

NAME : \_\_\_\_\_

CLASS : \_\_\_\_\_



## JURONG PIONEER JUNIOR COLLEGE JC2 Preliminary Examination 2025

### BIOLOGY Higher 2

**9744/02**  
**2 September 2025**

Paper 2 Structured Questions

**2 hours**

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

#### READ THESE INSTRUCTIONS FIRST

Write your class and name in the spaces at the top of this page.  
Write in dark blue or black pen.  
You may use an HB pencil for any diagrams or graphs.  
Do not use staples, paper clips, glue or correction fluid.

Answer **all** questions in the spaces provided on the Question Paper.

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.

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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This document consists of **19** printed pages and **1** blank page.

## Section A

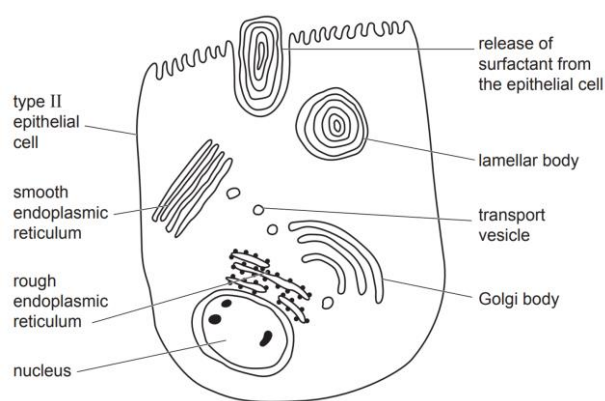
Answer **all** questions.

- 1 Alveoli are tiny air sacs in the lungs that are crucial for gas exchange. The walls of alveoli contain some specialised epithelial cells called type II epithelial cells. These cells secrete surfactant, which helps to prevent the alveoli collapsing during breathing.

The components of surfactant are synthesised in the rough endoplasmic reticulum and smooth endoplasmic reticulum and then passed to the Golgi body.

The surfactant that is produced is stored in secretory organelles called lamellar bodies.

The surfactant in the lamellar bodies is released onto the surface of the alveolar epithelium, as shown in Fig. 1.1.



**Fig. 1.1**

- (a) The cell surface membrane of type II epithelial cells has a fluid mosaic structure.

Describe what is meant by the term *fluid mosaic*.

..... [3]

**Fluid:**

1. "Fluid" means that the phospholipids and proteins are free to move within the membrane ;
2. Phospholipids are held by weak hydrophobic interactions and hence move about rapidly by diffusion in their own layers ;
3. Unsaturated fatty acid tails of phospholipids have kinks that keep the molecules from packing together, enhancing membrane fluidity ; (least important)

**Mosaic:**

4. Proteins are embedded within the phospholipid bilayer in a random manner ;

- (b) Each lamellar body is surrounded by a single membrane. Draw a diagram to show the arrangement of phospholipid molecules in the membrane surrounding the lamellar body. [2]

1. phospholipid with a head and two tails ;
2. bilayer shown ;

- (c) (i) Suggest the components present in the surfactant.

..... [2]

1. lipids/phospholipids /(cholesterol) ;
2. proteins ;

- (ii) Describe how the surfactant is released from the cell.

..... [3]

1. lamellar bodies containing surfactant move towards the cell surface membrane of the type II epithelial cells via the use of microtubules ;
2. membrane of the lamellar bodies fuses with the cell surface membrane ;
3. surfactant is secreted/released out of the type II epithelial cells via exocytosis ;
4. active process which requires ATP ;

- (iii) Scientists studying the production and secretion of lung surfactant have discovered that a reduction in cholesterol in the cell surface membrane of type II epithelial cells reduces the secretion of surfactant.

Suggest why secretion of surfactant is affected by a reduction in cholesterol in the cell surface membranes of type II epithelial cells.

..... [2]

1. cholesterol regulates the fluidity of the membrane ;
2. a reduction in cholesterol, decreases membrane fluidity/making the cell surface membrane more rigid ;
3. cell surface membrane less able to fuse with the membrane of lamellar body ;

[Total: 12]

- 2 Proteins have diverse roles that arise from their three-dimensional structures, which are determined by the sequence of amino acids and the nature of bonds formed between them. The structure-function relationship in proteins is critical to life, and disruption to this relationship may result in diseases.

Fig. 2.1 shows two examples of proteins:

- G-protein-linked receptors (GPLRs), which are membrane proteins that are involved in majority of cell signalling processes in the body.
- Collagen, a fibrous protein that forms structural scaffolds in connective tissues like skin, bone, and tendons.

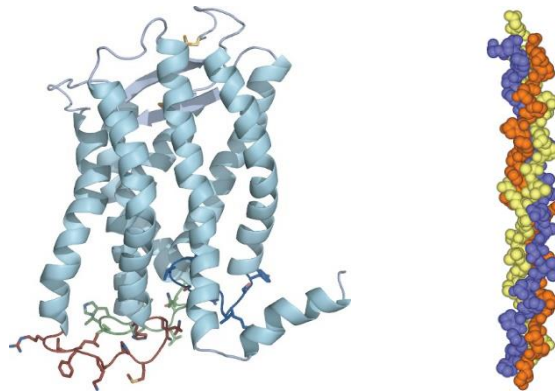


Fig. 2.1

- (a) With reference to Fig. 2.1, describe how the bonding and amino acid composition contribute to the shape of each protein.

..... [2]

#### GPLR:

1. Ionic bonds and hydrogen bonds between charged/polar amino acid residues stabilise, extracellular / intracellular. domains ;
2. Hydrogen bonds, ionic bonds, disulfide bonds, and hydrophobic interactions between R groups of amino acid residues maintain the globular/3D shape of the GPLR ;
3. (intramolecular) hydrogen bonds between the O of C=O group and the H of the -NH group of every fourth peptide bond in the main chain of the polypeptide stabilise/form the  $\alpha$ -helices ;

#### Collagen: (A!tropocollagen/ triple helix)

4. High proportion of glycine / Almost every third amino acid in each polypeptide chain is glycine, (the small size of glycine) allows the three (helical) polypeptide chains to form a tight coil/ a tropocollagen ;
5. (Intermolecular) hydrogen bonds form between the three helical polypeptide chains, forming/stabilising the tropocollagen ;

R: covalent cross-links, no fibrils shown

- (b) (i) Explain how the molecular structure of the G-protein linked receptor relates to its function.

