Biology

for the IB DIPLOMA

ANSWERS

C J Clegg

Answers to self assessment questions (SAQs) in Chapters 13–20

13 Option A Human nutrition and health

page 392

1 See **The kidney – excretion and osmoregulation**; *Why is the issue of nitrogenous excretion so important in animals?* page 370.

page 393

2 See **Abrupt change in hereditary information – mutations**, page 98.

page 396

3 See **The enzyme active site**, page 53.

page 398

4 The normal pH of the blood is 7.4, but for life to be maintained it cannot be allowed to vary outside the range pH 7.0–7.8. This is largely because blood pH affects the composition of the blood and its ability to transport respiratory gases, for example. pH also affects the balance of essential ions which are transported in the plasma solution. Clearly, constancy of composition of the blood is most important to brain function – failure of which quickly induces coma.

page 399

5 See **Table 7.6 Structural differences between arteries, veins and capillaries**, page 188.

page 405

6 **a** Oxidation and reduction:
Oxidation is the addition of oxygen or the removal of hydrogen (i.e. the gaining of one or more electrons) accompanied by the transfer of energy; **reduction** is the reverse of oxidation. When a substance is oxidised another is simultaneously reduced.

b Condensation and hydrolysis:
Condensation is formation of larger molecules involving the removal of water from smaller component molecules; **hydrolysis** is reaction in which hydrogen and hydroxidel ions are added to a large molecule, causing it to split into smaller molecules.

page 406

7 The alcohol (ethanol) in alcoholic drinks is absorbed and used as a source of energy (1 g of ethanol provides 29 kJ). Carbohydrate may also be present and provide additional energy. Diets which include a high level of alcohol intake may lead to obesity.

page 409

8 **a** At too high a concentration, blood glucose would tend to dehydrate tissues as the net movement of water would be into the plasma.

b At too low a concentration, the brain would be deprived of a steady supply of respiratory substrate, leading to lack of consciousness and then death.

page 416

9 **a** and **b** See **Figure 1.22** (function 3), page 23
c **Figure 7.46**, page 223.

page 420

10 See **The blood clotting mechanism**, page 349.

14 Option B Physiology of exercise

page 427

1 Effects of training on ventilation rate.

Ventilation rate at rest	Maximum ventilation rate	Vital capacity
since tidal volume is greater than when untrained, the ventilation rate is lower	maximum possible ventilation rate is increased	unchanged

2 With a lower than average heart (beat) rate, the period of diastole (rest period) in each cardiac cycle is longer. This allows greater coronary blood flow.

page 428

3 The blood is very powerfully buffered and successfully resists pH changes. A buffer solution is one that resists a pH change if a little acid or alkali is added to it. Many buffers used in laboratory experiments contain a weak acid (such as ethanoic acid – vinegar) and its soluble salt (such as sodium ethanoate). In this case, if acid is added, the excess hydrogen ions are immediately removed by being combined with ethanoate ions to form undissociated ethanoic acid. Alternatively, if alkali is added, the excess hydroxide ions immediately combine with hydrogen ions forming water. At the same time, more of the ethanoic acid dissociates, adding more hydrogen ions to the solution. The pH does not change in either case.

In the blood are several buffer systems. First, the carbon dioxide that is transported about the body, exists in two forms – as the weak acid carbonic acid (H_2CO_3) and as hydrogencarbonate ions (HCO_3^-). These form a powerful buffer. Secondly, two sodium salts of phosphoric acid are present in the plasma solution, and they also form a buffer system. Also, the haemoglobin of the red cells and plasma proteins have buffering qualities. In these ways, the blood is held between pH 7.35 and 7.45.

page 430

4 Base your advice on the blood flow data in Table 14.2. After eating, there is a requirement for blood supply to the gut to be maintained. In exercise, the skeletal muscles receive the bulk of the blood flow. People swimming after a heavy meal frequently experience cramp. Why?

page 433

5 See **The muscles hold reserves to sustain respiration**, page 432.

page 439

6 Preferably, choose a sporting activity you already practise. Take note of the section on warm-up routines on page 441, and the points in the paragraph *How can these attributes be effectively trained?*, page 439, and discuss your plans with a trained sports person.

