

Question 3: Scientific Investigation

4 points

Sand lances of the genus *Ammodytes* are small fish that function as keystone organisms in several coastal ecosystems. These sand lances are prey fish that support organisms at higher trophic levels. Scientists performed experiments to examine how sand lance populations are likely to be affected by the rising temperatures and CO₂ levels associated with climate change.

Sand lance embryos typically develop and mature into adult fish at low temperatures (approximately 5°C) and stable, low CO₂ levels (approximately 400 µatm). Over the course of two years, the scientists measured the survival rate of sand lance embryos allowed to develop and mature in a laboratory at three different temperatures, 5°C, 7°C, and 10°C, with the level of CO₂ maintained at 400 µatm, 1,000 µatm, and 2,100 µatm for each temperature.

- (a) **Describe** the effect of increased biodiversity on the resilience of an ecosystem in a changing environment. **1 point**
- (Ecosystem) resilience/it will be greater (with increased biodiversity).
- (b) **Justify** the scientists' selecting 5°C as the lowest temperature and 400 µatm as the lowest CO₂ level in their study of sand lance embryo survival. **1 point**
- Accept one of the following:
- These are the normal/current conditions at which the embryos develop and were used as a basis for comparison.
 - These (current) conditions were used as a basis to compare the effects of changes in environmental conditions/increases in temperature and CO₂.
- (c) **State** a null hypothesis for the experiment. **1 point**
- Accept one of the following:
- Climate change will have no effect on sand lance (embryo) survival/sand lance development/the size of sand lance populations.
 - (Increases in) temperature/CO₂ levels will have no effect on sand lance (embryo) survival/sand lance development /the size of sand lance populations.
 - There will be no difference in the sand lance (embryo) survival rates/sand lance development/the size of sand lance populations measured at all/different temperatures and CO₂ levels.
- (d) The scientists claim that a reduction in the population size of the *Ammodytes* sand lances will affect the stability of the entire coastal ecosystem. Provide reasoning to **support** the scientists' claim. **1 point**
- Accept one of the following:
- There will be a negative effect on other trophic levels because the sand lance provides food for many other species.
 - There will be a negative effect on other trophic levels because there will be reduced energy to transfer (to higher trophic levels).

Total for question 3 4 points

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Question 7

Smell perception in mammals involves the interactions of airborne odorant molecules from the environment with receptor proteins on the olfactory neurons in the nasal cavity. The binding of odorant molecules to the receptor proteins triggers action potentials in the olfactory neurons and results in transmission of information to the brain. Mammalian genomes typically have approximately 1,000 functional odorant-receptor genes, each encoding a unique odorant receptor.

- (a) **Describe** how the signal is transmitted across the synapse from an olfactory sensory neuron to the interneuron that transmits the information to the brain.

Description (1 point)

- Neurotransmitters are released from the olfactory neuron and bind to receptors in the postsynaptic neuron.
- (b) **Explain** how the expression of a limited number of odorant receptor genes can lead to the perception of thousands of odors. Use the evidence about the number of odorant receptor genes to **support** your explanation.

Explanation and support (2 points maximum: points may be earned from only one row)

	Explanation (1 point)	Support (1 point)
Molecular	- One odorant molecule can be recognized by more than one odorant receptor - One odorant receptor can bind to more than one odorant molecule	Mathematical combinations expand possible odors detected
CNS Control	Signals integrated in the brain	Multiple interactions among neurons in the brain
Genetic	Alternate processing/splicing (of pre-mRNA/primary transcript)	Multiple receptors can be produced from a gene