Researchers cook up a new way to remove microplastics from seawater

Researchers at Princeton Engineering have found a way to turn your breakfast food into a new material that can cheaply remove salt and microplastics from seawater.

The researchers used egg whites to create an aerogel, a lightweight and porous material that can be used in many types of applications, including water filtration, energy storage, and sound and thermal insulation. Craig Arnold, the Susan Dod Brown Professor of Mechanical and Aerospace Engineering and vice dean of innovation at Princeton, works with his lab to create new materials, including aerogels, for engineering applications.

One day, sitting in a faculty meeting, he had an idea.

“I was sitting there, staring at the bread in my sandwich,” said Arnold. “And I thought to myself, this is exactly the kind of structure that we need.” So he asked his lab group...
Radhika Nagpal, an expert in bio-inspired robotic systems and collective behavior, has joined the Princeton faculty as a professor of mechanical and aerospace engineering and computer science. On July 1 she was appointed the Norman R. Augustine ’57 *59 Professor in Engineering.

Nagpal joined Princeton in January from Harvard University, where she was the Fred Kavli Professor of Computer Science and a founding faculty member of the Wyss Institute for Biologically Inspired Engineering, launched in 2009.

Her research has explored the dynamic movements of fish schools, the highly successful collective decision-making of ant colonies, and the complex architectures of cell tissues. Informed by biological systems, Nagpal and her team develop novel hardware and mathematical approaches aimed at illuminating collective intelligence and expanding capabilities of robots for scientific exploration, structural monitoring and construction, and other applications.

Some of Nagpal’s recent work has focused on colonies of army ants, which use their own bodies to build bridges and ladders that are highly adaptable to changing terrain and traffic conditions. In collaboration with biologist Simon Garnier’s Swarm Lab at the New Jersey Institute of Technology, Nagpal’s group used field experiments and simulations to understand how the ants’ self-assembled bridges respond to changes and how individual decisions add up to collective adaptability. Their work was published earlier this year in Nature Communications.

“We’re thinking about ecology as a model for how to do robotics,” said Nagpal. She envisions robot teams that would fit into their environment, minimizing waste and disruption to ecosystems.

Her lab is well-known for the creation of the Kilobots, a swarm of 1,024 coin-sized robots with vibrating motors that can be programmed to self-assemble into particular shapes based on each individual robot’s sensing of its immediate surroundings.

The Kilobots project, published in Science in 2014, was a pioneering demonstration of a low-cost robot collective. “It’s a way of testing ideas for engineered collective intelligence — more real than a simulation, but still an abstraction of a robot,” said Nagpal. These robots have been commercialized and are now used by labs worldwide.

While Kilobots pushed the envelope in manufacturing and coordinating large numbers of robots, the system was “stuck in two dimensions,” said Nagpal. Now, her team is testing schools of 3D-printed, fish-like robots called Blueswarm that can be readily maneuvered in any direction and have a nearly 360-degree view of their surroundings.

“Bigger fish schools are actually more efficient than smaller schools at finding food and evading predators,” said Nagpal. “They get all these group benefits, so we’d like to be able to do that with robots … where each individual is actually doing pretty simple things, but the group itself is so much more powerful than the individual.”

Read the full profile here.

a word from the lab continued

to make different bread recipes mixed with carbon to see if they could recreate the aerogel structure he was looking for. None of them worked quite right initially, so the team kept eliminating ingredients as they tested, until eventually only egg whites remained.

“We started with a more complex system,” Arnold said, “and we just kept reducing, reducing, reducing, until we got down to the core of what it was. It was the proteins in the egg whites that were leading to the structures that we needed.”

Egg whites are a complex system of almost pure protein that — when freeze-dried and heated to 900 degrees Celsius in an environment without oxygen — create a structure of interconnected strands of carbon fibers and sheets of graphene. In a paper published Aug. 24 in Materials Today, Arnold and his coauthors showed that the resulting material can remove salt and microplastics from seawater with 98% and 99% efficiency, respectively.

“The egg whites even worked if they were fried on the stove first, or whipped,” said Sehmus Ozden, first author on the paper. Ozden is a former postdoctoral research associate at the Princeton Center for Complex Materials and now a scientist at Aramco Research Center. While regular store-bought egg whites were used in initial tests, Ozden said, other similar commercially available proteins produced the same results.

