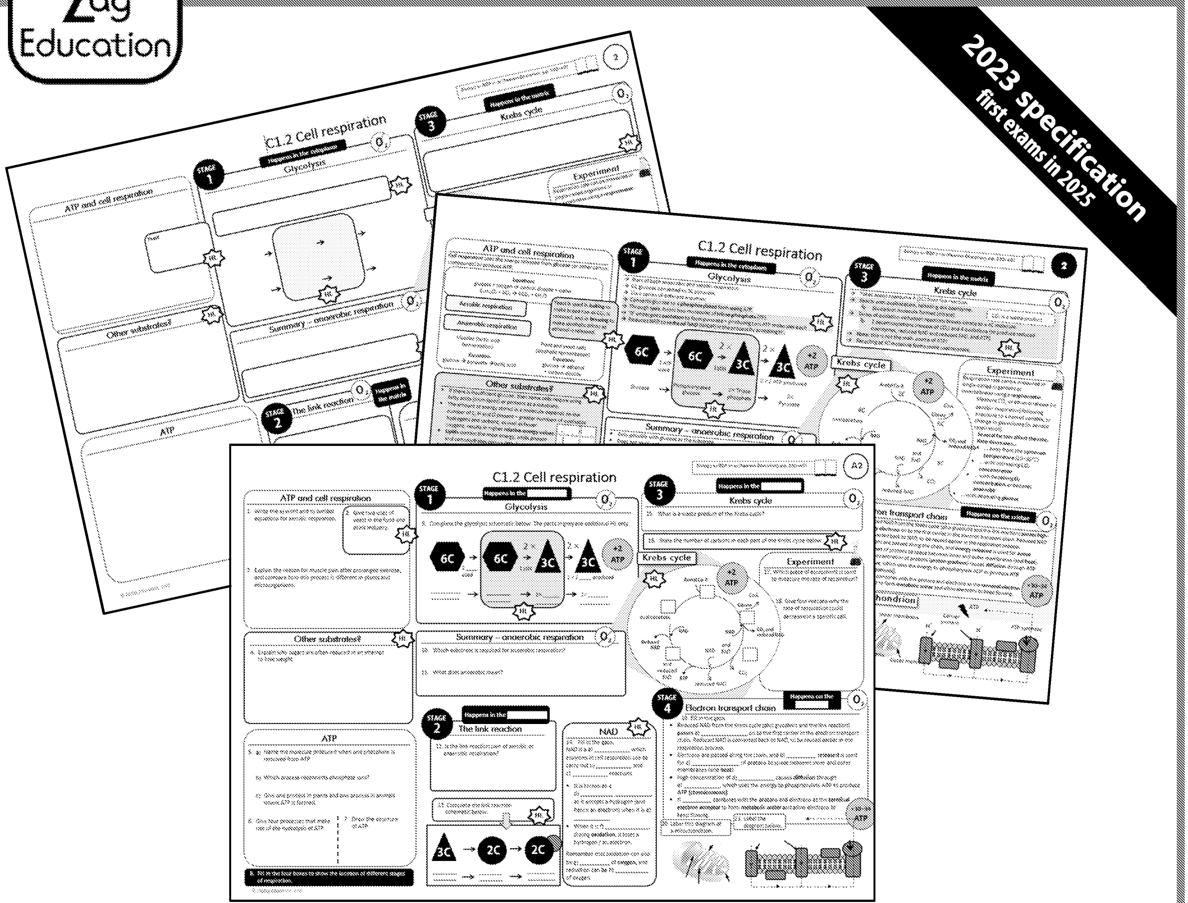
Biology International Baccalaureate Diploma Programme

2023 specification
first exams in 2025



Topic on a Page

for IB Biology

Theme C – Interaction and Interdependence

zigzageducation.co.uk

POD 12808

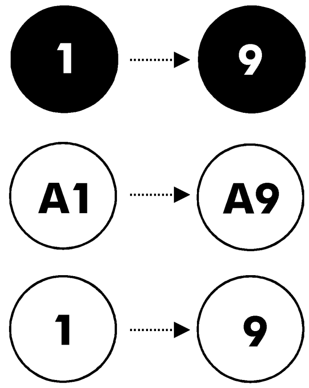
Contents

Teacher's Introduction

This Topic-on-a-page resource has been designed to help your students revise the key points of each topic and test their knowledge after you have taught each section of the **IB Biology: Theme C – Interaction and Interdependence** specification from topics C1.1 to C4.2. Each page is closely tied to the IB specification, ensuring all aspects of the course are covered.

There are four sections to this resource, each with its own features:

1. **Summary posters**: these are the main pages which intend to clearly consolidate and recap all the key information from the IB Biology course.
2. **Activity worksheets**: these are identical to the Summary posters, but contain a variety of tasks, from filling in missing words to completing diagrams. The activity worksheets aim to ensure the student understands all the key knowledge required of them and gives them the opportunity to demonstrate how well they have remembered and understood the content of the course.
3. **Outline-only pages**: these are the Summary posters, but with most of the content removed. Students can research the topics, e.g. for homework, and fill in as much information as they can.
4. **Mark scheme**: full answers for the activity worksheets.

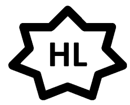


The Summary posters, Activity worksheets and Outline-only pages are designed to be A3 size, although they are still useable at A4 with no loss of detail. When photocopying activity pages on A3, we suggest photocopying the relevant worksheet on the reverse. If using at A4 size, we suggest photocopying each A3 'worksheet' (for writing answers) as a double-sided A4 page to avoid shrinking the space available for answers.

Each page presents information in a variety of ways, including:

- **Bullet-point processes** – complex processes and lists have been summarised into quick, easy-to-learn points.
- **Illustrative diagrams** – detailed diagrams that visually represent a concept or event.
- **Tips and tricks** – extra useful information that can help students when solving problems.

Additional higher level content is presented with a darker background and has been marked with this symbol for easy reference:



This resource is cross-referenced to the Pearson textbook *Higher Level Biology for the IB Diploma Programme (3rd edition)* by Alan Damon, Randy McGonegal and William Ward (ISBN 978-1292427744).
Additional information from the guide and textbook will be needed to explore these topics in greater detail.

We hope you find these pages useful during your teaching and your students' revision.

April 2025

C1.1 Enzymes and metabol

Enzymes and metabolism

Enzymes play an important role in **metabolism**, a term which encompasses all the chemical reactions in a living organism. It includes a diverse, interdependent collection of reactions, and as such, many **different** enzymes are needed.

- Enzymes are **proteins**, chains of amino acids folded to form a **specific 3D shape**. They are described as **globular** proteins.
- Their complex shape includes an **active site** made of just a few amino acids.
- The shape of an enzyme's active site is specific to the **substrate** it works on, and it is the **interaction** between these amino acids and the overall structure which creates the properties important for **catalysis**.

Metabolic reactions are inefficient, and produce **heat** (thermal energy) when energy is transferred. **Endotherms** (e.g. mammals and birds) rely on this heat to maintain their internal body temperature.

HL

Intracellular – within a cell, e.g. glycolysis and Krebs cycle
Extracellular – outside a cell, e.g. chemical digestion in the gut

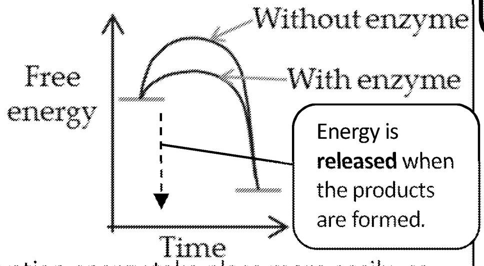
HL

Type

- **Anabolic** (building
  - Monomers ➔
  - Requires energy
  - Condensation
  - e.g. protein syn photosynthesis
- **Catabolic** (breaking
  - Macromolecule
  - Releases energy
  - Hydrolysis react
  - e.g. digestion, substrates in re

Enzymes as catalysts

Enzymes catalyse chemical reactions by lowering the **activation energy** (the **minimum** energy needed to break substrate bonds so that a reaction can occur).



Reactions with a **lower** activation energy take place more easily, so the overall **rate** of the reaction is **higher**. Without this increase in rate, many essential reactions would occur too slowly for life to be maintained.

Collisions

A collision is needed for a substrate molecule and the active site to interact. This can be made more likely by fixing one or other in place:

- Large substrate molecules or enzymes can be **immobilised** by attaching them to surfaces.
- Enzymes can be **embedded** in membranes to fix the orientation of the active site, e.g. in photosynthesis and respiration.

Collisions must occur with enough **kinetic energy** (speed) to exceed the activation energy for a reaction to happen.

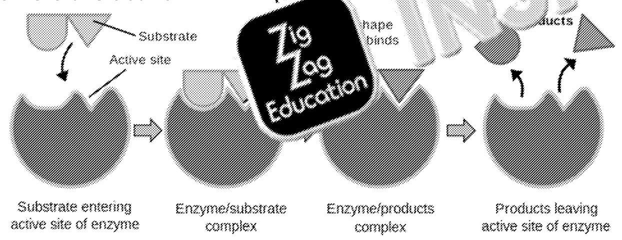
Mode of enzyme action

An enzyme binds with the substrate at the **active site**, forming an **enzyme-substrate complex**.

enzyme + substrate (reactant) ➔ enzyme-substrate complex
➔ product + enzyme

***Note:** enzymes are **not** reactants as they are not used up in a reaction and can be reused many times.*

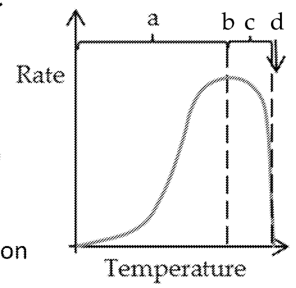
Induced-fit model of enzyme action: the active site changes shape to better fit the substrate, which causes the change in the substrate that lowers the activation energy.



Temperature

As temperature increases during *a*, **kinetic energy** increases. There are more encounters between molecules (and more of them have energy greater than the activation energy) so more enzyme-substrate complexes are formed.

b is the **optimum temperature**, where the rate of enzyme-substrate complex formation is highest.



During phase *c* enzymes **denature**; heat energy causes the active site to change shape so it is no longer **complementary**.

At *d* all enzymes are denatured.

Changes in pH causing it to changes and

Different enzymes have different **optimum** pH and, therefore best in different of the body.

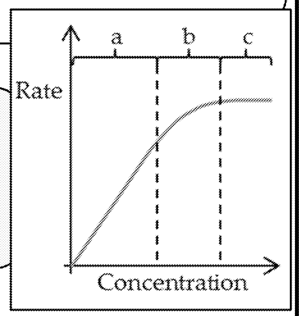
Effects of different co on enzyme acti

Substrate concentration

As substrate concentration increases during *a*, more substrates collide with enzyme active sites by **collision theory**.

During *b* almost all the enzymes' active sites are occupied by substrate.

During *c*, the addition of more substrate has **no effect** as all the available enzymes' active sites are occupied, so the rate of reaction is at its maximum.



Exam Tip!

The active site is **induced** to change by the substrate, but denaturing **disrupts** the shape.

Allosteric and competitive inhibition

★ **Non-competitive** (**allosteric**) inhib somewhere other than the active the structure, thereby altering the

★ **Competitive** inhibitors bind to an access for the substrate. They have substrate, e.g. **statins** can bind to involved in cholesterol synthesis and are prescribed to lower high cholesterol levels.

Both types of inhibitor bind **reversibly**. Increasing the substrate concentration can reduce the effects of competitive inhibitors, as more active sites are occupied by substrate than inhibit

C1.2 Cell respiration

ATP and cell respiration

Cell respiration uses the energy released from **glucose** (or other carbon compounds) to produce **ATP**.

Equation:
glucose + oxygen → carbon dioxide + water
$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$

Aerobic respiration

Anaerobic respiration

Yeas... ...aking to make ... ad rise as CO_2 is ...leased, and in **brewing** to make alcoholic drinks as ethanol is released.

HL

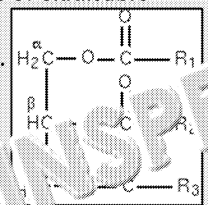
Muscles (lactic acid fermentation)
Equation:
glucose → pyruvate → lactic acid

Plant and yeast cells (alcoholic fermentation)
Equation:
glucose → ethanol + carbon dioxide

Other substrates?

HL

- If there is insufficient glucose, then some cells respire using fatty acids (from lipids) or proteins as a substrate.
- The amount of energy stored in a molecule depends on the number of C, H and O present – greater numbers of oxidisable hydrogens and carbons, as well as fewer oxygens, results in higher **relative energy values**.
- **Lipids** contain the most energy, while protein and carbohydrates carry a little less.
- Note that glycolysis and anaerobic re... ...ion can only occur in full if the respir... ...ate is a **carbohydrate** – acetyl groups ... ...eakdown of fatty acids enter the pathway into the ... ...rom acetyl-CoA.



ATP

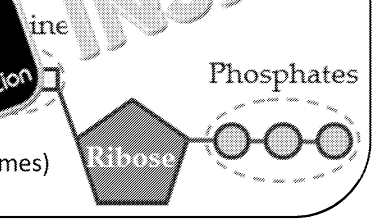
Adenosine triphosphate (ATP) is a phosphorylated **nucleotide** with a 5-carbon ribose sugar, an adenine base and three inorganic **phosphate** ions. The last two phosphate ions are bonded via **high-energy bonds** to the rest of the molecule.

ATP provides an **immediate** source of energy for cells. Phosphate ions are removed from ATP by **hydrolysis**, which creates energy and produces **adenosine diphosphate** (ADP) and phosphate.

Phosphates are reconnected through **condensation** reactions, which requires energy. This process occurs during photosynthesis in plants (**photophosphorylation**) and during respiration in animals (**oxidative phosphorylation**), and as such, ATP is continually used and s... ...a cyclic pathway to ensure cells have the energy they ...

Hydrolysis of ATP is used in:

- active transport
- metabolic processes (anabolism)
- cell movement
- cell component movement (e.g. chromosomes)



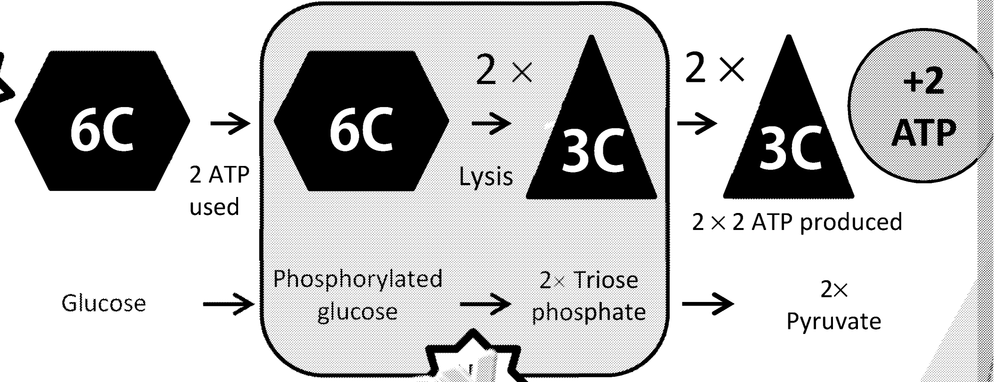
STAGE 1

...in the cytoplasm

Glycolysis

→ ... bo... ...obic and aerobic respiration.
→ ... converted to 3C pyruvate.
→ ... a series of different enzymes:
→ Converts glucose to a **phosphorylated** form **using** ATP.
→ Through **lysis**, forms two molecules of **triose phosphate** (TP).
→ TP undergoes **oxidation** to form pyruvate – producing two ATP molecules each.
→ Reduces NAD to **reduced NAD** (NADH) in the process by accepting H^+.

HL



... – anaerobic respiration

- ...ssi... ...th glucose as the substrate.
- ...e... ...involve the mitochondria; occurs in the cytoplasm.
- Produces ATP without oxygen – only glycolysis step (stage 1).
- Not as efficient as aerobic – 2 ATP per glucose molecule.
- Reduced NAD cannot be oxidised without oxygen, glycolysis could stop...
- **However**, lactate (animals) or ethanol/CO_2 (plants and microorganisms, e.g. yeast) is produced, which allows reduced NAD to become NAD.
- As a result, glycolysis can continue.

HL

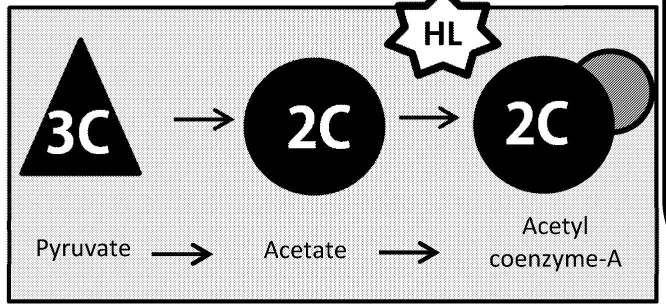
STAGE 2

The link reaction

Happens in the matrix

→ First of the aerobic reactions, linking **glycolysis** and **Krebs cycle**.
→ Pyruvate enters matrix by active ... ...ansport and is oxidised/decarbox... ...d dehydrogenated – ... ...ate producing r... ...uced ...
→ Ace... ...up ... ...ombines with c... ...A: **acetyl coenzyme A**.
T... ...carbons from acetyl coenzyme A fed into Krebs cycle.

