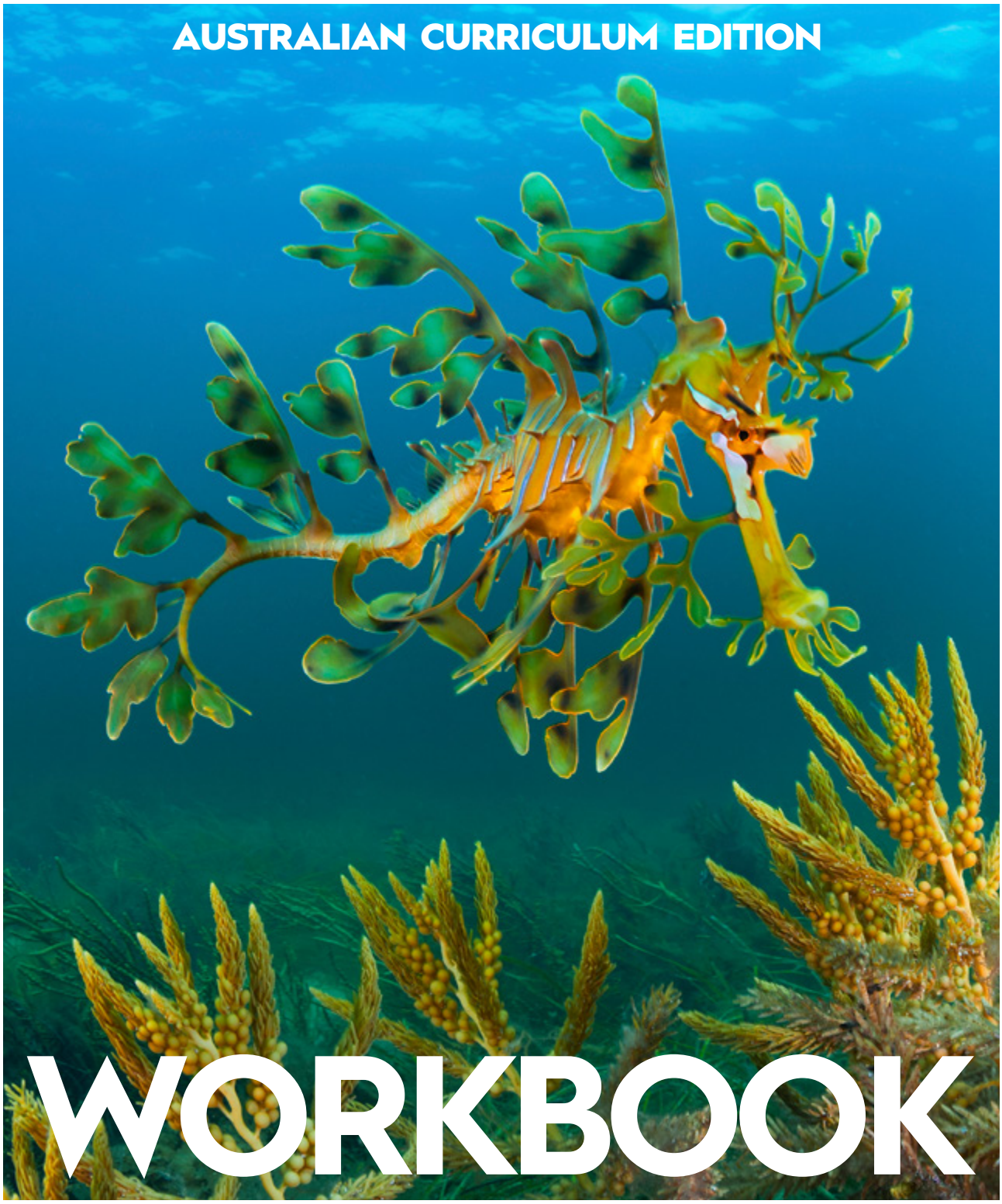
BIOLOGY

LEVELS OF LIFE

AUSTRALIAN CURRICULUM EDITION



WORKBOOK

BRIAN LECORNU TONY DIERCKS

BIOLOGY

LEVELS OF LIFE

AUSTRALIAN CURRICULUM EDITION

WORKBOOK

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BIOLOGY: LEVELS OF LIFE WORKBOOK
AUSTRALIAN CURRICULUM EDITION

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Cover Photograph:
Cover photograph © Gary Bell/OceanwideImages.com
A leafy seadragon off the coast of Yorke Peninsula, South Australia
Leafy Seadragons *(Phycodurus eques)* are endemic to Australia and are found from Lancelin WA, to Wilsons Promontory, Vic, but are mostly sighted in South Australian waters and southern WA waters. The Leafy Seadragon is the marine emblem of South Australia.

Contents

To the Student

BIOLOGY: Levels of Life Workbook (Australian Curriculum Edition), written specifically for the Stage 2 Biology subject outline of the SACE Board of South Australia, is designed to assist you as you work through the year and then be used as a resource and reference for final revision.

The questions in this workbook cover all of the Science Understandings that are examinable at the end of the year. There is a section designed to help you to select a topic and plan your Science as a Human Endeavour Investigation. We strongly advise that you seek help from your teacher in making this decision.

You will gain most benefit if you use this workbook in conjunction with its companion textbook **BIOLOGY: Levels of Life (Australian Curriculum Edition).**

As you work through the questions you should check your answers with your teacher. A complete set of Workbook answers is included in the **BIOLOGY: Levels of Life Teaching Notes (Australian Curriculum Edition),** and in the **Teacher Edition of the e-Workbook.**

We hope that you find the study of Biology interesting and enjoyable and that this workbook helps you to achieve success.

Acknowledgements

The authors would like to thank Sonya Johinke for editing the questions and for providing valuable suggestions during the preparation of this workbook. Phil Gibson at ApplePi Design has been extremely helpful in the preparation of the **BIOLOGY: Levels of Life Textbook, Workbook,** and **Teaching Notes.**

Brian LeCornu
Tony Diercks
January 2024

1 Chromosomes and DNA

Subject Outline terms and phrases	**DNA, double-stranded, helical, cytosol, prokaryote, nucleotide, genetic information, eukaryote, chromosome (linear, circular), nucleus**

1. Organisms are made of one or more cells and cells are made of chemicals.
   Define the following chemical terms:

   element:

   compound:

   molecule:

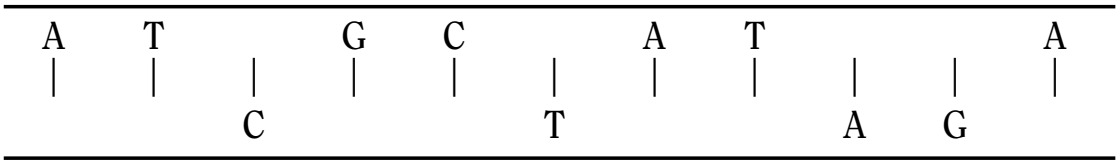
   organic compound:

2. (a) Describe how DNA stores and transmits genetic information.

   (b) DNA functions in the same way in all living things. Explain what this means.

3. (a) Describe a **nucleotide** molecule and name its subunits.

(b) Complete the following diagram of a segment of DNA to show the missing nitrogen bases.



(c) On the diagram in part (b) what has been used to represent the weak hydrogen bonds?

4. State four important features of DNA.

(1)

(2)

(3)

(4)

5. Explain why DNA is a suitable molecule for storing genetic information in organisms.

6. What is the difference between **cytosol** and **cytoplasm**?

7. (a) Describe the structure of a **chromosome** in a eukaryotic cell.

(b) What is the function of chromosomes?

8. Complete the following table comparing chromosomes in prokaryotes and eukaryotes:

	Chromosomes in prokaryotes	**Chromosomes in eukaryotes**
Shape		
Histones present or absent		
Location in cell		
Number per cell		
Introns present or absent (see glossary)		
Where centromere attaches during cell division		

2 The Language of Life

Subject Outline terms and phrases	**genetic information, nucleotide, weak bonds, complementary base-pairing, semi-conservative replication, universal, protein synthesis, gene, transcription, translation, mRNA, tRNA, amino acid, ribosome, codon, anticodon, exon, intron, polypeptide, DNA codon, RNA codon, coding strand, template strand**

1. DNA is generally described as a double helix. Explain what this term means by referring to the structure of DNA.

2. Explain what is meant by 'Base-pairing rules and method of DNA replication are universal'.

3. Refer to the diagram at right.

   (a) On the diagram label a **single nucleotide** [1], the **original DNA strands** [2], the **position of a weak bond between** the **strands of DNA** [3], and a **new DNA strands** [4].

   (b) Why is the replication of DNA called semi-conservative?

(c) Explain why the replication of DNA is necessary for DNA to carry genetic information from one generation to the next.

4. (a) Why is it that some of the information on a DNA molecule must be 'translated into proteins' in order to direct the activities of the cell?

(b) State the structure and function of a gene.

Structure:

Function:

5. Explain why the genetic code must be made up of codons that are at least three bases long.

6. What role does each of the following cell components play in protein synthesis?

(a) mRNA

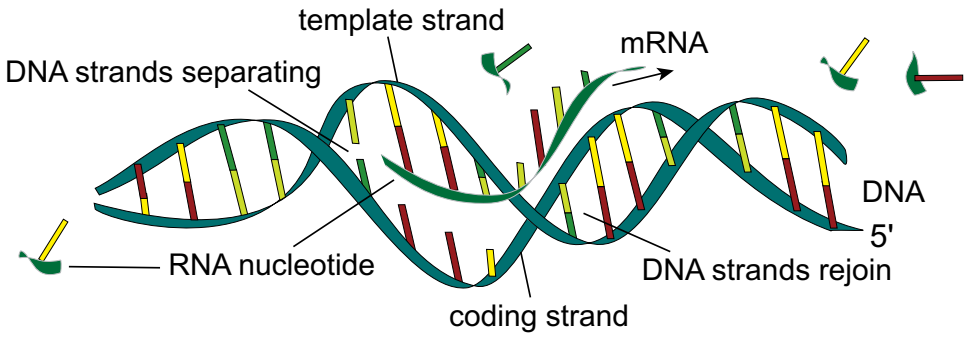
(b) tRNA

(c) ribosomes

7. Write the chromosome number on which the gene is located for the following human genetic diseases. (see textbook chapter 1 and 2)

haemophilia	red-green colourblindness
Huntington's disease	cystic fibrosis
Duchenne muscular dystrophy	retinitis pigmentosa

8. (a) On the diagram label the the coding strand, the template strand of DNA, the mRNA, the weak hydrogen bonds, and the ends of the strands



(b) Explain the meaning of 3' to 5' when referring to DNA.

9. Distinguish between DNA codons, RNA codons, and RNA anticodons.

DNA codons:

RNA codons:

RNA anticodons:

10. Complete the following table showing details of transcription and translation.

Process	Site in eukaryotic cells	Molecules involved	Product
Transcription		(1) (2) (3)	
Translation		(1) (2) (3)	

11. Use the words **gene, chromosome, DNA, bases,** and **protein** to fill in the gaps in the following sentence:

A segment of on a that contains the complete sequence of required to direct the synthesis of a is called a .

12. Use the genetic code (textbook P16) to complete the following table of codons and anticodons.

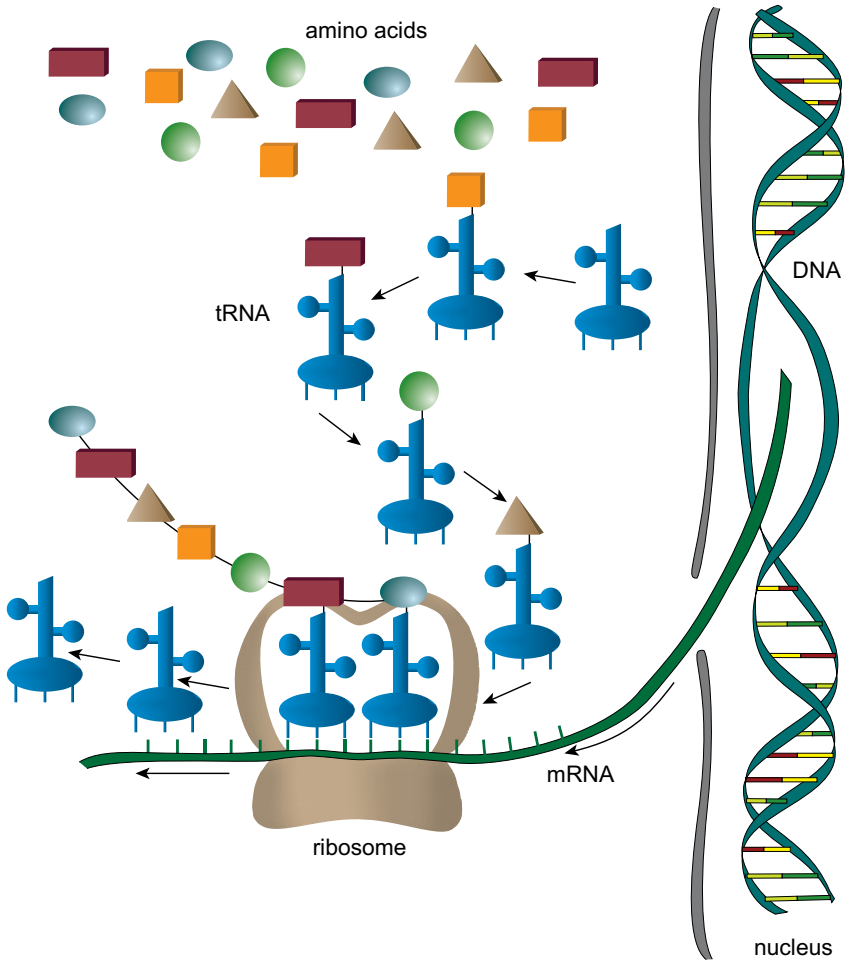
DNA (template)			TTA	
mRNA	CUA			
tRNA		GCC		
amino acid	leucine			glycine

13. How could a protein be affected by a change in the base sequence on the DNA?

14. Complete the following table showing details of nucleic acids. (see Textbook Chapter 1 and 2)

Nucleic acid	Overall shape	Bases present	Type of sugar present	Structure formed	Site in the cell
DNA	double helix				
mRNA					
tRNA					
				ribosome	

15. (a) Label each of the following structures on the diagram below.
amino acids, DNA, mRNA, nuclear membrane, ribosome, tRNA.



(b) In an eukaryotic cell transcription occurs in the

and translation occurs at the

16. (a) Distinguish between an **exon** and an **intron.**

(b) Describe how the RNA transcript is coverted to mature mRNA during the process of transcription.

3 Proteins

Subject Outline terms and phrases	**primary, secondary, tertiary, quaternary, three-dimensional shape, enzyme, hormone, receptor protein, antibody, substrate, induced-fit model, temperature, pH, inhibitors, activation energy**

1. Define the following terms used to describe protein formation.
   Primary structure:

   Secondary structure:

   Tertiary structure:

   Quaternary structure:

2. Explain how the primary and secondary structure of a protein give rise to a unique tertiary structure.

3. Complete the following table for protein function.

Function	Examples
structural	
	antibodies
	hormones
hormone recognition	
catalyse reactions	

4. Explain how the **three-dimensional shape** of proteins plays an important role in their ability to recognise and bind to specific molecules.

5. 'Antibodies are specific to their antigens'.

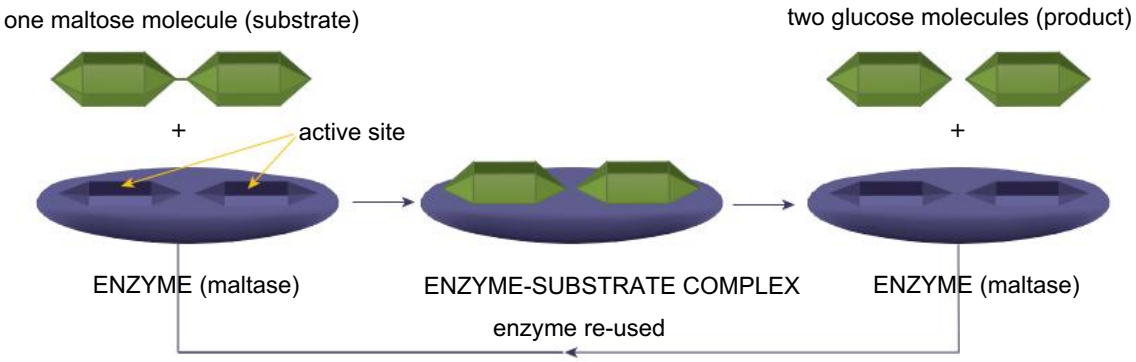
   Explain the statement above by referring to the molecular shapes of antigens and their corresponding antibodies.

6. (a) What is the function of **enzymes**?

   (b) What are enzymes made of and how do they differ from one another?

   (c) Explain the difference between **intracellular** and **extracellular** enzymes.

7. (a) On the diagram below label the **substrate, enzyme, enzyme-substrate complex** and **product.** Indicate the position of the **active site.**



(b) Use the example in the diagram above to explain why an enzyme is specific for its substrate.

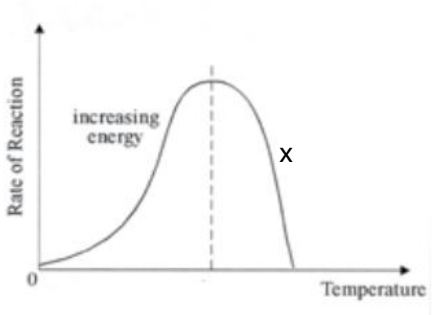
(c) Describe the induced-fit model of enzyme-substrate binding.

8. On the pH scale below label the positions that correspond to **acidic, basic,** and **neutral.**

9. Refer to the graph at the right.

(a) On the temperature axis, label the dotted line.

(b) Explain why the rate of reaction decreases in the region labelled X.

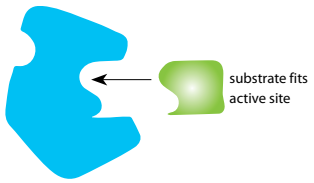


(c) Besides temperature, state two environmental factors that affect the activity of enzymes.

Factor 1:

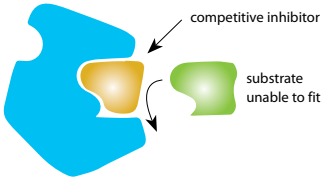
Factor 2:

10. (a) On the diagram at right label the enzyme (E), the competitive inhibitor (C), and the non-competitive inhibitor (NC).

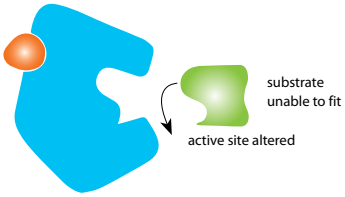


(b) Explain how (i) competitive and (ii) non-competitive inhibitors can affect the function of an enzyme.

(i) competitive inhibitors



(ii) non- competitive inhibitors



11. How do pH and temperature alter the binding of enzyme and substrate molecules?

pH

temperature

12. Explain the change in the rate of an enzyme-controlled reaction:

(a) as the concentration of reactants increases (See Textbook Fig. 3.17)

(b) as the concentration of the enzyme increases (See Textbook Fig. 3.18)

13. (a) What is meant by the term **activation energy**?

(b) What effect do enzymes have on the activation energy required for biological reactions?

4 Genes and Phenotypic Expression

Subject Outline terms and phrases	**phenotypic expression, cellular differentiation, tissue, gene expression, cytosine, methylation, epigenetic, cancer, mutation, cell division, ionising radiation, mutagenic chemicals, viruses, germ cells, somatic cells**

1. What is meant by:
   (a) **phenotypic expression**?

   (b) phenotype?

2. Complete the following table of gene products that influence phenotypic expression.

Gene Product	**Phenotypic expression**
increased EPO	
	diabetes
	increased body size and muscle mass
auxins	
	ripening of fruit
testosterone	
	female secondary sex characteristics

3. Complete the following table of environmental factors that affect transcription and translation, and hence phenotypic expression.

Environmental factor	**Phenotypic expression**
lack of oxygen in humans	
	change in skin colour
lack of iodine in axoltl diet	
	goitre in humans
malnutrition in children	
	increased plant growth

4. (a) What are **transcription factors**?

   (b) State two ways in which transcription factors control gene expression.

   (c) State two factors that affect translation.

5. Define the term cell differentiation, and give four examples of differentiated cells.

6. Explain how **methylation** of the **cytosine** nucleotide of a gene can affect the process of transcription.

7. Describe how **epigenetic** modifications such as changes in DNA methylation can lead to cancer.

8. (a) What is a '**mutation**'?

   (b) Explain what is meant by the idea that mutations can occur spontaneously.

   (c) List three factors that can increase the mutation rate.

9. Complete the following sentence.

   A change in the base sequence of _____ can cause a change in the _____ produced or the failure of a _____ to be produced. This may result in the appearance of new _____ in offspring.

10. (a) Explain the meaning of the term 'genetic disease'.

    (b) State three reasons why mutations that occur in your cells may have no apparent effect on you.

11. Explain why mutation of DNA in a **somatic cell**, such as a skin cell causing skin cancer, does not get passed on to the next generation.

12. Explain why mutation of DNA in a germ cell can lead to changes in the characteristics of descendants. Give three examples.

13. (a) State two examples of genetic and/or chromosomal abnormalities that result in disease in humans.

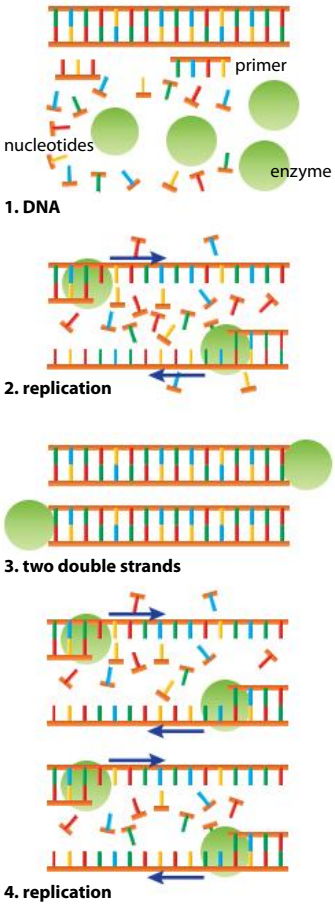
    (b) Describe the effects of these diseases. (see Textbook Chapter 13 for more details)

5 The Use of Genetic Information

Subject Outline terms and phrases	**polymerase chain reaction (PCR), base sequence, primer, heat-resistant enzymes, free nucleotides, electrophoresis, electropherogram, DNA profiling, forensic science, genome**

1. Outline the steps used to extract DNA from a cell.

2. By referring to the diagram at right describe how **PCR** is used to amplify small quantities of DNA. Use the terms heating and cooling, primers, free nucleotides, heat-resistant enzymes.



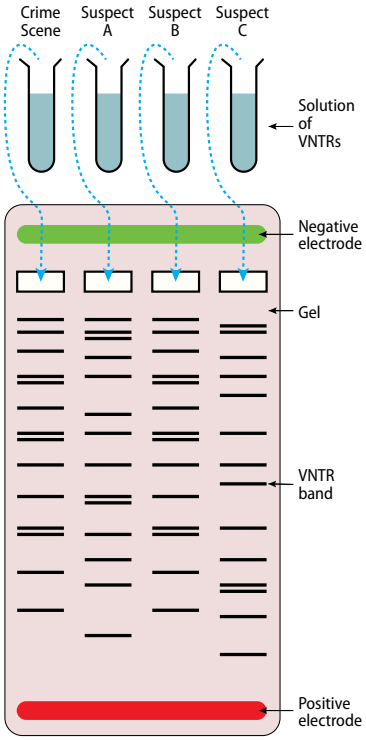
3. Explain how gel **electrophoresis** is used to:

   (a) produce an electropherogram that shows a DNA sequence

(b) separate DNA fragments of different lengths.

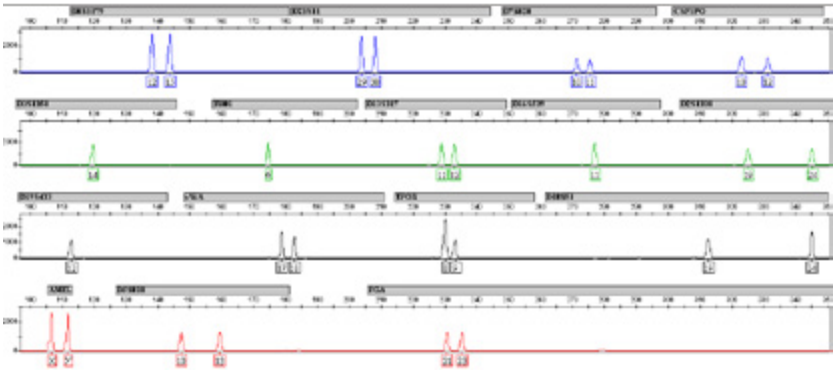
4. Explain why an individual can be identified by analysing their DNA fragments.

5. Refer to the diagram, which shows **DNA profiles** from a crime scene and three suspects. Which suspect's profile matches the DNA from the crime scene? Explain your answer, including why the other suspects' profiles do not match the DNA from the crime scene.



6. Make a list of the uses of the products of the PCR technique under each of the following headings:

forensic science	medicine	scientific research



Locus	Chromosome	STR	Allele values
D8S1179	8	TCTA	12,15
D21S11	21	TCTA	29,30
D7S820	7	GATA	10,11
CSF1PO	5	AGAT	10,12
D3S1358	3	TCTA	14,14
TH01	11	AATG	6,6
D13S317	13	TATC	11,12
D16S539	16	AGAT	11,11
D2S1338	2	TGCC	19,24
D19S433	19	AAGG	12,12
VWA	12	TCTA	17,18
TPOX	2	AATG	8,9
D18S51	18	AGAA	19,24
Amelogenin	X; Y		X,Y
D5S818	5	AGAT	10,13
FGA	4	TTTC	21,23

7. Refer to the diagram above, which shows an electropherogram and matching table of data for a DNA profile.

   (a) How many sites are represented on this electropherogram?

   (b) (i) At site D8S1179 this individual has a reading of 12,15. What does this mean?

   (ii) Why did the '12' and '15' fragments separate during electrophoresis?

   (c) List the sites at which this individual is homozygous.

   (d) What is an STR? Which STR is used at site VWA?

8. The Human Genome Project is one of the most ambitious undertakings by humanity.

   (a) State three benefits and potential benefits resulting from knowledge of the complete human genome.

   (b) State three problems that could arise from this knowledge.

9. (a) State three ethical issues that result from the collection of genetic information.

   (b) State and describe an economic issue that result from the collection of genetic information.

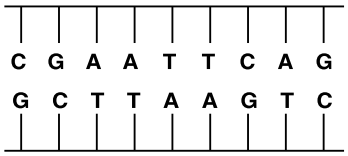
   (c) Explain why the collection of genetic information could be a cultural issue.

6 Biotechnology (Human Manipulation of DNA)

Subject Outline terms and phrases	**biotechnology, plasmid, vector, bacterial transformation, probe (DNA or RNA), restriction enzyme, virus, microinjection, CRISPR, electroporation**

1. (a) Describe the role of restriction enzymes in selecting and removing particular genes from a chromosome.

   (b) The DNA segment below is cut by the restriction enzyme ***EcoR1*** at the site 'AATT'.
   Write the base sequence of the sticky end of the left fragment after the DNA has been cut.



2. State three important features of a DNA or RNA probe.

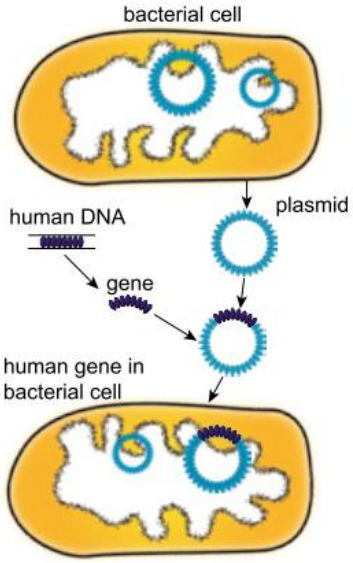
3. Describe how particular genes can be:

   (a) selected, using probes

   (b) removed, using restriction enzymes.

   (c) Name one method, other than DNA and RNA probes, that can be used to select a particular gene.

4. Use the diagram below to explain how a bacterial cell can be used to produce human insulin.



5. State three advantages and three disadvantages of the human manipulation of DNA.
   Advantages:

   Disadvantages:

6. Explain how and why a human gene needs to be altered before it can be expressed by a bacterial cell.

7. Describe how selected genes can be transferred between species using

   (a) **bacterial plasmids**

   (b) **viruses**

   (c) **microinjection**

8. What is meant by the term **transgenic organism**? Give an example to illustrate your answer.

9. Give three examples of chemicals or organisms that can be produced by genetic engineering.

10. Prior to the 1980s the hormone insulin was obtained by extracting it from cattle pancreases. Human insulin is now manufactured as a result of advances in genetic engineering. Discuss advantages and concerns of using genetic engineering to produce human insulin.
    Advantages:

    Concerns:

11. (a) What is **gene therapy**?

    (b) State two methods that are used in gene therapy.

12. (a) Present one argument for and one argument against the genetic manipulation of organisms for food and medicine.

Food:

Medicine:

(b) Discuss possible effects of the genetic manipulation of organisms on the environment.

13. (a) What is the function of the **CRISPR**/Cas9 system in bacteria?

(b) Describe how CRISPR can be used to edit genes.

(c) How can CRISPR be used to investigate the function of genes in embryos?

14. (a) Describe the steps involved in designing and manufacturing a specific protein.

(b) State three uses of designed proteins.

7 Living Things are Made of Cells

Subject Outline terms and phrases	**cell theory, cell membrane, cytoplasm, organelles, fluid mosaic model, prokaryotic, eukaryotic**

1. State six characteristics that together distinguish living things from non-living things.

   (1)

   (2)

   (3)

   (4)

   (5)

   (6)

2. By referring to your answers to question 1, explain why the cell is the smallest independent unit of life.

3. State the four main ideas of the **cell theory**.

4. Define the following terms.

   cell membrane

   cytoplasm

   organelle

5. Describe the structural differences between a lipid molecule and a phopholipid molecule.

6. Describe the fluid mosaic model of the cell membrane.

7. State four functions of the cell membrane.

8. Complete the following table, comparing prokaryotic and eukaryotic cells:

	Prokaryotic cells	**Eukaryotic cells**
Size		
Chromosome shape		
Presence of nucleus		
Organisation		
Membrane-bound organelles		
Number of chromosomes		
Location of chromosome/s		
Composition of cell wall		

9. State three features of prokaryotic cells and eukaryotic cells that are a reflection of their common evolutionary past.

