SCIENCE NEWS

Anti-solar Cells: A Photovoltaic Cell that Works at Night

Date: January 29, 2020
Source: University of California - Davis

What if solar cells worked at night? That's no joke, according to Jeremy Munday, professor in the Department of Electrical and Computer Engineering at UC Davis. In fact, a specially designed photovoltaic cell could generate up to 50 watts of power per square metre under ideal conditions at night, about a quarter of what a conventional solar panel can generate in daytime, according to a concept paper by Munday and graduate student Tristan Deppe. The article was published in, and featured on the cover of, the January 2020 issue of *ACS Photonics*.

Munday, who recently joined UC Davis from the University of Maryland, is developing prototypes of these night time solar cells that can generate small amounts of power. The researchers hope to improve the power output and efficiency of the devices.

Munday said that the process is similar to the way a normal solar cell works, but in reverse. An object that is hot compared to its surroundings will radiate heat as infrared light. A conventional solar cell is cool compared to the sun, so it absorbs light.

Space is really, really cold, so if you have a warm object and point it at the sky, it will radiate heat toward it. People have been using this phenomenon for night time cooling for hundreds of years. In the last five years, Munday said, there has been a lot of interest in devices that can do this during the daytime (by filtering out sunlight or pointing away from the sun).

Generating power by radiating heat

There's another kind of device called a thermoradiative cell that generates power by radiating heat to its surroundings. Researchers have explored using them to capture waste heat from engines.

"We were thinking, what if we took one of these devices and put it in a warm area and pointed it at the sky," Munday said.

This thermoradiative cell pointed at the night sky would emit infrared light because it is warmer than outer space.

"A regular solar cell generates power by absorbing sunlight, which causes a voltage to appear across the device and for current to flow. In these new devices, light is instead emitted and the current and voltage go in the opposite direction, but you still generate power," Munday said. "You have to use different materials, but the physics is the same."

The device would work during the day as well, if you took steps to either block direct sunlight or pointed it away from the sun. Because this new type of solar cell could potentially operate around the clock, it is an intriguing option to balance the power grid over the day-night cycle.

Climate Change Increases the Risk of Wildfires Confirms New Review

Date: January 14, 2020
Source: University of East Anglia

Human-induced climate change promotes the conditions on which wildfires depend, increasing their likelihood – according to a review of research on global climate change and wildfire risk published today.

In light of the Australian fires, scientists from the University of East Anglia (UEA), Met Office Hadley Centre, University of Exeter and Imperial College London have conducted a Rapid Response Review of 57 peer-reviewed papers published since the IPCC's Fifth Assessment Report in 2013.

All the studies show links between climate change and increased frequency or severity of fire weather – periods with a high fire risk due to a combination of high temperatures, low humidity, low rainfall and often high winds – though some note anomalies in a few regions.

Rising global temperatures, more frequent heatwaves and associated droughts in some regions increase the likelihood of wildfires by stimulating hot and dry conditions, promoting fire weather, which can be used as an overall measure of the impact of climate change on the risk of fires occurring.

Observational data shows that fire weather seasons have lengthened across approximately 25 per cent of the earth's vegetated surface, resulting in about a 20 per cent increase in global mean length of the fire weather season.

The literature review was carried out using the new ScienceBrief.org online platform, set up by UEA and the Tyndall Centre for Climate Change Research. ScienceBrief is written by scientists and aims to share scientific insights with the world and keep up with science, by making sense of peer-reviewed publications in a rapid and transparent way.

Dr Matthew Jones, Senior Research Associate at UEA's Tyndall Centre and lead author of the review, said: "Overall, the 57 papers reviewed clearly show human-induced warming has already led to a global increase in the frequency and severity of fire weather, increasing the risks of wildfire.

"This has been seen in many regions, including the western US and Canada, southern Europe, Scandinavia and Amazonia. Human-induced warming is also increasing fire risks in other regions, including Siberia and Australia.

"However, there is also evidence that humans have significant potential to control how this fire risk translates into fire activity, in particular through land management decisions and ignition sources."

At the global scale, burned area has decreased in recent decades, largely due to clearing of savannahs for agriculture and increased fire suppression. In contrast, burned area has increased in closed-canopy forests, likely in response to the dual pressures of climate change and forest degradation.

