AP® Biology
2001 Sample Student Responses

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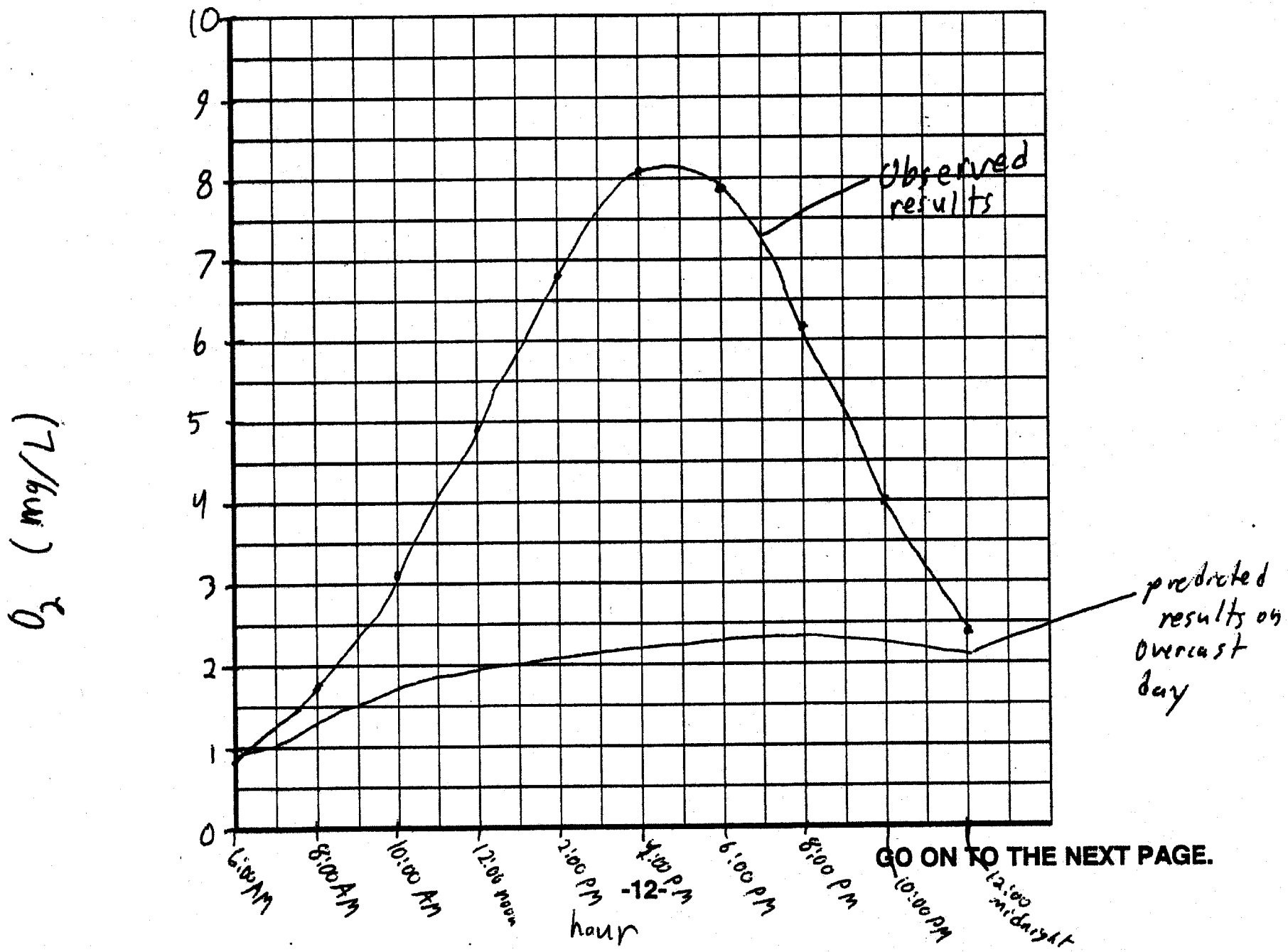
3. A biologist measured dissolved oxygen in the top 30 centimeters of a moderately eutrophic (mesotrophic) lake in the temperate zone. The day was bright and sunny, and the wind was calm. The results of the observations are presented below.

