RIVER VALLEY HIGH SCHOOL
YEAR 6
PRELIMINARY EXAMINATION

CANDIDATE NAME											
CENTRE NUMBER	S					CLASS		INDEX NUMBER				

H2 BIOLOGY **9744/02**

Paper 2 Structured Questions **10 Sep 2018**

2 hours

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, index number 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.
DO **NOT** WRITE IN ANY BARCODES.

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.

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

For Examiner's Use	
1	/ 6
2	/ 11
3	/12
4	/ 8
5	/ 12
6	/ 10
7	/ 10
8	/ 11
9	/ 10
10	/5
11	/5
Total	/ 100

This document consists of **24** printed pages.

Answer **all** questions.

1 Fig.1.1 shows a cell undergoing telophase and process **X** simultaneously.

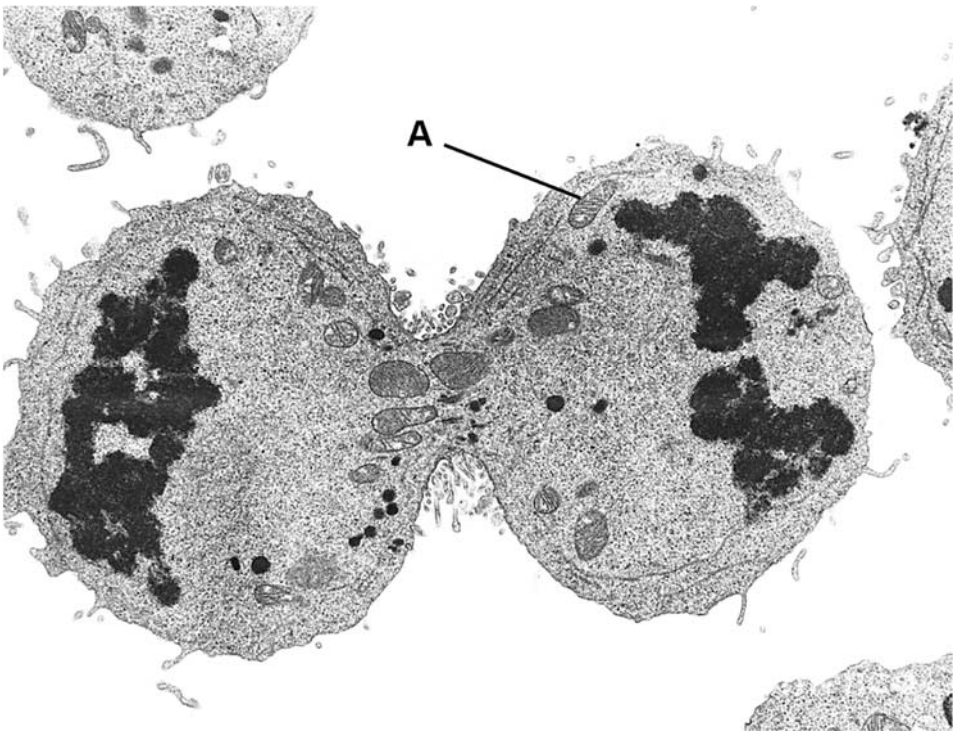


Fig. 1.1

Source: David M. Phillips, 2014

(a) Name structure **A**. [1]

mitochondrion

(b) Name process **X** and explain how it supports the cell theory. [2]

1. **Cytokinesis**
2. **The process shows that all cells come from pre-existing cells**

(c) Outline the role of **A** and explain its significance to process **X**. [3]

1. **(Site of) ATP synthesis;**
2. **during aerobic respiration**
3. **Provide energy**
4. **to form contractile ring of filaments**
5. **to form cleavage furrow**
6. **so as to separate the cell (into two)**

[Total: 6]

2 **(a)** Explain how the structure of fatty acids allow triglycerides to be a good store of energy. [2]

Fatty acids makes triglycerides

1. **(S) non-polar/uncharged/large/long hydrocarbon chain**
2. **(F) can be stored (in large amounts) without having any significant effect on the water potential of a cell**
3. **(S) have large number of hydrogen atoms**
4. **(F) store large amounts of energy**

Fig. 2.1 shows the structure of a lipoprotein. Lipoproteins transport fats from the liver to other tissues via the bloodstream. The proteins of lipoproteins play an important role in the deposition of fats to the correct tissue.

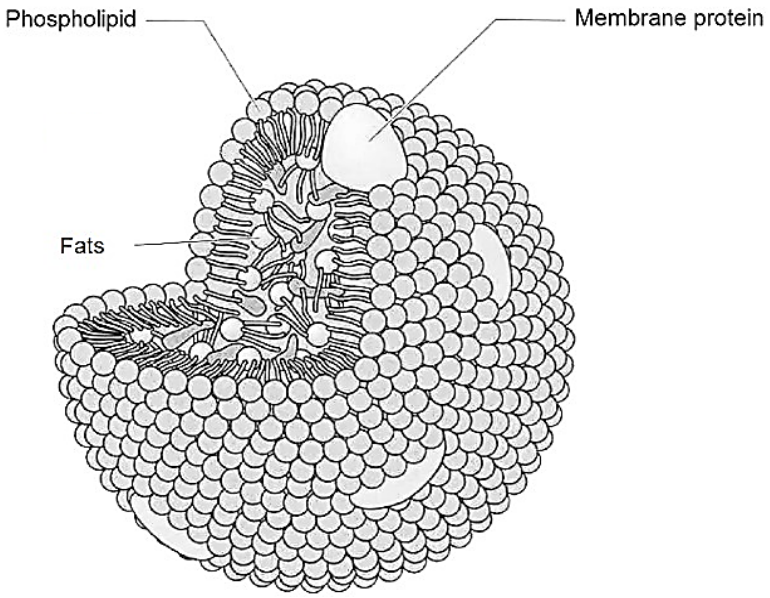


Fig. 2.1

(b) Describe how lipoproteins allow for the transport of fats from the liver to a specific tissue via blood. [4]

