Today's Program

Program: Scientific Contributions of Current Nobel Prize Winners in Chemistry, Medicine & Physics
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Nobel Prize in Chemistry for 2019
Alan Schmidt

The prize is awarded for the discovery and development of Lithium-ion batteries and is shared by three scientists mainly responsible for its current state of technology.

Stanley Whittingham first developed a lithium battery in 1970. Lithium is an unstable element that has only one electron at its outer electron 'shell'. This electron has a tendency to escape from the lithium atom leaving behind a positively charged and more stable lithium-ion.

Unlike a conventional battery, a non-aqueous electrolytic solvent such as propylene carbonate is used in combination with a lithium halide anode. The cathode contains titanium disulfide which is able to accommodate free lithium-ions. There is a separator between the two electrodes. This basic design allows the charging and discharging of a lithium-ion battery.

There is however a phenomenon known as lithium dendrite formation at the metal surface upon repeated charge-discharge cycles. This could result in a short circuit and become a fire hazard.
Scientists then decided to avoid metallic lithium and turned instead to intercalating materials that accommodate lithium-ions for both electrodes.

John B. Goodenough started to use cobalt oxide for his lithium battery cathode and doubled the battery's potential and made it much more powerful.

Akira Yoshino continued to use Goodenough's lithium-cobalt oxide in the cathode, and in the anode, he used a carbon material, petroleum coke that also intercalates lithium ions. The battery's functionality is no longer based on damaging chemical reactions but rather a back and forth flow between the electrodes. This gives the battery long life and allows it to become commercially viable.

John B Goodenough has since replaced his cobalt oxide cathode with iron phosphate which makes the battery more environmentally friendly.

The lithium-ion battery technology has an impact that goes beyond mobile electronics and electrically-powered vehicles. As we try to break away from carbon-based energy sources, efficient energy storage is a pre-requisite to other forms of power generation. The success in this technology will be a great improvement to our lives as well as to the health and sustainability of our planet.

2019 Nobel Peace Prize for Physiology or Medicine.

Tom Lauer

Lance Armstrong, the winner of multiple Tour de France, was found guilty of doping. What was his drug of choice? EPO (Erythropoietin). It is a peptide hormone naturally produced in the human kidneys and released to stimulate red blood cell production in the bone marrow.

Red blood cells are responsible for carrying oxygen to all cells of our bodies. Our red blood cells are regenerated about every 120 days normally. When our red blood cells are low, our body's regulatory mechanism sends a signal to our kidneys to step up its EPO production. Oxygen carried by the red blood cells interacts with the sugar (food) in our body to produce energy. Therefore, our energy and performance level is highly dependent on our red blood cell level and their oxygen-carrying capacity. Lance Armstrong cheated by artificially raising his red blood cell level with EPO injections to enhance his performance.

The 2019 Prize for Physiology or Medicine is awarded to three scientists whose works contributed to the understanding of this important homeostasis function of our body. They are **Drs. Williams G. Kaelin, Jr., Peter J. Ratcliff, and Gregg L. Semenza.** Their discoveries include how cells can sense and adapt to changing oxygen availability, the identification of molecular machinery that regulates gene expression in response to varying levels of oxygen. Semenza and Ratcliff discovered the oxygen sensing mechanism is present in all tissues, not just in the kidney cells where EPO is produced. Semenza further found a protein complex in cells, the hypoxia-inducible factor (HIF-1a), that binds to an identified DNA segment in an oxygen-dependent manner, i.e., the higher the oxygen level, the lesser HIF-1a the cells will contain, and more of it when oxygen levels are low and thus stimulate the EPO gene. In the presence of oxygen, H1F-1a is found to degrade rapidly, in low oxygen conditions, its existence lasts longer.

Von Hippel-Lindau (VHL) disease is a genetic condition that is sometimes associated with certain tumors' formation. While researching this condition, Williams G. Kaelin, Jr.

discovered that cancer cells that are lacking a functional VHL gene are hypoxic (low in oxygen content) while swapping it with a functioning VHL gene restores the cell to a normal oxygen level. The implication is the VHL gene plays a role in the regulation of oxygen at the cellular level. In a normal oxygen environment, the VHL gene attaches itself to the H1F-1a complex and facilitates its degradation by proteasomes. In hypoxic conditions, this does not happen and H1F-1a proceeds to stimulate EPO production. All these discoveries carry significance in the understanding of oxygen regulation and the generation of new blood cells. Potentially, it may have a role in disease treatment by activation or blocking oxygen sensing of certain cells.

Nobel Prize in Physics for 2019

Richard Carter

The 2019 Nobel Prize in Physics was awarded for contributions to our understanding of the evolution of the universe and Earth's place in the cosmos. One half was awarded to **James Peebles** for theoretical discoveries in physical cosmology. The other half was jointly awarded to **Michel Mayor and Didier Queloz** for the discovery of an exoplanet orbiting a solar-type star.