..... [3]

1. made up of a single polypeptide chain with seven transmembrane  $\alpha$ -helices , allowing it to be embedded in and span the cell surface membrane (to transmit signal) ;
2. has an extracellular region (which may be glycosylated) to serve as a specific binding site for ligand ;
3. has an intracellular / cytoplasmic region to serve as a specific binding site for G-protein ;

- (ii) A mutation in the *GPLR* gene leads to the substitution of a non-polar amino acid for an essential charged residue in the third intracellular loop, disrupting signal transduction.

Explain how this change alters the structure and function of the GPLR protein.

..... [2]

1. Substitution of a non-polar amino acid for a charged residue disrupts ionic bonds / hydrogen bonds, in the intracellular loop ;
2. Alters the conformation of the intracellular loop, prevents binding of G-protein (and prevents triggering downstream signalling pathways / signal transduction pathways) ;

- (iii) Mutations affecting collagen can lead to severe diseases such as osteogenesis imperfecta (OI) which is characterised by fragile bones that break easily.

OI is often caused by a missense mutation in the *COL1A1* or *COL1A2* genes encoding collagen type I. One such mutation replaces glycine with a bulkier amino acid such as cysteine in the collagen chain.

Explain how this mutation affects the structure and function of collagen in individuals with OI.

..... [2]

1. replacement of glycine with a bulkier amino acid disrupts tight packing/coiling of the tropocollagen ;
2. results in weakened/ abnormal collagen fibers with reduced tensile strength, increased bone fragility, leading to OI ;

**A: tropocollagen/ triple helix**

[Total: 9]

- 3  $\alpha$ -Amylase is an enzyme that binds to starch and catalyses the hydrolysis of starch into maltose. It plays a central role in carbohydrate metabolism and is one of the enzymes important in controlling blood sugar levels in the body.

Fig. 3.1 shows the structure of  $\alpha$ -amylase, which consists of 496 amino acids on a single polypeptide chain.



Fig. 3.1

- (a) With reference to Fig. 3.1, describe how the tertiary structure of  $\alpha$ -amylase allows it to perform its role.

..... [4]

1. Tertiary structure refers to the specific 3D conformation of a polypeptide maintained by hydrogen bonds, ionic bonds, disulfide bonds and hydrophobic interactions between the R groups of amino acids ;
2. The polypeptide chain (primary structure), after coiling and folding into geometrically regular repeating secondary structures/,  $\alpha$ -helices and  $\beta$ -pleated sheets respectively, is further bent, coiled and folded to form the specific tertiary structure ;
3. This allows the protein to assume a specific 3D conformation with a specific active site ;
4. which only allows starch with complementary shape (and charge) to bind, forming an enzyme-substrate complex ;
5. for hydrolysis of glycosidic bonds (in starch) to occur ;

- (b) For individuals suffering from insulin-dependent diabetes mellitus, inhibiting  $\alpha$ -amylase could be a beneficial treatment to slow down the breakdown of starch. Tendamistat, a protein molecule consisting of 74 amino acids, was found to be an effective inhibitor of  $\alpha$ -amylase.

Fig. 3.2 shows the investigation on the effect of increasing starch concentrations on the rate of maltose production by  $\alpha$ -amylase in the presence and absence of tendamistat.

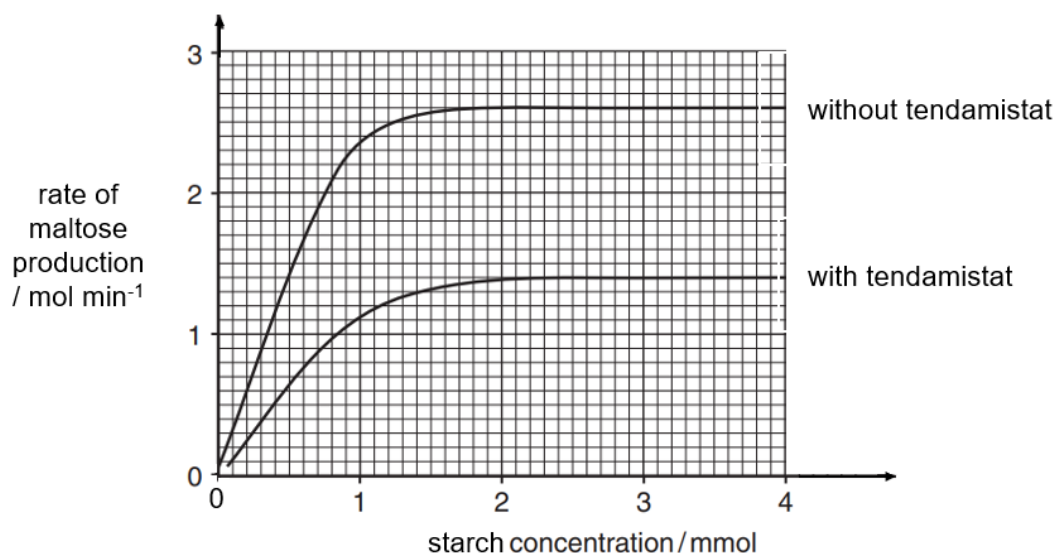


Fig. 3.2

- (i) Describe the shape of the curve when no inhibitor is present.

..... [2]

1. As starch concentration increases from 0 mmol to 0.8 mmol, the rate of maltose production increases rapidly/steeply from 0 mol min<sup>-1</sup> to 2.1 mol min<sup>-1</sup>;
2. As starch concentration increases from 0.8 mmol to 4 mmol, the rate of maltose production increases gradually from 2.1 mol min<sup>-1</sup> to 2.6 mol min<sup>-1</sup> and levels off to a plateau / remains constant at 2.6 mol min<sup>-1</sup>;

A: if break at different parts of graph e.g 0.9 instead of 0.8

A: if only 2 parts of graph description: increase till 1.7/1.8 mol min<sup>-1</sup> then plateau to 2.6 mol min<sup>-1</sup>

(ii) Explain how tendamistat inhibits  $\alpha$ -amylase.