HL



NAD

NAD is a **coenzyme** which ... cell respiration use to carr... oxidation and reduction re...

- It is known as a **hydrog**... as it accepts a hydroge... hence an electron) whe... **reduced**.
- When it is **dehydrogen**... **oxidation**, it loses a hy... electron.

Remember that oxidation ... gain of **oxygen**, and reduct... loss of oxygen.

C1.3 Photosynthesis

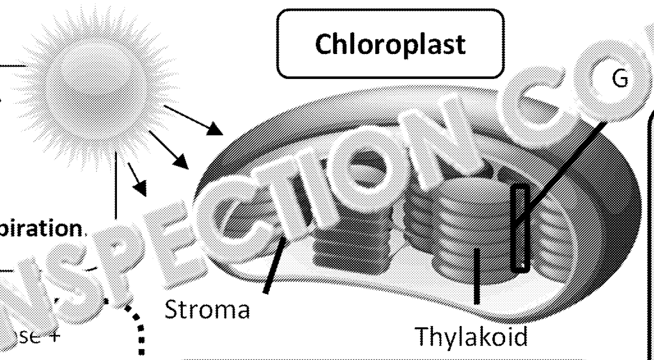
What is photosynthesis?

Light energy is converted to chemical energy by plants, algae and cyanobacteria in photosynthesis.

- Water is split, releasing hydrogens.
- These reduce carbon dioxide to glucose.
- Oxygen is a by-product needed by other life for **respiration**.

carbon dioxide + water → (Light energy) → glucose + oxygen

$6CO_2 + 6H_2O$ → (Light energy) → $C_6H_{12}O_6 + 6O_2$



Steps of photosynthesis:

1. Light-dependent (known as the Calvin cycle)
2. Light-independent

HL

$2H_2O \rightarrow 4H^+ + 4e^- + O_2$

(B) Photolysis

HL

→ An enzyme splits two water molecules in a proc… **photolysis**, forming protons, electrons and oxyg…

→ The protons (H^+) are used in photophosphorylat…

→ The electrons replace those lost from chlorophy… photoionisation.

→ The oxygen is a waste product either used by re… or released – accumulation of oxygen over time… many effects, including thinning the atmosphere… allow more sunlight through.

Photosynthetic pigments

→ Pigments such as **chlorophylls** absorb light. They are located in **thylakoid membranes** and absorb light at particular **wavelengths** – pigments appear the colour of the light that they reflect.

→ Pigments use the energy from light to **excite electrons** to higher energy levels, and these are used to form chemical bonds (i.e. light energy is converted to chemical energy).

→ Different energy levels require a different amount of energy, so different pigments absorb different wavelengths of light to do this.

→ Having many **accessory** pigments in addition to the primary pigment, chlorophyll *a*, increases the rate of photosynthesis substantially. HL

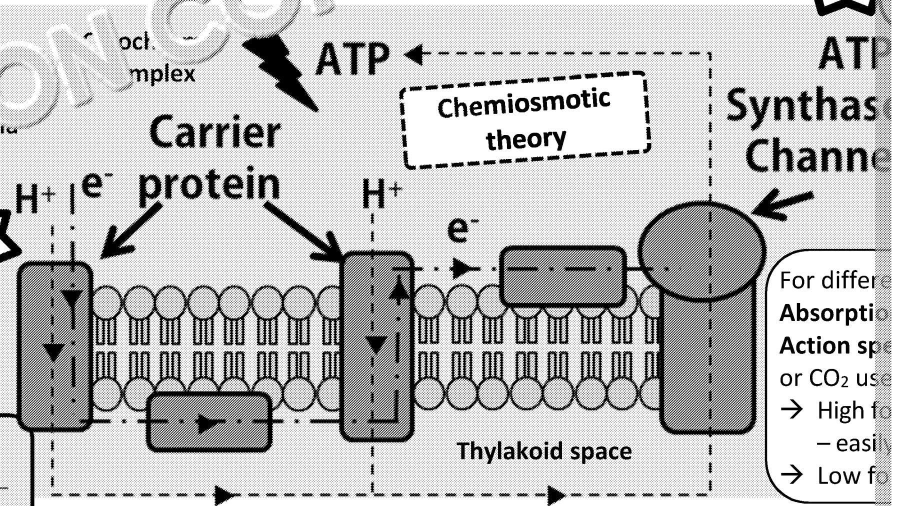
(C) Electron transport chain (photophosphorylatio…

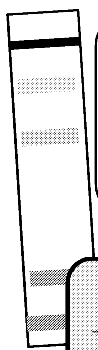
→ Electrons from chlorophyll passed along electron transfer chain, losing a small amount of energy each time they pass to a new **carrier**.

→ Energy allows pumping of **protons** from stroma across thylakoid membrane.

→ Forms **concentration gradi…** …protons.

→ Protons diffuse dow… …t, …rough ATP synthase, **producing ATP**. HL





Experiment

Pigments from leaves can be se… by **chromatography**. This allows … different pigments that are prese… which absorb different wavelengths of light!

M… …e di…ance …d by each …ment, and divide it by the distance travelled by the solvent to get its **R_f value**.

HL

For differe…
Absorptio…
Action spe…
or CO_2 use…
→ High fo… – easily…
→ Low fo…

(A) Light-dependent reaction - overview

→ Stage of photosynthesis that relies on sunlight.

→ Light (**photons**) falling on pigments in **photosystem II** are transferred to chlorophyll *a* (P680). HL

→ During **photoionisation**, electrons are excited and captured by electron acceptors in the reaction centre. **Photolysis** (B) also occurs.

→ Electrons enter the **electron transport chain** (C) from electron acceptors. **Chemiosmosis** produces ATP and reduced NADP.

→ Photons are absorbed by pigments in **photosystem I** and transferred acro… accessory pigments to chlorophyll *a* (P700).

→ High-energy electrons are captured by electron acceptors … the electron transport chain, and replaced by low-ener… photosystem II.

→ **NADP reductase** helps move … between electron carriers, re… NADP in the process.

…osystem I: P700 (700 nm)
Photosystem II: P680 (680 nm)

Cyclic vs non-cyclic photophosphorylation

Non-cyclic: two elec… …m photosystem II pass into the electron transport chai… …n i… photosystem I) and are used with hydrogen ions to …educ… one A…P molecule.

…lic: …cu… only if light is **not** limiting and reduced NADP accumulates. …rons come from photosystem I. Does not produce oxygen or reduced NADP, only ATP.

Photosystems are found in thylakoids of chloroplasts, and in membranes of cyanobacteria. The **light-receiving complex** is a collection of chlorophyll and accessory pigments which absorbs photons. The **reaction centre** contains a chlorophyll pigment capable of releasing electrons into the electron transport chain. HL

Light effec…

When night falls, then GP cannot be reduced to TP. If no TP, then GP accumulates.

C2.1 Chemical signall

HL – additional higher level only

Cell signalling

- → In a **signal transduction pathway**, a signal is released from one cell and is detected by another, leading to a series of steps which enact an effect. This can be considered as a **receptor-effector relationship**.
- → Four signalling chemicals that are used by organisms are:

Neurotransmitters in neurons
Act on neighbouring cells, e.g. diffuse across a synapse
Important for rapid response
Examples (usually hydrophilic – surface-binding): amino acids, peptides, amines, nitrous oxide

Hormones
Act on specific distant ...
Secreted by ...
... the ...
... for regulation
... mines and proteins
(... philic – surface-binding), steroids (hydrophobic – cross membrane and bind within a cell)

Cytokines
Glycoproteins (surface-binding)
Important for inflammation response and cell reproduction
Produce a cascade reaction

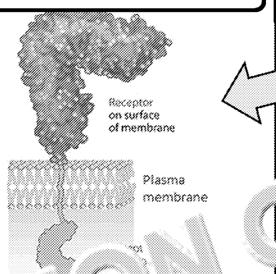
Calcium ions
Often second messengers
In muscles, regulate contraction
Also important for hormone secretion

- → There are many different **target** cells in the body
- → Using different ligands means receptors must be **specific** – they have a complementary shape to the ligand
- → Different ligands may have **short-** or **long-term** effects

Receptors

- → ...ptors ... protein structures that can detect a change in condition ... binding of a ligand. They might detect, for example, changes in temperature, pressure or pH.
- → When a ligand binds, the receptor changes shape, leading to a signal transduction pathway.
- → Receptors can be found on the surface of a cell, embedded in the plasma membrane (**transmembrane**), or within a cell in the cytoplasm or the nucleus (**intracellular**).

Intracellular receptors
Hydrophobic ligands can bind inside the cell as they can cross the cell membrane



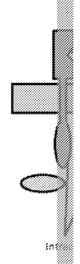
Transmembrane receptors

- Span the whole plasma membrane
- Hydrophilic domain is on the external (aqueous) side
- Hydrophobic domain is on the interior (cytoplasm) side
- **Hydrophilic ligands** bind outside the cell as they cannot cross the polar membrane
- Different ty...es include:
  (A) ...lly gated ion channel receptors
  (B) ...prote...-coupled receptors (ligands ...activate G proteins)
  (C) Enzymatic receptors (ligands activate intracellular enzymes)

- Ligand... gates...
- Positi... the ce...
- Voltag... furthe...

Example: *more det...*
- → Called ... doma...

Examp...
- → Si... (T...
- → W...
- Ty...
- Ty... (T...
- Si...
- Gl... m...



Steroid ho...es

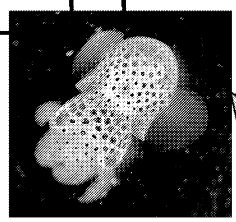
- → Steroids are **hydrophobic**, so bi... ...llular receptors
- → Binding forms a **receptor-signal c...**
- → Receptor-signal complexes can ac... **...anscription factors** in the nucleus when they bind to specific DNA sequences
- → Binding promotes transcription of DNA, the first step in protein synthesis
- → Examples: oestradiol, progesterone and testosterone

Quorum sensing

The marine bacterium *Vibrio fischeri* produces ligands called **autoinducers** when it reproduces. These pass through the cell membrane and into the surrounding environment.

The behaviour of the bacterial colony changes depending on the population density in the area:

More bacteria → More autoinducers → When threshold is reached, autoinducers re-enter bacterial cells → Autoinducers bind to protein LuxR → LuxR binds to DNA lux box → Lux box ix activated → Luminescent protein luciferase produced

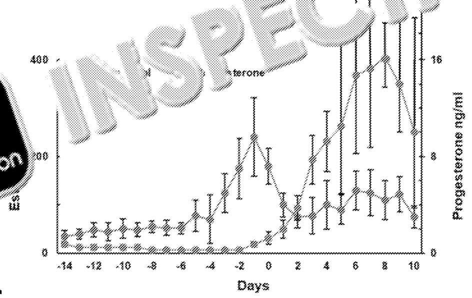


Some squid make use of these bacteria to camouflage themselves from below!

- → The... suc... blo...
- → Onc... con...

Oestradiol and progesterone

- → Both are **steroid** hormones produced in the ovaries
- → Both have effects on gene expression by affecting **transcription**
- → Oestradiol works on the hypothalamus, which controls secretion of gonadotropin-releasing hormone from the pituitary gland, stimulating the ovaries to release eggs (and more oestradio...)
- → Progesterone works on cells in th... endometrium to thicken the uteru... for pregnancy; if no pregnancy, production of progesterone decreases so the uterine lining is shed



Example A... ...e of negative feedbac... ...trol ...ater content. If too low, the bra... secre... hormone known as ADH. ... redu... urine output and restores ...ater content.

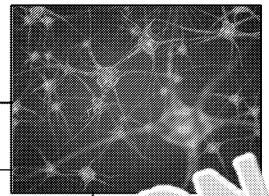
Low water content → ADH produced → Urine output decreased → Normal water content → Low water content

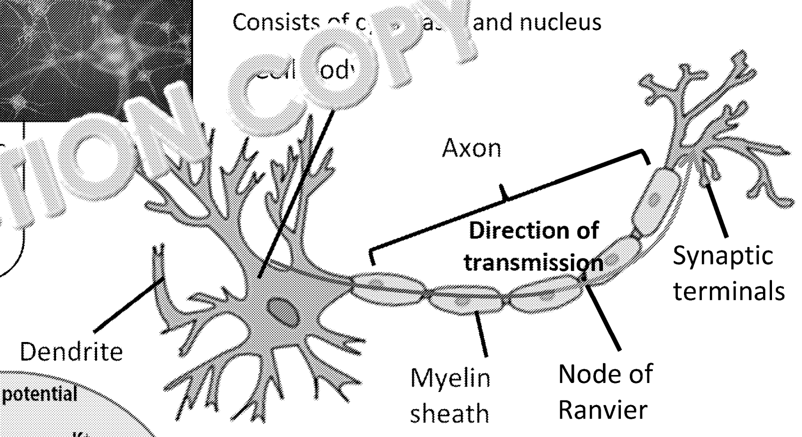
Neg...

The most commo... **negative feedbac...**
By negative feedb... condition is resto... optimal condition...

1. The body det...
2. Causes an eff... the body
3. Receptor det... been neutrali...
4. Effector is tu...

C2.2 Neural signalling





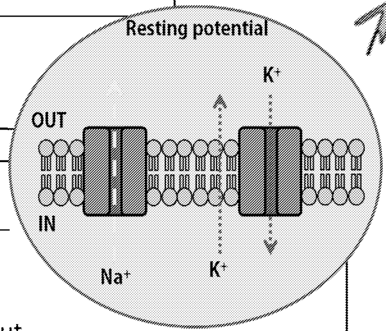
Affected by
- *Thickn... are 12×...*
- *Myelin...*
- *Temper... (higher ... can inc...*

What is a neuron?

- → Part of the nervous system which carries impulses across the body.
- → Action potentials pass along neurons, and rely on charge differences inside and outside of cells.
- → Neurons are separated by synapses which control where a ... spread through the nervous system.

Im...

- → Waves of electrical activity that ... the neuron.
- → Impulses are largely controlled by sodium-potassium pumps in the cell membrane.



Sodium-potassium pumps

- → Move 3 Na^+ out and 2 K^+ in, through an active process (using ATP).
- → Plasma membrane permeable to K^+ which diffuses back out.
- → More positive ions move out than are moved back in (membrane is polarised).
- → **Inside is negatively charged relative to outside.**
- → This is the **resting potential**, it measures **-70 mV** in the neuron.

Action potential

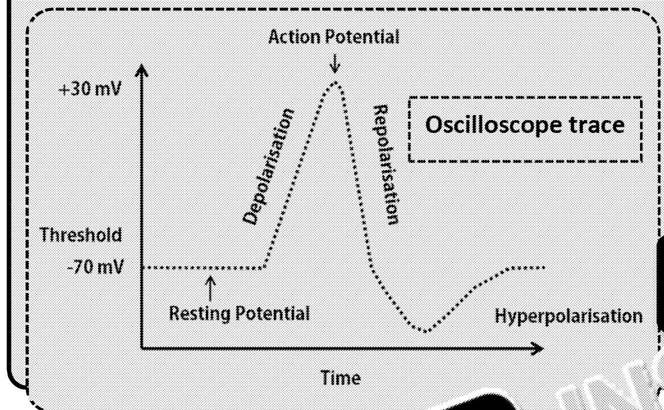
HL

When triggered by receptors on the membrane, a small change in the polarity of the neuron occurs. This must reach a **threshold pot...**

Once reached, voltage-gated Na^+ channels are o... Na^+ to flood back into the cell. Rapidly, the inside of ... be... ...ively charged (+30mV). This is the **action poten...**

A positively charged neuron is cons... ...**larised**.

- → At peak depolarisation (+30 mV), the Na^+ channels close.
- → **Repolarisation** causes voltage-gated K^+ channels to open, allowing positively charged ions to exit the cell, restoring the neuron's charge.



Depolarised regions initiate an action potential in the next region, causing a **self-propagating wave** which eventually reaches a synapse.

Anatomy of a... action p...

Co...ness

HL

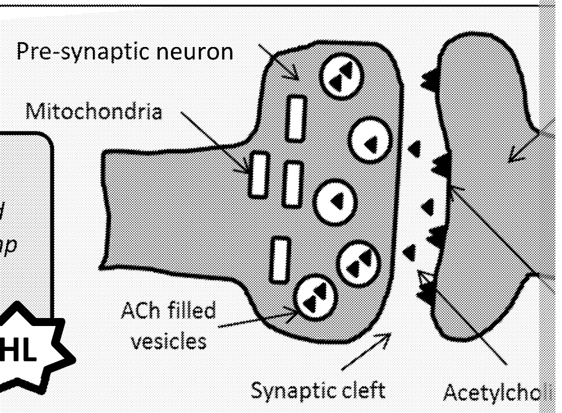
Consciousness **cannot** be explained b... **...ductionism** (just looking at the interaction of neurons in the brain). It is an example of **emergence**, which suggests that the whole is greater than the sum of the parts.

