Oxford Resources for IB

Biology – 2023 Edition

Answers

Topic A1 – Molecules

Page 5 Applying techniques: Demonstrating the strength of the hydrogen bond.

1. Friction will vary from syringe to syringe but the plunger should start moving downwards with force of about 2 N.
2. Expected force required is less than that exerted by a kilogram of masses hanging from the barrel;

   friction should not be relevant to final volume (as long as the weight is sufficient to overcome the frictional force so the syringe moves)

   pressure × volume = constant (at constant temperature and constant number of gas molecules – Boyle's Law)

   $p_1 \times V_1 = p_2 \times V_2$ so

   $$V_2 = \frac{p_1 \times V_1}{p_2}$$

   p_1 = 1 atmosphere = 100 000 Pa; V_1 = 5 mL;

   p_2 = 1 atmosphere – (pressure due to weight)

   $$\text{negative pressure due to the weight} = \frac{\text{force}}{\text{area}} = \frac{\text{mass} \times g}{\pi \times r^2} = \frac{9.8\text{ N}}{\pi \times (7.5\text{ mm})^2} = 0.055\text{ N mm}^{-2} = 55000\text{ Pa}$$

   p_2 = 100 kPa − 55 kPa = 45 kPa

   $$V_2 = \frac{p_1 \times V_1}{p_2} = \frac{100\text{ kPa} \times 5\text{ mL}}{45\text{ kPa}} = 11\text{ mL}$$

3. Volume can only increase if water separates to create new areas of water surface area with water vapour between. Area = 2 × π × 7.5 mm × 7.5 mm = 3.5×10^{-4} m^2

   Surface energy of water (which is the same as surface tension but expressed as energy area rather than force length) = 72 mN m^{-1}

   So energy required to create new surfaces is $3.5 \times 10^{-4} \times 72 \times 10^{-3} = 2.5 \times 10^{-5}$ J

   By conservation of energy, this can be equated to work required to move the syringe over a distance sufficient to separate the two water surfaces (work = force × distance) A rough estimate of the distance at which the water surfaces would be separate is the length of a hydrogen bond = 0.35 nm therefore:

   $$\text{force} = \frac{2.5 \times 10^{-5}}{0.35 \times 10^{-9}} = 70000\text{ N}$$

   Mass required is around 7000 g. In practice, a break would occur with less mass between the water surface and the inner surface of the syringe because the attractions are less strong. Also it is unlikely that all parts of the apparatus would withstand a mass of 7 kg so there is likely to be a failure with less weight (e.g. an air leak through the gate clip). Nevertheless, more than 1 kg of mass should hang from the plunger and it is impressive that the hydrogen bonds in a 10 mL syringe can potentially withstand 7 kg of mass before they break.

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Page 7 Data-based questions: Tall trees

1. **a.** the researchers had a free choice of heights at which to measure xylem pressure;
   b. xylem pressures depended on the height at which the researchers took measurements;
2. **a.** negative correlation / the greater the height, the lower the pressure;
   b. lower pressure needed to pull water to a greater height;
   lower pressures needed to overcome the pull of gravity;
   lower pressures needed to overcome resistance to flow over longer distances in xylem vessels;
3. **a.** similarity: there is a negative correlation;
   difference: at each height, the pressure is lower at midday;
   b. more evaporation at midday which lowers pressures in xylem
4. 132 m;
   extrapolate the line of best fit on the graph until it reaches −2.0 MPa;

Page 14 Data-based questions: Were comets the source of water in Earth's oceans?

