SCIENCE NEWS

We Need to Rethink Everything We Know About Global Warming

Summary: For a while now, the scientific community has known that global warming is caused by humanmade emissions in the form of greenhouse gases and global cooling by air pollution in the form of aerosols.

However, new research published in Science by Hebrew University of Jerusalem Professor Daniel Rosenfeld shows that the degree to which aerosols cool the earth has been grossly underestimated, necessitating a recalculation of climate change models to more accurately predict the pace of global warming.

Aerosols are tiny particles that float in the air. They can form naturally (e.g., desert dust) or artificially (e.g., smoke from coal, car exhaust). Aerosols cool our environment by enhancing cloud cover that reflect the sunlight (heat) back to space.

As for the first, clouds form when wind rises and cools. However, cloud composition is largely determined by aerosols. The more aerosol particles a shallow cloud contains, the more small water droplets it will hold. Rain happens when these droplets bind together. Since it takes longer for small droplets to bind together than it does for large droplets, aerosol-filled or 'polluted' clouds contain more water, live in the sky longer (while they wait for droplets to bind and rain to fall, after which the clouds will dissipate) and cover a greater area. All the while, the aerosol-laden clouds reflect more solar energy back into space, thereby cooling the Earth's overall temperature.

To what extent do aerosols cool down our environment? To date, all estimates were unreliable because it was impossible to separate the effects of rising winds which create the clouds from the effects of aerosols which determine their composition. Until now.

Rosenfeld and his colleague Yannian Zhu from the Meteorological Institute of Shaanxi Province in China developed a new method that uses satellite images to separately calculate the effect of vertical winds and aerosol cloud droplet numbers. They applied this methodology to low-lying cloud cover above the world's oceans between the Equator and 40S. With this new method,

Rosenfeld and his colleagues were able to more accurately calculate aerosols' cooling effects on the Earth's energy budget. And, they discovered that aerosols' cooling effect is nearly twice higher than previously thought.

However, if this is true then how come the earth is getting warmer, not cooler? For all of the global attention on climate warming, aerosol pollution rates from vehicles, agriculture and power plants is still very high. For Rosenfeld, this discrepancy might point to an ever deeper and more troubling reality. "If the aerosols indeed cause a greater cooling effect than previously estimated, then the warming effect of the greenhouse gases has also been larger than we thought, enabling greenhouse gas emissions to overcome the cooling effect of aerosols and points to a greater amount of global warming than we previously thought", he shared.

The fact that our planet is getting warmer even though aerosols are cooling it down at higher rates than previously thought brings us to a Catch-22 situation: Global efforts to improve air quality by developing cleaner fuels and burning less coal could end up harming our planet by reducing the number of aerosols in the atmosphere and by doing so, diminishing aerosols' cooling ability to offset global warming.

According to Rosenfeld, another hypothesis to explain why Earth is getting warmer even though aerosols have been cooling it down at an even a greater rate is a possible warming effect of aerosols when they lodge in deep clouds, meaning those 10 kilometres or more above the Earth. Israel's Space Agency and France's National Centre for Space Studies (CNES) have teamed up to develop new satellites that will be able to investigate this deep cloud phenomenon, with Professor Rosenfeld as its principal investigator.

Either way, the conclusion is the same. Our current global climate predictions do not correctly take into account the significant effects of aerosols on clouds on Earth's overall energy balance. Further, Rosenfeld's recalculations mean fellow scientists will have to rethink their global warming predictions, which currently predict a 1.5 to 4.5 degree Celsius temperature increase by the end of the 21st century — to provide us a more accurate diagnosis — and prognosis — of the Earth's climate

New Science Details Discovery of Bacterial Pathogen in Brains of Alzheimer's Patients

Summary: New science uncovers how an unlikely culprit, Porphyromonas gingivalis (Pg) — the bacterium commonly associated with chronic gum disease appears to drive Alzheimer's disease (AD) pathology.

A paper published today in Science Advances details how researchers identified Pg in the brains of patients with AD.

University of Louisville researcher Jan Potempa, Ph.D., Department of Oral Immunology and Infectious Diseases in the School of Dentistry, was part of the team of international scientists led by Cortexyme Inc., a privately held, clinical-stage pharmaceutical company.

