SCIENCE NEWS

Sweet Smell of Success: Simple Fragrance Method Produces Major Memory Boost

Date: 1 August 2023

Source: University of California, Irvine

Summary: When a fragrance wafted through the bedrooms of older adults for two hours every night for six months, memories skyrocketed. Participants in this study by University of California, Irvine neuroscientists reaped a 226 per cent increase in cognitive capacity compared to the control group. The researchers say the finding transforms the long-known tie between smell and memory into an easy, non-invasive technique for strengthening memory and potentially deterring dementia.

The team's study appears in Frontiers in Neuroscience.

The project was conducted through the UCI Center for the Neurobiology of Learning and Memory. It involved men and women aged 60 to 85 without memory impairment. All were given a diffuser and seven cartridges, each containing a single and different natural oil. People in the enriched group received full-strength cartridges. Control group participants were given the oils in tiny amounts. Participants put a different cartridge into their diffuser each evening prior to going to bed, and it activated for two hours as they slept. People in the enriched group showed a 226 per cent increase in cognitive performance compared to the control group, as measured by a word list test commonly used to evaluate memory. Imaging revealed better integrity in the brain pathway called the left uncinate fasciculus. This pathway, which connects the medial temporal lobe to the decision-making prefrontal cortex, becomes less robust with age. Participants also reported sleeping more soundly.

Scientists have long known that the loss of olfactory capacity or ability to smell, can predict development of nearly 70 neurological and psychiatric diseases. These include Alzheimer's and other dementias, Parkinson's disease , schizophrenia and alcoholism. Evidence is emerging about a link between smell loss

due to COVID and ensuing cognitive decrease. Researchers have previously found that exposing people with moderate dementia to up to 40 different odors twice a day over a period of time boosted their memories and language skills, eased depression and improved their olfactory capacities. The UCI team decided to try turning this knowledge into an easy and non-invasive dementia-fighting tool.

"The reality is that over the age of 60, the olfactory sense and cognition starts to fall off a cliff," said Michael Leon, Professor of neurobiology and behaviour and a CNLM fellow, "But it's not realistic to think people with cognitive impairment could open, sniff and close 80 odorant bottles daily. This would be difficult even for those without dementia." The study's first author, project scientist Cynthia Woo, said, "That's why we reduced the number of scents to just seven, exposing participants to just one each time, rather than the multiple aromas used simultaneously in previous research projects. By making it possible for people to experience the odors while sleeping, we eliminated the need to set aside time for this during waking hours every day."

The researchers say the results from their study bear out what scientists learned about the connection between smell and memory.

"The olfactory sense has the special privilege of being directly connected to the brain's memory circuits," said Michael Yassa, Professor and James L. McGaugh Chair in the Neurobiology of Learning and Memory. The Director of CNLM, he served as collaborating investigator, "All the other senses are routed first through the thalamus. Everyone has experienced how powerful aromas are in evoking recollections, even from very long ago. However, unlike with vision changes that we treat with glasses and hearing aids for hearing impairment, there has been no intervention for the loss of smell."

The team would next like to study the technique's impact on people with diagnosed cognitive loss. The researchers also say they hope the finding will lead to more investigations into olfactory therapies for memory impairment. A product based on their study and designed for people to use at home is expected to come onto the market this fall.

Global Diet Study Challenges Advice to Limit High-Fat Dairy Foods

Date: 6 July 2023

Source: European Society of Cardiology

Summary: Unprocessed red meat and whole grains can be included or left out of a healthy diet, according to a study conducted in 80 countries across all inhabited continents. Diets emphasising fruit, vegetables, dairy (mainly whole-fat), nuts, legumes and fish were linked with a lower risk of Cardiovascular Disease (CVD) and premature death in all world regions. The addition of unprocessed red meat or whole grains had little impact on outcomes.

"Low-fat foods have taken centre stage with the public, food industry and policy makers, with nutrition labels focused on reducing fat and saturated fat," said study author Dr. Andrew Mente of the Population Health Research Institute, McMaster University, Hamilton, Canada. "Our findings suggest that the priority should be increasing protective foods such as nuts (often avoided as too

energy dense), fish and dairy, rather than restricting dairy (especially whole-fat) to very low amounts. Our results show that up to two servings a day of dairy, mainly whole-fat, can be included in a healthy diet. This is in keeping with modern nutrition science showing that dairy, particularly whole-fat, may protect against high blood pressure and metabolic syndrome." The study examined the relationships between a new diet score and health outcomes in a global population. A healthy diet score was created based on six foods that have each been linked with longevity. The PURE diet included 2–3 servings of fruit per day, 2–3 servings of vegetables per day, 3–4 servings of legumes per week, 7 servings of nuts per week, 2–3 servings of fish per week, and 14 servings of dairy products (mainly whole fat but not including butter or whipped cream) per week. A score of 1 (healthy) was assigned for intake above the median in the group and a score of 0 (unhealthy) for intake at or below the median, for a total of 0 to 6. Dr. Mente explained, "Participants in the top 50 per cent of the population — an achievable level — on each of the six food components attained the maximum diet score of six."

Associations of the score with mortality, myocardial infarction, stroke and total CVD (including fatal CVD and non-fatal myocardial infarction, stroke and heart failure) were tested in the PURE study which included 147,642 people from the general population in 21 countries. The analyses were adjusted for factors that could influence the relationships such as age, sex, waist-to-hip ratio, education level, income, urban or rural location, physical activity, smoking status, diabetes, use of statins or high blood pressure medications, and total energy intake.

