

Question: 1

Fig. 5.1 is a circular representation of the genetic code.

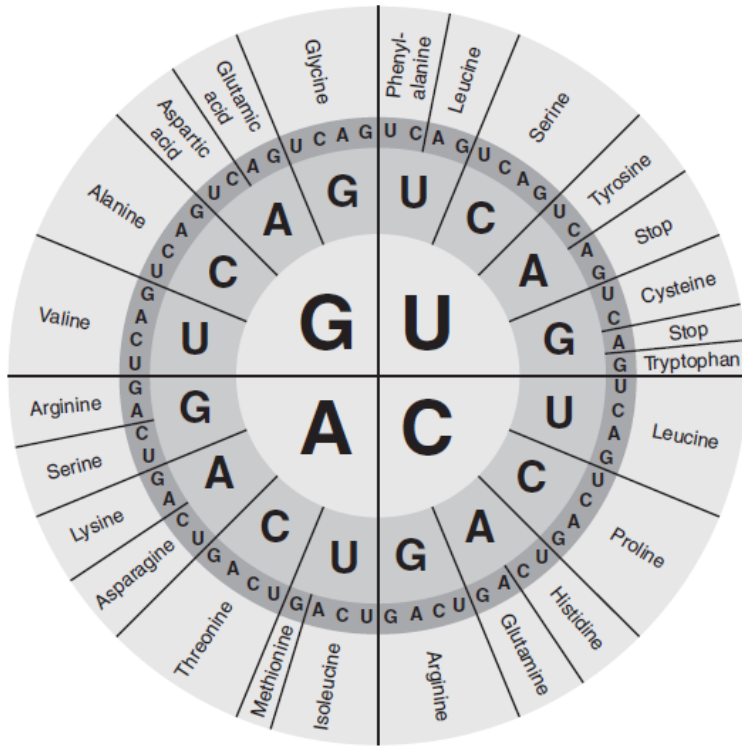


Fig. 5.1

(a) Fig. 5.2 shows a sequence of bases coding for a sequence of amino acids. The name of the third amino acid in the sequence has been filled in.

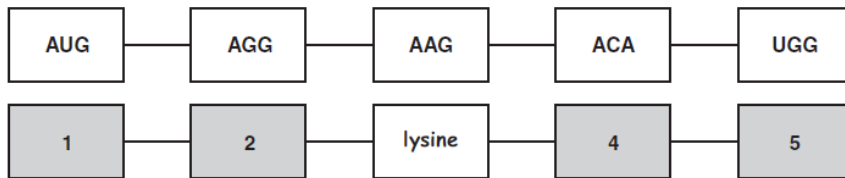


Fig. 5.2

Identify the remaining amino acids in the sequence.

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2

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3

Lysine

4

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5

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(b) State the name of the stage of protein synthesis represented in Fig. 5.2 and name the organelle in the cell where this takes place.

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[ 2 ]

(c) Identify the type of nucleic acid that holds the sequence of bases shown in Fig. 5.2.

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[ 2 ]

(d) Using the information in Fig. 5.1, list the three triplet codons that would cause termination of a polypeptide chain (stop codons) and explain why these codons have this effect.

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[ 2 ]

(e) What name would be given to a mutation that resulted in a change of the codon UUU to UUC?

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[ 1 ]

[Total: 9]

Question: 2

Two-spot ladybirds, *Adalia bipunctata*, show a colour polymorphism. They are normally red with two black spots. However, melanic individuals occur which are black with two red spots.

A student investigated the proportion of these colour forms in the ladybird population along a transect going up a hill near his school.

(a) (i) Suggest a suitable technique by which the student might have collected his samples of ladybirds along this transect.

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[ 1 ]

(ii) The student's teacher suggested he should make several transects up the hill rather than just one transect.

Explain why this is good experimental design.

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[ 1 ]

(b) The student's results are shown in Table 7.1.

