Applications of cell biology

Question Paper

Level	Pre U
Subject	Biology
Exam Board	Cambridge International Examinations
Topic	The Cell
Sub Topic	Applications of cell biology
Booklet	Question Paper

Time Allowed: **75 minutes**

Score: **/62**

Percentage: **/100**

Part - A

1 Lack of vitamin A in the diet is a major problem in the rice-based societies of south-east Asia. Rice plants produce the precursor of vitamin A, β-carotene, in their green tissues, but not in the edible endosperms of their seeds.

Rice seeds lack the enzymes for two steps of the pathway for β-carotene production. The genes for these two enzymes have been inserted into rice embryos by genetic engineering, giving rise to Golden Rice™. This rice produces seeds containing β-carotene.

The added genes were:

- the *psy* gene from daffodil plants,
- the *crt* 1 gene from the bacterium *Erwinia uredovora*.

(a) Explain why it is possible for rice plants to express genes from a bacterium.

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(b) The following steps were taken to produce Golden Rice™:

- **step 1** – a length of DNA was made including a rice endosperm-specific promoter + *psy* + *crt* 1,
- **step 2** – copies of this length of DNA were inserted into plasmids from the bacterium *Agrobacterium tumefaciens*,
- **step 3** – *A. tumefaciens* containing the plasmids were mixed with rice embryos in tissue culture,
- **step 4** – the embryos were grown into plantlets and then plants.

(i) Describe the role of the rice endosperm-specific promoter that was added to *psy* and *crt* 1 in **step 1**.

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(ii) Explain how a length of DNA can be inserted into a plasmid in **step 2**.

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(iii) Suggest why *A. tumefaciens* containing plasmids were used in **step 3**.

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(iv) State **one** method that is commonly used to insert DNA into cells of monocotyledonous plants.

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(c) The concentration of β-carotene in the seeds from the field trial of the original strain of Golden Rice™ in 2004 was only about $6\,\mu g\,g^{-1}$. The rate-limiting step in the production of β-carotene was found to be the activity of the enzyme encoded by the *psy* gene.

Suggest what is meant by a *rate-limiting step* in a metabolic pathway.

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(d) The concentration of β-carotene was increased by breeding with other varieties of rice and by further genetic engineering. More recent strains, such as Golden Rice 2™, contain about $31\,\mu g\,g^{-1}$ of β-carotene in the endosperm of its seeds.

Suggest what further genetic engineering was carried out to increase the concentration of β-carotene in rice seeds.

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(e) Field trials of genetically engineered crops, such as Golden Rice™, hope to identify any risks to the environment or to human health of growing and eating the crops.

Suggest:

(i) one possible risk to the environment of growing a genetically engineered crop;

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(ii) one possible risk to human health of eating a genetically engineered crop.

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[Total: 15]

2 ATP is a nucleotide that performs many essential roles in prokaryotic and eukaryotic cells. It is considered to be the major 'energy currency' of cells.

Fig. 21.1 shows the structure of ATP.

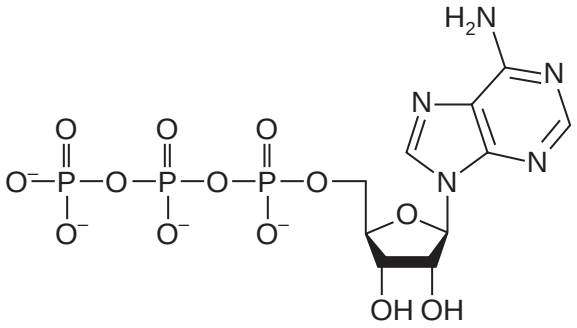

Fig. 21.1

(a) (i) Explain why ATP is said to be an 'energy currency' and describe the features of a molecule of ATP that make it suitable for its role.

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(ii) Describe an example of ATP acting as an 'energy currency'.

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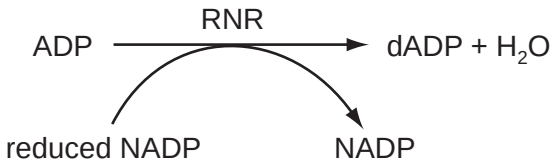
(b) The enzyme ribonucleotide reductase (RNR) is needed for DNA synthesis. The enzyme catalyses the reaction in which adenosine diphosphate is converted to deoxyadenosine diphosphate (dADP).



(i) State how adenosine diphosphate differs from deoxyadenosine diphosphate.

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(ii) Suggest how dADP is used in the synthesis of DNA.

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(c) Excess adenosine is deaminated to deoxyinosinol in a reaction catalysed by the enzyme, adenosine deaminase (ADA), which consists of one polypeptide.

Fig. 21.2 shows a ribbon model of ADA.

Fig. 21.2

Describe the structure of the enzyme, ADA, as shown in Fig. 21.2. You may add labels to the diagram to help your answer if you wish.

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A deficiency of ADA is a cause of severe combined immunodeficiency syndrome (SCID).

Children with non-functional adenosine deaminase are at risk of infections as a toxic product builds up inside T lymphocytes (T cells) and kills these cells.

(d) Outline the roles of named T lymphocytes in the immune system.

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(e) Gene therapy has been used to treat SCID.

Explain the problems encountered in using gene therapy as a treatment for genetic diseases, such as SCID.

