HWA CHONG INSTITUTION
JC2 Preliminary Examinations
Higher 2

CANDIDATE NAME		**CT GROUP**	**16S ___**
CENTRE NUMBER		**INDEX NUMBER**	

BIOLOGY

9744/02

Paper 2 Structured Questions

23 August 2017

No additional materials are required.

2 hours

INSTRUCTIONS TO CANDIDATES

There are **six** question booklets (**I** to **VI**) to this paper. Write your **name**, **CT group, Centre number** and **index number** in the spaces provided at the top of this cover page and on the lines provided at the top of the cover pages of Booklets **II**, **III**, **IV**, **V** and **VI**.

This paper contains **nine** structured questions. Answer **all** questions in the spaces provided on the question paper.

INFORMATION FOR CANDIDATES

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.

You are reminded of the need for good English and clear presentation in your answers.

For Examiners' Use	
1	**/ 12**
2	**/ 11**
3	**/ 9**
4	**/ 10**
5	**/ 14**
6	**/ 12**
7	**/ 10**
8	**/ 13**
9	**/ 9**
Total Mark	**/ 100**

This document consists of **28** printed pages and **8** blank pages.

BOOKLET I

QUESTION 1

The cell theory was developed in the 1830s. At the same time, it was proposed that living things arose spontaneously from non-living materials. This theory of "spontaneous generation" was later disproven, but the cell theory has stood the test of time to become widely accepted in the scientific community today.

(a) Outline the cell theory.

.....

.....

.....

..... [2]

Fig. 1.1 shows Louis Pasteur's famous swan neck flask experiment that disproved the spontaneous generation theory and supported the cell theory.

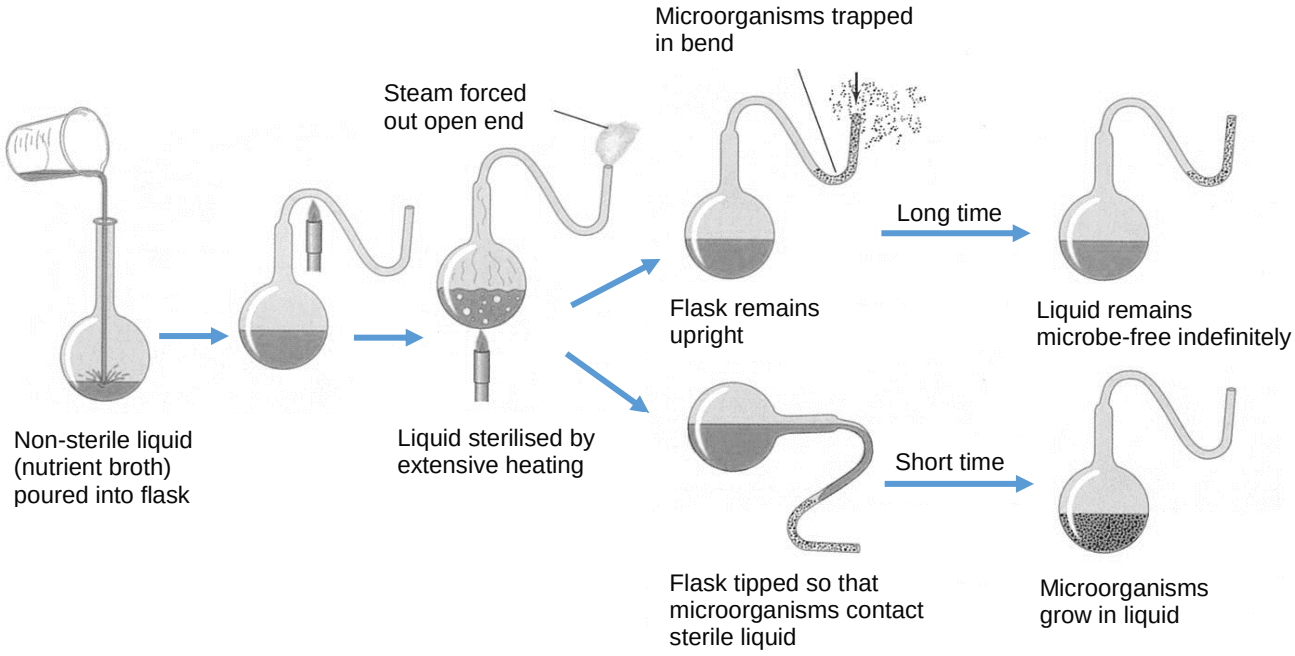


Fig. 1.1

(b)(i) With reference to Fig. 1.1, explain how Pasteur's experiment supports the cell theory.

.....

.....

.....

..... [2]

(ii) Suggest a reason for the universal acceptance of the cell theory in our world today.

.....

..... [1]

Pseudomonas syringae is a pathogen that can enter plants through wounds and cause disease in a wide variety of plants. Fig. 1.2 is an electronmicrograph of a cell belonging to the same domain as *P. syringae*.

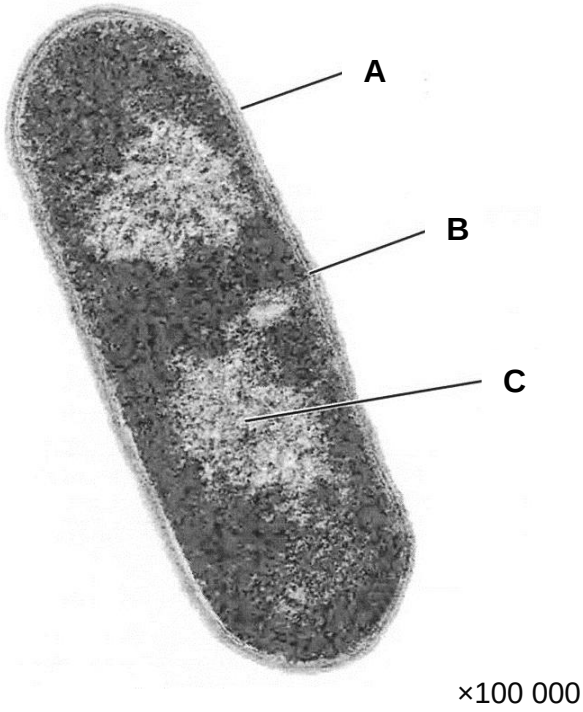


Fig. 1.2

(c)(i) State the name and chemical composition of the structures labelled **A** to **C**.

A .....

B .....

C ..... [3]

(ii) *P. syringae* colonises a host plant and obtains nutrients from the plant tissue. It can cause damage to the leaves of its host plant by secreting toxins and cell wall degrading enzymes, without causing harm to itself.

