

Name: _____

TA: _____

Question 1 (20 points)

The table below lists types of metabolism in the left column.

Type of metabolism	Electron source	Carbon source	Energy source
fermentation			
sulfur oxidation chemosynthesis			
oxygenic photosynthesis			
anaerobic respiration			
nitrification chemosynthesis			
aerobic respiration			
anoxygenic photosynthesis			

a) For each type of metabolism,

i) use the following list to fill in Electron source (column 2) and Carbon source (column 3) in the table above.

- A. sugar (Note, "sugar" here is a generic term for any organic carbon compound $(\text{CH}_2\text{O})_n$).
- B. Water (H_2O)
- C. hydrogen sulfide (H_2S)
- D. methane (CH_4)
- E. carbon dioxide (CO_2)
- F. NH_3

ii) fill in Energy source (column 4) in the table above. For this part, you are not limited to the list above.

b) For a number of the metabolisms above, the electron source is the same as the energy source. Explain why they are not the same for photosynthesis.

c) Organisms carrying out respiration need a final electron donor acceptor to keep the electron transport chain (ETC) functional. (Circle the correct term above.)

Explain how this compound enables the ETC to remain functional.

Question 1, continued

d) Using an argument based on redox and energetics, explain how aerobic respiration generates more ATP per molecule of glucose than anaerobic respiration.

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Type of metabolism	Electron source	Carbon source	Energy source
fermentation	<i>sugar</i>	<i>sugar</i>	<i>sugar</i>
sulfur oxidation chemosynthesis	H_2S	CO_2	<i>heat, H_2S</i>
oxygenic photosynthesis	H_2O	CO_2	<i>light</i>
anaerobic respiration	<i>sugar</i>	<i>sugar</i>	<i>sugar</i>
nitrification chemosynthesis	NH_3	CO_2	<i>heat, NH_3</i>
aerobic respiration	<i>sugar</i>	<i>sugar</i>	<i>sugar</i>
anoxygenic photosynthesis	H_2S	CO_2	<i>light</i>

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i) use the following list to fill in Electron source (column 2) and Carbon source (column 3) in the table above.

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ii) fill in Energy source (column 4) in the table above. For this part, you are not limited to the list above.

b) For a number of the metabolisms above, the electron source is the same as the energy source. Explain why they are not the same for photosynthesis.

The energy source in photosynthesis is light. While other energy sources are also sources of electrons (e.g. sugar), the energy source of photosynthesis, light, does not contain electrons. Therefore, organisms using light as an energy source must use a different source of electrons.

c) Organisms carrying out respiration need a final electron donor acceptor to keep the electron transport chain (ETC) functional. (Circle the correct term above.)

Explain how this compound enables the ETC to remain functional.

The final electron acceptor removes the electrons after they have traveled the length of the ETC. This then frees the last protein in the ETC to pull the next pair of electrons from the next to last protein in the chain. The newly freed protein can in turn pull the electrons from (only slightly) less electronegative protein.

If no final acceptor existed, the ETC would get "backed up" by accumulating electrons to capacity on ever less electronegative proteins. This back up would propagate to eventually saturate all proteins in the chain.

Having a final electron acceptor relieves this potential problem.

Question 1, continued

d) Using an argument based on redox and energetics, explain how aerobic respiration generates more ATP per molecule of glucose than anaerobic respiration.

O₂ is the electron acceptor used in aerobic respiration. All the possible electron acceptors used in anaerobic respiration are less electronegative than O₂. That means that each of these acceptors would operate with a shorter electron transport chain than O₂. A shorter chain would include fewer proton pumps, so a smaller number of protons will be pumped in such a chain per molecule of NADH (and, consequently, per molecule of glucose). ATP synthase makes a new molecule of ATP for each proton pumped by the ETC. Therefore, a chain with O₂ as a final acceptor will produce more ATP per molecule of glucose than a chain with any acceptor used in anaerobic respiration.