

# 3.4 Genetic Modification & Biotechnology

## Question Paper

Course	DP IB Biology
Section	3. Genetics
Topic	3.4 Genetic Modification & Biotechnology
Difficulty	Medium

**Time allowed:** 60  
**Score:** /50  
**Percentage:** /100

**Question 1a**

- a) State **two** features that allow nucleic acids or proteins to be separated by gel electrophoresis.

[2 marks]

**Question 1b**

- b) During gel electrophoresis of a sample of DNA fragments,
- Identify which electrode the DNA would move towards. Justify your answer.
  - State which component of DNA gives it its charge.

[3 marks]

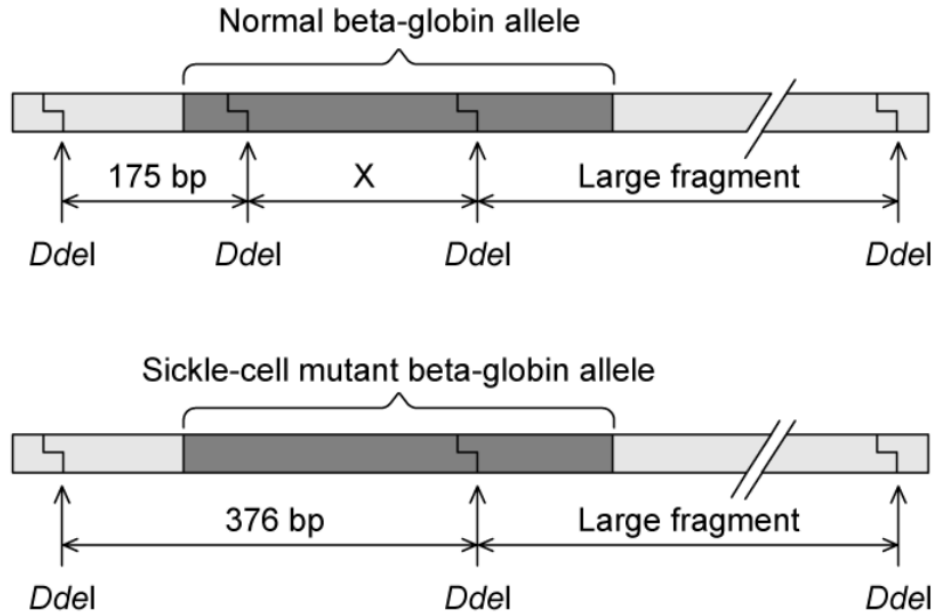
**Question 1c**

- c) State which class of enzymes can be used to cleave DNA into fragments prior to gel electrophoresis.

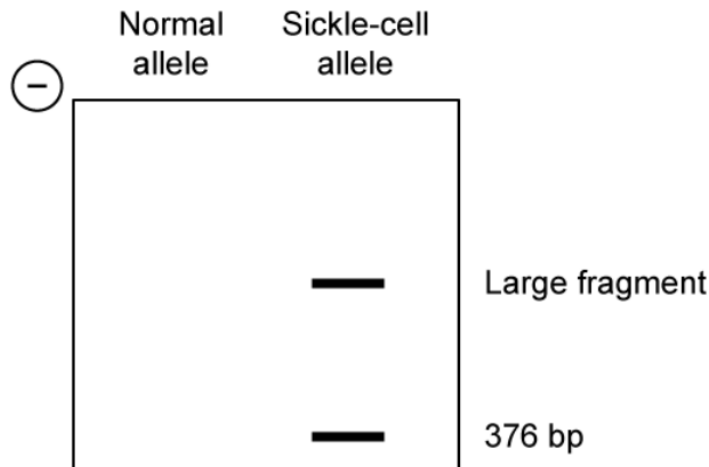
[1 mark]

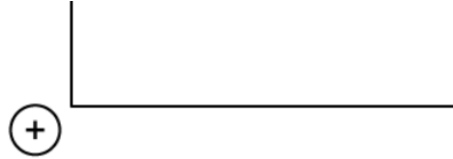
## Question 1d

- d) Restriction enzymes and gel electrophoresis can be used in genetic screening, to identify genes associated with a disease. The mutation of the Beta-globin gene which gives rise to sickle-cell anaemia removes a recognition site of the restriction enzyme *Ddel* as shown in the diagram below. The lengths of some fragments are shown in base pairs (bp).



