

1. Comparison of metabolic pathways: Fill out the table below.

	<b>Cellular Respiration</b>	<b>Fermentation</b>
Location	Cytoplasm, mitochondrial matrix	Cytoplasm
Is oxygen involved?	Yes	No
Production of lactic acid?	No	Yes
Example of terminal electron acceptor (TEA)	Oxygen	Organic carbon molecule
Relative amount of energy released	High; 32 ATP	Low; 2 ATP

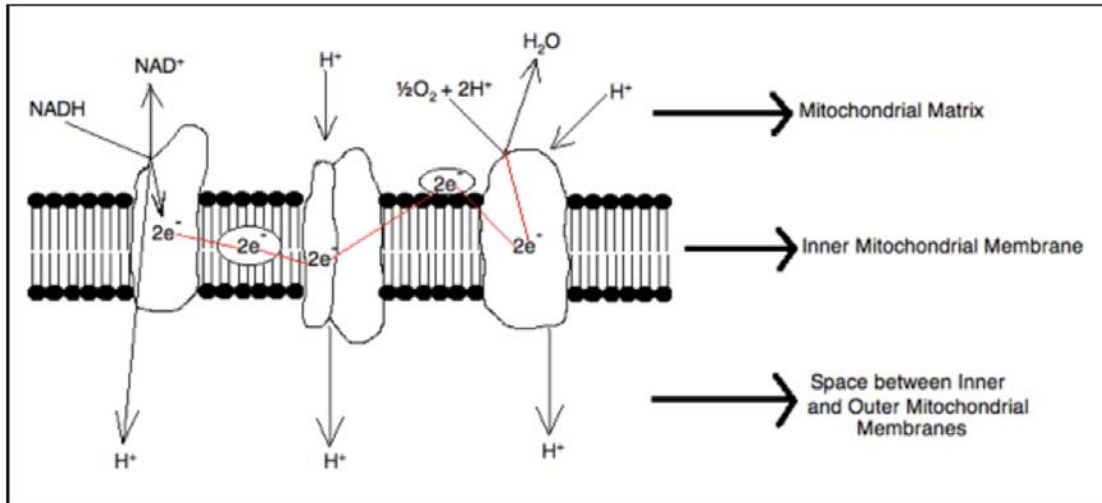
2. Comparison of cellular respiration locations in eukaryote vs. bacteria: Fill out the table below.

	<b>Subcellular location in eukaryotes</b>	<b>Subcellular location in bacteria</b>
Glycolysis	Cytoplasm	Cytoplasm
Pyruvate processing	Mitochondrial matrix	Cytoplasm
TCA cycle (Krebs cycle)	Mitochondrial matrix	Cytoplasm
Electron transport chain	Inner mitochondrial membrane	Cytoplasmic membrane

3. Consider free energy ( $\Delta G$ ) and Electron transport chain (ETC): Fill in the following table.

<b>Reaction type</b>	<b>Sign of <math>\Delta G</math> (positive/negative)</b>	<b>Reaction is spontaneous or non-spontaneous?</b>	<b>Explanation for the sign of <math>\Delta G</math></b>
Electrons passing down the ETC	Negative	spontaneous	This is an exergonic reaction because energy is being released as electrons pass from carrier to carrier in the ETC
Production of ATP by ATP synthase in ETC	Positive	not spontaneous	This is an endergonic reaction because energy is required by ATP Mitochondrial Matrix

4. Fill in the blanks with appropriate words in the box using the diagram showing the ETC below



Embedded in the inner membrane of the mitochondria there is a chain of electron carriers. This chain is called the electron transport chain. electrons from the oxidative reactions in the earlier stages of cell respiration pass along the chain. NADH and FADH<sub>2</sub> donate electrons to the carriers in the chain. These electrons pass along the chain and transfer energy from one carrier to the next. Enough energy is captured to pump the hydrogen ions across the inner mitochondrial membrane from the matrix to the intermembrane space.

ATP synthase is an enzyme that is also found in the inner mitochondrial membrane. Since a high concentration of hydrogen ions was built up in the intermembrane space, these ions will diffuse through a protein (ATP synthase) via chemiosmosis. The movement of hydrogen ions through ATP synthase causes ATP synthase to rotate. This provides the energy needed to add a phosphate group to ADP to form ATP.

