Laboratory 11: Animal Behavior

*describe the relationship between dependent and independent variables
*discuss the value of comparing experimental results with control results
*graph and interpret histogram data
*measure volumes, distances, and temperature using metric scales
*design and conduct an experiment to measure the effect of environmental variables on habitat selection

An organism's habitat is made up by both biotic factors (life forms) and abiotic factors (wind, moisture, temperature, pH, etc.). Brine shrimp are small crustaceans that occur in salt lakes or brine ponds worldwide; they are very hardy, and can be hatched from eggs in about 2 days. This lab allows students to find the most favored physical conditions of the brine shrimp *Artemia* by allowing them to migrate along a range of conditions until they congregate at the point best suited to their physiology.

Each setup will involve filling a 1-meter long tygon plastic hose with about shrimp in solution. Three clamps are placed 25 cm apart long the hose so that individual sections can be later closed off. All experiments will be run in the dark (under a black felt cloth) unless light is the variable.

One tube is set up as the "control"/ no range of conditions is created. A second tube has an ice bag placed at one end, a hot water bottle at the other so that a temperature gradient is set up. A third tube has 1 ml 1M HCl placed in one end, 1 ml 1M NaOH in the other. A fourth tube is placed under a florescent light with sections covered by 8 layers of screening, 4 layers, 2 layers, and no screen at all.

After 30 minutes, clamps are fastened in all the tubes, trapping the shrimp in one of four quadrants. The sections are individually emptied into test tubes and shrimp counted (usually just 1 ml is sufficient; count several and take the average). Dead shrimp are not counted since they could not migrate.

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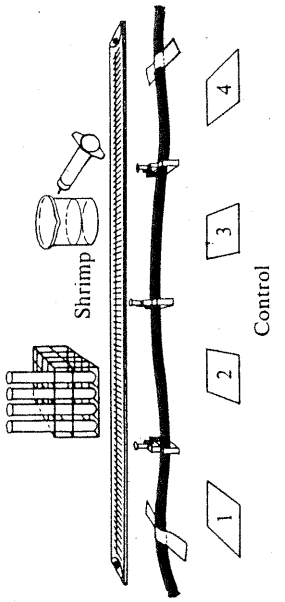
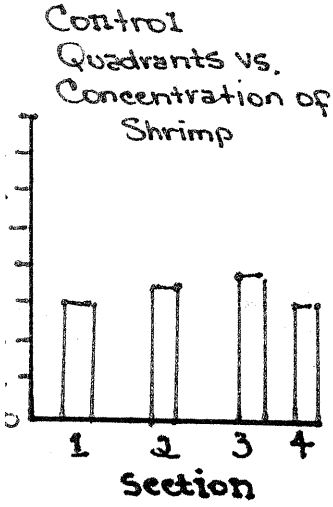
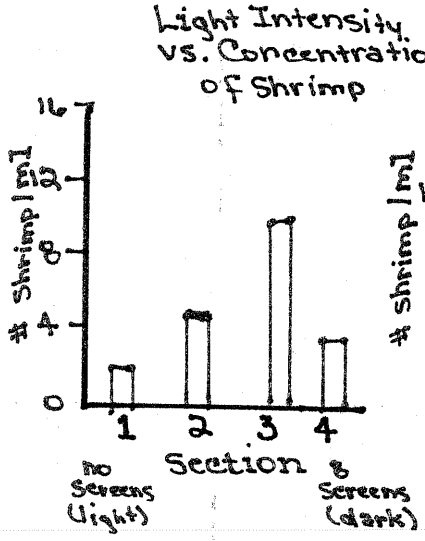