- i) Deduce the size of **fragment X**.
- ii) *Ddel* digested DNA from an individual who was a carrier for the sickle-cell beta-globin gene was analysed with gel electrophoresis as shown below. Draw and label the DNA fragments that would result from a normal individual.





[3 marks]

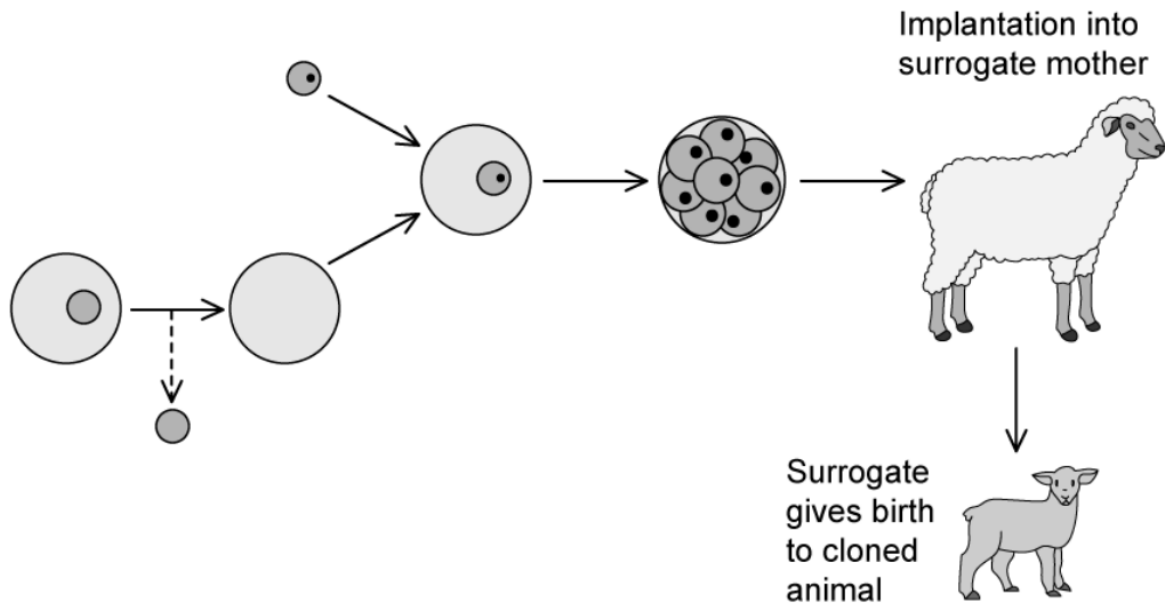
### Question 2a

- a) Explain what is meant by the term, 'clones'.

[1 mark]

