

# Cellular Respiration Breaking Down Energy Answer Key

## Cellular Respiration: Breaking down Energy

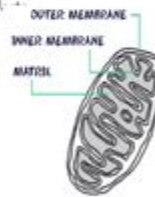
Objective: \_\_\_\_\_

\_\_\_\_\_

**Mitochondria** are known as the powerhouses of the cell. They are **organelles** that act like a digestive system that takes in nutrients, breaks them down, and creates energy for the cell. The process of creating cell energy is known as **cellular respiration**. Most of the chemical reactions involved in cellular respiration happen in the mitochondria. A mitochondrion is shaped perfectly to maximize its efficiency.

1. What process happens in the mitochondria?  
Cellular respiration

2. What is the purpose of the process in #1 (what does it create)?  
It creates energy for the cell



### Introduction to Cellular Respiration

Organisms, such as plants and algae, can trap the energy in sunlight through photosynthesis and store it in the chemical bonds of carbohydrate molecules. The principal carbohydrate formed through photosynthesis is **glucose**. Other types of organisms, such as animals, fungi, protozoa, and a large portion of the bacteria, are unable to perform this process. Therefore, these organisms must rely on the carbohydrates formed in plants to obtain the energy necessary for their metabolic processes. This means they must eat plants and other animals in order to gain energy.

4. Some organisms perform photosynthesis to produce energy. Other organisms cannot do photosynthesis. What can they do in order to generate energy?

They can produce energy using cellular respiration instead of photosynthesis

5. Animals and other organisms obtain the energy available in carbohydrates through the process of **cellular respiration**. What is the purpose of cellular respiration?

The purpose of cellular respiration is for animals to absorb energy taken from the outside and convert it into usable energy for the body

Cells take the carbohydrates into their cytoplasm, and through a complex series of metabolic processes, they break down the carbohydrates and release the energy. The energy is generally not needed immediately; rather it is used to combine adenosine diphosphate (ADP) with another phosphate to form adenosine triphosphate (ATP) molecules. The **ATP** can then be used for processes in the cells that require energy, much as a battery powers a mechanical device. During the process of cellular respiration, carbon dioxide is given off. Plant cells can use this carbon dioxide during photosynthesis to form new carbohydrates.

**CELLULAR RESPIRATION BREAKING DOWN ENERGY ANSWER KEY** IS FUNDAMENTAL TO UNDERSTANDING HOW LIVING ORGANISMS CONVERT NUTRIENTS INTO USABLE ENERGY. THIS COMPLEX PROCESS OCCURS IN ALL AEROBIC ORGANISMS AND IS ESSENTIAL FOR MAINTAINING LIFE. CELLULAR RESPIRATION ALLOWS CELLS TO EXTRACT ENERGY FROM NUTRIENTS, PRIMARILY GLUCOSE, AND CONVERT IT INTO ADENOSINE TRIPHOSPHATE (ATP), THE ENERGY CURRENCY OF THE CELL. THIS ARTICLE WILL EXPLORE THE STAGES OF CELLULAR RESPIRATION, ITS SIGNIFICANCE, AND ITS ROLE IN ENERGY METABOLISM.

## OVERVIEW OF CELLULAR RESPIRATION

CELLULAR RESPIRATION IS A MULTI-STEP PROCESS THAT CAN BE DIVIDED INTO THREE MAIN STAGES:

1. GLYCOLYSIS
2. KREBS CYCLE (CITRIC ACID CYCLE)

### 3. ELECTRON TRANSPORT CHAIN (ETC)

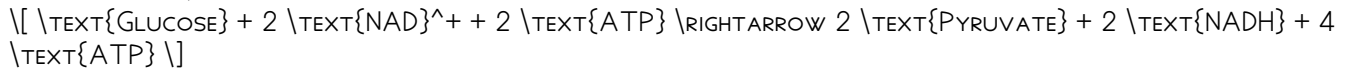
IN ADDITION TO THESE STAGES, WE WILL ALSO TOUCH UPON ANAEROBIC RESPIRATION, WHICH OCCURS IN THE ABSENCE OF OXYGEN.