The average diet score was 2.95. During a median follow-up of 9.3 years, there were 15,707 deaths and 40,764 cardiovascular events. Compared with the least healthy diet (score of 1 or less), the healthiest diet (score of 5 or more) was linked with a 30 per cent lower risk of death, 18 per cent lower likelihood of CVD, 14 per cent lower risk of myocardial infarction and 19 per cent lower risk of stroke. Associations between the healthy diet score and outcomes were confirmed in five independent studies including a total of 96,955 patients with CVD in 70 countries.

Dr. Mente said: "This was by far the most diverse study of nutrition and health outcomes in the world and the only one with sufficient representation from high-, middle- and low-income countries. The connection between the PURE diet and health outcomes was found in generally healthy people, patients with CVD, patients with diabetes and across economies."

"The associations were strongest in areas with the poorest quality diet, including South Asia, China and Africa, where calorie intake was low and dominated by refined carbohydrates. This suggests that a large proportion of deaths and CVD in adults around the world may be due to under-nutrition, that is, low intakes of energy and protective foods, rather than over nutrition. This challenges current beliefs," said Professor Salim Yusuf, senior author and principal investigator of PURE.

In an accompanying editorial, Dr. Dariush Mozaffarian of the Friedman School of Nutrition Science and Policy, Tufts University, Boston, US stated, "The new results in PURE, in combination with prior reports, call for a

re-evaluation of unrelenting guidelines to avoid whole fat dairy products. Investigations such as the one by Mente and colleagues remind us of the continuing and devastating rise in diet-related chronic diseases globally and of the power of protective foods to help address these burdens. It is time for national nutrition guidelines, private sector innovations, government tax policy and agricultural incentives, food procurement policies, labelling and other regulatory priorities, and food-based healthcare interventions to catch up to the science. Millions of lives depend on it."

For Experimental Physicists, Quantum Frustration Leads to Fundamental Discovery

Date: 14 June 2023

Source: University of Massachusetts, Amherst

Summary: A team of physicists, including University of Massachusetts, Assistant Professor Tigran Sedrakyan, recently announced in the journal *Nature* that they have discovered a new phase of matter called the 'chiral bose-liquid state,' the discovery opens a new path in the age-old effort to understand the nature of the physical world. Under everyday conditions, matter can be a solid, liquid or gas. But once you venture beyond the everyday into temperatures approaching absolute zero, things smaller than a fraction of an atom or which have extremely low states of energy—the world looks very different. "You find quantum states of matter way out on these fringes," says Sedrakyan, "and they are much wilder than the three classical states we encounter in our everyday lives." Sedrakyan has spent years exploring these wild quantum states, and he is particularly interested in the possibility of what physicists call 'band degeneracy,' 'moat bands' or 'kinetic frustration' in strongly interacting quantum matter. Typically, particles in any system bump into each other, and in so doing they cause predictable effects, like billiard balls knocking into each other and then reacting in a predictable pattern. In other words, the effects and the particles are correlated. But in a frustrated quantum system, there are infinite possibilities that stem from the interaction of particles perhaps the billiard ball levitates or zooms off at an impossible angle and some of these infinite possibilities can lead to novel quantum states. What Sedrakyan and his colleagues have done is to engineer a frustration machine: a bilayer semiconducting device. The top layer is electron-rich and these electrons can move freely. The bottom layer is filled with 'holes,' or places that a roving electron can occupy. Then the two layers are brought extremely close together—interatomic close. If the number of electrons in the top layer and holes in the bottom layer were equal, then you would expect to see the particles acting in a correlated manner, but Sedrakyan and his colleagues designed the bottom layer so that there is a local imbalance between the number of electrons and holes in the bottom layer. "It's like a game of musical chairs," Sedrakyan says, "designed to frustrate the electrons. Instead of each electron having one chair to go to, they must now scramble and have many possibilities in where they 'sit'."This frustration kicks off the novel chiral edge state, which has a number of surprising characteristics. For instance, if you cool quantum matter in a chiral state down to absolute zero, the electrons freeze into a predictable pattern, and the emergent

charge-neutral particles in this state will all either spin clockwise or counter-clockwise. Even if you smash another particle into one of these electrons or you introduce a magnetic field, you can't alter its spin—it's surprisingly robust and can even be used to encode digital data in a fault-tolerant way.

Even more surprisingly is what happens when an outside particle does smash into one of the particles in the chiral edge state. To return to the billiard ball metaphor, you would expect to send the eight-ball flying when the cue ball smacks into it. But if the pool balls were in a chiral bose-liquid state, all 15 of them would react in exactly the same way when the eight-ball was struck. This effect is due to the long-range entanglement present in this quantum system.

It is difficult to observe the chiral bose-liquid state, which is why it has remained hidden for so long. To do so, the team of scientists, including theoretical physicists Rui Wang and Baigeng Wang (both of Nanjing University) as well as experimental physicists Lingjie Du (Nanjing University) and Rui-Rui Du (Peking University) designed a theory and an experiment that used an extremely strong magnetic field that is capable of measuring the movements of the electrons as they race for chairs.

"On the edge of the semiconductor bilayer, electrons and holes move with the same velocities," says Lingjie Du, "This leads to helical-like transport, which can be further modulated by external magnetic fields as the electron and hole channels are gradually separated under higher fields." The magneto-transport experiments therefore successfully reveal the first piece of evidence of the chiral bose-liquid, which the authors also call the 'excitonic topological order' in the published paper.

High-quality Sleep Promotes Resilience to Depression and Anxiety

Date: 13 July 2023

Source: University of York

Summary: Research has shown quality sleep can help bolster resilience to depression and anxiety. The study, led by researchers at the University of York, highlights that chronic stress is a major risk factor for a number of mental health disorders, including depression and pathological anxiety, but high-quality sleep and coping strategies—such as the ability to reframe a situation to see the positive side which can help to prevent poor mental health when faced with negative or stressful experiences. The research studied data from over 600 participants during the COVID-19 pandemic in 2020—an extended stressful period of time. They aimed to test the theory that coping strategies supported positive mental health outcomes, which could be strengthened by high-quality sleep.

