Cambridge International A Level

Cambridge International Examinations
Cambridge International Advanced Level

CANDIDATE NAME **Script 4**

CENTRE NUMBER | | | | | |

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BIOLOGY **9700/41**

Paper 4 A2 Structured Questions **May/June 2015**

2 hours

Candidates answer on the Question Paper.

Additional Materials: Answer Paper available on request.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
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.

Section A
Answer **all** questions.

Section B
Answer **one** question.

Electronic calculators may be used.
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	
Section A	
1	
2	
3	
4	
5	
6	
7	
8	
Section B	
9 or 10	
Total	

This document consists of **21** printed pages and **3** lined pages.

CAMBRIDGE International Examinations

[Turn over

Section A

Answer **all** the questions.

1 **(a)** Fig. 1.1 shows a section through part of a dicotyledonous leaf of the tea plant *Camellia sinensis*.

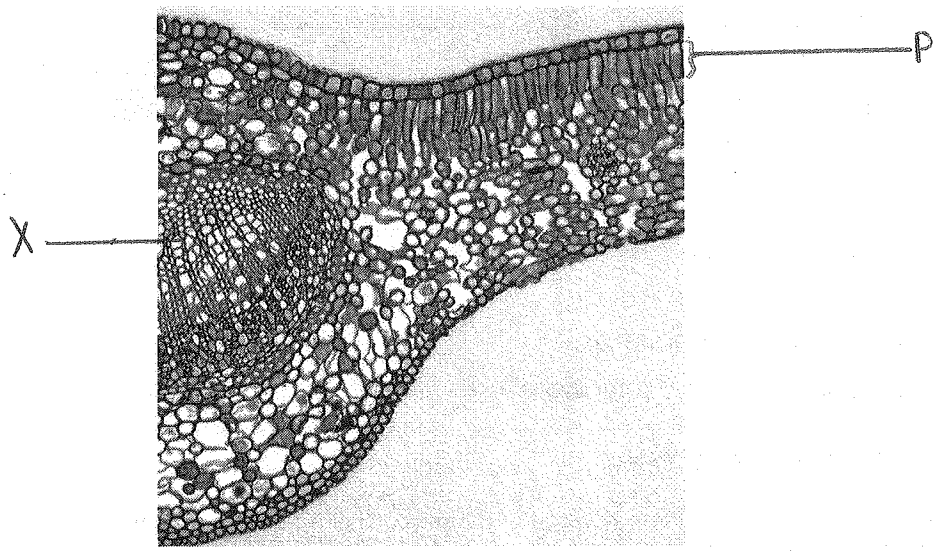


Fig. 1.1

On Fig. 1.1, use label lines and letters to label each of the following parts:

X – xylem tissue
P – palisade mesophyll tissue. [2]

(b) The leaves of *C. sinensis* have a large surface area and are thin.

Explain how each of these two features help the leaf to carry out photosynthesis.

Large surface area allows more CO_2 to diffuse into the cell. Thin leaves reduce water loss.

.....

.....

..... [2]

(c) The lower epidermis contains stomata.

(i) State **one** structural difference between a guard cell and other lower epidermal cells.

Guard cell have stomata. [1]

(ii) Abscisic acid has an important role in the closure of a stoma. It promotes the loss of potassium ions from guard cells.

Outline how the loss of potassium ions from guard cells will lead to the closure of a stoma.

Loss of potassium ions from guard cells allows sodium ion channels to open, causing sodium ions to enter the cytoplasm of guard cells and thus reduce water potential. This causes water to move into the guard cells via osmosis, down their concentration gradient. Water fills the guard cells and makes them turgid, so the close.

..... [3]

[Total: 8]

2 When preparing infertile women for in-vitro fertilisation (IVF), it is necessary to stimulate the growth and maturation of several ovarian follicles. This is done by giving daily injections of the glycoprotein hormone, follicle stimulating hormone (FSH).

Each molecule of FSH has quaternary structure and consists of two different polypeptide chains, α and β.