Explain why this is so.

.....

.....

.....

..... [2]

When two organisms live in close association with each other, the following are three different possible outcomes:

- parasitism occurs in the host-pathogen interaction between *P. syringae* and the host plant because the pathogen benefits while the host is damaged.
- mutualism occurs when both host and pathogen benefit.
- commensalism occurs when the pathogen benefits but the host neither gains nor loses.

Based on the endosymbiotic theory, mitochondria in eukaryotes originated from free-living oxygen-metabolising eubacteria that were engulfed by an ancestral eukaryotic cell, which was otherwise unable to use oxygen.

(d) State and explain which of the three types of interactions best describes the relationship between the ancestral eukaryotic cell and its endosymbiont.

.....

.....

.....

..... [2]

[Total: 12]

QUESTION 2

Fig. 2.1 is an electronmicrograph of a lymphocyte in the process of cell division during an immune response.

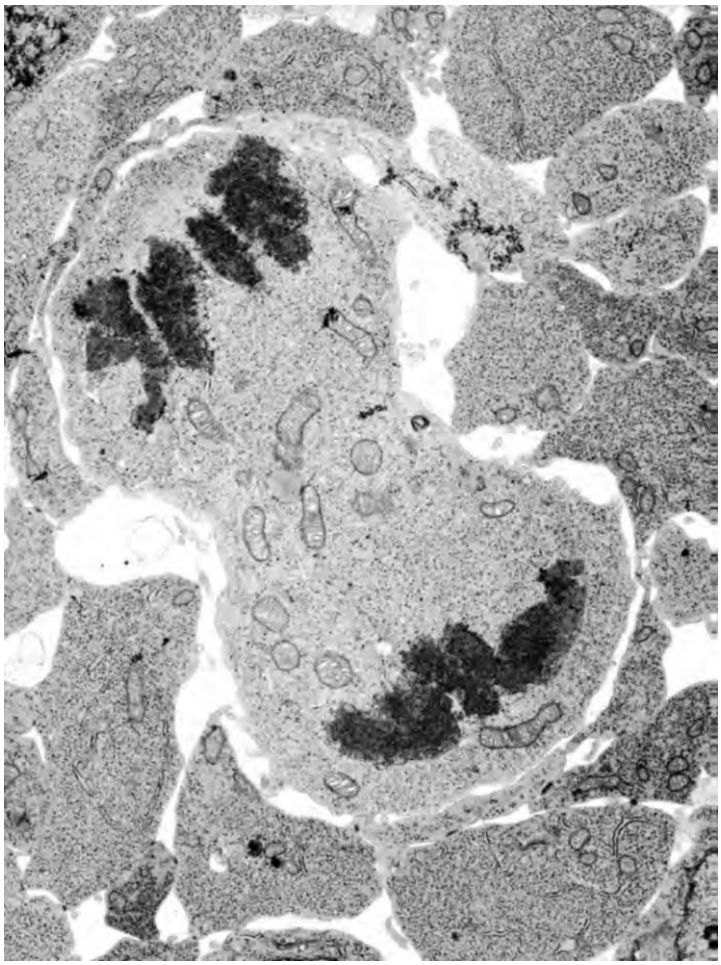


Fig. 2.1

(a) With reference to Fig. 2.1,

(i) name the stage of mitosis.

.....[1]

(ii) describe what is happening during this stage of mitosis.

.....

.....

.....

.....[2]

Stem cells from human bone marrow that are involved in blood cell formation are described as multipotent, rather than totipotent.

(b) Distinguish between multipotent cells and totipotent cells.

.....

.....

.....

..... [2]

Treatment of leukaemia using bone marrow transplants from donors with matching tissue types was first carried out in 1968. Treatment with adult stem cells extracted from the patient's bone marrow is a much more recent treatment. After removal of the stem cells, the remaining bone marrow cells and white blood cells in the patient, including the cancer cells, are killed. The stem cells are separated from the cancer cells in the extract. The remaining stem cells are returned to the patient's body. This procedure is still rarely used as it currently gives a greater risk of cancer in the future.

Several lines of research involving stem cells have shed some light on the causes of cancer. In some cases, the use of stem cells in treatment appears to increase the risk of cancer.

(c) Suggest why there might be a connection between the use of stem cells in treatment and cancer.

.....

.....

.....

.....

.....

..... [3]

In another line of research, scientists have discovered the formation of cybrids (cytoplasmic hybrid cells). Stem cells may be harvested from cybrids for research or medical purposes.

Fig. 2.2 shows the steps in the production of a cybrid. The DNA of such a cybrid is 99.6% human.