Co-author Professor Richard Betts, Head of Climate Impacts Research at the Met Office Hadley Centre and University of Exeter, said: "Fire weather does occur naturally but is becoming more severe and widespread due to climate change. Limiting global warming to well below 2°C would help avoid further increases in the risk of extreme fire weather."

Professor Iain Colin Prentice, Chair of Biosphere and Climate Impacts and Director of the Leverhulme Centre for Wildfires, Environment and Society, Imperial College London, added: "Wildfires can't be prevented, and the risks are increasing because of climate change. This makes it urgent to consider ways of reducing the risks to people. Land planning should take the increasing risk in fire weather into account."

NASA Planet Hunter Finds Earth-size Habitable-zone World

Date: January 6, 2020
Source: NASA/Jet Propulsion Laboratory

NASA's Transiting Exoplanet Survey Satellite (TESS) has discovered its first earth-size planet in its star's habitable zone, the range of distances where conditions may be just right to allow the presence of liquid water on the surface. Scientists confirmed the find, called TOI 700 d, using NASA's Spitzer Space Telescope and have modelled the planet's potential environments to help inform future observations.

TOI 700 d is one of only a few earth-size planets discovered in a star's habitable zone so far. Others include several planets in the TRAPPIST-1 system and other worlds discovered by NASA's Kepler Space Telescope.

"TESS was designed and launched specifically to find earth-sized planets orbiting nearby stars," said Paul Hertz, astrophysics division director at NASA Headquarters in Washington. "Planets around nearby stars are easiest to follow-up with larger telescopes in space and on earth. Discovering TOI 700 d is a key science finding for TESS. Confirming the planet's size and habitable zone status with Spitzer is another win for Spitzer as it approaches the end of science operations this January."

TESS monitors large swaths of the sky, called sectors, for 27 days at a time. This long stare allows the satellite to track changes in stellar brightness caused by an orbiting planet crossing in front of its star from our perspective, an event called a transit.

TOI 700 is a small, cool M dwarf star located just over 100 light-years away in the southern constellation Dorado. It's roughly 40% of the sun's mass and size and about half its surface temperature. The star appears in 11 of the 13 sectors TESS observed during the mission's first year, and scientists caught multiple transits by its three planets.

The star was originally misclassified in the TESS database as being more similar to our sun, which meant the planets appeared larger and hotter than they really are. Several researchers, including Alton Spencer, a high

school student working with members of the TESS team, identified the error.

"When we corrected the star's parameters, the sizes of its planets dropped, and we realized the outermost one was about the size of earth and in the habitable zone," said Emily Gilbert, a graduate student at the University of Chicago. "Additionally, in 11 months of data we saw no flares from the star, which improves the chances TOI 700 d is habitable and makes it easier to model its atmospheric and surface conditions."

Gilbert and other researchers presented the findings at the 235th meeting of the American Astronomical Society in Honolulu, and three papers – one of which Gilbert led – have been submitted to scientific journals.

The innermost planet, called TOI 700 b, is almost exactly earth-size, is probably rocky and completes an orbit every 10 days. The middle planet, TOI 700 c, is 2.6 times larger than earth – between the sizes of earth and Neptune – orbits every 16 days and is likely a gas-dominated world. TOI 700 d, the outermost known planet in the system and the only one in the habitable zone, measures 20 per cent larger than earth, orbits every 37 days and receives from its star 86 per cent of the energy that the sun provides to earth. All of the planets are thought to be tidally locked to their star, which means they rotate once per orbit so that one side is constantly bathed in daylight.

A team of scientists led by Joseph Rodriguez, an astronomer at the Center for Astrophysics | Harvard and Smithsonian in Cambridge, Massachusetts, requested follow-up observations with Spitzer to confirm TOI 700 d.

"Given the impact of this discovery – that it is TESS's first habitable-zone earth-size planet – we really wanted our understanding of this system to be as concrete as possible," Rodriguez said. "Spitzer saw TOI 700 d transit exactly when we expected it to. It's a great addition to the legacy of a mission that helped confirm two of the TRAPPIST-1 planets and identify five more."

The Spitzer data increased scientists' confidence that TOI 700 d is a real planet and sharpened their measurements of its orbital period by 56 per cent and its size by 38 per cent. It also ruled out other possible astrophysical causes of the transit signal, such as the presence of a smaller, dimmer companion star in the system.

Rodriguez and his colleagues also used follow-up observations from a 1-metre ground-based telescope in the global Las Cumbres Observatory network to improve scientists' confidence in the orbital period and size of TOI 700 c by 30 per cent and 36 per cent, respectively.

