Viruses – Lots of Them – are Falling from the Sky

[redacted]

layer above 2,500 to 3,000 metres. At that altitude, particles are subject to long-range

[redacted]

fundamentally alters brain and nervous system medicine – giving doctors new clues as to why patients with motor neuron disease, multiple sclerosis, spinal muscular atrophy and other neurological diseases often rapidly decline when their movement becomes limited.

"Our study supports the notion that people who are unable to do load-bearing exercises – such as patients who are bed–ridden, or even astronauts on extended travel–not only lose muscle mass, but their body chemistry is altered at the cellular level and even their nervous system is adversely impacted," says Dr Raffaella Adami from the Università degli Studi di Milano, Italy.

The study involved restricting mice from using their hind legs, but not their front legs, over a period of 28 days. The mice continued to eat and groom normally and did not exhibit stress. At the end of the trial, the researchers examined an area of the brain called the sub-ventricular zone, which in many mammals has the role of maintaining nerve cell health. It is also the area where neural stem cells produce new neurons.

Limiting physical activity decreased the number of neural stem cells by 70 per cent compared to a control group of mice, which were allowed to roam. Furthermore, both neurons and oligodendrocytes – specialized cells that support and insulate nerve cells – didn't fully mature when exercise was severely reduced.

The research shows that using the legs, particularly in weight-bearing exercise, sends signals to the brain that are vital for the production of healthy neural cells, essential for the brain and nervous system. Cutting back on exercise makes it difficult for the body to produce new nerve cells – some of the very building blocks that allow us to handle stress and adapt to challenge in our lives.

"It is no accident that we are meant to be active: to walk, run, crouch to sit, and use our leg muscles to lift things," says Adami. "Neurological health is not a one-way street with the brain telling the muscles 'lift,' 'walk,' and so on."

The researchers gained more insight by analyzing individual cells. They found that restricting exercise lowers the amount of oxygen in the body, which creates an anaerobic environment and alters metabolism. Reducing exercise also seems to impact two genes, one of which, CDK5Rap1, is very important for the health of mitochondria – the cellular powerhouse that releases energy the body can then use. This represents another feedback loop.

These results shed light on several important health issues, ranging from concerns about cardio-vascular impacts as a result of sedentary lifestyles to insight into devastating diseases, such as spinal muscular atrophy (SMA), multiple sclerosis, and motor neuron disease, among others.

"I have been interested in neurological diseases since 2004," says co-author Dr Daniele Bottai, also from the Università degli Studi di Milano. "The question I asked myself was: is the outcome of these diseases due exclusively to the lesions that form on the spinal cord in the case of spinal cord injury and genetic mutation in the case of SMA, or is the lower capacity for movement the critical factor that exacerbates the disease?"

This research demonstrates the critical role of movement and has a range of potential implications. For example, missions to send astronauts into space for months or even years should keep in mind that gravity and load-bearing exercise play an important role in maintaining human health, say the researchers.

"One could say our health is grounded on earth in ways we are just beginning to understand," concludes Bottai.

Engineering a Plastic-eating Enzyme

Scientists have engineered an enzyme which can digest some of our most commonly polluting plastics, providing a potential solution to one of the world's biggest environmental problems.

The discovery could result in a recycling solution for millions of tonnes of plastic bottles, made of polyethylene terephthalate, or PET, which currently persists for hundreds of years in the environment.

The research was led by teams at the University of Portsmouth and the US Department of Energy's National Renewable Energy Laboratory (NREL) and is published in *Proceedings of the National Academy of Sciences* (PNAS).

Professor John McGeehan at the University of Portsmouth and Dr Gregg Beckham at NREL solved the crystal structure of PETase – a recently discovered enzyme that digests PET – and used this 3D information to understand how it works. During this study, they inadvertently engineered an enzyme that is even better at degrading the plastic than the one that evolved in nature.

The researchers are now working on improving the enzyme further to allow it to be used industrially to break down plastics in a fraction of the time.

Professor McGeehan, Director of the Institute of Biological and Biomedical Sciences in the School of Biological Sciences at Portsmouth, said: "Few could have predicted that since plastics became popular in the 1960s huge plastic waste patches would be found floating in oceans, or washed up on once pristine beaches all over the world.

