Cambridge IGCSE · Biology 0610

Biology 0610 formulas and definitions

All 338 formulas, facts and definitions to learn, by syllabus topic. Formulas the exam gives you are left out.

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1 Characteristics and classification of living organisms

MRS GREN: movement, respiration, sensitivity, growth, reproduction, excretion, nutrition

Growth = a permanent increase in size **and dry mass**

Excretion = removal of the waste products of metabolism and substances in excess of requirements

Species = a group of organisms that can reproduce to produce **fertile offspring**

Scientific name = *Genus species*; genus first, with a capital letter

Insects: 3 pairs of legs, 1 pair of antennae, 3 body parts

Arachnids: 4 pairs of legs, no antennae, 2 body parts

Crustaceans: more than 4 pairs of legs, 2 pairs of antennae

Myriapods: legs on every segment, 1 pair of antennae

Extended: prokaryote = no nucleus; fungus = non-cellulose wall, no chloroplasts, feeds by releasing enzymes and absorbing; protoctist = mostly single-celled with a nucleus

Extended: monocot = parallel veins, parts in 3s; dicot = branching veins, parts in 4s or 5s

Extended: virus = protein coat + genetic material

Extended: more recent common ancestor → more similar DNA base sequences

2 Organisation of the organism

magnification $= \dfrac{\text{image size}}{\text{actual size}}$

actual size $= \dfrac{\text{image size}}{\text{magnification}}$; image size = actual size × magnification

Magnification has no units; write it as $\times 400$

1 cm $= 10$ mm (cm → mm: $\times 10$)

Extended: 1 mm $= 1000$ µm (mm → µm: $\times 1000$; µm → mm: $\div 1000$)

Plant cells only: cell wall (cellulose), chloroplasts, large permanent vacuole

In every cell: cell membrane, cytoplasm, ribosomes

Bacteria: no nucleus; circular DNA and plasmids; cell wall not made of cellulose

Nucleus: genetic material, controls the cell · mitochondria: aerobic respiration, release energy · ribosomes: make proteins · membrane: controls what enters and leaves · wall: support, stops bursting · chloroplasts: photosynthesis · vacuole: cell sap, keeps cell firm

Cell → tissue → organ → organ system → organism

Tissue = group of similar cells with one function; organ = several tissues working together

New cells are produced only by the division of existing cells

3 Movement into and out of cells

percentage change $= \dfrac{\text{final} - \text{starting}}{\text{starting}} \times 100$ (a loss is negative)

mean $= \dfrac{\text{sum of the readings}}{\text{number of readings}}$

Surface area of a cube of side x: $6x^2$; volume x^3

Faster diffusion: larger surface area, higher temperature, steeper gradient, shorter distance

Extended: water moves from higher to lower water potential; pure water has the highest; more negative kPa = lower

Plant cell that gains water: swollen, membrane pressed against the wall; loses water: membrane pulls away from the wall; the wall stops it bursting. Extended: turgid, flaccid, plasmolysed

4 Biological molecules

Carbohydrates and fats: C, H, O. Proteins: C, H, O, N

Starch, glycogen, cellulose ← glucose; protein ← amino acids; fats and oils ← fatty acids and glycerol

Iodine: yellow-brown → blue-black (starch). Benedict's + heat: blue → brick-red (reducing sugar). Biuret: blue → purple (protein). Ethanol then water: clear → cloudy white (fat). DCPIP: blue → colourless (vitamin C)

Extended: A pairs with T, C pairs with G

Extended: $\%A = \%T$, $\%C = \%G$, and $\%A + \%T + \%C + \%G = 100\%$, so $\%G = \dfrac{100 - 2 \times \%A}{2}$

Extended: in numbers of bases, $A = T$, $C = G$, $G = \dfrac{\text{total bases} - 2A}{2}$ (and $\text{total bases} = 2\times$ number of base pairs)

5 Enzymes

Catalyst: increases the rate of a chemical reaction and is not changed by the reaction

Enzyme: a protein that functions as a biological catalyst, involved in all metabolic reactions