Because TOI 700 is bright, nearby, and shows no sign of stellar flares, the system is a prime candidate for precise mass measurements by current ground-based observatories. These measurements could confirm scientists' estimates that the inner and outer planets are rocky and the middle planet is made of gas.

Future missions may be able to identify whether the planets have atmospheres and, if so, even determine their compositions.

While the exact conditions on TOI 700 d are unknown, scientists can use current information, like the planet's size and the type of star it orbits, to generate computer models and make predictions. Researchers

at NASA's Goddard Space Flight Center in Greenbelt, Maryland, modelled 20 potential environments of TOI 700 d to gauge if any version would result in surface temperatures and pressures suitable for habitability.

Their 3D climate models examined a variety of surface types and atmospheric compositions typically associated with what scientists regard to be potentially habitable worlds. Because TOI 700 d is tidally locked to its star, the planet's cloud formations and wind patterns may be strikingly different from earth's.

One simulation included an ocean-covered TOI 700 d with a dense, carbon-dioxide-dominated atmosphere similar to what scientists suspect surrounded Mars when it was young. The model atmosphere contains a deep layer of clouds on the star-facing side. Another model depicts TOI 700 d as a cloudless, all-land version of modern earth, where winds flow away from the night side of the planet and converge on the point directly facing the star.

When starlight passes through a planet's atmosphere, it interacts with molecules like carbon dioxide and nitrogen to produce distinct signals, called spectral lines. The modeling team, led by Gabrielle Englemann-Suissa, a Universities Space Research Association visiting research assistant at Goddard, produced simulated spectra for the 20 modelled versions of TOI 700 d.

"Someday, when we have real spectra from TOI 700 d, we can backtrack, match them to the closest simulated spectrum, and then match that to a model," Englemann-Suissa said. "It's exciting because no matter what we find out about the planet, it's going to look completely different from what we have here on earth."

TESS is a NASA Astrophysics Explorer mission led and operated by MIT in Cambridge, Massachusetts, and managed by NASA's Goddard Space Flight Center. Additional partners include Northrop Grumman, based in Falls Church, Virginia; NASA's Ames Research Center in California's Silicon Valley; the Harvard-Smithsonian Center for Astrophysics in Cambridge, Massachusetts; MIT's Lincoln Laboratory; and the Space Telescope Science Institute in Baltimore. More than a dozen universities, research institutes and observatories worldwide are participants in the mission.

The Jet Propulsion Laboratory in Pasadena, California, manages the Spitzer Space Telescope mission for NASA's Science Mission Directorate in Washington. Science operations are conducted at the Spitzer Science Center at Caltech in Pasadena. Space operations are based at Lockheed Martin Space in Littleton, Colorado. Data are archived at the Infrared Science Archive housed at IPAC at Caltech. Caltech manages JPL for NASA.

The modelling work was funded through the Sellers Exoplanet Environments Collaboration at Goddard, a multidisciplinary collaboration that brings together experts to build comprehensive and sophisticated computer models to better analyze current and future exoplanet observations.

New Technology Could Help Solve AI's 'Memory Bottleneck'

Date: February 10, 2020
Source: Northwestern University

Electrical engineers at Northwestern University and the University of Messina in

Italy have developed a new magnetic memory device that could potentially support the surge of data-centric computing, which requires ever-increasing power, storage and speed.

Based on antiferromagnetic (AFM) materials, the device is the smallest of its kind ever demonstrated and operates with record-low electrical current to write data.

"The rise of big data has enabled the emergence of artificial intelligence (AI) in the cloud and on edge devices and is fundamentally transforming the computing, networking and data storage industries," said Northwestern's Pedram Khalili, who led the research. "However, existing hardware cannot sustain the rapid growth of data-centric computing. Our technology potentially could solve this challenge."

The research will be published on 10 February in the journal *Nature Electronics*.

Khalili is an associate professor of electrical and computer engineering in Northwestern's McCormick School of Engineering. He co-led the study with Giovanni Finocchio, an associate professor of electrical engineering at the University of Messina. The team also included Matthew Grayson, a professor of electrical and computer engineering at McCormick. Jiacheng Shi and Victor Lopez-Dominguez, who are both members of Khalili's laboratory, served as co-first authors of the paper.

From promise to probable

Although AI offers promise to improve many areas of society, including health care systems, transportation and security, it can only meet its potential if computing can support it.

