H2

ANDERSON SERANGOON JUNIOR COLLEGE
HIGHER 2
ANSWERS

2023 JC2 PRELIMINARY EXAMINATIONS

CANDIDATE NAME							
CLASS					INDEX NUMBER		

BIOLOGY

9744/02

PAPER 2
SHORT STRUCTURED QUESTIONS

13 SEPTEMBER 2023
WEDNESDAY

Candidates answer on the Question Paper.
No Additional Materials are required.

2 HOURS

READ THESE INSTRUCTIONS FIRST

Write your name and class on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graph
Do not use paper clips, highlighters, glue or correction fluid.

Answer **all** questions.

The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
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Total	**/100**

This document consists of **25** printed pages and **7** blank page

Answer **all** the questions.

1 Archaea are single-celled microorganisms which inhabit extreme environments, such as hot springs and volcanic vents at temperatures over 100°C.

Fig. 1.1 shows the molecular structure of a phospholipid found in the cell membrane of an archaea and that of a eukaryote.

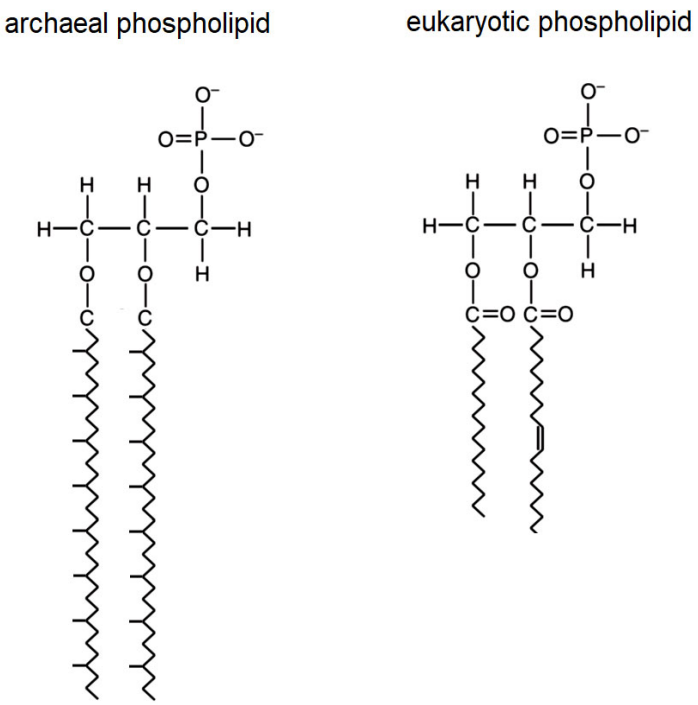


Fig. 1.1

(a) **(i)** With reference to Fig. 1.1, state **two** structural differences between the two phospholipids. [2]

[Any one]

1. The **fatty acid tails/ hydrocarbon chains** of archaeal phospholipid are **both saturated/ only contain C-C single bonds**, but the fatty acid tails/ chains of eukaryote phospholipid consist of **a saturated and an unsaturated chain/ contain a C=C double bond**.
2. The **fatty acid tails/ hydrocarbon chains** of archaeal phospholipid are **longer/ contained more C and H**, but the fatty acid tails/ chains of eukaryote phospholipid are **shorter/ contain fewer C and H**.
3. **Side chains** are present in the **fatty acid tails/ hydrocarbon chains** of archaeal phospholipid, but these are **absent** in the fatty acid tails/ chains of eukaryote phospholipid.

(ii) Explain why phospholipids are unable to provide structural support.

[3]

- Phospholipids is not a **long**, **linear,** macromolecule joined by **strong covalent bonds** which will then confer a **high tensile strength**.
- Phospholipids are fluid as it is held by weak **hydrophobic interactions between the hydrocarbon tails**, and hence can move **laterally**.

- (aka cellulose) Absence of numerous **inter-chain hydrogen bonds between hydroxyl groups** of adjacent **parallel, linear chains**, forming **rigid cross-links between chains.**
- many cross-linked cellulose chains are **bundled** together to form **microfibrils** which have **high tensile strength**.

OR

- Many **tropocollagen** molecules are **covalently cross-linked** with neighbouring tropocollagen molecules running **parallel** to them
- to form a **collagen fibril** → fibrils then **bundle** to form collagen **fibres.**

In an experiment to investigate the transport of ions into root cells, some pea plants were grown with their roots in a solution of ions. These ions were absent in the root cells at the beginning of the experiment.

The concentration of five ions in the solution and in the cytoplasm of root cells were determined after one hour. The results are shown in Table 1.2.

Table 1.2

ion	concentration of ions / mmol dm^{-3}	
	solution	cytoplasm of root cells
potassium (K^+)	1.0	75.0
magnesium (Mg^{2+})	0.3	3.5
calcium (Ca^{2+})	1.0	1.0
phosphate (PO_4^{3-})	1.0	21.1
sulfate (SO_4^{2-})	0.3	19.7

(b) Explain which components of the cell surface membrane of root cells are responsible for the results shown in Table 1.2. [4]

1. There is the presence of various **specific transport proteins** on the cell surface membrane

2. Uptake of **K^+, Mg^{2+}, PO_4^{3-} and SO_4^{2-}** is via **active transport**
3. with the aid of **carrier proteins**, **against their concentration gradients** with **energy from ATP hydrolysis (or quote data)**

4. Uptake of **Ca^{2+}** is via **facilitated diffusion**

5. with the aid of **channel proteins**, **down its concentration gradient (or quote data)**, until dynamic equilibrium is reached

6. Presence of **hydrophobic core** of phospholipid bilayer **prevents simple diffusion of ions** across/ hydrophobic core is **impermeable to ions**
7. hence **maintaining differential distribution of ions** across the cell surface membrane **(or quote data)**

[Total: 9]

2 Fig. 2.1 is a photomicrograph of root tip cells at different stages in the cell cycle.

A cell in interphase and telophase are labelled.

