Answer **all** the questions.

1 Domestic chickens have been bred for many years to increase the number of eggs laid by the females. It is useful to be able to identify the young female chicks on the day after they hatch, as only the females need to be kept for laying eggs.

Unlike mammals, where the sex chromosomes are known as X and Y, in chickens the sex chromosomes are known as Z and W.

- Male chickens have two Z chromosomes (ZZ).
- Female chickens have one Z chromosome and one W chromosome (ZW).

(a) Some genes for feather colour and pattern in chickens are carried on the Z chromosome but not on the W chromosome. One such example is the gene for striped feathers (barring).

State the name given to this type of inheritance.

..... **[1]**

(b) Inheritance of the barring pattern can be used to identify female chicks when they are one day old.

The phenotypes associated with the two alleles of the barring gene are shown in Table 1.1.

Allele	Adult phenotype	Day-old chick phenotype
dominant **B**	black feathers striped with white bars (barred)	black body with a white spot on head
recessive **b**	black feathers (non-barred)	black body and head

Table 1.1

(i) State the **adult phenotypes and sex** of the following individuals:

Z^BZ^b .....

Z^BW .....

Z^bW .....

[3]

(ii) A cross was carried out between a barred female and a non-barred male.

Complete the genetic diagram to show the parental genotypes, their gametes and the F1 genotypes. State the phenotypes of the offspring as **day-old chicks**.

Parent phenotypes	**Barred female**	**Non-barred male**
Parent genotypes	.....	.....
Gametes	.....	.....
F1 genotypes	.....	.....
F1 day-old chick phenotypes		

male .....

.....

female .....

.....

[5]

(c) The autosomal gene **I / i** shows epistasis over **all** other genes affecting feather colour in chickens.

Individuals carrying the dominant allele **I** have white feathers.

Chickens that are not white have the genotype **ii**.

(i) State the precise term used to describe the genotype **ii**.

..... **[1]**

(ii) Predict the colour(s) of the offspring of a cross between a male homozygous barred chicken and a white female chicken with the genotype **II**.

..... **[1]**

[Total: 11]

2 The Galapagos Islands are 600 miles away from the nearest land mass, South America. They consist of 15 main islands, 3 smaller islands, and 107 rocks and islets. This collection of islands is home to many endemic species of animals and plants. This means that these species are found nowhere else in the world.

(a) Explain, using scientific terms, why a collection of small islands remote from the mainland provides optimal conditions for speciation.

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..... **[2]**

(b) In 1978, the United Nations (UN) declared the Galapagos Islands a World Heritage Site. This led to a rise in the resident human population and the number of visitors to the Islands.

Table 2.1 shows how the number of people living on and visiting the Galapagos Islands changed between 1980 and 2005.

Year	Resident population	Number of visitors
1980	5500	16 000
1985	7000	19 000
1990	9500	42 000
1995	12 500	58 000
2000	17 500	68 000
2005	27 500	125 000

Table 2.1

(i) Calculate the percentage increase in the number of visitors to the Galapagos Islands between 1980 and 2005.

Show your working. **Give your answer to the nearest whole number**.

Answer = ... % **[2]**

(ii) Outline the main ways in which increased human presence and activity have put endemic species on the Galapagos Islands, and in the sea around them, at risk of extinction.

In your answer you should link the ecological pressures imposed by human activity to examples of Galapagos Island species that have been affected.

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..... **[7]**

Turn over

(c) In 2007, the United Nations (UN) put the Galapagos Islands on its Red List of endangered sites. The Galapagos government's response to this action included making new laws and placing restrictions on human activity, issuing eviction orders and culling introduced species of animals.

Suggest **one** economic and **one** ethical problem that might have arisen from this 2007 UN decision.

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..... **[2]**

[Total: 13]

3 A student who was interested in animal behaviour did a day's work experience at a zoo. He made these notes about some examples of animal behaviour that he observed.

A When I approached the otter enclosure tapping a bucket of food, the otters made rapid squeaking noises and ran to the door to meet me!

B A mother duck escaped from her enclosure and all her baby ducklings followed her through a hole in the wire.

C I moved a log in one enclosure and noticed that the woodlice, which had been resting underneath the log, began to move around quickly once the log was lifted.

D A banana had fallen a short distance away from the chimpanzee pen. A chimpanzee used a stick to reach out and drag the banana towards her.