(a) Explain what is meant by *quaternary structure.*

When more than one polypeptide curls/twists to form a complex 3D structure held by hydrogen bonds, disulphide bonds, hydrophobic interactions and ionic bonds. [1]

(b) Human FSH can be extracted from women's urine (u-hFSH). A procedure involving the use of monoclonal antibodies is used to produce purified u-hFSH.

Suggest how monoclonal antibodies can be used to obtain purified u-hFSH from urine.

Monoclonal Antibodies could be injected into a solution of u-hFSH which has been extracted from women's urine. Monoclonal antibodies would attack antigens and other foreign materials (non-self substances), leaving off self substances. ~~Monoclonal antibodies would not mix~~ After a coordinated immune response, the monoclonal antibodies may be left in the purified u-hFSH or extracted or destroyed.

[3]

(c) Recombinant human FSH (r-hFSH) can be produced by adding the genes coding for the α and β polypeptide chains of FSH to mammalian ovary cells.

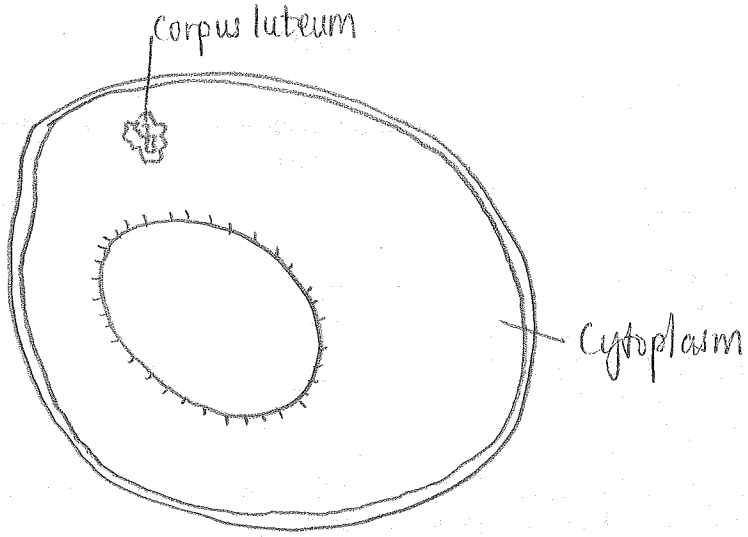
Suggest why mammalian cells are needed to produce r-hFSH, rather than bacterial cells.

Ones made by bacterial cells may be rejected by the body or recognised as non-self. Also, bacterial cells may not produce r-hFSH.

[1]

(d) In IVF treatment, a second hormone, human chorionic gonadotrophin (hCG) is injected when mature ovarian follicles (Graafian follicles) have developed.

Draw a **labelled** diagram to show the structure of a mature ovarian follicle.



[3]

(e) The effectiveness of r-hFSH was compared with that of u-hFSH. Women starting IVF treatment were randomly divided into two groups and given **either** r-hFSH **or** u-hFSH.

The differences between the two groups of women after FSH treatment are shown in Table 2.1.

Table 2.1

	women receiving r-hFSH	women receiving u-hFSH
number of women	119	102
mean number of mature follicles per woman	13	8
concentration of oestrogen in the blood/nmol dm^{-3}	6.55	3.95

(i) With reference to Table 2.1, compare the effects of treatment with r-hFSH and u-hFSH **and** suggest explanations for the differences.

Women receiving r-hFSH had a greater mean number of mature follicles per woman (13) than women receiving u-hFSH (8). Also women receiving r-hFSH had a higher concentration of oestrogen in the blood (6.55 nmol dm^{-3}) than women receiving u-hFSH (3.95 nmol dm^{-3}). This may be due to women receiving a rather impure version of u-hFSH making it less effective. Also, more women receiving r-hFSH were tested (119) than women receiving u-hFSH (102), so resulting in less mean number of mature follicles per woman and concentration of oestrogen in the blood. [4]

(ii) The probability of the results for the mean number of mature follicles per woman occurring by chance is < 0.002.

