SCIENCE NEWS

Super Elastic Electroluminescent 'Skin' will soon Create Mood Robots

Engineers have developed an electroluminescent 'skin' that stretches to more than six times its original size while still emitting light. The discovery could lead to significant advances in health care, transportation, electronic communication and other areas.

These are multi-pixel electroluminescent displays fabricated via replica molding. The device measures 5 mm thick, with each of the 64 pixels measuring 4 mm. It can be deformed and stretched in various ways.

Credit: Science, Organic Robotics Lab at Cornell University

Imagine a health care robot that could display the patient's temperature and pulse, and even reacts to a patient's mood. It sounds futuristic, but a team of Cornell graduate students led by Rob Shepherd, Assistant Professor of mechanical and aerospace engineering has developed an electroluminescent 'skin' that stretches to more than six times its original size while still emitting light.

"This material can stretch with the body of a soft robot, and that's what our group does," Shepherd said, noting that the material has two key properties: "It allows robots to change their color, and it also allows displays to change their shape."

This hyper-elastic light-emitting capacitor (HLEC) can endure more than twice the strain of previously tested stretchable displays. It consists of layers of transparent hydrogel electrodes sandwiching an insulating elastomer sheet. The elastomer changes luminance and capacitance (the ability to store an electrical charge) when stretched, rolled and otherwise deformed.

"We can take these pixels that change color and put them on these robots, and now we have the ability to change their color," Shepherd said. "Why is that important? For one thing, when robots become more and more a part of our lives, the ability for them to have emotional connection with us will be important. So to be able to change their

color in response to mood or the tone of the room we believe is going to be important for human-robot interactions."

In addition to its ability to emit light under a strain of greater than 480 per cent its original size, the group's HLEC was shown to be capable of being integrated into a soft robotic system. Three six-layer HLEC panels were bound together to form a crawling soft robot, with the top four layers making up the light-up skin and the bottom two the pneumatic actuators.

The chambers were alternately inflated and deflated, with the resulting curvature creating an undulating, "walking".

Greenland's Ice is Getting Darker, Increasing Risk of Melting

An aerial image of Greenland shows rivers of melt water and areas of dark ice. Greenland's surface is absorbing more solar radiation as melting increases grain size and brings old impurities to the surface.

Credit: Marco Tedesco/Lamont-Doherty Earth Observatory

Greenland's snowy surface has been getting darker over the past two decades, absorbing more heat from the sun and increasing snow melt, a new study of satellite data shows. That trend is likely to continue, with the surface's reflectivity, or albedo, decreasing by as much as 10 per cent by the end of the century, the study says.

While soot blowing in from wildfires contributes to the problem, it has not been driving the change, the study finds. The real culprits are two feedback loops created by the melting itself. One of those processes is not visible to the human eye, but it is having a profound effect.

The results, published in the European Geosciences Union journal *The Cryosphere*, have global implications. Fresh meltwater pouring into the ocean from Greenland raises sea level and could affect ocean ecology and circulation.

"You don't necessarily have to have a 'dirtier' snowpack to make it dark," said lead author Marco Tedesco, a research professor at Columbia University's Lamont-Doherty Earth Observatory and adjunct scientist at NASA Goddard Institute of Space Studies. "A snowpack that might look 'clean' to our eyes can be more effective in absorbing solar radiation than a dirty one. Overall, what matters, it is the total amount of solar energy that the surface absorbs. This is the real driver of melting."

The feedback loops work like this: During a warm summer with clear skies and lots of solar radiation pouring in, the surface starts to melt. As the top layers of fresh snow disappear, old impurities, like dust from erosion or soot that blew in years before, begin to appear, darkening the surface. A warm summer can remove enough snow to allow several years of impurities to concentrate at the surface as surrounding snow layers disappear. At the same time, as the snow melts and refreezes, the grains of snow get larger. This is because the meltwater acts like glue, sticking grains together when the surface refreezes. The larger grains create a less reflective surface that allows more solar radiation to be absorbed. The impact of grain size on albedo the ratio between reflected and incoming solar radiation is strong in the infrared

range, where humans can't see, but satellite instruments can detect the change.

"It's a complex system of interaction between the atmosphere and the ice sheet surface. Rising temperatures are promoting more melting, and that melting is reducing albedo, which in turn is increasing melting," Tedesco said. "How this accumulates over decades is going to be important, because it can accelerate the amount of water Greenland loses. Even if we don't have a lot of melting because of atmospheric conditions one year, the surface is more sensitive to any kind of input the sun can give it, because of the previous cycle."

The study used satellite data to compare summertime changes in Greenland's albedo from 1981 to 2012. The first decade showed little change, but starting around 1996, the data show that due to darkening, the ice began absorbing about 2 per cent more solar radiation per decade. At the same time, summer near-surface temperatures in Greenland increased at a rate of about 0.74?C per decade, allowing more snow to melt and fuel the feedback loops.

A likely cause for the large shift around 1996 was a change in atmospheric circulation, Tedesco said. The North Atlantic Oscillation, a large-scale natural weather cycle, went into a phase in which summer atmospheric conditions favoured more incoming solar radiation and warmer, moist air from the south. Later records show those conditions shifted in 2013-2014 to favour less melting, but the damage was already done the ice sheet had become more sensitive. In 2015, melting spiked again to reach more than half of the Greenland ice sheet.

While new snowfall can make the ice sheet brighter again, the dark material built up during the melt years is waiting just below the surface, preconditioning the surface to future melting, Tedesco said.

The scientists also ran a computer model to simulate the future of Greenland's surface temperature, grain size, exposed ice area and albedo. Over the current century, the model projects that the average albedo for the entire ice sheet will fall by as much as 8 per cent, and by as much 10 per cent on the western edge, where the ice is darkest today. Those are conservative estimates the change could be twice that, Tedesco said.

The scientists looked into the hypothesis that soot from forest fires in China, Siberia and North America could be driving the increased darkening of the ice sheet. Using the Global Fire Emissions Database, they analyzed trends in black-carbon emissions from wildfires in those regions and Europe. While the amount of black carbon released by fires varied year to year, the scientists found no statistically significant increase during 1997-2012 to match the darkening of Greenland.

How Many Types of Neurons are there in the Brain?

The image illustrates the molecular diversity of V1 inhibitory interneurons (indicated in green) in the mouse lumbar spinal cord. Subsets of V1 interneurons can be defined by the activation of particular combinations of transcription factors (indicated in red, blue, and gray), forming a complex network of microcircuits that likely influence limb motor control.

Credit: Jay Bikoff, PhD

For decades, scientists have struggled to develop a comprehensive census of cell types in the brain. Now, in a pair of companion papers, researchers at Columbia's Mortimer B. Zuckerman Mind Brain Behavior Institute describe powerful new approaches to systematically identify individual classes of brain cells, or neurons, in the spinal cord. In doing so, they reveal elements of the underlying circuit architecture through which these neurons shape movement— and highlight how statistical approaches could provide neuroscientists with a critical tool to quantify the cellular diversity of any region of the brain.

The papers are published online in the journal Cell.

"Our work allows scientists to assess the diversity of neuronal cell classes in specific regions of the central nervous system— in part by plugging basic cellular characteristics into this fundamental statistical model," said Thomas M. Jessell, PhD, senior author on one of the papers and a co-director of the Zuckerman Institute. "As we continue to build upon and refine this method, scientists could take any cellular circuit and reveal its basic component parts. And once we understand the brain at this level, there are key problems of circuitry and function that can be addressed at a detailed level of resolution."

In today's newly published research, scientists focused on a group of neurons in the spinal cord called V1 interneurons, which form connections that orchestrate the activity and output of motor neurons, the class of neurons that give us the power to move.

"Motor neurons are like the strings of a marionette, with interneurons directing which strings are to be pulled, and in what order," said Jay Bikoff, PhD, a postdoctoral scholar at Columbia and first author of one of the papers. "Previous studies had shown that V1 interneurons are intimately involved in shaping motor neuron activity, but had been unable to determine precisely how they did so. We needed to classify the varieties of V1 interneurons in a much more systematic and detailed manner— information that would then help to decipher the circuits that underlie movement at an unprecedented organizational level."

There are many characteristics that distinguish one type of neuron from another, such as where it is located or what it looks like. But ultimately, the researchers argue, a neuron can be defined by its genetic identity.