1. non-linear scale;
   equal intervals are multiples, for example 1, 10, 100;
2. 3×10^{-4} / 0.03;
3. only one comet;
   103P/Hartley 2;
4. reduces the likelihood;
   because the D/H ratio is much higher than that of water on Earth;
5. asteroids;
   because meteorites derived from them have D/H ratios closer to that of water on Earth than comets;
   some higher and some lower so average from lots of asteroids could have given the Earth's ratio:

Page 18 Data-based questions: Bases in DNA

1. all other bases contain oxygen;
2. it is used for the linkage between the base and the deoxyribose;
   base is linked to C1 of the deoxyribose;
3. both have two rings of atoms on their molecule;
   both have one six-membered and one five-membered ring;
   the nitrogen and carbon atoms are in the same places in the rings;
   both are purine bases;
4. both have one six-membered ring:
   with carbons and nitrogens in the same positions;
   both have an oxygen linked to a carbon in the ring;
   both are pyrimidines;

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5. distinctive shape needed for complementary base pairing;

   each base only pairs with one other;

   A to T and G to C;

   hydrogen bonds formed between complementary bases;

   allows accurate replication of DNA;

   essential for producing genetically identical cells/organisms/needed for inheritance;

   allows gene regulators to recognize specific sequences of bases;

Page 23 Data-based questions: DNA lengths

1. 1.85%;
2. G pairs with C so the percentage of each will be equal and C will also be 7.3%;

   100 − 14.6 = 85.4 is A + T;

   A pairs with T so the percentage of each will be equal and half of 85.4 = 42.7%
3. advantage: narrower than double-stranded DNA so takes up less space inside the protein coat of the virus / only 1 nm wide whereas double-stranded DNA is 2 nm wide;

   disadvantage: bases more vulnerable to chemical attack when unpaired so more mutations;
4. 3.155 Mb = 3 155 000 base pairs;

   3 155 000 ÷ 1440 = 2191;

   ratio is 2191 : 1
5. Answers will vary.

Page 29 Data-based questions: The Hershey–Chase experiment

1. a pellet is a solid that is spun to the bottom of the tube during centrifugation;

   supernatant is the fluid that remains above the pellet at the end of centrifugation;
2. genetic material (of T2) will have been injected into the bacteria;

   bacteria are relatively large so sediment in the pellet;
3. 80%
4. 35% in the supernatant;

   100 – 35% = 65% in the pellet;
5. T2 genetic material must be injected into the bacteria (as they start making T2 proteins);

   ^{35}S is in the protein coat of T2 and ^{32}P is in its DNA;

   ^{35}S is mostly in the supernatant and ^{32}P is mostly in the pellet;

Page 31 Data-based questions: Chargaff's data

1. quantities of the four bases are reasonably similar across all of the eukaryotes;

   relative quantities of bases in *Mycobacterium* are distinct from eukaryotes;

   Mycobacterium has less adenine and thymine but more guanine and cytosine;

   amount of adenine is approximately equal to amount of thymine in both;

   amount of guanine is approximately equal to amount of cytosine in both groups;

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2. 1.00 in both cases;

3. within experimental error the data supports the hypothesis;

differences in amounts of G/C and A/T are too small to be significant;

4. complementary base pairing between A and T would mean they would need to be present in equal quantities;

same argument for C and G;

5. proportions of bases are not equal;

there cannot be a repeating sequence of the four bases;

6. polio virus may be single-stranded/may be RNA virus (need uracil data to know); bacteriophage T2 may be double-stranded;

Page 34 End of chapter questions

1 a. i. water

ii. water would have a more stable thermal environment;

fewer adaptations necessary for fluctuating temperatures in water habitat/less energy has to be spent on maintaining body temperature;

homeothermic (warm-blooded) adaptations an advantage in air / poikilothermic (cold-blooded) adaptations for water;

b. i. (0.6 / 0.28);

Water has 21.4 times greater thermal conductivity than air.

ii. water

c. i. air provides less buoyant force and therefore more energy is required to counteract the force of gravity;

ii. air bladders full of air would lower the fish's density and cause it to float higher in the water column;

the volume of air within the bladder could be altered to adjust the fish's position in the water column;

d. i. $\frac{0.7978 \times 10^{-3}}{18.6 \times 10^{-6}} = 42.9$ times

water is approximately 43 times more viscous than air;

ii. water offers the greater resistance to movement

e.