Emma Sullivan, PhD student from the Department of Psychology at the University of York, said, "As the COVID-19 pandemic has been a prolonged period of stress for people across the entire world, it offered us with a unique context with which to address our research questions." This is the first study to investigate the ways in which positive coping strategies and sleep quality influence depression and anxiety when experiencing a real-world chronic stressor. We found that better sleep quality was associated with fewer symptoms of both depression and anxiety during the initial months of the COVID-19 pandemic. "These findings highlight the importance of targeting both positive coping strategies and sleep quality when enduring

periods of chronic stress." The team analysed data from the Boston College Daily Sleep and Well-being Survey where participants regularly self-reported their sleep quality and mental well-being during the pandemic. They also completed a baseline demographic survey to obtain information such as their age, gender and ethnicity. As well as collecting information on participants' sleep and mental well-being, the surveys also collected a wealth of additional information such as participants' alcohol consumption, their quarantine status and physical activity levels.

Dr Scott Cairney, PhD supervisor on the project from the Department of Psychology at the University of York, said, "We have known for a long time that high-quality sleep is associated with better health and well-being outcomes, but we wanted to know whether this would change if sleep and coping strategies were put under intense and prolonged periods of stress, as it was for so many during the pandemic."

"We found that sleep plays a hugely important role in the management of chronic stress and can sustain well-being over a long period of time, reducing symptoms of depression and anxiety."

Reinventing Cosmology: New Research Puts Age of Universe at 26.7 — Not 13.7 — Billion Years

Date: 11 July 2023

Source: University of Ottawa

Summary: Our universe could be twice as old as current estimates, according to a new study that challenges the dominant cosmological model and sheds new light on the so-called 'impossible early galaxy problem.' "Our newly-devised model stretches the galaxy formation time by a several billion years, making the universe 26.7 billion years old, and not 13.7 as previously estimated," says author Rajendra Gupta, adjunct professor of physics in the Faculty of Science at the University of Ottawa. For years, astronomers and physicists have calculated the age of our universe by measuring the time elapsed since the Big Bang and by studying the oldest stars based on the red-shift of light coming from distant galaxies. In 2021, thanks to new techniques and advances in technology, the age of our universe was thus estimated at 13.797 billion years using the Lambda-CDM concordance model. However, many scientists have been puzzled by the existence of stars like the Methuselah that appear to be older than the estimated age of our universe and by the discovery of early galaxies in an advanced state of evolution made possible by the James Webb Space Telescope. These galaxies, existing a mere 300 million years or so after the Big Bang, appear to have a level of maturity and mass typically associated with billions of years of cosmic evolution.

Furthermore, they're surprisingly small in size, adding another layer of mystery to the equation. Zwicky's tired light theory proposes that the red shift of light from distant galaxies is due to the gradual loss of energy by photons over vast cosmic distances. However, it was seen to conflict with observations. Yet Gupta found that, "by allowing this theory to coexist with the expanding universe, it becomes possible to reinterpret the red-shift as a hybrid phenomenon, rather than purely due to expansion."

In addition to Zwicky's tired light theory, Gupta introduces the idea of evolving "coupling

constants," as hypothesised by Paul Dirac. Coupling constants are fundamental physical constants that govern the interactions between particles. According to Dirac, these constants might have varied over time. By allowing them to evolve, the time-frame for the formation of early galaxies observed by the Webb telescope at high red-shifts can be extended from a few hundred million years to several billion years. This provides a more feasible explanation for the advanced level of development and mass observed in these ancient galaxies. Moreover, Gupta suggests that the traditional interpretation of the 'cosmological constant,' which represents dark energy responsible for the accelerating expansion of the universe, needs revision. Instead, he proposes a constant that accounts for the evolution of the coupling constants. This modification in the cosmological model helps address the puzzle of small galaxy sizes observed in the early universe, allowing for more accurate observations.

Greenhouse Gas Emissions at 'an All-time High' — And It is Causing an Unprecedented Rate of Global Warming, Say Scientists

Date: 8 June 2023

Source: University of Leeds

Summary: Human-induced warming, largely caused by the burning of fossil fuels, reached an average of 1.14°C for the most recent decade (2013 to 2022) above pre-industrial levels. This is up from 1.07°C between 2010 and 2019. Human-induced warming is now increasing at a pace of over 0.2°C per decade. The analysis also found that greenhouse gas emissions were 'at an all-time high', with human activity resulting in the equivalent of 54 (+/-5.3) giga tonnes (or billion metric tonnes) of carbon dioxide being released into the atmosphere on average every year over the last decade (2012–2021). Given the speed at which the global climate system is changing, the scientists argue that policymakers, climate negotiators and civil society groups need to have access to up-to-date and robust scientific evidence on which to base decisions.

The authoritative source of scientific information on the state of the climate is the UN's Intergovernmental Panel on Climate Change (IPCC) but the turnaround time for its major assessments is five or ten years, and that creates an 'information gap,' particularly when climate indicators are changing rapidly.

Critical decade for climate change

The Indicators of Global Climate Change Project is being co-ordinated by Professor Piers Forster, Director of the Priestley Centre for Climate Futures at Leeds. He said, "This is the critical decade for climate change. Decisions made now will have an impact on how much temperatures will rise and the degree and severity of impacts we will see as a result."