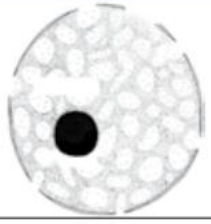
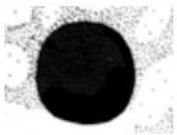
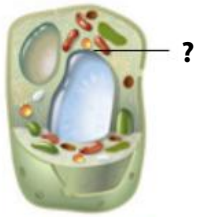
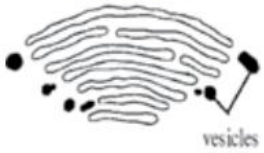
8 Cell Structure and Function

Subject Outline terms and phrases	**organelle, nucleus, nucleolus, mitochondrion, chloroplast, vacuole/vesicle, Golgi body, endoplasmic reticulum(rough and smooth), ribosome, lysosome, cytoskeleton**

1. For each of the following terms, state whether it refers to the **structure** or **function** of a cell:

microscopic	metabolic	cell wall
reproduces	synthesises protein	contains DNA
synthesises DNA	spherical	photosynthesises
respires	cell membrane	

2. Complete the table below which shows features of organelles in eukaryotic cells.

Organelle	Diagram	Function	Distinguishing feature(s)
		controls cell activities	
		rRNA synthesis	
		photosynthesis	
			
			inner membrane folded to form cristae
			

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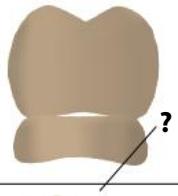
			made of rRNA and protein
		releases digestive enzymes	

3. Describe the following structures, their function, and their location.

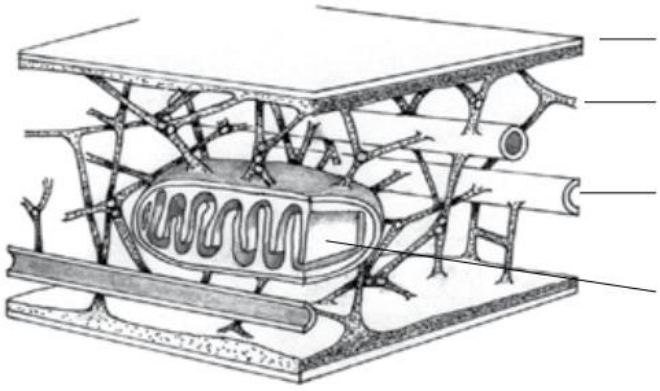
   nuclear envelope

   chromatin

   chromosome

   cristae

4. Label each of these structures:
   microfilament, microtubule, cell membrane, mitochondrion

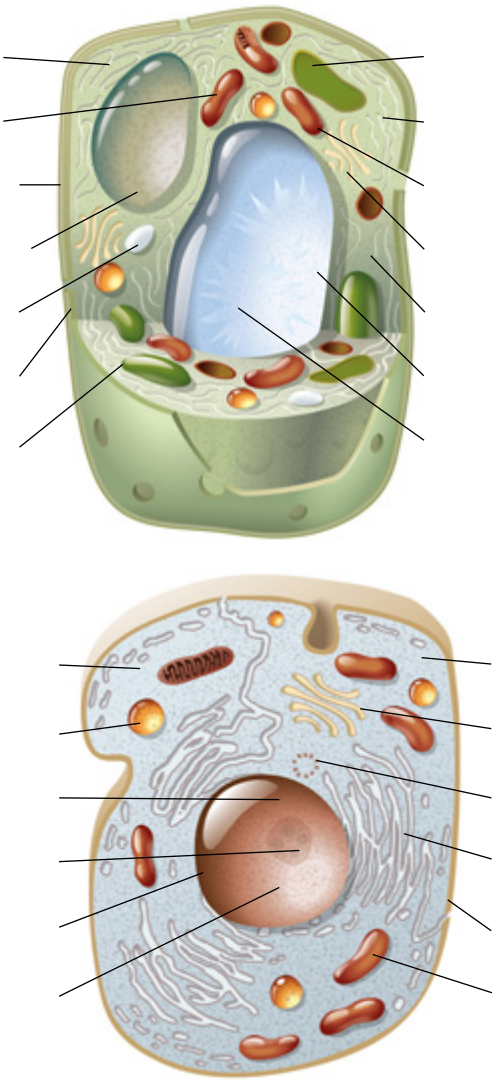


5. State three main functions of the cytoskeleton.

6. Complete the following table which shows the composition, function, and location of components of the cytoskeleton.

Component	Protein component	Description of subunits	Function	Found in
microfilament			intracellular movement	
	tubulin	globular		cilia and flagella
intermediate filament	keratin			skin cells

7. Complete the labelling of the diagrams of plant and animal cells.



8. Complete the following table which compares animal and plant structures.

Structure	Plant cell	Animal cell
cell wall	present	
cell membrane		
nucleus		
nucleolus		
mitochondrion		
chloroplast		absent
vacuole		
Golgi body		
vesicle		
endoplasmic reticulum		
ribosome		
lysosome		
cytoskeleton		

9 Living Cells Need Energy

Subject Outline terms and phrases	**energy, light energy, chemical energy, autotroph, heterotroph, photosynthesis, chlorophyll, energy transformation, chemical bond, ATP, ADP, Pi, metabolic reactions, aerobic respiration, fermentation (anaerobic respiration)**

1. (a) What is **energy**?

   (b) State three reasons why living cells need energy.

   (1) (4)

   (2) (5)

   (3) (6)

2. Complete the following sentences:

   The energy that cells obtain from their environment can be in either or form. Some cells use sunlight, a form of energy, while others must take in , a form of energy.

3. Define the following terms:

   (a) **autotroph**

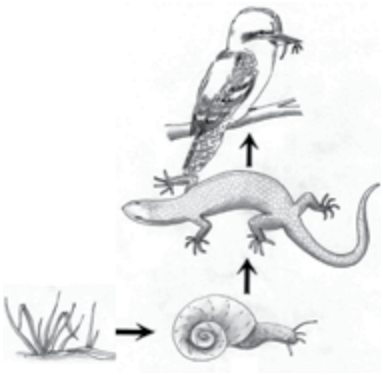
   (b) **heterotroph**

   (c) **photosynthesis**

4. Complete the following table which refers to energy transformations in cells.

Cell	Energy input	Energy output
photosynthetic cell		
muscle cell		
light-emitting cell (e.g. glow worm)	chemical	

5. By referring to the diagram on the right, state the source of organic molecules for each organism.



grass:

snail:

lizard:

kookaburra:

6. (a) What is the main source of energy for life on Earth?

(b) Explain how a heterotroph like yourself is able to obtain energy from this source.

(c) Explain why nearly all life on Earth is dependent on the process of **photosynthesis**.

7. Complete the missing information in the following chemical and word equations for photosynthesis.

$$+ \quad 6H_2O \xrightarrow[\text{chlorophyll}]{\text{light energy}} C_6H_{12}O_6 + $$

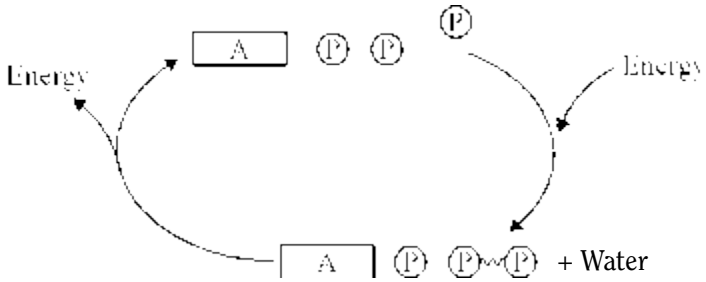
$$+ \quad \text{water} \xrightarrow[\text{chlorophyll}]{\text{light energy}} + \quad \text{oxygen}$$

8. What is the role of chlorophyll in photosynthesis?

9. (a) Explain why certain molecules, such as glycogen, starch, and lipids, are able to be used as stores of energy.

   (b) Energy changes occur when **chemical bonds** are broken and new bonds are formed. By referring to this statement, explain why the breakdown of glucose in the presence of oxygen, to form carbon dioxide and water, releases energy.

10. Use the following diagram of the **ATP** cycle to answer the questions below.



   (a) What is the source of the energy that enters the ATP cycle?

   (b) State three uses of the energy that is released in the ATP cycle.

11. Define the term **cellular respiration.**

12. Some cells provide themselves with energy using a chemical process requiring oxygen, while other cells use a chemical process that does not require oxygen. Certain cells are able to use both processes.

    Name these chemical processes that cells use to provide themselves with energy.

    (1) chemical process requiring oxygen

    (2) chemical process not requiring oxygen

13. Complete the missing information in the following summary equation for **aerobic respiration**.

    $C_6H_{12}0_6$ + ——————> + $6H_2O$

    + oxygen ——————> + water

14. Complete the following sentence.

    Energy that is released as a result of breakdown of glucose in the presence of oxygen is either lost as _____ or is used to make _____ which can be used by the cell for energy-requiring processes.

15. Complete the following table which shows details of the stages of aerobic respiration.

Name of reaction	Site of reaction	Reactants	Products	Net gain of ATP
glycolysis			pyruvate	
phosphorylation	cytoplasm and mitochondria			

16. Complete the missing information in the following summary equations for **fermentation (anaerobic respiration)**.

    In plants and yeasts

    $C_6H_{12}0_6$ ——————> $2C_2H_5OH$ + _____

    glucose ——————> _____ + _____

    In animals

    $C_6H_{12}0_6$ ——————> $2C_3H_6O_3$

    _____ ——————> _____

17. Complete the following table which summarises the main differences between aerobic respiration and fermentation (anaerobic respiration) in eukaryotes.

	Aerobic Respiration	Fermentation
Site of reaction(s)		
Reactants		
Products in animals		
Products in plants and yeasts		
Amount of ATP produced per glucose molecule		

18. (a) State two commercial uses of fermentation.

(b) Under what conditions would a human cell carry out lactic acid fermentation?

19. Explain why much less energy is released through fermentation than through aerobic respiration, even though both processes involve the breakdown of glucose.

20. Human sperms cells contain a large number of mitochondria.
Explain how this relates to their function.

A sperm cell containing mitochondria

10 Movement in and out of Cells

Subject Outline terms and phrases	**transport proteins, channel proteins, aquaporins, carrier proteins, diffusion, facilitated diffusion, osmosis, active transport, endocytosis, exocytosis, surface-area-to-volume ratio, concentration gradient, exchange**

1. Complete the tables below to summarise the differences in inputs and outputs for autotrophic and heterotrophic cells.

Table of inputs

Substance	Autotrophic cells	Heterotrophic cells
oxygen		
carbon dioxide		
nitrates, nitrites		
phosphates		
calcium		
other inorganic nutrients		
organic compounds		

Table of outputs

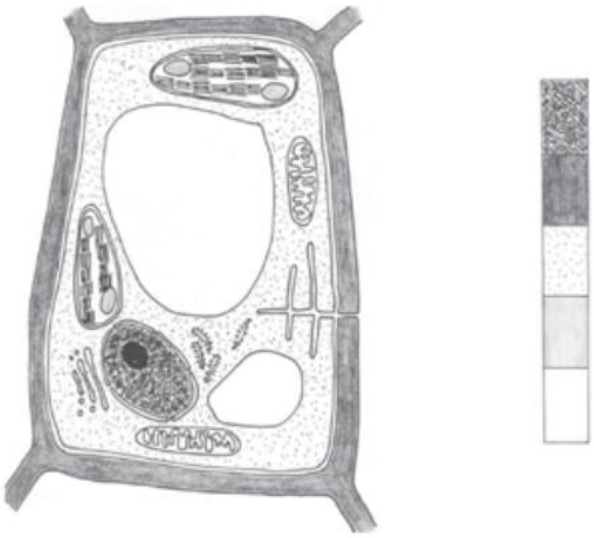
Substance	Autotrophic cells	Heterotrophic cells
oxygen		
carbon dioxide		
lactic acid		
ethanol		
urea		

2. The membrane of a human muscle cell maintains different concentrations of materials inside and outside the cell. Give an example of a substance that has a higher concentration inside a human muscle cell than outside, and an example of a substance that has a higher concentration outside a human muscle cell than inside.

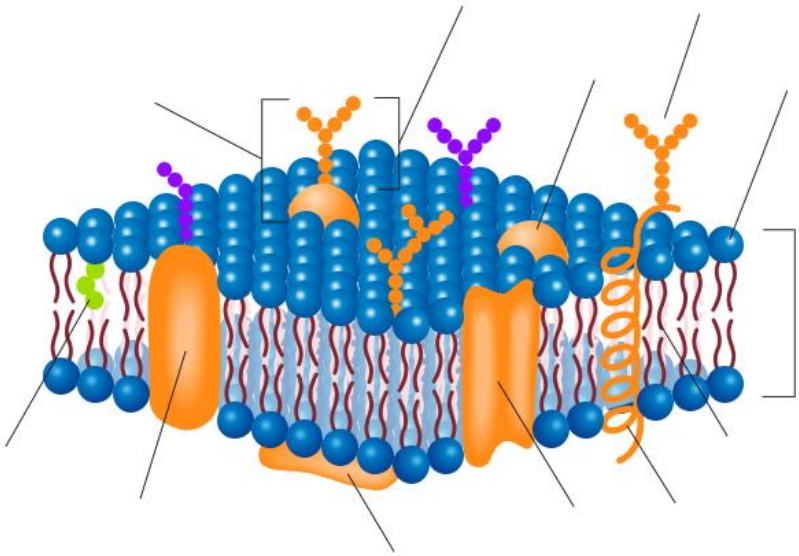
   Substance that has a higher concentration inside

   Substance that has a higher concentration outside

3. Label the key next to the diagram below to show the location of *starch, cellulose, water, protein* and *nucleic acids* in the cell. On the cell diagram label the location of *lipids.*



4. (a) Label the features of the fluid mosaic model of the Cell membrane shown below.



(b) State 3 functions of the cell membrane.

5. Give two examples of transport proteins

6. Define the following terms and give examples.

   concentration gradient

   passive process

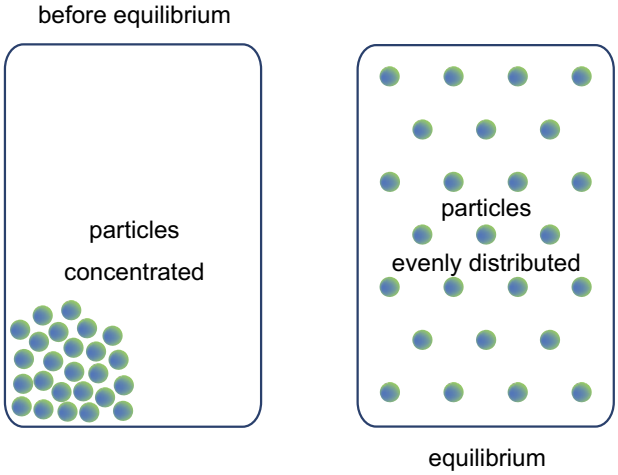
   semi-permeable

   active process

7. Complete the following table which refers to the processes by which substances move across membranes.

Process	Active/Passive	Example of substance moving	Direction of movement
diffusion			
facilitated diffusion			with concentration gradient
	passive	water	
	active	sodium ions and potassium ions	
pinocytosis			into cell
		bacterial cells	into cell of immune system
exocytosis			

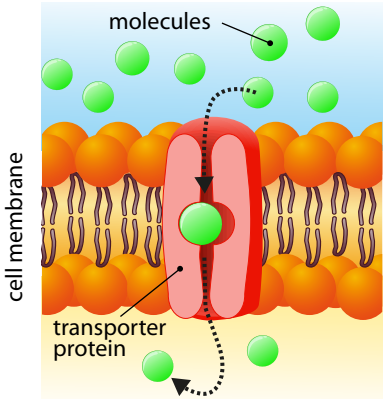
8. The following diagrams represent the position of molecules in a fluid before and after **diffusion** has occurred.



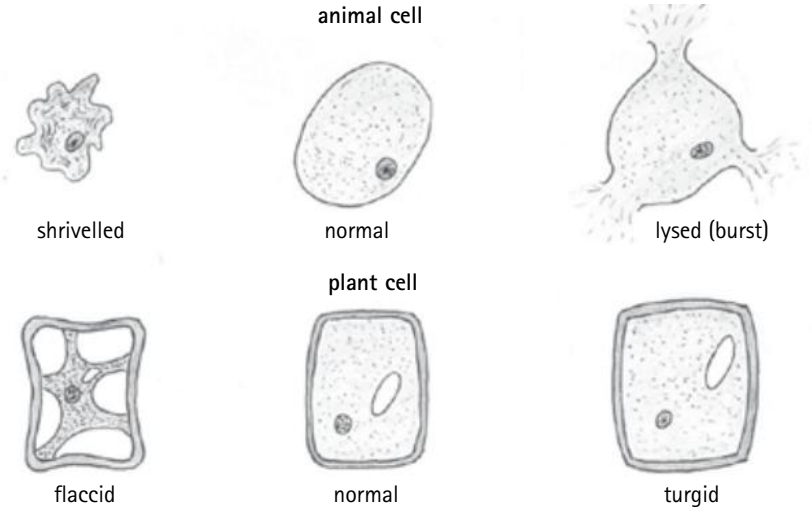
Explain what has happened between the first and second diagram.

9. (a) What is meant by the selective exchange of materials by the cell membrane?

(b) Explain how **facilitated diffusion** works, by referring to the following diagram.



10. The following diagram shows the effects of osmosis on animal and plant cells. In the spaces below the diagram explain what has happened to the flaccid/shrivelled and the turgid/lysed cells.

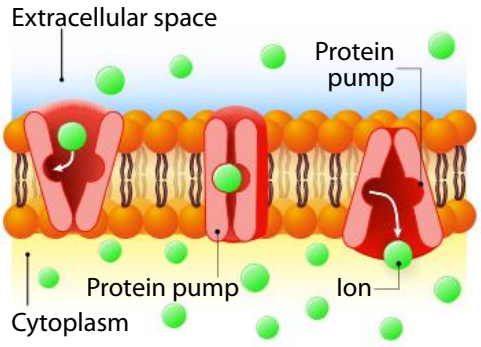


flaccid/shrivelled:

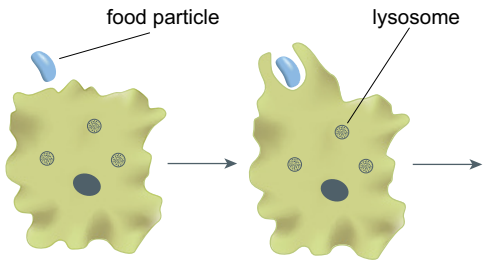
turgid/lysed:

11. Explain why osmosis is considered to be a special case of diffusion.

12. Explain how **active transport** works, by referring to the following diagram.



13. The following diagram shows a cell that is about to engulf a food particle.



(a) Describe the remaining steps in the process

(b) State the name of this cellular process.

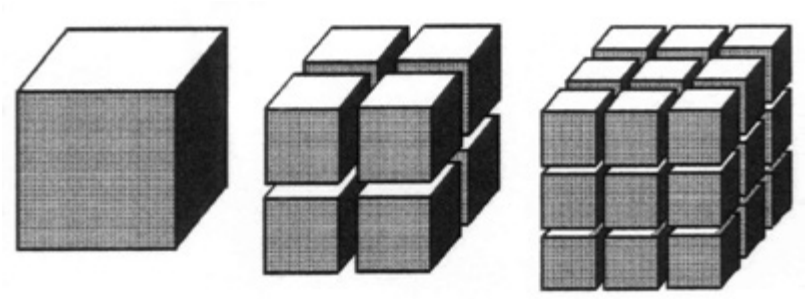
(c) Name two cells that carry out this process.

14. Complete the following table which shows features of some energy-requiring processes that move substances across cell membranes.

Type of movement	Direction of movement	Examples of cells involved	Example of substance moved	Energy supplied by
endocytosis (phagocytosis)	into the cell			ATP
endocytosis (pinocytosis)			fat droplets	
exocytosis		salivary glands		
active transport		human muscle cell		

15. Explain the meaning of the statement 'The cell membrane is a dynamic structure'. In your answer you should refer to the role of the membrane in active transport, endocytosis, and exocytosis..

16. The diagram below shows the change in surface area that occurs when a large cube (6 cm by 6 cm by 6 cm) is divided into eight equally-sized medium cubes or 27 equally-sized small cubes.



(a) Calculate the total surface area of

(i) the 27 small cubes

(ii) the eight medium cubes

(iii) the one large cube

(b) Use your answers to explain how the **surface-area-to-volume ratio** changes as the large cube is divided into smaller pieces.

(c) Explain why the relationship between surface area and volume is an important factor in determining the survival of cells.

17. (a) State two processes that contribute to in an increase in the size of a cell.

(b) Explain why the size of a cell is limited by the change in its surface area to volume ratio as it grows.

18. (a) Explain how the concentration gradient of a substance affects its direction and rate of diffusion across a cell membrane.

(b) Explain why active transport is needed to move some substances across a cell membrane.

19. Explain how the physical and chemical nature of the materials being exchanged affects their movement across a cell membrane

20. Describe the role of the Golgi body in moving substances, such as enzymes and hormones, out of the cell.

11 Cell Metabolism

Subject Outline terms and phrases	**cell metabolism, metabolic pathway, intermediate compound, environmental factor**

1. What is meant by the term **cell metabolism**?

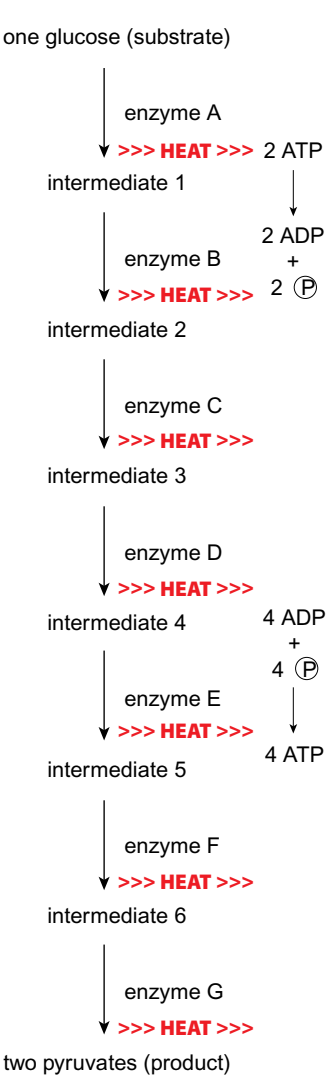
2. (a) Describe the structures of the internal membranes of mitochondria and chloroplasts.

   (b) Explain how the structures of the internal membranes of mitochondria and chloroplasts facilitate some biochemical processes.

3. Explain how biochemical processes in the cell are influenced by the presence of specific enzymes.

4. State three **environmental factors** that influence biochemical processes in the cell.

5. Refer to the diagram at right to answer the following questions.



   (a) Explain why a different enzyme is required for each step in the **metabolic pathway**.

   (b) Explain why the amount of energy in the glucose molecule is greater than the amount of energy in the two pyruvate molecules combined.

   (c) Explain what would happen if enzyme E was inactivated.

6. State four reasons why metabolic pathways in cells involve many small regulated steps.

   (1)

   (2)

   (3)

   (4)

7. (a) Complete the following sentence:

   Poisons are that with cell metabolism.

   (b) State three ways in which poisons can cause this effect on cells.

8. Complete the following table which shows the effects of some chemicals on protein synthesis in prokaryotic and eukaryotic cells.

Chemical	**Effect on prokaryotes**
Chloramphenicol	
	Stops growing peptide moving to new codon
Tetracycline	
	Prevents proper assembly of ribosomes
Rifamycin	
	Effect on eukaryotes
Amanitin	
	Same as chloramphenicol for prokaryotes
	Effect on both
Actinomycin	
	Causes incomplete peptides to fall off the ribosome

9. Complete the following table which shows the effects of some chemicals on cell metabolism.

Chemical	**Effect on cell metabolism**
Carbon monoxide	
	A non-competitive inhibitor
Cyanide	
	Attacks a step in the synthesis of bacterial cell walls
Barbiturates	
	Binds to potassium ion

10. Name the chemicals and provide information about their beneficial use as indicated in the brackets for each of the following categories:

    medical (5 uses):

    agriculture (3 uses):

    food preservation (3 substances)

11. State a harmful effect of each of the following chemicals and explain why the chemical is or was used by humans.

    radium

    mercury

    DDT

    sulfur dioxide

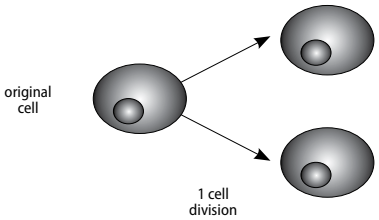
    thalidomide

12 New Cells from Old

Subject Outline terms and phrases	**cell division, somatic cells, gametes, germ-line cells, binary fission, mitosis (mitotic division), asexual reproduction**

1. (a) Where do all new cells come from?

   (b) Refer to the diagram that shows one cycle of cell division. State the number of cells that will be present after three cycles of cell division.



2. The chemical unit of genetic information in most organisms is DNA.

   (a) Explain why the amount of DNA in a cell doubles before cell division.

   (b) What would be the consequence if a cell divided before the replication of DNA occurred?

3. Define the following terms.

   (a) somatic cells

   (b) germ cells

   (c) diploid cells

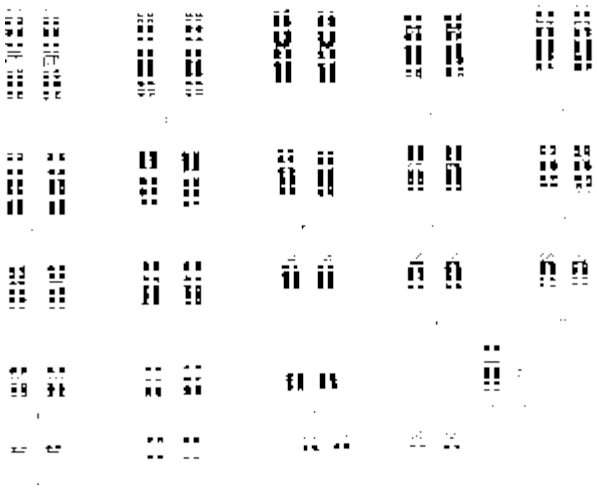
   (d) homologous chromosomes

   (e) haploid cells

   (f) zygote

   (f) germ-line cells

4. Use the human karyotype to answer the following questions. (also refer to Chapter 2)

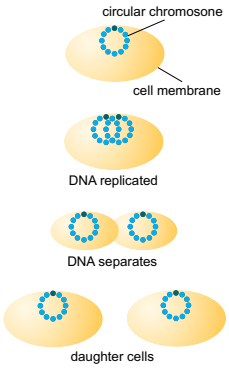


(a) Is this karyotype that of a male or a female? Explain:

(b) How many non-sex chromosomes (autosomes) are in this karyotype?

(c) How could biologists construct a human karyotype like the one shown above?

5. State the name of this process, and describe it using the terms *chromosome, cell membrane, daughter cells*



6. The process of cell division in eukaryotes involves **mitosis**, the precise division of the contents of the nucleus.

   Name the phases of mitosis and describe what happens to the chromosomes at each phase.

   (1)

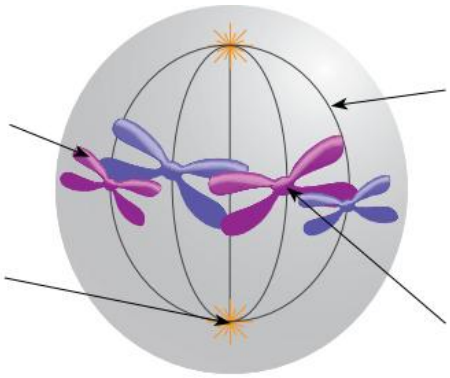
   (2)

   (3)

   (4)

7. The diagram below shows an animal cell that is entering metaphase of mitosis.

   (a) Label the following structures on the diagram:
   chromatid, centromere, spindle fibres and pole.



   (b) How many chromosomes does this cell contain?

8. The two daughter cells that result from a mitotic division contain identical sets of chromosomes. Explain the key events that occur leading up to and during mitosis that produce these genetically identical cells.
   In your answer you should use the following terms:
   replication, condensation, sister chromatids, centromere, spindle fibres, separation

9. Define the following terms.
   (a) asexual reproduction

   (b) budding

   (c) clone

10. (a) State three types of asexual reproduction used by plants.

(1)

(2)

(3)

(b) Name three types of animal that can reproduce asexually.

(1)

(2)

(3)

(c) Name the type of cell division that is involved in asexual reproduction in eukaryotes.

11. (a) Explain why the offspring produced by asexual reproduction are genetically identical to each other and to the parent.

(b) Explain how variation occurs in asexually reproducing organisms.

12. How do the number and type of chromosomes in the daughter cells produced by mitotic division or binary fission compare to those of the parent cells?

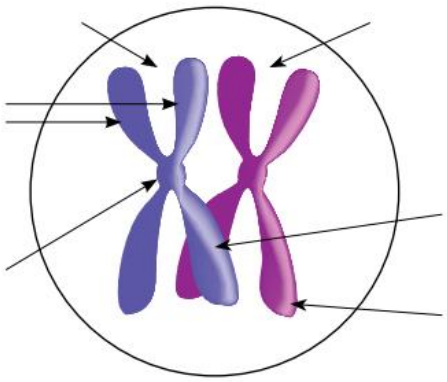
13 Sexual Reproduction and Meiosis

Subject Outline terms and phrases	**diploid, haploid, homologous, meiosis, crossing over, independent assortment, fertilisation, genetic variation, sexual reproduction**

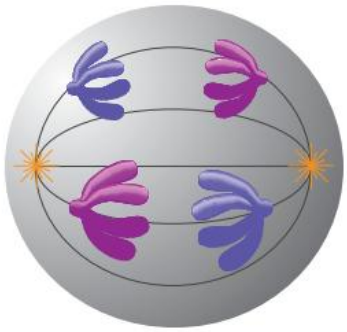
1. (a) How many types of autosome are present in a normal **diploid** human cell?

   (b) How many of each type of autosome are present in a normal diploid human cell?

2. Label the diagram below showing a pair of homologous chromosomes as they would appear while crossing over during late prophase I. Label the following features on your diagram:
   centromere, sister chromatids, chiasma, maternal chromosome and paternal chromosome

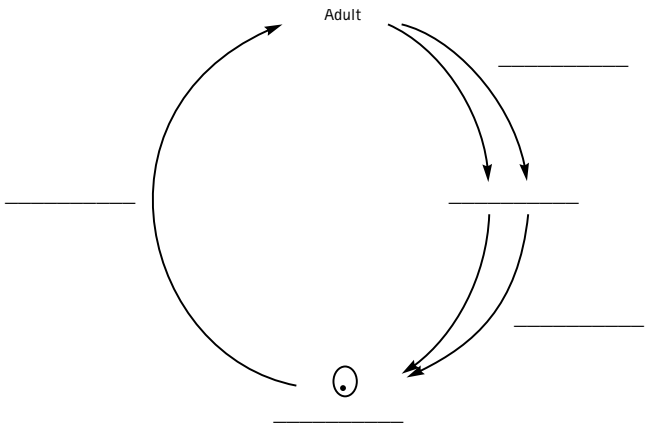


3. (a) Describe what is happening during anaphase I.



   (b) Describe how a second diagram could be drawn (and compared to the diagram in part (a)) to illustrate the idea of independent assortment.