## 1. GLYCOLYSIS

GLYCOLYSIS IS THE FIRST STAGE OF CELLULAR RESPIRATION AND OCCURS IN THE CYTOPLASM OF THE CELL. THIS PROCESS DOES NOT REQUIRE OXYGEN, MAKING IT AN ANAEROBIC PROCESS. THE MAIN FUNCTIONS OF GLYCOLYSIS INCLUDE:

- BREAKING DOWN GLUCOSE: ONE MOLECULE OF GLUCOSE (A SIX-CARBON SUGAR) IS CONVERTED INTO TWO MOLECULES OF PYRUVATE (A THREE-CARBON COMPOUND).
- ATP PRODUCTION: GLYCOLYSIS PRODUCES A NET GAIN OF 2 ATP MOLECULES, WHICH ARE USED DIRECTLY BY THE CELL FOR ENERGY.
- NADH GENERATION: DURING GLYCOLYSIS, ELECTRONS ARE TRANSFERRED TO THE ELECTRON CARRIER  $\text{NAD}^+$ , FORMING NADH. THIS MOLECULE WILL PLAY A CRUCIAL ROLE IN THE LATER STAGES OF CELLULAR RESPIRATION.

THE OVERALL EQUATION FOR GLYCOLYSIS CAN BE SUMMARIZED AS:



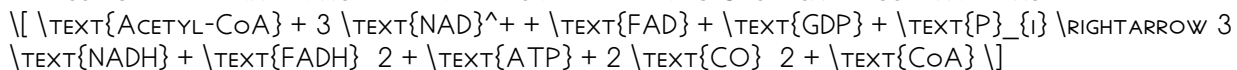
THOUGH GLYCOLYSIS PRODUCES FOUR ATP MOLECULES, TWO ARE CONSUMED IN THE INITIAL STEPS, RESULTING IN A NET GAIN OF 2 ATP.

## 2. KREBS CYCLE (CITRIC ACID CYCLE)

THE KREBS CYCLE TAKES PLACE IN THE MATRIX OF THE MITOCHONDRIA AND REQUIRES OXYGEN, MAKING IT AN AEROBIC PROCESS. THIS CYCLE IS CRUCIAL FOR FURTHER BREAKING DOWN THE PRODUCTS OF GLYCOLYSIS. KEY ASPECTS OF THE KREBS CYCLE INCLUDE:

- ACETYL-CoA FORMATION: BEFORE ENTERING THE KREBS CYCLE, PYRUVATE IS CONVERTED INTO ACETYL-CoA. THIS PROCESS RELEASES CARBON DIOXIDE ( $\text{CO}_2$ ) AND PRODUCES NADH.
- ATP AND ELECTRON CARRIER PRODUCTION: THE KREBS CYCLE PRODUCES:
  - 1 ATP (OR GTP) PER TURN
  - 3 NADH
  - 1  $\text{FADH}_2$  (ANOTHER ELECTRON CARRIER)
  - 2  $\text{CO}_2$  MOLECULES ARE RELEASED AS WASTE PRODUCTS.

THE CYCLE TURNS TWICE FOR EACH MOLECULE OF GLUCOSE, AS ONE GLUCOSE MOLECULE PRODUCES TWO PYRUVATE MOLECULES. THE OVERALL REACTION FOR ONE TURN OF THE KREBS CYCLE CAN BE SUMMARIZED AS:



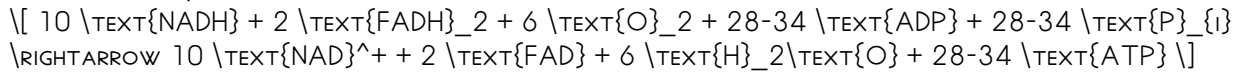
## 3. ELECTRON TRANSPORT CHAIN (ETC)