**Table 7.1**

| height above sea level (m) | total number of red form of ladybird | total number of black form of ladybird |
|----------------------------|--------------------------------------|--|
| 100                        | 93                                   | 7                                      |
| 200                        | 78                                   | 13                                     |
| 300                        | 71                                   | 16                                     |
| 400                        | 54                                   | 14                                     |

(i) Suggest a method of processing this data to make comparisons between the frequency of the red form and black form of ladybird at the different altitudes more valid.

Explain why your method is an improvement.

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[ 2 ]

(ii) Evaluate whether the student was correct to conclude as follows:

"My data showed a positive correlation between increasing altitude and the frequency of the black form of the ladybird. I therefore concluded that high altitude causes the black form to survive better."

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[ 3 ]

(c) The black, melanic, form of the ladybird is caused by an allele (B) that is dominant.

The red form of the ladybird is therefore homozygous recessive at this locus (bb).

(i) State what is meant by the term *recessive*.

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[ 1 ]

(ii) The data in Table 7.1 give the total number of the red form of ladybird found as 296, and the total number of the black form of ladybird as 50.

The Hardy-Weinberg principle states that:

$$p + q = 1$$

$$p^2 + 2pq + q^2 = 1$$

Use the Hardy-Weinberg principle and the figures given above to calculate the frequency of the dominant allele,  $p$ , and the recessive allele,  $q$ , in the two-spot ladybird population.

Show each step in your working. Give your answers to 2 decimal places.

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$p =$  .....

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$q =$  .....

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[3]  
[Total: 11]

Question: 3

Fig. 1.1 shows a metabolic pathway involving the amino acid, phenylalanine. One of the products of this pathway is melanin, the pigment that gives a brown colour to hair, skin and the iris of the eyes. This metabolic pathway also produces thyroid hormones.

