

Frances Arnold

Chemical engineer

Date of birth: July 25, 1956

Place of birth: Pittsburgh, Pennsylvania

Also known as: Frances H. Arnold; Frances Hamilton Arnold

Education: Princeton University; University of California, Berkeley

Significance: Frances Arnold, a chemical engineer and professor at California Institute of Technology (Caltech), was awarded half of the 2018 Nobel Prize in Chemistry for her groundbreaking work in developing a method to create enzymes based on the natural processes of evolution.

Background

Frances Arnold was born on July 25, 1956, in Pittsburgh, Pennsylvania, to Josephine and William Arnold. Her father was a Westinghouse executive and nuclear physicist. She grew up in a strict, conservative, Catholic home in the Pittsburgh borough of Edgewood. While she excelled academically during elementary school, by high school she was bored with school (often skipping classes) and resisted her parents' rules and discipline. She moved into an apartment when she was around seventeen and worked multiple jobs as a cocktail waitress and taxi driver to support herself. After graduating from Taylor Allderdice High School in 1974, she attended Princeton University. She took a year off to work in a nuclear reactor parts factory in Italy. In 1979, she graduated with a bachelor's degree in mechanical and aerospace engineering.

Frances Arnold, Stockholm, Sweden, December 2018.



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Arnold became interested in alternative energy during college. After she graduated, she decided to use her engineering education to make the world a better place. Envisioning a career as a researcher and developer of solar energy, she joined the Solar Energy Research Institute (now the National Renewable Energy Laboratory) in Colorado, which had been founded during President Jimmy Carter's administration as a result of the mid-1970s oil crisis. Though she had switched her interest to biofuels by the time she decided to go back to school in the early 1980s, attitudes toward renewable energy were changing and funding declined once oil prices dropped. Choosing to study the emerging field of biotechnology, she received her PhD in chemical engineering from the University of California, Berkeley (UC Berkeley) in 1985. She worked as a postdoctoral researcher at the UC Berkeley in 1985 and as a visiting associate at the California Institute of Technology (Caltech) in 1986.

Research and Teaching

Arnold joined Caltech as an assistant professor in 1987. She was promoted to associate professor in 1992 and became a full professor in 1996. Her research focused on enzymes, the proteins within living organisms that are catalysts for their chemical reactions. Enzymes are used in many sectors, including energy, pharmaceutical, agricultural, and food industries. For example, they are used to tan leather, brew beer, and make cheese.

Arnold wanted to find a replacement for chemical reactions that required heavy metals, hazardous organic solvents, and harmful acids. She attempted to customize an enzyme to modify its natural chemical reaction and give it additional properties but was unsuccessful. She subsequently pursued an alternative method of altering enzymatic function and looked to nature and evolution to replicate natural processes. Conducting a multitude of experiments in a hit-and-miss fashion, she hoped one would produce results. In the process, she discovered how to manipulate the evolutionary process and create new proteins, or enzymes.

Known as the directed evolution of enzymes, Arnold's process involved introducing mutations into enzymes via their genetic codes. After several generations, the mutated enzymes had higher-performing catalytic reactions than the original enzyme or had new properties, including some unfound in nature, such as the ability to form bonds between substances that do not naturally bind. Her 1993 paper, coauthored with Keqin Chen and published in *Proceedings of the National Academy of Sciences*, reported the results of her research using random mutagenesis to engineer enzymes and led to the adoption of her technique in research laboratories around the world. Other scientists built upon her research and developed new techniques, such as a way of splicing genes to create a greater variety of enzymes. Directed evolution has been used to create environmentally friendly detergents and has led to more environmentally friendly methods to manufacture biofuels and drugs.

At Caltech, Arnold directs student and postdoctoral researchers who are using evolutionary protein design methods to develop applications for the alternative energy as well as neurobiology, medicine, and chemical synthesis. She was named the Linus Pauling Professor of Chemical Engineering, Bioengineering, and Biochemistry in 2000.

In 2005, Arnold cofounded Gevo, a biofuel company that uses carbohydrates to make alcohol and convert that alcohol into fuel, gasoline, chemicals, polyester, and rubber products. Eight years later, in addition to becoming the director of the Rosen Bioengineering Center, she cofounded Provivi, which develops environmentally friendly pest-control methods based on insect pheromones.

Five years after being presented with the 2011 National Medal of Technology and Innovation, the Royal Swedish Academy of Sciences awarded Arnold one-half of the 2018 Nobel Prize in Chemistry for her work on the directed evolution of enzymes. She shared the prize with George P. Smith and Gregory P. Winter.

Impact

Arnold's directed evolution method transformed how laboratories researched enzymes and the way they produced many products, especially in industry. It allowed for the creation of products with less toxic chemicals as well as products, such as stain-resistant detergents, with enhanced properties. It is also being used in attempts to develop proteins used in brain research to understand neurological diseases such as Alzheimer's and Parkinson's disease.

Personal Life

A survivor of breast cancer, Arnold was married to James Bailey, who died of cancer in 2001. They had one son, James Bailey. Arnold had two sons, William and Joseph, with Andrew Lange, who died in 2010; William died in an accident in 2016.

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