	Air energy expenditure	Water energy expenditure
stable heat environment	more energy as less stable heat environment	less energy as more stable heat environment
buoyancy	more energy to counteract gravity	less energy to counteract gravity
viscosity	less energy to move through	more energy to move through
thermal conductivity	less energy expenditure as less heat losses to the air	more energy expenditure as more heat losses to the water

2. a. both show seasonal fluctuations;

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the bottom right graph represents water temperature and it is far more stable than the air temperature (top right) / air shows more pronounced seasonal variation;

b. 34 °C

c. **i.** the lower graph (B) represents 0.5 m above the water line;

it shows less variation which is to be predicted due to the higher specific heat capacity of water /water resists changes in temperature;

ii. 1.5 meters yields the higher mortality rate as the temperature crosses/approaches that lethal level more frequently

3. **a.** **i.** It has no 'thymine' suggesting that it contains uracil instead and is therefore made of RNA.

ii. It is single stranded as the amount of C and G is not equal.

Topic A2 – Cells

Page 39 Data-based questions: Titan's atmosphere

1. on Titan there is:

much less oxygen;

more nitrogen;

more methane;

more ethane/propane/propene;

orange smog due to the hydrocarbons;

2. more oxygen on Earth due to photosynthesis;

no life and no photosynthesis on Titan;

more methane on Titan because it is not oxidized;

methane is destroyed by oxidation in the Earth's atmosphere;

higher percentage of nitrogen in Titan's atmosphere because oxygen is lacking

Page 43 Data-based questions: Protocells

1. **a.** when they are mixed with protocells that contain RNA, they decreased in size;

rapidly at first;

when they are mixed with protocells that do not contain vesicles, their size remains relatively stable;

though they both decrease in size;

b. membrane was captured by the vesicles containing RNA from those that did not contain the RNA;

2. **a.** when mixed with the unswollen cells that contained RNA, they did not grow;

which is consistent with them being unable to capture membrane;

when mixed with the unswollen cells that did not contain RNA, they did grow;

which is what was predicted;

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b. both experimental results consistent with this hypothesis;

RNA containing vesicles were able to grow;

consistent with them capturing membrane;

RNA containing vesicles prevented growth of swollen vesicles;

consistent with them holding on to membrane;

mechanism is not clear;

Page 55 Data-based questions: Size, magnification and scale

1 a. magnification = $\frac{\text{size of image}}{\text{actual size of specimen}}$;

size of image (scale bar) = 20 mm;

actual size = 0.2 mm;

magnification = $\frac{20}{0.2}$ = 100×;

b. width of *Thiomargarita* in the image (image size) = 26 mm;

magnification = 100×;

actual size = $\frac{26}{100}$ = 0.26 mm;

2. a. 31 mm = 31 000 μm so

magnification = $\frac{31000}{8}$ = 3875×;

b. scale bar = 5 μm × 3875 = 19 375 μm = 19.375 mm (approx. 20 mm);

c. width = $\frac{11\,\text{mm}}{3875}$ = 0.0028 mm (2.8 μm);

3. a. 20 μm × 2000 (magnification) = 40 000 μm;

(or 40 mm scale bar);

b. actual size of specimen = $\frac{24\text{ mm}}{2000}$ = 0.012 mm = 12 μm;

4. a. hen's egg is 9 mm wide in diagram;

ostrich egg is 25 mm long in diagram;

real hen's egg is about 50 mm wide;

ostrich egg = $\frac{50 \times 25}{9}$ = 139 mm approx.;

b. magnification = $\frac{\text{size of image of egg}}{\text{actual size of egg}}$;

hen's egg = $\frac{9\text{ mm}}{50\text{ mm}}$ = 0.18×;