1. **Phospholipid molecules form a single layer**
2. **Non polar / hydrophobic hydrocarbon tail interact with (non polar / hydrophobic) fats**
3. **Polar / hydrophilic phosphate head interact with the (aqueous) blood**
4. **Membrane protein binds to cell of target tissue**
5. **via complementary shape**

Fig. 2.2 shows a protein embedded in a phospholipid bilayer.

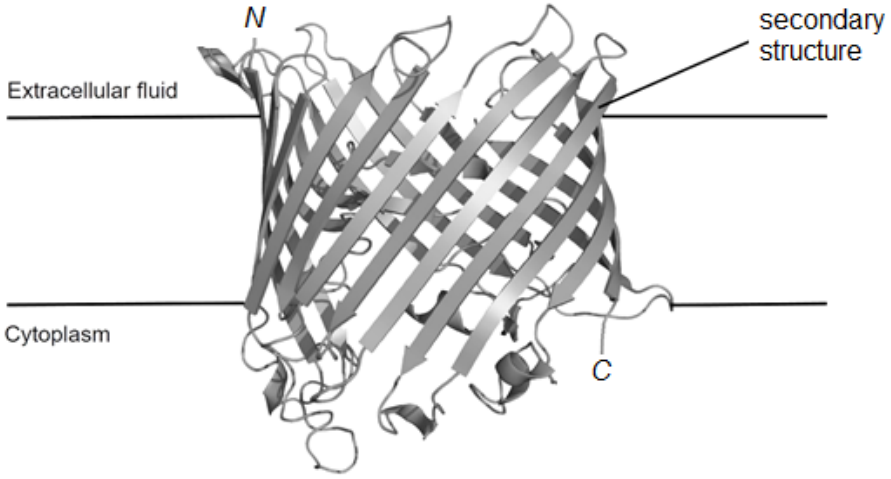


Fig. 2.2

Source: Adapted from RCSB Protein Data Bank

(c) With reference to Fig. 2.2,

(i) name the secondary structure and describe the bonding involved, and [3]

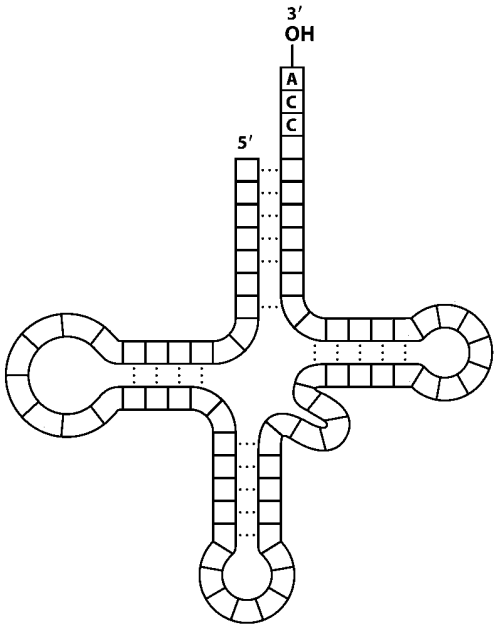
1. **β-pleated sheet**
2. **held in place by hydrogen bonds**
3. **between (O atom of) C=O and (H atom of) N-H groups**
4. **at regular intervals**
5. **of polypeptide chain <u>parallel</u> to each other**

(ii) describe how the structure of haemoglobin differs from that of the protein in Fig. 2.2. [2]

	Haemoglobin	Protein in Fig 2.2
Level of protein structure	Quaternary	Tertiary
Secondary structure	Largely α-helices	Largely β-pleated
Amino acids arrangement	Hydrophilic amino acids on the surface of protein.	Both hydrophobic and hydrophilic amino acids on the surface of protein
Haem group	Presence of haem group	No haem group

[Total: 11]

3 Fig. 3.1 shows the structure of a tRNA.



Source: Biochem, Seventh edition, 2012

Fig. 3.1

(a) Describe how the structure of tRNA allows for its role in translation. [4]

1. **3' CCA end of tRNA**
2. **Serve as attachment site of a specific amino acid**
3. **Contains anticodon at one end**
4. **Specifies the identity of amino acid attached to (the 3' CCA end of the) tRNA**
5. **(Sequence of bases of) anticodon able to complementary base pair**
6. **With the corresponding mRNA codon**
7. **(T) loop**
8. **binds to rRNA of ribosome (via base-pairing)**
9. **(D) loop**
10. **for binding to amino-acyl tRNA synthetase (that attaches tRNA with its specific amino acid)**
11. **tRNA folds into a clover-leaf shape (2-D structure)/L-shape (3-D structure)**
12. **to reduce steric hindrance**

Synthetic RNA, which binds to bacterial mRNA, could interfere with translation. Fig. 3.2 shows the sequences of a bacterial mRNA and two different synthetic RNA.