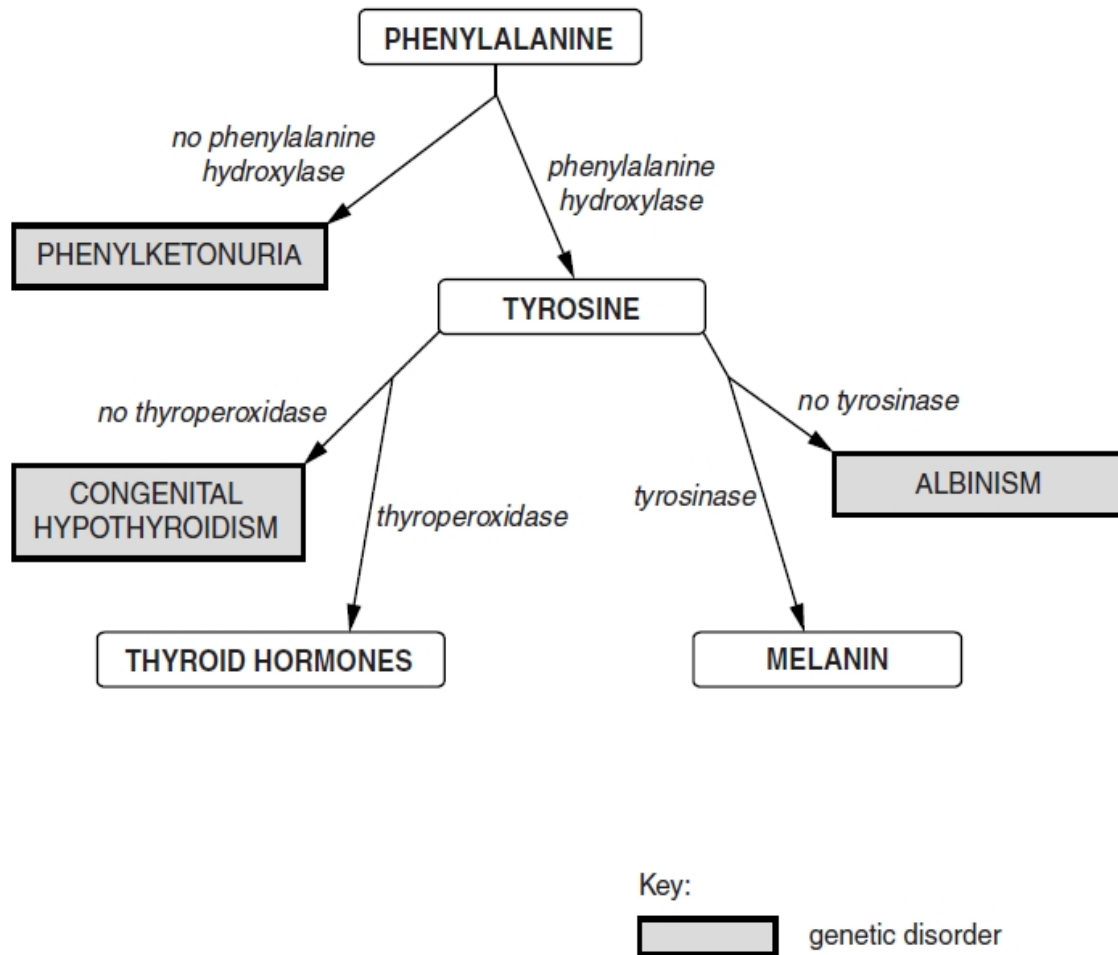


Fig. 1.1

(a) Use Fig. 1.1 to name:

(i) the enzyme that catalyses the last step in melanin production

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[ 1 ]

(ii) the genetic disorder resulting from the absence of the enzyme at the start of the metabolic pathway for melanin production.

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[ 1 ]

(b) Phenylalanine and tyrosine are both amino acids.

Explain why phenylalanine and tyrosine are classified as amino acids.

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[ 2 ]

(c) One effect of thyroid hormones is to increase the activity of mitochondria within cells. Suggest how the metabolism of a person with the condition congenital hypothyroidism might differ from that of a person who does not have this condition.

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[ 3 ]

(d) Albinism is a genetic disorder in which a person lacks melanin pigment in their skin, hair and the iris of their eyes. A person with this disorder is called an albino. The genotype of an albino has two copies of a recessive allele of the gene for an enzyme involved in melanin production.

(i) State the term used to describe a genotype that has two copies of the same allele at a particular gene locus.

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[ 1 ]

(ii) Explain what is meant by the following terms:

genotype

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allele

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[ 4 ]

(e) The Hardy-Weinberg principle can be used to predict the expected frequencies of albino and non-albino alleles in a population. However, this principle can only be applied to populations which fulfil all of the following criteria:

- sexually reproducing organisms
- diploid organisms
- large populations
- randomly-mating populations.

The tiger, an endangered species of mammal, is undergoing a worldwide captive breeding programme in zoos.

Suggest why the Hardy-Weinberg principle cannot be used to predict the expected frequencies of albino and non-albino alleles in the worldwide zoo population of tigers.

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[2]

(f) A change in allele frequencies in a population is described as an evolutionary change.

List two factors that might cause allele frequencies to change from generation to generation in a population that meets the Hardy-Weinberg criteria.

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[ 2 ]

[Total: 16]

Question: 4

Animals respond to frightening or stressful stimuli in their environment.

This question is about the 'fight or flight' response in mammals.

Fig. 2.1 (on the insert) shows a husky dog in a calm state.

Fig. 2.2 (on the insert) shows a different husky displaying external signs of the 'fight or flight' response.

(a) Describe three features in the external appearance of the husky in Fig. 2.2 that are due to the 'fight or flight' response.

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[ 3 ]

(b) The 'fight or flight' response is brought about by the hormone adrenaline and the autonomic nervous system working together. As well as causing external differences in appearance, the 'fight or flight' response causes numerous changes in the functioning of the internal organs.

Complete Table 2.1 to describe how two internal organs would function differently in a calm mammal compared to a frightened mammal.

Table 2.1

| internal organ | calm mammal | frightened mammal |
|----------------|-------------|-------------------|
|                |             |                   |
|                |             |                   |

[ 6 ]

(c) The differences you described in part (b) are coordinated by the autonomic nervous system. The autonomic nervous system has two divisions, each of which uses a different neurotransmitter to bring about effects in the internal organs.