THE ELECTRON TRANSPORT CHAIN IS THE FINAL STAGE OF CELLULAR RESPIRATION AND TAKES PLACE IN THE INNER MITOCHONDRIAL MEMBRANE. IT UTILIZES THE HIGH-ENERGY ELECTRONS CARRIED BY NADH AND  $\text{FADH}_2$  FROM GLYCOLYSIS AND THE KREBS CYCLE. THE MAIN COMPONENTS AND FUNCTIONS OF THE ETC INCLUDE:

- ELECTRON TRANSFER: ELECTRONS ARE PASSED THROUGH A SERIES OF PROTEIN COMPLEXES (COMPLEX I TO IV) AND MOBILE ELECTRON CARRIERS. THIS TRANSFER RELEASES ENERGY.
- PROTON GRADIENT FORMATION: THE ENERGY RELEASED DURING ELECTRON TRANSFER IS USED TO PUMP PROTONS ( $\text{H}^+$ ) FROM THE MITOCHONDRIAL MATRIX INTO THE INTERMEMBRANE SPACE, CREATING A PROTON GRADIENT.

- **ATP SYNTHESIS:** AS PROTONS FLOW BACK INTO THE MATRIX THROUGH ATP SYNTHASE (A PROTEIN COMPLEX), ATP IS GENERATED THROUGH A PROCESS CALLED CHEMIOSMOSIS. APPROXIMATELY 28-34 ATP MOLECULES CAN BE PRODUCED FROM ONE MOLECULE OF GLUCOSE AT THIS STAGE.
- **WATER FORMATION:** AT THE END OF THE CHAIN, ELECTRONS COMBINE WITH OXYGEN AND PROTONS TO FORM WATER, WHICH IS ESSENTIAL FOR MAINTAINING CELLULAR FUNCTION.

THE OVERALL EQUATION FOR THE ELECTRON TRANSPORT CHAIN CAN BE SUMMARIZED AS:



## SIGNIFICANCE OF CELLULAR RESPIRATION

CELLULAR RESPIRATION IS VITAL FOR SEVERAL REASONS:

- **ENERGY PRODUCTION:** ATP GENERATED DURING CELLULAR RESPIRATION IS USED FOR VARIOUS CELLULAR PROCESSES, FROM MUSCLE CONTRACTION TO BIOSYNTHESIS OF MACROMOLECULES.
- **METABOLIC PATHWAYS:** THE INTERMEDIATES PRODUCED THROUGHOUT CELLULAR RESPIRATION ARE USED IN VARIOUS METABOLIC PATHWAYS, INCLUDING AMINO ACID AND LIPID SYNTHESIS.
- **HOMEOSTASIS:** BY PROVIDING ENERGY, CELLULAR RESPIRATION HELPS MAINTAIN CELLULAR HOMEOSTASIS AND REGULATE METABOLIC ACTIVITIES.

## ANAEROBIC RESPIRATION

IN THE ABSENCE OF OXYGEN, SOME ORGANISMS CAN UNDERGO ANAEROBIC RESPIRATION, WHICH ALLOWS THEM TO SURVIVE IN OXYGEN-DEPRIVED ENVIRONMENTS. THE TWO MAIN TYPES OF ANAEROBIC RESPIRATION ARE:

1. **LACTIC ACID FERMENTATION:** OCCURS IN CERTAIN BACTERIA AND ANIMAL MUSCLES. GLUCOSE IS CONVERTED INTO LACTIC ACID, PRODUCING 2 ATP AND REGENERATING NAD<sup>+</sup>.

- OVERALL EQUATION:



2. **ALCOHOLIC FERMENTATION:** USED BY YEAST AND SOME BACTERIA. GLUCOSE IS CONVERTED INTO ETHANOL AND CARBON DIOXIDE, ALSO PRODUCING 2 ATP AND REGENERATING NAD<sup>+</sup>.

- OVERALL EQUATION:



WHILE ANAEROBIC RESPIRATION YIELDS LESS ATP COMPARED TO AEROBIC RESPIRATION, IT IS CRUCIAL FOR SURVIVAL IN LOW-OXYGEN CONDITIONS.