3 (c) Use the following terms to label the diagram below which represents the life cycle of a sexually reproducing organism.
growth and mitosis, gametes, meiosis, fertilisation, zygote



4. Explain how (a) crossing over and (b) independent assortment contribute to genetic variability in the offspring of a sexually reproducing species.

(a) crossing over:

(b) independent assortment:

5. (a) Give an example of a syndrome in humans that is caused by the presence of an extra autosome.

(b) How is it possible for a human to receive this extra autosome?

(c) State one environmental factor that can increase the incidence of this syndrome.

6. Complete the table below to show the differences between **haploid** and **diploid** cells in humans.

	Haploid cell	Diploid cell
Number of chromosomes		
Number of sex chromosomes		
Site of production		
Is further cell division possible?		
Number of autosomes		
Is fusion with another cell possible?		

7. Define the term **fertilisation.**

8. Fill in the missing details in the following description of fertilisation in humans.

SPERM	+	EGG	⟶	ZYGOTE
CHROMOSOMES		CHROMOSOMES		CHROMOSOMES

9. Complete the following table which compares the products of mitosis and meiosis in humans.

	Mitosis	Meiosis
Number of divisions		two
Type of parent cell		germ cell
Number of chromosomes in parent cell		
Type of cell produced	somatic cell	
Number of chromosomes in a daughter cell		
Is product haploid or diploid?		
Number of cells produced in males from one parent cell		

10. Compare the degree of genetic variation in the products of asexual reproduction and sexual reproduction.

11. Complete the following table to show whether the source of genetic variation contributes to the products of asexual and sexual reproduction.

Source of genetic variation	Asexual reproduction	Sexual reproduction
mutation	yes	
crossing over		
independent assortment		
random fertilisation		

12. Explain how fertilisation contributes to the genetic variability of offspring.

14 Control of Cell Division

Subject Outline terms and phrases	**internal factors, external factors, cell cycle, checkpoints, gene products, hormones, carcinogen, regulatory genes, cell culture**

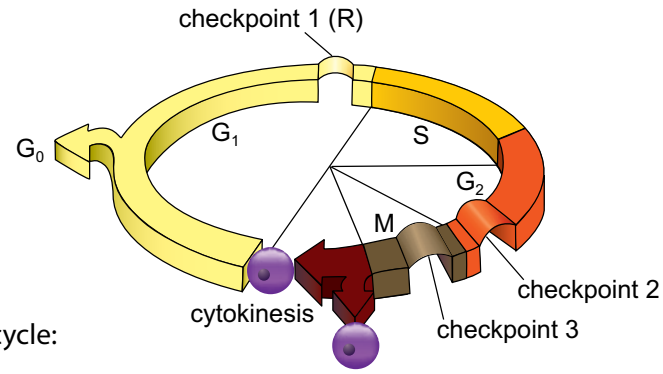
1. State two **gene products** that a cell produces to regulate the **cell cycle**.

2. State two **external factors** that regulate the cell cycle.

3. Complete the following table describing the cell cycle.

Stage	Event(s)	Major Checkpoint (yes or no)
G_0		no
G_1		
	DNA replication	
G_2		yes
mitosis		
cytokinesis		

4. The diagram shows phases of the cell cycle.



(a) State one process that occurs in:

G_1

S

G_2

(b) Explain the roles of each of the following gene products in the regulation of the cell cycle:

growth factors

cyclin

Cdk

MPF

5. Interphase refers to the period in the cell cycle when the cell is not dividing. State three processes that occur in the cell during interphase.

6. What are the two key factors that trigger a stem cell to divide?

7. Plant hormones and growth factors are important in the regulation of cell division. Give three examples of each.

plant hormones:

growth factors:

8. Explain how **carcinogens** upset the normal control of cell division.

   What can happen as a result of this?

9. Complete the following table which shows the most likely cause of mutations that result in different forms of cancer.

Type of cancer	Most likely cause of mutation
skin cancer	
	carcinogens in cigarette smoke
colon cancer	
	high energy radiation (e.g X-rays)
bladder cancer	
	asbestos

10. Humans have been unknowingly culturing cells for thousands of years.
    State three uses for culturing yeast cells and two uses for culturing bacterial cells that humans have been engaged in for centuries.

    uses for culturing yeast cells

    uses for culturing bacterial cells

11. State four contemporary uses of cell culture.

    (1)

    (2)

    (3)

    (4)

12. Cells can be cultured in a number of ways. Provide a contemporary use for each of the following:

    (a) bacterial cell culture on agar plates

    (b) HeLa cells

    (c) animal cell cultures

    (d) plant cell culture

13. (a) State four special provisions required for the growth medium used to culture animal cells.

    (b) State three steps, in the correct sequence, that need to be followed in the technique of plant tissue culture.

14. State two advantages of plant tissue culture over other methods of propagating plants.

    (1)

    (2)

15 Organisms Have Tolerance Limits/

Subject Outline terms and phrases	**internal factors, external factors, cell cycle, checkpoints, gene products, hormones, carcinogen, regulatory genes, cell culture**

1. (a) State five properties of tissue fluid that are kept reasonably constant in humans.

   (1)

   (2)

   (3)

   (4)

   (5)

   (b) Use the concept of **tolerance limits** to explain why it is important that the properties of the tissue fluid that surrounds cells remain reasonably constant.

2. By referring to the diagram below, explain the unique distribution of the trees in the arid outback of Australia.

3. Name a resource whose low level limits the productivity of communities in each of the following locations.

Community location	Resource
Sargasso sea	
an Australian desert	
River Murray	
deep ocean floor	
Mt Kilimanjaro	

16 Homeostasis

Subject Outline terms and phrases	**stimulus, response, stimulus-response model, sensory receptor, effector, homeostasis, internal environment, negative feedback, nervous system, endocrine system**

1. (a) What is meant by the term **stimulus**?

   (b) State four examples of a stimulus.

2. (a) List five main types of **sensory receptor** that are found in humans.

   (b) State five examples of changes in the external environment that humans detect, and to which they respond.

   (c) State two examples of changes in the external environment that humans do not detect, and to which they do not respond.

   (d) Explain why it is important that humans selectively detect and respond to changes in the external environment.

3. Choose one type of sensory receptor found in humans, and explain how the loss of this type of receptor would affect an individual.

4. (a) What is meant by the term **response**.

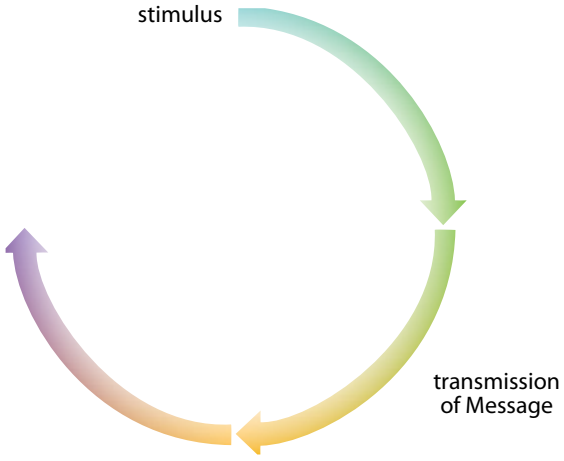
(b) List two types of effector

5. Define the following terms.

homeostasis:

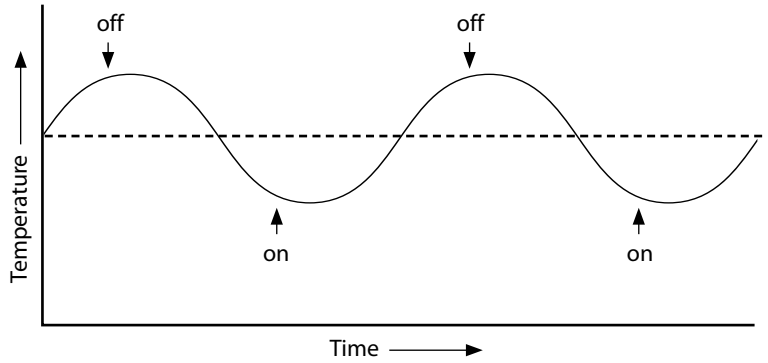
negative feedback:

6. (a) Fill in the missing words to show the five elements of a **stimulus-response model** in the correct sequence.



(b) By referring to the diagram explain the term negative feedback.

7. By referring to the graph below, explain how a homeostatic control mechanism works by responding to a change in the internal environment (such as body temperature), and explain why it cannot keep the factor constant.



8. State two organ systems that are involved in coordination and control in humans.

   (1)

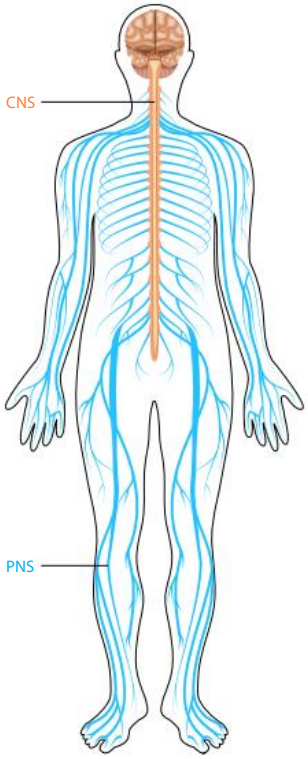
   (2)

17 The Nervous System

Subject Outline terms and phrases	**central nervous system (CNS), peripheral nervous system (PNS), sensory neuron, interneuron, motor neuron, nerve pathway, synapse, neurotransmitter, reflex response**

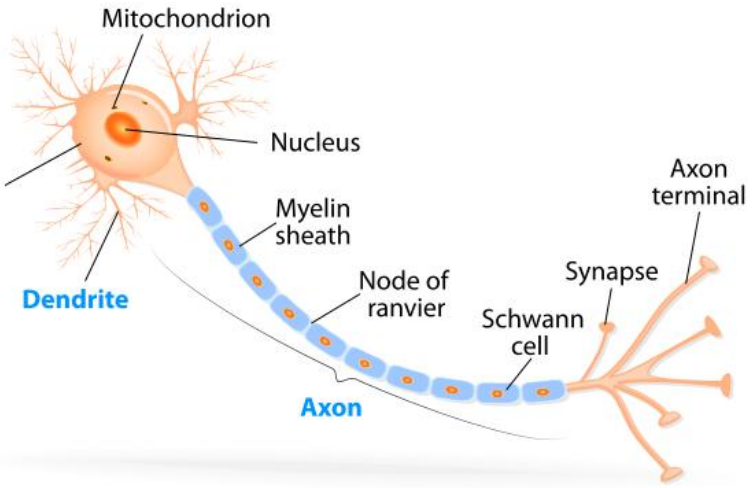
1. (a) On the diagram label the **central nervous system (CNS)** and the **peripheral nervous system (PNS)**.

   (b) State three functions of the CNS.



   (c) Name the two parts of the PNS and state which part of the body each one controls.

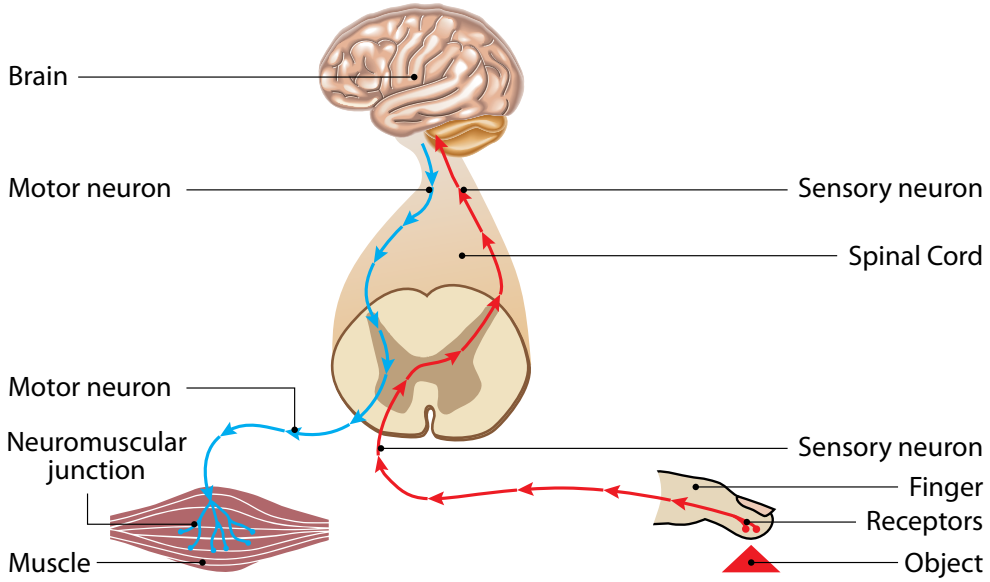
2. On the diagram below, label the following structures:
   cell body, dendrite, nucleus, axon, axon terminal



3. Complete the following table to show the structure and function of **sensory neurons**, **interneurons**, and **motor neurons**.

	sensory neuron	interneuron	motor neuron
unipolar or multipolar			
location	peripheral NS		
main role			
receives signal from	receptor		
sends signal to			

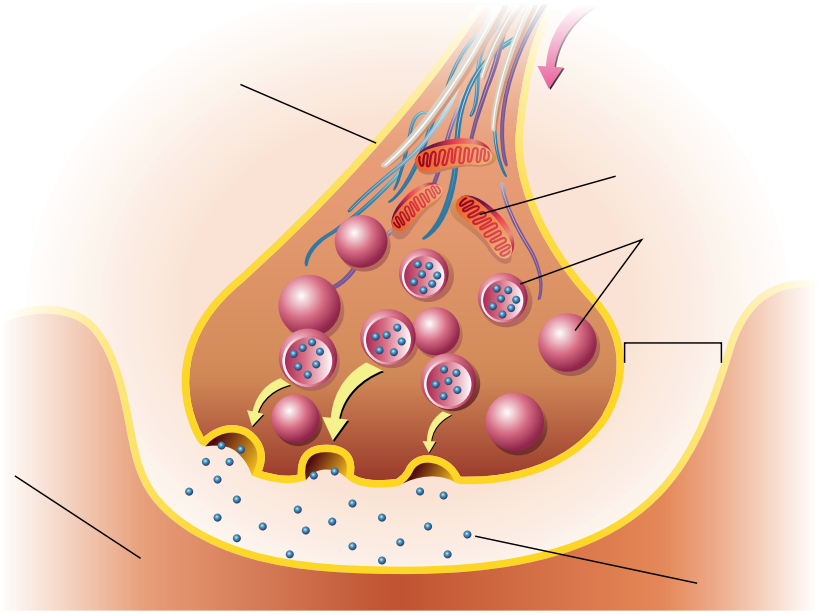
4. Use the following diagram to describe the structure of a **nerve pathway** from receptor to effector:



5. (a) What is a **synapse**?

(b) What is a **neurotransmitter**? Give two examples.

(c) Label the Synapse diagram below with the following: *Nerve Impulse, Mitocondria, Synaptic Cleft, Neurotransmitter, Axon, Vesicle, Dendrite,*



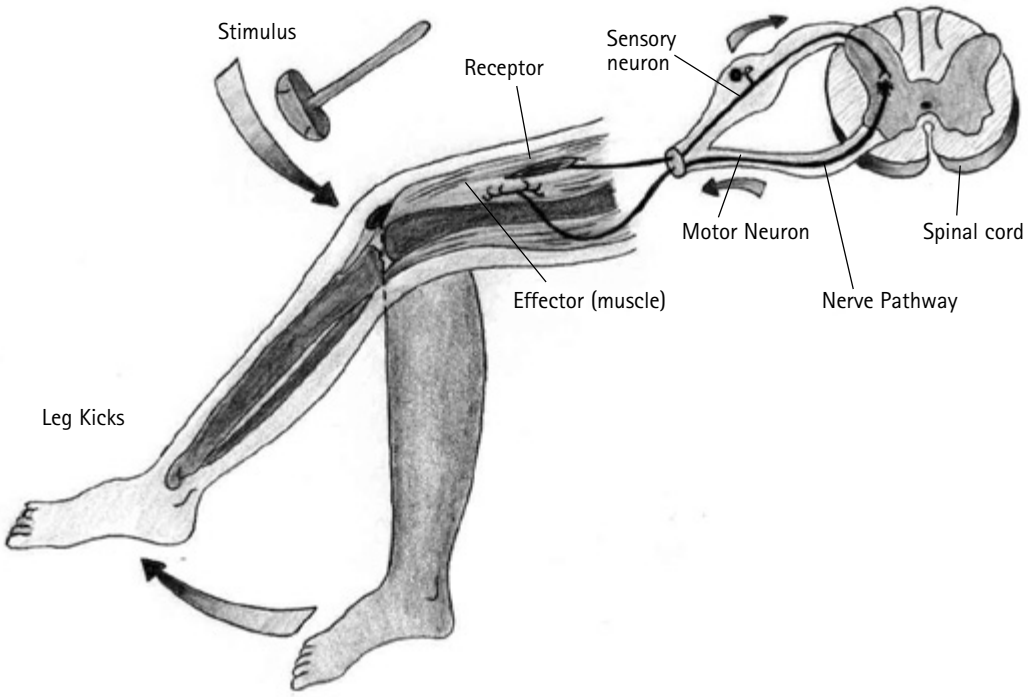
(d) (i) Why is it important that neurotransmitters do not remain in the synaptic cleft?

(ii) How are neurotransmitters removed from the synaptic cleft?

6. (a) What is meant by the term **reflex response**?

(b) State three examples of a reflex response in humans.

7. By referring to the diagram below, describe the sequence of events from the stimulus to the reflex response.



8. What is the advantage to an individual of having the signal from a stimulus, such as heat from a flame, processed directly by the spinal cord, without involving the brain?

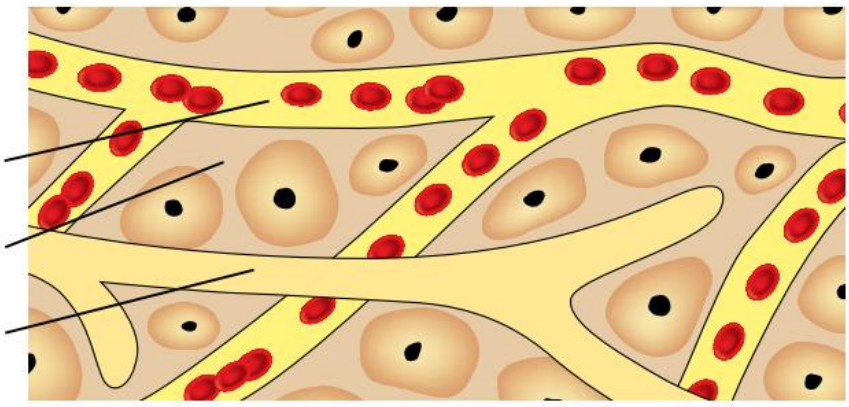
18 The Endocrine System

Subject Outline terms and phrases	**hormone, peptides, amino acid derivitive, steroid, target site, target cell, target tissue, target organ, adrenaline, 'fight or flight' response, thyroid stimulating hormone, thyroxine**

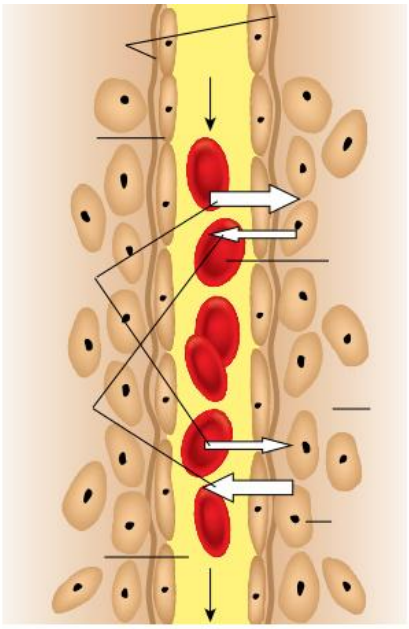
1. Complete the following table which shows different types of hormone.

Type of hormone	Name of hormone	Name of endocrine gland	Target cells, tissues, organs	Effect
	adrenaline			
		adrenal medulla	cardiac muscle, smooth muscle	
				increases oxidative metabolism
	antidiuretic hormone			
				stimulates breakdown of glycogen to glucose, increases blood sugar level
				lowers blood sugar level, increases glycogen storage
	thyroid stimulating hormone (TSH)		thyroid	
	aldosterone			

2. On the diagram, label a *blood capillary, a lymph capillary,* and the *tissue fluid.*



3. (a) Label the following on the diagram below: *red blood cell, plasma, capillary wall, tissue fluid, tissue cells, movement due to osmosis, movement due to blood pressure, direction of blood flow and basement menbranes.*



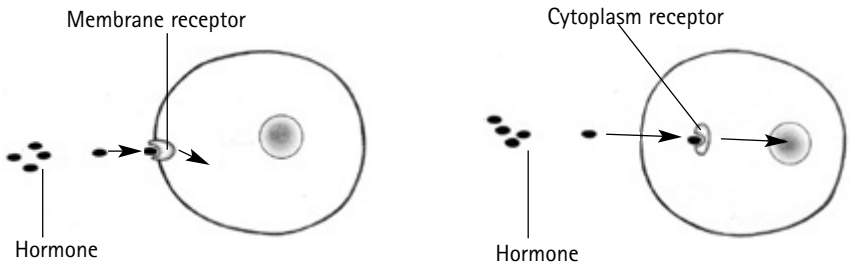
(b) Describe the role of the basement membrance.

4. (a) What is a membrane receptor molecule?

(b) Explain how the distinctive shape of membrane receptor molecules allows cells to recognise other molecules.

5. Explain why a hormone which is present in blood in all parts of the body will only produce an effect on a specific cell, tissue, or organ, and **not** other cells, tissues, or organs.

6. By referring to the following diagrams, explain how water-soluble and lipid-soluble hormones produce an effect on cells.



Water-soluble hormones:

Lipid-soluble hormones:

7. (a) State two examples of hormonal responses that are stimulated by the nervous system.

(b) State two examples of hormonal responses that are stimulated by other hormonal messages.

8. (a) In the **'fight or flight' response**, what do the terms 'fight' and 'flight' mean?

(b) Complete the following table to describe the responses of body structures to adrenaline in the 'fight or flight' response.

Body structure	Response to adrenaline	Effect
smooth muscle around blood vessels of skeletal muscle		increased blood flow
	constrict	redirect blood to the periphery
heart		
		increase air flow to lungs
	increase glucagon secretion	
radial muscles of the iris		

9. Describe the role of **thyroid stimulating hormone** in the production of **thyroxine**, including the importance of negative feedback.

10. Complete the following table which compares the action of the nervous and endocrine systems.

Communication	Pathway	Message	Site of action	Speed of action	Duration
Nervous system					
Endocrine system					

11. Explain why a nerve impulse is more appropriate than a hormonal message for controlling blinking of the eye, but a hormonal message is more appropriate than a nerve impulse for controlling the uptake of glucose from the blood by cells.

12. Explain how the hypothalamus acts as a 'bridge' between the nervous and endocrine systems.

19 Homeostatic Control Mechanisms

Subject Outline terms and phrases	**osmoregulation, anti-diuretic hormone (ADH), blood volume, blood pressure, insulin, glucagon, diabetes mellitus**

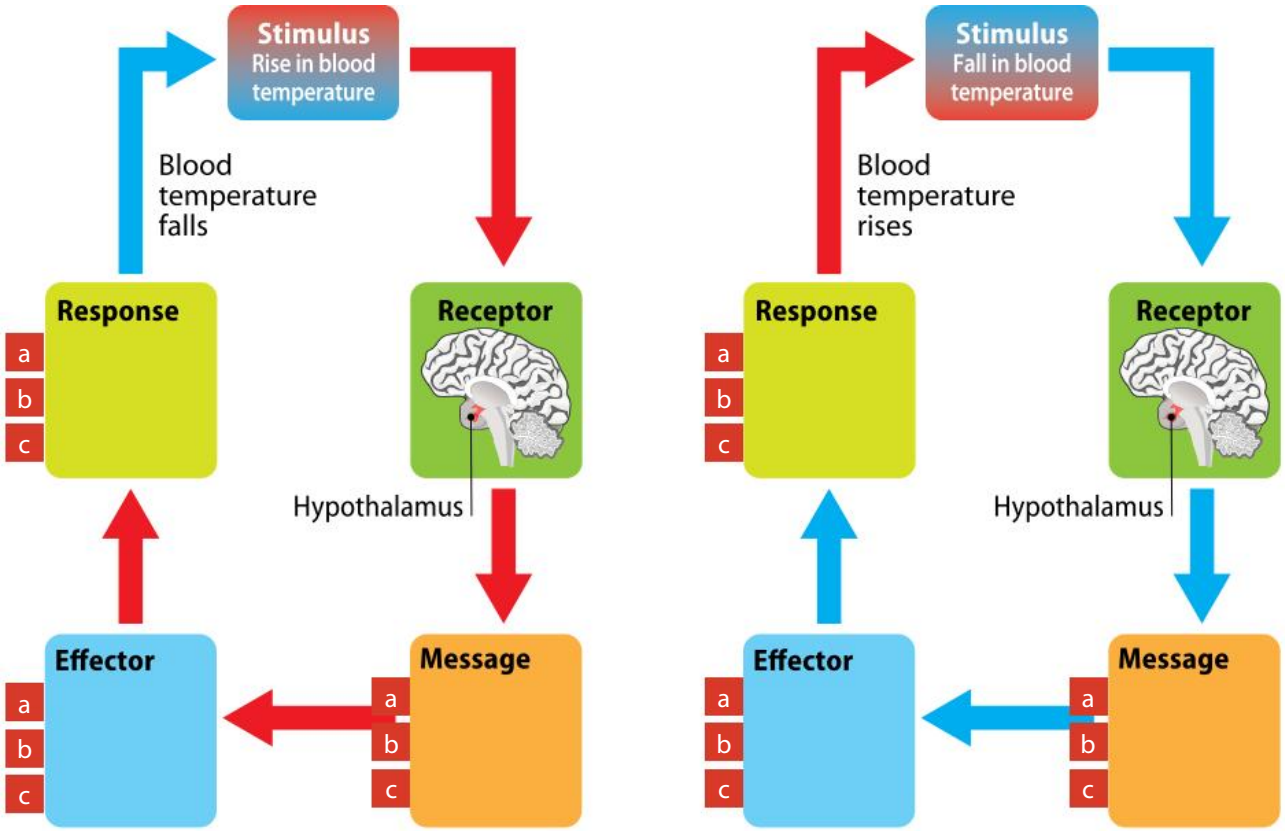
1. Complete the following table to show which body systems are involved in controlling the internal conditions listed.

Internal condition	Nervous system, endocrine system, or both
body temperature	
osmoregulation	
blood sugar level	
pH of blood	

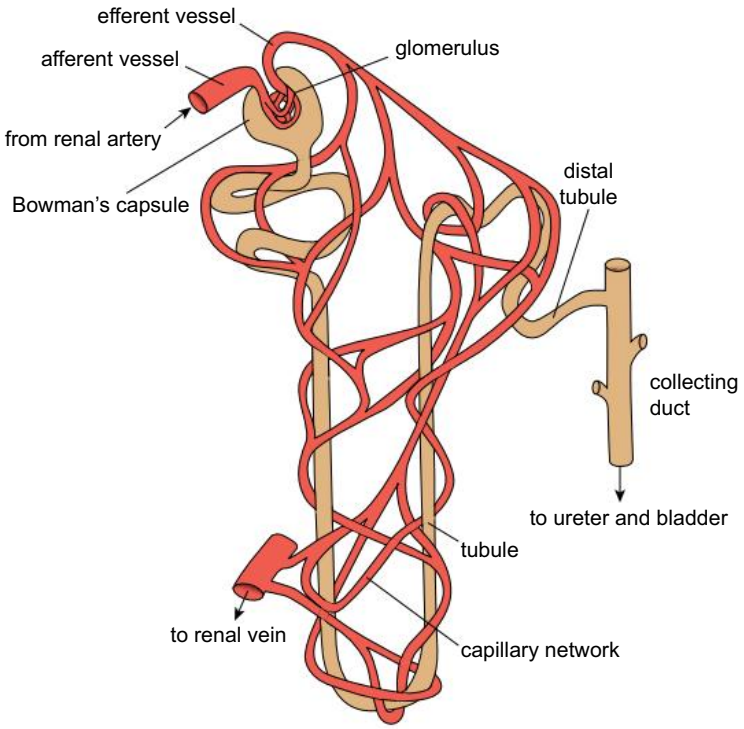
2. Complete the following table for the control of human body temperature.

Stimulus	Receptor	Message transmission	Effector(s)	Response(s)
Body temp. decreases				shivering
Body temp. increases				vasodilation
Body temp. decreases			thyroid gland	
Body temp. increases			sweat glands	
Body temp. decreases		nerve impulse		

3. Complete the labels on the following diagrams to show the **receptor, messages, effectors,** and **responses** involved in regulating human body temperature.



4. Label these structures on the nephron diagram below:
glomerulus, Bowman's capsule, tubule, collecting duct, capillary network, from renal artery, to renal vein



5. Use the terms *filtration* and *reabsorption* to explain how a nephron works.

6. (a) Describe the role of **anti-diuretic hormone (ADH)** in **osmoregulation**, including its effect on aquaporins.

   (b) Explain how the water content of the blood (osmoregulation) affects **blood volume** and **blood pressure**.

7. Complete the table below using the words *higher, lower,* or *same* to describe the concentrations of the following substances in the filtrate and urine, compared to their concentration in the plasma.

	Percentage present in:		
Substance	**Plasma**	**Filtrate**	**Urine**
water	92.0	higher	varies
urea	0.03		
glucose	0.1	same	
inorganic ions	0.72		
protein	8.0		lower

8. Name the kidney structures in the correct sequence to describe the pathway that would be followed by (a) water, and (b) glucose from the time they enter the afferent vessel (from the renal artery).
   (a) water

   (b) glucose

9. (a) What are the main target tissues for **insulin**, and what is the effect of insulin on the cells of these tissues?

   (b) What are the main target cells for **glucagon**, and what is the effect of glucagon on these cells?

   (c) How do insulin and glucagon work together to regulate blood sugar level?

10. Describe how **diabetes mellitus** (type 1 and type 2) can result from a hormonal imbalance.

11. Explain how pH is monitored in the brain to maintain a constant carbon dioxide level in the blood.

20 How Cells Have Evolved

Subject Outline terms and phrases	**evolution, fossil evidence, endosymbiotic event, ribozyme**

1. Explain how **evolution** has resulted in life on Earth diversifying over the last 3.5 billion years.

2. Explain how each of the following pieces of evidence supports the idea that eukaryotic cells did not exist on Earth before prokaryotic cells.

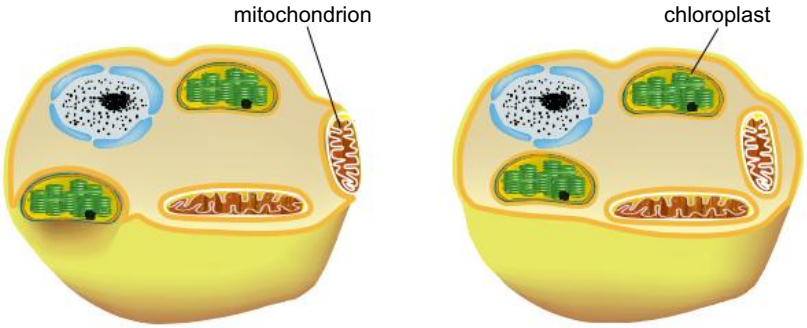
   (1) fossils

   (2) cell complexity

   (3) early Earth's atmosphere

3. (a) What is meant by the term **endosymbiotic event**?