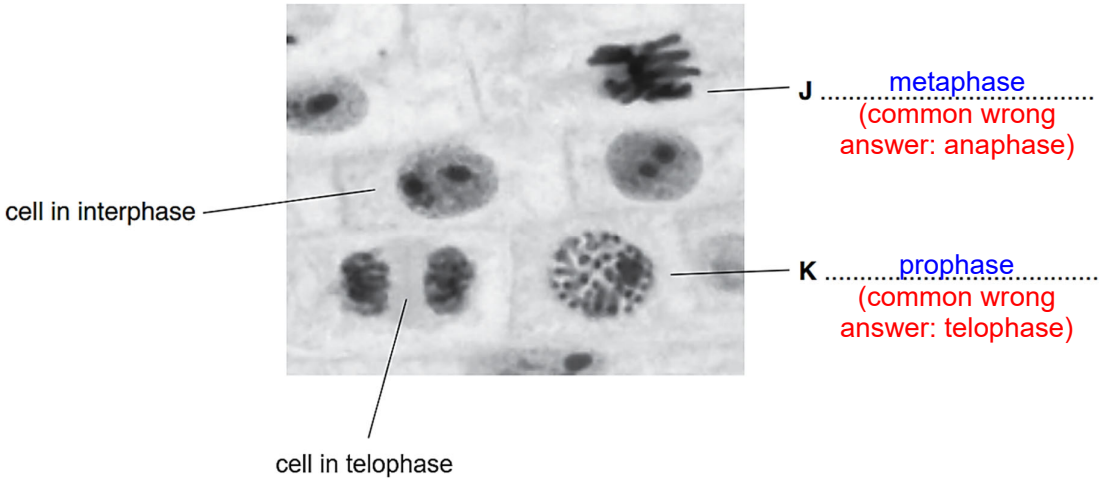


Fig. 2.1

(a) **(i)** Complete Fig. 2.1 by naming the stage of mitosis shown in each of cells **J** and **K.** [1]

(ii) State **one** feature of the cell in interphase, **visible** in Fig. 2.1, that shows this cell is **not** in early interphase. [1]

1. Large size / same size as cells in mitosis / same size as cells labelled in stages of mitosis;

(b) Describe the events that occur in telophase. [2]

1. Spindle fibres (reject: kinetochore/non-kinetochore microtubules only, must be both) disintegrate (reject: disappears)
2. Chromosomes reach (opposite) poles and uncoil/decondense → form chromatin fibres
3. Nuclear envelope reforms around each set of chromosomes at each pole (reject: reform around two daughter cells)
4. Nucleolus reappears (reject: reforms)

(c) Reduction division happens in meiosis.

(i) Describe the events that cause reduction division. [2]

1. During **metaphase I**, homologous chromosomes align along **metaphase plate** in **pairs** / one homologue of each homologous pair **facing each pole**.
2. During **anaphase I**, spindle fibres (kinetochore microtubules) shorten, **pulling homologous chromosomes** apart towards **opposite poles** of the cell.
3. During **anaphase II**, **centromere divides**, **sister chromatids separate**, each becomes a full-fledged daughter **chromosome** → **spindle fibres** / kinetochore microtubules **shorten**, **pulling chromosomes apart towards opposite poles** of the cell.
   (Reject phrasing: spindle fibres shorten, separating sister chromatids)

4. **(Compulsory) Telophase I or II** – **nuclear envelope reforms** leading to **haploid** number of chromosomes per nucleus

(ii) Explain the need for reduction division during meiosis. [3]

any three from:

1. (meiosis / reduction division) produces **gametes which are haploid** / are n / have half the normal number (of chromosomes); (reject: half amount of genetic material)
2. (two) gametes **fuse / fertilisation** occurs, to form a **diploid zygote** (reject: full set of chromosomes);
3. zygote will have maternal and paternal chromosomes / AW;
4. prevents, doubling of chromosome number / polyploidy / having too many chromosomes
   or
   allows chromosome number to remain constant / the same (for each species);

[3]

[Total: 9]

3 Fig. 3.1 shows the cell signalling pathways of insulin and glucagon in liver cells.

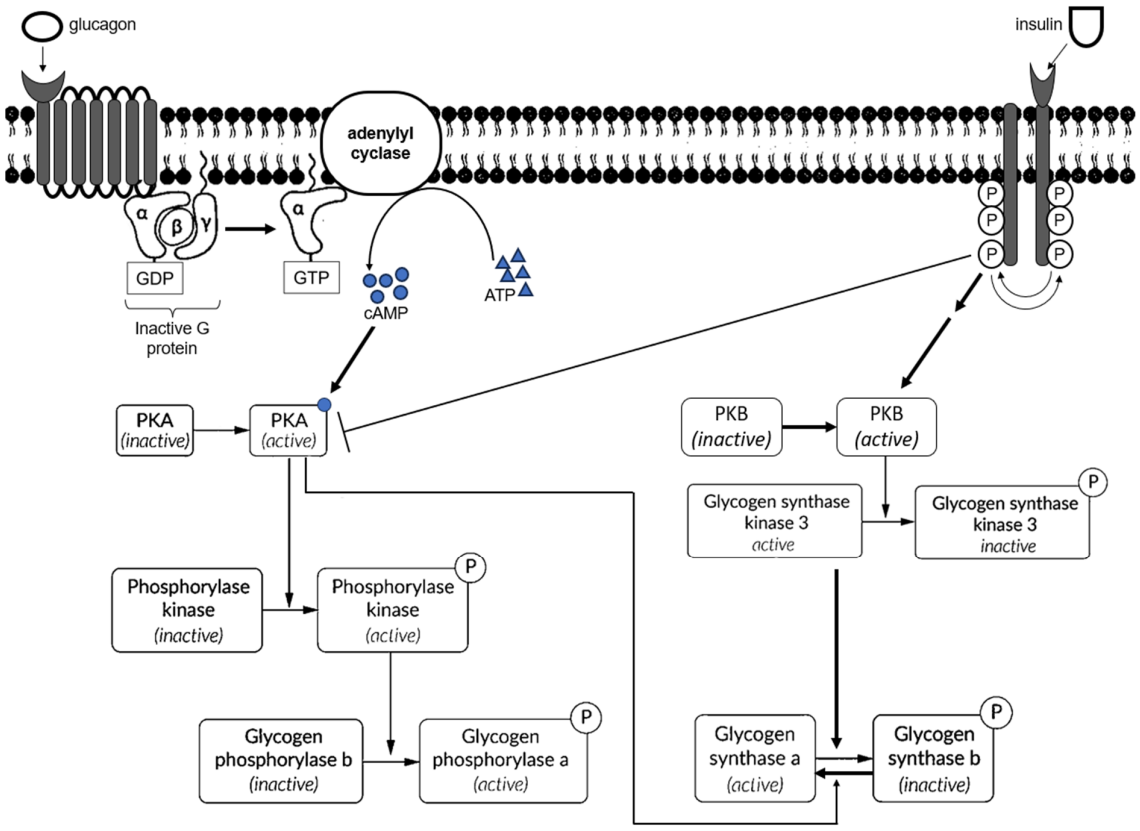


Fig. 3.1

(a) State the role of phosphate in Fig. 3.1. [1]

Activate enzymes (e.g. glycogen phosphorylase a) AND **inactivate** enzymes **(**e.g. glycogen synthase kinase 3).

