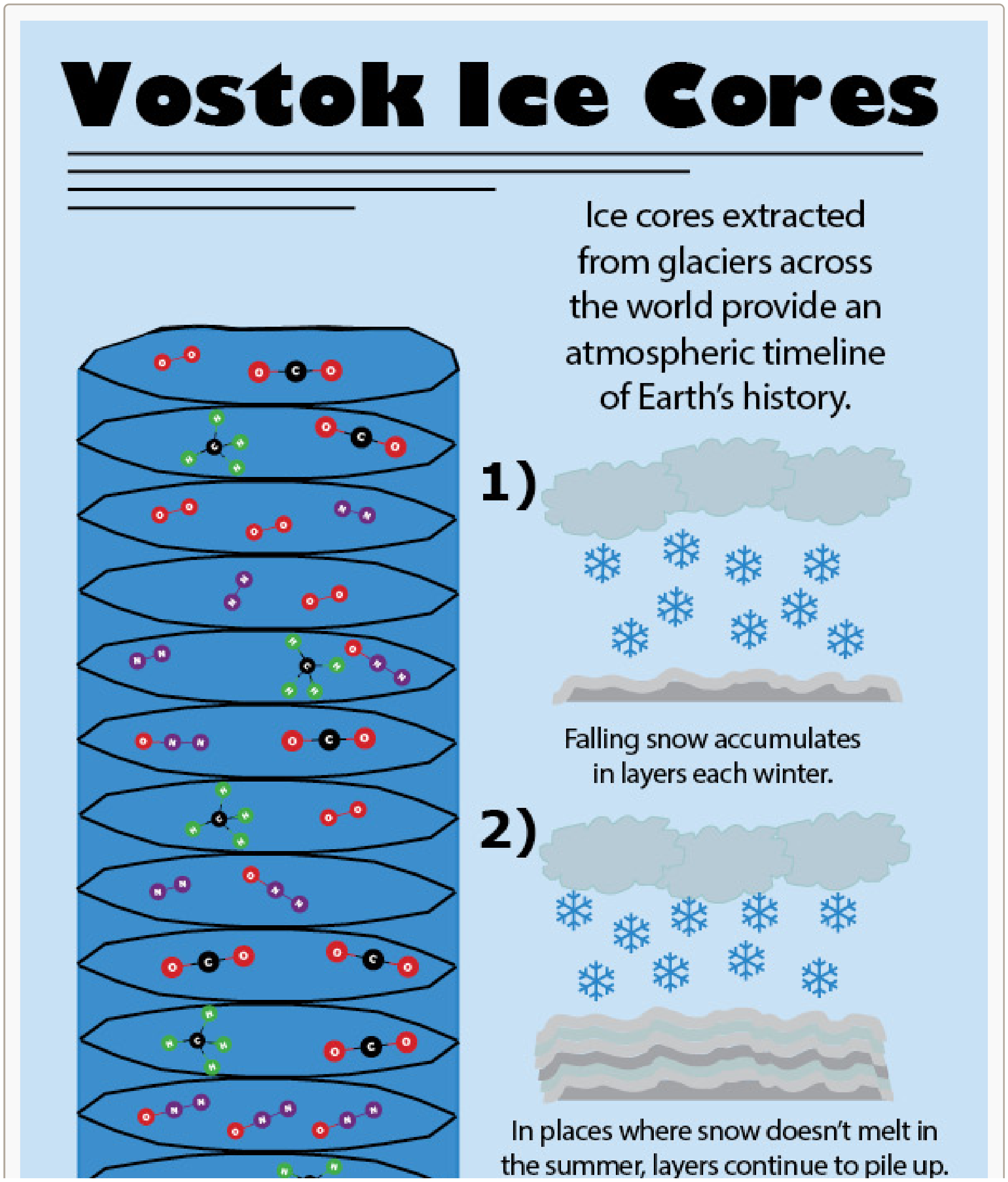
# Greenhouse Gases: What every college student should know

