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VCE Biology ¾

AOS 1 Revision [1.0]

SAC 8 Solutions

40 Marks.

Section A: SAC Questions (40 Marks)

Roundup Resistant Canola

- An herbicide is a chemical that is able to kill plants by inhibiting their growth or blocking important metabolic processes. Roundup Ready canola **(RRcanola)** has been genetically modified to be resistant to the Roundup herbicide.
- Roundup herbicide contains an inhibitor called glyphosate, which blocks an important enzyme 5-enolpyruvylshikimate 3-phosphate (EPSPS) which blocks aromatic amino acid production essential for plant growth. This inhibition ultimately blocks the pathway that can produce essential proteins needed for plant growth.
- The **RRcanola** can produce an alternative ESPSP enzyme that is not affected by the Roundup inhibitor. Therefore, the essential proteins for growth are still able to be produced, and the plant survives.

Space for Personal Notes

Question 1 (13 marks)

Roundup Ready canola (RRcanola) can be purchased and used by Australian farmers with a holding licence. As the name suggests, it is resistant to the glyphosate chemical that is the active ingredient in roundup. When the Roundup herbicide is sprayed on the crop, the weeds are killed, and the canola crop can survive.

a.

i. Discuss an ethical concern that could be raised about the use of **RRcanola** on the local environment and ecosyster

a. i) Discuss an ethical concern that could be raised about the use of RRcanola on the local environment and ecosystems.

- The use of a genetically modified canola crop (RRcanola) may have unknown long-term effects on the ecosystem, including decreasing the natural biodiversity of wild canola species, as well as its presence potentially disrupting the functioning of the ecosystem.
- the potential of interbreeding among RRcanola and wild type, may decrease genetic variety; hence doing more harm than good (consequence-based) 2 marks

ii) State an ethical concept addressed in your discussion and propose a feasible solution to this

ii. State an ethical concept addressed in your discussion and propose a feasible solution to this ethical concern. (2 marks)

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- the potential of interbreeding's negative effects can be minimised by isolating RRcanola and growing these crops in a regulated environment.
- Thus following concept of non-maleficence by attempting to reduce potential harm on ecosystem.
- this will reduce chances of interbreeding and chances of causing long term effects on ecosystem and biodiversity.

In order to produce **RRcanola**, a resistant gene, needs to be transported into the genome of the canola cells.

The diagram in **Figure 1**, below outlines this general process, using a bacterium called *Agrobacterium tumefaciens*.

