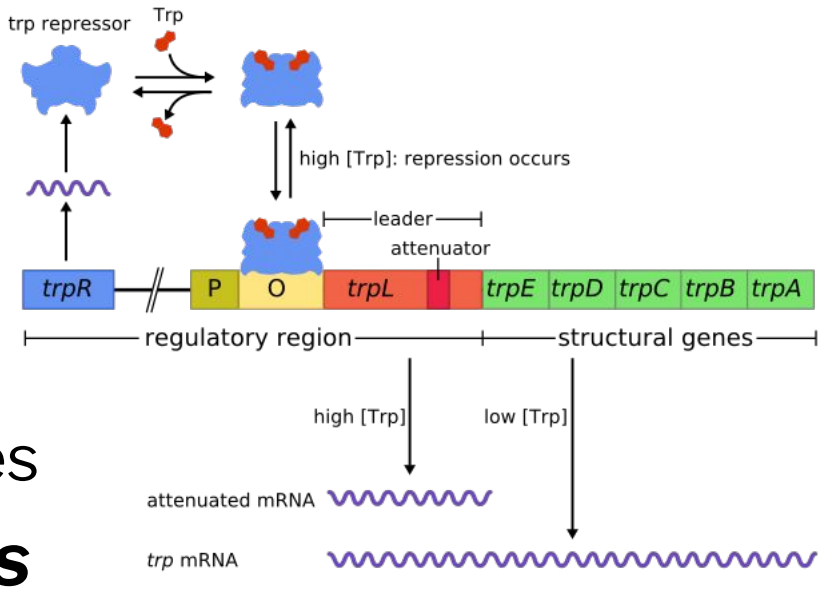
Low trp- Repression



Overview

trp Operon - Attenuation

- A second method of gene regulation in the *trp* operon is attenuation
- While repressors prevent transcription from starting, attenuation ***prevents transcription from completing***
- A region called the **leader** codes for an attenuator sequence
  - The attenuator sequence forms hairpin structures
- Within the leader are two ***tryptophan codons***
- This means to translate the leader we need tryptophan!



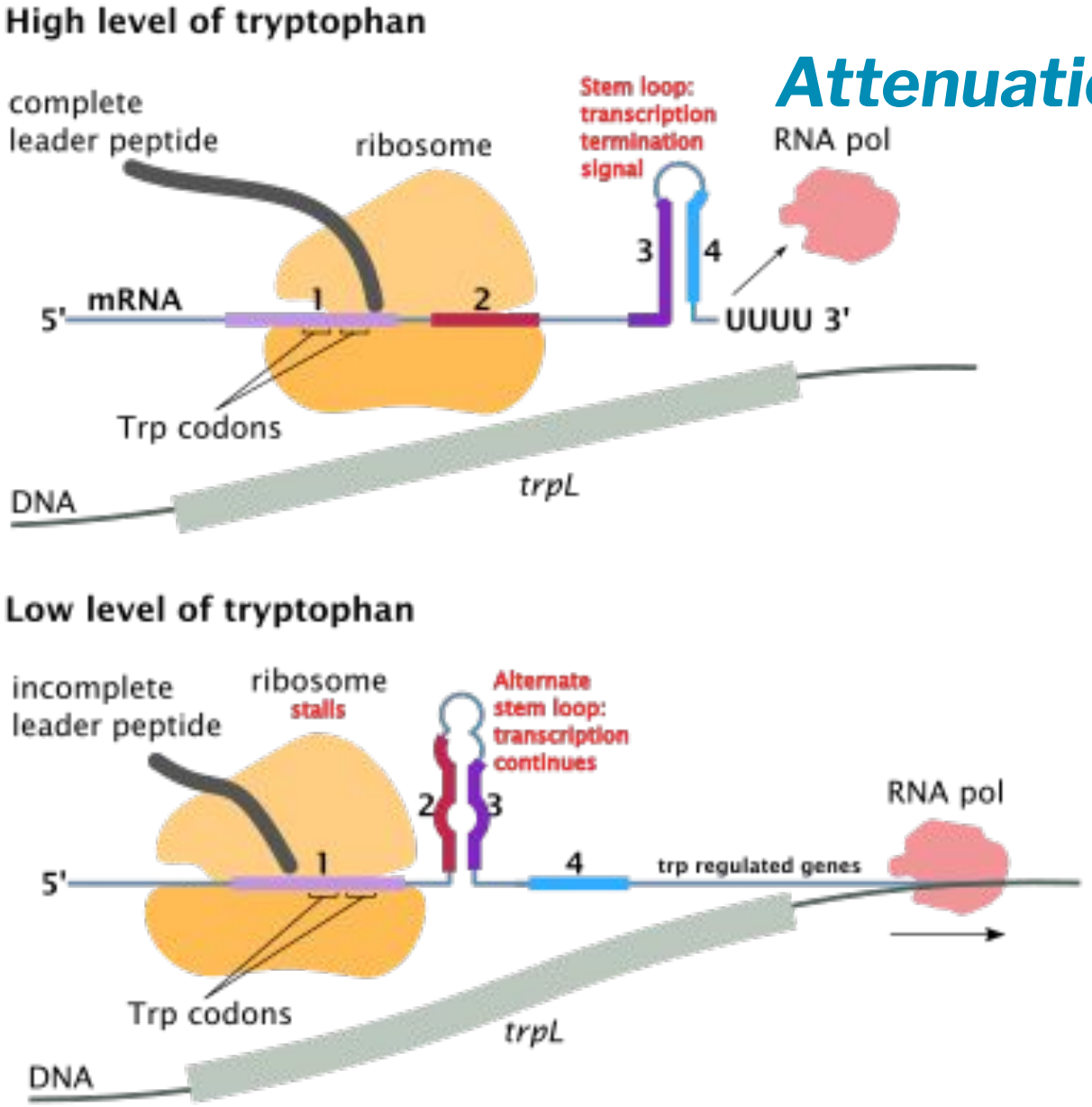
Overview

trp Operon - Attenuation

- **Low tryptophan levels:**
  - The ribosome moves through the leader ***slowly*** as we need tryptophan for translation
  - A hairpin structure is created that **does not** stop transcription – i.e. **transcription occurs** !!!
- **High tryptophan levels:**
  - The ribosome moves through the leader ***quickly*** as we have lots of tryptophan to translate the sequence
  - A hairpin structure is created that **does** stop transcription – i.e. **transcription doesn't occur**
  - The ribosome falls off the mRNA and RNA polymerase detaches from the operon
- Attenuation is possible because transcription and translation occur at the same place (i.e. the cytosol) – think about why this isn't possible in eukaryotes?
  - As RNA polymerase moves through the operon, the ribosome can begin translating the mRNA, even though the full strand isn't completed yet

Overview

Attenuation- trp Operon

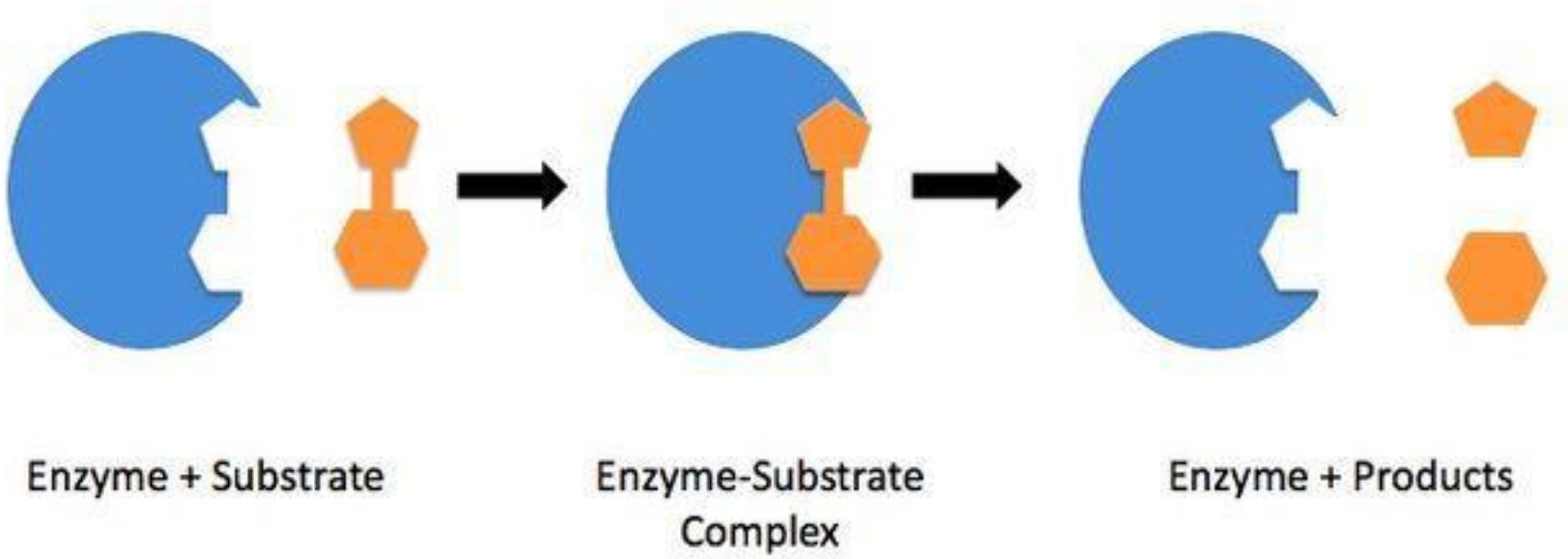


Overview

Levels of Protein Structure

	DESCRIPTION	IMPORTANT BONDING	EXAMPLE
PRIMARY	*Sequence of amino acids in the protein molecule*	*Peptide bonding*	*Literally just a sequence of amino acids bonded together*
SECONDARY	*Localised coiling + folding resulting from hydrogen bonds b/w peptide groups Gives qualities to overall molecule*	*Hydrogen bonding (b/w amino + carboxyl groups)*	*Alpha helix Beta-pleated sheet*
TERTIARY	*3D structure of protein that gives it its specific function Determines type / function of protein*	*Interaction b/w R-groups: h-bonding, ionic interactions, hydrophobic interactions, disulphide bridges (covalent bonds)*	*Globular, fibrous enzymes, hormones etc.*
QUATERNARY	*Multiple polypeptide chains*	*Same as tertiary – interactions b/w R-groups*	*Haemoglobin*

Overview


Enzyme + Substrate
Enzyme-Substrate Complex
Enzyme + Products

Overview

Endonucleases

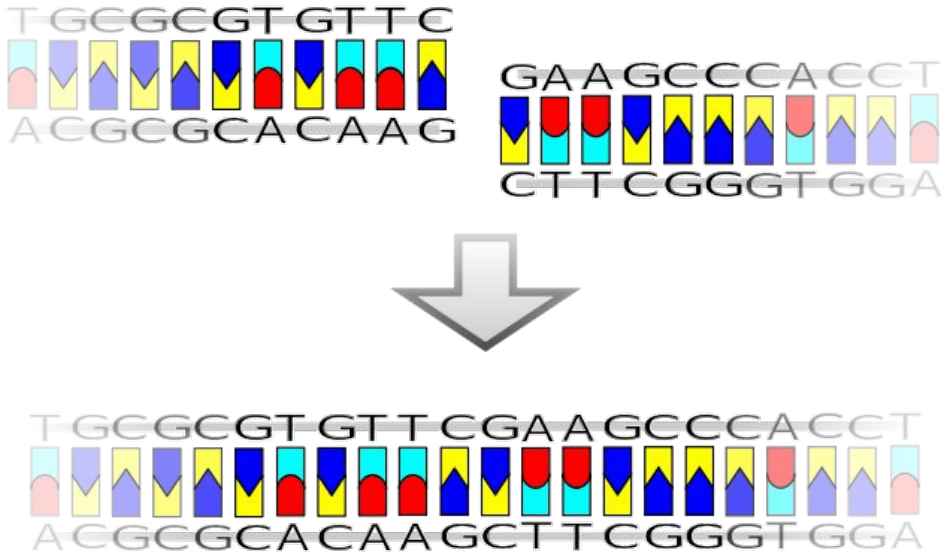
- These are our ‘molecular scissors’ – enzymes that **cut** a strand of DNA at a **specific base sequence** by breaking the bonds between DNA nucleotides (*phosphodiester linkages)*

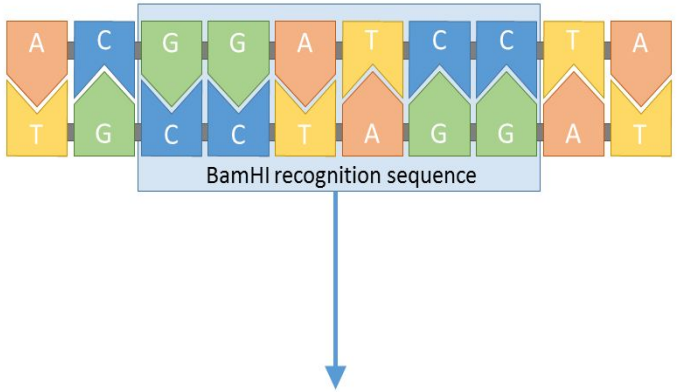
- Base sequences at which endonucleases cut are **palindromic**, meaning the sequence of one strand is the same as the sequence of the complementary strand read backward, e.g.:
  - TTTAAA base sequence of one strand and AAATTT sequence on the complementary strand

- Can get either **sticky ends** or **blunt ends**

Overview

Blunt + Sticky Ends

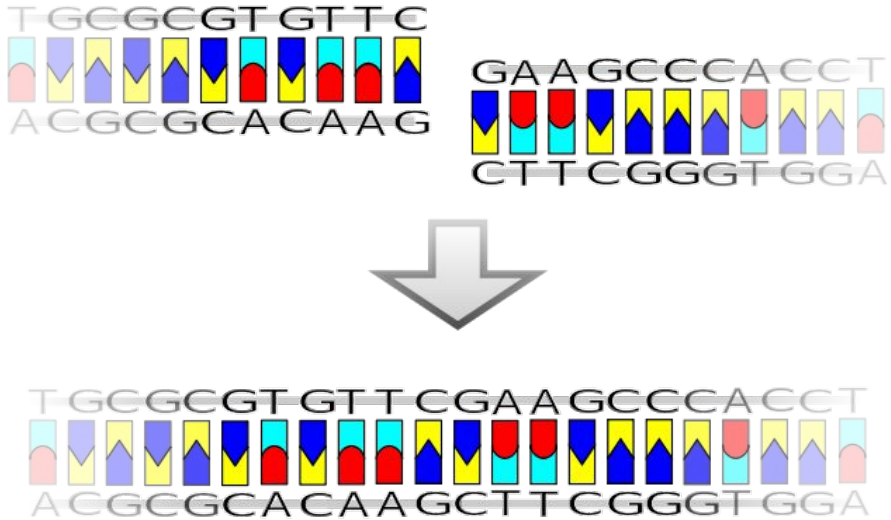




Overview

Ligase

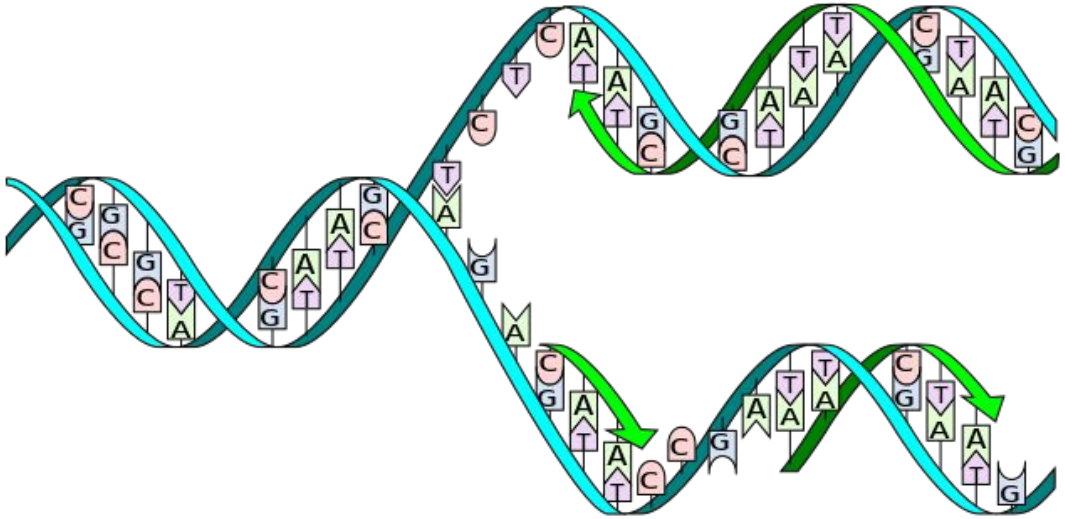
- Our ‘molecular glue’
- An enzyme that joins two DNA strands together, thereby forming one longer strand of DNA
  - Catalyses the formation of covalent bonds (phosphodiester linkages) between nucleotides of DNA strands



Polymerases

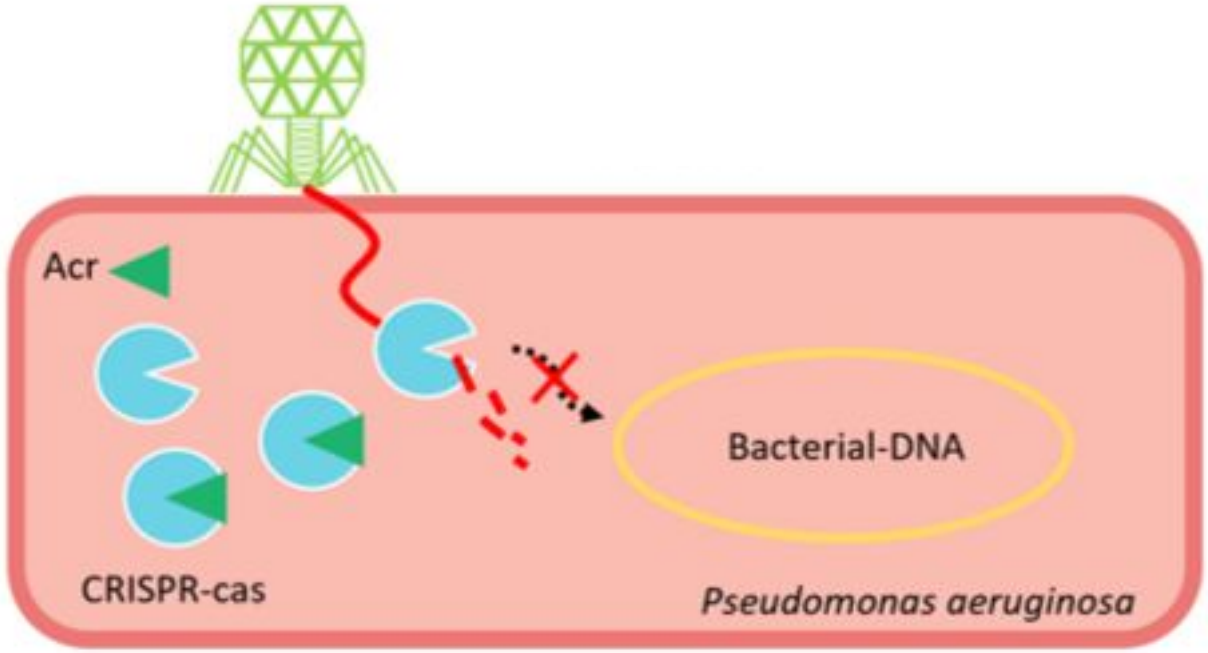
- Enzymes that join nucleotides together to synthesise larger chains of nucleic acids
- Use **DNA polymerase** to make many copies of a sample of DNA – to **amplify** a particular segment of the DNA sample