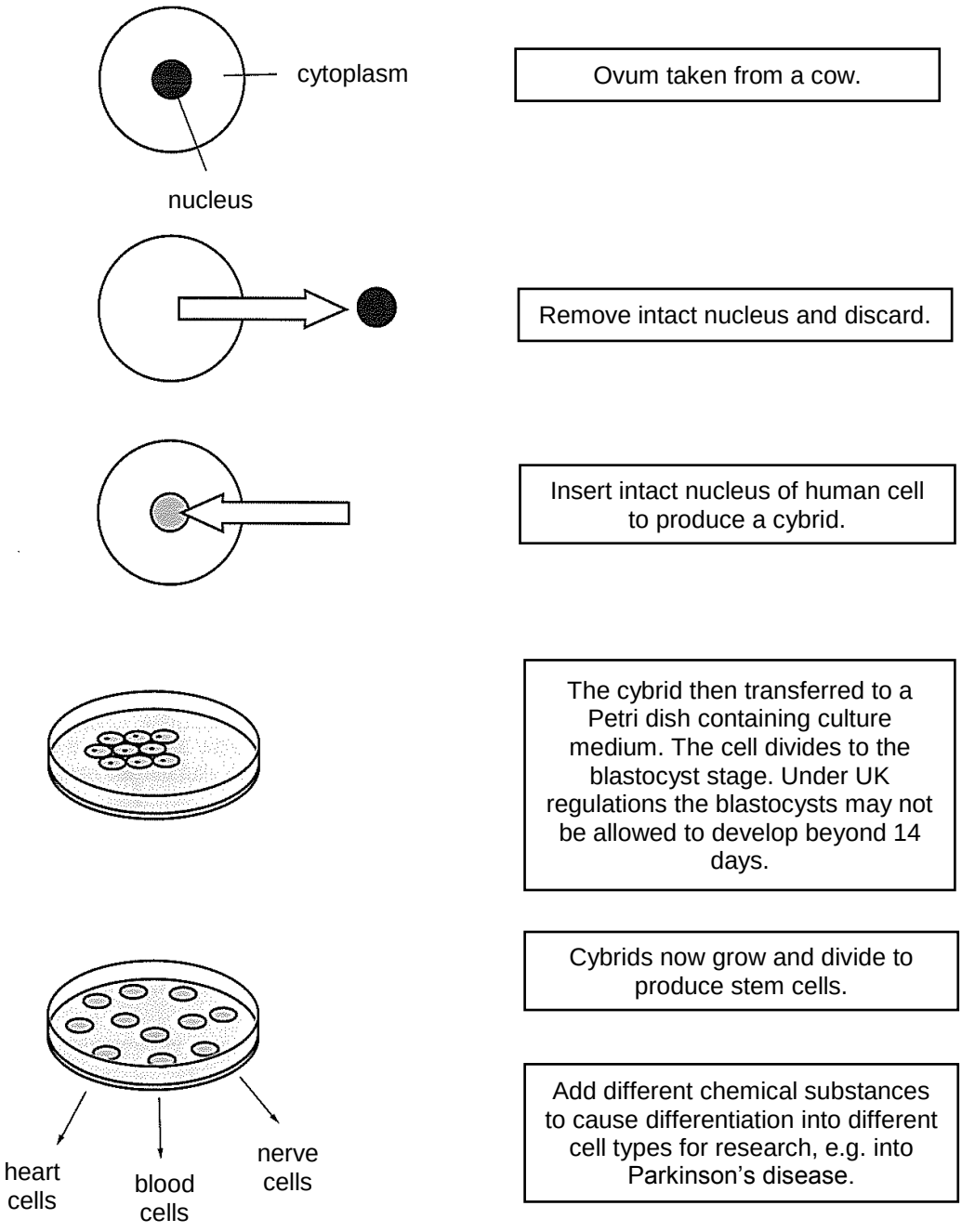


Fig. 2.2

(d) When the Human Fertilisation and Embryology Bill was considered by the UK Parliament in 2008, some people argued that it is unethical to allow the production of cybrids.

State whether you agree **or** disagree that this is unethical **and** explain why you reached this decision.

.....

.....

.....

.....

..... [3]

[Total: 11]

Candidate Name: _____ CT Group: 16S7 ____

BOOKLET II

BLANK PAGE

QUESTION 3

G-protein linked receptors (GPLRs) play a critical role in glucose homeostasis in mammals. Fig. 3.1 shows a GPLR on a section of the cell membrane of a liver cell.

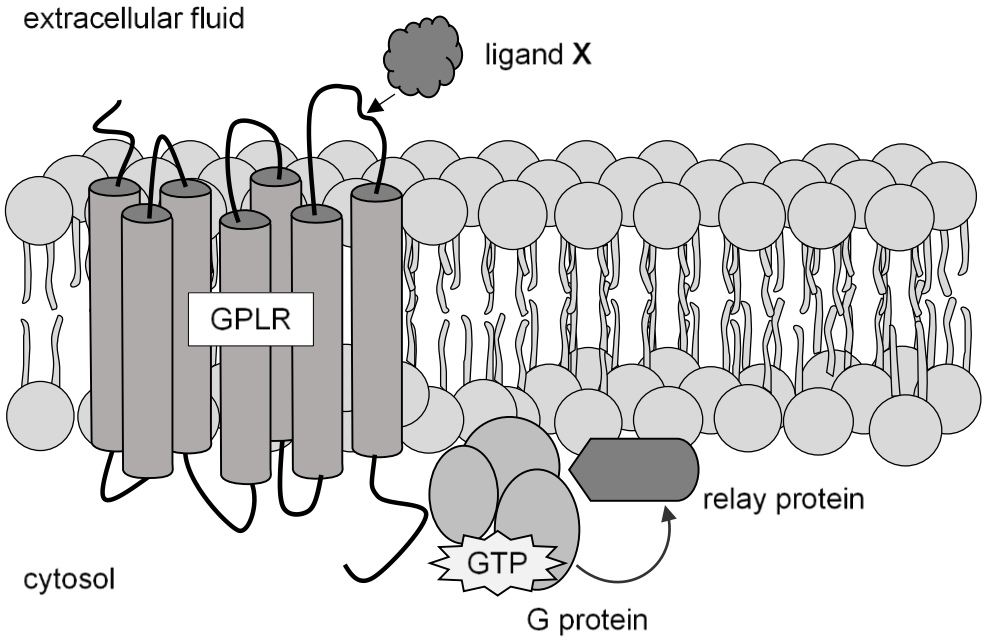


Fig. 3.1

(a)(i) State the identity of ligand **X**.

.....[1]

(ii) Explain why ligand **X** cannot diffuse directly into the liver cell to trigger a cellular response.

.....

.....

.....

.....[2]

(b) With reference to Fig. 3.1, describe how the structure of GPLR enables it to function as a membrane-bound receptor.

.....

.....

.....

.....

.....

.....[3]

If a mammal is in a fasting state, the ligand **X** binds to GPLR on liver cells to trigger the breakdown of stored glycogen into glucose that is released into the bloodstream. Fig. 3.2 shows part of the structure of the polymer glycogen.

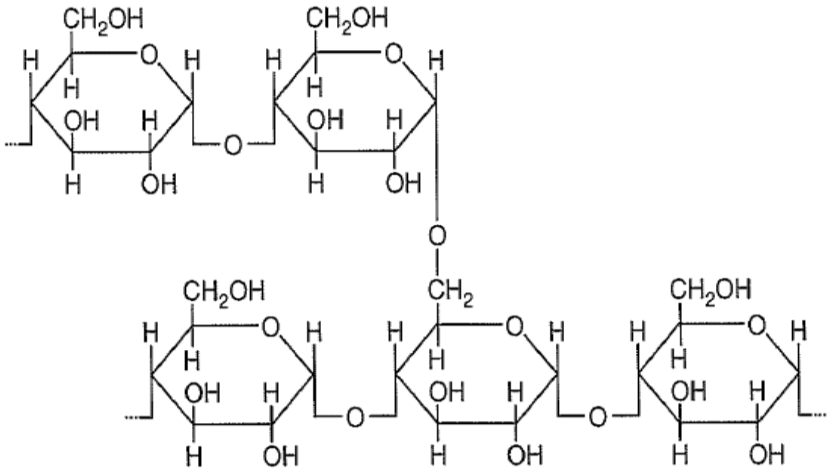


Fig. 3.2

(c) Explain how the structure of glycogen is adapted to its function as an efficient storage biomolecule.