E The ring-tailed lemurs showed mutual grooming behaviour, taking it in turns to search through another lemur's fur for parasites.

F Cockroaches living in the dark in the house for nocturnal animals ran away from the light of my torch.

G Zoo deer are free to roam amongst the visitors. Although deer usually run away from humans, the zoo deer do not.

H When a chimpanzee threw an apple at the keeper, the keeper ducked his head very fast.

Match the examples **A**–**H** to the names of different **types of behaviour** by writing the correct letter beside the name. One has been done for you.

1 social behaviour ..... **2** kinesis .....

3 imprinting ..... **4** escape reflex **H**

5 taxis ..... **6** operant conditioning .....

7 habituation ..... **8** insight learning .....

[7]

[Total: 7]

Turn over

4 Rhubarb, *Rheum x hybridum*, is a plant that is grown for its edible stems. In Spring, the stems and leaves grow from fleshy roots which survive the Winter underground.

Growers have developed many new varieties of rhubarb by growing plants from seed, choosing the best young plants and then asexually reproducing them.

Seeds are produced by sexual reproduction and the rhubarb plants that grow from seed show variation in characteristics such as stem colour, dormancy period and the concentration of oxalic acid in their leaves.

(a) Outline the events that lead to genetic variation in gametes **and** in the plants grown from seed.

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..... **[5]**

(b) Traditionally, rhubarb plants have been produced by vegetative propagation. The best young rhubarb plants are allowed to grow for three seasons until their underground root systems are large enough. They are then dug up in Winter, the roots are cut into pieces and the pieces are replanted. Each piece is then able to grow into a new rhubarb plant that is identical to the parent.

(i) State the biotechnological term for this type of vegetative propagation.

..... **[2]**

(ii) A gardener wished to multiply his rhubarb plants using the traditional method, but he discovered that his plants were infected by a virus.

Name the modern technique which allows commercial growers to produce large numbers of genetically identical plants that are also virus-free.

..... **[1]**

(iii) Rhubarb plants must spend seven to nine weeks at a temperature below 3 °C in order to break their winter dormancy and allow them to start growing stems and leaves again.

The length of the cold period that is required depends on the variety of rhubarb.

In the variety 'Timperley Early', the length of the cold period is shorter, so the plants grow and produce a crop earlier in the year than the variety 'Victoria'.

Suggest **two** ways in which the varieties may differ from one another **biochemically** to account for the difference in the length of the cold period required by each.

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..... **[2]**

Question 4(c) begins on page 10

(c) Rhubarb leaves contain oxalic acid, a relatively strong acid which is soluble in water and alcohol. High concentrations of oxalic acid makes rhubarb leaves poisonous to humans and other animals.

(i) The amount of oxalic acid in the leaves varies according to the variety of rhubarb, the age of the plant and environmental factors.

Suggest and plan an experiment to compare how the variety of rhubarb affects the amount of oxalic acid in rhubarb leaves.

Include in your plan:

- the variables that you could control
- an outline of the experimental procedure you would use
- any measurements that you would make.

In your answer you should make clear which are the independent, dependent and controlled variables.

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..... **[6]**

(ii) As rhubarb leaves are poisonous, they are cut off when the stems are harvested and may be left to decompose on the compost heap.

Outline the role of **decomposers** in the decomposition of leaves.

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..... **[3]**

(d) An early harvest of rhubarb stems can be obtained by placing an upturned bin over the root when it comes out of dormancy, so the emerging shoots are kept in the dark. The shoots then grow more quickly to a height suitable for picking.

Use your knowledge of **plant growth regulators** (plant hormones) to suggest why shoots kept in the dark grow taller than those left in the light.

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..... **[2]**

[Total: 21]

Turn over

5 Growth and development in organisms is controlled by a number of mechanisms that operate at the cellular level. The control elements involved in these mechanisms include hormones, the second messenger molecule cyclic AMP and regulatory genes.

- In eukaryotes the most important regulatory genes contain homeobox sequences and are called homeotic genes.

- The regulatory genes of the *lac* operon in prokaryotes are studied to help us to understand how regulatory genes and their products interact to switch structural genes on and off.

(a) Use your understanding of the biochemical identity and interactions of these control elements to complete Table 5.1 by putting a tick (✓) or a cross (✘) **in each box**.