## CONCLUSION

CELLULAR RESPIRATION IS A SOPHISTICATED AND ESSENTIAL BIOLOGICAL PROCESS THAT ENABLES ORGANISMS TO CONVERT FOOD INTO ENERGY. BY UNDERSTANDING THE STAGES OF GLYCOLYSIS, THE KREBS CYCLE, AND THE ELECTRON TRANSPORT CHAIN, ONE CAN APPRECIATE HOW CELLS EFFICIENTLY PRODUCE ATP. FURTHERMORE, RECOGNIZING THE IMPORTANCE OF BOTH AEROBIC AND ANAEROBIC RESPIRATION HIGHLIGHTS THE ADAPTABILITY OF LIFE IN VARIOUS ENVIRONMENTS. THIS INTRICATE ENERGY CONVERSION PROCESS IS AT THE HEART OF CELLULAR FUNCTION AND IS FUNDAMENTAL TO THE SUSTAINABILITY OF LIFE ON EARTH.

# FREQUENTLY ASKED QUESTIONS

## WHAT IS CELLULAR RESPIRATION?

CELLULAR RESPIRATION IS THE PROCESS BY WHICH CELLS CONVERT GLUCOSE AND OXYGEN INTO ENERGY, CARBON DIOXIDE, AND WATER.

## WHAT ARE THE MAIN STAGES OF CELLULAR RESPIRATION?

THE MAIN STAGES OF CELLULAR RESPIRATION ARE GLYCOLYSIS, THE KREBS CYCLE (CITRIC ACID CYCLE), AND THE ELECTRON TRANSPORT CHAIN.

## WHAT IS THE ROLE OF GLYCOLYSIS IN CELLULAR RESPIRATION?

GLYCOLYSIS IS THE FIRST STEP IN CELLULAR RESPIRATION, WHERE GLUCOSE IS BROKEN DOWN INTO PYRUVATE, PRODUCING A SMALL AMOUNT OF ATP AND NADH.

## HOW DOES THE KREBS CYCLE CONTRIBUTE TO ENERGY PRODUCTION?

THE KREBS CYCLE PROCESSES THE PYRUVATE PRODUCED IN GLYCOLYSIS, GENERATING ELECTRON CARRIERS (NADH AND FADH<sub>2</sub>) AND RELEASING CARBON DIOXIDE AS A WASTE PRODUCT, WHICH ARE ESSENTIAL FOR THE ELECTRON TRANSPORT CHAIN.

## WHAT IS THE FUNCTION OF THE ELECTRON TRANSPORT CHAIN?

THE ELECTRON TRANSPORT CHAIN USES THE ELECTRONS FROM NADH AND FADH<sub>2</sub> TO CREATE A PROTON GRADIENT ACROSS THE MITOCHONDRIAL MEMBRANE, ULTIMATELY PRODUCING ATP THROUGH OXIDATIVE PHOSPHORYLATION.

## HOW MUCH ATP IS PRODUCED FROM ONE MOLECULE OF GLUCOSE DURING CELLULAR RESPIRATION?

A TOTAL OF APPROXIMATELY 30 TO 32 ATP MOLECULES CAN BE GENERATED FROM ONE MOLECULE OF GLUCOSE DURING CELLULAR RESPIRATION, DEPENDING ON THE EFFICIENCY OF THE PROCESS.

## WHAT IS ANAEROBIC RESPIRATION AND HOW DOES IT DIFFER FROM AEROBIC RESPIRATION?

ANAEROBIC RESPIRATION OCCURS IN THE ABSENCE OF OXYGEN AND PRODUCES LESS ENERGY (TYPICALLY 2 ATP) COMPARED TO AEROBIC RESPIRATION, WHICH REQUIRES OXYGEN AND YIELDS SIGNIFICANTLY MORE ENERGY.

## WHAT BYPRODUCTS ARE FORMED DURING CELLULAR RESPIRATION?

THE MAIN BYPRODUCTS OF CELLULAR RESPIRATION ARE CARBON DIOXIDE AND WATER, ALONG WITH THE PRODUCTION OF ATP AS THE ENERGY CURRENCY OF THE CELL.

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