Long-term warming rates are currently at a long-term high, caused by highest-ever levels of greenhouse gas emissions. But there is evidence that the rate of increase in greenhouse gas emissions has slowed. We need to be nimble footed in the face of climate change. We need to change policy and approaches in the light of the latest evidence about the state of the climate system. Time is no longer on our side. Access to up-to-date information is vitally important.

Writing in the journal Earth System Science Data, the scientists have revealed how key indicators have changed since the publication of the IPCC's Sixth Assessment Working Group 1 report in 2021 which produced the key data that fed into the subsequent IPCC Sixth Synthesis Report.

What the updated indicators show

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There has been positive move away from burning coal, yet this has come at a short-term cost in that it has added to global warming by reducing particulate pollution in the air, which has a cooling effect.

'Indicators critical to address climate crisis'

Professor Maisa Rojas Corradi, Minister of the Environment in Chile, IPCC author and a scientist involved in this study, said, "An annual update of key indicators of global change is critical in helping the international community and countries to keep the urgency of addressing the climate crisis at the top of the agenda and for evidence-based decision-making.

"In line with the 'ratchet-mechanism' of increasing ambition envisioned by the Paris Agreement we need scientific information about emissions, concentration and temperature as often as possible to keep international climate negotiations up-to-date and to be able to adjust and if necessary correct national policies.

"In the case of Chile, we have a climate change law that aims at aligning government-wide policies with climate action."

Remaining carbon budget

One of the major findings of the analysis is the rate of decline in what is known as the remaining carbon budget, an estimate of how much carbon that can be released into the atmosphere to give a 50 per cent chance of keeping global temperature rise within 1.5°C.

In 2020, the IPCC calculated the remaining carbon budget was around 500 giga tonnes of carbon dioxide. By the start of 2023, the figure was roughly half that at around 250 giga tonnes of carbon dioxide.

The reduction in the estimated remaining carbon budget is due to a combination of continued emissions since 2020 and updated estimates of human-induced warming.

Professor Forster said, "Even though we are not yet at 1.5°C warming, the carbon budget will likely be exhausted in only a few years as we have a triple whammy of heating from very high CO_2 emissions, heating from increases in other GHG emissions and heating from reductions in pollution.

If we don't want to see the 1.5°C goal disappearing in our rear view mirror, the world must work much harder and urgently at bringing emissions down.

Our aim is for this project to help the key players urgently make that important work happen with up-to-date and timely data at their fingertips."

Dr. Valérie Masson-Delmotte, from the Université Paris Saclay who co-chaired Working Group 1 of the IPCC's Sixth Assessment report and was involved in the climate indicators project, said, "This robust update shows intensifying heating of our climate driven by human activities. It is a timely wake up call for the 2023 global stocktake of the Paris Agreement—the pace and scale of climate action is not sufficient to limit the escalation of climate-related risks."

As recent IPCC reports have conclusively shown, with every further increment of global warming, the frequency and intensity of climate extremes, including hot extremes, heavy rainfall and agricultural droughts, increases.

Evidence of Conscious-like Activity in the Dying Brain

Date: 1 May 2023

Source: Michigan Medicine, University of Michigan

Summary: A new study provides early evidence of a surge of activity correlated with consciousness in the dying brain.

Reports of near-death experiences—with tales of white light, visits from departed loved ones, hearing voices, among other attributes—capture our imagination and are deeply engrained in our cultural landscape.

The fact that these reports share so many common elements begs the question of whether there is something fundamentally real underpinning them and that those who have managed to survive death are providing glimpses of a consciousness that does not completely disappear, even after the heart stops beating. A new study published in the Proceedings of the National Academy of Science, provides early evidence of a surge of activity correlated with consciousness in the dying brain.

The study, led by Jimo Borjigin, Ph.D., associate professor in the Department of Molecular and Integrative Physiology, and the Department of Neurology and her team is a follow-up to animal studies conducted almost ten years ago in collaboration with George Mashour, M.D., Ph.D., the founding director of the Michigan Center for Consciousness Science.

Similar signatures of gamma activation were recorded in the dying brains of both animals and humans upon a loss of oxygen following cardiac arrest.

"How vivid experience can emerge from a dysfunctional brain during the process of dying is a neuroscientific paradox. Dr. Borjigin has led an important study that helps shed light on the underlying neurophysiologic mechanisms," said Mashour.

The team identified four patients who passed away due to cardiac arrest in the hospital while under EEG monitoring. All four of the patients were comatose and unresponsive. They were ultimately determined to be beyond medical help and with their families' permission, removed from life support.

Upon removal of ventilator support, two of the patients showed an increase in heart rate along with a surge of gamma wave activity,

considered the fastest brain activity and associated with consciousness. Furthermore, the activity was detected in the so-called hot zone of neural correlates of consciousness in the brain, the junction between the temporal, parietal and occipital lobes in the back of the brain. This area has been correlated with dreaming, visual hallucinations in epilepsy and altered states of consciousness in other brain studies.

These two patients had previous reports of seizures, but no seizures during the hour before their deaths, explained Nusha Mihaylova, M.D., Ph.D., a clinical associate professor in the Department of Neurology who has collaborated with Dr. Borjigin since 2015 by collecting EEG data from deceased patients under ICU care. The other two patients did not display the same increase in heart rate upon removal from life support nor did they have increased brain activity.

Because of the small sample size, the authors caution against making any global statements about the implications of the findings. They also note that it's impossible to know in this study what the patients experienced because they did not survive.

"We are unable to make correlations of the observed neural signatures of consciousness with a corresponding experience in the same patients in this study. However, the observed findings are definitely exciting and provide a new framework for our understanding of covert consciousness in the dying humans," she said.