Myelin and saltatory conduction

- → **Myelin** is the fatty sheath around an axon, made of Schwann ce... It acts as an insulator against ion movement.
- → Myelin plays a crucial role in speeding up axon transmission.
- → By covering the axon, ions can only cross the membrane where... no myelin – at n...**des of Ranvier**.
- → This me... ...he action potential 'jumps' from one node of R... t... ...spe...ing the impulse.
- → T... re...ui...s less energy than in non-myelinated neurons, wher... ...ntire length of an axon needs to be depolarised and repolarise... opposed to just specific sections.

Exam tip – *'Saltatory' comes from the Latin word 'saltare', which means jump – just like the action potential in this kind of conduction.*

HL



Synapses

Neurons are n... ...ed ... each other – nor do they touch. A small (~20 ... synapti... ...ists ...ween the synaptic terminals of one neuron and the d... of anot... ...hen a signal passes along a neuron, it reaches a synapse and re... ...**transmitters**, such as acetylcholine (ACh).

- → When an action potential reaches the synaptic terminal, depolarisation ... the uptake of Ca^{2+}.
- → Ca^{2+} causes vesicles to bind to the membrane, and release ACh into the ... cleft, where it diffuses across the gap.
- → The post-synaptic membrane has transmembrane receptors specific to A... which cause sodium channels to open – **one-directional signal**.
- → Na^+ enters the neuron, potentially triggering an action potential.
- → Bound ACh returns to the synaptic cleft, where it is degraded by enzyme... (acetylcholinesterase) and recycled in the presynaptic neuron.

C3.1 Integration of body syst

Communication systems

- → All cells must be in contact with each other. This does not mean they must touch!
- → **Communication systems** are vital as the environment is ever changeable – internal and external environments are both able to change.
- → The organism must **coordinate** the activities of all cells within it to respond to a change:
  1. Hormones used in plants and animals (slow but long-lasting effects)
  2. Neurons also used in ani... ...hor lived effects)
- → The two systems may work tog... stimuli detected by the nervous ... can trigger the release of the hormone epinephrine.

Organisation in living organisms

Cells The basic building blocks of organisms → **Tissues** Groups of similar cells → **Organs** Groups of different tissues performing a function → **Organ systems** Groups of organs working together to form organisms

Emergent properties arise when the sum of the parts (cells, tissues, organs, organ systems) creates new features in the **organism** when they are integrated.

Neurons

These cells carry nerve impulses ar... include many different ty...g;

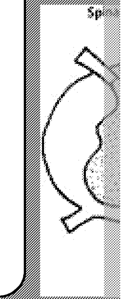
- → **Sensory neu...** ...rry ...lse from ...ptor ... CNS
- → ...ro... / **interneurons** – ...onn... neurons together
- → **Motor neurons** – carry impulse from cerebral hemispheres of the brain to effectors (neuromuscular junctions or motor end plates)

See page 5

Some neurons have a protective sheath made of **myelin** which increases the speed of transmission

The mammalian nervous system

- → The nervous system is broadly divided into two parts – the **central** nervous system (CNS) and the **peripheral** nervous system (PNS).
- → The CNS is the brain and the spinal cord – the PNS is the rest.
- → The PNS can be further divided into the **sensory** and **motor** systems, either detecting or responding to stimuli.
- → The motor system can be divided again into the **somatic** nervous system, over which we have control, and the **autonomic** nervous system, which is subconsciously controlled.



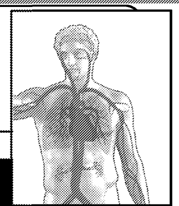
Receptor types

Receptor	Stimulus
Mechanoreceptor	Pressure
Chemoreceptor	Chemicals
Photoreceptor	Light
Thermoreceptor	Temperature
Nociceptor	Pain

Reflex arcs

- → It is vitally important for an organism to move away fro...
- → Simple pain reflexes are used by animals, consisting of a... neuron, ... **relay** neuron in the grey matter of the spinal c... ...**ctor** (skeletal muscle).
- → ... brai...s not involved in a typical reflex arc.

Transport mechanisms (...s...els) are needed for most multicellular ... cells are supplied with nutrients, and ...ducts ...ved.



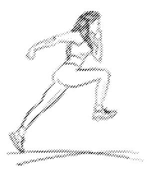
- → Tropism is a grow... external stimulus
- → **Phototropism** is a... stimulus) to light

The endocrine system

- → Glands that release hormones i... are called **endocrine glands**.
- → The **hypothalamus** in the brain can stimulate or inhibit these in response to changes, including from the nervous system.
- → The **pituitary gland** secretes hormones involved in many homeostatic processes, e.g. **osmoregulation**.

Control of heart and ventilation rate

- → At rest, the heart rate is controlled by the **sinoatrial node** (the pacemaker) and the ventilation rate by the **respiratory centres** in the medulla.
- → The **medulla** (in the brain) receives signals from receptors to respond to changes in activity levels.
- → **Baroreceptors** in the **aorta** and **carotid arteries** detect changes in blood pressure: high blood pressure → artery walls stretched → more action potentials sent to medulla → sinoatrial node decreases heart rate and stroke volume
- → **Chemoreceptors** in the capillaries near the baro... and brainstem detect changes in blood pH ...positi...n (CO_2 and O_2 levels): more respiratio... → less O_2 and more CO_2 i...d → lower blood pH ...rbo... ...forms → more a...p...e...nt to medulla → ...l no...e... increases heart rate and stroke vol... + diaphragm and intercostal muscles increase ventilation rate and volume of air moved

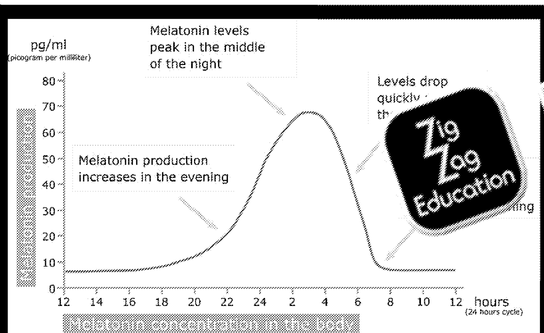


Practical in...

Phototropic responses can be inves... Investigations can be performed wi... either from one side or from all sid... the light.

Sleep patterns

- → Our wake and sleep cycle follows a **circadian** (24-hour) **rhythm**.
- → The hormone **melatonin** regulates sleep levels, and is secreted by the **pineal gland**.
- → High levels of melatonin induce sleepiness.



Epinephrine (adrenaline)

A polar **hormone** released from the adrenal glands above the kidneys. Has **many effects** in different situations, including

- → Increasing ventilation, heart rate, blood pressure, blood supply to muscles, pupil dilation, glucose production from glycogen and mental awareness following panic, stress, fear, excitement, etc.

Phytoho...

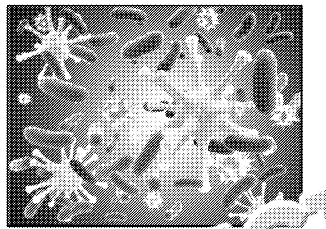
Phytohormones are hormones m... responding to stimuli and contro...

Hormone	
Auxin	→ Causes cell e... → Produced in... to roots via ...
Cytokinin	→ Causes cell d... → Produced in... to shoots via...
Ethylene (also called ethene)	→ Speeds fruit... → Works via p... ripening = m... → Gas spreads... **synchronise**...

C3.2 Defence against disea

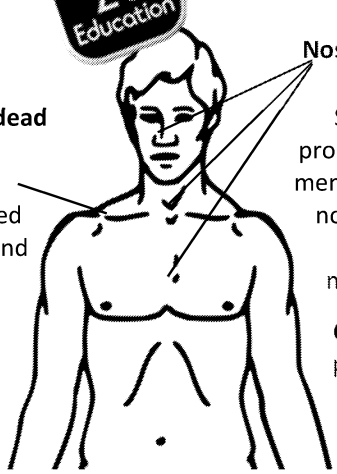
What are pathogens?

Microorganisms (viruses, bacteria, protists or fungi) that cause disease.



Primary defences

The first line of defence in th... syste... consists of non-specific barriers.



Skin

Epidermis = outer layer of dead cells that is difficult for microorganisms to break through. Continually replaced as deeper dermal cells die and migrate upwards.

Secretes **antimicrobial oils** that kill microorganisms

Nose, trachea and bronchi

Sticky **mucous** produced by mucous membranes lining the nose, trachea and bronchi traps microorganisms

Cilia waft trapped pathogens up and out of the body

Blood clotting

Blood clotting at cuts forms scabs to prevent entry of microorgan...s

- Damaged blood vessels release chemicals to stimulat... ...to form a clot.
- **Clotting factors** are released ... a ca... ...ay:
  - **Prothrombin → thrombi...**
  - Thrombin catalyses conver... ...**ogen** to **fibrin**
  - Fibrin forms a mesh, and er...es (red blood cells) are trapped to stabilise the clot

Innate immune system

- White blood cells respond to foreign antigens **in general** by recognising their type, e.g. bacteria
- **Does not change over time**
- **Phagocytes engulf** material by **endocytosis**

Adaptive immune system

- Responds differently to **specific** pathogens/antigens
- Becomes **more effective** over time as it builds up a catalogued **memory** of pathogens
- Memory cells are activated upon reinfection to give a **rapid** response

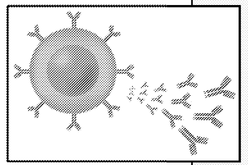
Response order

Primary response: initial response of T- and B-lymphocytes. Takes place while symptoms occur.

Secondary response: memory cells ...ive f... ...es ...llow a **rapid response to reinfection** ... pa... ...n, much quicker than another primary response... ...ber of antibodies are produced, and symptoms are u... ...or non-existent.

1 ...nti...s

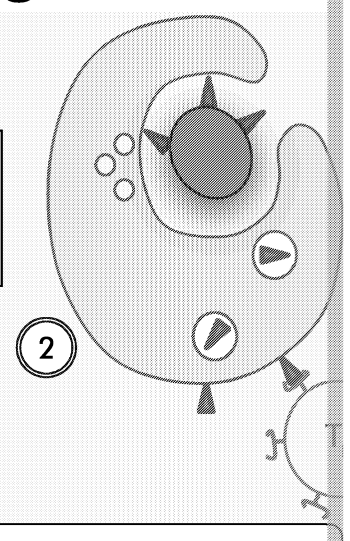
A... ...fore... substances that a... ...the outside of / ...ced by pathogens and recognised by the immune system as non-self. They are usually proteins or glycoproteins.



Phagocytes and helper T-lymphocytes absorb and **display antigens** to stimulate further immune responses.

The antigens produced by a pathogen can be **highly variable**, and **new strains** complicate medical treatment.

Erythrocytes (red blood cells) can have (or not have) three different antigens, which means a blood transfusion from someone of a **different blood group** can trigger an immune response.



Blood types

		A protein	
		✓	✗
B protein	✓	AB	B
	✗	A	O

Each can be Rh positive or negative.

Phagocyto...

Phagocy... ...e **le...oc...es** (white blood cells) that use **amoeboid m...ve...** ...move around the body. When they detect foreign antigens, ...their membrane to engulf the pathogen.

Lysosomes release **lysozymes** to digest the pathogen. Breakdown products are absorbed and antigens are **presented** to trigger lymphocyte response.

Phagocytes are **non-specific** and will target any antigen-bearing pathogen.

HIV and AIDS

Transmitted via: blood (e.g. sharing needles), sexual fluids and breast milk.

HIV positive: HIV (human immunodeficiency virus) vi... lay **dormant** in help... lymphocytes ...D4 ...lymph...es) for...

A... ...quired immune deficiency syndrome): when the viruses activate their DNA, replicate within and destroy CD4 T-lymphocytes cells. This leaves patients prone **to opportunistic infections** (e.g. pneumonia) as their immune system is weakened and fewer antibodies are produced.

Antibiotics and resista...

Antibiotics are designed to affect bacterial me... (e.g. production of new cell walls) and, therefo... **effect** on viruses which hijack a cell's metaboli... Antibiotics also do not affect human cells, as o... eukaryotic and bacterial cells are prokaryotic.

Antibiotics kill **all non-resistant bacteria** in a p... Some bacteria will have a **mutation** which allo... survive, and they form an **antibiotic-resistant** ... which cannot be killed by that antibiotic.

Now, many strains of deadly bacteria are resistant to **multiple antibiotics**, so the diseases cannot be treated until **new antibiotics** are developed.

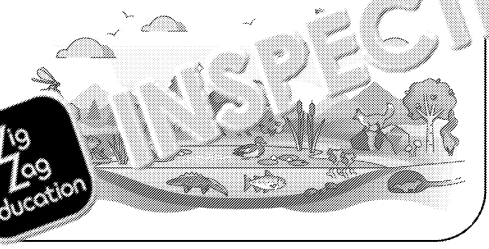
To limit the spread of resistant bacteria:

- Doctors prescribe antibiotics only when ne...
- Patients should always finish the full course...
- Farmers could reduce the use of antibiotics...
- Everyone should practise good hygiene, e.g... handwashing

C4.1 Populations and commu

What is an ecosystem?

- → **Populations** are groups of individuals of the same species living in the same area that can breed. Different populations of the same species may be **reproductively isolated**, e.g. by distance.
- → Groups of interacting populations in the same area are **communities**.
- → Ecosystem = community + abiotic factors

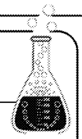


Random sampling

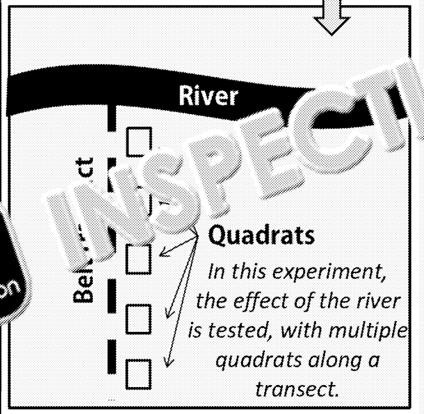
It is usually impossible to count every member of a population (individuals may be hiding, moving around, etc. and counting every organism would take too long), so scientists usually use an **estimate** obtained via **sampling**. There are two broad categories of sampling:

1. **Systematic sampling**: taking measurements at regular intervals on a line or grid
2. **Random sampling**: sampling arbitrarily to avoid bias towards certain areas. This creates a **sampling error**, which we try to minimise.

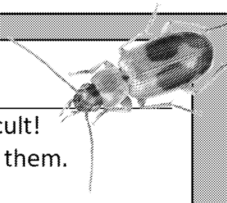
Quadrats



- → Quadrats are squares placed randomly in an area of interest.
- → Count the organisms in the square for an estimate of the population in that environment.
- → Scale up the average counte quadrat by the ratio of quad area : whole population area.
- → These methods are best used o **sessile** organisms (ones that do not move, or do not move much).



Capture-mark-release-recapture



- → Counting **motile** organisms using a quadrat is very difficult!
- → Ecologists capture a small number of animals and mark them.
- → They then release those animals back into the wild.
- → After a short time, they perform another capture and recount.
- → The size of the population can be estimated.

Lincoln index:

total population size = number of individuals **marked** in first captur total **number** of recaptured inc / number of marked **recaptured** inc

i.e. total population = M × N/R

Assumes that:

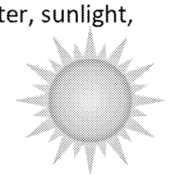
- → All animal from th
- → doe t make uals more likely to be caught/eaten
- → No animals entered or left the population (closed population)
- → No births or deaths during sampling

Carrying capacity (K)

- → axi capacity of an ecosystem.
- → ecosystem only has a certain amount of resources, which limits popula If the population gets too big, it crashes, bringing the population back down carrying capacity.

Limiting factors

- Resources, e.g. food, water, sunlight, space, oxygen
- Predation
- Disease/pathogens
- Waste, e.g. CO_2



- **Negative feedback** of **dens dependent** factors keeps a population around the carr capacity, even if it fluctuate
- **Density-independent** facto as climate change) can caus significant changes.

Relationships between individuals

Competition

Two types of competition exist: i **er**specific and **intra**specific.

- → Interspecific is comp tween different species. A **presence-ab rix** n be used to indicate e f s.
- → t spe fic competition **within the same** species. compete for food, water, light, **soil**, mates, etc. to ensure their own survival.

- ➢ In comp wins and **zero-su**
- ➢ Individu may also they **bot** hunting, for child

Endemic species (or can be outcompete (introduced from el natural predators), tortoises and fast-b

Other interspecific relationships

Predation

- → **Predators** (e.g. lions) eat **prey** (e.g. gazelles). Usually prey are living, but so predators are **scavengers** that eat animals which have recently died.
- → The population of predators depends on prey. No prey = no food.
- → However, prey depend on predators. Too many predators = prey might be wiped out!

Parasitism

- → Parasites live on or in a **host** for food and as part of their life cycle (e.g. to re
- → A host may be harmed by the interaction (e.g. ticks feed on other animals' b

Pathogenicity

- → **Pathogens** (dis ng icroorganisms) spread infections among othe organis the us *H. fraxineus* causes ash dieback in ash trees.

Herbi ry

- → e an s feed on plants, damaging or killing them (e.g. grasshoppers t cereals).

Mutualism

- → A form of interspecific cooperation, where two species both benefit.

