Notebook Pages on Cellular Respiration

I made these notebook pages for my kids as we went over cellular respiration. Feel free to use this with your kids/students.

We have been using lots of other resources for this portion of our unit… this just happens to be some review pages I made for the kids… so this is by no means a complete unit on cellular respiration. I'm just sharing these pages if they are helpful.

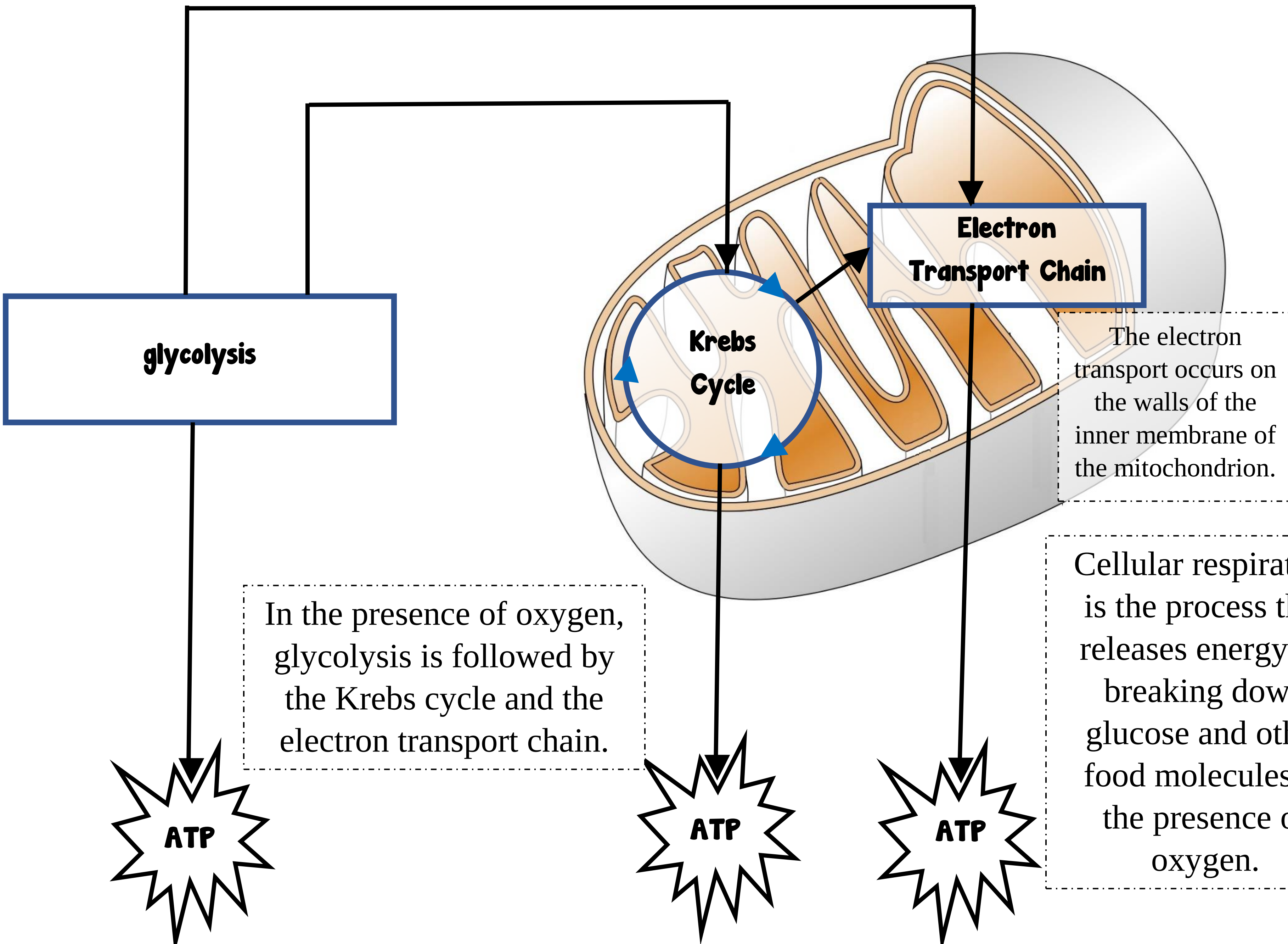
If you notice any errors or would like me to add anything, just drop me a note – Liesl@homeschoolden.com

Hope these come in handy!

~Liesl

P.S. The images used in this file are in the public domain.