In the table below, state which division of the autonomic nervous system will be active in each case, and name the

neurotransmitter that will be secreted by neurones into the organs.

|  | calm mammal | frightened mammal |
|--|-------------|-------------------|
| division of the autonomic nervous system activated |             |                   |
| name of neurotransmitter secreted by neurones      |             |                   |

[ 4 ]

(d) State precisely where in the body adrenaline is produced.

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[ 2 ]

(e) The adrenaline molecule is not lipid-soluble, therefore it cannot pass directly through the cell surface membrane. In order to bring about changes inside the cell, adrenaline relies on a second messenger system.

(i) Describe the events that occur after adrenaline reaches the cell surface membrane that then result in changes in metabolism inside the cell cytoplasm.

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[ 4 ]

(ii) The second messenger system is a multi-step mechanism. It enables large changes in cell metabolism to occur rapidly, although only relatively small numbers of adrenaline molecules are involved.

Suggest how having a number of steps in the signalling pathway enables a small number of adrenaline molecules to rapidly cause large effects.

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[ 2 ]

[Total: 21]

Question: 5

(a) Organisms do not live in isolation, but interact with other organisms and with their physical environment.

State the word used to describe:

(i) the study of the interactions between organisms and their environment

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[ 1 ]

(ii) the physical (non-living) factors in the environment

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[ 1 ]

(iii) a physical area that includes all the organisms present and their interactions with each other and with the physical environment.

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[ 1 ]

(b) State and describe two types of ecological interaction that can occur between different species in a habitat.

As part of each description, you should name the two species involved in your chosen example.

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2

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[ 6 ]

(c) Plants are able to respond to changes in their environment.

(i) Describe two ways in which hormones may alter a plant's growth in response to overcrowding by other plants.

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[ 4 ]

(ii) Suggest how hormones alter a plant's growth if the top of the plant shoot is eaten by an animal.

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[ 3 ]

(d) The distribution and abundance of plants in a habitat can show how a physical factor varies across the habitat.

Describe how you would measure the distribution and abundance of plants over a distance of 100 metres.



*In your answer you should make clear the sequence of procedures you would follow.*

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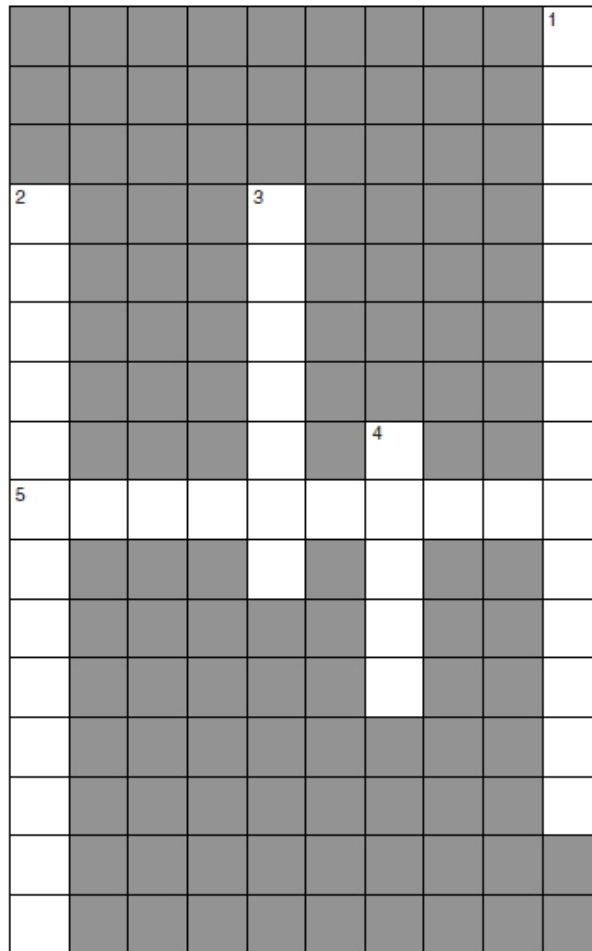
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[ 6 ]

[Total: 22]

Question: 6

Fig. 5.1 is a crossword that should contain five words relating to the use of microorganisms by humans.



[5]

Use the clues below to write the five appropriate words in the correct spaces on Fig. 5.1.