Example 1
Rhizobium bacteria in root nodules of Fabaceae fix N_2 gas into ammonia which the plants can use, and get carbohydrates and a favourable environment

Example 2
Mycorrhizae in Orchidaceae consist of a fungal hyphae network passing nutrients to a plant or seed, and receiving the nutrients back when it dies

Exampl
Zooxant tentacle carbon- corals a mineral

C4.2 Transfers of energy and m

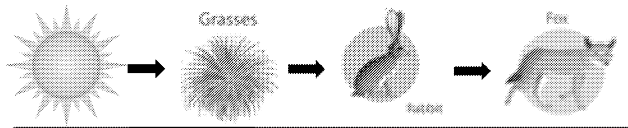
Energy transfer and systems theory

- Ecosystems are **open systems** where energy and matter can enter and leave.
- In **closed systems** (e.g. Earth as a whole), only energy can enter or leave.
- **Law of conservation of mass**: matter cannot be created or destroyed
- **Laws of thermodynamics**: energy ... thro... and can be transformed from ... an..., but not created or destroyed

Food chains

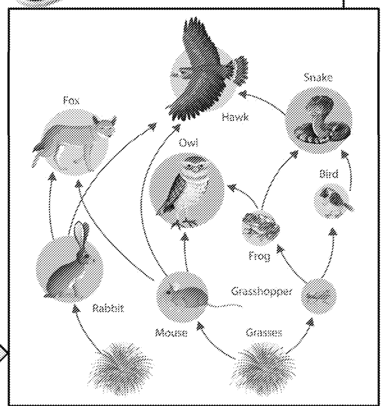
- Used to represent feeding relationships.
- Arrows show direction of energy and biomass transfer.

Chemical energy ➔ Producer ➔ Consumer(s)



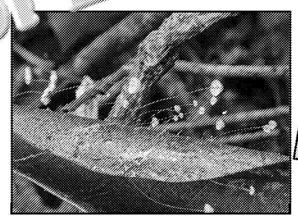
sunlight or chemicals	converts air and water into food	digests carbon compounds

- **Autotrophs** (**producers**) synthesise organic compounds from simple inorganic substances.
- Can be **chemoautotrophs** or **photoautotrophs**, these use chemical reactions / sunlight as a source of energy.
- Carbon dioxide from either the atmosphere or the ... fixed to produce organic compounds
- Plants use the products both ...tory ... and in building macromolec...
- **Heterotrophs** (**consumers**) n... ...gest other organisms to get their food.
- They digest polymers (proteins, lipids, DNA/RNA) into monomers (amino acids, fatty acids, nucleic acids), and use these to build their own polymers via **assimilation**.
- Food web shows interlinking food chains.



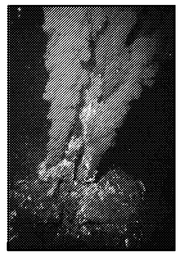
Decomposers

- Convert non-living organic matte... ...d b... ...c... dead parts, e.g. shed skin or ... mo... forms, and support soil forn... ...s)
- **Saprotrophs** (e.g. fungi) secre... ... to digest nutrients, which they th... ...sorb
- **Detritivores** (e.g. worms, beetles, flies) ingest and digest material inside their bodies



En... ...s...rces

- Photosynthe... o...ani...ns i... ...plants, algae and cyanobacteria.
- They u... ...r **photolysis** to oxidise water molecules, which ...e... ...el... ...s and hydrogen ions, used to produce **ATP**.
- A... ...used to produce organic compounds such as **glucose**.
- Chemoautotrophs often exist in places without sunlight, e.g. underground or deep in caves.
- They are usually bacteria which oxidise certain elements to produce energy.
- Iron-oxidising bacteria near hydrothermal vents convert iron(II) to iron(III). This releases electrons which are used to produce ATP.

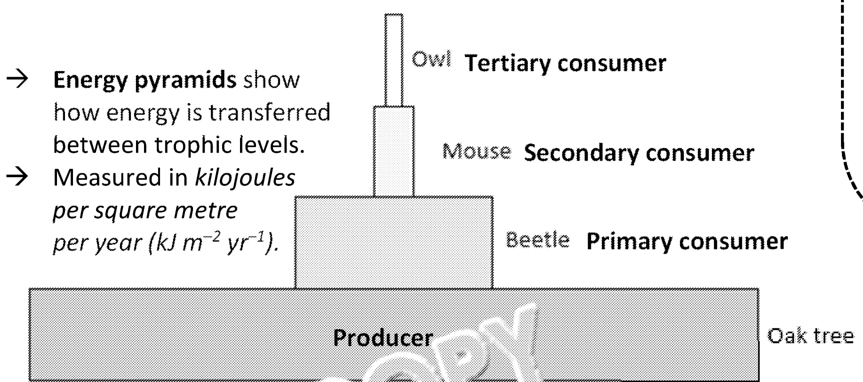


Photosynthesis and respiration

- You may have noticed that the processes of photosynthesis and aerobic respiration look similar.
- Both involve glucose, CO_2, O_2, H_2O and energy.
- Photosynthesis (in photoautotrophs) needs the CO_2 and H_2O from respiration.
- Respiration (in all autotrophs ...h...otr...hs) needs the O_2 and glucose from photosyn...esis
- We say that ...s a... ...nte...elationship between both processes, and au... ...tr... ...heterotrophs depend on each other.

Trophic levels

- Show how many organisms energy in a food chain has passed through.
- Organisms in a food web could be part of more than one trophic level.
- **Energy pyramids** show how energy is transferred between trophic levels.
- Measured in *kilojoules per square metre per year (kJ m^{-2} yr^{-1}).*



...eductions in energy

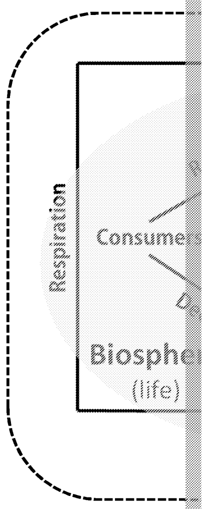
- Around 90 % of energy is lost at each trophic level, so levels decrease in size up an energy pyramid.
- A lot of energy is lost as **heat** as **cellular respiration** for movement (production of ATP) and maintaining body heat is not 100 % efficient.
- Not all individuals at a trophic level are consumed, and not all parts of organisms are eaten as food – instead they will **decay**.
- Some parts of organisms are **not digestible** or are not absorbed.

Fewer organisms / less **biomass** at higher trophic levels

- Defined as
- Measured i
- Gives an es
- Tends to b energy ava
- Although t per unit m

Prim

- **Productio** unit of tim
- **Primary pr** (producers or reprodu
- **Secondary** levels, whe
- Because so other wast **lower** tha



Ph
6CO₂ + 6H
Inorganic c

- Hu co fu ge of
- Se re ab w ph re

C1.1 Enzymes and metaboli

Enzymes and metabolism

1. Fill in the gaps.
   Enzymes play an important role in **metabolism**, a term which encompasses all the chemical reactions in a living a) ____ ____. It includes a diverse, interdependent collection of re...ns, and as such, many **different** enzymes are needed.

- Enzymes are **proteins**, c... b) ________ folded to form a **specific** c) __________ **shape**. ...scr...ed as d) ____________ proteins.
- Their complex shape in... ...ctive site made of just a few e) ________.
- The shape of an enzyme's f) ___________ is specific to the g) ____________ it works on, and it is the **interaction** between these h) ____________ and the overall structure which creates the properties important for **catalysis**.

2. How ... ...ers maintain ...eir ...ter... ...body temperature? (HL)

3. Give one example of an intracellular process and one example of an extracellular process. (HL)

Types

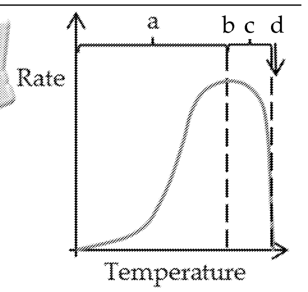
7. Label each of the f... C (catabolic).
   - Monomers → ...
   - Releases energ...
   - Hydrolysis reac...
   - e.g. protein sy... and photosynth...
   - Condensation r...
   - Requires energ...
   - Macromolecule...
   - e.g. digestion, ... substrates in re...

Enzymes as catalysts

4. Draw a graph comparing activation energy of a reaction with and without an enzyme.

Temperature

As temperature increases during *a*, **kinetic energy** increases. Ther... more encounters betwe... ...ules (and more of them have ... greater th... ...activation energy) so ... enz...-substrate complexes ...ed.



8. What happens at b and c?

9. Suggest w... saliva wo... the stoma...

C...s

5. Give two ways to increa... ...kelihood of collision of a substrate and active site.

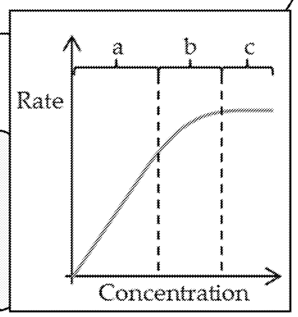
Effects of different co... on enzyme actio...

Substrate concentration

As substrate concentration increases during *a*, more substrates collide with enzyme active sites by **collision theory**.

During *b* almost all the enzymes' active sites are occupied by substrate.

10. Explain why the ...s ...onta... at c.

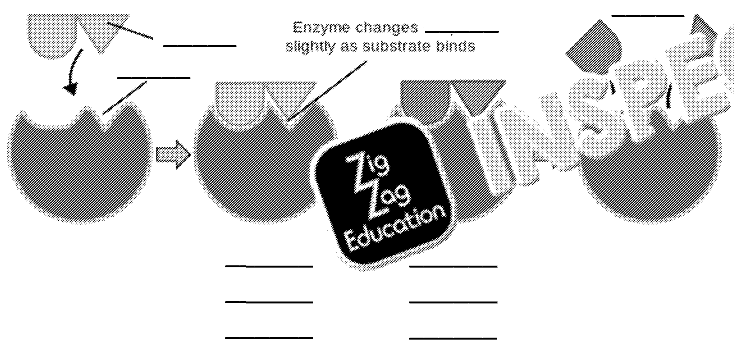


Exam Tip!

The active site is **induced** to change by the substrate, but denaturing **disrupts** the shape.

Mode of enzyme action

6. Label the induced-fit model of enzyme action.



Allosteric and competitive inhibitio...

11. Describe how a) allosteric inhi... b) competitive inhibitors wor...

C1.2 Cell respiration

ATP and cell respiration

1. Write the a) word and b) symbol equations for aerobic respiration.

2. Give two uses of yeast in the food and drink industry.

3. Explain the reason for muscle pain after prolonged exercise, and compare how this process is different in plants and microorganisms.

Other substrates? (HL)

4. Explain why sugars are often reduced in an attempt to lose weight.

ATP

5. a) Name the molecule produced when one phosphate is removed from ATP.

   b) Which process reconnects phosphate ions?

   c) Give one process in plants and one process in animals where ATP is formed.

6. Give four processes that make use of the hydrolysis of ATP.

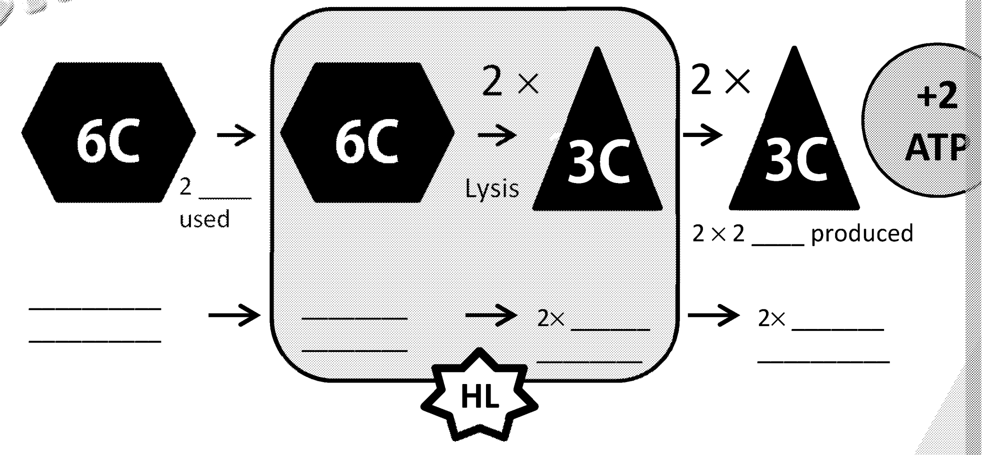
7. Draw the structure of ATP

8. Fill in the four boxes to show the location of different stages of respiration.

STAGE 1 – Glycolysis

Happens in the ____________ (O_2 not required)

9. Complete the glycolysis schematic below. The parts in grey are additional HL only



Summary – anaerobic respiration (O_2 not required)

10. Which substrate is required for anaerobic respiration?

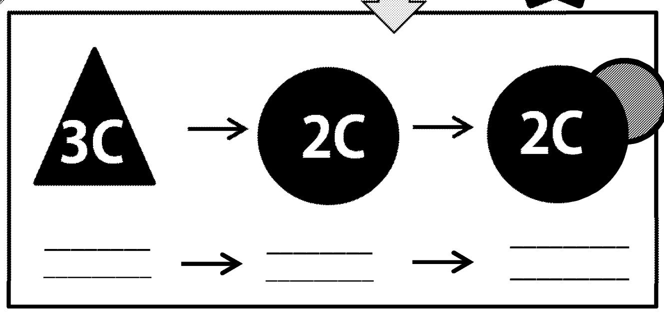
11. What does anaerobic mean?

STAGE 2 – The link reaction

Happens in the ____________

12. Is the link reaction part of aerobic or anaerobic respiration?

13. Complete the link reaction schematic below. (HL)



NAD

14. Fill in the gaps.
NAD is a a) ____________ enzymes in cell respiratio… carry out b) ____________ c) ____________ reactio…

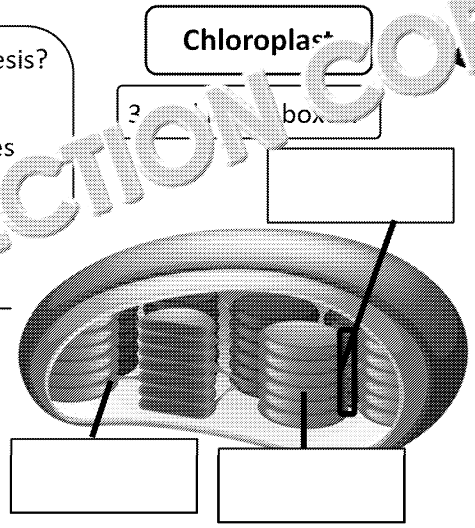
- It is known as a d) ____________ ____ as it accepts a hydrog… hence an electron) w… ____________.
- When it is f) ____________ during **oxidation**, it lo… hydrogen / an electro…

Remember that oxidatio… be g) __________ of **oxy**… reduction can be h) ____ of oxygen.

C1.3 Photosynthesis

What is photosynthesis?

1. Where does the source of energy come from in photosynthesis?
2. Why is it biologically important that photosynthesis produces oxygen as a by-product?

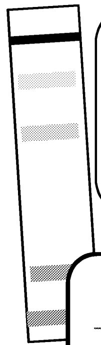


4. Write the word and symbol eq[...] photosynthesis.

Photosynthetic pigments

5. What do photosynthetic pigments do and where are they found?

6. What are accessory pigments and what are their roles? HL



Exp[...]en

7. How can chromatograph[...] st[...] photosynthesis?

(A) Light-dependent reaction - overview

8. Fill in the gaps.
   - → Stage of photosynthesis that relies on a) ____________.
   - → Light (**photons**) falling on pigments in b) ____________ are transferred to chlorophyll *a* (P680).
   - → During c) ________________, electrons are excited and captured by electron acceptors in the reaction centre. d) __________ also oc[...]
   - → Electrons enter the e) ________________ from electr[...]
     Chemiosmosis produces f) __________ and re[...] ____________.
   - → Photons are absorbed by pigments in [...] __________ and transferred across acc[...]me[...] [...]ophyll *a* (P700).
   - → i) ___________ elec[...] [...]ptu[...] by electron acceptors, passed to the electron transp[...] [...]nd replaced by j) ____________ electrons from photosys[...] II.
   - → k) ________________ helps move electrons between electron carriers, reducing NADP in the process.