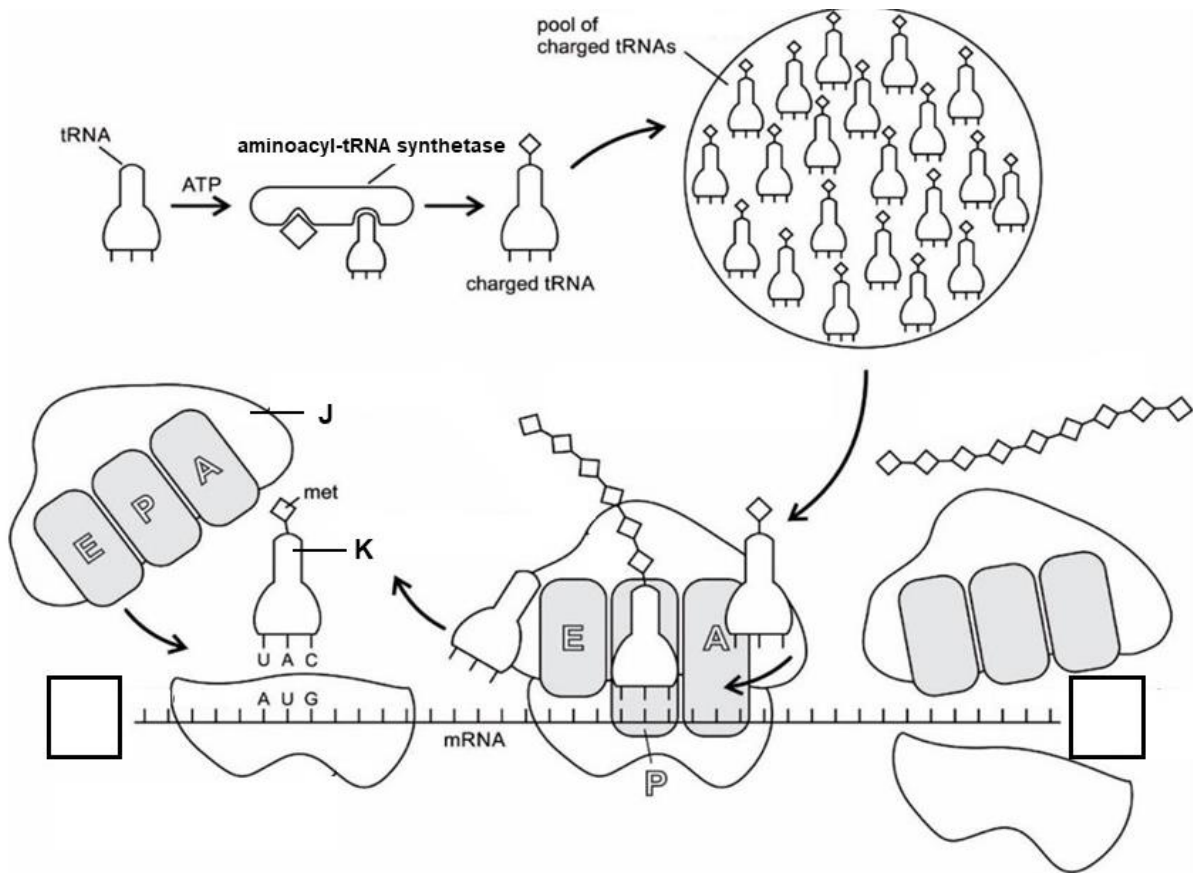
..... [4]

1. Tendamistat is a non-competitive inhibitor ;
2. not structurally similar to the substrate/starch and binds to the enzyme/  $\alpha$ -amylase at a site other than the active site / allosteric site ;
3. Upon binding of the non-competitive inhibitor to the allosteric site, the enzyme's 3D conformation / tertiary structure is changed such that the conformation of its active site is altered and the substrate can no longer bind to the enzyme active site;
4. (Formation of E-I complexes) prevent formation of enzyme-substrate complexes and formation of products, decreasing the rate of reaction ;
5. High substrate concentration/an increase in substrate concentration will not overcome/reduce the effect of the non-competitive inhibitor ;

[Total: 10]



**4** Fig. 4.1 shows the steps involved in translation.



**Fig. 4.1**

- (a)** On Fig. 4.1, label the 5' and 3' ends of the mRNA strand. [1]

**5' on left, 3' on right ;**

- (b)** Identify the molecules **J** and **K** shown in Fig. 4.1. [2]

**J: large ribosomal subunit ;**

**K:** initiator tRNA ;

- (c)** Outline the process by which the completed polypeptide chain is released from the ribosome.

---

 [3]

1. Termination occurs when a stop codon, UAA, UAG or UGA (any one), reaches the A site of the ribosome ;
2. A protein release factor recognises and binds to the stop codon on the mRNA, causing the addition of a water molecule to the polypeptide ;
3. This reaction hydrolyses the completed polypeptide from the tRNA that is in the P site, releasing the polypeptide from the tRNA and the ribosome ;

- (d) Genes coding for aminoacyl-tRNA synthetases can be mutated for the tRNAs to carry unnatural and modified amino acids for genetic code expansion in the laboratory.

With reference to Fig. 4.1, describe how mutations in the genes coding for the aminoacyl-tRNA synthetases can result in modified amino acids being incorporated into the polypeptide chain.

..... [4]

1. **Mutations in the genes can result in a change in the codon in the aminoacyl-tRNA synthetase mRNA ;**
2. **new amino acid coded for may have different property due to different R groups and result in a change in polypeptide sequence /primary structure ;**
3. **Resulting in change in 3D conformation and change in the active site of the aminoacyl-tRNA synthetase, which can now fit a specific combination of modified amino acid and an anticodon on the tRNA ;**
4. **Leading to the modified amino acid being brought to the ribosome and added into the polypeptide chain via peptide bond formation ;**
5. **A peptide bond is formed between the modified amino acid in the A site and the growing polypeptide chain in the P site, catalysed by peptidyl transferase ;**

[Total: 10]

5 HIV has a nucleic acid core. The virus also contains the enzyme reverse transcriptase.

(a) Describe the genome of HIV.