Enzyme + substrate → enzyme–substrate complex (Extended) → enzyme + products

Active site shape is **complementary** to the substrate (not the same shape)

Amylase: starch → simple reducing sugars. Protease: protein → amino acids. Lipase: fats → fatty acids and glycerol

Optimum: the temperature or pH at which the enzyme is most active; human enzymes about 37 °C

Denatured: the active site has permanently changed shape, so the substrate no longer fits. Caused by high temperature or extreme pH, not by cold

Extended: higher temperature (up to the optimum) → more kinetic energy → more frequent effective collisions → more enzyme–substrate complexes

$$\text{rate} = \frac{1}{\text{time taken}}$$

6 Plant nutrition

carbon dioxide + water → glucose + oxygen (light and chlorophyll above the arrow)

Extended: $6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$

Photosynthesis: plants make carbohydrates from raw materials using energy from light

Chlorophyll: green pigment in chloroplasts; transfers energy from light into energy in chemicals

Magnesium ions → chlorophyll; nitrate ions → amino acids → proteins

Glucose → respiration; starch → store; cellulose → cell walls; sucrose → phloem transport; nectar → attract insects

Iodine: blue-black = starch; orange-brown = no starch

Hydrogencarbonate indicator: yellow = more CO_2, red = air level, purple = less CO_2

Extended: limiting factors are light intensity, CO_2 concentration and temperature

$$\text{percentage change} = \frac{\text{new} - \text{original}}{\text{original}} \times 100$$

$$\text{rate} = \frac{\text{number of bubbles}}{\text{time}}$$

7 Human nutrition

7.1–7.3 Diet, the digestive system and physical digestion

Balanced diet: all the nutrient groups, in the right proportions, with enough energy

Seven components: carbohydrates, fats, proteins, vitamins, mineral ions, fibre, water

Vitamin C → gums, wound healing; lack → scurvy

Vitamin D and calcium → bones and teeth; lack → rickets

Iron → haemoglobin in red blood cells; lack → anaemia

Fibre → moves food through the gut; lack → constipation

Order: ingestion → digestion → absorption → assimilation → egestion

Bile: made in the liver, stored in the gall bladder, released into the duodenum

Physical digestion: smaller pieces, no chemical change, larger surface area for enzymes

Incisors (and canines) bite and cut; canines grip and tear; premolars and molars chew and grind

Tooth: enamel → dentine → pulp (nerves, blood vessels); cement on the root; in bone and gum

Mass of nutrient in a portion $= \dfrac{\text{mass per 100 g}}{100} \times \text{mass of portion}$

$\text{percentage of RDA} = \dfrac{\text{amount eaten}}{\text{RDA}} \times 100$

Surface area of a cube of side $s = 6s^2$

7.4–7.5 Chemical digestion and absorption

Chemical digestion: large insoluble molecules → small soluble molecules, so they can be absorbed

Amylase: starch → simple reducing sugars (maltose)

Protease: protein → amino acids

Lipase: fats and oils → fatty acids + glycerol

Amylase from the salivary glands (acts in the mouth) and pancreas (small intestine)

Protease from the stomach (acts there) and pancreas (small intestine); lipase from the pancreas (small intestine)

Hydrochloric acid: kills microorganisms; gives the acidic optimum pH for stomach enzymes

Nutrients absorbed in the small intestine; water mostly in the small intestine, some in the colon

Extended: maltase: maltose → glucose, on the epithelium membranes of the small intestine

Extended: pepsin in the acidic stomach; trypsin (from the pancreas) in the alkaline small intestine

Extended: bile is alkaline and neutralises stomach acid in the duodenum

Extended: capillaries → glucose and amino acids, to the liver; lacteal → fatty acids and glycerol

Rate $= \dfrac{1}{\text{time}}$; percentage change $= \dfrac{\text{change}}{\text{original}} \times 100$