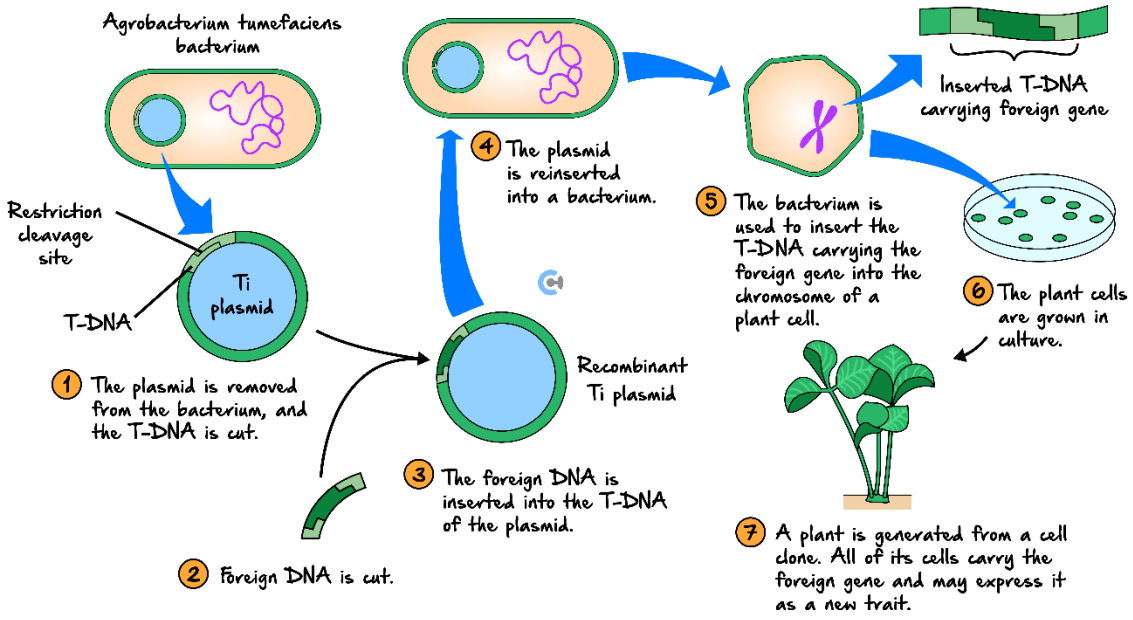

Figure 1

To achieve **step 4** in **Figure 1**, recombinant plasmids and bacteria are mixed together.

b. Explain the term recombinant plasmid. (1 mark)

- plasmid which contains genetic (DNA/gene) material sourced from two or more different species. ✓

c. Describe the process of producing a recombinant plasmid and name the two enzymes involved in this process. (3 marks)

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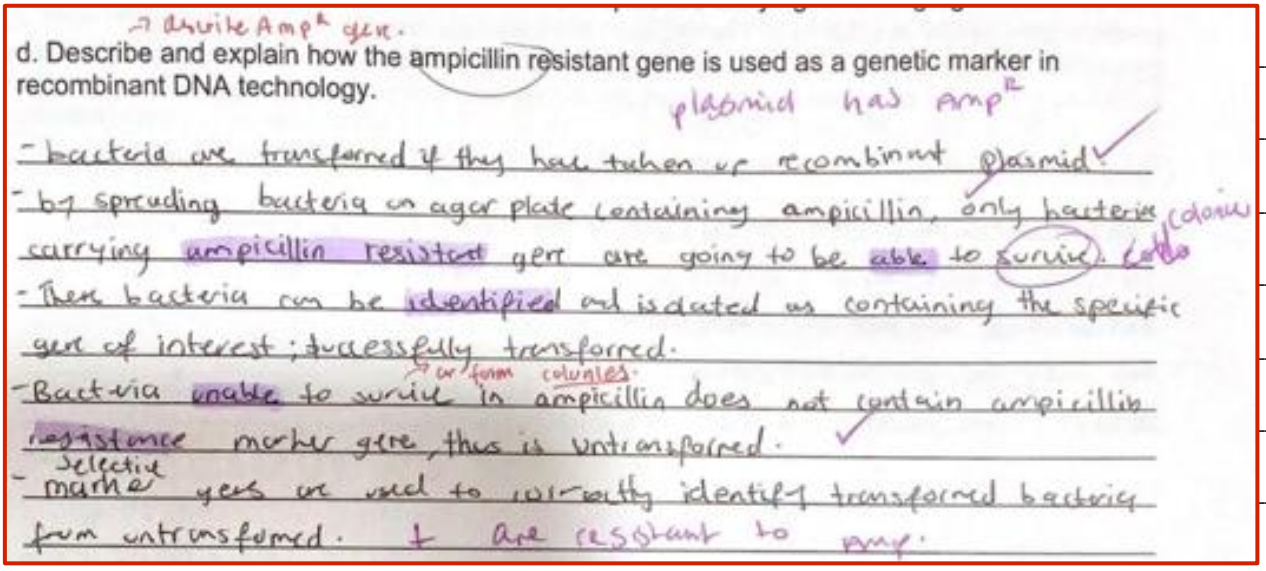
- The (resistant) gene of interest and plasmid are cut using the same (complementary) endonuclease at a specific restriction site, forming same sticky ends.
- Sticky ends anneal via H bonds and complementary base pairing occurs between gene and plasmid.
- DNA ligase joins both fragments via joining sugar phosphate backbone via phosphodiester bond
- This forming a recombinant plasmid containing foreign gene resistant to round-up.

