

# CELLULAR ENERGY AND METABOLISM

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**FOR USE IN:** General Science, Biology **LEVEL:** Grades 7-12  
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## EDUCATIONAL OBJECTIVES

To help the student understand these key concepts about cellular energy and metabolism:

- The process of photosynthesis
- Factors affecting the rate of photosynthesis
- Respiration and the transfer of energy from food
- Factors affecting the rate of respiration
- Enzymes as biological catalysts
- Factors affecting the rate of enzyme action

## BEFORE SHOWING THE VIDEO:

The three key concepts explained in this video are:

1. Photosynthesis
2. Respiration
3. Enzymes

Each concept runs for about 4 - 5 minutes. To play only concepts #2 or #3, simply fast-forward to its title. Laboratory demonstrations shown are generally too difficult, dangerous, or expensive to do in the classroom. Excellent computer graphics and superimposed text, clarify and explain what is happening during the experiments. The students may be alerted that some demonstrations shown in the video end with questions, and that they will have an opportunity to provide their answers after the showing.

## CONTENT OF THE VIDEO

### Photosynthesis

#### Introduction to photosynthesis

Photosynthesis is responsible for growth in plants. The raw materials are carbon dioxide and water, and light is the energy source transformed by chlorophyll. The products are glucose and oxygen. The rate of photosynthesis can be maximized in a greenhouse by using artificial light and supplying carbon dioxide.

#### How does light intensity affect the rate of photosynthesis?

The amount of CO<sub>2</sub> used (measured by a gas analyzer) indicates the rate of photosynthesis. If the light intensity increases, so does the uptake of CO<sub>2</sub> and the rate of photosynthesis.

#### How does the supply of carbon dioxide affect the rate of photosynthesis?

This sequence starts with a demonstration of pondweed photosynthesizing in water- The amount of oxygen produced (measured in capillary tubing) indicates the rate of photosynthesis. Next a solution of sodium hydrogen Carbonate is used to supply CO<sub>2</sub>. As the supply of CO<sub>2</sub> increases, so do the production of O<sub>2</sub> and the rate of photosynthesis. Data are displayed.

### Respiration

#### Life processes require energy

Respiration releases energy from food for the processes of life.

#### Food is our energy source

Here we see respiration releasing energy from food for humans. For most living things, including humans, this process requires oxygen and is therefore *aerobic*.

## **An equation for respiration**

This graphical sequence builds up the equation for respiration and shows the energy released. Respiration happens in every cell.

## **Monitoring the rate of respiration**

Sequences show the use of a gas analyser linked to a data-logger to record information on production of CO<sub>2</sub> and uptake of O<sub>2</sub> during respiration. The rates of respiration are compared for an athlete at rest, walking, jogging, and running.

Graphs show how exercise demands a greater rate of respiration. The rates of O<sub>2</sub> uptake and CO<sub>2</sub> release both increase with the rate of respiration.

## **Anaerobic respiration**

Breathing rate increases with exercise, to supply the necessary oxygen. What happens when breathing can't keep up with oxygen demand? Respiration becomes *anaerobic*, as happens in the leg muscles of sprinters. Lactic acid builds up and less energy is released when respiration is anaerobic. A portable blood test kit is used to show lactic acid levels before and after sprinting.

## **Enzymes**

### **Introduction to enzymes**

Enzymes are present in all cells and are secreted by some of them. They speed up or catalyze reactions. Using amylase as an example, sequences model how an enzyme acts.

### **Enzyme activity**

Enzyme activity is affected by temperature. An experiment, which is commonly carried out in schools, is demonstrated here: the digestion of starch by amylase at several temperatures. The amount of starch and enzyme is controlled, while the temperature is varied. Iodine solution is used as an indicator of the end-point (when the starch has disappeared). The higher the temperature, the greater the rate of enzyme action.

### **What is the optimum temperature for enzyme activity?**

Animated sequences model how enzyme molecules can be denature at temperatures; higher (above 42 degrees C), than the 25 degrees C optimum temperature of the experiment, causing a change in shape so that the substrate does not fit.

### **Catalase in plant and animal tissue**

The equation for the breakdown of catalase by hydrogen peroxide and the production of oxygen is shown, demonstrated through experiments with liver and potato tissue, which contain catalase.

### **Does pH affect enzyme activity?**

The amount of living potato tissue containing catalase, and hydrogen peroxide solution is constant, while the pH is altered, from acidic through alkaline. pH 9, neutral, is the optimum for catalase activity.

## **AFTER SHOWING THE VIDEO:**

The following questions and activities may be useful in stimulating student discussion and investigation:

1. Compare and contrast the functions of photosynthesis and respiration.
2. What is the formula for photosynthesis?
3. What other variables (beyond those shown in the video) could affect the rate of photosynthesis? How would you set up an experiment to determine their effect? (Increasing the amount of water? Typically, plant cells have an abundance of water so increasing the amount of water will not increase the rate of photosynthesis.) (Increasing the intensity of particular wavelengths in light? There are 5 types of chlorophyll which absorb different wavelengths of light, and which occur in different plants, algae, and other organisms) (Increasing the supply of carbon dioxide? In a greenhouse, additional carbon dioxide may be supplied up to a level of 1.0%, above which there is no further increase in photosynthesis and in fact the gas becomes toxic.)
4. What is the formula for respiration? What other variables (beyond those shown in the video of the more rapid and deeper intake of air) would affect the rate of respiration? (The lesser amounts of oxygen in the atmosphere at increasing altitudes above sea level, or the artificial mixture of oxygen in such breathing apparatus as that used in space exploration, and deep sea diving).
5. What are the differences between aerobic and anaerobic respiration? What are the formulas, and the relative energy production of each?
6. In the video experiment with amylase breaking down starch at 3 different temperatures of 5 degrees C, 20, and 35, the catalyst worked fastest at 35 degrees Celsius. Any idea why.? (Amylase has evolved to work best in the range of

body temperature, 98.6F or 37C. Without enzymes, biological reactions would be too slow at the temperature at which cells exist.)

7. What would happen were the enzyme amylase and the substrate starch in solution to be kept at 60 degrees C? (enzymes denature at temperatures over 42 degrees C and become ineffective because their molecular configuration no longer fits that of the substrate.)
8. This video's enzyme investigation, involving differing pH's while the amount of potato slices and hydrogen peroxide are held constant, could be duplicated in school, and adapted as an investigation for students.

**INTERNET WEB SITES FOR FURTHER INFORMATION ON:**

**Biological reactions and enzymes**

<http://www.purchon.co.uk/science/biology.html>

The Science Key Concepts Series consists of 16 videos:

for Biology: Cells and Tissues, Cellular Energy and Metabolism, Energy Transfer & Biogeochemical Cycles, Homeostasis, Sensory Responses and Tropisms

for Physics: Electricity and Magnetism, The Electromagnetic Spectrum, Force and Motion, Molecular Motion, Waves

for Chemistry: Applied Chemistry, Electrochemistry, Radioactivity, Reactions and Energy Changes, Reactivity of Elements, Uses of Natural Resources

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