Explain what is meant by this probability.

The results for the mean number of mature follicles per woman are significant and less likely to occur by chance.

[2]

[Total: 14]

3 The monkey flower, *Mimulus guttatus*, is cross-pollinated by bumblebees. It does not normally self-pollinate.

Since the number of bumblebees in many parts of the world is falling, an experiment was carried out in Kansas to investigate the effects on these plants of the loss of pollinators.

- 1600 *Mimulus* plants were grown in a field.
- 1600 *Mimulus* plants were grown in a glasshouse which bumblebees could not enter.

Seeds were repeatedly collected and sown for several generations at each site.

At first, the plants in the glasshouse produced few seeds, but after five generations the plants were able to self-pollinate and the number of seeds produced was almost the same as that of the plants in the field.

After five generations, the flowers of the plants in the glasshouse were significantly smaller than those of the plants in the field.

(a) Explain why offspring produced by cross-pollination and self-pollination differ in their genetic variation.

Self-pollination involves only one ~~plant~~ flower, which contain the same genes/alleles, so there is little/no genetic variation. Cross-pollination involves the transfer of pollen grains from the anther of one flower to the stigma of another. This involves a mixture of different genes/alleles, therefore increasing genetic variation.

[3]

(b) Suggest how smaller flowers could lead to an increase in self-pollination.

Pollen from smaller flowers may not reach stigma of taller flows and vice-versa, so self-pollination is more effective.

[1]

(c) Explain how natural selection produced the smaller flower size of the plants grown for five generations in the glasshouse.

Flowers grown in the glasshouse did not have a pollinator as bumblebees could not enter. As a result cross-pollination may be difficult. Survival of the fittest comes into play. and the The advantageous alleles increases in frequency over time. Disadvantages alleles decrease in frequency over time. Advantageous allele may be small size of flower, which allows the flower to survive over generations. This further down generations, may increase gene pool. Small sized flower reproduce more as natural conditions now ~~suit~~ favor them, so they increase in number, producing more seeds.

[5]

[Total: 9]

4 The Santa Cruz tarplant, *Holocarpha macradenia*, is a tall annual plant that grows only in the coastal grasslands in California. An annual plant is one that grows, flowers, produces seeds and dies in less than one year.

The tarplant used to be widely spread in California, but there are now only nine natural populations. It is listed as an endangered species.

(a) (i) Suggest **two** reasons why the tarplant has become endangered.

i) Habitat loss.

~~ii) Cut down by.~~

~~iii) Climate~~ ii) Cut down due to various reasons, eg: aesthetic value.

[2]

(ii) State three reasons why it is important to conserve species.

1. Promote tourism.

2. Maintain biodiversity.

3. Moral and ethical reasons, as we have no right to endanger species and it is our ~~duty~~ responsibility to conserve them.

[3]

(b) Tarplant seeds can survive in the soil for several years. Dormant seeds can be encouraged to germinate by scraping the soil, which exposes them to light. This stimulates the production of gibberellin in these seeds, which brings about germination.

Explain how gibberellin brings about germination in seeds.

Gibberellin switches on gene which codes for growth in seeds, allowing them to grow and germinate. Also, ge gibberellin switches on a gene which stimulates the release of the enzyme amylase. Amylase breaks down starch to maltose, which would be used as an energy source in various reactions. Reactions such as protein synthesis, which increases production of proteins, which is used for growth of cells and repair of tissues. This allows the seed to germinate.

..... [4]

(c) The long-term survival of tarplant seeds in the soil provides a store of seeds that can help to ensure the future survival of the tarplant.

Little is known about the survival of tarplant seeds in the soil, or what percentage of these seeds is able to germinate. Researchers therefore used computer models to predict how these factors could affect the likelihood that the tarplant might become extinct.

In their models they used:

- high or low survival values of tarplant seeds in the soil
- different germination percentages of tarplant seeds.

The predictions of the models are shown in Fig. 4.1.