Some of the boxes have been completed for you.

Control element	Made of protein	Binds with a protein	Codes for protein
insulin		✓	
cyclic AMP			✘
lac I (inhibitor) gene		✓	
lac O (operator) gene	✘		
homeotic gene product		✘	

[5]

Table 5.1

(b) RNA polymerase and DNA polymerase are both enzymes. RNA polymerase is involved in the action of some control elements, whereas DNA polymerase is not.

Describe and explain the difference between the **functions** of these two enzymes.

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..... **[4]**

(c) Another mechanism that can act to change the body plan of an organism during its development is **programmed cell death**.

Fill in the gaps in the following passage describing this process and the importance of its regulation.

Programmed cell death is known as ..... . Firstly, the fine network of protein filaments and microtubules known as the ..... , which gives structure to the cell, is broken down and digested by ..... .

The plasma (cell surface) membrane then changes, forming small bulges called ‘blebs’. The cell breaks into membrane-bound fragments that are removed by the process of ..... so that harmful substances are not released into surrounding tissues.

Programmed cell death is a controlled process. However, mutation in a gene called p53 can prevent programmed cell death. When this occurs, the rate at which somatic cells are produced by the process of ..... becomes greater than the rate at which cells die, resulting in the formation of a mass of cells known as a ..... . **[6]**

[Total: 15]

Turn over

6 Microorganisms are often used in biotechnological processes.

Fig. 6.1 shows the standard growth curve for a culture of bacteria.

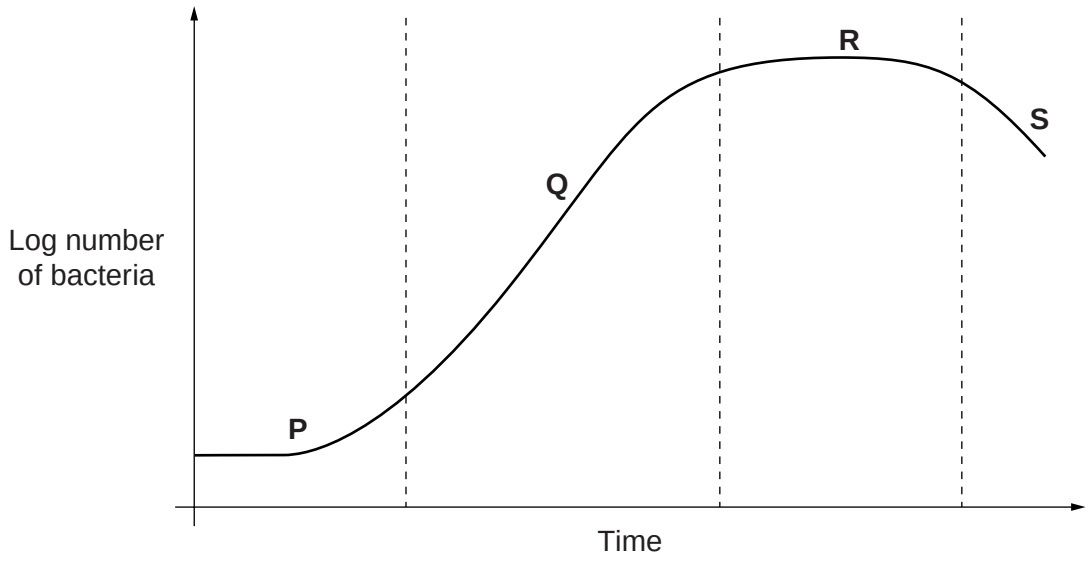

Fig. 6.1

(a) Identify the phases labelled **P**, **Q** and **R** in Fig. 6.1.

P .....

Q .....

R .....

[3]

Metabolic processes taking place in bacteria grown in a batch culture produce primary and secondary metabolites.

(b) Explain what is meant by a primary metabolite.

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..... **[2]**

(c) With reference to the information in Fig. 6.1, state the phase or phases, **P**, **Q**, **R** or **S**, when

(i) primary metabolite production is at its highest **rate**;

..... **[1]**

(ii) most secondary metabolites are produced;

..... **[1]**

(iii) the concentration of secondary metabolites reach a maximum.

..... **[1]**

(d) Some aerobic recombinant bacteria were grown in a fermenter. They synthesised the protein human growth hormone (HGH).