(b) Explain how the properties of the cell surface membrane facilitate the cell signalling pathways in Fig. 3.1. [4]

1. **P:** CSM has **hydrophobic** fatty acid tails forms **hydrophobic** interactions & **hydrophilic** phosphate heads.
2. **E: Allow embedment of glucagon and insulin receptors** so that insulin and glucagon are able to interact with their receptor by binding to the extracellular ligand binding site → Insulin and glucagon are hydrophilic/large and are unable to pass through/diffuse across the hydrophobic core/fatty acid tails of the phospholipid bilayer
3. **P:** CSM is **fluid** & therefore enables tyrosine kinase receptors to **dimerise** (after insulin binds at extracellular ligand binding site), and
4. **E: hence cross-phosphorylation of tyrosine amino acid residues at the intracellular tails** by tyrosine kinases of the other receptor monomer;
5. **E:** Enables **activated G protein** bound to GTP to **move to bind and activate adenylyl cyclase**, so that ATP can be converted to cAMP;

(c) PKA is an enzyme involved in the signalling pathways in Fig. 3.1.

Explain how the features of PKA allow it to perform its function in cell signalling. [4]

[Any one of the following]:
1. Reusable, unchanged at the end,
2. can phosphorylate many molecules in the phosphorylation cascade/ signal amplification;
3. specific active site.
4. Can only phosphorylate specific molecules. Quote molecules in Fig. 3.1.
5. Allosteric control – cAMP (activator) binds to PKA allosterically to activate it.
6. AVP: Induced fit.

[Total: 9]

4 Red blood cells are formed from cells called reticulocytes. Stem cells in the bone marrow produce reticulocytes which differentiate into red blood cells.

(a) Identify precisely the stem cells in the bone marrow that produce reticulocytes. [1]

1. **Myeloid** stem cells

(b) Suggest how the expression of specific genes is likely to change when stem cells in the bone marrow differentiate ultimately into red blood cells. [2]

(any 2)
1. genes involved in **multipotency**/ giving **ability to differentiate into limited range of blood cells** are **switched off**
2. genes involved in **self-renewal** are **switched off**
3. **haemoglobin** gene is **switched on**

(c) Fig. 4.1 shows the structure of a small section of DNA of a reticulocyte.

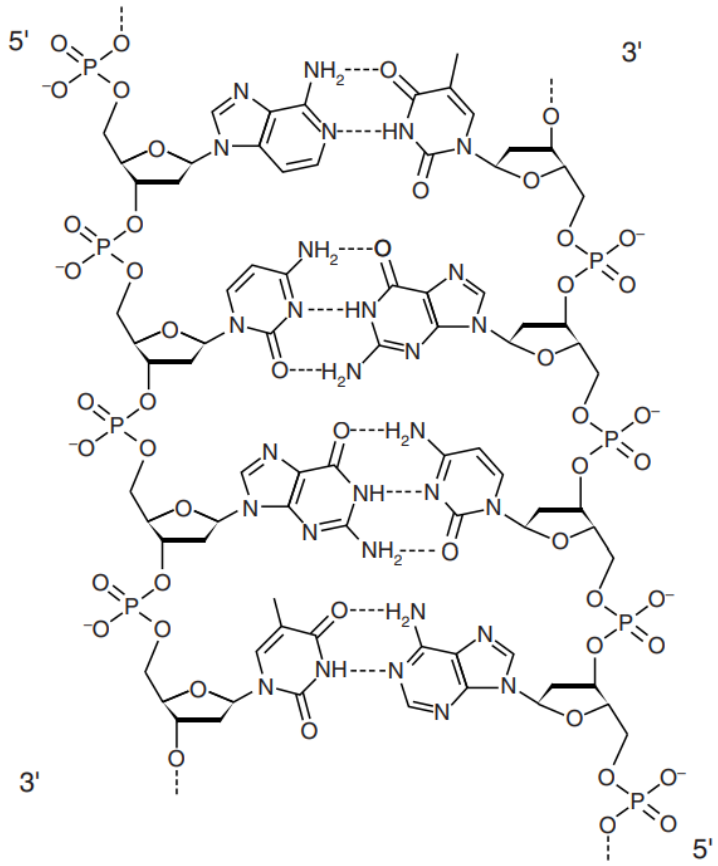


Fig. 4.1

(i) Explain how the features evident in Fig. 4.1 facilitate the replication of reticulocyte DNA. [3]

(at least MP 3 or 5 to be present, else max 2)

1. **Two template strands** present to synthesise **two daughter/complementary strands** OR **each strand** serves as a **template** for the synthesis of a **daughter/complementary strand**
2. **Specific sequence of bases** exposed on each template strand determines **complementary** sequence of bases in daughter strand
3. hence genetic information stored is copied accurately/ OWTTE
4. Both template strands are held together by **weak hydrogen bonds**
5. hence allowing for **easy separation** during replication to expose the bases

(ii) Explain how the replication of DNA is similar to the synthesis of cellulose. [3]

(any 3)

1. Both involve **condensation** reactions of monomer units
2. with the **loss** of **one water** molecule **per covalent bond** formed
3. and the addition of **monomer** units/ formation of **polymers** *(reject: large molecules)*
4. AVP, e.g. catalysed by **enzymes**

[Total: 9]

5 The *lac* operon is a segment of DNA on the chromosome of *Escherichia coli*. The structural genes of the *lac* operon are only fully expressed when the bacteria are exposed to high lactose concentrations.

Fig. 5.1 is a diagram showing the *lac* operon and a nearby region of the *E. coli* genome.

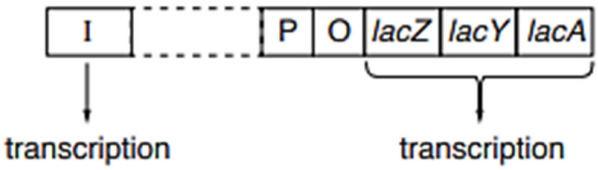


Fig. 5.1

(a) Describe a difference in control between the *lac* operon and the *trp* operon. [1]

[Any one of the following]:

1. *lac* operon uses an inducer (allo)lactose while trp operon uses a repressor tryptophan
2. Allolactose binds and inactivates the repressor, so that repressor cannot bind to operator, while tryptophan binds and activates the repressor, so that repressor can bind to operator
3. (Allo)lactose causes the structural genes to be transcribed/expressed/switched on while tryptophan causes the structural genes to be not transcribed/expressed/switched off

In an experiment, β-galactosidase concentration was measured in the presence of different concentrations of lactose and glucose. The results are shown in Fig. 5.2.