James Peebles' insights laid a foundation for the transformation of cosmology over the last fifty years from speculation to science. His theoretical framework, developed since the mid-1960s, is the basis of our contemporary ideas about the universe. Peebles made many important contributions to the Big Bang model. Along with Robert Dicke and others (George Gamow, Ralph A. Alpher, and Robert C. Herman), Peebles predicted Cosmic Microwave Background radiation prior to its signal's accidental discovery. Peebles also was the leading pioneer in the theory of Cosmic Structure Formation in the 1970s. He made major contributions to Big Bang Nucleosynthesis, Dark Matter, and Dark Energy theories.

The Big Bang, 13.8 billion years ago**,** was the initiation of the creation of our universe! The timing of the emerging events is a major area of study that has developed, and its comprehension is still becoming better understood, today. The Big Bang started as an enormous amount of energy that created both matter and space-time! It set the development of the universe on a pathway that is still evolving. Today, some popular TV science shows continue to tell about many new theories regarding the Universe with many scientists active in cosmology reporting.

Now, newer telescopes allow us to see a wider range of electromagnetic radiation, so we can now examine the temperatures in the heart of a nebula with Infrared views. Some darker nebulae are numerous degrees below freezing temperatures, and they are the basic nurseries for forming stars in hotspots developing within those massively densified zones, using nuclear reactions. Thus, "A Star is Born" using the nuclear fusion of hydrogen within a densified mass core area to create helium and some other basic elements. The initiation of this reaction starts with a gravitational compression of a massive ball of hydrogen, where the core temperature of that ball rises significantly. This allows energized protons to combine in a nuclear fusion reaction to form helium. The nuclear reaction also releases additional heat, forming a glowing light and heat source pressing outward against the gravitational compression to establish an equilibrium-sized ball in space-time.

Our star, the Sun, is about 5 billion years old, and it is at its half-life in using up its fuel supply of hydrogen. This nucleosynthesis is the process that creates new atomic nuclei from pre-existing nucleons (protons and neutrons). Then formation of the heavier chemical elements evolves through other nuclear reactions. Spectrographically, hydrogen is the most abundant element in our galaxy with a mass fraction of 74%. Helium is 24%. All of the other elements comprise the remaining 2% of the mass fraction of **"Ordinary Matter".**

Dark Matter is said to exist for several reasons: (1) In clusters of galaxies, the galaxies are traveling fast enough to escape the cluster unless a large quantity of unseen matter is holding them within the cluster. (2) Galaxy rotation curves only make gravitational sense if galaxies are embedded in large clouds of unseen gravitating matter. (3) The universe appears to have flat space curvature and there is not enough regular matter to cause this. There must be unseen matter (and dark energy too) to flatten the geometry of the universe.

Dark Energy is proposed to explain the unknown energy source needed to cause the more recent increase in the expansion of the universe. The content of matter and energy in our visible universe is:

Ordinary Matter is 4.9%, Dark Matter is 26.8%, and Dark Energy is 68.3%. The mass of Ordinary Matter in the known visible universe is about 1.5×10^{53} kilograms, and its average density is equivalent to 6 protons per cubic meter. The mean temperature is 2.7 K.

The expansion of the space-time of the universe can be visualized as a loaf of raisin bread rising and baking. Think of the raisins as galaxies and the dough as space-time. The rising dough grows in size, causing rapid separation of the raisins. So, in the space-time the matter separates in distance, and **matter can separate at greater than the speed of light limitation, since only space-time is expanding and not matter moving through space-time.** Thus the Inflation Theory said to happen at the beginning of the Big Bang is possible. In fact, the Red Shift, due to the expanding universe lengthened the original visible wavelength of the Cosmic Background Radiation to that for microwaves, as we view them now. They say that the universe has expanded to be 93 billion light-years in diameter in its 13.8 billion years of existence so far. The outer edges of the current universe are way beyond our detection capability now since the speed of light limits how far our visible universe can ever be seen by electromagnetic or gravitational waves. It is now said that there are at least 2 trillion galaxies in the observable universe.