Bacterial mRNA

5'- GUCAACCAUGCCAAUUAUCACGGACAUUCAUGGUAGGCCUUAGUAGACAACUG-3'

Synthetic RNA 1

5'- CAGUUGUCUA-3'

Synthetic RNA 2

5'- CUAGGUUGAC-3'

Fig. 3.2

(b) With reference to Fig. 3.2, suggest how synthetic RNA binds to mRNA. [1]

Synthetic RNA and mRNA

1. **forms hydrogen bonds**
2. **between complementary base-pair**

The effectiveness of synthetic RNA 1 and 2 are investigated by introducing them to separate bacterial cultures and incubating for 24 hours. The results of the investigation is shown in Fig. 3.3.

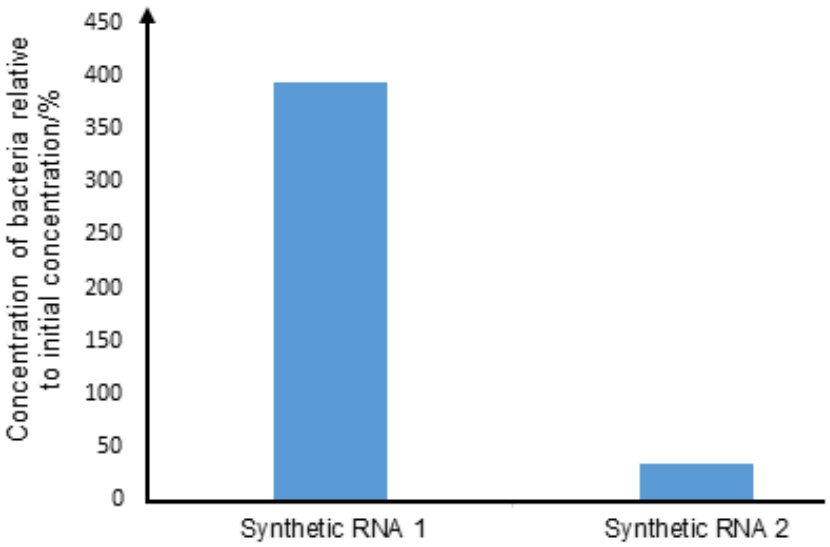


Fig. 3.3

(c) With reference to Fig. 3.2 and Fig. 3.3, explain the results of the investigation. [6]

1. **Synthetic RNA 1 will bind to 3' end of bacterial mRNA**
2. **Ribosome can still bind to 5' end of mRNA**
3. **Stabilises mRNA**
4. **Polypeptide for growth synthesised**
5. **for cell to divide / undergo binary fission**
6. **Synthetic RNA 2 will bind to 5' end of bacterial mRNA**
7. **to form double stranded RNA**
8. **Block binding of ribosome to (5' end) mRNA (for translation)/block AUG**
9. **Proteins for normal cellular functions not produced**
10. **killing bacteria**

(d) Suggest a limitation of using synthetic RNA as an oral antibiotic for bacterial infections in humans. [1]

1. **Synthetic RNA broken down during digestion**
2. **Kills good bacteria in gut**
3. **Enters human cells and inhibit translation**

[Total: 12]

4 *Morbillivirus*, which causes measles, has a structure as shown in Fig. 4.1.

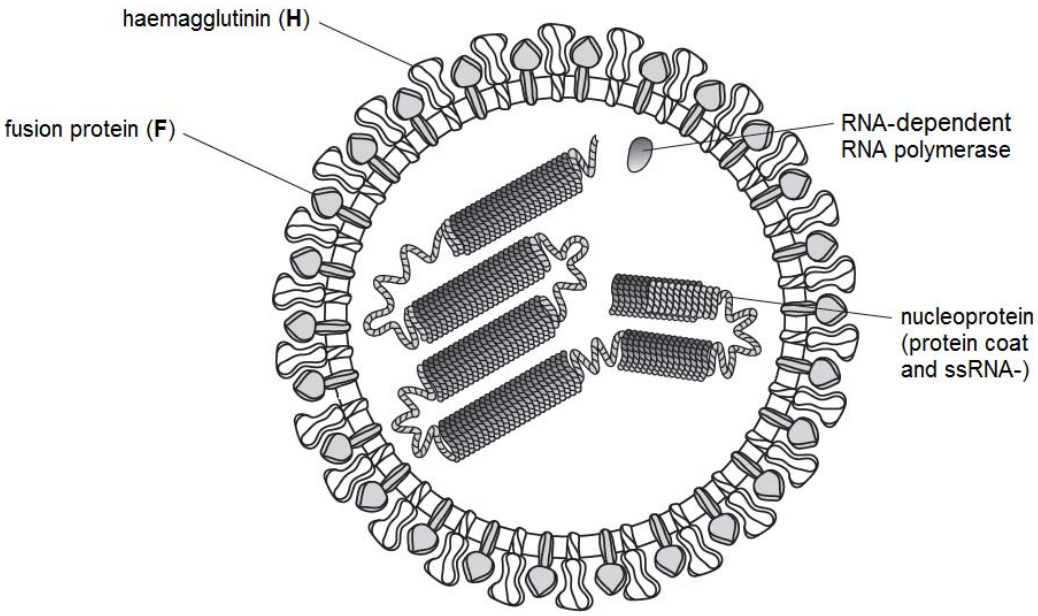


Fig. 4.1

Source: UCLES, 2016

Morbillivirus only infects cells that have a membrane glycoprotein known as signaling lymphocyte activation protein (SLAM). When *Morbillivirus* infects a cell, **H** acts before **F**.