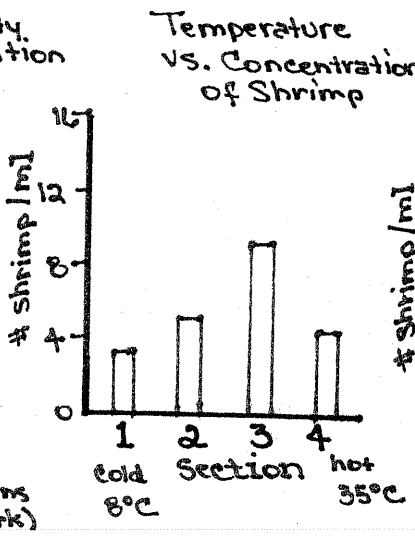
Sample Table for Reporting Data

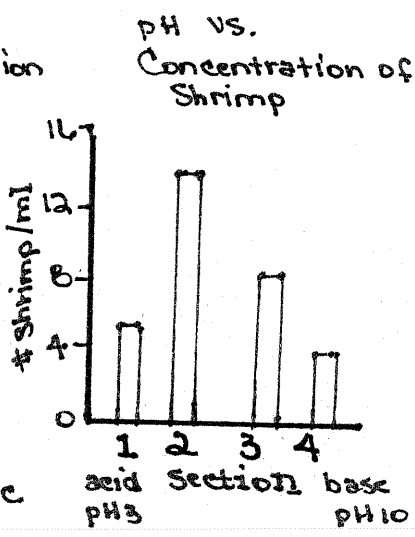
	Section																							
	light cold acid		1					2					3					4 dark hot base					
	1	2	3	4	5	Av.	1	2	3	4	5	Av.	1	2	3	4	5	Av.	1	2	3	4	5	Av.
Control	5	7					8	5					7	9					6	5				
	1	2	3	4	5	Av.	1	2	3	4	5	Av.	1	2	3	4	5	Av.	1	2	3	4	5	Av.
Light Gradient	2	2					4	7					12	10					5	3				
	1	2	3	4	5	Av.	1	2	3	4	5	Av.	1	2	3	4	5	Av.	1	2	3	4	5	Av.
Temperature Gradient	2	4					4	7					7	14					3	7				
	1	2	3	4	5	Av.	1	2	3	4	5	Av.	1	2	3	4	5	Av.	1	2	3	4	5	Av.
pH Gradient	6	5					16	13					7	9					1	6				

Shrimp / ml









Free-Response Question 3

*A scientist working with **Bursatella leachi,** a sea slug that lives in an intertidal habitat in the coastal waters of Puerto Rico, gathered the following information about the distribution of the sea slugs within a ten-meter square plot over a 10-day period.*

DISTRIBUTION OF SLUGS WITHIN A TEN-METER SQUARE PLOT

Time of Day	*Average Distance Between Individuals (cm)*
Midnight	*8.0*
4 A.M.	*8.9*
8 A.M.	*44.8*
NOON	*174.0*
4 P.M.	*350.5*
8 P.M.	*60.5*
Midnight	*8.0*

a. *For the data above, provide information on each of the following.*
   - *Summarize the pattern.*
   - *Identify THREE physiological or environmental variables that could cause the slugs to vary their distance from each other.*
   - *Explain how each variable could bring about the observed pattern of distribution.*

b. *Choose ONE of the variables that you identified and design a controlled experiment to test your hypothetical explanation. Describe results that would support or refute your hypothesis.*

Question 3 Standards

Overall Commentary for Question 3

Question 3 was composed of two discrete parts in which part a asked the student to analyze and interpret data; and part b directed the student to choose one of the variables identified and design an experiment. Three bullets in part a directed the student to: (1) summarize the pattern; (2) identify three physiological or environmental variables that would account for the observed data; and (3) explain how each variable would support the observed pattern of distribution. Part b asked the student to design a controlled experiment and describe how the experiment would support or refute the hypothesis.

Part a: From the data

Maximum for part a = 6 points

1 point — Summarize pattern (dispersal — day / clumped — night)
1 point — 3 physiological or environmental variables (1st three **only** and **TESTABLE**)

carbon dioxide	light	rhythms
competition	mating	salinity
desiccation	metabolism	taxis
endogenous	oxygen	temperature
feeding	pH	tidal exchange
foraging	predation	water depth
hormonal	protection	(**Others possible**)

1 point each — For a clear and plausible explanation of variable as it influences
(3 maximum) the observed distribution pattern (vary)

1 point — Elaboration

Part b: Controlled experiment for one variable

Maximum for part b = 6 points

1 point — Control — constants (explicit)
1 point — Manipulation of variable
1 point — Measurement (quantitative)
1 point — Verification (sample size / repetition)
1 point — Hypothesis (if:then) **TESTABLE**
1 point — Statistical analysis of data
1 point — Results as related to hypothesis
1 point — Elaboration

Only ONE extra elaboration point may be earned in either part a or part b — for extensive, unique, or exceptional effort.

