Answers

CHAPTER 1
Cell
Data-based questions
page 13

1 a Magnification = size of image / actual size of the specimen
Size of the image (scale bar) = 20 mm
Actual size = 0.2 mm
Magnification 20 / 0.2 = 100 ×

b Width of thiomargarita in the image (image size) = 26 mm
magnification = 100 ×
actual size = 26/100 = 0.26 mm

2 a Magnification = length mitochondrion in the image (63 mm) / actual size of the specimen (8 µm / 0.008 mm)
= 63 / 0.008
= × 7875

b Scale bar 5 µm × 7875 = 39 375 µm (approx 40 mm)

c Width on the image 23 mm / magnification 7875 = 0.0029 mm (2.9 µm)

3 a 20 µm × 2000 (magnification) = 40,000 µm (or 40 mm scale bar)

b Actual size of specimen 34 mm / 2000 × 0.017 mm

4 a Hens egg is 16 mm in diagram. Ostrich egg is 46 mm long in diagram. Real hen egg is about 50 mm wide.
Ostrich egg (50 × 46) / 16 = 144 mm approx

b Magnification = size image / actual size of the specimen
Hens egg: Magnification 16 mm / 50 mm × 0.32

Data-based question: size and surface area of small mammals
page 14

1 Diameter is half radius
For egg cell 4(3.14) (50m)² = 3.14 × 10⁻⁹ m²
For white blood cell = 3.14 × 10⁻¹⁰ m²
For Streptococcus pneumoniae = 3.14 × 10⁻¹¹ m²

2 For egg cell \(\frac{4 \times (3.14) \times (50 \text{ µm})^3}{3} = 5.23 \times 10^{-13} \text{ m}^3\)
For white blood cell = 5.23 × 10⁻¹⁶ m³
For Streptococcus pneumoniae = 5.23 × 10⁻¹⁹ m³

3 For egg cell \(6 \times 10^3 \text{ m}^{-1}\)
For white blood cell \(6 \times 10^3 \text{ m}^{-1}\)
For Streptococcus pneumoniae \(6 \times 10^7 \text{ m}^{-1}\)

4 As the diameter decreases, surface area to volume ratio increases.

5 a Advantages include a more efficient release of waste products of metabolism and more efficient uptake of the raw materials required for metabolism.

b Reasons could include: large size should trigger cell division; cells could not survive because metabolism could not be carried out efficiently.

CHAPTER 2
Membranes
Data-based question: diffusion of proteins in membranes
page 27

1 a The membrane proteins can move within the bilayer; the movement is indifferent of species; the movement is random.

b ATP is required for active transport; the movement of membrane proteins is passive/ it does not require ATP/energy.

c The mixing is not caused by the breaking down and reassembly of the markers since re-assembly was made impossible.

2 a The movement of markers increases with temperature, because the molecules move faster with higher temperatures. Then it levels off.

b At lower temperatures the membrane proteins hardly move, therefore the markers are hardly mixed.

3 A rise in marker movement can be expected at lower incubation temperatures. Since these animals are adapted to a colder environment.

Data-based questions: patch clamp analysis
page 31

1 a 0 pA

b Pico = 10⁻¹² therefore 1 × 10⁻¹² picoamps in an Amp

2 a Gap length = 2 mm
Scale bar 1 mm = 20 ms
Time open 2 × 20 ms = 40 m
b – 4 pA

3 The motor neuron synapse.

4 a The ACh binds to the receptor opening the ion channel. Higher concentrations of ACh remain in the receptor region and open the channel again and again.
b  ACh opens the channel in an ‘all or none’ response: the period of time the channel is open is dictated by another mechanism; the concentration of ACh required to open the channel at a set level; there are no degrees of ‘opening’ of the channel, this is an ‘all open’ or ‘all closed’ mechanism. Therefore the excess concentrations of ACh remain within the region of the channel opening it again.

5 a  When both channels are closed the current flow is 0pA. When the channel is open the current flowing is at a maximum of -12pA. The open channel shows variation in the current flowing when it is open. Channels remain open for longer.

b  Reasons for the differences between the two traces:
- The membranes contain different types of channel.
- Membrane receptors are different in for ACh and glycine.
- The spinal neuron channel response is stronger than for the muscle.

Data-based question: albumin in the blood, page 32

1 a  The control has most blood plasma albumin concentration which is around 37%. With marasmus the blood albumin plasma levels drop to approx 28%. In kwashiorkor shows the blood plasma albumin is lower still at 15%.

b  Less albumin (protein) is absorbed into the bloodstream when a person has a poor protein diet, as is the case with marasmus and kwashiorkor. The latter is a specific lack of dietary protein, which therefore results in less albumin (protein) being absorbed into the blood;

2 Albumin is a soluble molecule which has an electrostatic attraction for water molecules. These water molecules bond to the albumin thereby creating a region of effectively lower water concentration. Water will tend to move towards this region of lower water concentration (blood plasma) from regions of higher water concentration (gut).

3 The children most at risk are those with the lowest blood plasma albumin levels. Children with kwashiorkor have the lowest albumin levels (15%) and therefore the lowest re-absorption of blood into the plasma. These children will develop oedema since the fluids will remain within the tissues.

Data-based question: osmosis in plant tissues, page 33

1 a  Water moved into the tissues (all show increases in mass due to water uptake).

b  Water moved into the pine kernel (mass increase) but moved out of the other three tissues that all show a decrease in mass.

2 Cactus – when bathed in a solution with only 0.1 mol dm$^{-3}$ salt it starts to lose mass, therefore the solute concentration of cactus must be lower than that.

3 a  Cactus is adapted to arid conditions (xerophytes) and has stored water in its tissues resulting in a low solute potential. The butternut squash and sweet potato show intermediate mass changes suggesting they are mesophytes with higher solute potential in their tissues. The pine kernel has a high solute potential in its tissue as an adaption to allow maximum water uptake in brief periods of exposure to water or due to the accumulation of solute in the cytoplasm to lower freezing points.

4 Reasons for using percentage mass change rather than the actual mass change in this type of experiment:
- different tissues may have different densities
- the initial mass of tissue used in the experiment may be different
- percentage change is a way to standardize the comparison.

Data-based question: phosphate absorption in barley roots, page 35

1 Below 21% to 2.1% $O_2$ there is a slight reduction in phosphate absorption. There is a significant reduction in phosphate absorption below 0.9 umol g$^{-1}$ h$^{-1}$

2 Answer to refer to:
- Root cells generate an electronegative charge through the secretion of $H^+$. Root cell accumulate phosphates ions within the cytoplasm of the root cells. Phosphates need to be absorbed against and electronegative concentration gradient. Phosphate is absorbed by active transport.

3 Answer should refer to:
- Phosphate is mainly absorbed by active transport. The graph shows a reduction in phosphate active membrane transport as the concentration of DNP is increased up to 6 umol g$^{-1}$ h$^{-1}$
• As the concentration of DNP increases there is a reduction in ATP synthesis.
• With no or reduced ATP available the active transport mechanism in the membrane stop functioning.
• There is some phosphate absorption even above 6 umol g\(^{-1}\) h\(^{-1}\) which will be due to the uptake of minerals in the mass flow of water through the apoplastic pathway.