(a) State how the structure of *Morbillivirus* envelope is similar to that of human immunodeficiency virus (HIV). [2]

1. **Both have glycoproteins embedded in viral envelope**
2. **Both viral envelopes are made up of phospholipid bilayer**

(b) *Morbillivirus* and HIV utilise a similar mechanism to enter host cells.

Describe how *Morbillivirus* enters a host cell. [3]

1. **H binds to SLAM on host cell (surface membrane)**
2. **causing H to change its three-dimensional conformation**
3. **F triggers fusion**
4. **of viral envelope with host cell surface membrane**
5. **releasing nucleoprotein and viral polymerase**
6. **into host cell's cytoplasm**

(c) Describe how the *Morbillivirus* genome enables the *Morbillivirus* reproductive cycle. [3]

1. **Serves as a template**
2. **for viral RNA polymerase**
3. **to synthesise (complementary) ssRNA+**
4. **for synthesis of F / H / protein coat / viral polymerase**
5. **via translation / by host ribosomes**
6. **for synthesis of viral genome**
7. **via transcription / by viral RNA polymerase**

[Total: 8]

5 The *ara* operon is an inducible operon involved in the breakdown of a pentose sugar, arabinose. The organisation of the *ara* operon differs from that of a *lac* operon. Fig. 5.1 shows the organisation of the *ara* operon in a bacterium.

The *ara* operon encodes three structural genes (*araB*, *araA* and *araD*) and is regulated by the regulatory gene *araC*. The arrows in Fig 5.1 represent the directions of transcription of the respective genes.

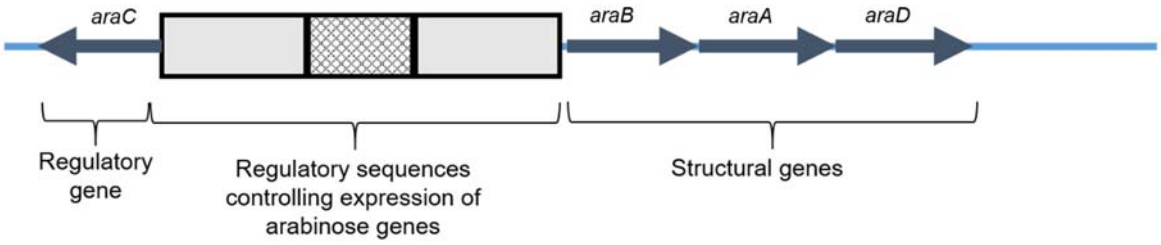


Fig. 5.1

(a) Using the *ara* operon, explain what is meant by the term operon. [2]

1. **Gene involved in the metabolism of arabinose (*araB*, *araA* and *araD*)**
2. **Clustered/grouped together**
3. **Under the control of the same promoter**
4. **and operator**

(b) Suggest why the transcription of the structural genes (*araB*, *araA* and *araD*) proceeds in a different direction from the regulatory gene (*araC)*. [2]

Templates of structural genes and regulatory gene are

1. **found on different strands**
2. **antiparallel**
3. **read from 3' to 5' direction**

Fig. 5.2 shows how araC protein interact with arabinose and the regulatory sequences to regulate the expression of the structural genes of the *ara* operon.

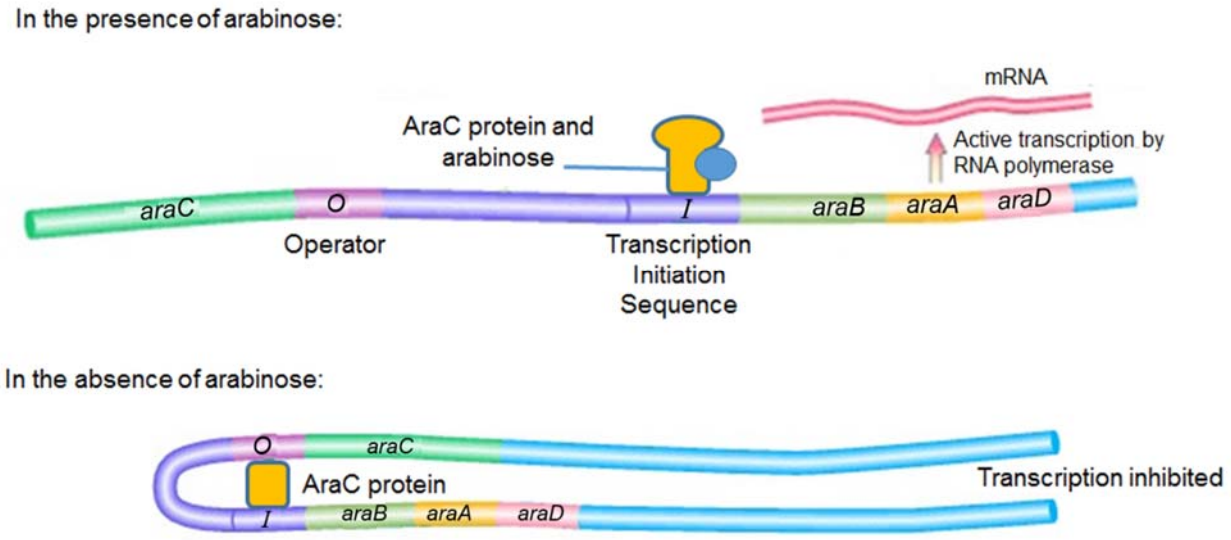


Fig. 5.2

(c) With reference to Fig. 5.2, describe how transcription of the *ara* operon is inhibited. [3]

1. **No arabinose bound to araC protein**
2. **araC is in active conformation**
3. **araC protein binds to transcription initiation sequence**
4. **DNA bends**
5. **resulting in araC protein binding to the operator**
6. **RNA polymerase cannot bind**
7. **to promoter**
8. **ara operon is turned off**

Plasmids can be transferred from one bacterium to another via the process shown in Fig. 5.3.