Samples of Student Wording

Hypothesis — I hypothesize that as the temperature of the water increases the distance between the slugs will increase.

Manipulation of variable — One tank of slugs was kept at 20 degrees C and the other tank at 25 degrees C.

Measurement — A ruler was used to measure the distance between the slugs — initial-final. (This point was given when a student explicitly describe how to measure the effect of the variable. Implication was insufficient.)

Verification — The experiment was repeated five times to verify the results.

Control — Both tanks of slugs were exposed to the same amount of light. The water in both tanks was held at a constant pH, dissolved oxygen and salinity. (We considered that it was necessary to explain how the control was to function for this point. Additionally, we were looking for a discrete if:then hypothesis prediction or a close equivalent for describing the hypothesis rather than the implied hypothesis resulting from part a explanations.)

Statistical Analysis — The results from the five trials were averaged (or students could cite the use of Chi-square).

Results as related to hypothesis — If the slugs in the tank at 25 degrees C had a larger mean distance between them the hypothesis would be supported.

Elaboration — of any of the above such as a reference to the literature, an exceptional design, or use of tables.

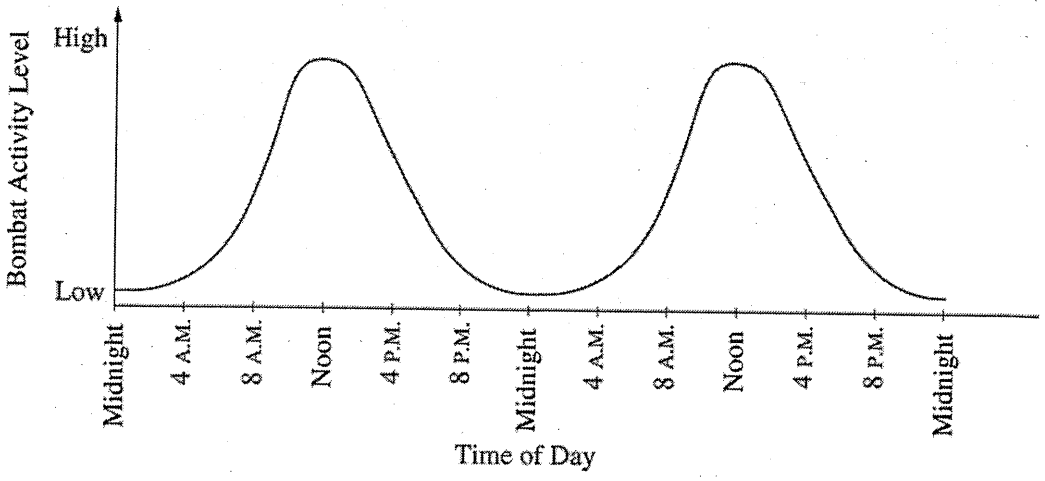
EXCELLENT ESSAY (10 points)

(a) In the experiment with the sea slug, there is a definite pattern involved around midnight the slugs are the closest together and they then proceed, as the day goes on to move farther and farther from each other until 4:00 pm when they are at their farthest. They then proceed to quickly move closer together until midnight when they are again very close together. Three physical or environmental variables that could cause the slugs to vary their distance could be the temperature, the amount of light available, and the tide as it comes in and goes out. Temp. differences could cause changes in the slugs metabolic rate of activity and colder night air could cause them to move closer and less as their systems are slowed down. Light could cause them to not move as much and congregate because they are sensitive to the light. When there is more light, they are more active. Finally, the tide because it cycles every 24 hours, could have been out at night causing the slugs to congregate in tide pools whereas during the day they could go wherever they wanted as long as they could stay in the water.