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5. a. 12 EPU in the scale is equivalent to 10 mm measured with a ruler

$$\frac{10000}{12} = 833\times$$

Worm is 75 mm long measured with a string and ruler, and 5 mm wide

$$\text{maximum length} = \frac{75000}{833} = 90 \text{ EPU}$$

$$\text{maximum width} = \frac{5000}{833} = 6 \text{ EPU}$$

b. actual maximum width is 6 × 9.5 = 57 μm;

actual length is 90 × 9.5 = 855 μm;

c. actual maximum width is 0.057 mm;

actual length is 0.855 mm;

μm more convenient because the sizes are less than 1 mm;

Page 63 Data-based questions: Ultrastructure of *Clostridium*

1. ribosomes;

high concentrations of enzymes/proteins;

2. circular;

3. divide into two cells;

each daughter cell receives one copy of the DNA/chromosome by receiving one of the nucleoids;

4. length of scale bar = 13 mm;

$$\frac{13000 \text{ μm}}{0.5 \text{ μm}} = 26000\times;$$

5. length of cell in micrograph = 72 mm;

$$\frac{72000 \text{ μm}}{26000} = 2.77 \text{ μm};$$

Page 66 Data-based questions: Processes of life in a testate amoeba

1. 150–160 μm;

$$\text{magnification} = \frac{23000 \text{ μm}}{50 \text{ μm}};$$

= 460×;

2. food cannot pass through the test;

must fit through the aperture in the test; 40–45 μm;

3. lower solute concentration in freshwater habitat than in cytoplasm of cell;

water enters cell by osmosis; cytoplasm will increase in volume;

cell would burst at the aperture in the test;

contractile vacuole needed to expel water;

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4. a. many food vacuoles visible in the cytoplasm;

white droplets of stored food visible in the cytoplasm;

cell has nutrients needed for growing;

b. two nuclei are visible;

cell division possible with each daughter cell receiving a nucleus;

5. mitochondria present;

because the cell is eukaryotic;

use electron microscopy to look for mitochondria;

Page 78 Data-based questions: Diversity in green algae

1. a. *Klebsormidium* has cylindrical cells;

Crucigenia has triangular/pyramidal cells with a corner truncated;

b. 7–8 μm long and 5–6 μm wide;

flattened ellipsoid shape;

green/contains chlorophyll;

has grana/stacks of thylakoids;

c. two chloroplasts are needed when a cell divides;

d. stain the nuclei using methylene blue/another suitable stain;

e. both have more than one cell linked together;

but no cell differentiation is visible;

cells do not rely on each other for different functions;

cells live independently apart from adhering to each other;

perhaps colonial (single-cell) rather than multicellular;

2. a. 50–60 μm long without spines;

75 μm long including spines;

b. deters predators;

by making the cell larger/more difficult to ingest/spikes might burst vacuole;

c. 3.5–4.0 μm long;

d. bacteria gain oxygen produced in the alga by photosynthesis;

mucus helps bacteria to adhere to the alga;

bacteria provide carbon dioxide for the alga to use in photosynthesis;

e. one cell;

because it only has one nucleus/because all its cytoplasm forms one continuous body;

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3. a. both have a cell wall;

both have spines protruding from their cell wall;

both have chloroplasts;

eight or more cells together in *B. brebissonii* but only two in *S. senarium*;

double flowerpot shape in *B. brebissonii* whereas *S. senarium* has a double muffin shape;

b. 6.0–6.5 μm diameter;

c. digesting *Chlorella* provides a source of nutrition;

allows nutrients from *Chlorella* to be absorbed into the cytoplasm;

nutrients needed for growth/energy supply;

not digesting allows oxygen produced by photosynthesis in *Chlorella* to be used by the ciliated protozoan;

allows *Chlorella* to go on producing food by photosynthesis;

could result in the evolution of a chloroplast;

Page 86 Data-based questions: Marine viruses

1. values for the two variables are directly proportional so would form a straight line when plotted on a graph;

2. a. as one variable increases, the other variable tends to increase;

b. as one variable increases, the other variable tends to decrease;