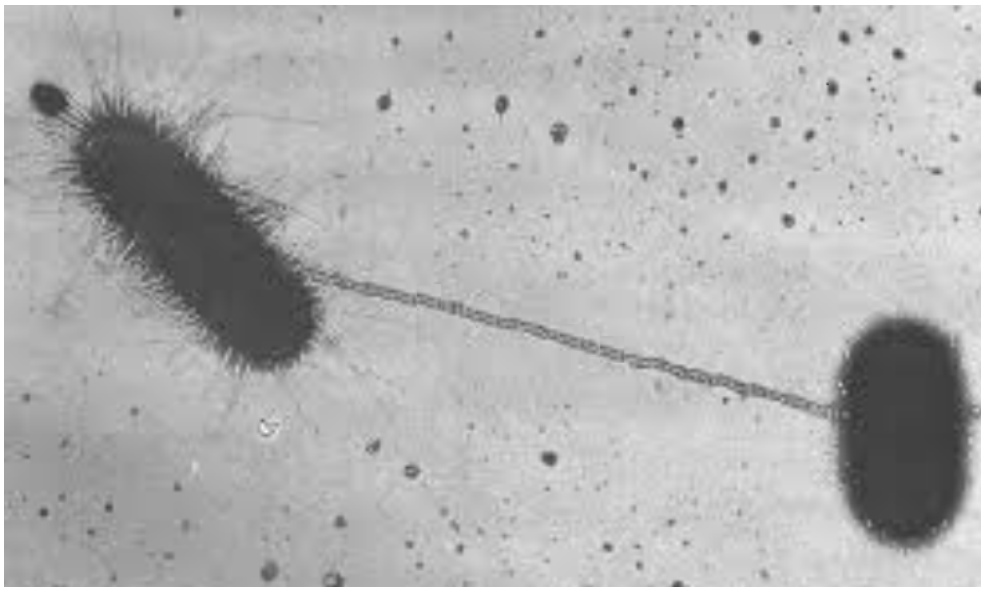


Fig. 5.3

Source: Appl. Environ. Microbiol. October 2016 vol. 82 no. 19 5940-5950

(d) With reference to Fig. 5.3,

(i) state the process, and [1]

Conjugation

(ii) describe the main features of the process. [4]

1. **donor F^+ cell synthesises a sex pilus**
2. **and makes direct contact with a recipient cell**
3. **forming a temporary mating bridge between the two cells**
4. **single stranded nick on Fertility plasmid**
5. **followed by transfer of a single strand (of F plasmid from donor cell to recipient cell)**
6. **DNA replication occur in both cells**
7. **F plasmid circularise in both cells**
8. **Both cells are now F^+ cell**

[Total: 12]

6 A germline cell is undergoing meiosis to produce gametes. Fig. 6.1 shows a stage in this process.

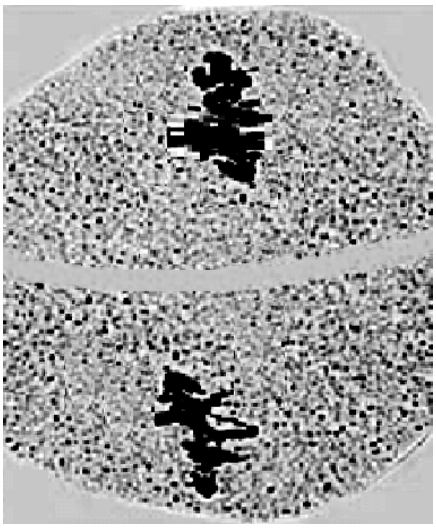


Fig. 6.1

(a) (i) Identify the stage of meiosis shown in Fig. 6.1 [1]

Metaphase II

(ii) Explain you answer in **(a)(i)**. [2]

1. **Cytoplasm / chromosomes has separated into two**
2. **Chromosomes are gathered at the centre of each cell**

(b) Describe the role of centrioles in the next stage of meiosis. [3]

1. **Centrioles organise spindle fibres**
2. **that shortens**
3. **to separate sister chromatids**
4. **to opposite poles of the cell**
5. **Centrioles move apart**
6. **as (interpolar) microtubules lengthen**
7. **to elongate cell**

Fig. 6.2 shows an error in anaphase II.