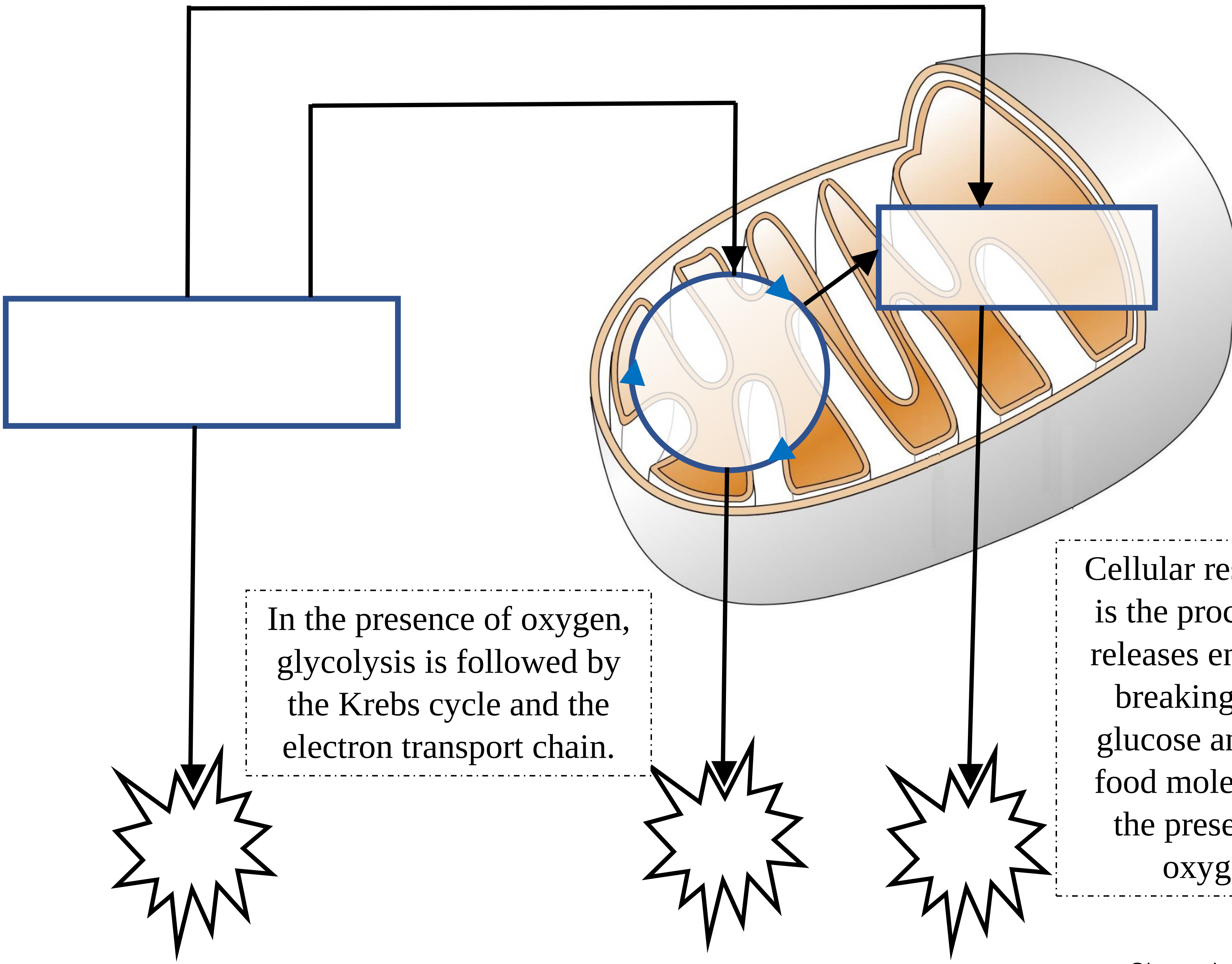
Cellular Respiration



In the presence of oxygen, glycolysis is followed by the Krebs cycle and the electron transport chain.

Cellular respiration is the process that releases energy by breaking down glucose and other food molecules in the presence of oxygen.

Cellular Respiration



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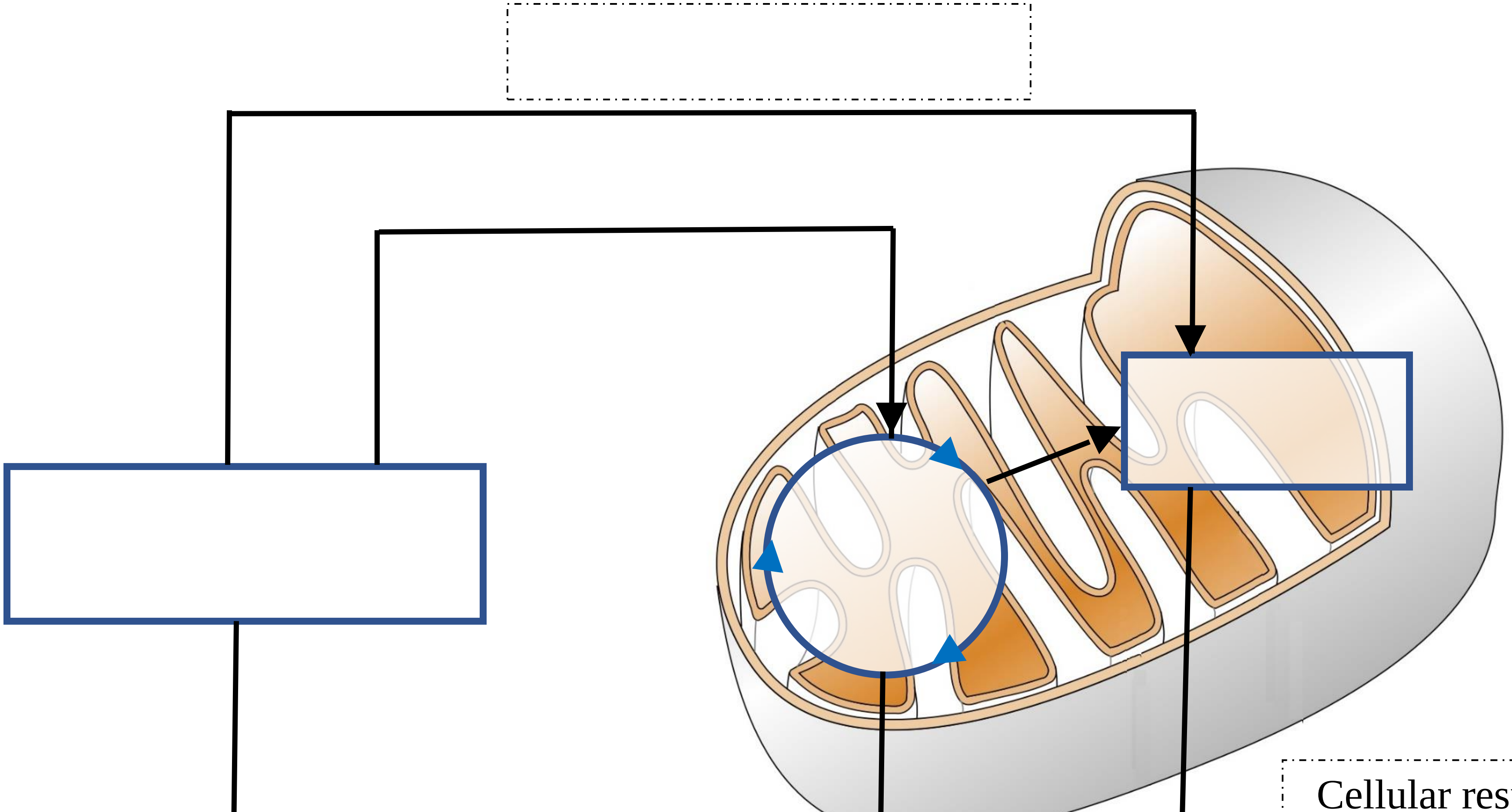


In the presence of oxygen, _____________ is followed by the __________ cycle and the _____________ _____________ __________.