3. a. viruses/bacteriophages can increase/multiply when there are more bacteria to use as hosts;

b. higher chlorophyll *a* indicates more algae which viruses can use as hosts;

c. higher salinity might reduce the numbers of potential hosts;

higher salinity in winter when there is less rainfall/fewer bacterial hosts/fewer algal hosts;

4. correlation does not indicate causation;

difficult to know whether a correlation is due to cause or to co-correlation with another variable;

5. 40%;

Page 90 Data-based questions: Progression in HIV infection

1. initial rapid decrease over 6 weeks;

slight increase from 6 to 12 weeks;

slow decrease over the next 10 years;

reaching zero CD4 T cells at 10–11 years;

2. same concentration until year 8;

in typical progressors the levels of HIV increases to 950 at 11 years, whereas in the long-term survivors the levels remain at 460 between years 8 to 11;

3. a. 8–9 years; **b.** 2–3 years;

4. different levels of nutrition/general health;

differences in the immune system/differences in CD4 T cells;

differences in CD4 T cell membrane receptors;

different medication;

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Page 90 Data-based questions: COVID-19

1. 30 000;

2. ORF1/1a;

because it is the longest;

3. most closely related to Bat CoV RaTG13;

because Bat CoV RaTG13's nucleotide identity is closest to 100% indicating fewest base differences;

4. very similar to SARS-CoV BJ01;

similar to Bat CoV ZC45 from nucleotide 12 000 to 23 000;

least similar to Bat CoV RaTG13;

5. **a.** least similar in gene S;

b. the spike protein is used as an antigen by the immune system so there may be more selective pressure for it to change;

Page 94 End of chapter questions

1. **a.** **i.** eukaryotic as it has a nucleus

ii. root tip as rectangular shape formed by cell wall

b. **i.** width of image is measured at 3.8 cm.

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

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

$$\frac{38000\ \mu\text{m}}{2500} = 15.2\ \mu\text{m}$$

ii. image size = magnification × actual size

image size = $2500 \times 5 \times 10^{-3}$ mm = 12.5 mm

2. **a.** C–nucleus; D–starch granule; G–chloroplast; H– Golgi apparatus

b. positive phototaxis;

light needed for photosynthesis;

move to light allows for greater carbohydrate production;

c. maintains solute concentration;

when cytoplasm becomes too dilute, pumps out excess water

d. **i.** in high concentration of carbon dioxide there is little to no difference in carbohydrate production;

in low concentration of carbon dioxide, mutant cells produce no carbohydrate and appear to use carbon dioxide;

suggests that the pyrenoid functions to capture/store carbon dioxide for use in photosynthesis;

ii. carbon dioxide is a raw material for photosynthesis;

iii. it is fixed to RuBP to form an unstable six carbon intermediate

e. glucose has an osmotic effect, it draws water;

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starch does not have an osmotic effect so advantage of starch storage is that it is a form of carbohydrate storage that doesn't disrupt osmotic balance;

f. error bars signify the variability of the data;

the data for the normal cells is more variable than the mutant cells;

the size of the error bars for normal cells suggests that there is no significant difference between the different types of cells

g. there are two independent variables: level of CO_2 and mutant or normal pyrenoid;

the dependent variable is percent change in chlorophyll (an indirect measure of photosynthetic activity);

3. a. Advantages of multicellular organisms:

cell specialization / systems;

can grow to a larger size;

more efficient use of resources;

longer life span;

Advantages of single celled organisms:

small size;

less need for regulation / control systems;

faster reproduction;

b. Quantitative:

the rotifer's body is approximately 1.5 × 122 μm long;

the width of the rotifer body is approximately 4 times wider than the stalk;

Qualitative: structures within the spirogyra appear to be coiled;

within the transparent shell of the spirogyra, there is an alternating pattern of green matter and transparent space;

c. 1.8×10^{-4} m

d. the spirogyra cells appear to be much larger and more elongated;

it is difficult to distinguish individual rotifer cells;

e. $\frac{\text{image size}}{\text{actual size}} = \text{magnification}$

$\frac{22000\ \mu\text{m}}{122\ \mu\text{m}} = 180\times$

Thus, probably a combination of the 10× ocular and the 40× objective.