According to Potempa, although infectious agents have been implicated in the development and progression of Alzheimer's disease, the evidence of causation hasn't been convincing.

However, we now have strong evidence connecting P. gingivalis and Alzheimer's pathogenesis, but more research needs to be done before P. gingivalis is explicitly implicated in the causation or morbidity of AD.

"An even more notable aspect of this study is demonstration of the potential for a class of molecule therapies targeting major virulence factors to change the trajectory of AD, which seems to be epidemiologically and clinically associated with periodontitis", Potempa said.

In animal models, oral Pg infection led to brain colonization and increased production of amyloid beta (Aβ), a component of the amyloid plaques commonly associated with AD.

The study team also found the organism's toxic enzymes, or gingipains, in the neurons of patients with AD. Gingipains are secreted and transported to outer bacterial membrane surfaces and have been shown to mediate the toxicity of Pg in a variety of cells.

The team correlated the gingipain levels with pathology related to two markers: tau, a protein needed for normal neuronal function, and ubiquitin, a small protein tag that marks damaged proteins.

Seeking to block Pg-driven neurotoxicity, Cortexyme Set out to design a series of small molecule therapies targeting Pg gingipains.

In preclinical experiments detailed in the paper, researchers demonstrated that by inhibiting the compound COR388, there was reduced bacterial load of an established Pg brain infection, blocked Aβ42 production, reduced neuroinflammation and protected neurons in the hippocampus — the part of the brain that mediates memory and frequently atrophies early in the development of AD.

In October 2018, Cortexyme announced results from its Phase 1b clinical trial of COR388 at the 11th Clinical Trials in Alzheimer's Disease Conference. COR388 showed positive trends across several cognitive tests in patients suffering from AD, and Cortexyme plans to initiate a Phase 2 and 3 clinical trial of COR388 in mild to moderate AD in 2019.

2D Materials May Enable Electric Vehicles to Get 500 Miles on a Single Charge

Summary: Lithium-air batteries are poised to become the next revolutionary replacement for currently used lithium-ion batteries that power electric vehicles, cell phones and computers.

Lithium-air batteries, which currently are still in the experimental stages of development, can store 10 times more energy than lithium-ion batteries and they are much lighter. That said, lithium-air batteries could be even more efficient and provide more charge with the incorporation of advanced catalysts made from two-dimensional materials. Catalysts help increase the rate of chemical reactions inside batteries, and depending on the type of material from which the catalyst is made, they can help significantly boost the ability of the battery to hold and provide energy.

"We are going to need very high-energy density batteries to power new advanced technologies that are incorporated into phones, laptops and especially electric vehicles", said Amin Salehi-Khojin, associate professor of mechanical and industrial engineering in UIC's College of Engineering. Salehi-Khojin and his colleagues synthesised

several 2D materials that can serve as catalysts. A number of their 2D materials, when incorporated into experimental lithium-air batteries as the catalyst, enabled the battery to hold up to 10 times more energy than lithium-air batteries containing traditional catalysts. Their findings are published in the journal Advanced Materials.

"Currently, electric vehicles average about 100 miles per charge, but with the incorporation of 2D catalysts into lithium-air batteries, we could provide closer to 400 to 500 miles per charge, which would be a real game-changer", said Salehi-Khojin, who is also the corresponding author of the paper. "This would be a huge breakthrough in energy storage."

Salehi-Khojin and his colleagues synthesised 15 different types of 2D transition metal dichalcogenides or TMDCs. TMDCs are unique compounds because they have high electronic conductivity and fast electron transfer that can be used to participate in reactions with other materials, such as the reactions that take place inside batteries during charging and discharging.

The investigators experimentally studied the performance of 15 TMDCs as catalysts in an electrochemical system mimicking a lithium-air battery.

"In their 2D form, these TMDCs have much better electronic properties and greater reactive surface area to participate in electrochemical reactions within a battery while their structure remains stable", explained Leily Majidi, a graduate student in the UIC College of Engineering and first author of the paper.

"Reaction rates are much higher with these materials compared to conventional catalysts used such as gold or platinum", Majidi said.