Data-based questions: autoradiography
page 36
1 a In the rough endoplasmic reticulum (86.3%).
   b The rER is the site of protein synthesis; amino acids are the raw material of protein synthesis;
2 Answer should refer to:
   • After synthesis in the rER, vesicles transport the proteins to the Golgi apparatus.
   • This can be derived from the data, which shows that the highest percentage of autoradiographic grains after 7 minutes is in the vesicles and after that in the Golgi apparatus.
3 Answer should refer to:
   • Most proteins are synthesized within 7 minutes and then moved to the large storage vesicles within 117 minutes.
   • Minimum time is between 37 minutes and 117 minutes.
   • Only small level at 117 minutes so on average perhaps a little longer than 117 minutes.
   • No data between 37 and 117 minutes.
4 The proteins are not released in large quantities/ regulation of the quantity released or flow rate prevents build-up.

CHAPTER 4
Chemicals of life
Data-based question: elemental composition of living organisms
page 44
1 Hydrogen, oxygen, carbon.
2 a Nitrogen and calcium.
   b Potassium and calcium.
3 a Chara 22 mg g\(^{-1}\) and Canis 82 mg g\(^{-1}\)
   \[
   \frac{(82 - 22)}{22} \times 100\% = 272\% \text{ higher nitrogen content in Canis}
   \]
   b Answer should refer to:
      • Canis has a skeletal-muscular system which is protein based.
      • More proteins and amino acids in Canis.
4 Answer should refer to:
   • Canis has higher nitrogen/phosphorous/calcium.
   • Chara has higher Mg/K.
   • Higher mass of elements per g dry matter in Canis.
   • Na/S levels similar in both.
   • Mn insignificant in Canis/Cl insignificant in Chara.

Data-based question: Emperor penguins
page 50
1 a i) wild birds 13.3 kg
   ii) captive birds 16.2 kg
   b Both groups lose most of their lipid; captive birds lose more of their lipids than wild ones; 11.2 versus 9.6 kg/93% lost versus 81%/other valid figures comparing the change.
   c Insulation/source of waste heat when metabolized/source of metabolic water.

CHAPTER 5
DNA structure and replication
Data-based question: Chargaff’s data
page 58
1 The quantities of the four bases are reasonably similar across all of the eukaryotes:
   • The relative quantities of bases in Mycobacterium are distinct from eukaryotes.
   • Mycobacterium has less adenine and thymine but more guanine and cytosine.
   • The amount of adenine approximately equal to the amount of thymine in both.
   • The amount of guanine is approximately equal to the amount of cytosine in both groups.
2 1.00 in both cases.
Within experimental error the data supports the hypothesis.

Complementary base pairing between A and T would mean that they would need to be present in equal quantities – same argument for C and G.

Polio virus may be single stranded/may be RNA virus; (need uracil data to know).

Bacteriophage T2 may be double stranded.

**Data-based question: the Meselson-Stahl experiment**

**Page 63**

- A DNA molecule composed of only N-14 should have a peak at 1.710.
- After one generation grown in N-14, there was no peak at 1.710.
- Therefore replication is not conservative.
- If dispersive, no matter how many generations, all molecules would have same ratio of N-14 to N-15.
- Not dispersive as there would always be only one peak and second generation grown in N-14 has two peaks.

**Data-based question: evidence for discontinuous synthesis**

**Page 64**

1 Answer to refer to:
   - More radioactive fragments of all sizes at 30 seconds.
   - Increase in ratio of larger fragments to smaller fragments at 30 seconds/2 peaks at 30 seconds versus one peak at 10 seconds.

2 Answer to refer to:
   - Two peaks suggests two different sizes of molecules predominate.
   - Higher peak represents large number of small fragments/lagging strands.
   - Smaller peak represents a number of longer fragments/leading strands.

3 Answer to refer to:
   - If lagging strands are joined together by DNA ligase, then the number of initial small molecules would decrease and the number of larger molecules would increase. This is what is observed so the hypothesis is supported.

**CHAPTER 6**

**Transcription and translation**

**Data-based questions: DNA and RNA structure**

**Page 67**

1 Answer should refer to:
   - The sugars are different (ribose v. deoxyribose).
   - RNA contains uracil while DNA contains thymine.

2 DNA is doubles stranded while RNA is single stranded.

<table>
<thead>
<tr>
<th>DNA</th>
<th>RNA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Double stranded</td>
<td>Single stranded</td>
</tr>
<tr>
<td>Contains deoxyribose</td>
<td>Contains ribose</td>
</tr>
<tr>
<td>Contains thymine</td>
<td>Contains uracil</td>
</tr>
</tbody>
</table>

4 Answer should refer to:
   - Both are polymers of nucleotides/nucleic acids.
   - They both have the bases adenine, cytosine and guanine.
   - The sugar in both is a pentose.
   - Both have a backbone of phosphate-sugar-phosphate.

**Data-based questions: exons and species complexity**

**Page 69**

1 95%

2 5 (15% of genes)

3 Answer should refer to:
   - Data deals with exons only.
   - Does not provide details about other non-coding sequences.
   - Number of exons does scale with size of organism if we define complexity in this way.
   - Number of exons does scale with number of cells in organism if we define complexity in this way.

**Data-based questions: interpreting electron micrograph**

**Page 73**

Left picture: translation (polysomes are visible)
Middle picture: replication (replication bubble is shown)
Right picture: transcription (literally coupled with translation)

**CHAPTER 7**

**Enzymes**

**Data-analysis questions: biosynthesis of glycogen**

**Page 81**

1 One enzyme catalyzes the formation of 1”4 bonds; the other enzyme catalyzes the formation of 1”6 bonds.
2. Once the 1→6 bond is formed, then this starts a new chain that can be extended by the enzyme that makes 1→4 bonds; in other words the substrate for this enzyme is doubled.

3. Answer should refer to:
   - Heat-treatment denatures enzyme.
   - Curve A shows no enzyme activity/no enzyme mediated conversion.

4. a. Answer should refer to:
   - Increasing rate of conversion earlier/until 35 minutes.
   - Rate of conversion levels off.

   b. Answer should refer to:
   - Every bond formed can either be creating a new glycogen molecule or adding to an existing one.
   - The former leads to an exponential increase in number of glycogen molecules/substrate molecules.
   - Until growth in new glycogen molecules slows and available enzyme becomes limiting.

**Data-based question: the effectiveness of enzymes**

**page 84**

1. OMP decarboxylase has the slowest uncatalyzed rate.

2. OMP decarboxylase has the highest catalyzed rate.

3. Ketosteroid isomerase $3.8 \times 10^{11}$
   Nuclease $5.6 \times 10^{20}$
   OMP decarboxylase $1.4 \times 10^{24}$

4. OMP decarboxylase is the most effective as it is the slowest reaction without a catalyst and the most rapid reaction with a catalyst.

5. Answer should refer to:
   - The substrate binds to the active site of the enzyme.
   - The binding leads to a conformational change in the enzyme that strains bonds within the substrate making it more reaction.
   - Or it makes collisions between substrates more effective in terms of promoting a reaction.

**CHAPTER 8**

**Cell Respiration**

**Data-based questions: production and consumption of ATP**

**page 89**

1. a. $\text{dm}^3$
   
   b. g and kg
   
   2. a. $\frac{18.25 \text{ kg ATP}}{134.4 \text{ dm}^3} = 0.1358 \text{ kg dm}^{-3}$

**page 91**

1. (560-544) g
   
   15/16 g total mass loss divided by 13 days
   
   1.2 g per day

2. Answer should refer to:
   - Alcoholic fermentation.
   - $\text{CO}_2$ is the waste product.
   - $\text{CO}_2$ release leads to mass loss.

3. Answer should refer to:
   - Population growth of yeast/more yeast respiring.
   - Positive feedback/increasing amounts of $\text{CO}_2$ from higher population leads to lower solubility/higher rate of release.
   - Waste heat decreases $\text{CO}_2$ solubility.