(b) In a controlled experiment to test my hypothetical explanation of the Tides part in the slugs distance, I would have 3 three different boxes all with sand and algae and the components of the ocean floor that the slugs need to live on. I would keep the temperature of the air and water at a constant 32°C, and the light would be constantly equal to that of mid day. In one of the three boxes there would be plenty of water to cover the entire box. In the second, there would be only tidal pools. In the third the water level would be changed as that of an incoming and outgoing tide. For a couple weeks I would watch the slugs and take information regarding their position at 4 hour intervals. If the slugs did not congregate in the pools of tank two and tank 3 when the "tide" is out, then my hypothesis would be incorrect, or if the congregated in the tank 1 or in Tank 3 when the "tide" was in, I would be wrong as well. If I was correct, In tank 1, the slugs would be dispersed in tank two they would be clustered, and in Tank 3 they would alternate depending if the tide was in or out.

Lab #11
Animal Behavior

2. The activities of organisms change at regular time intervals. These changes are called biological rhythms. The graph depicts the activity cycle over a 48-hour period for a fictional group of mammals called pointy-eared bombats, found on an isolated island in the temperate zone.



(a) **Describe** the cycle of activity for the bombats. **Discuss** how **three** of the following factors might affect the physiology and/or behavior of the bombats to result in this pattern of activity.

- temperature
- food availability
- presence of predators
- social behavior

(b) **Propose** a hypothesis regarding the effect of light on the cycle of activity in bombats. **Describe** a controlled experiment that could be performed to test this hypothesis, and the results you would expect.

3. The complexity of structure and function varies widely across the animal kingdom. Despite this variation, animals exhibit common processes. These include the following.

- transport of materials
- response to stimuli
- gas exchange
- locomotion

(a) Choose **two** of the processes above and for each, describe the relevant structures and how they function to accomplish the process in the following phyla.

Cnidaria (e.g., hydra, jellyfish)
Annelida (e.g., earthworm)
Chordata (e.g., mouse)

(b) Explain the adaptive (evolutionary) value(s) of the structural examples you described in part a.

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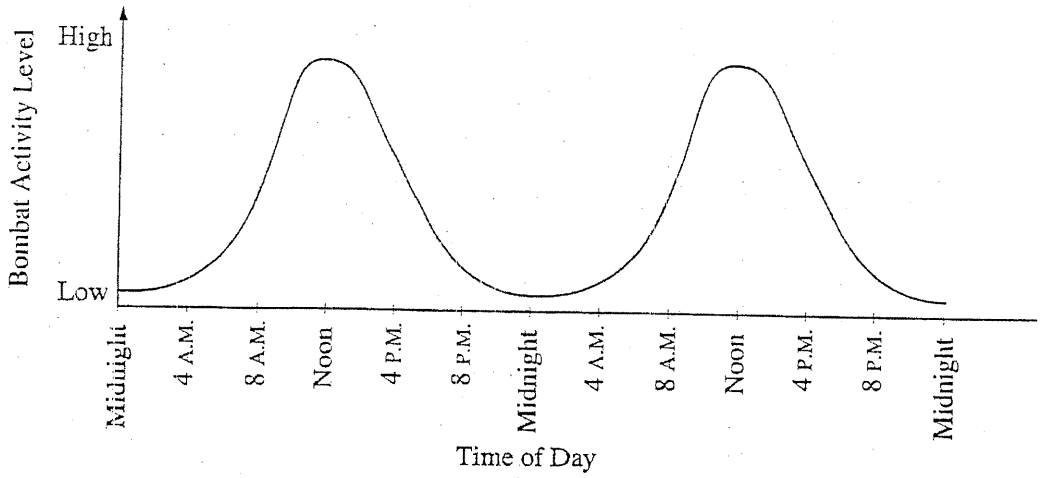

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- temperature
- food availability
- presence of predators
- social behavior

(b) **Propose** a hypothesis regarding the effect of light on the cycle of activity in bombats. **Describe** a controlled experiment that could be performed to test this hypothesis, and the results you would expect.