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Topic A3 – Organisms

Page 102 Data-based questions: Differences in chromosome number

1. 13 is an odd number/none of the species has an odd number of chromosomes;
   all species have a diploid number of chromosomes which is an even number;
   organisms produced by fusion of male and female gametes have two sets of chromosomes;
2. hypothesis supported by insects having fewer chromosomes than mammals;
   hypothesis not supported by chromosome numbers among mammals;
   for example, dogs have more chromosomes than humans;
   hypothesis not supported among plants as no clear trend;
3. chromosomes vary in size;
4. reduction from 48 to 46;
   as chimpanzee is our closest relative and has 48 chromosomes;

Page 103 Data-based questions: Primate chromosome numbers

1. banding pattern of the long arm of chimp 13 is very similar to (much of) the long arm of human 2;
   long arm of chimp 12 and short arm of human 2 have the same banding pattern;
   some bands on the short arm of chimp 13 are missing from human 2;
   centromere from chimp 13 is missing from human 2;
2. either telomere from chimp chromosomes deleted;
   or non-functional telomeres still present;
   or numbers of repeats reduced;
3. centromere from chimp chromosome 12 has become the centromere of human chromosome 2;
   centromere from chimp 13 remains in part as a remnant on human 2;
4. evidence is strong;
   considerable similarity in banding/sequences;
   very unlikely to be due to chance;
   banding patterns from chimp chromosome 12 and 13 both found on human 2;
   remnant of a second centromere is further evidence;

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Page 107 Data-based questions: Genome sizes

1. positive correlation;

number of protein-coding genes increases as genome size increases;

2. **a.** straight line increase

b. fewer protein-coding genes in larger genomes than if directly proportional;
more DNA that does not code for proteins in larger genomes;

3. **a.** R^2 is the coefficient of determination;

b. the high value shows that the data points fit the trend line closely;

most of the variation in the number of protein-coding genes is predictable from genome size;

4. **a.** 1000

b. 10 000 kbp; = 10 000 000 base pairs

Page 113 Data-based questions: Chromosome numbers in *Sphagnum* mosses

1. the mass of DNA is similar between the varieties;

except for *S. arcticum* and *S. olafii;*

2. they are descended from a common ancestor;

which had 19 chromosomes;

3. **a.** 2*n*/38 chromosomes;

because they have double the mass;

the 2*n* chromosome number is 38;

b. more resources required to create a new cell;

4. mosses have alternation of generations in their life cycle;

the gametophyte is dominant and is haploid;

Page 126 Data-based questions: Origins of turtles and lizards

1. they are more closely related to the short-tailed opossum;

because there are fewer differences;

2. 6 + 3; = 9;

3. the evidence suggests that painted turtles and lizards are a clade;

only four differences in their microRNA genes;

more closely related to each other than to alligators / some other reptiles;

they share a clade that excludes birds and mammals;

4. alligators are classified conventionally as reptiles;

but this evidence suggests they are more closely related to birds than some other reptiles;

suggests that birds and reptiles are not separate clades / should not be classified separately:

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Page 128 Data-based questions: Mustelid classification

1. position where there is branching on the cladogram;

point at which a common ancestral species split to form two or more clades

2. time elapsed since the species diverged;

idea of the molecular clock;

3. **a.** should be moved to a different genus according to this data;

separated from all other species of *Martes* by node 35 whereas the other species separate at node 37;

Gulo gulo is more similar than *Martes pennanti* to the other species of *Martes*;

b. should be subdivided into smaller groups;

differences within the larger Mustelinae group are greater than between that group and the Lutrinae;

splits between groups within the larger Mustelinae group happened before splits with the Lutrinae;

c. should not be included in the Mustelidae family;

much greater differences between *B. astutus*/*P. lotor* and the Mustelidae than within the Mustelidae;

branched off/last common ancestor longer ago;