One of the reasons the 2D TDMCs performed so well is because they help speed both charging and discharging reactions occurring in lithium-air batteries.

"This would be what is known as bi-functionality of the catalyst", Salehi-Khojin said.

The 2D materials also synergize with the electrolyte — the material through which ions move during charge and discharge.

"The 2D TDMCs and the ionic liquid electrolyte that we used acts as a co-catalyst system that helps the electrons transfer faster, leading to faster charges and more efficient storage and discharge of energy."

"These new materials represent a new avenue that can take batteries to the next level, we just need to develop ways to produce and tune them more efficiently and in larger scales", Salehi-Khojin said.

Poya Yasaei, Zahra Hemmat, Pedram Abbasi, Shadi Fuladi, Xuan Hu, Robert Klie, Fatemeh Khalili-Araghi and Baharak Sayahpour of the University of Illinois at Chicago and Robert Warburton and Jeffrey Greeley of Purdue University are coauthors on the paper.

Indoor Exposure to Air Pollution Studied

Summary: In an Indoor Air study conducted in a suburb of the city of Kuopio, Finland, relatively short-lasting wood and candle burning of a few hours increased residents'

daily exposure to potentially hazardous particulate air pollution. Associations between indoor air pollutants and building ventilation or cooking were also observed.

The study found that the local outdoor levels of certain pollutants and ozone were the most important determinants of indoor levels of the same air pollutants.

"Ample burning of wood in small-scale room heaters and sauna stoves is likely to increase chronic personal exposures in the neighborhood to particulate matter that contains substantial amounts of soot and hazardous organic compounds like polycyclic organic hydrocarbons. This exposure does not take place only while staying outdoors but also indoors at home due to effective passage of the small particles through the building shield", the authors wrote. "Part of the emissions adding this type of hazardous exposure among residents, also including susceptible population groups, originates directly from the personal use of a wood-fired room heater or sauna stove. Insufficient natural ventilation in older houses further elevates the indoor levels of the hazardous particles."

Scientists Develop First Fabric to Automatically Cool or Insulate Depending on Conditions

Summary: Despite decades of innovation in fabrics with high-tech thermal properties that keep marathon runners cool or alpine hikers warm, there has never been a material that changes its insulating properties in response to the environment. Until now.

University of Maryland researchers have created a fabric that can automatically regulate the amount of heat that passes through it. When conditions are warm and moist, such as those near a sweating body, the fabric allows infrared radiation (heat) to pass through. When conditions become cooler and drier, the fabric reduces the heat that escapes. The development was reported in the February 8, 2019 issue of the journal Science.

The researchers created the fabric from specially engineered yarn coated with a conductive metal. Under hot, humid conditions, the strands of yarn compact and activate the coating, which changes the way the fabric interacts with infrared radiation. They refer to the action as 'gating' of infrared radiation, which acts as a tunable blind to transmit or block heat.

"This is the first technology that allows us to dynamically gate infrared radiation", said YuHuang Wang, a professor of chemistry and biochemistry at UMD and one of the paper's corresponding authors who directed the studies.

The base yarn for this new textile is created with fibers made of two different synthetic materials — one absorbs water and the other repels it. The strands are coated with carbon nanotubes, a special class of lightweight, carbon-based, conductive metal. Because materials in the fibres both resist and absorb water, the fibres warp when exposed to humidity, such as that surrounding a sweating body. That distortion brings the strands of yarn closer together, which does two things. First, it opens the pores in the fabric. This has a small cooling effect because it allows heat to escape. Second and most importantly, it modifies the electromagnetic coupling between the carbon nanotubes in the coating.

"You can think of this coupling effect like the bending of a radio antenna to change the wavelength or frequency it resonates with", Wang said. "It's a very simplified way to think of it, but imagine bringing two antennae close together to regulate the kind of electromagnetic wave they pick up. When the fibers are brought closer together, the radiation they interact with changes. In clothing, that means the fabric interacts with the heat radiating from the human body."