8 Transport in plants

Xylem: water and mineral ions, and support; phloem: sucrose and amino acids

Root: xylem a central star, phloem between its arms; stem: bundles in a ring, phloem outside, xylem inside; leaf vein: xylem upper, phloem lower
Root hair cells: absorb water (by osmosis) and mineral ions; large surface area
Water pathway: root hair cells → root cortex cells → xylem → mesophyll cells
Transpiration: loss of water vapour from leaves; evaporation from mesophyll surfaces into air spaces, then diffusion out through stomata
Faster transpiration: higher temperature, higher wind speed; **Extended:** lower humidity
Extended: xylem: thick lignified walls, no cell contents, no cross walls (continuous tube)
Extended: transpiration pull draws up a column of water held together by attraction between water molecules
Extended: wilting: water loss > water uptake → cells lose water by osmosis → flaccid, no turgor
Extended: translocation: sucrose and amino acids in phloem, source → sink
Rate $= \frac{\text{distance moved by bubble (or mass lost)}}{\text{time}}$; percentage change $= \frac{\text{change}}{\text{original}} \times 100$

9 Transport in animals

9.1–9.2 Circulatory systems and the heart

Circulatory system = blood vessels + a pump (heart) + valves for one-way flow
Arteries carry blood away from the heart; veins bring it back; heart → arteries → capillaries → veins → heart
Atria receive blood from veins; ventricles pump blood into arteries
Vena cava → right atrium → right ventricle → pulmonary artery → lungs → pulmonary vein → left atrium → left ventricle → aorta
Valves prevent backflow; the septum separates the two sides
Monitoring: ECG, pulse rate, listening to the valves closing
Heart rate rises during exercise and takes time to return to resting
CHD: blockage of the coronary arteries; risk factors diet, lack of exercise, stress, smoking, genetic predisposition, age, sex
Extended: fish heart → gills → body → heart (single); mammal: through the heart twice per circuit (double)
Extended: atrioventricular valves between atria and ventricles; semilunar valves at the base of the aorta and pulmonary artery
Extended: left ventricle wall thickest (pumps to the whole body); atria thinnest (pump only into the ventricles)
Heart rate (beats per minute) $= \frac{\text{beats counted}}{\text{seconds counted}} \times 60$; from an ECG $= 60 \div$ time for one beat in seconds

Percentage change $= \dfrac{\text{new} - \text{original}}{\text{original}} \times 100$

9.3–9.4 Blood vessels and blood

Arteries carry blood away from the heart; veins back to it; heart → artery → capillaries → vein → heart

Artery: thick wall, narrow lumen, no valves. Vein: thin wall, wide lumen, valves. Capillary: wall one cell thick, very narrow lumen

Valves in veins prevent backflow (one-way flow towards the heart)

Capillaries exchange substances with cells: deliver oxygen and nutrients, remove carbon dioxide and wastes

Vena cava, aorta, pulmonary artery, pulmonary vein, renal artery, renal vein: from, to, oxygenated or not

Blood = red blood cells + white blood cells + platelets + plasma

Red cells: oxygen, haemoglobin; white cells: phagocytosis and antibodies; platelets: clotting; plasma: transport

Clotting prevents blood loss and the entry of pathogens

Extended: thick elastic, muscular artery wall for high pressure; thin wall, wide lumen and valves in veins for low pressure

Extended: capillary wall one cell thick (short diffusion distance), narrow lumen (slow flow), network (large surface area)

Extended: hepatic artery (aorta → liver), hepatic portal vein (intestine → liver), hepatic vein (liver → vena cava)

Extended: phagocytes engulf pathogens (lobed nucleus); lymphocytes make antibodies (large round nucleus)

Extended: soluble fibrinogen → insoluble fibrin → mesh that traps red blood cells

Actual size $= \dfrac{\text{image size}}{\text{magnification}}$; $1\ \text{mm} = 1000\ \mu\text{m}$; percentage change $= \dfrac{\text{new} - \text{original}}{\text{original}} \times 100$

10 Diseases and immunity

Pathogen = disease-causing organism; transmissible disease = the pathogen can be passed from one host to another

Direct transmission: blood and other body fluids. Indirect: contaminated surfaces, food, water, air, animals