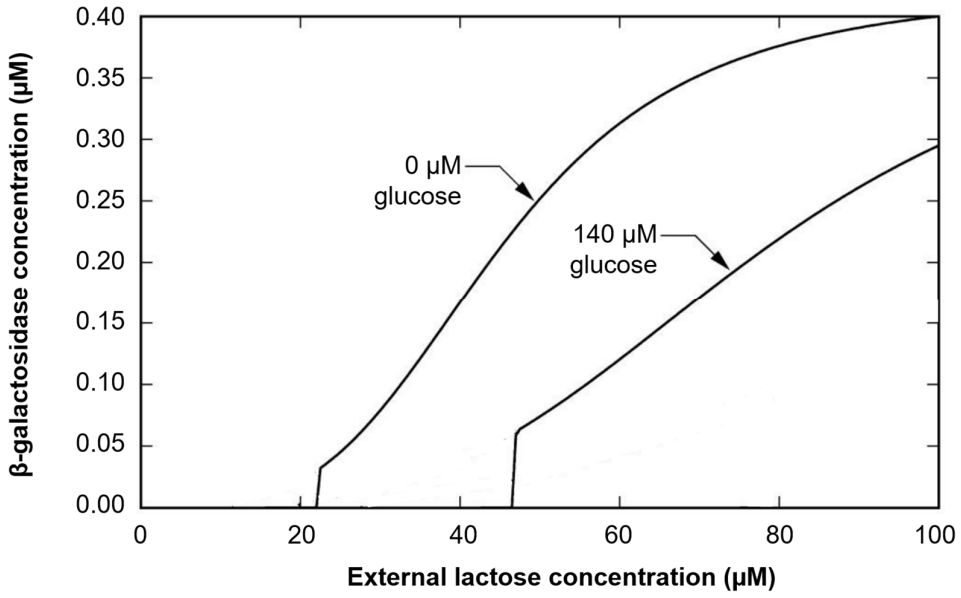


Fig. 5.2

(b) With reference to Fig. 5.2, explain the effect of increasing glucose concentration on the *lac* operon. [4]

1. [Quote data at any external lactose concentration] When external concentration of lactose is at 60μM, and glucose concentration increases from 0μM to 140μM, β-galactosidase concentration decreases from 0.31μM to 0.12μM.
2. As glucose concentration increases, **cAMP** concentration/levels decreases, more catabolite activator protein **CAP** are inactive and unable to bind to CAP binding site/ promoter.
3. **RNA polymerase** binds at low affinity to **promoter /** binding of RNA polymerase to promoter not enhanced *(reject RNA pol does not bind promoter)* → lac structural genes/ operon is transcribed at **low rate** *(reject lac operon turned off)*
4. Bacteria **preferentially breakdown/metabolise glucose** over lactose as to release energy (reject "bacteria use glucose")

(c) A student claimed that if a mutant *E. coli* strain had a mutated *lacZ* gene where one nucleotide was added, no functional β-galactosidase and permease would be produced.

[4]

Discuss the validity of his claim.

1. Not valid - **Coding sequence** for ***lacY* gene** (and *lacA* gene) **remains unchanged** (accept either no change in DNA or mRNA) (despite the addition of one nucleotide in lacZ gene) →
2. mRNA will thus be translated into **permease with normal structure hence functional**
3. Ref to mRNA being (polycistronic**)** where **each** of the coding sequence of lac Z, lac Y and lac A is **punctuated with a start and stop codon**
4. Addition of one nucleotide in ***lacZ* gene** would only cause a **frameshift mutation** (and maybe even a nonsense mutation) in the *lacZ* gene and hence, **no functional β-galactosidase** would be produced.
5. AVP – mutation at the end of coding sequence may still code for a functional β-galactosidase.

[Total: 9]

6 A plant breeder crossed a plant from a pure-bred line of tomato plants with red fruit with uniformly pigmented skin with a plant from another pure-bred line of plants with orange-coloured fruit, but with unattractive dark patches at the base of the unripe fruit. The resulting generation all produced red fruit with dark patches.

Plants from this generation were interbred. The resulting progeny showed the following numbers of plants in each of the three phenotypes:

red fruit with dark patches skin	98
red fruit with uniformly pigmented skin	46
orange fruit with dark patches skin	44

The height of the plants was also measured and the data collected is shown in Table 6.1.

Table 6.1

Height / cm	number of tomato plants
131 – 135	3
136 – 140	9
141 – 145	21
146 – 150	12
151 – 155	2

(a) Distinguish between the two types of variation shown in fruit colour and height in the tomato plants. [2]

1. * Fruit colour shows discontinuous variation	**While height shows continuous variation;**
2. Discrete phenotypic classes and no intermediates are observed	**A range of phenotypes are observed;**
3. Fruit colour is controlled by one or two major genes, which may have two or more allelic forms.	**Height is controlled by a large number of genes (polygenes);**
4. Effect of individual genes can be observed.	**Effect of individual genes cannot be observed;**
5. Effect of genes is not additive.	**Effect of genes is additive;**
6. The environment has a small effect on the phenotype.	**Environment has a large effect on the phenotype;**

**** Compulsory point;***

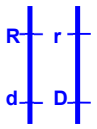
(b) The genes involved in the cross above are hypothesised to be completely linked. State the meaning of the term 'complete linkage'. [1]

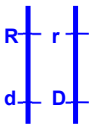
1. Both genes involved in the cross are adjacent to each other on the same chromosomes;
OR
2. No crossing over/ No formation of recombinant gametes / always inherited together;

(c) Using the symbols R/r for the gene for colour and D/d for the gene for patched/pigmented skin, draw a genetic diagram to show how the second cross could lead to the three phenotypes.