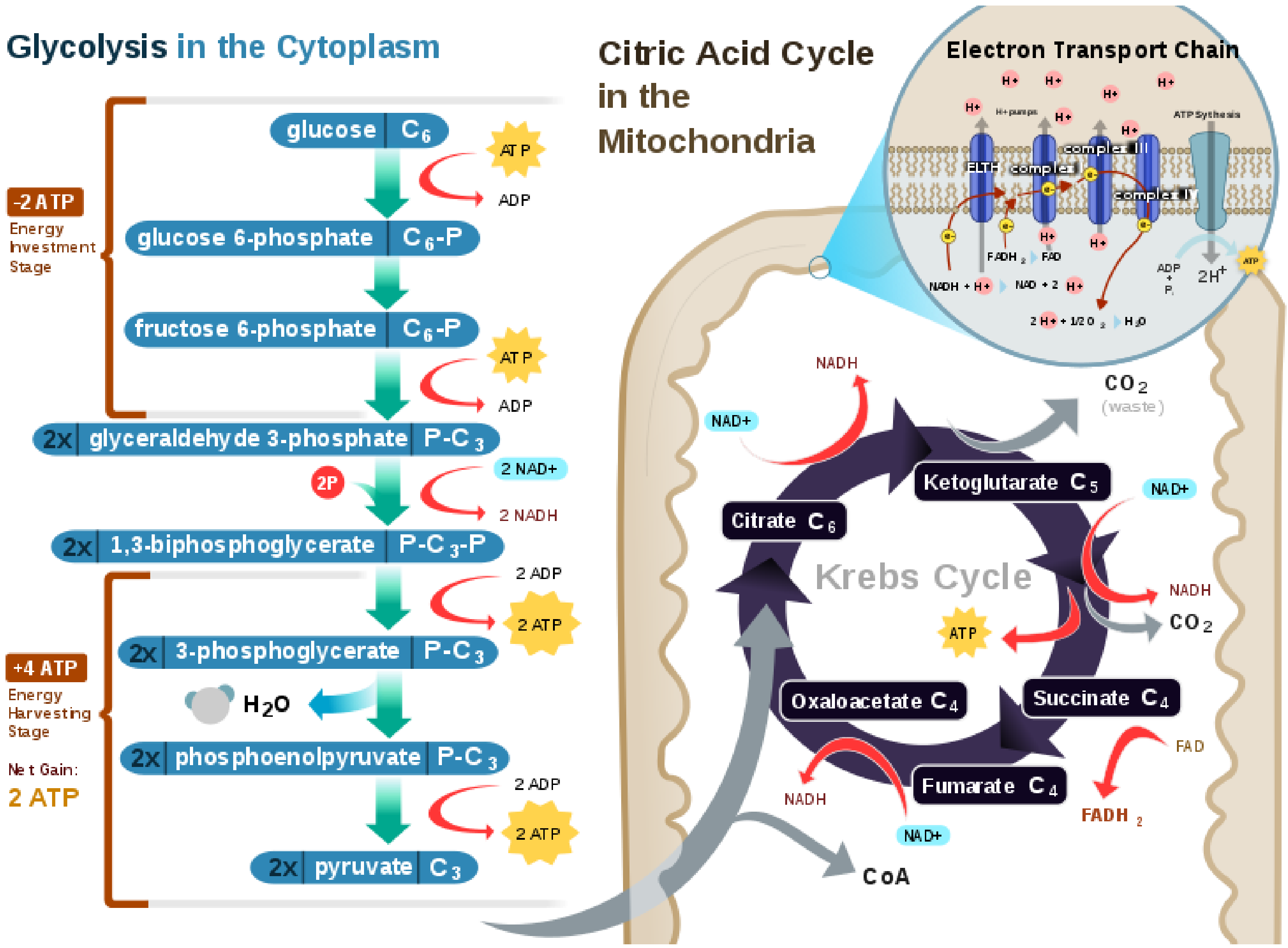
Cellular respiration is the process that releases __________ by breaking down _____________ and other __________ molecules in the presence of ________________.

Name: ______________________________

Glycolysis is the process in which one molecule of glucose is broken in half, producing two molecules of pyruvic acid, a 3-carbon compound.

Pyruvic acid is a 3-carbon compound.

To get glycolysis going, the cell has to put in a little energy – 2 molecules of ATP.



One of the reactions of glycolysis removes 4 high-energy electrons and passes them to an electron carrier called NAD^+.

NAD^+ carries a pair of high-energy electrons. This molecule, known as NADH, holds the electrons until they can be transferred to other molecules. NAD^+ helps to pass energy from glucose to other pathways in the cell.

Glycolysis does not require oxygen. Thus, glycolysis can supply chemical energy to cells when oxygen is not available.

[Note: Without NAD^+, the cell cannot keep glycolysis going.]

At the end of glycolysis about 90% of the chemical energy that was available in glucose is still unused. It is locked in the high-energy electrons of pyruvic acid.

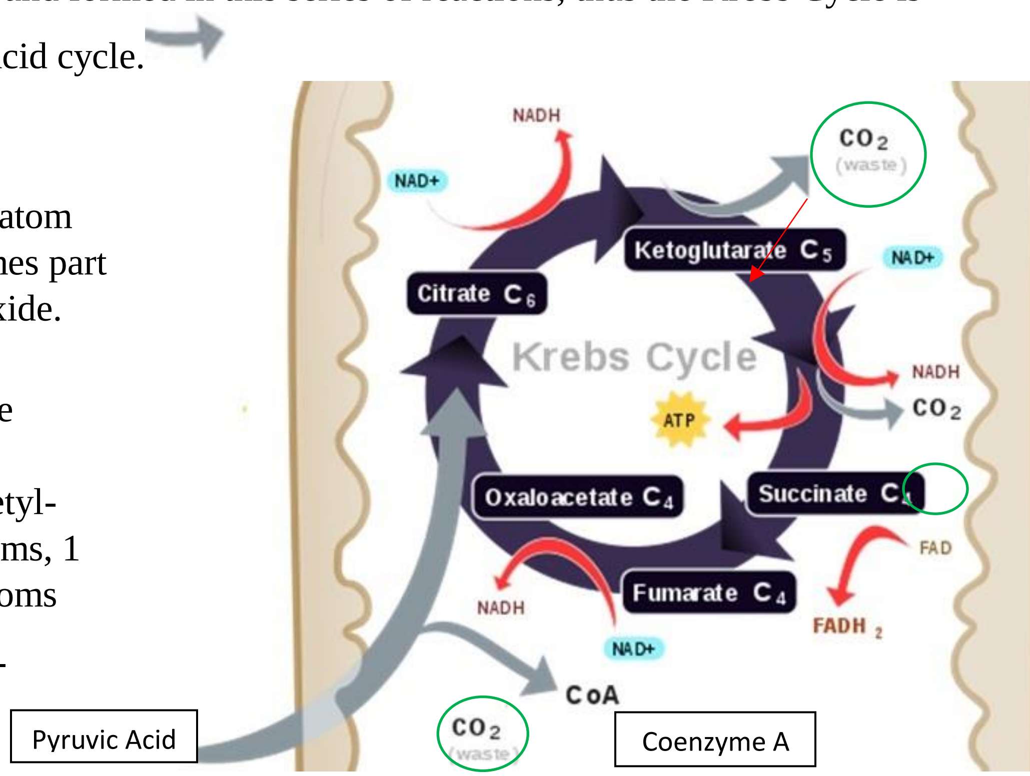
The cell turns to oxygen to help extract the rest of that energy. Oxygen is required for the final steps of cellular respiration.