"While at its core every neuron essentially contains the same genetic information, differences between the genes that are switched on, and those that remain dormant confer neurons with individual identities, like a fingerprint," said Mariano Gabitto, a doctoral candidate at Columbia in the department of neuroscience and the first author of the second paper. "So if you have a neuron's fingerprint, you can then use it to distinguish one class of neuron from the next, which is critical for dissecting the functional organization of the nervous system."

In this research, the scientists focused on finding that fingerprint. By studying the V1 interneurons of laboratory mice, researchers first identified 19 genetic 'switches,' called transcription factors, which— when activated in a particular combination— made the genetic profile of one V1 interneuron class different from another. What the scientists needed to do next was match the unique pattern of transcription factors to a particular

type of interneuron, a feat that proved difficult with traditional experimental techniques.

After facing this challenge, the researchers turned to theoretical neuroscientist Larry Abbott, PhD, and statistician Liam Paninski, PhD— colleagues at Columbia's Zuckerman Institute— as well as Ari Pakman, PhD, a postdoctoral fellow in Dr Paninski's lab and co-first author in the second paper, to build a more powerful statistical model. Drs Abbott and Paninski developed a mathematical approach based on Bayesian regression analysis that provides the ability to account for uncertainty in a principled way, while also incorporating the complex genetics of the 19 transcription factors. Using this statistical model the research team was able to distinguish 50 distinct types of V1 interneurons— results that withstood even the toughest statistical and experimental scrutiny.

"Not only did this model reveal to us the number of distinct V1 interneuron types, it also allowed us to infer their precise locations in the spinal cord," said Dr Jessell, who is also the Claire Tow Professor of Motor Neuron Disorders in the Department of Neuroscience and of Biochemistry and Molecular Biophysics at Columbia. "By combining experimental observation with statistical inference, it has been possible to develop a method that can take information about an interneuron's genetic identify and glean insight into its role directing muscle activation."

"What makes this work so foundational is that even with very limited data— such as the prevalence of these transcription factors combined with information on where the neurons were located— we could infer a detailed repertoire of cellular diversity," said Dr Abbott, the William Bloor Professor of Theoretical Neuroscience, Physiology and Cellular Biophysics at Columbia who served as a senior author on the second paper.

"Some of the most exciting work in neuroscience these days involves efforts to combine many different kinds of experimental measurements using a single unified statistical model— and these papers are one example of this," said Dr Paninski. "We're looking forward to further extending and generalizing these methods and applying them in other parts of the nervous system."

Long-term Stress Erodes Memory

This is the first study of its kind to establish the relationship between short-term memory and prolonged stress. In the case of the mice, that meant repeat visits from a larger, nasty intruder mouse.

Credit: © Stepan Popov/Fotolia

Sustained stress erodes memory, and the immune system plays a key role in the cognitive impairment, according to a new study from researchers at the Ohio State University.

The work in mice could one day lead to treatment for repeated, long-term mental assault such as that sustained by bullying victims, soldiers and those who report to beastly bosses, the researchers say.

"This is chronic stress. It's not just the stress of giving a talk or meeting someone new," said lead researcher Jonathan Godbout, Associate Professor of neuroscience at Ohio State.

Mice that were repeatedly exposed to the aggressive intruder had a hard time recalling

where the escape hole was in a maze they'd mastered prior to the stressful period.

"The stressed mice didn't recall it. The mice that weren't stressed, they really remembered it," Godbout said.

They also had measurable changes in their brains, including evidence of inflammation brought on by the immune system's response to the outside pressure. This was associated with the presence of immune cells, called macrophages, in the brain of the stressed mice.

The research team was able to pin the short-term memory loss on the inflammation, and on the immune system.

Their work, which appears in The Journal of Neuroscience, builds on previous research substantiating the connections between chronic stress and lasting anxiety.

The impact on memory and confirmation that the brain inflammation is caused by the immune system are important new discoveries, Godbout said.

"It's possible we could identify targets that we can treat pharmacologically or behaviorally," he said.

It could be that there are ways to interrupt the inflammation, said John Sheridan, who worked on the study and is associate director of Ohio State's Institute for Behavioral Medicine Research.

The mice used in the study are exposed to repeated social defeat— basically dominance by an alpha mouse— that aims to mimic chronic psychosocial stress experienced by humans.

Researchers at Ohio State seek to uncover the secrets behind stress and cognitive and mood problems with a long-range goal of finding ways to help those who are anxious, depressed and suffer from lasting problems, including post-traumatic stress disorder.

This new research focused on the hippocampus, a hub of memory and emotional response.

The researchers found that the stressed mice had trouble with spatial memory that resolved within 28 days. They found that the mice displayed social avoidance, which measures depressive-like behaviour, that continued after four weeks of monitoring.

And they were able to measure deficits in the development of new neurons 10 days and 28 days after the prolonged stress ended.

When they gave the mice a chemical that inhibited inflammation, neither the brain-cell problem nor the depressive symptoms went away. But the memory loss and inflammatory macrophages did disappear.

And that led them to conclude that the post-stress memory trouble is directly linked to inflammation— and the immune system— rather than to other damage to the brain. That type of information can pave the way for immune-based treatments, Godbout said.

"Stress releases immune cells from the bone marrow and those cells can traffic to brain areas associated with neuronal activation in response to stress," Sheridan said. "They're being called to the brain, to the center of memory."

Penguin Brains not Changed by Loss of Flight

This is an ancient penguin skull and endocast. Scale bar is 2.5 cm and letters indicate parts of the brain: ce, cerebellum; el, endosseus labyrinth; fl, floccular lobe; ol, optic lobe; os, occipital sinus impression; pb, pituitary bulb; t, telencephalon; w, wulst.

Credit: Courtesy of James Proffitt

Losing the ability to fly gave ancient penguins their unique locomotion style. But leaving the sky behind didn't cause major changes in their brain structure, researchers from the University of Texas at Austin suggest after examining the skull of the oldest known penguin fossil.

The findings were published in the Journal of Anatomy in February.

"What this seems to indicate is that becoming larger, losing flight and becoming a wing-propelled diver does not necessarily change the [brain] anatomy quickly," said James Proffitt, a graduate student at the university's Jackson School of Geosciences who led the research. "The way the modern penguin brain looks doesn't show up until millions and millions of years later."

Proffitt conducted the research with Julia Clarke, a professor in the Jackson School's Department of Geological Sciences, and Paul Scofield, the senior curator of Natural History at the Canterbury Museum in Christchurch, New Zealand, where the skull fossil is from.

The skull is from a penguin that lived in New Zealand over 60 million years ago during the Paleocene epoch. According to Proffitt, it likely lived much like penguins today. But while today's penguins have been diving instead of flying for tens of millions of years, the change was relatively new for the ancient penguin.

"It's the oldest [penguin] following pretty closely after the loss of flight and the evolution of flightless wing-propelled diving that we know of," Proffitt said.

The shape of bird skulls is influenced by the structure of the brain. To learn about early penguin brain anatomy, Proffitt used X-ray CT-scanning to digitally capture fine features of the skull's anatomy, and then used computer modelling software to create a digital mold of the brain, called an endocast.

The researchers thought that loss of flight would impact brain structure— making the brains of ancient penguins and modern penguins similar in certain regions. However, after analyzing the endocast and comparing it to modern penguin brain anatomy, no such similarity was found, Proffitt said. The brain anatomy had more in common with skulls of modern relatives that both fly and dive such as petrels and loons, than modern penguins.

"It's difficult to know why modern penguins' brains look different than their ancestors' brains", Proffitt said. It's possible that millions of years of flightless living created gradual changes in the brain structure. But the analysis shows that these changes are not directly related to initial loss of flight because they are not shared by the ancient penguin brain.

However, similarities in the brain shape between the ancient species and diving birds living today suggest that diving behaviour may be associated with certain anatomical structures in the brain.

"The question now is do the old fossil penguins' brains look that way because that's

the way their ancestors looked, or does it have something maybe to do with diving?" Proffitt said. "I think that's an open question right now."

Alma spots Baby Star's Growing Blanket

Artist's impression of the baby star TMC-1A. The star is located in the centre and surrounded by a rotating gas disk. Gas is infalling to the disk from the envelope further out.