Ideally, AI needs all the best parts of today's memory technologies: Something as fast as static random access memory (SRAM) and with a storage capacity similar to dynamic random access memory (DRAM) or Flash. On top of that, it also needs low power dissipation.

"There is no existing memory technology that meets all of these demands," Khalili said. "This has resulted in a so-called 'memory bottleneck' that severely limits the performance and energy consumption of AI applications today."

To meet this challenge, Khalili and his collaborators looked to AFM materials. In AFM materials, electrons behave like tiny magnets due to a quantum mechanical property called 'spin,' but the material itself does not demonstrate a macroscopic magnetization because the spins are aligned in antiparallel fashion.

Typically, memory devices require an electric current to retain stored data. But in AFM materials, it is the magnetically ordered spins that perform this task, so a continuously applied electric current is not needed. As an added bonus, the data cannot be erased by external magnetic fields. Because densely packed devices will not interact with magnetic fields, AFM-based devices are very secure and easy to scale down to small dimensions.

Easily adoptable technology

Because they are inherently fast and secure and use lower power, AFM materials have been explored in past studies. But previous researchers experienced difficulties controlling the magnetic order within the materials.

Khalili and his team used pillars of antiferromagnetic platinum manganese – a geometry not previously explored. With a diameter of just 800 nanometers, these pillars are 10 times smaller than earlier AFM-based memory devices.

Importantly, the resulting device is compatible with existing semiconductor manufacturing practices, which means that current manufacturing companies could easily adopt the new technology without having to invest in new equipment.

"This brings AFM memory – and thus highly scaled and high-performance magnetic random-access memory (MRAM) – much closer to practical applications," Khalili said. "This is a big deal for industry as there is a strong demand today for technologies and materials to extend the scaling and performance of MRAM and increase the return on the huge investment that industry has already made in this technology to bring it to manufacturing."

Khalili's team is already working on the next steps toward this translation to applications.

"We are working now to further downscale these devices and to improve methods to read out their magnetic state," Khalili said. "We also are looking at even more energy-efficient ways to write data into AFM materials, such as replacing the electric current with an electric voltage, a challenging task that could further increase the energy efficiency by another order of magnitude or more."

Astronomers Detect Biggest Explosion in the History of the Universe

Date: February 27, 2020
Source: International Centre for Radio Astronomy Research

Scientists studying a distant galaxy cluster have discovered the biggest explosion seen in the Universe since the Big Bang.

The blast came from a supermassive black hole at the centre of a galaxy hundreds of millions of light-years away.

It released five times more energy than the previous record holder.

Professor Melanie Johnston-Hollitt, from the Curtin University node of the International Centre for Radio Astronomy Research, said the event was extraordinarily energetic.

"We've seen outbursts in the centres of galaxies before but this one is really, really massive," she said.

"And we don't know why it's so big.

"But it happened very slowly – like an explosion in slow motion that took place over hundreds of millions of years."

The explosion occurred in the Ophiuchus galaxy cluster, about 390 million light-years from earth.

It was so powerful it punched a cavity in the cluster plasma – the super-hot gas surrounding the black hole.

Lead author of the study Dr Simona Giacintucci, from the Naval Research Laboratory in the United States, said the blast was similar to the 1980 eruption of Mount St. Helens, which ripped the top off the mountain.

"The difference is that you could fit 15 Milky Way galaxies in a row into the crater this eruption punched into the cluster's hot gas," she said.

Professor Johnston-Hollitt said the cavity in the cluster plasma had been seen previously with X-ray telescopes.

But scientists initially dismissed the idea that it could have been caused by an energetic outburst, because it would have been too big.

"People were sceptical because the size of outburst," she said. "But it really is that. The Universe is a weird place."

The researchers only realised what they had discovered when they looked at the Ophiuchus galaxy cluster with radio telescopes.

"The radio data fit inside the X-rays like a hand in a glove," said co-author Dr Maxim Markevitch, from NASA's Goddard Space Flight Center.

"This is the clincher that tells us an eruption of unprecedented size occurred here."

The discovery was made using four telescopes; NASA's Chandra X-ray Observatory, ESA's XMM-Newton, the Murchison Widefield Array (MWA) in Western Australia and the Giant Metrewave Radio Telescope (GMRT) in India.

Professor Johnston-Hollitt, who is the director of the MWA and an expert in galaxy clusters, likened the finding to discovering the first dinosaur bones.