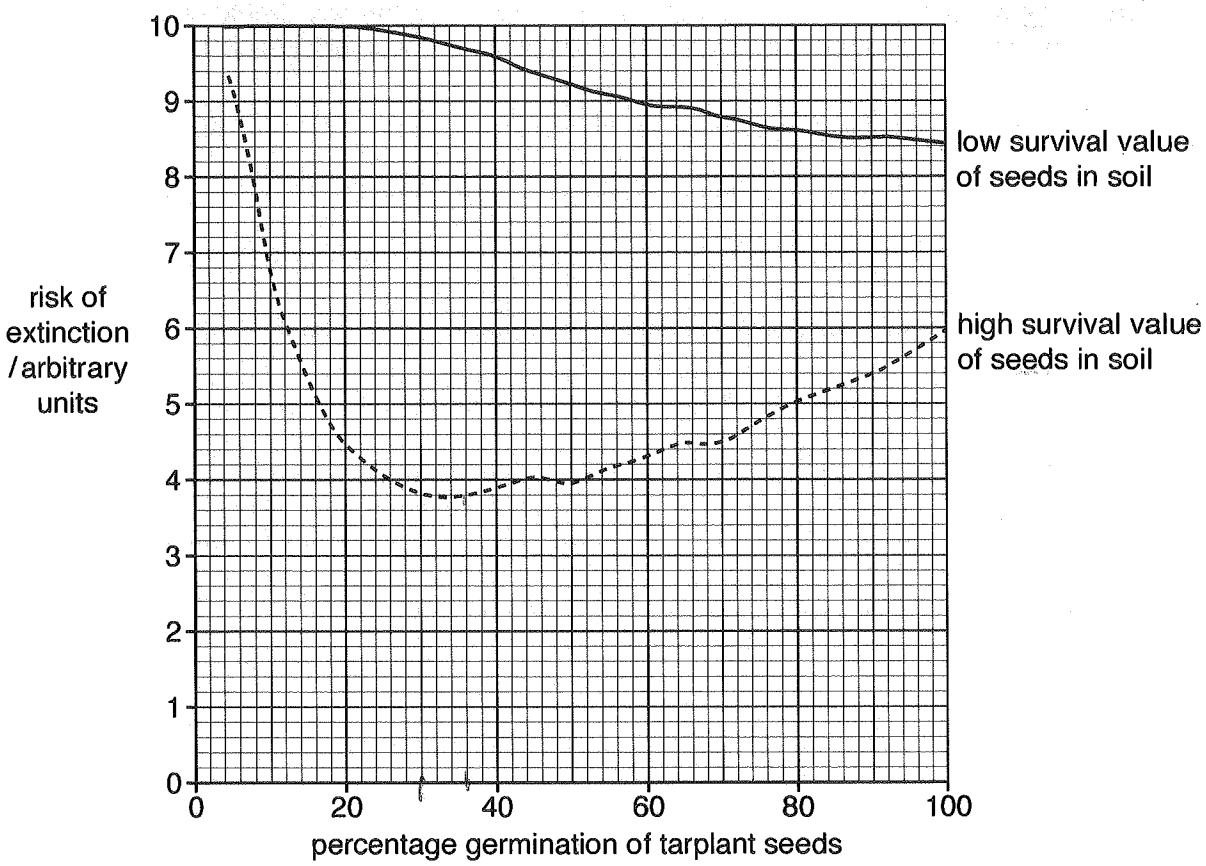


Fig. 4.1

(i) With reference to Fig. 4.1, describe the effect of each of the following on the risk of extinction of the tarplant:

high compared to low survival of the tarplant seeds

Low survival of tarplant seeds have an ~~decreased~~ decreased risk of extinction as percentage germination increases, whereas high surival of tarplant seeds decrease in risk of extinction as percentage germination increases, but increases in risk of extinction after 37% germination.

different germination percentages of the tarplant seeds.