**ACROSS**

**5** Microbial culture method in which nutrients are added and the product harvested throughout the fermentation process.

**DOWN**

**1** Technique that makes enzymes more thermostable and allows them to be re-used.

**2** The industrial use of living organisms to produce food, drugs or other products.

**3** Sterile technique that prevents the growth of undesirable microorganisms

**4** Kingdom of eukaryotic microorganisms with cell walls made of chitin.



Question: 7

Homeobox genes show astonishing similarity across widely different species of animal, from fruit flies, which are insects, to mice and humans, which are mammals. The sequences of these genes have remained relatively unchanged throughout evolutionary history and the same genes control embryonic development in flies and mammals.

(a) State what is meant by a homeobox gene.

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[ 2 ]

(b) Homeobox genes show 'astonishing similarity across widely different species of animal'.

Explain why there has been very little change by mutation in these genes.

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[ 2 ]

(c) Frogs reproduce by laying eggs in water. Each egg develops into a tadpole, which has external gills to extract oxygen from the water, and a tail to help it swim. The tadpole gradually changes into an adult frog as it grows. During this time its gills and tail disappear.

List two cellular processes that must occur during the development of a tadpole into a frog.

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[ 2 ]

(d) Name another kingdom of organisms, other than animals, that have similar homeotic genes.

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[ 1 ]

[Total: 7]



Question: 8

Animals behave in ways that enhance their survival and reproductive capacity. This behaviour may be innate or learned.

(a) Describe what is meant by:

(i) innate behaviour

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[ 2 ]

(ii) learned behaviour.

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[ 2 ]

(b) Describe the advantages to animals of innate and learned behaviour, with reference to specific examples of each type of behaviour.



*Your answer should include both types of behaviour and make clear the advantages to the animals of your chosen examples.*

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[ 11 ]  
[Total: 15]

Question: 9

Molecular evidence has shown that all specimens of the English Elm tree, *Ulmus procera*, form a genetically isolated clone. English Elms developed from a variety of elm brought to Britain from Rome in the first century A.D.

Although English Elm trees make pollen, they rarely produce seeds. Instead they spread by developing structures known as suckers from their roots. Each sucker can grow into a new tree.

This tendency of elms to create suckers has been exploited by humans, who have separated the suckers, with roots attached, and used them to plant hedges and establish new woodlands.

(a) (i) Suggest a technique that could be used to provide molecular evidence that all English Elm trees form a clone.

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[ 1 ]

(ii) State why the English Elm clone is genetically isolated from other varieties of elm.

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[ 1 ]

(iii) State the name given to the process in which plants reproduce asexually by means such as suckers.

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[ 1 ]

(b) In 1967, a new, virulent strain of an elm disease fungus arrived in Great Britain on imported timber. Beetles that lived under the bark of elm trees spread the fungus.

The saws used to cut down dead branches were not sterilised after use. When the saws were used to prune healthy trees, these trees became infected. Approximately 25 million elm trees, most of the English Elm population, died within a few years of the arrival of this fungus.

Explain why there was such a rapid loss of elm trees in Britain as a result of this elm disease.

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[ 4 ]

(c) Elm trees respond to fungal infection by plugging their xylem vessels. The leaves on the upper branches of the tree then turn yellow and die. When most of the branches have lost their leaves and died, the roots are weakened and may also die.

(i) Explain why the plugging of xylem vessels will result in the leaves of the upper branches turning yellow.

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[ 2 ]

(ii) Explain why the loss of leaves from the tree may result in the death of the tree's roots.

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[ 2 ]

(d) Many ornamental plants for gardens can be cloned by tissue culture.

Describe the process of cloning plants by tissue culture.



*In your answer you should make clear the order in which the steps of the process occur.*

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[ 7 ]

(e) List two advantages and two disadvantages of cloning plants by tissue culture.

advantage 1

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advantage 2

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disadvantage 1

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disadvantage 2

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[ 4 ]  
[Total: 22]

Question: 10

Wading birds (waders) are birds that feed in shallow water. Table 4.1 shows changes in the population size of four species of wader in two areas of the Western Isles off the coast of Scotland.