Larger, multi-center studies including EEG-monitored ICU patients who survive cardiac arrest, could provide much needed data to determine whether or not these bursts in gamma activity are evidence of hidden consciousness even near death.

Researchers Identify 135 New Melanin Genes Responsible for Pigmentation

Date: 11 August 2023

Source: University of Oklahoma

Summary: The skin, hair and eye colour of more than eight billion humans is determined by the light-absorbing pigment known as melanin. An article recently published in the journal Science features research from Vivek Bajpai, Ph.D., lead author and an assistant professor in the School of Sustainable Chemical, Biological and Materials Engineering at the University of Oklahoma, and collaborators from Stanford University. Their research has identified 135 new genes associated with pigmentation.

Melanin is produced within special structures called melanosomes. Melanosomes are found inside melanin-producing pigment cells called melanocytes.

Although all humans have the same number of melanocytes, the amount of melanin they produce differs and gives rise to the variation in human skin color.

"To understand what actually causes different amounts of melanin to be produced, we used a technology called CRISPR-Cas9 to genetically engineer cells," Bajpai said. "Using CRISPR, we systematically removed more than 20,000 genes from hundreds of millions of melanocytes and observed the impact on melanin production."

To identify which genes influence melanin production, cells that lost melanin during the gene removal process needed to be separated from millions of other cells that did not.

Using in vitro cell cultures, Bajpai developed a novel method to achieve this goal that detects and quantifies the melanin-producing activity of melanocytes.

By passing light through the melanocytes, he could record if the light was either absorbed or scattered by the melanin inside.

"If there are a lot of melanin-producing melanosomes, the light will scatter much more than in cells with little melanin," Bajpai said.

"Using a process called side-scatter of flow cytometry, we were able to separate cells with more or less melanin. These separated cells were then analysed to determine the identity of melanin-modifying genes. We identified both new and previously known genes that play important roles in regulating melanin production in humans."

The researchers found 169 functionally diverse genes that impacted melanin production. Of those, 135 were not previously associated with pigmentation.

They further identified the function of two newly discovered genes: KLF6 and COMMD3.

The DNA-binding protein KLF6 led to a loss of melanin production in humans and animals, confirming the role KLF6 plays in melanin production in other species as well.

The COMMD3 protein regulated melanin synthesis by controlling the acidity of melanosomes.

Historically, darker pigmentation has been needed to protect against ultraviolet radiation in areas closer to the equator and for people who spend hours in direct sunlight. As humans moved into areas with less direct sunlight or fewer hours of daylight overall, less melanin was needed.

Over time, this resulted in melanosomes that produced less melanin, thus absorbing more sunlight.

"By understanding what regulates melanin, we can help protect lighter-skinned people from melanoma, or skin cancer," Bajpai said. By targeting these new melanin genes, we could also develop melanin-modifying drugs for vitiligo and other pigmentation diseases."

The technological processes developed and used by the research team could also be applied to identify genes that regulate melanin production in fungi and bacteria.

Melanin production in fungi and bacteria enables them to be more pathogenic to humans or crops. Researchers could develop effective interventions against these microbes and their diseases by discovering and targeting such melanin-producing genes.

Bajpai's role in the study was completed during his professorship at the University of Oklahoma. However, a portion of this research took place during his postdoctoral research fellowship at Stanford University. A grant from the Oklahoma Center for Adult Stem Cell Research supported the study. Additional funding was provided by the U.S. Department of Defense, CA160997; Howard Hughes Medical Institute; National Institute of General Medical Sciences, NIH R35 GM131757; Stinehart-Reed Award; and the Ludwig Center for Cancer Stem Cell Research and Medicine.

Scientists Slow Aging by Engineering Longevity in Cells

Date: 27 April 2023

Source: University of California, San Diego

Summary: Researchers have developed a biosynthetic 'clock' that keeps cells from reaching normal levels of deterioration related to aging. They engineered a gene oscillator that switches between the two normal paths of aging, slowing cell degeneration and setting a record for life extension. As described 28 April 2023 in Science, they have now extended this research using synthetic biology to engineer a solution that keeps cells from reaching their normal levels of deterioration associated with aging. Cells, including those of yeast, plants, animals and humans, all contain gene regulatory circuits that are responsible for many physiological functions, including aging.

"These gene circuits can operate like our home electric circuits that control devices like appliances and automobiles," said Professor Nan Hao of the School of Biological Sciences' Department of Molecular Biology, the senior author of the study and co-director of UC San Diego's Synthetic Biology Institute.

However, the UC San Diego group uncovered that, under the control of a central gene regulatory circuit, cells don't necessarily age the same way. Imagine a car that ages either as the engine deteriorates or as the transmission wears out, but not both at the same time. The UC San Diego team envisioned a 'smart aging process' that extends cellular longevity by cycling deterioration from one aging mechanism to another.

In the new study, the researchers genetically rewired the circuit that controls cell aging. From its normal role functioning like a toggle switch, they engineered a negative feedback loop to stall the aging process. The rewired circuit operates as a clock-like device, called a gene oscillator, that drives the cell to periodically switch between two detrimental 'aged' states, avoiding prolonged commitment to either and thereby slowing the cell's degeneration.

These advances resulted in a dramatically extended cellular lifespan, setting a new record for life extension through genetic and chemical interventions.

As electrical engineers often do, the researchers in this study first used computer simulations of how the core aging circuit operates. This helped them design and test ideas before building or modifying the circuit in the cell. This approach has advantages in saving time and resources to identify effective pro-longevity strategies, compared to more traditional genetic strategies.

"This is the first time computationally guided synthetic biology and engineering principles were used to rationally redesign gene circuits and reprogram the aging process to effectively promote longevity," said Hao.