15 Option C Cells and energy

page 446

1

Reaction	Oxidised reactant	Reduced reactant
Iron reacting with copper sulphate	iron	copper ions
Ethanol conversion involving NAD^+	ethanol	NAD^+ (→ NADH + H^+)
Aerobic respiration – summary	glucose	oxygen

page 447

2 Enzymes bring about chemical change by formation of an E–S complex at the active site (page 53).

3 A non-competitive inhibitor alters the shape of the active site (**Figure 8.32**, page 265).

4 An enzyme that converts triose phosphate to pyruvate (actually triose phosphate dehydrogenase) is inhibited.

5 In the presence of this inhibitor the further breakdown of glucose beyond the triose phosphate step is slowed down. As a consequence, ADP will accumulate as ATP synthesis (step 4 of **Figure 9.3**, page 271) is blocked too. The ATP used in Step 1 is not re-formed in the presence of inhibitor, whereas in the control it will be.

page 448

6 The link reaction, Krebs cycle, and electron transport and the formation of ATP all occur within the mitochondria.

7 Until the addition of Krebs cycle acids, the isolated mitochondria were without intermediates to process (they were 'starved', in effect).

8 The Krebs cycle acids supplied to the mitochondria have been converted (to carbon dioxide, etc.), and once again the mitochondria are without intermediates to process. Consequently, the pool of hydrogen-acceptor molecules present (NAD^+) is in the oxidised state (**Figure 9.6**, page 274), and electron transport and oxygen uptake are no longer taking place.

9 The mitochondria are isolated (artificially) and are not linked to any of the many life processes or cell biochemical changes by which ATP is normally consumed and by which ADP + P_i are made available for re-use.

10 Addition of **a** Krebs cycle acids and **c** pyruvate would lead to further oxygen consumption. Addition of **b**, and **d** would have no effect.

11 Reduced NAD^+ is produced in the respiratory pathway during glycolysis, in the Krebs cycle, and in terminal oxidation.

12 ATP formed in terminal oxidation in mitochondria in intact, growing cells is used to bring about anabolic reactions, movement, etc.

13 ATP and ADP pass into and out of the mitochondria by facilitated diffusion (page 26).

14 The consumption of oxygen is dependent on the regular addition of ADP (at X and Y) because these are isolated mitochondria, not connected with the full range of cell reactions by which the limited amount of ATP present is converted back to ADP.

15 In the presence of dinitrophenol, the steps of the terminal oxidation process can go ahead without any need for a supply of ADP + P_i (that is, the linkage to ATP formation is removed), so unrestricted terminal oxidation can occur, and rapid uptake of oxygen is observed.

16 The rate of respiration is naturally regulated in cells by the availability of the pool of ADP and P_i, which is converted into ATP during terminal oxidation (**Figure 9.6**, page 274). If ATP-dependent reactions and processes are occurring, then there is a large pool of ADP and P_i maintained, and there is no restriction on terminal oxidation (to which ATP synthesis is obligatorily linked). When many anabolic reactions are occurring and much ATP is required for cell metabolism, respiration will be rapid. Otherwise, accumulation of ATP will soon slow respiration. So respiration is regulated by the demand for energy.

page 449

17 The component in air which may be detected by a pH indicator is carbon dioxide; this gas dissolves in water to form a weak solution of carbonic acid.
$CO_2 + H_2O \rightarrow H_2CO_3 \rightarrow HCO_3^- + H^+$

