
AP[®] Biology

Sample Student Responses and Scoring Commentary

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2019 SCORING GUIDELINES

Question 2

A student studying two different aquatic, plant-eating, unicellular protist species (species A and B) designed an experiment to investigate the ecological relationship between the two species (Table 1).

TABLE 1. EXPERIMENTAL TREATMENT GROUPS

Group I.	Species A and B are each grown in separate containers.
Group II.	Species A and B are grown together in the same container.

In treatment group I, the student placed 10 individuals of species A into a container with liquid growth medium and 10 individuals of species B into a separate container with an equal amount of the same liquid growth medium. In treatment group II, the student placed 5 individuals of each species into a single container with the liquid growth medium. The student then maintained the containers under the same environmental conditions and recorded the number of individuals in each population at various time points. The results are shown in Table 2.

TABLE 2. NUMBER OF INDIVIDUALS IN EACH PROTIST POPULATION IN BOTH TREATMENT GROUPS

Time (h)	Group I. Grown Separately		Group II. Grown Together	
	Species A	Species B	Species A	Species B
0	10	10	5	5
10	100	50	45	20
20	400	200	100	50
30	1100	500	250	25
40	1400	650	525	20
50	1500	700	900	10
60	1500	700	1250	0
70	1500	700	1400	0

(a) The growth curves for species B in group I and for species A in group II (shaded columns) have been plotted on the template. Use the template to **complete** an appropriately labeled line graph to illustrate the growth of species A in treatment group I and species B in treatment group II (unshaded columns).

Completion (3 points)

- Correctly plotted lines for remaining two treatments
- Correctly labeled axes including units
- Correctly labeled data lines

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Question 2 (continued)

(b) As shown in the table, the researcher established treatment group II with 5 individuals of each species. **Provide reasoning** for the reduced initial population sizes.

Reasoning (1 point)

- Reduced initial population sizes keep the total number of organisms the same in all containers.
- Reduced initial population sizes serve as a control for population density.

(c) The student claims that species A and B compete for the same food source. **Provide TWO pieces of evidence** from the data that support the student's claim.

Evidence (1 point per row; 2 points max.)

Comparison of Groups	Evidence
I-A to II-A	<ul style="list-style-type: none">• Growth rate is faster in I/slower in II
I-A to II-A	<ul style="list-style-type: none">• Grows to a higher population density in I/lower population density in II
I-B to II-B	<ul style="list-style-type: none">• Growth rate is faster in I/slower in II
I-B to II-B	<ul style="list-style-type: none">• Grows to a higher population density in I/lower population density in II/ II dies out/II goes to zero

(d) **Predict** TWO factors that most likely limit the population growth of species A in treatment group I.

Prediction (2 points)

Acceptable factors include:

- Food
- Space
- Metabolic waste
- Dissolved oxygen

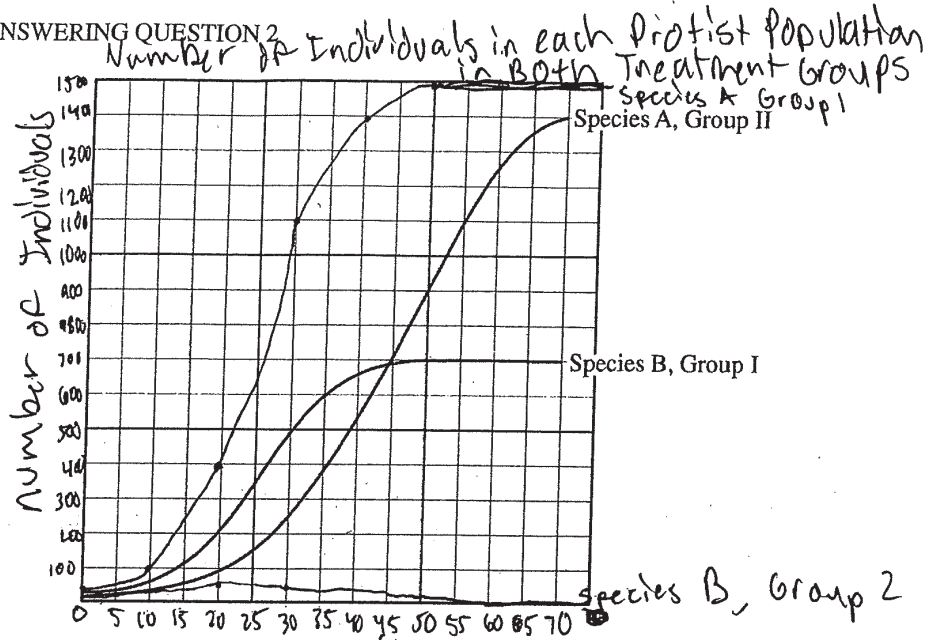
(e) Many protists contain an organelle called a contractile vacuole that pumps water out of the cell. The student repeated the experiment using a growth medium with a lower solute concentration. **Predict** how the activity of the contractile vacuole will change under the new experimental conditions. **Justify** your prediction.

Prediction (1 point)

- The contractile vacuole will be more active.