(b) Explain how endosymbiotic events may have led to the formation of the first eukaryotic cells. In your answer you should refer to the following diagram, on which you should put suitable labels.



(c) State four pieces of evidence that support the idea that the first eukaryotic cells were formed by endosymbiotic events.

(1)

(2)

(3)

(4)

4. (a) Explain how the first membranes may have formed spontaneously, eventually giving rise to simple cells.

(b) Describe the possible roles of RNA and **ribozymes** in the first simple cells.

(c) Explain why proteins were not used as enzymes in the first primitive cells.

21 Defining a Species

Subject Outline terms and phrases	**species, mode of reproduction, interbreed, fertile, morphological similarity, biochemical similarity, gene pool, zygote, pre-zygotic, temporal isolation, behavioural isolation, mechanical isolation, gamete isolation, post-zygotic, hybrid, hybrid inviability, hybrid sterility**

1. Define the following terms.
   (a) species

   (b) community

   (c) population

   (d) gene pool

2. A species can be defined using methods based on structural features, biochemical similarity, ability to interbreed to produce fertile offspring, or gene pool. Explain how each of these methods is used to define a species.

   structural features (morphological):

   biochemical similarity:

   ability to interbreed:

   gene pool:

3. (a) List four **pre-zygotic** mechanisms that maintain reproductive isolation of species in a community.

(1)

(2)

(3)

(4)

(b) Explain how each of these pre-zygotic mechanisms helps to maintain reproductive isolation.

(1)

(2)

(3)

(4)

4. (a) List two **post-zygotic** mechanisms that maintain reproductive isolation of species in a community.

(1)

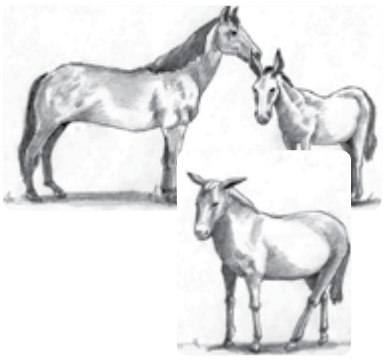
(2)

(b) Explain how each of these post-zygotic mechanisms helps to maintain reproductive isolation.

(1)

(2)

5. Explain why horses and donkeys are considered to be different species even though they are able to produce offspring (the mule).



22 Evidence for Evolution

Subject Outline terms and phrases	**comparative genomics, cytochrome, DNA-DNA hybridisation, DNA sequencing, phylogenetic tree, evolutionary relationships, rRNA gene sequencing**

1. (a) What is meant by 'the universal presence of DNA'?

   (b) Explain how the universal presence of DNA provides evidence for the common ancestry of all living things.

2. (a) Explain the term **mutation**.

   (b) Explain how the sequence of amino acids in a protein is related to the genetic code in the nucleus of the cell. (also see Chapter 2)

   (c) State three factors that can induce mutations.

3. (a) State one piece of evidence that indicates that DNA on Earth has diversified over billions of years.

   (b) State two processes that have brought about this diversity.

4. Explain three sources of genetic variation in a species that reproduces sexually.

(1)

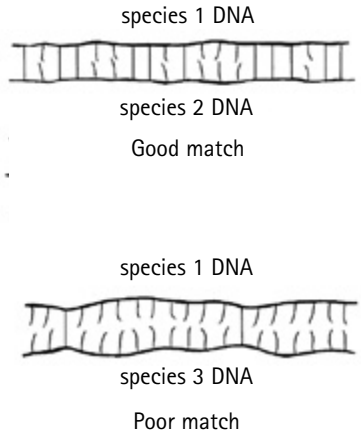
(2)

(3)

5. (a) What is meant by the term **comparative genomics**?

(b) Explain how comparative genomics can help establish the likely evolutionary relationships between different species.

6. Use the information in the following diagram to explain how the degree of matching of DNA strands from two different species in **DNA-DNA hybridisation** provides a clue as to how closely related the two species are.

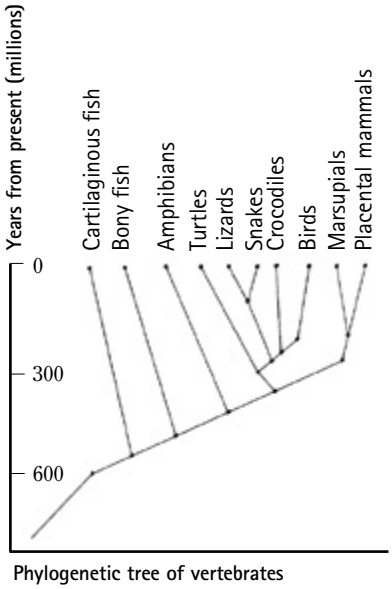


7. Explain how the degree of similarity of the DNA sequences and the degree of similarity of protein sequences in closely related organisms provide evidence for the theory of evolution.

8. (a) Explain why the protein *cytochrome c* is useful for studying the evolutionary relationship between different species.

(b) How can a protein provide this kind of information for comparison?

9. The **phylogenetic tree** below was constructed by comparing the nucleotide sequences of DNA in the different groups. Use the information in the diagram to answer the following questions.



Phylogenetic tree of vertebrates

(a) State which two groups of vertebrates are most likely to have separated most recently.

(b) Which group has DNA which is most dissimilar to that of mammals?

23 Gene Pools and Natural Selection

Subject Outline terms and phrases	**gene pool, natural selection, adapted, selection pressure, frequency of alleles, genetic drift, genetic diversity**

1. Define the term **gene pool**. (review Chapter 21)

2. What reasoning did Thomas Malthus use to show that not all offspring in natural populations survive to reproduce?

3. State why most natural populations of organisms do not increase in size, but remain fairly constant from one year to the next.

4. List four factors that restrict the size of a natural population.

   (1)

   (2)

   (3)

   (4)

5. Explain why genetic variability is an advantage to a population.

6. (a) State one example of a genetically controlled characteristic that may *increase* an individual *human's* chances of survival and reproduction.

   (b) State one example of a genetically controlled characteristic that may *decrease* an individual *rabbit's* chances of survival and reproduction.

7. List the five points that Darwin used to explain the theory of evolution by **natural selection**.

   (1)

   (2)

   (3)

   (4)

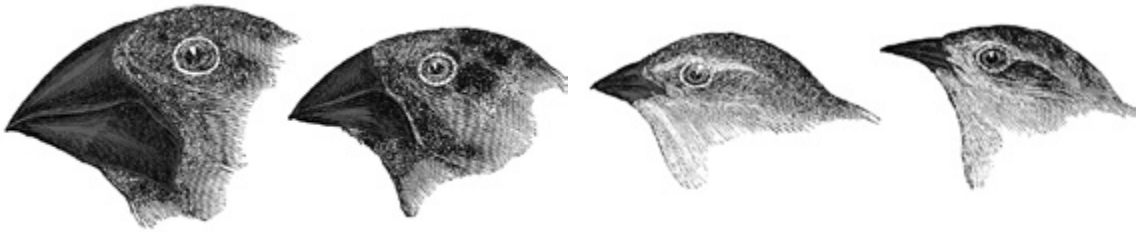
   (5)

8. Explain how a strain of bacterium resistant to the antibiotic streptomycin could evolve by natural selection. In your answer you should use the following terms: *mutation, genetic variation, selecting agent, selection pressure, survival, reproduction, favourable gene, change in the gene pool.*

9. (a) What is meant by a **large gene pool**?

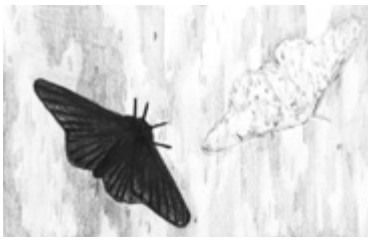
   (b) Explain why a population with a large gene pool is more likely to survive **selection pressures**.

10. In 1831 Darwin sailed on the Beagle as the ship's naturalist. He was particularly fascinated by the distribution of finches on the Galapagos Islands to the west of South America. Darwin found a number of different species of finch and he noticed that each species seemed to be restricted to one island or a small number of neighbouring islands. Differences between the species included such features as beak shape which seemed to be suited to the food available to the particular species. From these observations Darwin began to formulate an idea of how the different species of Galapagos finches could have developed in such a way as to ensure that each species was well suited (adapted) to its own environmental conditions.



Use the example of the Galapagos Island finches to outline the reasoning that Darwin used to explain how the finches developed in such a way as to ensure that each species was well suited (adapted) to its own environmental conditions.

11. One of the classic examples of natural selection involves the peppered moth *Biston betularia*. This moth is found in England in two main shades. One is light with patches of darkness (hence the name 'peppered') and the other is dark in colour. Before the Industrial Revolution almost all the moths were light in colour and dark ones were extremely rare.



Explain how the proportion of darker moths increased and the proportion of paler ones decreased over many generations after the Industrial Revolution.

12. State three processes that could cause the **frequency of alleles** in a population to alter and result in evolutionary change.

    (1)

    (2)

    (3)

13. Explain the term **genetic drift**.

14. Explain how evolutionary changes are affected by factors such as:

    (a) sexual reproduction.

    (b) genetic drift.

24 Speciation and Evolution

Subject Outline terms and phrases	**speciation, geographically isolated populations, allopatric speciation, sympatric speciation, convergent evolution, niche, succession, divergent evolution, adaptive radiation, low genetic diversity, extinction**

1. State three examples of geographical barriers, other than a desert, that could lead to reproductive isolation.

   (1)

   (2)

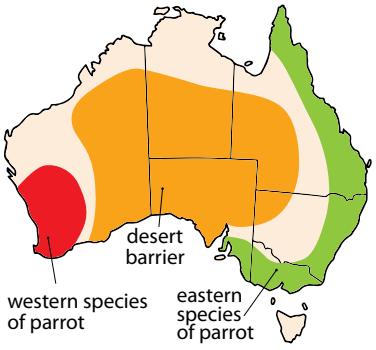
   (3)

2. Geographical isolation (separation) by itself does not lead to **speciation**. What else is needed in order for speciation to occur?

3. Describe the process of allopatric speciation.

4. The habitats of two species of parrot are shown on the map.

   The eastern and western species of parrot have descended from a common ancestor, but have become so different from one another that they are no longer able to interbreed. Use the ideas of **geographical isolation (separation), gene flow,** and **natural selection** to explain how this speciation occurred.



5. State two pre-zygotic and two post-zygotic barriers that maintain reproductive isolation between different species. (revise Chapter 21)

   two pre-zygotic barriers:

   two post-zygotic barriers:

6. Explain what is meant by **convergent evolution**. Give three examples to illustrate your answer.

7. (a) What is meant by **adaptive radiation**? Give an example.

   (b) How does adaptive radiation differ from **divergent evolution**.

8. In the natural community shown below, there could be flood, drought, high temperatures, heavy rain, or fires in the coming year. Choose three of these abiotic factors and describe the changes that they would cause to the populations in this community.

   Factor 1:

   Factor 2:

   Factor 3:

9. Define the following terms.

   (a) succession

   (b) colonisers

   (c) climax community

10. Describe the series of events that could have occurred on each of the following two sites.

   (a) The sand dunes in the south-east of South Australia, after they became exposed due to a fall in sea level.

   (b) The island of Surtsey, after the bare volcanic rock arose out of the sea.

11. (a) What conditions are necessary for primary **succession** to occur?

   (b) How does primary succession differ from secondary succession?

12. (a) Give two examples of species with low genetic diversity, and describe how their genetic diversity was reduced.

   (b) Explain why species or populations that have a reduced **genetic diversity** have a higher risk of extinction.

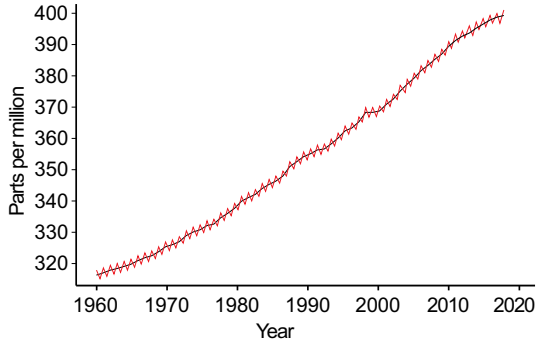
25 Human Impact

Subject Outline terms and phrases	**biodiversity, ethical issue**

1. Complete the table below which shows how human activities have led to climate change, environmental change, or both.

Human activity	Climate change, environmental change, or both	How the change was (changes were) caused
clearing tropical land		
lighting fires		
introducing rabbits to Australia		
altering water courses		
polluting the atmosphere		
burning fossil fuels		

2. (a) By referring to the graph and data below, state the likely trend of carbon dioxide levels in the atmosphere beyond the year 2024.



DATE	CO_2 LEVEL
24/12/2023	421.86 ppm
24/12/2022	419.41 ppm
24/12/2013	397.53 ppm

(b) State the factor that is the most likely cause of this trend.

(c) Explain how this trend could lead to changes in communities on a global scale.

3. (a) State what is meant by the extinction of a species.

(b) State three human activities that have caused animals to become extinct and for each one give an example of a species that was affected.

(c) State three factors, other than human activity, that could cause the extinction of a species.

(d) Explain why maintaining **biodiversity** is an **ethical issue.**

4. The three main arguments for the importance of biodiversity are the human-centred view, the interconnection of life on Earth, and human respect for all living things.

   (a) State the main point of each of these three arguments, and give an example of each.

   human-centred view:

   interconnection of life on Earth:

   respect for all living things:

   (b) Which one of the three arguments in part (a) suggests that biodiversity is essential for the perpetuation of communities?

   (c) State two examples in which the loss of one population from a community has had a severe effect on other populations of the community.

5. Define the following terms.

   habitat:

   biosphere:

6. Although there are several hundred species of eucalypt in Australia, the koala can only feed on the leaves of a few of these species. The koala's distribution is limited to regions where these species of eucalypt are found. Use this information to explain why the best way to preserve a species is to preserve its habitat.

7. State the size of the habitat that is now generally accepted to be the minimum to ensure the survival of an animal species.

8. (a) What is meant by the term resources?

   (b) List two resources from each of the following categories.

   soil:

   air:

   other organisms:

9. Why do biological communities need to recycle resources?

10. (a) What observation made during the Hubbard Brook experiment provides evidence that disturbed communities lose their chemical resources?

    (b) What conclusion was made about the fate of resources in undisturbed communities?

11. Explain why crops need to be provided with fertiliser, whereas natural communities can flourish without the addition of fertiliser.

12. (a) List two types of decomposer.

    (b) Explain why decomposers are essential to a natural community.

13. State three advantages that have resulted from the introduction of African dung beetles into Australia.

    (1)

    (2)

    (3)

Science as a Human Endeavour Questions

Subject Outline terms and phrases	**Communication and Collaboration, Development, Influence, Application and Limitation**

Answer these SHE questions on your own paper or device.

1. Although DNA was identified by around 1850 as the major chemical occupying a cell's nucleus, its role in storing and transmitting genetic information was not accepted by the scientific community until 1952. Up until then many scientists believed that proteins were the most likely storage form of genetic information in cells. The first people to recognise the importance of chromosomes in inheritance were Walter Sutton and Theodor Boveri who, in 1902, independently put forward the concept that chromosomes carry hereditary material. It was not until 1952 that two biologists, Alfred Hershey and Martha Chase, performed an experiment that supported the proposal that DNA and not protein contained the inheritable material of life.

   James Watson and Francis Crick are the names most often associated with the discovery of the structure of DNA, but two other people contributed significantly. Rosalind Franklin and Maurice Wilkins from Kings College, London, had generated information of the DNA structure from their research using X-ray crystallography that Watson and Crick then used.

   - Discuss how this information illustrates at least one of the science as a human endeavour key concepts.

2. Unlike DNA profiling, DNA phenotyping uses coding regions of a person's DNA. It can be used to deduce certain physical characteristics such eye colour, gender, and ethnic background. While DNA phenotyping is not currently in common usage, it has been used in some countries, when a DNA profile is not available. Some people are concerned about the way that humans might choose to use this new technology.

   - Discuss the **applications** and **limitations** of DNA profiling and DNA phenotyping.
   - Explain why the use of DNA profiling is more likely to be acceptable in society than the use of DNA phenotyping.

     (In your answer you could address social, economic, cultural, and ethical considerations and/or beneficial or unexpected consequences.)

3. Telomeres are repetitive sequences of DNA found at the end of most eukaryotic chromosomes. The telomeres in humans are single stranded DNA with several thousand repeats of the sequence TTAGGG.

   During each DNA replication, a few nucleotides are removed from the ends of the chromosomes, so if the telomere is present, it will be shortened rather than sacrificing essential DNA. When the telomere becomes too short, the cell dies. The enzyme telomerase reverse transcriptase (TeRT) can repair the damaged ends of telomeres and extend the life of the cell. This enzyme is found in high concentrations in both stem cells and cancer cells. (See textbook Fig. 1.11)

   In 2009, an Australian scientist, Elizabeth Blackburn, and her American colleagues, Carol Greider and Jack Szostak, were awarded the Nobel Prize for their research into telomeres. They showed that telomeres prevent the ends of chromosomes fusing with each other, thus preventing mutations, and that telomerase reverse transcriptase (TeRT) repairs telomeres, thus increasing the life expectancy of cells and the organism in which they reside. TeRT could be seen as the key to increasing life expectancy.

   - Discuss how the scientific knowledge resulting from Elizabeth Blackburn and her colleagues' work on telomeres may have **applications** that could have beneficial or unexpected consequences.
   - How might the acceptance and use of this scientific knowledge to increase human longevity be **influenced** by social, economic, cultural, and ethical considerations?

4. The protein cytochrome oxidase is found in the mitochondria of all **eukaryotes**. There are slight differences in the sequence of nucleotides that code for cytochrome oxidase in each species. Short DNA segments, about 700 nucleotides in length, can be quickly processed from thousands of specimens and unambiguously analyzed by computer programs. These unique sequences can be used to establish a database of different species and construct DNA 'barcodes' for each species. A region of the chloroplast gene rbcL is used for barcoding plants.

   Scientists from around two hundred countries are involved in the program *International Barcode of Life (iBol)* which is now used to detect food fraud, such as identifying various commercial fish species, and identifying products taken from conserved species such as timber from rain forests and ivory from elephants.

   Scientists at the University of Adelaide are also working on a DNA tracking system to identify even the specific region of origin of foods.

   - Explain how international **collaboration** is essential for the iBol project and why clear communication, international conventions, and review and verification of results is required for this project to be successful.
   - Describe how the **development** of new technologies contribute to the iBol project.

5. Human babies inherit their mitochondria from their mother. This means that a zygote contains DNA from three sources: nuclear DNA from each parent, and mitochondrial DNA from the mother only.

   Although mitochondrial DNA only comprises a small portion of a person's 'genome', faults in this DNA can have significant consequences. For example, Leber's Hereditary Optic Neuropathy is a form of mitochondrial disease that causes blindness,

   New technology, recently legalised in the United Kingdom, enables a zygote to be formed using the nuclear DNA of two parents and the mitochondrial DNA of a 'donor', in order to ensure that faulty mitochondrial DNA is not inherited. Thus, a baby produced in this way will have 'three biological parents', although 99.9 percent of their DNA comes from their 'natural' parents. There would still be only two legal parents.

   Some people have opposed the use of this technology, saying that it will lead to 'designer babies' and 'selective breeding'.

   - Discuss how social, ethical, economic, and cultural considerations can **influence** the use of this technology.

6. In 1951 a young woman named Henrietta Lacks was found to have cancer of the cervix. A sample of the tumour was taken and the cells were found to be most unusual as they grew vigorously and went through each cell cycle without restraint. Up until then human cells had been very difficult to grow and died after a few cycles. The cells from Henrietta, referred to as HeLa cells, were the first human cells to be successfully cultured and they were initially distributed, free of charge, to a large number of medical and scientific institutions.

   Late in the 1950s cultures of HeLa cells were used to develop a vaccine against polio, and since then, the cells have been used as the host cells in genetic engineering to produce a variety of proteins. The HeLa cell line is now found in biological laboratories throughout the world and continues to be the 'work-horse' for many human tissue experiments, including testing safety of pharmaceuticals, investigating the action of mutagens, and researching the control of the cell cycle. Interestingly, neither Henrietta nor her family gave permission for her cells to be used in this way.

   - Explain how **communication and collaboration** played an important role in the **development** of Hela cells for use in human tissue experiments.
   - Discuss how social, ethical, economic, and cultural considerations can **influence** the use of this technology.

7. Drugs in Sport (See textboxes *Drugs in Sport*, P146 and *Human Growth Hormone,* P119)

   The endocrine system is made up of endocrine glands which produce and secrete hormones. Disorders of the endocrine system include diabetes, goitre, dwarfism, gigantism, and Addison's disease, and these are due to the production of incorrect amounts of hormone or production of a faulty hormone.

   Genetic engineering processes use bacteria to produce human proteins such as insulin, growth hormone, adrenaline, erythropoietin (EPO), oestrogen, and testosterone, and these are used to treat endocrine disorders.

   Genetically engineered growth hormone, EPO, and testosterone have also been used by athletes to improve performance and their use has been the subject of intense scrutiny in the sporting world.

   - Discuss how the **development** of scientific understanding of the effect of hormones such as EPO and growth hormone can **influence** and be influenced by other areas of science such as sports science.
   - Use the production of EPO and growth hormone as examples of how the **application** of scientific knowledge may have beneficial or unexpected consequences and requires monitoring, assessment and evaluation of risk, and provides opportunities for innovation.

8. Initally, Darwin's and Wallace's views on evolution by natural selection were not universally accepted. Even today, some people are reluctant to accept the elegance of modern evolutionary theory, despite the huge body of scientific evidence in support of it.

   In June 2017 a decision was made in Turkey to remove the teaching of evolution from the school curriculum. The reason given was that the theory of evolution is 'too hard' for students to understand, although many people disagreed with this.

   The increased use of antibiotics in agriculture and medicine has caused populations of bacteria without genes that enable the host bacterial cell to resist antibiotics to decrease in number and those with the genes for resistance to increase. An unfortunate result of this is that more pathogenic bacteria are now resistant to antibiotics. Despite this knowledge, antibiotics are still overprescribed and used unnecessarily in many parts of the world, including Australia.

   - Use this information to describe how social and cultural considerations can **influence** the acceptance of scientific knowledge.
   - Explain how **communication** and **collaboration** will play an important role in addressing the **limitations** resulting from a lack of understanding of evolution in bacteria.

Science as a Human Endeavour Investigation

Subject Outline terms and phrases	**Communication and Collaboration, Development, Influence, Application and Limitation**

The Science as a Human Endeavour investigation involves researching and presenting evidence for the idea that science involves **Communication and Collaboration (CC), Development (D), Influence (I),** and **Application and Limitation (AL).** Details of these Key Concepts are in the subject outline, and are expressed as nine 'dot points'.

The table below has been developed to help students to choose an example of how science interacts with society. The Investigation should focus on a *recent* example linked to a biological topic, and focus on at least one of the key concepts. The table simply shows where Science as a Human Endeavour is highlighted in the textbook, and may provide some useful background information. As the range and scope of possible investigations is large (and growing), it is not possible nor desirable to provide more than this.

Example	Textbook page	Key concept	Scientists / Applications
History of DNA discovery	7	CC; D; I; AL	Sutton, Boveri, Avery, Hershey, Chase
Double-helix discovery	6, 11	CC; D; I; AL	Watson, Crick, Wilkins, Franklin
Telomeres	8	CC; D2; AL	Blackburn, Greider, Szostak (Fennic)
PCR	40	CC; D2; I; AL	Mullis (virus testing)
Sequencing DNA	42, 173, 174	D; I; AL	Sanger (synthetic proteins)
DNA profiling	43	D; I; AL	Jeffreys (ancestry investigation)
HUGO	46	CC; D; I; AL	Watson, Collins, Venter
DNA databases	44, 46, 47	CC; D; I; AL	**BOLD,** tracing sources of products
manipulation of DNA, gene therapy	49, 52-54, 114	CC; D; I; AL	vaccines
CRISPR	56	CC; D; I; AL	Doudna, Charpentier, Zhang, Church
design of specific proteins	56, 57	CC; D; I; AL	Nikolai Petrovsky
membrane structure	63	CC; D; I; AL	Davson, Danielli, Singer, Nicolson
effects of chemicals human use	98, 99, 119, 148	CC; I; AL	Carson, herbicides
cloning	104	CC; D; I; AL	Campbell, Wilmut
penicillin	121	CC; I; AL	Fleming, Florey, Chain
cell culturing	121, 122, 123	I; AL	vaccines, plant propagation
use of neurotoxins	139, 140	D; I; AL	botox, Bt gene
drugs in sport	146	D; I; AL	recent techniques
use of hormones	119, 148	CC; D; I; AL	HTR, insulin
diabetes mellitus	156, 157	I; AL	treatments
membranes and ribozymes	163; 164	CC; D; I; AL	Szostak, Cech, Altman
natural selection / evolution	179, 188	CC; I; AL	Darwin, Wallace
Mendelian genetics	181	D; I; AL	Mendel
superbugs	182	D; I; AL	
humans and succession	191	AL	
human impact	194 - 203	I; AL	

ANSWERS

1 Chromosomes and DNA

Subject Outline terms and phrases	**DNA, double-stranded, helical, cytosol, prokaryote, nucleotide, genetic information, eukaryote, chromosome (linear, circular), nucleus**

1. Organisms are made of one or more cells and cells are made of chemicals.
   Define the following chemical terms:

   element:

   a chemical substance made up of one kind of atom *(See Textbook Glossary Page 208)*

   compound:

   a chemical substance made up of two or more different elements chemically combined

   molecule:

   an uncharged group of atoms chemically combined

   organic compound:

   a compound that contains carbon. Note that carbon dioxide is not considered to be organic, due to its simplicity.

2. (a) Describe how DNA stores and transmits genetic information.

   DNA is a unique molecule because it is able to self-replicate — that is, it can make a copy of itself. In addition, its sequence of nucleotides allows it to store information that can be copied and passed on to daughter cells. Thus DNA, which is found in all known organisms, provides the link between one generation and the next.

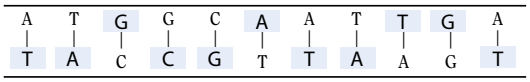
   (b) DNA functions in the same way in all living things. Explain what this means.

   The genetic code is the same for all living things. This code, which is the sequence of bases on the cell's DNA, uses three bases at a time, called codons, to direct protein synthesis - the assembling of proteins from amino acids. Thus, DNA functions in the same way in all living things.

3. (a) Describe a **nucleotide** molecule and name its subunits.

   Nucleic acids (DNA and RNA) are long molecules made up of subunits called nucleotides. Each nucleotide is made up of three parts, a pentose sugar (deoxyribose in DNA and ribose in RNA), a phosphate group, and a nitrogen base. *(See Fig. 1.4)*

   (b) Complete the following diagram of a segment of DNA to show the missing nitrogen bases.



   (c) On the diagram in part (b) what has been used to represent the weak hydrogen bonds?

   The vertical line between the letters that are representing the nucleotides.

4. State four important features of DNA.

   (1) double helix
   (2) two chains of nucleotides
   (3) sugar-phosphate backbone with strong bonds to maintain nucleotide sequence
   (4) four nitrogen bases

5. Explain why DNA is a suitable molecule for storing genetic information in organisms.

   Two chains (strands) of nucleotides - more stable than a single chain
   The sequence of nucleotides stores information
   Long chains of nucleotides - can store large amount of information
   Weak hydrogen bonds allows the two strands to be separated for replication
   Complementary base pairing enables DNA to self-replicate
   Can carry genetic information from one cell generation to the next

6. What is the difference between **cytosol** and **cytoplasm**?

   Cytoplasm is the material in a cell, including the fluid and organelles, but excluding the nucleus.
   Cytosol is the fluid part of the cytoplasm, not including organelles such as ribosomes.

7. (a) Describe the structure of a **chromosome** in a eukaryotic cell.

   Chromosomes: long linear threadlike structures made up of DNA and proteins called histones.

   (b) What is the function of chromosomes?

   Carry genetic information.

8. Complete the following table comparing chromosomes in prokaryotes and eukaryotes:

	Chromosomes in prokaryotes	**Chromosomes in eukaryotes**
Shape	circular	linear
Histones present or absent	no histones	contain histones
Location in cell	located in the cytoplasm	located in the nucleus
Number per cell	one per cell	two or more per cell
Introns present or absent (see glossary)	most have no introns (non-coding DNA)	have introns (non-coding DNA)
Where centromere attaches during cell division	centromere-like structure attaches to cell membrane during cell division (binary fission)	centromere attaches to spindle fibres during cell division

2 The Language of Life

Subject Outline terms and phrases	**genetic information, nucleotide, weak bonds, complementary base-pairing, semi-conservative replication, universal, protein synthesis, gene, transcription, translation, mRNA, tRNA, amino acid, ribosome, codon, anticodon, exon, intron, polypeptide, DNA codon, RNA codon, coding strand, template strand**

1. DNA is generally described as a double helix. Explain what this term means by referring to the structure of DNA.

   A helix is a spiral shape.
   DNA consists of two complementary strands of nucleotides wound around each other in a spiral.
   Hence the term double-helix.

2. Explain what is meant by 'Base-pairing rules and method of DNA replication are universal'.

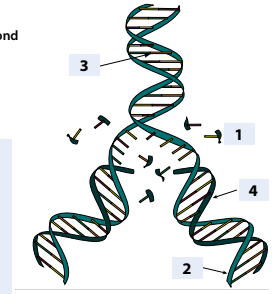
   The specific base pairing rules are: adenine (A) always forms hydrogen bonds with thymine (T), and cytosine (C) always bonds with guanine (G). RNA contains uracil (U) in place of thymine.
   These base-pairing rules and method of DNA replication apply to all life on Earth – that is, they are universal. *(See Fig. 2.3)*

3. Refer to the diagram at right.

   (a) On the diagram label a **single nucleotide [1],** the **original DNA strands [2],** the **position of a weak bond between** the **strands of DNA [3],** and a **new DNA strands [4].**

   (b) Why is the replication of DNA called semi-conservative?

   The two strands of a DNA molecule are complementary and the bases on one strand join to the bases on the other, according to the following base-pairing rules: A pairs with T, and C pairs with G. Semi-conservative replication: the replication of DNA that results in two new double helices, each consisting of one original strand and one new strand - half (semi) of the original double helix is kept (conserved).



(c) Explain why the replication of DNA is necessary for DNA to carry genetic information from one generation to the next.

Each time a cell divides in two, each new daughter cell receives a set of chromosomes (DNA). Genetic information on the chromosomes is then carried from one generation to the next.

4. (a) Why is it that some of the information on a DNA molecule must be 'translated into proteins' in order to direct the activities of the cell?