Defences: skin and nose hairs (mechanical), mucus and stomach acid (chemical), white blood cells (cells)

Clean water, food hygiene, personal hygiene, waste disposal and sewage treatment each break a route of transmission

Extended: each pathogen has its own antigens; antibodies are proteins with a complementary shape to one antigen

Extended: antibodies destroy pathogens directly or mark them for phagocytes

Extended: vaccine (weakened pathogen or antigens) → lymphocytes make antibodies → memory cells → long-term immunity

Extended: active = own antibodies, memory cells, long-term; passive = antibodies from another individual, no memory cells, short-term

Extended: cholera toxin → Cl^- secreted into small intestine → water potential falls → water into gut by osmosis → diarrhoea, dehydration

Percentage $= \frac{\text{part}}{\text{total}} \times 100$; percentage change $= \frac{\text{new} - \text{original}}{\text{original}} \times 100$; pie chart slices add to 100%

11 Gas exchange in humans

Features of gas exchange surfaces: large surface area, thin surface, good blood supply, good ventilation with air

Path of air: nose/mouth → larynx → trachea → bronchi → bronchioles → alveoli

Oxygen diffuses from the alveoli into the blood; carbon dioxide diffuses from the blood into the alveoli

Inspired air: O_2 21%, CO_2 0.04%, water vapour variable. Expired air: O_2 16%, CO_2 4%, water vapour saturated

Limewater: clear → cloudy (milky) with carbon dioxide

Physical activity: rate and depth of breathing both increase

Extended: inspiration: external intercostals and diaphragm contract → ribs up and out, diaphragm flattens → thorax volume up → pressure down → air in

Extended: expiration: external intercostals and diaphragm relax → volume down → pressure up → air out; internal intercostals contract in forced expiration

Extended: cartilage (C-shaped rings) keeps the trachea open

Extended: more respiration → more CO_2 in blood → detected by the brain → faster, deeper breathing

Extended: goblet cells make mucus that traps; cilia sweep mucus up to the throat

Breaths per minute = breaths counted × (60 ÷ seconds counted); volume per minute = breaths per minute × volume per breath

12 Respiration

Uses of energy: muscle contraction, protein synthesis, cell division, active transport, growth, passage of nerve impulses, constant body temperature

Aerobic: glucose + oxygen → carbon dioxide + water

Anaerobic in muscles: glucose → lactic acid

Anaerobic in yeast: glucose → alcohol + carbon dioxide

Anaerobic respiration releases much less energy per glucose molecule than aerobic

Aerobic respiration takes place in the mitochondria

Extended: $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$

Extended: $C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$

Extended: oxygen debt removal: high heart rate carries lactic acid to the liver; deep, fast breathing supplies oxygen; lactic acid respired aerobically in the liver

Carbon dioxide turns limewater from clear to cloudy

Rate $= \frac{\text{amount}}{\text{time}}$ (for example mm per minute); rate $= \frac{1}{\text{time}}$ when the same amount is timed

Percentage change $= \frac{\text{new} - \text{original}}{\text{original}} \times 100$

13 Excretion in humans

Excretion = removal of waste products of metabolism and substances in excess of requirements

Lungs excrete carbon dioxide; kidneys excrete urea, excess water and excess ions

Path of urine: kidney → ureter → bladder → urethra

Renal artery: blood to the kidney; renal vein: blood away from it

Extended: cortex = outer layer of the kidney; medulla = inner part

Extended: glomerulus filters water, glucose, urea and ions (not proteins or cells)

Extended: nephron reabsorbs all the glucose, most of the water and some of the ions

Extended: urine = urea + excess water + excess ions

Extended: assimilation: liver converts amino acids to proteins

Extended: deamination: removal of the nitrogen-containing part of excess amino acids to form urea, in the liver

Extended: urea is toxic, so it must be excreted

Percentage reabsorbed = (amount filtered – amount in urine) ÷ amount filtered × 100