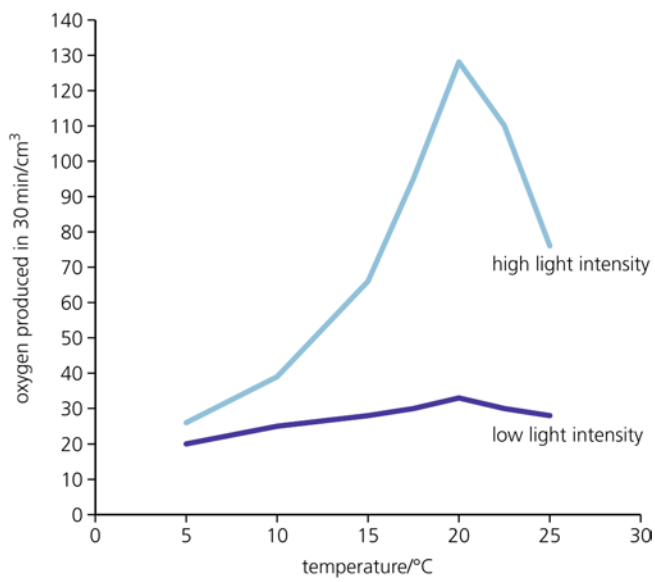
18 The light was arranged to pass through a tube containing water to remove the heat (infra-red rays) in light, thereby preventing any uncontrolled heating effect on the experimental tubes.

19 The causes of the colour changes were:
- **tube A** – in the dark, respiration occurs, and the carbon dioxide produced passes out of the leaf and is registered as more acid conditions by the yellow hydrogencarbonate indicator solution
- **tube C** – in the light, photosynthesis causes the uptake of carbon dioxide from the air (as well as carbon dioxide produced in the leaf by respiration) and this is registered as less acid conditions by the purple hydrogencarbonate indicator solution.

20 In **tube B**, dim light supports just sufficient photosynthesis to use all the carbon dioxide produced inside the leaf by respiration, so there is no uptake or output of carbon dioxide by the leaf, so no colour change occurs. The leaf is at compensation point.

page 450

21 Your graph should look like the one provided below.



Graph of effects of temperature on gas production at high and low light intensity

22 Your answer should be something like the following paragraph.

The effect of increasing temperature in the range from 10 °C to 20 °C depends on the light intensity. At low light intensities, a rise in temperature has little effect. At higher light intensities, the rise in temperature increases the rate of photosynthesis significantly.

23 A temperature rise of 10 °C has a negligible effect on photochemical reactions (they are temperature insensitive), but a rise of 10 °C at least doubles the rate of chemical reactions (they are temperature sensitive).

At low light intensity, the rate of photosynthesis was temperature insensitive which leads to the conclusion that at least one of the components of photosynthesis is a photochemical reaction (and is rate limiting at low light intensity).

At high light intensity, the rate of photosynthesis was temperature sensitive which leads to the conclusion that at least one of the components of photosynthesis is a chemical reaction (and is rate limiting at high light intensity).

24 The change in rates of photosynthesis at the higher temperatures may be due to the effect of heat energy, which denatures enzymes.

25 A summary of the two interconnected reactions of photosynthesis, namely **light-independent reactions** and **light-independent reactions**, is shown in **Figure 3.12** (page 87).

page 451

26 The leaf discs initially float because of the air trapped in all the air space, a feature of the leaves of terrestrial plants.

27 The gas bubbles come from the air in the air spaces in the leaves. The air is progressively replaced by water.

28 The illuminated discs rise in the barrel as oxygen (the waste product of photosynthesis) collects in the leaves.

29 To use this procedure to investigate the effect of different carbon dioxide concentrations on the rate of photosynthesis, replica experiments need to be set up, each at a different concentration of carbon dioxide ($NaHCO_3$ solutions of different molarities/concentrations).

page 452

30 At point A, the light intensity is sufficient for photosynthesis to produce as much oxygen as respiration in the leaf is consuming – the **compensation point**.

31 The stages of the curves at which light intensity is limiting the rate of photosynthesis are B and C.

32 The stages of the curves at which light intensity is *not* limiting the rate of photosynthesis are D and E.

33 The conclusion to be drawn from the results of repeating the investigation at a higher concentration of carbon dioxide is that at D, the rate is limited by the carbon dioxide concentration.

34 The factor that may be limiting the rate of photosynthesis at E is the carbon dioxide concentration (or the temperature).