Depending on the tuning, the fabric either blocks infrared radiation or allows it to pass through. The reaction is almost instant, so before people realize they're getting hot, the garment could already be cooling them down. On the flip side, as a body cools down, the dynamic gating mechanism works in reverse to trap in heat.

"The human body is a perfect radiator. It gives off heat quickly", said Min Ouyang, a professor of physics at UMD and the paper's other corresponding author. "For all of history, the only way to regulate the radiator has been to take clothes off or put clothes on. But this fabric is a true bidirectional regulator."

According to the ***Science*** paper, this is first textile shown to be able to regulate heat exchange with the environment.

"This pioneering work provides an exciting new switchable characteristic for comfort-adjusting clothing", said Ray Baughman, a professor of chemistry at the University of Texas who was not involved in the study. "Textiles were known that increase porosity in response to sweat or increasing temperature, as well as textiles that transmit the infrared radiation associated with body temperatures. However, no one before had found a way to switch both the porosity and infrared transparency of a textile so as to provide increased comfort in response to environmental conditions."

More work is needed before the fabric can be commercialised but according to the researchers, materials used for the base fiber are readily available and the carbon coating can be easily added during standard dyeing process.

"I think it's very exciting to be able to apply this gating phenomenon to the development of a textile that has the ability to improve the functionality of clothing and other fabrics", Ouyang said.

Engineers Harvest Heart's Energy to Power Life-saving Devices

Summary: The heart's motion is so powerful that it can recharge devices that save our lives, according to new research from Dartmouth College.

Using a dime-sized invention developed by engineers at the Thayer School of Engineering at Dartmouth, the kinetic energy of the heart can be converted into electricity to power a wide-range of implantable devices, according to the study funded by the National Institutes of Health.

Millions of people rely on pacemakers, defibrillators and other live-saving implantable devices powered by batteries that need to be replaced every five to 10 years.

Those replacements require surgery which can be costly and create the possibility of complications and infections.

"We're trying to solve the ultimate problem for any implantable biomedical device", says Dartmouth engineering professor John X.J.

Zhang, a lead researcher on the study his team completed alongside clinicians at the University of Texas in San Antonio.

"How do you create an effective energy source so the device will do its job during the entire life span of the patient, without the need for surgery to replace the battery?"

"Of equal importance is that the device not interfere with the body's function", adds Dartmouth research associate Lin Dong, first author on the paper.

"We knew it had to be biocompatible, lightweight, flexible and low profile, so it not only fits into the current pacemaker structure but is also scalable for future multi-functionality."

The team's work proposes modifying pacemakers to harness the kinetic energy of the lead wire that's attached to the heart, converting it into electricity to continually charge the batteries.

The added material is a type of thin polymer piezoelectric film called 'PVDF' and when designed with porous structures — either an array of small buckle beams or a flexible cantilever — it can convert even small mechanical motion to electricity.

An added benefit: the same modules could potentially be used as sensors to enable data collection for real-time monitoring of patients.

The results of the three-year study, completed by Dartmouth's engineering researchers along with clinicians at UT Health San Antonio, were just published in the cover story for Advanced Materials Technologies.

The two remaining years of NIH funding plus time to finish the pre-clinical process and obtain regulatory approval puts a self-charging pacemaker approximately five years out from commercialisation, according to Zhang.

"We've completed the first round of animal studies with great results which will be published soon", says Zhang. "There is already a lot of expressed interest from the major medical technology companies, and Andrew Closson, one of the study's authors working with Lin Dong and an engineering PhD Innovation Program student at Dartmouth, is learning the business and technology transfer skills to be a cohort in moving forward with the entrepreneurial phase of this effort."

1 in 3 Students with ADHD Receive No School Interventions

Summary: At least one in five students with ADHD receive no school services despite experiencing significant academic and social impairment, a gap particularly evident for adolescents and youth from non-English-speaking and/or lower-income families, researchers found in the largest study of children and teens with ADHD ever conducted.

The new findings are based on data on 2,495 youth with ADHD aged 4 to 17 years from across the United States, collected through the National Survey of the Diagnosis and Treatment of ADHD and Tourette Syndrome (NS-DATA). The survey, the largest to date of parents of youth with ADHD, documents the extent to which students receive school services, the types of services they receive and the factors that may predict what kinds of services they receive.