14 Coordination and response

14.1–14.2 The nervous system and sense organs

CNS = brain + spinal cord; PNS = nerves outside them

Reflex arc: stimulus → receptor → sensory neurone → relay neurone → motor neurone → effector → response

Effector = muscle or gland

Reflex action: automatic (involuntary) and rapid

Synapse = junction between two neurones

Extended: synapse: vesicles → neurotransmitter released → diffuses across the gap → binds to receptor proteins → impulse in the next neurone

Extended: synapses make impulses travel in one direction only

Sense organ = group of receptor cells responding to specific stimuli (light, sound, touch, temperature, chemicals)

Cornea refracts; iris controls light entering the pupil; lens focuses; retina has receptors; optic nerve carries impulses to the brain

Bright light: pupil constricts; dim light: pupil dilates

Extended: bright light: circular muscles contract, radial relax (antagonistic)

Extended: near object: ciliary muscles contract, ligaments slack, lens fatter, more refraction

Extended: rods: night vision; three types of cone: colour vision; cones packed at the fovea; no receptors at the blind spot

Percentage change = (new – original) ÷ original × 100

14.3–14.4 Hormones and homeostasis

Hormone = a chemical substance, produced by a gland, carried by the blood, that alters the activity of one or more specific target organs

Adrenal glands → adrenaline; pancreas → insulin; testes → testosterone; ovaries → oestrogen

Adrenaline increases breathing rate, heart rate and pupil diameter

Nervous control: faster, shorter-lasting; hormonal control: slower, longer-lasting

Homeostasis = the maintenance of a constant internal environment

Insulin decreases blood glucose concentration

Extended: the pancreas also secretes glucagon, which increases blood glucose concentration

Extended: adrenaline increases blood glucose concentration and heart rate

Extended: negative feedback: a change from the set point causes a response that returns the value to the set point

Extended: insulin: liver converts glucose → glycogen; glucagon: liver converts glycogen → glucose

Extended: internal body temperature set point: about 37 °C

Extended: too hot: vasodilation of arterioles, sweating; too cold: vasoconstriction of arterioles, shivering, hairs raised

Percentage change = (new value – original value) ÷ original value × 100

Range = highest value – lowest value, with units

14.5 Tropic responses

Gravitropism: growth towards or away from gravity

Phototropism: growth towards or away from the direction of the light source

Positive = towards the stimulus; negative = away from it

Shoots: positive phototropism, negative gravitropism; roots: negative phototropism, positive gravitropism

In the dark only gravitropism can happen

Clinostat: rotation makes a one-sided stimulus act equally on all sides; a control

Extended only: auxin is made in the shoot tip and diffuses down from it

Extended only: auxin collects on the shaded side (light) and on the lower side (gravity) of a shoot

Extended only: auxin stimulates cell elongation, so the side with more auxin grows more

Percentage change = (new value – original value) ÷ original value × 100

15 Drugs

Drug = any substance taken into the body that modifies or affects chemical reactions in the body

Antibiotics treat bacterial infections; they kill bacteria but do not affect viruses

Some bacteria are resistant to antibiotics, which reduces the effectiveness of antibiotics

Agar plate: largest clear zone = most effective antibiotic; no clear zone = bacteria resistant

Percentage change $= \frac{\text{new} - \text{original}}{\text{original}} \times 100$; mean = total ÷ number of values

Extended only: mutation → resistant bacteria survive the antibiotic → reproduce → pass on the resistance allele → proportion resistant increases (natural selection)

Extended only: using antibiotics only when essential → less natural selection for resistant bacteria such as MRSA

16 Reproduction

16.1–16.3 Asexual reproduction and reproduction in plants

Asexual: one parent, no gametes, offspring genetically identical (to the parent and each other)

Sexual: nuclei of two gametes fuse to form a zygote; offspring genetically different

Fertilisation: fusion of the **nuclei** of two gametes; in a plant, pollen nucleus + nucleus in the ovule

Extended: gamete nuclei haploid (one set), zygote nucleus diploid (two sets): $n + n = 2n$

Stamen = anther + filament; carpel = stigma + style + ovary (containing ovules)

