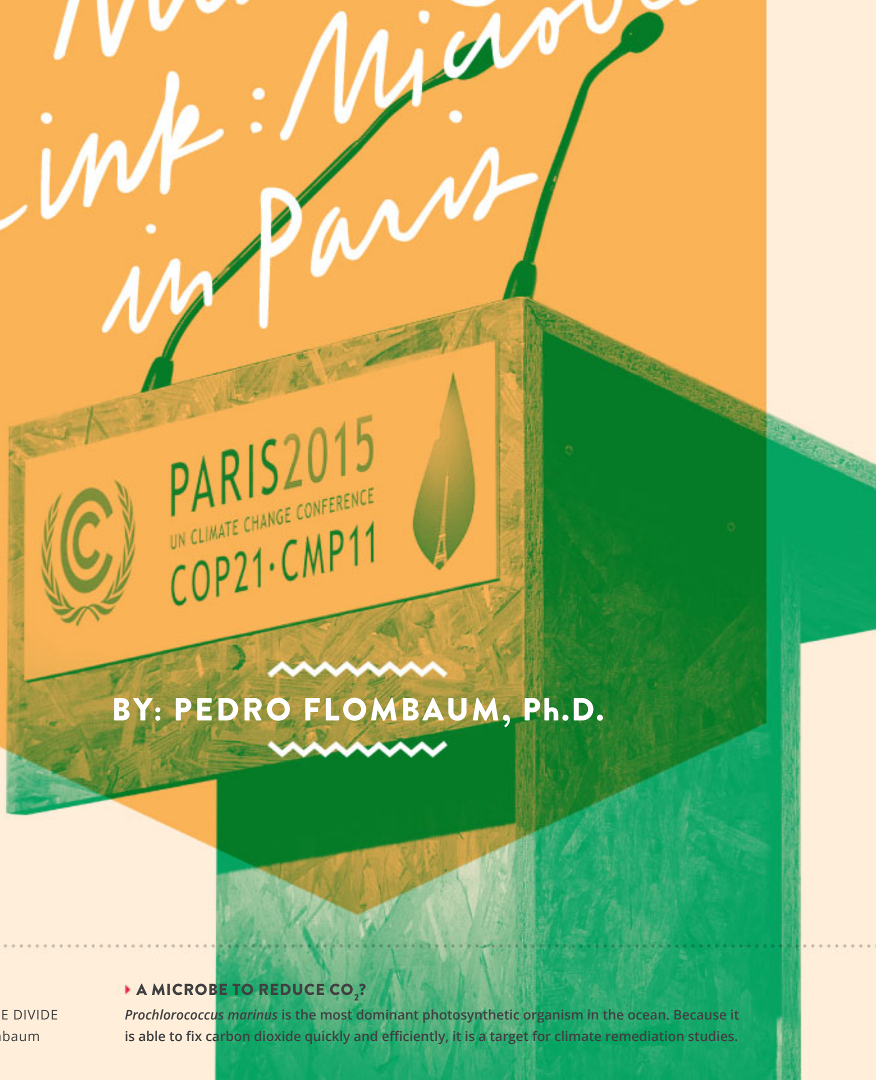
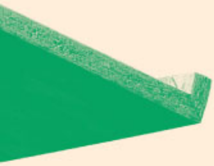
ACROSS THE DIVIDE

The Missing Link: Microbes in Paris



BY: PEDRO FLOMBAUM, Ph.D.

The Conference of the Parties on Climate Change in Paris places this pressing environmental issue at the forefront of our attention. Many of us might wonder if and how microbes are affected by climate change, and ultimately, if what we know about them is of any use in Paris. The relationship between microbes and climate is a two-way street. In one regard, microbes have an immense effect on climate as major controllers of greenhouse gases (GHGs), such as carbon dioxide, methane, and nitrous oxide. Conversely, microbes and microbial communities largely respond to temperature and, thus, will shift along with increasing global temperatures.



SOURCE
https://microbewiki.kenyon.edu/index.php/Prochlorococcus_marinus#Application_to_Biotechnology

A CHANGING ENVIRONMENT FOR CYANOBACTERIA

Oceans provide a comprehensive example of this two-way relationship. Oceans host microscopic photosynthetic organisms that fix half of the carbon dioxide globally, a quantity 6.4 times greater than anthropogenic emissions. The marine cyanobacteria that are the focus of my research are among the smallest photosynthetic organisms in the world. Despite their lack of individual size, they are unrivaled in abundance; there are one million of these cyanobacteria in the oceans for every star in the universe! This abundance allows these and other microbes to essentially act as mediators of carbon pathways, whether released back into the atmosphere via respiration, remaining fixed in ocean debris, or sinking to the bottom of the ocean.

