

Researchers report that warming from short-lived compounds — greenhouse gases such as methane and chlorofluorocarbons, that linger in the atmosphere for just a year to a few decades — can cause sea levels to rise for hundreds of years after the pollutants have been cleared from the atmosphere.

Short-lived greenhouse gases cause centuries of sea-level rise

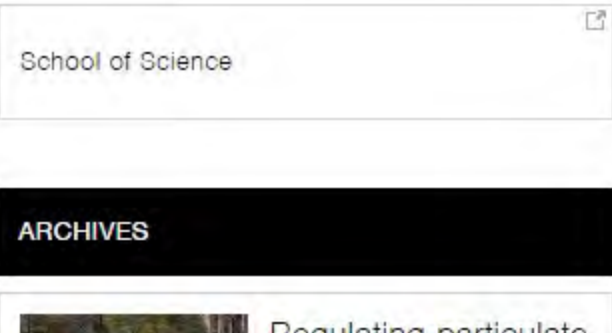
Through warming effects, methane and other gases impact rising seas long after leaving the atmosphere.

Jennifer Chu | MIT News Office

January 9, 2017

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In a paper published this week in the *Proceedings of the National Academy of Sciences*, the researchers report that warming from short-lived compounds — greenhouse gases such as methane, chlorofluorocarbons, or hydrofluorocarbons, that linger in the atmosphere for just a year to a few decades — can cause sea levels to rise for hundreds of years after the pollutants have been cleared from the atmosphere.

"If you think of countries like Tuvalu, which are barely above sea level, the question that is looming is how much we can emit before they are doomed. Are they already slated to go under, even if we stopped emitting everything tomorrow?" says co-author Susan Solomon, the Ellen Swallow Richards Professor of Atmospheric Chemistry and Climate Science at MIT. "It's all the more reason why it's important to understand how long climate changes will last, and how much more sea-level rise is already locked in."

Solomon's co-authors are lead author Kirsten Zickfeld of Simon Fraser University and Daniel Gilford, a graduate student in MIT's Department of Earth, Atmospheric and Planetary Sciences.

Short stay, long rise

Recent studies by many groups, including Solomon's own, have shown that even if human-caused emissions of carbon dioxide were to stop entirely, their associated atmospheric warming and sea-level rise would continue for more than 1,000 years. These effects — essentially irreversible on human timescales — are due in part to carbon dioxide's residence time: The greenhouse gas can stay in the atmosphere for centuries after it's been emitted from smokestacks and tailpipes.

In contrast to carbon dioxide, other greenhouse gases such as methane and chlorofluorocarbons have much shorter lifetimes. However, previous studies have not specified what their long-term effects may be on sea-level rise. To answer this question, Solomon and her colleagues explored a number of climate scenarios using an Earth Systems Model of Intermediate Complexity, or EMIC, a computationally efficient climate model that simulates ocean and atmospheric circulation to project climate changes over decades, centuries, and millennia.

With the model, the team calculated both the average global temperature and sea-level rise, in response to anthropogenic emissions of carbon dioxide, methane, chlorofluorocarbons, and hydrofluorocarbons.

The researchers' estimates for carbon dioxide agreed with others' predictions and showed that, even if the world were to stop emitting carbon dioxide starting in 2050, up to 50 percent of the gas would remain in the atmosphere more than 750 years afterward. Even after carbon dioxide emissions cease, sea-level rise should continue to increase, measuring twice the level of 2050 estimates for 100 years, and four times that value for another 500 years.

The reason, Solomon says, is due to "ocean inertia": As the world warms due to greenhouse gases — carbon dioxide included — waters heat up and expand, causing sea levels to rise. Removing the extra ocean heat caused by even short-lived gases, and consequently lowering sea levels, is an extremely slow process.

"As the heat goes into the ocean, it goes deeper and deeper, giving you continued thermal expansion," Solomon explains. "Then it has to get transferred back to the atmosphere and emitted back into space to cool off, and that's a very slow process of hundreds of years."

Stemming tides

In one particular climate modeling scenario, the team evaluated sea level's response to various methane emissions scenarios, in which the world would continue to emit the gas at current rates, until emissions end entirely in three different years: 2050, 2100, and 2150.

In all three scenarios, methane gas quickly cleared from the atmosphere, and its associated atmospheric warming decreased at a similar rate. However, methane continued to contribute to sea-level rise for centuries afterward. What's more, they found that the longer the world waits to reduce methane emissions, the longer seas will stay elevated.

"Amazingly, a gas with a 10-year lifetime can actually cause enduring sea-level changes," Solomon says. "So you don't just get to stop emitting and have everything go back to a preindustrial state. You are going to live with this for a very long time."