- Area 1 is an area that has remained free of hedgehogs.
- Area 2 is an area where four hedgehogs were introduced from the mainland in 1974.

Since then, they have established a large population.

Hedgehogs eat the eggs of ground-nesting birds like waders.

Table 4.1

|                         |      | number of breeding pairs of wader birds |      |                            |  |
|-------------------------|------|---|------|----------------------------|--|
|                         |      | area 1 (hedgehogs absent)               |      | area 2 (hedgehogs present) |  |
| species of wader \ year | 1983 | 2000                                    | 1983 | 2000                       |  |
| lapwing                 | 1104 | 1364                                    | 1869 | 1287                       |  |
| redshank                | 486  | 733                                     | 1288 | 760                        |  |
| dunlin                  | 803  | 558                                     | 2016 | 884                        |  |
| snipe                   | 172  | 154                                     | 655  | 280                        |  |

(a) (i) Calculate the percentage decrease in the number of breeding pairs of snipe in area 2 between 1983 and 2000.

Show your working.

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Answer = .....%

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[ 2 ]

(ii) Use the data in Table 4.1 to describe and explain the effect of the introduction of hedgehogs on the number of breeding pairs of waders in area 2.

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[ 6 ]

(iii) Suggest two factors that might have allowed a large population of hedgehogs to increase from just four individuals in area 2.

Explain how each factor has led to an increase in the hedgehog population.

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2

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[ 4 ]

(b) Three suggested methods to reduce the effect of hedgehogs on the numbers of waders in area 2 were considered. These were:

- trapping and moving hedgehogs to the mainland
- trapping hedgehogs and keeping them in captivity indefinitely
- trapping of hedgehogs followed by humane killing.

The third method was judged to be the most effective and likely to succeed in reducing hedgehog numbers.

Comment on the ethical issues involved in making this decision.

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[ 3 ]

[Total: 15]

Question: 11

Describe the differences between:

(a) somatic cell gene therapy and germ line cell gene therapy

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[ 2 ]

(b) the central nervous system and the peripheral nervous system

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[ 4 ]

(c) prophase 1 of meiosis and prophase 2 of meiosis.

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[ 2 ]  
[ Total: 8 ]

Question: 12

(a) Microorganisms include fungi and bacteria. Fungi are eukaryotes. Bacteria are prokaryotes.

Describe one distinctive feature of the cell structure of each of these microorganisms.

fungus cell

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bacterial cell

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[ 2 ]

(b) The use of microorganisms in biotechnology involves aseptic technique. Aseptic technique prevents pathogens contaminating products.

What is meant by the term pathogen?

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[ 1 ]

(c) State what is meant by biotechnology using suitable examples from different areas of biotechnology and explain why microorganisms are used in biotechnological processes.



*In your answer you should give examples of products and the microorganisms used to make them, as well as the advantages of using microorganisms.*

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[ 8 ]

[Total: 11]



Question: 13

Total plant growth within an ecosystem depends on the light intensity, temperature and the supply of water and inorganic minerals to the ecosystem.

Table 3.1 shows the net primary production by plants in four different ecosystems.

**Table 3.1**

| ecosystem           | net primary production<br>(kJ m <sup>-2</sup> year <sup>-1</sup> ) |
|---------------------|--|
| temperate grassland | 9240   |
| temperate woodland  | 11340  |
| tropical grassland  | 13440  |
| tropical rainforest | 36160  |

(a) Discuss possible reasons for the differences in net primary production in these ecosystems.

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[ 4 ]

(b) To calculate the net primary production figures in Table 3.1 in kJ m<sup>-2</sup> year<sup>-1</sup>, it is necessary to measure the energy content of the primary producers.

Outline how the energy content, in kJ, of a primary producer such as grass can be measured in the laboratory.

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[ 2 ]

(c) The efficiency with which consumers convert the food they eat into their own biomass is generally low.

Table 3.2 compares the energy egested, absorbed and respired in four types of animal.

