CELLULAR RESPIRATION

SUMMARY EQUATION

STEPWISE REDOX REACTION

Oxidation:

Reduction:

\[ \text{Xe}^- + \text{Y} \rightarrow \text{X} + \text{Ye}^- \]

\[ \text{CH}_4 + 2\text{O}_2 \rightarrow \text{CO}_2 + \text{H}_2\text{O} + \text{energy} \]

\[ \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2 \rightarrow 6\text{CO}_2 + 6\text{H}_2\text{O} + \text{energy} \]
ROLE OF NAD+

PHOSPHORYLATION

<table>
<thead>
<tr>
<th>SUBSTRATE LEVEL</th>
<th>OXIDATIVE</th>
</tr>
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STRUCTURE OF MITOCHONDRION
GLYCOLYSIS SUMMARY

<table>
<thead>
<tr>
<th><strong>ENERGY INVESTMENT</strong></th>
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<table>
<thead>
<tr>
<th><strong>ENERGY YIELDING</strong></th>
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<table>
<thead>
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<th><strong>IN</strong></th>
<th><strong>OUT</strong></th>
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KREBS CYCLE – ACETYL COA PREP

ACETYL CO A PREP PER PYRUVATE

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<th>OUT</th>
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ACETYL CO A PREP PER GLUCOSE

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<th>In</th>
<th>OUT</th>
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### KREBS CYCLE

<table>
<thead>
<tr>
<th>![Diagram 1]</th>
<th>![Diagram 2]</th>
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<tbody>
<tr>
<td>![Diagram 3]</td>
<td>![Diagram 4]</td>
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<td>![Diagram 5]</td>
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<td>![Diagram 7]</td>
<td>![Diagram 8]</td>
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<td>![Diagram 9]</td>
<td>![Diagram 10]</td>
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<td>![Diagram 11]</td>
<td>![Diagram 12]</td>
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<td>![Diagram 13]</td>
<td>![Diagram 14]</td>
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</tbody>
</table>
**Krebs Cycle Summary per Pyruvate**

<table>
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<tr>
<th>Krebs Cycle In</th>
<th>Krebs Cycle Out</th>
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**Krebs Cycle Summary per Glucose**

<table>
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<tr>
<th>Krebs Cycle In</th>
<th>Krebs Cycle Out</th>
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</table>
QUESTIONS

1. Use Figure 9.1 on page 148 in your textbook to answer the following questions.
   a. In general, describe what happens during photosynthesis.
      _____________________________________________________________
   b. What are the reactants in photosynthesis?
      _____________________________________________________________
   c. What are the products of photosynthesis?
      _____________________________________________________________
   d. Where in the cell does photosynthesis occur?
      _____________________________________________________________
   e. In general, describe what happens during cellular respiration.
      _____________________________________________________________
   f. What are the reactants in cellular respiration?
      _____________________________________________________________
   g. What are the products of cellular respiration?
      _____________________________________________________________
   h. What substance(s) is(are) recycled?
      _____________________________________________________________
   i. What substance(s) is(are) not recycled?
      _____________________________________________________________
   j. Which reaction (photosynthesis or cellular respiration) is:
      Anabolic?___________________________________________________
      Catabolic?_________________________________________________
      Exergonic?________________________________________________
      Endergonic?______________________________________________
2. Write the summary equation for cellular respiration.

________________________________________________________________

3. Most commonly glucose is represented as the molecule broken down in the respiration equation. Does this mean that glucose is the only source of energy (fuel) in cellular respiration? Explain.

________________________________________________________________

________________________________________________________________

4. Define:
   a. Oxidation: ________________________________
   b. Reduction: ________________________________

5. Cellular respiration is described as a stepwise redox reaction.
   a. What substance is oxidized?______________________________
   b. What substance is reduced?______________________________

6. What happens to the amount of potential energy of electrons as they shift from carbon and hydrogen toward oxygen in cellular respiration?

________________________________________________________________

How is the energy used?____________________________________________

7. What is the role of NAD+ in cellular respiration?

________________________________________________________________

8. What are dehydrogenases?__________________________________________________________________________

________________________________________________________________

What is their role in cellular respiration?______________________________________________

________________________________________________________________
9. Indicate if each of the following characteristics / descriptions is true of Substrate-level and Oxidative phosphorylation.

_____ Produce ATP by adding a phosphate to ADP
_____ Involves the direct transfer of a phosphate from an intermediate to ADP
_____ Couples the addition of a phosphate to ADP with the exergonic slide of electrons down the electron transport chain
_____ Oxygen used as the terminal electron acceptor
_____ Accounts for 90% of ATP production in aerobic respiration

10. Use the diagram below to answer the questions that follow:

_____ Outer membrane          _____ Inner membrane
_____ Cytoplasm                _____ Matrix
_____ Intermembrane space      _____ Crista
_____ Site of glycolysis       _____ Site of Krebs cycle
_____ Location of electron transport chain  _____ High [H^+]
_____ Location of ATP synthase molecules
11. Fill in the missing labels on the diagram below.

```
1. [Diagram of metabolic pathway]

glyceraldehyde 3-phosphate
1,3-diphosphoglycerate
3-phosphoglycerate
2-phosphoglycerate
phosphoenolpyruvate (PEP)
```
12. Use the diagram in Question 11 to answer the following questions.
   a. What process is occurring in the diagram?_________________________
   b. Which step(s) show the transfer of a P (phosphate) from ATP to an
      intermediate?________________________________________________
   c. Which step shows a reduction reaction?___________________________
   d. Which steps are included in the energy-investment phase?
      _____________________________________________________________
   e. Which steps are included in the energy-yielding phase?
      _____________________________________________________________
   f. Which step shows the splitting of a 6-C compound into two 3-C
      compounds?_________________________________________________
   g. How many ATP molecules, per glucose, are used in this series of
      reactions?___________________________________________________
   h. How many NADH, per glucose, are produced?______________________
   i. How many ATP, per glucose, are produced?_______________________