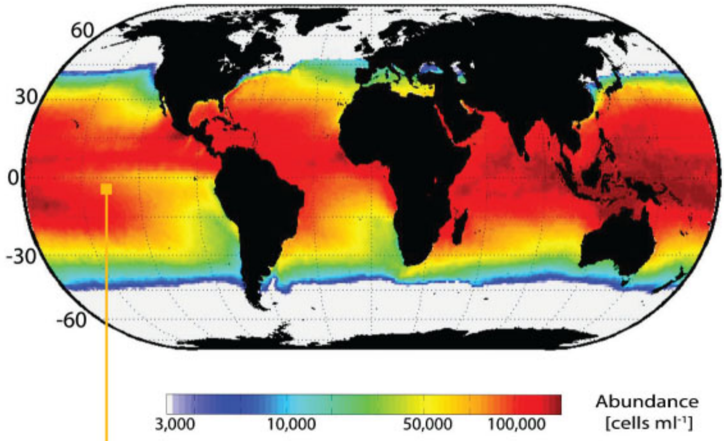
As ocean temperatures increase, this continued change can affect the abundance, distribution, and diversity of marine microbes and, in turn, their effect on ecosystems. Along with changes in temperature, other projected changes can impact microbes, such as the already noticeable acidification of the ocean, or changes in oceanic currents that supply nutrients to microbes. Using a moderate climate change scenario for the end of this century, a group of colleagues and I estimate that cyanobacteria will expand toward the poles, but, more importantly, they will increase in abundance in areas where they are abundant already.

BRINGING THE SCIENCE TO PARIS

Many of us might also wonder how this evidence impacts the Conference of the Parties on Climate Change (or COP21) in Paris. The meeting is aimed to update the United Nations Framework Convention on Climate Change, which started in 1992 in Rio de Janeiro. Previous meetings intended to update the Rio summit were held in Kyoto in 1997 (when the Kyoto Protocol was signed) and Copenhagen in 2009 (where new agreements failed to materialize). Although COP21 is primarily a political meeting, the discussions and decisions are influenced by scientific evidence compiled and presented by the Intergovernmental Panel on Climate Change (IPCC).

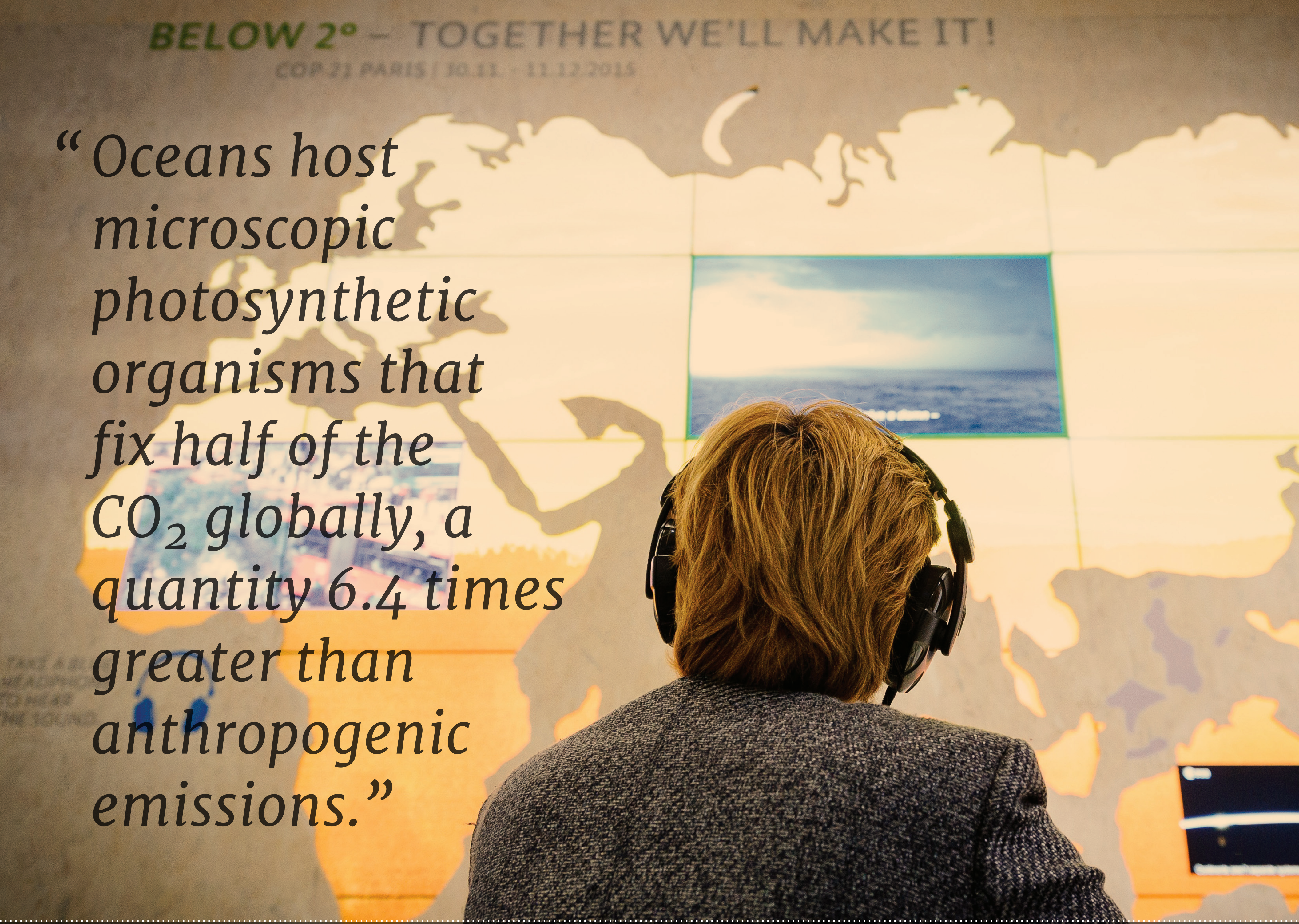
The IPCC is a scientific body that reports on the latest research and evidence on climate change in the form of Assessment Reports (ARs). The latest of the five reports, the AR5, is the main vehicle for scientific evidence to reach political leaders at COP21.