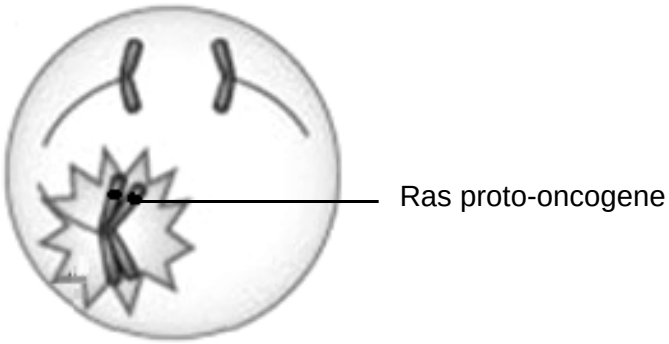


Fig. 6.2

(c) Explain why this error may increase the risk of cancer in a newborn. [3]

1. **Non-disjunction (in meiosis II)**
2. **results in <u>two</u> copies of (Ras) proto-oncogene in gamete**
3. **and <u>three</u> copies of (Ras) proto-oncogene in zygote (after fertilisation)**
4. **resulting in excessive Ras proteins**
5. **This causes overstimulation of cell cycle**
6. **resulting in uncontrolled cell proliferation**

(d) Kinase inhibitors are often used to target such cancers associated with Ras proto-oncogenes by interrupting their downstream signalling.

Suggest how kinase inhibitors can interrupt Ras signalling pathway. [1]

Prevent activation of <u>phosphorylation cascade</u>, thus prevent signal transduction

[Total: 10]

7 **(a)** Distinguish between polygenic inheritance and multiple allele inheritance. [3]

	Polygenic inheritance	Multiple alleles
Number of genes/gene loci	Involves two or more gene loci	Involves only one gene locus
Number of alleles present at each gene locus in a population	May not have more than two alleles present	More than two alleles present
Variation	Results in continuous variation	Results in discontinuous variation
Additive effect of genes	Additive effect of multiple genes at involved gene loci.	No additive effect of genes only one gene locus is involved

In humans, an individual's blood group is a combination of the ABO system and the Rhesus (Rh) system. The ABO system divides blood into four types: A, B, AB and O. The Rh system divides blood type into negative (–) or positive (+). The genes for ABO blood type and Rh blood type are inherited independently.

As part of family planning, Claudia, with blood group O^- consulted a genetic counsellor who charted the inheritance of Rh blood type in the family, shown in Fig. 7.1.

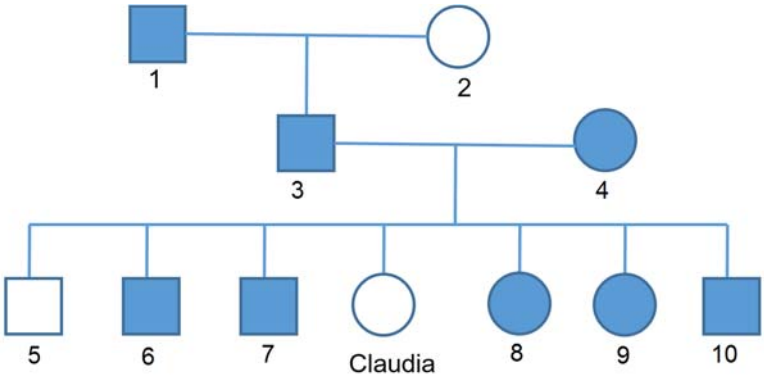


Fig. 7.1

(b) With reference to Fig. 7.1, explain why the two claims below are correct.

Claim 1: The Rh^+ phenotype is expressed in heterozygotes.

Claim 2: The Rh gene is not found on sex chromosomes. [3]

Rh blood type is expressed in heterozygotes as

1. **Individual II-1 and II-2 are Rh^+ but have children who are Rh^-**
2. **Indicating that II-1 and II-2 are heterozygotes**
3. **II-1 and II-2 are Rh^+**

Rh blood type is found on the autosome as

Not found on X chromosome

4. **II-1 is a Rh^+ father but Claudia is Rh^-**
5. **II-1 is a Rh^+ male with Rh^+ father and Rh mother, II-1 inherited Rh^+ allele from father**

Not found on Y chromosome

6. **There are Rh^+ female (II-2 / III-5 / III-6)**
7. **II-1 is Rh^+ but has a Rh^- son (III-1)**

Claudia is married to a man whose blood group is AB^+. Their first child has blood group A^-. She is expecting a second child.

(c) Using the symbols $\mathbf{I^A}$, $\mathbf{I^B}$ and $\mathbf{I^O}$ to represent the alelles of the ABO blood type and the symbols $\mathbf{Rh^+}$ and $\mathbf{Rh^-}$ to represent the alleles of the Rh blood type, draw a genetic diagram to show all the possible phenotypes of her second child. [4]

1. **Parents genotype ($I^O I^O Rh^- Rh^-$ x $I^A I^B Rh^+ Rh^-$)**
2. **Parents gametes [($I^O Rh^-$) x ($I^A Rh^-$) ($I^A Rh^+$) ($I^B Rh^-$) ($I^B Rh^+$)**
3. **All possible genotype $I^A I^O Rh^- Rh^-$, $I^B I^O Rh^- Rh^-$, $I^A I^O Rh^+ Rh^-$, $I^B I^O Rh^+ Rh^-$**
4. **and correctly matched phenotype (A^-, B^-, A^+, B^+)**

[Total: 10]

8 Fig. 8.1 shows the absorption spectrum (——) of a photosynthetic pigment from a plant, and the rate of photosynthesis (- - -) of the same plant in different colours of light.

