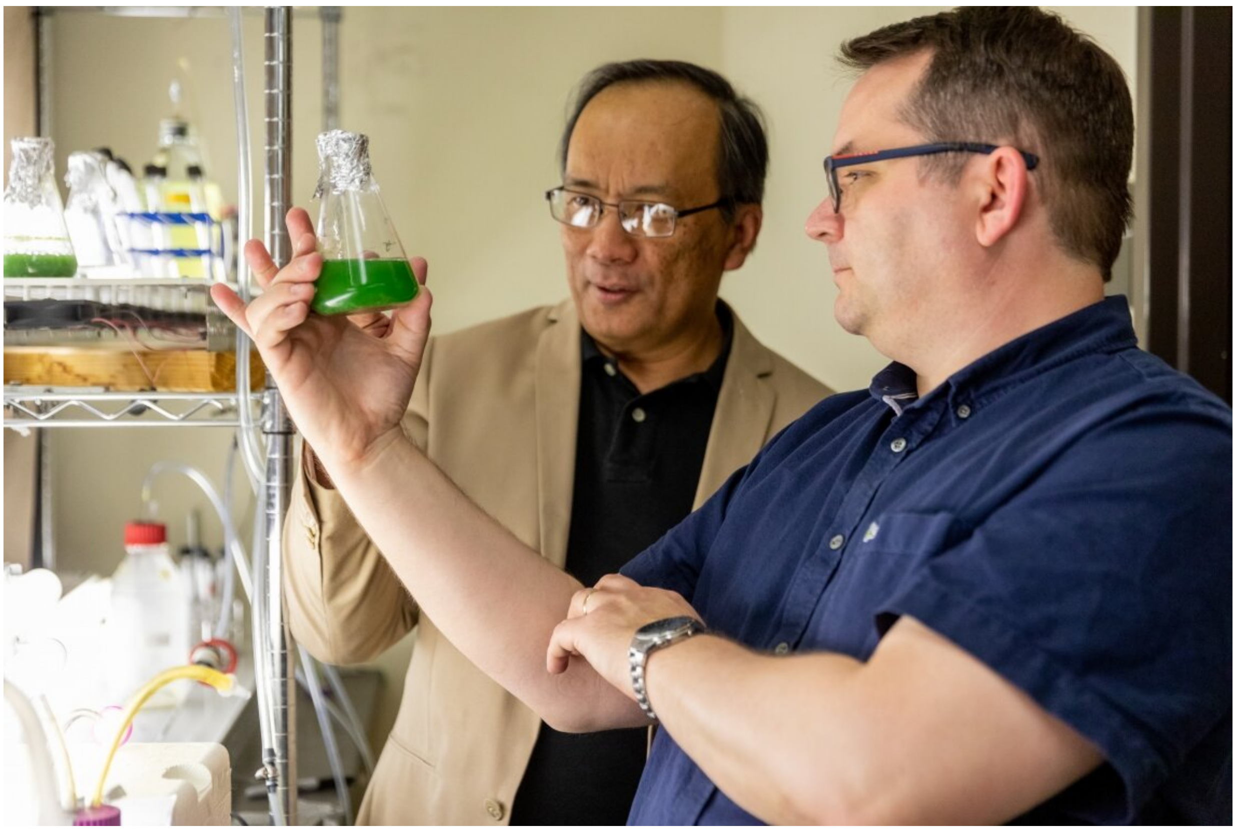
Small but mighty: Harnessing the power of algae to capture carbon

April 20 2022, by Mikayla MacE Kelley



Astrobiologist Daniel Apai (right) and biosystems engineer Joel Cuello (left) work with algae in the lab. Their team aims to harness the power of coccolithophores, which are a single-celled marine algae that use atmospheric carbon dioxide and calcium from saltwater to create intricate shells made of calcium carbonate. The shells are made from a very stable, chalk-like mineral. They can be grown efficiently, then stored to trap carbon dioxide. Credit: Chris Richards

As a University of Arizona professor of astronomy and planetary sciences who studies planets orbiting other stars, Daniel Apai spends much of his time thinking about what makes worlds habitable.

On Earth, the carbon cycle plays a key role in maintaining conditions for life. Earth releases carbon into the atmosphere and reabsorbs it through geological and biological processes. But humans have released more carbon dioxide into the atmosphere than the carbon cycle naturally would, causing global temperatures to rise.

Apai has assembled a team that plans to harness the principles of the carbon cycle to trap massive amounts of carbon dioxide and curb the worst impacts of climate change.

They call themselves Atmospherica. In addition to Apai, the team includes Joel Cuello, a professor of agricultural and biosystems engineering and BIO5 Institute member; Régis Ferrière, an associate professor of ecology and evolutionary biology; Martin Schlecker, an astrophysicist and postdoctoral research associate; and Jack Welchert, a biosystems engineering doctoral student.

Reports from the Intergovernmental Panel on Climate Change and future climate projections find that preventing the worst effects of climate change will require carbon removal from the atmosphere at gigaton-per-year levels.

