

CHEMISTRY

Nobel for test-tube evolution

Controlling protein evolution in the lab has led to greener technologies and new medicines.

BY ELIZABETH GIBNEY, RICHARD VAN NOORDEN, HEIDI LEDFORD, DAVIDE CASTELVECCHI & MATTHEW WARREN

Ways to speed up and control the evolution of proteins to produce greener technologies and new medicines have won three scientists the 2018 Nobel Prize in Chemistry.

Chemical engineer Frances Arnold, at the California Institute of Technology in Pasadena, is just the second woman to have won the prize in the past 50 years. She was awarded half of the 9-million-Swedish-krona (US\$1-million) pot. The remaining half was shared between Gregory Winter at the MRC Laboratory of Molecular Biology in Cambridge, UK, and George Smith at the University of Missouri in Columbia.

Arnold carried out pioneering work in the 1990s on the ‘directed evolution’ of enzymes — proteins that catalyse chemical reactions. She devised a method for inducing mutations in enzyme-producing bacteria and then screening and selecting the bacteria to speed up and direct enzyme evolution. These enzymes are now used in the production of biofuels and drugs.

“Biology has this one process that’s responsible for all this glorious complexity we see in nature,” she told *Nature* shortly after the prize announcement on 3 October. But whereas nature operates blindly, Arnold’s techniques accelerate natural selection towards producing enzymes with known properties. “It’s like

breeding a racehorse,” she says.

In 1985, Smith pioneered a technique that uses a bacteriophage — a virus that infects bacteria — as a host that displays a protein on its outer coat, allowing researchers to find other molecules that interact with the protein. Winter developed and improved this technology, called phage display, and invented ways to use it to evolve antibodies adapted for use as

was launched, says co-founder David Chiswell, and it struggled to find investors. “Nobody in the world believed that antibodies were really good,” says Chiswell, who is now chief executive of Kymab, an antibody company in Cambridge.

Arnold also faced a battle when she put forward the idea of evolving proteins in the lab, says Dane Wittrup, a protein engineer at the Massachusetts Institute of Technology in Cambridge. Researchers thought then that they would be able to sit down at a computer and rationally design proteins to carry out specific functions. “But now, by and large, directed evolution is how the work is done.”

Winter says that a woman with cancer who had received an early, experimental version of one of his humanized antibodies against a cancer-related protein drove him to push his research out of the laboratory and into the clinic. When Winter warned her that the effects of the therapy might not last, she told him she only needed to live for a few more months, so that she could help her dying husband. “I was so choked by that,” Winter says.

Before Arnold, the last woman to win the Nobel Prize in Chemistry was Ada Yonath, a crystallographer at the Weizmann Institute of Science in Rehovot, Israel, who won in 2009 for mapping the structure of the ribosome, which generates proteins from the genetic code in cells. Before her, the most recent woman to win was crystallographer Dorothy Hodgkin, in 1964. Arnold is just the fifth female winner in the prize’s history. ■



Nobel laureates Gregory Winter (left), Frances Arnold and George Smith.

therapeutics. Today, antibodies evolved using this method can neutralize toxins and counteract autoimmune diseases.

The first humanized antibody, called adalimumab (Humira), was discovered by Cambridge Antibody Technology — a company that Winter co-founded in 1989 — and was approved for treating rheumatoid arthritis in 2002. It is also used to treat psoriasis and inflammatory bowel diseases. In 2017, it was the world’s top-selling drug, generating revenues of \$18.4 billion.

Scepticism abounded when the company

EUROPE

Tiny space fleet could track CO₂

Project could help to show whether nations are meeting pledges to cut emissions.

BY ALEXANDRA WITZE

European researchers are developing a miniaturized instrument that could precisely measure carbon dioxide coming from cities and power plants. If it works, the device could fly aboard a constellation of small satellites starting in the late 2020s, helping to

track daily fluctuations in greenhouse-gas emissions.

Developers with the 3-year, €3-million (US\$3.5-million) project envisage it complementing more-expansive efforts to monitor CO₂ from space, such as a proposed set of new Sentinel Earth-observing satellites from the European Space Agency. If approved, those

might also come online in the late 2020s.

Several satellites currently monitor CO₂ emissions, including Japan’s GOSAT, the United States’s Orbiting Carbon Observatory-2 (OCO-2) and China’s TanSat. But none of them launched with the explicit goal of tracking compliance with global treaties.

In 2015, before the signing of the Paris

accord to limit greenhouse-gas emissions, the European Commission began exploring how it could develop satellites to assess whether nations are abiding by their climate pledges.

The new, small sensor could play a part in that. “We want to improve the accuracy of monitoring anthropogenic CO₂ emissions,” says Laure Brooker Lizon-Tati, an engineer with Airbus Defence and Space in Toulouse, France. She coordinates the project, called the Space Carbon Observatory (SCARBO), which is being developed by a consortium of eight European companies and research institutions.

Team scientists were scheduled to describe the first results at a space-optics conference this week in Chania, Greece.

The proposed Sentinel satellites would precisely measure greenhouse gases around the world. But they would not be able to make daily measurements above places of interest, such as cities. “This is where a constellation of tiny SCARBO systems could come into the game,” says Heinrich Bovensmann, a remote-sensing researcher at the University of Bremen in Germany.

SMALL STEPS

SCARBO satellites would weigh just 50 kilograms each, roughly one-tenth the mass of OCO-2 or TanSat. An estimated two dozen working together would be able to cover the

globe once a week, and could fly over particular areas of interest once a day. Together, they could monitor frequent changes in carbon emissions, such as morning and afternoon surges from an industrial area.

But first, SCARBO scientists have to show that their plan can work. At its heart is a miniaturized spectrometer — no longer than an outstretched

“We want to improve the accuracy of monitoring anthropogenic CO₂ emissions.”

hand — that would detect CO₂ concentrations in the air below.

Fitting a spectrometer onto a small satellite requires shrinking optics and developing new methods for analysing CO₂ concentrations. “It’s a real challenge,” says Bovensmann.

The scientists’ goal is to measure CO₂ concentrations to an accuracy of less than 1 part per million at a resolution of 2 kilometres — comparable to the data collected by larger satellites now in orbit.

“We want to prove the technology can achieve these types of measurements,” says Etienne Le Coarer of the University Grenoble-Alpes in France, which is building the instrument along with the ONERA French aerospace laboratory in Palaiseau.

NASA’s Jet Propulsion Laboratory in Pasadena, California, has worked on a similar

concept for miniaturized sensors, but using a different type of spectrometer.

SCARBO scientists plan to test their instrument aboard a research aeroplane in 2020. It will fly alongside a Dutch-built instrument to study atmospheric aerosols, which are a major source of error when trying to measure greenhouse gases. The test will be the first time that aerosols and CO₂ are measured simultaneously to improve the quality of data on greenhouse-gas emissions, says Lizon-Tati.

SCARBO is focusing on CO₂ monitoring, although it would also be useful for tracking methane emissions, says Le Coarer. Several private efforts to monitor methane emissions cheaply from space are already under way, including a Canadian microsatellite that has been flying since 2016 and a planned small satellite from the Environmental Defense Fund, an advocacy group in New York City. ■

CORRECTION

The News story ‘Peru plans oil clean-up’ (*Nature* **562**, 18–19; 2018) erroneously stated that the United Nations Development Programme (UNDP) funded a study on remediation strategies. In fact, the Peruvian government funded the study and the UNDP conducted it.