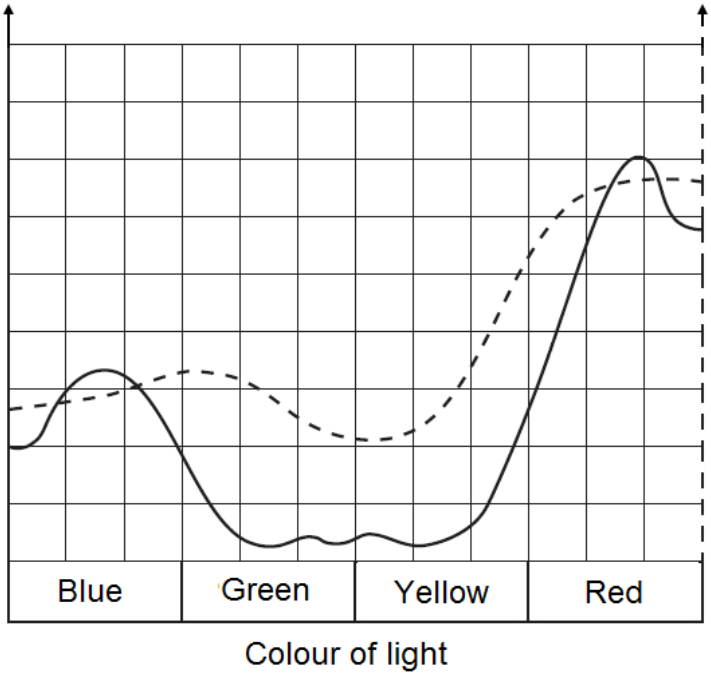


Fig. 8.1

(a) Explain what is meant by an absorption spectrum. [2]

An absorption spectrum

1. **Shows the amount of light absorbed**
2. **at each wavelength of light**
3. **by a particular pigment**

(b) State whether this plant contains more than one type of photosynthetic pigment. Explain you answer. [2]

1. **Yes**
2. **Relatively higher rate of photosynthesis despite low absorption in green and yellow light**

(c) Plants typically have several photosynthetic pigments, some of which function as accessory pigments.

Suggest the role of accessory pigments in photophosphorylation. [1]

Increase the range of wavelength / light in which plants can absorb photons

Facilitate transfer of energy from main photosynthetic pigment via resonance to special pair of chlorophyll a

In a separate experiment to study photophosphorylation in plants, chloroplasts are isolated, and the pH levels in various compartments are monitored.

The table below shows the results of this experiment.

Table 8.1

environmental condition	pH	
	stroma	thylakoid lumen
dark	7.2	6.8
light	8.8	5.2

(d) Describe and explain the changes in pH as environmental conditions change from dark to light. [6]

As environment condition change from dark to light

1. **pH in stroma increases from 7.2 to 8.8, while that in thylakoid lumen decreases from 6.8 to 5.2**

In the presence of light,

2. **photon excites a photosynthetic pigment**
3. **This causes electron displacement**
4. **from a special pair of chlorophyll a**
5. **Electron is then transferred down electron transport chain**
6. **Energy released**
7. **during sequential reduction and oxidation (of electron carriers)**
8. **is used to pump H^+**
9. **from stroma to thylakoid lumen**
10. **decrease H^+ concentration in stroma / increase H^+ concentration in thylakoid lumen**
11. **Photolysis of water contributes H^+ to thylakoid lumen**

[Total: 11]

9 Mudskippers are fish which have evolved to use their modified pectoral fins to move onto land to avoid being eaten by larger oceanic fish.

Fig. 9.1 shows a mudskipper. The arrow indicates the modified pectoral fin.

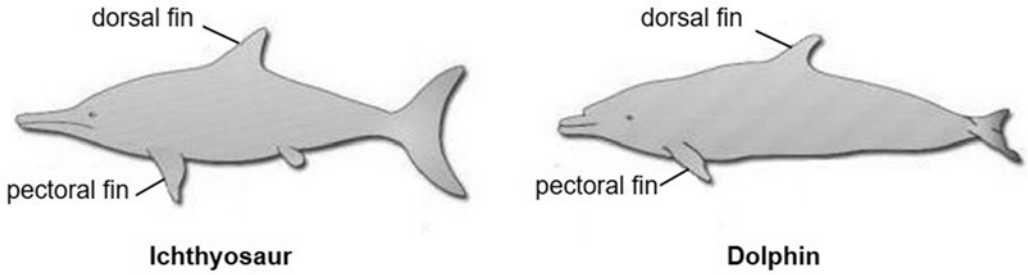
Fig. 9.1

Adapted from: http://www.mudskipper.it/ita/SpeciesPages/noveIT.html

(a) Explain how mudskippers evolved from their fully aquatic ancestors to have modified pectoral fins. [4]

1. **Mutation**
2. **leads to phenotypic variation in pectoral fins**
3. **Predation acts as a selection pressure**
4. **Natural selection takes place**
5. **individuals with modified pectoral fins survive and reproduce**
6. **pass down alleles coding for modified pectoral fins to offspring**
7. **over generations, there is an increase in allele frequency (coding for modified pectoral fins)**
8. **lack of gene flow (between populations of mudskippers and oceanic ancestor)**
9. **due to habitat/behavioural isolation**

Fig. 9.2 shows the body plan of Ichthyosaurs, which are extinct marine reptiles, and dolphins, which are mammals. Both types of animals can swim quickly to catch prey.