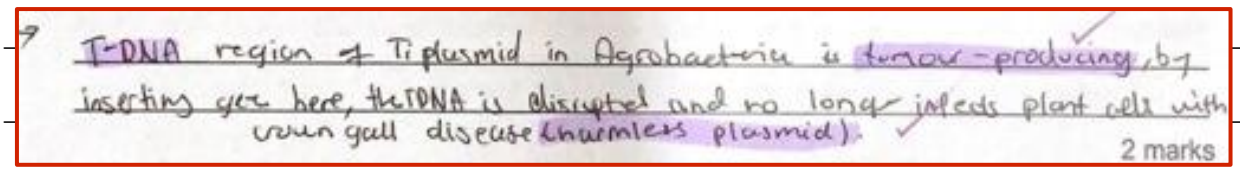
3 marks

The process of bacterial transformation is not always successful. Some bacteria do not take up a plasmid and not all plasmids that are taken up are recombinant. A genetic marker, such as an ampicillin resistant gene, is often inserted into the plasmid carrying the foreign gene.

d. Describe and explain how the ampicillin resistant gene is used as a genetic marker in recombinant DNA technology. (3 marks)



e. **Step 3** in **Figure 1**, shows that the foreign DNA is inserted into the T-DNA of the plasmid. Explain the reason for this step. (2 marks)



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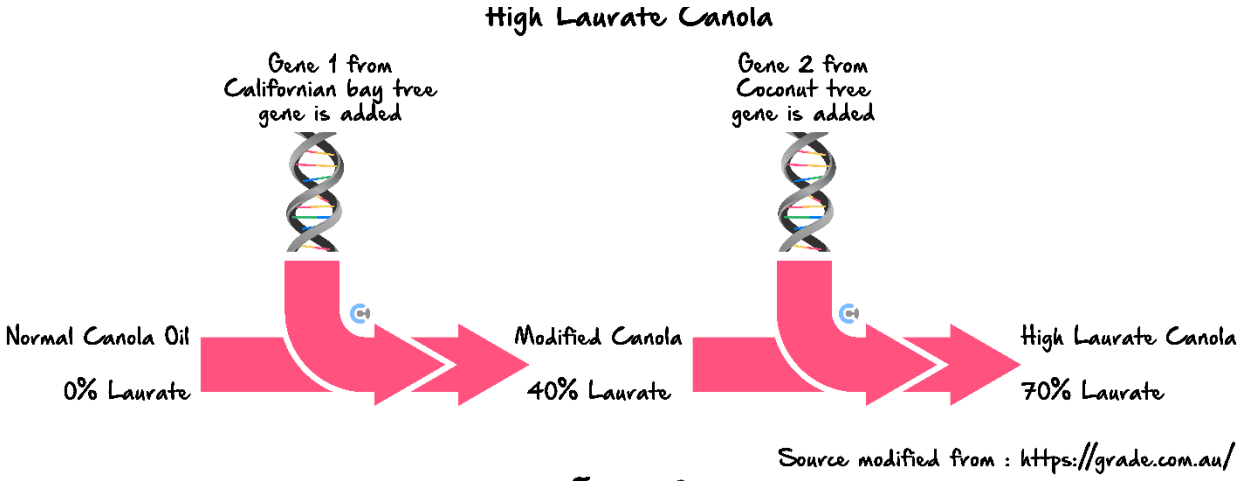
High Laurate Canola

- Canola oil can be genetically modified to closely resemble the properties of coconut oil and palm oil. Palm oil is grown only in the tropics of continents such as Asia, Africa and Latin America. The global demand for palm oil has meant that plantations are expanding at the expense of tropical rainforests. Large areas of rainforest are being destroyed to make way for new plantations to meet increased consumer demands. Canola can be grown in large crops in different climates, which can reduce the environmental strain of having to grow and harvest the largest number of palm trees.

- Canola can be genetically modified to increase the **'laurate levels'**, which is a protein found in coconut oil. While **laurate** is not usually present in canola, modified plants can produce up to 70% **laurate** and this oil is quite comparable in quality to natural palm/coconut oil. **Figure 2** below summarises the process of creating **High Laurate Canola**.