4. Substrate has run out; death of yeast (from high alcohol).

**Working with data: aerobic cell respiration in yeast**

**page 94**

1. a. Answer should refer to:
   - At time zero, glucose concentration is 42 g l$^{-1}$
   - Glucose concentration falls gradually between 0 and 5 hours.
   - Sharp decline in glucose concentration between 5 and 10 hours.
   - At 10 hours, glucose concentration is close to 0 g/l.
   - As time increases, rate of uptake of glucose increases.
b Answer should refer to:
- Between zero and 5 hours, decline in glucose concentration correlates with a gradual increase in yeast population.
- After 5 hours, rate of growth of yeast increases and rate of uptake of glucose increases correspondingly.
- Between zero and ten hours, ethanol production matches yeast growth.
- At 10 hours, yeast growth slows as glucose runs out.
- After 15 hours, rate of yeast growth increases as ethanol concentration decreases.

2 Estimates based on the small graph:
   a 5 hours = 0.02A, 10 hours = 0.08A therefore yeast growth = 0.06A
   b 10 hours = 0.08A, 15 hours = 0.10A therefore yeast growth = 0.02A

3 Answer should refer to:
   - 5-10 hours represents exponential growth phase and fastest uptake of glucose.
   - 10-15 hours represents stationary phase - growth limited by space or resources (e.g. glucose availability).
   - After 10 hours, rate of growth decreases as glucose concentration decreases.

4 Answer should refer to:
   - Increasing levels of ethanol between 0 and 15 hours suggests high anaerobic activity.
   - Initial low rates of glucose consumption, suggests initial higher rates of aerobic respiration.
   - Beyond 15 hours, ethanol decreases – aerobic respiration produces water, possibly reducing ethanol concentration.
   - Absence of glucose as substrate after 10 hours would limit both kinds of respiration.

**Data-based questions: oxygen consumption by mitochondria**

**Page 97**

1 Answer should refer to:
   - Pyruvate is a substrate for aerobic respiration.
   - Pyruvate is broken down in the link reaction which will not occur in absence of oxygen.
   - Oxygen is consumed during oxidative phosphorylation which requires reduced molecules produced from pyruvate breakdown.

2 Answer should refer to:
   - ADP needed to be added so that Krebs cycle could occur.
   - As ADP is raw material for Krebs cycle.

- No Krebs cycle, no electron transport chain.
- No electron transport chain, no oxygen consumption.

3 Answer should refer to:
   - Oxygen level would not have declined any lower.
   - As no Krebs cycle would occur and therefore no electron transport chain would occur.

4 Answer should refer to:
   - All pyruvate has been used up.
   - No more Krebs cycle occurring.
   - So no oxygen consumption in the electron transport chain.
   - So ADP is no longer rate limiting.

**CHAPTER 9**

**Photosynthesis**

**Data-based questions: measuring the effect of temperature by data logging**

**Page 105**

1 Carbon dioxide produced in respiration dissolves in water lowering pH; use of carbon dioxide in photosynthesis will raise pH.

2 Independent variable is temperature and dependent variable is pH though it could be argued that time is independent and dependent is pH.

3 Time should go on the x-axis and pH on the y-axis; different temperatures could be different coloured curves.

4 Answer should refer to:
   - Changes overall are significant for all temperatures.
   - Due to uncertainty in pH sensor.
   - Differences in temperatures do not appear to lead to significant differences in end pH.
   - Cannot conclude which is the optimum temperature.
   - Though data suggests it is between 22.5 and 27.5 C.

5 Answer should refer to:
   - Differences in optimum temperature.
   - Differences in conditions required to promote optimum rates of photosynthesis.

6 Answer should refer to:
   - Changes in pH are not large.
   - Precision of pH sensor limited.
   - Temperature range is not broad enough.
   - Measurements can be taken for long.
   - Suggest using dissolved oxygen sensor or dissolved carbon dioxide sensor.
- Might have greater sensitivity.
- Could look at oxygen production.

**Data-based questions: photosynthesis rates in red light**

*Page 106*

1. With increasing wavelength there is limited effect up until about 680 nm. Then there is a significant decrease in yield as wavelength increases.
2. The supplementary light has a limited effect up to about 680 nm. It leads to a fixed rate of photosynthesis.
3. The error bars show the variability of the data. Where the error bars overlap up to 680 nm. Suggest that there is no significant difference; up to 680 nm.

\[
\frac{1 \text{ photon}}{0.125 \text{ molecules}} = 8 \text{ photons molecule}^{-1}
\]

4. Answer should refer to:
   - Eight photons produces one oxygen molecule.
   - Eight electrons are excited per oxygen molecule.
   - Eight electrons are excited per four electrons produced by photolysis.
   - So each electron must be excited twice.

**Data-based questions: Frezze-Fracture of chloroplasts**

*Page 109*

1. Multiple fracture layers are visible.
2. Intagral protons are embedded in both halves of a bilayer. The bilayer fractures down the middle, but the protons remain embedded in one half giving the studded appearance.

**Data-based questions: evidence for chemiosmosis**

*Page 110*

1. a. The higher the pH of ADP solution, the more rapid is the rate of ATP production. This is a direct relationship at lower pH but rate of increase increases with pH.
   
   b. Because the magnitude of concentration gradient between inside and outside is being increased.
2. The lower the incubation pH, the higher the yield of ATP. This also increases the magnitude of the concentration gradient/difference in concentration.
3. ATP production powered by movement of H\(^{+}\) down concentration gradient. Once movement occurs, concentration difference is lowered so less ATP production.
4. In the presence of light, photolysis occurs, which generates H\(^{+}\) and therefore affects concentration gradient.

**Data-based questions: identifying the first products of carbon fixation**

*Page 112*

1. Answer should refer to:
   - The highest amount of radioactivity was in the glycerate-3–phosphate initially and then fell with time in the glycerate-3–phosphate.
   - Suggesting that other molecules being synthesized depended on the radioactive glycerate-3–phosphate as a raw material.

2. Answer should refer to:
   - As concentration of glycerate-3–phosphate falls with time.
   - Concentration of triose phosphate rises.
   - Suggesting glycerate-3–phosphate is a raw material for triose phosphate production.

**Data-based questions: the effect of light and dark on carbon dioxide fixation**

*Page 113*

1. The dark period causes the concentration of glycerate 3-phosphate to rise. The dark period causes the concentration of ribulose bisphosphate to fall.

2. a. Answer should refer to:
   - In the light reactions energy for Calvin cycle is produced.
   - In the dark, RuBP is converted to glycerate-3–phosphate.
   - Glycerate-3–phosphate cannot be converted to RuBP.
   - Some of the glycerate-3–phosphate is converted to carbohydrate.

3. RuBP concentration would rise and glycerate-3–phosphate levels would fall.

4. a. Lower concentration of glycerate-3–phosphate.
   
   b. Lower concentration of RuBP.

**Data-based questions: plant cell ultrastructure**

*Page 114*

1. Features as follows:
   - I cell wall
   - II cytoplasm
   - III plasma membrane
   - IV nuclear membrane
   - V nucleus
   - VI nucleolus
   - VII chloroplast membrane
   - VIII thylakoid/granum
   - IX ribosome
   - X lamellar membrane
   - XI starch granul
2 Presence of starch granule; suggests that it has been in the light.

3 Golgi body; mitochondria; vacuole.

**Data-based questions: photosynthesis in Zea mays**

**page 115**

2 Bundle sheath chloroplasts are larger; bundle sheath chloroplasts lack grana; bundle sheath chloroplasts have more starch granules; mesophyll chloroplasts have more higher density of thylakoid membrane.