(A.) The lowest point of activity occur consistently at midnight. As the day progresses the activity continues to increase until it peeks around noon time. Then after that the activity begins a steady decline until its lowest point at midnight. One reason that may cause this is food availability. Since many organisms are inactive during the night the bombats wouldn't be able to acquire a lot of food and would just waste energy finding it. However, as the day wears on activity increases, which means the prey the bombat hunts also increases its activity. The high point for both is around noon, and continues to decrease after that as night begins to approach.

The second factor could be temperature. During the night it is cooler and the sun is not out. That means that organisms

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2R2

ADDITIONAL PAGE FOR ANSWERING QUESTION 2

sleep to conserve body heat and energy. ~~[illegible]~~ As the sun begins to rise temperature goes up and more and more organisms ~~[illegible]~~ begin to move about. When the sun is at its highest point around noon the temperatures are high and ~~[illegible]~~ organisms are now everywhere. This means that it is easier for combats to find food and they expend less energy keeping warm because the sun's rays do it for them. As temperatures begin to cool down organisms begin to retreat back into their homes and activity decreases.

The last factor could be predators. The organisms that hunt combats may be nocturnal and hunt them at night. The combats activity decreases so that they have a better chance of NOT getting captured by a predator. Since most nocturnal animals sleep during the day the combats are most active then because their chances of getting killed are less. As night approaches they slow down their activity because predators will be around and more and more of them will become active during the night so again, decreasing their activity at night lowers their chances of dying.

(5) The problem is whether or not ~~[illegible]~~ light has an effect on the activity of combats. One testible hypothesis is that ~~[illegible]~~ more light helps the combats see their prey better, which would account for their increased activity during the hours around noontime.

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2R3

ADDITIONAL PAGE FOR ANSWERING QUESTION 2

One way to test this is to first select an area of land where ~~the~~ combats and their prey are living. ~~For the experimental group~~. For the control group monitor how effectively the combats can capture prey during certain times of the days and record results. It will be necessary to mark about 30 individuals and monitor their progress only over a period of about 3 days.

For the experiment group, catch a new group of 30 combats and mark them. Use another plot of land with the same / near same conditions as the other one. Record results for how effectively this group of combats can capture prey for three days using the same method as before. For the variable, at night set up a large flood-light as light source. Then record the amount of prey caught by the combats for three more days. Recording the results would be displayed best on a bar graph. The x-axis would be the time of day and the y-axis would be the amount of prey caught. If the light did have an affect on improving the combats sight then the amount of prey caught in the ~~experimental~~ experimental group should be higher.

Thus, if the results proved the hypothesis, then that means that light does have an ~~affect~~ effect on combats catching their prey. This would also prove why they hunt more during the day time then at night.

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Laboratory 12: Dissolved Oxygen and Aquatic Primary Productivity

*describe the physiological importance of carbon and oxygen in an ecosystem
*understand the physical and biological factors that affect the solubility of dissolved gases in aquatic ecosystems
*describe a technique for measuring dissolved oxygen
*define primary productivity
*describe the relationship between dissolved oxygen and the process of photosynthesis and respiration as they affect primary productivity in an ecosystem
*design an experiment to measure primary productivity in an aquatic ecosystem
*understand the effect of light and nutrients on photosynthesis

Oxygen is critical to the maintenance of the life processes of nearly all organisms. In the aquatic environment, it must be in solution in a free state before it is available for use by organisms. Its concentration and distribution are directly dependent on the chemical and physical factors of the water, and are greatly affected by biological processes. The atmosphere is about 20% O_2; the water contains only 0.5-1% dissolved oxygen (DO). Measurement of oxygen in an aquatic environment is a very important indicator of water quality.

Salinity and temperature have great effects on DO; both seem to decrease the available oxygen as they increase. Respiration and photosynthesis rates are also important.

The fertility of any body of water depends on the productivity of the green plants there: the primary productivity of an ecosystem is the rate at which sunlight is stored by plants in the form of organic materials (rate of photosynthesis). The rate of oxygen production in this process can be used to calculate the fixation rate [1 ml O_2 = 0.536 mg of carbon]. One method of measuring O_2 production is the light and dark bottle method. DO concentrations of samples are measured and compared after incubation in light and darkness; the difference between the bottle is the total oxygen productivity = gross productivity.

