

Some significant scientific developments of 2016

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Scientific advances during the past year shed light on a variety of topics, from the nature of space and time to the increasingly dire state of Earth's environment. The exploration of our solar system continued and work in paleontology and genetics has deepened our understanding of the development and origins of life.

At the same time, research is still affected by the past year's political events: the conflict in Syria, the near-coup in Turkey, the anti-Russian hysteria of the American media, Brexit and the election of Donald Trump. Rising tensions among various countries make it more difficult to do work across national borders even as more and more scientific endeavors are by necessity international. Funds and personnel are increasingly scarce as resources around the world are diverted to preparing the world's militaries for war.

In spite of this, groundbreaking research has still occurred. In February, the Laser Interferometer Gravitational-Wave Observatory (LIGO) Collaboration announced the measurement of tiny ripples in spacetime caused by the merger of two black holes over a billion light-years from Earth. The observations confirmed predictions made by Albert Einstein in 1916.

As shown in Einstein's General Theory of Relativity, space and time are not separate, but rather a unified spacetime throughout which matter travels. At the same time, matter itself distorts spacetime, causing ripples that sometimes become gravitational waves. As a result of this discovery, the new field of gravitational wave astronomy has begun, allowing for more detailed investigations into previously more difficult areas of research such as black holes, the moments after the Big Bang and dark matter.

Research by an international collaboration of astronomers using more traditional methods to study outer space have discovered a potentially Earth-like

planet found in the habitable zone of Proxima Centauri, the nearest star to our Solar System. The exoplanet, Proxima b, was discovered by observing tiny variations in the light emitted by its parent star caused by gravitational effects as the planet orbits around the star.

The astronomers calculated that Proxima b is at least 1.3 times the Earth's mass, though we have no knowledge yet of its size, its composition or the nature of its atmosphere (if any). Our limited knowledge of solar systems suggests that such a planet would be of rocky composition and retain some sort of atmosphere. The planet's characteristics are likely to be very different from Earth's due to its close orbit to the star, which is much smaller and dimmer than the sun, which results in an inhospitable combination (to humans) of low temperatures with high levels of stellar radiation.

While a large number of exoplanets have already been catalogued, the major significance of this discovery is that a potentially Earth-like world has been discovered at a close enough distance to make it potentially traversable within a single human lifetime.

Closer to home, studies of climate change have determined that 2016 was the hottest year on record and that the overall temperature rise since the industrial revolution, currently 0.8 degrees Celsius, is "very unlikely" to remain below 2 degrees. This warming, almost entirely produced by human activity, is causing rising sea levels, more common extreme weather patterns, and mass coral death, and poses an increasing threat to ecosystems and cities across the planet.

In particular, Arctic sea ice levels reached a new historic minimum, as part of a long-term trend of sea ice thinning due to warmer climate conditions. Decades-old ice formations are melting so that seasonal ice structures form an increasing proportion of the ice pack. This in turn speeds up warming as there is less

ice to reflect sunlight back into space.

Alongside the growing dangers of climate change are the increasing numbers of animal species being threatened with extinction. The Red List maintained by the International Union for the Conservation of Nature grew from 755 to 1,199 endangered species during the last three years while a total of one-sixth of all animals and plants on Earth are threatened with extinction due to global warming.

This year, cheetahs were among the most recognisable creatures to be added to the list. The global cheetah population fell to approximately 7,100 individuals, covering a geographical extent ten times smaller than its original range. It is already extinct in most of Asia and only a few dozen survive in an Iranian refuge. They are dying off due to a number of factors, such as the increasing use of their African habitat for farming and the hunting of their food sources. Their cubs are also trafficked to meet demand for furs in the Gulf states where they are sold for up to \$10,000 on the black market.

The 0.1 percent of species driven to extinction each year is between 1,000 and 10,000 times greater than the natural rate as calculated through fossil records. Up to half of all species are threatened with extinction during this century. The number of vertebrate species has dropped by three-fifths since 1970, mainly due to human activity.

Even as growing numbers of species go extinct, biologists may have uncovered what allowed for the proliferation of so many forms of life in the first place. The origin of multi-cellular life is a major unsolved problem in evolutionary biology. Single-celled organisms are the oldest and simplest form of life, which evolved into multi-celled organisms independently many times at different points in the development of complex life. Early in 2016, researchers announced the discovery of an ancient molecule that likely played a key role in how multi-cellular organisms originally evolved.

The data suggests that approximately 800 million years ago, the GK-PID molecule evolved and allowed for the formation of tissue structure, in which cells must divide in the correct position relative to adjacent cells. The molecule is effectively a “scaffolding” protein that assists in the formation of complex organic structures. The researchers used “ancestral protein

reconstruction” to extrapolate from the properties of modern proteins using computer models to recreate ancient proteins for experimental study.

Different research in this field of study has given biologists the most up-to-date estimate of the properties of the common ancestor to all life on Earth, an idea first developed by Charles Darwin in 1859: “Therefore I should infer from analogy that probably all the organic beings which have ever lived on this earth have descended from some one primordial form, into which life was first breathed.”

This is the outcome of the genetic sequencing of huge numbers of species during recent decades that has added an incredible amount of detail to the evolutionary history of life. The scientists analysed this data to find 355 genes that are common to all current species. These genes suggest that this last universal common ancestor may have been a single-celled organism adapted to the environment surrounding deep-sea hydrothermal vents, where water erupts due to heating by volcanic activity. This is consistent with the hypothesis that life originated in such underwater habitats approximately 3.8 billion years ago.

Other notable developments in 2016 include research on into the effects of the Agricultural Revolution on human evolution, the discovery of a feathered dinosaur tail preserved in amber, evidence hinting at the existence of a fourth neutrino and the measurement of the spectrum of anti-hydrogen.



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