Several years ago the multidisciplinary UC San Diego research team began studying the mechanisms behind cell aging, a complex biological process that underlies human longevity and many diseases. They discovered that cells follow a cascade of molecular changes through their entire lifespan until they eventually degenerate and die. But they noticed that cells of the same genetic material and within the same environment can travel along distinct aging routes. About half of the

cells age through a gradual decline in the stability of DNA, where genetic information is stored. The other half ages along a path tied to the decline of mitochondria, the energy production units of cells.

The new synthetic biology achievement has the potential to reconfigure scientific approaches to age delay. Distinct from numerous chemical and genetic attempts to force cells into artificial states of 'youth,' the new research provides evidence that slowing the ticks of the aging clock is possible by actively preventing cells from committing to a pre-destined path of decline and death, and the clock-like gene oscillators could be a universal system to achieve that.

"Our results establish a connection between gene network architecture and cellular longevity that could lead to rationally-designed gene circuits that slow aging," the researchers note in their study.

During their research, the team studied Saccharomyces cerevisiae yeast cells as a model for the aging of human cells. They developed and employed microfluidics and time-lapse microscopy to track the aging processes across the cell's lifespan.

In the current study, yeast cells that were synthetically rewired and aged under the direction of the synthetic oscillator device resulted in an 82 per cent increase in lifespan compared with control cells that aged under normal circumstances. The results revealed "the most pronounced lifespan extension in yeast that we have observed with genetic perturbations," they noted.

"Our oscillator cells live longer than any of the longest-lived strains previously identified by unbiased genetic screens," said Hao.

"Our work represents a proof-of-concept example, demonstrating the successful application of synthetic biology to reprogram the cellular aging process," the authors wrote, "and may lay the foundation for designing synthetic gene circuits to effectively promote longevity in more complex organisms."

The team is currently expanding their research to the aging of diverse human cell types, including stem cells and neurons.

Controlled Cruelty: New Study Finds Aggression can Arise from Successful Self-control

Date: 13 July 2023

Source: Virginia Commonwealth University

Summary: A new study by a Virginia Commonwealth University researcher has found that aggression is not always the product of poor self-control but, instead, often can be the product of successful self-control in order to inflict greater retribution.

The new paper, 'Aggression As Successful Self-Control,' by corresponding author David Chester, Ph.D., an associate professor of social psychology in the Department of Psychology at VCU's College of Humanities and Sciences, was published by the journal Social and Personality Psychology Compass and uses meta-analysis to summarise evidence from dozens of existing studies in psychology and neurology.

"Typically, people explain violence as the product of poor self-control," Chester said. "In the heat of the moment, we often fail to inhibit our worst, most aggressive impulses. But that is only one side of the story."

Indeed, Chester's study found that the most aggressive people do not have personalities characterized by poor self-discipline and that training programs that boost self-control have not proved effective in reducing violent tendencies. Instead, the study found ample evidence that aggression can arise from successful self-control.

"Vengeful people tend to exhibit greater premeditation of their behaviour and self-control, enabling them to delay the gratification of sweet revenge and bide their time to inflict maximum retribution upon those who they believe have wronged them," Chester said. "Even psychopathic people, who comprise the majority of people who commit violent offenses, often exhibit robust development of inhibitory self-control over their teenage years."

Aggressive behaviour is reliably linked to increased—not just decreased—activity in the brain's prefrontal cortex, a biological substrate of self-control, Chester found. The findings make it clear that the argument that aggression is primarily the product of poor self-control is weaker than previously thought.

"This paper pushes back against a decades-long dominant narrative in aggression research, which is that violence starts when self-control stops," Chester said. "Instead, it argues for a more balanced, nuanced view in which self-control can both constrain and facilitate aggression, depending on the person and the situation."

The findings also argue for more caution in the implementation of treatments, therapies and interventions that seek to reduce violence by improving self-control, Chester said.

"Many interventions seek to teach people to inhibit their impulses, but this new approach to aggression suggests that although this may reduce aggression for some people, it is also likely to increase aggression for others," he said. "Indeed, we may be teaching some people how best to implement their aggressive tendencies."

The findings surprised Chester, a psychologist whose team frequently studies the causes of human aggression.

"Over the years, much of our research was guided by the field's assumption that aggression is an impulsive behaviour characterized by poor self-control," he said. "But as we started to investigate the psychological characteristics of vengeful and psychopathic people, we quickly realised that such aggressive individuals do not just have self-regulatory deficits; they have many psychological adaptations and skills that enable them to hurt others by using self-control."

Chester and his team plan to continue exploring questions around aggression and self-control based on the study's findings.

"Our research going forward is now guided by this new paradigm shift in thinking: that aggression is often the product of sophisticated and complex mental processes and not just uninhibited impulses," Chester said.

This research was supported by a grant from the National Institute on Alcohol Abuse and Alcoholism, part of the National Institutes of Health.

Decoding How Molecules 'Talk' to Each Other to Develop New Nano-Technologies

Date: 15 August 2023

Source: University of Montreal

Summary: Scientists recreate and compare molecular languages at the origin of life—opening new doors for the development of novel nano-technologies.

Two molecular languages at the origin of life have been successfully recreated and mathematically validated, thanks to pioneering work by Canadian scientists at Université de Montréal.

Published this week in the Journal of American Chemical Society, the breakthrough opens new doors for the development of nano-technologies with applications ranging from bio-sensing, drug delivery and molecular imaging.

Living organisms are made up of billions of nano-machines and nano-structures that communicate to create higher-order entities able to do many essential things such as moving, thinking, surviving and reproducing.