HL

(B) Photolysis

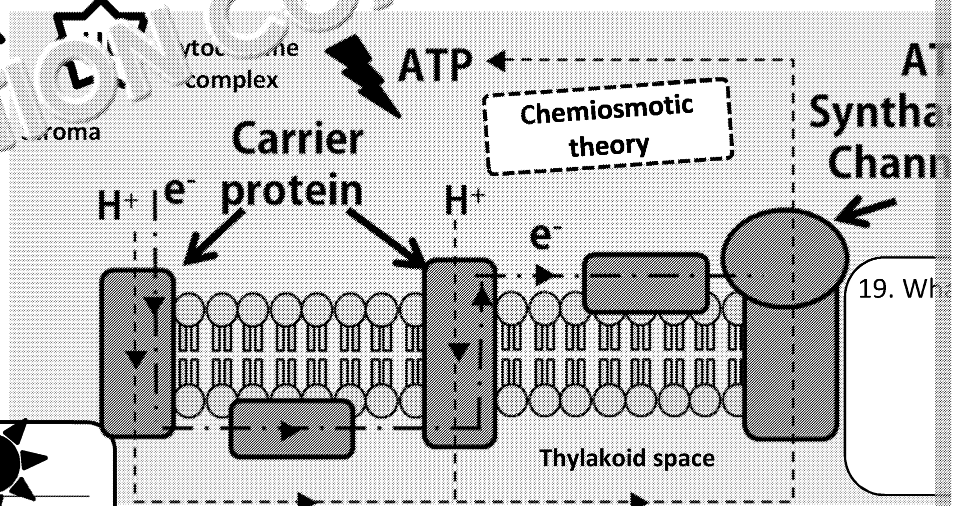
HL

9. What is the equation for photolysis?
10. Give one use of each of the products of p[...]

(C) Electron transport chain (photophosphorylat[...]

11. Describe the role of the electron transport chain in photosynthesis.

HL



19. Wh[...]

Cyclic vs non cyclic photophosphorylatio[...]

12. Descri[...] [...]ere[...]ce between cyclic and non-cyclic [...]otop[...]ylation.

13. State the purpose of the light-receiving complex and the reaction centre of a photosystem.

HL

21. Draw a line [...] show the le[...] of GP over t[...] on the graph

C2.1 Chemical signal

HL – additional higher level only

Cell signalling

1. How do the neural system and the hormonal system differ?

2. Give two other signalling ch

3. Why are ligands specific to target cells?

Steroid hormones

4. Are steroid hormones hydrophobic or hydrophilic?

Oestradiol and [illegible]terone

5. Fill in the gaps.

→ Both are a) __________ hormones produced in the b) __________

→ Both have effects on gene expression by affecting c) ____________

→ Oestradiol works on the d) ____________, which controls secretion of gonadotropin-releasing hormone from the e) __________ gland, stimulating the ovaries to release f) __________ (and more oestradiol)

→ Progesterone works on cells in the g) ____ to thicken the uterus wall f[illegible]cy; pregnancy, production of h) ____ decreases so the uterine lining is shed

Receptors

6. H[illegible]w [illegible] receptors work?

7. Describe the difference between intracellular and transmembrane receptors.

Quorum sensing

8. Briefly describe how quorum sensing works in *Vibrio fischeri*.

[illegible]edback mechanisms

16. [illegible] why feedback mechanisms are essential in the human body.

(A) Chemical

9. Briefly describe receptors work

10. What is a mu

(C

13. Fill in the gap

Example: Tyrosine

→ Single-pass pr domain

→ Works in pairs

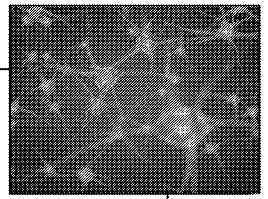
- Two ligands (b) domain
- Tyrosine (d) _ phosphorylate
- Signal cascade
- Glucose transp membrane to

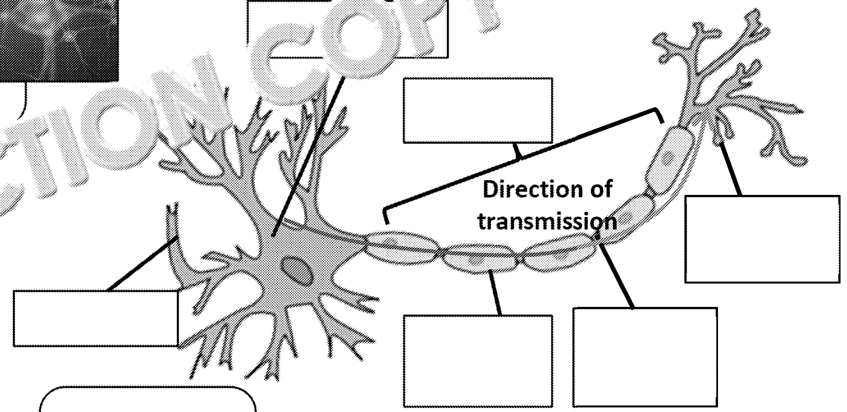
N

17. Describe

C2.2 Neural signalling

1. What is a neuron?





6. Label the diagram above.

7. Give thr… impulse…

Impulses

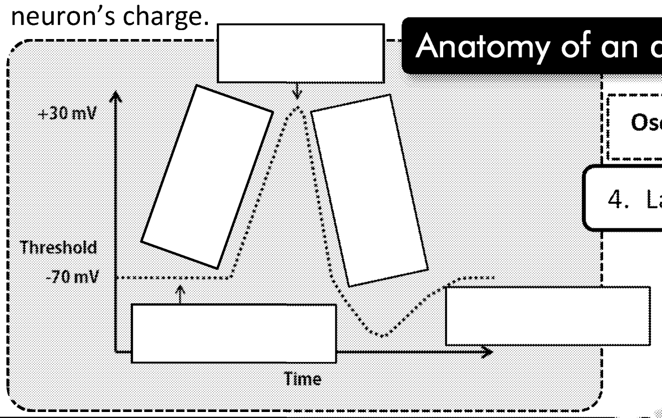
2. Explain, with a simple diagra… ion… …volved, how the resting potential … is m…tained.

Action potential

HL

3. Fill in the gaps.
When triggered by receptors on the membrane, a small change in the
a) __________ of the neuron occurs. This must reach a
b) __________ **potential**.
Once reached, c) ________________________ are opened, al…
d) ______ to flood back into the cell. Rapidly, the in… … becomes positively charged (+30mV). … is … ______________.
A positively charged neuron is c… …) ______________.
→ At peak g) ________________ … the h) _______ channels close.
→ i) _________________ causes …age-gated K^+ channels to open, allowing positively charged ions to exit the cell, restoring the neuron's charge.

Anatomy of an action potential



4. Label the graph.

HL

Myelin and saltatory conduction

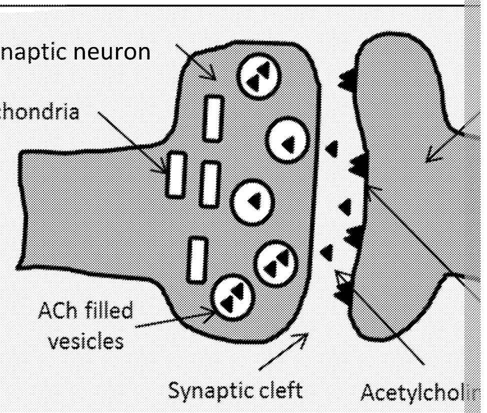
8. Define the following terms:
   a) myelin sheath

   b) nodes of Ranvier

   c) …ti…n potential

   d) saltatory conduction

HL



Synapses

Neurons are no… …ed … each other – nor do they touch. A small (~20 nm) … exists between the synaptic terminals of one ne… …d … the … another. When a signal passes along a neuron, it r… …se and releases **neurotransmitters**, such as acetylcholine (ACh).

9. How does an action potential cross a cholinergic synapse?

Consc…sn…

HL

5. Fill in the gaps.
Consciousness **cannot** be explain… ________________ (just looking at the interaction of b) __________ in the brain). It is an example of
c) _____________, which suggests that the whole is greater than the
d) ___________ of the parts.

C3.1 Integration of body syst

Communication systems

1. How do the nervous and endocrine systems differ?

2. Write the names of the c... s ar... add arrows to show the c... ture.

Organisation in living organisms

________ The basic building blocks of organisms	________ Groups of similar cells
________ Groups of organs working together to form organisms	________ Groups of different tissues performing a function

3. What are emergent properties?

Neurons

4. Fill in the names of each ne...ron type below.
→ [ ] – ...n...e from receptor to CNS
→ [ ] – connect neurons together
→ [ ] – carry impulse from cerebral hemispheres of the brain to effectors (neuromuscular junctions or motor end plates)

5. Complete the table below.

Receptor	Stimulus
Mechanoreceptor	
Chemoreceptor	
Photoreceptor	
Thermoreceptor	
Nociceptor	

The mammalian nervous system

6. a) What are the components of the CNS?

b) What are the two divisions of the PNS?

c) Name the part of the nervous system under voluntary control.

7. →
→

8.

Reflex arc

9. True or f...se? Correct each false statement.
[ ] ...Re...ex arcs help an organism to move away fro
[ ] ...) A simple reflex arc contains just a sensory neu
[ ] c) The brain is always involved in a typical reflex

...t...nsport mechanisms needed in multicellular organisms?

The endocrine system

13. Fill in the gaps.
→ Glands that release hormo... a) __________ are called b) __________ **glands**.
→ The c) ________________ in the brain can stimulate or inhibit these in response to changes, including from the d) __________ system.
→ The e) __________________ secretes hormones involved in many homeostatic processes, e.g. **osmoregulation**.

Sleep patterns

14. Sketch a graph to show how melatonin levels change throughout the day, and annotate it to explain how this regulates sleep.

Control of heart and ventilation rate

15. Where are baroreceptors found and how do they control heart rate?

16. Following running 100 m at high speed, the h...rt ...nd ventilation rate are significantly incre... ...ai... how the endocrine system brin...s a...out th...s change.

Epinephrine (adrenaline)

17. State five effects of the hormone epinephrine.

18. a) What is a tro

b) Name one ex

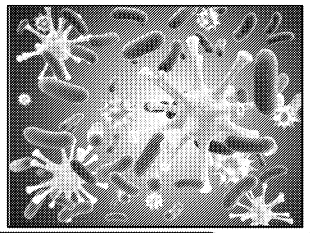
Phytoh

19. Complete the table bel... include where they are p... they are transported.

Hormone	
Auxin	
Cytokinin	
Ethylene (also called ethene)	

C3.2 Defence against disea

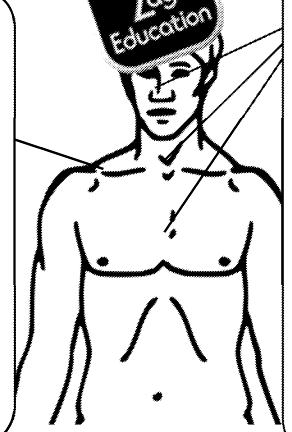
1. What are pathogens?



Primary defences

The first line of defence in the im... une ... con... s of non-specific barriers.

2. State two functions of the skin as a primary defence.



3. State two functions of the nose, trachea and bronchi as primary defences.

Blood clotting

4. Fill in the gaps.

Blood clotting at cuts forms a) __________ to prevent en... of microorganisms.

- Damaged blood vessels relea... ...ica... b) __________ to form a c...
- **Clotting factors** are release... ...g a cascade pathway:
  - c) _______________ ➔ **th...bin**, an enzyme
  - Thrombin catalyses conversion of d) ________________ to **fibrin**
  - Fibrin forms a mesh, and cells e) ______________________ are trapped to stabilise the clot

5. Compare the innate and adaptive immune systems.

Response order

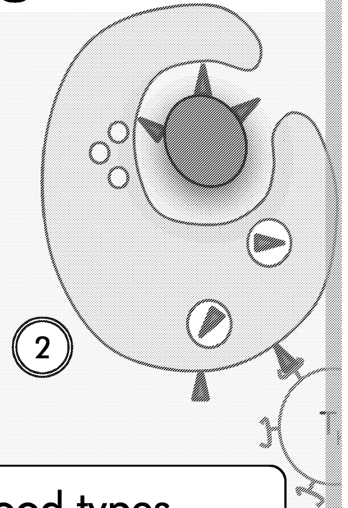
6. Compare the primary and ... re... ...s ...of the immune system.

① Antige...

7. Wh... ...e a...ige...s?

8. Which two cell types absorb and display antigens to stimulate further immune responses?

9. Explain why someone of blood type A should not receive a transfusion of blood type B.



Blood types

10. Complete the table to show the four blood types.

		A protein ✓	A protein ✗
B protein	✓		
B protein	✗		

② Phagocytosis

... ...p...in the process of phagocytosis.

HIV and AIDS

13. Give three ways that HIV can be transmitted.

14. What is AIDS and w... ... dangerous fo... HIV ...si...e ...i...s?

Antibiotics and resistance

15. Explain why antibiotics are ineffective against HIV.

16. a) How do antibiotic-resistant strains o... bacteria develop?

b) Give two ways we can limit the spread of these strains.

C4.1 Populations and commu

What is an ecosystem?

1. Define the following terms:
   a) population

   b) community

   c) ecosystem

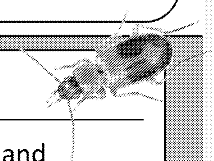
Random sampling

2. a) Give two reasons why sampling may be used to estimate the size of a population.

   b) Explain the difference between random sampling and systematic sampling.

Quadrats

3. Describe how you could use qu[illegible]ats [illegible] [illegible]ate [illegible] population size of plants in a field.



Capture-mark-release-recapture

4. On Friday morning, 60 beetles were caught, marked and released. On Saturday morning, 80 beetles were caught, and 32 of them bore a mark from Friday. Use the Lincoln index to estimate the total population size of beetles in the area.

5. State four assumptions of [illegible] capture-[illegible] release [illegible]

Lincoln inde

total population size = number o[illegible] individuals **marked** in first capture × total **number** of recaptured individuals / number of marked **recaptured** individuals

i.e. total population = M × N/R

6. a) Why does t[illegible] fluctuate around the dashed line?

   b) [illegible]el 1–3 and X on the sigmoid growth curve.

   c) Explain the overall shape of the curve.

Limiting factors

7. List four limiting factors which could affect a plant population.

Relationships between individuals

Competition

9. Describe the difference between interspecific and intraspecific competition.

10. Give two examples of cooperation seen in animals of the same species.

11.

Other interspecific relationships

12. Fill in the gaps.

Predation: a) ___________ (e.g. lions) eat b) __________ (e.g. gazelles)

c) ___________ eat animals which have recently died.

Parasitism: Parasites live on or in a d) __________ for food and as part o

their life cycle (e.g. to reproduce). The parasite may cause e) __________

as part of the interaction (e.g. ticks feed on other animals' blood).

f) ___________ [illegible] which spread infections among other or

fungus *H. fraxineus* causes ash dieback in ash trees.

g) __________ → Some animals feed on plants, damaging or killing them

(e.g. grasshoppers eat cereals).

Mutualism: A form of h) _______________ cooperation, where two species both benefit.

13. Give one example of a mutualistic relationship, stating how each organism benefits.

C4.2 Transfers of energy and

Energy transfer and systems theory

1. Explain whether an ecosystem is an example of a closed or an open system.

2. Fill in the gaps.

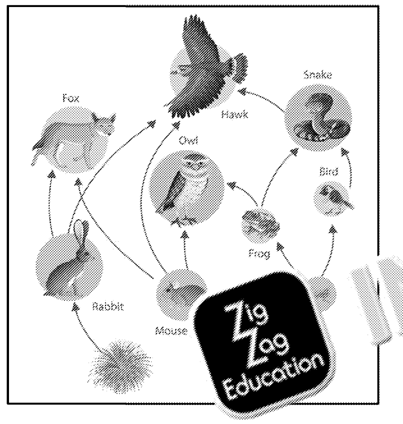
→ **Law of conservation of mass**: a) __________ ca... created or b) ____________

→ **Laws of thermodynamics**: ... ___ ...through a system and can be d) ____ from one form to another, but not e) ______ destroyed

Food chains

3. What do arrows represent in food chains?

4. Label the elements of the food web with all the letters which apply to them: A) Autotroph, B) Consumer, C) Heterotroph, D) Producer



5. Give an example of one food chain with four organisms from this food web.

6. Fill in the gaps.

Heterotrophs digest a) __________ (proteins, lipids, DNA/RNA) into b) __________ (amino acids, fatty acids, nucleic acids), and use these to build their own polymers via c) _______________.

Decomposers

7. Why are decomposers important in e...

8. Describe the difference be... a saprotroph and a detritivore.

Energy sources

9. a) How do ...hotoautotrophs and chemoautotrophs differ?

b) Give one example of each.

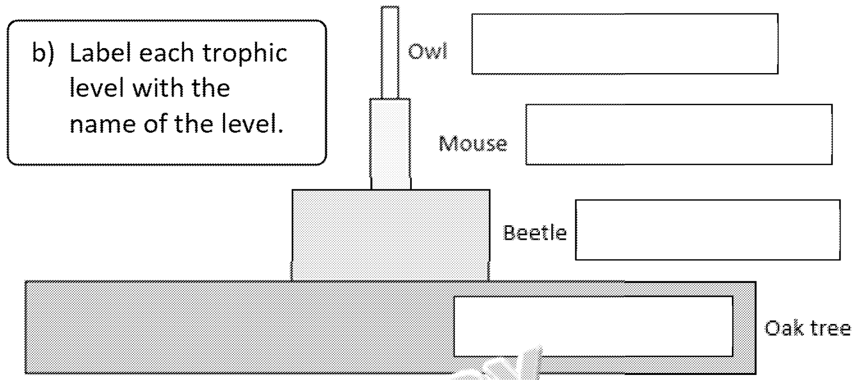
Photosynthesis and respiration

10. Explain how photosynthesis and respiration are interrelated.

Trophic levels

Th... energy pyramid below has four trophic levels. a) Which units are used?

b) Label each trophic level with the name of the level.



