

AP[®] BIOLOGY
2008 SCORING GUIDELINES

Question 2

2. Consumers in aquatic ecosystems depend on producers for nutrition.

(a) **Explain** the difference between gross and net primary productivity. **(2 points)**

- Definition of gross primary productivity **(1 point)**
 - Total energy converted/transformed by photosynthesis
 - Total organic molecules produced or carbon fixed
- Definition of net primary productivity **(1 point)**
 - The biomass or total energy converted minus the amount used by the producers for cell respiration
 - The amount of energy or organic molecules left for the next trophic level
 - The energy that is available to organisms that eat primary producers
 - Gross primary productivity minus respiration

(b) **Describe** a method to determine net and gross primary productivity in a freshwater pond over a 24-hour period. **(1 point for each bullet; 4 points maximum)**

Measurement described

- Dissolved oxygen production or increase in biomass, or carbon dioxide uptake

Instrument/technique used to collect the data

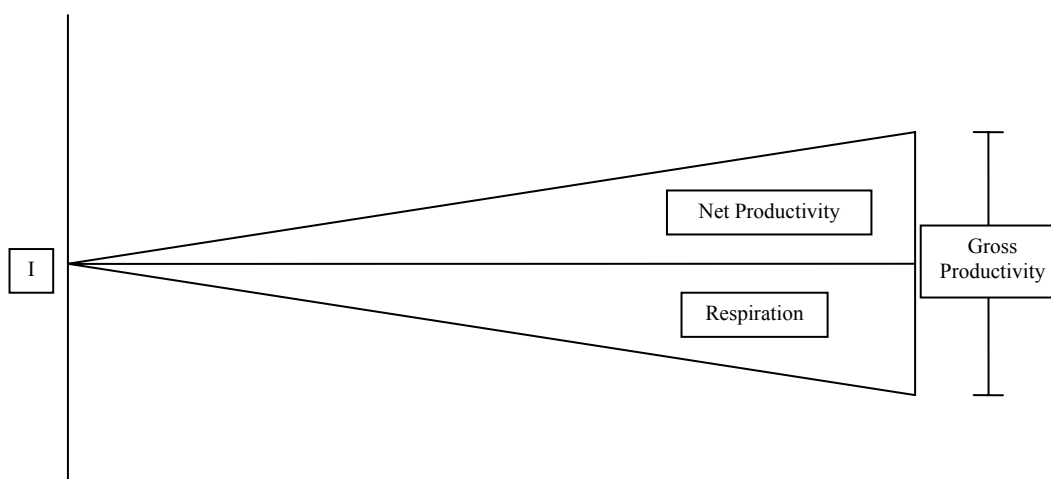
- Winkler or C¹⁴ or oxygen probe

Methodology/design described

- Initial/baseline comparison
- Light and dark bottle comparison

Data analysis

- Light minus initial = net productivity
- Initial minus dark = respiration
- Light minus dark = gross productivity



AP[®] BIOLOGY
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Question 2 (continued)

- (c) **Explain** the data presented by the graph, including a description of the relative rates of metabolic processes occurring at different depths of the pond. **(1 point for each bullet; 4 points maximum)**

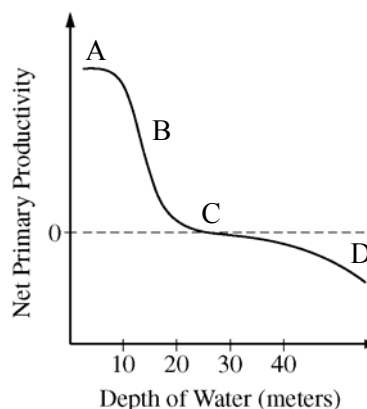
Explanation of data:

- As depth is increased, the net primary productivity decreases because light decreases/lower rates of photosynthesis.

Description of relative rates of metabolic process occurring at specific depths according to the graph (letters added to graph to simplify rubric):

- A: The upper area of the graph is equally productive because light availability is not a limiting factor at the surface/ photosynthesis is not limited.
- B: The rapidly decreasing productivity region is a result of decreasing light available for photosynthesis/photosynthesis is decreasing rapidly.
- C: At 0 (the compensation point) the photosynthetic product is equal to the cell respiration requirements due to light availability/photosynthesis equals cell respiration.
- D: Below 0 the photosynthetic product does not meet the cell respiration requirements due to insufficient light. Photosynthesis less than respiration.