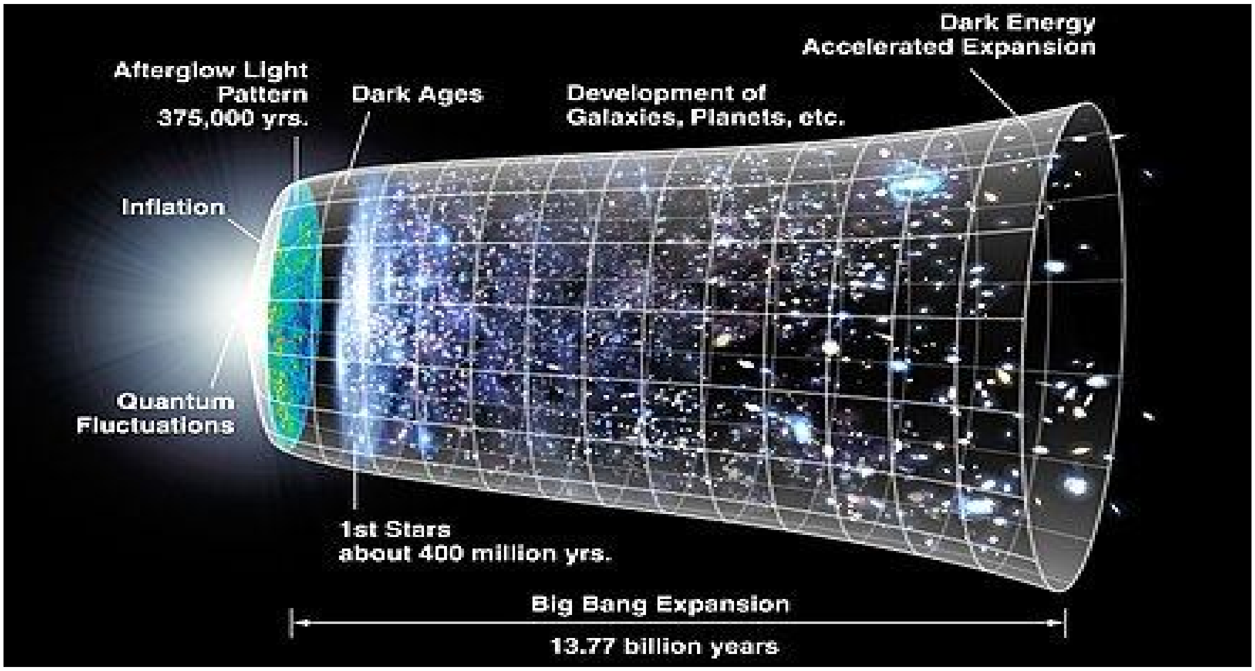
As the stars of various sizes age, they form heavier chemical elements – helium, lithium, beryllium, carbon, etc. up to iron. We and all around us initially started in a nebula that formed a star. Stars like our Sun die when their hydrogen has been converted to carbon and oxygen. They never get hot enough to fuse carbon and oxygen into heavier elements. In massive stars (= > 8x Mass-of our sun), iron formation quenches a star's nuclear reaction by taking in more energy than it produces, causing that star to collapse. That dying star's collapse, rapidly, bouncing off of a hard-nuclear core, explodes violently, releasing copious neutrinos during the formation of a neutron star or black hole. This is called a Type II supernova explosion. That produces a new heavier-elements-rich nebula. Colliding neutron stars also make elements heavier than iron and enrich the interstellar medium. Neutron stars can have up to 2.3 Sun masses contained in a 10-mile diameter ball! Primordial black hole sizes were even much smaller according to Janna Levin. Currently black holes of 25 Sun masses and larger have been documented by the LIGO facilities when detecting gravitational waves.

Now we will transition to **the other half of the Nobel Prize in Physics** that was jointly awarded to **Michel Mayor and Didier Queloz** for the discovery of an exoplanet orbiting a solar-type star. In October 1995, Mayor and Queloz announced the first discovery of a planet outside our solar system, an exoplanet, orbiting a solar-type star in our home galaxy, the Milky Way. They worked at the Haute-Provence Observatory in southern France. Using custom-made instruments, they were able to see Planet 51 Pegasi b, a gaseous ball comparable with our solar system's biggest gas giant, Jupiter.
One way to search for exoplanets is to look for "wobbly" stars. A star that has planets orbits about their common center of gravity, rather than moving smoothly through space. From far away, this oscillating orbital motion makes the star look like it's wobbling. Small planets do not cause an accurately detectable wobble measurement because their tug is too weak on their parent star.
So, another method is to look for a planet transiting across a glowing star. This causes the illumination measurements for that star to vary during the transit time of the planet. In less than ten years, the 2009 Kepler Space Telescope observed 530,506 stars and detected 2,662 planets in only a limited area of the galaxy, using this method.

More recently, per NASA based upon the number of M-class stars in the galaxy, it is estimated that about 10 billion potentially habitable, Earth-like worlds smaller than 1.6 times the earth's diameter exist. These fit into the habitable "Goldilocks's Zone" orbit where things could be "just right" for life to exist. It should be noted that M class stars, though quite common, are smaller, fainter, dimmer, and redder than our Sun. Planets in the Goldilocks Zone around such faint stars would have to be very close in and, thus, may be tidally locked to their parent star. That means one face would always be

towards the star and one away. It would be a vastly different sort of place to live with perpetual day or perpetual night. See: https://astrobiology.nasa.gov/news/where-is-the-habitable-zone-for-m-dwarf-stars/

Michel Mayor and Didier Queloz explored our cosmic neighborhoods on the hunt for unknown planets. Their discoveries have forever changed our conceptions of the world and the universe. Now, exomoons are being searched out too. Our own solar system has over 150 moons.



Without Life, why is any of this existence of a complex Universe important at all?

Rocks, neutron stars, pulsars, plasma, planets, chemicals, etc. just do not care, yet they do exist within the universe along with life! Truth can often be stranger than our fiction. Where and by whom is that knowledge detected and understood?

May we each come to understand and treasure that prize, too!