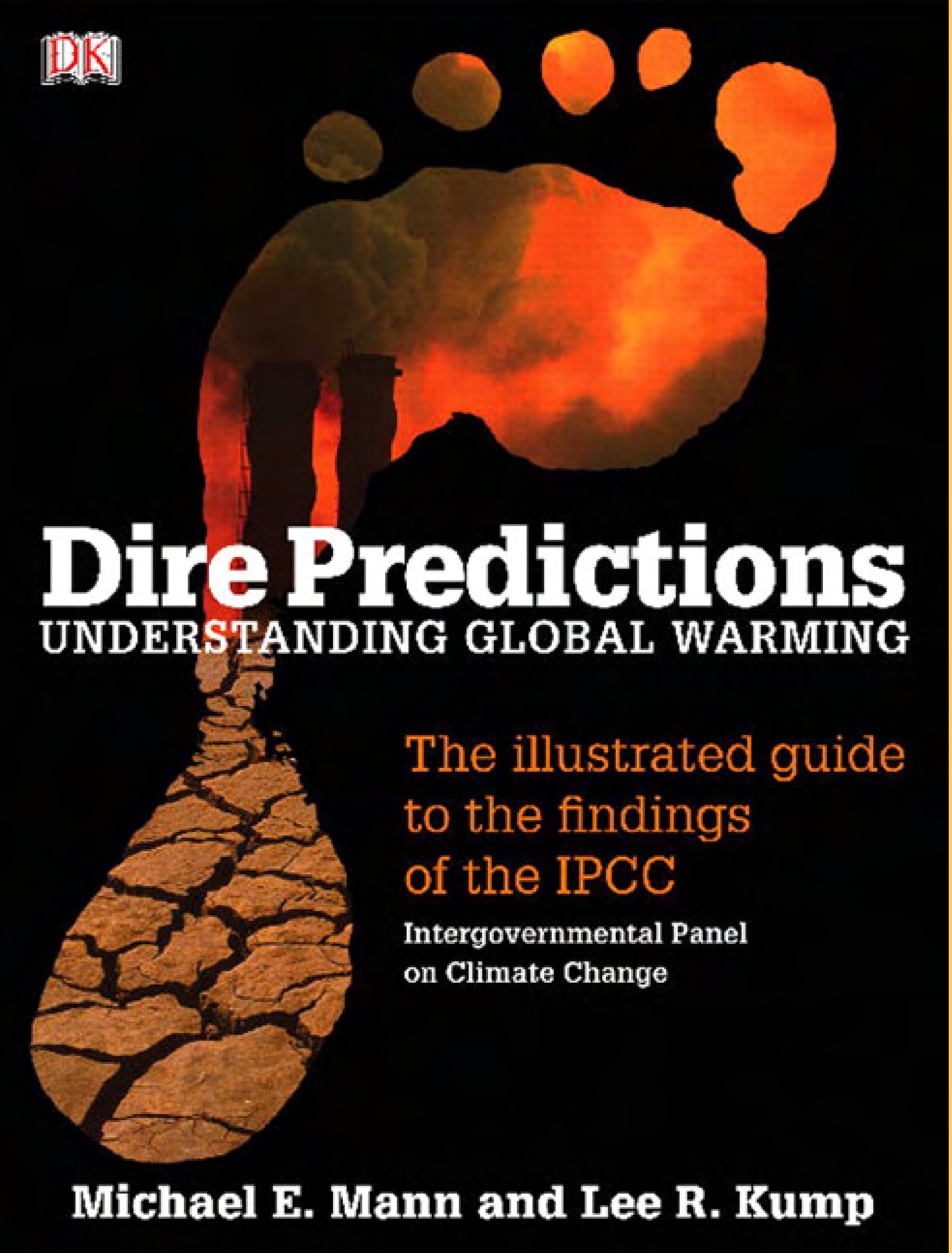

The Intergovernmental Panel on Climate Change (IPCC) was established in 1988 to evaluate the risk of climate change brought about by humans. Since then, the organization's periodic assessment reports have become the de facto standard for conservative scientific accuracy about the facts of global climate change.

In ***Dire Predictions***, esteemed climate scientists Michael E. Mann (his work, along with that of others who also contributed to the IPCC reports, was awarded the Nobel Prize in 2007—a distinction the IPCC shares with Al Gore) and Lee R. Kump, have partnered with the "information architects" at DK Publishing to present an important book in this time of global need. ***Dire Predictions*** presents and expands upon the essential findings documented by the IPCC in an illustrated, visually stunning, and undeniably powerful way to the lay reader—in just over 200 pages.

