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Understanding Earth's geologic history to predict the future

8 December 2017, by Rebecca Fowler, Earth Institute, Columbia University

Pratigya Polissar is an organic geochemist at Lamont-Doherty Earth Observatory and a Center for Climate and Life Fellow. Polissar uses molecular fossils—the remnants of plants and animals preserved in ocean, lake, and terrestrial sediments—to identify these organisms, understand what past landscapes and ecosystems looked like, and examine how climate shapes Earth's ecosystems.

Q. What exactly are the climate questions you're trying to address?

A. The big question I'm trying to ask is how far back in time do you need to go in Earth history to find carbon dioxide levels comparable to today? And are these levels comparable to what we might see in this century as we continue to increase the carbon dioxide concentration in the atmosphere? When you go back to that time period and look forward to today, what are the major changes you see, particularly in the kinds of plants and ecosystems? I try to understand what those changes and thresholds mean for the coming centuries as temperatures and carbon dioxide levels rise and rainfall patterns change.

My Center for Climate and Life project is about developing new tools to look at the history of plants and ecosystems on Earth over the past 20 million years. A challenge in my field has been to identify and relate the particular molecules we see to the types of plants they're coming from. It's historically been a very slow, painstaking process.

This new project takes tools that are already in practice in other fields, particularly in biochemistry and health, and applies them to the analyses of organic molecules and sediments. Rather than trying to guess at the outset what molecules are going to be useful, we'll rapidly screen many hundreds of samples and identify the molecules that are useful.

This will enable us to find patterns that are not immediately apparent from the way we look at the samples now. Ultimately we'll create a sort of electronic library of sample information that relates molecules to an environment. So, when someone takes a sample and analyzes the molecular composition, they can immediately search on that and find all the places in the world and all the times where those particular molecules have been found. And then we can investigate more to understand the details about their preservation and such.

Q. What do you find most exciting about this work?

A. One part is understanding Earth's history: the big picture. The time periods I'm looking at are not that far back geologically, about 15 million years. The Earth looked very different then. There were forests in places where there are savannahs today. The poles were much warmer; there was an ice-free Arctic. I like exploring how we went from that time period to today. I get to be among the first to understand that and then share this knowledge with my colleagues and the public.

I also really love molecular mass spectrometry. It's the nuts and bolts of what we do. It's how you identify these molecules. You have to piece together the fragments of a molecule to see the bigger picture and learn about the structure of the molecule. Basically, it's solving puzzles. Some people do crosswords; I like to look at mass spectra.

Q. How might this work help us understand the global challenges posed by climate change?

A. My work is about understanding the role of carbon dioxide levels, and the role of climate more indirectly, in shaping the ecosystems we see today and what that means for the future. So it could help in a couple of ways. One is nailing down these questions: When was the last time Earth saw carbon dioxide levels like today? And what are they likely to be in the future if we continue with business as usual?

Many things are likely to change. Carbon dioxide levels are going up, temperatures are rising in many regions, and rainfall patterns are shifting. Using lessons from the past will enable us to better predict which ecosystems are going to thrive and which ecosystems are going to whither and be replaced by other kinds of ecosystems.

There's also a very human aspect to it. People rely on these ecosystems for food, water, and shelter. So the predictions are very important for understanding what kinds of pressures humans are going to face in the future. How are ecosystems going to change? And how might those changes impact our societies, governments, and food supplies?

Q. What gives you hope?

A. I don't want to play down the challenges we're facing today, but the earth has kind of a resilience; it will survive whether there are humans or not. I hope that humans are able to adapt in both the way we live on Earth and adapt to changes in the coming centuries in ways that allow us to thrive. There are major challenges ahead in terms of social and political changes that will be driven by these rapid environmental changes. But I think organisms are resilient, and so is the Earth and the ecosystems on this planet.

Q. What's your favorite climate read?

A. I'm re-reading How to Build a Habitable Planet by Charles Langmuir and Wally Broecker. It's not easy but it lays out everything a person should know about the Earth. The book humbles me, and I think humans should be in a kind of wonder and amazement at Earth history and the Earth today.

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