"It's a bit like archaeology," she said.

"We've been given the tools to dig deeper with low frequency radio telescopes so we should be able to find more outbursts like this now."

The finding underscores the importance of studying the Universe at different wavelengths, Professor Johnston-Hollitt said.

"Going back and doing a multi-wavelength study has really made the difference here," she said.

Professor Johnston-Hollitt said the finding is likely to be the first of many.

"We made this discovery with Phase 1 of the MWA, when the telescope had 2048 antennas pointed towards the sky," she said.

"We're soon going to be gathering observations with 4096 antennas, which should be ten times more sensitive."

"I think that's pretty exciting."

How Meditation Can Help You Make Fewer Mistakes

Date: November 11, 2019
Source: Michigan State University

New research tested how open monitoring meditation altered brain activity in a way that suggests increased error recognition. Meditating just once proves to make a difference

If you are forgetful or make mistakes when in a hurry, a new study from Michigan State University–the largest of its kind to-date–found that meditation could help you to become less error prone.

The research, published in *Brain Sciences*, tested how open monitoring meditation–or, meditation that focuses awareness on feelings, thoughts or sensations as they unfold in one's mind and body – altered brain activity in a way that suggests increased error recognition.

"People's interest in meditation and mindfulness is outpacing what science can prove in terms of effects and benefits," said Jeff Lin, MSU psychology doctoral candidate and study co-author. "But it's amazing to me that we were able to see how one session of a guided meditation can produce changes to brain activity in non-meditators."

The findings suggest that different forms of meditation can have different neurocognitive effects and Lin explained that there is little research about how open monitoring meditation impacts error recognition.

"Some forms of meditation have you focus on a single object, commonly your breath, but open monitoring meditation is a bit different," Lin said. "It has you tune inward and pay attention to everything going on in your mind and body. The goal is to sit quietly and pay close attention to where the mind travels without getting too caught up in the scenery."

Lin and his MSU co-authors – William Eckerle, Ling Peng and Jason Moser – recruited more than 200 participants to test how open monitoring meditation affected how people detect and respond to errors.

The participants, who had never meditated before, were taken through a 20-minute open monitoring meditation exercise while the researchers measured brain activity through electroencephalography, or EEG. Then, they completed a computerized distraction test.

"The EEG can measure brain activity at the millisecond level, so we got precise measures of neural activity right after mistakes compared to correct responses," Lin said. "A certain neural signal occurs about half a second after an error called the error positivity, which is linked to conscious error recognition. We found that the strength of this signal is increased in the meditators relative to controls."

While the meditators didn't have immediate improvements to actual task performance, the researchers' findings offer a promising window into the potential of sustained meditation.

"These findings are a strong demonstration of what just 20 minutes of meditation can do to enhance the brain's ability to detect and pay attention to mistakes," Moser said. "It makes us feel more confident in what mindfulness meditation might really be capable of for performance and daily functioning right there in the moment."

While meditation and mindfulness have gained mainstream interest in recent years, Lin is among a relatively small group of researchers that take a neuroscientific approach to assessing their psychological and performance effects.

Looking ahead, Lin said that the next phase of research will be to include a broader group of participants, test different forms of meditation and determine whether changes in brain activity can translate to behavioural changes with more long-term practice.

"It's great to see the public's enthusiasm for mindfulness, but there's still plenty of work from a scientific perspective to be done to understand the benefits it can have, and equally importantly, how it actually works," Lin said. "It's time we start looking at it through a more rigorous lens."

Even Mild Physical Activity Immediately Improves Memory Function

Now you just need to remember to exercise!

Date: September 24, 2018
Source: University of California - Irvine

Researchers found that even very light workouts can increase the connectivity between parts of the brain responsible for memory formation and storage.

People who include a little yoga or tai chi in their day may be more likely to remember where they put their keys. Researchers at the University of California, Irvine and Japan's University of Tsukuba found that even very light workouts can increase the connectivity between parts of the brain responsible for memory formation and storage.

In a study of 36 healthy young adults, the researchers discovered that a single 10-minute period of mild exertion can yield considerable cognitive benefits. Using high-resolution functional magnetic resonance imaging, the team examined subjects' brains shortly after exercise sessions and saw better connectivity between the hippocampal dentate gyrus and cortical areas linked to detailed memory processing.

Their results were published in *Proceedings of the National Academy of Sciences*.