16 Option D Evolution

page 454

1 Sedimentary rock layers are added to, year after year. Fossils laid down in the deeper strata of sedimentary rocks are older than the fossils of the higher (more recent) strata. Life has changed in many ways with time.

page 457

2 **Condensation** of small molecules to form larger ones (e.g. eventually nucleic acids, cell wall materials, cell membrane components); **hydrolysis** of larger molecules to make a pool of smaller molecules available for re-synthesis or for digestion/nutrition; **redox** reactions as part of energy transfer.

page 458

3 It is the photosynthesis of green plants – initially only the cyanobacteria (the first known photosynthetic organisms) but later also the algae and green land plants – that has introduced oxygen into the Earth's atmosphere. As oxygen has accumulated, the formation of high-level ozone has become possible (see **Atmospheric pollution and the ozone of the atmosphere**, page 627). Effectively, the ozone layer removes most harmful UV light which would otherwise reach the Earth's surface and make terrestrial life impossible. (Life under water is protected from UV light rays.)

page 460

4 See **Extension: The development of the ideas of evolution**, page 164.

page 461

5 A variety is a grouping within a species whose members consistently differ in some significant respect from other members of the species. A Shetland pony and a racehorse are examples of varieties; a horse and a donkey are examples of different species and the product of a mating between them is a mule, which is sterile.

page 463

6 Comparing the DNA from a variety of living species can indicate quantitatively the degree of relatedness of their genes, as shown for example in **Figure 16.36**, page 498.

page 467

7 Polyploids are unable to produce gametes that can form a zygote with gametes from their parents.

page 472

8

Convergent evolution	Divergent evolution
Similarity between two organs or organisms is due to independent evolution along similar lines, rather than to a common ancestor.	Descent from a common ancestor showing divergence to occupy different niches, as illustrated by comparing the mouthparts among insects (**Figure 16.14**, page 471) and adaptation of the pentadactyl limb among vertebrates (**Figure 16.12**, page 469)
See **Analogous structures** in **Figure 6.22**, page 159	See **Homologous structures** in **Figure 6.22**, page 159

page 477

9 Changes in the environment are a major selecting agent.

page 479

10

Radioactive potassium dating		Radioactive carbon dating
involves the natural decay of ^{40}K (potassium) to ^{40}Ar (argon)	**chemical change**	involves the natural decay of ^{14}C (carbon) to ^{14}N (nitrogen)
1.3×10^9 years	**half-life**	5.6×10^3 years
used to date rock layers above, below or around fossil	**used**	used to date fossilised remains, rather than rock layers
permits accurate dating of fossil from 580 mya, until about 0.5 mya	**application**	permits accurate dating of fossil of the last 60 000 years

page 485

11 See **Using the ratio of ^{40}K:^{40}Ar**, page 479.

12 The functioning brain is critical for survival in any mammal (see **Brain function**, page 535) so the prevention of impairment of the brain should take precedence over the needs of the rest of the body.

page 486

13 Tool use is defined as the use of an external object as a functional extension of the body in the attaining of immediate goals. For example:

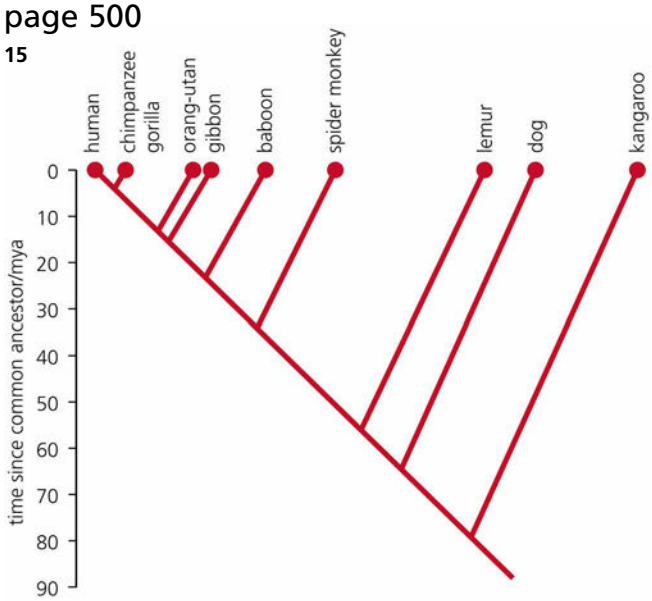
- the Galapagos woodpecker finch probes for insects in crevices in the bark of trees using a cactus spine
- the archer fish swims close to the surface of the water in mangrove swamps, and on seeing an insect on over-hanging vegetation, it spits out an accurate jet of water and dislodges the prey, which is eaten as it lands on the water surface
- the Egyptian vulture throws selected stones at ostrich eggs to break them open.