Read the full story here.
faculty awards and honors

2022 Tiger Entrepreneurship Award

For the last six years, the Tiger Entrepreneur Award has been given by the Princeton Entrepreneurship Council to celebrate the value of entrepreneurship across the Princeton community and to emphasize the University’s commitment to Entrepreneurship the Princeton Way.

One of the 2002 winners is Princeton NuEnergy, a spinout from the labs of Yiguang Ju, Robert Porter Patterson Professor of Mechanical and Aerospace Engineering, and Bruce Koel, professor of chemical and biological engineering. NuEnergy is developing green technologies to recycle and upcycle cathode materials of lithium ion batteries for electric vehicles and energy storage. The team has raised $7.5 million in government and private funding. They will be opening their new cathode recycling plant with a dedication ceremony in McKinney, Texas on October 25th.

“Since the creation of PNE in 2019, the core research team members (all from Princeton University) of Chao Yan (Founder), Xiaofang Yang (CTO) and Jerry Xiang (engineer) has led a very successful technology, product, market, and demonstration plant development,” said Ju.

Hultmark wins experimental physics award

The Gordon and Betty Moore Foundation has awarded Marcus Hultmark, professor of mechanical and aerospace engineering, an Experimental Physics Investigators Initiative award. Hultmark’s research focuses primarily on turbulent flows, which are chaotic motions in fluid. The Moore Foundation award will support Hultmark’s research using a unique new facility that will be housed on Princeton’s Forrestal Campus. The Eric and Wendy Schmidt Transformative Technology Fund provided initial funding for the facility.

The Moore Foundation award supports tenured, mid-career faculty doing experimental work in physics. Hultmark is one of sixteen researchers from across the United States to receive the award, which will provide a total of $1,250,000 over the next five years.

Hatzell and Majumdar win early career award from the Office of Naval Research

Professors Kelsey Hatzell and Anirudha Majumdar have received Young Investigator Program awards from the Office of Naval Research.

The Young Investigator Program is a highly competitive and popular early-career award program which recognizes academic achievement and potential for significant scientific breakthrough.
## Events: Fall 2022

<table>
<thead>
<tr>
<th>Date</th>
<th>Title</th>
<th>Speaker</th>
<th>Institution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Friday, September 9, 2022</td>
<td>Synchronization in Nature, Technology, and Mathematics</td>
<td>Steven Strogatz</td>
<td>Cornell University</td>
</tr>
<tr>
<td>Tuesday, September 11, 2022</td>
<td>From Snapping to Buckling: A Path for New Multifunctional Materials</td>
<td>Eleonora Tubaldi</td>
<td>University of Maryland</td>
</tr>
<tr>
<td>Thursday, October 6, 2022</td>
<td>Using Delays for Control</td>
<td>Emilia Fridman</td>
<td>Tel Aviv University</td>
</tr>
<tr>
<td>Friday, October 7, 2022</td>
<td>Effective Practices for Teaching Engineering Undergraduates</td>
<td>Lamyaa El-Gabry</td>
<td>Princeton University</td>
</tr>
<tr>
<td>Friday, October 14, 2022</td>
<td>Fluid Instabilities and Interfacial Mixing</td>
<td>Snezhana I. Abarzhi</td>
<td>University of Western Australia</td>
</tr>
<tr>
<td>Friday, October 28, 2022</td>
<td>Nano Joining: The Past, Today and Beyond</td>
<td>Anming Hu</td>
<td>University of Tennessee, Knoxville</td>
</tr>
<tr>
<td>Friday, November 4, 2022</td>
<td>The Death and Re-Birth of the Intervertebral Disc Cell</td>
<td>Lori A. Setton</td>
<td>Washington University in St. Louis</td>
</tr>
<tr>
<td>Friday, November 11, 2022</td>
<td>From Snapping to Buckling: A Path for New Multifunctional Materials</td>
<td>Eleonora Tubaldi</td>
<td>University of Maryland</td>
</tr>
</tbody>
</table>

## In the Media

**Radhika Nagpal** and **Aimy Wissa** featured in *Nature* for their work on bioinspired robots.

**Egemon Kolemen** featured in *Popular Mechanics* for his work on devices that can contain nuclear fusion reactions.

Alumna **Annie Yu Kleinman** featured in *Princeton Alumni Weekly* for her work with Afghan refugees.

**Jesse Jenkins** interviewed on the *Ezra Klein Show* about decarbonization and climate change.