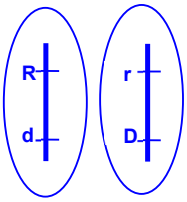
Symbols: Let R be the dominant allele for red fruit and r be the recessive allele for orange fruit.
Let D be the dominant allele for dark patched skin and d be the recessive allele for pigmented skin;

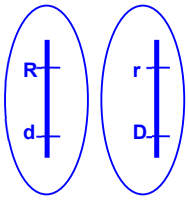
Parental Phenotypes **Red Fruit, Dark Patches** **x** **Red Fruit, Dark Patches**
Parental Genotypes;



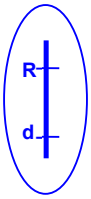
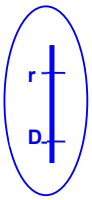
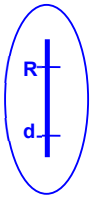
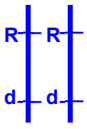
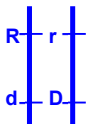
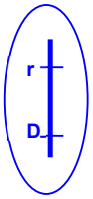
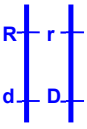
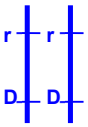


Meiosis
Gametes (2 sets);





Fertilisation (Punnett Square showing correct genotypes and phenotypes);

		
	 Red fruit, pigmented skin	 Red fruit, dark patches
	 Red fruit, dark patches	 Orange fruit, dark patches

Offspring Genotypic ratio
red fruit, dark patches : red fruit, pigmented skin : orange fruit, dark patches

Offspring Phenotypic ratio;
2 : 1 : 1

[4]

The χ^2 distribution table (Table 6.2) and equation to calculate χ^2 are shown below. Using the formula, the calculated χ^2 value for the cross was 0.38.

$$\chi^2 = \Sigma \frac{(O-E)^2}{E}$$

Table 6.2

degree of freedom	probability, p				
	0.10	0.05	0.02	0.01	0.001
1	2.71	3.84	5.41	6.64	10.83
2	4.61	5.99	7.82	9.21	13.82
3	6.25	7.82	9.84	11.35	16.27
4	7.78	9.49	11.67	13.28	18.47

(d) **(i)** State the null hypothesis. [1]

There is **no significant difference** between expected and observed results. Any difference observed is due to **chance**.

(ii) Using the calculated value of χ^2 and Table 6.2, explain what conclusion can be drawn from the data. [2]

1. **df = 3-1 = 2, p>0.10, since p>0.05, at a level of significance of 5% we do not reject the null hypothesis that states that the expected results and observed results are not significantly different;**
2. **Thus, there is no significant difference between the expected and observed results and**
3. **(compulsory) R and D genes are completely linked;**

[Total: 10]

7 Cystic fibrosis (CF) is a genetic disease caused by mutations of the gene that encodes the cystic fibrosis transmembrane conductance regulator (CFTR).

The most common cystic fibrosis mutation, ΔF508, is a three-base-pair (bp) deletion of codon 508 at exon 10 of the *CFTR* gene.

Another cystic fibrosis mutation is the G551D mutation. This mutation creates a recognition site for the restriction enzyme *Mbo*I at codon 551. This recognition site is not present in the normal allele.

The *CFTR* gene is amplified via the polymerase chain reaction (PCR) and digested with a restriction enzyme, *Mbo*I.

(a) Explain the role of primers in the PCR used to amplify the *CFTR* gene. [2]

1. Primer provides **free 3'-OH** group allows ***Taq* DNA polymerase** to add deoxyribonucleotides to
2. ***Taq* DNA polymerase** has a specific active site complementary only to a **free 3'-OH** group.
3. Primers are **specific**, only binds to DNA sequences flanking the target *CFTR* gene

Fig. 7.1 shows the results of agarose gel electrophoresis of *Mbo*I digest products.

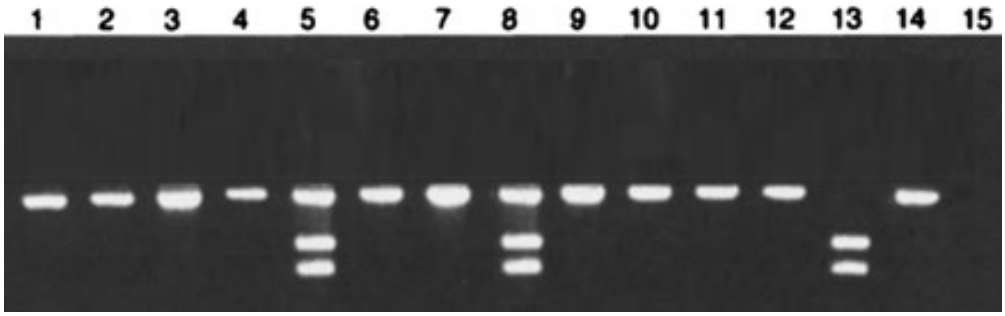


Fig. 7.1

(b) Explain which individual(s) is/are carrier(s) of the disease. [2]

1. Both individuals 5 & 8 are heterozygous / 1 mutant and 1 normal allele as they have 3 bands;
2. Band nearest well / longest band (R: longer) represents normal allele;
3. 2 shorter bands presents 2 smaller fragments that resulted from *Mbo1* digestion of mutant allele;

To detect cystic fibrosis in individuals, a modified Southern hybridisation technique is used.

Target DNA is amplified using PCR and then denatured and labelled with biotin and streptavidin-alkaline phosphatase.

The amplified target DNA is then allowed to hybridise with a specific probe that is attached to a nitrocellulose membrane strip. When a chromogen is added, it is converted to a purple precipitate by alkaline phosphatase.

If the allele is present, it will hybridise with the respective probe. This leads to the conversion of the chromogen to a purple precipitate by alkaline phosphatase. This will then show up as a band on the strip.

Fig. 7.2 shows the PCR products of seven individuals (in lanes A – G) which are tested with four different probes. The following probes are used for the respective alleles:

Probes	Alleles to detect
W.ΔF508	ΔF508 wild-type allele
M.ΔF508	ΔF508 mutant allele
W.G551D	G551D wild-type allele
M.G551D	G551D mutant allele

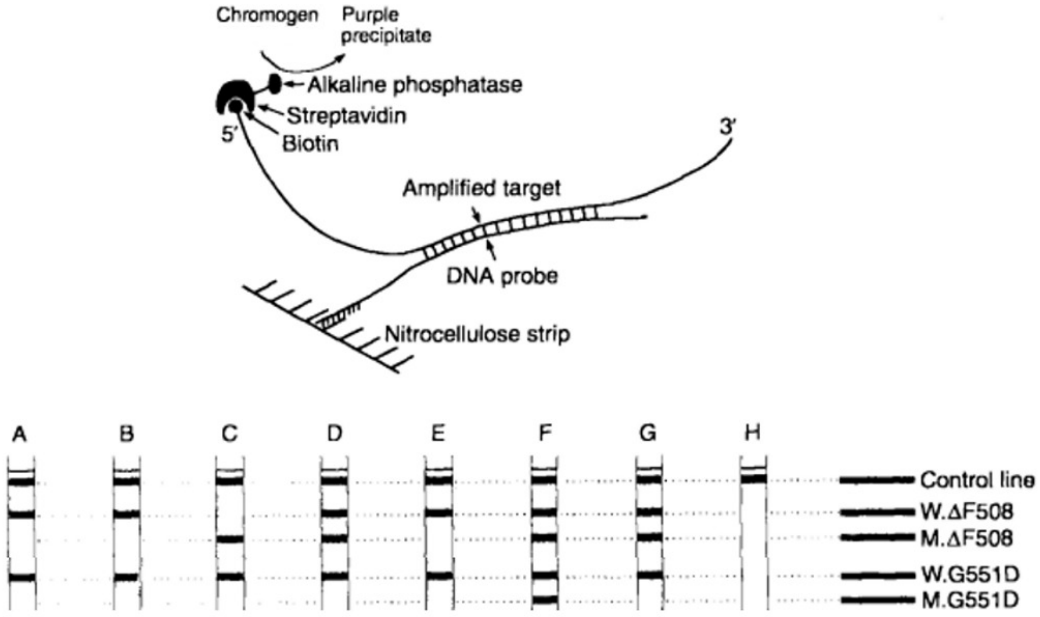


Fig. 7.2

(c) With reference to the information provided in Fig. 7.2,

(i) describe the characteristics of the probes used.[2]