page 494

14 **A** = 0.5875; **a** = 0.4125 (see **Using the Hardy–Weinberg formula**, page 494).

page 500

15



A cladogram based on the biochemical data in Table 16.8

17 Option E Neurobiology and behaviour

page 506

1

	Sensory neurone	Relay neurone	Motor neurone
Relationship to CNS	connects a receptor with the CNS	connects sensory and motor neurones within the CNS	connects an effector with the CNS
Position of cell body	in ganglion of dorsal root of spinal nerve – outside the CNS	in grey matter of the CNS	in grey matter of the CNS
Type and role of dendrites	connect dendron to receptor and bring impulses from receptor to dendron	bring impulses body via short dendrons	bring impulses towards the cell body
Type and role of dendron	brings impulses towards the cell body	several, all short in length	absent
Type and role of axon	carries impulses away from cell body into CNS	singe axon, short in length	carries impulses from cell body to effector
Presence of myelin sheath	present along dendron and axon	absent	present along axon
Role in reflex arc	pathway of impulses towards CNS	connects sensory and motor neurones and provides opportunity to relay impulses to and from the brain	pathway of impulses away from CNS

page 507

2 **a** See **The resting potential** and **Figure 7.32**, page 211.
b See **The action potential** and **Figure 7.33**, page 212.

page 509

3 This requires an example native to habitats you are familiar with, near your home, school or college. You may need to seek local advice.

page 511

4

Stimulus (sense data)	Type of receptor	Location in the body
Mechanoreceptors		
movement and position	stretch receptors (e.g. muscle spindles, proprioceptors)	skeletal muscle
blood pressure	baroreceptors	aorta and carotid artery

table continues

Stimulus (sense data)	Type of receptor	Location in the body
Thermoreceptors		
internally	cells of hypothalamus	brain
Chemoreceptors		
blood O_2, CO_2, H^+	carotid body	carotid artery
osmotic concentration of the blood	osmoregulatory centre in hypothalamus	brain

5 The **fovea** is the point on the retina with greatest density of photoreceptors. It is formed only of cones.

The **blind spot** is the point on the retina where the optic nerve leaves and is without rods or cones.

page 516

6

Rods		Cones
human retina contains about 10–20 million rods	**relative numbers**	human retina contains about 7 million cones
evenly throughout the retina	**distribution**	throughout the retina, but particularly concentrated in and around the fovea
sensitive to low light intensities	**light sensitivity**	sensitive to high light intensities
used in dim light and night vision	**type of vision they facilitate**	used in high light intensities (bright light)
synapse with several bipolar neurones	**relationship to bipolar neurones**	synapse with a single bipolar neurone
poor resolution	**resolution**	high degree of resolution
one type of rod cell	**types of cell present**	three types of cone cell
visual purple (rhodopsin)	**visual pigment**	iodopsin – three different forms
'black and white'	**vision facilitated**	colour

page 520

7 There are numerous ways of tackling this, depending on equipment and facilities available. Unicellular algae, in dense cultures, colour the pond water green. Most simply, perhaps, when a dense culture is placed in a long shallow glass (or plastic) culture dish which is totally dark at one end and strongly illuminated by a beam of light at the other, the culture will collect at the illuminated end. What control situations do you need to confirm the response is to unilateral light?

page 523

8 Instinctive behaviour:
- automatic
- genetically programmed
- not learned behaviour
- automatically triggered by the environment
- reflex action
- not automatically involving higher centres of CNS.