- E.g. RNApol, DNApol III, Taq Pol



Overview

CRISPR-Cas9: Role in Bacteria



Overview

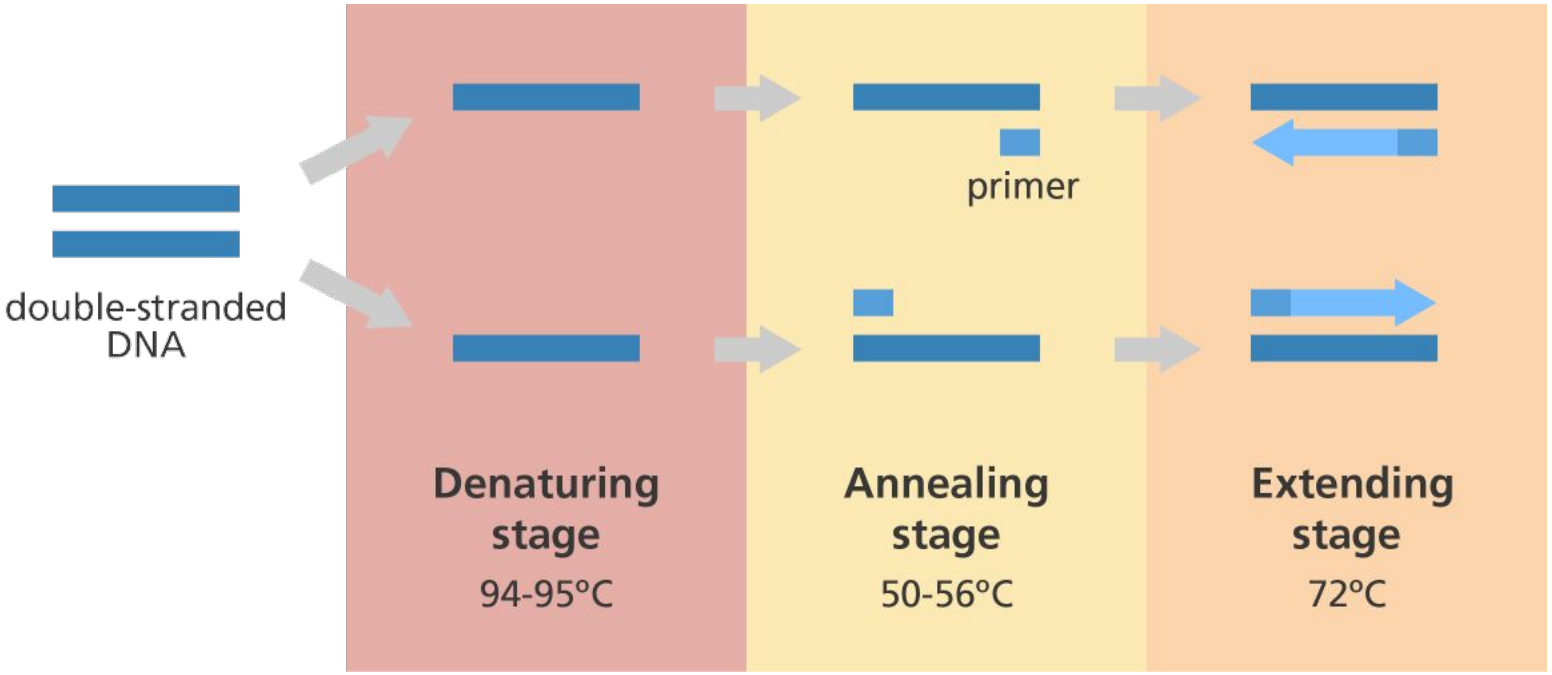
Polymerase Chain Reaction

- A technique used to **amplify** segments of a DNA sample by producing many copies of the same DNA.

- To do this, we need:
  - **Taq polymerase** (a type of DNA polymerase taken from *Thermus aquaticus* bacteria that live in hot springs).
  - **DNA primers** (short, single-stranded segments of DNA).
  - **DNA nucleotides**

Overview

PCR steps

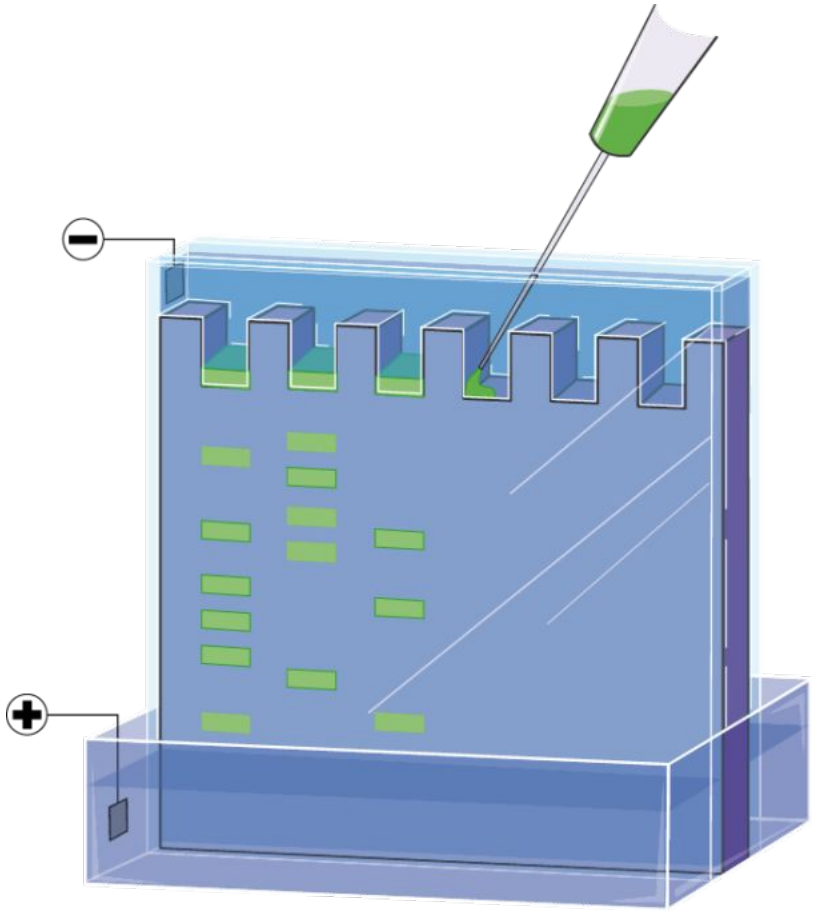


Overview

Gel Electrophoresis

- A technique used to **separate** DNA fragments in a mixture on the basis of **molecular weight / size**

- Load DNA sample into wells in gel
- Pass electric current through solution
- **Positive terminal must be at the far end, and negative terminal must be at the origin**
- Gel is **porous** so smaller fragments move through faster
- Stain fragments to make them **visible**

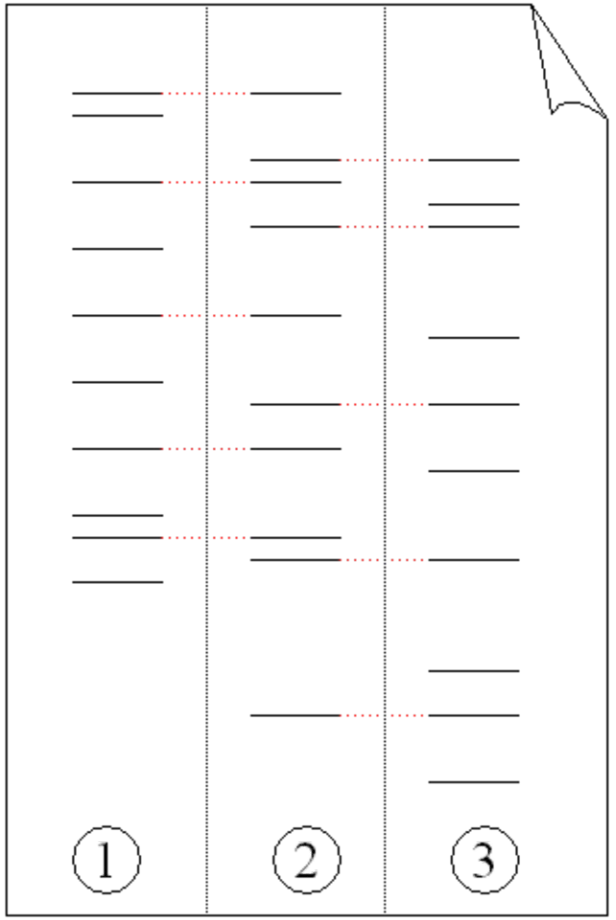


Overview

DNA Profiling

- Involves **identifying** individuals using their DNA
- We use **short tandem repeats (STRs)** – repetitions of 2-5 base pairs
- Different individuals will have a different number of 'repeats' at a particular **locus**

- Procedure is:
  - Take a DNA sample from the individual and perform **PCR** on the sample
    - The **primers** used here are designed to copy the DNA segments at the STR loci
  - Then separate DNA fragments using **gel electrophoresis**
  - Use different fluorescent markers to identify the alleles of each STR locus
  - Can therefore determine **genotype** of the individual at each locus
    - All of the genotypes together make up the **DNA profile** of the individual



Overview

- **Genetically modified organisms (GMOs)** are organisms that have had their **genome artificially altered**

- One of these involves **inserting** a gene from **another species** into the genome of an organism
  - We call the organism a **transgenic organism (TGO)**

- ***NOTE THE (SLIGHT) DIFFERENCE:***
  - A transgenic organism has had a gene from another species **added** to their genome
  - GMO is a more broad term, describing any organism who has had their genome **altered** in some way (doesn't have to necessarily be adding a gene)

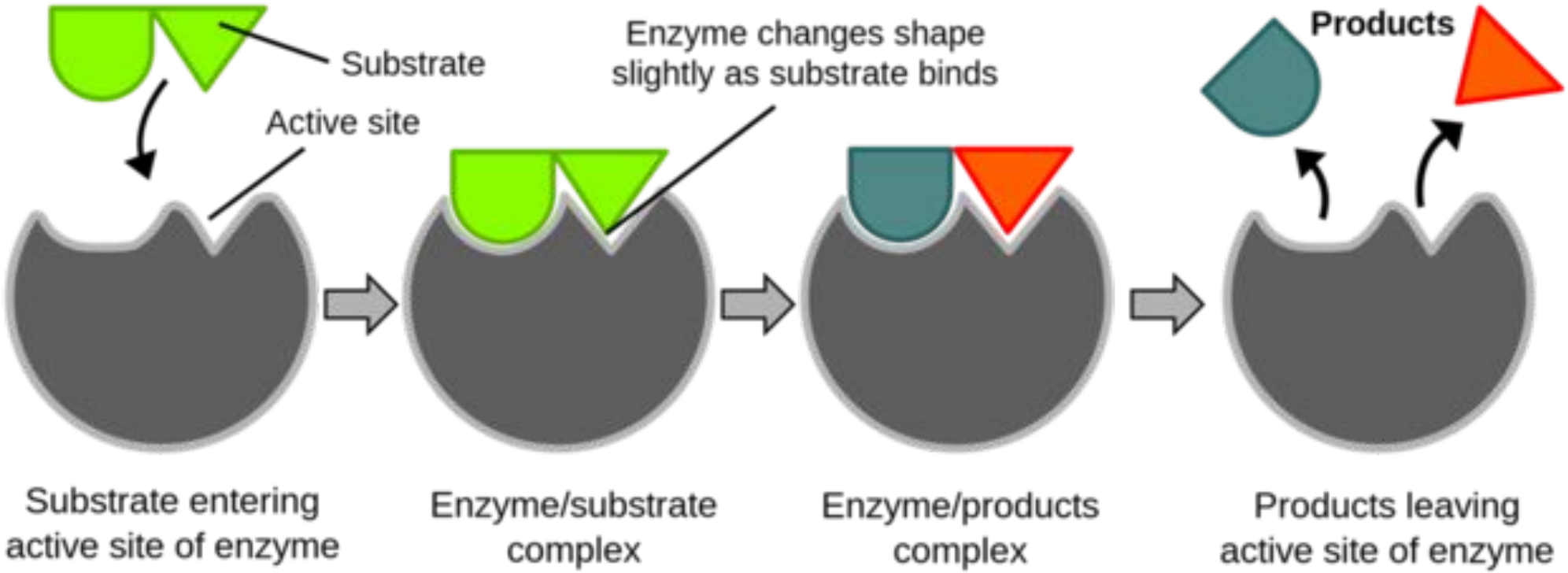
Enzymes

Active site specificity

- Enzymes are protein catalysts – they speed up vital reactions in living things
- Recall the important terms + concepts we went over in our last area of study
  - Active site is complementary to the enzyme's substrate/s
  - Active site undergoes a conformational change
  - SPECIFICITY !!!
  - Tertiary structure of the protein determines shape / charge of active site

How binding occurs

Enzyme substrate complex



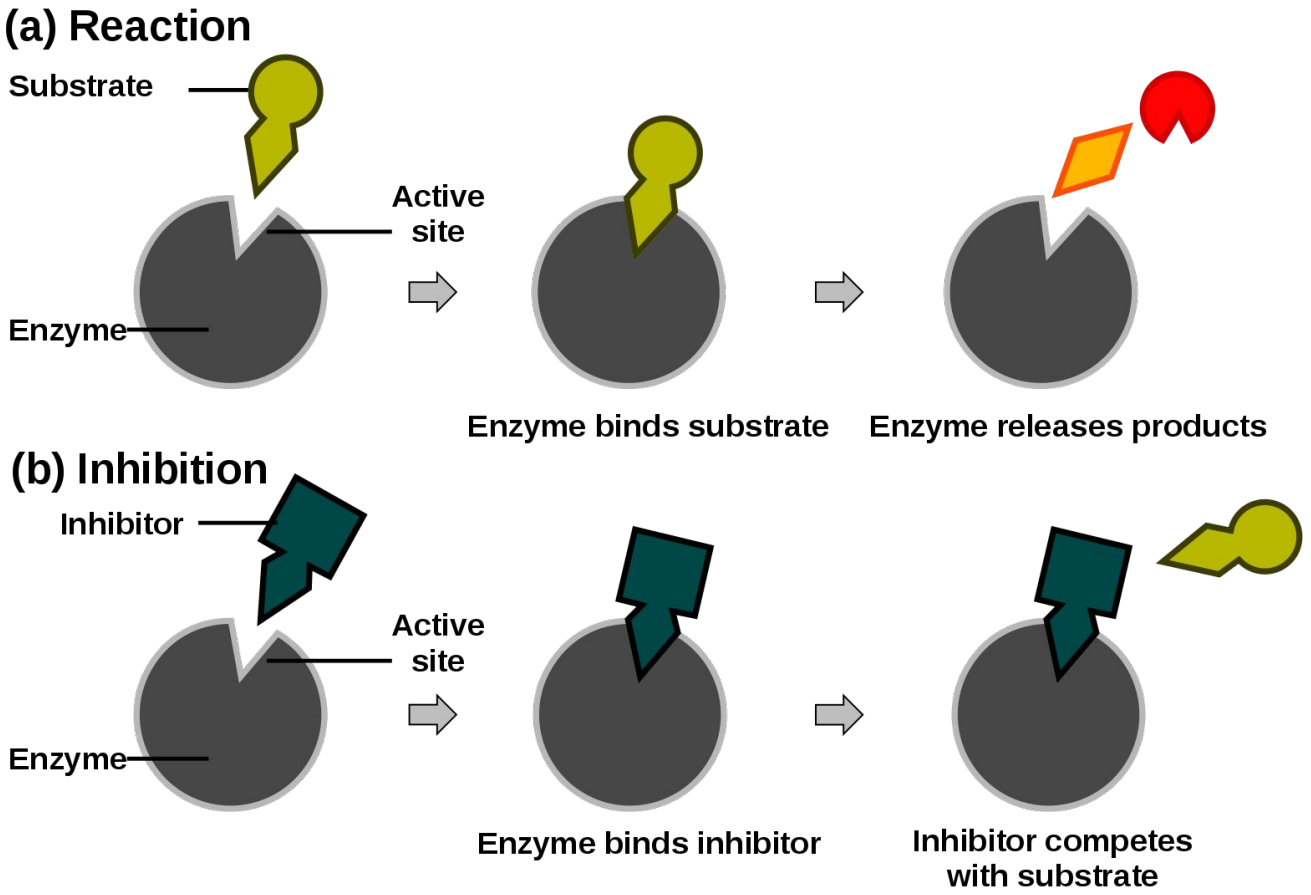
Denaturation

- If an enzyme is exposed to **high temperature** or a **pH level** that is outside its optimal range then it can become **denatured**
- Denaturation occurs when the **shape/structure** of the **active site** is **altered**
- **High temperatures** can break **hydrogen bonding**
- **pH changes** can interfere with **ionic interactions**
- Denaturation is **permanent**
- An enzyme that is denatured can no longer bind to its substrate and therefore cannot catalyse its reaction

Enzymes

Enzyme Inhibition

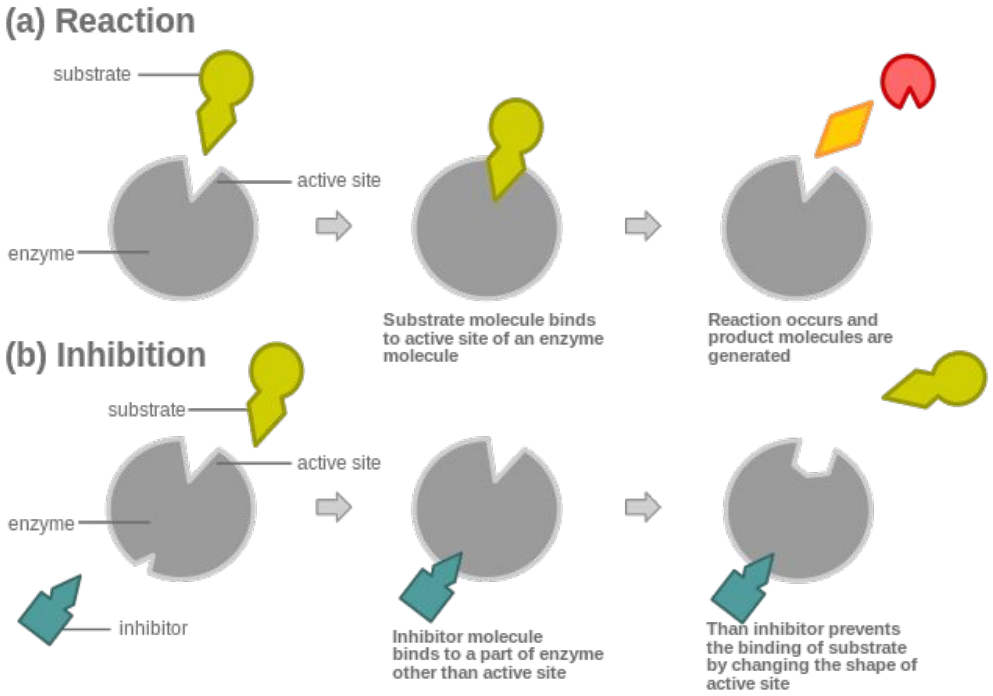
- **Competitive inhibition:** when an inhibitor binds to the ***active site*** of the enzyme
  - Blocks substrates from binding
  - Prevents the reaction from being catalysed