3 a Mesophyll chloroplast because of higher density of thylakoid membrane.

b Bundle sheath chloroplasts because of the presence of the starch granules.

c Mesophyll because of the higher density of thylakoid membrane.

**CHAPTER 10**

**Plant science**

**Data-based questions: comparing stem structure**

**page 118**

1 This is a diagram of a tissue not cells. Structures named are not cell organelles different tissue types.

2 Answer should to refer to:
   - Both have an epidermis.
   - Both have vascular bundles.
   - Both have a cortex tissue.
   - Both have xylem and phloem.

3 Phloem is positioned outside the xylem relative to the stem epidermis. The phloem is oriented toward the outside and the xylem is oriented toward the inside.

4 Answer should to refer to:
   - Monocots do not possess a cambium in between the phloem and xylem.
   - The cambium is a lateral meristem, which creates secondary xylem growth, adding to the thickness of the wood of the stem.

**Data-based questions: fungal hyphae and mineral ion absorption**

**page 122**

1 a Answer should to refer to:
   - Addition of the fungus has an effect on shoot dry mass and root dry mass which has a greater effect on shoot dry mass.
   - Different species have different effects.
   - Paxillii has the greatest effect.
   - Pisolithus has least effect.

b Answer should to refer to:
   - Increases surface area of roots.
   - Allowing greater mineral absorption and greater water absorption;
   - Promoting plant growth.

2 a As root dry mass increases, shoot dry mass also increases – the relationship is direct.

b More roots can support greater shoot mass.

2 The two species of Laccaria and the two species of Thelophora all have a significant effect. Conclusion is supported by Thelophora less so by Laccaria.

**Data-based questions: the Renner experiment**

**page 127**

1 The rate of water uptake decreases 17 cm$^3$ hr$^{-1}$ to 0.

2 Cutting the top of the shoot resulted in a decrease from 10 cm$^3$ hr$^{-1}$ to 4 cm$^3$ hr$^{-1}$

3 10 cm$^3$ hr$^{-1}$ to 5 cm$^3$ hr$^{-1}$ to = 5 cm$^3$ hr$^{-1}$

4 The pressure generated in the xylem by the leaves on the shoot resulted in a greater uptake of water than that of the vacuum (18 cm$^3$ hr$^{-1}$ vs 5 cm$^3$ hr$^{-1}$).

**Data-based questions: water permeance of waxy cuticle**

**page 128**

1 As temperature increases, permeance also increases. At higher temperatures, rate of increase of permeance increases. Liriodendron shows this relationship in particular.

2 Increases in permeance means more water loss. The plant will need an alternative strategy for preserving water.

3 a 1.3 um

b 1.7 um

4 Data is highly variable and the highest permeance values are at lower thicknesses. Data does not support the hypothesis;

**Data-based questions: fire and seed dormancy in a plant of the chaparral**

**page 129**

1 0.5 μm

2 The dye appears only on the outside of the cuticle. It was able to penetrate through the testa but was not able to reach through to the embryo.

3 a In the control seed, the stain is only on the surface of the cuticle. In the smoke treated seed, the stain has penetrated further (nearly to the embryo).

b Answer should to refer to:
   - Fire damages/melts cuticle.
   - Allowing water to penetrate and promote germination.
• In the absence of fire seeds do not germinate because of the cuticle.

4 a In climax ecosystem the plant can’t compete – *Emmenanthe* is a colonizer species. After fire, more nutrients and more light are available.

**Data-based questions: sowing times for soybeans**

page 132

1 Answer should refer to:

• For all planting dates there is an initial low rate of increase in the number of nodes.

• A linear increase in the number of nodes.

• All groups produce nodes at the same rate/slope of lines are approximately equal.

• All plants stop producing new nodes at the same time.

• The earliest plantings produce the greatest number of nodes.

2 a Approximately 20 August.

b Day length is a key factor; day (light) length grows shorter in late August; critical day length reached/soybeans are short day plants.

3 Earlier planting yields more nodes; by flowering time more fruits produced per plant.

4 Possible frost risk; possible drought risk; early flowering if day length is critical length early in season.

**CHAPTER 11**

**Meiosis**

**Data-based questions: life cycles**

page 134

1 Similarities between the life cycle of a moss and of a human include:

• Both have haploid sperm and egg.

• Both have an ‘n’ stage.

• Both have a ‘2n’ stage.

• Both have mitosis, meiosis and fertilization.

• Both have a zygote stage.

2 Answer should refer to:

• In humans the zygote gives rise to either male or female in individuals but in moss, the zygote gives rise to sporophyte.

• In moss sporophyte gives rise to spores whereas diploid human gives rise to gametes.

• Eggs and sperm created by mitosis in moss but meiosis in humans.

• Moss plant can give rise to male or female, but separate genders create gametes in humans.

• In moss, there is a gametophyte and a sporophyte but we don’t have this in humans.

**Data-based questions: bog moss chromosomes**

page 136

1 Except for *S. arcticum* and *S. olafii*, the mass of DNA is similar between the varieties;

2 The ancestral species had 19 chromosomes; they are descended from a common ancestor.

3 a Answer should refer to:

• Because they have double the mass.

• The 2n chromosome number is 38.

• A leaf cell will be 2n/will have 38 chromosomes.

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 a haploid.

**Data-based questions: risk of chromosomal abnormalities with advancing age of the parent**

page 137

1 Limited change in incidence until mid-30s; exponential increase after mid-30s;

2 a 1% +/− 0.5%;

b 1.7−1.0; 0.7%

3 Answer should refer to:

• Overall incidence of abnormalities is low to begin with.

• Many types lead to spontaneous abortion.

• Some abnormalities may be present in live birth and be undetected if symptoms are mild.

• May be a number of different types of trisomy 21.

4 Answer should refer to:

• Data doesn’t discuss risk of advanced age of father.

• Before age of 40, risk of non-disjunction is still relatively small.

• Other possible complications besides chromosomal abnormalities.

• Risk might be balanced by other benefits of postponed parenthood.

**Data-based questions: a human karyotype**

page 138

1 a i) Chromosome 5 is longer; the banding pattern differs.

ii) Chromosome 17 is longer; the banding pattern differs.

iii) The X chromosome is significantly longer.

2 Female.

3 The karyotype does not seem to indicate an abnormality.
Data-based questions: coat colour in the house mouse
page 145
1 198 grey: 72 albino; 2.75 grey: 1 albino;
2 Albino is recessive; the presence of the albino
is masked by the grey allele; in a cross of
heterozygotes, approximately 25% are albino.
3 GG grey
   GG homozygous dominant;
   Gg heterozygous
   gg albino
   gg homozygous recessive
4 Answer should refer to:
   • The parental phenotypes are grey and albino.
   • The parental genotypes are GG and gg.
   • The alleles in the gametes are G and g.
   • The hybrid phenotype is grey.
   • The hybrid genotype is Gg.

<table>
<thead>
<tr>
<th></th>
<th>G</th>
<th>g</th>
</tr>
</thead>
<tbody>
<tr>
<td>G</td>
<td>GG</td>
<td>Gg</td>
</tr>
<tr>
<td>g</td>
<td>Gg</td>
<td>gg</td>
</tr>
</tbody>
</table>

5 White fur and red eyes can be due to lack of
pigment being produced; due to mutation in single
gene for a protein in the pigment production
pathway.