Fiaure 2

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Question 2 (10 marks)

The addition of two genes to increase the **laurate** concentration from 0% to 70% has many possible commercial applications. The resultant **high laurate canola** oil contains new properties that can be used as a suitable substitute for coconut and palm oil products - not just for consumption but also used in other products like lipstick, cosmetics and soaps.

a. Explain whether the **high laurate canola** is genetically modified and/or transgenic. (2 marks)

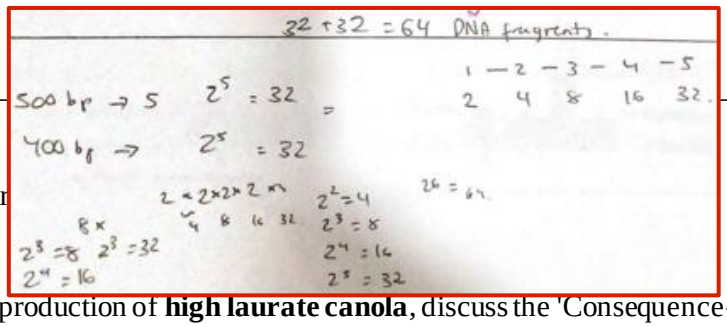
- both genetically modified (GM) and transgenic; as high laurate canola contains foreign DNA/genes inserted from two different plant species, Californian Bay tree and coconut tree. GM organisms contain DNA that has undergone genetical engineering and posess novel traits to wild species, however high laurate canola also is transgenic.

Before plasmids are incorporated into the genome of plant cells, scientists need to amplify the DNA.

b. Explain each stage of the polymerase chain reaction needed to make many copies of this new plasmid. (4 marks)

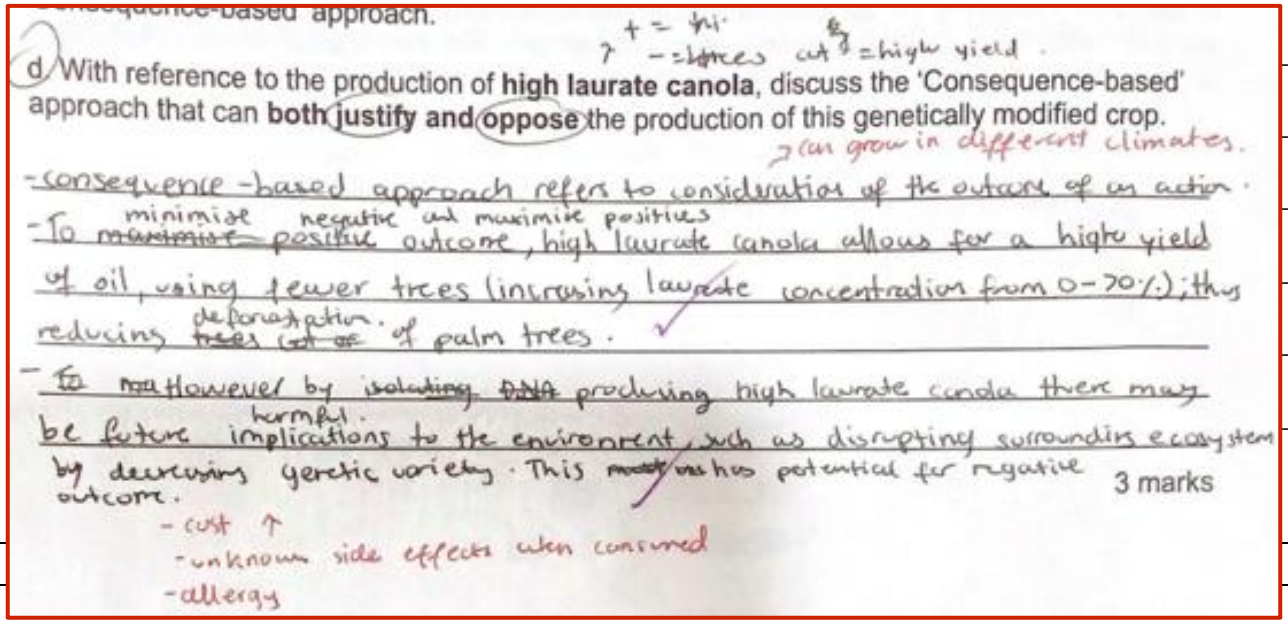
Name of Stage	Temperature	Description of Process
Denaturation	94°C	H bonds between double strands of DNA are broken; this separates DNA into single strands.
Annealing	55°C	Primers attach to 3′ ends of single-stranded DNA.
Extension	72°C	Taq Polymerase adds complementary nucleotides to (5'-3'), using primers as a starting point, joining sugar-phosphate backbone via phosphodiester bonds - forming double stranded DNA copy. 4