.....

.....

.....

.....

.....

..... [3]

[Total: 9]

QUESTION 4

Semi-conservative DNA replication results in the formation of genetically identical DNA molecules. Fig. 4.1 shows a replication fork involved in DNA replication.

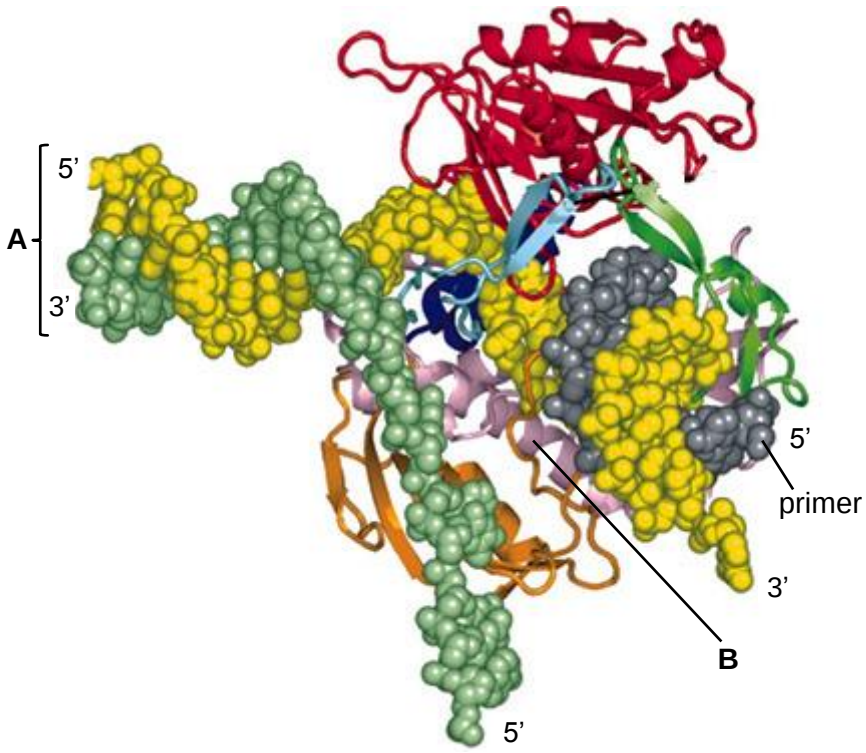


Fig. 4.1

(a) Describe two structural differences between helices **A** and **B**.

.....

.....

.....

..... [2]

(b)(i) Describe how a primer strand is synthesised.

.....

.....

.....

.....

.....

..... [3]

(ii) With reference to Fig. 4.1, explain if the primer is priming the synthesis of the leading strand or lagging strand.

.....

.....

.....

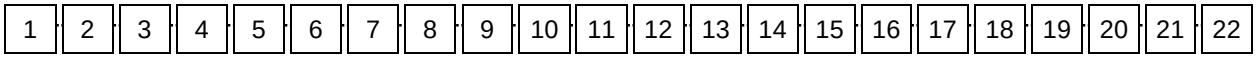
..... [2]

The gene encoding insulin receptor is located on chromosome 19 and contains 22 exons. There are two forms of the insulin receptor (IR) that differ by 12 amino acids. These two forms of the receptor are:

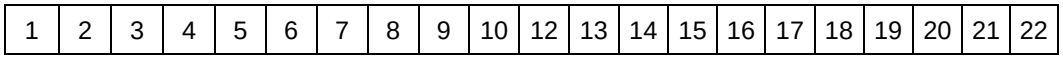
- IR-A, which binds insulin and insulin-like growth factor 2, and is expressed in the brain and ovary.
- IR-B, which binds only insulin, and is expressed in the skeletal muscle and liver.

Fig. 4.2 is a schematic diagram that illustrates the pre-mRNA sequence and the mRNA sequences for the two forms of IR.

IR pre-mRNA:



IR-A mRNA:



IR-B mRNA:

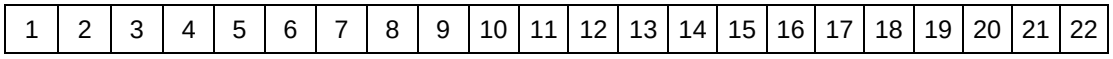


Fig. 4.2

(c) Explain the role of splicing in the structure and function of the two forms of IR.

.....

.....

.....

.....

.....

..... [3]

[Total: 10]

BLANK PAGE

Candidate Name: _____ CT Group: 16S7 ____

BOOKLET III

BLANK PAGE

QUESTION 5

A geneticist is studying the pattern of inheritance of glucose-6-phosphate dehydrogenase (G6PD) deficiency in a family, as shown in Fig 5.1.

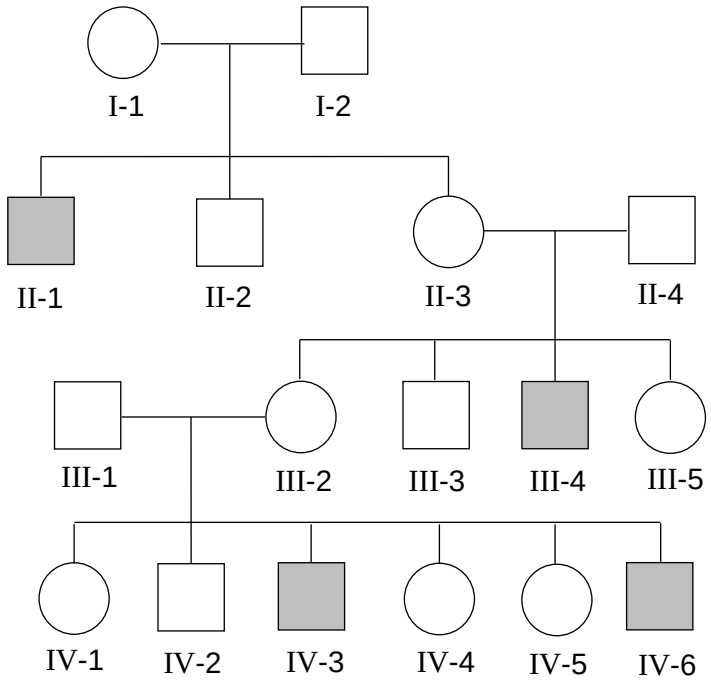


Fig. 5.1

(a) With reference to Fig. 5.1, predict and explain the most likely mode of inheritance of G6PD deficiency.