The report is the summed contribution of three Working Groups (WGI, WGII, and WGIII), each focusing on particular aspects of climate change: WGI is focused on the causes, WGII on the consequences, and WGIII on mitigation. WGs are formed by hundreds of scientists from a wide range of countries who summarize the latest climate change research. Each WG produces a ~1000-page volume, divided in thematic chapters, and written by several authors on specific subjects. Prior to publication, authors respond to thousands of comments from accredited scientific reviewers.



Present global distribution of **Prochlorococcus**, *the most abundant photosynthetic organism in the ocean.* **Prochlorococcus** *abundance is driven by ocean temperature and thus projected to change in future climate scenarios.*

IMAGE SOURCE
http://www.pnas.org/content/110/24/9824.full?sid=e3734795-9702-4aac-a439-47b1f54a53d1



“Oceans host microscopic photosynthetic organisms that fix half of the CO_2 globally, a quantity 6.4 times greater than anthropogenic emissions.”

IMAGE SOURCE

ARE MICROBES ADEQUATELY REPRESENTED IN THE AR5?

The AR5 reported on observed and modeled climate change data. The report recognizes three major sources of uncertainty: natural climate variability, scientific understanding and technical limits, and a societal component that defines scenarios. Since the first AR, climate models have advanced greatly to include more processes and components of climatic systems, first by coupling oceanic and atmospheric dynamics (climatologists now say that it is unthinkable to model climate without including oceans!), and later by refining the spatial scale, to name a few. Recently, climate models have been paired with dynamic biological, chemical, and geological models (known as biogeochemical models). In this new generation of models, climate influences ecosystems, which regulate GHG concentrations, which then regulate climate. In previous climate models, GHG concentrations were fixed and did not include ecosystem feedback.

> ***"There are one million* Prochlorococcus *in the oceans for every star in the universe!"***

In terms of microbes and climate, the AR5 reports on models and field and laboratory experiments that include microbial processes in various ecosystems. The effect of climate change on oceanic microbes is reported on in much more detail than the effect on terrestrial microbes, but it is possible to find pieces of evidence for both ecosystem types; for example, the results of future abundance and distribution of marine cyanobacteria, is part of the AR5.

Microbial processes remain underrepresented, however. For terrestrial systems, key processes relevant to decomposition and nutrient cycling dynamics are missing, all of which are related to microbial activity. For ocean systems, many bacteria-related processes and their responses to temperature are represented minimally. In addition, while cyanobacteria are mentioned, their roles are not included in biogeochemical models. Although incorporating the role of microbes in biogeochemical models proves challenging, this is a critical component in creating a comprehensive scientific picture.

IMAGE SOURCE

As newer versions of climate models are paired with biogeochemical models, an increased representation of microbes will be essential to reducing the uncertainty of the effect of microbes on climate. In turn, this will hopefully increase our understanding of climate change as a whole. What we know now is represented within the current IPCC assessment, but we can always improve. As a scientist, I hope to continue using my research to contribute to the understanding of an issue that truly affects us all, large and small. ■

PEDRO FLOMBAUM

Pedro Flombaum obtained a B.S. in biology from the University of Buenos Aires. Under the advice of Osvaldo Sala, he studied how plant diversity influenced ecosystem functioning in the Patagonian Steppes, and obtained a Ph.D. at Brown University. His postdoctoral work focused on present and future distribution of cyanobacteria at the laboratory of Adam Martiny at the University of California, Irvine. Currently, he works in Argentina at the Center for Research on Marine and Atmospheric sciences (CIMA), and is a professor in the Department of Ecology, Genetics and Evolution at the University of Buenos Aires.