Pollination: pollen from anther to stigma

Extended: self: same flower or same plant; cross: different plant, same species

Insect: large coloured petals, scent, nectar, anthers and sticky stigma inside, larger sticky or spiky pollen

Wind: small or no petals, anthers hanging outside, large feathery stigmas outside, small light smooth pollen in huge amounts

Extended: pollen tube: stigma → style → ovary → ovule; male nucleus moves down the tube

Germination needs water, oxygen and a suitable temperature (not light, not carbon dioxide)

Actual size $= \dfrac{\text{measured length}}{\text{measured scale bar}} \times \text{scale bar value}$; percentage change $= \dfrac{\text{change}}{\text{original}} \times 100$

16.4–16.6 Sexual reproduction in humans

Testis: sperm and testosterone; scrotum: holds testes; sperm duct: testis → urethra; prostate gland: fluid for sperm; urethra: semen and urine out; penis: semen into vagina

Ovary: releases eggs, makes oestrogen and progesterone; oviduct: carries egg, site of fertilisation; uterus: implantation and growth; cervix: neck of uterus; vagina: receives sperm, birth canal

Fertilisation: fusion of the **nuclei** of a sperm and an egg cell → zygote

Sperm: flagellum (swim), mitochondria (release energy), acrosome enzymes (digest jelly coat)

Egg: energy stores (early divisions), jelly coat changes at fertilisation (only one sperm enters)

Egg: large, non-motile, few; sperm: small, motile, millions

Zygote → embryo (ball of cells) → implants in the uterus lining → fetus

Placenta: exchange; umbilical cord: links fetus to placenta; amniotic sac: holds fluid; amniotic fluid: protects from shock

Extended: mother → fetus: oxygen, glucose, amino acids, antibodies; fetus → mother: carbon dioxide, urea; by diffusion, bloods separate

Extended: umbilical artery: to placenta, low O_2, high CO_2 and urea; umbilical vein: to fetus, high O_2 and nutrients

Testosterone (testes): deep voice, facial hair, muscles; oestrogen (ovaries): breasts, wider hips, periods start

Cycle: menstruation days 1–5, lining thickens to day 14, ovulation about day 14, lining kept thick days 14–28, thickest about day 21

Extended: FSH: egg matures, oestrogen made; LH: ovulation; oestrogen: lining repairs and thickens; progesterone: lining maintained

Extended: oestrogen and progesterone: ovaries in the cycle; placenta (mainly) in pregnancy

HIV: a virus; causes an STI; may lead to AIDS; spread by unprotected sex, blood, mother to baby

Percentage change $= \dfrac{\text{new} - \text{original}}{\text{original}} \times 100$; $1\ \text{mm} = 1000\ \mu\text{m}$

17 Inheritance

17.1 Chromosomes, genes and proteins

Chromosomes are made of DNA; DNA carries genetic information as genes; chromosomes are in the nucleus

Gene: a length of DNA that codes for a protein

Allele: an alternative form of a gene

Inheritance: the transmission of genetic information from generation to generation

Size order: gene < chromosome < nucleus < cell

Female XX, male XY; every egg carries X; half the sperm carry X and half carry Y

Chance of a girl (or a boy) $= \frac{2}{4} = 0.5 = 50\%$ for every child

Extended: base sequence in a gene → amino acid sequence → shape of the protein → its function

Extended: DNA controls cell function through proteins: enzymes, membrane carriers, receptors for neurotransmitters

Extended: gene stays in the nucleus → mRNA copy made in the nucleus → mRNA to the cytoplasm → through a ribosome → ribosome assembles amino acids into a protein

Extended: most body cells have the same genes; many genes are not expressed; a cell makes only the proteins it needs

Extended: haploid = one set of chromosomes; diploid = two sets (a pair of each type); human diploid cell: 23 pairs = 46; human gamete: 23

Extended: in DNA, %A = %T and %C = %G, and all four add up to 100%

17.2–17.3 Mitosis and meiosis

Mitosis: nuclear division giving rise to genetically identical cells

Mitosis is for growth, repair of damaged tissues, replacement of cells and asexual reproduction