page 526

9

Trial-and-error learning	Insight learning
typically investigated experimentally using a maze	problem solving without recourse to trial-and-error behaviour
animals with a well-developed nervous system learn a maze quickly	the most sophisticated type of learning
success based on exploratory behaviour	assessed by the ability to solve problems not previously experienced
level of interest is best maintained when success receives some reward	involves exploiting currently received sense data together with experiences held in memory
learning in which random and spontaneous responses become associated with a particular stimulus because of subsequent reward	results in abstracting general principles (we call them concepts)
also known as operant conditioning	may exploit early trial-and-error learning typically called play

page 530

10 See **Decision making in the central nervous system** and **Figures 17.20** and **17.21**, pages 528–530.

page 532

11 See **The liver and alcohol**, page 660. This is a research task best followed up by a discussion of the outcomes with your peers, given that ethnic, cultural and social values and norms may play a significant part in all aspects of the issue.

page 533

12 This is a research task best followed up by a discussion of the outcomes with your peers, given that ethnic, cultural and social values and norms may play a significant part in all aspects of the issue.

page 536

13 The medulla oblongata (in the hindbrain) contains control centres for vital body functions.

page 539

14 See **Brain function**, page 535 and **Table 17.4**, page 539.

page 546

15 See **The evolution of altruistic behaviour**, page 544.

18 Option F Microorganisms and biotechnology

page 554

1

Forms of RNA	Role in protein synthesis
messenger RNA (mRNA)	single-stranded RNA that is formed by the process of transcription of the genetic code in the nucleus, and then moves to the ribosomes in the cytoplasm
transfer RNA (tRNA)	short lengths of specific RNA that combine with specific amino acids prior to protein synthesis
ribosomal RNA	component of the ribosomes, site where mRNA is 'read' and amino acid condensation to form protein occurs

page 562

2 See **Table 1.4**, page 17.

page 563

3 The information required for replication of a virus is present as the genetic code in the nucleic acid (DNA or RNA) at the centre of the virus particle. If this reaches the interior of a host cell, it takes over the replication machinery and engineers replication of the viruses – very many are produced. The protein coat (capsid) contains no genetic information (and typically remains outside the host cell).

page 566

4 *Rhizobium* respires glucose. From the cell respiration process it obtains reducing power ($NADH_2$) and metabolic energy in the form of ATP – used, among other things, in nitrogen fixation. *Rhizobium* present in root nodules obtains glucose to respire from the leguminous plant in which it lives.

5 See **Cycling of nutrients** and **Figure 6.10**, page 146.

page 572

6 See **Cycling of nutrients** and **Figure 6.10**, page 146, and **Figure 18.19**, page 570.

page 574

7 See **The central dogma** and **Figure 8.16**, page 252. Genes exist as alleles that may be dominant or recessive, and so be expressed or not in any generation, but which are unchanging as the environment and conditions in cells change. Reverse transcriptase apparently contradicts this one-way flow of influence of the DNA of genes.

(An alternative, **discredited view** of inheritance, known as Lamarkian inheritance, suggested that the environment experienced might change the organism's genes and that these changes could be inherited.) According to Mendel and Darwin, the role of the environment is as a selection force, influencing which genes are effective, but not changing genes themselves.

8 This observation suggests that issues which become news are better funded than those which quietly bring about effective change and improvement without attracting publicity. Also, if expensive drugs or equipment are not central to the innovation, then the innovation does not get the same degree of commercial or industrial support. Meanwhile, clean water, healthy living conditions, a good diet and a supportive community working in a peaceful environment may contribute the most to good health. What do you think? Does this situation arise in your country?

page 577

9 The gene that is introduced is added to ordinary body cells but not to the germinal epithelium in the testes or to the oocytes in the ovaries. The affected individual's body (soma) is treated, but not his or her germ line.

page 579

10 Yeast does not produce hydrolysing enzymes that break down insoluble food reserves (mainly starch) in the grain. The starch must first be hydrolysed into sugar (mainly sucrose and maltose) by some other process, before the yeast can ferment the sugar to alcohol.

page 582

11 Sugar: see **Health consequences of energy-rich diets; Excess carbohydrates**, page 408.
Salt: a high salt concentration alters the osmotic concentration of body fluids. See **Osmosis – a special case of diffusion**, page 26.
Organic acid (ethanoic acid – vinegar), see answers to SAQ4, Chapter 13; SAQ3, Chapter 14.

page 583

12 See **Treatment of food poisoning**, page.

page 584

13 If you have difficulty with this, seek advice from your teacher or tutor.

page 591

14 See **Pasteur's experiment** in **Figure 1.2**, page 3. Can a similar experiment be devised easily, using simple apparatus available in the laboratory you study in?