1. Single-stranded;
2. Complementary in nucleotide/base sequence to specific allele (A: target sequence) that it binds to;

(ii) Explain which of the individual(s) is/are sufferer(s) of the disease.[2]

1. C - Presence of band M. ΔF508 but no W. ΔF508 / only band M. ΔF508 and W.G551D (quote data) shows that it;
2. Carries two mutant alleles for ΔF508 / homozygous for M.ΔF508;
3. No functional CFTR protein produced;

(iii) explain the purpose of H. [1]

Negative control to show that purple bands will form only when specific alleles are present and binds to the strip;

[Total: 9]

8 A group of students investigated the growth of yeast in their school laboratory.

The students learned that the respiration rate is proportional to the rate of growth of a yeast culture.

Respiration rates can be measured using the redox indicator TTC.

- During respiration, hydrogen ions are removed from glucose to reduce hydrogen carriers in yeast cells.
- TTC can be used as a hydrogen carrier in experimental conditions instead of the hydrogen carriers in yeast cells.
- TTC changes from colourless to pink when it is reduced. The colour change can be measured using a colorimeter.

The students carried out a preliminary experiment using TTC to monitor the growth of a yeast culture over time. The yeast was grown in a liquid culture in a conical flask, as shown in Fig. 8.1. TTC was added to the flask, which was incubated at a constant temperature for a fixed period of time.

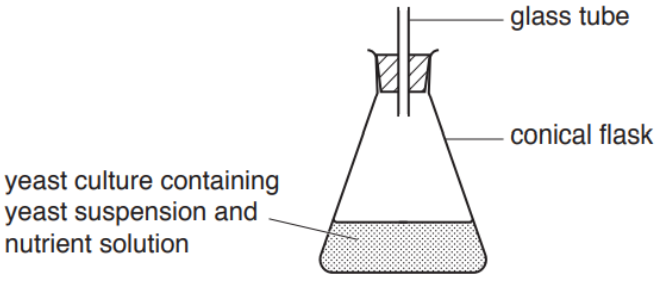


Fig. 8.1

(a) Explain why respiration rate is proportional to the rate of growth of a yeast culture. [3]

1. *ref. to* higher rate of respiration in the culture indicating the presence of **increasing number of yeast cells** that are respiring
2. *ref. to* respiration producing **ATP**
3. *ref. to* ATP needed for **cell division**/ **budding**/ **increased synthesis of proteins/organelles**
   (ignore: mitosis)

(b) Identify the hydrogen carriers that are found in yeast cells. [1]

1. **NAD** and **FAD**

(c) Besides the removal of its hydrogen ions, outline the fate of a glucose molecule during aerobic respiration in a yeast cell.

Your answer should include the specific location(s) within the yeast cell. [4]

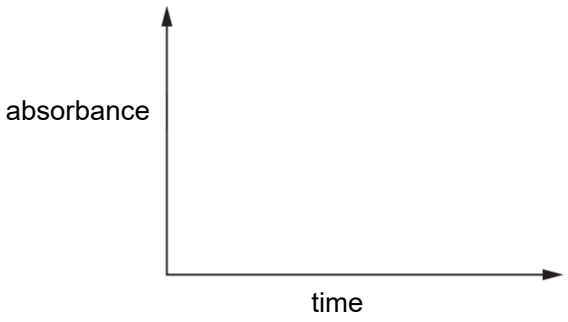
1. In **glycolysis**, glucose is broken down to **two molecules of pyruvate**
2. in the **cytosol/ cytoplasm**
3. pyruvate enters the **mitochondrial matrix**

4. **pyruvate** is **decarboxylated/one molecule of CO_2 is lost** to become **acetyl-coA** in the **link reaction**
5. **acetyl-coA** combines with **oxaloacetate** in the **Krebs cycle**
6. **two molecules of CO_2 are lost** by the end of the Krebs cycle

(d) Samples were taken from the flask at intervals and the absorbance was measured in the colorimeter.

A colorimeter passes a beam of light through a coloured filter into a solution and measures the light absorbance of that solution. A standard solution is used to set the colorimeter scale to zero before taking any measurements.

Complete the graph below to show the expected change in absorbance over time during the incubation of yeast.



[1]

1. line showing increasing absorbance with time

[Total: 9]

9 The zebra finch, *Taeniopygia guttata castanotis*, and the budgerigar, *Melopsittacus undulatus*, are two species of songbirds found in Australia.

Fig. 9.1 shows photographs of the physical appearance of these songbirds, and of their skulls.

Fig. 9.1

(a) Discuss whether the evidence in Fig. 9.1 is sufficient to conclude that *Taeniopygia guttata castanotis* and *Melopsittacus undulatus* are two distinct species of songbird. [4]

1. Both birds appear **physically/morphologically different** + give one example, e.g. zebra finch has large beak/ spotted plumage/ skull of zebra finch is more elongated/ skull of budgerigar is more rounded/ AVP

   (max 3)
2. but this could be due to **variation that exists within the population** (of the same species)
3. unable to tell if both birds are **able to interbreed** and **produce fertile/viable offspring** (*ref.* biological species concept)
4. **physical/ anatomical/ morphological differences** are **subjective** (or OWTTE)/ **difficult to quantify how many differences determine separate species** (*ref.* morphological species concept)
5. no information about **ecological niches** that both birds occupy (*ref.* ecological species concept)
6. no information about **DNA/genetic sequences** which, if available, can be **compared to determine extent of genetic differences** (*ref.* genetic species concept)
7. no information about **other** (closely related) **songbirds** to **compare** with to examine phylogenetic relationships/ divergence from a common ancestor (*ref.* phylogenetic species concept)
8. AVP

Scientists have found very little evolutionary change in populations of zebra finch in Australia.