The types of proteins that a cell contains determine its structure (eg cytoskeleton) and function (eg enzymes). The information on the DNA determines which proteins are produced.

(b) State the structure and function of a gene.

Structure: a segment of a chromosome (DNA)

Function: codes for the manufacture of a protein or RNA molecule.

5. Explain why the genetic code must be made up of codons that are at least three bases long.

There are only four different bases (A, C, G, and T), but there are twenty different amino acids. A code consisting of two bases would provide sixteen different codes. A code consisting of three bases would provide 64 different codes, and this is more than enough.

6. What role does each of the following cell components play in protein synthesis?

(a) mRNA

mRNA carries information from DNA in the nucleus to the ribosomes in the cytoplasm.

(b) tRNA

Each tRNA molecule brings a specific amino acid to the ribosome.

(c) ribosomes

ribosomes are the site of the final stage of protein synthesis — translation.

7. Write the chromosome number on which the gene is located for the following human genetic diseases. (see textbook chapter 1 and 2)

haemophilia X

Huntington's disease 4

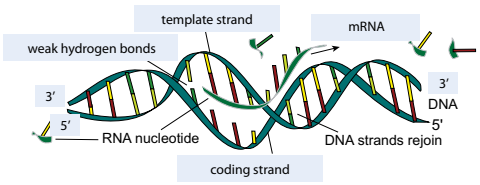
Duchenne muscular dystrophy X

red-green colourblindness X

cystic fibrosis 7

retinitis pigmentosa X

8. (a) On the diagram label the the coding strand, the template strand of DNA, the mRNA, the weak hydrogen bonds, and the ends of the strands



(b) Explain the meaning of 3' to 5' when referring to DNA.

The pentose sugars in nucleotides contain five carbon atoms numbered 1', 2', 3', 4', and 5'. The phosphate group is attached to the 5' carbon of the sugar so where phosphate is at the end of the strand this is the 5' end. Where the strand ends with a nucleotide this is the 3' end. DNA (and RNA) is directional — 3' and 5' are used to indicate the direction. *(See text box page 11 of Textbook)*

9. Distinguish between DNA codons, RNA codons, and RNA anticodons.

DNA codons:

DNA codons are on the coding strand of DNA, also called the 'gene'.

RNA codons:

RNA codons are on the mRNA.

RNA anticodons:

An anticodon is a triplet of bases on a tRNA molecule that is complementary to the corresponding codon on an mRNA molecule.

10. Complete the following table showing details of transcription and translation.

Process	Site in eukaryotic cells	Molecules involved	Product
Transcription	nucleus	(1) DNA (2) RNA (3) protein (enzymes)	mRNA
Translation	ribosomes	(1) RNA (mRNA & tRNA) (2) amino acids (3) protein (enzymes)	protein

11. Use the words **gene, chromosome, DNA, bases,** and **protein** to fill in the gaps in the following sentence:

A segment of DNA on a chromosome that contains the complete sequence of bases required to direct the synthesis of a protein is called a gene.

12. Use the genetic code (textbook P16) to complete the following table of codons and anticodons.

DNA (template)	GAT	GCC	TTA	CC*
mRNA	CUA	CGG	AAU	GG*
tRNA	GAU	GCC	UUA	CC*
amino acid	leucine	arginine	asparagine	glycine

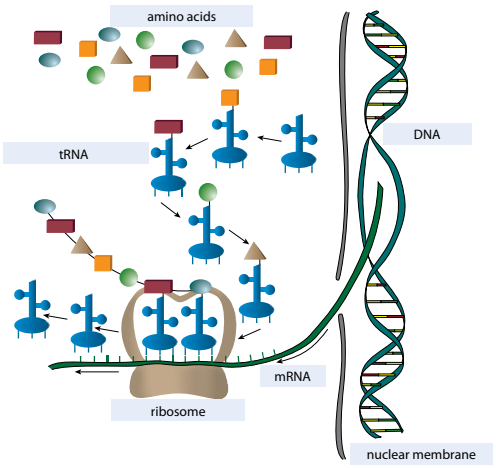
13. How could a protein be affected by a change in the base sequence on the DNA?

If the base sequence in DNA is changed then the base sequence of the mRNA will be changed. This may result in a change in the sequence of amino acids, and hence the protein produced may have a different 3D shape.

14. Complete the following table showing details of nucleic acids. (see Textbook Chapter 1 and 2)

Nucleic acid	Overall shape	Bases present	Type of sugar present	Structure formed	Site in the cell
DNA	double helix	A,C,G,T	deoxyribose	chromosome	nucleus
mRNA	single strand	A,C,G.U	ribose		nucleus, cytoplasm
tRNA	clover leaf	A,C,G.U	ribose		cytoplasm
rRNA		A,C,G.U	ribose	ribosome	cytoplasm

15. (a) Label each of the following structures on the diagram below.
amino acids, DNA, mRNA, nuclear membrane, ribosome, tRNA.



(b) In an eukaryotic cell transcription occurs in the nucleus and translation occurs at the ribosome

16. (a) Distinguish between an **exon** and an **intron.**

Biologists use the term exon for the DNA sequences that are translated ('expressed') into protein, and the sequences that are transcribed but then cut out of the mRNA are called introns.

(b) Describe how the RNA transcript is coverted to mature mRNA during the process of transcription.

The introns are removed by enzymes and the exons are spliced (joined together) to form mature rRNA

3 Proteins

Subject Outline terms and phrases	**primary, secondary, tertiary, quaternary, three-dimensional shape, enzyme, hormone, receptor protein, antibody, substrate, induced-fit model, temperature, pH, inhibitors, activation energy**

1. Define the following terms used to describe protein formation.

Primary structure:

this is the sequence of amino acids in the polypeptide chain

Secondary structure:

this is the coiling or folding of localised sections of the polypeptide chain

Tertiary structure:

this is the three-dimensional shape of the entire polypeptide chain

Quaternary structure:

if the protein consists of two or more polypeptide chains, then this is the complex structure resulting from their bonding together

2. Explain how the primary and secondary structure of a protein give rise to a unique tertiary structure.

The primary structure of a protein is determined by the sequence of amino acids and this gives rise to the degree of folding or coiling in the secondary structure.
The protein then takes up a unique three-dimensional (tertiary) structure based on the secondary structure.

3. Complete the following table for protein function.

Function	Examples
structural	hair, nails, ligaments
defence	antibodies
coordination	hormones
hormone recognition	receptor protein
catalyse reactions	enzymes

4. Explain how the **three-dimensional shape** of proteins plays an important role in their ability to recognise and bind to specific molecules.

Molecules recognise each other on the basis of complementary shapes, in which, part or all of one molecule fits into part of another.
For example, substrates and enzymes *(see Page 25)* and antigens and antibodies *(see Page 23)*

5. 'Antibodies are specific to their antigens'.

Explain the statement above by referring to the molecular shapes of antigens and their corresponding antibodies.

The shape of the antigen molecule and the antigen-binding sites on the antibody molecule are complementary. The antigen-binding site specifically recognises the shape of the antigen, and binds to it.

6. (a) What is the function of **enzymes**?

Enzymes speed up chemical reactions by lowering the activation energy required to start the reaction.
This occurs without altering the products that are formed and without affecting the enzyme.

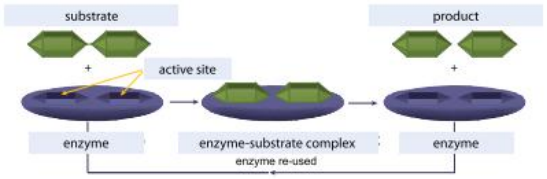
(b) What are enzymes made of and how do they differ from one another?

Enzymes are made of protein. Each enzyme has a unique tertiary structure and unique active site.

(c) Explain the difference between **intracellular** and **extracellular** enzymes.

Intracellular enzymes catalyse reactions inside cells and extracellular enzymes act outside cells.

7. (a) On the diagram below label the **substrate, enzyme, enzyme-substrate complex** and **product.** Indicate the position of the **active site.**



(b) Use the example in the diagram above to explain why an enzyme is specific for its substrate.

The active site of each enzyme has a specific shape and the shape of the substrate is complementary to the shape of the active site. E.g. only maltose (substrate) will fit into the active site of maltase (enzyme).

(c) Describe the induced-fit model of enzyme-substrate binding.

When the enzyme and substrate join together, the enzyme changes shape slightly, so that the active site fits even more exactly to the substrate. *(Refer to Textbook Page 26 Fig 3.12)*

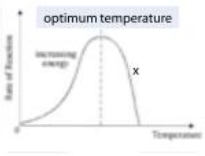
8. On the pH scale below label the positions that correspond to **acidic, basic,** and **neutral.**

9. Refer to the graph at the right.

(a) On the temperature axis, label the dotted line.

(b) Explain why the rate of reaction decreases in the region labelled X.

High temperature has denatured the enzyme



(c) Besides temperature, state two environmental factors that affect the activity of enzymes.

Factor 1: Choose any two of pH, inhibitors, concentration of reactants.
Factor 2: concentration of enzyme

10. (a) On the diagram at right label the enzyme (E), the competitive inhibitor (C), and the non-competitive inhibitor (NC).

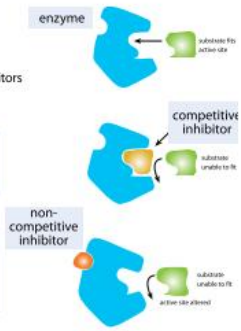
(b) Explain how (i) competitive and (ii) non-competitive inhibitors can affect the function of an enzyme.

(i) competitive inhibitors

Competitive inhibitors bind to the active site thus preventing the substrate from joining to it.

(ii) non- competitive inhibitors

Non-competitive inhibitors bind to the enzyme in a position other than the active site, and distort the shape of the active site so that its shape is no longer complementary to that of the substrate.



11. How do pH and temperature alter the binding of enzyme and substrate molecules?

pH

Enzyme structure is sensitive to changes in pH. Thus, altering the pH can alter the shape of the active site, so that the substrate molecule will not fit.

temperature

High temperature denatures the enzyme and alters the shape of the active site.

12. Explain the change in the rate of an enzyme-controlled reaction:

(a) as the concentration of reactants increases (See Textbook Fig. 3.17)

Initially an increase in reactant concentration will allow the enzyme and reactants to find each other more readily, resulting in an increase in reaction rate. When the active sites of all the enzyme molecules are occupied, an increase in reactant concentration will not increase the reaction rate.

(b) as the concentration of the enzyme increases (See Textbook Fig. 3.18)

Initially the increase in enzyme concentration for the same substrate concentration will allow the enzyme and reactants to find each other more readily, resulting in an increase in reaction rate. When all of the reactant molecules have bound to the active sites any further increase in enzyme concentration will not increase reaction rate.

13. (a) What is meant by the term **activation energy**?

Activation energy is the energy required to start a chemical reaction. *(See Textbook Glossary, Page 204)*

(b) What effect do enzymes have on the activation energy required for biological reactions?

Enzymes lower the activation energy required for biological reactions by positioning the reactant molecules in optimum orientation for the reaction to occur and putting stress on the bonds that need to be broken.

4 Genes and Phenotypic Expression

Subject Outline terms and phrases: **phenotypic expression, cellular differentiation, tissue, gene expression, cytosine, methylation, epigenetic, cancer, mutation, cell division, ionising radiation, mutagenic chemicals, viruses, germ cells, somatic cells**

1. What is meant by:
   (a) **phenotypic expression**?

   The phenotypic expression of a gene refers to the physical, biochemical, or physiological characteristics that it produces. Eye colour and height are examples of physical characteristics. Blood group and the ability to produce insulin are examples of biochemical or physiological characteristics.

   (b) phenotype?

   The phenotype of an individual refers to its detectable features.

2. Complete the following table of gene products that influence phenotypic expression.

Gene Product	Phenotypic expression
increased EPO	Increase in red blood cells
Lack of insulin	diabetes
Growth hormone	increased body size and muscle mass
auxins	Plant stem elongation
gibberellins	ripening of fruit
testosterone	Embryonic development Male secondary sex characteristics
oestrongen	female secondary sex characteristics

3. Complete the following table of environmental factors that affect transcription and translation, and hence phenotypic expression.

Environmental factor	Phenotypic expression
lack of oxygen in humans	Increased red blood cell production
Change in UV exposure	change in skin colour
lack of iodine in axoltl diet	No metamorphosis
Lack of iodine	goitre in humans
malnutrition in children	Reduced body size
Increased light intensity	increased plant growth

4. (a) What are **transcription factors**?

   Transcription factors are specific regulatory proteins that control gene expression.

   (b) State two ways in which transcription factors control gene expression.

   Some transcription factors switch genes 'on', by binding to a specific site on the DNA called the promoter region. Other transcription factors turn genes 'off' by blocking the attachment of RNA polymerase to the DNA, preventing transcription.

   (c) State two factors that affect translation.

   Some proteins can prevent translation by binding to mRNA. Also, small interfering RNA (siRNA) can cut mRNA after transcription, preventing it from being translated.

5. Define the term cell differentiation, and give four examples of differentiated cells.

   Cell differentiation is the process in which a cell become different from the stem cell that gave rise to it. It is now *specialised* in its structure and function. E.g. nerve cells, red blood cells, white blood cells, epithelial cells, adipose cells.

6. Explain how **methylation** of the **cytosine** nucleotide of a gene can affect the process of transcription.

   Genes can become locked 'off' by the addition of a methyl group (CH3) to cytosine nucleotides. This is called methylation and typically results in repression of transcription.
   (See Page 34 Fig. 4.7)

7. Describe how **epigenetic** modifications such as changes in DNA methylation can lead to cancer.

   Human cells contain tumour suppressor genes that regulate cell division, and reduce the incidence of cancer. If these genes become methylated (an epigenetic change), then they will not be transcribed, their protein products will not be available to control cell division, and cancer may result.

8. (a) What is a '**mutation**'?

   a mutation is any spontaneous or induced change in the genetic material of a cell.

   (b) Explain what is meant by the idea that mutations can occur spontaneously.

   mutations can occur for no particular reason, without a specific cause, i.e. not induced.

   (c) List three factors that can increase the mutation rate.

   ionising radiation, mutagenic chemicals, viruses.

9. Complete the following sentence.

   A change in the base sequence of DNA can cause a change in the protein produced or the failure of a protein to be produced. This may result in the appearance of new characteristics in offspring.

10. (a) Explain the meaning of the term 'genetic disease'.

    Genetic diseases are not infectious, but are transmitted from one generation to the next via the genetic material.

    (b) State three reasons why mutations that occur in your cells may have no apparent effect on you.

    They may occur in a part of the DNA that is not in use. The mutation may be recessive. It may occur in a gamete. The mutation could kill the cell. A base substitution could occur that results in a different codon for the same amino acid.

11. Explain why mutation of DNA in a **somatic cell**, such as a skin cell causing skin cancer, does not get passed on to the next generation.

    Mutations that occur in somatic (body) cells will be confined to the individual organism in which they occur. They may even be confined to a particular tissue or location. Only mutations in gametes can be passed on to the next generation.

12. Explain why mutation of DNA in a germ cell can lead to changes in the characteristics of descendants. Give three examples.

    If mutations occur in germ cells (cells that produce gametes), then there is the potential for them to be passed on to the next generation. Examples include phenylketonuria (PKU), thalassaemia, sickle cell anaemia, haemophilia, and Huntington's disease.

13. (a) State two examples of genetic and/or chromosomal abnormalities that result in disease in humans.

    Down syndrome, Turner syndrome, Klinefelter syndrome

    (b) Describe the effects of these diseases. (see Textbook Chapter 13 for more details)

    See textbox P 109, 110

5 The Use of Genetic Information

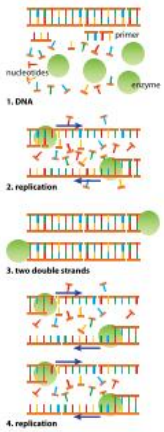
Subject Outline terms and phrases: **polymerase chain reaction (PCR), base sequence, primer, heat-resistant enzymes, free nucleotides, electrophoresis, electropherogram, DNA profiling, forensic science, genome**

1. Outline the steps used to extract DNA from a cell.

   The cells are broken up and the nuclei are separated from the rest of the cell components by centrifugation. The nuclei are then treated with chemicals that remove the nuclear membrane, and the DNA is isolated from the nuclear proteins.

2. By referring to the diagram at right describe how **PCR** is used to amplify small quantities of DNA. Use the terms heating and cooling, primers, free nucleotides, heat-resistant enzymes.

   The DNA to be amplified is mixed with primers, heat-resistant enzymes, and free nucleotides.
   The solution is heated and the DNA strands separate.
   The solution is then cooled and some of the primers attach to some of the DNA.
   The enzymes complete replication of the incomplete strands using the free nucleotides.
   These steps are repeated many times, each time doubling the amount of DNA in solution.



3. Explain how gel **electrophoresis** is used to:

   (a) produce an electropherogram that shows a DNA sequence

   A segment of DNA is cut into small fragments and added to a solution containing primers, heat tolerant DNA polymerase, and free nucleotides, some of which a modified to be labelled and also prevent further addition of more nucleotides. The solution is heated to separate the DNA strands and then cooled so some of the strands joined to primers. The DNA polymerase joins nucleotides to the strand with the primer until a labelled nucleotide is added. The DNA fragments are analysed using gel electrophoresis. The resulting banding pattern shows the order of labelled bases, which can be used to determine their sequence in the DNA segment.

(b) separate DNA fragments of different lengths.

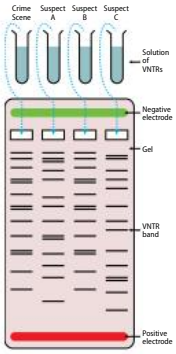
DNA samples are placed into wells at one end of a block of gel, such as agar, which has electrodes at each end. When the current is turned on, the DNA fragments, which are negatively charged, move towards the positive electrode, with the smaller fragments moving faster than the longer fragments. This results in a banding pattern. *(See Pages 42, 43 Fig. 5.5 and Fig. 5.7)*

4. Explain why an individual can be identified by analysing their DNA fragments.

In modern DNA profiling, short tandem repeats (STRs) are used instead of variable number tandem repeats (VNTRs). STRs are regions of DNA scattered throughout the genome. They are made up of a repeated sequence of between two and eight nucleotide bases. The frequency of these STRs is unique for an individual, just as fingerprints or eye iris patterns are unique. This enables the DNA to be matched to a person with a very high degree of confidence.

5. Refer to the diagram, which shows **DNA profiles** from a crime scene and three suspects. Which suspect's profile matches the DNA from the crime scene? Explain your answer, including why the other suspects' profiles do not match the DNA from the crime scene.

Suspect B matches. The VNTR bands for suspect B are identical to those found at the crime scene.
For suspect A, some of the bands match those at the crime scene, but some do not. Starting from the top, the following bands from suspect A do not match: 3, 4, 6, 10, 12, 13, 14.
Similarly, for suspect C, bands 1, 3, 5, 8, 10, 11, 12, 13, and 14 do not match those from the crime scene.



6. Make a list of the uses of the products of the PCR technique under each of the following headings:

forensic science	medicine	scientific research
DNA fingerprinting	to detect viral DNA in blood	studying the DNA in fossils
identifying criminals	gene therapy	classifying extinct organisms
identifying parents	diagnosis of genetic disorders	

8. The Human Genome Project is one of the most ambitious undertakings by humanity.

(a) State three benefits and potential benefits resulting from knowledge of the complete human genome.

1. Understand the causes of genetic disease.
2. Provide possible treatments for genetic disease.
3. Understand how organisms develop.
4. Understand how evolution has occurred.

(b) State three problems that could arise from this knowledge.

1. Misuse of the information.
2. Invasion of privacy.
3. Discrimination by employers/insurance companies against people with genetic faults.

9. (a) State three ethical issues that result from the collection of genetic information.

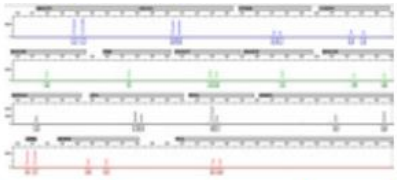
Should a life insurance company be able to insist on having this information before taking on a new client? Should an employer be entitled to make it a prerequisite for employment? Should it be carried out without the individual's knowledge or consent? The privacy of personal genetic information remains an important ethical issue.

(b) State and describe an economic issue that result from the collection of genetic information.

Examples include the protection of fish stocks and forests. It is possible to compare the DNA of fish that are being caught and sold, with the DNA stored in the database, to determine whether endangered species are being exploited. It is also possible to determine whether fish are being falsely labelled in order to inflate prices. Timber from specific forests can also be identified and tracked in this way, making it easier to protect the environment.

(c) Explain why the collection of genetic information could be a cultural issue.

We cannot assume that people from all cultures will value or interpret genetic information in the same way. For example, due to cultural mores or religious ideology, they may have differing views on abortion and the importance of genetic disorders. People from some cultures might consider the prediction of diseases or disorders unnatural. Others may not permit invasive procedures that they consider to disturb the natural harmony of the human body. Invasive procedures, such as amniocentesis and taking samples of blood or tissues, are routinely used in the collection of genetic information. The disclosure of this kind of information may also result in certain ethnic or cultural groups being stigmatised, or even victimised, because some genetic conditions are more prevalent within them. Examples of genetic conditions that are more common in certain groups include thalassaemia and Tay-Sachs disease.



Locus	Chromosome	STR	Allele values
D8S1179	8	TCTA	12,15
D21S11	21	TCTA	29,30
D7S820	7	GATA	10,11
CSF1PO	5	AGAT	10,12
D3S1358	3	TCTA	14,14
TH01	11	AATG	6,6
D13S317	13	TATC	11,12
D16S539	16	AGAT	11,11
D2S1338	2	TGCC	19,24
D19S433	19	AAGG	12,12
VWA	12	TCTA	17,18
TPOX	2	AATG	8,9
D18S51	18	AGAA	19,24
Amelogenin	X; Y		X,Y
D5S818	5	AGAT	10,13
FGA	4	TTTC	21,23

7. Refer to the diagram above, which shows an electropherogram and matching table of data for a DNA profile.

(a) How many sites are represented on this electropherogram?

16

(b) (i) At site D8S1179 this individual has a reading of 12,15. What does this mean?

This individual has two different alleles at this locus.

(ii) Why did the '12' and '15' fragments separate during electrophoresis?

The fragment (12) moved faster through the gel than the fragment (15) and would be shorter.

(c) List the sites at which this individual is homozygous.

D3S1358, TH01, D16S539, D19S433

(d) What is an STR? Which STR is used at site VWA?

STRs (short tandem repeats) are repetitive segments of DNA, two to five nucleotides in length, scattered throughout the genome in the noncoding regions between genes or within genes (introns), often used as marker for DNA profiling because of the high variability in repeat number between individuals.
The STR at the VWA locus is TCTA (on chromosome 12)

6 Biotechnology (Human Manipulation of DNA)

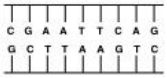
Subject Outline terms and phrases

biotechnology, plasmid, vector, bacterial transformation, probe (DNA or RNA), restriction enzyme, virus, microinjection, CRISPR, electroporation

1. (a) Describe the role of restriction enzymes in selecting and removing particular genes from a chromosome.

A restriction enzyme will cut a DNA molecule at a specific location.
The chromosomes, made of DNA, are mixed with restriction enzymes that will cut the DNA on either side of the particular gene.
This makes it possible to select and remove a particular gene.

(b) The DNA segment below is cut by the restriction enzyme ***EcoR1*** at the site 'AATT'.
Write the base sequence of the sticky end of the left fragment after the DNA has been cut.



TTAA

2. State three important features of a DNA or RNA probe.

A short segment of single-stranded DNA or RNA with a sequence of bases that is complementary to part of the required gene is selected. This segment is radioactively or fluorescently labelled.

3. Describe how particular genes can be:

(a) selected, using probes

Probe molecules will bind to DNA fragments containing the specific complementary base sequence. The labelled probe identifies and locates the gene.

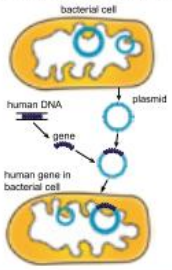
(b) removed, using restriction enzymes.

The DNA is cut up into small fragments using restriction enzymes. Each of the resulting DNA fragments will only contain a small number of genes.

(c) Name one method, other than DNA and RNA probes, that can be used to select a particular gene.

The antibody method.

4. Use the diagram below to explain how a bacterial cell can be used to produce human insulin.



The human gene for insulin is selected using a DNA probe, and then cut from the segment of chromosome using a restriction enzyme. Plasmids are removed from bacterial cells and cut using the same type of restriction enzyme. These plasmids are then mixed with the isolated insulin genes, allowing them to join to one another, forming recombinant plasmids, in the presence of an enzyme called DNA ligase. The bacterial cells will take up these recombinant plasmids under appropriate conditions. These bacterial cells will then produce human insulin by normal protein synthesis.
(The process is actually more complicated than this — see textbox "Introns and Bacterial Cells", Page 51.)

5. State three advantages and three disadvantages of the human manipulation of DNA.
Advantages:

1. Purer pharmaceuticals can be produced.
2. Cheaper food production in greater quantities.
3. Increased ability to identify criminals using forensic science.

Disadvantages:

1. Genetically modified organisms could endanger the environment.
2. An individual's DNA information could be misused.
3. Genetically modified foods could cause allergic reactions in some consumers

6. Explain how and why a human gene needs to be altered before it can be expressed by a bacterial cell.

When transferring genes, such as the gene for human insulin, from eukaryotic cells into bacterial cells, the introns must first be removed, as bacterial cells do not have a mechanism for removing them from mRNA.

7. Describe how selected genes can be transferred between species using

(a) **bacterial plasmids**

Selected genes can be transferred between plant species using Ti plasmids from Agrobacterium, a bacterium that causes tumours in plants. The Ti plasmid is removed from the bacterium and the desired gene is added to it. The plasmid is returned to the bacterium, which is then used to infect the plant. The bacterium inserts the Ti plasmid (carrying the desired gene) into the plant cells.

(b) **viruses**

Viruses can be modified so that they carry a desired gene, which they can then inject into a host cell.

(c) **microinjection**

In animals, a selected gene from one species can be injected into a fertilised ovum of another species using microinjection.

8. What is meant by the term **transgenic organism**? Give an example to illustrate your answer.

A transgenic organism is formed by combining DNA from different species. An example is goats that have been genetically engineered with a human gene to produce milk containing human tissue plasminogen activator (TPA).

9. Give three examples of chemicals or organisms that can be produced by genetic engineering.

Chemicals - Human insulin, growth hormone, hepatitis B vaccine.
Organisms - Any transgenic organism - see answer to Question 8.
Bacterial cells containing the recombinant plasmids are cultured to produce human insulin. (Note that the term genetic modification is also used to describe genetic engineering.)

10. Prior to the 1980s the hormone insulin was obtained by extracting it from cattle pancreases. Human insulin is now manufactured as a result of advances in genetic engineering. Discuss advantages and concerns of using genetic engineering to produce human insulin.
Advantages:

Able to produce pure pharmaceutical products economically on a large scale. No side effects from using non-human products.

Concerns:

Genetically engineered bacteria may develop unexpected characteristics, threaten survival of natural populations, or may be unable to be controlled using current antibiotics.

11. (a) What is **gene therapy**?

A process in which a genetic disease may be treated by inserting a normal gene into cells.

(b) State two methods that are used in gene therapy.

Method 1. Insert the gene into cells and then implant these cells into the patient.
Method 2. Use a vector, such as a virus, to "infect" particular cells of the patient with the desired

12. (a) Present one argument for and one argument against the genetic manipulation of organisms for food and medicine.

Food:

FOR: Increased food production, improved food quality, cheaper to produce.
AGAINST: GM food may cause side effects. (e.g. peanut genes in other foods.) GM crops may transfer to natural ecosystems causing unpredicted consequences in the environment. Ethical issue of animal genes being placed in plant food.

Medicine:

FOR: Production of pure and cheap vaccines in large quantities. Improved ability to diagnose genetic diseases. Gene therapy to treat diseases such as cystic fibrosis.
AGAINST: Bacteria used in GM may acquire characteristics that make them impossible to control using current antibiotics.

(b) Discuss possible effects of the genetic manipulation of organisms on the environment.

Use of GM crops reduces the amount of chemicals needed as pesticides and fertilisers.
OR
The GM organisms may transfer to the wild, and threaten the survival of natural populations.

13. (a) What is the function of the **CRISPR**/Cas9 system in bacteria?

Some bacteria are able to protect themselves from invasion by viruses by storing part of the viral DNA in a part of the bacterial DNA called CRISPR. If the same virus attacks the bacterial cell some time later, the bacterial cell recognises this and makes a complementary RNA copy of the viral DNA segment that it had stored. This RNA is then 'loaded' into an enzyme called Cas9 (CRISPR associated protein 9), which is then able to cut DNA at a specific site corresponding to the viral DNA. Cas9 is an endonuclease protein that is able to cut DNA. Thus, any 'invading' viral DNA is quickly destroyed.

(b) Describe how CRISPR can be used to edit genes.

the Cas9 protein is 'programmable'. The site at which it will cut DNA is determined by the base sequence of the RNA that is 'loaded' into it. That means that the CRISPR/Cas9 system can be used to accurately cut DNA at any predetermined location. The technique can be used in live cells to edit genes, and to switch them on or off.

(c) How can CRISPR be used to investigate the function of genes in embryos?

One way researchers can find out the function of a gene is to "knock it out". That is, to edit it so it does not produce its normal mRNA and the corresponding protein, and then observe the effect on the cell or tissue. Scientists are currently using CRISPR technology to edit genes in embryos to understand the role of genes in the embryos' development.

14. (a) Describe the steps involved in designing and manufacturing a specific protein.

The steps involved are:
› design the required shape of the specific protein
› determine the amino acid sequence that will produce this shape
› use the genetic code to construct a DNA molecule with the base sequence that codes for the chain of amino acids
› incorporate the DNA into bacterial cells, probably with plasmids
› clone the bacteria, isolate and harvest the specific protein molecules.

(b) State three uses of designed proteins.

Uses of designed proteins include:
› vaccines, that bind to viruses or bacteria, making them ineffective
› hollow protein 'spheres' that can deliver specific molecules (such as pharmaceuticals) to parts of the body
› channel proteins that regulate movement of specific substances across membranes enhancing their uptake
› proteins that change colour, or even glow, when they detect specific molecules.

7 Living Things are Made of Cells

Subject Outline terms and phrases: **cell theory, cell membrane, cytoplasm, organelles, fluid mosaic model, prokaryotic, eukaryotic**

1. State six characteristics that together distinguish living things from non-living things.
   (1) are complex and have an organised structure.
   (2) take in energy from their surroundings and use it.
   (3) preserve a composition that is chemically different from that of their external environment.
   (4) respond to stimuli.
   (5) are able to reproduce themselves.
   (6) grow and develop.

2. By referring to your answers to question 1, explain why the cell is the smallest independent unit of life.
   Anything smaller than a cell (e.g. a virus) cannot fulfil all six of the criteria. (Viruses cannot reproduce themselves, and they do not grow and develop.)

