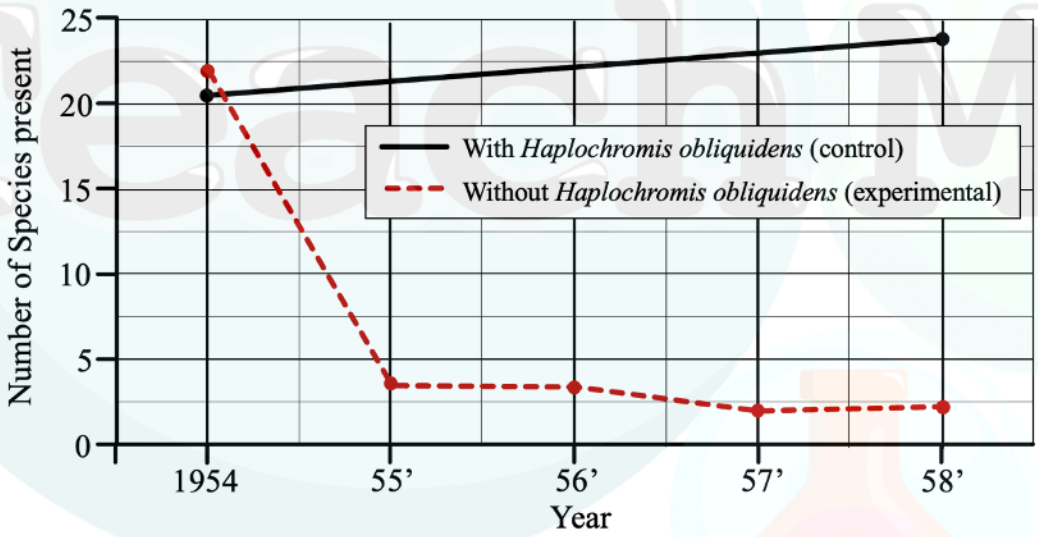
Answer **all** questions. Answers must be written within the answer boxes provided.

1. A freshwater ecosystem in Lake Victoria is home to the algivorous (algae-eating) Haplochromis fish species. To determine the relative impact of *Haplochromis obliquidens* on the ecosystem biodiversity, a scientist carried out a field experiment, where over a period of five years the effect of the presence and absence of this species was investigated.



(a) Based on the data in this graph, deduce with a reason whether or not *Haplochromis obliquidens* is a keystone species. [2]

From the 1960s an invasive fish species, the Nile perch (*Lates niliticus*) started to infiltrate this ecosystem. An experiment tracked the spread of the invasive fish species. The fish population was estimated using the capture-mark-release-recapture method.

Date	Number of Initially Captured, Marked Fish	Total Number of Recaptured Fish	Number of Recaptured, Marked Fish
1960.01	52	98	7
1961.01	65	122	12
1962.01	71	139	15
1963.01	89	160	17
1964.01	96	194	19

(b) (i) Calculate the estimated population size in January of 1962 using the Lincoln-Petersen Index. Round the answer to 3 significant figures. [2]

(ii) State an assumption made when using this method. [1]

(iii) Outline how population size estimates could be affected if marked individuals are more likely to be spotted by predators than unmarked individuals. [2]

(c) The invasive fish species carries out excessive consumption of native *Haplochromis obliquidens*. Predict how this could affect long term dissolved oxygen levels. [2]

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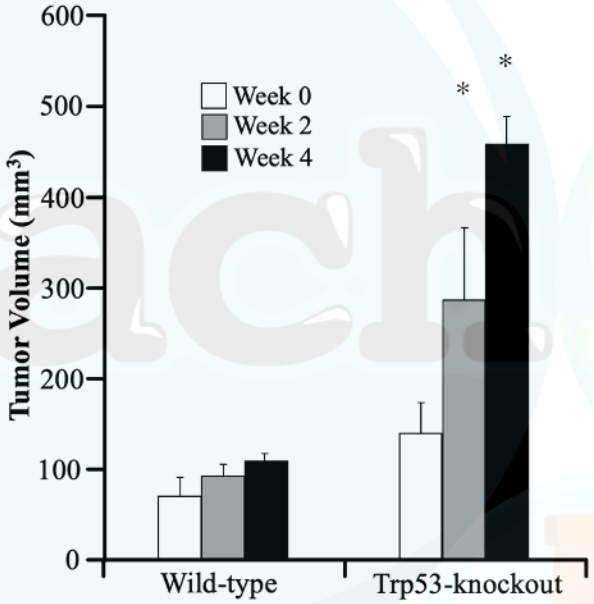
2. A group of scientists want to study the role of the tumor suppressor gene *Trp53* in cancer development using CRISPR-Cas9 gene knockout in mice.