Data-based questions: deducing genotypes from pedigree charts
page 146
1 It is recessive as unaffected parents in generation I
   produce affected children.
2 a 100% that they will be homozygous recessive.
   b 0%
   c 0%
3 a Dd; the mother is dd.
   b Dd or DD; most likely DD as condition is rare
   and person is marrying into family with history
   of disease.
4 II-4 + II-5
   II-11 + II-12
   II-7 + II-8

Data-based questions: the two-spot ladybird
page 147
1 Both typica and annulata have black and red
colouration; annulata has more black pigmentation.
2 In both cases, they are pure breeding strains.
3 All F1 hybrids have more black pigmentation than
   typica and less than annulata.
4 TA × TA; ¼ TT (typica) ½ TA (hybrid) ¼ AA
   (annulata)

Data-based questions: distribution of ABO
blood groups
page 148
1 a 25–30%
   b 20–25%
   c 5–10%
2 Iₐ is 5–10% from the map; i is 5% from data;
   therefore Iₐ is between 85% and 90%
3 They are reproductively isolated from the general
   Eastern European population; they may have
   originated from Northern India or other high
   frequency area.
4 Prediction would be that Iₐ would have a lower
   frequency because South American frequency is
   lower.

Data-based questions: hemophilia in Queen
Victoria’s family
page 153
1 The condition is sex-linked – if a male possesses the
   allele then they will be affected.
2 The female would need two copies of the allele
   which would require a carrier mother and an
   affected father. This is a rare combination.
3 Only males are affected – inheritance in males
   appears to be from maternal line. Carrier female
   and unaffected male produces affected male.
4 Alexandria is a carrier and Nicholas is unaffected.
   Daughters could be carriers/ XₐXᵦ or possess no
   copies of the allele / XₐXₐ
5 The normal male symbol in the pedigree suggests
   that they are XₐY, though without reference to the
   pedigree there would a 50% chance that they could
   be XₐY.

Data-based questions: differences in chromosome number
page 155
1 Such an organism would be sterile; meiosis requires
   synapsis/chromosome splitting; odd number means
   meiosis.
2 Not supported when considering plants; meaning of complex needs to be established as all are multicellular; no difference in complexity of cat and dog yet dog has more chromosomes etc; threadworm is least complex so possible; would need to see chromosome number of prokaryotes etc.

3 Some chromosomes may be long/fused.

4 Two chimp chromosomes fused leading to a decrease in chromosome number.

CHAPTER 13
Advanced genetics
Data-based questions: gene linkage in Zea mays page 159
1 Coloured, starchy both dominant traits Cc
   White, waxy recessive traits Ss
   F1 are all CcSs
   so F1 × F1
   CcSs × CcSs produces typical dihybrid ratio of 9 coloured starchy: 3 coloured waxy: 3 white starchy: 1 white waxy in F2
2 The actual frequencies do not follow the 9:3:3:1 ratio and so the genes must be linked as they differ from the theoretical ratio for dihybrid crosses.
3 Coloured, shrunken CCnn
   White, non-shrunken ccNN
   F1 coloured, non-shrunken is CcNn are test-crossed with homozygous recessive: ccnn
   CcNn × ccnn
   Typical ratio of 1 coloured non-shrunken: 1 coloured shrunken: 1 white non-shrunken: 1 white shrunken
4 Actual frequencies differ from typical ratio of 1:1:1:1, so genes must be linked.
5 If starchy/waxy and non-shrunken/shrunken are both linked to colour, then they must also be linked to each other.

Data-based questions: gene linkage in mutant tomatoes page 160
1 a Peach round and smooth oblate; both have different combinations of characters than the parents.
   b Smooth fruits and clustered flowers is a recombinant as is peach fruits and few flowers.
2 a
   S r × s R
   ________ ________
   s r s r
   crossing over yields the gametes
   S r and s R
   and recombinants
   S r s R
   ________ ________
   s r s r

b Test cross is:
   S F × s f
   ________ ________
   s f s f
crossing over yields the gametes
   S f and s F
   ________ ________
   s f s f
   and recombinants
   S f s F
   ________ ________
   s f s f

3 a \(\frac{210}{1000} \times 100\% = 21\%\)
   b \(\frac{342}{1000} \times 100\% = 34.2\%\)
4 Answer should refer to: different distances between loci in combination with a small degree of sampling error.

CHAPTER 14
Biotechnology and genetic engineering
Data-based questions: PCR and Neanderthals page 168
1 7
2 Answer should refer to:
   • Data suggests Neanderthals more closely related to humans.
   • Because of the fewer differences in bases between humans and Neanderthals.
   • Minimum difference in human-Neanderthal exceeds maximum human-human difference, therefore humans and Neanderthals not the same species.
3 Based on the bones of single neanderthal/limited support.

Data-based questions: comparing mouse and human genomes page 171
1 20
2 X, 1, 14
3 1 and 13
4 Common evolutionary history; conserved function.
5 Duplication; fusion; translocation.
Data-based questions: determining an open reading frame  

page 172

1 64  
2 3 in 64  
3 Answer should refer to:  
   • Stop codons should occur with a frequency of about 1 in 20 codons; their frequency would be lower in an open reading frame.  
   • The first reading frame has one stop codon, the second has two, but the third has none, so the third is possibly an open-reading frame.  
   • A much longer sequence is necessary to identify the ORF.

CHAPTER 15  

Ecology  

Data-based questions: an entangled bank  

page 175

1 Food web; biotic/abiotic interactions; decomposition.  
2 Ecosystem  
3 a Predation  
   b Decomposition

Data-based questions: unexpected diets  

page 176

1 Venus fly trap; ghost orchid; euglena.  
2 Dodder (some are photosynthetic); euglena; ghost orchid (some are photosynthetic).  
3 Dodder – consumer; euglena – consumer; ghost orchid – saprotroph.

Data-based questions: a marine food web  

page 179

1 Producer.  
2 From: microzooplankton/macarozooplankton/krill/small fish and squid.  
3 a bacteria → nanozooplankton  
   b Seven trophic levels:  
      nanozooplankton → micorzooplankton → macrozooplankton → small fish/squid → emperor penguin →  
      leopard seal → toothed whale  
      bacteria → microzooplankton → macrozooplankton → small fish/squid → emperor penguin → leopard seal → toothed whale;  
   c Small fish and squid/krill.  
   d Toothed whales.  
4 Answer should refer to:  
   • Trophic level can be tertiary or quartenary depending on whether krill or small fish are eaten.  
   • Variability in the diet of the krill changes the trophic level of the penguin.  
   • Variability in the diet of the small fish changes the trophic level of the penguin.

Data-based questions: fishing down marine food webs  

page 180

1 Check its stomach contents; determine trophic level of organisms within the stomach.  
2 a Both have been declining over the study period; rate of decline is faster in fresh water populations; rate of decline is more constant in marine/accelerating in freshwater.  
   b Freshwater fisheries are more established/have been overfished for longer; freshwater populations smaller/more susceptible to disruption.  
3 Increasing age means increasing size; increasing size means broader range of prey including larger fish/higher trophic level fish.  
4 Age correlated with trophic level; lowering of trophic level means lowering of mean age.  
5 Greater biomass of lower trophic level means higher sustainable yield which allows higher trophic levels to recover.

Data-based questions: a simple food web  

page 181

1 Answer should refer to:  
   • Both are top predators.  
   • Both occupy more than one trophic level.  
   • Both can be predator/prey of the other.  
   • Belostoma has higher productivity.  
2 Ranatra and Belostoma both can be considered as secondary, tertiary and quartenary consumers.  
3 a Metaphyton → Hyalella → Telebasis → Belostoma  
   b Telebasis
4 First rung is sum of metaphyton and epiphyton energy values; first rung labelled as producers or with species name.  
   Second rung is labelled primary consumers; second rung shown 5% as wide as first rung.  
5 \[
\text{final-initial} \times \frac{100\%}{\text{initial}} = -95.3\%
\]  
6 Answer should refer to:  
   • Some organisms can occupy more than one trophic level at the same time.
• some organisms can occupy different trophic levels at different points in their life cycle.
• Easier to define trophic level in a food chain rather than a food web.