Credit: Image courtesy of National Astronomical Observatory of Japan

Researchers using the Atacama Large Millimeter/submillimeter Array (ALMA) have made the first direct observations delineating the gas disk around a baby star from the infalling gas envelope. This finding fills an important missing piece in our understanding of the early phases of stellar evolution. A research team, led by *Yusuke Aso* (a graduate student at the University of Tokyo) and Nagayoshi Ohashi (a professor at the Subaru Telescope, National Astronomical Observatory of Japan) observed the baby star named TMC-1A located 450 light years away from us, in the constellation Taurus (the Bull). TMC-1A is a protostar, a star still in the process of forming. Large amounts of gas still surround TMC-1A.

Stars form in dense gas clouds. Baby stars grow by taking in the surrounding gas, like a fetus receiving nutrition from the mother's placenta. In this process, gas cannot flow directly into the star. Instead it first accumulates and forms a disk around the star, and then the disk feeds into the star. However, it is still unknown when in the process of star formation this disk appears and how it evolves. Lack of sensitivity and resolution in radio observations has made it difficult to observe these phenomena.

"The disks around young stars are the places where planets will be formed," said Aso, the lead author of the paper that appeared in the *Astrophysical Journal*. "To understand the formation mechanism of a disk, we need to differentiate the disk from the outer envelope precisely and pinpoint the location of its boundary."

Using ALMA, the team directly observed the boundary between the inner rotating disk and the outer infalling envelope with high accuracy for the first time. Since gas from the outer envelope is continuously falling into the disk, it had been difficult to identify the transition region in previous studies. In particular, the tenuous but high speed gas in rotating disks is not easy to see. But ALMA has enough sensitivity to highlight such a component and illustrate the speed and distribution of gas in the disk very precisely. This enabled the team to distinguish the disk from the infalling envelope.

The team found that the boundary between the disk and envelope is located 90 astronomical units from the central baby star. This distance is three times longer than the orbit of Neptune, the outermost planet in the solar system. The observed disk obeys Keplerian rotation: the material orbiting closer to the central star revolves faster than material further out.The high-sensitivity observations provided other important information about the object. From detailed measurement of the rotation speed, the research team could calculate that the mass of the baby star is 0.68 times the mass of the

sun. The team also determined the gas infall rate to be a millionth of the mass of the sun per year, with a speed of 1 km per second. Gravity causes gas to fall towards the central baby star, but the measured speed is much less than the free-fall speed. Something must be slowing the gas down. The researchers suspect that a magnetic field around the baby star might be what is slowing the gas.

"We expect that as the baby star grows, the boundary between the disk and the infall region moves outward," said Aso. "We are sure that future ALMA observations will reveal such evolution."

These observational results were published as Aso et al. "ALMA Observations of the Transition from Infall Motion to Keplerian Rotation around the Late-phase Protostar TMC-1A " in the *Astrophysical Journal*, issued in October 2015.

Monkeys drive Wheelchairs using only their Thoughts

A computer in the lab of Miguel Nicolelis, M.D., Ph.D., monitors brain signals from a rhesus macaque. Nicolelis and Duke researchers record signals from hundreds of neurons in two regions of the monkeys' brains that are involved in movement and sensation. As the animals think about moving toward their goal— in this case, a bowl containing fresh grapes— computers translate their brain activity into real-time operation of a wheelchair.

Credit: Shawn Rocco/ Duke Health

Neuroscientists at Duke Health have developed a brain-machine interface (BMI) that allows primates to use only their thoughts to navigate a robotic wheelchair.

The BMI uses signals from hundreds of neurons recorded simultaneously in two regions of the monkeys' brains that are involved in movement and sensation. As the animals think about moving toward their goal— in this case, a bowl containing fresh grapes— computers translate their brain activity into real-time operation of the wheelchair.

The interface, described in the March 3 issue of the online journal *Scientific Reports*, demonstrates the future potential for people with disabilities who have lost most muscle control and mobility due to quadriplegia or ALS, said senior author Miguel Nicolelis, M.D., Ph.D., co-director for the Duke Center for Neuroengineering.

"In some severely disabled people, even blinking is not possible," Nicolelis said. "For them, using a wheelchair or device controlled by noninvasive measures like an EEG (a device that monitors brain waves through electrodes on the scalp) may not be sufficient. We show clearly that if you have intracranial implants, you get better control of a wheelchair than with noninvasive devices."

Scientists began the experiments in 2012, implanting hundreds of hair-thin microfilaments in the premotor and somatosensory regions of the brains of two rhesus macaques. They trained the animals by passively navigating the chair toward their goal, the bowl containing grapes. During this training phase, the scientists recorded the primates' large-scale electrical brain activity. The researchers then programmed a computer system to translate brain signals into digital motor commands that controlled the movements of the wheelchair.

As the monkeys learned to control the wheelchair just by thinking, they became more efficient at navigating toward the grapes and completed the trials faster, Nicolelis said.

In addition to observing brain signals that corresponded to translational and rotational movement, the Duke team also discovered that primates' brain signals showed signs they were contemplating their distance to the bowl of grapes.

"This was not a signal that was present in the beginning of the training, but something that emerged as an effect of the monkeys becoming proficient in this task," Nicolelis said. "This was a surprise. It demonstrates the brain's enormous flexibility to assimilate a device, in this case a wheelchair, and that device's spatial relationships to the surrounding world."

The trials measured the activity of nearly 300 neurons in each of the two monkeys. The Nicolelis lab previously reported the ability to record up to 2,000 neurons using the same technique. The team now hopes to expand the experiment by recording more neuronal signals to continue to increase the accuracy and fidelity of the primate BMI before seeking trials for an implanted device in humans, he said.

In addition to Nicolelis, study authors include Sankaranarayani Rajangam; Po-He Tseng; Allen Yin; Gary Lehew; David Schwarz; and Mikhail A. Lebedev.

The National Institutes of Health (DP1MH099903) funded this study. The Itau Bank of Brazil provided research support to the study as part of the Walk Again Project, an international non-profit consortium aimed at developing new assistive technologies for severely paralyzed patients.

Tunnel through the Head: Internally Coupled Ears Enable Directional Hearing in Animals

An air-filled cavity connects the eardrums of the two ears of this lizsard. In this "tunnel through the head" external and internal sound waves superimpose to produce signals enabling the animal to localize the direction of the sound source.

Credit: Prof. Dr Frieder Mugele, University of Twente

Humans use the time delay between the arrival of a sound wave at each ear to discern the direction of the source. In frogs, lizards and birds the distance between the ears is too small. However, they have a cavity connecting the eardrums, in which internal and external sound waves are superimposed. Using a universal mathematical model, researchers at the Technical University of Munich (TUM) have now for the first time shown how new signals are created in this 'inner ear' used by animals for localizing sounds.

Whether perceiving an encroaching predator or finding prey in the dark, precisely localizing the source of a sound is indispensable in the animal kingdom. Almost all mammals, including humans, localize sound sources horizontally via the delay in time in which sound signals arrive at each ear. Using this time difference the brain can calculate the direction from which the sound emanated.

Frogs, many reptiles and birds do not have this option since the distance between their ears often measures merely a few centimetres. The time difference is thus so small that it cannot be processed by the brain. To make up for this disadvantage these

animals have developed a simple albeit very effective system: An air-filled cavity connects the eardrums of the two ears.

This cavity, which runs right through the head, couples the eardrums. The scientists refer to this as "internally coupled ears" or ICE. This "tunnel in the head" is clearly visible when light falls into one ear of a gecko: the light then shines out of the other ear.

Unlike humans, the animals perceive not only external signals, but also a superposition of external sound waves with those that are created internally through the coupling of the two sides. Scientists have determined in experiments that animals use the resulting signals for pinpointing sound sources. But what exactly happens in the coupled ears remains a mystery.

A Model for 15,000 Species

Now, scientists working led by Leo van Hemmen, Professor of Theoretical Biophysics at the Technical University of Munich (TUM) have for the first time developed a universal mathematical model that describes how sound waves propagate through the internally coupled ears and which clues for localizing sound sources are created in the process.

"Our model is applicable to all animals with this kind of hearing system, regardless that the cavities between the eardrums of the various species look very different," explains van Hemmen. "We now understand what exactly happens inside the ears of these animals and can both explain and predict the results of experiments in all sorts of animals." Over 15,000 species have internally coupled ears— that is more than half of all land-dwelling vertebrate animals.