"The hippocampus is critical for the creation of new memories; it's one of the first regions of the brain to deteriorate as we get older– and much more severely in Alzheimer's disease," said project co-leader Michael Yassa, UCI professor and Chancellor's Fellow of neurobiology and behaviour. "Improving the function of the hippocampus holds much promise for improving memory in everyday settings."

The neuroscientists found that the level of heightened connectivity predicted the degree of recall enhancement.

Yassa, director of UCI's Center for the Neurobiology of Learning and Memory and the recently launched UCI Brain Initiative, said that while prior research has centred on the way exercise promotes the generation of new brain cells in memory regions, this new study demonstrates a more immediate impact: strengthened communication between memory-focused parts of the brain.

"We don't discount the possibility that new cells are being born, but that's a process that takes a bit longer to unfold," he said. "What we observed is that these 10-minute periods of exercise showed results immediately afterward."

A little bit of physical activity can go a long way, Yassa stressed. "It's encouraging to see more people keeping track of their exercise habits – by monitoring the number of steps they're taking, for example," he said. "Even short walking breaks throughout the day may have considerable effects on improving memory and cognition."

Yassa and his colleagues at UCI and at the University of Tsukuba are extending this avenue of research by testing older adults who are at greater risk of age-related mental impairment and by conducting long-term interventions to see if regular, brief, light exercise done daily for several weeks or months can have a positive impact on the brain's structure and function in these subjects.

"Clearly, there is tremendous value to understanding the exercise prescription that best works in the elderly so that we can make recommendations for staving off cognitive decline," he said.

One of Darwin's Evolution Theories Finally Proved

Date: March 17, 2020
Source: St John's College, University of Cambridge

Scientists have proved one of Charles Darwin's theories of evolution for the first time – nearly 140 years after his death.

Laura van Holstein, a PhD student in Biological Anthropology at St John's College, University of Cambridge, and lead author of the research published today (March 18) in *Proceedings of the Royal Society*, discovered mammal subspecies play a more important role in evolution than previously thought.

Her research could now be used to predict which species conservationists should focus on protecting to stop them becoming endangered or extinct.

A species is a group of animals that can interbreed freely amongst themselves. Some species contain subspecies – populations within a species that differ from each other by having different physical traits and their own breeding ranges. Northern giraffes have three subspecies that usually live in different locations to each other and red foxes have the most subspecies – 45 known varieties– spread all over the world. Humans have no subspecies.

van Holstein said: "We are standing on the shoulders of giants. In Chapter 3 of *On the Origin of Species* Darwin said animal lineages with more species should also contain more 'varieties'. Subspecies is the modern definition. My research investigating the relationship between species and the variety of subspecies proves that sub-species play a critical role in long-term evolutionary dynamics and in future evolution of species. And they always have, which is what Darwin suspected when he was defining what a species actually was."

The anthropologist confirmed Darwin's hypothesis by looking at data gathered by naturalists over hundreds of years — long before Darwin famously visited the Galapagos Islands on-board HMS Beagle. *On the Origin of Species by Means of Natural Selection*, was first published in 1859 after Darwin returned home from a five-year voyage of discovery. In the seminal book, Darwin argued that organisms gradually evolved through a process called 'natural selection'–often known as survival of the fittest. His pioneering work was considered highly controversial because it contradicted the Bible's account of creation.

van Holstein's research also proved that evolution happens differently in land mammals (terrestrial) and sea mammals and bats (non-terrestrial) because of differences in their habitats and differences in their ability to roam freely.

van Holstein said: "We found the evolutionary relationship between mammalian species and subspecies differs depending on their habitat. Subspecies form, diversify and increase in number in a different way in non-terrestrial and terrestrial habitats, and this in turn affects how subspecies may eventually become species. For example, if a natural barrier like a mountain range gets in the way, it can separate animal groups and send them off on their own evolutionary journeys. Flying and marine mammals – such as bats and dolphins – have fewer physical barriers in their environment."

The research explored whether subspecies could be considered an early stage of speciation – the formation of a new species. van Holstein said: "The answer was yes. But evolution isn't determined by the same factors in all groups and for the first time we know why because we've looked at the strength of the relationship between species richness and subspecies richness."