Page 130 Data-based questions: Similarities and differences in microbial cell wall structure

1. all have double layer/bilayer of phospholipids;

all have proteins/mosaic of proteins;

2. all contain polymers of N-acetylglucosamine;

all have 1–4 bonding of monomers;

3. V–Y have polymers of N-acetylmuramic acid whereas Z does not;

V–Y have cross-links/1–6 links between N-acetylglucosamine polymers and N-acetylmuramic acid whereas Z does not;

4. **a.** outer membrane only in V;

outer layer of lipopolysaccharide only in V;

layer of N-acetylmuramic acid and N-acetylglucosamine is thinnest in V / thickest in W, X and Y / thickest in W;

only W has D-alanine/glycerol phosphate/N-acetylmannosamine;

only X and Y have arabinose/arabinogalactan/mannose-arabinose polymers/phospholipids as an outer surface;

b. first branch to Z; second branch to V; third branch to W; node with branches to X and Y

5. Z is fungi because the cell wall contains only N-acetylglucosamine so is chitin whereas V–Y have peptidoglycan walls which also contain N-muramic acid;

[For reference: V is Gram negative bacteria, W–Y are Gram negative bacteria (W is *Staphylococcus*, X is *Corynebacterium*, Y is *Mycobacterium*) and Z is fungi.]

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Page 134 End of chapter questions

1. a. Model C shows gorillas and chimps being more closely related and they both have the same number of chromosomes.

b. The myoglobin evidence suggests a closer relationship between chimps and gorillas, which is model C. However, the hemoglobin model suggests a closer relationship between chimps and humans.

c. Chimps would have gorilla-like teeth unlike humans.

d. tough bark and plant tissues such as lignified xylem with tough cells walls need to be ground by chewing;

muscle tissue contains animal cells which do not have tough cell walls;

e. humans have 2N = 46 whereas chimps and gorillas have 2N = 48;

human chromosome 2 appears to be a fusion of two shorter chromosomes;

there are telomeric sequences in the centre of chromosome 2;

the sequences of chimp chromosome 12 and 13 are similar to the sequences found on chromosome 2;

fusion of the two q arms / head-to-head arrangement;

Topic A4 – Ecosystems

Page 140 Data-based questions

1. cladistic analysis;

maximum parsimony / how all sequence differences can be accounted for with the fewest base changes;

2. more differences between e and v;

accumulation of sequence differences over time;

3. multiple species give more evidence for base sequences of P and Q / the common ancestor;

multiple proteins allow the analysis to be repeated/replicated/checked;

4. chance is one in 10^{80} which is 1×10^{-80}; which is a very small chance (but more than 10^{50} times larger than 1×10^{-132});

5. 1×10^{-132} is not zero chance / there is still a chance that the observed differences were due to another cause;

but it is an extremely small chance;

so 'beyond reasonable doubt' is an appropriate name;

Page 147 Data-based questions: Flightless steamer ducks

1. migration to / from Malvinas/Falklands during GPG / when sea levels were low;

separation of populations when sea levels rose;

2. no: do not interbreed;

ranges do not overlap;

flightless so cannot travel far;

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3. common ancestor's range was divided up by ice during the glaciation;

   separated populations did not interbreed;

   differential selection so traits diverged;

4. might interbreed on the coast / where ranges overlap;

   no interbreeding on inland lakes as flightless ducks do not occur there / flightless steamer ducks unable to reach inland lakes;

   lakes formed after the last glaciation;

5. might diverge because only flying ducks breed on inland lakes;

   reproductive isolation could lead to speciation;

   depends on differential selection between coastal and inland populations;

   might not diverge if there is interbreeding between flightless and flying ducks on the coast;

Page 166 Data-based questions: Satellite monitoring

1. 6 × 3.5 km;

   = 21 km^2;

2. forest at 900, 110;

   plowed land at 910, 116;

3. Part of Quatero forest;

   light green in wet season and light brown in dry season;

   no evidence of plowing;

   no evidence of burning; probably grassland;

   probably grazed by livestock;