External and Internal Signals in Concert

Using their model, van Hemmen and his team discovered that the animals have even developed two different methods of hearing with internally coupled ears. They occur in different frequency domains and augment each other.

In sounds below the fundamental frequency of the eardrum the time difference in the superposition of the internal and external signals is amplified up to five-fold. That is sufficient to facilitate sound localization. In higher frequencies the time difference can no longer be evaluated. Here, another property of the signal becomes relevant: the difference in the amplitude, i.e. the loudness, of the sound perceived by the ears. "The amplitude difference occurs solely through the coupling of the two ears," explains van Hemmen. "That was a surprising result."

This new insight on the mechanisms and especially the advantages of hearing with internally coupled ears is also relevant for industrial applications. It is conceivable that robots will be equipped with this kind of hearing system. "I can very well imagine applications in robotics, because this kind of amplification doesn't need energy" expresses van Hemmen. In the future van Hemmen and his team of scientists hope to refine their model in collaboration with the experimental work of colleagues.

Exposure to Air Pollution Increases Risk of Obesity

Forbidden City in Beijing (stock image). A new study shows that exposure to air pollution increases the risk of obesity.

Credit: © bizoon/Fotolia

Laboratory rats who breathed Beijing's highly polluted air gained weight and experienced cardio-respiratory and metabolic dysfunctions after three to eight weeks of exposure.

A study appearing in the March issue of the *Journal of the Federation of American Societies for Experimental Biology* (FASEB) placed pregnant rats and their offspring in two chambers, one exposed to outdoor Beijing air and the other containing an air filter that removed most of the air pollution particles.

After only 19 days, the lungs and livers of pregnant rats exposed to the polluted air were heavier and showed increased tissue inflammation. These rats had 50 per cent higher LDL cholesterol; 46 per cent higher triglycerides; and 97 per cent higher total cholesterol. Their insulin resistance level, a precursor of Type 2 diabetes, was higher than their clean air-breathing counterparts.

All of these measures support the study's conclusion that air pollution exposure results in metabolic dysfunction, a precursor to obesity. Indeed, pollution-exposed rats were significantly heavier at the end of their pregnancy even though the rats in both groups were fed the same diet.

Similar results were shown in the rat offspring, which were kept in the same chambers as their mothers.

However, the results showed that the negative effects of air pollution were less pronounced after three weeks than they were at eight weeks, suggesting that long-term exposure may be needed to generate the continuous inflammatory and metabolic changes that ultimately increase body weight. At eight weeks old, female and male rats exposed to the pollution were 10 per cent and 18 per cent heavier, respectively, than those exposed to clean air.

The results of this study, which was funded by several agencies of the Chinese government, are consistent with other studies that show air pollution induces oxidative stress and inflammation in the organs and circulatory system. The findings also echo previous studies linking air pollution with increased insulin resistance and altered fat tissue.

"Since chronic inflammation is recognized as a factor contributing to obesity and since metabolic diseases such as diabetes and obesity are closely related, our findings provide clear evidence that chronic exposure to air pollution increases the risk for developing obesity," said Junfeng "Jim" Zhang, a professor of global and environmental health at Duke University and a senior author of the paper.

"If translated and verified in humans, these findings will support the urgent need to reduce air pollution, given the growing burden of obesity in today's highly polluted world," Zhang said.

The Intestinal Microbiota: A New Ally for Optimum Growth

In the mouse, the intestinal microbiota is necessary for optimum postnatal growth and thus contributes to determining the size of adult individuals. Left: an infant mouse reared with its intestinal microbiota; right: a young adult mouse devoid of intestinal microbiota. Note their difference in size. The bacterial colonization of the mice is illustrated by the presence or absence of colonies in bacterial cultures on agar plates.

Credit: © Vincent Moncorgé

The intestinal microbiota is necessary to ensure optimum postnatal growth and contributes to determining the size of adult individuals, notably in the event of undernutrition. The key element in this relationship is Insulin-like Growth Factor-1 (IGF-1), whose production and activity are in part controlled by the microbiota. This has recently been demonstrated in mice by scientists at the Institut de Génomique Fonctionnelle de Lyon (CNRS/ENS Lyon/ Université Claude Bernard Lyon 1), the Laboratoire CarMeN (INSERM/INRA/ Université Claude Bernard Lyon 1/Insa Lyon), and Unit BF2I (INRA/INSA Lyon). These findings, published on 19 February 2016 in *Science*, and obtained in collaboration with researchers from the Czech Academy of Sciences, also show that some strains of intestinal bacteria belonging to the *Lactobacillus plantarum* species may favour the postnatal growth of animals, thus offering a new opportunity to combat the harmful effects of chronic infantile undernutrition.

During the juvenile phase, animal growth is influenced by interactions between nutritional intake and hormone signalling. Acute undernutrition for a few days in the mouse results in marked weight loss, which has been widely documented and attributed— among other factors -- to a disturbance of the intestinal microbiota. Chronic undernutrition will result in the onset of growth retardation. The complex mechanisms underlying this retardation involve a state of resistance to the action of growth hormone secreted by the pituitary, an endocrine gland situated beneath the brain, which normally stimulates the production by numerous tissues of growth factors such as Insulin-like Growth Factor 1 (IGF-1). This tissue resistance to growth hormone causes a drop in the production of IGF-1, leading to a delayed development and reduced size of an individual compared with age. Until now, the influence of the microbiota on these mechanisms remained unknown.

Under different nutritional conditions, the scientists compared the development of standard mice with a normal microbiota with that of so-called germ-free mice without intestinal microbiota. They were able to demonstrate, for the first time, the role played by the bacteria in the intestinal flora in controlling growth. Whether under a normal diet or in a situation of undernutrition, the researchers observed that the germ-free mice had not only gained less weight but were also smaller than their standard counterparts. In germ-free specimens, numerous bone growth parameters such as bone length or thickness were reduced, without bone mineral density (the amount of calcium in the bones) being affected. In addition, the team showed that the germ-free mice displayed lower IGF-1 levels, with less activity, than the other mice. By interferring with the activity of IGF-1 in normal mice, or by injecting IGF-1 into the germ-free mice, the scientists determined that the intestinal microbiota favoured growth by influencing the production and activity of this important growth factor.

Previous studies in Drosophila had demonstrated the ability of bacterial strains in the *Lactobacillus plantarum* species to favour postnatal growth in the event of chronic undernutrition. The researchers therefore analyzed the growth of so-called monocolonized mice (i.e. containing a single bacterial strain as their microbiota).

They thus demonstrated that mice monocolonized with a specific *Lactobacillus plantarum* strain (called LpWJL), and reared under standard nutrition or chronic undernutrition, produced more IGF-1, gained more weight and grew better than germ-free mice or those monocolonized with other strains. These results thus prove that certain strains of Lactobacillus, including LpWJL, are able to favour postnatal growth in mammals.

The 'Ugliest Fossil Reptiles' who roamed China

The skeleton of Shihtienfenia, a large pareiasaur from the latest Permian of Shanxi Province, China. The skeleton outline is based on close relatives from Russia, and known bones are shaded.

Credit: Image courtesy of University of Bristol

Long before the dinosaurs, hefty herbivores called pareiasaurs ruled earth. Now, for the first time, a detailed investigation of all Chinese specimens of these creatures— often described as the 'ugliest fossil reptiles'— has been published by a University of Bristol, UK palaeontologist.

Pareiasaurs have been reported from South Africa, Europe (Russia, Scotland, Germany), Asia (China), and South America, but it is not known whether there were distinct groups on each of these continents.

In a new study published in the *Zoological Journal* of the Linnean Society, Professor Mike Benton of Bristol's School of Earth Sciences shows there are close similarities between Chinese fossils and those found in Russia and South Africa, indicating that the huge herbivores were able to travel around the world despite their lumbering movement.

Professor Benton said: "Up to now, six species of pareiasaurs had been described from China, mainly from Permian rocks along the banks of the Yellow River between Shaanxi and Shanxi provinces. I was able to study all of these specimens in museums in Beijing, and then visited the original localities. It seems clear there were three species and these lived over a span of one to two million years."