NET PRIMARY PRODUCTIVITY IN A FRESHWATER POND ECOSYSTEM DURING SPRING



- (d) **Describe** how the relationship between net primary productivity and depth would be expected to differ if new data were collected in mid-summer from the same pond. **Explain** your prediction. **(1 point for each bullet; 2 points maximum)**

- Description of a plausible prediction of a change in graph or a change in the relationship between productivity and depth from spring graph to mid-summer graph.
- Explanation of a plausible prediction of a shift in the graph must be tied to a valid or plausible reason.

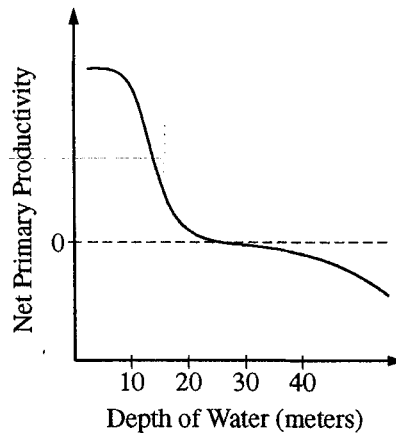
2. Consumers in aquatic ecosystems depend on producers for nutrition.

2A,

- (a) **Explain** the difference between gross and net primary productivity.
- (b) **Describe** a method to determine net and gross primary productivity in a freshwater pond over a 24-hour period.

In an experiment, net primary productivity was measured, in the early spring, for water samples taken from different depths of a freshwater pond in a temperate deciduous forest.

NET PRIMARY PRODUCTIVITY IN A FRESHWATER POND ECOSYSTEM DURING SPRING



- (c) **Explain** the data presented by the graph, including a description of the relative rates of metabolic processes occurring at different depths of the pond.
- (d) **Describe** how the relationship between net primary productivity and depth would be expected to differ if new data were collected in mid-summer from the same pond. **Explain** your prediction.

(a) Gross productivity is total productivity over a period of time. It is the amount of photosynthesis that occurs over a period of time. Net productivity is gross productivity minus cellular respiration.

(b) Take equal-volume samples of pondwater. Determine the dissolved-oxygen content of each. Expose one sample to light, and one sample to zero light. Leave the samples alone for 24 hours; measure the dissolved-oxygen content again, and determine the differences in dissolved-oxygen content. The first difference is gross productivity; the second first minus the second is net productivity.

GO ON TO THE NEXT PAGE.

(c) From 0-10 meters, photosynthesis is occurring at max rate. From 10-20 meters the rate of photosynthesis declines sharply. At 25 meters, the rate of photosynthesis is equal to the rate of cellular respiration. From 25-40 and beyond meters, ~~the~~ the rate of cellular respiration exceeds that of photosynthesis, and the rate of photosynthesis continues to decline.

(d) Net primary productivity would be higher overall; the ~~rate~~ ^{rate} of photosynthesis would equal the rate of cellular respiration at a lower depth. This is because ~~the~~ during mid-summer, the sun's light would reach deeper into the water, allowing more photosynthesis to occur at lower depths.

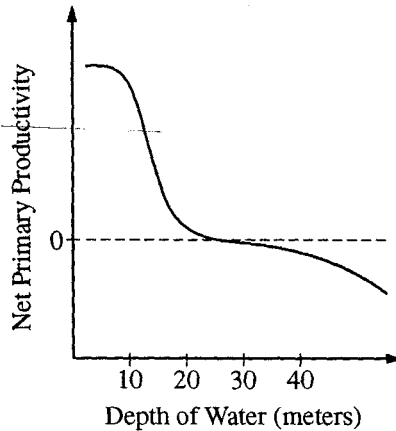
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2B,

2. Consumers in aquatic ecosystems depend on producers for nutrition.
- (a) **Explain** the difference between gross and net primary productivity.
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In an experiment, net primary productivity was measured, in the early spring, for water samples taken from different depths of a freshwater pond in a temperate deciduous forest.