c. Two pieces of DNA, one 500 base pairs long, and the other 400 base pairs long, undergo PCR. If each DNA fragment completes 5 cycles of PCR, state the number of DNA fragments that will be present in total at the end. (1 mark)



There are three major appr is a 'Consequence-based' approach.

d. With reference to the production of **high laurate canola**, discuss the 'Consequence-based' approach that can **both justify** and **oppose** the production of this genetically modified crop. (3 marks)



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Bt Resistant Canola

- A gene from *Bacillus thuringiensis*, a naturally occurring soil-borne bacteria, has been inserted into the genome of the canola and it is from the bacteria that the **'Bt Canola'** gets its name. The gene produces a crystal toxin protein, therefore making all parts of the plant poisonous for insects to eat. The crystal toxin is also able to kill the larval stage of insects such as caterpillars. Insect pests cause millions of dollars of damage to crops and can severely impact the yield for farmers. The Bt crystal toxic proteins are very specific in their action and only bind to a specific receptor. Consequently, the toxin tends to only impact insects within a particular taxonomic order.

Question 3 (3 marks)

Existing canola genes can be modified using a process known as CRISPR. This process is able to create **Bt canola** with inbuilt insecticide.

Below are the steps a scientist would take to create CRISPR-Cas9 to modify existing canola cells to carry *Bacillus thuringiensis* gene. Place these steps in sequential order from 1-6.

Cas9 and Guide RNA are combined to produce the CRISPR-Cas9 complex.	2
Cas9 cuts both strands of DNA, removing the target DNA sequence.	5
Guide RNA is created that matches the target DNA sequence on the canola plant genome.	1
The Bacillus thuringiensis gene is incorporated into the canola genome.	6
Guide RNA recognises the target canola DNA sequence to be removed.	4
A vector is used to transport the CRISPR-Cas9 complex into canola cells.	3

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Growing GM Plants

- A farmer who is testing the different varieties of canola is concerned that one of their GM varieties might have interbred with normal non-GM canola. The resulting 'hybrid' canola plants are growing along the fence line between the paddock 1 and the pond.

- The map in **Figure 3**, below shows the layout of the paddocks.

