

Is ATP worth the investment?

ATP (adenosine tri-phosphate) can be thought of as the *currency* of the cell. Most cellular metabolic processes *cost* a certain amount of ATP in order to happen. Furthermore, during glycolysis and cellular respiration when ATP is produced, ATP must be *invested* before more ATP can be generated.

Part I

Work the following example to learn how to use the table and calculate the return on an investment. Then use your knowledge in Part II of the exercise calculating the same thing for ATP in cellular respiration.

In biology class, Robin has just learned how to test foods for the presence of lipids, carbohydrates, and proteins. She decides to set up a testing booth in the cafeteria during lunch in which she will test the food of her classmates for a small fee. Since most of her peers are very interested in which types of biomolecules they are eating, she has high hopes for her little business!

As you read about Robin’s business finances, identify her expenses (money spent) and her revenue (money received). Record each expense and revenue on a separate line, then calculate net profit by subtracting total expenses from total revenue.

Expense	Revenue	
TOTAL	TOTAL	PROFIT

Robin bought a lab coat and goggles for \$7 to wear for safety. A 20 oz bottle of Iodine for testing starch cost her \$30, but she sold half of it to her biology teacher for \$20. She also purchased some Benedict’s and Biuret’s solution for \$10 and again sold some of it to her teacher for \$3. The cafeteria booth she rented from the student council for \$1 a day. She charged 50 cents per plate to test food. She tested 10 plates a day for 10 days before running out of Iodine

and deciding that the return on her investment just wasn't enough to justify all the lunch time she was losing to her business.

1. Calculate and record on the table her total expense, total revenue, and net profit.
2. Return on investment (ROI) is how much you get back relative to how much you put in. More technically, it is the ratio between your profit and your expense. To get Robin's return on her investment, divide the net profit by total expense then multiply by 100 to express your answer as a percentage. $ROI = (\text{net profit}/\text{total expense}) \times 100$

In this example, Robin didn't make much more money than she invested, so the return on her investment was low. Think of molecules of ATP as money used by cellular processes. How good is the return on investment of ATP during cellular respiration? How good is the return on investment of ATP when oxygen is not present and cells must undergo anaerobic respiration and fermentation? Complete the next section to find out.

Part II

Aerobic Respiration

Expense	Revenue	
TOTAL	TOTAL	PROFIT

The first step in cellular respiration is glycoylsis (which means glucose splits). At first, 2 ATP are used to change glucose into other forms of sugar. As glycolysis continues, and one type of sugar changes into the next, 2 ATP are given off and again, as the final product forms (2 molecules of pyruvate) another 2 ATP are generated.

During the second step, the 2 pyruvate molecules enter the mitochondria and oxygen is used to change them into Acetyl-CoA. This releases a total of 6 ATP. Once converted, the Acetyl-CoA can enter the Krebs's Cycle (an 8-step chemical reaction that releases carbon dioxide and generates 2 more ATP).

Finally, the products from the Krebs's Cycle go to the inner membrane of the mitochondria (the cristae) where about 28 ATP are generated with the help of ATP synthase (an enzyme that helps add a phosphate to ADP to make ATP). Water is also a product of this phase.

Anaerobic Respiration

Expense	Revenue	
TOTAL	TOTAL	PROFIT

When oxygen is not present, cells must undergo anaerobic respiration in order to make ATP. Glycolysis still happens like it was described above: glucose is split and converted from one type of sugar to another. This uses 2 ATP to get things started, but 4 ATP are produced by the time the glucose is turned into pyruvate.

Next, since there is no oxygen, the pyruvate can not be converted in Acetyl-CoA and can not enter the mitochondria. Instead, the pyruvate is converted into lactic acid or alcohol via fermentation. This doesn't generate any ATP, but is important because it produces NADH (a less powerful energy molecule), which provides enough energy to keep splitting additional glucose molecules.

1. On each table, calculate the total expense, total revenue, and net profit.
2. What is the return on the ATP investment for aerobic respiration? Anaerobic respiration?
3. Given that a human uses an amount of ATP equivalent to their body weight over the course of a day, why is it so important for our cells to get a lot of oxygen?
4. In these examples, we have been comparing ATP to cash. It is actually more accurate to compare it to a rechargeable gift-card. Why?

Is ATP Worth the Investment?

Answer Guide

ATP (adenosine tri-phosphate) can be thought of as the *currency* of the cell. Most cellular metabolic processes *cost* a certain amount of ATP in order to happen. Furthermore, during glycolysis and cellular respiration when ATP is produced, ATP must be *invested* before more ATP can be generated.

Part I

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As you read about Robin's business finances, identify her expenses (money spent) and her revenue (money received). Record each expense and revenue on a separate line, then calculate net profit by subtracting total expenses from total revenue.

Expense	Revenue	
7		
30		
	20	
10		
	3	
10		
	50	
TOTAL	TOTAL	PROFIT
69	83	14

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Part II

Aerobic Respiration

Expense	Revenue	
2		
	2	
	2	
	6	
	2	
	28	
TOTAL	TOTAL	PROFIT
2	40	38

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Anaerobic Respiration

Expense	Revenue	
2		
	4	
TOTAL	TOTAL	PROFIT
2	4	2

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5. On each table, calculate the total expense, total revenue, and net profit.
6. What is the return on the ATP investment for aerobic respiration? Anaerobic respiration?

1,900% 100%
7. Given that a human uses an amount of ATP equivalent to their body weight over the course of a day, why is it so important for our cells to get a lot of oxygen? **Since we need so much ATP, it's important that our cells can undergo aerobic respiration most of the time since it generates so much from so few ATP. (Furthermore, lactic acid is can be harmful to our cells and oxygen is required to break it down.)**
8. In these examples, we have been comparing ATP to cash. It is actually more accurate to compare it to a rechargeable gift-card. Why? **ATP is generated when a phosphate is added to a molecule of ADP (adenosine diphosphate). In this way, most of the molecule is simple reused over and over just like a gift-card after more money has been added to the account.**