AP® BIOLOGY
2008 SCORING GUIDELINES (Form B)

Question 1

1. Measurements of dissolved oxygen (DO) are used to determine primary productivity in bodies of water.

- Explain the relationship of dissolved oxygen to primary productivity.

  Primary productivity **(4 points maximum)**
  - Primary productivity: rate at which autotrophs convert light energy into stored chemical energy
  - Increase in oxygen = increase in primary productivity
  - Rate of carbon compound formation measured indirectly through oxygen production
  - $6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$
  - Gross productivity\GPP = rate at which primary producer synthesizes O_2
  - Net productivity = GPP – producer respiration
  - Autotrophs produce/consume oxygen; heterotrophs consume oxygen

- How would the predicted levels of DO differ in each of the following pairs of water samples? Provide support for your prediction. Be sure to include a discussion of net productivity and gross productivity in your answer.

  I. Pond water at 25°C vs. pond water at 15°C **(4 points maximum)**
  - Prediction: DO at 15° greater than DO at 25°
  - Why: [saturation DO] 15° greater than [saturation DO] 25°
  - Example **(1 point maximum)**
    - Higher metabolic rate of aquatic organisms at warmer temperature = less available oxygen
    - Fish die in summer ponds/trout live in cold streams
    - Drinks at room temperature hold less dissolved gas than when cold
  - Elaboration of the example

  II. Pond water placed in the dark for 24 hours vs. pond water placed in light for 24 hours **(4 points maximum)**
  - Prediction: DO in light greater than DO in dark
  - Why: photosynthesis ↑ and oxygen ↑
    - Photosynthesis is light dependent
    - Light bottle is the NET productivity
    - Dark bottle uses O_2/respiration

BIOLOGY
SECTION II
Time—1 hour and 30 minutes

1A,

Directions: Answer all questions.

Answers must be in essay form. Outline form is not acceptable. Labeled diagrams may be used to supplement discussion, but in no case will a diagram alone suffice. It is important that you read each question completely before you begin to write. Write all your answers on the pages following the questions in this booklet.

1. Measurements of dissolved oxygen (DO) are used to determine primary productivity in bodies of water.

   - Explain the relationship of dissolved oxygen to primary productivity.
   - How would the predicted levels of DO differ in each of the following pairs of water samples? Provide support for your prediction. Be sure to include a discussion of net productivity and gross productivity in your answer.

   I. Pond water at 25°C vs. pond water at 15°C
   II. Pond water placed in the dark for 24 hours vs. pond water placed in light for 24 hours

Primary productivity is photosynthesis and conducted by photoautotrophs (the exception is chemoautotrophs). Photosynthesis produces O_2 (oxygen) as a byproduct.

$$6CO_2 + 6H_2O \longrightarrow C_6H_{12}O_6 + 6O_2$$

photosynthesis reaction

Thus O_2 in water, or dissolved oxygen (DO) can be used to measure the photosynthetic output of aquatic primary producers ~~in the water~~ (i.e. primary productivity).

I. Gross productivity is the total photosynthetic output of primary producers. Net productivity is gross productivity with cellular respiration taken into account (thus reducing overall primary productivity). At 25°C, pond water microorganisms will conduct more cellular respiration than at 15°C, thus net productivity in 25°C pond water will be less than that of 15°C pond water. As a result, DO levels should be less in the 25°C pond water than in the 15°C pond water. This is because increased temperature is increased average kinetic energy, and with more kinetic energy there are more collisions between enzymes that conduct cellular respiration and its substrate, thus increasing cellular respiration.

GO ON TO THE NEXT PAGE.

1A2

II. Pond water placed in the light will allow its microorganisms to conduct photosynthesis. Pond water microorganisms in the dark will not conduct photosynthesis. Thus the gross productivity of dark pond water will be zero, and its net productivity will be negative due to cellular respiration. Consequently its DO levels should be less than that of lighted pond water. Conversely, lighted pond water organisms will ~~[illegible]~~ conduct primary productivity. Thus their ~~gross productivity~~ net productivity will be positive, and one would expect the pond water to have higher DO levels.