"Yet, no existing technology is thought to be scalable enough to succeed in this," Apai said. "What we need to do as a civilization is to reduce our emissions as much as possible, because extracting from the air is much more difficult than not emitting it. No one has come up with a solution that extracts carbon dioxide so efficiently as to allow the continued burning of fossil fuels."

The Atmospherica team team hopes to be a part of the solution, by harnessing the power of algae.

It's all in the algae

"Climate change is one of the great challenges we are facing as a species and civilization," Apai said.

He began the search for potential climate change solutions as a hobby seven years ago. He found that most existing carbon removal solutions could not be scaled up to the levels required, were prohibitively expensive or were harmful to the environment.

As an astrobiologist, he decided to pursue solutions inspired by nature. That's when he learned about coccolithophores—single-celled marine algae. What makes these algae special is the fact that they use atmospheric carbon dioxide and calcium from saltwater to create intricate shells made of calcium carbonate—a very stable, chalk-like mineral. These shells evolved to protect the algae and regulate the algae's buoyancy and light exposure.

Coccolithophores naturally extract carbon dioxide from the ocean as part of their life cycle. While most of them are consumed by predators, a very small fraction decompose, uneaten, while their carbon-containing shells sink to the ocean floor, where they remain indefinitely. The White Cliffs of Dover on the English coastline are huge 90-million-year-old deposits of these shells and demonstrate their incredible stability.

Apai wondered if it would be possible to grow coccolithophores on a large enough scale to change Earth's atmospheric composition. To do this would require a safe and controlled environment for the algae to grow.

Enter the air accordion

Cuello and his Biosystems Engineering Lab have developed a portfolio of patented low-cost novel photobioreactors in which to grow algae and other types of cell cultures in an efficient and productive way. One of the designs is the air accordion photobioreactor.

The air accordion photobioreactor that Joel Cuello and his biosystems engineering team designed. This photobioreactor will be further optimized to grow coccolithophores most efficiently. Credit: Joel Cuello

The air accordion photobioreactor consists of a rectangular metal frame with horizontal bars—like steps on a ladder—spaced closer together at the bottom and farther apart at the top. A polyethylene bag full of nutrient-rich saltwater is woven throughout this ladder-like frame. Air is pumped in from the bottom and circulated through the saltwater mixture. The design maximizes the liquid-mixing capacity of air bubbles pumped in from the bottom and allows for even distribution of light and dissolved nutrients.

The photobioreactor make it possible to efficiently grow large amounts of algae. And because the algae is grown in a controlled environment, within the polyethylene bag, it is protected from predators. The researchers say their air accordion photobioreactor is also easy to scale up.

Cuello and Apai patented the use of coccolithophore algae for carbon dioxide removal in this kind of photobioreactor, and they hope to continue to optimize the design for even more efficient coccolithophore growth and carbon uptake.

"Our goal is to reach a gigaton-per-year level of carbon dioxide extraction capacity, while remaining affordable and with very limited environmental impact," Apai said.

The researchers hope the photobioreactors can be made even more sustainable in the future. They envision a world in which solar-powered bioreactors would be located by the ocean, allowing for easy access to the seawater required to help the coccolithophores grow. Even better, the researchers say, would be to establish the photobioreactors near desalination plants, which produce calcium as a waste product. Calcium is an important nutrient for coccolithophores and is used in the saltwater mixture.

The team hopes the design offers a viable solution for carbon removal that overcomes some of the limitations of existing technologies, such as chemical filtration techniques, which are difficult to scale up because they are energy intensive and often require rare minerals. They also can produce environmentally harmful waste products.

To ensure that their method is scalable and confirm how much net carbon dioxide it pulls from the atmosphere, members of the Atmospherica team plan to build a demonstration facility in a greenhouse atop the university's Sixth Street Garage and a larger facility at the university's Biosphere 2 research facility.

They also plan to "do a full accounting of its carbon footprint, from cradle to grave," Apai said.

"We have completed a promising exploratory analysis and plan to publish a paper on the subject this summer," Apai said.

The team is also aiming to keep the cost of carbon removal to less than $100 per ton extracted.

"Anything more expensive is not viable," Apai said.

The urgency

Apai stressed that even if we can transition most industries efficiently toward zero emissions, for a few decades we will still end up producing about 15% of our current emissions, or about 6 billion tons of carbon dioxide annually. That's partly because things like large airplanes and cargo ships rely on fossil fuels that pack a lot of energy in a small volume. They physically cannot be battery powered.

That remaining 6 billion tons of carbon dioxide is what Atmospherica hopes the coccolithophores can successfully absorb.

"Our governments have delayed action so much that we now need to be successful on both counts: building a sustainable future and fixing the damage we keep doing in the meantime," Ferrière said. "With its emphasis on resilience science, our university and its international partners are committed to advance the interdisciplinary research that will solve this grand challenge."

Provided by University of Arizona

Citation: Small but mighty: Harnessing the power of algae to capture carbon (2022, April 20) retrieved 16 July 2024 from https://phys.org/news/2022-04-small-mighty-harnessing-power-algae.html