The researchers found one silver lining in their analyses: Curious as to whether past regulations on pollutants have had a significant effect on sea-level rise, the team focused on perhaps the most successful global remediation effort to date — the Montreal Protocol, an international treaty ratified by 197 countries in 1989, that effectively curbed emissions of ozone-depleting compounds worldwide.

Encouragingly, the researchers found that the Montreal Protocol, while designed to protect the ozone layer by phasing out pollutants such as chlorofluorocarbons — has also helped stem rising seas. If the Montreal Protocol had not been ratified, and countries had continued to emit chlorofluorocarbons to the atmosphere, the researchers found that by 2050, the world would have experienced up to an additional 6 inches of sea-level rise.

"Half a foot is pretty significant," Solomon says. "It's yet another tremendous reason why the Montreal Protocol has been a pretty good thing for the planet."

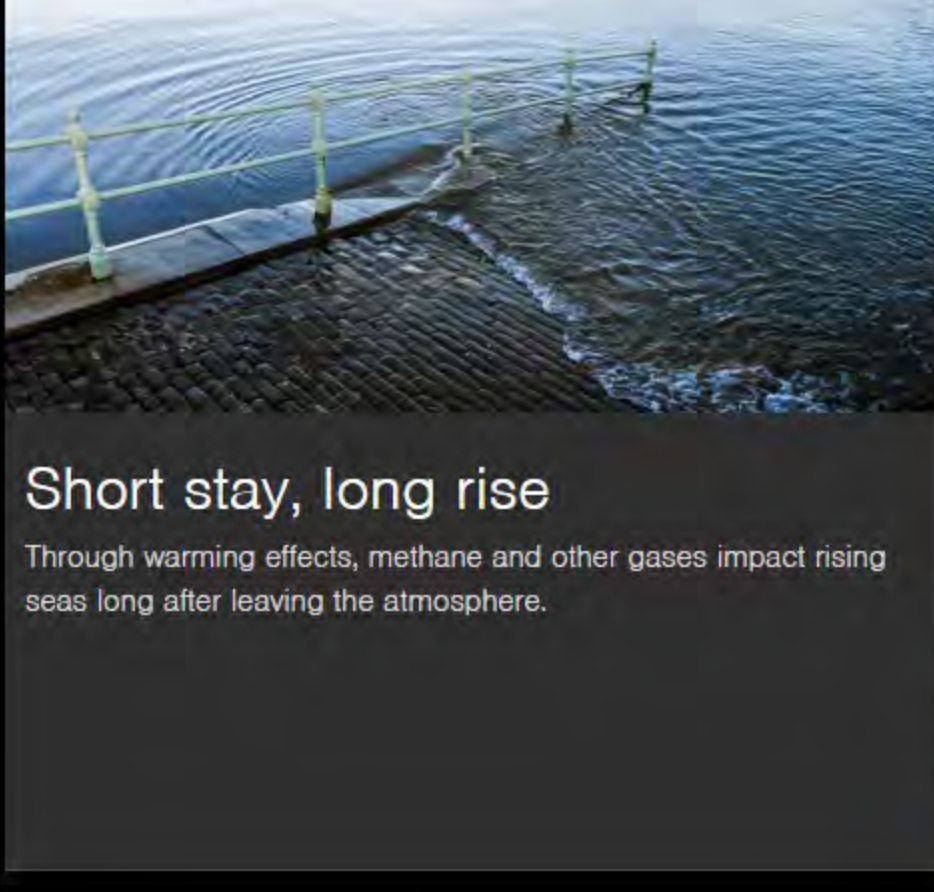
In their paper's conclusion, the researchers point out that efforts to curb global warming should not be expected to reverse high seas quickly, and that longer-term impacts from sea-level rise should be seriously considered: "The primary policy conclusion of this study is that the long-lasting nature of sea-level rise heightens the importance of earlier mitigation actions."

This research was supported, in part, by the Natural Sciences and Engineering Research Council of Canada, and NASA.

