



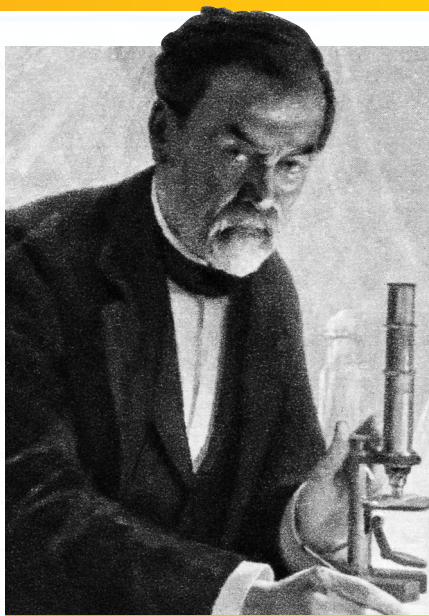
# It's ALIVE!!

*Arbois, France, 1864*

Something was wrong with the French winemaking industry. Some batches had spoiled, and no one understood why. Emperor Napoleon III invited Dr. Louis Pasteur, a professor of chemistry, to look into the problem. He chose the right man: Pasteur had been investigating the process for making wine and beer for several years and had some surprising answers.

## Basically Biological

People had been making wine and beer for centuries, using a process known as fermentation. This was how juices from fruits and vegetables such as grapes and barley became wine and beer. Fermentation is also what makes bread rise. Most scientists at the time assumed fermentation was a chemical process of some kind. But Pasteur proved that tiny living things caused fermentation. Certain one-celled organisms absorb sugars and other nutrients through their membranes. After breaking down these substances, the organisms give off various substances as waste products—one of which is alcohol.



**Dr. Louis Pasteur**

Pasteur had been investigating the process of fermentation since 1854. By examining samples of beer under a microscope, Pasteur observed small, round particles in the liquid. In the spoiled beer, these were oval-shaped, while in the unspoiled beer they were shaped more like spheres. After more investigations and tests, he concluded that these particles were actually microscopic organisms. Fermentation took place when these organisms were healthy and able to reproduce. But if conditions were unhealthy—if, for example, the temperature was too hot—the microorganisms would not function properly and fermentation would fail. As a result, the beer or wine would be spoiled.

Through his experiments, Pasteur revolutionized the scientific community. He had proved that fermentation was a chemical process and that it was a biological one as well.

## “Life Without Air”

Like all living things on Earth, cells need chemical energy to perform their various functions.

Cells use chemical energy to process nutrients, to expel wastes, to grow, and to

reproduce. This energy comes

from nutrients absorbed and broken down by the cell, a

process that for many organisms also requires oxygen. Just as we need oxygen to survive, our individual cells need oxygen to carry on their functions. And many one-celled organisms need oxygen for the same reasons.


Fermentation is one way a cell can get energy without oxygen. Pasteur observed one-celled organisms functioning and reproducing in environments without oxygen and concluded: “Fermentation is the consequence of life without air.” Before this discovery, no one believed that life could survive without oxygen. Pasteur opened up a whole new world of investigation by proving that many forms could, through the process of fermentation.

A cell gets energy through fermentation by converting

nutrients such as sugars into usable chemical energy, but without using oxygen. The process gives off various waste products, which the cell disposes of through its membrane. Waste products vary, depending on the organism. Some yeasts give off carbon dioxide, which causes bread to rise. Others produce ethyl alcohol, which is the alcohol in beer and wine. And our muscle cells use fermentation, too, when they need extra amounts of energy. Ever notice how your muscles sting and ache after you've been exercising very hard? This is caused by lactic acid, a by-product of the fermentation taking place in your muscle cells.

## The Germ Theory

Pasteur's work with fermentation led him to form one of the most important theories in the history of microbiology. His discovery that life could exist without air led him to examine microorganisms in a completely new way. If one-celled organisms were the cause of fermentation, couldn't they also be the cause of disease? Until then, people didn't understand that infections were caused by microscopic life-forms. Pasteur identified several disease-causing bacteria and demonstrated how these could be killed by heat. The process he recommended is still used to kill harmful bacteria in



**In the background picture is a magnification of a one-celled fungus commonly called baker's yeast. Its waste product, carbon dioxide, causes bread to rise.**

milk. Today we call it pasteurization. Pasteur's work also led to the sterilization of medical instruments, which greatly reduced infections in operations.

Pasteur devoted his work to understanding life on the smallest scale. Although he

completely revolutionized the fields of industry and medicine, Pasteur always put his faith in the scientific process. "Imagination should give wings to our thoughts," he once said, "but we always need decisive experimental proof."

## Activity

**YEAST IN ACTION** You've learned that yeast organisms cause bread to rise, but you can't easily see it as it's happening. Try this experiment to observe the by-products of fermentation. Take five glass bottles, and label and fill them halfway with the following solutions:

**Bottle #1: Water**

**Bottle #2: Sugar-water** (1 part sugar to 4 parts water)

**Bottle #3: Starch-water** (1 part mashed potato flakes to 4 parts water)

**Bottle #4: Sugar-protein water** (1 part beef broth and 1 part sugar-water)

**Bottle #5: Protein-water** (beef broth diluted to half-strength with water)

Then add a pinch of baker's yeast to each bottle and cover each bottle opening with a balloon. Record the appearance of each solution and then leave the bottles at room temperature.

On the next day, record the appearance of each solution and make a table of your observations. The table should indicate changes in appearance from the first to the second day, and any differences between the five solutions. Write a brief report based on your observations. What do the different solutions reveal about yeast and fermentation?