(a) (i) State the purpose of using a control group of wild-type mice in this experiment. [1]

(ii) Predict with a reason the effect of a *Trp53* knockout on cell division. [1]

The researchers extract DNA and use gel electrophoresis to confirm the gene knockout.

(b) Describe how the gel electrophoresis results would indicate a successful knockout. [1]

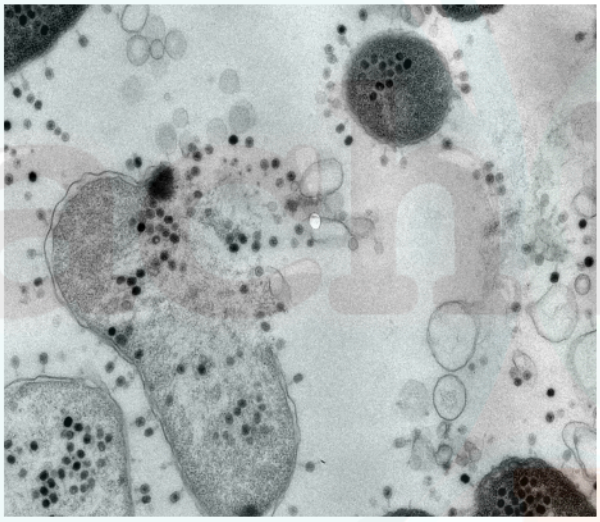
CRISPR is not only used for research but can also be used to introduce beneficial genes to improve disease resistance in endangered wild species.

(c) (i) Predict how this could affect natural selection in the population over several generations. [2]

(ii) Mention two long-term ecological or evolutionary risks of using CRISPR in wild animal populations. [2]

(d) Evaluate the use of CRISPR versus traditional selective breeding for improving traits in populations. [4]

3. Hershey and Chase used bacteriophages labeled with radioactive sulfur (^{35}S) and phosphorus (^{32}P) to determine whether DNA or protein carried genetic information. After infecting *E. coli*, they separated the viral coats from bacterial cells and measured radioactivity to determine which macromolecule entered the host cell.



Bacteriophages infecting Escherichia coli bacteria

(a) Which macromolecule can be found inside the bacterial cell after infection? [1]

(b) Explain why the experiment would have been inconclusive if Hershey and Chase used radioactive carbon (^{14}C) to label DNA and protein instead. [2]

"Bacteriophages are considered living."

(c) (i) State whether the above statement is true or false. [1]

(ii) Explain why viruses require host cells to replicate. [2]

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4. A team investigates membrane fluidity in red blood cell membranes of two species of marine fish.

Species A: Lives in Arctic waters (close to 0°C).
Species B: Lives in temperate waters (around 15°C)

Membrane fluidity is measured by tracking the proportion of phospholipids moving more than 1μm/sec at 5°C and 15°C. Each species is tested under two conditions: Normal membrane and membrane treated with a desaturase inhibitor.

Fatty acid desaturase enzymes catalyze conversion of saturated fatty acids into unsaturated fatty acids by introducing double bonds. This changes the structure and properties of membrane phospholipids.

Species	Condition	% phospholipids moving >1μm/sec at 5°C	% phospholipids moving >1μm/sec at 15°C
Arctic	Desaturase active	62%	76%
	Desaturase inhibited	28%	74%
Temperate	Desaturase active	33%	70%
	Desaturase inhibited	32%	69%

(a) (i) Calculate the percentage change in membrane fluidity for the arctic species at 5°C when a desaturase inhibitor is added. [2]

(ii) Outline the mechanism by which membrane fluidity is altered by the introduction of double bonds by fatty acid desaturase enzymes. [1]

(b) (i) Compare the phospholipid movement between the arctic and temperate species in the absence of the desaturase enzyme inhibitor at 5°C. [1]

(ii) Deduce a potential reason for this observed difference in membrane fluidity. [1]

(iii) Discuss the significance of this difference as an adaptation to their environment. [1]

Artificial cell membrane models are created in a lab and incubated at 5°C. Cholesterol is then added to the membrane models to determine its contribution to membrane fluidity.

(c) Explain the likely effect of the added cholesterol on phospholipid movement at 5°C. [1]

(d) Membrane fluidity is essential for immune cell function. Outline one reason why fluidity is important for macrophages during an immune response. [2]