Cellular respiration refers to the energy-releasing pathways within the cell (which require oxygen).

In the presence of oxygen, pyruvic acid produced in glycolysis passes to the second stage… the Krebs cycle.

During the Krebs cycle, pyruvic acid is broken down into carbon dioxide in a series of energy-extracting reactions.

Citric acid is the first compound formed in this series of reactions, thus the Krebs Cycle is sometimes called the citric acid cycle.



1. The Krebs cycle begins – pyruvic acid enters the mitochondrion. One carbon atom from the pyruvic acid becomes part of a molecule of carbon dioxide.

Circle it!

The other 2 carbon atoms are joined to a compound called coenzyme A. This forms acetyl-CoA – made of 2 carbon atoms, 1 oxygen atom, 3 hydrogen atoms

Acetyl-CoA then adds the 2-carbon acetyl group to a 4-carbon molecule producing a 6-carbon molecule called citric acid.

2. Citric acid is broken down into a 4-carbon molecule and more carbon dioxide is released.

Electrons are transferred to energy carriers.

ATP. For each turn of the cycle, a molecule similar to ADP is converted to a molecule that is similar to ATP.

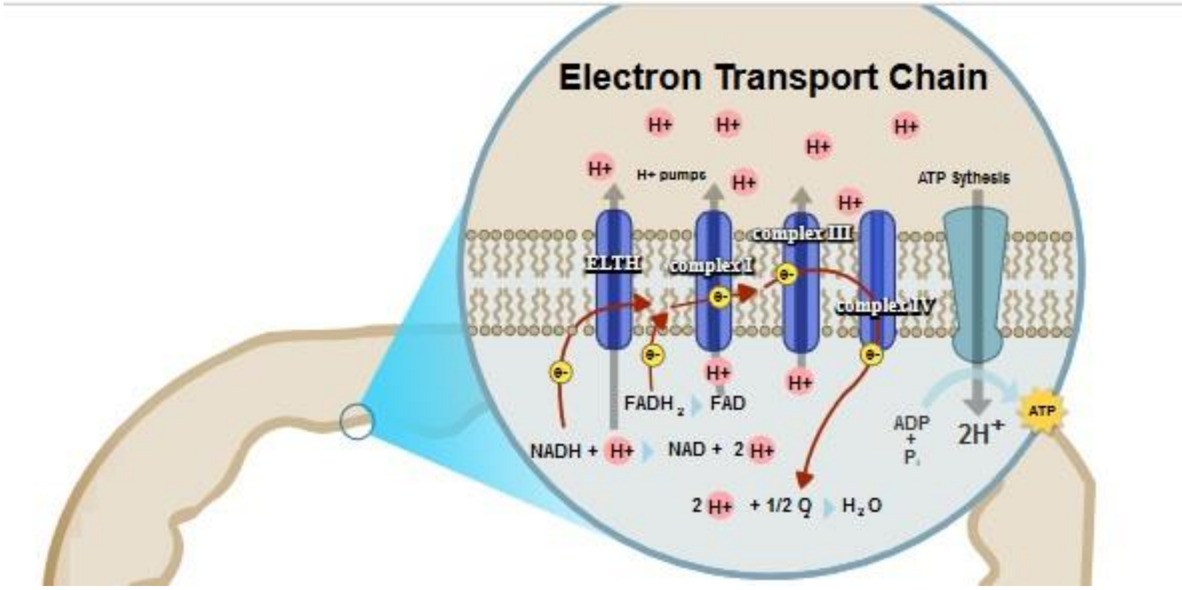
NAD – at 5 places in the cycle a pair of high-energy electrons is accepted by electron carriers, changing NAD^+ to NADH and FAD to $FADH_2$

What does the cell do with the high-energy electrons in carriers like NADH? In the presence of oxygen, those high-energy electrons can be used to generate huge amounts of ATP.

Name: ______________________________

The Krebs cycle generates high-energy electrons that are passed to NADH and $FADH_2$.

The electrons are then passed from those carriers to the electron transport chain.



The electron transport chain uses high-energy electrons from the Krebs cycle to convert ADP into ATP.

In Eukaryotes, the electron transport chain is composed of a series of carrier proteins located in the inner membrane of the mitochondrion.

In prokaryotes, the same chain is in the cell membrane.

High-energy electrons are passed from one carrier protein to the next.

At the end of the electron transport chain is an enzyme that combines these electrons with hydrogen ions and oxygen to form water.

Oxygen serves as the final electron acceptor of the electron transport chain. Oxygen is essential for getting rid of low-energy electrons and hydrogen ions… the wastes of cellular respiration.

Every time 2 high-energy electrons transport down the electron transport chain, their energy is used to transport hydrogen ions (H^+) across the membrane. During electron transport H+ ions build up in the intermembrane space making it positively charged.

The other side of the membrane is now negatively charged.