The Winkler method is often used to measure DO.

a. add alkaline iodide and manganous sulfate to water sample
b. manganous hydroxide is produced/ when acidified, is converted to tetravalent manganese compound by available O_2
c. compound reacts with iodide to release iodine, coloring the water yellow
d. titration with sodium thiosulfate will finally render solution colorless (amount = amount of dissolved O_2)

Using BOD bottles (biological oxygen demand), you can take initial DO reading: one over 24-hour period with light, one over same period with dark, and in bottles with nitrogen and phosphorus added ("enriched").

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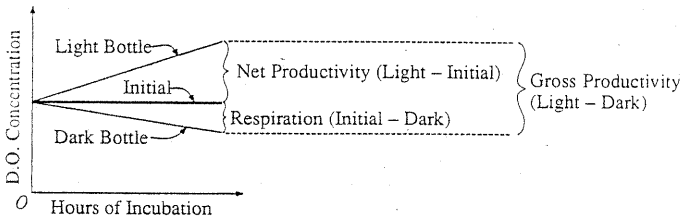


Class Averages for different Light Intensities using a *Chorella* culture

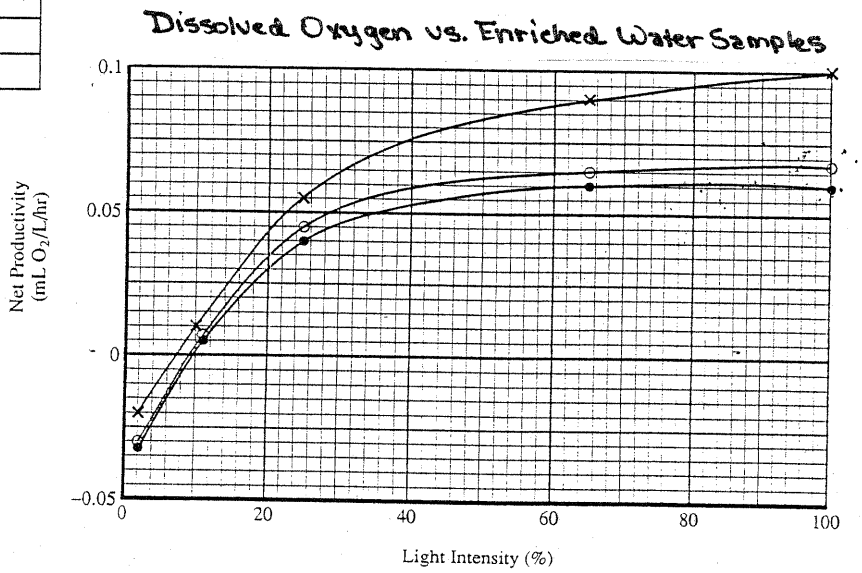
% Light	Gross*			Net*		
	N	P	—	N	P	—
100	0.19	0.16	0.15	0.10	0.07	0.06
65	0.18	0.15	0.15	0.09	0.06	0.06
25	0.14	0.13	0.13	0.06	0.04	0.04
10	0.10	0.10	0.10	0.01	0.01	0.01
2	0.07	0.06	0.06	-0.02	-0.03	-0.03

*$mL O_2/L/hr$

Respiration*
0.09

DO Concentration Data Sheet — Class Sample

Temperature	Mean DO (mg/L)	%DO Saturation
5°c	9.3	>0
20°c	8.9	95
30°c	8.5	110



Lab #12 Dissolved Oxygen

Question 3
2001

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	[O2]
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
4:00P.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.