..... [1]

1. **2 copies of single-stranded RNA ;**

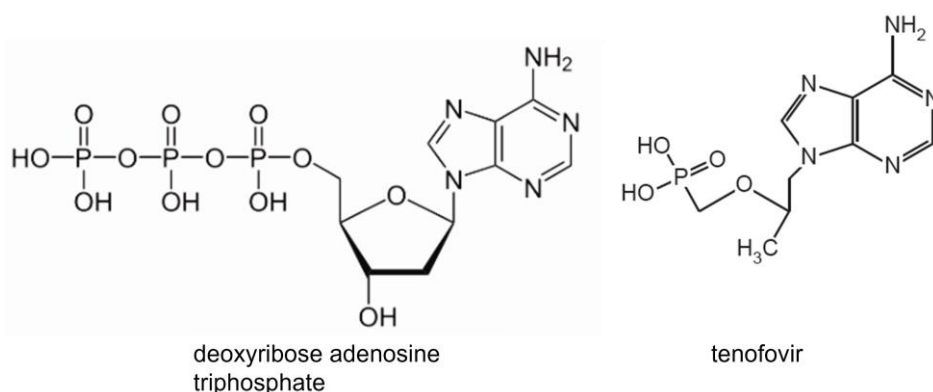
(b) State **two** other viral enzymes required in the replication cycle of HIV.

..... [2]

1. **integrase ;**

2. **HIV protease ;**

Some drugs, such as tenofovir, have been developed to inhibit the action of reverse transcriptase. The structure of tenofovir is similar to the structure of deoxyribose adenosine triphosphate, as shown in Fig. 5.1.



**Fig. 5.1**

After tenofovir is absorbed into cells, it is phosphorylated twice and can be used by reverse transcriptase in the synthesis of DNA. When a tenofovir molecule is added to the DNA strand being synthesised, the process stops.

(c) With reference to Fig. 5.1, suggest the mechanism of action of tenofovir to prevent infection by HIV.

..... [3]

1. **tenofovir acts as a competitive inhibitor ;**

2. **tenofovir is structurally similar to dATP, thus competes for binding (to reverse transcriptase) active site ;**

3. **tenofovir is added to the 3' end of existing/elongating DNA strand, but as tenofovir has no 3' -OH for next nucleotide to be added/form phosphodiester bond to, (c)DNA synthesis stops ;**

4. **viral DNA not synthesised, thus not integrated into host DNA/genome ;**

5. **Idea marking: This will limit the ability of HIV to reproduce as viral replication / assembly of mature virus are affected, no mature/infectious virus to infect host cells for reproduction ; (compulsory)**

- (d) Pre-exposure prophylaxis (PrEP) is the use of therapeutic drugs to prevent the replication of HIV in the body following infection. The drugs are taken by people who are at risk of becoming infected. Tenofovir is one of these therapeutic drugs.

In 2016, the United Nations (UN) set a global target of 3 million PrEP users by 2020.

Table 5.1 shows the number of people across the world who received a therapeutic drug for PrEP in each of the years between 2012 and 2019.

**Table 5.1**

<b>year</b>	<b>number of people who received PrEP</b>
2012	10 000
2013	15 000
2014	27 500
2015	57 500
2016	95 000
2017	145 000
2018	340 000
2019	605 000

- (i) Calculate the percentage of people who received PrEP in 2019 as a percentage of the target set by the UN in 2016. Show your working and give your answer to the **nearest whole number**.

**1. Percentage of people**      **= 605 000 / 3 000 000 x 100%**  
    **= 20.16 %**  
    **= 20% (to nearest whole) ;**

percentage = ..... [2]

- (ii) PrEP does not prevent transmission of HIV. Suggest a way that health authorities can further reduce the transmission of HIV.

..... [1]

- 1. use, new needles / new syringes / sterilised equipment for medical procedures to decrease risk of transmission from contaminated blood ;**
- 2. prevent people who are HIV positive being blood donors / screen donated blood to prevent people receiving blood infected with HIV, during blood transfusions / operations ;**
- 3. provide education / information, about HIV treatments / HIV transmission to raise awareness of ways to reduce infection e.g. use of barrier methods during sex ;**

[Total: 9]

**6** Inheritance of wing shape and eye colour in the fruit fly, *Drosophila melanogaster*, is controlled by two genes.

- Gene **N/n** controls wing shape. Allele **N** for wrinkled wings is dominant to allele **n** for normal wings.
- Gene **E/e** controls eye colour. Allele **E** for rosy eyes is dominant to allele **e** for red eyes.

A biologist predicted that, if the genes are on **different** chromosomes, the ratio of the phenotypes of the F<sub>2</sub> generation would be 9:3:3:1. The biologist carried out a breeding experiment. Homozygous dominant fruit flies with wrinkled wings and rosy eyes were crossed with homozygous recessive fruit flies with normal wings and red eyes. All the F<sub>1</sub> fruit flies had wrinkled wings and rosy eyes. The F<sub>1</sub> fruit flies were crossed with each other.

Table 6.1 shows the results for the F<sub>2</sub> generation.

**Table 6.1**

<b>F<sub>2</sub> phenotype</b>	<b>frequency</b>
wrinkled wings rosy eyes	44
wrinkled wings red eyes	2
normal wings rosy eyes	2
normal wings red eyes	16
total	64



(b) Explain why there is a greater number than expected of the parental phenotypes.

..... [3]

1. The 2 genes for type of wings and eye colour are linked and the alleles of the two genes will be inherited together as one linkage group, resulting in a higher proportion of gametes/higher chances of getting gametes carrying the parental types ;
2. Crossing over between the two linked genes on non-sister chromatids of homologous chromosomes may occur, as crossing over is a chance event, resulting in a lower proportion of recombinant gametes/lower chances of getting recombinant gametes ;
3. thus the observed offspring of the cross are majority of parental combinations and minority of recombinants combinations ;

(c) The chi-squared test was used to analyse the data in Table 6.1.

State **two** reasons why the chi-squared test was used.

..... [2]

1. to determine if the observed results are significantly different from the expected results ;
2. to estimate the probability that differences between observed and expected results were due to chance ;

[Total: 10]

- 7 (a) In light-dependent reactions, photoactivation of chlorophyll results in the synthesis of ATP.

Describe the photoactivation of chlorophyll in photosystem II.

..... [3]

1. A photon of light strikes a photosynthetic pigment in photosystem II (PS II) ;
  2. Energy in the photon of light is passed on from one pigment molecule to the neighbouring pigment molecule via resonance energy transfer until it reaches the special chlorophyll a (P680) in the reaction centre of PS II ;
  3. An electron in special chlorophyll a / P680 is excited and boosted to a higher energy level, and this excited electron is accepted by a primary electron acceptor ;
- (b) Fig. 7.1 shows some biochemical events that occur in a chloroplast during the light-dependent stage of photosynthesis. Photosystems I and II (PSI and PSII) and some associated proteins of the thylakoid membrane are shown.