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Part 1
Climate Change Basics

Basic principles of physics and chemistry dictate that Earth will warm as concentrations of atmospheric greenhouse gases increase. Though various natural factors can influence Earth's climate, only the increase in greenhouse gas concentrations linked to human activity, principally the burning of fossil fuels, can explain recent patterns of global warming. Other changes in Earth's climate, such as shifting precipitation patterns, worsening drought in many locations, increasingly severe heat waves, and more intense Atlantic hurricanes, are also likely repercussions of human's impact.

Back to the future

Deep time holds clues to climate change

When a doctor receives a new patient, a detailed health history is taken. Did the patient suffer these ills previously, and if so, what was the course of the illness? What are the symptoms? What brought on the illness? A physician needs to know these things before making a diagnosis.

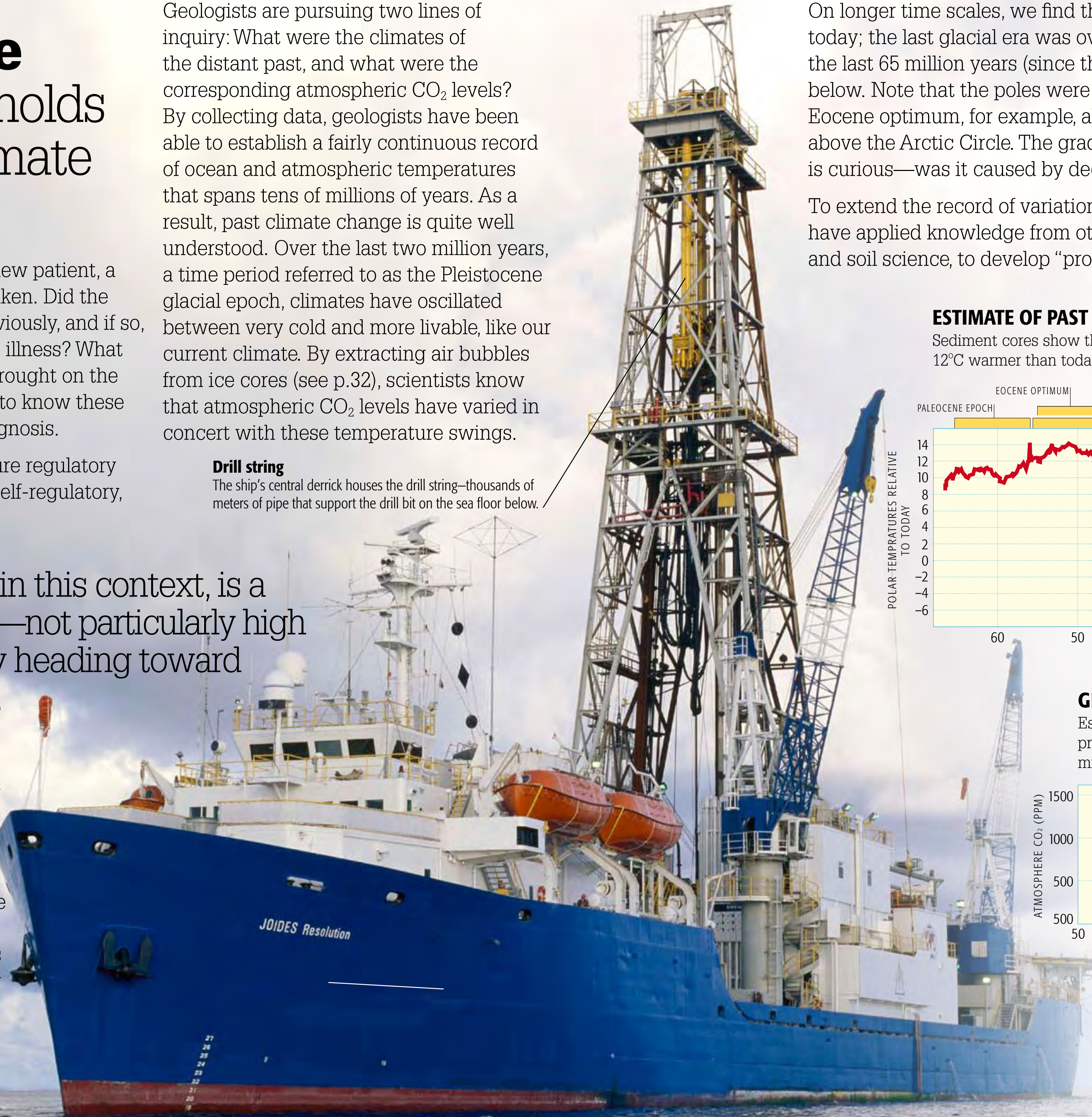
Like your body's temperature regulatory system, Earth's climate is self-regulatory, able to resist change but subject to disturbances.

