SCIENCE & SOCIETY

Nobel Prize winners announced

Research explored exoplanets, batteries and poverty

This year's Nobel science prizes, announced in October, celebrate basic discoveries of how the world works as well as practical advances that have directly impacted society.

Research that began in the 1990s on how cells sense and respond to oxygen earned Gregg Semenza of Johns Hopkins University, William Kaelin of the Dana-Farber Cancer Institute in Boston and Peter Ratcliffe of the Francis Crick Institute in London the Nobel Prize in physiology or medicine.

Semenza and Ratcliffe discovered that all cells can sense when oxygen levels drop. Semenza identified hypoxia-inducible factor, or HIF, a complex of proteins that turns on genes needed to make proteins that help cells adjust to low-oxygen states. Cells constantly make the HIF proteins, Ratcliffe found, but if there's enough oxygen, cells chew up the proteins. Work by Kaelin and Ratcliffe indicated that proteins called the VHL complex help affix a molecular "eat me" sign to HIF proteins, marking them for destruction.

Researchers are now working on therapies that might shut down HIF proteins as a way to suffocate cancer cells.

Two sets of cosmic discoveries won the physics prize. James Peebles of Princeton University was honored for developing theoretical tools to study the universe. His work helped establish that only 5 percent of the universe is the ordinary matter that makes up planets and people. The rest is dark matter (about 27 percent), which scarcely interacts with ordinary matter except through gravity, and dark energy (about 68 percent), which forces the universe to expand ever faster.

Peebles' work also explains how the universe transformed over eons from a nearly uniform slurry of matter to a cosmos filled with complex structures, like galaxies, as a result of gravity's pull.

Michel Mayor of the University of Geneva and Didier Queloz of the University of Geneva and the University of Cambridge also won, for the first discovery of an exoplanet orbiting a solar-type star (*SN: 11/25/95, p. 358*). In 1995, the pair found a planet orbiting 51 Pegasi by watching the way the planet's gravity tugged on the star. Since then, over 4,000 exoplanets have been found.

The development of lithium-ion batteries won the chemistry prize for John B. Goodenough of the University of Texas at Austin, M. Stanley Whittingham of Binghamton University in New York and Akira Yoshino of the Asahi Kasei Corporation in Tokyo and Meijo University in Nagoya, Japan. These lightweight, rechargeable batteries power everything from portable electronics to electric cars.

Lithium-ion batteries improved on standard batteries' two electrodes, the anode and the cathode. Chemical reactions in the anode release electrons that travel through a circuit and are accepted by the cathode, forming a current.

In the 1970s, Whittingham tested lithium as an anode material because it's lightweight and readily releases electrons and positively charged lithium ions. His rechargeable battery scheme used a cathode made of titanium disulfide, which contains many layers that can house lithium ions released from the anode. His battery boasted two volts.

Goodenough upgraded the cathode by using cobalt oxide, which houses more ions than titanium disulfide, and doubled lithium batteries' voltage potential. In 1985, Yoshino used a by-product of oil production called petroleum coke as an anode. Like cobalt oxide, petroleum coke is finely layered, and while not made of lithium, it can store lithium ions that can be released when the battery is used — similar to the way lithium metal releases these ions. When paired with the cathode that Goodenough designed, Yoshino's anode led to a more durable, lightweight and rechargeable battery. That design was used in the first commercial lithium-ion batteries in 1991.

The Nobel Memorial Prize in Economic Sciences honored a scientific approach to reducing poverty's effects. Abhijit Banerjee and Esther Duflo, both of MIT, and Michael Kremer of Harvard University test interventions aimed at lessening poverty's effects in education, health care and other areas.

In the 1990s, Kremer tested a range of interventions to improve learning among students in Kenya. Banerjee and Duflo, often with Kremer, then did similar studies elsewhere. One line of research developed "Teaching at the Right Level" programs, which enable teachers to target instruction to students' learning levels rather than forcing students through a standardized curriculum for each grade.

The team's studies cemented randomized controlled trials and field experiments as standard practice in development economics, the study of how emerging nations grow into more prosperous ones, says economist Tessa Bold of Stockholm University. And the work showed that the daunting question "How can we fight global poverty?" could be broken into smaller, testable questions, such as "Why do children not attend school?" and "Why do small-scale farmers not use technologies that are known to be profitable?" *— Bruce Bower, Emily Conover, Aimee Cunningham, Lisa Grossman, Jonathan Lambert, Tina Hesman Saey and Maria Temming*

2019 Nobel Laureates

PHYSIOLOGY OR MEDICINE

Gregg Semenza
Johns Hopkins University

William Kaelin
Dana-Farber Cancer Institute

Peter Ratcliffe
Francis Crick Institute

PHYSICS

James Peebles
Princeton University

Michel Mayor
University of Geneva

Didier Queloz
University of Geneva
University of Cambridge

CHEMISTRY

John B. Goodenough
University of Texas at Austin

M. Stanley Whittingham
Binghamton University

Akira Yoshino
Asahi Kasei Corporation
Meijo University

ECONOMIC SCIENCES

Abhijit Banerjee
MIT

Esther Duflo
MIT

Michael Kremer
Harvard University