1B,

BIOLOGY
SECTION II
Time—1 hour and 30 minutes

Directions: Answer all questions.

Answers must be in essay form. Outline form is not acceptable. Labeled diagrams may be used to supplement discussion, but in no case will a diagram alone suffice. It is important that you read each question completely before you begin to write. Write all your answers on the pages following the questions in this booklet.

1. Measurements of dissolved oxygen (DO) are used to determine primary productivity in bodies of water.

   - Explain the relationship of dissolved oxygen to primary productivity.
   - How would the predicted levels of DO differ in each of the following pairs of water samples? Provide support for your prediction. Be sure to include a discussion of net productivity and gross productivity in your answer.

   I. Pond water at 25°C vs. pond water at 15°C
   II. Pond water placed in the dark for 24 hours vs. pond water placed in light for 24 hours

Primary Productivity is the amount of the organic sugar compounds, such as glucose, that is produced by photosynthetic organisms. So, primary productivity is determined by the rate of photosynthesis of the producers.

$$Light + 6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$$

Figure 1. The equation for Photosynthesis

As from the equation of photosynthesis, oxygen is produced by photosynthesis. Thus, the greater the primary productivity, the greater the oxygen produced, and greater the amount of oxygen dissolved in bodies of water

GO ON TO THE NEXT PAGE.

ADDITIONAL PAGE FOR ANSWERING QUESTION 1

Along with photosynthesis, producers also go through respiration, which decreases DO level. While photosynthesis occurs only if there is sunlight, respiration always occurs. Photosynthesis occurs due to several enzymes. For example, during the light phase, enzymes such as primary electron acceptors accept excited e^- from photosystems, and $NADP^+$ become reducted to NADPH. During the Calvin Cycle, enzymes such as RUBISCO are used to produce glucose. Such enzymes become more active with increased temperature. Thus, the DO of pond at 25°C will be higher than that of pond at 15°C.

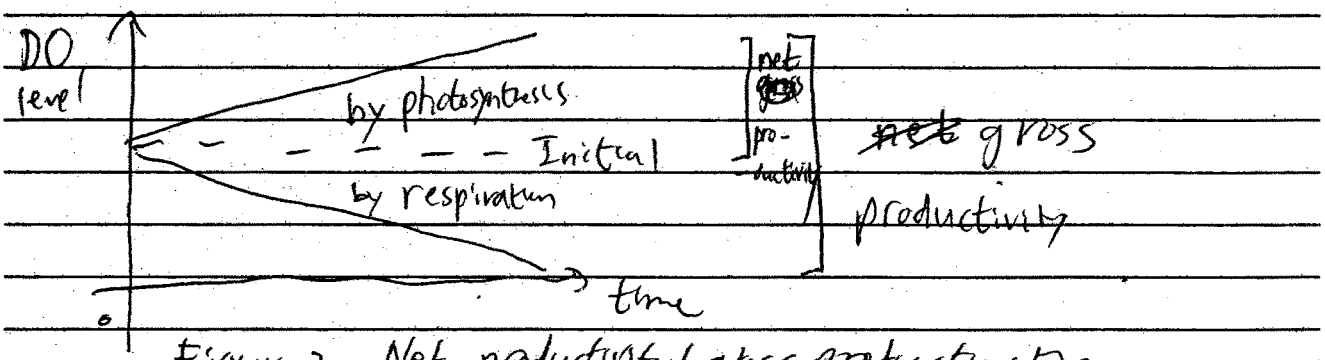

Figure 2. Net productivity/gross productivity

So, as from figure 2, the net productivity and gross productivity of the pond at 25°C will be higher than those of the pond at 15°C.