"The key to life's emergence relies on the development of molecular languages—also called signalling mechanisms—which ensure that all molecules in living organisms are working together to achieve specific tasks," said the study' s principal investigator, UdeM bioengineering professor Alexis Vallée-Bélisle.

In yeasts, for example, upon detecting and binding a mating pheromone, billions of molecules will communicate and coordinate their activities to initiate union, said Vallée-Bélisle, holder of a Canada Research Chair in Bioengineering and Bionano-technology.

"As we enter the era of nanotechnology, many scientists believe that the key to designing and programming more complex and useful artificial nano-systems relies on our ability to understand and better employ molecular languages developed by living organisms," he said.

Two types of languages

One well-known molecular language is allostery. The mechanism of this language is 'lock-and-key': a molecule binds and modifies the structure of another molecule, directing it to trigger or inhibit an activity.

Another, lesser-known molecular language is multi-valency also known as the chelate effect. It works like a puzzle: as one molecule binds to another, it facilitates (or not) the binding of a third molecule by simply increasing its binding interface.

Although these two languages are observed in all molecular systems of all living organisms, it is only recently that scientists have started to understand their rules and principles—and so use these languages to design and program novel artificial nano-technologies.

"Given the complexity of natural nano-systems, before now nobody was able to compare the basic rules, advantage or limitations of these two languages on the same system," said Vallée-Bélisle.

To do so, his doctoral student Dominic Lauzon, first author of the study, had the idea of creating a DNA-based molecular system that could function using both languages.

"DNA is like Lego bricks for nano-engineers," said Lauzon. "It's a remarkable molecule that offers simple, programmable and easy-to-use chemistry."

Simple mathematical equations to detect antibodies

The researchers found that simple mathematical equations could well describe both languages, which unravelled the parameters and design rules to program the communication between molecules within a nano-system.

For example, while the multivalent language enabled control of both the sensitivity and cooperativity of the activation or deactivation of the molecules, the corresponding allosteric translation only enabled control of the sensitivity of the response.

With this new understanding at hand, the researchers used the language of multi-valency to design and engineer a programmable antibody sensor that allows the detection of antibodies over different ranges of concentration.

"As shown with the recent pandemic, our ability to precisely monitor the concentration of antibodies in the general population is a powerful tool to determine the people's individual and collective immunity," said Vallée-Bélisle.

In addition to expanding the synthetic toolbox to create the next generation of nano-technology, the scientist's discovery also shines a light on why some natural nano-systems may have selected one language over another to communicate chemical information.

Gravitational Waves from Colossal Black Holes Found Using 'Cosmic Clocks'

Date: 29 June 2023

Source: National Science Foundation

Summary: You can't see or feel it, but everything around you, including your own body, is slowly shrinking and expanding. It's the weird, spacetime-warping effect of gravitational waves passing through our galaxy. New results are the first evidence of the gravitational wave background—a sort of soup of spacetime distortions pervading the entire universe and long predicted to exist by scientists.

The findings published today in The Astrophysical Journal Letters are from the North American Nanohertz Observatory for Gravitational Waves (NANOGrav), a collaborative team of researchers from more than 50 institutions in the U.S. and abroad. The team conducted an analysis of burned-out stars known as millisecond pulsars, which rotate hundreds of times per second and emit radio pulses like ticks from highly accurate cosmic clocks. The team discovered what appeared to be variations in the 'ticking rate' of such pulsars by comparing observations of more than 60 pulsars within radio telescope data spanning 15 years. Their analysis provides evidence that the variations are caused by low-frequency gravitational waves which are distorting the fabric of physical reality known as spacetime.

According to the NANOGrav team's findings, the spatial distortion from the gravitational waves creates the appearance that the pulsars' radio-signal ticking rates are

changing. But really, it's the stretching and squeezing of space between Earth and the pulsars which causes their radio pulses to arrive at Earth billionths of seconds earlier or later than expected. The results are the first evidence of the gravitational wave background—a sort of soup of spacetime distortions pervading the entire universe and long predicted to exist by scientists.

"The NSF NANOGrav team created, in essence, a galaxy-wide detector revealing the gravitational waves that permeate our universe," said NSF Director Sethuraman Panchanathan. "The collaboration involving research institutions across the U.S. shows that world-class scientific innovation can, should and does reach every part of our nation."

Gravitational waves were first predicted by Albert Einstein in 1916. They would not be confirmed until 2015, when the Laser Interferometer Gravitational-Wave Observatory (LIGO) detected spacetime ripples passing through the Earth. Although the source of those gravitational ripples was a collision of two far-off black holes, the resulting spatial distortion that LIGO detected was smaller than the nucleus of an atom.

By comparison, the apparent pulsar time shift measured by the NANOGrav team is a few hundred billionths of a second and represents a flexing of spacetime between Earth and the pulsars about the length of a football field. Those spacetime distortions were caused by gravitational waves so immense that the distance between two crests is 2–10 light-years or about 9–90 trillion kilometers.

"These are by far the most powerful gravitational waves known to exist," said West Virginia University astrophysicist Maura McLaughlin, co-director of the NANOgrav Physics Frontiers Center. "Detecting such gargantuan gravitational waves requires a similarly massive detector and patience."

Using 15 years of astronomical data recorded by radio telescopes at NSF-supported observatories—including Green Bank Observatory in West Virginia, the Very Large Array in Socorro, New Mexico and Arecibo Observatory in Puerto Rico — the NANOGrav team created a 'detector' of 67 pulsars distributed all across the sky and compared the ticking rate of pairs of those pulsars. Through a sophisticated data analysis, they deduced the presence of the gravitational wave background causing the distortion of space and thus explained the apparent timing changes of the pulsars.

