Website: contoureducation.com.au | Phone: 1800 888 300
Email: hello@contoureducation.com.au

VCE Biology ¾
AOS 1 Revision [1.0]
SAC 1

50 Marks. 5 Minutes Reading. 60 Minutes Writing.

Section A: SAC Questions (50 Marks)

Definition

Revive & Restore's Woolly Mammoth Revival Project

- In 2015, Revive & Restore launched the Woolly Mammoth Revival Project with the goal of re-engineering a creature with genes from the woolly mammoth and introducing it back into the tundra to combat climate change.
  - In order to de-extinct the woolly mammoth, researchers theorise that they can manipulate the genome of the Asian elephant, which is the mammoth's closest living evolutionary relative, to make it resemble the genome of the extinct woolly mammoth.
  - While their goal is to create a new elephant-mammoth hybrid species or a mammophant, that looks and functions like the extinct woolly mammoth, critics have suggested researchers involved in the project have misled and exaggerated the process.
- Researchers broadly define de-extinction as a method for reintroducing extinct species.
  - However, the methods of de-extinction that the Woolly Mammoth Revival Project pursued would not lead to a perfect biological replica of a mammoth.
- Revive & Restore researchers are attempting to use genome editing and engineering to make mammoth-like species instead of perfect replications of mammoths.
  - Researchers from the Woolly Mammoth Revival Project are experimenting with CRISPR-Cas9, a genome editing tool derived from bacteria that involves cutting out specific sequences of DNA and replacing them with other sequences.
- In the case of the de-extinction of the woolly mammoth, scientists would edit the Asian elephant genome to make it more similar to the genome of the woolly mammoth.
  - The Asian elephant is ninety-nine per cent genetically identical to the mammoth.
  - Genetic engineers can use CRISPR-Cas9 to cut out and remove precise sequences of elephant DNA and replace them with the DNA sequences that make up specific genes that code for features that can make an elephant more mammoth-like, such as promoting the development of thicker layers of fat and longer hair.
  - Researchers will not have created a biological woolly mammoth once an organism with that genome develops. However, it would theoretically be a mammoth-like creature.
  - They speculate the organism will be able to survive in the Arctic, where woolly mammoths once lived to promote biodiversity in that area.

  - Researchers at Revive & Restore expect the introduction of their hybrid species can help prevent the melting of permafrost, the thick layer of soil and bedrock that stays frozen year-round in the Arctic, thereby preventing the release of greenhouse gases.

- Out of concern for animal welfare, the team have stated they plan to avoid forcing Asian elephants to act as surrogates for the mammophant by growing the mammophant embryo in an artificial womb outside of the body instead.

  - Additionally, critics such as Matthew Cobb, a professor of zoology at the University of Manchester, doubt that scientists can achieve the capability to produce a functional artificial womb within the next decade.

  - Cobb explained that an artificial womb would deprive a foetus of many important pre-birth interactions with its gestational carrier that help the foetus to properly develop.

- Many critics also question whether we should be trying to de-extinct the mammoth at all.

  - For example, David Ehrenfeld, a professor of biology at Rutgers University has raised concerns that the mammophants may not be able to survive in the Arctic because they are genetically different from the extinct mammoths and will not be able to learn survival skills without a herd.

  - He suggests those factors could also lead the mammophants to behave unpredictably in their environment and possibly even cause more destruction than help.

  - To avoid that problem, Revive & Restore has stated plans to raise eventual mammophants with captive Asian elephant families in zoos who may teach them survival and herding behaviours so the mammophants can one day form herds of their own.

- Additionally, many ethicists have expressed concern over de-extinction being an immoral endeavour.

  - De-extinction, if successful, may eventually undermine the conservation movement by making extinction seem like less of a problem.

  - If extinction suddenly seems reversible, the public may feel less responsible for behaviours and actions that contribute to global warming and biodiversity loss.

  - For example, Ben Minteer, a professor of environmental ethics at Arizona State University, has noted that the premise of de-extinction may teach people that technology alone can reinforce the idea that humans will remain unaccountable for changing their behaviours to prevent such damage from occurring in the first place.

  - Other conservationists like Stuart Pimm, a professor of conservation ecology at Duke University, worry that the time, money and effort dedicated to de-extinction efforts could divert important funds dedicated to protecting the many endangered species and ecosystems still around today.

Question 1 (1 mark)

Which of the following is a major concern regarding the use of CRISPR-Cas9 in gene editing for de-extinction?

A. CRISPR-Cas9 cannot cut DNA at precise locations.

B. CRISPR-Cas9 lacks the ability to insert genes.

C. Off-target mutations may occur, leading to unintended genetic changes.

D. CRISPR-Cas9 is ineffective in mammalian cells.

Question 2 (1 mark)

Which of the following **modifications** occurs to pre-mRNA around the same time as intron splicing, and what is its primary purpose?