Enzymes

Enzyme Inhibition

- **Non-competitive inhibition:** when an inhibitor binds to a site on the enzyme ***other than*** the active site, which changes the shape of the active site
  - Prevents substrates from binding
  - Prevents the enzyme from catalysing the reaction
  - This site is known as an ***allosteric site***



Enzyme Inhibition

Competitive
VS
Non
Competitive
Inhibitor
(IMP)

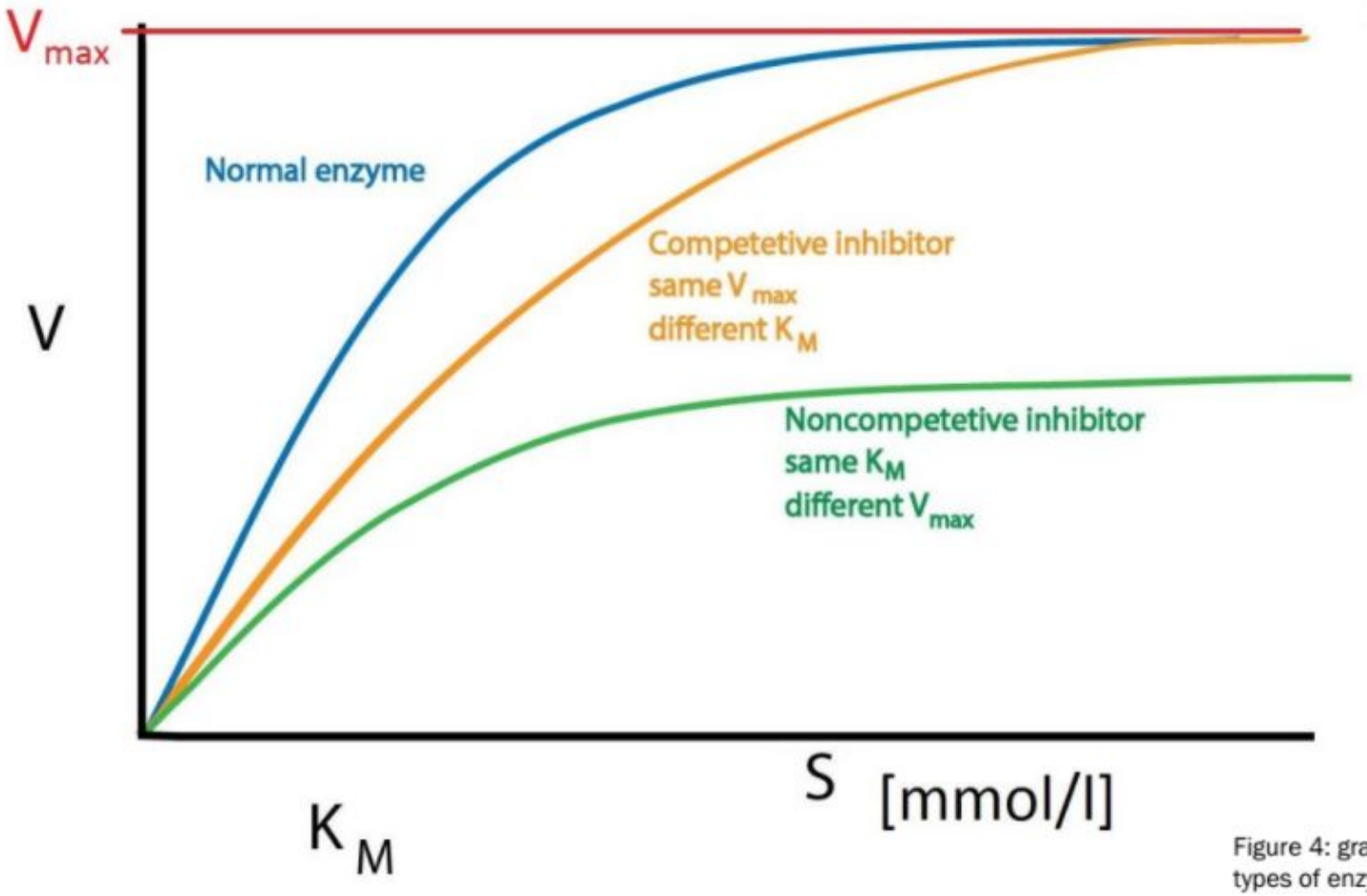
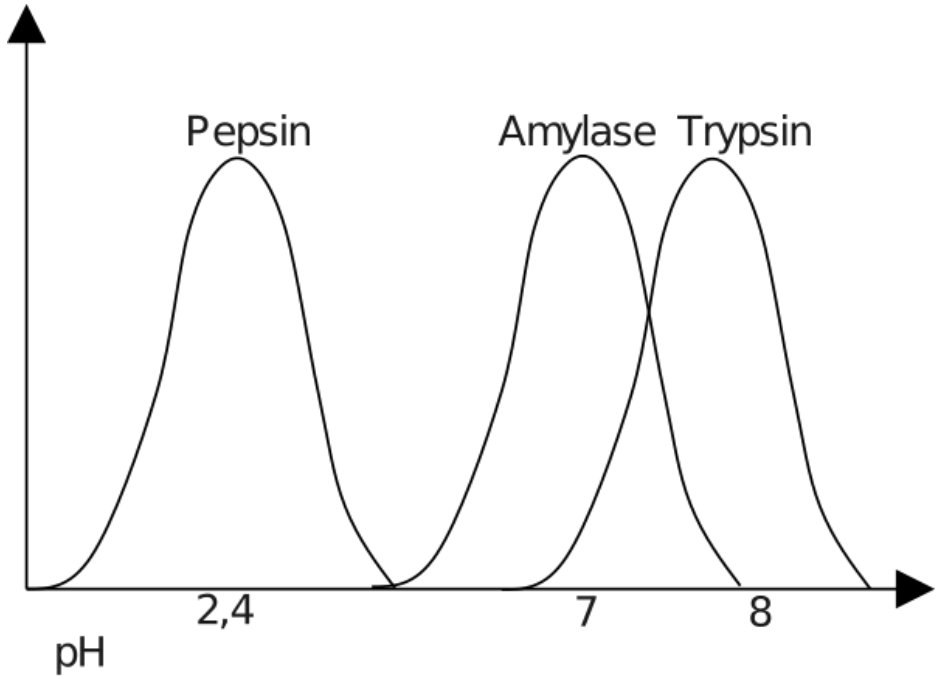
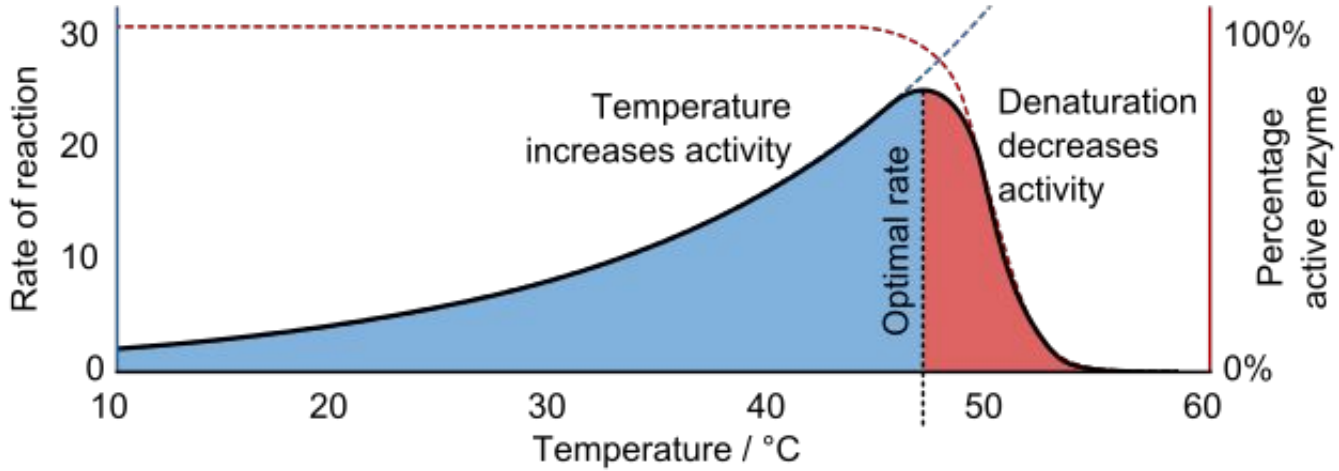


Figure 4: graph showi
types of enzyme inhib

Enzymes

Temperature + pH





Photosynthesis & Respiration

Coenzymes

COENZYME	FUNCTION	METABOLIC REACTION INVOLVED
ATP	*High energy molecule that provides energy for many chemical, reactions/processes*	*Lots, like legit almost everything E.g. active transport, DNA synthesis, protein synthesis etc…*
NADH	*Electron carrier molecule*	*Cellular respiration. Provides H+ and e- For electron transport chain*
NADPH	*Electron carrier molecule*	*Photosynthesis. Provides H+ and e- For light independent reaction*

Light Dependent Reaction

- Site: **GRANA**
- Light energy is absorbed by the chlorophyll and used to split water molecules into H^+ ions, O atoms and electrons
- Oxygen atoms join to form O_2, H^+ and electrons are collected by NADP forming NADPH
- There energy harnessed by the chlorophyll is also used to form ATP (in a similar way to the electron transport chain)
- The ATP and NADPH are then used in the light independent reaction

Light Independent Reaction

- Site: **STROMA**
- Commonly referred to as the Calvin cycle
- In a series of reactions similar but opposite to the Krebs cycle, carbon dioxide is turned into glucose
- The ATP produced in the light dependent stage provides the energy to drive the reaction
- The NADPH also provides hydrogen and electrons that are needed in the reactions
- **RuBisCO** is an important enzyme in photosynthesis

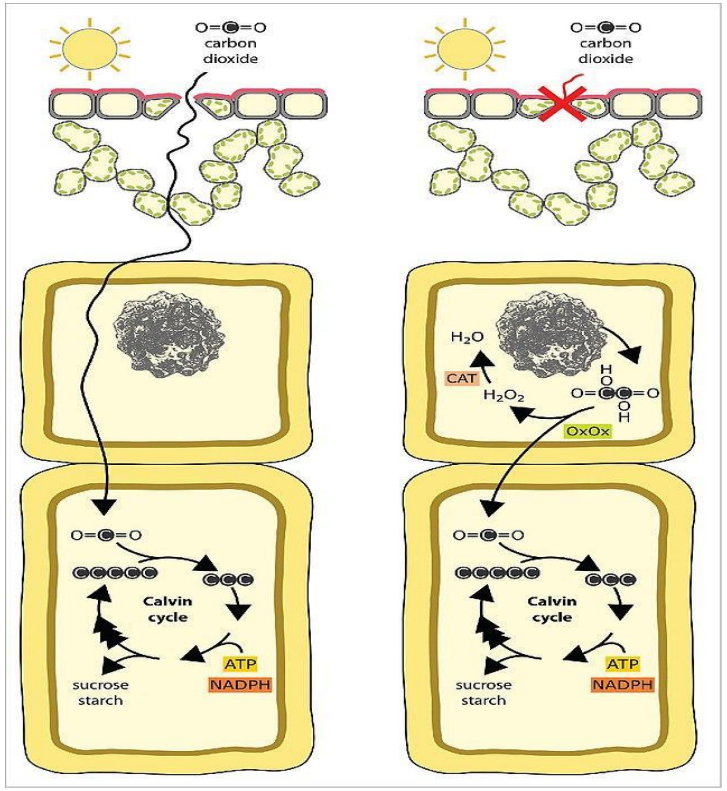
Photosynthesis & Respiration

Summary

	GLYCOLYSIS	KREBS CYCLE	ELECTRON TRANSPORT CHAIN	AEROBIC RESPIRATION OVERALL	ANAEROBIC RESPIRATION OVERALL
INPUTS	• *glucose* • *ADP + P_i* • *NAD^+*	• *Acetyl CoA* • *NAD^+* • *FAD* • *ADP + P_i*	• *NADH* • *$FADH_2$* • *O_2* • *ADP + P_i*	• *glucose* • *6 O_2* • *30 or 32 ADP + P_i*	• *pyruvate* • *NADH* • *2 ADP + P_i*
OUTPUTS (per glucose)	• *pyruvate* • *2 ATP* • *NADH*	• *2 ATP* • *4 CO_2* • *6 NADH* • *2 $FADH_2$*	• *26 or 28 ATP* • *H_2O* • *NAD^+* • *FAD*	• *30 or 32 ATP* • *6 H_2O* • *6 CO_2*	• *2 lactate (animals)* • *2 ethanol + 2 CO_2 (yeasts)* • *2 ATP*
LOCATION	• *cytosol*	• *mitochondrial matrix*	• *mitochondrial cristae*	• *cytosol + mitochondria*	• *cytosol*

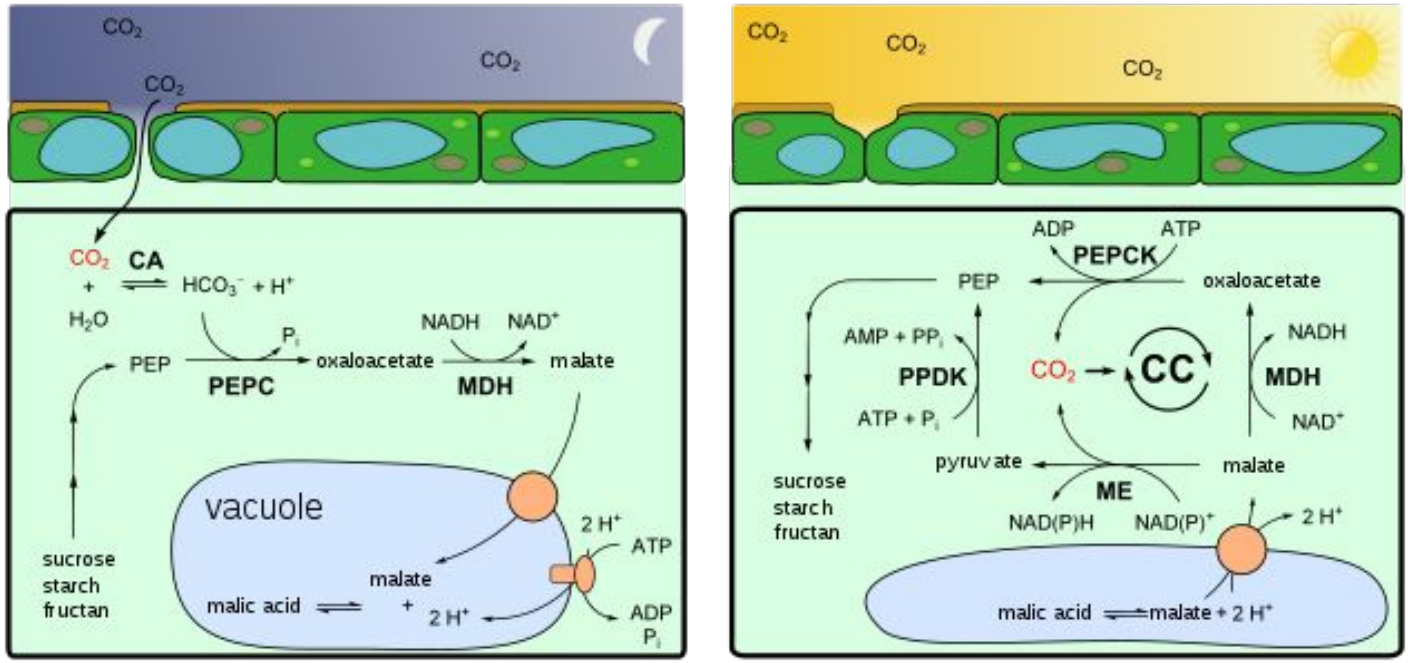
C_4 Plants

- C_4 plants separate the light dependent and independent stages into different cells- mesophyll cell and bundle sheath cells
- Suited for hot environments



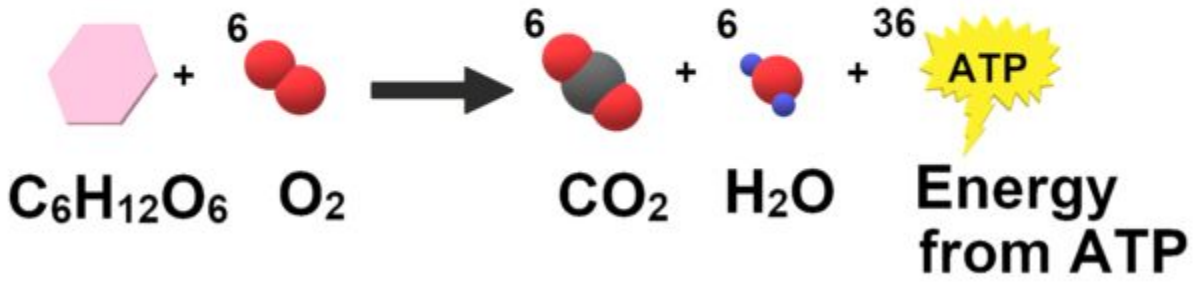
CAM Plants

- CAM plants separate the light dependent + independent reactions over time (day vs night)
- Suited for dry environments



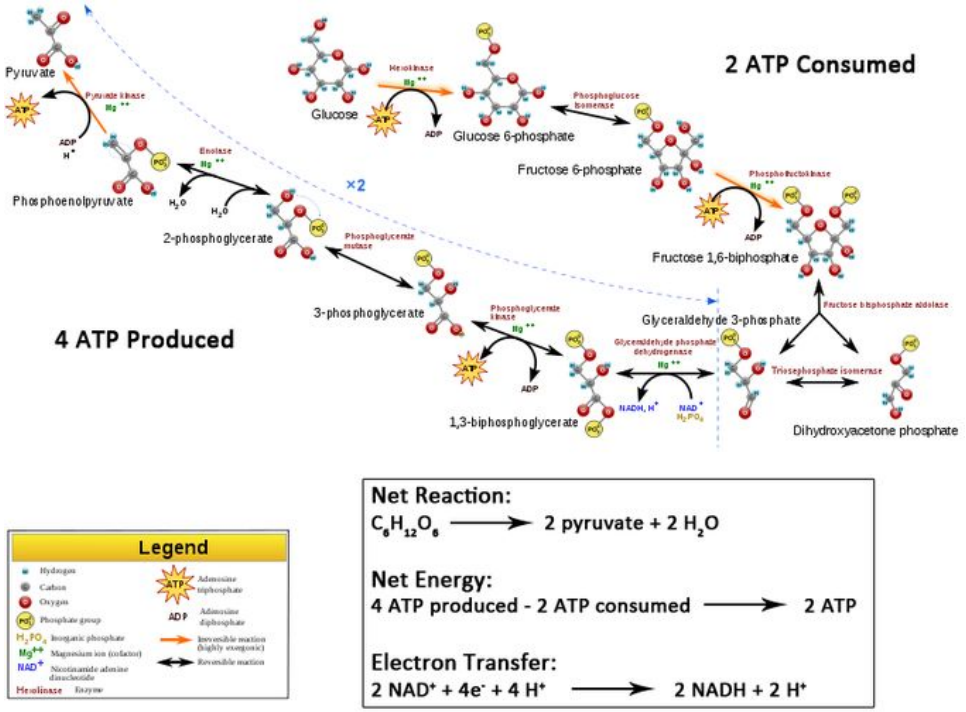
Chemical equation

- Function: to breakdown glucose into a usable form of energy for the cell



Glycolysis

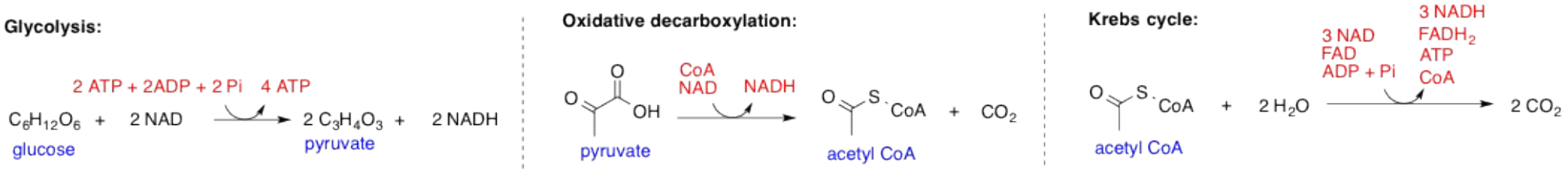
- The first stage of both the aerobic ***and*** anaerobic pathway of respiration
- First step of breaking down glycolysis
- Inputs are 1 glucose,
- 2ADP and Pi and 1 NAD+
- Outputs are
- 2 pyruvates
- 2 ATP and 1 NADH