(i) Suggest **two** ways in which named factors inside the fermenter could be adjusted in order to maximise the yield of HGH.

1 .....

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2 .....

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[4]

(ii) HGH made in this way is given by injection to some children who have a genetic mutation. The mutation means that they do not produce enough HGH to enable them to grow at the normal rate.

Explain why injecting recombinant HGH in this way is **not** an example of gene therapy.

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..... **[3]**

[Total: 15]

7 **(a)** A number of new techniques for manipulating cells and genomes are now available, and it is hoped this manipulation will allow cures for diseases to be developed.

Five goals that scientists would like to achieve are described below and are listed **A** to **E**:

A producing large numbers of genetically identical 'model' transgenic mice that show symptoms of diabetes

B growing a replacement kidney identically tissue-matched to an individual patient

C obtaining replacement hearts from transgenic pigs, partially tissue-matched to humans

D genetically manipulating cells of one adult to cure a genetic disease in that individual

E altering a prokaryotic pathogen for use as a vaccine.

The names of the procedures corresponding to **four** of the five goals **A** to **E** are written below.

Match the correct letters to the names. **No letter should be used more than once**.

xenotransplantation .....

somatic gene therapy .....

non-reproductive cloning .....

animal reproductive cloning .....

[4]

(b) Table 7.1 shows four different combinations of techniques used to achieve goals **A** to **E**.

Write the letters **A, B, C, D or E** in the first column of the table to match each goal to the appropriate combination of techniques needed to achieve it.

Use each letter only once.

	Technique			
Goal	**Vector used to transfer genes**	**Embryonic stem cells manipulated**	**Non-embryonic stem cells manipulated**	**Tissue designed for use in a different species**
	✓	×	✓	×
	✓	✓	×	×
	×	✓	×	×
	✓	✓	×	✓
	✓	×	×	×

[5]

Table 7.1

[Total: 9]

8 Earthworms are abundant in fertile soil where they play an important role in the transfer of energy in the ecosystem. An example of a food chain involving earthworms is shown in Fig. 8.1.

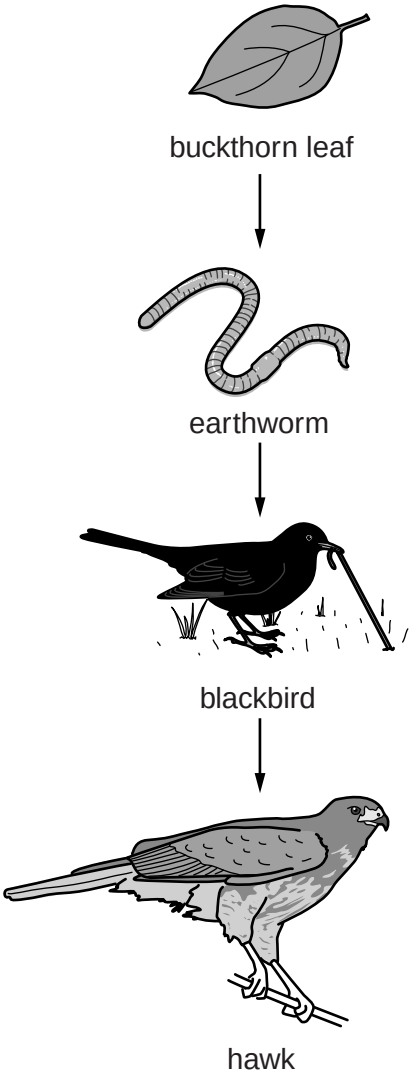

Fig. 8.1

(a) Define the following terms:

producer .....

.....

.....

consumer .....

.....

.....

trophic level .....

.....

.....

[3]

Turn over

(b) One way of measuring the abundance of earthworms is as follows:

- place quadrat frames of known area onto the ground
- pour a chemical solution onto the soil to cause the earthworms to come up to the surface
- wait and then count the earthworms.

Researchers used this technique in 2004 and 2006 to compare the abundance of earthworms in four areas of soil:

- soil underneath buckthorn plants
- soil underneath honeysuckle plants
- bare soil after the removal of buckthorn plants
- bare soil after the removal of honeysuckle plants.

The results are shown in Fig. 8.2.