(b) The number of eggs a bird lays in its nest is called the clutch size. Eggs that hatch in each clutch give chicks, which develop into adult finches ultimately if they manage to survive.

The variation in clutch size was investigated in the zebra finch over several years. The data are shown in Fig. 9.2.

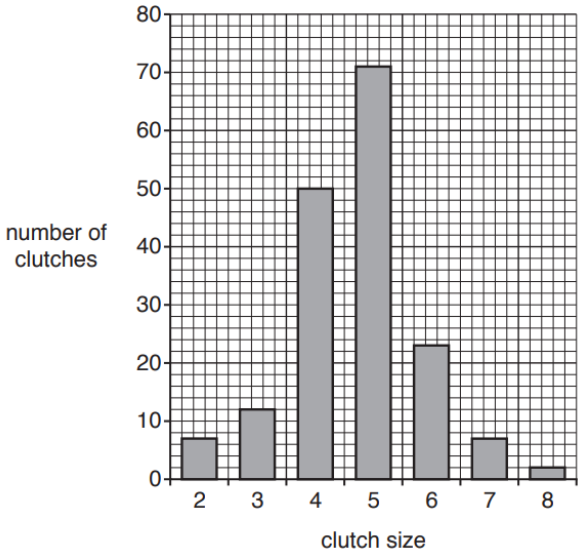


Fig. 9.2

(i) Describe the pattern shown by the data in Fig. 9.2. [2]

(any 2)
1. **normal distribution**
2. 5 is the **commonest/ most frequent/ peak clutch size**
3. **few(er)** clutches are **very large or very small/ of size 2 and 8/ lie at the extremes**

(ii) The data in this investigation were collected over 60 years ago. The same investigation, carried out today, would produce the same pattern of results.

Suggest how the selection factors acting on zebra finches would maintain the same pattern of results. [3]

1. 4 or 5 eggs/ mean/average clutch size gives **selective advantage/ has the most surviving offspring**
   OR not all offspring survive for very small (2 or 3) or very large (6, 7 or 8) clutch sizes

2. **small clutch size** linked to **weaker/diseased parents** who tend to produce **weak/diseased eggs/offspring**

3. large clutch size linked to **more competition** between chicks for **food/ parental care**
4. large clutch size linked to **increased predation of unhatched eggs/chicks**

[Total: 9]

10 Fig. 10.1 shows a macrophage engulfing the pathogen that causes tuberculosis (TB).

magnification ×4400

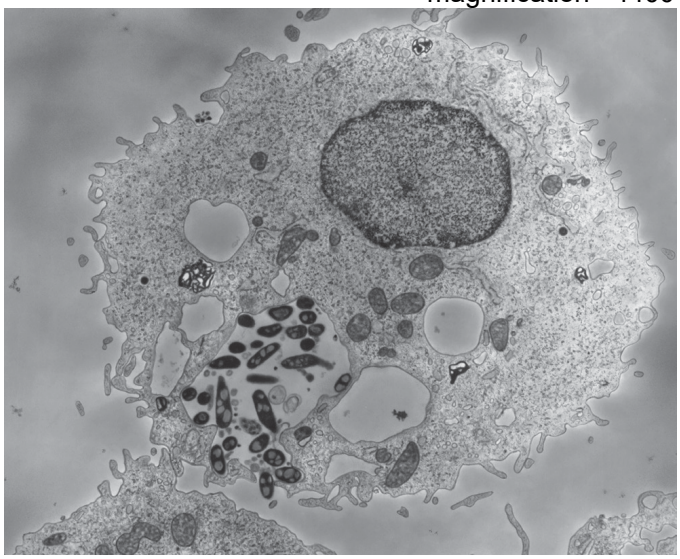


Fig. 10.1

(a) **(i)** Name the pathogen that causes TB. [1]

Mycobacterium tuberculosis. (Students must **underline separately**)

(ii) Describe how this pathogen is transmitted. [2]

max1 if no reference to, infected / uninfected

1. airborne droplets, breathed / sneezed / AW, out by infected person **;**
2. breathed in / inhaled / inspired, by uninfected person **;**

(b) Explain how the innate immune system minimises TB infections. [3]

Chemical barrier

1. **Nasal cavity or upper respiratory tract** covered with **mucus** that **traps** foreign particles, including bacteria;
2. The mucus also **prevents** bacteria from **attaching to the epithelium / epithelial cells**;
3. The entrapped bacteria is then carried/swept back to the throat / pharynx (together with the mucus) by **ciliary action** of epithelial cells and swallowed. / In the **lower respiratory tract**, foreign particles, including bacteria, are brought up by the **ciliary action** of epithelial cells.

Innate immune cells

4. (Alveolar) macrophages (in mucus / on epithelial layer of cells/ lungs) **phagocytose** influenza viruses / engulf them by **phagocytosis**, preventing them from infecting epithelial cells;
5. Macrophages secrete cytokines and chemokines which recruit more phagocytes;

(No need to talk about what happens inside the macrophage)

(c) Antigen presentation occurs during the immune response against the pathogen that causes TB.
Describe **three** ways in which antigen presentation differs in phagocytes and B lymphocytes. [3]

Features	**Phagocytes**	**B lymphocytes**
Process to internalise antigen	Phagocytosis → pathogen in phagosome	Receptor-mediated endocytosis → pathogen in endosome
Purpose of antigen presentation	To activate naïve T cells	To activate itself
Target cells	Antigen peptide presented to both naïve CD4 and CD8 T cells	Antigen peptide presented to CD4 T helper cell (already) activated by the same antigen

[Total: 9]

11 The Himalayan region, one of the world's biodiversity hotspots, has the highest concentration of medicinal herb species. About 2000 recorded species of medicinal herbs are found in Nepal, one of the Himalayan countries.

Fig. 11.1 shows the altitude ranges and the temperatures at which three different species of medicinal herbs belonging to the family of Ranunculaceae can be found growing in the wild mountainous regions in Nepal.