.....

.....

.....

.....

..... [3]

Individual II-3 has blood group O and individual II-4 has blood group AB. The ABO gene locus is located on chromosome 9.

(b) Using suitable symbols, draw a genetic diagram to show the expected phenotypic ratio of the ABO blood group and G6PD production in offspring of II-3 and II-4.

[6]

The geneticist carried out another investigation on 200 couples where both partners have the blood group AB. The blood groups of their children are shown as follows:

99 children with blood group A
155 children with blood group AB
106 children with blood group B

The expected phenotypic ratio of a cross between a couple where both partners have the same blood group AB is 1 blood group A : 2 blood group AB : 1 blood group B.

The chi-squared (χ^2) test is used to determine if the results of this investigation are in accordance with the expected results. The formula for χ^2 and the table of probabilities are given as follows:

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

degrees of freedom	probability		
	0.10	0.05	0.01
1	2.71	3.84	6.64
2	4.69	5.99	9.21
3	6.25	7.82	11.35
4	7.78	9.49	13.28

(c)(i) Using the information provided, calculate the χ^2 value for the observed results. Show your working clearly.

[2]

(c)(ii) Deduce if the observed results follow the expected phenotypic ratio of 1 blood group A : 2 blood group AB : 1 blood group B.

Explain your answer.

.....

.....

.....

.....

.....

..... [3]

[Total: 14]

Candidate Name: _____ CT Group: 16S7 ____

BOOKLET IV

BLANK PAGE

QUESTION 6

Fig. 6.1 shows the outer layers of two different bacteria **X** and **Y**.

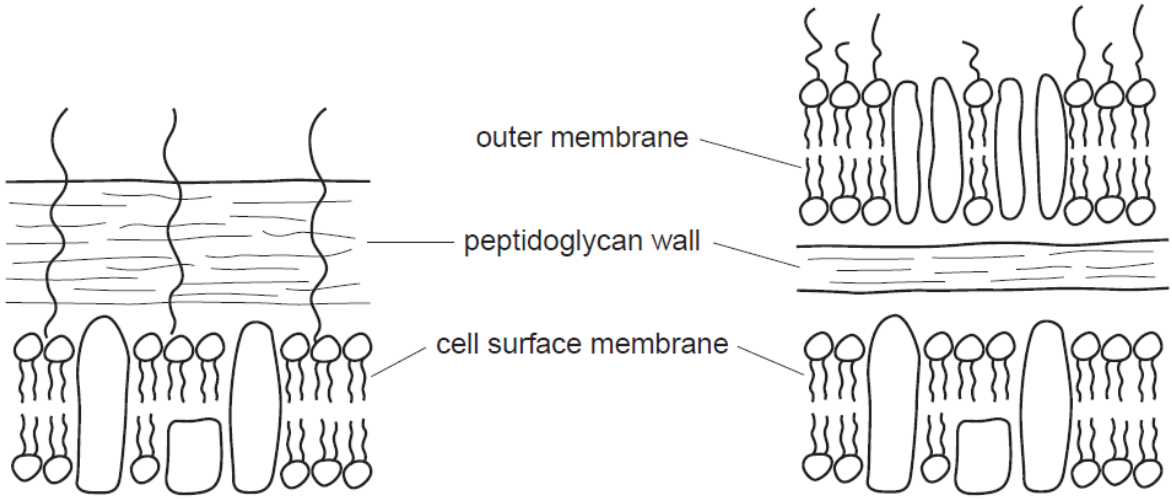


Fig. 6.1

(a) Describe how the outer layers of bacterium **Y** differs from those of bacterium **X**.

.....

.....

.....

..... [2]

Gram staining is a technique used to classify bacteria based on the structures of their outer layers. One of the two bacteria shown in Fig. 6.1 turns purple when stained with the Gram stain.

(b)(i) Identify the bacterium which turns purple when stained with the Gram stain.

..... [1]

(ii) Explain your answer to **(b)(i)**.

.....

.....

.....

..... [2]

Antibiotics such as penicillin are commonly used to treat bacterial infections. However, their effects on different bacteria may be different.

(c) Explain the different effects of penicillin on bacteria **X** and **Y**.

.....

.....

.....

.....

.....

..... [3]

The bacterium that causes cholera, *Vibrio cholerae*, releases a toxin. Fig 6.2 shows the mode of infection of *V. cholerae*.

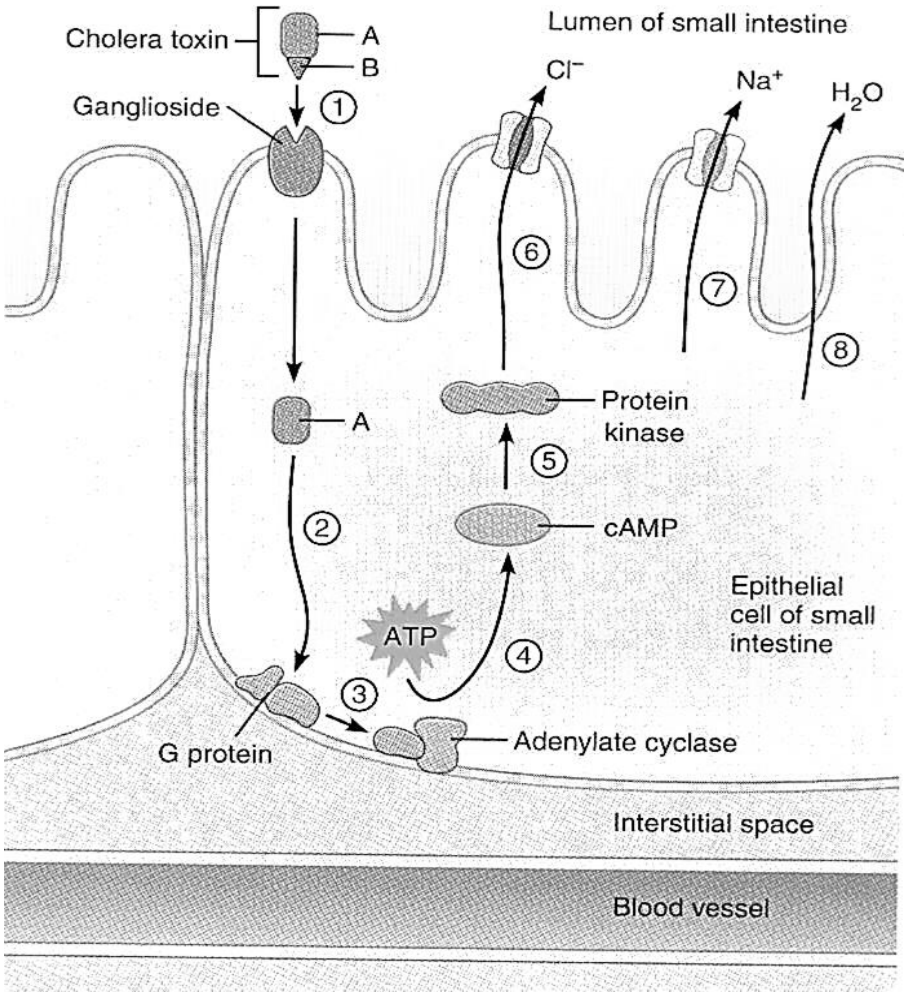


Fig. 6.2

(d) With reference to Fig. 6.2, describe and explain the mode of infection of *V. cholerae*.