"We can all play a significant part in dealing with the plastic problem, but the scientific community who ultimately created these 'wonder-materials', must now use all the technology at their disposal to develop real solutions."

The researchers made the breakthrough when they were examining the structure of a natural enzyme which is thought to have evolved in a waste recycling centre in Japan, allowing a bacterium to degrade plastic as a food source.

PET, patented as a plastic in the 1940s, has not existed in nature for very long, so the team set out to determine how the enzyme evolved and if it might be possible to improve it.

The goal was to determine its structure, but they ended up going a step further and accidentally engineered an enzyme which was even better at breaking down PET plastics.

"Serendipity often plays a significant role in fundamental scientific research and our discovery here is no exception," Professor McGeehan said.

"Although the improvement is modest, this unanticipated discovery suggests that there is room to further improve these enzymes, moving us closer to a recycling solution for the ever-growing mountain of discarded plastics."

The research team can now apply the tools of protein engineering and evolution to continue to improve it.

The University of Portsmouth and NREL collaborated with scientists at the Diamond Light Source in the United Kingdom, a synchrotron that uses intense beams of X-rays 10 billion times brighter than the sun to act as a microscope powerful enough to see individual atoms.

Using their latest laboratory, beamline I23, an ultra-high-resolution 3D model of the PETase enzyme was generated in exquisite detail.

Professor McGeehan said: "The Diamond Light Source recently created one of the most advanced X-ray beamlines in the world and having access to this facility allowed us to see the 3D atomic structure of PETase in incredible detail. Being able to see the inner workings of this biological catalyst provided us with the blueprints to engineer a faster and more efficient enzyme."

Chief Executive of the Diamond Light Source, Professor Andrew Harrison, said: "With input from five institutions in three different countries, this research is a fine example of how international collaboration can help make significant scientific breakthroughs.

"The detail that the team were able to draw out from the results achieved on the I23 beamline at Diamond will be invaluable in looking to tailor the enzyme for use in large-scale industrial recycling processes. The impact of such an innovative solution to plastic waste would be global. It is fantastic that UK scientists and facilities are helping to lead the way."

With help from the computational modelling scientists at the University of South Florida and the University of Campinas in Brazil, the team discovered that PETase looks very similar to a cutinase, but it has some unusual features including a more open active site, able to accommodate human-made rather than natural polymers. These differences indicated that PETase may have evolved in a PET-containing environment to enable the enzyme to degrade PET. To test that hypothesis, the researchers mutated the PETase active site to make it more like a cutinase.

And that was when the unexpected happened – the researchers found that the PETase mutant was better than the natural PETase in degrading PET.

Significantly, the enzyme can also degrade polyethylene furandicarboxylate, or PEF, a bio-based substitute for PET plastics that is being hailed as a replacement for glass beer bottles.

Professor McGeehan said: "The engineering process is much the same as for enzymes currently being used in bio-washing detergents and in the manufacture of biofuels – the technology exists and it's well within the possibility that in the coming years we will see an industrially viable process to turn PET and potentially other substrates like PEF, PLA, and PBS, back into their original building blocks so that they can be sustainably recycled."

The paper's lead author is postgraduate student jointly funded by the University of Portsmouth and NREL, Harry Austin.

He said: "This research is just the beginning and there is much more to be done in this area. I am delighted to be part of an international team that is tackling one of the biggest problems facing our planet."

New Smart Contact Lens for Diabetics Introduced

This breakthrough has been jointly conducted by Professor Jang-Ung Park in the School of Materials Science and Engineering and Professor Franklin Bien in the School of Electrical and Computer Engineering at UNIST in collaboration with Professor Jung Heon Lee in the School of Advanced Materials Science and Engineering at Sungkyunkwan University.

According to the research team, this innovative smart lens with built-in pliable, transparent electronics can monitor glucose levels from tears in the eye. The device has not yet been tested in humans. However, the research team expects that the release of this device will offer diabetics a pain-free way to measure their glucose levels with the blink of an eye. Their findings have been published in *Science Advances* on 25 January, 2018.