3. State the four main ideas of the **cell theory**.
   All living things are made up one or more cells. Cells are the structural and functional units of life. Cells arise from pre-existing cells. Cells contain hereditary material.

4. Define the following terms.
   cell membrane
   dynamic structure made of lipid and protein that separates the contents of a cell from the external environment and regulates the passage of materials into and out of the cell
   cytoplasm
   the fluid matrix in a cell excluding the nucleus.
   organelle
   a structure in a cell with a specific function. For example, a mitochondrion, chloroplast, nucleus, or ribosome.

5. Describe the structural differences between a lipid molecule and a phopholipid molecule.
   A lipid molecule is made up of three fatty acids joined to a glycerol molecule. A phospholipid molecule two fatty acids joined to a glycerol molecule which also connects to a phosphate and an ethanolamine.
   See Textbook Page 63, Fig. 7.5 and Fig. 7.6

6. Describe the fluid mosaic model of the cell membrane.
   The membrane is not static, but a dynamic structure that can have sections added and removed from it - much like a fluid. The membrane is made of a bilipid layer penetrated by proteins and carbohydrates - a mozaic.
   See Textbook Page 63, Fig. 7.4

7. State four functions of the cell membrane.
   Separate contents of the cell from the external environment.
   Regulate passage of materials into and out of the cell.
   Enable cells to recognise one another, and to recognise certain substances, such as hormones.
   Enable attachment of the cytoskeleton.

8. Complete the following table, comparing prokaryotic and eukaryotic cells:

	Prokaryotic cells	Eukaryotic cells
Size	small	Larger
Chromosome shape	circular	Linear
Presence of nucleus	Not present	Present
Organisation	little	High level of organisation
Membrane-bound organelles	none	present
Number of chromosomes	single	Two or more
Location of chromosome/s	In cytoplasm	In nucleus
Composition of cell wall	peptidoglycan	cellulose

9. State three features of prokaryotic cells and eukaryotic cells that are a reflection of their common evolutionary past.
   Features that prokaryotic and eukaryotic cells have in common include a phospholipid cell membrane, chromosomes made of DNA, similar protein synthesis mechanisms, (ribosomes are the site of translation), and the same genetic code.

8 Cell Structure and Function

Subject Outline terms and phrases: **organelle, nucleus, nucleolus, mitochondrion, chloroplast, vacuole/vesicle, Golgi body, endoplasmic reticulum(rough and smooth), ribosome, lysosome, cytoskeleton**

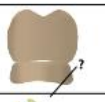
1. For each of the following terms, state whether it refers to the **structure** or **function** of a cell:

microscopic	structure	metabolic	function	cell wall	structure
reproduces	function	synthesises protein	function	contains DNA	structure
synthesises DNA	function	spherical	structure	photosynthesises	function
respires	function	cell membrane	structure		

2. Complete the table below which shows features of organelles in eukaryotic cells.

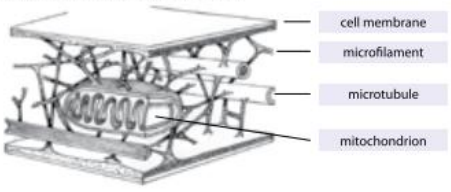
Organelle	Diagram	Function	Distinguishing feature(s)
nucleus		controls cell activities	double-membrane nuclear envelope with nuclear pores contains chromatin (DNA and protein) one or more nucleoli
nucleolus (part of the nucleus)		rRNA synthesis	found in nucleus; not surrounded by a membrane
chloroplast		photosynthesis	bounded by two membranes contains pigments such as chlorophyll contains grana and stroma
vacuole/vesicle		maintains water and solute balance stores waste products contributes to growth	bounded by a single membrane filled with fluid may contain pigments
mitochondrion		site of latter stages of aerobic respiration	inner membrane folded to form cristae
Golgi body		packaging and secretion of cell products	stacks of flattened sacs made of smooth membrane

CONTINUED NEXT PAGE

Endoplasmic reticulum		(rough ER) intracellular transport of materials; protein synthesis on attached ribosomes (smooth ER) lipid synthesis; carbohydrated metabolism	rough ER: flat sheets with ribosomes attached smooth ER: tubular membranes
ribosome		protein synthesis	made of rRNA and protein
lysosome		releases digestive enzymes	vesicle (with a single membrane) containing digestive enzymes

3. Describe the following structures, their function, and their location.
   nuclear envelope
   a two-membrane structure enclosing the nucleus and containing nuclear pores.
   chromatin
   DNA and protein located in the nucleus during interphase.
   chromosome
   long threadlike structure made of DNA and protein, located in the nucleus; only visible with the light microscope during mitosis and meiosis.
   cristae
   in foldings of inner mitochondrial membrane (singular crista)

4. Label each of these structures:
   microfilament, microtubule, cell membrane, mitochondrion



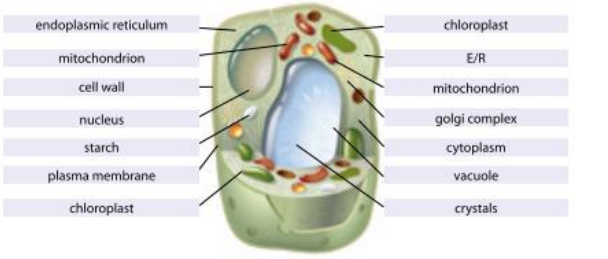
5. State three main functions of the cytoskeleton.

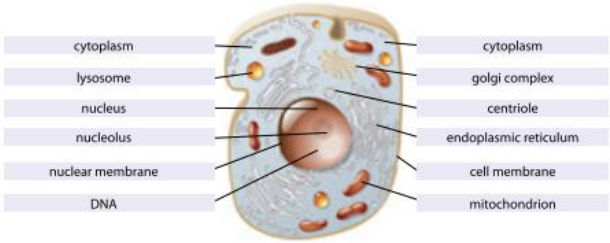
To maintain the shape of the cell.
To be involved in movement.
To hold organelles in place.

6. Complete the following table which shows the composition, function, and location of components of the cytoskeleton.

Component	Protein component	Description of subunits	Function	Found in
microfilament	actin	globular	intracellular movement	muscle cells phagocytic cells
microtubule	tubulin	globular	movement of cilia, flagella, form spindle fibres	cilia and flagella
intermediate filament	keratin	fibrous	provide strength maintain cell shape	skin cells

7. Complete the labelling of the diagrams of plant and animal cells.





8. Complete the following table which compares animal and plant structures.

Structure	Plant cell	Animal cell
cell wall	present	absent
cell membrane	present	present
nucleus	present	present
nucleolus	present	present
mitochondrion	present	present
chloroplast	May be present	absent
vacuole	Present, large central	small
Golgi body	present	present
vesicle	present	present
endoplasmic reticulum	present	present
ribosome	present	present
lysosome	present	present
cytoskeleton	present	present

9 Living Cells Need Energy

Subject Outline terms and phrases

energy, light energy, chemical energy, autotroph, heterotroph, photosynthesis, chlorophyll, energy transformation, chemical bond, ATP, ADP, Pi, metabolic reactions, aerobic respiration, fermentation (anaerobic respiration)

1. (a) What is **energy**?

Energy is the capacity to do work.

(b) State three reasons why living cells need energy.

(1) Active transport.
(2) Synthesis.
(3) Exocytosis.
(4) Movement of organelles.
(5) Endocytosis.
(6) Cell division.

2. Complete the following sentences:

The energy that cells obtain from their environment can be in either physical or chemical form. Some cells use sunlight, a physical form of energy, while others must take in energy-rich compounds, a chemical form of energy.

3. Define the following terms:

(a) **autotroph**

an organism that is able to manufacture all of its complex organic compounds from simple inorganic substances.

(b) **heterotroph**

organism that cannot produce all its complex organic compounds from simple inorganic substances and relies on other organisms or their products or remains.

(c) **photosynthesis**

a chemical process in which glucose (an organic compound) is manufactured from water and carbon dioxide using light energy; oxygen is a byproduct; the necessary light energy is trapped by a photosynthetic pigment, most commonly chlorophyll.

4. Complete the following table which refers to energy transformations in cells.

Cell	Energy input	Energy output
photosynthetic cell	physical (light)	chemical (glucose)
muscle cell	chemical (glucose)	physical (movement, heat)
light-emitting cell (e.g. glow worm)	chemical	physical (light, heat)

5. By referring to the diagram on the right, state the source of organic molecules for each organism.

grass: photosynthesis
snail: grass
lizard: snail
kookaburra: lizard

6. (a) What is the main source of energy for life on Earth?

The Sun

(b) Explain how a heterotroph like yourself is able to obtain energy from this source.

Plants obtain light energy from the Sun and convert it to chemical energy – in the form of organic molecules.
Heterotrophs feed on plant material, or on other organisms that have fed on plant material to obtain energy from their organic molecules.

(c) Explain why nearly all life on Earth is dependent on the process of **photosynthesis**.

Ultimately, all heterotrophs rely on autotrophs for their supply of organic compounds.
Autotrophs produce carbohydrates by photosynthesis, and these are used to make other organic compounds.

7. Complete the missing information in the following chemical and word equations for photosynthesis.

$$6CO_2 + 6H_2O \xrightarrow[\text{chlorophyll}]{\text{light energy}} C_6H_{12}O_6 + 6O_2$$

carbon dioxide + water $\xrightarrow[\text{chlorophyll}]{\text{light energy}}$ glucose + oxygen

8. What is the role of chlorophyll in photosynthesis?

Chlorophyll traps light energy that is used to carry out chemical reactions.

9. (a) Explain why certain molecules, such as glycogen, starch, and lipids, are able to be used as stores of energy.

When these large molecules are broken down and simpler molecules are formed, energy is released.

(b) Energy changes occur when **chemical bonds** are broken and new bonds are formed. By referring to this statement, explain why the breakdown of glucose in the presence of oxygen, to form carbon dioxide and water, releases energy.

Less energy is needed to break the bonds of the glucose and oxygen molecules than is released when the new bonds of the water and carbon dioxide molecules are formed. (There is more energy stored in the glucose and oxygen molecules than in the water and carbon dioxide molecules that are formed.)

10. Use the following diagram of the **ATP** cycle to answer the questions below.

(a) What is the source of the energy that enters the ATP cycle?

Cellular respiration

(b) State three uses of the energy that is released in the ATP cycle.

Active transport.
Movement of organelles.
Synthesis.
Endocytosis.
Exocytosis.

11. Define the term **cellular respiration.**

energy to make ATP.

12. Some cells provide themselves with energy using a chemical process requiring oxygen, while other cells use a chemical process that does not require oxygen. Certain cells are able to use both processes.

Name these chemical processes that cells use to provide themselves with energy.

(1) chemical process requiring oxygen — aerobic respiration

(2) chemical process not requiring oxygen — fermentation (an anaerobic alternative to aerobic)

13. Complete the missing information in the following summary equation for **aerobic respiration**.

$C_6H_{12}0_6$ + $6O_2$ ——————> $6CO_2$ + **$6H_2O$**

glucose + oxygen ——————> carbon dioxide + **water**

14. Complete the following sentence.

Energy that is released as a result of breakdown of glucose in the presence of oxygen is either lost as heat or is used to make ATP which can be used by the cell for energy-requiring processes.

15. Complete the following table which shows details of the stages of aerobic respiration.

Name of reaction	Site of reaction	Reactants	Products	Net gain of ATP
glycolysis	cytoplasm	glucose	pyruvate	2
phosphorylation	cytoplasm and mitochondria	ADP and phosphate	ATP	

16. Complete the missing information in the following summary equations for **fermentation (anaerobic respiration)**.

In plants and yeasts

$C_6H_{12}0_6$ ——————> $2C_2H_5OH$ + $2CO_2$

glucose ——————> ethanol + carbon dioxide

In animals

$C_6H_{12}0_6$ ——————> $2C_3H_6O_3$

glucose ——————> lactic acid

17. Complete the following table which summarises the main differences between aerobic respiration and fermentation (anaerobic respiration) in eukaryotes.

	Aerobic Respiration	Fermentation
Site of reaction(s)	cytoplasm and mitochondria	cytoplasm
Reactants	glucose and oxygen	glucose
Products in animals	carbob dioxide and water	lactic acid
Products in plants and yeasts	carbob dioxide and water	ethanol and carbon dioxide
Amount of ATP produced per glucose molecule	36	2

18. (a) State two commercial uses of fermentation.

brewing, wine-making, breadmaking

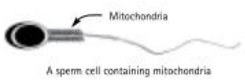
(b) Under what conditions would a human cell carry out lactic acid fermentation?

low oxygen concentration (anaerobic conditions).

19. Explain why much less energy is released through fermentation than through aerobic respiration, even though both processes involve the breakdown of glucose.

The products of fermentation still retain a significant amount of energy and can be further broken down (in the presence of oxygen) to release more energy. On the other hand, the products of aerobic respiration (carbon dioxide and water) have much less chemical energy and cannot be further broken down to release more energy.

20. Human sperms cells contain a large number of mitochondria.
Explain how this relates to their function.



A sperm cell containing mitochondria

Sperm cells require a lot of energy to propel themselves.
This energy is obtained from the latter stages of aerobic respiration, which occur in the mitochondria.

10 Movement in and out of Cells

Subject Outline terms and phrases

transport proteins, channel proteins, aquaporins, carrier proteins, diffusion, facilitated diffusion, osmosis, active transport, endocytosis, exocytosis, surface-area-to-volume ratio, concentration gradient, exchange

1. Complete the tables below to summarise the differences in inputs and outputs for autotrophic and heterotrophic cells.

Table of inputs

Substance	Autotrophic cells	Heterotrophic cells
oxygen	for aerobic respiration when rate of respiration exceeds rate of photosynthesis	for aerobic respiration
carbon dioxide	for photosynthesis when the rate of photosynthesis exceeds the rate of respiration	not required
nitrates, nitrites	source of nitrogen for amino acid synthesis	source of nitrogen for amino acid synthesis
phosphates	source of phosphorus for nucleotide synthesis	source of phosphorus for nucleotide synthesis
calcium	a component of plant cell walls	an enzyme cofactor
other inorganic nutrients	required for synthesis reactions	required for synthesis reactions
organic compounds	not required, as they are manufactured by the cell	some are required (e.g. glucose, some amino acids, lipids), as not all can be manufactured by the cell

Table of outputs

Substance	Autotrophic cells	Heterotrophic cells
oxygen	from photosynthesis when rate of photosynthesis exceeds rate of respiration	no output
carbon dioxide	from respiration and fermentation when their rate exceeds rate of photosynthesis	from aerobic respiration
lactic acid	not normally produced	a waste product of fermentation
ethanol	a product of fermentation	mainly yeasts
urea	not normally produced	a nitrogenous waste product from the breakdown of excess amino acids

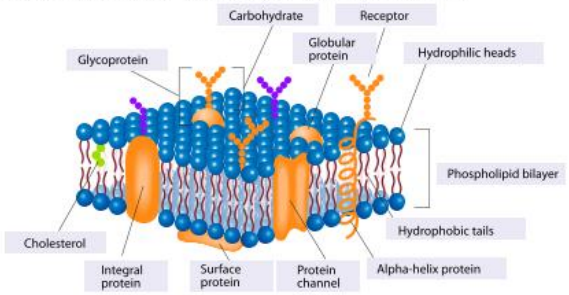
2. The membrane of a human muscle cell maintains different concentrations of materials inside and outside the cell. Give an example of a substance that has a higher concentration inside and outside a human muscle cell than outside, and an example of a substance that has a higher concentration outside a human muscle cell than inside.

Substance that has a higher concentration inside	potassium ions, magnesium ions
Substance that has a higher concentration outside	sodium ions, chloride ions, calcium ions

3. Label the key next to the diagram below to show the location of *starch*, *cellulose*, *water*, *protein* and *nucleic acids* in the cell. On the cell diagram label the location of *lipids*.

nucleic acid
cellulose
protein
starch
water

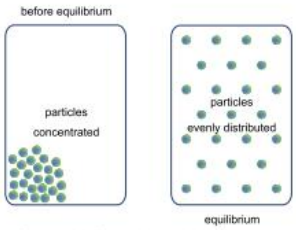
4. (a) Label the features of the fluid mosaic model of the Cell membrane shown below.



(b) State 3 functions of the cell membrane.

Separate contents of the cell from the external environment.
Regulate passage of materials into and out of the cell.
Enable cells to recognise one another, and to recognise certain substances, such as hormones.
Enable attachment of the cytoskeleton.

8. The following diagrams represent the position of molecules in a fluid before and after **diffusion** has occurred.



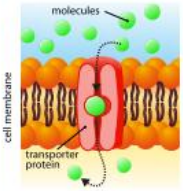
Explain what has happened between the first and second diagram.

The molecules move about randomly and eventually become evenly distributed throughout the space available. This process is called diffusion.

9. (a) What is meant by the selective exchange of materials by the cell membrane?

The movement of selected substances across a membrane.

(b) Explain how **facilitated diffusion** works, by referring to the following diagram.



The transporter proteins bind to certain ions or molecules and carry assist them across the membrane. The movement of these substances occurs **with** the concentration gradient, and no input of energy is required – it is a passive process.

5. Give two examples of transport proteins

Channel protein, aquaporin, carrier protein

6. Define the following terms and give examples.

concentration gradient

the difference in concentration of a substance between two different regions (for example, inside and outside a cell).

passive process

not requiring input of energy; not active. For example, diffusion, osmosis.

semi-permeable

more permeable to some substances than to others.

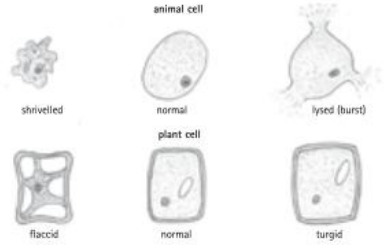
active process

requires the input of energy (not passive). For example, active transport, endocytosis, exocytosis

7. Complete the following table which refers to the processes by which substances move across membranes.

Process	Active/Passive	Example of substance moving	Direction of movement
diffusion	passive	oxygen	with concentration gradient
facilitated diffusion	passive	glucose	with concentration gradient
osmosis	passive	water	with concentration gradient
active transport	active	sodium ions and potassium ions	against concentration gradient
pinocytosis	active	fat droplets	into cell
phagocytosis	active	bacterial cells	into cell of immune system
exocytosis	active	hormones, sweat, saliva	out of cell

10. The following diagram shows the effects of osmosis on animal and plant cells. In the spaces below the diagram explain what has happened to the flaccid/shrivelled and the turgid/lysed cells.



flaccid/shrivelled:

Water has been lost from the cell by osmosis.

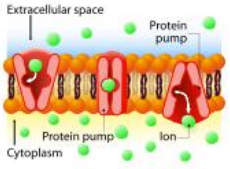
turgid/lysed:

Water has entered the cell by osmosis. This has caused the animal cell to burst, but the cell wall of the plant cell prevents it from bursting.

11. Explain why osmosis is considered to be a special case of diffusion.

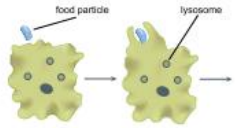
Osmosis is diffusion of water across a semi-permeable membrane. It is a passive process in which there is an overall movement of water from a high concentration of water to a lower concentration of water. Note that it is the solvent that is being considered, and that a semi-permeable membrane (which is more permeable to the solvent than to the solute) is needed.

12. Explain how **active transport** works, by referring to the following diagram.



The substance to be transported binds to a protein pump. This membrane protein then expends energy (in the form of ATP) to move the substance across the membrane against the concentration gradient.

13. The following diagram shows a cell that is about to engulf a food particle.



(a) Describe the remaining steps in the process

The cell's membrane completely wraps itself around the food, forming a vacuole. Lysosomes fuse with the vacuole and release enzymes, which digest the food. *See Textbook Page 91 Fig 10.12*

(b) State the name of this cellular process.

Phagocytosi

(c) Name two cells that carry out this process.

Amoeba, white blood cell.

14. Complete the following table which shows features of some energy-requiring processes that move substances across cell membranes.

Type of movement	Direction of movement	Examples of cells involved	Example of substance moved	Energy supplied by
endocytosis (phagocytosis)	into the cell	white blood cell	bacterium	ATP
endocytosis (pinocytosis)	into the cell	cells lining the small intestine	fat droplets	ATP
exocytosis	out of the cell	salivary glands	saliva	ATP
active transport	into or out of the cell	human muscle cell	sodium out magnesium in	ATP

15. Explain the meaning of the statement 'The cell membrane is a dynamic structure'. In your answer you should refer to the role of the membrane in active transport, endocytosis, and exocytosis..

The membrane's role in the movement of certain substances across it may involve recognition (selectivity) and the expenditure of energy. In active transport substances are moved across the membrane against the concentration gradient. Endocytosis involves the membrane changing shape to form vesicles, or vacuoles, which carry substances into the cell. In exocytosis, vesicles within the cell fuse with the membrane to enable substances to be secreted.

16. The diagram below shows the change in surface area that occurs when a large cube (6 cm by 6 cm by 6 cm) is divided into eight equally-sized medium cubes or 27 equally-sized small cubes.

(a) Calculate the total surface area of

(i) the 27 small cubes

27 Cubes 2cm x 2cm x 2cm
Surface Area 27 x 6 x (2 x 2) = 648 cm^2

(ii) the eight medium cubes

8 Cubes 3cm x 3cm x 3cm
Surface Area 8 x 6 x (3 x 3) = 432 cm^2

(iii) the one large cube

1 Cube 6cm x 6cm x 6cm
Surface Area 1 x 6 x (6 x 6) = 216 cm^2

(b) Use your answers to explain how the **surface-area-to-volume ratio** changes as the large cube is divided into smaller pieces.

The volume remains the same for all (216 cm3).
Hence the SA:V changes from 216:216 = 1:1 for the large cube, 432:216 = 2:1 for the eight medium cubes, and 648:216 = 3:1 for the 27 small cubes.

(c) Explain why the relationship between surface area and volume is an important factor in determining the survival of cells.

As the cell gets bigger, there is proportionally less SA, and a decrease in efficiency for exchange of materials between the cell and its surroundings.

17. (a) State two processes that contribute to in an increase in the size of a cell.

Water uptake. Synthesis of new materials.

(b) Explain why the size of a cell is limited by the change in its surface area to volume ratio as it grows.

As the cell gets bigger there is proportionally less surface area compared to the volume, and hence there is a decrease in the efficiency in the exchange materials with its surroundings. It may be that the ability of a cell to perform these functions efficiently limits its size.

18. (a) Explain how the concentration gradient of a substance affects its direction and rate of diffusion across a cell membrane.

When particles diffuse, they move with the concentration gradient (high to Low).
As the concentration gradient increases, the rate of diffusion increases.

(b) Explain why active transport is needed to move some substances across a cell membrane.

To move a substance from a lower concentration to a higher concentration - against the concentration gradient - requires energy, usually in the form of ATP. This is called active transport.

19. Explain how the physical and chemical nature of the materials being exchanged affects their movement across a cell membrane

Small, uncharged particles diffuse easily through cell membranes while particles that are large or charged require assistance from channel proteins, carrier proteins or even whole sections of the membrane. Cell membranes contain proteins called aquaporins that act as channels for the movement of water molecules. *See Fig. 10.7*

20. Describe the role of the Golgi body in moving substances, such as enzymes and hormones, out of the cell.

The Golgi body packages the substances into vesicles that break off, travel to the cell membrane and fuse with it to allow secretion. *See Fig. 10.14 on P91.*
In some cases, a protein product is modified in the Golgi body before being secreted.

11 Cell Metabolism

Subject Outline terms and phrases	**cell metabolism, metabolic pathway, intermediate compound, environmental factor**

1. What is meant by the term **cell metabolism**?

The biochemical processes that take place in a cell are referred to as cell metabolism.

2. (a) Describe the structures of the internal membranes of mitochondria and chloroplasts.

Each mitochondrion has an outer membrane and an inner membrane which is folded to form structures called cristae.
Chloroplasts have two outer membranes, and an internal system of membranous flattened sacs called thylakoids. These thylakoids are arranged in stacks called grana (singular granum).

(b) Explain how the structures of the internal membranes of mitochondria and chloroplasts facilitate some biochemical processes.

The cristae provide a large surface area for the attachment of enzymes such as ATP synthase. Photosynthetic pigments such as chlorophyll are contained within the thylakoid membranes which also have a large surface area and play an important role in the conversion of light energy into chemical energy. *See Textbook Fig. 11.1 on P94 and Fig. 11.2 on P95*

3. Explain how biochemical processes in the cell are influenced by the presence of specific enzymes.

In cells, biochemical processes take place in a series of regulated steps and each step is controlled by a specific enzyme. In the absence of these enzymes, the chemical processes might occur too slowly, or not at all.

4. State three **environmental factors** that influence biochemical processes in the cell.

Biochemical processes in the cell are affected by factors including temperature, pH, the presence of inhibitors, the concentration of reactants, and the concentration of enzyme.

5. Refer to the diagram at right to answer the following questions.

(a) Explain why a different enzyme is required for each step in the **metabolic pathway**.

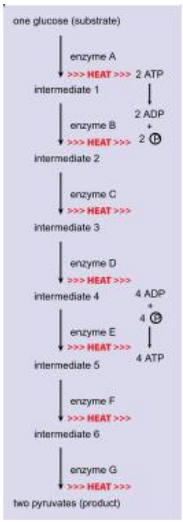
Each enzyme is specific to its substrate. Therefore, every substrate requires a different enzyme.

(b) Explain why the amount of energy in the glucose molecule is greater than the amount of energy in the two pyruvate molecules combined.

Some of the energy from the original glucose molecule has been lost as heat.

(c) Explain what would happen if enzyme E was inactivated.

There would be an accumulation of intermediate compound 4.



6. State four reasons why metabolic pathways in cells involve many small regulated steps.

(1) Large steps would produce unfavourable conditions, such as high temperatures and changes in pH.

(2) The small steps release small quantities of energy that can be trapped by energy molecules like ATP.

(3) Each step is catalysed by a specific enzyme.

(4) The small steps provide intermediate compounds that can be used as the starting points for other reactions.

7. (a) Complete the following sentence:

Poisons are substances that interfere with cell metabolism.

(b) State three ways in which poisons can cause this effect on cells.

disable enzymes, alter properties of the mitochondrial membrane, inhibit protein synthesis.

8. Complete the following table which shows the effects of some chemicals on protein synthesis in prokaryotic and eukaryotic cells.

Chemical	Effect on prokaryotes
Chloramphenicol	Stops the growing peptide moving on from one tRNA to the next
Erythromycin	Stops growing peptide moving to new codon
Tetracycline	Inhibit tRNA binding to ribosomes
Streptomycin	Prevents proper assembly of ribosomes
Rifamycin	Prevents mRNA synthesis
	Effect on eukaryotes
Amanitin	Stops mRNA synthesis
Cycloheximide	Same as chloramphenicol for prokaryotes
	Effect on both
Actinomycin	Prevents RNA synthesis
Puromycin	Causes incomplete peptides to fall off the ribosome

9. Complete the following table which shows the effects of some chemicals on cell metabolism.

Chemical	Effect on cell metabolism
Carbon monoxide	disrupts cellular respiration
lead	A non-competitive inhibitor
Cyanide	disrupts cellular respiration
penicillin	Attacks a step in the synthesis of bacterial cell walls
Barbiturates	disrupt cellular respiration
valinomycin	Binds to potassium ion

10. Name the chemicals and provide information about their beneficial use as indicated in the brackets for each of the following categories:

medical (5 uses):

immunosuppressive drugs,
insulin (for diabetes),
growth hormone,
contraceptive hormones,
antibiotics.

agriculture (3 uses):

herbicides,
insecticides,
hormones.

food preservation (3 substances)

sulfur dioxide,
vinegar,
salt.

11. State a harmful effect of each of the following chemicals and explain why the chemical is or was used by humans.

radium

causes mutations and cancer.

mercury

disrupts metabolic pathways by inhibiting enzymes and denaturing essential proteins

DDT

enters the food chain, accumulates in higher order animals, interferes with cell metabolism.

sulfur dioxide

contributes to acid rain, can cause allergic an reaction.

thalidomide

causes deformities during foetal development.

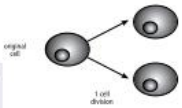
12 New Cells from Old

Subject Outline terms and phrases	**cell division, somatic cells, gametes, germ-line cells, binary fission, mitosis (mitotic division), asexual reproduction**

1. (a) Where do all new cells come from?

Pre-existing cells.

(b) Refer to the diagram that shows one cycle of cell division. State the number of cells that will be present after three cycles of cell division.



After one cycle of division, there are two cells. After two cycles of cell division, if each of these divides, there will be 4 cells. If each of the 4 cells now divides (three cycles of cell division), there will be 8 cells.

2. The chemical unit of genetic information in most organisms is DNA.

(a) Explain why the amount of DNA in a cell doubles before cell division.

So each daughter cell will receive an identical set of genetic information.

(b) What would be the consequence if a cell divided before the replication of DNA occurred?

Either one or both of the resulting daughter cells will lack sufficient genetic information for its continued survival.

3. Define the following terms.

(a) somatic cells

body cells (not sex cells or gametes)

(b) germ cells

male or female haploid sex cells that fuse with another gamete to form a diploid zygote

(c) diploid cells

cells with two of each kind of chromosome (homologous pairs); 2n

(d) homologous chromosomes

chromosomes with the same appearance that carry information for the same characteristics; pair up and segregate during meiosis

(e) haploid cells

cells that contain one of each type of chromosome; n

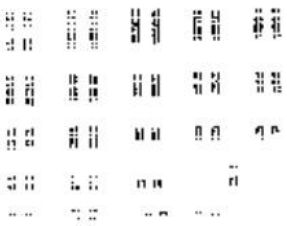
(f) zygote

the diploid cell that is formed when two gametes fuse

(f) germ-line cells

cells that give rise to gametes (germ cells)

4. Use the human karyotype to answer the following questions. (also refer to Chapter 2)



(a) Is this karyotype that of a male or a female? Explain:

Male. Has an X and a Y chromosome

(b) How many non-sex chromosomes (autosomes) are in this karyotype?

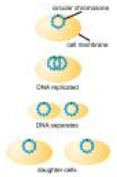
44

(c) How could biologists construct a human karyotype like the one shown above?

1. Photograph the chromosomes in a dividing cell.
2. Cut the photograph into individual chromosomes.
3. Find matching pairs of chromosomes.
4. Arrange the pairs in order of size.

Note that this process can be done using a computer image.

5. State the name of this process, and describe it using the terms *chromosome, cell membrane, daughter cells*



The process is binary fission and is the way prokaryotes reproduce. The circular chromosome replicates and the two centromeres attach to the cell membrane. The cell takes in water by osmosis and the cell membrane expands moving the two chromosomes apart. The cell pinches across its equator forming two daughter cells each with a duplicate chromosome.

6. The process of cell division in eukaryotes involves **mitosis**, the precise division of the contents of the nucleus.

Name the phases of mitosis and describe what happens to the chromosomes at each phase.

(1) **prophase:** the nuclear membrane disintegrates, the spindle apparatus (made of microtubules) begins to form, the chromosomes condense. In animal cells the centrioles divide.