Pareiasaurs were hefty animals, two to three metres long, with massive, barrel-shaped bodies, short, stocky arms and legs, and tiny head with small teeth. Their faces and bodies were covered with bony knobs.

It is likely the pareiasaurs lived in damp, lowland areas, feeding on huge amounts of low-nutrition vegetation. No stomach contents or fossilized faeces from pareiasaurs are known to exist, but in Russia, pareiasaurs have been found with evidence they had made wallows in the soft mud probably to cool off or coat themselves in mud to ward off parasites.

The new study confirms that the three Chinese pareiasaur species differed from each other in body size and in the shapes of their teeth.

Professor Benton added: "My study of the evolution of pareiasaurs shows that the Chinese species are closely related to relatives from Russia and South Africa. Despite their size and probably slow-moving habits, they could walk all over the world. We see the same sequence of two or three forms worldwide, and there is no evidence that China, or any other region, was isolated at that time."

Pareiasaurs were the first truly large herbivores on earth, and yet their tenure was short.

As in other parts of the world, the species in China were wiped out as part of the devastation of the end-Permian mass extinction 252 million years ago, when 90 per cent of species were killed by the acid rain and global warming caused by massive volcanic eruptions in Russia.

Without forests, landscapes were denuded of soils which washed into the seas. Shock heating of the atmosphere and oceans as a result of the massive release of carbon dioxide and methane also killed much of life. The end-Permian mass extinction killed off the pareiasaurs after they had been on earth for only 10 million years.

Fifty-seven Different Pesticides Found in Poisoned Honeybees

Honeybees are under threat globally: in the US, dramatic declines in bee populations due to a condition called colony collapse disorder (CCD) continues to put crops at risk and farmers out of business.

Credit: © luigipinna/Fotolia

European honeybees are being poisoned with up to 57 different pesticides, according to new research published in the *Journal of Chromatography*. A new method for detecting a whole range of pesticides in bees could help unravel the mystery behind the widespread decline of honeybees in recent years, and help develop an approach to saving them.

Honeybees are under threat globally: in the US, dramatic declines in bee populations due to a condition called colony collapse disorder (CCD) continues to put crops at risk and farmers out of business. Several studies have shown a link between pesticide use and bee deaths and the European Union has banned the use of neonicotinoid pesticides.

But it is not as simple as banning one pesticide that is killing bees; the relationship between pesticide use and bee death is complex and scientists are still trying to figure out exactly what is happening. In the new study, researchers from the National Veterinary Research Institute in Poland have developed a method for analyzing 200 pesticides at the same time, to figure out what's really putting honeybees at risk.

"Bee health is a matter of public concern—bees are considered critically important for the environment and agriculture by pollinating more than 80 per cent of crops and wild plants in Europe," said Tomasz Kiljanek, lead author of the study from the National Veterinary Research Institute in Poland. "We wanted to develop a test for a large number of pesticides currently approved for use in the European Union to see what is poisoning the bees."

With so many pesticides currently in use, it is difficult to work out which ones are harming the bees. Certain combinations of pesticides, or their use over time, could affect honeybees in different ways. In order to understand what is really going on, we need to know which pesticides and at what concentration levels are present in honeybees.

Kiljanek and the team used a method called QuEChERS, which is currently used to detect pesticides in food. With this analysis, they could test poisoned bees for 200 different pesticides simultaneously, as well as several additional compounds created when the

pesticides are broken down. About 98 per cent of the pesticides they tested for are approved for use in the European Union.

The team used the method to investigate more than 70 honeybee poisoning incidents. Their findings revealed 57 different pesticides present in the bees— it is a toxic puzzle they hope their new method will help solve.

"This is just the beginning of our research on the impact of pesticides on honeybee health," said Kiljanek. "Honeybee poisoning incidents are the tip of the iceberg. Even at very low levels, pesticides can weaken bees' defense systems, allowing parasites or viruses to kill the colony. Our results will help expand our knowledge about the influence of pesticides on honeybee health, and will provide important information for other researchers to better assess the risk connected with the mix of current used pesticides."

Links between Money and Happiness Uncovered

A new study explores the link between money and happiness.

Credit: © Minerva Studio/Fotolia

Changes in income do not affect most people's happiness, most of the time, according to a new study led by the University of Stirling.

The research, which examined levels of life satisfaction and income changes in more than 18,000 adults over a nine year period, revealed that income change is only important when individuals with specific personality characteristics experience an income loss.

Researchers at the universities of Stirling and Nottingham found that for most people happiness is likely to rest on avoiding loss, rather than aiming for continual financial gain.

The study, involving two separate samples from Germany and the UK, asked participants annually about their income level and how satisfied they were with life. Participants also answered questions on their personality at the start of the study.

Results revealed that regardless of personality, income increases did not affect life satisfaction. When people lost income, however, there was a reduction in their life satisfaction. This was far greater for those who reported themselves as being conscientious, namely they were thorough in their attitudes to life and work, energetic, and effective and efficient in how they did things.

Leading the research, Dr Christopher Boyce of the Behavioural Science Centre at the University of Stirling, said: "It is often assumed that as our income rises so does our life satisfaction, however, we have discovered this is not the case. What really matters is when income is lost and this is only important for people who are highly conscientious."

The study, which accounted for shifting circumstances such as entering or leaving work, and changes to health and household make up, found that for people that were only even moderately conscientious, a loss of income had a negative impact at least two and a half times greater than less conscientious individuals.

Dr Boyce said: "Continually increasing our income is not an important factor for achieving greater happiness and well-being for most people living in economically developed countries. Instead, we should aim for financial stability to achieve greater

happiness, while protecting those individuals who experience negative income shocks."

The study was funded by the Economic and Social Research Council.

Form of Genetically Elevated 'Good' Cholesterol may actually be Bad

HDL, or 'good' cholesterol, can remove cholesterol from arteries and shuttle it to the liver where it is eliminated, but this process can be disrupted in certain circumstances (such as deficiency of SCARB1).

Credit: The lab of Daniel Rader, MD, Perelman School of Medicine, University of Pennsylvania

The generally accepted medical maxim that elevated HDL cholesterol (HDL-C) is 'good' has been overturned by a multi-centre, international study, led by researchers from the Perelman School of Medicine at the University of Pennsylvania. They show that a certain genetic cause of increased HDL-C may actually be 'bad', noting that a specific mutation in a gene which encodes a cell receptor protein that binds to HDL prevents the receptor from functioning. The mutation causes an increased risk of coronary heart disease even in the presence of elevated levels of HDL-C or 'good' cholesterol. Their findings are published this week in *Science*.

Previous research raised the possibility that HDL might not be quite as protective against heart disease as generally believed by cardiologists, especially after several clinical trials of HDL-raising drugs showed little or no effect. "The thinking about HDL has evolved recently to the concept that it may not directly protect against all heart disease," said senior author Daniel J. Rader, MD, chair of the department of Genetics. "Our results indicate that some causes of raised HDL actually increase risk for heart disease. This is the first demonstration of a genetic mutation that raises HDL but increases risk of heart disease."

Rader and his colleagues sequenced the lipid-modifying regions of the genomes of 328 people with markedly elevated HDL (along with a control group with lower HDL) to identify genetic causes of high HDL. One of the genes they focused on was SCARB1, which encodes for Scavenger Receptor B1 (SR-B1), the major receptor for HDL on cell surfaces.

In the course of this sequencing, they identified, for the first time, a person without any SCARB1 function, typified by an extremely high HDL-C level of about 150 mg/dL, whereas the normal level is about 50 mg/dL. The subject had two copies of a SCARB1 mutation called P376L, which the team showed caused a breakdown in HDL receptor function.

Among the many approaches they took, the researchers generated induced pluripotent stem cells (iPSCs) from the SCARB1-deficient person, used them to create liver cells, and showed these new cells had profound reduction in their ability to take up HDL. "This mutation prevents the receptor from getting to the cell surface where it needs to be situated in order to bind and take up HDL," Rader explained. "This disruption in the receptor's job is due to mistakes in its folding and processing during protein synthesis."

Going back to the other sequenced genomes, the researchers were then able to show that persons who carry only one copy of the SCARB1 P376L mutation have significantly

higher HDL-C levels. From this, Rader and colleagues had a hunch, based on their knowledge of SCARB1 function and previous studies in mice, that having the SCARB1 P376L mutation, despite raising HDL, might paradoxically increase the risk of heart disease.