page 594

15 **a** Antibiotics and vaccines:
antibiotics – organic compounds produced by microorganisms which selectively inhibit or kill other microorganisms
vaccines – preparations of attenuated microorganisms or inactivated components that confer immunity from a disease when injected.

b Inflammation and immunity:
inflammation – painful swelling caused in response to infection
immunity – resistance to the onset of disease after infection or vaccination.

c Vector and host:
vector – an agent that acts as an intermediate carrier or alternative host
host – any organism in which another spends part or all of its life.

19 Option G Ecology and conservation

page 605

1

Location	Plant	Animal
a a **high water** location	spiral wrack	rough winkle
b a **low water** location	oar weed	acorn barnacle

page 606

2 It is not possible to be confident of any factor from the data, other than to say that competition has greatest influence during early growth. Above ground, plants compete for light in particular; below ground, for the supply of mineral ions and water.

page 609

3 You will need local advice to correctly quote an example of competitive exclusion (page 608) from a habitat you are familiar with.

page 611

4 The water content of most species is between 70% and 95%, and varies with time and local conditions such as heat, wind, water supply and nutritional status. The density of water means that the mass of living things varies significantly with their degree of hydration.

page 612

5 Net production by secondary consumers: 1602 – 1322 = 280 kJ m^{-2} yr^{-1}

Net production by tertiary consumers: 88 – 54 = 34 kJ m^{-2} yr^{-1}

page 613

6 Trophic levels occupied by seabirds in this example vary between levels 3 and 6.

page 617

7

	Primary succession of rocky shore	Secondary succession on burnt forest land
Initial colonisers	attached algae of gradually increasing size, up to larger, attached seaweeds	small rooted plants from seeds carried in from surrounding land, or that survived the fire in the soil
Primary consumers **Secondary consumers** **Subsequently**	subsequent succession as represented in the food web in **Figure 19.11**, page 612.	subsequent succession as represented in **Figure 19.14**, page 615.

page 620

8 The Simpson diversity index (*D*) for this habitat:

Species (no of individuals)	*n*	*n*–1	*n*(*n*–1)
Groundsel	45	44	1980
Shepherd's purse	40	39	1560
Dandelion	10	9	90
Total (*N*)	95		

$\sum n(n-1) = 1980 + 1560 + 90 = 3630$

$D = \frac{95 \times 94}{3630}$

$= \frac{8930}{3630}$

$= 2.46$

9 Your results will indicate a higher diversity index with increasing age of dune. A high diversity index suggests the community is ecologically stable. A low diversity index is typical of a community of recent origin.

page 623

10 An important role of all forests may be as sinks for atmospheric carbon dioxide at a time when the concentration of this component of the atmosphere is rising. Much of the carbon built up into cellulose via the process of photosynthesis is retained in wood of the trunks of trees. These stand for many hundreds of years before decay converts them back to simple molecules. However, this view of forest is not accepted by all. Ultimately, all organic matter decays back to CO_2, and this is endlessly recycled.

page 624

11 A virus within the blood stream of a rabbit presents as an antigen. See **The immune system and the response to 'invasion'**, page 350.

page 627

12 See **Pesticide pollution and food chains**, page 624.

page 633

13 You will need to discuss your ideas with a conservationist in your country and area. Are there national or local reserves or conservation areas, with voluntary or professional management who can give you guidance?

page 637

14 The estimated population size would be halved (i.e. 40/2 = 20)

15 a The size of the population at days 2, 16, 31 and 46 and 76:

Day	$n_1 \times n_2 / n_3$	*N*
2	7 × 6 / 2	21
16	14 × 12 / 2	84
31	25 × 24 / 3	200
46	19 × 16 / 2	152
76	19 × 14 / 2	133

b Concerning 'time in days' and '*N*', which will you plot on the *x* and the *y* axis?

c The annotations to the curve are an opportunity to speculate:

- on the initial rapid rise in numbers (continuing immigrations? initial absence of competition for abundant resources? lack of presence of predators when population new or low in numbers?)
- on subsequent stabilisation of population numbers (balance between reproduction and predation pressures? the idea of carrying capacity for that habitat?).