7 Determine the fraction of each organism’s diet coming from each specific trophic level.

CHAPTER 16
The carbon cycle and greenhouse effect

Data-based questions: nutrient cycles

page 185
1 Trees/plants.
2 Equatorial forest.
3 Nutrients primarily stored in above ground compartment/not in soil; transfer of nutrients out of system when trees removed.
4 Respiration.
5 Nutrients are locked in the permafrost.
6 Detritus trapped in permafrost; with melting, detritus becomes available for respiration.

Data-based questions: release of carbon from tundra soils

page 186
1 a Increasing the temperature increases the release of carbon; the effect is more significant in moist soils than waterlogged soils.
b Higher temperature means higher rates of chemical reactions, including respiration which releases CO₂.
2 a In both cases, carbon release increases with temperature; an increase in carbon release is much higher in moist rather than water logged soils.
b In water-logged soils, more anaerobic respiration in bacteria and fungus; only some have alcoholic fermentation; anaerobic respiration releases less carbon.
3 Adding fertilizer impacts carbon release – in moist soils only.
4 Water-logging of soils has the highest negative impact on carbon release; temperature has the most significant positive impact.

Data-based questions: phenology

page 188
1 a 1990
   b 1970
2 a The higher the temperature, the earlier the opening of the chestnut leaves.
b Over the final 10 year period, highest average temperatures occurred; previous pattern appeared to be cyclical; supports claim of global warming.

Data-based questions: Uncertainty in temperature rise projections

page 190
1 AIFI
2 Minimum 1.1 °C; maximum 5.9 °C
3 1.8 °C
4 2.1 °C in the Arctic versus 1.8 °C global average; Arctic temperature rise is higher than global average.
5 whether positive feedback cycles will exacerbate the problem;
such as melting of polar ice caps;
or permafrost melting;
or increase in cloud cover;
6 Answer should refer to:
• Depends on whether data used by centres is the same or independently gathered.
• More centres means more validity.
• similar logic applies to positive impact of sample size on certainty in IA experiments.

7 Answer should refer to:
• According to precautionary principle strong action called for because consequences of inaction are potentially catastrophic.
• Costs of mitigating should be borne equally.
• Developing nations need access to carbon production to achieve higher standard of living;
• Will require greater reductions in developed world.

8 Answer should refer to:
• Forces acting in support of avoiding economic risk are more powerful.
• Some shifts in economic activity possible.
• Local versus global economies.
• Shift to greater degree of subsistence activities.
• Fossil fuel shortage may aid shift.

Data-based questions: spruce bark beetles

page 191
a The late 1960s and the 1990s.
b i) Answer should refer to:
• The number of years with an infestation is a longer stretch in the 1990s.
• The number of affected hectares is much higher in the 1990s.
ii) Answer should refer to:
• Increase in the number of cycles in one season.
• Population explosion with limited predation due to global warming.
c Data suggests decline; possibly because forest is completely destroyed or new equilibrium might be reached; plant resistance/increase in predation possible.

CHAPTER 17
Evolution

Data-based questions: domestication of corn page 194

1 \[\frac{170 - 14}{14} \times 100\% = 1114\% \text{ increase in length}\]

2 \[\frac{4100 - 150}{150} \times 100\% = 2633\% \text{ increase in yield}\]

3 Seed texture; seed colour; starchiness/kernal size; kernal per cob.

4 Loss of hybrid vigour; inbreeding; purebred for weaknesses.

Data-based questions: missing links page 196

1 1600 mm/ 1.6 m

2 Answer should refer to:
   • Similar skull bones.
   • Similar dentition.
   • Similar tail vertebrae.

3 Maintenance of a stable body temperature/insulation.

4 Modified forelimbs; smaller body size.

5 Direct observation not possible; DNA/molecular evidence not available.

Data-based questions: Galapogas finches page 201

1 a Population increases at a fixed rate up until a peak population in 2003 of approximately 300 birds, after which the population falls to a low level/nearly zero.

b Answer should refer to:
   • Both have a population peak in 2003, followed by a decline.
   • *G. fortis* reaches a much higher level of population.
   • *G. fortis* pattern appears cyclical/has two instances of a peak and decline in the same period that *G. magnirostris* has one peak and decline.

2 Minimum: presuming 100 birds per 0.34 km²
   Density is \[\frac{294 \text{ birds}}{\text{km}^2}\]
   Maximum: 1,500 birds per 0.34 km²
   Density is 4,411 birds per km²

3 a *G. magnirostris* eats all three seeds with a preference for large seeds.
   *G. fortis* eats all three seeds with a preference for small seeds.
   *G. scandens* eats only small and medium seeds with a preference for small seeds.

b *G. magnirostris* and *G. scandens* ate more medium sized seeds after the drought; *G. fortis* ate fewer large seeds

4 a 1977 to 1978 and 2003 to 2004

b Answer should refer to:
   • Reduction in food supply leads to natural selection/survival of best adapted until reproductive age.
   • For those varieties that can take advantage of available food supply.

5 Answer should refer to:
   • Geographic isolation.
   • Small island size.
   • Limited resources.
   • Short generation time in birds.

6 Answer should refer to:
   • Funding formulas for scientific research that favour results being generated in the short-term.
   • Turnover of scientists.

Data-based questions: evolution in rice plants page 203

Page 203: evolution in plants

1 Natural selection depends on variation in a population and there is no variation in a pure bred variety.

2 Mean flowering date becomes later; variety in flowering dates has been reduced.

3 a Lower latitudes have later flowering times.

b At higher latitudes, shorter growing season favours plants that flower early.

4 a Reduction in variation and stronger correlation between latitude and flowering time.

b Possible crop failure if no intermediate alleles present; if intermediate alleles exist at low frequency, in either F10 population, these alleles will become more common at 35°.
CHAPTER 18
Classification
Data-based questions: classifying cartilaginous fish
page 206
<Answers missing for data based questions and other questions on pages 205, 206, 209, 210, 211
Only text document has in it is:
Need to wait for second proof as picture for single dbq is not present.

CHAPTER 19
Digestion
Data-based questions: the wall of the esophagus
page 214
2 Absorption does not occur in the esophagus; thin layer is suitable for diffusion, but not the constant physical abrasion that occurs in the esophagus.
3 Longitudinal muscles are toward the outside, circular muscles are toward the inside.
4 Mucus; to lubricate the esophagus to ease the passage of the food bolus.
5 For gas exchange; to support cellular respiration; which supports muscular contraction.
6 Striated muscle at the top of the esophagus allows voluntary control – we can choose when to swallow some food, or indeed whether to swallow it or spit it out. Once we have made this decision, we don’t need to go on deciding whether the food should go on down the esophagus, so involuntary/autonomic control with smooth muscle fibres is used.