4. on sloping ground;

   too steep to plough / less accessible to livestock;

   in river valleys;

   dark green areas in the same pattern as river systems;

5. **a.** areas coloured dark brown; 881, 111 / other example;

   smoke; 886, 113 / other example;

   b. 5%

6. provides data for the government;

   provides objective data;

   quick and easy to identify areas of burning / plowing;

   allows changes in land use to be detected;

   allows violations of land use regulations to be detected;

   discourages illegal burning or plowing;

   allows natural habitats to be protected;

   provides data for scientific research;

   useful for investigating climate change;

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Page 168 Data-based questions: Human population increases

1. **a.** 1980–1990;

   b. 1960–1970;

2. **a.** 1974;

   b. 2023;

3. **a.** 127 years;

   b. 47 years;

   c. 49 years;

4. **a.** slower from 1700 to 1900;

   then accelerating up to 1968;

   lower % increases after that but huge absolute increases;

   not possible to say objectively if the increases are rapid;

   b. exponential only if population doubles repeatedly over a fixed time;

   this happened as the population rose from 2 to 4 billion and from 4 to 8 billion;

   but not exponential before or after this;

5. about 11 billion based on the graph forecasts;

   might be lower if climate change / pandemics / other harmful processes reduce birth rates;

   might be higher if birth rates remain high because of nationalism / religious teaching / economic forces;

Page 175 End of chapter questions

1. **a.** Note that a comparison requires identification of similarities. In both cases, there was a change in the number of families.

   b. while the number of immigrant families increased, the total number of all families combined declined;

   the immigrant families might have led to the extinction of a species that was the only member of its family;

   c. 9 million years ago, there were 70 genera; presently there are 170 genera;

   this represents a 143% increase in the number of genera;

   d. the total number of families went down but the number of genera went up;

   this may be due to diversification within a family;

   an immigrant family might have started with ancestral species that eventually spread to different niches in a process of adaptive radiation;

   e. the data could be based on fossil evidence;

   f. the competitive exclusion principle refers to interspecific competition ;

   no two species can occupy the same niche in the same location at the same time;

   one will be driven to extinction or a narrower niche;

   immigrant families must have occupied similar niches to native families;

   the lack of predation of non-native species gave them a competitive advantage;

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g. marsupial gestation occurs outside the uterus;

internal organs protect the developing embryo in placental mammals;

less resources are put into developing the early embryo and eggs in placental mammals;

h. a single species from an immigrant family might have started with an ancestral species;

descendants of this ancestor spread out into different habitats;

that favoured different adaptations;

reproductive isolation led to speciation;

and descendents occupying different niches;

2. a. with trout: 4 (allow a range of 3.5–4.0)

without trout: 700 (allow a range of 690–710

b. more tadpoles/frogs without trout / vice versa;

trout decrease tadpole numbers more than frog numbers / vice versa;

c. tadpoles / frogs are eaten by trout;

trout could catch/eat more tadpoles than frogs (as frogs not fully aquatic);

trout could introduce diseases/change breeding sites that affect frogs and tadpoles;

d. this may not lead to a permanent recovery since in Upper LeConte Lake numbers are decreasing after 2004;

because tadpoles/frogs can migrate from Upper to Lower LeConte as there are no barriers / reinvasion of trout from streams / other valid reason;

removal of trout causes an exponential increase in frogs;

e. Could use the Lincoln Index / capture-mark-release-recapture method;

capture a sample of frogs and mark them;

release them;

do a second capture and the percentage that are marked allows for a calculation of the total population size based on the number marked in the first capture;

3. a 200 m

b. an indicator species is one that is only present under certain conditions;

the appearance of disturbance adapted beetles indicates that there is a disturbance;

c. reserve designers should seek to minimize the edges of a reserve;

by having connecting corridors;

by maximizing reserve size;

by designing circular shaped reserves which maximize internal area: surface area ratio;

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