Exact replication of chromosomes happens **before** mitosis; DNA mass per cell doubles

During mitosis the copies of chromosomes separate, so each daughter cell keeps the same chromosome number

Stem cells: unspecialised cells that divide by mitosis to produce daughter cells that can become specialised for specific functions

Meiosis is involved in the production of gametes

Meiosis: a reduction division; chromosome number halved from diploid to haploid; genetically different cells

Haploid: one set of chromosomes (n); diploid: two sets ($2n$). Human: $2n = 46$, $n = 23$

Gamete number $= \frac{\text{diploid number}}{2}$; zygote number = gamete + gamete

$2n \rightarrow n$: meiosis; $2n \rightarrow 2n$ or $n \rightarrow n$: mitosis; $n + n \rightarrow 2n$: fertilisation

17.4 Monohybrid inheritance

Genotype: the alleles an organism has; phenotype: its observable features

Homozygous: two identical alleles; heterozygous: two different alleles

Dominant: expressed if present; recessive: expressed only with no dominant allele

Two identical homozygous parents are pure-breeding; a heterozygote is not

$Aa \times Aa \rightarrow$ 3 dominant : 1 recessive (recessive probability $\frac{1}{4}$ = 25%)

$Aa \times aa \rightarrow$ 1 dominant : 1 recessive (each 50%)

$AA\times$ anything $\rightarrow$ all dominant phenotype

Expected number = probability $\times$ total number of offspring

Test cross: unknown dominant × homozygous recessive; all dominant $\rightarrow AA$; any recessive $\rightarrow Aa$ (Extended)

Codominance: $C^RC^W \times C^RC^W \rightarrow 1:2:1$; $C^RC^W \times C^WC^W \rightarrow 1:1$ (Extended)

ABO: I^A and I^B codominant, both dominant to I^o; AB $= I^AI^B$, O $= I^oI^o$ (Extended)

Female XX, male XY; colour blindness: X^B normal, X^b colour-blind, Y carries no allele (Extended)

18 Variation and selection

Continuous: range of phenotypes between two extremes; genes **and** environment; histogram

Discontinuous: limited number of phenotypes, no intermediates; usually genes **only**; bar chart

Mutation = genetic change; the way new alleles are formed; rate increased by ionising radiation and some chemicals

Extended only: gene mutation = random change in the base sequence of DNA

Extended only: sources of genetic variation = mutation, meiosis, random mating, random fertilisation

Adaptive feature = **inherited** feature that helps an organism to **survive and reproduce** in its environment

Percentage change $= \frac{\text{new value} - \text{original value}}{\text{original value}} \times 100$

Mean $= \frac{\text{sum of the values}}{\text{number of values}}$

$1\ \text{cm}^2 = 100\ \text{mm}^2$, so per mm² $\times\ 100$ = per cm²

$1\ \text{mm} = 1000\ \mu\text{m}$, so $\mu\text{m} \div 1000$ = mm

Total stomata = stomata per unit area $\times$ area (in the same units)

19 Organisms and their environment

19.1–19.2 Energy flow, food chains and food webs

The Sun is the principal source of energy input to biological systems

Light energy enters (photosynthesis) → chemical energy passes along the chain → heat is lost to the environment

Arrows in a food chain or web point from the food to the organism that eats it (the direction of energy flow)

Producer = level 1; primary consumer = 2; secondary = 3; tertiary = 4; quaternary = 5

Biomass of a level = number of organisms × mass of one organism

Percentage transferred $= \dfrac{\text{energy at the higher level}}{\text{energy at the lower level}} \times 100$

Percentage lost $= \dfrac{\text{energy in} - \text{energy passed on}}{\text{energy in}} \times 100$

Energy passed on = energy at the level – energy lost (heat, waste, not eaten)

Roughly 10% passed on and 90% lost at each transfer

Extended only: pyramid of energy units: kJ per m² per year; always a true pyramid