...uctions in energy

12. a) Approximately what percentage of energy is lost at each trophic level?

b) Give three reasons for these energy losses.

13. Fill in the ...

→ Defined ...

→ Measure...

→ Gives an ...

→ Tends to ... more org...

→ Although ...

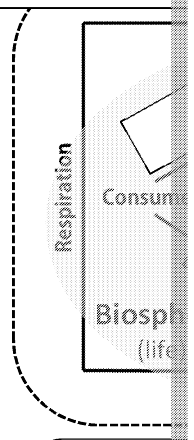
Pri...

14. What are ...

15. a) Define ...

b) Explain ... primar...

17. Label the pro...



19. Give the ... equation...

22. a) Ske... sha... cur...

C1.1 Enzymes and metabol

Enzymes and metabolism

Metabolic r… ineffi…nt HL

Intracellular –
Extracellular –
HL

Typ

Enzymes as catalysts

Temperature

Collisions

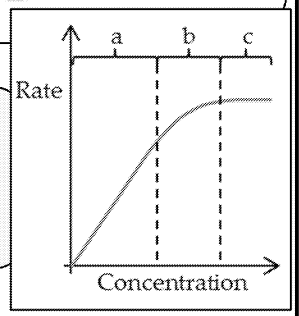
Substrate concentration

Effects of different co
on enzyme acti

Mode of enzyme action

Allosteric and competitive inhibitio

Exam Tip!
The active site is **induced** to change by the substrate, but denaturing **disrupts** the shape.



C1.2 Cell respiration

ATP and cell respiration

Yea...

HL

Other substrates?

HL

ATP

STAGE 1

Happ... ...he cytoplasm

O_2

Glycolysis

Overall c...

Intermediate steps:

HL

→ → →

→ → →

HL

Su...mar... ...naerobic respiration

O_2

Reduced NAD cannot be oxidised without oxygen...

HL

STAGE 2

The link reaction

O_2

Happens in the matrix

Pyruvate enters matrix...

HL

HL

→ →

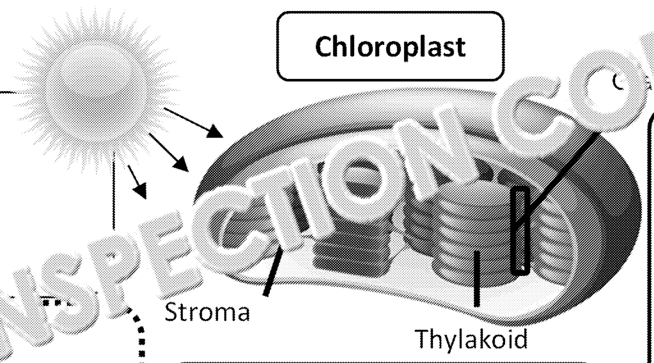
→ →

NAD

C1.3 Photosynthesis

→

What is photosynthesis?



Steps of photosynthesis:

HL

HL

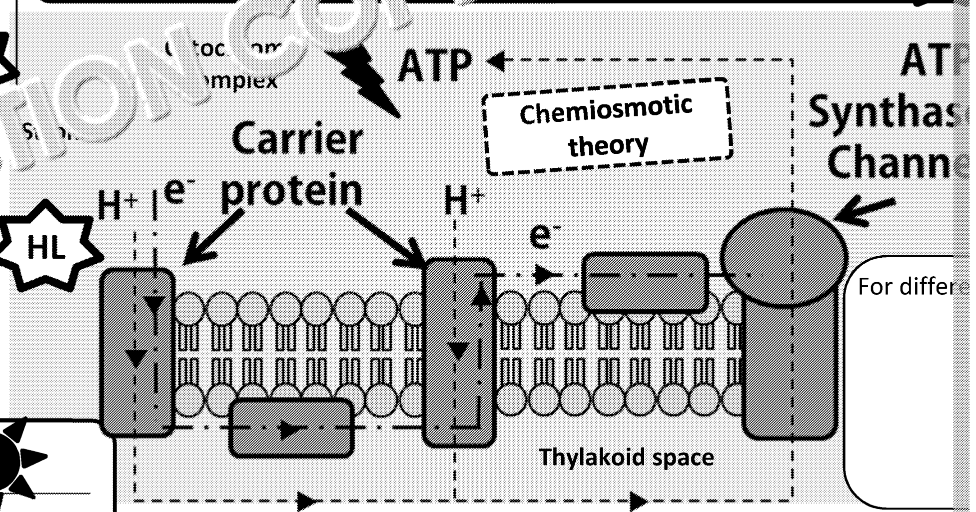
(B) Photolysis

Photosynthetic pigments

HL

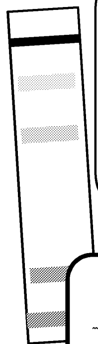
(C) Electron transport chain (photophosphorylatio

HL



HL

For differe



Experiment

Pigments from leaves can be separated by chromatography

(A) Light-dependent reaction - overview

HL

Cyclic vs non-cyclic photophosphorylation

Photosystems

HL

Light effe

C2.1 Chemical signall

HL – additional higher level only

Cell signalling

Neurotransmitters in neurons

Hormones

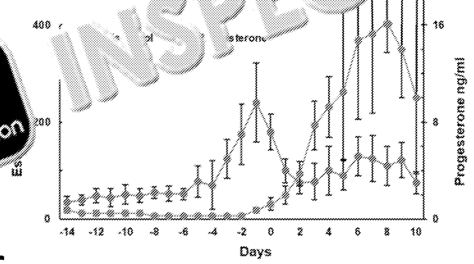
Cytokines

Calcium ions

→ There are many different **target** cells in the body

Steroid hor...es

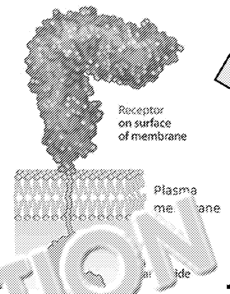
Oestradiol and progesterone



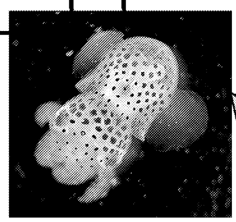
Receptors

Intracellular receptors

Transmembrane receptors



Quorum sensing

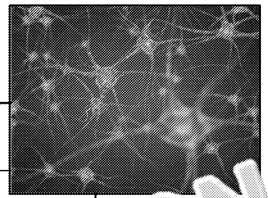


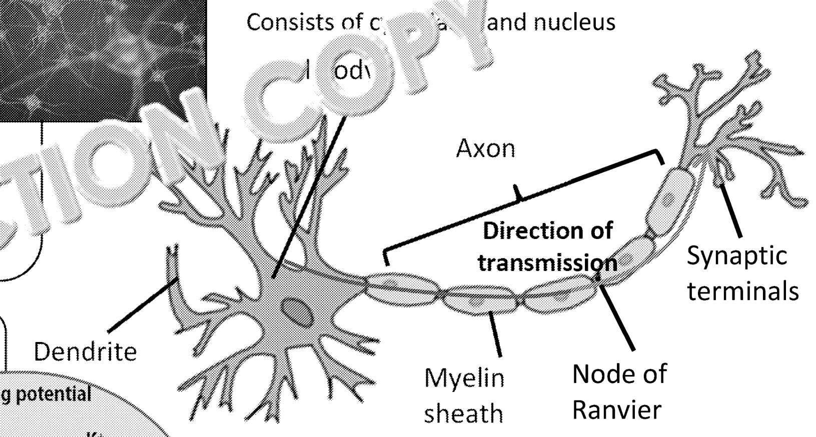
Example

An example of negative feedback

Neg...

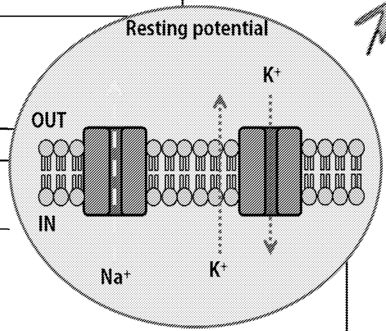
C2.2 Neural signalling





What is a neuron?

In



Sodium-potassium pumps

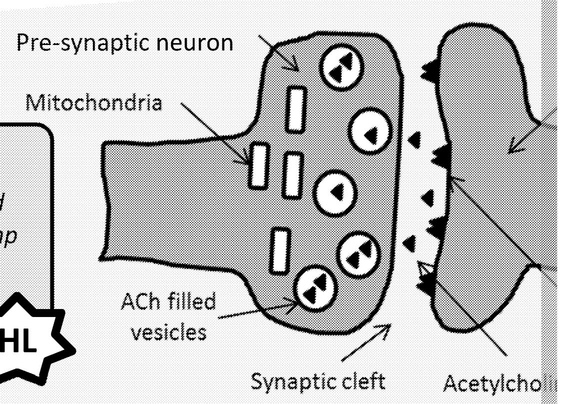
Myelin and saltatory conduction

Action potential

HL

Exam tip – *'Saltatory' comes from the Latin word 'saltare', which means jump – just like the action potential in this kind of conduction.*

HL



Synapses

Co ness

HL

C3.1 Integration of body sys

Communication systems

Organisation in living organisms

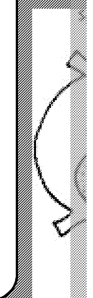
Emergent properties

Neurons

Receptor types

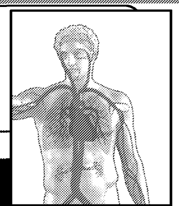
Receptor	Stimulus

The mammalian nervous system



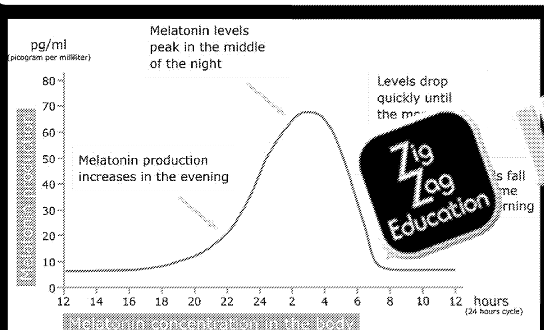
Reflex ar

Transport mechanisms

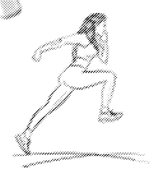


The endocrine system

Sleep patterns



Control of heart and ventilation rate



Epinephrine (adrenaline)

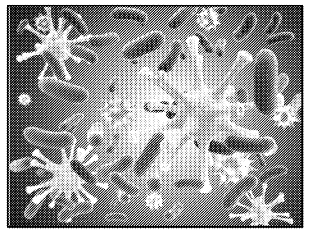
Practical i

Phytoh

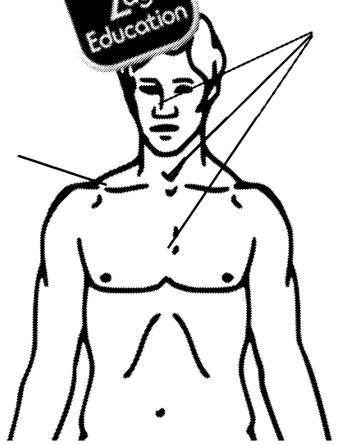
Hormone	

C3.2 Defence against disea

What are pathogens?



Primary defences



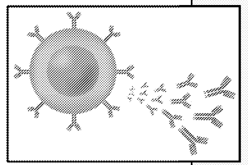
Blood clotting

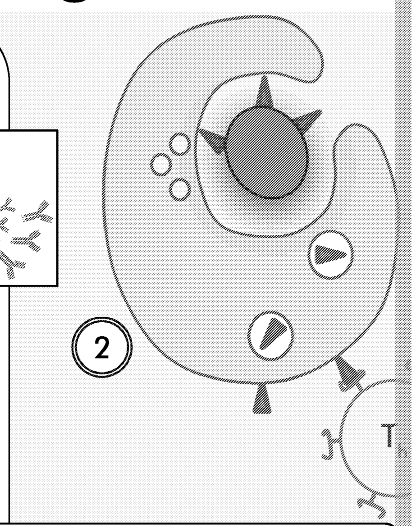
Innate immune system

Adaptive immune system

Response order

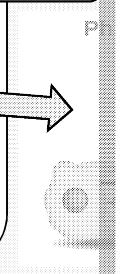
1 Antig





Blood types

Phagocytosis



HIV and AIDS

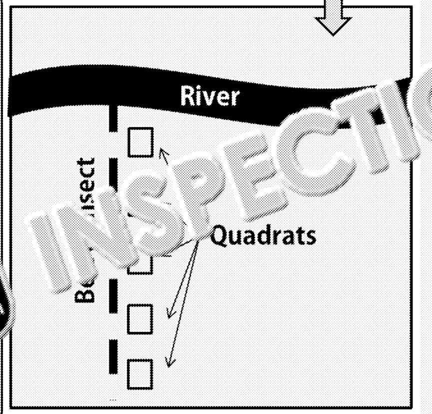
Antibiotics and resista

C4.1 Populations and commu

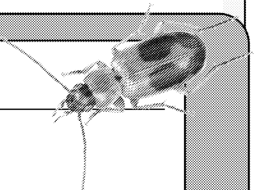
What is an ecosystem?

Random sampling

Quadrats



Capture-mark-release-recapture



Lincoln index:

Assumes that:

Carrying capacity (K)

Limiting factors

- **Negative feedback** of **den dependent** factors
- **Density-independent** fact

Relationships between individuals

Competition

Endemic species

Other interspecific relationships

Example 1

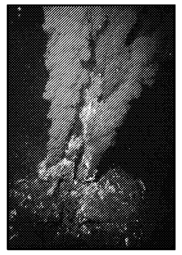
Example 2

Exam

C4.2 Transfers of energy and

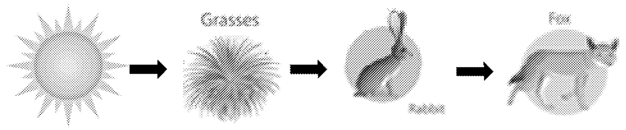
Energy transfer and systems theory

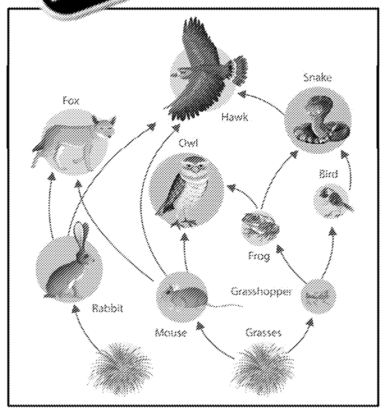
Energy sources



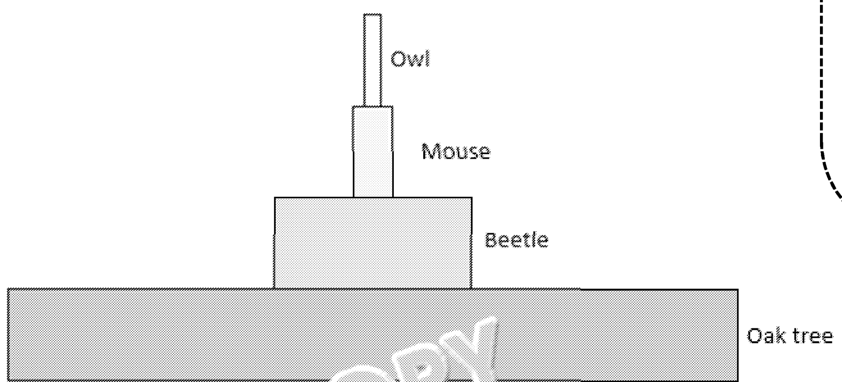
Photosynthesis and respiration

Food chains

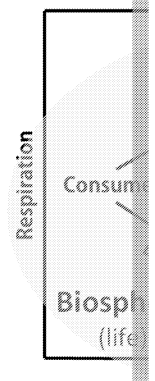




Trophic levels



Pri



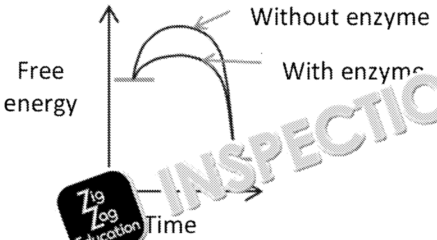
Ph

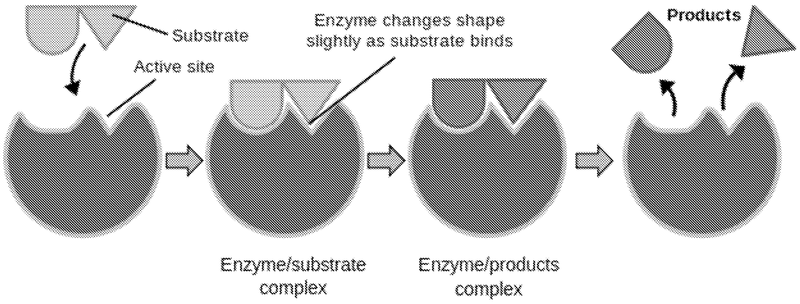
Decomposers

Reductions in energy

IB Topic on a Page, Theme C: Mark

C1.1 Enzymes and metabolism

1. organism, amino acids, 3D, globular, amino acids, active site, substrate, amino ac
2. **(HL)** They use heat produced from metabolic reactions, which are inefficient.
3. **(HL)** Intracellular: Any correct example, e.g. glycolysis / Krebs cycle
   Extracellular: Any correct example, e.g. chemical digestion in the gut
4. 

