

A Modern Scientist-Engineer in the World of Fermentation

by Joyce Parker



Left: Louis Pasteur discovered in the 1800s how to prevent fermented drinks like wine from going bad (image from biography.com). Right: Dr. Donna Bates is a modern-day researcher who studies how to ferment plant stems, leaves, and wood into biofuels. Both Pasteur and Bates ask similar “why” and “how” science and engineering questions to study fermentation.

Which came first—the engineer or the scientist? Scientists find out why things happen. Engineers solve problems to make particular things happen. Both science and engineering are processes that people use to solve problems and answer questions, but the type of the questions are different. Scientists tend to ask “why” questions, while engineers tend to ask “how” questions. People have been engaging in both kinds of pursuits for thousands of years, and one has frequently influenced the other.

Consider fermentation. Long ago, people all over the world discovered that letting their grain ferment into beer or grapes ferment into wine meant that they could keep the food longer. Beer and wine were products that didn’t spoil as quickly as grain or grapes. They solved the engineering problem of *how* to keep their food from spoiling by making beer and wine.

But occasionally the beer or wine *would* go bad. The scientist Louis Pasteur figured out *why*. The spoiled alcoholic drinks had the wrong microbes growing in them. Using a microscope, he could see that different outcomes of fermentation were associated with different microbes. Round yeast grew in the healthy batches, but small, rod-like bacteria grew in the spoiled batches.

Pasteur used his scientific understanding of microbes to solve the engineering problem of *how* to prevent the spoilage of the beer and wine. He experimented with ways of sterilizing liquids by boiling and then cooling them so that there were no live microbes in them. He also found ways to heat liquids to somewhat lower temperatures and cool them quickly so that most of the microbes were destroyed, but the quality of the food was not. He applied this process, which is called pasteurization in his honor, to wine making and milk. If freshly fermented wine is

pasteurized and then cooled, no undesirable microbes grow and the wine ages properly without spoiling. Pasteurizing milk increases its shelf life and destroys disease-causing microbes that grow easily in raw milk.

Modern day fermentation science and engineering problems. Dr. Donna Bates is a modern scientist-engineer working on fermentation at the Great Lakes Bioenergy Research Center. Louis Pasteur studied fermentation of grain and grapes to produce ethanol in alcoholic drinks. Dr. Bates works on larger research effort to make ethanol by fermenting plant materials such as corn stalks, grasses, and wood. The goal is to make cost-effective fuel for cars and trucks that can substitute for fossile fuels such as gasoline.

People already know how to make ethanol from plant materials like grass and wood, but the process is not cost-effective. Before the plant material is fermented, it goes through a special process using heat and chemicals to release a mixture of sugars. Unfortunately, this process also releases toxins which harm the fermenting microbes (yeast). Some of the engineering problems that still need to be solved are: 1) *how* to get fermenting microbes to use all of the sugars and 2) *how* to get efficient fermentation in the presence of the toxins. If researchers can figure out how to get the fermenters to use more of the sugars in the mix they are given, the production of ethanol will be more efficient. If they also can find ways to do fermentation in the presence of the toxins, this will mean less handling of the mixture and again, a more efficient production process.

Dr. Bates and members of her lab team work on this as both a science investigation and an engineering problem. *Science questions:* What causes fermenters, such as yeast, to use all of the sugars, not just their favorites? What effects do the toxins have on the fermenters? *Engineering problems:* How can we make fermenters use all of the sugars all of the time? How can we make fermenters that can live in the presence of the toxins?

Dr. Bates' team used a variety of new bioengineering techniques to answer these questions. They grew yeast in ever-increasing concentrations of different sugars or toxins. Only a few rare mutants survived. In another study, they found that by doing genetic engineering to remove a particular gene, the yeast could grow in the presence of toxins. In both cases, they are studying *why* the mutants are different from the original strains of yeast. They are also asking *how* the new strains perform in the ethanol production process. Pasteur's engineering and science studies of fermentation led to more effective production of safe beverages. Dr. Bates' team's engineering and science is helping us move forward in the important quest for biofuels.



Dr. Bates ferments a liquid mixture of sugars and other materials from plants in a special container. Yeast ferment the sugars into ethanol (biofuel) but the liquid also contains substances that are toxic to yeast. Dr. Bates and her team are trying to solve the problem of how to engineer yeast that can survive in these toxins and make biofuels efficiently.

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