Table 3.2

| animal                            | percentage of energy consumed that is: |          |          |                      |
|-----------------------------------|--|----------|----------|----------------------|
|                                   | egested                                | absorbed | respired | converted to biomass |
| grasshopper, a herbivorous insect | 63                                     | 37       | 24       | 13                   |
| perch, a carnivorous fish         | 17                                     | 83       | 61       | <input type="text"/> |
| cow, a herbivorous mammal         | 60                                     | 40       | 39       | <input type="text"/> |

|                              |    |    |    |   |
|------------------------------|----|----|----|---|
| bobcat, a carnivorous mammal | 17 | 83 | 77 | 6 |
|------------------------------|----|----|----|---|

(i) Complete Table 3.2 to show the percentage of energy consumed that is converted into biomass in the perch and the cow.

You may use the space below for your working.

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[ 2 ]

(ii) Describe and explain, using the data from Table 3.2, how the trophic level of a mammal affects the percentage of its food energy that it is able to convert to biomass.

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[ 3 ]

(iii) Using the data from Table 3.2 and your knowledge of energy flow through food chains, suggest which of these four animals could be farmed to provide the maximum amount of food energy in  $\text{kJm}^{-2} \text{year}^{-1}$  for humans.

Explain the reasons for your choice.

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[ 3 ]

[Total: 14]

Question: 14

The antibiotic penicillin is produced by batch culture of the fungus *Penicillium chrysogenum*.

(a) Fig. 4.1 shows the concentration of penicillin, lactose and ammonia as well as the fungal biomass over time when penicillin is being produced by batch culture.