A. The addition of a 5' Methyl-G cap, which helps prevent mRNA degradation as it exits the nucleus.

B. The removal of exons, which prevents the mRNA from being translated into a non-functional protein.

C. The conversion of mRNA into DNA, allowing it to be permanently stored in the genome.

D. The removal of the Poly-A tail to speed up mRNA degradation before translation.

Question 3 (1 mark)

If mammophants are successfully created and introduced into the Arctic, which of the following ecological concerns is **most valid**?

A. Mammophants will migrate to warmer climates, abandoning the Arctic ecosystem.

B. Mammophants may disrupt Arctic ecosystems by trampling permafrost and altering vegetation.

C. Mammophants will interbreed with surviving woolly mammoths, creating genetic instability.

D. Mammophants will naturally integrate into modern elephant populations.

Space for Personal Notes

Question 4 (1 mark)

Why might mammophants struggle to survive despite being genetically similar to woolly mammoths?

A. They lack cultural knowledge and survival behaviours passed down through herds.

B. Their DNA will mutate rapidly and make them unsuitable for cold climates.

C. Their reproductive cycles will not function outside of captivity.

D. They will have no predators in the Arctic, making survival impossible.

Question 5 (1 mark)

One major challenge in developing an artificial womb for mammophants is:

A. Artificial wombs can only support external fertilisation, not internal fertilisation.

B. Mammophant embryos do not undergo cell division in early development.

C. The mammophant placenta cannot exchange gases outside a living organism.

D. Mammalian embryos require biochemical signals from the mother for proper development.

Question 6 (1 mark)

Why might an introduced mammoth gene fail to be expressed at expected levels in a hybrid mammophant?

A. The Asian elephant's cellular machinery cannot recognise mammoth genes.

B. The mammoth gene may be silenced and as a result, transcription will not occur.

C. The ribosomes of an Asian elephant cannot translate mammoth mRNA into protein.

D. Mammophant cells will reject mammoth genes as foreign DNA and destroy them.

Space for Personal Notes

Question 7 (1 mark)

One major challenge in successfully developing mammophants is:

A. The inability to ensure proper embryonic development due to limitations in cellular reprogramming and early-stage viability.

B. Mammophant embryos require exposure to specific Arctic temperatures for proper genetic activation.

C. The mammophant genome is too large to be replicated accurately in laboratory conditions.

D. Mammophant embryos must undergo direct interaction with living mammoth cells to trigger development.

Question 8 (1 mark)

Scientists at *Revive & Restore* are debating whether to use germline editing (modifying embryos) or somatic cell editing (modifying an adult elephant's cells) to create mammophants.
Why is germline editing considered more controversial?

A. Germline edits are temporary, whereas somatic edits are permanent.

B. Germline edits affect all future generations, whereas somatic edits affect only the individual.

C. Somatic gene editing is more ethically controversial than germline editing.

D. Germline editing cannot be done in elephants due to their large genome size.

Question 9 (1 mark)

To confirm whether mammoth DNA has been successfully integrated into the Asian elephant genome, researchers extract DNA from edited cells and run it through gel electrophoresis. The gel shows an additional DNA band in some samples, which is not present in the original elephant or mammoth controls.
What is the most likely explanation for this extra DNA band?

A. DNA from different species merged during electrophoresis, forming hybrid fragments.

B. The gel was contaminated with mammoth proteins, leading to an artefact.

C. The mammoth DNA sequence was inserted, creating a novel fragment of intermediate size.

D. The electric field reversed polarity, causing the DNA to migrate unpredictably.

Question 10 (1 mark)

Scientists at *Revive & Restore* are using gel electrophoresis to verify whether mammoth DNA has been successfully integrated into the mammophant genome. After running the gel, the researcher notices that all DNA fragments appear much lower (further down) than expected on the gel.
What is the most likely error in the experiment?

A. The voltage was too high, causing the DNA to degrade and move faster than expected.

B. The DNA samples were loaded at the positive electrode, causing them to run in the wrong direction.

C. The agarose gel was too thick, slowing down DNA migration.

D. The DNA samples were too diluted, leading to faint bands rather than shifted positions.

Question 11 (4 marks)

In order to “revive” the woolly mammoth, scientists plan to insert woolly mammoth genes into the genome of the Asian elephant. One such gene is responsible for the production of long hair.

Below is a section of double-stranded DNA from a woolly mammoth gene that is associated with hair growth. The DNA sequences that code for the corresponding introns are in bold.