Global warming, in this context, is a planetary "fever"—not particularly high now, but possibly heading toward critical extremes.

If Earth has a planetary fever, then geologists are acting as "geo-physicians," compiling the patient's history by delving into the rock record. Rocks preserve a record of climate history, so studying rocks can tell scientists if there is any link between changing levels of atmospheric CO_2 and climate over Earth's 4.6 billion-year history.

The last two million years

Geologists are pursuing two lines of inquiry: What were the climates of the distant past, and what were the corresponding atmospheric CO_2 levels? By collecting data, geologists have been able to establish a fairly continuous record of ocean and atmospheric temperatures that spans tens of millions of years. As a result, past climate change is quite well understood. Over the last two million years, a time period referred to as the Pleistocene glacial epoch, climates have oscillated between very cold and more livable, like our current climate. By extracting air bubbles from ice cores (see p.32), scientists know that atmospheric CO_2 levels have varied in concert with these temperature swings.



Drill string
The ship's central derrick houses the drill string–thousands of meters of pipe that support the drill bit on the sea floor below.

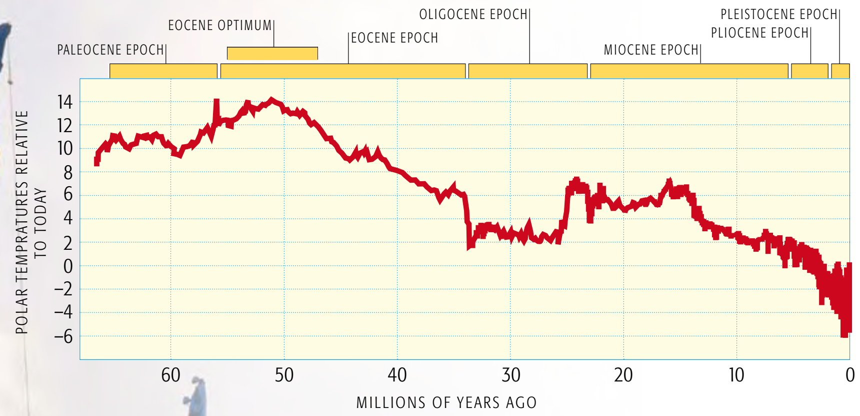
Sediment study
Scientists spend months on the *JOIDES Resolution* recovering sediment cores from the deep-ocean floor.

The last 65 million years

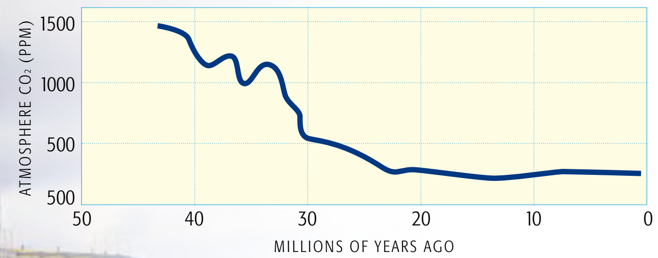
On longer time scales, we find that climates were generally warmer than today; the last glacial era was over 300 million years ago. The record for the last 65 million years (since the extinction of the dinosaurs) is shown below. Note that the poles were considerably warmer in the past; in the Eocene optimum, for example, alligators and sequoia forests were thriving above the Arctic Circle. The gradual cooling over the past 50 million years is curious—was it caused by declining atmospheric CO_2 levels?

To extend the record of variations in atmospheric CO_2 levels, geologists have applied knowledge from other fields, including biology, biochemistry, and soil science, to develop "proxy" measures (see p.42).

ESTIMATE OF PAST POLAR TEMPERATURE
Sediment cores show that polar temperatures 50 million years ago were up to 12°C warmer than today, and have fallen subsequently in a series of steps.



GEOLOGIC RECORDS OF CO_2 LEVELS
Estimates of atmospheric CO_2 levels, based on various proxies, show that levels have fallen over the last 50 million years.