Hour	$[O_2]$
6:00 A.M.	0.9 mg/L
8:00 A.M.	1.7 mg/L
10:00 A.M.	3.1 mg/L
12:00 noon	4.9 mg/L
2:00 P.M.	6.8 mg/L
4:00 P.M.	8.1 mg/L
6:00 P.M.	7.9 mg/L
8:00 P.M.	6.2 mg/L
10:00 P.M.	4.0 mg/L
12:00 midnight	2.4 mg/L

(a) Using the graph paper provided, **plot** the results that were obtained. Then, using the same set of axes, draw and label an additional line/curve representing the results that you would predict had the day been heavily overcast.

(b) **Explain** the biological processes that are operating in the lake to produce the observed data. **Explain** also how these processes would account for your prediction of results for a heavily overcast day.

(c) **Describe** how the introduction of high levels of nutrients such as nitrates and phosphates into the lake would affect subsequent observations. **Explain** your prediction.



ADDITIONAL PAGE FOR ANSWERING QUESTION 3

There are two main factors that account for the oxygen level of the lake – production and consumption. Production of oxygen is the result of the photosynthetic process in plants, which uses carbon dioxide and gives of O_2. Animals in the lake then consume the O_2, giving off CO_2. The animals in the lake use O_2 at a fairly constant rate, so consumption stays relatively constant – there is some increase in consumption by individual animals when they are not dormant, but a lake has nocturnal animals and day animals. The graph, therefore, shows primarily the levels of oxygen production by photosynthesis in plants. The bell-curve shape of the graph is the level of photosynthesis, which corresponds with the level of sunlight. My prediction for an overcast day is low, because on a heavily overcast day there is little sunlight. Little sunlight means little photosynthesis, and therefore little oxygen production.

The introduction of high levels of nitrates, phosphates, and other nutrients into the lake would greatly boost the O_2 levels. These nutrients are essential to plants – a glut of them would stimulate plant reproduction. More plants would lead to more photosynthesis, and therefore more oxygen. After a time, however, the levels would decrease, as the animals in the lake are produced rapidly in response to the increased food supply of plants.