Template strand: GTT–TCC– **AGG–CAT**–GTT–TGG–GGG–**GGA–ATA–TGG**–CGT–CCA–AGG–GCC–**GGA**–CTT–CCC

Coding strand: CAA–AGG–**TCC–GTA**– CAA–ACC–CCC– **CCT–TAT– ACC**–GCA–GGT–TCC–CGG–**CCT**–GAA–GGG

a. Describe the second step in gene expression that is applied to this genetic code in the nucleus, before being transported to the ribosome. (3 marks)

b. Give the sequence of the molecule that leaves the nucleus after the process described in part **a.** (1 mark)

____

Question 12 (6 marks)

Researchers from the Woolly Mammoth Revival Project are experimenting with CRISPR-Cas9, a genome editing tool derived from bacteria that can cut out specific sequences of DNA and replace these with other sequences.

a. Outline how CRISPR-Cas9 performs its function in bacteria. (3 marks)

____

____

____

____

____

____

____

____

b. Below are the steps required to use CRISPR-Cas9 to revive the woolly mammoth. Place these steps in sequential order, from 1-6. (3 marks)

Cas9 and Guide **RNA** are combined to produce the **CRISPR-Cas9** complex.	
Cas9 cuts both strands of DNA, removing the target DNA sequence.	
Guide RNA is created that matches the target DNA sequence on the elephant genome.	
Mammoth DNA is incorporated into the elephant DNA.	
Guide RNA recognises the target elephant DNA sequence to be removed.	
Elephant zygote cells are injected with the CRISPR-Cas9 complex.	

Question 13 (10 marks)

The process of knocking in or incorporating new DNA segments using CRISPR-Cas9 is not always successful and relies on the DNA repair machinery of the Asian elephant cell to take up the mammoth DNA.

The steps below show the process used to confirm the successful hybridisation of elephant and mammoth DNA.

Step 1: CRISPR-Cas9 is used in an attempt to knock-in mammoth DNA into the Asian elephant genome.
Step 2: The DNA from step 1 is cut at specific recognition sites to extract the target gene/s.
Step 3: The target gene/s are amplified.
Step 4: The target gene/s are compared to both elephant and mammoth DNA using gel electrophoresis.

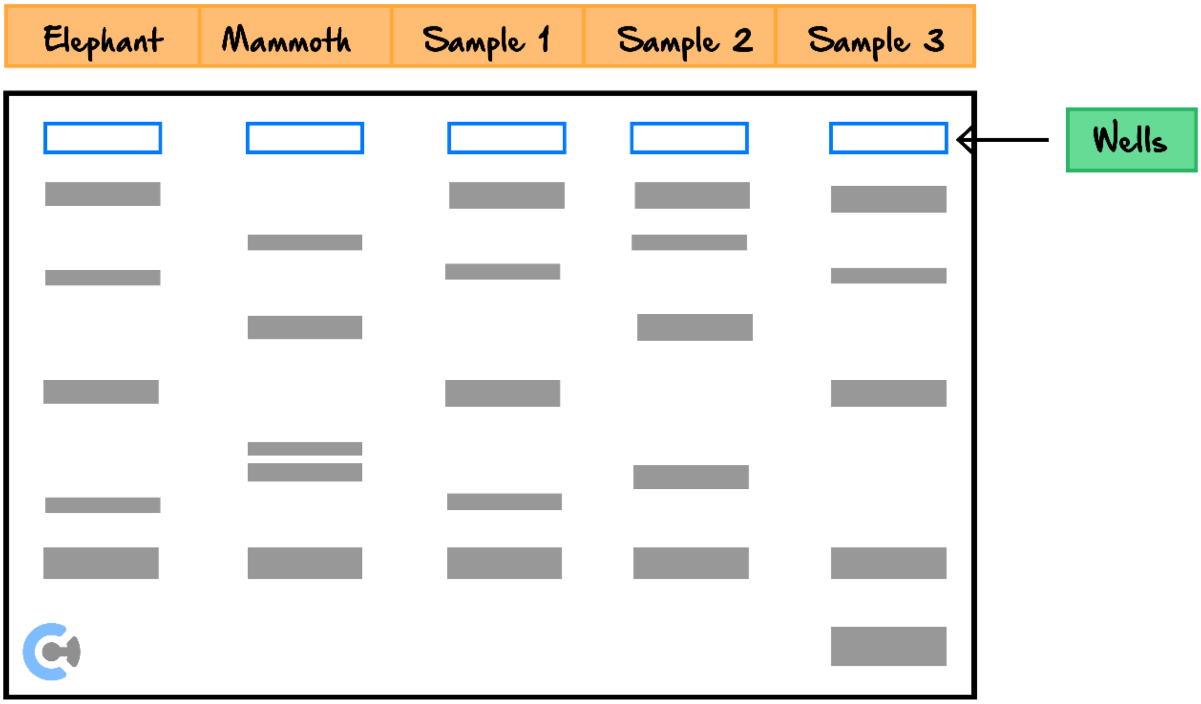
a. What is the full name of the process required for the amplification of DNA? (1 mark)

____

b. Apart from Cas9, in the table below name three types of enzymes required to manipulate DNA across Steps 1 to 3, and state the function of each. (3 marks)

Enzyme	**Function**

c. Scientists attempted to knock in the mammoth genes three times. The resulting DNA (Samples 1, 2, and 3) were run through gel electrophoresis and compared to genes from the Asian elephant and mammoth. The results are shown below.