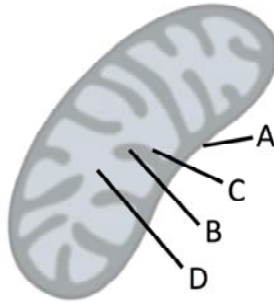
The ATP production relies on energy captured by oxidation and it is therefore called oxidative phosphorylation

**Terms to fill in the blanks:**

Inner membrane    hydrogen ions    Energy    FADH<sub>2</sub>    ATP synthase    electrons    NADH  
 chemiosmosis    oxidative phosphorylation    movement of hydrogen ions through ATP synthase

## 5. Match the letter in the diagram of the mitochondria with the label:

(you may use each letter more than once or not at all)

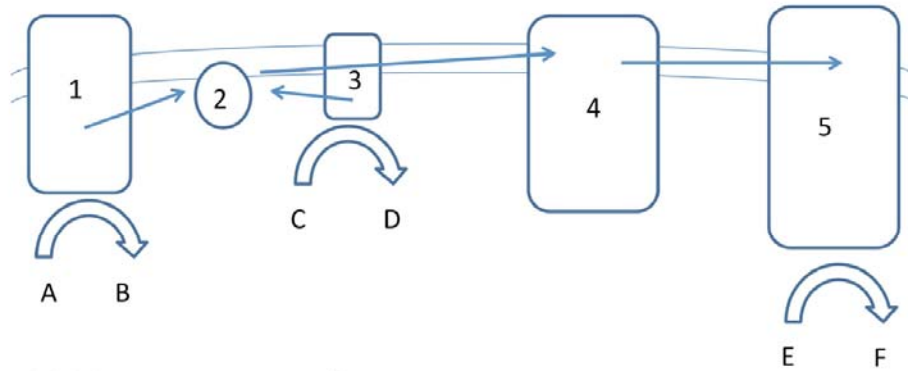


- D    Place where  $H^+$  ions move to as they pass through ATP synthase
- C    Place where enzymes for the Electron Transport Chain are located
- B    Place that fills with  $H^+$  ions as electrons move down the ETC
- D    Place where ADP and P join to make ATP
- D    Place where oxygen acts as the final electron acceptor to make water

## 6. Compare and contrast types of phosphorylation:

	Oxidative photophosphorylation	Photophosphorylation
Where does it happen?	In mitochondria (eukaryote); In cytoplasm (bacteria)	In chloroplast (in eukaryote); In cytoplasm (bacteria)
It happens during what cellular activity?	Respiration	Photosynthesis
What are the inputs?	NADH, FADH <sub>2</sub> , O <sub>2</sub>	H <sub>2</sub> O NADP <sup>+</sup> ADP, Pi
What are the outputs?	NAD <sup>+</sup> , FAD H <sub>2</sub> O ATP	O <sub>2</sub> NADPH ATP
Is there electron flow?	Yes	Yes
Where are electron carriers located?	On inner membrane of mitochondria (in eukaryotes); in cell membrane (in bacteria)	On thylakoid membrane (in eukaryotes); in cell membrane (in bacteria)
Molecule(s) that deliver electrons to the ETC	NADH, FADH <sub>2</sub>	H <sub>2</sub> O
Electrons end up on	O <sub>2</sub>	NADP <sup>+</sup>
Energy source	glucose	Sun light
What is the path of electron carriers that the electrons follow, from each electron donor?	NADH: – complex I – Q – complex III – complex IV – O <sub>2</sub> FADH <sub>2</sub> : complex II – Q – complex III – complex IV – O <sub>2</sub>	H <sub>2</sub> O – PSII – PQ – Cytochrome b6f – PC – PSI – NADP <sup>+</sup>
Establishment of transmembrane H <sup>+</sup> gradient during electron transport?	Yes	Yes
H <sup>+</sup> is pumped from where to where?	H <sup>+</sup> is pumped from matrix to intermembrane space	H <sup>+</sup> is pumped from stroma to lumen
Where is ATP synthesized?	Through ATP synthase	Through ATP synthase

7. In the diagram of the electron transport chain, the movement of electrons is shown by arrows. Answer the questions below to interpret this diagram.



- Which letter represents  $\text{NAD}^+$ ?  
Answer: B
- Which represents Q?  
Answer: 2
- Is ATP synthase shown?  
Answer: No
- Which side of membrane is matrix and which side of membrane is intermembrane space?  
Answer: top is intermembrane space, bottom is matrix