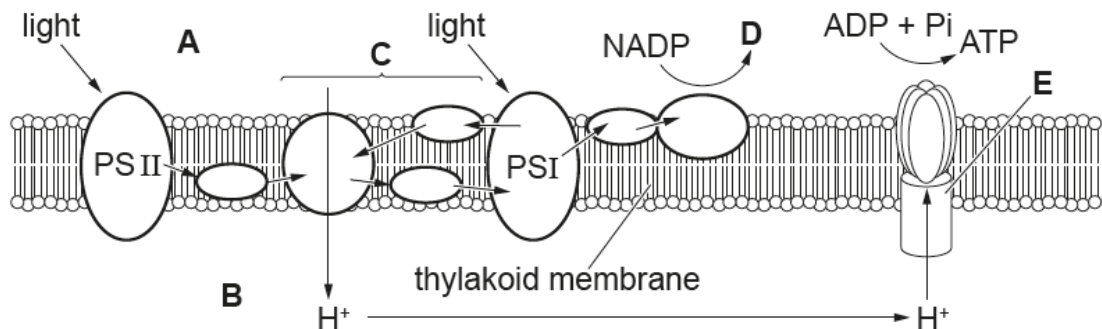


Fig. 7.1

- (i) State the names of location **A** and location **B** within the chloroplast.

**A** .....

**B** .....

[2]

1. **A – stroma ;**  
**B - thylakoid lumen ;**

- (ii) The group of proteins labelled **C**, PSI and the protein labelled **E** are involved in a specific biochemical process during the light-dependent stage of photosynthesis.

Name this specific biochemical process and the protein labelled **E**.

process .....

**E** .....

[2]

1. **process - cyclic photophosphorylation,**  
**E - ATP synthase ;**



(iii) Product **D** is used during the Calvin cycle.

Identify product **D** and describe its specific role in the Calvin cycle.

**D** .....

role .....

[2]

1. **D = reduced NADP / NADPH ;**
2. **Provide reducing power / act as reducing agent for PGA reduction ;**
3. **To reduce glycerate biphosphate to triose phosphate ;**  
**A! glycerate phosphate;**

(c) Experiments were carried out to determine the effect of light intensity on the rate of photosynthesis of a species of the unicellular protocist, *Chlorella*. A cell suspension of *Chlorella* was used.

Carbon dioxide uptake was used as a measure of the rate of photosynthesis.

- The suspension of *Chlorella* was illuminated at a light intensity of 3 lux for 20 seconds.
- The carbon dioxide uptake by *Chlorella* was measured at the end of the 20 second period of illumination.
- The experiment was repeated at 6 lux, 9 lux, 12 lux, 15 lux, 18 lux and in a dark room.
- The suspension was maintained at a temperature of 20°C.

Table 7.1 shows the results of the experiments.

**Table 7.1**

light intensity / lux	total CO <sub>2</sub> uptake after 20s / $\mu\text{mol}$	rate of photosynthesis / $\mu\text{mol s}^{-1}$
0	0	0.0
3	20	1.0
6	44	
9	72	3.6
12	80	4.0
15	80	4.0
18	80	4.0

[1]

- (i) Use Table 7.1 to calculate the rate of photosynthesis at a light intensity of 6 lux.

Complete the missing value in Table 7.1.

1. 2.2 ;

- (ii) With reference to Table 7.1, suggest an explanation for the data from 12 lux to 18 lux.

..... [3]

1. As light intensity increases from 12 lux to 18 lux, rate of photosynthesis reaches maximum and remain constant at  $4 \mu\text{mol s}^{-1}$  ;
2. light saturation had occurred / light intensity is no longer a limiting factor ;
3. other factors e.g. temperature / carbon dioxide concentration, are now limiting;

[Total:13]

- 8 Fig. 8.1 shows changes in the concentration of glucose in a person's blood following a meal.

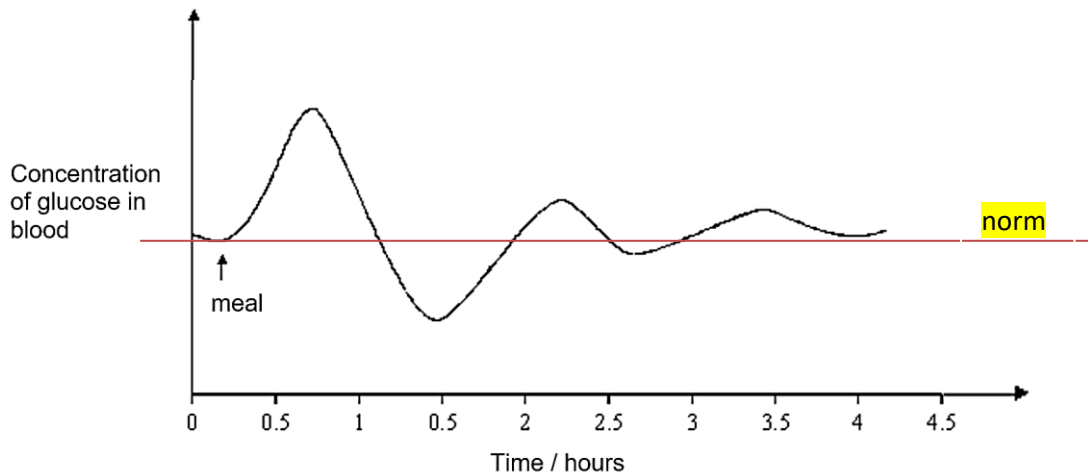


Fig. 8.1

- (a) Changes in the concentration of glucose are controlled by the hormones glucagon and insulin.

Write the letters **X** and **Y** on Fig. 8.1 to show

**X**, a time when glucagon secretion would be high;

**Y**, a time when insulin secretion would be high.

[1]

1. On graph: **X** where glucose level is below norm AND **Y** where glucose level is above norm ;

- (b) Describe how the binding of insulin leads to the control of blood sugar concentration.