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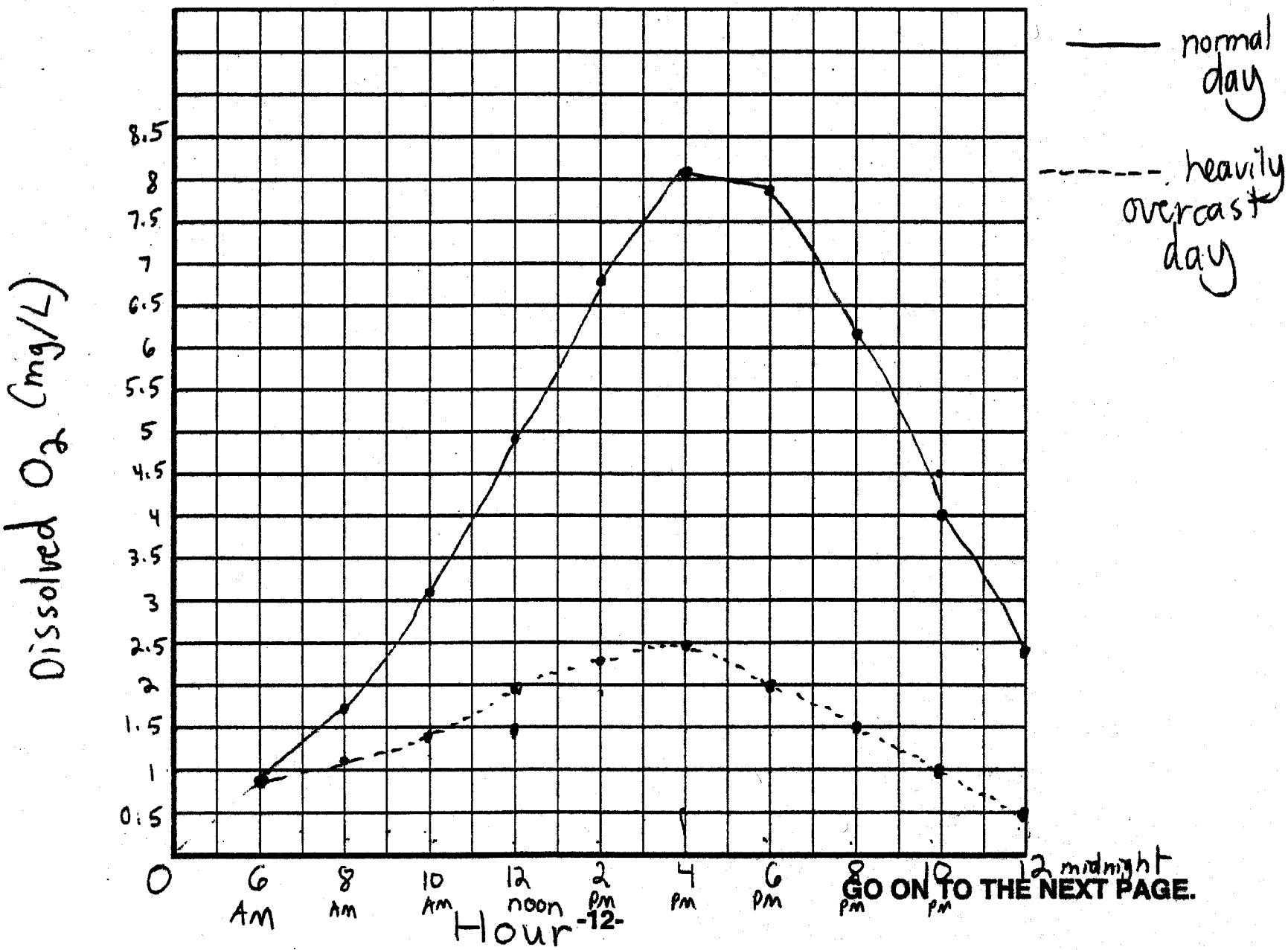

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Respiration and photosynthesis would produce the observed data. During the day (6 AM – 4 PM) oxygen levels increase from 0.9 mg/L to 8.1 mg/L. This is because photosynthesis occurs during the day. Plants near the water surface absorb the sunlight available, which causes electrons in the pigments of their leaves to become energized + leave the photosystem. Water is constantly split so that the hydrogen can replace these lost electrons. As a result, oxygen is given off as a by-product. Therefore, dissolved oxygen accumulates in the water throughout the day as plants undergo photosynthesis. At night (4 PM – 12 midnight), oxygen levels decrease from 8.1 mg/L to 2.4 mg/L because both plants and animals in the water are taking in oxygen for cellular respiration. Since no additional sunlight is available, plants can no longer give off oxygen thru photosynthesis. Oxygen concentration lowers as the amount of O_2 consumed is higher than O_2 produced. On a heavily overcast day, the amount of dissolved O_2 increases only slightly throughout the day, because very little light is able to penetrate the clouds and reach the photosynthetic pigments in the plant leaves. Since no less photosynthesis is occurring, less O_2 is produced. At night, O_2 level still declines at a steady rate because organisms need O_2 for respiration regardless of the amount of light available. They also use up the O_2 much faster since not as much was produced.

Introduction of ^nitrate ~~from the~~ to + phosphate in the lake would affect subsequent observations