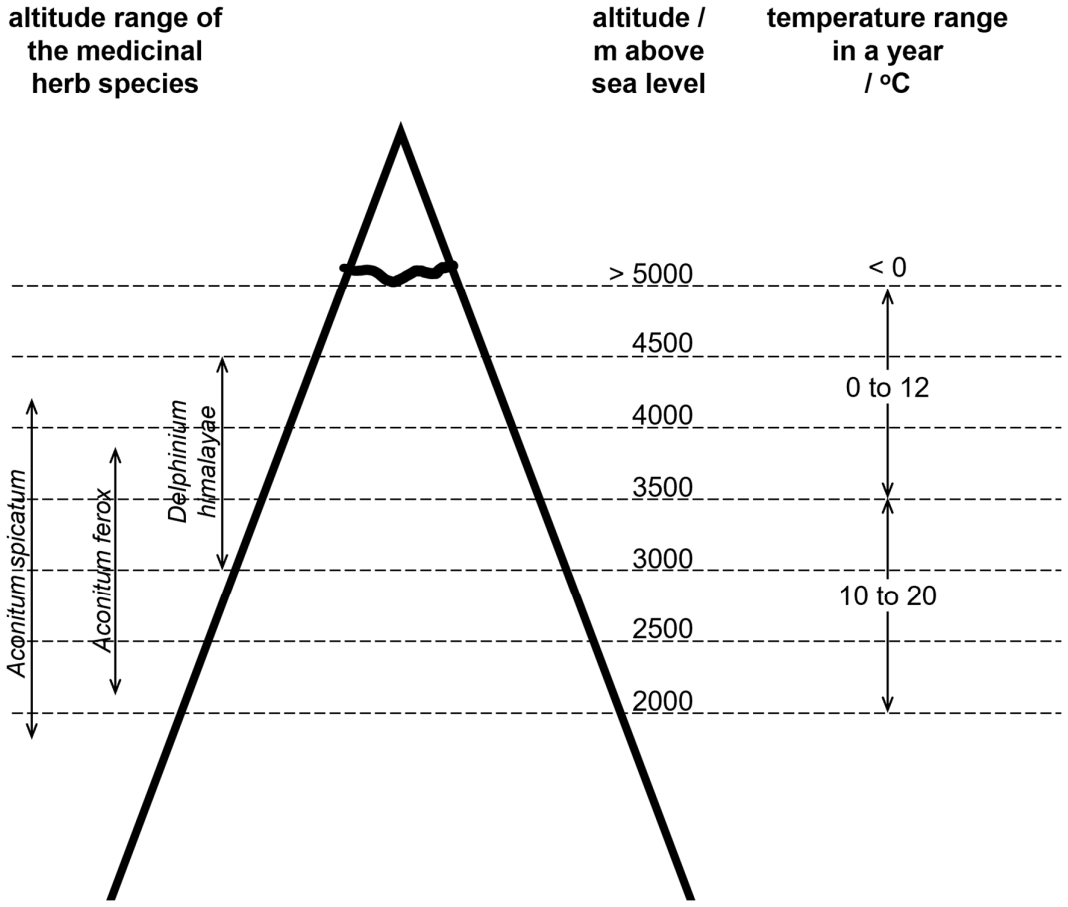


Fig. 11.1

The survival and distribution of these medicinal herbs have been under increasing pressure from the effects of climate change. The future impacts are shown in Table 11.1.

Table 11.1

species	altitude range / m above sea level	suitable land area in the mountainous region for growth and survival / km^2		
		under current climate	under future climate	percentage change
Aconitum spicatum	1800 – 4200	4010	3817	-4.8
Aconitum ferox	2100 – 3800	4664	3359	-28.0
Delphinium himalayae	3000 – 4500	2648	970	-63.4

(a) Complete Table 11.1 by calculating the change in suitable area in the mountainous region for growth and survival of two of these species. [1]

1. Both calculated correctly with negative sign.

(b) Outline how human activities contribute to global warming. [2]

[Any 1 of these points]:

1. Human activities such as **combustion of fossils fuels** such as **coal, oil and gas** for energy, produces **carbon dioxide and nitrate oxide.**
2. Trees help to regulate the climate by absorbing carbon dioxide from the atmosphere. When massive number of trees are cut down during **deforestation/ clearing of forest, reduction in size of carbon sink**. **Trees are burned**, carbon stored in trees is released into atmosphere as **carbon dioxide**.
3. Increasing **livestock (e.g. cattle) farming to meet demands of food choices such as increasing consumption of meat** produce large amount of methane when they digest food

AND

[Compulsory point]:

4. **Greenhouse gases** **absorbed long-wave/ infrared** radiation, **trapping/holding heat** within **atmosphere**.

(c) Due to global warming, the largest increase in mean annual temperature of Nepal is expected to be about 4 °C by the end of 2100.

Using the data given in Fig. 11.1 and Table 11.1, predict and explain the effect of climate change on the distribution of the three medicinal plant species at the different altitudes. [4]

1. **Quote "new" temperature at different altitudes**:
    - altitudes between 3500 to 5000 m above sea level would be between 4 °C to 16 °C;
    - altitudes between 2000 to 2500 m above sea level would be between 14 °C to 24 °C;
2. In 2100, the **temperatures at current altitude would be too warm for all 3 species** of medicinal herbs (quote one example, temperature within reasonable range derived from Fig. 11.1)
    - *Aconitum spicatum*'s grows at temperature between 10 °C to 20°C but future climate would increase temperature to between 14°C to 24 °C at altitudes between 1800 – 4200 m above sea level.
    - *Aconitum ferox* grows at temperature between 0°C to 20°C but future climate would increase temperature to between 4°C to 24°C at altitudes between 2100 – 3800 m above sea level.
    - *Delphinium himalayae* grows at temperature between near 0°C to 12°C but future climate would increase temperature to between 4°C to 16°C at altitudes between 3000 – 4500 m above sea level.
3. hence they are expected to **migrate / move upwards to higher elevation/altitudes**;
4. **Because warmer climates** (at their current altitude) **could result in some plants undergoing water stress** (stomata close to reduce transpiration and hence lesser CO_2 for Calvin cycle)
5. **Suitable land area** (in the mountainous region for growth and survival) **would decrease** (range contraction), with *Aconitum spicatum* suffering the smallest decrease (-4.8%/193 km^2), followed by *Aconitum ferox* (-28.0%/1305 km^2) and *Delphinium himalayae* (-63.4%1678 km^2) [sufficient to quote 2, allow ecf from (a)].
6. *Delphinium himalayae* will have the largest decrease in suitable land area because it **loses areas at low altitudes but are unable to gain more area as they migrate to higher altitudes**, / face **competition** from species such as *A. spicatum* and *A. ferox* which may have migrated into their original range.
7. *Aconitum spicatum* has the **lowest decrease** in suitable land area because it is able to **survive at a wider temperature range** of about above 0°C to 20°C.

(d) Suggest how the melting of snow and glaciers on the Himalayan mountains could increase stress on freshwater supplies. [2]

1. Less ice melt/ water contributed to the rivers after initial melt, leading to rivers drying up
2. Increased pumping of underground water/ aquifers worsens freshwater stress
3. AVP, e.g., pollutants, e.g., DDT trapped in ice that melts rapidly could contaminate freshwater

[Total: 9]