[4]

[Total: 12]

Candidate Name: _____ CT Group: 16S7 ____

BOOKLET V

BLANK PAGE

QUESTION 7

Fig. 7.1 shows how influenza viruses attack the cells on the inside of the nose.

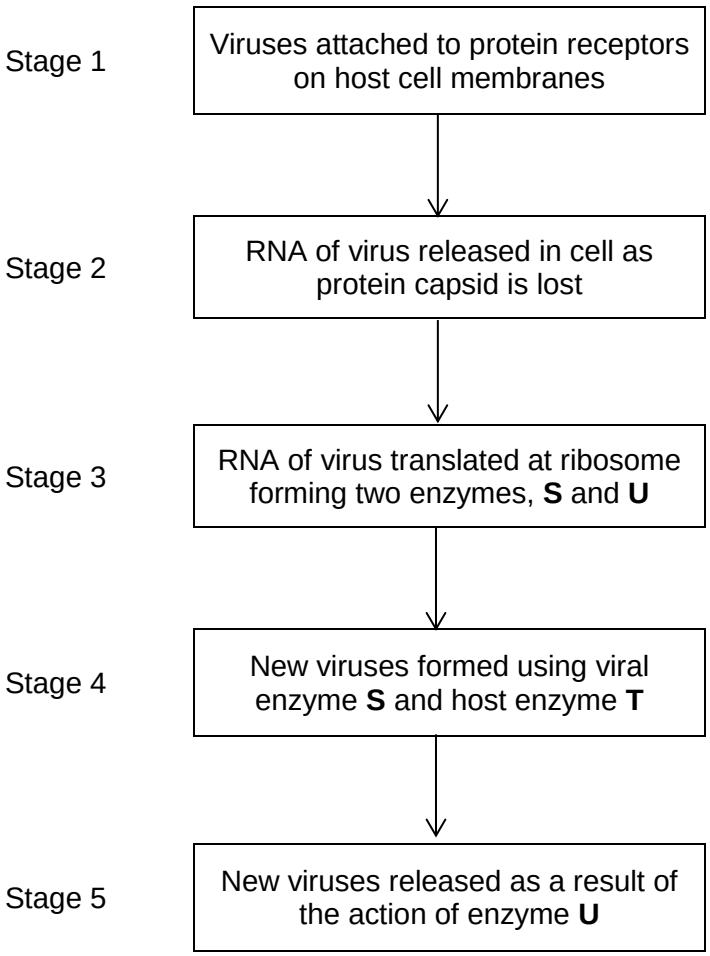


Fig. 7.1

(a) Explain why influenza viruses can only attack the cells on the inside of the nose.

.....

.....

.....

..... [2]

(b) Suggest why enzymes **S** and **T** are needed at Stage 4.

.....

.....

.....

..... [2]

(c) Suggest how enzyme **U** might catalyse the breakdown of the host cell membrane at Stage 5.

.....

.....

.....

..... [2]

When an organism is infected with two different strains of the influenza virus, different segments of single-stranded RNA can sometimes be transferred between the two strains, forming a new viral strain, as shown in Fig. 7.2.

In 1957, a new virus caused an influenza pandemic, known as the Asian influenza, in human populations.