CHAPTER 20
The transport system
Data-based questions: heart action and blood pressures
page 220
1 Blood is pumped from atria to ventricles 0 seconds to 0.1 seconds (N.B the slight rise in atrial pressure at 0.15 seconds is probably due to the AV valve bulging back into the atria as ventricular systole starts.)
2 Ventricles start to contract at 0.10 seconds.
3 AV valve closes at 0.1 seconds (atrial pressure falls below ventricular pressure).
4 SL valve opens at 0.15 seconds (ventricular pressure rises above arterial pressure).
5 SL valve closes at 0.4 seconds (ventricular pressure falls below arterial pressure).
6 Blood is pumped from the ventricle to the artery from 0.15 to 0.4 seconds.
7 a Blood in the ventricle is at a maximum at 0.1 seconds (just before the SL valve opens).
b Blood in the ventricle is at a minimum at 0.35 seconds (at the peak of ventricular systole).

CHAPTER 21
Defence against infectious disease
Data-based questions: skin pH
page 227
1 Skin pH of neonates is higher than adults/skin ph of neonates is neutral while pH of adults is acidic; skin pH varies over the body in both adults and neonates.
2 Colonization by harmless bacteria that produce acid as a by-product of metabolism.
3 Neonate skin is neutral; adding a base will raise pH to an irritating level.
4 Answer should refer to:
   • Normal skin flora adapted to certain Ph.
   • Changing pH might favor pathogens.
   • Changing pH might affect competence of the skin.

Data-based questions: antibiotic resistance
page 230
1 a Answer should refer to:
   • Increasing to peak in 1993.
   • Decreasing to 1996.
   • Increasing to a peak in 1998.
   • Declines to lowest level in 2002.
b Pattern appears to be cyclical.
2 (5.2 – 16.0) ÷ 16.0 × 100% = -67.5%
3 Answer should refer to:
   • Lowest levels of resistance occurred after programme implementation; therefore some success.
   • Peak in 1998 suggests programme not fully effective.

Data-based questions: Aids in Africa
Page 231
1 The 1980s.
2 Both show an improvement in life expectancy leading up to the onset of the pandemic. Both show a precipitous decline in the mid to late 1980s. Life expectancy in Zimbabwe lower for all years compared to South Africa.
3 From: improved diet; improvements in health care; improved public health education; higher incomes.
4 Botswana.
5 From: possible origin of the pandemic; violence/civil war.
**Data-based questions: use of monoclonal antibodies to diagnose pregnancy**

*page 233*

**Data-based questions: antibodies in colostrum**

*page 234*

1. Declines after birth; sharpest decline over first six hours; ability eventually falls to zero.
2. The calf would be weaker so they can’t nurse during the critical period when antibodies are more likely to be absorbed.
3. The concentration of antibodies would fall – production of antibodies would be wasteful of resources if they are not absorbed.
4. The mother would develop immunity/antibodies that could be transferred to lamb through colostrums.
5. Active transport.

**Data-based questions: MMR and DTP vaccines**

*page 236*

1. More cost effective; ensures coverage of a greater range of diseases with same public health effort.
2. Answer should refer to:
   - Increase in uptake up to 1992.
   - Relatively constant % uptake until 1997.
   - Significant decline from 1998;
3. 1998/99 significant decline after this point.
4. Increases in the rates of autism over the study period.
5. Answer should refer to:
   - MMR uptake fell to nearly zero as rates of autism are increasing.
   - Hypothesis does not appear to be supported by the data.
6. Answer should refer to:
   - Between 1950 and early 1970s, rates of pertussis fell due to vaccine;
   - Media stories resulted in decline in vaccine uptake leading to an increase in pertussis.
   - Once limits to data about side effects known.
   - Uptake of vaccine increases again and incidence of pertussis decreases.

**Data-based questions: concentration gradients**

*page 240*

1. Some oxygen has diffused into capillaries that surround the alveoli due to low partial pressure of oxygen in those capillaries.
2. a) \( \frac{105 - 40}{40} \times 100\% = 163\% \)
   - The partial pressure of oxygen is 163% higher in the alveolus.
   b) Diffusion.
   c) i) \( \frac{3 - 27}{3} \times 100\% = 800\% \)
   - 800% increase in CO\(_2\) concentration between inhaled and exhaled air;
   ii) CO\(_2\) has diffused out of the blood into the alveolus raising the CO\(_2\) concentration in the alveolus.
   d) Nitrogen is not used in the body so there is no concentration difference between air and the blood.

**Data-based questions: treating chronic obstructive pulmonary disease**

*page 241*

1. 53%  
2. a) 22% increase (75% - 53% = 22%)  
   b) 13%  
   c) 02%  
   d) 02%  
3. At normal atmospheric concentration hemoglobin is not saturated; increasing the concentration of oxygen means greater saturation of hemoglobin is achieved.

**CHAPTER 22**

**Gas exchange**

**Data-based questions: emphysema and gas exchange**

*page 239*

1. a) Mean number of times ruler crosses a gas exchange surface per image width is 8 times for the healthy lung is 4 times.
4 Answer should refer to:
- At an initial 21%, there is a saturation rate of 53%. There will be a rise of 22% at 24% concentration. The increase then slows to 13%, finally reaching a plateau.
- Increasing concentration of oxygen beyond that point, does not increase hemoglobin saturation.
- It might be dangerous because it is flammable/explosive.

5 28%

6 Answer should refer to:
- Smoking is addictive.
- Smokers find it difficult to stop despite knowing they should.
- Onset of disease is not sudden so people adapt to disease state.

CHAPTER 23
The kidney

Data-based questions: blood supply to the kidney
page 244

1 The kidney has the highest blood flow rate of the tissues shown – five times more than the heart muscle and nearly 200 times resting skeletal muscle.

2 The kidney receives 420 mL per minute. In 2.38 minute 1 litre is delivered to 100 mg of tissue; in this time \(84.0 \times 2.38\) = 200 mL of oxygen is delivered.

3 Skin 14.6%
   Skeletal muscle 36%
   Heart muscle
   Kidney 8%

4 Answer should refer to:
- Blood flows to different organs for different reasons.
- All blood needs toxic waste products removed so must flow to kidney.
- Some oxygen demand is variable depending on activity.
- Such as by skeletal muscle during activity.
- Some blood flow is variable such as thermoregulation and the skin.

5 Selective re-absorption/active transport.

6 Blood flow to the skin would change; to support thermoregulation.

Data-based questions: ultrafiltration of charged and uncharged dextrans
page 246

1 The larger the particle size, the lower the permeability to them of the filter unit.

2 a Answer should refer to:
- All show a decline in permeability with an increase in size.
- Neutral dextran shows the most direct relationship.
- Dextran sulfate permeability decline most rapidly with an increase in size.
- DEAE permeability declines most slowly with an increase in particle size.

b Answer should refer to:
- Large particles of any type cannot pass easily through the membrane.
- Electric charge has an impact on ultrafiltration with negatively charged particles decreasing ultrafiltration and positively charged particles increasing the rate of ultrafiltration.

3 Answer should refer to:
- Regardless of charge, particles as large as 4.4 nm do not end up in the filtrate.
- The presence of such particles in the urine indicates kidney function disability because it has been able to pass through the glomerulus when it normally would not pass through.