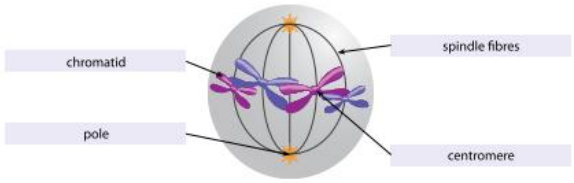
(2) **metaphase:** the chromosomes line up at the equator, and become attached to the spindle fibres by their centromeres. Sister chromatids face opposite poles.

(3) **anaphase:** centromeres divide, sister chromatids separate and move towards opposite poles. This may be due to the contraction of spindle fibres.

(4) **telophase:** the two new nuclear envelopes form, nucleoli reappear, chromosomes revert to long, thin strands (chromatin).

7. The diagram below shows an animal cell that is entering metaphase of mitosis.

(a) Label the following structures on the diagram: *chromatid, centromere, spindle fibres and pole.*



(b) How many chromosomes does this cell contain?

4

8. The two daughter cells that result from a mitotic division contain identical sets of chromosomes. Explain the key events that occur leading up to and during mitosis that produce these genetically identical cells.
In your answer you should use the following terms:
replication, condensation, sister chromatids, centromere, spindle fibres, separation

In the parent cell there is replication of DNA, followed by condensation of the chromosomes. Mitosis begins with prophase, followed by metaphase during which each chromosome becomes attached to spindle fibres by its centromere. In anaphase, the next stage of mitosis, the centromeres divide and the separation of sister chromatids occurs, in which they move towards opposite poles of the cell.
During telophase, two new nuclei form.
Finally the cell divides into two daughter cells, each with an identical set of genetic material.

9. Define the following terms.

(a) asexual reproduction

the production of new individuals without the mixing of genetic material.

(b) budding

method of asexual reproduction in which a new individual forms on the parent and then breaks away.

(c) clone

a group of genetically identical organisms produced as a result of asexual reproduction.

10. (a) State three types of asexual reproduction used by plants.

(1) Budding
(2) Bulbs
(3) Runners

(b) Name three types of animal that can reproduce asexually.

(1) Seastars
(2) Sea anemones
(3) Hydra, some worms

(c) Name the type of cell division that is involved in asexual reproduction in eukaryotes.

Mitotic cell division.

11. (a) Explain why the offspring produced by asexual reproduction are genetically identical to each other and to the parent.

The genetic material of the parent cell is replicated and each offspring receives an identical copy to the parent and each other.

(b) Explain how variation occurs in asexually reproducing organisms.

Mutation, a spontaneous or induced change in the genetic material gives rise to genetic variation. Environmental conditions can give rise to non-inheritable variation.

12. How do the number and type of chromosomes in the daughter cells produced by mitotic division or binary fission compare to those of the parent cells?

Each daughter cell has the same number and type of chromosomes as the parent cell.

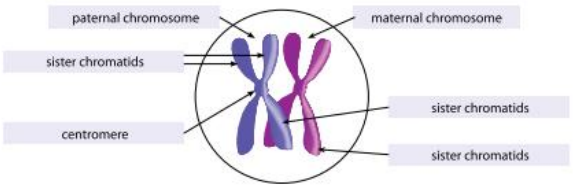
13 Sexual Reproduction and Meiosis

Subject Outline terms and phrases	**diploid, haploid, homologous, meiosis, crossing over, independent assortment, fertilisation, genetic variation, sexual reproduction**

1. (a) How many types of autosome are present in a normal **diploid** human cell? 22

(b) How many of each type of autosome are present in a normal diploid human cell? 2

2. Label the diagram below showing a pair of homologous chromosomes as they would appear while crossing over during late prophase I. Label the following features on your diagram: *centromere, sister chromatids, chiasma, maternal chromosome and paternal chromosome*



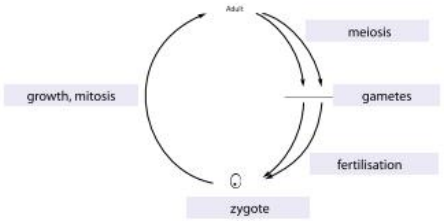
3. (a) Describe what is happening during anaphase I.

During anaphase homologous chromosomes are moved apart, going to opposite poles.

(b) Describe how a second diagram could be drawn (and compared to the diagram in part (a)) to illustrate the idea of independent assortment.

Instead of one maternal and one paternal chromosome going to each pole, two maternal could be shown moving to one pole and two paternal going to the other pole.

3 (c) Use the following terms to label the diagram below which represents the life cycle of a sexually reproducing organism.
growth and mitosis, gametes, meiosis, fertilisation, zygote



4. Explain how (a) crossing over and (b) independent assortment contribute to genetic variability in the offspring of a sexually reproducing species.

(a) crossing over:

alters the combination of genes that is passed on from one generation to the next.

(b) independent assortment:

increases the number of possible combinations of genes in the gametes, by distributing the maternal and paternal chromosomes of each homologous pair at random.

5. (a) Give an example of a syndrome in humans that is caused by the presence of an extra autosome.

Down syndrome - Extra chromosome 21

(b) How is it possible for a human to receive this extra autosome?

Failure of homologous chromosomes to separate during meiosis. (non-disjunction)

(c) State one environmental factor that can increase the incidence of this syndrome.

Age of mother.

6. Complete the table below to show the differences between **haploid** and **diploid** cells in humans.

	Haploid cell	Diploid cell
Number of chromosomes	23	46
Number of sex chromosomes	1	2
Site of production	ovaries, testes	body cells
Is further cell division possible?	no	yes
Number of autosomes	22	44
Is fusion with another cell possible?	yes	no

7. Define the term **fertilisation.**

Fusion of a sperm cell and an ovum to form a zygote.

8. Fill in the missing details in the following description of fertilisation in humans.

SPERM + EGG ⟶ ZYGOTE

23 CHROMOSOMES 23 CHROMOSOMES 46 CHROMOSOMES

9. Complete the following table which compares the products of mitosis and meiosis in humans.

	Mitosis	Meiosis
Number of divisions	one	two
Type of parent cell	somatic cell	germ cell
Number of chromosomes in parent cell	46	46
Type of cell produced	somatic cell	gamete
Number of chromosomes in a daughter cell	46	23
Is product haploid or diploid?	diploid	haploid
Number of cells produced in males from one parent cell	two	four

10. Compare the degree of genetic variation in the products of asexual reproduction and sexual reproduction.

In asexual reproduction, genetic material comes from only one parent and mutation is the only source of variation.
In sexual reproduction the offspring's genetic material comes from two sources. Crossing over and independent assortment during meiosis lead to variation in the gametes. Random fertilisation further increases the genetic variation in the offspring.

11. Complete the following table to show whether the source of genetic variation contributes to the products of asexual and sexual reproduction.

Source of genetic variation	Asexual reproduction	Sexual reproduction
mutation	yes	yes
crossing over	no	yes
independent assortment	no	yes
random fertilisation	no	yes

12. Explain how fertilisation contributes to the genetic variability of offspring.

Each gamete is unique and chance determines which eggs develop and which sperm cells will fertilise them..

14 Control of Cell Division

Subject Outline terms and phrases

internal factors, external factors, cell cycle, checkpoints, gene products, hormones, carcinogen, regulatory genes, cell culture

1. State two **gene products** that a cell produces to regulate the **cell cycle**.

Choose two of the following. The enzyme cyclin-dependent kinase (Cdk), the regulatory protein cyclin, the maturation promoting factor or MPF (also called mitosis promoting factor).

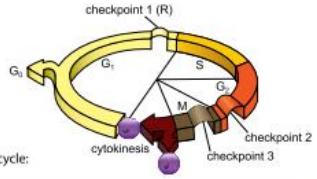
2. State two **external factors** that regulate the cell cycle.

Growth factors (hormones)
Contact inhibition

3. Complete the following table describing the cell cycle.

Stage	Event(s)	Major Checkpoint (yes or no)
G_0	cell differentiation	no
G_1	accumulation of energy, growth	yes
S	DNA replication	no
G_2	growth	yes
mitosis	division of nuclear contents	yew
cytokinesis	splitting of cell into two	no

4. The diagram shows phases of the cell cycle.



(a) State one process that occurs in:

G_1 growth, protein synthesis, lipid synthesis

S phase - DNA replication

G_2 growth, protein synthesis, lipid synthesis

(b) Explain the roles of each of the following gene products in the regulation of the cell cycle:

growth factors

Growth factors are proteins secreted by other cells and they bind to the receptor molecules in the cell's plasma membrane. Once this has occurred, the receptor molecules induce changes in proteins in the cytoplasm. These are called relay proteins, as they relay the signal from the growth factors to the cell cycle control mechanism which causes it to proceed past the restriction checkpoint.

cyclin

Cyclin activates the enzyme Cdk.

Cdk

Cdk combines with cyclin to form MPF.

MPF

An increase in MPF causes the cell to proceed through prophase and metaphase. Anaphase cannot commence until there is a decrease in MPF.

5. Interphase refers to the period in the cell cycle when the cell is not dividing. State three processes that occur in the cell during interphase.

New organelles are synthesised. DNA is replicated. Energy is accumulated. The cell increases in size.

6. What are the two key factors that trigger a stem cell to divide?

Its size and the signals that it receives from its environment.

7. Plant hormones and growth factors are important in the regulation of cell division. Give three examples of each.

plant hormones:

cytokinins, auxins, gibberellins. Their importance is to coordinate the growth of the plant (so that the top does not grow more than the roots can support, and vice versa).

growth factors:

epidermal growth factor, erythropoietin, LH and FSH. Their importance is to coordinate and regulate the growth of cells and tissues.

8. Explain how **carcinogens** upset the normal control of cell division.

What can happen as a result of this?

Carcinogens upset the normal control of cell division by causing mutations. A mutation is any spontaneous or induced change in the genetic material of a cell. In cancer cells the checkpoints in the cell cycle may not function correctly, and some cancer cells produce excess amounts of growth factors. This results in the uncontrolled division of cells.

9. Complete the following table which shows the most likely cause of mutations that result in different forms of cancer.

Type of cancer	Most likely cause of mutation
skin cancer	high energy radiation
lung cancer, throat cancer	carcinogens in cigarette smoke
colon cancer	chemical mutagens, low-fibre diet
leukaemia	high energy radiation (e.g X-rays)
bladder cancer	2-naphthylamine
mesothelioma	asbestos

10. Humans have been unknowingly culturing cells for thousands of years. State three uses for culturing yeast cells and two uses for culturing bacterial cells that humans have been engaged in for centuries.

uses for culturing yeast cells

brewing
breadmaking
winemaking

uses for culturing bacterial cells

making cheese
yoghurt

11. State four contemporary uses of cell culture.

(1) Producing bacterial cells for use in the Ames test.

(2) Providing skin tissue.

(3) Producing animal cell cultures for testing the effects of cosmetics and drugs.

(4) Producing clones of valuable plants.

12. Cells can be cultured in a number of ways. Provide a contemporary use for each of the following:

(a) bacterial cell culture on agar plates

Testing the effect of antibiotics.

(b) HeLa cells

Used as host cells in genetic engineering to produce human proteins. *See Textbox p121.*

(c) animal cell cultures

Producing reserve cells for organs.

(d) plant cell culture

Producing large numbers of genetically identical plants.

13. (a) State four special provisions required for the growth medium used to culture animal cells.

vitamins and other organic compounds; maintain correct osmotic balance; suitable pH; well-aerated medium; sterile.

(b) State three steps, in the correct sequence, that need to be followed in the technique of plant tissue culture.

small group of cells cut from the donor plant; sterilised to remove pathogens; put into suitable nutrient medium.

14. State two advantages of plant tissue culture over other methods of propagating plants.

(1) Large numbers of genetically identical plants (clones)

(2) Production of these plants is rapid and economical.

15 Organisms Have Tolerance Limits/

Subject Outline terms and phrases

internal factors, external factors, cell cycle, checkpoints, gene products, hormones, carcinogen, regulatory genes, cell culture

1. (a) State five properties of tissue fluid that are kept reasonably constant in humans.

(1) pH

(2) temperature

(3) carbon dioxide concentration

(4) water and solute balance

(5) oxygen concentration

(b) Use the concept of **tolerance limits** to explain why it is important that the properties of the tissue fluid that surrounds cells remain reasonably constant.

This allows cells to maintain their internal environment, and so continue to function normally.

2. By referring to the diagram below, explain the unique distribution of the trees in the arid outback of Australia.

The trees grow only along creek lines. Although the trees may disperse the seeds over a wide area, only those seeds that fall near creeks, where water is more abundant, will develop into mature trees.

3. Name a resource whose low level limits the productivity of communities in each of the following locations.

Community location	Resource
Sargasso sea	iron
an Australian desert	water
River Murray	nitrogen
deep ocean floor	light
Mt Kilimanjaro	heat

16 Homeostasis

Subject Outline terms and phrases	**stimulus, response, stimulus-response model, sensory receptor, effector, homeostasis, internal environment, negative feedback, nervous system, endocrine system**

1. (a) What is meant by the term **stimulus**?

a stimulus is any change that an organism detects in its internal or external environment.

(b) State four examples of a stimulus.

Examples include light, sound, touch, temperature, and the concentration of certain chemicals.

2. (a) List five main types of **sensory receptor** that are found in humans.

photoreceptors, mechanoreceptors, chemoreceptors, thermoreceptors, proprioceptors, pain receptors.

(b) State five examples of changes in the external environment that humans detect, and to which they respond.

light, sound, touch, temperature, concentration of chemicals.

(c) State two examples of changes in the external environment that humans do not detect, and to which they do not respond.

very high and very low frequency sounds, X-rays, UV, certain chemicals such as animal pheromones

(d) Explain why it is important that humans selectively detect and respond to changes in the external environment.

We do not need to waste energy responding to stimuli that do not affect us.

3. Choose one type of sensory receptor found in humans, and explain how the loss of this type of receptor would affect an individual.

Sight (and hearing) - communication restricted, dangers not detected. *See textbox p133*

4. (a) What is meant by the term **response**.

a response is an action carried out by an effector. Responses include movement or secretion.

(b) List two types of effector

a muscle or a gland.

5. Define the following terms.

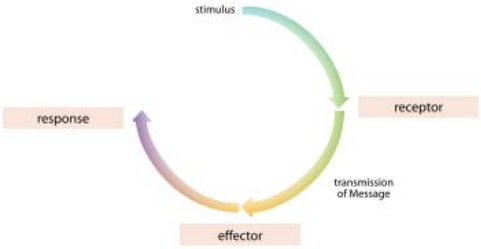
homeostasis:

Homeostasis is the maintenance of a relatively stable internal environment.

negative feedback:

Negative feedback is a process in which a response inhibits or opposes the effect of the stimulus that caused it. This results in regulation or control, and is an important process in homeostasis.

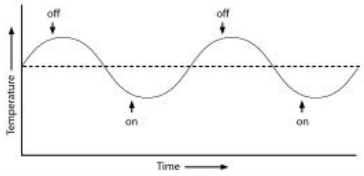
6. (a) Fill in the missing words to show the five elements of a **stimulus-response model** in the correct sequence.



(b) By referring to the diagram explain the term negative feedback.

The response from the effector causes the stimulus to be reduced, hence the feedback is negative.

7. By referring to the graph below, explain how a homeostatic control mechanism works by responding to a change in the internal environment (such as body temperature), and explain why it cannot keep the factor constant.



Using body temperature as an example: When the temperature rises past the optimum (represented by the dotted line), the thermoregulatory centre sends messages to effectors that cause the temperature to begin to fall. However, during the time that this takes, the temperature continues to rise. As the temperature then falls below the optimum, the thermoregulatory centre sends messages to effectors that cause the temperature to begin to rise. When the temperature is at the optimum level, there are no messages sent from the thermoregulatory centre, and the temperature will begin to deviate from the optimum. There will always be a small time lag between this deviation and a response, so that the temperature always fluctuates about the optimum.

8. State two organ systems that are involved in coordination and control in humans.

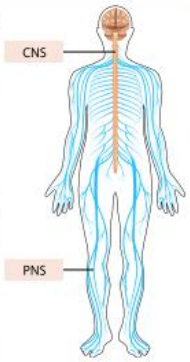
(1) Endocrine system

(2) Nervous system

17 The Nervous System

Subject Outline terms and phrases	**central nervous system (CNS), peripheral nervous system (PNS), sensory neuron, interneuron, motor neuron, nerve pathway, synapse, neurotransmitter, reflex response**

1. (a) On the diagram label the **central nervous system (CNS)** and the **peripheral nervous system (PNS)**.



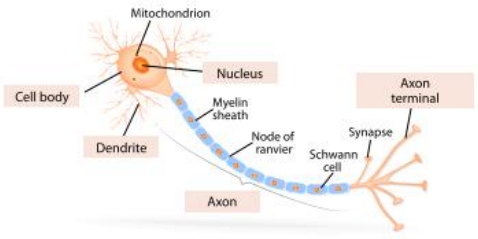
(b) State three functions of the CNS.

The role of the CNS is to detect internal changes in the brain, receive stimuli from peripheral nerves, process information, and send nerve impulses to relevant tissues and organs to bring about a response.

(c) Name the two parts of the PNS and state which part of the body each one controls.

The peripheral nervous system is made up of the somatic nervous system (SNS) and the autonomic nervous system (ANS). The SNS controls skeletal muscles and is 'voluntary'. The ANS controls things you don't have to think about, such as gut movement, heart rate, and breathing. It is 'involuntary'. The ANS also plays a role in the 'fight or flight' response.

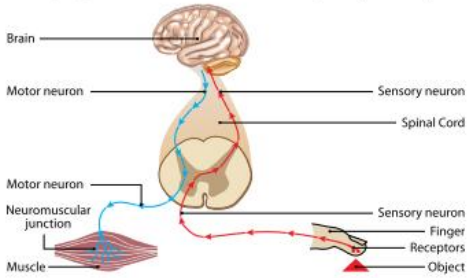
2. On the diagram below, label the following structures:
cell body, dendrite, nucleus, axon, axon terminal



3. Complete the following table to show the structure and function of **sensory neurons, interneurons, and motor neurons.**

	sensory neuron	interneuron	motor neuron
unipolar or multipolar	unipolar	multipolar	multipolar
location	peripheral NS	CNS	cell body and dendrites in the CNS; remainder in the PNS
main role	detect stimuli and carry nerve impulse to CNS	to receive signal from sensory neuron and transmit to motor neuron	transmit nerve impulse from CNS to effector
receives signal from	receptor	sensory neuron	interneuron
sends signal to	interneuron	motor neuron	effector

4. Use the following diagram to describe the structure of a **nerve pathway** from receptor to effector:



A receptor detects a stimulus and this triggers a nerve impulse which travels along a sensory neuron towards the spinal cord in the CNS. The impulse is transmitted along nerve fibres in the spinal cord to the brain. The information is processed by the brain, which sends a nerve impulse down the spinal cord along a motor neuron. The motor neuron carries a nerve impulse to an effector, either a muscle or gland, and this results in a response.

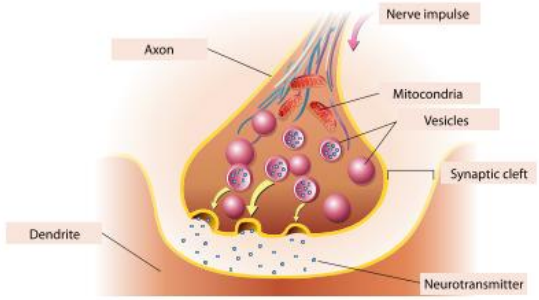
5. (a) What is a **synapse**?

the junction between an axon of one neuron and the dendrite of the next.

(b) What is a **neurotransmitter**? Give two examples.

a chemical secreted by the axon terminal of a neuron into the synaptic cleft at the synapse that initiates a nerve impulse in the next neuron in the nerve pathway.
Examples of neurotransmitters include acetylcholine, dopamine, noradrenaline, and even some amino acids and small peptides.

(c) Label the Synapse diagram below with the following: *Nerve Impulse, Mitocondria, Synaptic Cleft, Neurotransmitter, Axon, Vesicle, Dendrite,*



(d) (i) Why is it important that neurotransmitters do not remain in the synaptic cleft?

If a neurotransmitter, such as acetylcholine, remained in the synaptic cleft it would cause continual stimulation of the next neuron in the pathway or the effector.

(ii) How are neurotransmitters removed from the synaptic cleft?

Following their secretion neurotransmitters are either destroyed by an enzyme, diffuse away quickly, or are absorbed by the cell that secreted them.

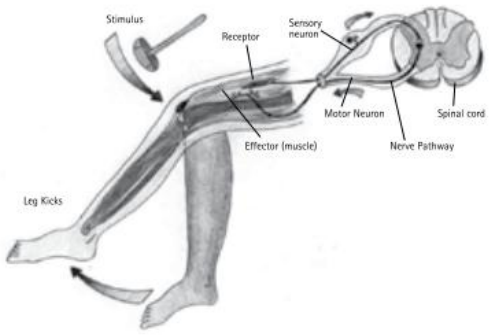
6. (a) What is meant by the term **reflex response**?

an automatic reaction to a stimulus that does not necessarily involve the brain.

(b) State three examples of a reflex response in humans.

knee-jerk reflex, removing hand from hot object, opening and closing of the iris, swallowing reflex.

7. By referring to the diagram below, describe the sequence of events from the stimulus to the reflex response.



Stimulus – hammer hits tendon. Receptor – detects stretched muscle. Message - nerve impulse travels along sensory neuron to the spinal cord and then along a motor neuron to an effector. Effector – a leg muscle. Response – leg muscle contracts causing lower leg to kick.

8. What is the advantage to an individual of having the signal from a stimulus, such as heat from a flame, processed directly by the spinal cord, without involving the brain?

Reduced time to respond so there is minimal damage.

18 The Endocrine System

Subject Outline terms and phrases	**hormone, peptides, amino acid derivitive, steroid, target site, target cell, target tissue, target organ, adrenaline, 'fight or flight' response, thyroid stimulating hormone, thyroxine**

1. Complete the following table which shows different types of hormone.

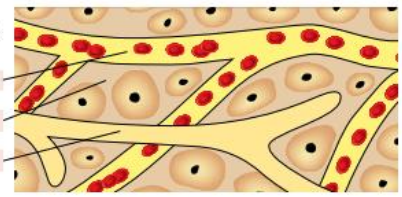
Type of hormone	Name of hormone	Name of endocrine gland	Target cells, tissues, organs	Effect
amino acid derivative	adrenaline	adrenal medulla	most cells, mainly muscle	increases blood sugar level, heart rate and blood pressure, blood flow to muscles, breathing rate, pupil dilation
amino acid derivative	noradrenaline (also called norepinephrine)	adrenal medulla	cardiac muscle, smooth muscle	similar effects to adrenaline - also a neurotransmitter in the cardiovascular system
amino acid derivative	thyroxine	thyroid gland	most cells	increases oxidative metabolism
peptide	antidiuretic hormone	hypothalamus (via posterior pituitary)	renal collecting ducts	increased reabsorption of water by kidneys
polypeptide	glucagon 29 amino acids long	pancreas	most cells, particularly liver	stimulates breakdown of glycogen to glucose, increases blood sugar level
protein	insulin 51 amino acids (in 2 chains)	pancreas	mainly liver and muscle cells	lowers blood sugar level, increases glycogen storage
glycoprotein	thyroid stimulating hormone (TSH)	anterior pituitary	thyroid	stimulates production of thyroxine by thyroid gland
steroid	aldosterone	adrenal cortex	kidneys	increases sodium reabsorption and water reabsorption in kidneys, increases blood pressure

2. On the diagram, label a *blood capillary, a lymph capillary,* and the *tissue fluid.*

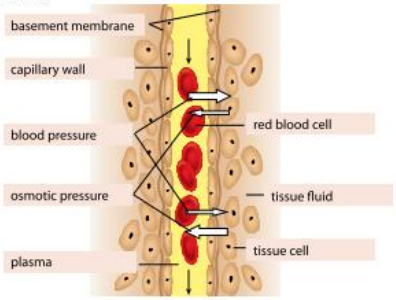
blood capillary

tissue fluid

lymph capillary



3. (a) Label the following on the diagram below: *red blood cell, plasma, capillary wall, tissue fluid, tissue cells, movement due to osmosis, movement due to blood pressure, direction of blood flow and basement membranes.*



(b) Describe the role of the basement membrance.

The basement membrane provides the structure on which epithelial cells sit to form a layer.

4. (a) What is a membrane receptor molecule?

Protein and carbohydrate molecules embedded in the bilipid layer that have distinct shapes and act as "markers" that enable cells to be recognised by each other and by molecular messages such as hormones.

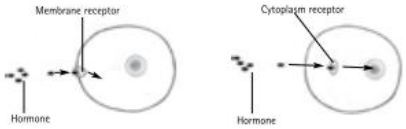
(b) Explain how the distinctive shape of membrane receptor molecules allows cells to recognise other molecules.

The region of the receptor molecule that has a shape that is complementary to another specific molecule enables binding and recognition. If the shapes are not complementary, then recognition does not occur.

5. Explain why a hormone which is present in blood in all parts of the body will only produce an effect on a specific cell, tissue, or organ, and **not** other cells, tissues, or organs.

Hormones will only produce an effect in cells, tissues, or organs that have the appropriate (complementary) receptor molecules. *See Textbook Page 145, Fig 18.6 and Fig 18.7.* Other cells, tissues, or organs that do not have complementary receptor molecules will not be affected.

6. By referring to the following diagrams, explain how water-soluble and lipid-soluble hormones produce an effect on cells.



Water-soluble hormones:

hormone attaches to a membrane receptor and initiates an effect in the proteins of the cytoplasm.

Lipid-soluble hormones:

hormone passes through the cell membrane and attaches to a cytoplasm receptor. This initiates a reaction in the nucleus of the cell.

7. (a) State two examples of hormonal responses that are stimulated by the nervous system.

the secretion of insulin by the pancreas and the secretion of adrenaline and noradrenaline by the adrenal medulla.

(b) State two examples of hormonal responses that are stimulated by other hormonal messages.

TRH from the hypothalamus stimulates the production of TSH from the pituitary; TSH acts on the thyroid gland, causing it to release thyroxine;
hormones released by the pituitary control sex hormone production by the ovaries and testes, and the production of cortisol by the adrenal cortex;
the pancreas is stimulated by adrenaline to increase glucagon secretion.

8. (a) In the **'fight or flight' response**, what do the terms 'fight' and 'flight' mean?

fight means to stay and defend; flight means to retreat (rapidly) and avoid.

(b) Complete the following table to describe the responses of body structures to adrenaline in the 'fight or flight' response.

Body structure	Response to adrenaline	Effect
smooth muscle around blood vessels of skeletal muscle	dilate	increased blood flow
smooth muscle around intestinal blood vessels	constrict	redirect blood to the periphery
heart	rate and output increased	increased blood pressure and blood flow
smooth muscles around the bronchi	relax	increase air flow to lungs
pancreas	increase glucagon secretion	release of glucose from the liver into the blood.
radial muscles of the iris	contract	pupil dilation

9. Describe the role of **thyroid stimulating hormone** in the production of **thyroxine**, including the importance of negative feedback.

The anterior pituitary secretes TSH, which triggers the production and release of thyroxine by the thyroid gland. An increase in the level of thyroxine in the blood inhibits the production of TSH – negative feedback.

10. Complete the following table which compares the action of the nervous and endocrine systems.

Communication	Pathway	Message	Site of action	Speed of action	Duration
Nervous system	nerve	electrical	specific	Very fast	short
Endocrine system	blood	chemical	wide	slower	long

11. Explain why a nerve impulse is more appropriate than a hormonal message for controlling blinking of the eye, but a hormonal message is more appropriate than a nerve impulse for controlling the uptake of glucose from the blood by cells.

Blinking requires a rapid on/off signal to specific eyelid muscles. Hormones would be too slow, would not "turn off" quickly, and would not be specific. Glucose uptake by cells occurs over a long period of time, and involves a wide range of tissues.

12. Explain how the hypothalamus acts as a 'bridge' between the nervous and endocrine systems.

The hypothalamus receives signals via nerves and sends nerve impulses via autonomic nerves, and secretes hormones and hormone-like substances that control the secretion of hormones by the pituitary gland.

19 Homeostatic Control Mechanisms

Subject Outline terms and phrases: **osmoregulation, anti-diuretic hormone (ADH), blood volume, blood pressure, insulin, glucagon, diabetes mellitus**

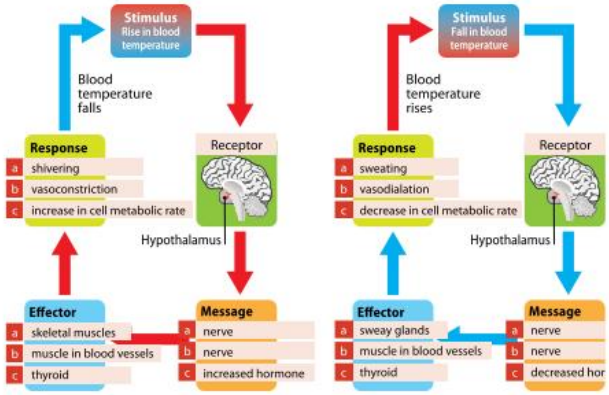
1. Complete the following table to show which body systems are involved in controlling the internal conditions listed.

Internal condition	Nervous system, endocrine system, or both
body temperature	both
osmoregulation	endocrine system
blood sugar level	endocrine system
pH of blood	nervous system

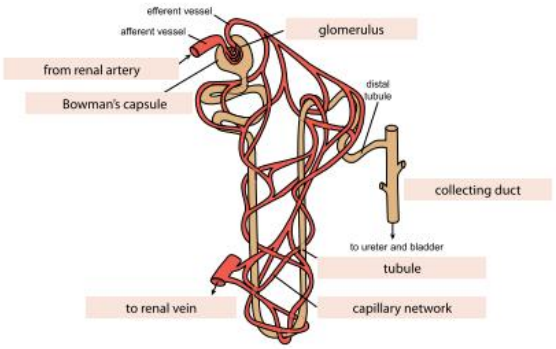
2. Complete the following table for the control of human body temperature.

Stimulus	Receptor	Message transmission	Effector(s)	Response(s)
Body temp. decreases	thermoregulatory centre (hypothalamus)	nerve impulse	skeletal muscles	shivering
Body temp. increases	thermoregulatory centre (hypothalamus)	nerve impulse	smooth muscle in walls of arterioles	vasodilation
Body temp. decreases	thermoregulatory centre (hypothalamus)	hormone	thyroid gland	increased metabolic rate
Body temp. increases	thermoregulatory centre (hypothalamus)	nerve impulse	sweat glands	sweating
Body temp. decreases	thermoregulatory centre (hypothalamus)	nerve impulse	smooth muscle in walls of arterioles	vasoconstriction

3. Complete the labels on the following diagrams to show the **receptor, messages, effectors,** and **responses** involved in regulating human body temperature.



