AP® BIOLOGY
2006 SCORING GUIDELINES (Form B)

Question 4

In many ways, all organisms in a food web can be said to be solar-powered. The producer level of the food web is responsible for the transformation of the solar energy into a form that can be used by other living organisms.

(a) Discuss the role of green plants in transforming the Sun's energy into a form that can ultimately be used by heterotrophs. **(6 points maximum)**

Required (Student cannot earn the maximum of 6 points without earning these 3 points)

- Energy transformation (photosynthesis -> chemical energy/glucose/G3P/ PGAL/starch/carbohydrate/chemical bonds)
- Chlorophyll or chloroplast required ("green pigment" not credited)
- Function of chlorophyll—light/energy capture concept

Parts of photosynthesis (in context or with explanation) (3 points maximum)

- Photolysis (splitting of water)—oxygen and/or electrons released
- Chemiosmosis (or explanation)
- ATP production
- NADPH production/reduction
- Photosystems II and I in correct order
- Calvin Cycle
- CO_2 fixation
- Products of light-dependent reactions used in light-independent (dark) reactions

(b) Discuss the flow of energy from producers through top carnivores in a food web in terms of the laws of thermodynamics. **(6 points maximum)**

Required (Student cannot earn the maximum of 6 points without earning these 2 points)

- Statement/definition of 1st Law of Thermodynamics
- Statement/definition of 2nd Law of Thermodynamics (definitions must be correct, but students are not penalized for misnumbering the laws)

Concepts of energy flow (in context or with explanation) (4 points maximum)

- 10 percent rule/Not all energy transferred to next level/Very little energy transferred to next level/energy lost at each level
- Explanation of energy loss (e.g., used in metabolism, locomotion, etc.)
- Lost energy as heat/entropy/2nd law illustrated as heat loss or inefficiency
- Energy pyramid (explained)
- More energy at producer level than at consumer levels
- Scarcity of energy at higher trophic levels
- Limited number of consumer levels
- Very few top carnivores
- 1st law illustrated as conversion of solar energy to chemical energy or as conversion of chemical energy to chemical energy (e.g., Glucose to ATP)

4. In many ways, all organisms in a food web can be said to be solar-powered. The producer level of the food web is responsible for the transformation of the solar energy into a form that can be used by other living organisms.

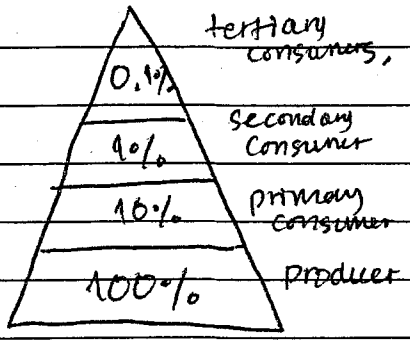
   (a) Discuss the role of green plants in transforming the Sun's energy into a form that can ultimately be used by heterotrophs.

   (b) Discuss the flow of energy from producers through top carnivores in a food web in terms of the laws of thermodynamics.

(a) Green plants play a major role in our ecosystem because they change light energy to chemical energy through photosynthesis. In chlorophylls, light is gathered around with the aid of antenna molecules and ~~[illegible]~~ breaks down water to produce electrons. These electrons are excited by reaction center at photosystem II, which is responsible for absorbing light having wavelength of 680nm, and as they go down through electron transport chain and undergo another photosystem I, ATP and NADPH are produced. Then light-independent stage starts through calvin cycle, fixing CO_2 and resulting in G3P (PGAL) glucose with the aid of ATP and NADPH.

These produced glucose is the main products of photosynthesis. Heterotrophs, unable to photosynthesize, then ingest green plants (primary producers) which contain rich nutrients of glucose (carbohydrates). Clearly, green plants fixed CO_2 to glucose, a form that heterotrophs (secondary, primary, tertiary consumers) can ultimately use and obtain energy.

(b)



The first law of thermodynamics states the total energy is never changed, ~~[illegible]~~ even though some of the energies can alternate their forms.

4A2

In food web, among the energy (100%) produced by producers only 10% of it is achieved by primary consumers (herbivores) and the rest of it is converted to other heat or light energy. As this process continues, the amount of energy that top tertiary consumers (carnivores) can ~~use~~ ultimately use is only 0.1% of initial energy produced. However, since 99.9% of energy was converted to other forms (heat released by animals, light), the TOTAL energy in this ecosystem is intact and not changed, thus confirming the first law of thermodynamic

The second law of thermodynamic states the entropy of energy (randomness in particles) increases. Surely, as the ~~free~~ energy flows from green plants to top carnivores, much of the energy dissipates around the air and to other regions, creating great randomness in energy. Thus, second law is also guaranteed and explained by this food web system.