NET PRIMARY PRODUCTIVITY IN A FRESHWATER POND ECOSYSTEM DURING SPRING



- (c) **Explain** the data presented by the graph, including a description of the relative rates of metabolic processes occurring at different depths of the pond.
- (d) **Describe** how the relationship between net primary productivity and depth would be expected to differ if new data were collected in mid-summer from the same pond. **Explain** your prediction.

a) Gross ~~productivity~~ primary productivity is the measurement of the total amount of light energy converted into chemical energy (in the form of glucose ($C_6H_{12}O_6$)). Whereas, net primary productivity is the amount of energy that the producers store. To get the net primary productivity you subtracts the amount of energy the organism uses from how much it creates.

~~the net primary productivity is the amount of energy that the producers store. To get the net primary productivity you subtracts the amount of energy the organism uses from how much it creates. In mid-summer, the amount of light energy is greater, so the net primary productivity is positive. In early spring, the amount of light energy is less, so the net primary productivity is negative.~~

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~~Water in freshwater ponds does not have the same amount of sunlight as the deep part of the pond. The deeper you go, the less sunlight there.~~

b) ~~One~~ One way to determine net and gross primary productivity in a freshwater pond ecosystem is to create one ~~in~~ in a closed environment. This way you can keep all the variables constant such as temperature, humidity, etc. To measure the gross productivity, you can measure the amount of O_2 released over intervals of time. And for the net productivity compare that with the metabolic rates and the amount of mass gained by the organism in the form of stored glucose.

c) In this graph of the net primary productivity in a fresh water pond in spring, the productivity is greatest closest to the surface. As you get deeper, the productivity decreases and eventually goes negative. This is because of the murky water of freshwater ponds. Close to the surface, organisms can get a lot of sunlight, but the ~~deeper~~ deeper you go, the less sunlight reaches there.

d) If new data were to be collected in the middle of the summer I would expect an increase in the overall ~~productivity~~ productivity because of the increased intensity of the sunlight. The light would penetrate farther down into the pond and therefore the organisms ~~at~~ at the deeper depths would be able to photosynthesize more.

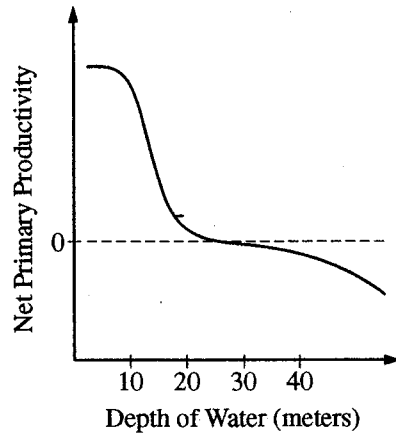
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2. Consumers in aquatic ecosystems depend on producers for nutrition.

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In an experiment, net primary productivity was measured, in the early spring, for water samples taken from different depths of a freshwater pond in a temperate deciduous forest.

NET PRIMARY PRODUCTIVITY IN A FRESHWATER POND ECOSYSTEM DURING SPRING



- (c) **Explain** the data presented by the graph, including a description of the relative rates of metabolic processes occurring at different depths of the pond.
- (d) **Describe** how the relationship between net primary productivity and depth would be expected to differ if new data were collected in mid-summer from the same pond. **Explain** your prediction.

Gross ^{primary} productivity is the actual total amount of ~~all~~ everything being made in an area. Net primary productivity is the ~~amount of gross primary productivity~~ ^{gross primary productivity} when the things that are dying or being used up are subtracted from the gross primary productivity. To determine ~~the~~ ^{the} gross primary productivity in a freshwater pond over 24 hours, ~~CO2~~ ^{CO2} levels should be recorded for ten different ~~depth~~ ^{depths} of the ~~pond~~ ^{pond} every two hours for 24 hours. The ~~water~~ ^{water} samples should be kept constant as well as the tests used to figure out ~~CO2~~ ^{CO2} levels. ~~The change of~~

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The same thing should be done with Oxygen levels at the same time with CO_2 levels to figure out the net primary production. These CO_2 levels should be subtracted from the O_2 levels for each time recorded. Then take these final 12 #'s and average them for the average net primary production. The O_2 levels should all be added up and then divided by 12 to calculate the gross primary production.