Photosynthesis & Respiration

Krebs Cycle

- Main purpose is to produce coenzymes (our electron carriers) that will go into the electron transport chain



KREBS CYCLE

- *Acetyl CoA*
- *NAD^+*
- *FAD*
- *$ADP + P_i$*

- *2 ATP*
- *4 CO_2*
- *6 NADH*
- *2 $FADH_2$*

- *mitochondrial matrix*

Photosynthesis & Respiration

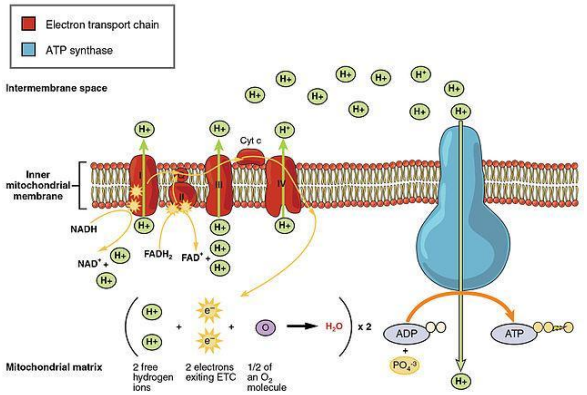
Electron Transport Chain

- Electron carrier molecules give up H^+ and electrons at the cristae of the mitochondria
- The electrons are accepted by and passed along a series of cytochromes on the cristae, the interaction between the electrons and protein complexes facilitates the production of ATP
- Oxygen captures electrons after they are passed along which are combined with hydrogen to form water

Electrons are passed along electron acceptors / a series of cytochromes

Oxygen captures electrons, which are combined with hydrogen

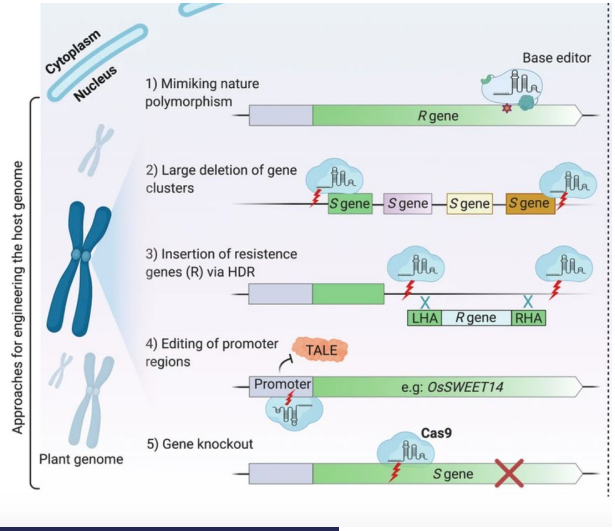
Carrier molecules give up hydrogen as it is passed along



Photosynthesis & Respiration

CRISPR-Cas9

- CRISPR-Cas9 can be used to edit the genome of certain plants, resulting in increased photosynthetic efficiency + greater crop yields
- Processes within photosynthesis itself can be edited, for example improving enzyme activity
- Improving crop yield may involve silencing disease susceptibility genes, upregulating plant growth genes etc.



Biofuel

- Bioethanol is produced via the process of anaerobic respiration
- Yeasts breakdown the sugars in biomass and produce ethanol, which can be processed and used as a transport fuel, amongst other uses

- Biogas is another type of biofuel produced by anaerobic digestion of biomass by bacteria

Photosynthesis & Respiration

1 min break

One Minute Break

Immunity

Pathogen Types

Bacteria	• Unicellular, prokaryotes
	• Reproduce via binary fission
	• Not all bacteria cause disease
	• Cell wall made of peptidoglycan
	• Produce toxins
	  - Exotoxins
	  - Endotoxins e.g. LPS
	• Invade tissues, consume nutrients, inhibit normal cell functioning

Viruses	• Obligate intracellular parasites
	  • Non cellular – cannot independently reproduce
	• Hijack host cells' machinery and enzymes in order to produce more virions
	• There are many different types of viruses
	  - DNA viruses
	  - RNA viruses (retroviruses e.g. HIV)
	  - Bacteriophages
	  - 'naked' viruses and viruses with a lipid coat

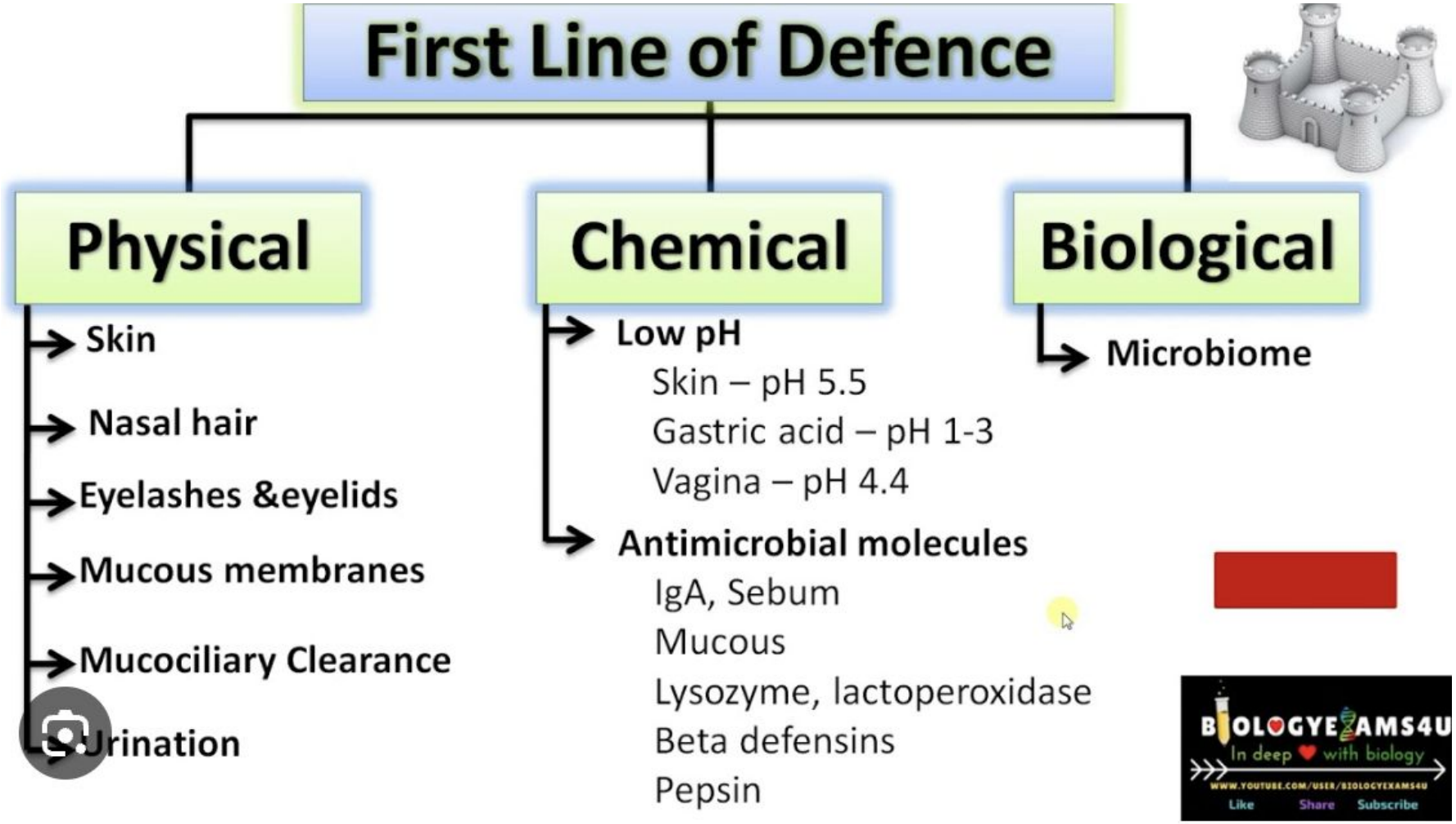
Protozoa	• Non cellular, Infectious proteins • Convert certain normal proteins in the brain into the infectious prion form • Cannot be broken down into amino acids by the body • Build up in neurons and cause neurodegenerative disease such as mad cow disease
Eukaryotic Pathogens	• Fungi e.g. athletes foot - cell wall made of chitin • Protozoa 'plasmodium' the cause of Malaria - Single celled eukaryotic pathogen • Worms tape worms and liver flukes • Harder to treat than prokaryotic

Innate vs Adaptive Immunity

SPECIFIC / ADAPTIVE	NON-SPECIFIC / INNATE
- Reacts in a specific way dependent on the infection - Specific - 'memory' - Level of response greater for subsequent encounters with same pathogen - Stronger response - Delayed response	- Reacts the same way to all pathogens - Broad - No 'memory' - Level of response same each encounter of same pathogen - Weaker response - Immediate response

Immunity

Innate: First line of Defence



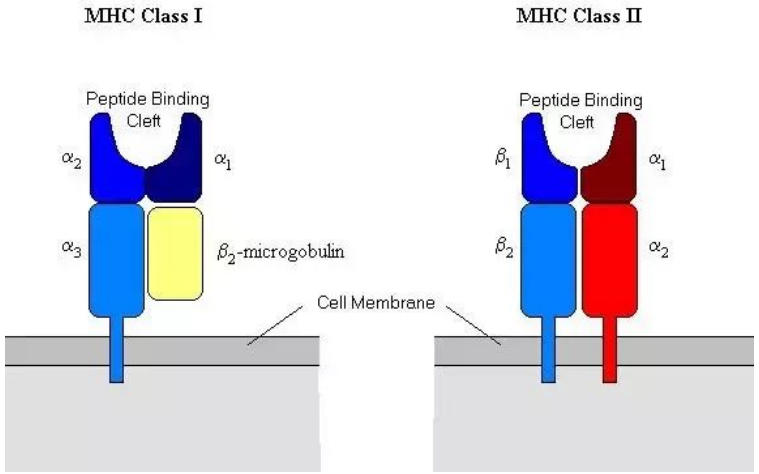
Immunity

Self vs Non-self

- **Antigen** = a molecule which can induce an immune response
  - Self / Non-self
  - Antigen = '**Anti**body **gen**erating'

- MHC class I markers are found on all nucleated cells and present self antigens
- MHC class II markers are found on specific immune cells and present non-self antigens
  - Examples of cells with MHC class II?

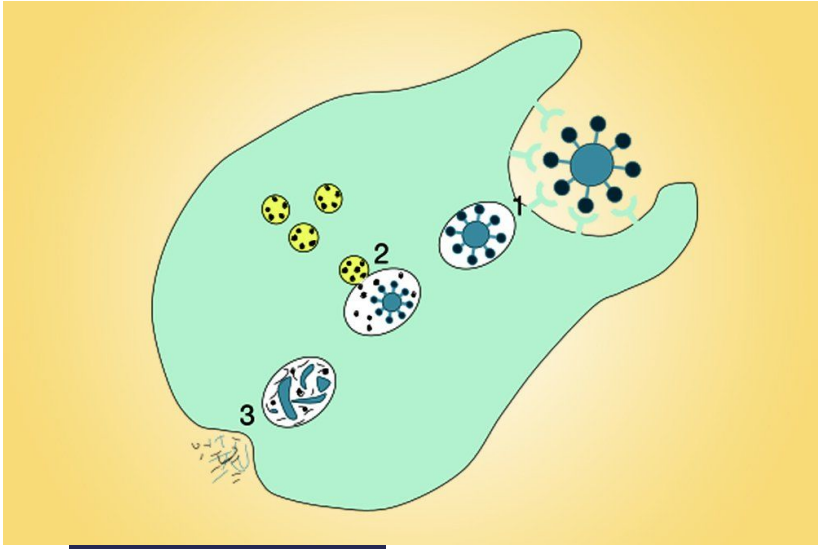
- Non-self antigens are found on pathogens / cells that do not belong to the individual
- Allergens are antigens that cause allergic responses



Innate: Second Line of Defence

- If the first line is breached then the second line is initiated

- The second line involves a broad response in order to eliminate the pathogen through the use of phagocytic leukocytes and numerous non-cellular molecules



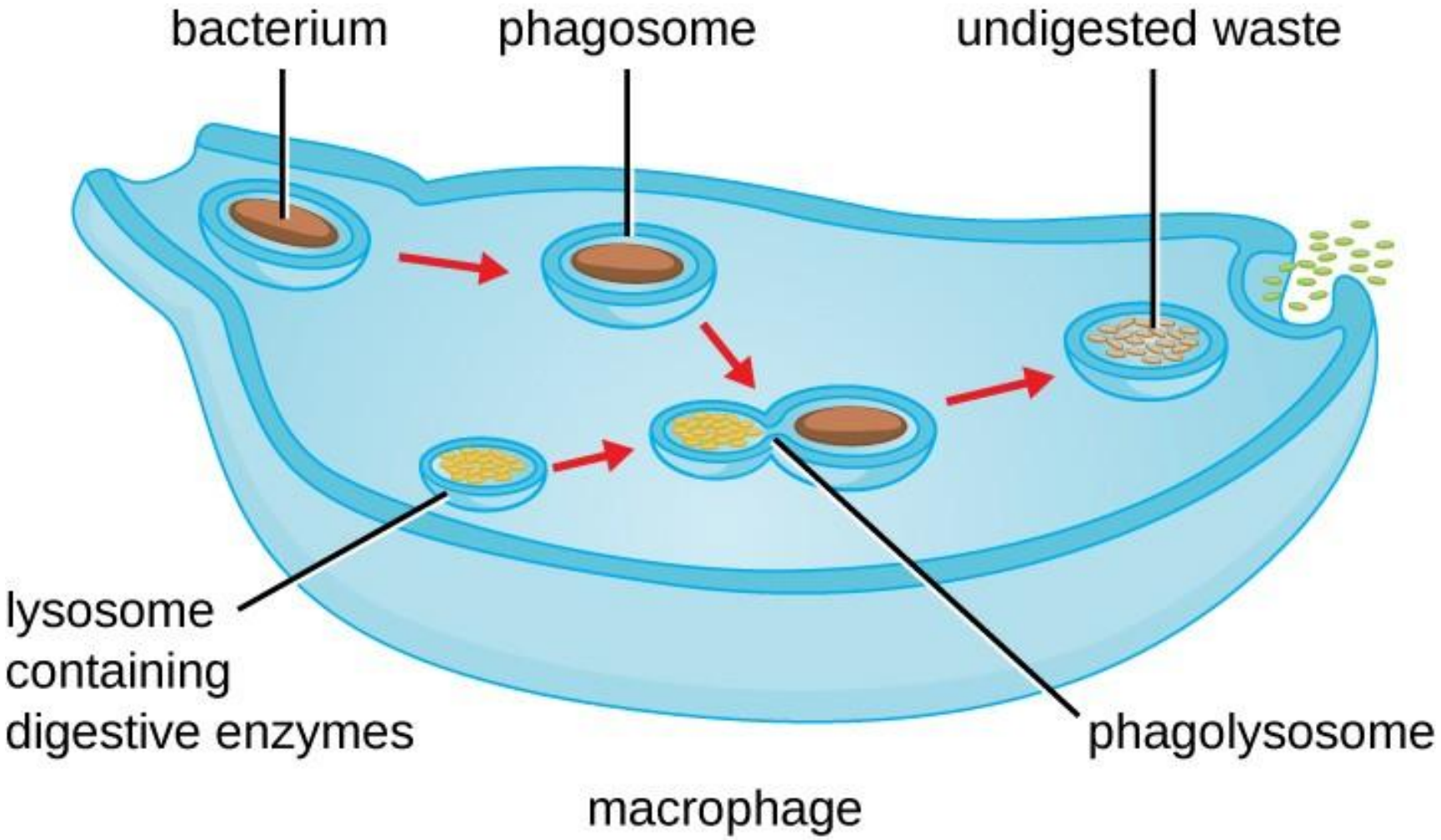
Innate Immune Cells

CELL	FUNCTION
Macrophages	• Phagocytic – extremely good • APC (MHC class II) • Derivative of Monocytes
Dendritic Cells	• Phagocytic • APC (MHC class II) – extremely good • Derivative of monocytes
Neutrophils	• Phagocytic • Undergo apoptosis after phagocytosis - kamikaze • Granulocytes • Large numbers
Mast Cells	• Granulocytes – release histamine • Important in inflammatory and allergic response • Reside in connective tissues and mucous membranes
Natural Killer Cells	• Detects changes in MHC class I • Release perforins or granzymes which induce apoptosis • Lymphocyte
Eosinophils	• Phagocytic • Important in parasitic infections • Granulocyte

Immunity

Innate: Phagocytosis

Features



Immunity

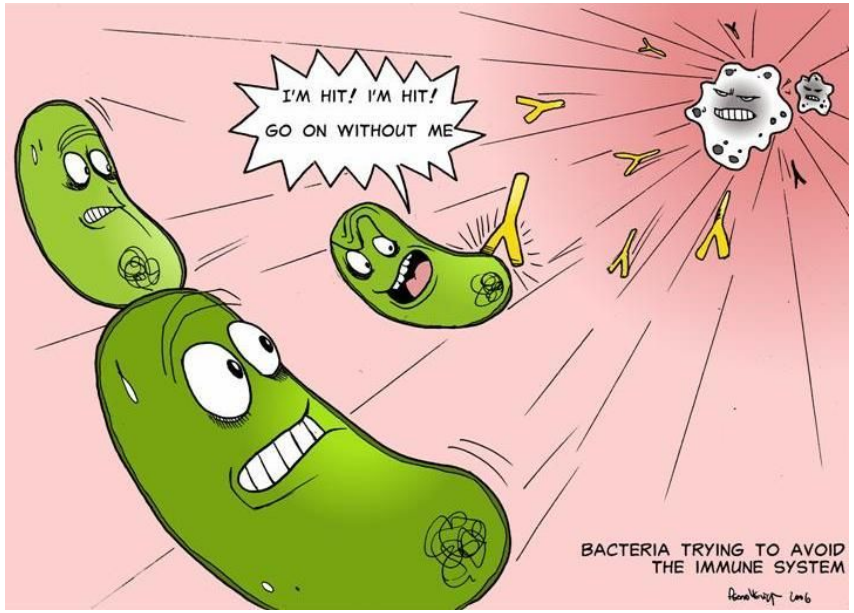
Innate: The Inflammatory Response

1. When damage occurs to tissues (a cut, burn, force etc.) ***damaged cells release cytokines***
2. The ***presence of pathogens*** can also initiate the inflammatory response (macrophages release cytokines to attract immune cells)
3. This triggers cells such as ***mast cells to release histamine***
4. Histamine and other chemicals cause the surrounding ***blood vessels to dilate and become more permeable*** (increased blood flow to the area)
5. Neutrophils (and other phagocytes) migrate to the site and ***phagocytose pathogens and debris***
6. APC's will present antigen in their MHC II