Justification (1 point)

- The environment is hypotonic with respect to the cell.
- The cell is hypertonic with respect to environment.
- Water has entered the cell (which could cause lysis).
- The cell has lower water potential than the environment/the environment has higher water potential than the cell.



(B) The student started with 5 individuals of each population to keep the starting total population at 10 individuals as in group 1

(C) When both populations are in the same containing, Species A does not reach 1500 individuals as it did in group 1. ~~It~~ Species A only reached 1400 individuals. Species B also did not reach the same number of individuals as it did in group 1. It reached 50 instead of 200 individuals.

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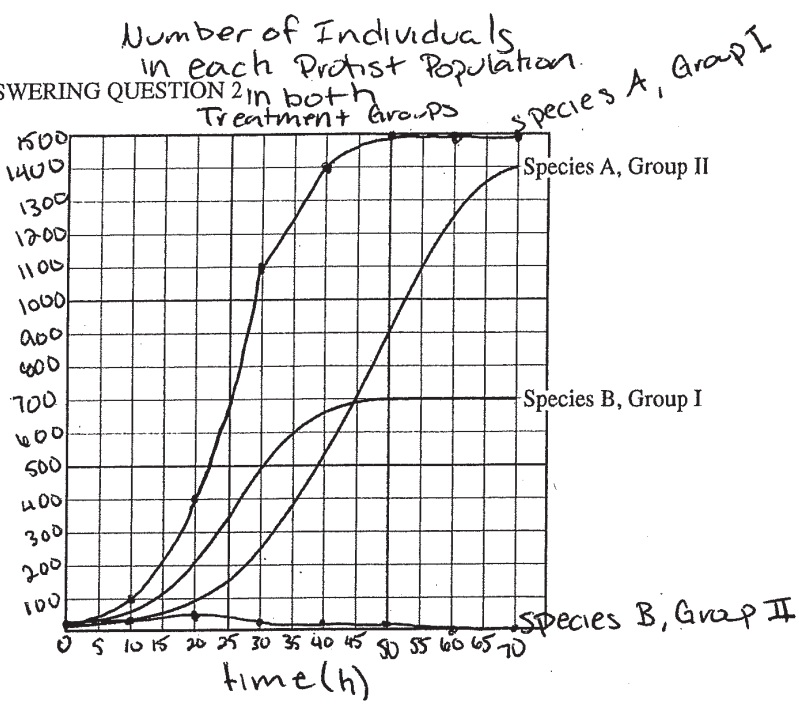
ADDITIONAL PAGE FOR ANSWERING QUESTION 2

(D) The population growth is limited by lack of enough food and lack of space.

(E) The activity of the contractile vacuole will increase because the cell will have become more hypertonic to the solution. Freshwater from the medium will come into the cell to try and create an isotonic cell/medium.

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Number of individuals



- b.) The student reduced the initial population size because, since the species were grown together, he did not want them to interfere with each other in the very beginning.
- c.) One piece of evidence that supports the claim of the 2 species competing for food is the fact that in group II, species B did not grow as much as it did when it was grown alone, ~~because~~ and eventually, species A ate more of the food than species B did, so it died off. Another piece of evidence is that species A grew more when it was alone because

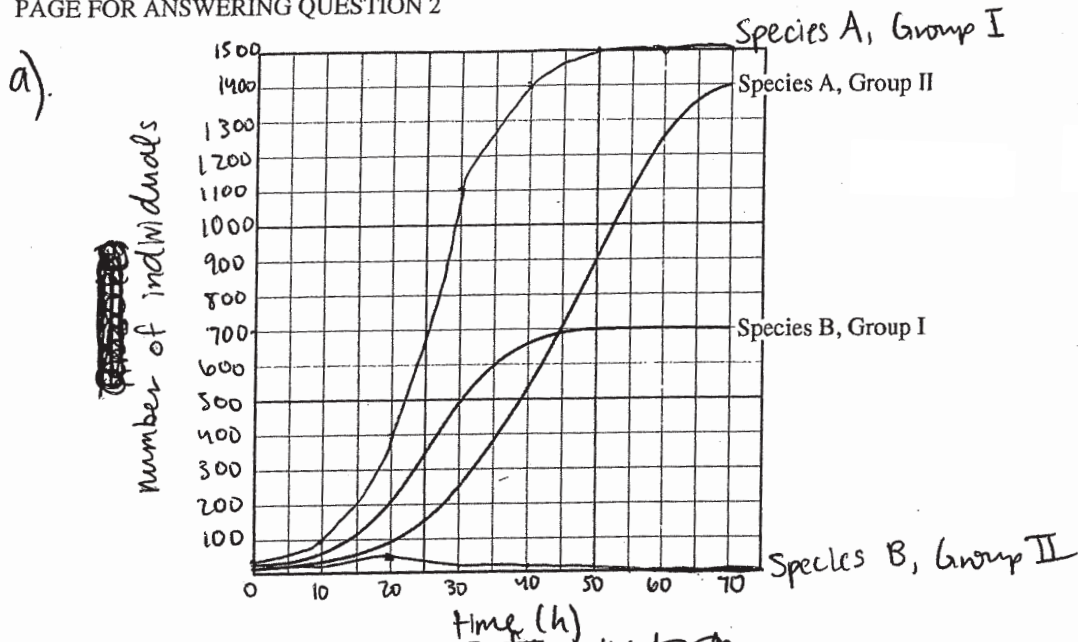
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Species B did not take any of its food source in Group I, but it did in Group II.