..... [4]

1. Insulin recognises and binds to the specific binding site of tyrosine kinase receptors (RTK) on the target cell surface membrane, causing the two receptor polypeptides to undergo a conformational change and dimerise ;
2. Dimerisation activates the tyrosine kinase region of each polypeptide; each tyrosine kinase phosphorylates the tyrosines of the other polypeptide ;
3. Activated RTK is recognised by specific relay proteins which pass the signal on and lead to the activation of glycogen synthase ;
4. Glycogen synthase catalyses the conversion of glucose to glycogen (glycogenesis) ; in the target cell to reduce the blood glucose concentration

[max 1 from pt 5-7] Insulin also stimulates:

5. an increase in the rate of respiration using glucose as a respiratory substrate in target cells, which will be broken down and oxidised to form carbon dioxide and water ;  
OR
6. an increase in the permeability of the plasma membrane of target cells to glucose, to increase the rate of uptake of glucose from the blood by almost all body cells, especially muscle cells ;  
OR
7. the conversion of excess glucose to fats for storage in adipose cells/tissues ;

- (c) Some people produce no insulin and develop diabetes mellitus. In an investigation, a man with diabetes drank a glucose solution. The concentration of glucose in his blood was measured at regular intervals. The results are shown in Fig. 8.2.

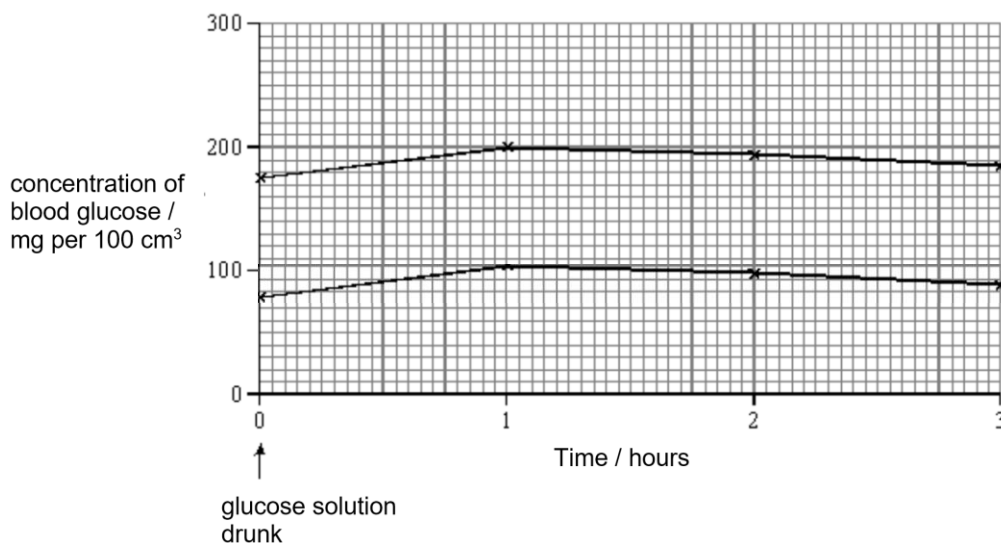


Fig. 8.2

- (i) Suggest a reason why the concentration of glucose decreased after 1 hour even though this man's blood contained no insulin.

..... [1]

1. glucose is used as respiratory substrate + in glycolysis/aerobic respiration/cell metabolism ; (must qualify how glucose is used)
2. glucose enters cells / converted to glycogen in cells;
3. glucose is excreted / in urine

- (ii) The investigation was repeated on a man who did not have diabetes. The concentration of glucose in his blood before drinking the glucose solution was 80 mg per 100 cm<sup>3</sup>.

Sketch a curve on Fig. 8.2 to show the results you would expect. [1]

1. Line **MUST** start and end 80 mg  
+  
line from 80 mg, increasing but keeping below line for diabetic, dropping to 80 mg; (line must stabilise at, or fluctuate around 80 mg)  
A! fluctuate in between / shape as Fig. 8.1
2. R: line touching original curve

[Total: 7]

- 9 The orca, *Orcinus orca*, has the largest distribution of all aquatic mammals and is found in nearly all seas and oceans. Orca are social mammals that usually live in groups. These groups can vary in size.

Fig. 9.1 shows an orca.



Fig. 9.1

There are a number of distinct types of orca. These distinct types of orca are classified as members of the same species. However, there is evidence that sympatric speciation is occurring.

- (a) (i) There are two distinct types of orca in the Northeast Atlantic Ocean: Type 1 and Type 2. Type 1 orca feed mainly on fish. Type 2 orca feed mainly on aquatic mammals, such as seals.

Fig. 9.2 shows the locations in the Northeast Atlantic Ocean where Type 1 orca and Type 2 orca have been observed. Orca do **not** occur only in these areas and some groups of orca travel great distances.

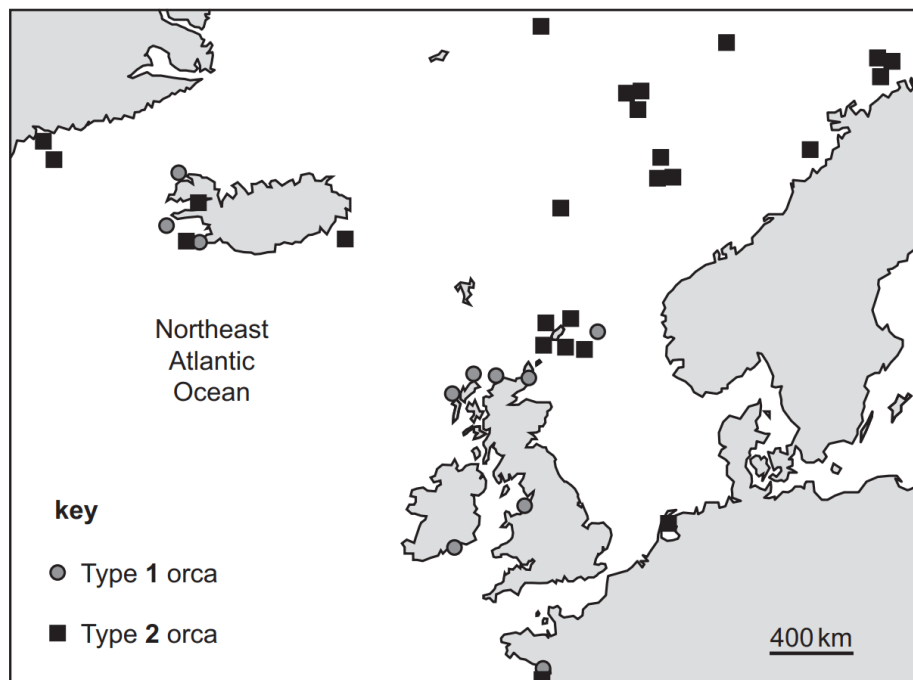


Fig. 9.2

With reference to Fig. 9.2, explain why the type of speciation that is occurring in the orca is described as sympatric speciation.