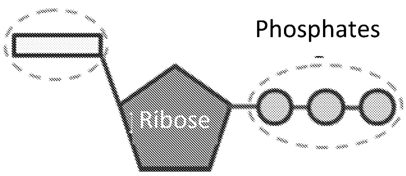
5. Immobilise large substrate molecules/enzymes
   Embed enzymes in membranes to fix the orientation of the active site
6. 

7. Monomer → macromolecules (A)
   Releases energy (C)
   Hydrolysis reactions (C)
   e.g. protein synthesis, glycogen form[illegible]d photosynthesis (A)
   Condensation reactions (A)
   Requires energy ([illegible])
   Macro[illegible]omers (C)
   e.g. [illegible]n, oxidation of substrates in respiration (C)
8. b is th[illegible]mum temperature, where the rate of enzyme-substrate complex for
   During phase c enzymes denature; heat energy causes the active site to change s
9. An enzyme found in saliva would have an optimum pH which is close to neutral, s
   in the stomach would cause it to become denatured, changing the shape of the ac
10. During c, the addition of more substrate has no effect on the rate, as all the availa
    occupied, so the rate of reaction cannot increase.
11. a) **(HL)** Allosteric inhibitors are non-competitive and they bind to an allosteric s
       active site. This alters the structure of the enzyme and the shape of the activ
    b) **(HL)** Competitive inhibitors bind directly to an enzyme's active site and block
       a similar shape to the substrate).
12. a) **(HL)** Any correct example of a linear metabolic pathway, e.g. glycolysis
    b) **(HL)** Any correct example of a cyclical metabolic pathway, e.g. Krebs cycle / C
13. 1. Place test tubes of **starch solutions** in a water bath at 37 °C.
    2. Add a **buffer** with a different pH value to each tes[illegible] of starch solution.
    3. Set up **spotting tiles** with drops of iodine [illegible]
    4. Add **amylase** into one of the te[illegible] and start the **stopwatch**.
    5. Every 20 seconds, use a [illegible] **take a sample** from the test tube and add it
    6. If the reaction [illegible]ace, **iodine** will turn from yellow-red to blue-black
    7. **R**[illegible] each of the test tubes. Record the time it takes for the reacti
14. **(HL)** [illegible]l product of an enzyme-driven metabolic pathway inhibits the action
    stops [illegible]uch product being produced. The inhibition is reversible, so when the
    decreases, the other enzyme starts to bind to its substrate again.
15. **(HL)** irreversibly, antibiotic, transpeptidase, reproduce, resistance, transpeptidase

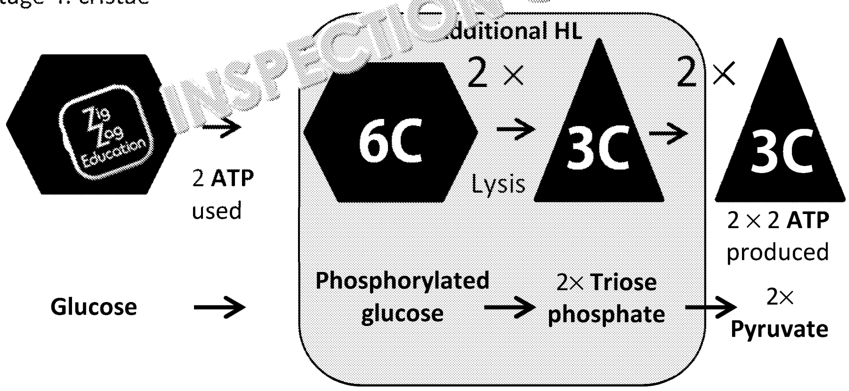
C1.2 Cell respiration

1. a) glucose + oxygen → carbon dioxide + water
   b) $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$
2. **(HL)** Any two correct examples using yeast, e.g.
   - brewing
   - baking
3. Excessive exercise produces lactic acid because of anaerobic respiration. Lactic acid
   In plants and microorganisms, anaerobic respiration produces ethanol and CO_2.
4. **(HL)** If there are no carbohydrates, the body looks for another fuel source. Fat stores
   lipids are respired instead of glucose. Fat is used for energy, and is, therefore, remov
5. a) Adenosine diphosphate (ADP)
   b) Condensation
   c) Plants: any correct example, e.g. photophosphorylation / photosynthesis
      Animals: any correct example, e.g. oxidative phosphorylation / respiration
6. Any four correct examples, e.g.
   - Active transport
   - Metabolic processes / anabolism
   - Cell movement
   - Movement of cell components (e.g. chromosomes)

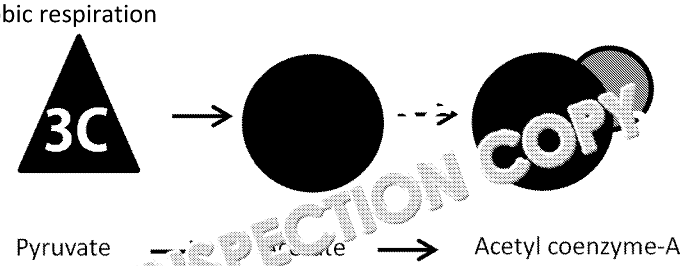
7.



8. Stage 1: cytoplasm
   Stage 2: matrix
   Stage 3: matrix
   Stage 4: cristae
9.



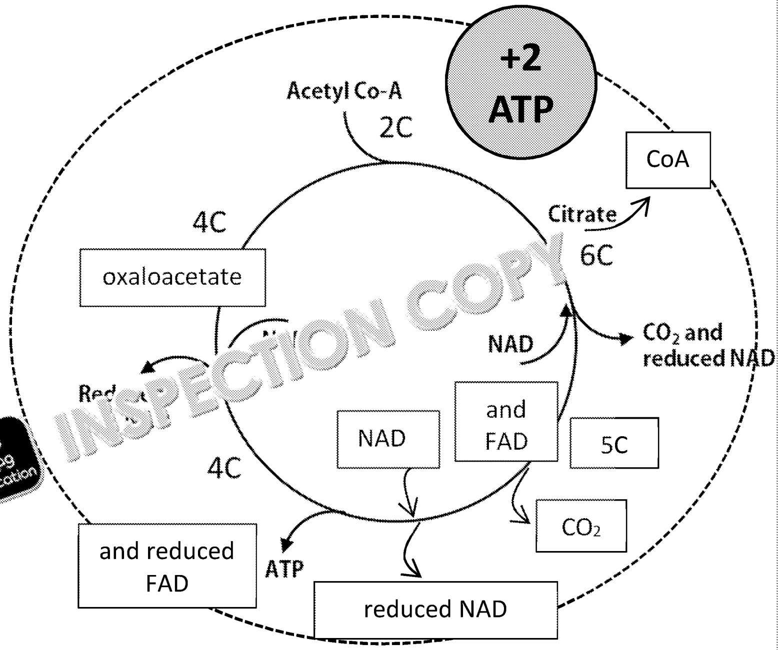
10. Glucose
11. Without oxygen
12. Aerobic respiration
13. **(HL)**



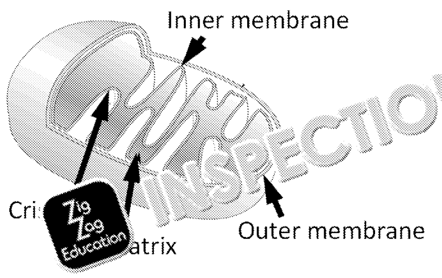
14. **(HL)** coenzyme, oxidation, reduction, hydrogen carrier, reduced, dehydrogenated, g
15. CO_2 / carbon dioxide

16.

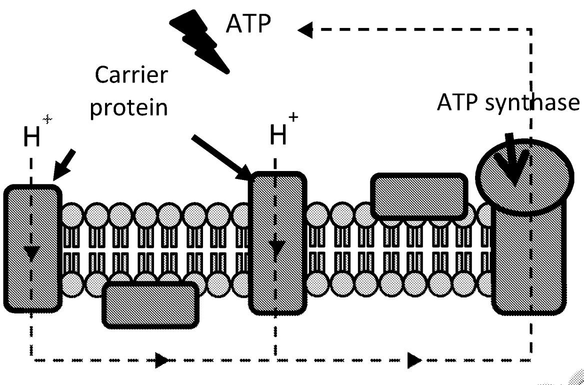
17. **(HL)**



18. Respirometer
19. Any four correct reasons, e.g.
    - Temperature moves away from the optimum
    - CO_2 concentration increases
    - O_2 concentration decrease / anaerobic respiration starts
    - Glucose concentration decreases
20. high-energy electrons, energy, active transport, protons / proton gradient, ATP synth
21.

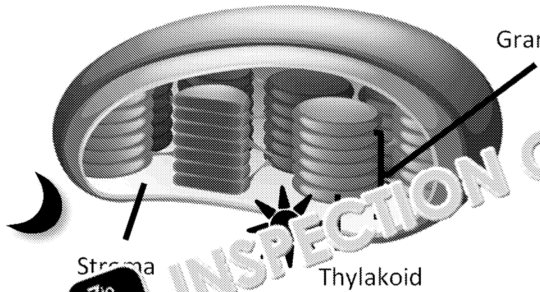


21.



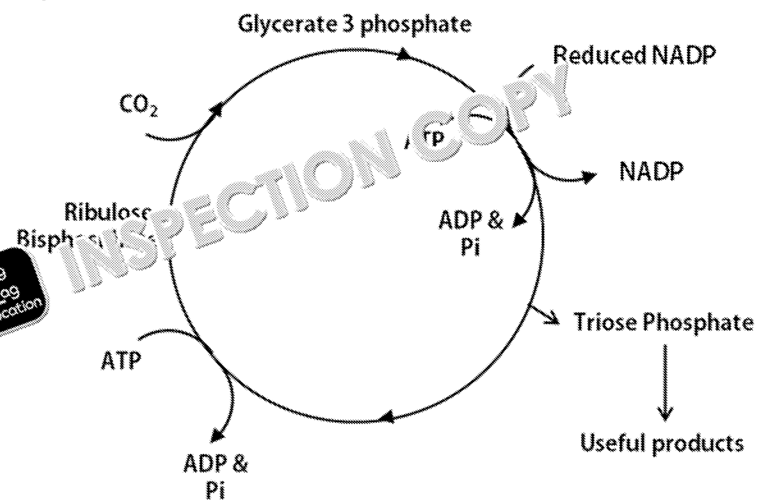
C1.3 Photosynthesis

1. Sunlight
2. It is needed for respiration in most organisms.
3.

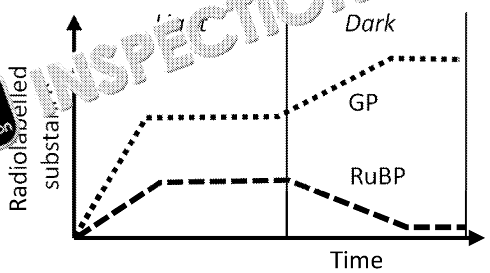


4. carbon dioxide + water $\xrightarrow{\text{Light energy}}$ glucose + oxygen

   $6CO_2 + 6H_2O \xrightarrow{\text{Light energy}} C_6H_{12}O_6 + 6O_2$
5. Photosynthetic pigments absorb light at specific wavelengths and reflect the rest. Th excite electrons to higher energy levels in order to form chemical bonds. They are fo of chloroplasts.
6. **(HL)** Accessory pigments increase the rate of photosynthesis as they increase the am can be absorbed.
7. Pigments from leaves can be separated by chromatography in order to identify what which different wavelengths of light are absorbed.
8. **(HL)** sunlight/light, photosystem II/P680, photoionisation, photolysis, electron transp I/P700, high-energy, low-energy, NADP reductase
9. **(HL)** $2H_2O \rightarrow 4H^+ + 4e^- + O_2$
10. **(HL)** Hydrogen/protons: photophosphorylation
    Electrons: Replace those lost from chlorophyll during photoionisation
    Oxygen: Respiration
11. **(HL)** Electrons are passed along the chain, losing a small amount of energy each time energy is used to pump protons from the stroma across the thylakoid membrane, fo protons. Protons then diffuse down the gradient through ATP synthase, which produ
12. **(HL)** Cyclic photophosphorylation only occurs if light is not limiting and reduced NAD from photosystem I, and only ATP is produced (not oxygen or reduced NADP).
    Non-cyclic photophosphorylation can happen in light or dark conditions. The electro and then pass into photosystem I. They are used to reduce one NADP molecule.
13. **(HL)** The light-receiving complex is a collection of chlorophyll and accessory pigments The reaction centre contains chlorophyll and releases electrons into the electron tra
14. **(HL)** In the light-independent reaction / Calvin cycle, Rubisco catalyses the reaction o molecules of GP. The GP is then reduced to TP using reduced NADP and ATP.
15. **(HL)** Catalyses **inorganic → organic** / ~~organic -> inorganic~~ carbon
    Relatively ~~fast~~ / **slow** to work
    Not effective in **low** / ~~high~~ CO_2
    Needs ~~low~~ / **high** concentrations
16. **(HL)**



17. **(HL)** 5/6
18. Any two correct methods to measure rate of photosynthesis, e.g. counting oxygen b
19. Absorption spectra show the amount of light being absorbed, whereas action spectr
for different pigments/wavelengths of light.
20. Any three correct limiting factors, e.g.
    - Light intensity
    - CO_2 concentration
    - Temperature
    - Water availability
21. **(HL)**



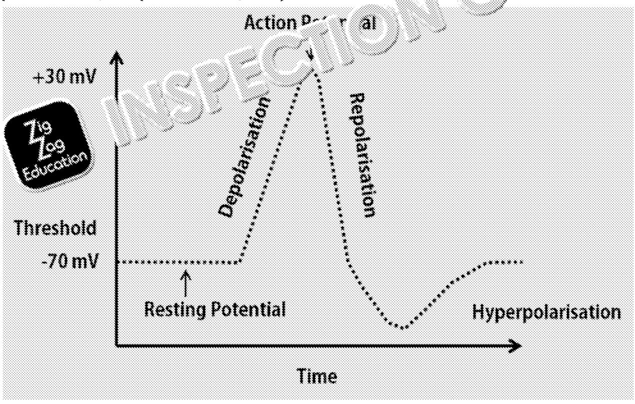
22. Free-air carbon dioxide enrichment
23. b

C2.1 Chemical signalling (HL only)

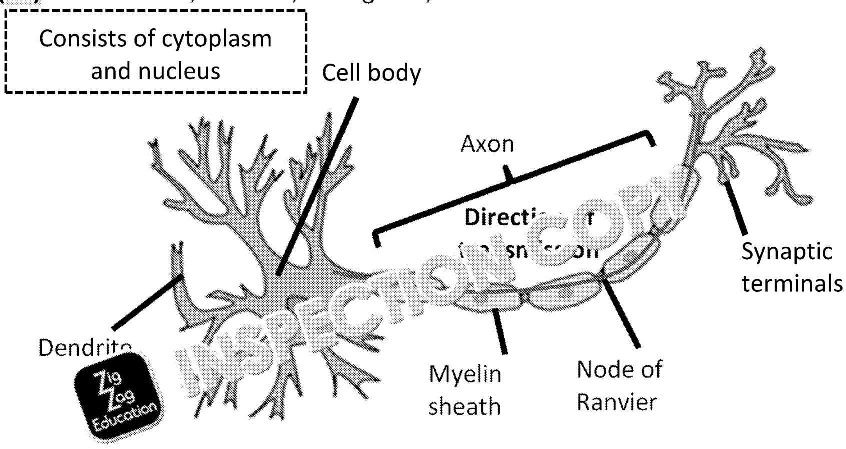
1. The neural system acts on neighbouring cells and is for rapid, short-lived responses,
distant cells and generally act more slowly and for a longer period.
2. Cytokines and calcium ions
3. Ligands need to have a complementary shape to their target cells, which come in ma
4. Hydrophobic
5. steroid, ovaries, transcription, hypothalamus, pituitary, eggs, endometrium, progest
6. A receptor is a protein structure that can detect a change in a condition via the bindi
binds, the receptor changes shape, which leads to a signal transduction pathway.
7. Intracellular receptors are found inside cells and bind hydrophilic ligands which can c
Transmembrane receptors span the whole plasma membrane and have a hydrophili
domain outside the cell where hydrophobic ligands bind.
8. When there are more bacteria present in an area, more autoinducers are produced
When a threshold is reached, the autoinducers re-enter the bacterial cells and bind t
DNA lux box, which is activated and produces luciferase, a luminescent protein.
9. Acetylcholine ligands bind to receptors and cause ion channels to open. Positive sodi
channel, which changes the voltage of the cell membrane, causing an effect in the ce
10. Multi-pass proteins have several domains passing through a single membrane.
11. G protein-coupled receptor
12. a) G protein
    b) Ligands
13. transmembrane, insulin, extracellular, intracellular, kinase, phosphorylations, blood
14. Adrenal glands
15. 1. Epinephrine binds to GPCR
    2. G protein activated
    3. Adenylyl cyclase enzyme activated
    4. ATP converted to cyclic AMP (cAMP)
    5. cAMP binds to protein kinase A (PKA), activating it
    6. Phosphorylase kinase activated
    7. Glycogen phosphorylase activated
    8. Glycogen converted to glucose
16. They allow the body to control whether to stop a signal pathway in response to a sti
17. Any correct example of negative feedback, e.g. a reduction in water content causes t
ADH, which means less urine is produced and more water is conserved.
18. Any correct example of negative feedback, e.g. when the skin is cut, clotting factors s
releases more clotting factors.