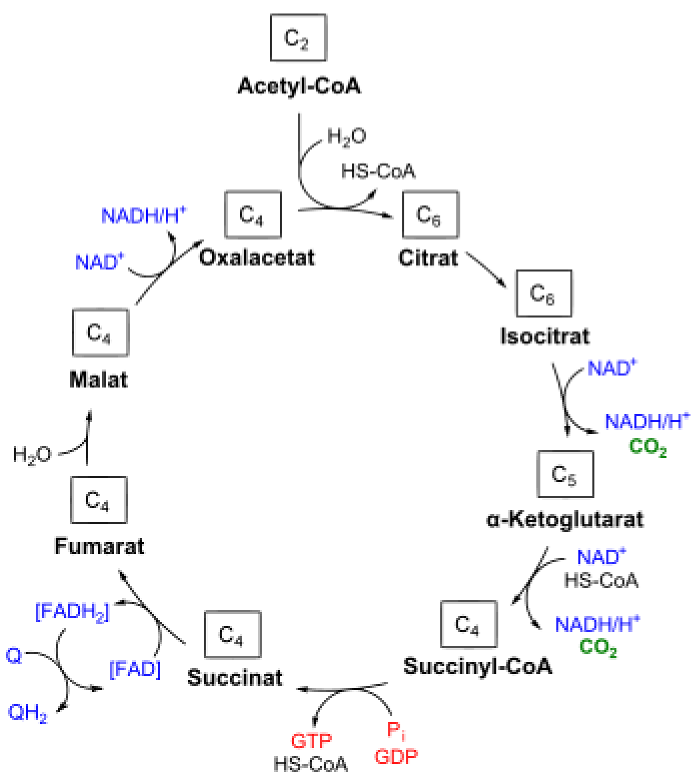
How does the cell use the charge differences that build up as a result of electron transport? The inner membranes of the mitochondria contain protein spheres called ATP synthases. As H^+ ions escape through channels into these proteins, the ATP synthases spin. Each time it rotates, the enzyme grabs a low-energy ADP and attaches a phosphate forming a high-energy ATP.

The beautify of this system is the way in which it couples the movement of high-energy electrons with the production of ATP. Every time a pair of high-energy electrons moves down the electron transport chain, the energy is used to move H^+ ions across the membrane.

These ions then rush back across the membrane producing enough force to spin the ATP synthase and generate enormous amounts of ATP.

On average each pair of high-energy electrons that moves down the electron transport chain provides enough energy to produce three molecules of ATP from ADP.

Another example of the Krebs Cycle:

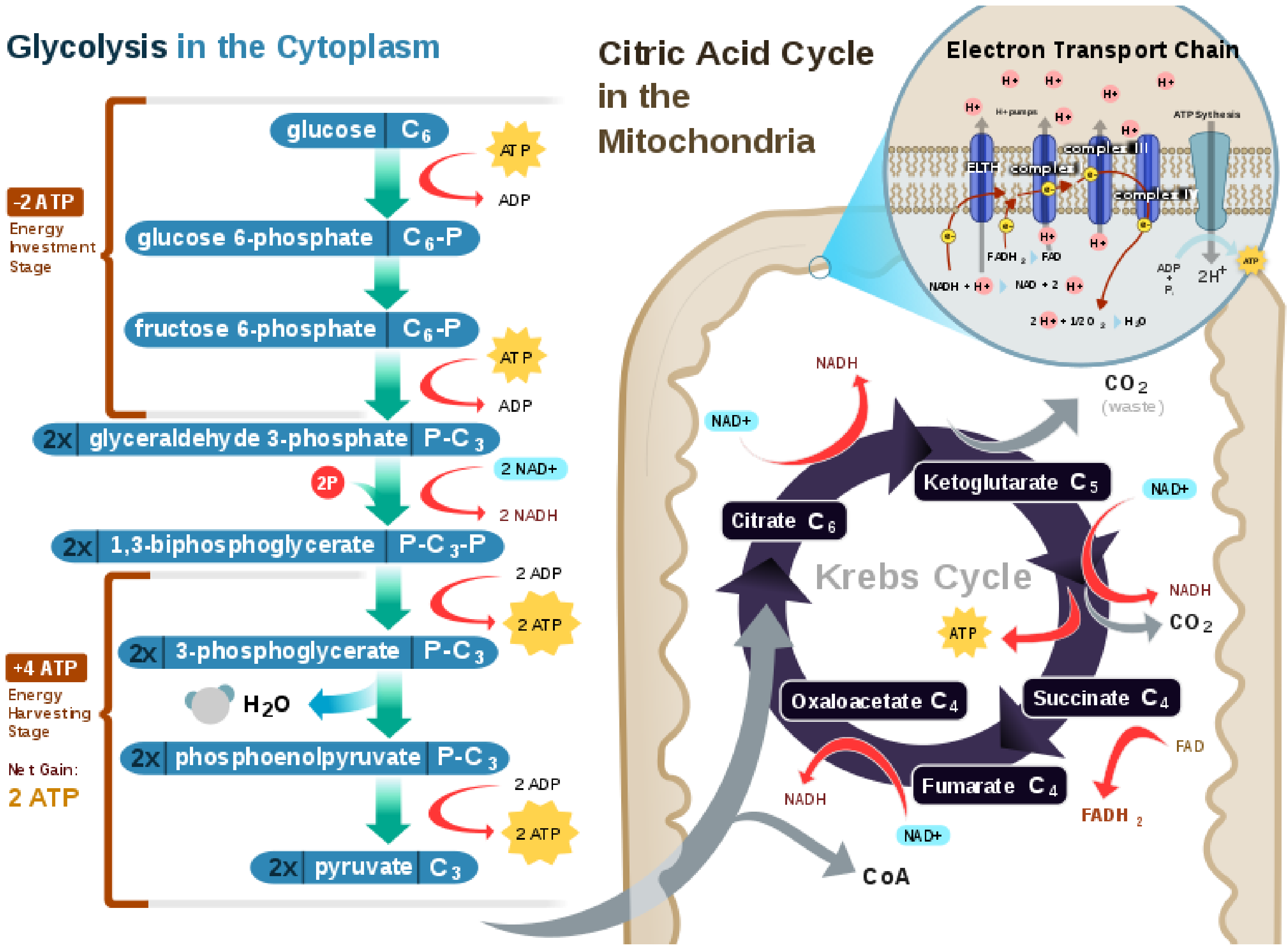


Name: ______________________________

_________________ is the process in which one molecule of _________________ is broken in half, producing two molecules of ______________ acid, a_____-carbon compound.

Pyruvic acid is a______-carbon compound.

To get glycolysis going, the cell has to put in a little _____________ – 2 molecules of _______.



One of the reactions of glycolysis ______________ 4 high-energy electrons and passes them to an electron carrier called ______________.

NAD+ carries a pair of high-energy _______________. This molecule, known as ___________, holds the electrons until they can be ________________ to other molecules. NAD^+ helps to pass energy from glucose to other pathways in the cell.

Glycolysis _________________ require oxygen. Thus, glycolysis can supply chemical energy to cells when ___________________ is not available.

[Note: Without NAD^+, the cell cannot keep _______________ going.]

At the end of glycolysis about _______% of the chemical energy that was available in ______________ is still unused. It is locked in the high-energy electrons of pyruvic acid.

The cell turns to ________________ to help extract the rest of that energy. Oxygen is required for the final steps of cellular __________________.

Cellular respiration refers to the _________________-releasing pathways within the cell (which require oxygen).