..... [1]

1. **There is no geographical isolation/separation between the types/subpopulations of orca ;**  
**OR**  
**the types/subpopulations of orca are found in the same geographical area ;**

- (ii) Suggest examples of behavioural separation that would contribute to sympatric speciation of Type 1 orca and Type 2 orca.

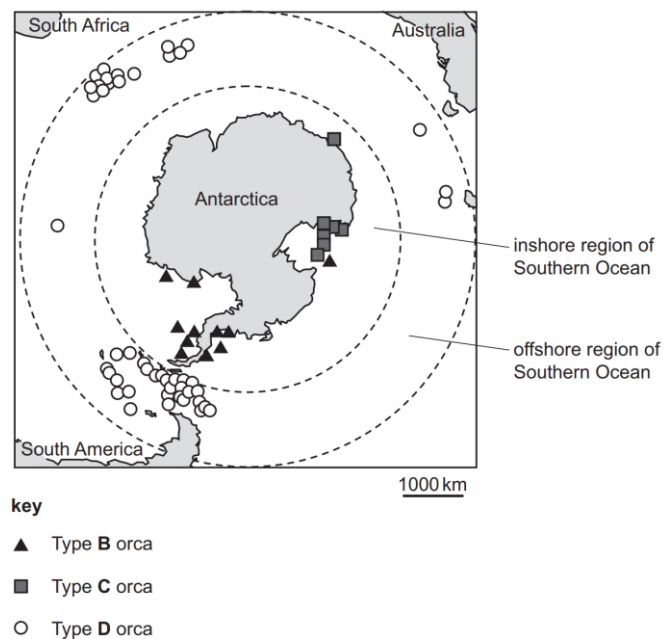
..... [2]

1. differences in, courtship / mating ; e.g. mating calls / mating rituals / time of year
2. different group sizes ;  
**A! description (e.g. groups vs solitary)**
3. different, hunting / feeding / diets food preference;

- (b) In the Southern Ocean, which surrounds Antarctica, there are three distinct types of orca: Type **B**, Type **C** and Type **D**.

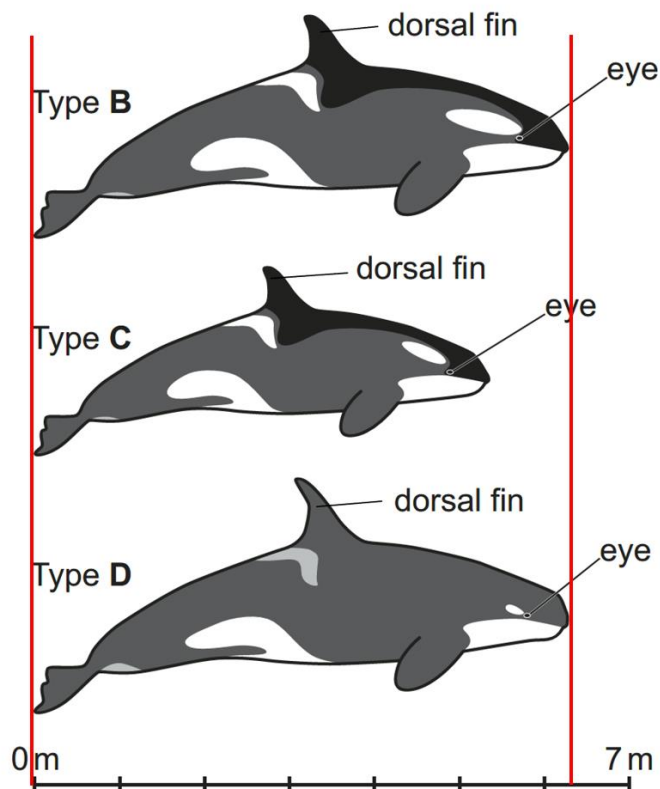
Fig. 9.3 shows the locations around Antarctica where Type **B** orca, Type **C** orca and Type **D** orca have been observed.

- Type **B** orca and Type **C** orca are mainly seen near the coastline of Antarctica (inshore).
- Type **D** orca are mainly seen in the Southern Ocean further away from the coastline of Antarctica (offshore)



**Fig. 9.3**

There are phenotypic differences between the different types of orca. Fig. 9.4 shows a diagram of a Type **B** orca, a Type **C** orca and a Type **D** orca.



**Fig. 9.4**

- (i) With reference to Fig. 9.4, state two ways in which the Type **D** orca is different from both the Type **B** orca **and** the Type **C** orca.

..... [2]

1. Absence of black patch on, top of body / back for Type D orca but presence of black patch on, top of body / back for Type B orca and the Type C orca ;
2. smaller white patch/eyepatch/spot for Type D orca but larger white patch/eyepatch/spot for Type B orca and the Type C orca ;
3. presence of grey patch just behind dorsal fin for Type D orca but presence of white patch just behind dorsal fin for Type B orca and the Type C orca ;
4. taller/sharper dorsal fin for Type D orca but shorter/curved dorsal fin for Type B orca and the Type C orca ;
5. larger grey/pale patch on underside near tail for Type D orca but smaller grey/pale patch on underside near tail for Type B orca and the Type C orca;

- (ii) Phenotypic differences between Type **D** orca and the other types of orca shown in Fig. 9.4 could have resulted from the process of genetic drift.

Suggest how genetic drift could result in phenotypic differences between Type **D** orca and the other types of orca shown in Fig. 9.4.