Immunity

Adaptive Immune System

- Strong, targeted response towards a specific antigen.
- Has **memory**
- Cells involved: Naïve B cells, Plasma cells, Memory B cells, Helper T cells, Cytotoxic T cells



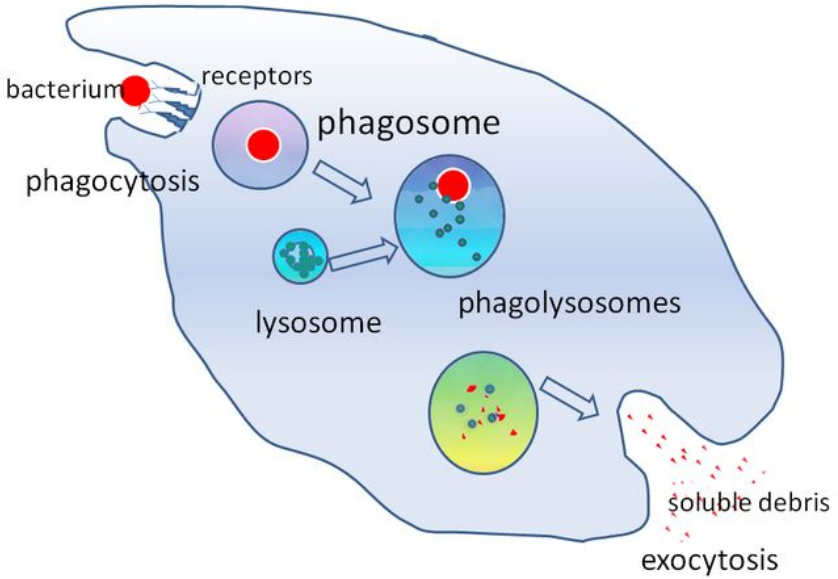
Immunity

Adaptive Immune System

Triggering the adaptive immune response:

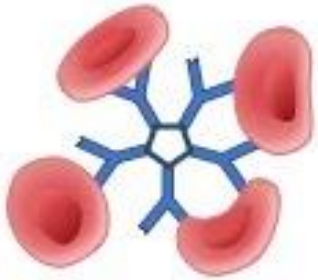
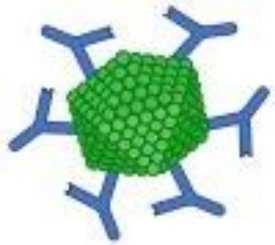
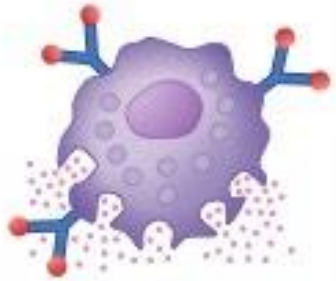
- APC phagocytoses a pathogen
- A lysosome fuses with the phagosome
- Antigen is then presented on MHC class II markers
- APC migrates to lymph nodes

Why does the APC migrate to the lymph node



Immunity

Adaptive Immune Response

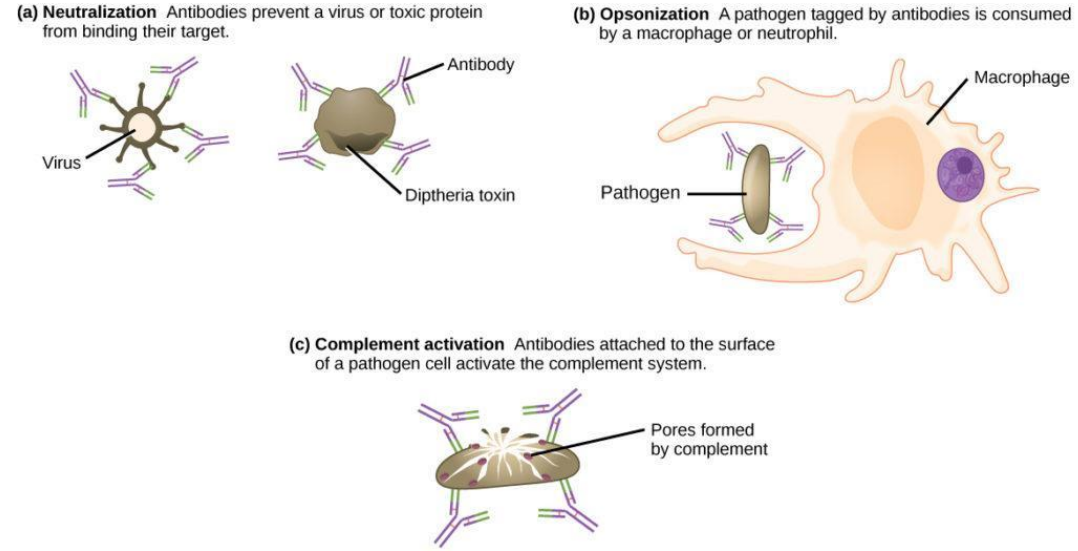
Precipitation	Agglutination	Neutralisation	Inflammation	Complement	Phagocytosis
					
Makes soluble antigens insoluble, aiding elimination	Links cell-bound antigens together, causing clumping	Masks dangerous parts of pathogen, such as exotoxins	Triggers histamine release, increasing immune mobility	The complement system is triggered to lyse pathogens	Improves detection by the phagocytes (via opsonisation)

Collectively, the actions of antibodies increase the efficacy of the **innate immune response** (specifically **phagocytosis**)

Immunity

B Lymphocytes

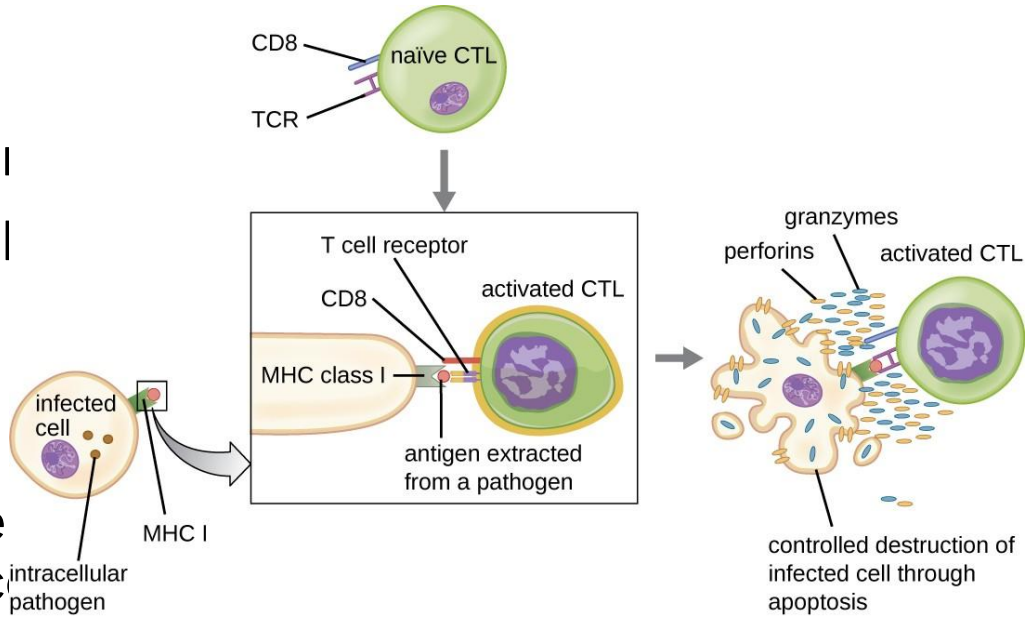
- The effector cells of the humoral response are **plasma B cells**, activated by helper T cells
- These cells produce and secrete large numbers of **antibodies** complimentary to the specific antigen
- Antibodies are protein complexes that defend against pathogens by:
  - Agglutination
  - Opsonisation
  - Activating complement proteins
  - Neutralisation
  - Promoting inflammation



Immunity

T Lymphocytes

- Cytotoxic T cells are activated by activated T helper cells
- Cytotoxic T cells differentiate into memory and more cytotoxic T cells
- How do Cytotoxic T cells carry out their respo
  - Infected self cells present the antigen of t class I markers
  - Cytotoxic T cells detect non-self antigens I markers via their T cell receptors
  - Cytotoxic T cells kill these infected self ce pathway or perfin/granzymes which induc



Monoclonal Antibodies

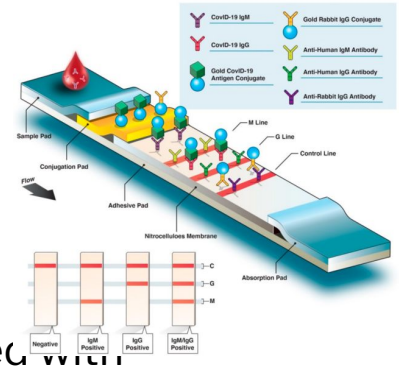
- Antibodies produced in an immune response bind to specific regions of an antigen known as an epitope
- One antigen may have multiple epitopes which different antibodies bind to and some bind more tightly than others. These different antibodies are produced by different B cell specificities
  - This is a ***polyclonal response***

- We are able to isolate and produce more of a specific B cells to produce antibodies not just targeting a certain pathogen but have high binding affinities too!
- These are known as **monoclonal antibodies**

Immunity

Pathogen Identification

- **Serology**
  - Conducting tests on individual's blood serums

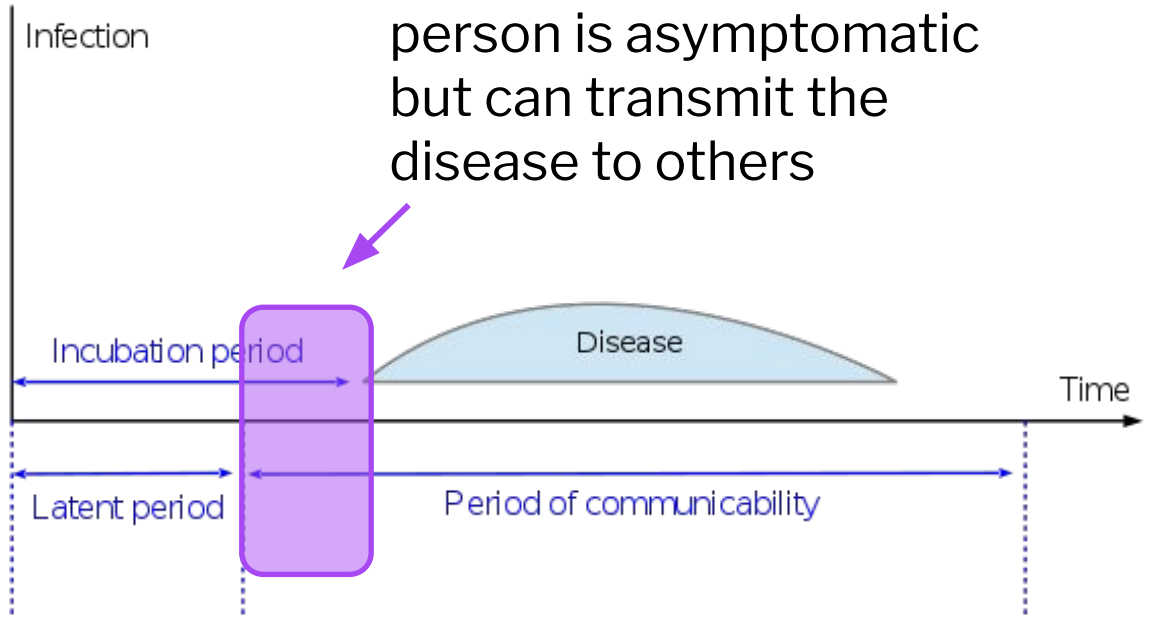


- **ELISA**
  - A sample (e.g. blood) taken from the patient is added to a plate with multiple wells coated with antibodies that are complementary to the protein of interest
  - If the sample contains proteins complementary to the antibody in one of the wells they form an antibody-antigen complex which remains after the plate is washed.
  - The plate is then treated with certain chemicals and if antibody-antigen complexes are present these will fluoresce a particular colour

- **PCR**
  - Can be used to detect certain viral DNA in a sample from a patient through the use of fluorescent primers specific for the genes/alleles of interest
  - Often used in conjunction with gel electrophoresis

Modes of Transmission

- Respiratory transmission
- Droplet transmission
- Contact transmission
- Vector transmission
- Sexual transmission

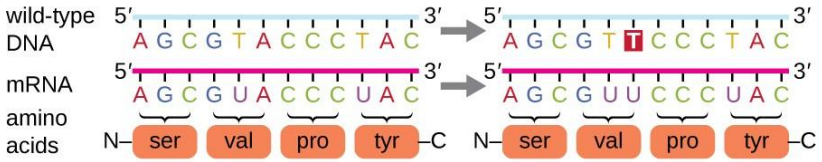


Genetics & Evolution

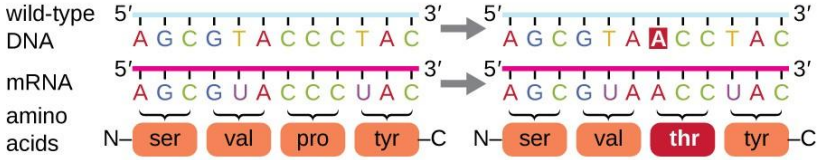
Substitution Mutations

point mutation: substitution of a single base

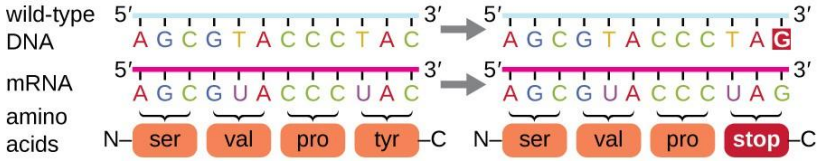
silent: has no effect on the protein sequence



missense: results in an amino acid substitution

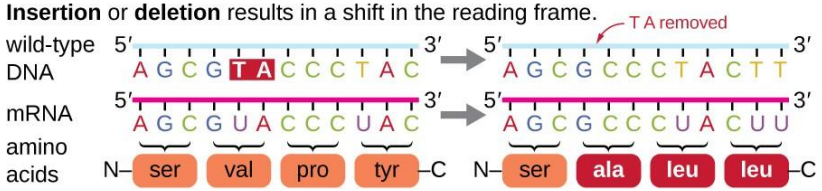


nonsense: substitutes a stop codon for an amino acid



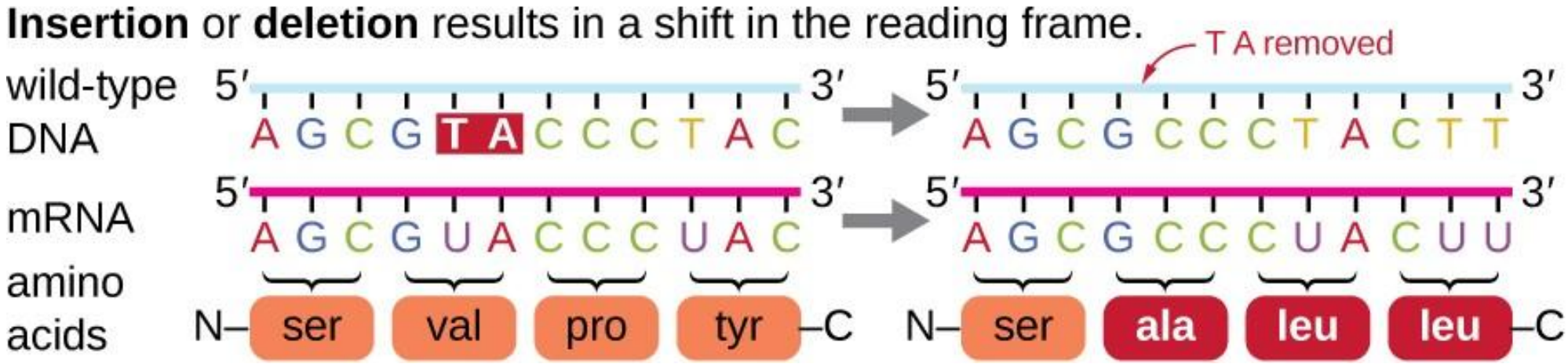
frameshift mutation: insertion or deletion of one or more bases

Insertion or **deletion** results in a shift in the reading frame.



Frameshift Mutations

frameshift mutation: insertion or deletion of one or more bases



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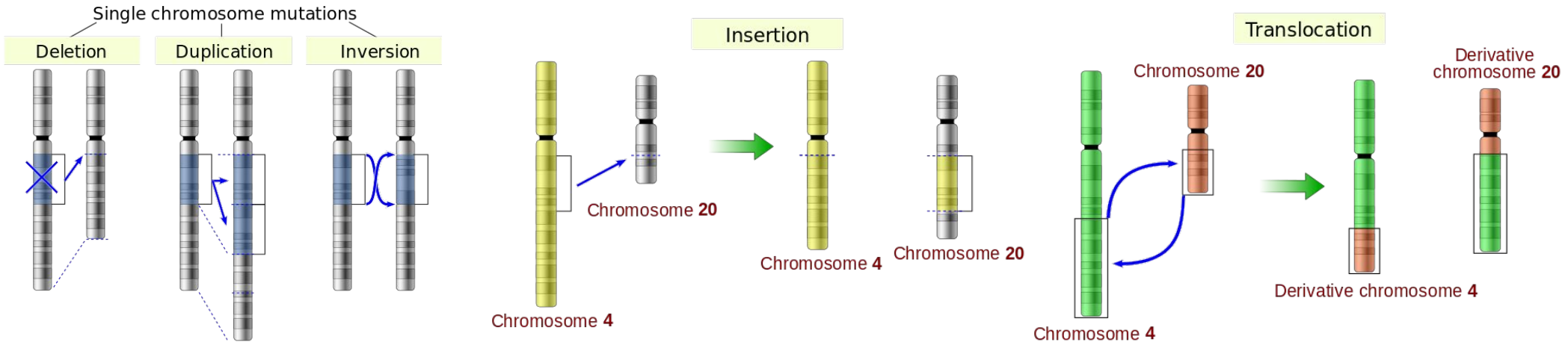
Block Mutations



Natural Selection Questions

1. **Variation exists in a population**
2. A **selection pressure** acts on the **phenotypes** of the members of the population so that some members are more likely to survive and reproduce
3. The alleles that correlate with the characteristics that give survival advantage are therefore more likely to be passed on and **increase in frequency** over time
4. This means that overtime the population evolves to suit their environment

Genetics & Evolution

VCAA 2017 NHT

Question 9 (5 marks)

In Africa, the malaria-carrying mosquito *Anopheles gambiae* has been the focus of a mosquito-eradication campaign using the insecticide pyrethroid. Researchers found that allele 1 of gene L1014 produces resistance to pyrethroid in these mosquitoes; however, allele 2 does not produce resistance to pyrethroid. Researchers studied the frequency of both of these alleles over a period of time. In the particular population of mosquitoes where this study was carried out, an intense program of pyrethroid spraying was begun in 2008 and was maintained until 2011.