**Question 2b**

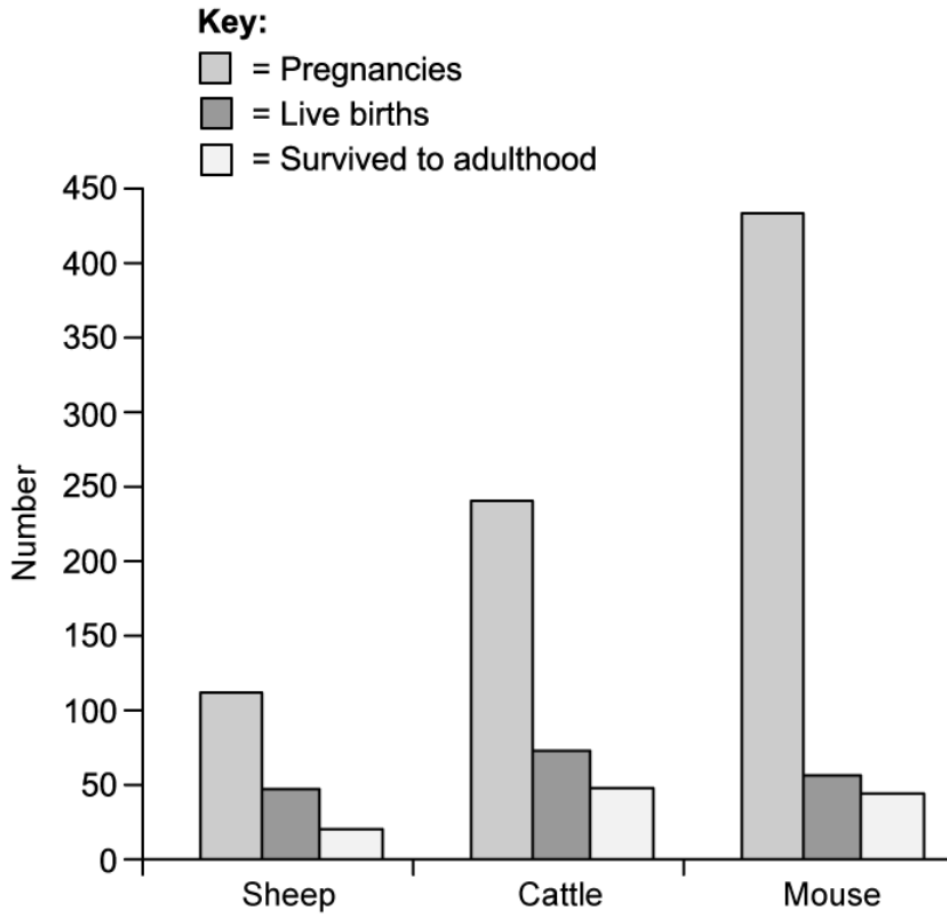
- b) The diagram below outlines the process of somatic cell nuclear transfer that was used to create Dolly the sheep. Describe each of the different steps that lead up to implantation.



[4 marks]

**Question 2c**

c) The graph below shows the survival rates for different cloned animals.



i) Identify trends in the data.

ii) State why this data could not be used in isolation to assess the successfulness of animal cloning.

[3 marks]

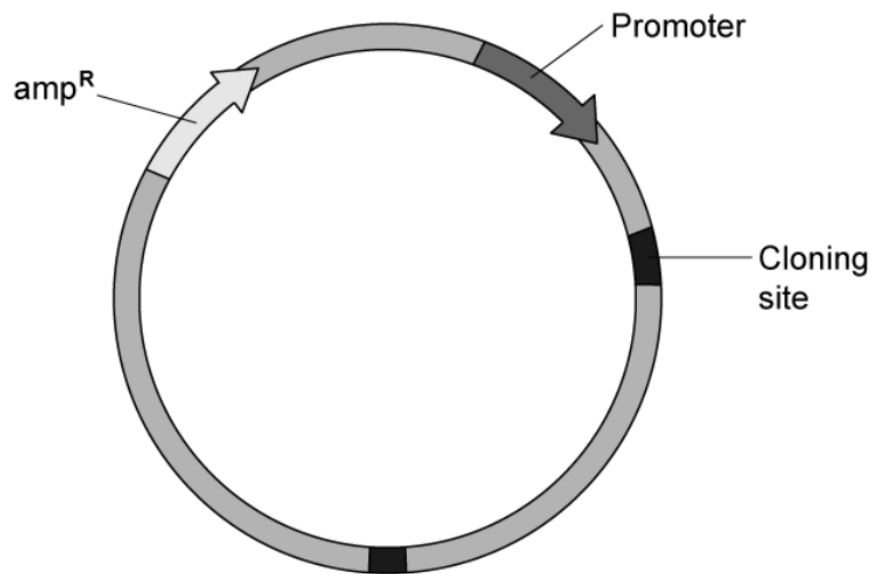
**Question 3a**

- a) Describe what a genetically modified “transgenic” organism is.

[2 marks]

**Question 3b**

- b) A bacterial plasmid used for recombinant DNA technology is represented in the diagram below. The *amp<sup>R</sup>* gene encodes for antibiotic resistance.



Explain the usefulness of the *amp<sup>R</sup>* and promoter elements in recombinant DNA technology.