"We found that although the majority of students were currently receiving one or more school services, only a minority received support to manage their behaviour, and at least one out of five students did not receive any school support despite experiencing significant educational impairment", said lead author George DuPaul, professor of school psychology and associate dean for research in the College of Education at Lehigh University. "The gap between impairment and service receipt was particularly evident for adolescents with ADHD and for youth with ADHD from non-English speaking and/or low-income families."

The research appears in the Journal of Attention Disorders, in the article, "Predictors of Receipt of School Services in a National Sample of Youth With ADHD," co-authored by DuPaul with Andrea Chronis-Tuscano of the University of Maryland (College Park) and Melissa Danielson and Susanna Visser of the Centers for Disease Control and Prevention.

ADHD linked to social and academic impairment

Attention Deficit Hyperactivity Disorder (ADHD) occurs in 2 to 15 per cent of young children, with 11 per cent of children in the U.S. receiving an ADHD diagnosis at some point in their lives. The chronic condition, which often lasts through adolescence and adulthood, is marked by persistent inattention, hyperactivity and impulsivity.

Students with ADHD are at higher risk for grade retention, underachievement, identification for special education services, and school dropout and are at a higher risk of learning disabilities. Students with ADHD also exhibit academic performance difficulties as a function of lower rates of on-task behaviour and work completion. Adolescents with ADHD show deficits in reading, math and spelling compared to their peers. ADHD is also associated with social impairment, such as difficulty interacting with peers and adult authority figures, building and sustaining friendships and experiencing higher rates of peer rejection.

The scope and severity of functional impairment experienced by youth with ADHD in academic and social domains often makes school-based intervention and services necessary, the researchers said. Previous studies have shown that school-based interventions improve classroom behaviour and academic performance. Students with ADHD may also qualify for individualised instruction and related special education services, through an individualised education program (IEP) or educational accommodations under the federal disability civil rights code (504 plan).

Few studies have examined the extent to which students with ADHD receive school-based support and intervention services, and this is the first to look at these issues in a national sample across elementary, middle and high school students.

For the study, school services included school-based educational support, intervention or accommodation (such as tutoring, extra help from a teacher, preferential seating, extra time to complete work, or being enrolled in special education) and classroom management (such as reward systems, behavioural modification or a daily report card). Parents were also asked if their child had an IEP or 504 plan.

1 in 3 students receive no school-based interventions

The study found that about one in three students with ADHD received no school-based interventions and two of three received no classroom management, representing a major gap in addressing chronic impairment related to ADHD symptoms. One-fifth of students with ADHD who experience significant academic and social impairment — those most in need of services — received no school intervention. Nearly one in four students had repeated a grade and one in six had been expelled from school. Middle and high school students with ADHD were significantly less likely than elementary school students to receive any type of school service (except 504 plans), despite generally similar, if not worse, impairment and higher risk for academic failure and expulsion.

"We expected that most students with ADHD would be receiving some form of support, but were surprised that so few were receiving services to manage their behaviour (the latter being the primary difficulty that students with this disorder experience)", DuPaul said. "We expected that there would be disparities in service receipt based on age (ie. teens received less support) and race/ethnicity; however we were surprised with the extent to which these gaps were evident and the magnitude of the disparities."

"The impairment vs. services gap is a serious issue given that these students are at higher-than-average risk for educational underachievement and school dropout", said DuPaul. "The finding that youth from non-English-speaking families are far less likely to have a 504 educational support plan than youth from English-speaking families indicates the need for educators to advocate for and assist non-English-speaking families in obtaining necessary school services for their children with ADHD", he added.

The findings have direct implications for educational policy and practices and should be of interest to parents and individuals with ADHD, teachers and other educational professionals, mental health professionals and policy makers, the researchers said.

"Children with ADHD may benefit from initiatives to proactively identify students with this disorder and directly target their specific impairments with evidence-based intervention approaches", they concluded. "Furthermore, families of secondary-school students and youth from non-English-speaking and/or low socio-economic status backgrounds may benefit when bilingual mental health professionals work to increase awareness of and access to effective school supports and interventions."