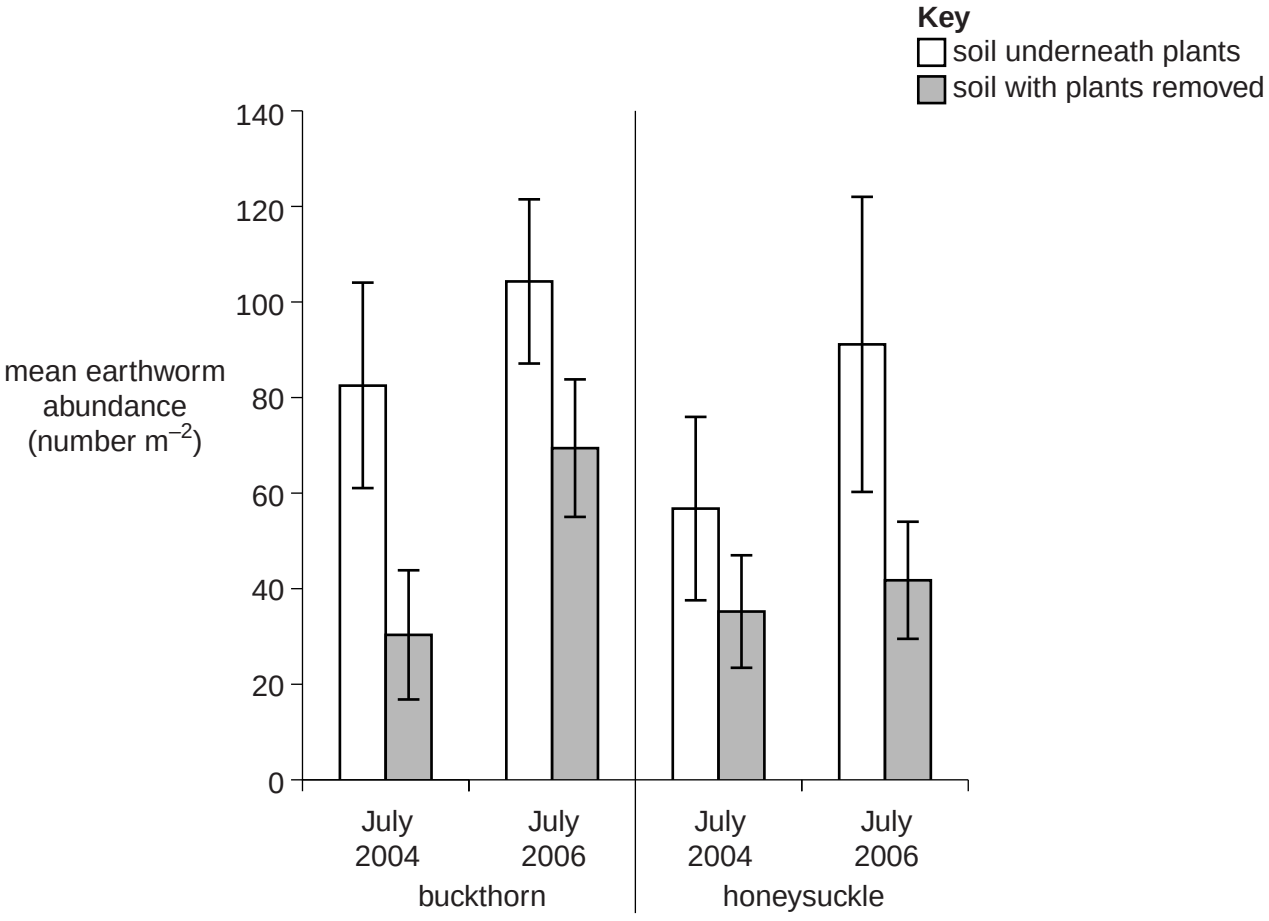

Fig. 8.2

(i) Suggest **two** variables which the researchers should have controlled in order to make the results comparable.

1 .....

.....

2 .....

.....

[2]

(ii) Evaluate, with reference to the error bars in Fig. 8.2, whether the data show a valid difference in the abundance of earthworms between the 'soil underneath honeysuckle' and 'soil with honeysuckle removed' sites for July 2004.

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..... **[2]**

(iii) Ecosystems can be described as dynamic.

State **two** pieces of evidence from Fig. 8.2 that show that the ecosystem is dynamic.

1 .....

.....

2 .....

.....

[2]

[Total: 9]

END OF QUESTION PAPER