For high survival of tarplant seeds, as percentage germination increases, risk of extinction decreases from 9.3 to 3.8 arbitrary units. As percentage germination exceeds 37%, the risk of extinction increases. For low survival of the tarplant seeds, as the percentage germination increases the risk of extinction decreases (from 10 to 8.4 arbitrary units)

..... [3]

(ii) With reference to Fig. 4.1, discuss whether scraping the soil should be recommended as part of the management strategy to attempt to conserve the tarplant.

Scraping the soil would allow low survival tarplants to decrease risk of extinction even further from 10 to possibly 6, as percentage germination increases, as they have low survival in soil. High survival tarplants should not not have their soil scraped as they have high survival and a decreased risk of extinction as % germination increases.

[3]

[Total: 15]

5 Mole rats, *Spalax ehrenbergi*, are mammals that live in groups in underground burrows. They are blind, and communicate with each other through sound and scent. Males make a purring call when they are attempting to persuade females to mate with them.

In Israel, the mole rats found in different parts of the country all look identical. However, there are actually four different populations with different chromosome numbers, which live in different climatic regions.

These are shown in Table 5.1.

This table also shows information about the purring calls used by the males in each population. The calls of the males were analysed by measuring the number of sound pulses per second, and also the frequencies of the sounds that they made.

Table 5.1

chromosome number of population		52	54	58	60
climatic region in which population lives		cool and humid	cool and dry	warm and humid	warm and dry
purring call made by males	mean number of pulses per second	21.0	25.3	23.9	23.2
	mean major frequency /kHz	595	555	583	562

(a) Explain why the chromosome number of each of the four populations of mole rats is an even number.

- Prevent mutations
- Two halves (haploids) fuse to form a diploid number which is even.

..... [2]

(b) Researchers investigated how female mole rats from each of the four populations responded to purring calls made by males from the same population, and by males from different populations.
A female was placed midway between two loudspeakers, and recorded calls from two males were played to her simultaneously. The researchers noted which loudspeaker the female moved towards. This was repeated with many different females from each population.
The results are shown in Table 5.2.

Table 5.2

population chromosome number	percentage of females preferring the purring call of males from their own population
52	79
54	77
58	77
60	44

With reference to Table 5.2, describe the extent to which female mole rats show a preference for the purring calls of males from their own population.

Female mole ~~rates~~ rats with chromosome numbers 52, 54, 58 have a high percentage for preference of purring call of their mates. However, a low percentage (44%) prefer the purring call of males from their own population of chromosome number 60.

..... [2]

(c) With reference to the data in both Table 5.1 and Table 5.2, discuss whether these four populations of mole rats should be classified as different species.

They are different species due to differences in population chromosome number. Also, there are differences in the mean number of pulses per second of the purring call made by males (Chromosome 52 is 21, Chromosome 54 is 25.3) Different populations live and breed in different climates (C. 58 is warm and ~~dry~~ humid and C. 60 is warm and dry). The purring call by males are also of different frequencies (C. 52 is 595 Hz, ~~C. 54~~ C. 60 is 562 Hz).

..... [4]

[Total: 8]

6 The Indian cobra (*Naja naja*) is a species of venomous snake found in South Asia.

Fig. 6.1 shows an Indian cobra.