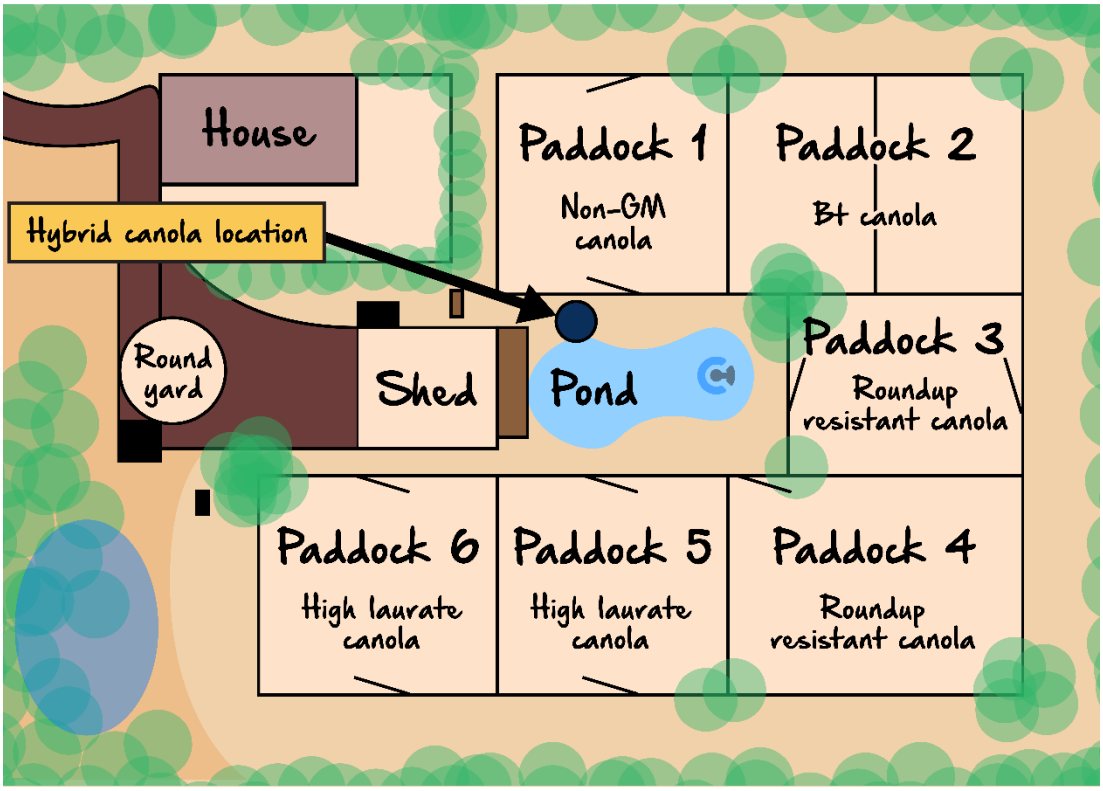

Figure 3

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Question 4 (14 marks)

DNA from the canola plants grown in the different paddocks shown in **Figure 3**, as well as the hybrid canola was collected. The DNA was then cut, amplified and the DNA fragments run through gel electrophoresis. **Figure 4**, below shows the outcome of the gel run.