Working with other researchers around the world, the Penn team was able to show exactly what they had surmised. "This SCARB1 variant, while rare, is just frequent enough that it allowed us to ask the question about its effect on HDL and heart disease in people with only one copy of the mutation," Rader said.

The Penn team and their colleagues plan to characterise and test other SCARB1 mutations for their relationship to HDL levels and heart disease. Other genes may also have similar effects. "Eventually we may want to perform genetic testing in persons with high HDL to make sure they don't have mutations— like this one--that raise HDL but don't protect against, or may even increase, risk for heart disease," Rader said. Since the P376L mutation in SCARB1 appears to be specific to people of Ashkenazi Jewish descent, testing in this ethnic group might be particularly important.

Rader suggests that a therapeutic approach to increase the expression or activity of SCARB1 could be a new way to reduce the risk of heart disease even though it would reduce HDL blood levels. "The work demonstrates that the protective effects of HDL are more dependent upon how it functions than merely how much of it is present," Rader concluded. "We still have a lot to learn about the relationship between HDL function and heart disease risk."

'Ultra-processed' Foods make up more than Half of all Calories in US Diet

Lady using a modern vending machine

Credit: © kasto/Fotolia

'Ultra-processed' foods make up more than half of all calories consumed in the US diet, and contribute nearly 90 per cent of all added sugar intake, finds research published in the online journal BMJ Open.

Ultra-processed foods are formulations of several ingredients. Besides salt, sugar, oils and fats, they include substances not generally used in cooking, such as flavourings, emulsifiers, and other additives designed to mimic the qualities of 'real foods'.

Ultra-processed foods include mass produced soft drinks; sweet or savoury packaged snacks; confectionery and desserts; packaged baked goods; chicken/fish nuggets and other reconstituted meat products; instant noodles and soups.

To assess the contribution of ultra-processed foods to the intake of added sugars in the US diet, the researchers drew on dietary data involving more than 9000 people from the 2009-10 National Health and Nutrition Examination Survey (NHANES), an ongoing nationally representative cross sectional survey of US civilians.

They looked at the average dietary content of added sugars and the proportion of people who consumed more than 10% of their total energy intake— the maximum recommended limit— from this source.

Ultra-processed foods made up over half of total calorie intake (just under 60%) and contributed almost 90% of energy intake from added sugars.

Added sugars represented 1 in every 5 calories in the average ultra-processed food product— far higher than the calorie content of added sugars in processed foods and in unprocessed or minimally processed foods and processed culinary ingredients, including table sugar, combined.

A strong linear association emerged between the dietary content of ultra-processed foods and the overall dietary intake of added sugars.

Furthermore, the proportion of people exceeding the recommended upper limit of 10% of energy from added sugars was far higher when ultra-processed food consumption was high, rising to more than 80% among those who ate the most ultra-processed foods.

Notably, only those Americans whose ultra-processed food consumption was within the lowest 20% had an average daily added sugar intake that fell below the maximum recommended limit.

Several leading health bodies, including the World Health Organisation, the Canadian Heart and Stroke Foundation, the American Heart Association, and the US Dietary Guidelines Advisory Committee have concluded that excess added sugar intake increases the risk not only of weight gain, but also of obesity and diabetes, which are associated with a heightened risk of cardiovascular disease, and tooth decay.

Cutting back on the consumption of ultra-processed foods could be an effective way of curbing excessive added sugar intake in the US, conclude the researchers.

Prolonged Daily Sitting Linked to 3.8 per cent of all-cause Deaths

Sedentary behaviour, particularly sitting, has recently become a prevalent public health topic and target for intervention. As work and leisure activities shift from standing to sitting, increased sitting time is starting taking a toll on our bodies. A new study in the *American Journal of Preventive Medicine* found that sitting for more than three hours per day is responsible for 3.8% of all-cause mortality deaths. Investigators also estimate that reducing sitting time to less than three hours per day would increase life expectancy by an average of 0.2 years.

In order to properly assess the damaging effects of sitting, the study analyzed behavioural surveys from 54 countries around the world and matched them with statistics on population size, actuarial table, and overall deaths. Researchers found that sitting time significantly impacted all-cause mortality, accounting for approximately 433,000, or 3.8%, of all deaths across the 54 nations in the study. They also found that sitting had higher impact on mortality rates in the Western Pacific region, followed by European, Eastern Mediterranean, American, and Southeast Asian countries, respectively.

This type of information is crucial to evaluating the effect sitting has on our lives, especially in light of recent research that shows prolonged sitting is associated with an increased risk of death, regardless of activity level. Researchers now believe that periods of moderate or vigorous physical activity might not be enough to undo the detrimental effects of extended sitting.

While researchers found that sitting contributed to all-cause mortality, they also estimated the impact from reduced sitting time independent of moderate to vigorous physical activity. "It was observed that even modest reductions, such as a 10% reduction in the mean sitting time or a 30-minute absolute decrease of sitting time per day, could have an instant impact in all-cause mortality in the 54 evaluated countries, whereas bolder changes (for instance, 50% decrease or 2 hours fewer) would represent at least three times fewer deaths versus the 10% or 30-minute reduction scenarios," explained lead investigator Leandro Rezende, MSc, Department of Preventive Medicine, University of Sao Paulo School of Medicine.

Studies are beginning to show us exactly how detrimental prolonged sitting is for our health, even when coupled with exercise; however, changing habits is a difficult proposition. "Although sitting is an intrinsic part of human nature, excessive sitting is very common in modern societies," commented Rezende. "Sedentary behaviour is determined by individual, social, and environmental factors, all strongly influenced by the current economic system, including a greater number of labor-saving devices for commuting, at home and work, and urban environment inequalities that force people to travel longer distances and live in areas that lack support for active lifestyles."

The results of this analysis show that reducing sitting time, even by a small amount, can lead to longer lives, but lessening time spent in chairs may also prompt people to be more physically active in general. "Although sitting time represents a smaller impact compared with other risk factors, reducing sitting time might be an important aspect for active lifestyle promotion, especially among people with lower physical activity levels," emphasised Rezende. "In other words, reducing sitting time would help people increase their volumes of physical activity along the continuum to higher physical activity levels."

The public health burden of prolonged sitting is real. Accounting for 3.8% of all-cause mortality in this study, sitting is shortening the lives of people across the world. "The present findings support the importance of promoting active lifestyles (more physical activity and less sitting) as an important aspect for premature mortality prevention worldwide, and therefore the need for global action to reduce this risk factor."

Change by the Bundle: Study Shows People are Capable of Multiple, Simultaneous Life Changes

Let's say you've decided to make some changes in your life. You're out of shape, your mind wanders, your self-esteem is wavering, and you have no idea what you just read. So you decide to focus on one thing— losing weight, maybe— and tackle the other issues later. You don't want to take on too much at once, right?

A new paper by researchers at UC Santa Barbara, however, suggests you're selling yourself short. "Pushing the Limits: Cognitive, Affective and Neural Plasticity Revealed by an Intensive Multifaceted Intervention," published this week in *Frontiers in Human Neuroscience*, strongly suggests that we have seriously underestimated our ability to change our lives for the better.

Michael Mrazek, director of research at UCSB's Center for Mindfulness and Human

Potential and lead author of the paper, said the six-week study from which the paper is drawn demonstrates that simultaneous and significant improvement across a broad range of mental and physical functions is possible. Participants in the intervention all showed dramatic improvements in more than a dozen different outcomes, including strength, endurance, flexibility, working memory, standardised test performance, focus, mood, self-esteem, mindfulness and life satisfaction.

"Part of what distinguishes this work is finding such broad improvements across so many different domains, particularly given that the effect sizes were so large," Mrazek explained. Large effect sizes signify that the results were not only statistically significant but also indicative of substantial changes. "Many of these effects were very large— larger than you tend to find in studies that focus on changing only one thing."

In the study, 31 college students were recruited for an intensive lifestyle change programme; 15 participated in the intervention and 16 were in the waitlist control group. Those in the intervention put in five hours a day each weekday for six weeks. They did 2.5 hours of physical exercise (including yoga and Pilates), one hour of mindfulness practice and 1.5 hours of lecture or discussion on topics such as sleep, nutrition, exercise, mindfulness, compassion, relationships or well being. They were advised to limit alcohol consumption to one drink a day, eat a diet of mostly whole foods and sleep 8-10 hours a day.

