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THE ROYAL SWEDISH ACADEMY OF SCIENCES

The Royal Swedish Academy of Sciences has decided to award the Nobel Prize in Chemistry 2018 with one half to **Frances H. Arnold** "for the directed evolution of enzymes" and the other half jointly to **George P. Smith** and **Sir Gregory P. Winter** "for the phage display of peptides and antibodies".

The Nobel Prize 2018 **in Chemistry**

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They harnessed the power of evolution

The power of evolution is revealed through the diversity of life. The Nobel Prize in Chemistry 2018 is awarded to Frances H. Arnold, George P. Smith and Sir Gregory P. Winter because they have taken control of evolution and used it for purposes that bring the greatest benefit to humankind. Enzymes produced through directed evolution are used to manufacture biofuels and pharmaceuticals, amongst a great deal else. Antibodies evolved using a method called phage display combat autoimmune diseases and can, in some cases, cure metastatic cancer.

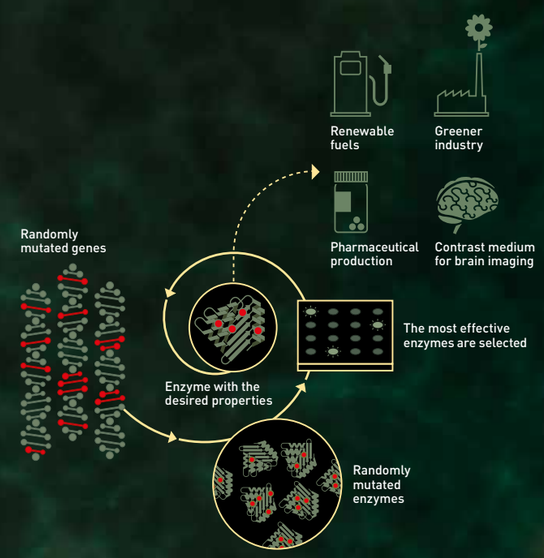
Since the first seeds of life arose around 3.7 billion years ago, almost every crevice on Earth has filled with different organisms. Life has spread to hot springs, deep oceans and dry deserts, all because evolution has solved numerous chemical problems. Life's chemical tools – proteins – have been optimised, changed and renewed. Chemistry has become increasingly advanced, producing new organisms and resulting in the fantastic diversity of life that now exists.

Because proteins are masters of chemistry, researchers have used rational approaches to try to change them to solve humankind's chemical problems, but proteins are complex and human intelligence is limited. Success was first achieved when the 2018 Laureates in Chemistry started imitiating evolution. By using the principles of evolution – random genetic mutations and selection – they have revolutionised chemistry and the development of pharmaceuticals.

Frances H. Arnold
Born 1956 in Pittsburgh, USA. Linus Pauling Professor of Chemical Engineering, Bioengineering and Biochemistry at California Institute of Technology, Pasadena, USA.

George P. Smith
Born 1941 in Norwalk, USA. Curators' Distinguished Professor Emeritus of Biological Sciences at University of Missouri, Columbia, USA.

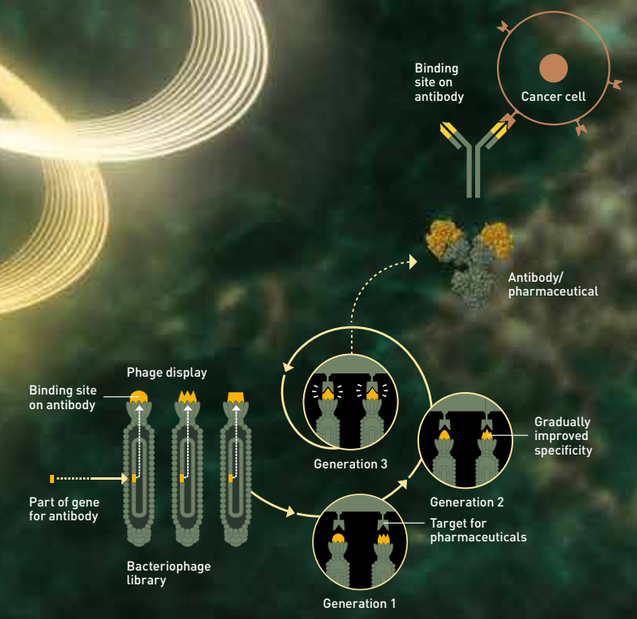
Sir Gregory P. Winter
Born 1951 in Leicester, UK. Research Leader Emeritus at MRC Laboratory of Molecular Biology, Cambridge, UK.



Arnold starts playing with evolution

In 1993, Frances Arnold conducted the first directed evolution of enzymes (proteins that catalyse chemical reactions). She mutated genes and produced a library of randomly mutated enzymes. From this, she chose the enzymes that were most effective at catalysing a chemical reaction. Then she repeated the process, so the enzyme gradually improved.

Using directed evolution, Frances Arnold has produced enzymes that can, among other things: work as a contrast medium during brain imaging; produce renewable fuels for a greener transport sector; replace corrosive acids and toxic heavy metals in the production of pharmaceuticals and in other chemical manufacturing.



Smith uses a bacteria virus

In 1985, George Smith developed an elegant method that is called phage display, in which bacteriophages – viruses that infect bacteria – can be used to produce new proteins.
A bacteriophage has a protein capsule that surrounds the genetic material that codes for the capsule. Smith put the gene for a foreign protein into the gene for a phage capsule protein, so the foreign protein ended up on the surface of the phage. The strength of phage display is that it provides a physical link between a protein and its gene.

Winter develops targeted pharmaceuticals

In the early 1990s, Gregory Winter started to use phage display for the directed evolution of antibodies. He created a library of phages that carried millions of different types of antibodies on their surface. Then he used a protein as a kind of fishing hook to catch phages with antibodies that attached to the protein. Using random mutations and numerous cycles of directed evolution, he then improved the accuracy of the antibodies.

Using phage display, Gregory Winter started to develop antibodies that can work as pharmaceuticals. The first one, adalimumab, was approved in 2002 and is used to treat rheumatoid arthritis, psoriasis and inflammatory bowel diseases. Since then, phage display has produced antibodies that can neutralise toxins, combat autoimmune diseases and even cure metastatic cancer.

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