

Data Response Practice

PRACTICE 1

Pyruvate dehydrogenase is a tetrameric enzyme found in the mitochondria that catalyses the conversion of pyruvate to acetyl CoA during cellular respiration.

The activity of pyruvate dehydrogenase is inhibited by acetyl Co-A.

Fig. 1 shows the relationship between the initial rate of reaction of pyruvate dehydrogenase activity and the concentration of pyruvate at the optimal temperature and pH of the enzyme. All other variables are kept constant.



Fig 1

(a) Comment on the trend shown on the graph. [6]

(b) On Fig 1, sketch and label a curve to show the effect of adding acetyl Co-A on the initial rate of reaction of pyruvate dehydrogenase activity. [1]

Fig. 2 shows the effect of increasing temperature on the activity of three protein-digesting enzymes:

- thermitase from thermophilic Thermoactinomyces vulgaris
- subtilisin from Bacillus subtilis
- modified subtilisin



Fig. 2

(a) Describe, with reference to Fig. 2, the effect of temperature on the rate of protein digestion by thermitase.

(b) Modified subtilisin is similar to subtilisin, but had eight of its amino acids replaced with different amino acids.

Describe **and** explain the effect of this modification on the activity of subtilisin. [4]

PRACTICE 3

In 1954, an article was published in the British Medical Journal entitled, *The mortality of doctors in relation to their smoking habits*.

One aspect of the investigation studied a very large number of doctors in the UK aged 35 years and older. A survey established the quantity of tobacco smoked per day.

Twenty-nine months later, the case of any deaths in the study group was recorded.

Table 3 summarises the results obtained.

| | Number of deaths | Death rate per year per 1000 men in the study | | | |
|------------------------------------|------------------------|---|-----------------------------|-------|---------------------------|
| Cause of death | | Non- | Smokers, tobacco smoked / g | | ked / g day ⁻¹ |
| | | smokers | 1-14 | 15-24 | 25 and above |
| Coronary thrombosis (heart attack) | 235 | 3.89 | 3.91 | 4.71 | 5.15 |
| Lung cancer | 36 | 0.00 | 0.48 | 0.67 | 1.14 |

Table 3

| (a) | State which group in the study is most at risk from dying of lung cancer. | [1] |
|-----|--|------------|
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| | | |
| (b) | Using information from Table 3 to support your answer, discuss the evidence linking toba smoking to coronary thrombosis and early death. | cco [4] |
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| (c) | Suggest a significant limitation of this study. | [1] | |
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p53 is a tumor suppressor protein which plays an important role at cell cycle checkpoints. An experiment was carried out to investigate the effect of p53 on the cell cycle in human liver cells. Two types of cells were used in the investigation, one with normal *p53* gene and the other with mutated *p53* gene, resulting in p53-deficient cells. Both cell types were subjected to γ -radiation, which is a DNA damaging agent.

Mitotic index of the cells were then measured and the results are shown in Fig. 4. Mitotic index reflects the percentage of cells in a population that are dividing. It is calculated by counting the number of cells with condensed chromosomes and dividing it by the total number of cells observed.





(a) With reference to Fig. 4, account for the difference in results obtained after 12 hours. [3]

A chemical substance, 2-carboxy-D-arabitinol 1-phosphate (also known as CA1P), is naturally found in plants and it is structurally similar (analogue) to ribulose bisphosphate (RuBP).

Fig. 5 is a graph showing the effects of adding CA1P to a sample of purified chloroplasts. A control containing chloroplasts in the absence of CA1P was also set up. Light intensity, carbon dioxide concentration and temperature were kept constant.



Fig. 5

(a) With reference to Fig. 5, describe and explain the effect of CA1P on carbon fixation. [4]

A recent research study indicates that bed bugs have increased resistance to neonicotinoids, the most widely used insecticide in the world. Resistant strains were found to have elevated detoxifying enzymes. Scientists say non-chemical methods of control now need to be considered.

Fig. 6 shows the volumetric units of insecticides used per thousand household per month, over a period of eleven years from 1984 to 1994. The figure also shows the percentage of infestations each year caused by resistant strains of *Cimex lectularius*.



Fig. 6

- (a) With reference to Fig. 6,
 - (i) Describe and explain the trend in percentage of infestations each year caused by resistant strains of *Cimex lectularius* between 1986 and 1993. [3]

(ii) Use evidence from the graph to suggest why the percentage of infestations each year caused by resistant strains of *Cimex lectularius* decreased in 1994 compared to previous years.

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People with Alzheimer's disease (AD) lose their ability to form new memories. One form of AD is caused by a mutation of the amyloid precursor protein (APP) gene, which encodes the APP transmembrane glycoprotein. when APP is incorrectly cleaved, an insoluble protein known as β -amyloid will be formed. This results in the formation of hard, insoluble plaques. These plaques accumulate in the brain of an individual with AD.