4. Label these structures on the nephron diagram below:
glomerulus, Bowman's capsule, tubule, collecting duct, capillary network, from renal artery, to renal vein



5. Use the terms *filtration* and *reabsorption* to explain how a nephron works.

Filtration of blood occurs under pressure from the glomerulus into Bowman's capsule. Cells and protein molecules are generally too large to pass through the walls of the glomerulus. As the filtrate moves along the nephron tubule, there is reabsorption of useful materials such as glucose, amino acids, and water from the tubule into the blood.

6. (a) Describe the role of **anti-diuretic hormone (ADH)** in **osmoregulation**, including its effect on aquaporins.

ADH increases water reabsorption from the collecting ducts into the blood in the kidneys, reducing urine output (diuresis); ADH is also known as vasopressin. It makes the collecting duct walls more permeable to water by increasing the number of aquaporins present in the cell membranes on the filtrate side of the collecting ducts. *See page 153 fig. 19.5.*

(b) Explain how the water content of the blood (osmoregulation) affects **blood volume** and **blood pressure**.

An increase in the water content of the blood will increase the volume of the blood and result in an increase in blood pressure. A decrease in the water content of the blood will decrease the volume of the blood and result in a decrease in blood pressure.

7. Complete the table below using the words *higher, lower,* or *same* to describe the concentrations of the following substances in the filtrate and urine, compared to their concentration in the plasma.

	Percentage present in:		
Substance	**Plasma**	**Filtrate**	**Urine**
water	92.0	higher	varies
urea	0.03	same	higher
glucose	0.1	same	lower
inorganic ions	0.72	same	higher
protein	8.0	lower	lower

8. Name the kidney structures in the correct sequence to describe the pathway that would be followed by (a) water, and (b) glucose from the time they enter the afferent vessel (from the renal artery).
(a) water

glomerulus, Bowman's capsule, tubule, collecting duct, ureter, bladder, urethra.
and
glomerulus, Bowman's capsule, tubule, collecting duct, capillaries, renal vein.

(b) glucose

glomerulus, Bowman's capsule, tubule, capillaries, renal vein.

9. (a) What are the main target tissues for **insulin**, and what is the effect of insulin on the cells of these tissues?

Many cells of the body are targets for insulin, particularly in the liver, and muscle and fat tissue. Insulin causes liver cells to convert glucose into glycogen, an insoluble storage polysaccharide. It causes muscle and fat cells to take in glucose from the blood. Thus, insulin causes a decrease in blood sugar level.

(b) What are the main target cells for **glucagon**, and what is the effect of glucagon on these cells?

Glucagon binds to glucagon receptors on liver cells causing the cells to convert glycogen to glucose and release glucose in to the blood. This increases the blood sugar level.

(c) How do insulin and glucagon work together to regulate blood sugar level?

When blood sugar level rises, insulin acts to reduce it, when blood sugar level falls, glucagon acts to increase it. Blood sugar level is regulated by the respective concentrations of insulin and glucagon.

10. Describe how **diabetes mellitus** (type 1 and type 2) can result from a hormonal imbalance.

Type 1 diabetes results from the inability to produce insulin due to an auto-immune disease that destroys insulin-producing cells of the pancreas. Type 2 diabetes results from the body becoming resistant to insulin and/or being unable to make enough insulin.

11. Explain how pH is monitored in the brain to maintain a constant carbon dioxide level in the blood.

Molecules of carbon dioxide pass from the blood to the cerebro-spinal fluid and form hydrogencarbonate ions and hydrogen ions that lower the pH of the cerebro-spinal fluid. This decrease in pH results in more nerve impulses from the brain to the respiratory muscles of the chest and diaphgram and an increase in breathing rate. The carbon dioxide concentration in the blood is lowered and this results in an increase in the pH of the blood. The increased pH is detected in the respiratory centre and results in fewer nerve impulses to the chest and diaphragm muscles, resulting in a decreased breathing rate. This is an example of negative feedback.

20 How Cells Have Evolved

Subject Outline terms and phrases	**evolution, fossil evidence, endosymbiotic event, ribozyme**

1. Explain how **evolution** has resulted in life on Earth diversifying over the last 3.5 billion years.

This means that many different forms of life have evolved over the past 3.5 billion years from one origin. The first prokaryotic cells were photosynthetic. They produced oxygen and changed the composition of the atmosphere. Prokaryotic cells that respire aerobically evolved. Then eukaryotic cells formed as a result of endosymbiosis. Since then, millions of different species have evolved – this is what is meant by diversification.

2. Explain how each of the following pieces of evidence supports the idea that eukaryotic cells did not exist on Earth before prokaryotic cells.

(1) fossils

The oldest known fossils provide evidence of the existence of prokaryotic cells at least 3.5 billion years ago. Some of the oldest known fossils have been found in structures called stromatolites (ancient bacterial mats). *See p162.* The first eukaryotic cells are thought to have been formed about 1.5 billion years ago.

(2) cell complexity

The activities of simple photosynthetic bacteria began to drastically change the composition of the atmosphere by increasing the concentration of oxygen. This made it possible for some cells to use oxygen as part of their metabolism and thus become more complex. Eukaryotic cells would not have been able to survive in the hostile conditions provided by the Earth's early atmosphere and the best available evidence suggests that prokaryotic cells existed long before the first eukaryotic cells appeared.

(3) early Earth's atmosphere

It seems that the atmosphere at that time contained no oxygen but had large amounts of carbon dioxide and nitrogen. This hostile environment would not have supported life as we know it today.

3. (a) What is meant by the term **endosymbiotic event**?

An endosymbiotic event is one in the evolution of life on Earth that involved the development of the first eukaryotic cells. In a process similar to modern-day phagocytosis larger cells may have engulfed smaller cells to form a more complex 'super-cell'.

(b) Explain how endosymbiotic events may have led to the formation of the first eukaryotic cells. In your answer you should refer to the following diagram, on which you should put suitable labels.

The larger prokaryote cell engulfs (some) smaller prokaryotic cell(s). Some of these smaller cells could respire aerobically, while others were able to photosynthesise. The new 'super-cell' could then carry out more functions than its component cells could do on their own.

(c) State four pieces of evidence that support the idea that the first eukaryotic cells were formed by endosymbiotic events.

(1) Chloroplasts and mitochondria have their own DNA, which resembles prokaryotic DNA.

(2) Chloroplasts and mitochondria contain their own ribosomes, which resemble bacterial ribosomes.

(3) Chloroplasts and mitochondria are able to self-replicate in a process similar to binary fission.

(4) Chloroplasts and mitochondria have two membranes that are distinctly different from one another. The outer membrane is similar to the host cell's plasma membrane, while the inner membrane contains proteins similar to those found in bacterial membranes.ribosomes.

4. (a) Explain how the first membranes may have formed spontaneously, eventually giving rise to simple cells.

Some organic molecules were fatty acid chains that probably gave rise to simple membranes in the form of primitive vesicles. *See Textbook p164 fig. 20.5.*

(b) Describe the possible roles of RNA and **ribozymes** in the first simple cells.

It is likely that the very first simple cells used RNA as genetic material.
Under certain circumstances RNA can catalyse chemical reactions - like enzymes do. RNA molecules with this ability are called ribozymes.

(c) Explain why proteins were not used as enzymes in the first primitive cells.

Proteins did not exist, as there was no means of making them at that time.

3. (a) List four **pre-zygotic** mechanisms that maintain reproductive isolation of species in a community.

(1) The species may produce gametes in different seasons.

(2) Their mating behaviour may be sufficiently different as not to interest the other species.

(3) The habitat preferences within an area may be so different that they don't meet.

(4) There may be anatomical differences in the genitals of animals or the floral structures of plants of different species.

(b) Explain how each of these pre-zygotic mechanisms helps to maintain reproductive isolation.

(1) produce gametes in different seasons – if the gametes don't meet they can't fuse.

(2) mating behaviour may be sufficiently different as not to interest the other species – hence no mating occurs.

(3) habitat preferences so different that they don't meet – hence no mating occurs.

(4) anatomical differences in the genitals of animals or the floral structures of plants of different species – gametes will not be transferred.

4. (a) List two **post-zygotic** mechanisms that maintain reproductive isolation of species in a community.

(1) Even if mating does occur, the zygote may not develop normally.

(2) If two species differ in chromosome number and a hybrid offspring is formed, it may be sterile.

(b) Explain how each of these post-zygotic mechanisms helps to maintain reproductive isolation.

(1) zygote may not develop normally, due to genetic incompatibility.

(2) two species differ in chromosome number and a hybrid offspring is formed which is sterile. Some chromosomes will not have a homologous partner so the process of meiosis cannot proceed normally.

5. Explain why horses and donkeys are considered to be different species even though they are able to produce offspring (the mule).

The offspring of a horse and donkey, the mule, is infertile. This is because the chromosomes of the horse and donkey are not homologous, and cannot form pairs.

21 Defining a Species

Subject Outline terms and phrases	**species, mode of reproduction, interbreed, fertile, morphological similarity, biochemical similarity, gene pool, zygote, pre-zygotic, temporal isolation, behavioural isolation, mechanical isolation, gamete isolation, post-zygotic, hybrid, hybrid inviability, hybrid sterility**

1. Define the following terms.

(a) species

members of a species share a common gene pool. In a natural environment members of a species can reproduce fertile offspring

(b) community

the sum of all the populations living in a particular place at a particular time.

(c) population

a group of organisms of the same species living together in the same area at the same time.

(d) gene pool

the total of all the genes of all the individuals in a population.

2. A species can be defined using methods based on structural features, biochemical similarity, ability to interbreed to produce fertile offspring, or gene pool. Explain how each of these methods is used to define a species.

structural features (morphological):

Members of the same species have common structural characteristics. The presence or absence of these common characteristics are used to sort organisms into species.

biochemical similarity:

Members of the same species have much greater biochemical similarity than members of different species. This is evident in their DNA base sequences and in the sequences of amino acids in their proteins.

ability to interbreed:

A species is a group of organisms that are able breed and produce fertile offspring.

gene pool:

Members of the same species share a common gene pool, and they are reproductively isolated from other species.

22 Evidence for Evolution

Subject Outline terms and phrases	**comparative genomics, cytochrome, DNA-DNA hybridisation, DNA sequencing, phylogenetic tree, evolutionary relationships, rRNA gene sequencing**

1. (a) What is meant by 'the universal presence of DNA'?

All known living things contain DNA.

(b) Explain how the universal presence of DNA provides evidence for the common ancestry of all living things.

All living things have DNA and they use the same genetic code. If life on Earth had many separate beginnings, then we would expect different information systems to be evident. We also find that all living things use the same 20 amino acids.

2. (a) Explain the term **mutation**.

Any spontaneous or induced change in the genetic material of a cell.

(b) Explain how the sequence of amino acids in a protein is related to the genetic code in the nucleus of the cell. (also see Chapter 2)

Each amino acid is coded for by a triplet of bases (called a codon) on the DNA. Therefore the sequence of amino acids in a protein is determined by the sequence of bases on the DNA (the genetic code) in the nucleus.

(c) State three factors that can induce mutations.

High energy radiation, chemical mutagens, viruses.

3. (a) State one piece of evidence that indicates that DNA on Earth has diversified over billions of years.

The increase in diversity of life forms on Earth provides evidence that DNA on Earth has diversified over millions of years. If it were not for this diversity, life on Earth would have remained the same as it was originally. Also, higher-order organisms have an increased complexity in their DNA.

(b) State two processes that have brought about this diversity.

Mutation. Processes in sexual reproduction – see answer to Q4 below.

4. Explain three sources of genetic variation in a species that reproduces sexually.

(1) crossing over - alters the combination of genes that is passed on from one generation to the next.

(2) independent assortment - increases number of possible combinations of genes in gametes, by distributing the maternal and paternal chromosomes of each homologous pair at random.

(3) random fertilisation - In sexual reproduction each gamete is unique, so each offspring that results from fertilisation has a unique combination of alleles.

5. (a) What is meant by the term **comparative genomics**?

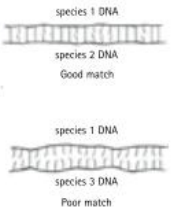
Comparative genomics involves comparing the genomes of species to determine their evolutionary relationships.

(b) Explain how comparative genomics can help establish the likely evolutionary relationships between different species.

If two species have evolved from a common ancestor and their separation was recent, it is likely that there will not have been enough time for more than a few new mutations in each species to have taken place. Their DNA sequences should therefore be very similar. On the other hand, two species that have been separated for a much longer time will probably have many more differences in their nucleotide sequences as a greater number of mutations will have occurred. Biologists are able to construct evolutionary trees using comparative genomics - by comparing the sequence of nucleotides of corresponding genes of different species.

6. Use the information in the following diagram to explain how the degree of matching of DNA strands from two different species in **DNA-DNA hybridisation** provides a clue as to how closely related the two species are.

The DNA of species 1 and 2 match closely, indicating that their base sequences are very similar. The DNA of species 1 and 3 match poorly, indicating that their base sequences are significantly different. This suggests that species 1 and 2 are closely related, whereas species 1 and 3 are distantly related.



7. Explain how the degree of similarity of the DNA sequences and the degree of similarity of protein sequences in closely related organisms provide evidence for the theory of evolution.

The theory of evolution arose as a result of observations of the features of closely related species, and as a result of fossil evidence. It has been found that the DNA and protein sequences of species that were thought to be closely related are very similar, while those of species thought to be distantly related are less similar. This is consistent with earlier observations, and so provides supporting evidence for the theory of evolution.

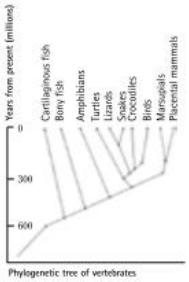
8. (a) Explain why the protein *cytochrome c* is useful for studying the evolutionary relationship between different species.

Cytochrome C is found in almost all species. Its universality makes it useful for comparison between species.

(b) How can a protein provide this kind of information for comparison?

Like all proteins, cytochrome c is coded for by the sequence of bases on DNA. Therefore, variation in the amino acid sequence of the cytochrome c of a species is a reflection of variation of its DNA base sequence.

9. The **phylogenetic tree** below was constructed by comparing the nucleotide sequences of DNA in the different groups. Use the information in the diagram to answer the following questions.



Phylogenetic tree of vertebrates

(a) State which two groups of vertebrates are most likely to have separated most recently.

Lizards and snakes.

(b) Which group has DNA which is most dissimilar to that of mammals?

Cartilaginous fish.

23 Gene Pools and Natural Selection

Subject Outline terms and phrases

gene pool, natural selection, adapted, selection pressure, frequency of alleles, genetic drift, genetic diversity

1. Define the term **gene pool**. (review Chapter 21)

The total of all the genes of all the individuals in a population.

2. What reasoning did Thomas Malthus use to show that not all offspring in natural populations survive to reproduce?

Even the slowest reproducer of the animal world - the elephant - would overrun the world in a few thousand years, if left to reproduce unchecked. This has not happened, indicating that not all the offspring survive to reproduce.

3. State why most natural populations of organisms do not increase in size, but remain fairly constant from one year to the next.

Not all offspring survive to reproduce. A range of agents limits the population size.
(See answer to Q4.)

4. List four factors that restrict the size of a natural population. (any of the factors listed below)

(1) disease — predators

(2) competition within the population — environmental temperature

(3) food availability — water availability

(4) shelter

5. Explain why genetic variability is an advantage to a population.

This makes it more likely that at least some members of the population will survive if the environmental conditions change. If there was no genetic variability then it is likely that either all population members would survive, or that all would die.

6. (a) State one example of a genetically controlled characteristic that may *increase* an individual *human's* chances of survival and reproduction.

Resistance to disease, ability to produce gametes.

(b) State one example of a genetically controlled characteristic that may *decrease* an individual *rabbit's* chances of survival and reproduction.

Coat colour not providing camouflage, lack of resistance to disease, inability to burrow.

7. List the five points that Darwin used to explain the theory of evolution by **natural selection**.

(1) Within a population there is genetic variability between individuals.

(2) Some individuals are therefore better suited (adapted) than others to the biotic and abiotic factors in the environment.

(3) These individuals are more likely to survive longer and produce more offspring than the less well adapted ones. In particular, this applies if there are limited resources

(4) These better suited individuals will tend to pass genes for the favourable characteristics on to their offspring.

(5) Over many generations the proportion of individuals in the population with the favourable genes will increase and eventually be maintained.

8. Explain how a strain of bacterium resistant to the antibiotic streptomycin could evolve by natural selection. In your answer you should use the following terms: *mutation, genetic variation, selecting agent, selection pressure, survival, reproduction, favourable gene, change in the gene pool.*

In about one in a billion cell generations, a **mutation** arises spontaneously in *E. coli* which makes it resistant to streptomycin. This gives rise to **genetic variation** in the *E. coli* population. If streptomycin is present, it acts as a **selecting agent**, and the non-resistant cells are inhibited or killed. Thus, the presence of streptomycin applies selection pressure and increases the chances of **survival** and **reproduction** of the resistant bacteria, compared to those that are not resistant. These resistant bacteria pass on the **favourable gene** when they reproduce. Thus a **change in the gene pool** results in the evolution of a resistant strain of *E. coli*.

9. (a) What is meant by a **large gene pool**?

a population with a range of different alleles has a 'large' gene pool.

(b) Explain why a population with a large gene pool is more likely to survive **selection pressures**.

a population with a diverse (large) gene pool is likely to have at least some individuals with a genetic makeup that can survive a change in selection pressures. The survival and reproduction of these individuals will ensure the survival of the population.

10. In 1831 Darwin sailed on the Beagle as the ship's naturalist. He was particularly fascinated by the distribution of finches on the Galapagos Islands to the west of South America. Darwin found a number of different species of finch and he noticed that each species seemed to be restricted to one island or a small number of neighbouring islands. Differences between the species included such features as beak shape which seemed to be suited to the food available to the particular species. From these observations Darwin began to formulate an idea of how the different species of Galapagos finches could have developed in such a way as to ensure that each species was well suited (adapted) to its own environmental conditions.

Use the example of the Galapagos Island finches to outline the reasoning that Darwin used to explain how the finches developed in such a way as to ensure that each species was well suited (adapted) to its own environmental conditions.

There was genetic variability for beak shape within the original population of finches. On a particular island, some individuals had a beak shape that was better suited for feeding on the food that was most readily available. These individuals were more likely to survive longer and produce more offspring than the less well adapted ones. They tended to pass genes for the suitable beak shape on to their offspring. Over many generations the proportion of individuals in the population with this beak shape increased.

11. One of the classic examples of natural selection involves the peppered moth *Biston betularia*. This moth is found in England in two main shades. One is light with patches of darkness (hence the name 'peppered') and the other is dark in colour. Before the Industrial Revolution almost all the moths were light in colour and dark ones were extremely rare.

Explain how the proportion of darker moths increased and the proportion of paler ones decreased over many generations after the Industrial Revolution.

There was genetic variability for colour within the original moth population. Before the Industrial Revolution almost all the moths were light in colour and dark ones were extremely rare. However, during the Industrial Revolution trees and buildings in the environment became darkened by black smoke from chimneys. As a result of this, pale moths that settled on tree trunks were easily spotted by predators such as birds, while darker moths were camouflaged. Over many generations the proportion of darker moths increased and the proportion of paler ones decreased. It was the proportion of colours that changed. *No individual moth changed colour.*

12. State three processes that could cause the **frequency of alleles** in a population to alter and result in evolutionary change.

(1) mutation

(2) natural selection

(3) sexual reproduction genetic drift

13. Explain the term **genetic drift**.

Genetic drift refers to changes in the frequencies of alleles in a population due to chance events, such as catastrophes. *See Textbook fig. 23.6 p183.*

14. Explain how evolutionary changes are affected by factors such as:

(a) sexual reproduction.

Evolutionary changes depend on genetic variation in a population. The offspring resulting from meiosis and fertilisation, the key cellular events in sexual reproduction, will be genetically different from one another, even if they have the same parents.

(b) genetic drift.

In small populations it is likely that an allele can be completely removed from the gene pool by the death of a small number of individuals. This is known as genetic drift and it decreases the gene pool and results in evolution.

24 Speciation and Evolution

Subject Outline terms and phrases	**speciation, geographically isolated populations, allopatric speciation, sympatric speciation, convergent evolution, niche, succession, divergent evolution, adaptive radiation, low genetic diversity, extinction**

1. State three examples of geographical barriers, other than a desert, that could lead to reproductive isolation.

(1) Ocean

(2) valley, river

(3) mountain range

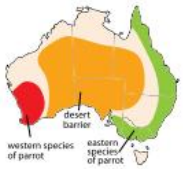
2. Geographical isolation (separation) by itself does not lead to **speciation**. What else is needed in order for speciation to occur?

Genetic variation, different environmental conditions, natural selection.

3. Describe the process of allopatric speciation.

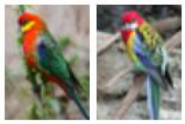
Allopatric speciation is the process of forming new species from a single population that becomes divided, often by a geographical barrier.
Classic examples of allopatric speciation include 'Darwin's finches' and the Australian rosellas.

4. The habitats of two species of parrot are shown on the map.



The eastern and western species of parrot have descended from a common ancestor, but have become so different from one another that they are no longer able to interbreed. Use the ideas of **geographical isolation (separation)**, **gene flow**, and **natural selection** to explain how this speciation occurred.

The original population of parrots extended from East to West. The climate changed such that a desert formed (as shown on the map). This led to **geographical isolation** of the Eastern and Western populations, as the desert prevented **gene flow** between them. The environmental conditions in the East and the West were different, and **natural selection** resulted in evolution of the two populations so that they became so different that they could no longer interbreed. They are now considered to be separate species.



5. State two pre-zygotic and two post-zygotic barriers that maintain reproductive isolation between different species. (revise Chapter 21)

two pre-zygotic barriers:

temporal isolation, behavioural isolation, mechanical isolation, gamete isolation.

two post-zygotic barriers:

hybrid inviability, hybrid sterility.

6. Explain what is meant by **convergent evolution**. Give three examples to illustrate your answer.

Convergent evolution is the evolution of similar characteristics in species that are not closely related; this is observed when the different species inhabit environments with similar conditions. Examples include the marsupial mole and the placental mole, the platypus and the beaver, the whale and the dugong, sharks and dolphins. Features such as eyes and wings have also evolved many times independently and are examples of convergent evolution.

7. (a) What is meant by **adaptive radiation**? Give an example.

Adaptive radiation is a special case of divergent evolution in which there is a sudden emergence of new species from a common ancestor. Examples include Darwin's finches and Australian marsupials.

(b) How does adaptive radiation differ from **divergent evolution**.

Divergent evolution involves the slow and gradual accumulation of new characteristics, culminating in the formation of new species, whereas adaptive radiation takes place more rapidly - a 'sudden' emergence of new species from a common ancestor.

8. In the natural community shown below, there could be flood, drought, high temperatures, heavy rain, or fires in the coming year. Choose three of these abiotic factors and describe the changes that they would cause to the populations in this community.

Factor 1:

Flood would remove organisms from the area. There would be an increase in plant growth after the flood subsides.

Factor 2:

Drought would result in the pond drying up. Organisms may either leave or die.

Factor 3:

Fire could cause the death of some animals and plants. After fire there will be regrowth. Some species may even benefit from such an event due to reduced competition, or the need for fire to trigger germination.

9. Define the following terms.

(a) succession

the progression in area over time from pioneer species to a climax community.

(b) colonisers

the first plants to grow on bare surfaces. Also called pioneers.

(c) climax community

a community that is stable and has ceased succession.

10. Describe the series of events that could have occurred on each of the following two sites.

(a) The sand dunes in the south-east of South Australia, after they became exposed due to a fall in sea level.

The sea retreated and colonising plants settled on the dunes, altering the habitat and making it suitable for other organisms to live there. These in turn made further changes, resulting in a climax community

(b) The island of Surtsey, after the bare volcanic rock arose out of the sea.

Decaying seaweed drifted onto the bare rock and provided a foothold for colonising plants such as Sea Rocket. The early colonisers altered the conditions on the island, making it more suitable for other organisms. New species of organisms drifted in by sea or were brought in by seabirds that nested on the island.

11. (a) What conditions are necessary for primary **succession** to occur?

Bare rock with no soil.

(b) How does primary succession differ from secondary succession?

Primary succession begins with bare rock, whereas secondary succession begins when a disturbance such as fire or flood destroys most or all of the original vegetation, but leaves the soil.

12. (a) Give two examples of species with low genetic diversity, and describe how their genetic diversity was reduced.

The habitat of the cheetah has contracted to less than a quarter of its previous size, and has become fragmented due to human activity. Each population is now so small that there is very little genetic diversity.
The genetic diversity of European bison is extremely low. Between the 16th and 20th centuries their numbers were reduced (by human hunters) from more than 100 000 to a mere 12. All living bison are descended from only 7 of those 12.

(b) Explain why species or populations that have a reduced **genetic diversity** have a higher risk of extinction.

If there is a (sudden) change in environmental conditions it is less likely that some individuals in the population will survive and reproduce.

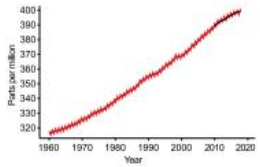
25 Human Impact

Subject Outline terms and phrases	**biodiversity, ethical issue**

1. Complete the table below which shows how human activities have led to climate change, environmental change, or both.

Human activity	Climate change, environmental change, or both	How the change was (changes were) caused
clearing tropical land	both	Clearing tropical land reduces humidity, which affects rainfall. The natural community has been removed or replaced. Habitats destroyed, rise in water table, increased salinity of soil, increased light penetration.
lighting fires	environmental	Increase in the proportion of fire-resistant plants and consequent change in animal population.
introducing rabbits to Australia	environmental	Increased competition with native animals, vegetation depleted.
altering water courses	environmental	Artificial dams flood natural communities, new aquatic communities develop, reduced availability of water in some communities.
polluting the atmosphere	both	Formation of acid rain, increased greenhouse effect.
burning fossil fuels	both	Formation of acid rain, increased greenhouse effect.

2. (a) By referring to the graph and data below, state the likely trend of carbon dioxide levels in the atmosphere beyond the year 2024.



DATE	CO_2 LEVEL
24/12/2023	421.86 ppm
24/12/2022	419.41 ppm
24/12/2013	397.53 ppm

The carbon dioxide levels in the atmosphere will continue to increase..

(b) State the factor that is the most likely cause of this trend.

Increased burning of fossil fuels.

(c) Explain how this trend could lead to changes in communities on a global scale.

Due to the greenhouse effect there could be an increase in the atmospheric temperature, polar ice caps could melt. This will cause considerable changes to communities along the shoreline, as well as changing the world's weather patterns.

3. (a) State what is meant by the extinction of a species.

the death and disappearance of all the populations of a species.

(b) State three human activities that have caused animals to become extinct and for each one give an example of a species that was affected.

The Tasmanian tiger was hunted to extinction.

When two imported pests, the rabbit and the fox were introduced into South Australia, the rabbit competed for the bilby's food and the fox found the bilby easy prey. Thus the lesser bilby became extinct.

The destruction of (forest) habitat has led to the (probable) extinction of the Javan tiger.

(c) State three factors, other than human activity, that could cause the extinction of a species.

Competition with another species for a resource, the emergence of a new disease, natural disaster (such as fire) in the habitat of a species with a very localised distribution.

(d) Explain why maintaining **biodiversity** is an **ethical issue.**

an issue is ethical if it relates to a moral judgement of whether something is 'right' or 'wrong'. There are several arguments that maintaining biodiversity is 'right'. See Q4(a) below.

4. The three main arguments for the importance of biodiversity are the human-centred view, the interconnection of life on Earth, and human respect for all living things.

(a) State the main point of each of these three arguments, and give an example of each.

human-centred view:

This concentrates on what we can obtain from living things. For example, foods, medicines and raw materials.

interconnection of life on Earth:

All life on Earth is interconnected and if the balance of nature is altered by allowing biodiversity to decrease it may have severe and unpredictable implications for us all. For example, clearing of rainforests reduces the uptake of carbon dioxide, thus contributing to the greenhouse effect. There will also be a reduction in the humidity in the air and a corresponding decrease in rainfall.

respect for all living things:

Other species have just as much right to live as humans. The diversity of life has an aesthetic value that we should preserve to allow others to appreciate. Examples include the giant panda of China, the bilby in Australia, and the Malaysian rhino.

(b) Which one of the three arguments in part (a) suggests that biodiversity is essential for the perpetuation of communities?

The "interconnection of life on Earth".

(c) State two examples in which the loss of one population from a community has had a severe effect on other populations of the community.

The loss of the Dodo bird from Mauritius is leading to a decline in the number of Calvaria major trees. The loss of jarrah trees from the Western Australian forests has led to a decrease in the numbers of smaller plants requiring shelter from the jarrah canopy. The water table has also risen, and this has increased the salinity, killing many other plant species. The decrease in the numbers of the small Australian honeybee in subtropical forests has led to a decrease in pollination of many native Australian plants.

5. Define the following terms.

habitat:

the place where an organism lives

biosphere:

that portion of the Earth that is inhabited by organisms

6. Although there are several hundred species of eucalypt in Australia, the koala can only feed on the leaves of a few of these species. The koala's distribution is limited to regions where these species of eucalypt are found. Use this information to explain why the best way to preserve a species is to preserve its habitat.

The only way to maintain a population of koalas in an area is to ensure that their requirements, e.g. food, are met. The food requirements for koalas are very specific - a few species of eucalypt. The habitats containing these species of eucalypts need to be preserved in order to allow the continued survival of koalas.

7. State the size of the habitat that is now generally accepted to be the minimum to ensure the survival of an animal species.

An area that is large enough to support 500 individuals of the species. (This particularly applies to large carnivore species.)

8. (a) What is meant by the term resources?

A resource is anything from the environment that an organism uses.

(b) List two resources from each of the following categories.

soil: minerals, water

air: oxygen, carbon dioxide

other organisms: are a source of food, provide shelter (e.g. trees, hollow logs etc.)

9. Why do biological communities need to recycle resources?

Resources are in limited supply. If resources were not recycled in communities they would be locked up in living things, and would not be available to future generations.

10. (a) What observation made during the Hubbard Brook experiment provides evidence that disturbed communities lose their chemical resources?

In the clear-felled areas of the experimental forest there was an immediate loss of nitrate from the soil into the streams. This loss of nitrate remained much higher for many years than in the control areas in which there was no clear-felling.

(b) What conclusion was made about the fate of resources in undisturbed communities?

It was concluded that the undisturbed communities were retaining nearly all of their nitrogen by recycling it.

11. Explain why crops need to be provided with fertiliser, whereas natural communities can flourish without the addition of fertiliser.

When crops are harvested, the minerals contained in the produce are removed from the community, and need to be replaced in the form of fertiliser. In natural communities the minerals are recycled when the wastes and remains of organisms are broken down by decomposers.

12. (a) List two types of decomposer.

Bacteria, fungi, termites, earthworms.

(b) Explain why decomposers are essential to a natural community.

Decomposers break down organic matter and return essential resources to the environment. (They recycle nutrients.)

13. State three advantages that have resulted from the introduction of African dung beetles into Australia.

(1) Decreased the problem of buffalo flies and bushflies.

(2) Removed cowpats from the soil surface.

(3) Minerals in the cowpats are recycled.

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