The pond water placed in light for 24 hours will have higher DO level than that placed in darkness because photosynthesis requires light. Thus, the water placed at light will have both higher net productivity and gross productivity

GO ON TO THE NEXT PAGE.

1C1

BIOLOGY
SECTION II
Time—1 hour and 30 minutes

Directions: Answer all questions.

Answers must be in essay form. Outline form is not acceptable. Labeled diagrams may be used to supplement discussion, but in no case will a diagram alone suffice. It is important that you read each question completely before you begin to write. Write all your answers on the pages following the questions in this booklet.

1. Measurements of dissolved oxygen (DO) are used to determine primary productivity in bodies of water.

   - Explain the relationship of dissolved oxygen to primary productivity.
   - How would the predicted levels of DO differ in each of the following pairs of water samples? Provide support for your prediction. Be sure to include a discussion of net productivity and gross productivity in your answer.

   I. Pond water at 25°C → active vs. pond water at 15°C
   II. Pond water placed in the dark for 24 hours vs. pond water placed in light for 24 hours

In the water, there are some biological organisms which can respirate or photosynthelize to make a oxygen. That is primary productivity is able to be increased due to the active movement - respiration or photosynthesis of organisms which extract air into the water.

The quantity of this water is different based on temperature and the light. To be specific, in the circumstances of warm water, it is easy to create / extract more oxygen into the water, since activation energy of water is increased. In other words, organisms make more oxygen into the liquid, which is warmer. Thus, dissolved oxygen can be high.

In addition, whether exposed in the dark or light is the major factor of extraction more oxygen into the water. In the light time, organisms which do in photosynthesis ~~can~~ are responsible for participating it. By this process, they can emit more oxygen. However, during the dark time, organisms creating oxygen with photosynthesis do not function it anymore. This is because there is no more light which is necessary to make oxygen. Rather, this organisms consume ~~oxy~~ ~~oxygen~~ oxygen in the pond so it is hard to keep high productivity.

GO ON TO THE NEXT PAGE.

ADDITIONAL PAGE FOR ANSWERING QUESTION 1

To summarize, during the warm and bright circumstances organisms in the pond do photosynthesis; there is ~~@~~ ~~@~~ increasing amount of oxygen which activates the productivity. However, in an inverse ~~time~~ condition, they need to respirate and can not do ~~pho~~photosynthesis, so the productivity of water is getting low with the lower level of dissolved oxygen.

AP® BIOLOGY
2008 SCORING COMMENTARY (Form B)

Question 1

Sample: 1A
Score: 10

The first point was earned for the correct equation for photosynthesis. A second point was earned by noting that primary productivity can be determined by measuring dissolved-oxygen content. The definitions of gross productivity and net productivity earned the third and fourth points. Recognizing that pond water at 15° would have more dissolved oxygen than pond water at 25° earned the fifth point, and the sixth was earned for supporting this prediction with the discussion of cellular respiration increasing with the higher temperature, thus removing oxygen from the 25° pond. The second prediction—that pond water placed in light would produce more oxygen than when exposed to darkness—earned a seventh point. The student earned the eighth point for stating that the lower amount of dissolved oxygen in the dark pond could be due to cellular respiration, which would remove some of the available oxygen. The ninth and tenth points were earned by stating that photosynthesis is light dependent, and the "net productivity will be positive" in the pond in the light environment.

Sample: 1B
Score: 5

A point was earned for the definition of primary productivity, and another point was earned for correctly expressing the equation for photosynthesis. Stating that the primary productivity was proportional to the amount of oxygen produced received a point. Stating that "pond water placed in light for 24 hours will have [a] higher DO level than that placed in darkness" earned a point as did stating that the net productivity increase would be expected with a light treatment.

Sample: 1C
Score: 2

The student earned a point for observing that more oxygen would be produced by the pond water exposed to the light than in the dark. The second point was earned for noting that the organisms in the pond water exposed to the dark would be carrying on respiration, which in turn would decrease the amount of dissolved oxygen available.