The results of the allele frequency studies are presented in the table below.

Allele frequencies for gene L1014 in *A. gambiae*

Allele type	Frequency in 2007	Frequency in 2011
1	36.4%	77.7%
2	63.6%	22.3%

It is considered that this data provides evidence that the process of natural selection has occurred in the *A. gambiae* species.

a. Using the information above, explain how natural selection has operated in this population of the *A. gambiae* mosquito. 3 marks

VCAA NHT 2017 Examiner Response

Question 9a.

Variation in original population

Individuals with resistance will survive if exposed to insecticide and reproduce; individuals with allele type 2 will die if exposed to insecticide.

The frequency of allele type 1 has increased in the population.

Template for these questions

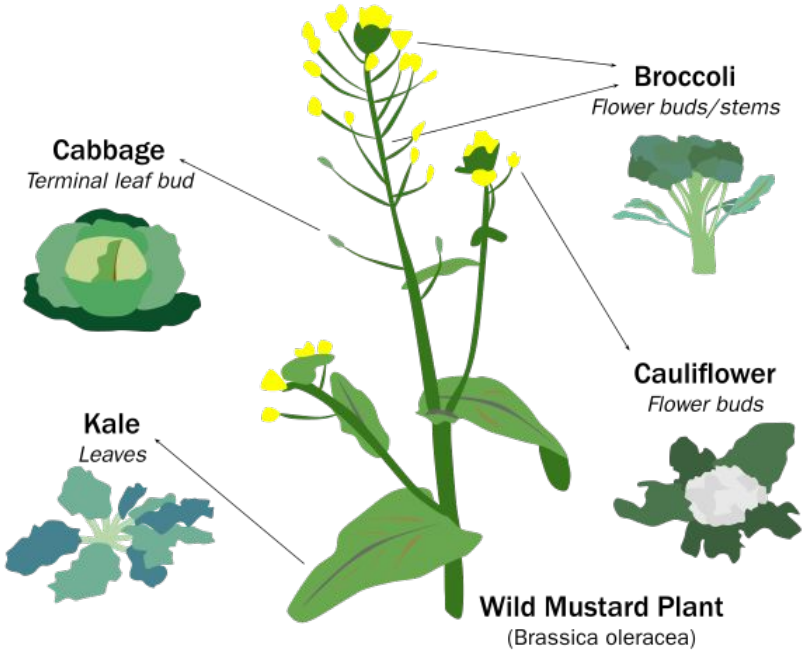
1. Variation existed in the resistance of the mosquito population to insecticide
2. The insecticide is a selection pressure, as it kills more of the mosquitoes with less resistance (allele type 1), so resistant mosquitoes (allele type 2) are more likely to survive and reproduce (pass on their alleles)
3. The allele for resistance (allele type 2) increases in the population so that overtime the mosquito population becomes more resistant to the insecticide

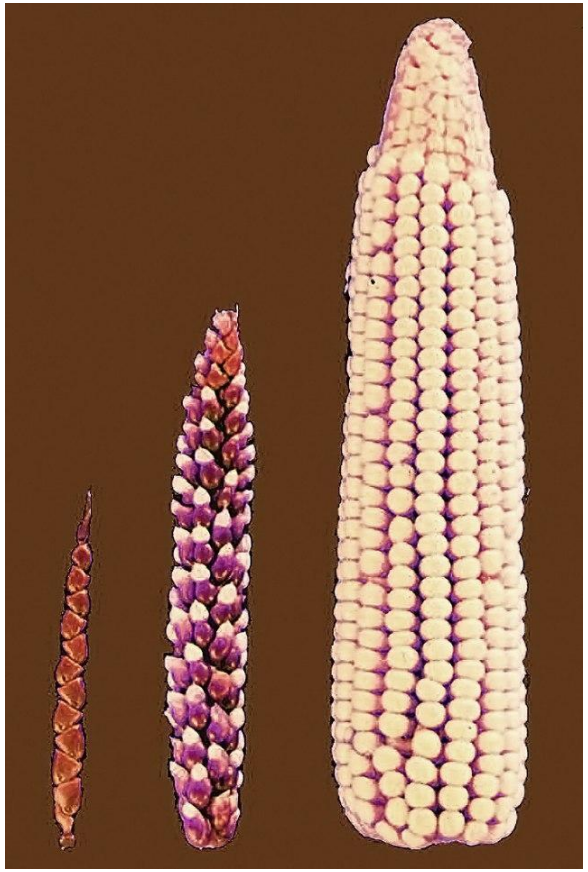
Selective Breeding

- Breeders choose which members of a species are allowed to breed based on characteristics that are desirable to the breeder. (e.g. aesthetic or economic appeal)
- **Humans are acting as the selection pressure!**
- Suits the breeder but often does not necessarily increase the animal's ability to survive in the wild.
- ***Also tends to decrease the genetic variation of the gene pool!***

Genetics & Evolution

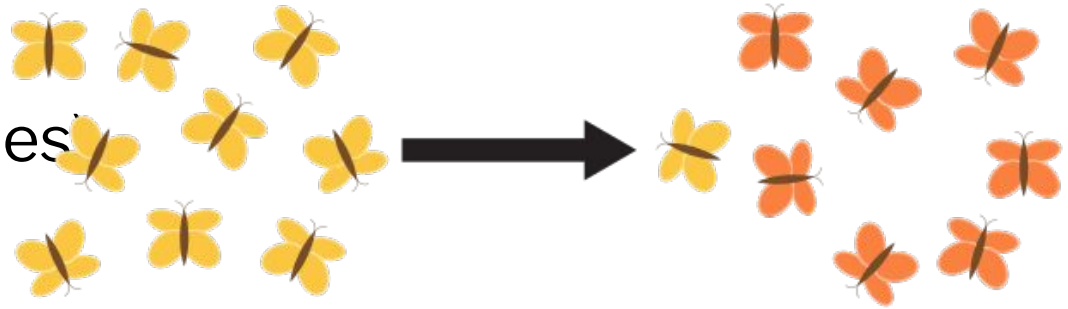
Selective Breeding





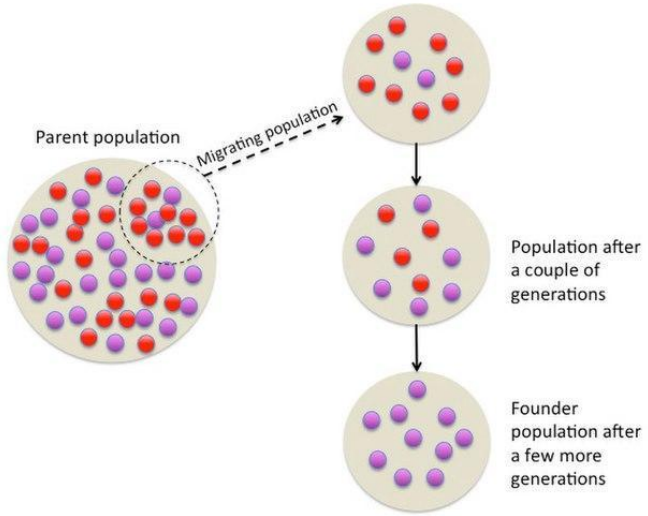
Gene Flow

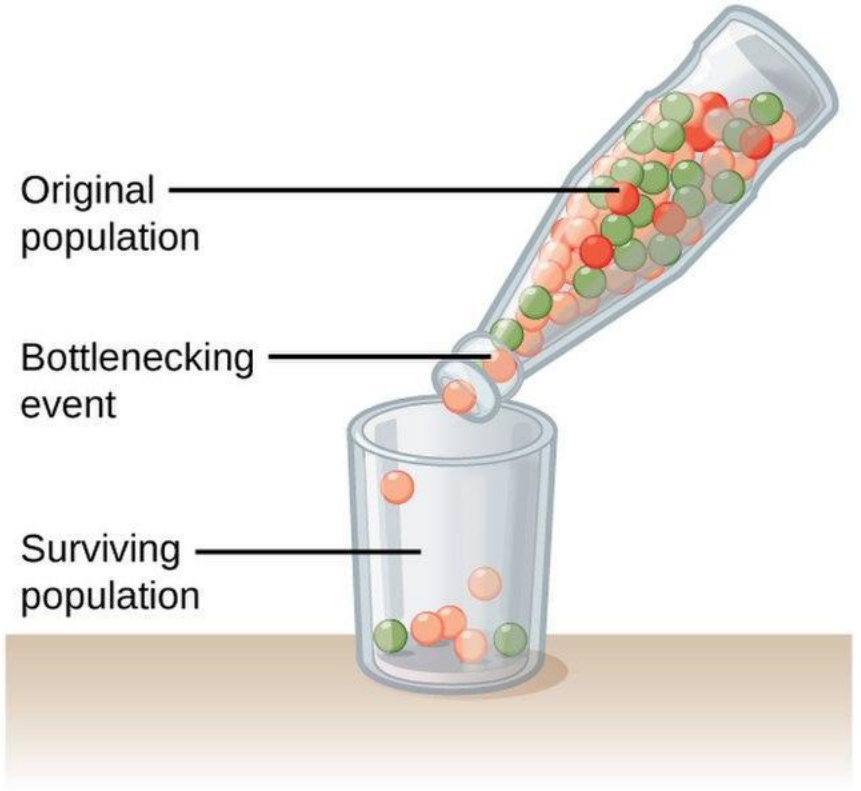
- **Gene flow:** the movement of alleles between populations of the same species
  - When gene flow exists between populations the populations' gene pool become more similar over time
- **Immigration:**
  - Individuals entering a population
  - Can increase diversity (introduce alleles)
- **Emigration:**
  - Individuals leaving a population
  - Can reduce diversity



Genetic Drift

- Changes in allele frequencies between one generation and the next due to **chance events**
- More evident in **small** populations





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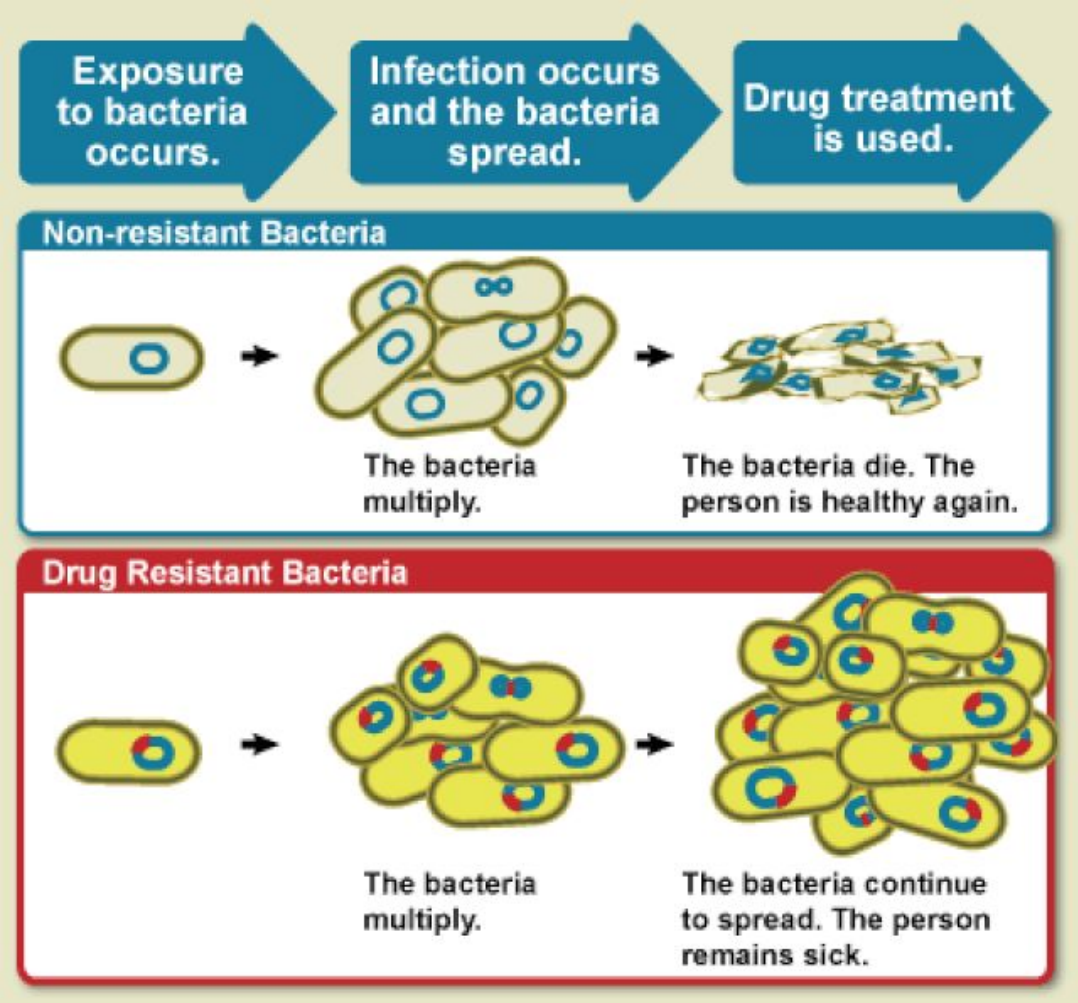
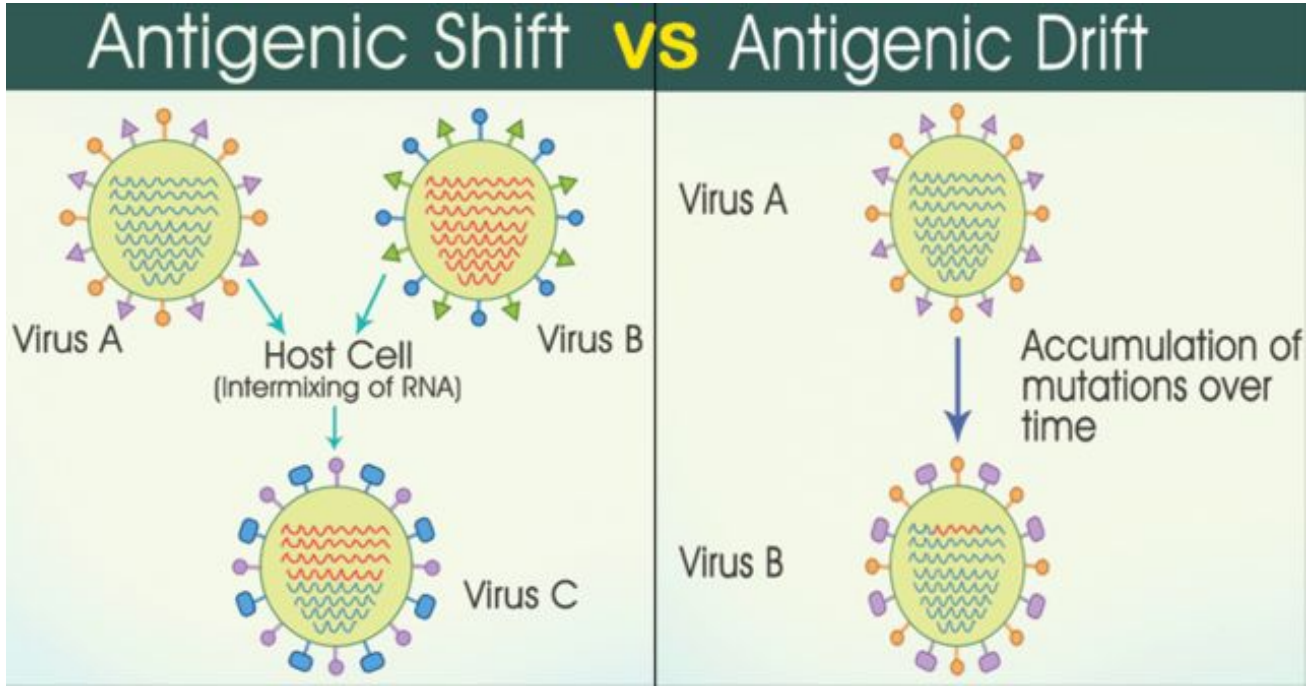
Bacterial Resistance



Antigenic Shift + Drift

Differences



Allopatric Speciation Questions

- Usually 3-4 marks

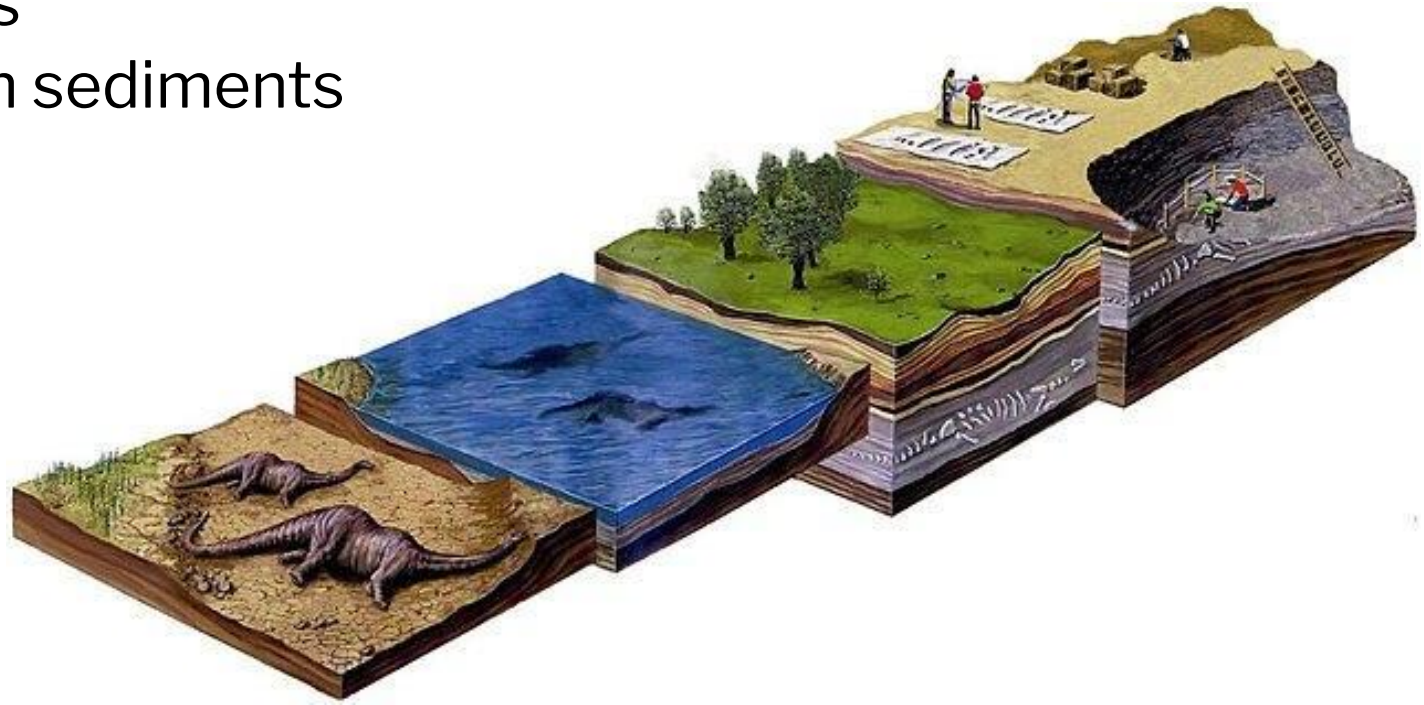
1. Geographic isolation has occurred, preventing gene flow between the populations
2. Explain how natural selection acts over time due to differing selective pressures (includes changing allele frequencies and new mutations)
3, When the populations are brought back together they are unable to produce fertile / viable offspring