This is the first evidence for gravitational waves at these low frequencies," said Vanderbilt University astrophysicist Stephen Taylor, chair of the NANOGrav collaboration and co-leader of the research effort. "The likely source of these waves are distant pairs of close-orbiting, ultra-massive black holes."

"There is so much we have yet to understand about the physical nature of the universe and that's why the National Science Foundation supports daring team efforts like NANOGrav—to expand our knowledge for the benefit of society," said NSF Assistant Director for Mathematical and Physical Sciences Sean L. Jones.

The team's results are providing new insights into how galaxies evolve and how super massive black holes grow and merge. The widespread spacetime distortion revealed in their findings implies that extremely massive pairs of black holes may be similarly widespread across the universe, numbering

perhaps in the hundreds of thousands or even millions. Eventually, the NANOGrav team expects to be able to identify specific super massive black hole pairs by tracing the gravitational waves they emit. They may even uncover traces of gravitational waves from the very early universe.

"While our early data told us that we were hearing something, we now know that it's the music of the gravitational universe," said NANOGrav co-director and Oregon State University astrophysicist, Xavier Siemens. "As we keep listening, individual instruments will come to the fore in this cosmic orchestra."

Half of World's Largest Lakes Losing Water

Date: 18 May 2023

Source: University of Colorado at Boulder

Summary: Fifty-three percent of the world's largest freshwater lakes are in decline, storing less water than they did three decades ago, according to a new study. The study analysed satellite observations dating back decades to measure changes in water levels in nearly 2,000 of the world's biggest lakes and reservoirs. It found that climate change, human consumption and sedimentation are responsible.

More than 50 percent of the largest lakes in the world are losing water, according to a ground breaking new assessment published today in Science . The key culprits are not surprising: warming climate and unsustainable human consumption. But lead author Fangfang Yao, a CIRES visiting fellow, now a climate fellow at University of Virginia, said the news is not entirely bleak.

With this new method of tracking lake water storage trends and the reasons behind them, scientists can give water managers and communities insight into how to better protect critical sources of water and important regional ecosystems.

"This is the first comprehensive assessment of trends and drivers of global lake water storage variability based on an array of satellites and models," Yao said.

He was motivated to do the research by the environmental crises in some of Earth's largest water bodies, such as the drying of the Aral Sea between Kazakhstan and Uzbekistan.

So he and colleagues from the University of Colorado Boulder, Kansas State University, France and Saudi Arabia created a technique to measure changes in water levels in nearly 2,000 of the world's biggest lakes and reservoirs, which represent 95 per cent of the total lake water storage on Earth.

The team combined three decades of observations from an array of satellites with models to quantify and attribute trends in lake storage globally.

Globally, freshwater lakes and reservoirs store 87 per cent of the planet's water, making them a valuable resource for both human and Earth ecosystems. Unlike rivers, lakes are not well monitored, yet they provide water for a large part of humanity, even more than rivers.

But despite their value, long-term trends and changes to water levels have been largely unknown, until now.

"We have pretty good information on iconic lakes like Caspian Sea, Aral Sea and Salton Sea, but if you want to say something on a

global scale, you need reliable estimates of lake levels and volume," said Balaji Rajagopalan, a CIRES fellow, professor of engineering at CU Boulder and co-author. "With this novel method ...we are able to provide insights into global lake level changes with a broader perspective."

For the new paper, the team used 250,000 lake-area snapshots captured by satellites between 1992–2020 to survey the area of 1,972 of Earth's biggest lakes. They collected water levels from nine satellite altimeters and used long-term water levels to reduce any uncertainty. For lakes without a long-term level record, they used recent water measurements made by newer instruments on satellites. Combining recent level measurements with longer-term area measurements allowed scientists to reconstruct the volume of lakes dating back decades.

The results were staggering: 53 per cent of lakes globally experienced a decline in water storage. The authors compare this loss with the magnitude of 17 Lake Meads, the largest reservoir in the United States.

To explain the trends in natural lakes, the team leveraged recent advancements in water use and climate modeling. Climate change and human water consumption dominated the global net decline in natural lake volume and water losses in about 100 large lakes, Yao said. "And many of the human and climate change footprints on lake water losses were previously unknown, such as the desiccations of Lake Good-e-Zareh in Afghanistan and Lake Mar Chiquita in Argentina."

Lakes in both dry and wet areas of the world are losing volume. The losses in humid tropical lakes and Arctic lakes indicate more widespread drying trends than previously understood.

Yao and his colleagues also assessed storage trends in reservoirs. They found that nearly two-thirds of Earth's large reservoirs experienced significant water losses.

"Sedimentation dominated the global storage decline in existing reservoirs," said Ben Livneh, also a co-author, CIRES fellow and associate professor of engineering at CU Boulder. In long-established reservoirs — those that filled before 1992 — sedimentation was more important than droughts and heavy rainfall years.

While the majority of global lakes are shrinking, 24 per cent saw significant increases in water storage. Growing lakes tend to be in underpopulated areas in the inner Tibetan Plateau and Northern Great Plains of North America and in areas with new reservoirs such as the Yangtze, Mekong, and Nile river basins.

The authors estimate roughly one-quarter of the world's population, 2 billion people, resides in the basin of a drying lake, indicating an urgent need to incorporate human consumption, climate change and sedimentation impacts into sustainable water resources management.

And their research offers insight into possible solutions, Livneh said. "If human consumption is a large factor in lake water storage decline, then we can adapt and explore new policies to reduce large-scale declines."

This happened in one of the lakes the team studied, Lake Sevan in Armenia. Lake Sevan has seen an increase in water storage, in the last 20 years, which the authors linked to enforcement of conservation laws on water withdrawal since the early 2000s.