Topics: Climate Climate change EAPS Earth and atmospheric sciences Emissions Environment Global Warming Greenhouse gases International initiatives Pollution Research School of Science NASA Global

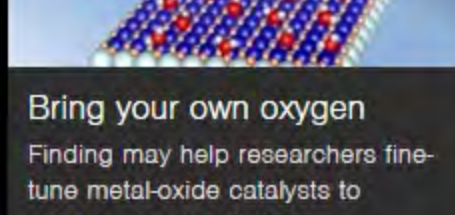
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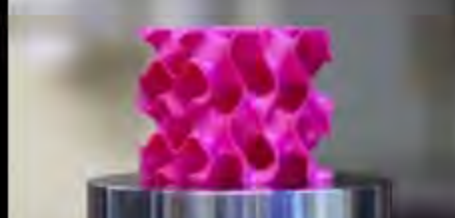
Short stay, long rise

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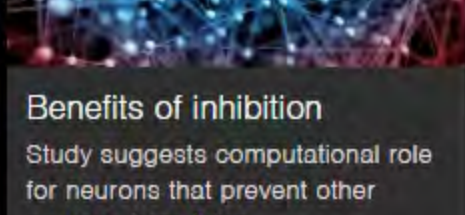
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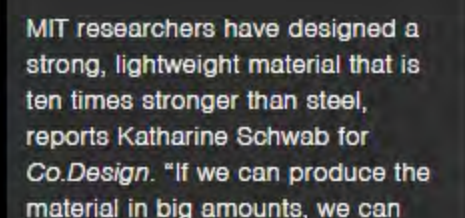
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Benefits of inhibition

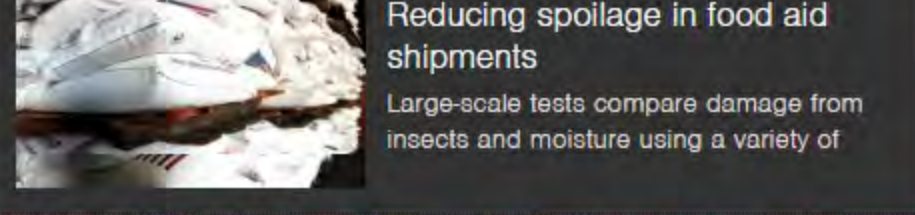
Study suggests computational role for neurons that prevent other neurons from firing.



MIT researchers have designed a strong, lightweight material that is ten times stronger than steel, reports Katharine Schwab for Co.Design. "If we can produce the material in big amounts, we can use that to somehow substitute some of the steel used for construction," says research scientist Zhao Qin.

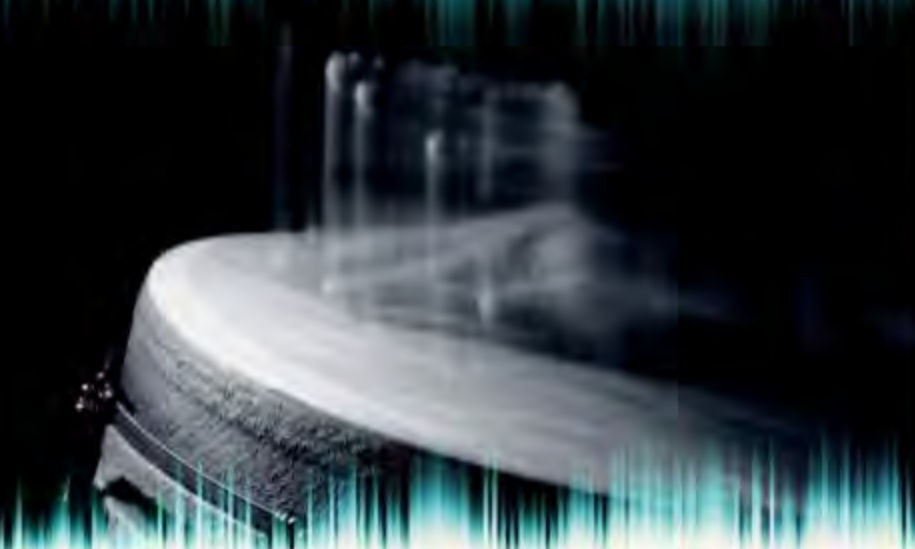
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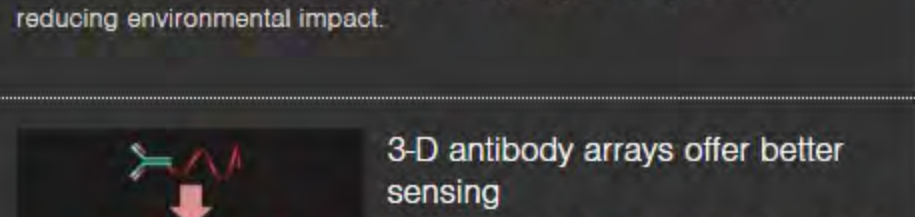
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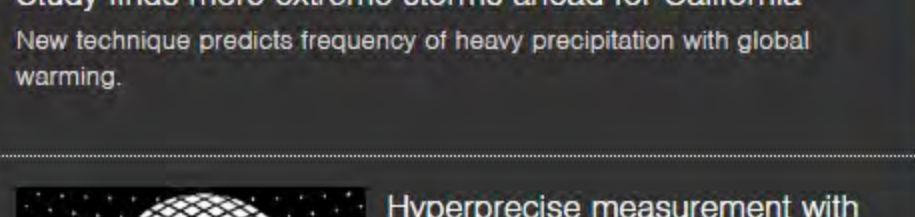
Exploring the tug-of-war over metals during infection

Chemist Elizabeth Nolan studies the battle between microbes and hosts for essential metals.