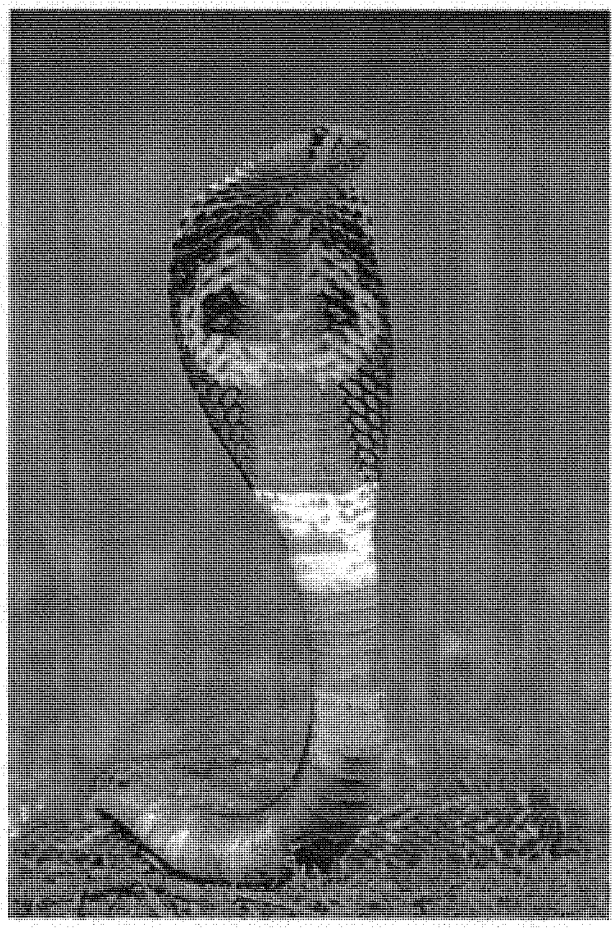


Fig. 6.1

(a) The Indian cobra's venom contains a toxin which causes muscle paralysis in mammals bitten by the snake. The toxin acts at cholinergic synapses.

Suggest ways by which the toxin in cobra venom may cause muscle paralysis.

Prevent nerves from receiving impulses

.....

.....

.....

.....

.....

..... [3]

(b) Describe the role played by calcium ions in synaptic transmission.

Calcium ions enter the presynaptic membrane ~~causing~~ affecting the vesicles with transmitter substances eg: Acetyl choline. The vesicles fuse with the membrane of the pre-synaptic membrane and its contents are released by exocytosis into the synaptic left. They move to fuse with the ~~molecules~~ membrane of the post-synaptic membrane, causing sodium ion channels to open.

[3]

(c) Synapses slow down the rate of transmission of nerve impulses but have an important role in the nervous system.

Outline **two** of the roles of synapses in the nervous system.

i) Ensures one way movement of impulses.

ii) Allows proper coordination of action potential

[2]

[Total: 8]

7 (a) Outline the process of glycolysis in a mammalian cell.

Glucose is phosphorylated as two ATP molecules donate phosphate to it. This forms two hexose-bisphosphate molecules. The hexose-bisphosphate molecules split into two three-carbon molecules called triose-phosphate. A coenzyme NAD oxidises the two triose-phosphate molecules, by taking hydrogen ions from them. This causes NAD to be reduced forming reduced NAD. The triose-phosphate molecules change to two pyruvate molecules. Phosphates from the triose-phosphate molecules are added to ADP to form two ATP molecules. So glycolysis uses ~~two~~ four ATPs and yields 2 ATPs. All this occurs in the cytoplasm.

[6]

(b) Within a mammalian cell, ATP can be produced in a number of ways, including:

- substrate level phosphorylation during the Krebs cycle
- oxidative phosphorylation.

Table 7.1 compares both processes.

Complete Table 7.1.

Use a tick (✓) if the statement is correct or a cross (✗) if the statement is incorrect.
The first row has been done for you.

Table 7.1

statement	substrate level phosphorylation	oxidative phosphorylation
enzymes are involved	✓	✓
occurs in cytoplasm	X	X
occurs in mitochondria	✓	✓
channel proteins are involved	X	✓

[3]

(c) An investigation into the RQ values of germinating maize seeds was carried out.

- A sample of maize seeds was soaked in water for one hour.
- The mean RQ value of some of the seeds was then calculated and the remaining seeds were then planted in soil.
- After 12 hours, the mean RQ value of some of the planted seeds was calculated.
- The remaining seeds were allowed to germinate and grow into seedlings.
- After 21 days, the mean RQ value of some of the seedlings was calculated.

Table 7.2 shows the results of the investigation.