d.) One factor that would limit the growth of species A is the availability of food, because eventually there will be too many organisms and they will compete for food. Another factor is that the species could run out of space, and the environment would be at its carrying capacity.

e.) The growth medium with a lower solute concentration would cause the vacuole to pump more water out of the cell because ~~there is not enough solute for the cell~~ there is not enough solute for the cell, so the cell needs to balance the concentration.

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- b.) The initial population size was reduced so that each container would have 10 total individuals.
- c.) In Group I, each population had its own food source, thus there was no competition and each population thrived. In Group II, there was observed competition for a food source because both populations had to live off the same liquid growth medium.
- d.) Two growth inhibiting factors would be a size-limiting container and a lack of sufficient food.
- e.) The contractile vacuole would not be able to expel its contents because the outside concentration of the new growth medium would not allow equilibrium to be achieved if it did.

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Question 2

Note: Student samples are quoted verbatim and may contain spelling and grammatical errors.

Overview

This question provided students with an experimental design where 10 individuals of two species of protist (A and B) were grown separately (group I) or 5 individuals of each species were grown together (group II). A data table was provided with the number of individuals of each species in each group over time. Students were asked to construct an appropriately plotted and labeled graph of the data on a template where half of the data had already been plotted. In an experimental design question, the students were asked to provide reasoning for why only 5 individuals of each species were placed in group II. Students were then asked to interpret the data to provide two pieces of evidence from the data that indicated species A and B were competing for the same food source. Students then considered basic ecological concepts when they were asked to predict two factors that most likely limited the population growth of species A in group I. Lastly, the students were required to use their understanding of tonicity and cellular organelles. They were provided with another scenario, where the growth medium had a lower solute concentration and were asked to predict how the activity of the contractile vacuole in the protists would be affected. They were also asked to justify their prediction.

Sample: 2A

Score: 10

The response earned 1 point in part (a) for correctly plotting lines for Species A, Group 1 and Species B, Group 2. The response earned 1 point in part (a) for correctly labeling the axes (“number of individuals” on the y-axis and “time (h)” on the x-axis). The response earned 1 point in part (a) for correctly labeling the lines as “Species A Group 1” and “Species B, Group 2.” The response earned 1 point in part (b) for reasoning that the reduced initial population size was “to keep the starting total population at 10 individuals as in group 1.” The response earned 1 point in part (c) for providing evidence that “[w]hen both populations are in the same containing, Species A does not reach 1500 individuals as it did in group 1.” The response further clarifies that Species A “only reached 1400 individuals” in group 2. The response earned 1 point in part (c) for providing evidence that “Species B also did not reach the same number of individuals as it did in group 1.” The response further clarifies that “[i]t reached 50 instead of 700 individuals” in group 2. The response earned 1 point in part (d) for predicting that population growth is limited by “lack of enough food.” The response earned 1 point in part (d) for predicting that population growth is limited by “lack of space.” The response earned 1 point in part (e) for predicting that the activity of the contractile vacuole will increase. The response earned 1 point in part (e) for justifying that the cell “will have become more hypertonic to the solution ... water from the medium will come into the cell.”

Sample: 2B

Score: 8

The response earned 1 point in part (a) for correctly plotting lines for Species A, Group I and Species B, Group II. The response earned 1 point in part (a) for correctly labeling the axes (“number of individuals” on the y-axis and “time (h)” on the x-axis). The response earned 1 point in part (a) for correctly labeling the lines as “Species A, Group I” and “Species B, Group II.” The response earned 1 point in part (c) for providing evidence that “in group II, species B did not grow as much as it did when it was grown alone.” The response earned 1 point in part (c) for providing evidence that, when comparing Group I and Group II, “species A grew more when it was alone.” The response earned 1 point in part (d) for predicting that a factor that would limit growth of species A is “the availability of food.” The response earned 1 point in part (d) for predicting that “the species

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Question 2 (continued)

could run out of space.” The response earned 1 point in part (e) for predicting that the vacuole would “pump more water out of the cell.”

Sample: 2C

Score: 6

The response earned 1 point in part (a) for correctly plotting lines for Species A, Group I and Species B, Group II. The response earned 1 point in part (a) for correctly labeling the axes (“number of individuals” on the y-axis and “time (h)” on the x-axis). The response earned 1 point in part (a) for correctly labeling the lines as “Species A, Group I” and “Species B, Group II.” The response earned 1 point in part (b) for reasoning that the initial population size was reduced “so that each container would have 10 total individuals.” The response earned 1 point in part (d) for predicting that one growth-inhibiting factor would be “a size-limiting container.” The response earned 1 point in part (d) for predicting that one growth-inhibiting factor would be “a lack of sufficient food.”