Sympatric Speciation

- Sympatric speciation involves the separation of species due to other forms of isolation than geographical
  - temporal
  - behavioural
  - sexual

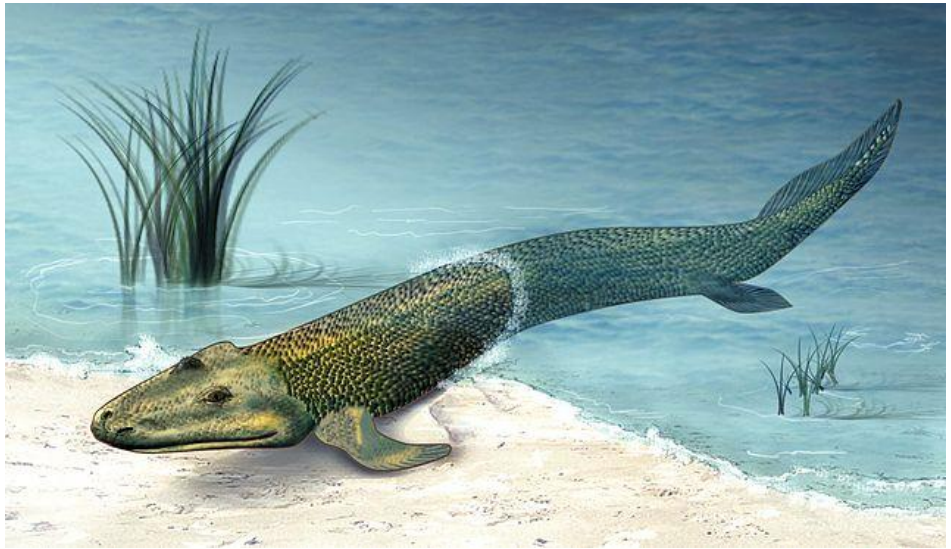
Fossilisation

- Conditions needed for fossilisation:
  - Lack of oxygen
  - Alkaline environment (basic)
  - Lack of scavengers
  - High pressure from sediments
  - Hard body parts



Transitional Fossils

- **Transitional Fossils:** any fossilised remains of a life form that exhibits traits common to both an ancestral group and its derived descendant group. They are fossils of organisms that are in the intermediate stage of evolution from one species to another species



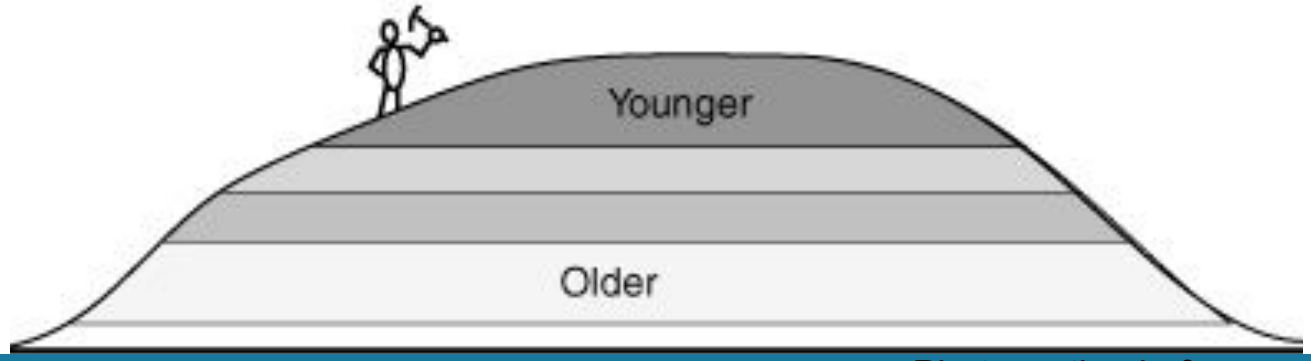
Genetics & Evolution

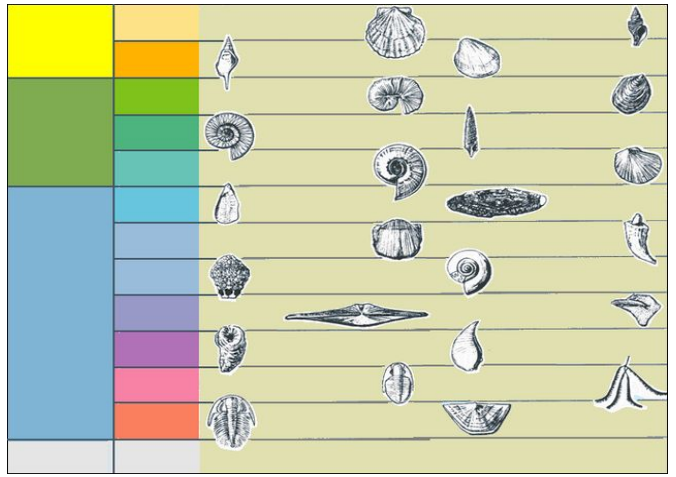
Relative Age

The principle of superposition: the oldest strata (layers) of rock are at the bottom and the youngest/newest are at the top (except in cases of major movement).

Stratigraphy: estimating the relative age of a rock strata, by the position of the layers using igneous strata as a reference

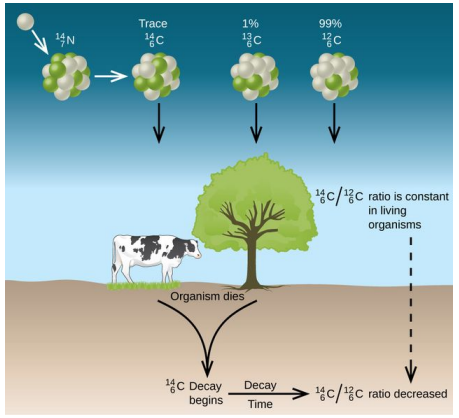
Indicator/index fossils: fossils of species that are known to have only lived for a short period during a specific time can be used to identify the age of the rock strata that they are found in





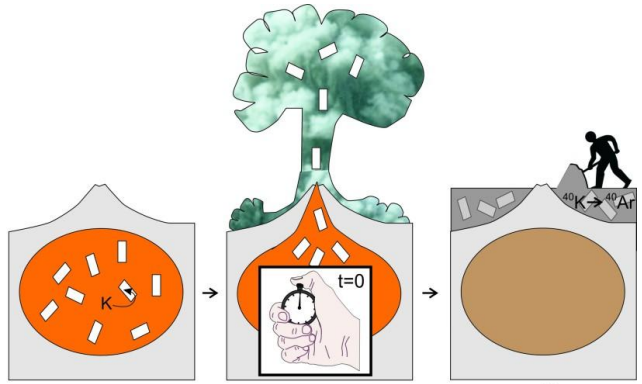
Absolute Dating

- Carbon 14 is a radioactive isotope that decays to the stable product Nitrogen 14
- Half life of 5730 years
- Can only be used to date organic compounds aged **< 50,000** years
- Age is determined by comparing the ratio of **C14** to **C12** in the actual **fossil**



Absolute Dating

- The radioactive isotope potassium 40 decays into the more stable product Argon 40
- Has a half life of 1.25 billion years (**can be used to date very old fossils)**
- The ratio of **Potassium 40** to **Argon 40** in the **rock** surrounding the fossil is measured to determine the age



Structural Morphology

- **Homologous structures:** features in different species that have a similar structure but a different function
  - Evidence of sharing common ancestry

- **Analogous structures:** structures that have the same function in different species but that may have a different structure
  - Evidence of similar environmental conditions/selection pressures

- **Vestigial structures:** a structure that was fully functional in an ancestor but has largely no function in the current organism and is usually very reduced in size

Molecular Homology

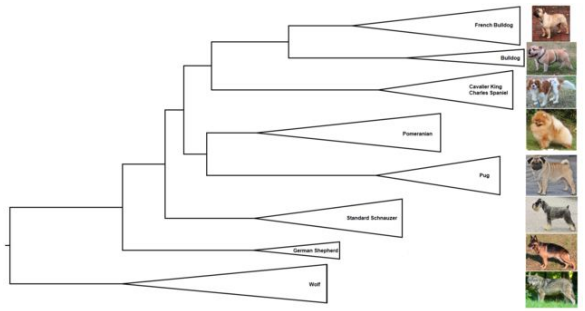
- **DNA sequencing** is the process of determining the precise order of nucleotides in a segment of DNA
  - The more differences in the DNA sequence the less related the two species are (they diverged from a common ancestor longer ago) because there has been more time for different mutations to accumulate
- **Amino acid sequencing** is the process of determining the precise order of amino acids in a polypeptide / protein
  - Equivalent proteins in different species can be compared to determine relatedness, as a change in the nucleotide sequence of a gene could result in a change in the amino acid sequence of the protein that it codes for

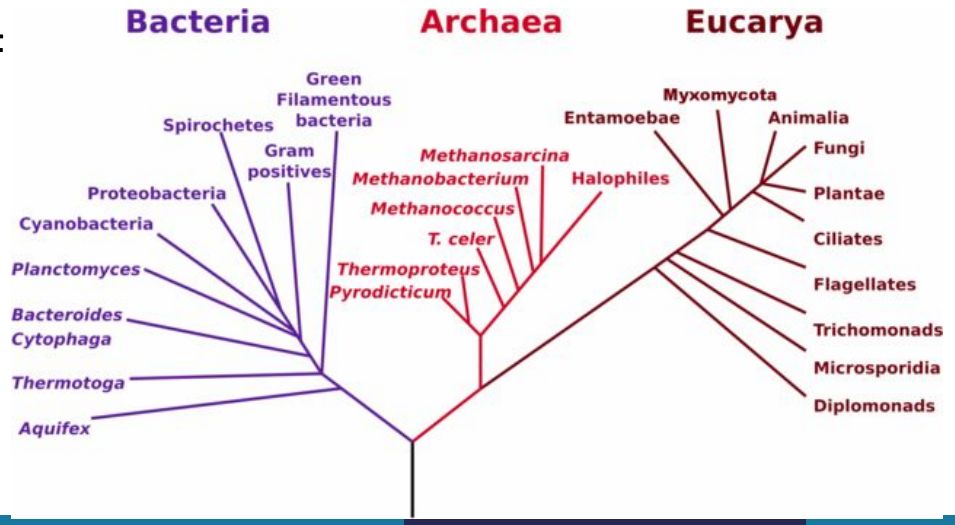
Phylogenetic Trees

- **Phylogenetic trees** are diagrams that are used to show the evolutionary relatedness between different species

- Molecular techniques such as DNA sequencing and hybridisation can be used to establish this relatedness and therefore create the tree

- Shows common ancestors and points of





Mammals + Primates

Mammals: common features

- Sweat glands – mammary glands
- Fur or hair

Primates: common features

- Forward facing eyes (3D vision) and colour vision
- Long gestation -period between conception and birth
- Large cranial (skull) size (relatively)
- Five digits and opposable thumb

Hominoids + Hominins

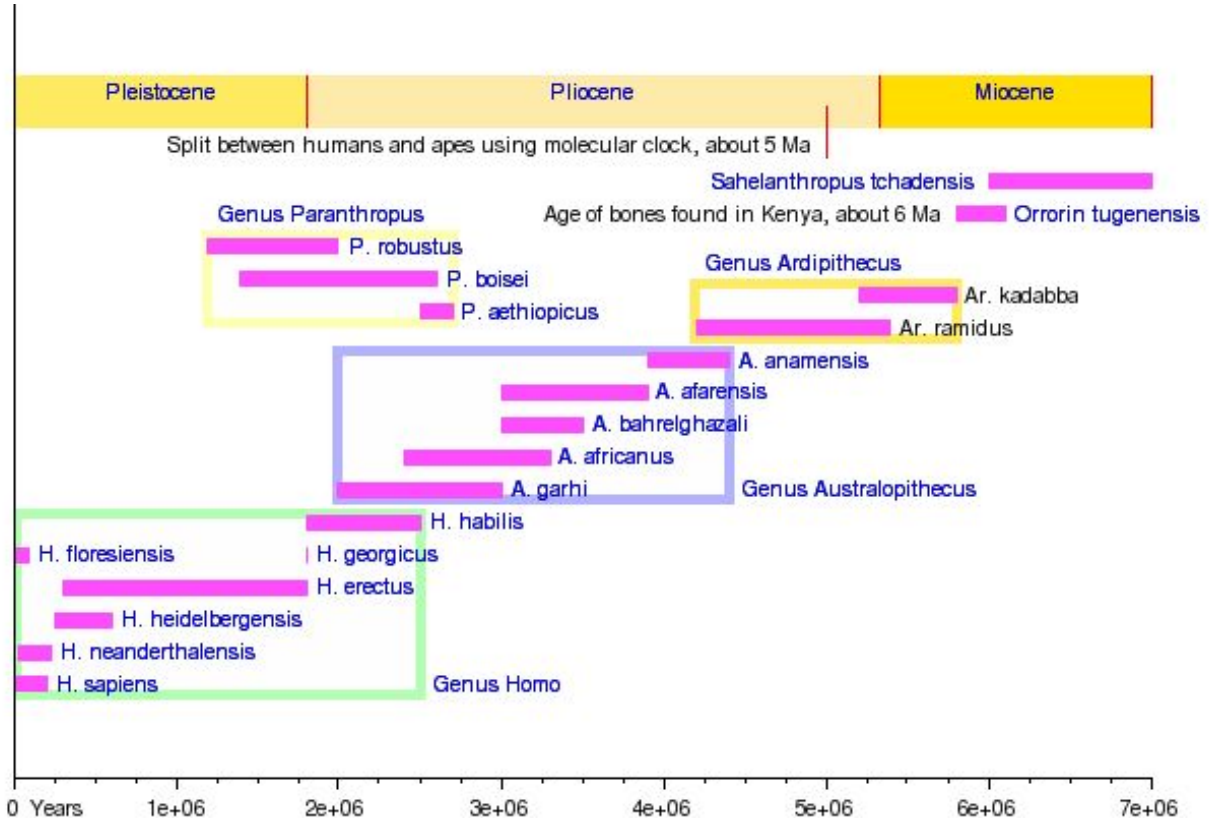
Hominoids:

- Great apes (humans, chimps, gorillas and orangutans)
- Lesser apes (gibbons and siamangs)
- Do not have tails

Hominins:

- Modern humans (Homo sapiens)
- Extinct humans species and their immediate ancestors
- **Are bipedal (walk on two legs)**

Genetics & Evolution

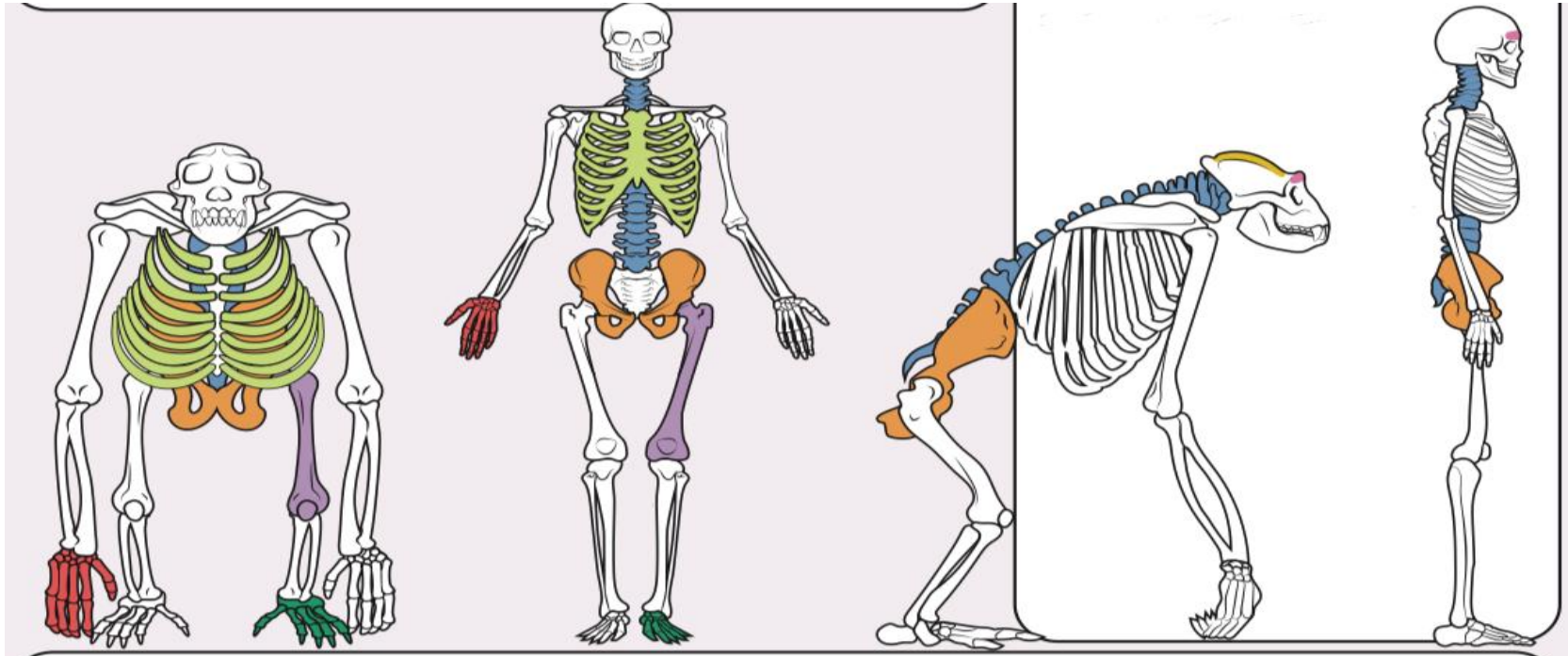


Timeline of Evolution

- Different researchers have different theories about hominin evolution (different people will interpret the same evidence differently)
- The timeline generally needs to be adapted when new evidence is discovered - **new species**
- Many of the relationships are just inferred

Genetics & Evolution

Bipedalism



Rib cage* – The rib cage in humans is more barrel-shaped than gorillas who have funnel-shaped rib cages instead. This helps humans to maintain an upright posture for a lengthy period of time.

Hand – Human hands have shorter, straighter fingers and longer thumbs compared to gorillas, making it possible for humans to have a further refined precision grip.

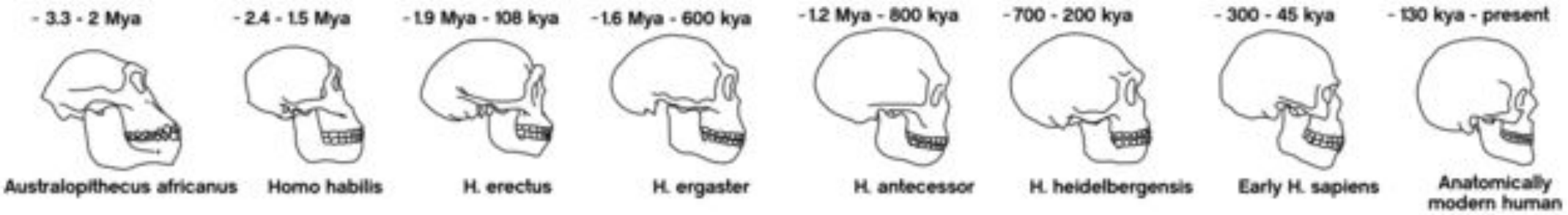
Pelvis* – Human pelvises are more shallow and bowl-shaped than other primates, whose pelvises tend to be vertically long and narrow. The bowl-shaped pelvis helps provide support for the upper body whilst standing and walking upright.