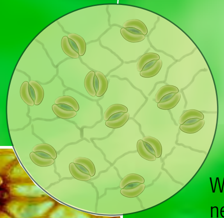


A fossilized imprint of a prehistoric fern leaf

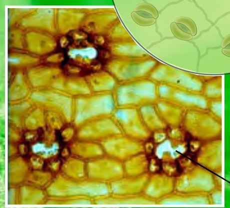
PROXY MEASURE

Proxies are substitutes for what one is really after. Climate scientists study proxies because there are no thermometer records for prehistoric times. Proxies may even include the pores on fossil leaves: when atmospheric carbon dioxide levels are low, plants need more pores on their leaves to bring in more carbon dioxide. Under the microscope, well-preserved fossils reveal the number of pores; comparing this pore density to that of living plants allows scientists to establish carbon dioxide levels in the distant geologic past.

Living fern leaf



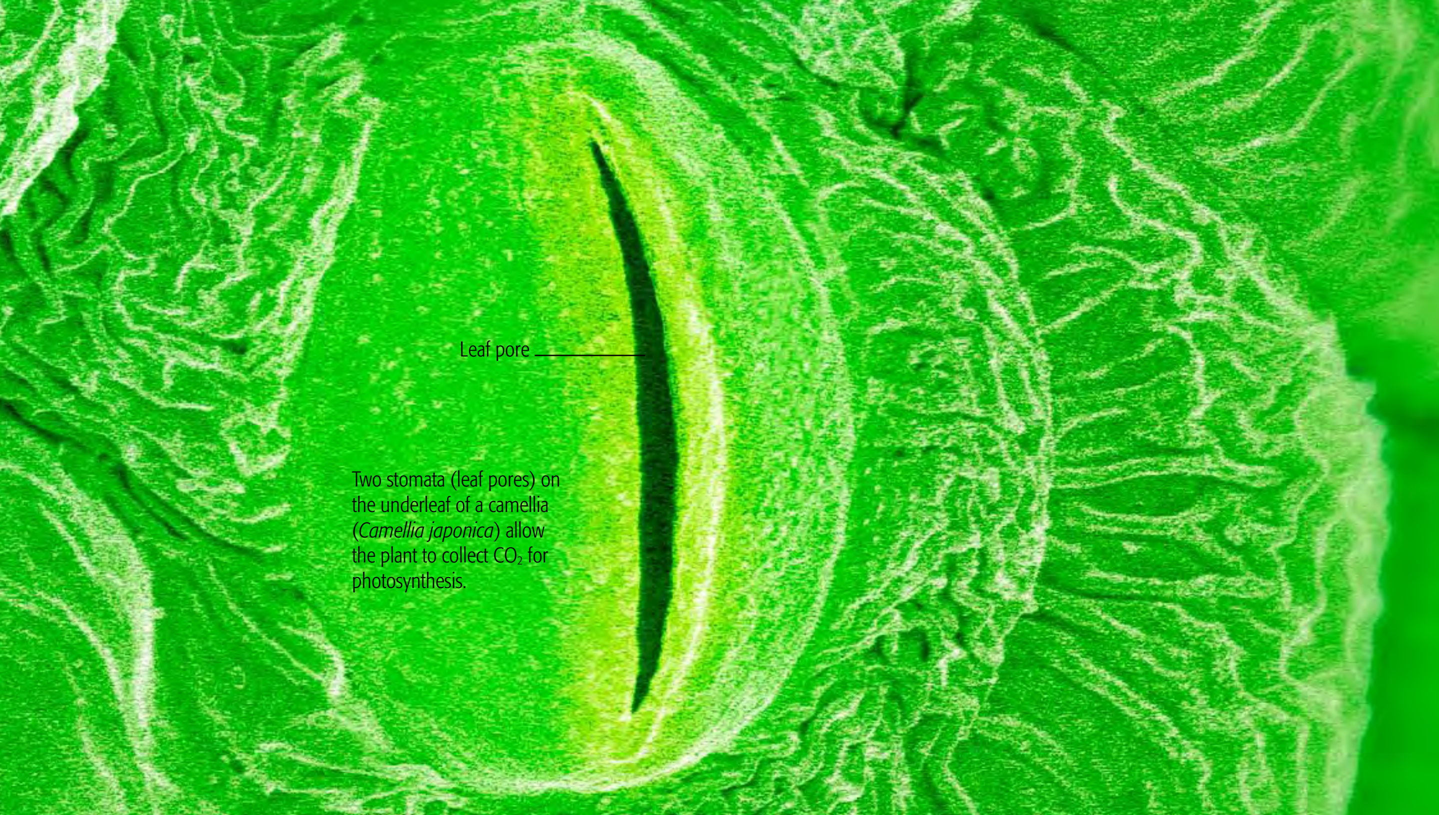
When alive, this tree fern needed a lower density of pores because CO_2 levels were high.