In the presence of oxygen, pyruvic acid produced in glycolysis passes to the second stage… the ____________________ cycle.

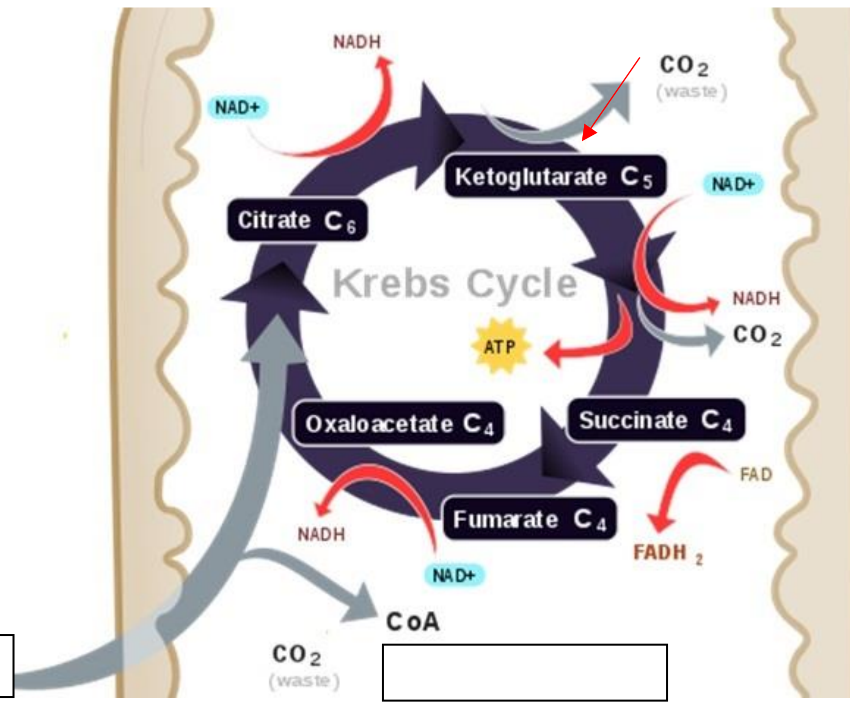
During the Krebs cycle, ______________ acid is broken down into carbon dioxide in a series of energy-extracting reactions.

___________ acid is the first compound formed in this series of reactions, thus the Krebs Cycle is sometimes called the citric acid cycle.

1. The Krebs cycle begins – pyruvic acid enters the _________________. One ____________ atom from the pyruvic acid becomes part of a molecule of carbon dioxide. Circle it!

The other 2 carbon atoms are joined to a compound called ________________ A. This forms acetyl-CoA – made of 2 carbon atoms, 1 oxygen atom, 3 hydrogen atoms.

Acetyl-CoA then adds the 2-carbon acetyl group to a 4-carbon molecule producing a 6-carbon molecule called citric acid.



2. Citric acid is broken down into a 4-carbon molecule and more carbon dioxide is released. Circle it!

_________ are transferred to ____________ carriers.

ATP: For each turn of the cycle, a molecule similar to ADP is converted to a molecule that is similar to ATP.

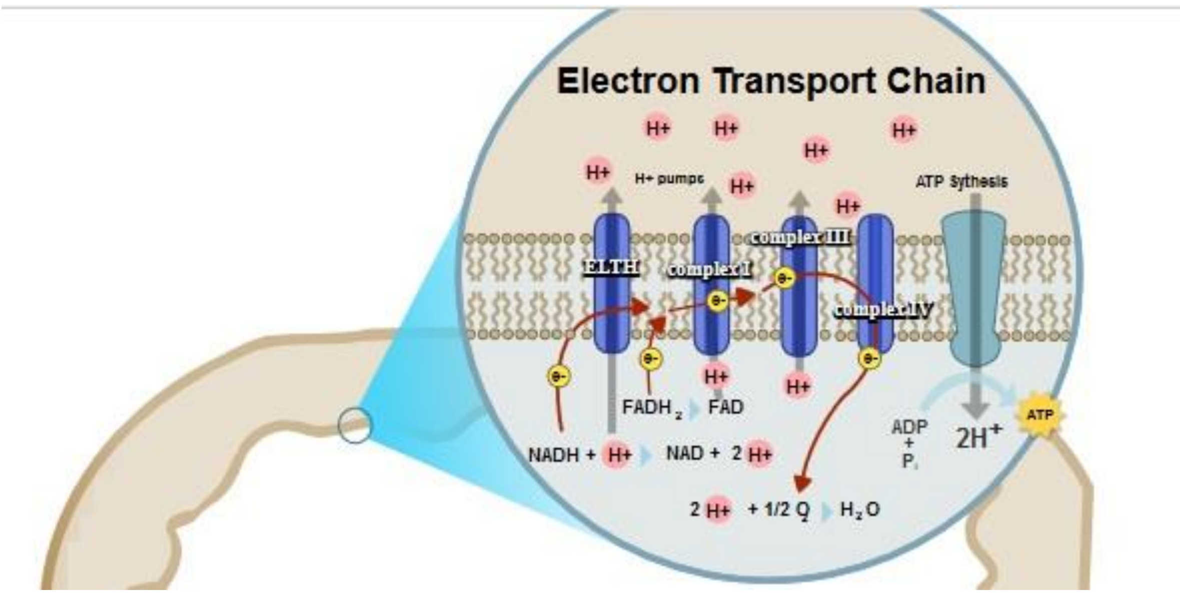
NAD – at 5 places in the cycle a pair of high-energy electrons is accepted by electron carriers, changing NAD^+ to __________ and FAD to ___________.

What does the cell do with the high-energy electrons in carriers like NADH? In the presence of oxygen, those high-energy electrons can be used to generate huge amounts of ATP.

Name: ________________________________

The Krebs cycle generates high-energy ________________ that are passed to ___________ and ___________.

The electrons are then passed from those carriers to the electron transport chain.



The electron transport chain uses high-energy electrons from the ___________ cycle to convert _____________ into ATP.

In Eukaryotes, the electron transport chain is composed of a series of carrier _______________ located in the __________________ membrane of the __________________.

In prokaryotes, the same chain is in the cell __________________.

High-energy __________________ are passed from one carrier protein to the next.

At the end of the electron transport chain is an __________________ that combines these electrons with hydrogen ions and oxygen to form __________________.

__________________ serves as the final electron acceptor of the electron transport chain. Oxygen is essential for getting rid of low-energy __________________ and __________________ ions… the __________________ of cellular respiration.