Throughout the study, the participants were tested on a variety of factors, including physical fitness, cholesterol and triglyceride levels, working memory capacity, reading comprehension and more. They also underwent Magnetic Resonance Imaging (MRI) of their brains to examine areas known to be associated with a range of cognitive functions.

"The neuroimaging findings help us understand and contextualise the other significant results," Mrazek explained. "For instance, participants made dramatic improvements in their mindfulness, their reading comprehension, their working memory capacity. So we look to the neuroimaging data to understand what's happening in the communication between brain networks that's allowing for these changes."

Overall, the results were clear and striking, Mrazek said. Even six weeks after the intervention, participants continued to show improvement in all areas. "We predicted that the intervention would lead to substantial improvements in health, cognitive abilities and well-being, but we didn't know how long they would last. It seemed possible that some of the benefits wouldn't extend beyond the training. So I was surprised that even without any contact and support, participants maintained significant improvements at the six-week follow up."

Determining exactly why all these changes were possible will require future study, Mrazek noted, but he suspects that a comprehensive approach allows each area of improvement to reinforce the others. "Recent research suggests it's often more effective to make two or more changes simultaneously, especially when those changes reinforce one another. It's easier to drink less coffee if at the same time you get more sleep. Our intervention extended this logic by helping people make progress in many ways, which

can create an upward spiral where one success supports the next," he said.

Mrazek said conventional thinking about changing one's behaviour focuses on working on one thing at a time. This is also the way most science is done— manipulating just one thing and observing the effect. He and his team, however, decided to try a fresh approach. "It occurred to us that real changes in people's lives don't occur in a vacuum. We wanted to see how much change is possible if you help someone improve all these dimensions of their life simultaneously."

The study could have wide applications beyond the college campus, Mrazek noted. Although the subjects were college students, they weren't extraordinary in any way. "People showed up with all sort of different challenges, including in some cases mental illness and physical limitations. These were just college students, some of whom were doing great and others who were really struggling," he said. "More research is necessary to know if these results generalise to other populations, but there may eventually be opportunities for similarly modelled programmes to be integrated into education, medicine, or social services."

Students in K-12 schools might particularly benefit from programmes similar to the study's intervention, Mrazek said. "Many students spend nearly all day in school for 10 or more years of their lives," he observed. "Our intervention was fairly intensive in spending six weeks with these participants, but that's nothing in comparison to how much time kids spend in school. If future research can show similar benefits among middle school or high school students, then multifaceted programmes like ours could help schools advance their priorities of improving both academic achievement and student well-being."

At the other end of the age spectrum, new retirees might also benefit from a programme to kick-start the next phase of their lives, Mrazek said. "My intuition is that these things can be very helpful at any age," he said. "I think there's a big opportunity for people who are finishing up their careers and hopefully have decades of life still to enjoy. They have time, wisdom and in some cases resources to contribute to the world. Could something like this help them avoid cognitive decline and find an exciting new way forward as they transition into a later stage in their lives? I think it might, and that's something we would like to assess in future research."

Jonathan Schooler, senior author on the paper and a professor in the Department of Psychological and Brain Sciences and director of the Center for Mindfulness and Human Potential, also observed that the research has both scientific and societal relevance. "This work advances society in demonstrating a straightforward route toward realizing people's full potential, and science in elucidating the brain mechanisms that may underpin such gains," he said.

Ultimately, Mrazek said, he'd like the study to be a source of optimism. "I hope this research raises a sense of possibility, and maybe even sense of expectation, about what is possible for someone who wants to improve his or her life," he said. But he also doesn't think we have all the

answers yet. "As encouraging as these results are, I think this is only a preview of what will ultimately be achieved through future interventions that draw on continual advances in science and technology," he said. "The true limits of how much a person can change is a mostly unexplored frontier of scientific understanding."

Smartphones could improve Skin Cancer Detection in Developing Countries

With the help of a smartphone microscope, UTHealth's Richard Jahan-Tigh, MD, was able to detect non-melanoma skin cancer about 90 per cent of the time.

Credit: The University of Texas Health Science Center at Houston (UTHealth)

Everyone knows smartphones can be used as calendars, calculators, radios and cameras. But, did you know they can also be used as microscopes that have the potential to save lives?

They are called smartphone microscopes and dermatologists at the University of Texas Health Science Center at Houston (UTHealth) think these devices could improve the detection of skin cancer in developing countries.

"Doctors in some remote areas don't have access to the high-powered microscopes we use to evaluate skin samples," said Richard Jahan-Tigh, MD, Assistant Professor of Dermatology at John P. and Kathrine G. McGovern Medical School at UTHealth. "Doctors there could conceivably use their smartphones to photograph growths and forward them for examination."

When it comes to the diagnosis of cancer, smartphone microscopes are reasonably accurate, according to a study conducted by Jahan-Tigh and colleagues at McGovern Medical School and Harvard Medical School. Findings appear in the *Archives of Pathology & Laboratory Medicine*.

"We did a head-to-head comparison with a traditional light microscope and while the smartphone microscope wasn't as accurate it resulted in the detection of about 90 per cent of the non-melanoma skin cancers," said Jahan-Tigh, the paper's lead author. "With the smartphone microscope, the detection rate for melanomas was 60 per cent."

The incidence of both non-melanoma and melanoma skin cancers has been increasing in recent decades, the World Health Organisation reports. Between two and three million non-melanoma skin cancers and 132,000 melanoma skin cancers occur globally each year.

"This is a good first step to show that smartphone microscopy has a future in dermatology and pathology," Jahan-Tigh said.

A smartphone microscope can be made with a 3 mm ball lens, a tiny piece of plastic to hold the ball lens over the smartphone lens and tape to grip everything in place. A ball lens costs about $14 at an electronics store and is typically used for laser optics.

Here is how a smartphone microscope works. A doctor or technician holds a smartphone microscope over a skin sample that has been placed on a slide and waits for the sample to come into focus. The doctor then either reads the sample if he or she is a pathologist, or takes a photo and emails it to a pathologist for its interpretation.

Researchers examined 1,021 slides of specimens, which had a total of 136 basal cell carcinomas, 94 squamous cell carcinomas and 15 melanomas. The smartphone microscope was used to pick up 95.6 per cent of the basal cell carcinomas and 89 per cent of squamous cell carcinomas.

Jahan-Tigh said additional studies are needed to enhance the detection rate.

Jahan-Tigh used a smartphone microscope to evaluate the specimens and the conventional microscope was operated by Ronald Rapini, MD, chairman of the Department of Dermatology, Marvin E. Chernosky, MD, Endowed Distinguished Chair in Dermatology and Josey, Professor in Dermatology with McGovern Medical School.

Both men are dermatologists and dermatopathologists, which means that in addition to being able to screen patients for skin cancer they can examine biopsied tissue to determine if it cancerous.

Rapini was the paper's senior author and Garrett M. Chinn, MD, of Harvard, a co-author.

In their conclusion, the authors wrote that mobile phone-based microscopy has excellent performance characteristics for the inexpensive diagnosis of non-melanoma skin cancers in a setting where a traditional microscope is not available.

"This is just the tip of the iceberg," Jahan-Tigh said.

Detecting Radioactive Material from a Remote Distance

Researchers have proposed a new way to detect radioactive material using two co-located laser beams that interact with elevated levels of oxygen ions near a gamma-ray emitting source.

Credit: Joshua Isaacs, et al/ University of Maryland

In 2004 British national Dhiren Barot was arrested for conspiring to commit a public nuisance by the use of radioactive materials, among other charges. Authorities claimed that Barot had researched the production of "dirty bombs," and planned to detonate them in New York City, Washington DC, and other cities. A dirty bomb combines conventional explosives with radioactive material.

Although Barot did not build the bombs, national security experts believe terrorists continue to be interested in such devices for terror plots. Now researchers from the University of Maryland have proposed a new technique to remotely detect the radioactive materials in dirty bombs or other sources. They describe the method in a paper in the journal *Physics of Plasmas*, from AIP Publishing.

While the explosion of a dirty bomb would likely cause more damage than the radioactive substances it spreads, the bombs could create fear and panic, contaminate property, and require potentially costly cleanup, according to the US Nuclear Regulatory Commission.