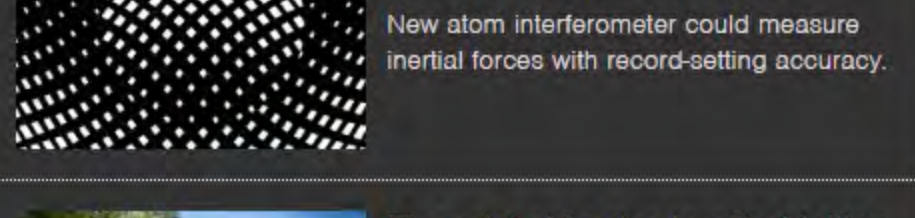
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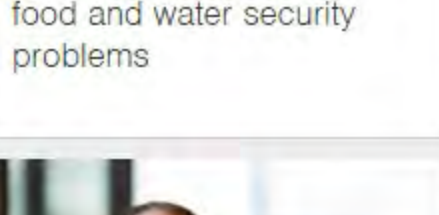
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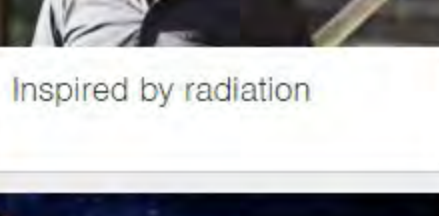
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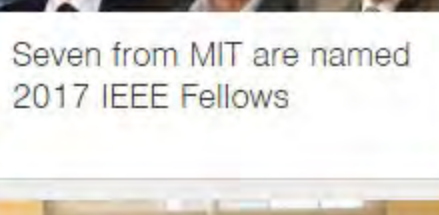
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Rethinking how we get around

IN THE MEDIA

Boston Globe reporter J.M. Lawrence writes about the legacy of D. Reid Weedon Jr., an MIT alumnus and life member who died on Nov. 2 at age 96. Lawrence notes that Weedon was a "key fund-raiser for MIT for 60 years," and "worked with nine MIT presidents while mentoring many young fund-raisers."

The Boston Globe

By fusing graphene into a porous 3-D form, MIT researchers have created a strong, lightweight material, writes Brooks Hays for UPI. "The findings suggest a 3D material's tensile and compressive properties are dependent on the geometry of its structure, not the strength of the 2D material from which it is derived," explains Hays.

UPI

Saqib Shah writes for FOX News that researchers from the Media Lab's Electome project are launching an interactive tool "that compares tweets shared by the White House with a sampling of those shared by the public."

FOX NEWS

MIT researchers have found that reduced plasticity in the brains of people with dyslexia may explain why they experience difficulties with reading and with processing spoken speech, writes Kevin Murnane of Forbes. Murnane explains that the findings "indicate that dyslexia is not just about reading; it involves a reduction in neural adaptation to a variety of perceptual stimuli."

Forbes

The Boston Globe Magazine's list of some of the most innovative ideas, people, and companies of 2016 features graduate student Dheeraj Roy, whose research suggests that one day optogenetics could potentially be used to help stimulate memories in patients with Alzheimer's disease.

The Boston Globe

The City of Haverhill will test a solar-powered bench designed by Sofoa, a Media Lab spinoff, reports Brenda J. Buote for The Boston Globe. The city will "track how often the bench is used as a way to measure positive community development."

The Boston Globe

CSAIL researchers have found that ride-sharing services could reduce the number of cars on the road by 75 percent, reports Maria Kendall for The Mercury News. The researchers developed an algorithm that can increase service speeds by 20 percent by rerouting cars to "their most efficient routes, including automatically sending idle cars to areas of high demand."

The Mercury News

Writing for The Wall Street Journal, Visiting Lecturer Irving Wladawsky-Berger praises MIT's Inclusive Innovation Competition, a contest that honors companies aimed at improving economic opportunities for all workers. Wladawsky-Berger writes that it's heartening that MIT is "searching for breakthrough innovations to help improve [the] economic prospects" of workers impacted by advanced technologies.

THE WALL STREET JOURNAL

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