..... [4]

1. **Founder effect** occurs ;
2. Some members of an ancestral orca population moved/migrated to the away from coastline/offshore region of the Southern Ocean to form sub-populations ; sA! other parts of the ocean
3. When small numbers of orcas colonise the offshore region of the Southern Ocean, **genetic drift** may occur and there is a **smaller gene pool** / **low genetic diversity** ;
4. The sub-populations were exposed to **different environments** and were thus subjected to **different selection pressures** e.g. food availability / temperature ;
5. Since there was **variation within the sub-populations**, **individuals with favourable characteristics were at a selective advantage (or vice versa)** and **evolutionary changes/change in allele frequency** occurred **independently** in each subpopulation ;

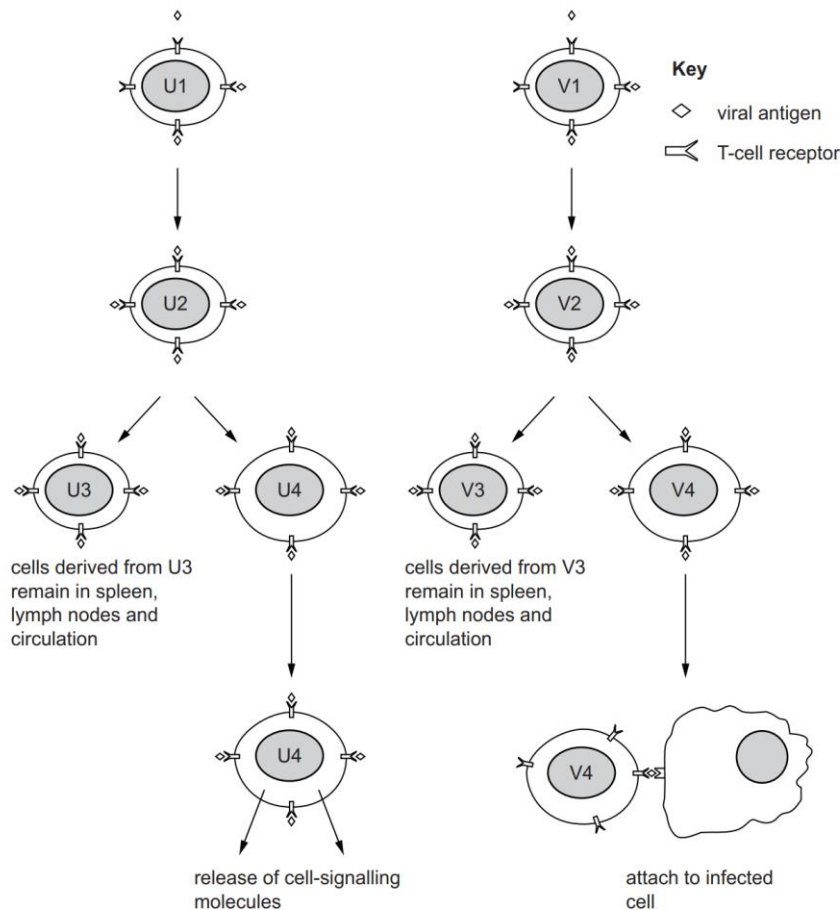
[Total: 9]



**10** T-lymphocytes are produced in bone marrow and mature in the thymus gland.

When mature, T-lymphocytes leave the thymus gland to travel throughout the body. They remain inactive inside organs, such as the spleen and lymph nodes, until activated by the presence of antigens.

Fig. 10.1 shows what happens to two inactive T-lymphocytes, U1 and V1, in the presence of an antigen from a virus.



**Fig. 10.1**

- (a) (i) U4 and V4 are different types of active T-lymphocyte. State the names given to these types of T-lymphocyte.

**U4 : Helper T-lymphocyte** .....

**V4 : Cytotoxic T-lymphocyte** .....

[2]

- (ii) Describe the roles of cells U4 and V4 in a primary immune response.

..... [3]

(max 2) Helper T lymphocytes secrete cytokines which

1. activate B lymphocytes to proliferate / undergo clonal expansion and differentiate into plasma cells and memory B lymphocytes.
2. stimulate CD8<sup>+</sup> T lymphocytes to proliferate / undergo clonal expansion and differentiate into cytotoxic T lymphocytes.
3. promote the recruitment of more monocytes, macrophages and helper T lymphocytes from blood to area of damage.

4. Cytotoxic T lymphocytes kill virally infected cells ;

- (b) Polio is a highly infectious viral disease. The virus infects the nervous system of humans. The disease can cause total paralysis within hours and can be fatal.

The Global Polio Eradication Initiative (GPEI) was started in 1988 by the World Health Organization. In 2022, polio had been successfully eradicated from most of the world. However, cases of the disease have been recorded in some countries.

Explain one step that must be taken by health authorities during a vaccination programme if an infectious disease, such as polio, is to be eradicated from the whole world.

..... [1]

1. Mass vaccination – Each country to run their own mass vaccination campaigns to vaccinate, a large proportion / >90%, of the population and eradicate the disease within their own borders to achieve herd immunity ;
2. Mandatory / compulsory vaccination – Governments may enforce laws that require individuals to be vaccinated, especially in high-risk populations/during outbreaks, to eliminate the disease/prevent it from re-emerging ;
3. Free vaccination to allow even poor people to access vaccine – Vaccines should be provided especially in low-income communities/developing countries, to ensure, that cost does not become a barrier/ all individuals, regardless of socioeconomic status, can be protected ;
4. Consistent high vaccination rates across all countries – To prevent reintroduction and outbreaks of the diseases ;

[Total: 6]

- 11** Climate change has altered global temperature and rainfall patterns, leading to phenological shifts — changes in the timing of biological events like flowering, migration, or hatching.

*Gentiana algida* is a high-altitude alpine wildflower in the Rocky Mountains, dependent on the bumblebee *Bombus sylvicola* for pollination. As global warming advances spring, flowering has shifted earlier, but insect emergence may lag, causing phenological mismatch.

Table 11.1 shows the time of first flowering and bee emergence from 1985 to 2020.

**Table 11.1**

year	first flowering ( <i>G. algida</i> )	bee emergence ( <i>B. sylvicola</i> )
1985	Day 178	Day 176
1995	Day 172	Day 174
2005	Day 166	Day 171
2015	Day 163	Day 170
2020	Day 162	Day 169

- (a)** With reference to Table 11.1, describe the changes shown from 1985 to 2020.

..... [2]

1. From 1985 to 2020, the day of first flowering for *G. algida* has shifted earlier from Day 178 to Day 162(, advanced by 16 days) ;
2. From 1985 to 2020, the day of bee emergence for *B. sylvicola* has shifted earlier from Day 176 to Day 169(, advanced by 7 days) ;

- (b)** Explain how the synchrony between *G. algida* and *B. sylvicola* has been affected to lead to potential ecological consequences for the alpine wildflowers.

..... [3]

1. *G. algida* is now flowering significantly earlier than the pollinator/bee emerges, earlier by 7 days ;
2. This reduces overlap between flowering and pollinator activity, (causing phenological mismatch) ;
3. If pollinators are absent during peak flowering, pollination success may decline;
4. This can reduce plant reproduction, threatening population stability of alpine wildflowers and potentially disrupting food chains ; (idea marking)

[Total: 5]