19.3–19.4 Nutrient cycles and populations

Carbon dioxide is **removed** from the air only by photosynthesis; it is **added** by respiration, decomposition and combustion

Carbon dioxide is about 0.04% of the air

Extended only: decomposition: protein, amino acids, urea $\rightarrow$ ammonium ions

Extended only: nitrification: ammonium ions $\rightarrow$ nitrite ions $\rightarrow$ nitrate ions

Extended only: denitrification: nitrate ions $\rightarrow$ nitrogen gas

Extended only: nitrogen fixation: nitrogen gas $\rightarrow$ ammonium or nitrate, by lightning or bacteria

Extended only: deamination: removal of the nitrogen-containing part of amino acids to make urea, in the liver

Population: one species, same area, same time. Community: all the populations in an ecosystem. Ecosystem: community + environment, interacting

Sigmoid curve phases, in order: lag, exponential (log), stationary, death

Percentage change $= \dfrac{\text{new} - \text{original}}{\text{original}} \times 100$
One cell dividing n times gives 2^n cells; the **increase** is $2^n - 1$

20 Human influences on ecosystems

20.1–20.2 Food supply and habitat destruction

Fertilisers supply mineral ions (nitrate, phosphate, potassium); herbicides kill weeds (less competition); insecticides kill insect pests
Monoculture: one type (species) of crop plant grown over a large area
Biodiversity: the number of different species that live in an area
Reasons for habitat destruction: housing, crop and livestock production, extraction of natural resources, freshwater and marine pollution
Effects of deforestation: reduced biodiversity, extinction, loss of soil, flooding, more carbon dioxide in the atmosphere
Deforestation raises carbon dioxide: less photosynthesis, plus burning and decomposition of the felled trees
Percentage change $= \dfrac{\text{new} - \text{original}}{\text{original}} \times 100$
$1\ \text{tonne} = 1000\ \text{kg}$

20.3–20.4 Pollution and conservation

Sewage and fertiliser add nitrate ions; sewage also carries pathogens
Eutrophication: more ions → faster growth of producers → more producers die and are decomposed → more aerobic respiration by decomposers → less dissolved oxygen → organisms needing oxygen die
Greenhouse gases: carbon dioxide (combustion of fossil fuels, deforestation) and methane (cattle, rice fields, landfill)
More greenhouse gases → enhanced greenhouse effect → climate change
Sustainable resource: produced as quickly as it is removed, so it does not run out
Causes of endangerment: climate change, habitat destruction, hunting, overharvesting, pollution, introduced species
Conserving species: monitoring and protecting species and habitats, education, captive breeding, seed banks
Percentage change $= \dfrac{\text{new} - \text{original}}{\text{original}} \times 100$
Percentage of a total $= \dfrac{\text{part}}{\text{total}} \times 100$

$1\ \text{cm} = 10\ \text{mm}$

21 Biotechnology and genetic modification

Bacteria: rapid reproduction, make complex molecules; Extended: few ethical concerns, plasmids

Yeast anaerobic respiration: glucose → ethanol + carbon dioxide

Extended: $\text{C}_6\text{H}_{12}\text{O}_6 \rightarrow 2\text{C}_2\text{H}_5\text{OH} + 2\text{CO}_2$

Bread: carbon dioxide makes the dough rise; biofuel: ethanol is the fuel

Pectinase breaks down pectin: more juice, clearer juice

Protease → protein stains; lipase → fat and oil stains; amylase → starch stains

Extended: lactase breaks down lactose → glucose + galactose, giving lactose-free milk

Extended: fermenter conditions: temperature, pH, oxygen, nutrients, waste products; plus stirring and sterile conditions

GM: changing genetic material by removing, changing or inserting individual genes

Extended: restriction enzyme cuts (sticky ends) → same enzyme cuts plasmid → DNA ligase joins → recombinant plasmid → into bacteria → multiply → express the gene

Percentage change $= \dfrac{\text{new} - \text{original}}{\text{original}} \times 100$

Rate $= \dfrac{1}{\text{time}}$