Every time 2 high-energy electrons transport down the electron transport chain, their energy is used to transport __________________ ions (______) across the membrane. During electron transport H+ ions build up in the intermembrane space making it positively charged.

The other side of the membrane is now _____________________ charged.

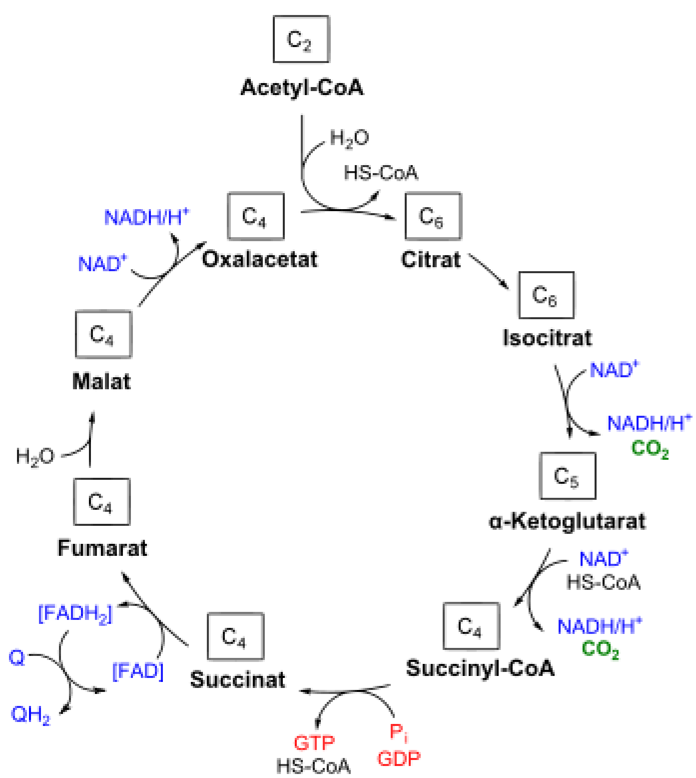
How does the cell use the charge differences that build up as a result of electron transport? The inner ________________ of the mitochondria contain protein spheres called ATP synthases. As H^+ ions escape through channels into these proteins, the ATP synthases spin. Each time it rotates, the enzyme grabs a low-energy ________ and attaches a phosphate forming a high-energy _________.

The beautify of this system is the way in which it couples the movement of high-energy electrons with the production of ATP. Every time a pair of high-energy ____________ moves down the electron transport chain, the energy is used to move H^+ ions across the ____________.

These ions then rush back across the membrane producing enough force to spin the ATP synthase and generate enormous amounts of ATP.

On average each pair of high-energy electrons that moves down the electron transport chain provides enough energy to produce ____ molecules of ATP from ADP.

Another example of the Krebs Cycle:



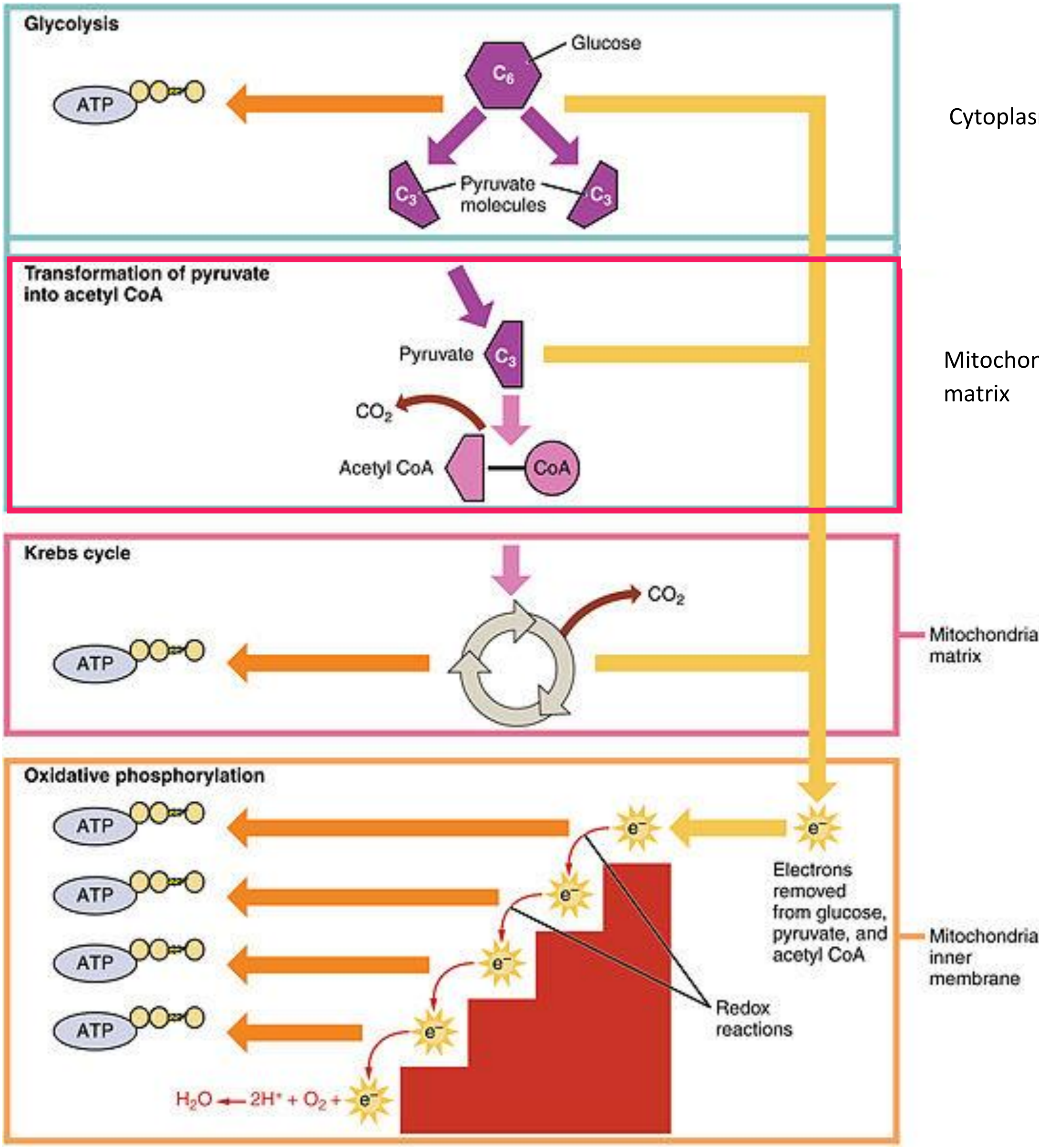
Name: ______________________________

Cellular Respiration Review

Draw an ATP molecule

ANSWER PAGE

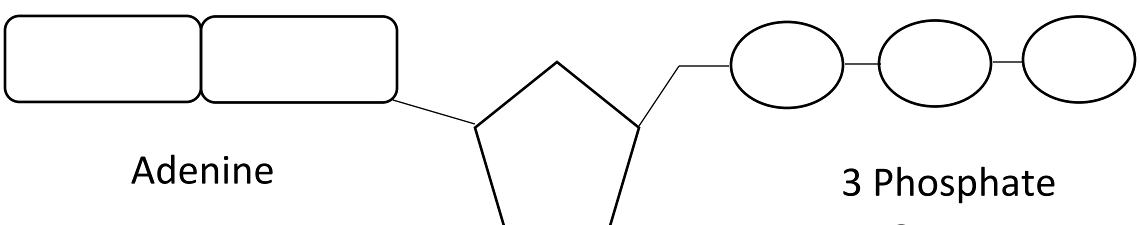
Cellular Respiration Review



Cytoplasm

Mitochondrial matrix

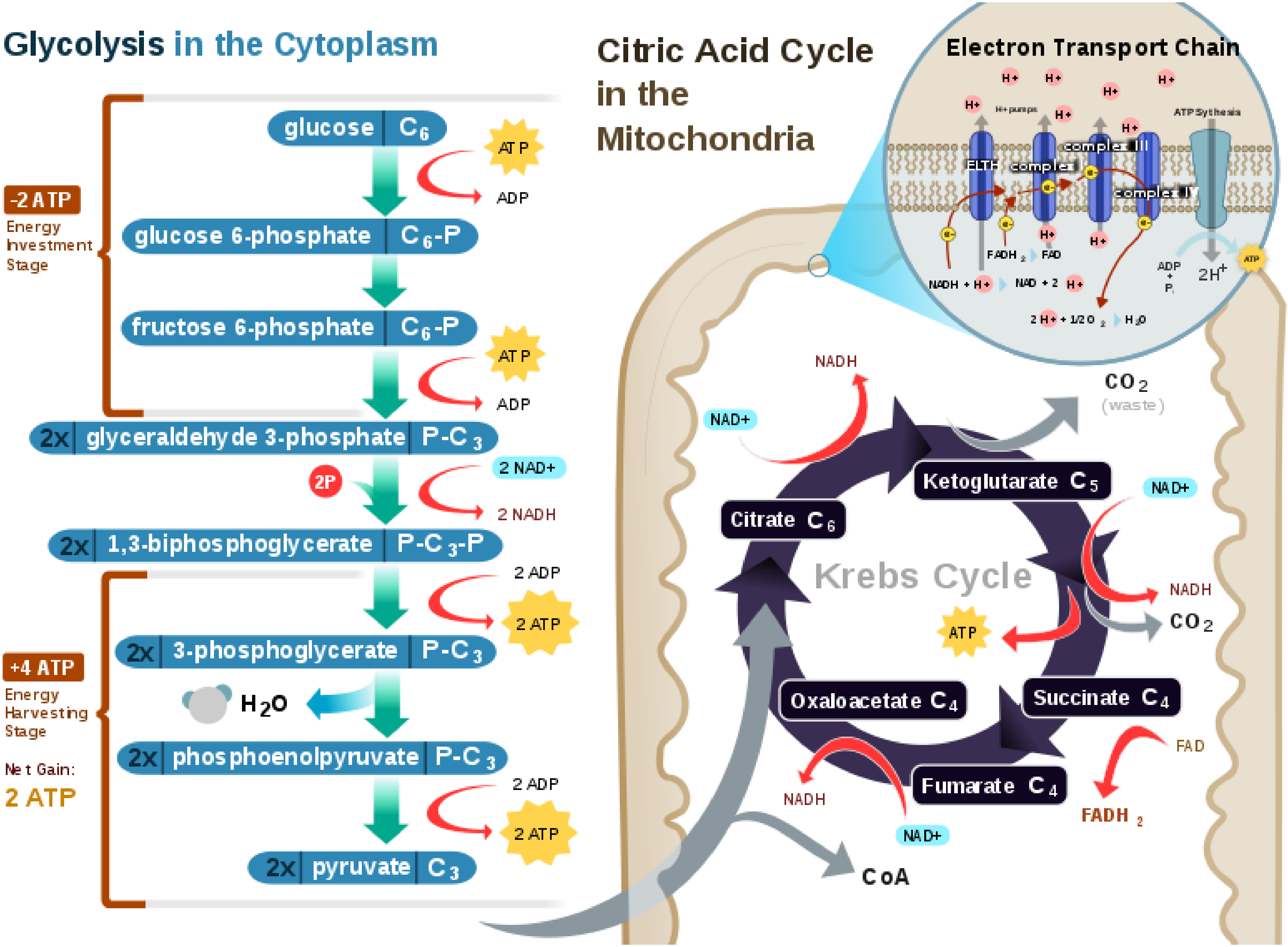
Draw an ATP molecule



Adenine

Ribose

3 Phosphate Groups


Glycolysis in the Cytoplasm
glucose C6
ATP
ADP
-2 ATP
Energy Investment Stage
glucose 6-phosphate C6-P
fructose 6-phosphate C6-P
ATP
ADP
2x glyceraldehyde 3-phosphate P-C3
2P
2 NAD+
2 NADH
2x 1,3-biphosphoglycerate P-C3-P
2 ADP
2 ATP
+4 ATP
Energy Harvesting Stage
2x 3-phosphoglycerate P-C3
H2O
2x phosphoenolpyruvate P-C3
Net Gain:
2 ATP
2 ADP
2 ATP
2x pyruvate C3
Citric Acid Cycle in the Mitochondria
Electron Transport Chain
H+
complex III
complex I
complex IV
ATP Sythesis
FADH2
FAD
NADH + H+
NAD + 2 H+
2 H+ + 1/2 O2
H2O
ADP + Pi
2H+
ATP
NADH
NAD+
CO2
(waste)
Ketoglutarate C5
Citrate C6
NAD+
Krebs Cycle
NADH
CO2
ATP
Oxaloacetate C4
Succinate C4
FAD
Fumarate C4
NADH
NAD+
FADH2
CoA