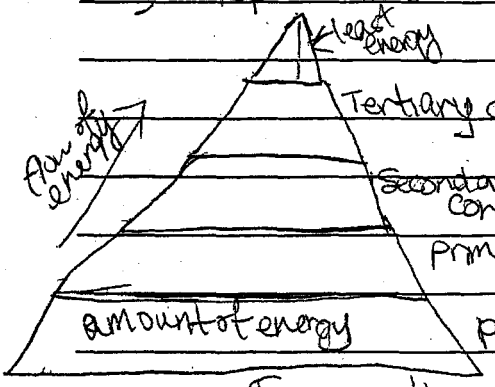
4. In many ways, all organisms in a food web can be said to be solar-powered. The producer level of the food web is responsible for the transformation of the solar energy into a form that can be used by other living organisms.

   (a) Discuss the role of green plants in transforming the Sun's energy into a form that can ultimately be used by heterotrophs.

   (b) Discuss the flow of energy from producers through top carnivores in a food web in terms of the laws of thermodynamics.

a.) Green plants are ~~[illegible]~~ producers. Through the process of photosynthesis (involving the light reactions and the dark/calvin cycle), plants capture photons and transfer it into energy that heterotrophs, primary or not consumers, can eat and use that energy to survive. ~~[illegible]~~ First, when light hits chlorophyll ~~[illegible]~~, photosystem II's electrons get excited. It rushes through photosystem II and activates the electrons in photosystem I, which finally activate NAD+ to accept the electrons and go to the electron transport chain (ETC). The dark reactions (calvin cycle) uses CO_2 and is also part of the process. Photosynthesis ends up with transformed energy. Primary consumers eat plants to recieve this energy. Secondary consumers eat the primary consumers, recieving less energy. Tertiary eat Secondary, and so on.

b.) Top carnivore



As shown in the diagram, the final top carnivore recieves the least energy. The law of ~~[illegible]~~ thermodynamics is the cause. The flow of energy goes up, from producers to consumers. However, as each ~~[illegible]~~ animal transfers the energy recieved

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4B 2

ADDITIONAL PAGE FOR ANSWERING QUESTION 4

to themselves, they use it ~~next~~ until eaten themselves. Less of the energy first generated by plants remains, so the animal has to eat more to gain enough energy. This flow of energy is because of the laws of thermodynamics, the amount of energy decreasing as intermediate animals consume and then are consumed.

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4C

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   (b) Discuss the flow of energy from producers through top carnivores in a food web in terms of the laws of thermodynamics.

(a) Green plants are the producers of the whole food web, which ~~generate the chemical energy~~ convert the sun light energy to ~~the~~ chemical energy. Green plants have chloroplasts in ~~its~~ their plant cells. Chlorosomes, the green pigments in chloroplasts absorb the sunlight energy (light reaction) and synthesize ~~the~~ chemical energy in the form of ATP through the Calvin cycle. ATP-type chemical energy is ~~stored in it~~ converted into glucose and stored in the plant cells. Hervibores, the primary consumers, eat green plants and absorb these sugars, which ~~later on~~ may ~~then~~ be later used as energy source.

No other organisms besides green plants can convert the light energy into the chemical energy, except some bacteria which can do photosynthesis.

(b) Though predators gain energy from ~~its~~ preys in the lower level of the food web, they cannot get 100% of energy the ~~preys ga~~ obtained from the previous producers. As all the organism use energy for their metabolism, (for example, breathing, moving, muscle contracture, maintaining the constant body-temperature, etc) some energy is lost ~~through the~~ in the each level of the food web. In average, only 10% of the energy obtained by previous level in food web is transported to the latter level. in the whole ecosystem.

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AP® BIOLOGY
2006 SCORING COMMENTARY (Form B)

Question 4

Sample: 4A
Score: 10

The response earned the maximum of 6 points in part (a). The 3 required points were earned for mentioning the conversion of light energy to chemical energy, the presence of chlorophyll, and the function of chlorophyll. Points were also earned for photolysis, photosystem II/I, and ATP production. Additional points could have been earned for the Calvin cycle and CO_2 fixation if the maximum for part (a) had not already been reached. In part (b) the response earned a point for a description of the first law, a point for the 10 percent rule, a point for the loss of energy as heat, and a point for the description of the second law.

Sample: 4B
Score: 6

The first sentence restates the question and did not earn points. In part (a) the response earned a point for the presence of chlorophyll, and a point for its function. The response also earned the photosystem II/I point, the Calvin cycle point, and the CO_2 fixation point. In part (b) the response mentions the laws but does not describe them. A point was earned for explaining that less energy is available for organisms at higher trophic levels.

Sample: 4C
Score: 4

In part (a) the response earned a point for the conversion of light energy into chemical energy, and a point for the participation of chloroplasts in this process. No points were earned for the mention of the Calvin cycle, since it is confused with chemiosmosis. In part (b) the response earned a point for the loss of usable energy in metabolism, and a point for the 10 percent rule.