On the above gel, label the:

i. Largest segment of mammoth DNA. (1 mark)
ii. Positive electrode. (1 mark)
iii. Direction of DNA movement. (1 mark)

d. Which DNA sample (1, 2, or 3) indicates that the CRISPR-Cas9 process has been successful? (1 mark)

---

e. Sample 3 shows a fragment of DNA that is not present in either the elephant or mammoth DNA. Explain how this could have resulted from the CRISPR-Cas9 process. (2 marks)

Question 14 (2 marks)

Researchers involved in this project to 'revive' the woolly mammoth have cited many potential benefits for this use of the CRISPR-Cas9 technology. However, there are also critics who argue that the use of CRISPR-Cas9 in this way is unethical.

Before researchers can begin new projects, it is important to evaluate the bioethical issues associated with the research. The ethical concepts of integrity, justice, beneficence, non-maleficence, and respect are used to inform researchers' decision-making.

Describe the ethical concepts of justice and non-maleficence.

Justice:

____

____

____

Non-maleficence:

____

____

____

Space for Personal Notes

Question 15 (3 marks)

Scientists involved in this project claim they will "de-extinct" the woolly mammoth. However, "critics have suggested researchers involved in the project have misled and exaggerated the process".

With reference to the ethical concept of integrity, suggest why the scientists' claim of de-extinction is problematic.

Question 16 (2 marks)

Suggest one social and one economic implication scientists may consider when designing the woolly mammoth research.

Social:

Economic:

Question 17 (4 marks)

How might the de-extinction of mammophants lead to issues regarding beneficence and respect? Provide two points that are relevant to each ethical concept.

Question 18 (2 marks)

Outline the difference between a virtues-based and a duty-/rule-based approach to resolving bioethical issues.

Question 19 (4 marks)

Apply a consequences-based approach to make an argument for and against the use of CRISPR-Cas9 in the de-extinction of the woolly mammoth.

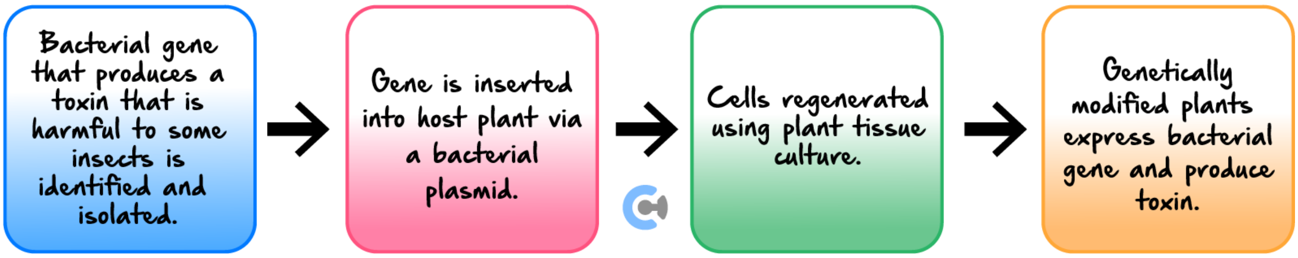
For:

Against:

Space for Personal Notes

Question 20 (3 marks)

Genetic modification technologies also have agricultural applications. Below is a flowchart that represents one application of genetic modification in agriculture.



a. Explain whether the genetically modified plants are transgenic organisms or not. (1 mark)

____

____

____

b. What issue could scientists be trying to solve by creating these genetically modified plants? (1 mark)

____

____

____

c. Outline one ethical implication of genetically modifying food crops. (1 mark)

____

____

____

Space for Personal Notes

CONTOUREDUCATION

Website: contoureducation.com.au | **Phone:** 1800 888 300 | **Email:** hello@contoureducation.com.au

VCE Biology ¾

Free 1-on-1 Support

Be Sure to Make The Most of These (Free) Services!

- Experienced Contour tutors (45+ raw scores, 99+ ATARs).
- For fully enrolled Contour students with up-to-date fees.
- After school weekdays and all-day weekends.

1-on-1 Video Consults	Text-Based Support
• Book via bit.ly/contour-biology-consult-2025 (or QR code below). • One active booking at a time (must attend before booking the next).	• Message +61 440 137 387 with questions. • Save the contact as "Contour Biology".

Booking Link for Consults
bit.ly/contour-biology-consult-2025

Number for Text-Based Support
+61 440 137 387