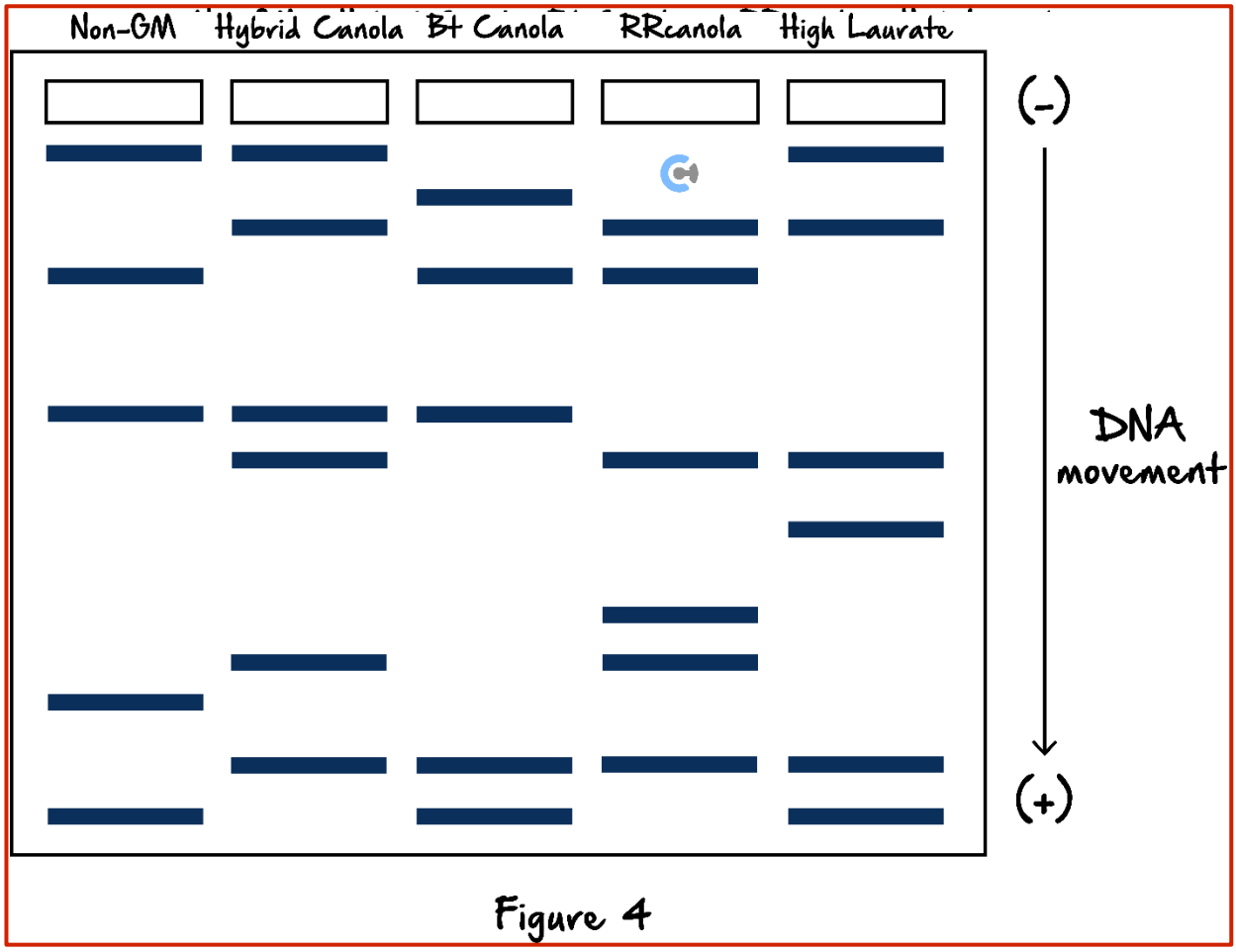

Figure 4

a. On the gel electrophoresis diagram in **Figure 4**, label the positive and negative terminals and use an arrow to show the direction of DNA movement through the gel. (2 marks)

The processing of the gel electrophoresis test results takes a few days to be completed and released.

b. Explain **two** ways that the gel electrophoresis part of the test could be conducted in a shorter time. (2 marks)

- by increasing voltage applied to the gel; as higher voltage will allow DNA fragments to move faster through gel.
- by decreasing concentration of Agarose gel; fragments will be less resistant in gel and able to move at a greater rate - thus less time taken.

2 marks

c. Identify and name the component that is missing on the gel electrophoresis diagram in **Figure 4**, and describe its purpose. (2 marks)

-DNA ladder (standard); contains DNA of known fragment length (usually bp) to determine the sizes of unknown DNA.
-accounts for differences in concentration of gel, voltage applied, time run for, thus results in more accurate data.

Once the gel run is complete, the separate DNA bands must be made visible.

d. What is a probe? (2 marks)

single stranded (small) DNA molecule with a flourescent/radioactive marker, which is complementary to a specific target region of DNA. Binds to single stranded DNA via hybridisation.
2 marks

e. Describe how a probe is used to allow DNA to become visible on the gel. (2 marks)

e. Describe how a probe is used to allow DNA to become visible on the gel.

- Probes contain flourescent/radioactive tag (marker) which binds to specific target DNA via complementary base pairing.
- This can be seen under UV light as an illuminated band, thus locating specific positions of DNA/genes.

2 marks

f. Based on the results of gel electrophoresis in **Figure 4**, identify the likely paddock that pollinated the hybrid species found between paddock 1 and the pond and explain how this may have occurred. (2 marks)

f. Based on the results of gel electrophoresis in **Figure 4**, identify the likely paddock that pollinated the hybrid species found between paddock 1 and the pond and explain how this may have occurred.

- RR canola, is likely to have pollinated hybrid species. Paddock 3, 4 and 1
- likely to have occured by wind blowing seeds/pollen from region (pollinated) between pond and paddock 1, thus allowing for interbreeding, and combining of non-GM canola and GM canola.

g. Give **two** reasons why the hybrid plants might be an issue for the farmer. (2 marks)

- may then contaminate all surrounding species (RR canola, non-GM canola etc.); hence species will no longer express unknown long term effects in traits, such as decreasing yield or causing disease in plants, overall negative outcome for farmer and crops.
  ↳ might not be able to sell it ↓ money.

2 marks

Total 40 marks

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