Fossilized leaf pore

This modern leaf has a higher density of pores because the current atmospheric CO_2 levels are low.

Leaf pore



Leaf pore

Two stomata (leaf pores) on the underleaf of a camellia (*Camellia japonica*) allow the plant to collect CO_2 for photosynthesis.

Interpreting the results

Taken together, the geologic records of climate and atmospheric CO_2 levels reveal an expected relationship: when carbon dioxide levels were high, the climate was warm, and vice versa. The correlation isn't perfect, and the mismatches are areas of current research. In particular, the cooling trend from 20 million years ago to the present doesn't seem to be reflected in a reduction in atmospheric CO_2. Are the proxies for climate and CO_2 in error during these times, or is there a third (or fourth or fifth) climate variable that we are neglecting? In this case, the growth of polar ice sheets and their high reflectivity may have provided extra cooling.

Modern measurements of atmospheric CO_2 are 386 ppm. Current estimates of available fossil-fuel reserves translate into the potential for atmospheric CO_2 to rise above 2000 ppm.

If we utilize existing fossil-fuel reserves and do nothing to capture the CO_2 released, the atmospheric CO_2 level will exceed anything experienced on Earth for over 50 million years.

But weren't scientists warning us of an imminent *ice age* only decades ago?

Hollywood License
While human action can have a serious impact on climate, the premise behind the movie *The Day After Tomorrow*—that human activity could send Earth into another ice age—was scientifically flawed.

> "Scientists ponder why world's climate is changing; a major cooling widely considered to be inevitable"
>
> ***THE NEW YORK TIMES***
> MAY 21, 1975

A myth still perpetuated today in popular critiques of global warming science involves the supposed consensus among climate scientists in the 1970s that Earth was headed into an ice age. As this has obviously turned out not to be the case—the argument typically goes—why should we believe what scientists are saying today about global warming? As is typical with urban myths, there is a small grain of truth to this claim. Ultimately, however, the assertion is incorrect and misleading on several grounds.

It is true that decades ago climate scientists were uncertain about future trends in global average temperature, but there was no consensus that an ice age was imminent, or even that the future trend would be one of cooling. Those ideas were conveyed in sometimes quite alarmist accounts in the popular media during the mid-1970s (e.g., in *Newsweek*, *Time*, and *The New York Times*)—not in scientific publications. Indeed, the National Academy of Sciences concluded in a report published in 1975: "*…we do not have a good quantitative understanding of our climate machine and what determines its course. Without the fundamental understanding, it does not seem possible to predict climate…*"

So why all the uncertainty? First, scientists recognized that Earth was eventually due for another ice age as part of the natural cycles of cold ("glacial") and warm ("interglacial") periods that occur due to slow changes in Earth's orbit around the Sun. Just how far away the next ice age might be was not very well known. Second, scientists were already aware that human impacts on climate included both a regional cooling effect from industrial aerosols and the global warming effect of increased greenhouse gas concentrations due to fossil-fuel burning. But it was still not fully understood which of these effects would dominate in the end. We know now that the cooling from the 1950s to the 1970s was probably due to a substantial increase in the regional aerosol cooling impact, which at the time was overwhelming the greenhouse warming impact in the northern hemisphere (see p.68).

More than 30 years after the ice age scare, much has changed scientifically.

The rate of increase in greenhouse gas concentrations due to fossil-fuel burning has accelerated, while policies such as the Clean Air Acts have dramatically reduced aerosol production in most industrial regions. So the impact of increasing greenhouse gas concentrations has considerably overtaken any aerosol-related cooling. Accordingly, since the 1970s there has been even more warming than during the entire preceding century. Equally important, climate scientists now work with far more reliable models of Earth's climate system than they did 30 years ago (see p.64), and they have a better knowledge of the various natural and human factors that influence climate. It is now clear that a natural ice age is not due for many millennia, and we know that the relative impact of aerosols has been small compared to that of greenhouse gas concentrations in recent decades. We also have considerably more data, and we know that the rate of warming in recent decades is greater than can be explained by any natural factors (see p.68).

NORTHERN HEMISPHERE CONTINENTAL TEMPERATURE TRENDS
When we compare northern hemisphere temperature trends through the current decade with the shorter record that was available in the mid-1970s (inset), we see that the trend is actually toward elevated temperatures, not cooling.