13. Identify whether each of the following occurs during the energy-investment phase
    (EI) of glycolysis or the energy-yielding phase (EY).
    ______ 2 glyceraldehyde phosphates are oxidized
    ______ 2 NAD+ are reduced to 2 NADH
    ______ Substrate-level phosphorylation occurs
    ______ 4 ADP + 4P → 4 ATP
    ______ 2 ATP molecules are used
    ______ Glucose & intermediate compounds are phosphorylated
    ______ Fructose 1,6-diphosphate split into two 3-C compounds
14. List the reactants and products of glycolysis.

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<thead>
<tr>
<th>Reactants</th>
<th>Products</th>
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</table>

15. Use the diagram below to answer the questions that follow:
a. Identify the molecule represented by each of the following letters in the diagram.

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<tbody>
<tr>
<td>A</td>
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<td>B</td>
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<td>C</td>
<td>H</td>
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<td>D</td>
<td>I</td>
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<tr>
<td>E</td>
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</tbody>
</table>

b. What process is occurring in the series of reactions labeled I?

___________________________________________________________

Where do these reactions occur within the cell (be specific)?

___________________________________________________________

c. Complete the following chart by providing the number of each molecule produced per glucose molecule.

<table>
<thead>
<tr>
<th>Molecule</th>
<th># Produced per glucose</th>
<th>Molecule</th>
<th># Produced per glucose</th>
</tr>
</thead>
<tbody>
<tr>
<td>NADH</td>
<td></td>
<td>ATP</td>
<td></td>
</tr>
<tr>
<td>CO₂</td>
<td></td>
<td>FADH₂</td>
<td></td>
</tr>
</tbody>
</table>
16. What are the reactants and products of the Krebs cycle?

<table>
<thead>
<tr>
<th>Reactants</th>
<th>Products</th>
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</thead>
<tbody>
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</table>

17. Use the diagram below to answer the questions that follow.

a. Identify the molecules/parts represented by each letter in the diagram.

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<tbody>
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<td>A</td>
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<tr>
<td>B</td>
<td>H</td>
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<tr>
<td>C</td>
<td>I</td>
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<tr>
<td>F</td>
<td></td>
</tr>
</tbody>
</table>

b. Where is this structure located within the cell (be specific)?
c. Which letter represents:

High H+ concentration? ________________________________
Low H+ concentration? ________________________________
Mitochondria matrix? ________________________________
Inner membrane? ________________________________
Intermembrane space? ________________________________

d. Describe what is happening in this diagram.

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

18. Put the following steps in the correct order. (Use Figure 9-13 p. 158 for help.)

_____ Water forms
_____ NADH oxidized
_____ Flavoprotein oxidized
_____ Fe-S protein oxidized
_____ Flavoprotein reduced
_____ Fe-S protein reduced
_____ Ubiquinone reduced
_____ Oxygen reduced
_____ cyt a₃ passes electrons to oxygen
_____ Ubiquinone passes electrons to cytochromes
_____ Reduced oxygen picks up 2 H+
19. As electrons are transported through the electron transport chain to oxygen, they lose potential energy. This energy is used to do what work?

________________________________________________________________________

20. The electrons from 1 NADH results in the production of 3 ATP molecules while the electrons from 1 FADH$_2$ results in the production of 2 ATP molecules. Why is there a difference?

________________________________________________________________________

________________________________________________________________________

21. Each NADH generated during glycolysis results in the production of 2 ATP molecules while each NADH generated during the Krebs cycle results in the production of 3 ATP molecules. Why is there a difference?

________________________________________________________________________

________________________________________________________________________

22. What are the reactants and products of electron transport & oxidative phosphorylation?

<table>
<thead>
<tr>
<th>Reactants</th>
<th>Products</th>
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23. Account for the 36 ATP molecules produced from the complete oxidation of 1 glucose molecule.

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________
24. Some desert animals such as the kangaroo rat never have to drink water. Explain how kangaroo rats can obtain the water they need to survive from the dry seeds they eat.

________________________________________________________________
________________________________________________________________

25. How is aerobic respiration different from anaerobic respiration?

<table>
<thead>
<tr>
<th>Aerobic Respiration</th>
<th>Anaerobic Respiration</th>
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26. Describe what happens during lactic acid fermentation.

________________________________________________________________
________________________________________________________________
________________________________________________________________

27. Describe what happens during alcohol fermentation.

________________________________________________________________
________________________________________________________________
________________________________________________________________

28. Define the following terms:

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<tr>
<th>Strict Aerobes</th>
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<table>
<thead>
<tr>
<th>Strict Anaerobes</th>
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<table>
<thead>
<tr>
<th>Facultative Anaerobes</th>
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29. Carbohydrates, fats, and proteins can all be used as fuel for cellular respiration. Trace the path of each of these food groups from the point of digestion in the intestines to where and in what form they enter cellular respiration.

<table>
<thead>
<tr>
<th>Carbohydrates</th>
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<tbody>
<tr>
<td>Fats</td>
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<tr>
<td>Proteins</td>
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