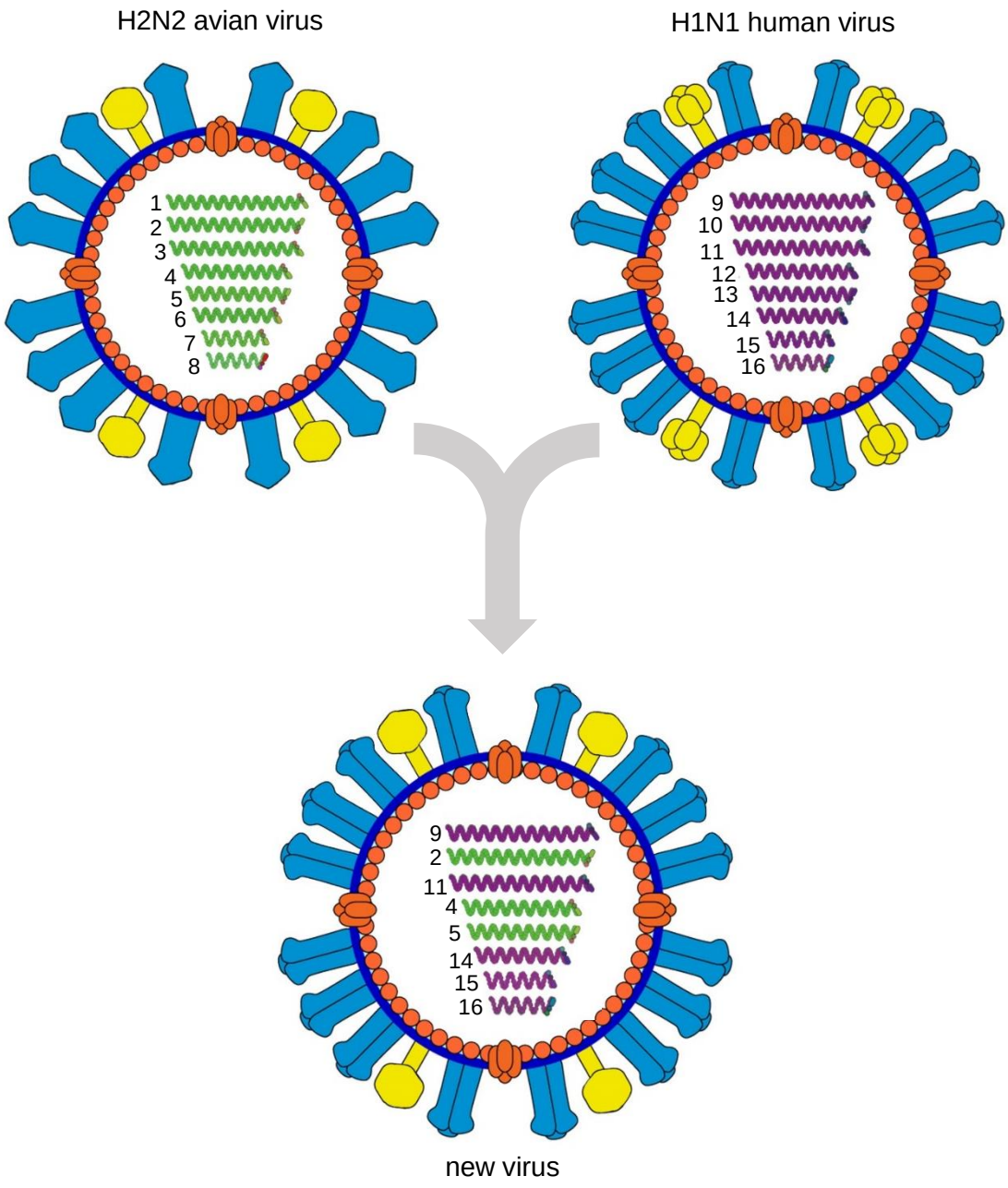


Fig. 7.2

(d) Most people in 1957 were susceptible to influenza caused by the new virus.

Explain why.

.....

.....

.....

.....

.....

.....

..... [4]

[Total: 10]

BLANK PAGE

Candidate Name: _____ CT Group: 16S7 ____

BOOKLET VI

BLANK PAGE

QUESTION 8

Biologists have identified about 1.8 million species of extant (currently living) organisms and estimate that several million more remain to be discovered. In the 18th century, Carolus Linnaeus developed a system for biological classification.

(a) Define *biological classification*.

.....

.....

.....

..... [2]

The genetic code is the information encoded within the mRNA sequence that is translated into proteins by living cells. The codon table is shown in Fig. 8.1.

First position	Second position: U		Second position: C		Second position: A		Second position: G		Third position
U	UUU	Phe (F)	UCU	Ser (S)	UAU	Tyr (Y)	UGU	Cys (C)	U
	UUC		UCC		UAC		UGC		C
	UUA	Leu (L)	UCA		UAA	**STOP**	UGA	**STOP**	A
	UUG		UCG		UAG		UGG	Trp (W)	G
C	CUU	Leu (L)	CCU	Pro (P)	CAU	His (H)	CGU	Arg (R)	U
	CUC		CCC		CAC		CGC		C
	CUA		CCA		CAA	Gln (Q)	CGA		A
	CUG		CCG		CAG		CGG		G
A	AUU	Ile (I)	ACU	Thr (T)	AAU	Asn (N)	AGU	Ser (S)	U
	AUC		ACC		AAC		AGC		C
	AUA		ACA		AAA	Lys (K)	AGA	Arg (R)	A
	AUG	**Met (M)**	ACG		AAG		AGG		G
G	GUU	Val (V)	GCU	Ala (A)	GAU	Asp (D)	GGU	Gly (G)	U
	GUC		GCC		GAC		GGC		C
	GUA		GCA		GAA	Glu (E)	GGA		A
	GUG		GCG		GAG		GGG		G

Fig. 8.1

The first part of the cytochrome b protein sequence alignment of mold fungus (*Neurospora*), horse (*Equus*), human (*Homo*), corn (*Zea*) and rice (*Oryza*) is shown in Fig. 8.2 using the amino acids as a one letter code.

```
Neurospora      AIGTVILILMMATAFLGYVLPYGQMSLWGATVITNLISAIPWIGQDIVEFIWGGFSVNNA
Equus           NIGIILLFTVMATAFMGYVLPWGQMSFWGATVITNLLSAIPYIGTTLVEWIWGGFSVDKA
Homo            NIGIILLLATMATAFMGYVLPWGQMSFWGATVITNLLSAIPYIGTDLVQWIWGGYSVDSP
Zea             CLGVVIFLLMIVTAFIGYVPPWGQMSFWGATVITSLASAIPVVGDTIVTWLWGGFSVDNA
Oryza           CLGVVIFLLMIVTAFIGYVPPWGQMSFWGATVITSLASAIPVVGDTIVTWLWGGFSVDNA
                 :* ::::  :.***:*** *:****:*******.* **** :*  :* ::***:**:.
```

Fig. 8.2

(b)(i) Explain how multiple sequence alignment can be used in biological classification of the five genera of organisms.

[3]

(ii) Identify the longest amino acid sequence where there are no differences amongst the five genera.

[1]

(iii) Suggest, with a reason, whether the DNA coding for the amino acid sequence identified in **(b)(ii)** must be identical for the five genera.

[2]

International agreement limits the hunting of whales. Only the meat of the Minke, Fin and Humpback whales from Southern Hemisphere populations is allowed to be sold on the domestic market in Japan.

Scientists obtained five samples of food that were being sold as “whale meat” in a Japanese market place. In this study, the gene for cytochrome b at the mitochondrial DNA was used for sequence alignment to obtain a cladogram of these organisms.

The scientists identified the species and probable geographic origin of the meat using genetic analysis. The results were used to construct the cladogram in Fig. 8.3.

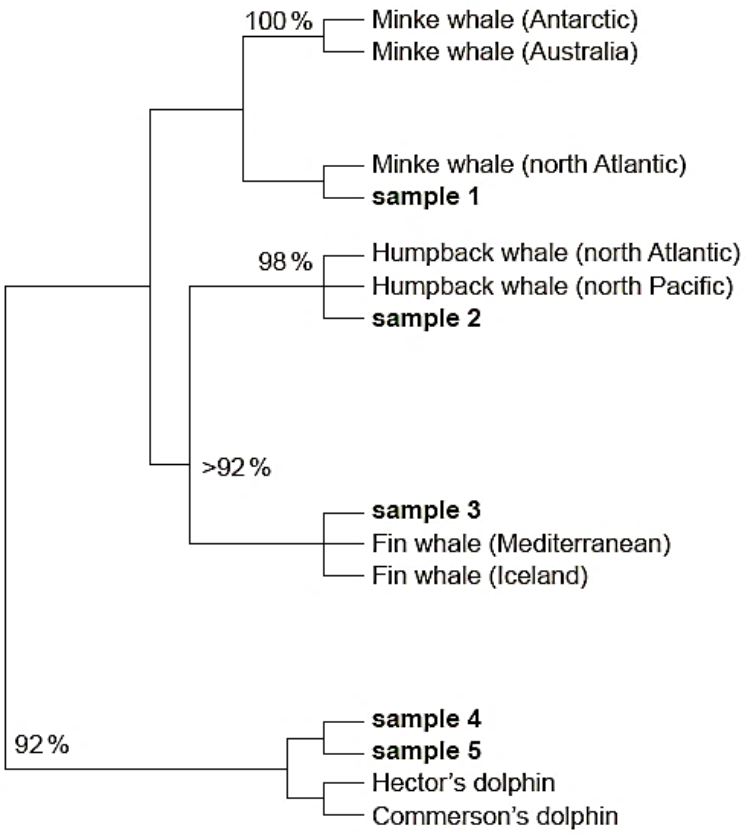


Fig. 8.3

(c) Describe what a cladogram represents.