The Grading Standards for Question 3:

*(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.* (4 points possible)

(1) Proper orientation of graph (independent variable on x-axis)

(1) Graph (all must be present):
- Uniform spacing of units
- Correct labeling of axes:
  - proper numbering (a minor error acceptable)
  - X-axis label: "Time"/ "Hour"/AM, PM labels/a conversion to integers requires unit label as well
  - Y-axis: oxygen label and mg/L Unit

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(1) Correct plot of data points
-no connecting line necessary
-No point if more than one data point is misplotted
-No point if there is a solid extrapolation line beyond the 6:00 AM data point to the origin or beyond the 12 midnight data point

(1) Drawing the cloudy day prediction Line/Curve (all must be present):
- Distinguish between the two curves with a legend or direct labeling of one curve
- Position completely under the bright-day curve (may touch toward the tails)
- There must be some curve to the line (no flat lines)

(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.* (5 points possible)

(1) Photosynthesis: production of O_2 correlated with light changes (i.e. explains changes in shape of bright-day curve). The student must link photosynthesis to increase in light to increase in O_2 production. The student must use the term "photosynthesis" or an excellent replacement such as the chemical equation for the process.

(1) Respiration: consumption of O_2. Must link respiration to decrease in O_2. The student must use the term "respiration" or an excellent replacement such as the chemical equation for the process or the name of another process such as "decomposition."

(1) Description of the interaction of the above: photosynthetic rate changes while respiration rate remains relatively constant.

(1) Overcast prediction curve explanation:
- Reduced light leads to decreased photosynthetic O_2 production, etc.
- No point given if there is no prediction line/curve on the graph.

(1) Elaboration point (1 max) for any one of the above. Examples of elaboration may include, but are not limited to
- Water split/photolysis to produce O_2 in the light phase, etc.
- Balanced equation for photosynthesis or respiration (unless used as a substitute for the term above)
- Description of "light phase" processes (photosystem II, etc)
- Gross vs. net productivity

(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. (3 points possible)*

(1) Describe (predict) a change in lake conditions such as (must be related to the question):
- increased/decreased O_2
- increased/decreased biomass or numbers of organisms
- increased/decreased CO_2
- long-term or short-term changes
- no change

(1) Explanation of the prediction above
- may include toxic effects due to significant changes in pH, altered osmolarity, etc.

(1) Elaboration on the explanation of the prediction above or long term ecological consequences to lake.

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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.

3Q, (10 pts)

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.

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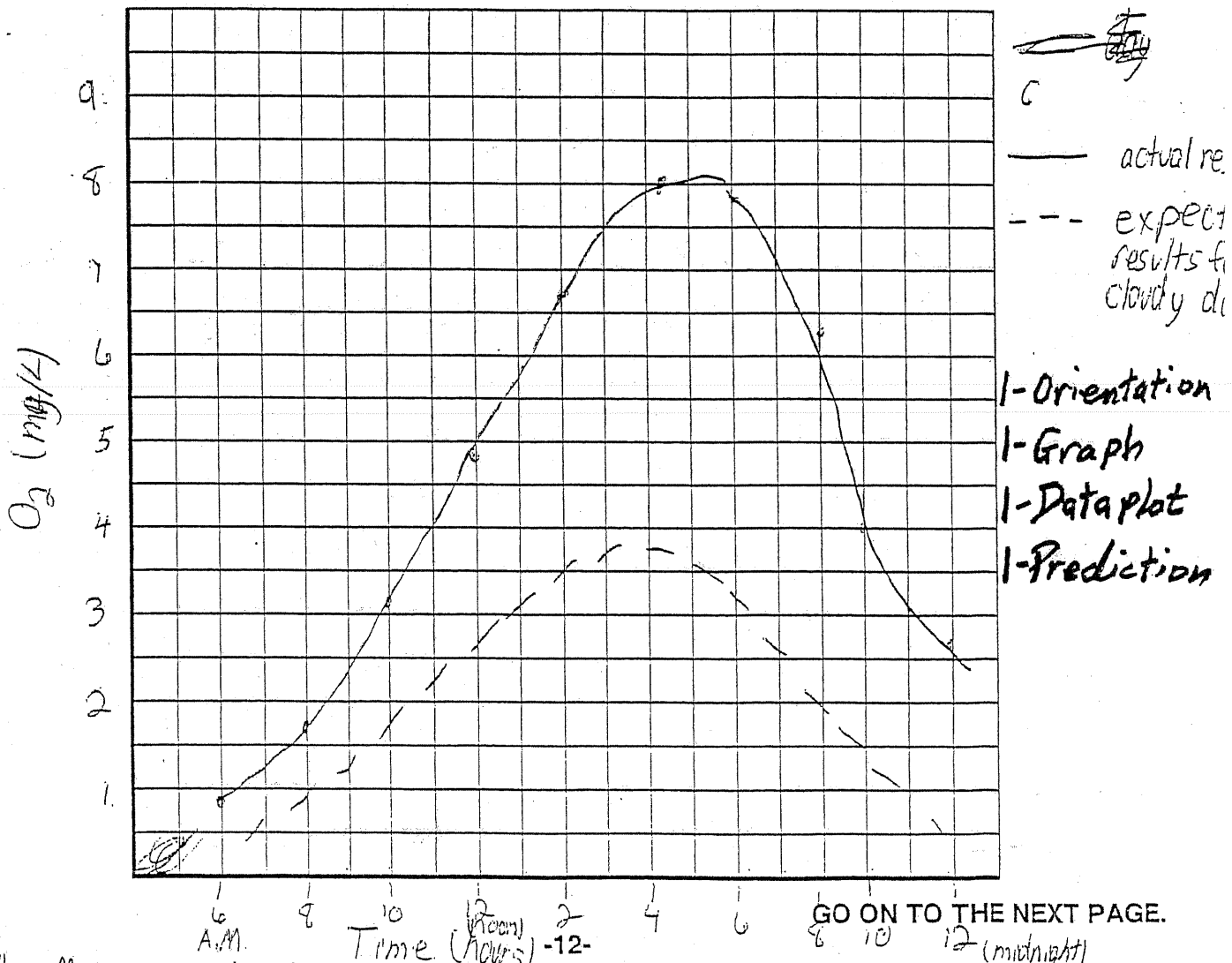