Table 7.2

stage of germination and growth	mean RQ
seeds soaked in water	5.6
seeds after 12 hours in the soil	0.8
seedlings after 21 days	1.0

Suggest an explanation for each of the RQ values shown in Table 7.2.

seeds soaked in water ..Soaking seeds in water reduces O_2 concentration and volume so therefore resulting in a high mean RQ. ($RQ = \frac{\text{Vol. } CO_2}{\text{Vol. } O_2}$). ✗ Volume and concentration of CO_2 may be constant.

.....

seeds after 12 hours in the soil ..Seeds may have used proteins as a respiratory substrate, as the RQ value exceeds 0.7 and proceeds to 0.9. There was more O_2 than CO_2.

.....

seedlings after 21 days ..Seeds use carbohydrates as a respiratory substrate, causing the RQ to be a 1. The volumes and concentrations of O_2 & CO_2 were equal.

..... [6]

[Total: 15]

8 In mice, the intensity of pigmentation of the fur is controlled by multiple alleles of a single gene.

The alleles are listed below in order of dominance, with **C** as the most dominant.

- **C** = full colour
- $\mathbf{C^{ch}}$ = chinchilla
- $\mathbf{C^{h}}$ = himalayan
- $\mathbf{C^{p}}$ = platinum
- $\mathbf{C^{a}}$ = albino

(a) Explain how multiple alleles arise.

Various mice of different fur and eye colour interbreed with each other, creating various genetically diverse offsprings and thus increasing allele frequency. Some may be dominant, co-dominant or recessive.

C^BC^ab

.....

.....

..... [2]

(b) Eye colour in mice is controlled by two alleles of a single gene, **B**/**b**:

- allele **B** codes for black eyes
- allele **b** codes for red eyes.

C^BC^ab C^hBC^ab

A mouse with full colour fur and black eyes was crossed with a mouse with himalayan fur and black eyes. One of the offspring was albino with red eyes.

Using the symbols above, draw a genetic diagram to show the genotypes and phenotypes of the offspring of this cross.

Genotype CC^aBb C^hC^aBb

C^B C^ab C^hB C^ab

[6]

[Total: 8]

Section B

Answer **one** question.

9 (a) Describe how the gene coding for human insulin can be obtained and inserted into a plasmid vector. [8]

(b) Explain how bacteria can be genetically modified and then identified using antibiotic resistance genes. [7]

[Total: 15]

10 (a) Describe the **advantages** of using batch culture for penicillin production and continuous culture for mycoprotein production. [8]

(b) Outline the hybridoma method for the production of a monoclonal antibody. [7]

[Total: 15]

10a) Batch culture involves the setting up of a culture and allowing microorganisms to reproduce until nutrients are used up. The contents of the fermenter are then harvested. For penicillin production, fed-batch culture is used where the fermenter is given nutrients continously up to a point, then contents are harvested. It's advantages are:
i) low risk of contamination as after contents are harvested, the fermenter is cleaned and sterilised.
ii) It operates over a shorter period.
iii) When there is a contamination, it is relatively easier to stop the culture, harvest the products, and clean then sterilise the fermenter.
iv) It is cost efficient (cheaper). v) After cleaning and sterilisation fermenter can be used for a different process
Continuous culture involves setting up a culture and ~~continuot~~ continously adding nutrients to the fermenter over a period of time. It is ideal for mycoprotein production. It's advantages include:
i) No down time as fermenter is continuously given nutrients.
ii) Gives steady supply of products as fermenter is continuously given nutrients so more products are formed.
iii) Produces more products as fermenter runs for a long period.

b) - Antigen inserted into a rat

- B lymphocytes activated as antigens attach to their receptors
- Stimulation of an immune response
- B lymphocytes ~~secre~~ divide by mitosis producing clones similar to plasma cells
- ~~Cancer~~ Plasma cells isolated
- Cancer cells added to plasma cells, causing them to fuse and produce hybridoma cells
- Hybridoma cells extracted and fed into fermenter
- Hybridoma cells given nutrients, so they can divide and produce many clones
- Contents of fermenter harvested.