.....

.....

.....

.....

.....

..... [3]

(d) State a reason each for illegal sale of the respective meat samples in Japan:

(i) sample 1

.....

..... [1]

(ii) sample 4

.....

..... [1]

[Total: 13]

QUESTION 9

The poison ivy plant, *Toxicodendron radicans,* when handled or damaged, releases an oily substance, known as urushiol, onto the outside of its roots, stems, leaves and fruits.

On first skin contact with urushiol, a person will not notice any ill effects, but if the person is sensitive to urushiol, second and subsequent contacts will cause poison ivy rash. This is an itchy, often painful, red rash that can become blistered.

On contact with human skin, urushiol diffuses through to the deeper skin layers, where it stimulates a series of changes.

- It enters skin cells, known as keratinocytes, and immune system cells, known as Langerhans cells, and is oxidised to quinones.
- Quinones become attached to the exterior surface of cell surface membrane proteins of the two cell types, forming complexes known as haptens.
- The Langerhans cells presenting the haptens migrate to nearby lymph nodes, where T-cells are located.
- The keratinocytes presenting the haptens are induced to produce and release cytokines.

The keratinocytes presenting the haptens have a short life span.

These events are summarised in Fig. 9.1.

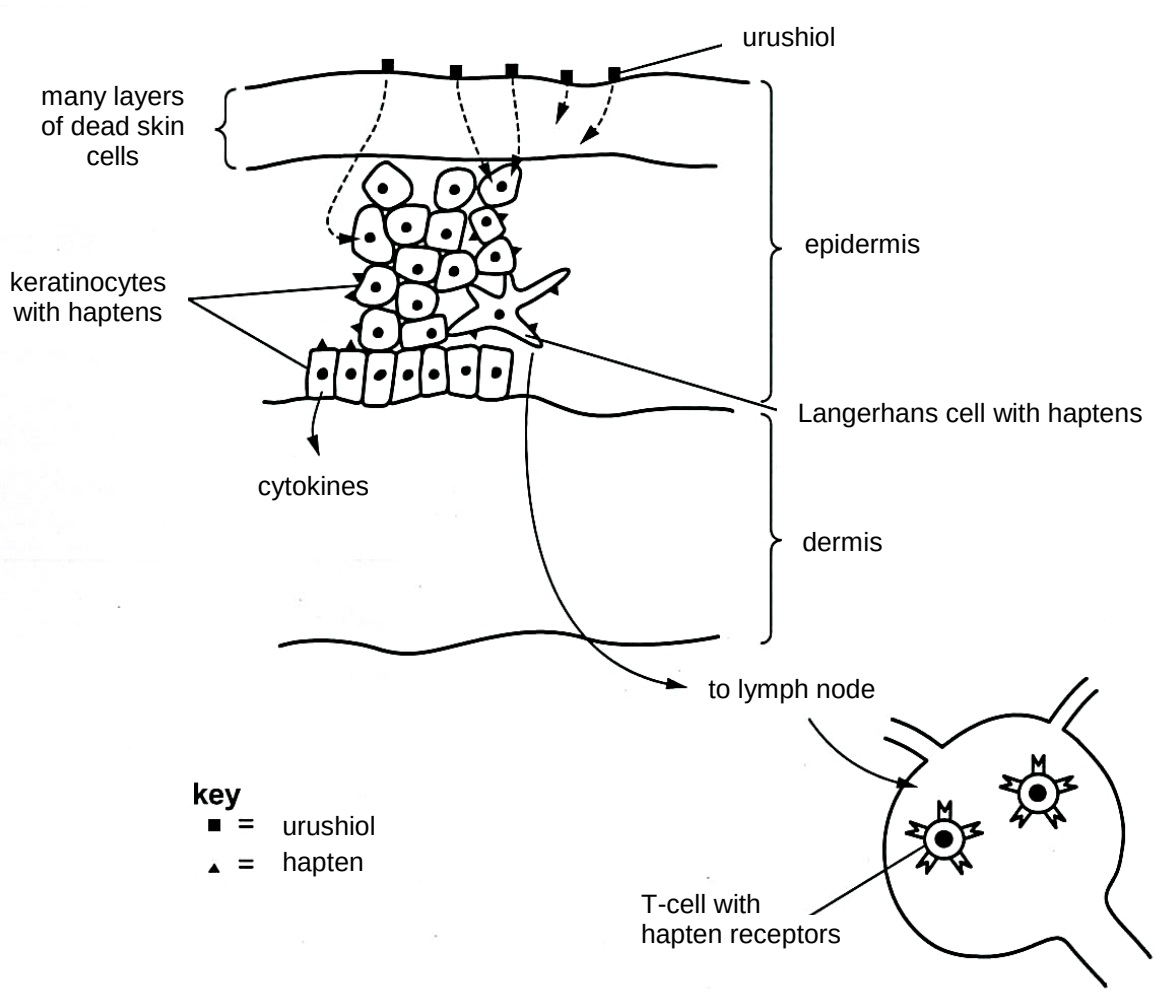


Fig. 9.1

(a) Outline **one** possible mechanism by which urushiol could enter the keratinocytes and Langerhans cells.

[2]

(b) Poison ivy rash occurs as a result of destruction, by an immune system response, of keratinocytes displaying haptens. Langerhans cells, T-cells and macrophages, but not B-cells, are involved in this immune response.

(i) Describe and explain the events that are likely to occur during an immune response to bring about poison ivy rash.

[6]

(ii) Suggest **one** reason why some people are not sensitive to skin contact with urushiol.

[1]

[Total: 9]

-- END OF PAPER---

BLANK PAGE