Data-based questions: medulla thickness and urine concentration
page 248

1 The drier the habitat, the more concentrated the urine; some variation evident.

2 Raw data in table below for constructing scattergraph.

<table>
<thead>
<tr>
<th>RMT</th>
<th>MSC</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.3</td>
<td>517</td>
</tr>
<tr>
<td>1.6</td>
<td>1076</td>
</tr>
<tr>
<td>3.0</td>
<td>1399</td>
</tr>
<tr>
<td>4.3</td>
<td>2465</td>
</tr>
<tr>
<td>4.8</td>
<td>3122</td>
</tr>
<tr>
<td>5.8</td>
<td>2465</td>
</tr>
<tr>
<td>6.1</td>
<td>2071</td>
</tr>
<tr>
<td>8.5</td>
<td>5597</td>
</tr>
<tr>
<td>9.3</td>
<td>6459</td>
</tr>
<tr>
<td>9.4</td>
<td>7080</td>
</tr>
<tr>
<td>10.7</td>
<td>4952</td>
</tr>
<tr>
<td>11.4</td>
<td>8612</td>
</tr>
<tr>
<td>12.3</td>
<td>8773</td>
</tr>
<tr>
<td>14.0</td>
<td>7440</td>
</tr>
</tbody>
</table>

3 a The higher the RMT, the higher the MSC produced.

b The length of the loop of Henle determines the solute concentration established in the medulla; the higher the RMT, the longer the loops of Henle.
CHAPTER 24
Nerves and hormones

Data-based questions: ouabain
page 253

1 a As ouabain concentration increases, Na⁺/K⁺ pump activity decreases.
   b Ouabain concentration would be approximately 0.0035 M.
   c Answer should refer to:
      • Overstimulation of cardiac muscle would occur.
      • Ouabain binds to ATPase inhibiting Na⁺/K⁺ pump action.
      • This inhibition allows for Na⁺ to leak back into the cell.
      • Increased Na⁺ concentration triggers Na⁺/Ca⁺⁺ pump to move Ca⁺⁺ into the cell, stimulating muscle contraction.

Data-based questions: abnormal action potentials
page 255

1 a The magnitude of the depolarization is lower and it takes longer to reach.
   b The action potential has a longer duration; highest value takes longer to reach; re-polarization takes longer.
2 With reduced extra-cellular Na⁺ then magnitude of depolarization will be lower, as the concentration difference is lower and the electrochemical gradient is lower.
3 With lower extracellular Na⁺, then resting potential is lower and pressure for K⁺ to flow out is lower.
4 Answer should refer to:
   • The magnitude of the action potential is lower in the mutants.
   • The rate of depolarization is approximately equal.
   • The rate of re-polarization is much longer in the mutant.
   • As a result the duration of the action potential is longer in the mutant.
   • Final resting potential is the same in both.
5 Because K⁺ are faulty, it is possible they open early preventing maximum depolarization; possible they don’t all open delaying the movement of K⁺ ions; alternative is that they don’t stay open for long enough.

Data-based questions: speeds of conduction
page 256

1 A higher diameter increases speed of conduction but not to the same degree as presence of the sheath. A 7.5 × increase in diameter increases conduction by 2.5 × in unsheathed. Compared to a 1.5 × increase in diameter causing a 2.5 × increase in conduction.
2 a Myelination increases rate of conduction to a much greater extent than diameter.
   b As neuron becomes myelinated, diameter increases; type of diameter increase has an effect; myelination lowers resistance to current flow at cell surface.
3 Both play a role in combination with myelination playing a more important role.

Data-based questions: Parkinson’s disease
page 257

1 a Precursor to L-Dopa so increases dopamine production in existing neurons.
   b Prevents dopamine breakdown, prolonging dopamine effects.
   c Favours dopamine production pathway by blocking alternative pathway.
   d An agonist either mimics or promotes the activity of a chemical such as dopamine.
   e Normally neurotransmitter is broken down, so if it is not broken down, its activity is prolonged.
2 a Non-functional neurons might be supplemented by the activity of transplanted neurons; cultured from cell cultures originally generated from stem cells.
   b Insert functional copy of gene to replace mutant gene; insert into vector such as a virus; inject large numbers of transgenic viruses into patient.

Data-based questions: wind-chill nomogram
page 260

1 7MJ/m²/h
2 Cool.
3 Wind-chill is 0.9MJm⁻²h⁻¹
   energy lost = 2 × 0.9
   = 1.8MJ
4 Wind chill increases with increasing wind speed but decreases with increasing temperature; linear increase with decreasing temperature but non-linear with wind speed/significant increase at lower wind speeds.
Data-based questions: the glucose tolerance test

page 261

In person with diabetes:

- a higher concentration of glucose at time zero.
- b longer time to return to baseline (hasn’t occurred after 5 hours).
- c much higher maximum glucose.
- d delay in time before glucose begins to fall.

Data-based questions: flight muscles

page 268

1 26 flaps

2 Answer should refer to:
   - Vigorous contractions during take off and landing, less vigorous contractions during fast flight.
   - Decreasingly vigorous contractions during take off and fast flight/increasingly during landing.
   - Fewer contractions per unit time in (later stages) of fast flight than other phases.
   - Most vigorous contractions during landing.

3 TB is used (mainly) for landing.

4 The upstroke of the wing.

5 Similar frequency to the SB muscles/same number of contractions; the peaks of activity would be out of phase/alternate with those of the SB and TB.

Data-based questions: the female athlete triad

page 272

1 a The more menstrual cycles, the higher the bone mineral density; significant increase in bone density once the number of cycles surpasses 10; effect on bone density is not uniform across the bone.

   b Answer should refer to:
      - As few as 1-3 has clear effect on entire bone but 4-10 has a different effect depending on the part of the bone.
      - Neck of femur has lower density when number is between 4-10.
      - Trochanter has higher density when number is between 11-13.
• Lowest density reached in neck/highest density reached in trochanter.
• Both show the relationship that the more menstrual cycles, the higher the bone mineral density.

2 a May have better diets; may have more moderate running regimes.
b Lower bone density might be caused by insufficient nutrient intake; lower bone density might be caused by low estrogen levels; older runners might be over-represented in this category; high energy consumption might forestall bone maintenance.

3 a Preserving resources for demanding exercise regime; reduced estrogen impacts uterine and ovarian hormone cycles.
b Reduced appetite/exercise regime is part of weight loss strategy.

**Data-based questions: sperm counts and male fertility**

*page 276*

1 (within a group) higher in winter than summer; summer count in Finnish men (nearly) equal to winter count in Danish men; no change in % normal sperm occurs with the change in seasons.

2 Younger men without pregnant partners have fewer defective sperm; younger men have a lower sperm count; less variability in younger men between the two national groups;

3 Hypothesis supported by sperm count data.

**Data-based questions: sizes of sperm**

*page 278*

1 Pattern is not clear; longer sperm tend to have higher cross sectional area.

2 Answer should refer to:
   • Scaling of all dimensions related to overall size of sperm.
   • Shearing stress in longer sperm; needs thicker cross-sectional area to support.

3 Answer should refer to:
   • Data is not supplied about relative sizes of rodents but in general no as humans and bulls are larger organisms with relatively small sperm.

**Data-based questions: maternal age and pregnancy**

*page 282*

1 Slight improvement at 20-24 over teenage years; stable over the 20’s; begins to decline in early 30s; with significant declines after that.

2 Growth not completed; socioeconomic status/general health and welfare status of the cohort of girls getting pregnant at this age.

3 Cumulative frequency data would make it necessarily higher in the 35+ age bracket; women returning to college after childbirth; women postponing childbirth until college education and career established.

4 A number of factors determine ideal situation for a child to be born:
   • Socioeconomic status of parent is better at a later age.
   • The 20s are the ideal age to carry a pregnancy to term/avoid miscarriage.
   • Risk of ectopic pregnancy is higher with advanced age.

**Data-based questions: electron micrograph of placenta**

*page 283*

1 a Microvilli, coming in and out of the plane of section.
b Active transport of glucose and other foods; osmosis for water absorption; facilitated diffusion of mineral ions or other substances; increased surface area; gas exchange.

2 Progesterone is a steroid hormone; so the sER produces the hormones.

3 Nucleus because it is adjacent to the ER; nucleus because it is a large organelle.