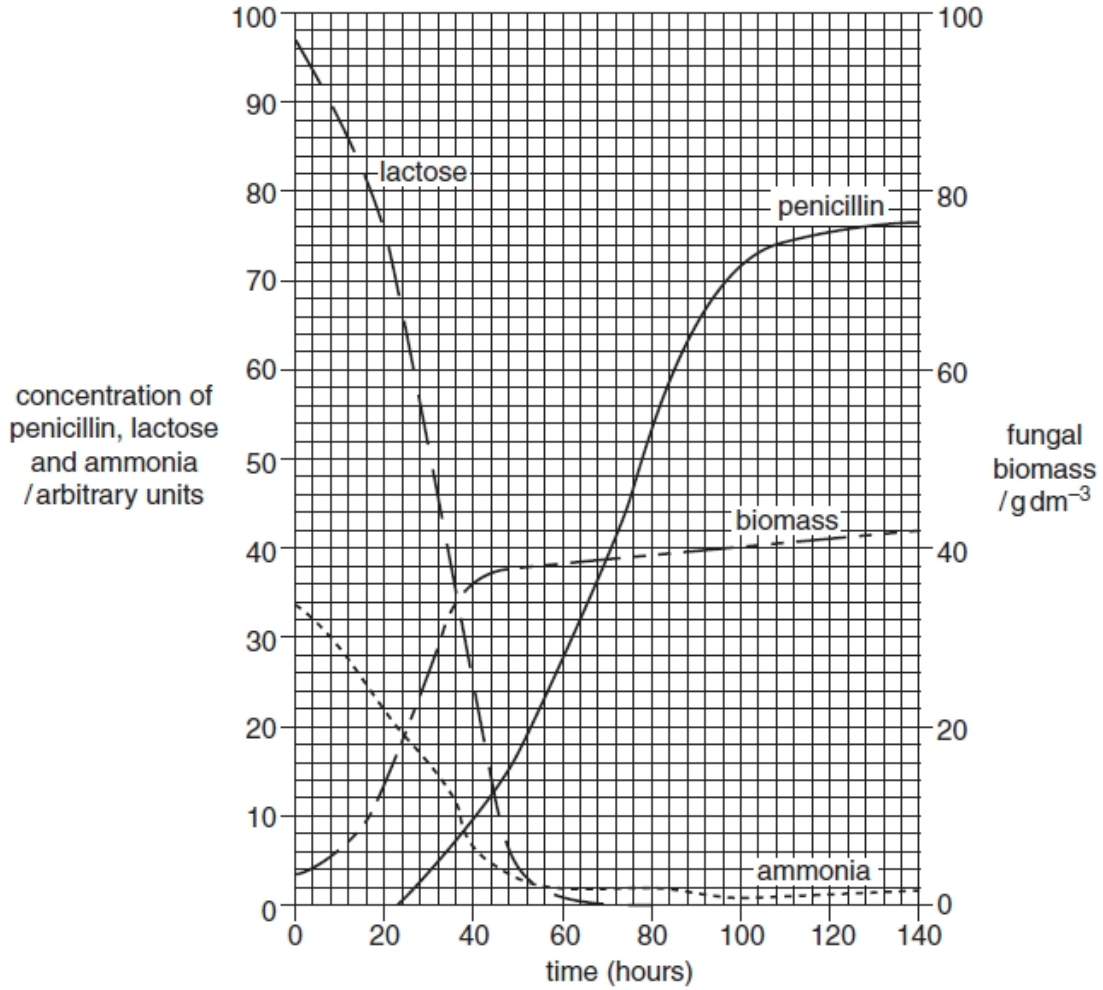


Fig. 4.1

(1) With reference to Fig. 4.1, describe and explain the changes in concentration of lactose and ammonia.

description

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explanation

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[ 4 ]

(ii) A student incorrectly suggested that penicillin might be produced by continuous culture fermentation instead of by batch culture.

Suggest how the curves for lactose, ammonia and biomass on Fig. 4.1 might differ in continuous culture.

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[ 2 ]

(iii) A second student said that continuous culture would not be suitable, as penicillin is a secondary metabolite.

What evidence is there in Fig. 4.1 that penicillin is a secondary metabolite?

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[ 2 ]

(b) (i) Explain the importance of maintaining aseptic conditions in manufacturing penicillin by fermentation.

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[ 3 ]

(ii) State three physical or chemical factors within the fermenter, other than nutrient levels, that need to be monitored and controlled.

For each factor, explain why it must be controlled.

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[3]

[Total: 14]

Question: 15

This question is about genetic engineering and the techniques used for making multiple copies of genes (gene cloning).

(a) Genetic engineering uses the following:

- A an enzyme that synthesises new DNA
- B an enzyme that cuts DNA at specific sequences
- C an enzyme that reseals cut ends of DNA
- D small circular pieces of DNA found in bacteria; these pieces of DNA have antibiotic resistance genes
- E an enzyme found in some viruses with an RNA genome; this enzyme converts RNA into DNA.

Name A to E.

A

B

C

D

E

[ 5 ]

(b) Genes are cloned for a number of reasons. For example,

- one group of research scientists at a hospital wanted to sequence a disease-causing mutation to learn more about a human disease; these scientists started their research using white blood cells;
- another group of scientists at a biotechnology company wanted to clone the insulin gene in order to manufacture its protein product to treat diabetes; these scientists started their research using cells from the pancreas.

Suggest and explain the biological reasons why the two groups each started with a different cell.

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[ 4 ]

(c) A gene can be cloned in vitro (in a test-tube) by the polymerase chain reaction (PCR). Alternatively, a gene can be cloned in vivo (in living cells) by introducing the gene into bacterial host cells.

Table 5.1 identifies some of the key steps in each process.

**Table 5.1**

| <i>in vitro</i> gene cloning (PCR)   | <i>in vivo</i> gene cloning   |
|--|---|
| At 95 °C, DNA extracted from a cell separates into two strands.                        | A library of gene fragments is produced and introduced into host bacteria.              |
| At 50 °C, specially-made primer sequences attach to the ends of the desired gene only. | Bacteria are screened for antibiotic resistance to identify those with recombinant DNA. |
| At 72 °C complementary copies of both DNA strands are made.                            | A gene probe is used to select the bacterial colony containing the desired gene.        |
| The cycle of temperature changes is repeated and more copies of the gene are made.     | This colony is grown on in nutrient broth and the DNA is then purified.                 |

Compare the two processes of gene cloning by explaining the advantages of each.



*In your answer you should ensure that clear comparisons between the two processes are made and explained.*

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[ 8 ]

[Total: 17]