The graph shows that ~~net primary productivity~~ net primary productivity is lower in deep water than it is at water closer to the surface. Less and/or slower metabolic processes are taking place in deep areas than areas close to the surface.

The net primary production of the same pond would be higher in all levels of the water during summer rather than spring. This is because more light is allowed into pond at greater intensities for longer periods of time during summer than spring. This allows for more metabolic processes to occur and therefore allows more net primary productivity.

GO ON TO THE NEXT PAGE.

AP[®] BIOLOGY

2008 SCORING COMMENTARY

Question 2

Overview

This was a lab-based question dealing with the principles of primary productivity and the procedures for determining the productivity of an aquatic ecosystem. Students were first asked to differentiate between gross primary productivity (GPP) and net primary productivity (NPP) and then to describe a method for determining GPP and NPP of an aquatic ecosystem. This portion of the question very closely paralleled lab exercise 12B (“Dissolved Oxygen and Aquatic Primary Productivity”) in the *AP Biology Lab Manual for Students*. There was also a graphical analysis portion to the question in which students were asked to provide metabolic explanations relating to a graph of NPP versus depth in a freshwater pond. This allowed them to tie the concept of the availability of sunlight at various depths to the effect on net productivity. Finally, students were asked to describe and explain how the relationship between depth and productivity as displayed in the graph might differ if the data were collected in midsummer rather than spring as was originally indicated.

Sample: 2A

Score: 10

In part (a) the student earned 1 point under the definition of net primary productivity by stating that “net productivity is gross productivity minus cellular respiration.”

In part (b) the student earned the point for indicating that “dissolved-oxygen content” is measured. A point was earned for the light and dark bottle methodology by stating: “Expose one sample to light, and one sample to zero light.” The student earned the initial/baseline point from the scoring guidelines by stating: “Determine the dissolved-oxygen content of each” and then later indicating the need to “[m]easure the dissolved-oxygen content again, and determine the differences.”

In part (c) the student very succinctly earned all 4 points for the description of the relative rates of metabolic process at all four levels indicated on the scoring guidelines. In each case a correct description of the effect of depth on the photosynthetic rate is given.

In part (d) 1 point was earned for the description of the prediction that “the rate of photosynthesis would equal the rate of ... respiration at a lower depth.” The point for explaining the prediction was earned when the student notes “the sun’s light would reach deeper into the water, allowing more photosynthesis to occur.”

Sample: 2B

Score: 6

The student earned both points for part (a): 1 point for a correct definition of gross primary productivity (“the measurement of the total amount of light energy converted into chemical energy”) and 1 point for a correct description of net productivity (“the amount of energy that the producers store” and “subtract the amount of energy the organism uses from how much it creates”).

The student earned 1 point in part (b) for indicating that “the amount of O₂ released” is how productivity will be measured. None of the other methodology discussed is accurate.

The student earned 1 point in part (c) for the general explanation of the data and for relating it to the amount of light reaching the levels. The student does not adequately describe metabolic processes at each level to earn any points for describing the various regions of the graph.

AP[®] BIOLOGY
2008 SCORING COMMENTARY

Question 2 (continued)

In part (d) the student earned 1 point for the description of the prediction (“increase in the overall productivity” and “the deeper depths would be able to photosynthesize more”). A point was also earned for the explanation of the prediction (“increased intensity of the sunlight ... [t]he light would penetrate farther down into the pond”).

Sample: 2C

Score: 3

No points were earned in part (a) as neither the definition for net primary productivity nor that for gross primary productivity is correct. Stating that the “total amount of everything being made” does not identify what the product is or how it is made (photosynthesis).

One point was earned in part (b) for stating that “O₂ levels should be recorded” as a means for measuring productivity. The rest of the experimental methodology is incorrect.

No points were earned in part (c). Although the student mentions that “productivity is lower in deep water than [in] water closer to the surface,” no mention is made that this is due to either decreased light or lower photosynthetic rates. The student restates the phrase “metabolic processes” written in part (c) of the question.

The student earned both points available in part (d). One point was earned for the description of the prediction (“net primary production ... would be higher in all levels”), and 1 point was earned for the explanation of the prediction (“because more light is allowed into [the] pond at greater intensities for longer periods of time”).