Ichthyosaur Dolphin

Fig. 9.2

(b) **(i)** State the type of evolution shown by Ichthyosaurs and dolphins. [1]

Convergent evolution

(ii) Explain your answer in **(b)(i)**. [2]

1. **Animals from different evolutionary branches / with no recent common ancestor**
2. **face similar selection pressures**
3. **lead to formation of analogous structures**
4. **such as fins / streamlined body**

There are more than 40 species of dolphins known to scientists. To determine the evolutionary relationships between the different species, scientists are gathering genomic data to construct a phylogenetic tree.

(c) Describe the advantages of using molecular methods in constructing a phylogenetic tree. [3]

1. **To assess phylogenetic relationships that cannot be measured by comparative anatomy**
2. **To compare species too closely related to display much divergence in morphology**
3. **To trace evolutionary relationships of species that are so different that there is little morphological homology**
4. **Each nucleotide/ amino acid position along a stretch of DNA/ polypeptide represents a point of comparison → multiple points of comparison**
5. **Each nucleotide/ amino acid are unambiguous/ objective**
6. **provides a quantitative tool for constructing cladograms**
7. **Molecular data are easily converted to quantitative data/ numerical form (amenable to mathematical and statistical analysis)**

[Total: 10]

10 **(a)** Describe how *Mycobacterium tuberculosis* is transmitted. [2]

1. **Inhalation of**
2. **airbone particles / droplet nuclei**
3. **that traverse nasal passage / respiratory tract to reach alveoli (of the lungs)**
4. **when infected person cough / sneeze / shout**

(b) **(i)** Penicillin is often used to treat bacterial infections due to its ability to interfere with bacterial cell wall synthesis.

Describe the mode of action of penicillin. [2]

1. **β-lactams ring of penicillin**
2. **binds to active sites**
3. **of penicillin binding proteins (in bacteria)**
4. **preventing cross-linking of bacterial cell wall**

(ii) Suggest why penicillin is ineffective against *M. tuberculosis*. [1]

Penicillin unable to reach *M. tuberculosis* in pulmonary cavities / due to granuloma barrier

[Total: 5]

11 Arctic foxes in Iceland hunt for prey such as lemmings, which are rodent-like animals. Due to global warming, there were milder and shorter winters from 2000 to 2006. This led to the melting of and collapse of snow burrows inhabited by the lemmings.

Fig. 11.1 shows the populations of arctic foxes and lemmings between 2000 and 2008.

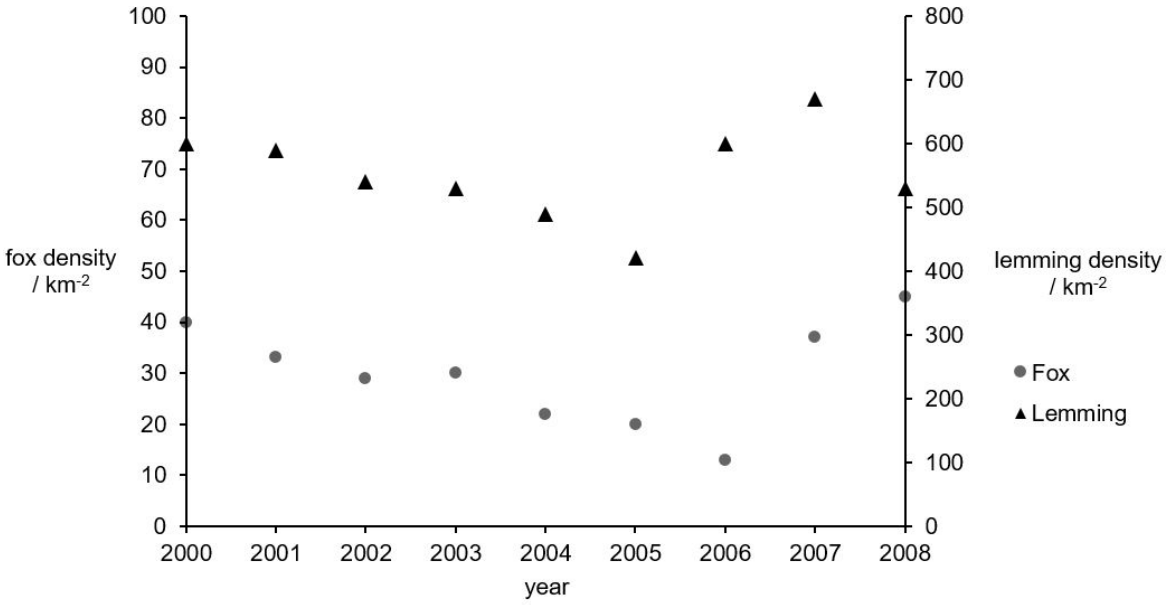


Fig. 11.1

(a) Explain how the melting of snow may lead to further warming of the island. [1]

1. **Due to the albedo effect / albedo of ground lower than snow**
2. **More solar radiation is absorbed by the ground / reflected into the atmosphere**

(b) With reference to Fig. 11.1,

(i) describe the change in fox density, [2]

1. **From 2000 to 2006, fox density decreased gradually from 40 km^{-2} to 13 km^{-2}**
2. **From 2006 to 2008, fox density increased sharply from 13 km^{-2} to 45 km^{-2}**

(ii) explain why the density of lemmings increased from 2005 to 2006, and [1]

1. **Fox density decreased**
2. **fewer predators**

(iii) suggest why arctic fox population density would not increase indefinitely beyond 2008. [1]

1. **decreased food availability as lemming population density decreases further**

[Total: 5]