It was hypothesised that plaque formation was dependent on two critical factors:

- the type of organism human and mouse
- the type of cells nerve and monocytes.

To investigate these factors, a solution containing a fixed concentration of β -amyloid was added to three different samples labelled **1** to **3** and incubated for a fixed duration of time.

Fig. 7.1 shows plaque formation after the incubation, as measured and recorded as percentage plaque formation.



Fig. 7.1

(a) With reference to Fig. 7.1, evaluate the extent to which these factors promote plaque formation. [4]

Further investigation was conducted to find out the effect of heating on plaque formation in human monocytes. A solution containing a fixed concentration of β -amyloid was added to a sample of heat-killed monocytes and living monocytes respectively. These samples were then incubated for a fixed duration of time. Control for each sample was set up where no β -amyloid was added.

Fig. 7.2 shows the results of the investigation.



Fig. 7.2

(b) With reference to Fig. 7.2, describe the effect of heating on plaque formation in monocytes with and without β-amyloid. [2]

- (c) Another genetic disease that leads to a loss of brain function is Huntington's disease. The gene involved contains a section of DNA with many repeats of the base sequence CAG. The number of these repeats determines whether or not an allele of this gene will cause Huntington's disease.
 - An allele with 40 or more CAG repeats will cause Huntington's disease.
 - An allele with 36-39 CAG repeats may cause Huntington's disease.
 - An allele with fewer than 36 CAG repeats will not cause Huntington's disease.

Fig. 7.3 shows the age at which a sample of patients with Huntington's disease first developed symptoms and the number of CAG repeats in the allele causing Huntington's disease in each patient.



Fig. 7.3

(i) People can be tested to see whether they have an allele for this gene with more than 36 CAG repeats. Some doctors suggest that the results can be used to predict the age at which someone will develop Huntington's disease.

| | Use the information in Fig. 7.3 to evaluate this suggestion. | [2] |
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| (ii) | Huntington's disease is always fatal. Despite this, the allele is passed on in populations. | human |
| | With reference to Fig. 7.3, suggest and explain why this is so. | [2] |
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PRACTICE 8 Unlike the animals where the oxygen is obtained through breathing, plants have to first synthesize oxygen through photosynthesis.

A scientist carried out the following experiment to investigate the effect of light intensity on the rate of oxygen produced from a water plant, Elodea.

- Elodea was cut into three pieces, each 10 cm long. •
- Each piece of *Elodea* was placed in a glass tube, containing 0.5% sodium hydrogen • carbonate solution, which was then sealed with a bung.
- Tube **A** was placed 10 cm away from a lamp. •
- Tube **B** was placed 5 cm away from a lamp.
- Tube **C** was placed in a dark room.
- An oxygen sensor was used to measure the percentage of oxygen in the solutions at the • start of the experiment and again at 5, 10 and 20 minutes.

The results are shown in Fig. 8.



Fig. 8

(a) With reference to Fig. 8, calculate the rate of oxygen production for tube A from 0 to 5 minutes of the experiment.

Express your answer to two decimal places. Show your working. [1]

(b) Compare the results for tubes A and B. [4]

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PRACTICE 9

In an attempt to control the spread of dengue, using genetic modification, a piece of DNA is inserted into the *Aedes aegypti* mosquito genome at the embryonic stage. This DNA contains a lethal gene (*tTAV* gene) which codes for a protein called tTAV. This protein acts as a molecular switch to shut down the expression of **all** other genes, leading to death of the insect.

This tTAV protein, however, is inactivated by a compound called tetracycline, which is incorporated into the food that the developing larvae feed on. Hence, the genetically-modified (GM) larvae survive to adulthood, with much of the tetracycline still remaining in them. Male GM mosquitoes are then selected to breed with females to produce large number of offspring. The male GM offspring are selected and fed with tetracycline until they reach adulthood. They are then released into the wild to mate with wild-type females. Any offspring larvae produced will contain the *tTAV* gene, which is expressed to cause death of the larvae.

(a) Suggest two advantages of using GM mosquitoes over the use of pesticides in controlling the spread of dengue. [2]



Male GM mosquitoes have been used in open field trials in countries such as Cayman Islands. The town where the *Aedes aegypti* mosquitoes predominate was divided into three areas, as shown in Fig. 9.1.

- Area A the treatment site where male GM mosquitoes are released
- Area **B** buffer zone
- Area **C** the non-treated control site

The mosquito populations in area **A** and area **C** were measured using an ovitrap – a device that is attractive as an egg-laying site for female mosquitoes.



Fig. 9.1

(b) (i) State why the release of male GM mosquitoes in area A will not increase the risk of transmission of dengue.



The number of ovitraps that contain eggs were recorded every week for 6 months. Fig. 9.2 shows the ovitrap index, which is calculated based on the percentage of ovitraps containing eggs.



Fig. 9.2



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