C2.2 Neural signalling

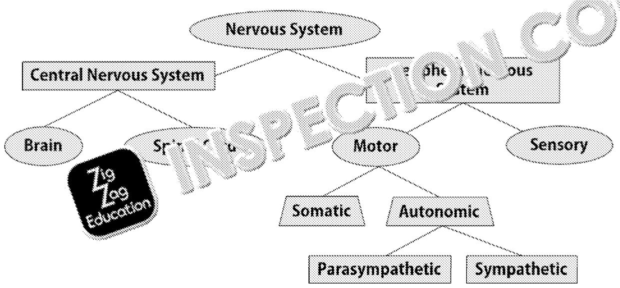
1. A neuron is part of the nervous system which carries impulses / action potentials ac other neurons.
2. Sodium is pumped out, and potassium is pumped in in a 3 : 2 ratio through an active process. The plasma membrane is permeable to potassium and allows it to leak out, so more positive ions leave than are brought into the cell. The inside is therefore negatively charged, relative to outside, and this is the resting potential.
3. **(HL)** polarity, threshold, voltage-gated Na^+ channels, Na action potential, depolarised, depolarisation, Na rep... risation
4. **(HL)**



5. **(HL)** reductionism, neurons, emergence, sum
6.



7. Any three correct factors, e.g.
   - Axon thickness
   - Myelination
   - Temperature
8. a) Fatty layer that wraps around axons to increase the speed of the impulse
   b) Spaces on myelin sheath where an action potential can form
   c) A peak of depolarisation within a neuron
   d) **(HL)** Jumping of action potential across an insulated axon
9. An action potential reaches the synaptic knob, and Ca^{2+} causes binding of vesicles to The neurotransmitter (acetylcholine) is released into the cleft. The post-synaptic me neurotransmitter, and sodium channels open when the neurotransmitter binds to th sodium ions, which leads to an action potential in the next neuron.
10.



11. A neuromuscular junction links a neuron and a muscle fibre, whereas an ordinary syr
12. **(HL)** outside, endogenous, neonicotinoid, ACh, cocaine, dopamine, dopamine, tolera

13. **(HL)** The capsaicin is detected by nociceptors and causes ion channels to open. An inf[illegible] potential to be reached, and an action potential is generated, which travels to the bra[illegible]
14. a) **(HL)** Any correct example of an excitatory neurotransmitter, e.g. acetylcholine
    b) **(HL)** Any correct example of an inhibitory neurotransmitter, e.g. GABA
15. **(HL)** The all-or-nothing principle states that a single synapse acting on a neuron migh[illegible] threshold, in which case, nothing happens.
16. a) **(HL)** An impulse which does not travel further, because it causes local hyperpol[illegible]
    b) **(HL)** An impulse which continues to travel, because it [illegible] local depolarisatio[illegible]

C3.1 Integration of body systems

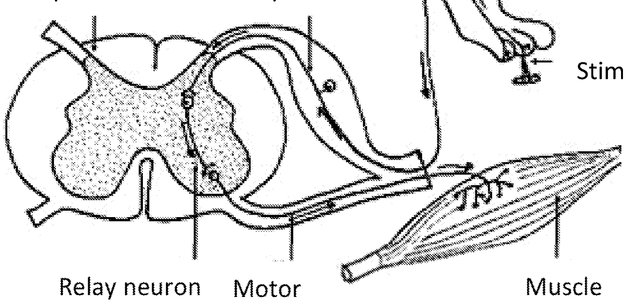
1. Hormones are used [illegible] animals, and are generally slow to take effect but h[illegible] are use[illegible], and are generally faster but have more short-lived effects.
2.

[illegible]s The basic building blocks of organisms	➡	**Tissues** Groups of similar cells
		⬇
Organ systems Groups of organs working together to form organisms	⬅	**Organs** Groups of different tissues performing a function

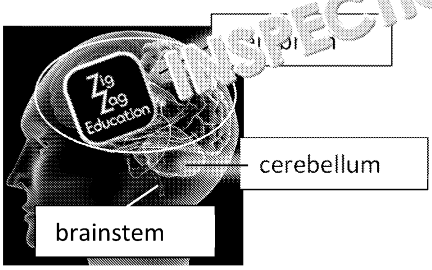
3. When the sum of the parts (e.g. cells, tissues, organs and organ systems) creates ne[illegible] they are integrated.
4. sensory neurons, relay neurons / interneurons, motor neurons
5.

Receptor	Stimulus
Mechanoreceptor	Pressure
Chemoreceptor	Chemicals
Photoreceptor	Light
Thermoreceptor	Temp[illegible]
Nociceptor	[illegible]

6. a) Br[illegible]
   b) M[illegible]tem, sensory system
   c) So[illegible] nervous system
7. unconscious reflexes, white matter / axons, grey matter
8.

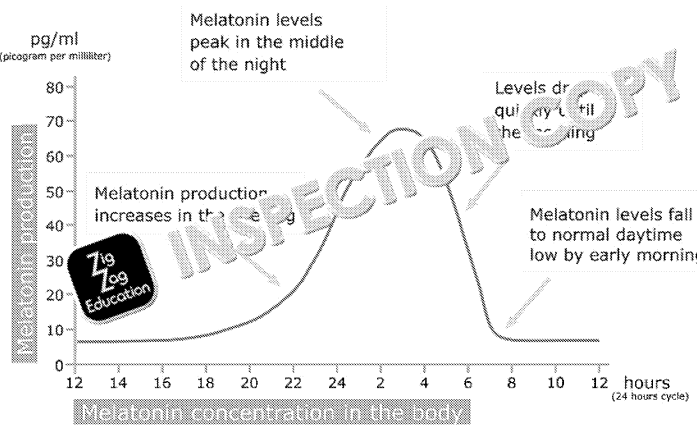


9. a) True
   b) False. A relay neuron links the sensory and motor neurons.
   c) False. The brain is never invol[illegible]
10.



Structure	
Cerebrum	Higher f[illegible] Motor co[illegible]
Cerebellum	Balance a[illegible] 'Muscle m[illegible]
Brainstem / medulla oblongata	Control o[illegible] breathin[illegible]

11. Coordination of neurons in the ENS allows contraction of muscles behind a round m
canal and relaxation of muscles in front of the bolus to move it along smoothly.
12. Cells must be supplied with nutrients and waste products removed, as multicellular
on simple diffusion.
13. blood, endocrine, hypothalamus, nervous, pituitary gland
14.



Higher levels of melatonin induce sleepiness.

15. Baroreceptors are found in the aorta and carotid arteries. Changes in blood pressur
artery walls, which changes the frequency of action potentials sent to the medulla,
sinoatrial node change heart rate and stroke volume.
16. During intense exercise, more respiration takes place than normal, leading to less o
the blood. This lowers the blood pH as carbonic acid forms, and this change is detec
capillaries near the baroreceptors and in the brainstem. More action potentials are
sinoatrial node increase the heart rate and stroke volume, as well as ventilation and
increasing via the increased action of the diaphragm and intercostal muscles.
17. Any five from:
- Increased ventilation
- Increased heart rate
- Increased blood pressure
- Increase blood supply to muscles
- Pupil dilation
- Glucose production from glycogen
- Increased mental awareness

18. a) **(HL)** A growth or turning response to an external stimulus.
b) **(HL)** Any correct example, e.g. phototropism (positive response to light) or grav
result of gravity).
19. **(HL)**

Hormone	Functions
Auxin	• Causes cell elongation • Produced in shoot tips and sent to roots via phloem
Cytokinin	• Causes cell division • Produced in root tips and sent to shoots via xylem
Ethylene (also called ethene)	• Speeds fruit ripening and drop • Works via positive feedback – more ripening = mor • Gas spreads to nearby fruit to **synchronise** ripening

20. **(HL)** Auxin accumulates on the dark parts of shoots and promotes synthesis of hydro
acidification of the apoplast in the cell wall, allowing expansins (enzymes) to loosen
to become less rigid, thus expanding. This bends the shoot towards light (away from

C3.2 Defence against diseases

1. Microorganisms that cause disease
2. The epidermis is a thick layer of dead cells that is difficult for microorganisms to brea
   The skin also secretes antimicrobial oils that kill microorganisms.
3. Sticky mucous is produced by mucous membranes in the nose, trachea and bronchi t
   Cilia in the nose, trachea and bronchi waft trapped pathogens up and out of the bod
4. scabs, platelets, prothrombin, fibrinogen, erythrocytes / red blood cells
5. The innate immune system responds to foreign antigens in general, while the adapti
   differently to specific pathogens/antigens. The innate immune system does not chan
   immune system becomes more effective over time as it builds up a memory of path
6. The primary response happens initially when first infected, and occurs at the same ti
   The secondary response is a more rapid response to a pathogen which has already b
   More antibodies are produced and symptoms may not develop at all.
7. Antigens are foreign substances made of glycoproteins or proteins which are display
   produced by pathogens. They are recognised as non-self by the immune system.
8. Phagocytes and helper T-lymphocytes
9. The protein B on the foreign blood will be recognised by the immune system as non-
   that protein on their blood.
10.

		A protein ✓	A protein ✗
B protein	✓	AB	B
B protein	✗	A	O

11. Phagocytes (white blood cells / leucocytes) detect foreign antigens and project their
    antigens/pathogens. Lysosomes inside the phagocytes release lysozymes to digest th
    absorbed. The antigens are presented to trigger a lymphocyte response.
12. cell-mediated, helper T-lymphocytes, cytokines, mitosis, B-lymphocytes, memory T-ly
    clonal selection, mitosis, adaptive, antigen, plasma B-cells, agglutination, phagocytes
    activated T-lymphocyte
13. Any three correct answers, e.g.
    - Sharing needles
    - Blood transfusions
    - Unprotected sexual contact
    - Breastfeeding
14. AIDS stands for acquired immune deficiency syndrome. An HIV positive individual wh
    will have a weakened immune system because the HIV virus replicates within specifi
    T-lymphocytes) and destroys them, which means fewer antibodies are produced in re
15. Antibiotics target bacterial metabolism and so don't have any effect on either viruses
    replicate inside.
16. a) When a bacterial population is exposed to antibiotics, some of them will have a
       survive and reproduce to form an antibiotic-resistant population.
    b) Any two correct suggestions, e.g.
       - Frequent handwashing and/or good hygiene
       - Finishing courses of antibiotics (not stopping when symptoms are gone)
       - Not prescribing antibiotics unnecessarily
       - Not using / reducing use of antibiotics in animal feed on farms
17. A modified / a dead / an inactive pathogen, or the DNA/RNA coding for specific antig
18. If enough of a population are immunised against a disease, the transmission of the d
    means a non-immunised individual is unlikely to catch the disease.
19. A disease which can be passed from a non-human vertebrate to a human
20. rabies, dog, COVID-19, respiratory/lung, tuberculosis, lungs, Japanese encephalitis
21. $\frac{28-7}{\left(\frac{7+28}{2}\right)} \times 100 = \frac{21}{17.5} \times 100 = 120\ \%$
22. $\frac{7-28}{28} \times 100 = -75\ \%$

C4.1 Populations and communities

1. a) A group of individuals of the same species living in the same area that can bree
   b) A group of populations interacting in the same area
   c) A community plus the abiotic factors of an area
2. a) Any two appropriate suggestions, e.g.
      - Not all individuals may be accessible (e.g. some may be hiding)
      - It would take too long to count every individual
      - It may be impractical to count every indivi[illegible] e.g. [illegible] individuals are movi
   b) Random sampling avoids bias towards c[illegible] by sampling arbitrarily. Sys measurements at regular inter[illegible] or grid.
3. Divide the field into a series [illegible] areas, and randomly select a set of coordi the number of indivi[illegible] of each species in every quadrat. Take the average a this up [illegible] quadrat area : whole field.
4. Total p[illegible]n size = (number of individuals marked on Friday × total number of re number [illegible]marked recaptured individuals on Saturday
   = (60 × 80) / 32
   = 150
5. Four assumptions are:
   - All individuals come from the same population
   - Marking doesn't make individuals more likely to be caught or eaten
   - There was a closed population (no individuals left the population)
   - There were no births or deaths during sampling
6. a) The dashed line is the carrying capacity, which is the maximum number of indiv the population increases above this amount, it crashes, bringing the populatio
   b) 1: Exponential/logarithmic phase
      2: Transitional phase
      3: Plateau/stationary phase
      X: Carrying capacity
   c) The population initially expands rapidly due to favou[illegible] conditions, plentiful r disease or competition. The growth then slo[illegible] a [illegible]her number of individua disease spreads more quickly and [illegible]rs [illegible] be attracted to the area. Once approached, growth levels [illegible] are limited.
7. Any four from:
   - Nutri[illegible]
   - C[illegible]ox[illegible]
   - W[illegible]
   - Sunlight
   - Space
   - Disease/pathogens
   - Waste
8. Negative feedback
9. Interspecific competition occurs between different species. Intraspecific competitio same species.
10. Any two appropriate examples, e.g.
    - Hunting in packs
    - Taking turns to stay on watch
    - Taking turns to care for children
11. a) Species only found in one place
    b) Species introduced from elsewhere
12. predators, prey, scavengers, host, harm/dam[illegible] pat[illegible]icity, herbivory, interspe
13. Any appropriate example, e.g.
    - *Rhizobium* bacteria (get [illegible] / favourable environment) in root nodu fixed into ammo[illegible]
    - M[illegible]iza [illegible] nutrients when plant dies) in Orchidaceae (receive nutrie
    - Zo[illegible]llae (receive carbon dioxide and minerals for photosynthesis) embed car[illegible]based nutrients)
14. A change in the population of the snowshoe hare causes a change in the population number of hares increases, this then allows the population of lynxes to increase as t However, once the number of lynxes rises high enough, the number of hares decrea This then leads to a decrease in lynxes as their prey becomes scarcer.

15. a) 3 – 1 = 2
    b) Yes; 3.87 > 3.65 so the null hypothesis is rejected
16. a) Bottom-up
    b) Top-down
    c) Top-down
17. A species producing secondary metabolites which interfere with the growth of other
    Any appropriate example, e.g. garlic mustard produces sinigrin to inhibit seed germina
18. The antibiotic creates an area where bacteria cannot grow, creating more space for t

C4.2 Transfers of energy and matter

1. Open, because energy and matter can enter and leave.
2. matter, destroyed, energy, transformed, created
3. Direction of energy and biomass transfer
4. A) and ... only to grasses. B) and C) apply to all other organisms, e.g. rabbit, fox
5. Grasses → Grasshopper → Frog → Owl
6. polymers, monomers, assimilation
7. They convert non-living organic matter into more usable forms and support soil form
8. A saprotroph secretes enzymes to digest nutrients, which they then absorb. A detriti
   inside its body.
9. a) Photoautotrophs use sunlight to produce ATP, whereas chemoautotrophs oxidi
   b) Any one example of a photoautotroph, e.g. plant, algae, cyanobacteria or a nan
      Chemoautotroph must be a description of or named element-oxidising bacteria
10. Photosynthesis requires carbon dioxide and water produced from respiration, and re
    from photosynthesis. Their chemical equations are the reverse of each other.
11. a) kJ m^{-2} yr^{-1}
    b) Oak tree = Producer, Beetle = Primary consumer, Mouse = Secondary consumer
12. a) 90 %
    b) Any three valid reasons, e.g.
       - Energy is lost as heat via cellular respiration / for movement
       - Maintaining body heat is not 100 % efficient
       - Not all individuals at a trophic level are consumed
       - Not all parts of organisms are eaten as food
       - Some parts of organisms are not digestible / not absorbed
13. dry, mass, time, ... greater/more, more, remain/are similar
14. g m^{-2} y...
15. a) (i) Biomass generated by autotrophs at a certain time and place
       (ii) Biomass generated in the second plus trophic levels
    b) Some biomass will always be lost, e.g. as carbon dioxide or other waste materia
16. sink, uptake, source, release
17. a) respiration
    b) combustion
    c) photosynthesis
    d) feeding
    e) decomposition
18. lightning strikes, energy, fuel, renewable, growth rate, non-renewable, million
19. $6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$
20. respiration, photoautotrophs, atmosphere
21. Methane / CH_4
22. a) Should be an increasing curve
    b) Photosynthetic organisms absorb more carbon dioxide in seasons which are wa
       and darker seasons
23. Any three named chemical elements ... by organisms, e.g. carbon, nitrogen, sulfur
    Decomposers recycle elements from decaying organisms and provide them in a more
    growing organisms.