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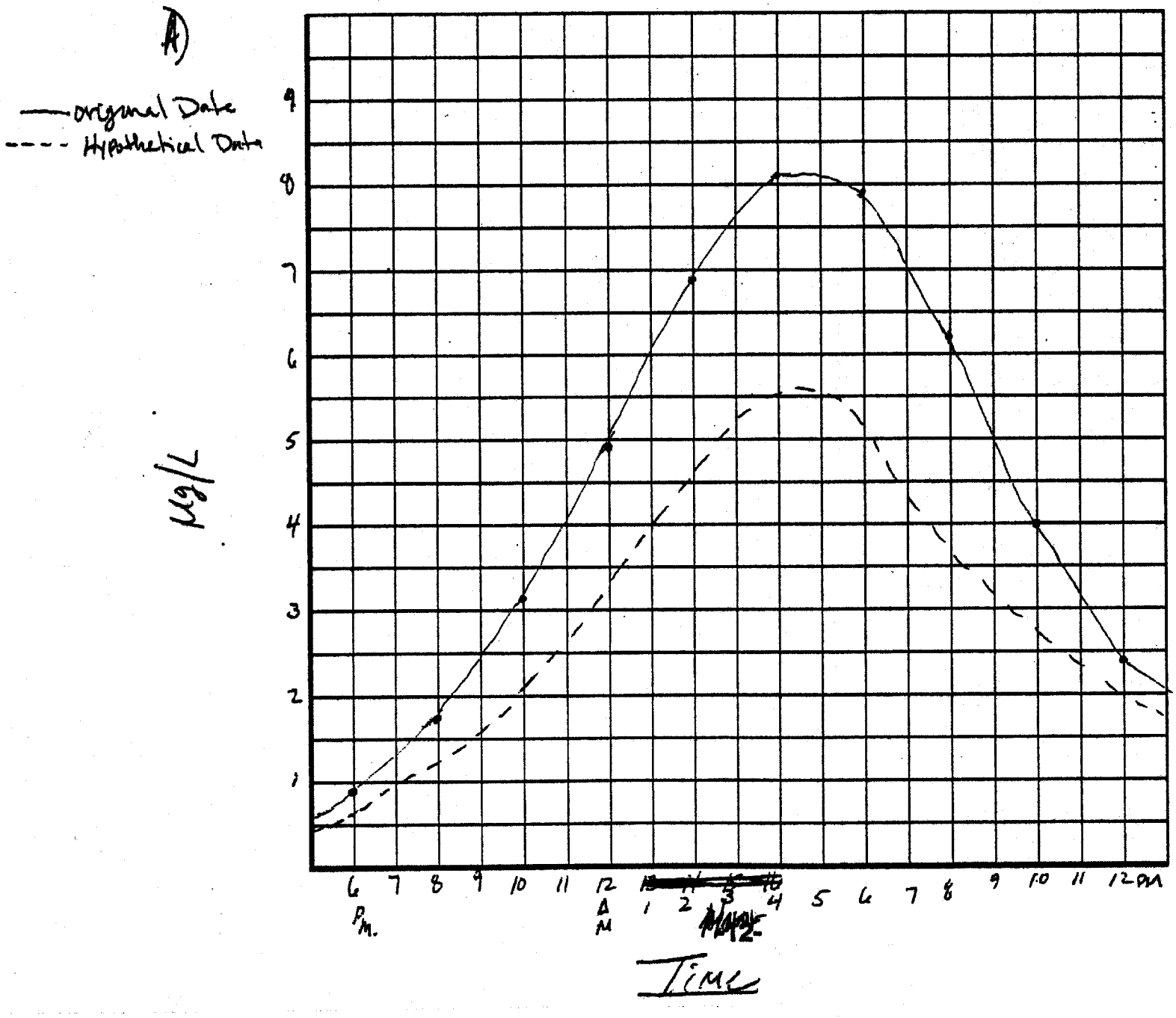
A)



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B) There is photosynthesizing green algea and other plants in the lake. On the day that is bright and sunny, there is more light energy available to the green algea and other plants. This increases the amount of photosynthesis they can perform and the amount of oxygen gas released to be dissolved in the water. Because the amount of dissolved oxygen increased as the day got brighter and decreased as the day neared night, my hypothetical data revolved around this hypothesis: if the day were overcast and less light was available to the producers, then less photosynthesis would occur and less dissolved oxygen would be obtained.

C) The introduction of nitrates and phosphorous would increase the number of producers in the lake. This would initially raise the dissolved oxygen level in the lake because more photosynthesis would be taking place and more O_2 would be released. Eventually, however, the increase in producers would support an increase of primary and secondary consumers that would feed off the producers and utilize the O_2 they give off. The increase in heterotrophs would decrease the dissolved O_2 levels in the lake.