Name: _____ Block: _____

Metabolism and Glycolysis Worksheet

To help you better understand the steps of cellular respiration, you will work with the products of the various steps and cycles. This worksheet is designed to help you understand the big picture in terms of ATP.

Let's work on the idea that everything depends on how many ATP molecules you get. Remember that some molecules are going to be changed into ATP. The electron carriers have ATP equivalents (like money exchange). **NADH = 3 ATP, $FADH_2$ = 2 ATP.**

1. If an enzymatic pathway yielded 3 ATP, 2 NADH, and 1 $FADH_2$, how many total ATP could potentially be accumulated?

2. During glycolysis, one glucose molecule can yield a net gain of 2 ATP and 2 NADH. After exchanges, how many total ATP can potentially come from one glucose molecule from glycolysis alone? How many (net) would be made from five glucose molecules from glycolysis alone?

Of course, there is more to our story than NADH, $FADH_2$ and ATP. Carbon skeletons are important as well. The carbon locked up in one glucose molecule (6C) is passed on to other pathways. **The end products of glycolysis includes 2 pyruvate molecules**. Each is a 3C molecule that is carried into the mitochondria.

3. How many pyruvate molecules are made from just one glucose molecule during glycolysis?

4. How many pyruvate molecules are generated from the glycolysis of six glucose molecules? How many carbon atoms does this represent?

Fermentation is a "primitive" pathway because it does not yield a great amount of energy. In fact, its real purpose is to convert the leftover **pyruvate** into something else that is low-toxic and replenishes enough **NAD^+** to restart the glycolysis cycle. No additional ATP is made in these fermentation steps. The conversion of pyruvate into lactate is one way bacteria cells might replenish NAD^+. **For each lactate made in fermentation, one NAD^+ is regained**.

5. How many fermentation reactions must happen in order to replace the NAD^+ after the processing of ten glucose molecules through glycolysis? (Careful!)

Lastly, we learn about another molecule which travels to the rest of the respiration pathway. From one glucose molecule, two acetyl CoA molecules can be made. These are molecules that enter the Krebs cycle. Acetyl CoA is made from pyruvate. **The conversion of pyruvate to acetyl CoA yields one NADH and gives off 1 CO_2.** Keep in mind that this conversion is <u>not</u> part of glycolysis or Krebs, but is an "intermediate" step.

6. Starting with 1 glucose molecule at the beginning of glycolysis, how many NADH are produced upon the generation of 2 pyruvates **and** their conversion into acetyl CoA molecules?

Each acetyl CoA represents a block of energy because each one will yield more NADH, $FADH_2$, and ATP in subsequent reactions in the Krebs Cycle. Remember that **one acetyl CoA will go on to make 3 NADH, 1 $FADH_2$, and 1 ATP**.

7. From two acetyl CoA molecules, how many potential ATP can be generated overall. (That is, if all NADH and $FADH_2$ were converted to ATP, plus accounting for the actual ATP made.)

8. Assume you have one glucose molecule. Take it through glycolysis, Krebs and ETS. Convert all electron carriers into ATP and add in pure ATP made directly from these processes. How many ATP are made from just one glucose molecule (theoretically)?

Practice: Now try these on your own, using scratch paper. **<u>Put only your final answers here</u>**.

1. How many ATP molecules are represented by 4 NADH, 6 $FADH_2$, and three acetyl CoA molecules collectively?

2. How many NADH can be generated from five glucose sugars through glycolysis alone?

3. How many <u>total</u> ATP molecules could be made from five glucose sugars through glycolysis alone if <u>all NADH</u> were made into ATP? (Don't forget to include actual ATP directly made.)

4. How many total carbon atoms would be sent to the mitochondrion (in the form of acetyl CoA) if three glucose molecules are broken down by glycolysis?

5. How many acetyl CoA molecules are made from nine glucose molecules?

6. If you had three acetyl CoA molecules, how many $FADH_2$ molecules could you make?

7. If four acetyl CoA molecules were processed by the Krebs cycle, how many potential ATP could you make if all electron carriers were converted into ATP, including ATP directly made as well?

8. Now calculate the <u>sum total</u> of ATP generated from 5 glucose molecules.