20 Option H Further human physiology

page 645

1 See **Two modes of hormone action** and **Figure 20.2**, page 645.

page 646

2 See the answer to SAQ20, Chapter 12 (page B406).

Negative feedback	Positive feedback
concentration of respiratory gases (O_2 and CO_2) being transported in the blood	role of oxytocin in control of uterine contractions at birth, page 388
pressure of blood in the arteries	passage of an action potential along a nerve fibre, page 213
blood sugar level – the osmotic concentration of the blood	

page 649

3 The pancreatic enzymes would be inactivated at low pH values. See **Factors which change the rate of enzyme-catalysed reactions – pH**, page 561.

page 655

4 See **Absorption in the small intestine**, page 653. This question can be answered by adapting the information in **Table 7.4**.

5 Very few of the contents of faeces are waste products of metabolism. The presence of so many saprotrophic bacteria ensures that many (but not all) of the epithelial cells, sloughed-off from the villi, have been broken down before they pass out in the faeces. The bile pigments (breakdown products of red cells – added to the bile in the liver) are true excretory products. Any enzymes among the undigested food that have not been broken down will be present, too.

page 656

6 See **Mutualism**, page 610.

page 657

7 Blood from the gut via the hepatic portal vein, as well as containing the absorbed products of digestion, will be low in O_2 and relatively high in CO_2. So where is the supply of oxygen that the highly metabolic liver cells constantly require? See **Figure 20.16**.

page 659

8 See **Roles of proteins** and **Figure 8.26**, page 260.

9 See **Figure 7.17**, page 197.

page 660

10 The liver is a very active organ metabolically, and most reactions there require energy (endergonic reactions – **Figure 8.28**, page 261). Claude Bernard, the French physiologist and originator of the concept of homeostasis, published data showing the liver as a major exporter of heat in a mammal's body. But his values for the temperature of the blood entering and leaving the liver were obtained at different times from different dogs.

Subsequent investigations, involving thermocouples placed in the hepatic vein and the hepatic portal vein, show that the liver is thermally neutral. Nevertheless, this misunderstanding about the liver as a heat exporting organ has persisted.

page 663

11 **a** Pressure in the aorta is always significantly higher than in the atria because blood is pumped under high pressure into the aorta, and during diastole and atrial systole the semilunar valves prevent backflow from the aorta. Meanwhile, blood enters the atria under low pressure from the veins, and the pumping action of the atria is slight compared to that of the ventricles, which generates pulse.

b Pressure falls abruptly in the atrium once ventricular systole is underway because atrial diastole begins then.

c The semi-lunar valves in the aorta open immediately when pressure in the ventricles exceeds pressure in the aorta.

d When ventricular diastole commences, pressure in the ventricles starts to fall and the bicuspid valve opens when the ventricular pressure falls below atrial pressure.

e About 50% of the cardiac cycle is given over to diastole - the resting phase in each heart beat. The heart beats throughout life and takes limited rest at these moments.

page 664

12 See **The immediate effects of exercise on cardiac output and venous return**, page 428.

page 668

13 A fall of about 20%.

page 670

14 See **The transport of carbon dioxide in the blood** and **Figure 20.27**, page 669.

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15 Changes that occur to the breathing rate and its control as the body makes long-term adaptation to high altitude are:

- as the pO_2 falls, loading of haemoglobin in the lungs decreases
- the O_2 chemoreceptors of the respiratory centre (**Figure 20.28**) detect this, and breathing rate is increased
- more CO_2 is respired at the lungs, and a significant rise in blood pH occurs
- ventilation regulation by the respiratory centre is hampered
- slowly (as the hypothalamus monitors the internal environment and ensure homeostasis, see **Brain function**, page 535) the distal convoluted tubule removes more H^+ ions from the blood, and the pH of the blood returns to normal (see **Blood pH and ion concentration in the distal convoluted tubule**, page 374).

  (Meanwhile, red cell composition of the blood is adjusted, so there are more red cells at this pO_2 to carry the necessary oxygen to respiring cells.)