The research acts as another scientific warning that the human impact on the habitat

of animals will not only affect them now, but will affect their evolution in the future. This information could be used by conservationists to help them determine where to focus their efforts.

van Holstein explained: "Evolutionary models could now use these findings to anticipate how human activity like logging and deforestation will affect evolution in the future by disrupting the habitat of species. The impact on animals will vary depending on how their ability to roam, or range, is affected. Animal subspecies tend to be ignored, but they play a pivotal role in longer term future evolution dynamics."

van Holstein is now going to look at how her findings can be used to predict the rate of speciation from endangered species and non-endangered species.

Notes to editors: What Darwin said on page 55 in '*On the Origin of Species*': "From looking at species as only strongly-marked and well-defined varieties, I was led to anticipate that the species of the larger genera in each country would oftener present varieties, than the species of the smaller genera; for wherever many closely related species (i.e species of the same genus) have been formed, many varieties or incipient species ought, as a general role, to be now forming. Where many large trees grow, we expect to find saplings."

Datasets: Most of the data is from Wilson and Reeder's 'Mammal Species of the World,' a global collated database of mammalian taxonomy. The database contains hundreds of years' worth of work by taxonomists from all over the world. The current way of 'doing' taxonomy goes all the way back to botanist Carl Linnaeus (1735), so the accumulation of knowledge is the combined work of all taxonomists since then.

Regular Exercise Benefits Immunity – even in Isolation

Date: March 31, 2020
Source: University of Bath

A new analysis highlights the power of regular, daily exercise on our immune system and the importance of people continuing to work-out even in lockdown.

Being in isolation without access to gyms and sports clubs should not mean people stop exercising, according to a new study from researchers at the University of Bath. Keeping up regular, daily exercise at a time when much of the world is going into isolation will play an important role in helping to maintain a healthy immune system.

The analysis, published in the international journal *Exercise Immunology Review*, involving leading physiologists Dr James Turner and Dr John Campbell from the University of Bath's Department for Health, considers the effect of exercise on our immune function.

Over the last four decades, many studies have investigated how exercise affects the immune system. It is widely agreed that regular moderate intensity exercise is beneficial for immunity, but a view held by some is that more arduous exercise can suppress immune function, leading to an 'open-window' of heightened infection risk in the hours and days following exercise.

In a benchmark study in 2018, this 'open window' hypothesis was challenged by

Dr Campbell and Dr Turner. They reported in a review article that the theory was not well supported by scientific evidence, summarising that there is limited reliable evidence that exercise suppresses immunity, concluding instead that exercise is beneficial for immune function.

They say that, in the short term, exercise can help the immune system find and deal with pathogens, and in the long term, regular exercise slows down changes that happen to the immune system with ageing, therefore reducing the risk of infections.

In a new article, published this month, leading experts, including Dr Turner and Dr Campbell, debated whether the immune system can change in a negative or positive way after exercise, and whether or not athletes get more infections than the general population. The article concludes that infections are more likely to be linked to inadequate diet, psychological stress, insufficient sleep, travel and importantly, pathogen exposure at social gathering events like marathons – rather than the act of exercising itself.

Author Dr James Turner from the Department for Health at the University of Bath explains: "Our work has concluded that there is very limited evidence for exercise directly increasing the risk of becoming infected with viruses. In the context of coronavirus and the conditions we find ourselves in today, the most important consideration is reducing your exposure from other people who may be carrying the virus. But people should not overlook the importance of staying fit, active and healthy during this period. Provided it is carried out in isolation – away from others – then regular, daily exercise will help better maintain the way the immune system works – not suppress it."

Co-author, Dr John Campbell added: "People should not fear that their immune system will be suppressed by exercise placing them at increased risk of Coronavirus. Provided exercise is carried out according to latest government guidance on social distancing, regular exercise will have a tremendously positive effect on our health and wellbeing, both today and for the future."

Regular moderate intensity aerobic exercise, such as walking, running or cycling is recommended, with the aim of achieving 150 minutes per week. Longer, more vigorous exercise would not be harmful, but if capacity to exercise is restricted due to a health condition or disability, the message is to 'move more' and that 'something is better than nothing'. Resistance exercise has clear benefits for maintaining muscles, which also helps movement.

At this current time in particular, the researchers underline the importance of maintaining good personal hygiene when exercising, including thoroughly washing hands following exercise. To give the body its best chance at fighting off infections, they suggest in addition to doing regular exercise, people need to pay attention to the amount of sleep they get and maintain a healthy diet, that is energy balanced to account for energy that is used during exercise. They hope that this debate article will lead to a wave of new research exploring the beneficial effects of exercise on immune function.

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