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[Total: 19]

Part - B

3 It is possible to restore insulin secretion in a diabetic patient by transplanting a pancreas or isolated islets of Langerhans, but limited donor organs and risks involved restrict these therapies to a small proportion of people with diabetes. Recent experiments suggest that it may, in future, be possible to treat diabetes with adult stem cells from the patient's own bone marrow.

Explain why such an approach, once perfected, is more likely to offer, at least initially, a treatment for type 1 rather than type 2 diabetes **and** discuss why this approach may be preferable to the use of transplants or embryonic stem cells.

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Part - B

4 **(a)** Outline the advantages of using a patient's own stem cells to treat a damaged bronchus, as described in the passage, rather than transplanting a complete bronchus.

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

Distinguish between multipotent cells and totipotent cells.

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(c) Name three types of cell which may form from bone marrow stem cells.

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5 A cybrid (cytoplasmic hybrid cell) is produced as shown in Fig. 7.1.

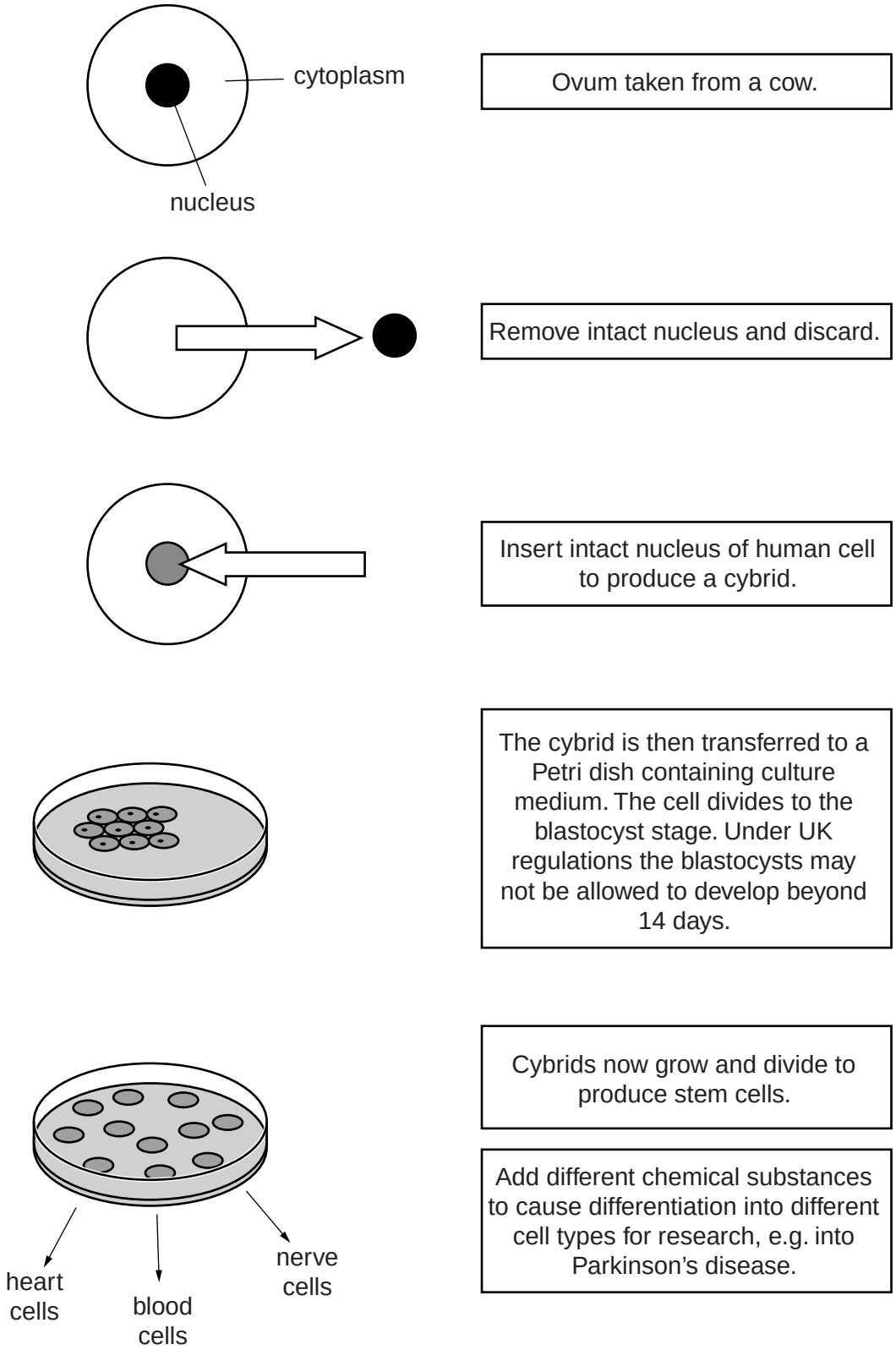

Fig. 7.1

(a) The DNA of such a cybrid is 99.6% human. The remaining 0.4% of the DNA is in the cytoplasm. Explain why there is DNA in the cytoplasm of the cybrid.

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(b) 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.

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(c) 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.

Explain what is meant by cancer and suggest why there might be a connection between the use of stem cells in treatment and cancer.

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[Total: 10]