Radioactive materials are routinely used at hospitals for diagnosing and treating diseases, at construction sites for inspecting welding seams, and in research facilities. Cobalt-60, for example, is used to sterilize medical equipment, produce radiation for cancer treatment,

and preserve food, among many other applications. In 2013 thieves in Mexico stole a shipment of cobalt-60 pellets used in hospital radiotherapy machines, although the shipment was later recovered intact.

Cobalt-60 and many other radioactive elements emit highly energetic gamma rays when they decay. The gamma rays strip electrons from the molecules in the surrounding air, and the resulting free electrons lose energy and readily attach to oxygen molecules to create elevated levels of negatively charged oxygen ions around the radioactive materials.

It is the increased ion density that the University of Maryland researchers aim to detect with their new method. They calculate that a low-power laser aimed near the radioactive material could free electrons from the oxygen ions. A second, high-power laser could energize the electrons and start a cascading breakdown of the air. When the breakdown process reaches a certain critical point, the high-power laser light is reflected back. The more radioactive material in the vicinity, the more quickly the critical point is reached.

"We calculate we could easily detect 10 milligrams [of cobalt-60] with a laser aimed within half a metre from an unshielded source, which is a fraction of what might go into a dirty bomb", said Joshua Isaacs, first author on the paper and a graduate student working with University of Maryland physics and engineering professors Phillip Sprangle and Howard Milchberg. Lead could shield radioactive substances, but most ordinary materials like walls or glass do not stop gamma rays.

The lasers themselves could be located up to a few hundred metres away from the radioactive source, Isaacs said, as long as line-of-sight was maintained and the air was not too turbulent or polluted with aerosols. He estimated that the entire device, when built, could be transported by truck through city streets or past shipping containers in ports. It could also help police or security officials detect radiation without being too close to a potentially dangerous gamma ray emitter.

The proposed remote radiation detection method is not the first, but it has advantages over other approaches. For example, terahertz radiation has also been proposed as a way to breakdown air in the vicinity of radioactive materials, but producing terahertz radiation requires complicated and costly equipment. Another proposed method would use a high-power infrared laser to both strip electrons and break down the air, but the method requires the detector be located in the opposite direction of the laser, which would make it impractical to create a single, mobile device.

So far the researchers at the University of Maryland have analyzed the feasibility of the new approach and experiments are underway to test it in the lab.

Isaacs said it would be difficult to estimate when a detection device based on the new method might be commercialised, but he didn't foresee a specific manufacturing challenge that would stand in its way.

"We specifically chose well developed technology for each component of the proposed system," he said.

Scientists Part the Clouds on How Droplets Form

Cloud droplets form when the amount of water vapor reaches a threshold value. Larger cloud droplets form when organic molecules (in red) are present on the surface instead of dissolving in the interior, or bulk, of the droplet.

Credit: James Davies, Berkeley Lab

There is enough known about cloud formation that replicating its mechanism has become a staple of the school science project scene. But a new study by scientists at the US Department of Energy's Lawrence Berkeley National Laboratory (Berkeley Lab) reveals that much more is going on at the microscopic level of cloud formation than previously thought.

The scientists determined that organic molecules effectively depressed the surface tension of the water, allowing for more efficient formation of bigger cloud droplets.

"Conventional wisdom says that the water solubility of the aerosol is the key factor in the formation of cloud droplets," said study senior author Kevin Wilson, the deputy director of science at Berkeley Lab's Chemical Sciences Division. "The more easily a particle dissolves in water, the easier it is for a cloud droplet to form. What we're finding is that relying upon solubility alone doesn't always work. Our study suggests that what the aerosol is doing at the interface with water is what matters in accurately predicting whether it will go on to form cloud droplets."

The findings, to be published in the March 25 issue of the journal *Science*, could improve the accuracy of climate change models that predict the potential cooling effect of reflective clouds based upon the particles in the air.

"Accurately describing the connection between the chemistry of aerosol particles and the formation of cloud droplets remains difficult, and it is a key challenge for models to correctly predict climate," said Wilson.

Wilson worked with study lead author Christopher Ruehl, who did the research while he was a postdoctoral scholar; and co-author James Davies, a current postdoctoral scholar at Berkeley Lab.

The devil's in the details

The current understanding of how cloud droplets form involves water vapor that encounters cooler air, often at higher altitudes and lower pressure. The vapor then condenses into small droplets of water or ice crystals that comprise clouds.

But the real catalyst in this process is the condensation of water on aerosol particles. These particles, known as cloud condensation nuclei, seed the formation of the cloud droplets. The details surrounding this microphysical process remain unclear, but the belief took hold among many atmospheric scientists and meteorologists that the main factor of significance when cloud droplets formed was the solubility of the aerosol.

These microscopic interactions could have macroscopic effects. The size of the droplets in a cloud affects its brightness. The smaller

and more numerous the droplets, the more light gets scattered. Reflecting more light has the effect of cooling earth's surface.

Certain inorganic particles, like sea salt, dissolve easily in water, but the atmosphere is typically a complex mixture of organic and inorganic aerosols. Sources of organic aerosols include diesel and gasoline emissions, forests, wildfires and even algal blooms in the ocean.

To account for this mix of particles, the Berkeley Lab researchers conducted experiments using custom-built equipment to model cloud droplet formation. They used dicarboxylic acids, a type of organic compound, and ammonium sulfate, an inorganic salt. They measured the size of the droplets formed when the particles were exposed to water vapor under typical cloud-forming conditions.

"We were finding that the cloud droplets were 50 to 60 per cent larger than predicted using standard models that relied upon how easily the particles could dissolve," said Ruehl, who is now an engineer studying vehicle emissions at the California Air Resources Board. "That's when we realised something else was going on, so we created a new model."

By factoring in the effects of surface tension depression, the researchers were able to correctly predict the size of the droplets formed.

"The role of inorganic and organic aerosols in cloud formation has been a highly contentious issue that's been argued about for many years," said Wilson. "Based on the paper's findings, I would say that these surface interactions play a central role in cloud droplet formation, and that they should be considered in climate models."

Embryo Development: Some Cells are more Equal than others even at Four-cell Stage

This is a four-cell stage embryo.

Credit: Zernicka-Goetz Lab, University of Cambridge

Genetic 'signatures' of early-stage embryos confirm that our development begins to take shape as early as the second day after conception, when we are a mere four cells in size, according to new research led by the University of Cambridge and EMBL-EBI. Although they seem to be identical, the cells of the two day-old embryo are already beginning to display subtle differences.

Once an egg has been fertilised by a sperm, it divides several times, becoming a large free-floating ball of stem cells. At first, these stem cells are 'totipotent', the state at which a stem cell can divide and grow and produce everything— every single cell of the whole body and the placenta, to attach the embryo to the mother's womb. The stem cells then change to a 'pluripotent' state, in which their development is restricted to generating the cells of the whole body, but not the placenta. However, the point during development at which cells begin to show a preference for becoming a specific cell type is unclear.

Now, in a study published in the journal *Cell*, scientists at the University of Cambridge and the European Bioinformatics Institute (EMBL-EBI) suggests that as early as the four-cell embryo stage, the cells are indeed different.

The researchers used the latest sequencing technologies to model embryo development in mice, looking at the activity of individual genes at a single cell level. They showed that some genes in each of the four cells behaved differently. The activity of one gene in particular, Sox21, differed the most between cells; this gene forms part of the 'pluripotency network'. The team found when this gene's activity was reduced, the activity of a master regulator that directs cells to develop into the placenta increased.

"We know that life starts when a sperm fertilises an egg, but we're interested in when the important decisions that determine our future development occur," says Professor Magdalena Zernicka-Goetz from the Department of Physiology, Development and Neuroscience at the University of Cambridge. "We now know that even as early as the four-stage embryo— just two days after fertilisation— the embryo is being guided in a particular direction and its cells are no longer identical."

Dr John Marioni of EMBL-EBI, the Wellcome Trust Sanger Institute and the Cancer Research UK Cambridge Institute, adds: "We can make use of powerful sequencing tools to deepen our understanding of the molecular mechanisms that drive development in individual cells. Because of these high-resolution techniques, we are now able to see the genetic and epigenetic signatures that indicate the direction in which early embryonic cells will tend to travel."

Source : Science Daily Online