Graph 1. Measurement of Dissolved O_2

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3 Q2

ADDITIONAL PAGE FOR ANSWERING QUESTION 3

B. ~~At~~ In the ~~morning~~ morning dissolved O_2 levels are low. At mid-day the levels peak, and then later in the day the levels lower. One reason for the dO_2 levels is the amount of sunlight reaching the lake. As the day continues, more sunlight reaches the plants in the lake. Because sunlight is used to initiate photosynthesis, more photosynthesis occurs with more sunlight. The sunlight helps excite the electrons in photosystems I & II which aid in the production of ATP and NADPH which are used to produce glucose and as a waste product O_2. the more ~~plan~~ sunlight the more photosynthesis, the more O_2 is given off as a waste product. The O_2 levels are also lower at night because the pl animals in the lake still have to perform cellular respiration which causes the O_2 levels to drop because O_2 is needed. ① Resp. ① photo. Photosynthesis also slows down or stops because there is no light which is needed for the process. The O_2 levels would be lower on an overcast day because there is not as much sunlight reaching the plants, thus causing less photosynthetic activity thus producing less O_2. ① Explanation of curve Also the animals ~~and~~ & plants continue cellular respiration. Since plants don't photosynthesize as much, there is not an equal production and consumption of O_2 causing O_2 levels to be lower than normal. ① Interaction

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3Q3

ADDITIONAL PAGE FOR ANSWERING QUESTION 3

C. If high levels of nutrients such as nitrates and phosphates were added then the lake would have higher levels of O_2. (1) Prediction This is because the nitrates would become part of the nitrogen cycle. It has been shown increased levels of nitrogen increase plant fertility. This may be because the nitrogen ~~are~~ is used in the production of DNA and nucleotides such as NADPH. Since NADPH is an energy molecule, and there is more energy w/the nitrogen, the plant has more energy to make food. The added phosphate will also help because it too is part of the NADPH ~~and~~ nucleotide. Phosphate can also be used in another energy molecule ATP. Phosphate will help provide more energy. Nitrogen & phosphate are both macronutrients meaning they are required in large amounts for plants.

(1) Explanation + possible elaboration

(10)

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