For patients with diabetes, monitoring and controlling blood sugar levels are extremely important because having high blood glucose levels for extended periods of time can lead to a host of diabetes complications. An enzyme based finger-pricking method is the most commonly used technology in diabetic assessment. However, such approach has been said to reduce compliance among diabetic patients.

In the last several decades, many attempts have been made to monitor glucose levels in tears with smart contact lenses, but they are often not used due to poor wearability.

To solve contact lens discomfort issues, Professor Park and his research team have unveiled a new smart contact lens that uses electrodes made up of highly stretchable and transparent materials. This clear, flexible lens also contains a glucose sensor that sends electrical signals to an LED. With this sensor, patients can transmit their health information in real-time using the embedded wireless antenna in the lens. Electric power that activates the LED pixel and the glucose sensor is wirelessly transmitted to the lens through the antenna. After detecting the glucose concentration in tear fluid above the threshold, this LED pixel turns off.

In the study, the research team has successfully tested their prototype lens on a live rabbit via non-invasive in-vivo testing. The rabbit showed no signs of abnormal behaviour during repeated eye blinks and the LED pixel turned off when tear fluids with glucose concentration was over the threshold. In addition, during the wireless operations, this smart contact lens could still maintain the eye temperature stably without abrupt heating.

"These smart contact lenses are made of transparent nanomaterials and therefore do not obstruct the wearer's view," says Jihun Park in the Combined M.S./Ph.D. of Materials Science and Engineering, the first author of the study. "Besides, because the system uses wireless antenna to read sensor information, no separate power source, like battery is required for the smart contact lens sensors."

"The in vivo tests using a live rabbit ... provided the substantial promise of future smart contact lenses for noninvasive health care monitoring using human eyes and tears," says the research team.

"Our smart contact lens provides a platform for wireless, continuous, and noninvasive monitoring of physiological conditions, as well as the detection of biomarkers associated with ocular and other diseases," says Professor Park. "It also offers the potential for expanded applicability in other areas, such as smart devices for drug delivery and augmented reality."

He adds, "We are now a step closer to the implementation of a fictional idea for a smart contact lens in the films, like "Minority Report" and "Mission: Impossible."

Ecosystems Are Getting Greener in the Arctic

Researchers develop technique to better predict how plants in cold regions respond to warming

In recent decades, scientists have noted a surge in Arctic plant growth as a symptom of climate change. But without observations showing exactly when and where vegetation has bloomed as the world's coldest areas warm, it is difficult to predict how vegetation will respond to future warming. Now, researchers at the U S Department of Energy's Lawrence Berkeley National Laboratory (Berkeley Lab) and UC Berkeley have developed a new approach that may paint a more accurate picture of Arctic vegetation and our climate's recent past – and future.

In a study published online on 20 August in *Nature Climate Change*, the researchers used satellite images taken over the past 30 years to track – down to a pixel representing approximately 25 square miles – the ebb and flow of plant growth in cold areas of the northern hemisphere, such as Alaska, the Arctic region of Canada, and the Tibetan Plateau.

The 30-year historic satellite data used in the study were collected by the National Oceanic and Atmospheric Administration's Advanced Very High Resolution Radiometre. The data was processed by Boston University, and is hosted on NEX – the NASA Earth Exchange data archive.

At first, the satellite data showed what they expected – that as Arctic climates warmed, tree and plant growth increased. After comparing these observations with state-of-the-art climate models developed for CMIP5 – the Coupled Model Intercomparison Project Phase 5 – what they discovered next surprised them.

Their data analysis revealed that 16 per cent of earth's vegetated land where plant growth was limited by cold temperatures three decades ago is no longer predominantly temperature-limited today, a result that was not reproduced by the CMIP5 models tested. "Our findings suggest that CMIP5's predictions may have significantly underestimated changes in the Arctic ecosystem, and climate models will need to be improved to better understand and predict the future of the Arctic," said first author Trevor Keenan, a faculty scientist in Berkeley Lab's Earth and Environmental Sciences Area and an assistant professor in UC Berkeley's department of Environmental Science, Policy, and Management.

Keenan and Riley used the satellite data to build a new observational benchmark that quantifies the growing expanse of vegetated land in the northern hemisphere. They also estimated changes in the proportion of the

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