[2 marks]



**Question 3c**

- c) Before the discovery of recombinant DNA technology, diabetics had to be treated with animal insulin obtained directly from animal pancreatic tissue which led to many complications and premature deaths.

Outline the key steps involved in the commercial production of human recombinant insulin.

[5 marks]

**Question 4a**

- a) The table below shows historic annual mortality from different public health diseases.

<b>Global mortality (millions)</b>	<b>2010</b>	<b>2017</b>
Vitamin A deficiency	2.8	1.9
HIV/AIDS	1.8	0.9
Tuberculosis (TB)	1.4	1.6
Malaria	0.7	0.5

Genetic modification has assisted in the fight against four major human diseases. Calculate the disease which showed the largest percentage drop in global mortality in the period 2010 - 2017.

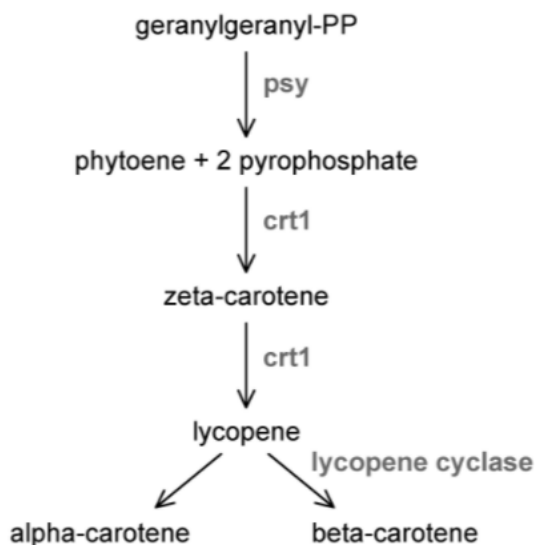
[1 mark]

**Question 4b**

b) Vitamin A deficiency is prevalent in many developing countries as a result of poor nutrition and is a common source of blindness. ‘Golden Rice’ is a variety of genetically modified rice developed to produce beta-carotene (pro-vitamin A). Golden rice was created by introducing rice with the following beta-carotene biosynthesis genes:

- *psy* (phytoene synthase) from wild daffodil (*Narcissus pseudonarcissus*)
- *crt1* (phytoene desaturase) from a soil bacterium (*Erwinia uredovora*)

The pathway for beta-carotene biosynthesis is shown below.



The table below shows the total amount of beta-carotene produced when different *psy* genes were inserted into ‘Golden Rice’

Transgene source	Total beta-carotene (arbitrary units)
<i>Arabidopsis thaliana</i> (thale cress)	410
<i>Daucus carota</i> (wild carrot)	430
<i>Narcissus pseudonarcissus</i> (wild daffodil)	380
<i>Zea mays</i> (maize)	1 800
<i>Capsicum annuum</i> (cayenne pepper)	800

Originally, ‘Golden rice’ did not accumulate high levels of beta-carotene. Identify, with a reason, how it was improved.

[2 marks]

**Question 4c**

- c) Discuss the risks and benefits associated with GM crops.

[6 marks]

**Question 5a**

*One mark is available for clarity of communication throughout this question.*

- a) Archaeologists in Pompeii recently discovered the remains of seven human skeletons within a house that was buried under volcanic ash when Mount Vesuvius erupted during ancient Roman times in 79 AD. Researchers were interested to know if the skeletons were from related individuals, they isolated DNA from the skeletons and used it in the Polymerase Chain Reaction (PCR).

PCR utilises multiple cycles of three simple steps, describe these steps and suggest why the researchers used PCR in their investigation.

[5 marks]

**Question 5b**

- b) DNA profiling was carried out on the PCR products to identify if the skeletons came from related individuals. The results are seen in the image below.

Adult A	Adult B	Adult C	Adult D	Child 1	Child 2	Child 3
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It was determined that the three children were siblings and shared the same biological parents. Their mother is **Adult B**.

- i) Predict which adult is the children’s father. Justify your answer.
- ii) Suggest why the profiles for Child 1 and Child 2 are the same.

[3 marks]

**Question 5c**

- c) Outline the method by which DNA profiling is undertaken and describe why it is a useful technique.

[7 marks]