Femur angle* – Humans have a relatively large **femur angle** compared to gorillas. This helps to increase stability in humans while walking upright by ensuring the knee and foot are more centrally placed below the body.

Foot* – The human foot no longer has prehensile capabilities, and the big toe is in line with the other toes. Human feet also have two arches and a wide heel, making bipedalism more energy efficient and less impactful on the foot.

Genetics & Evolution

Changes to Skull Morphology



- **Brain size**
- Rounding of skull
- Eyebrow ridge shrinking
- Teeth size decreasing
- Face becoming flatter (decreased prognathism)
- Increased nose prominence
- Zygomatic arches reduce in size

Which hominin species doesn't fit the trend of increasing cranial capacity?

Genetics & Evolution

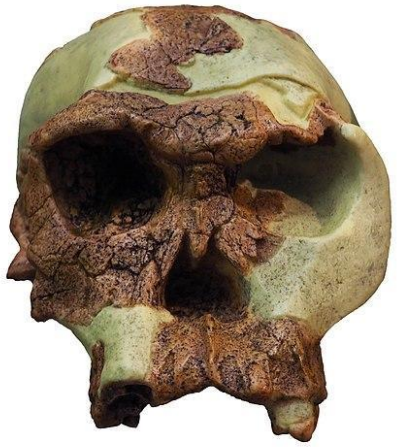
A. afarensis + *Paranthropus*

- Short stature (1.5m)
- Lived between 3.9 and 2.8 million years ago
- Small cranial capacity (around 450 cc)
- Long arms and curved fingers

- Large molars + jaw
- Large sagittal crest
- Not believed to be ancestors of *Homo sapiens* and other hominin species

Genetics & Evolution

H. habilis + H. erectus



- Brain size around 500cc
- Small body size

- Likely the first hominin to migrate out of Africa
- Medium brain size

Genetics & Evolution

H. neanderthalensis + H. sapiens

- Coexisted with H. sapiens
- Large brain size (larger than *H. sapiens*)
- Large cranial capacity + more rounded skull
- Tallest hominin
- Short arms compared to legs

Putative (new) *Homo* species

- ***Homo floresiensis***
  - short
  - small brain size
  - doesn't fit trend – more modern but small features
- ***Homo naledi***
  - mix of *Australopithecus* and *Homo*
  - small brain size
  - similar skull shape to more modern hominins
- **Denisovans**
  - separate species from *H. sapiens* and *H. neanderthalensis*
  - evidence of interbreeding – so are they a separate species?

Interbreeding

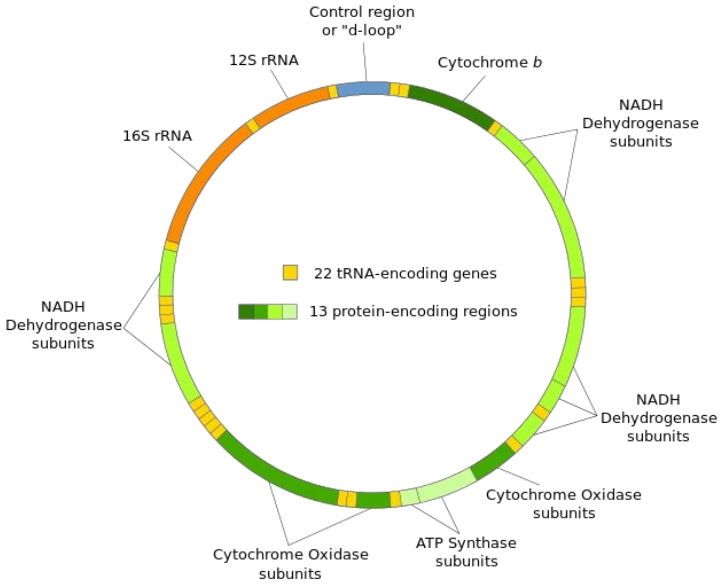
Are *H. sapiens* + *H. neanderthalensis* two separate species or two different races of the same species?

Evidence that they did interbreed:

- Both H. sapiens and H. neanderthalensis coexisted in the same regions around 80,000 years ago (although there is some new evidence that Homo sapiens and neanderthalensis interbred as long ago as 100,000 years)
- Neanderthal DNA (1-4%) has been found in modern human (Homo sapiens) populations

mtDNA

- Small (16.5kbp), circular DNA found inside mitochondria
- Only contains genes for a few proteins (mainly for cellular respiration)
- **Is only inherited from the maternal line** (no recombination takes place)
- Useful in studying human evolution



Theories

Out of Africa hypothesis: Homo sapiens evolved in Africa and then migrated out across the globe

Multiregional hypothesis: Homo sapiens evolved in multiple regions around the world at the same time from Homo erectus

1. Forget about your SACs... kind of?

- SACs are (hopefully, R.I.P. if not) over, and you can't change your marks now.
- The good news? SAC marks probably don't matter as much as you think.
- Most important thing is to ***learn*** from your SACs. Go back over them if you can, identify the errors you made and make sure you don't make those same mistakes again.

2. Practice (exams) makes perfect!

- VCAA is the *gold* standard, the best exams by far (apart from ATAR Notes exams of course hahaha)
- How many? Everyone is different! Quality of practice exams **much** more important than quantity.

Starting a new series on Netflix

Practice Questions, Practice Questions, Practice Questions! Did I mention Practice Questions?!?!

3. Make your practice exams count!

- Actually use the reading time!
- After you have a bit of experience, try emulate your exam conditions as close as possible (including time of day, clothes, etc.)
- Make a day-by-day plan of the practice exams you're going to tackle (e.g. so you don't leave it to the last minute)
- Make sure you spend adequate time *correcting* your exam!

4. Keep track of your mistakes -> Mistake or error booklet

Multiple choice:

Stoichiometry:

- ALWAYS pay close attention to mole ratio in equation. Especially when working with gas equations, you **must** set out your work correctly. Do not write n=... instead, must write n(element) to ensure clear thinking and working out.

Short answer:

Titration:

- Need to be super clear on which measurement the question is asking for. Is this answer pre or post dilution? In the volumetric or titration flask? Read carefully, set out work neatly. Use a pencil. Spend reading time thoroughly reading these questions.
- Need to revisit this question, I still don't understand it.
- When asked to give errors with titration, consider procedural errors, e.g. washing equipment with wrong fluids, overshooting end point.
- However, don't use rinsing pipette with water; when delivering the aliquot this only usually effects first trial, which then isn't considered concordant anyway. Need systematic error.

5. The day before…

- Just chill, you've already put in all the hard work. Learning stuff is the difficult part, kick back and show the examiner your hard work!
- If you want to do something: lightly brush over past mistakes so you don't make silly errors in the real thing

6. Most importantly…

- Look after yourselves <3
- Don’t stress too much, get plenty of sleep, eat well, exercise if you can.
- Cliché stuff but being healthy for the exam is as important as having studied for it!

EXAM STRATEGIES: ON THE DAY

- Get to the exam hall early!
- Avoid talking to others about bio and just *be chill*!
- Have an exam plan!
  - What will you do in reading time?
  - Will you start with MCQs or SAQs?
- Avoid silly mistakes!
  - Use a highlighter to make sure you *actually* answer the question
- There ***will*** be curveball questions in the exam, but don't panic!
  - Take a deep breadth and re-read the question
  - If you're still stuck, move on and come back to it at the end!
  - Go for a toilet break to stretch your legs

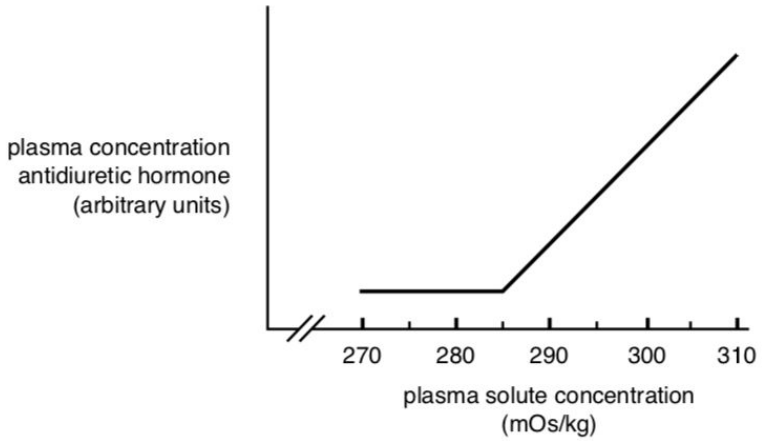
Exam Prep

DATA QUESTIONS

- ALWAYS **CITE FIGURES** FROM DATA
- ALWAYS **CITE UNITS** OF MEASUREMENT

Several hormones are involved in maintaining homeostasis in mammals.

Antidiuretic hormone is important in controlling water balance. The following graph shows changes in the concentration of this hormone as plasma solute concentration increases.



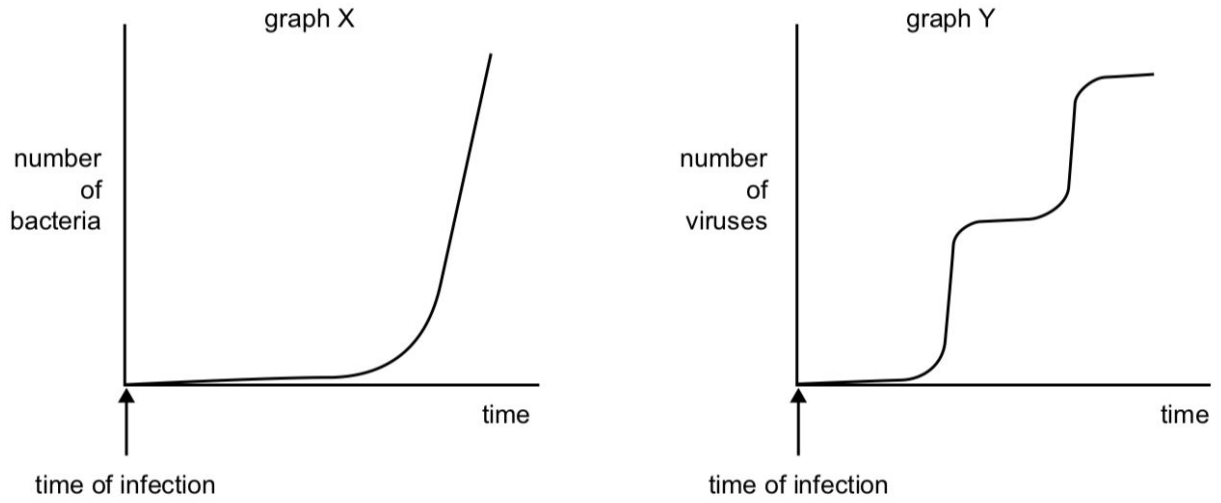
c. At what plasma solute concentration is the release of antidiuretic hormone triggered?

1 mark

Exam Prep

DESCRIBE VS EXPLAIN QUESTIONS

- If asked to **describe** data, just comment on the trend
- If asked to **explain** data, mention the relevant biological concepts



Graph X shows the increase in the number of bacteria in an organism after infection. Graph Y shows the increase in number of viruses in a similar organism after infection.

d. Explain why there is a difference between the patterns of growth of bacteria and viruses after infection of an organism.

Exam Prep

EXPLAIN QUESTIONS

- Not only do you need to give the right answer, but you also have to justify it in a watertight way, so if the examiner can say “so what?” after reading your answer, you have not fully answered the question.

Question 1 (4 marks)

Hepatitis B is a viral infection that attacks the liver of its host. It is transmitted between hosts via blood to blood contact.

Women who are pregnant can have hepatitis B and are at risk of transmitting the virus to their babies during labour, due to the trauma of delivery and the potential for blood to blood contact between the mother and her baby.

In order to protect the baby from contracting hepatitis B, after delivery the baby is administered hepatitis B immunoglobulin as well as a hepatitis B vaccine.

a. Explain what type of immunisation is being demonstrated in the administration of hepatitis B immunoglobulin. **2 marks**

Exam Prep

EXPLAIN QUESTIONS

- ✔ Gets straight to the point
- ✔ Subsequently explains why it is artificial and passive
  - Though note that this could be more clear!
- ✔ Uses key terminology

a. Explain what type of immunisation is being demonstrated in the administration of hepatitis B immunoglobulin. 2 marks

Artificial passive; the antibodies (immunoglobulins) are directly administered to the baby from an exogenous source, instead of antibodies being produced by the baby. Also, this is done by a non-natural process (i.e. not via placental transfer or breastfeeding).

Exam Prep

AGREE/DISAGREE QUESTIONS

- Don't just put yes/no responses -> **marks are allocated to your reasoning**

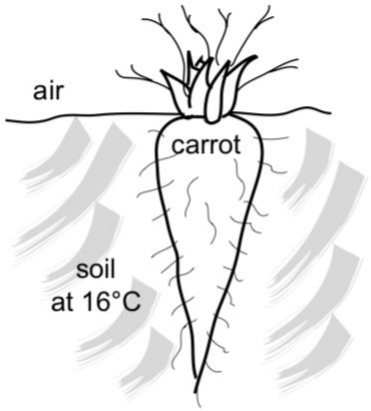
A student predicted that if a temperature graph was prepared for carrot catalase activity, the optimal temperature would be expected to be much lower than that shown by catalase from humans.

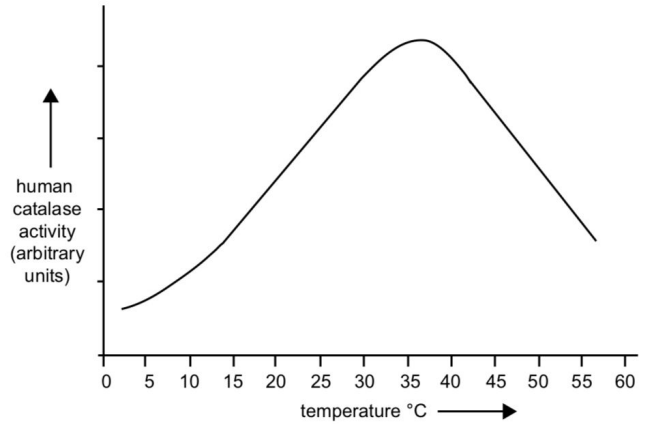
b. Do you agree or disagree with the student's prediction? Explain the reason for your choice.

_____

_____

1 mark





Exam Prep

OTHER ADVICE

- The word '**complementary**' excites an examiner for some reason, so use it – especially with enzymes, cell signaling, and translation
- Marks are not awarded for restating information from the question stem
- If asked to give a function of a structure, do not simply describe or define it!
- Spelling errors won't be penalised unless there is an ambiguity (such as glucagon vs glycogen)
- Watch for the switches in focus within questions – questions commonly combine theory across multiple dot points from the study design

Exam Prep

Q&A & EXAM TIPS

1. At this moment in time, you should be beginning your full revision. I'd recommend printing out all the study design dotpoints and ticking them off as you go revise/relearn each point.
2. I'd recommend buying a study guide (optional; no need if you have amazing notes already)
3. Annotate notes/study guides with mnemonics, diagrams, drawings, etc. (Remember u need to store all of this info in your actual brain for the exam– can't bring anything in with you.)
4. Find as many practice exams as you can. Personally, I find 15+ to ~20ish to be a number that I feel is suitable to help you attain a 40+ study score.
5. DO THE EXAMS

Exam Prep

Q&A & EXAM TIPS

6. Make a note of EVERY question you feel unsure of. Put this in a notebook.

7. Correct/mark your exams. I would recommend doing this yourself and consulting your teacher/tutor when you need a bit of extra help.

8. Make a note of EVERY question you got wrong.

9. For EVERY question you were unsure of or got wrong, go back and STUDY IT.
Write a whole paragraph in your notebook about why you got it wrong, what you didn't understand. RESEARCH that q and the underlying theory and ADD THIS TO YOUR NOTES. Keep track of what kind of questions you are getting wrong.

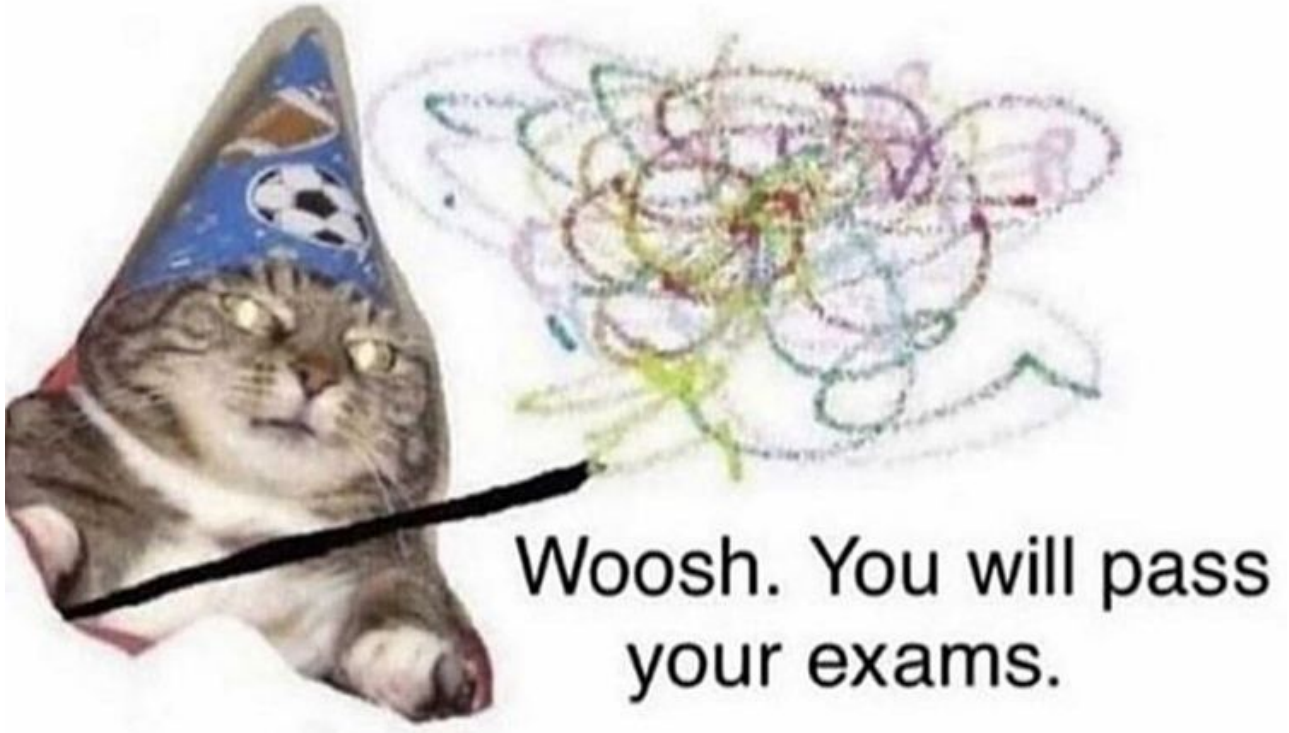
10. DO MORE EXAMS.

11. REVISE your notebook & notes/guide EVERY DAY/NIGHT. Keep track of all the qs you got wrong/were unsure of and REVIEW, REVIEW, REVIEW every day.

12. KILL THE EXAM.

Exam Prep

Good luck!



Please leave us a review

SCAN

Thanks so much!

ATARNotes