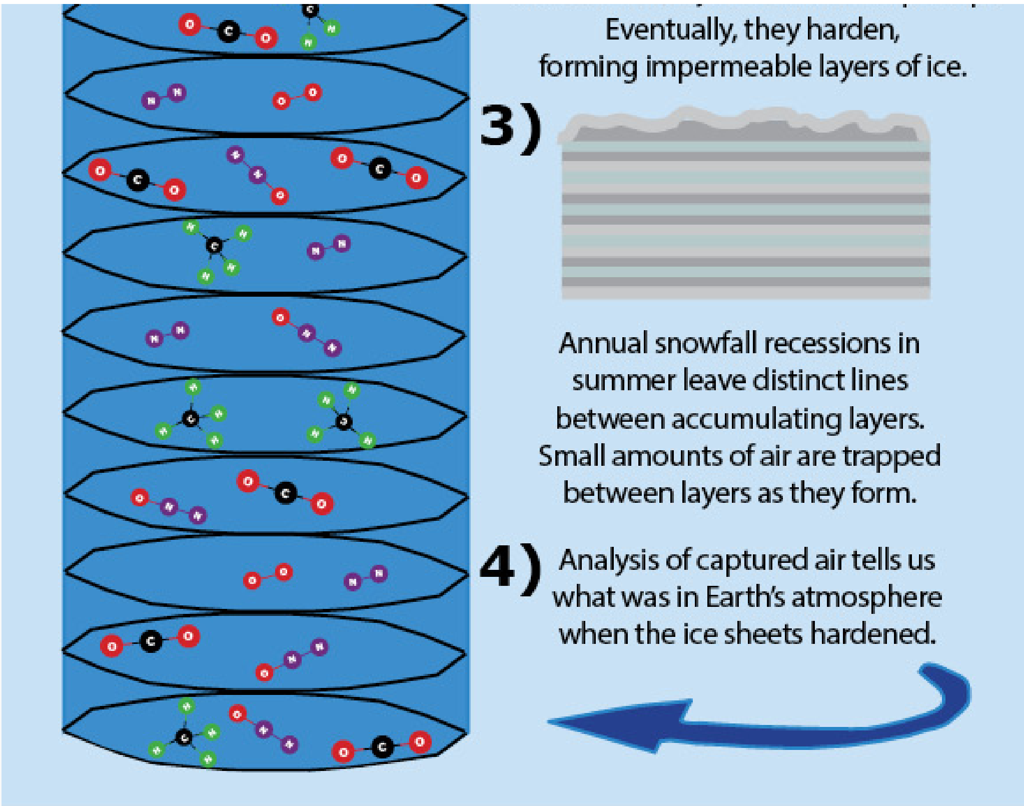
There's really no debate in the scientific community that climate change is occurring or that its effects are being driven by human emissions of greenhouse gases, which get trapped in the atmosphere and increase the average temperature of the globe.

What's less well understood is exactly how these inputs will affect us, our descendants or the other inhabitants of the planet.

A glance through Earth's atmospheric history emphasizes just how dramatically human beings have increased greenhouse gas emissions since the Industrial Revolution, when the burning of fossil fuels and the intensification of agriculture became widespread.

To assemble the atmosphere's biography, scientists conducted studies at places like Vostok, Antarctica, where the formation of slow-forming glaciers has captured ancient air samples between layers of solid ice.






Air is frozen between layers of forming glacial ice. Upon analysis, these conserved air samples tell researchers what was in the Earth's atmosphere through time. Graphic by Will Beaton.

The process, though not without limitations, is one of the most ingenious ways humankind has made use of the existing environment to learn about what it was like in the past.

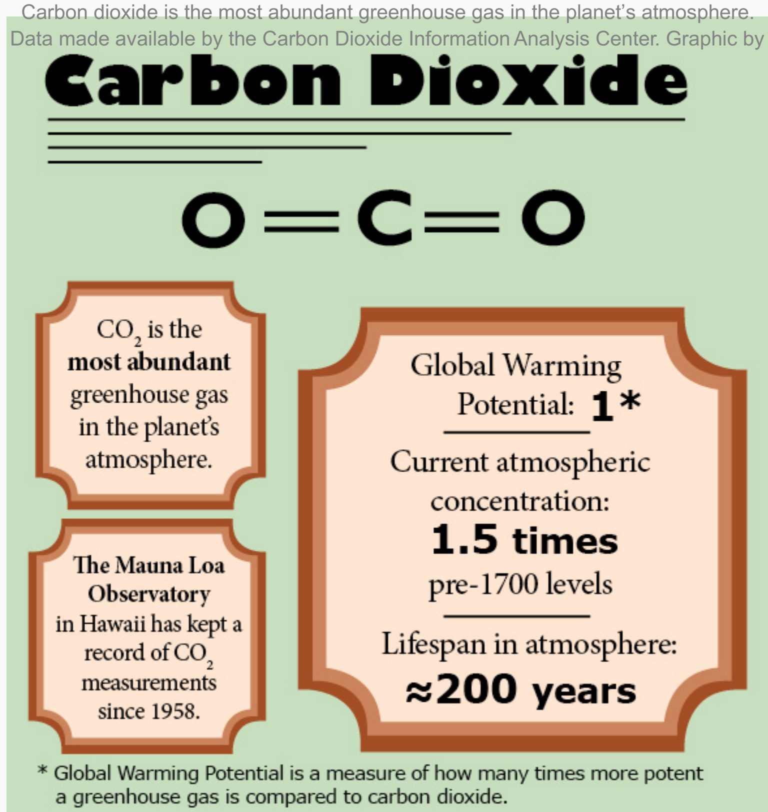
Combining data from overlapping ice cores, scientists have assembled an 800,000-year-long history of Earth's atmospheric makeup. How this record differs from current greenhouse gas concentrations shows just how strongly — and how quickly — the presence of human culture has influenced the world's atmospheric contents and, in turn, its climate.

Of the three major molecules we call greenhouse gases, carbon dioxide ($CO_2$) is the most abundant in the atmosphere.

The ice core data show that $CO_2$ concentrations in the atmosphere fluctuated between about 180 ppm (parts per million) and 280 ppm in 100,000-year-long cycles for nearly the last one million years.[1] When human beings arrived on the scene, $CO_2$ levels had just reached the upper crest of one of these fluctuations and were ready to fall once more.

But not only have we not seen the beginnings of an expected decrease, we've actually recorded massive increases; the current $CO_2$ concentration of the atmosphere has now surpassed more than 400 ppm.

Carbon dioxide is the most abundant greenhouse gas in the planet's atmosphere. Data made available by the Carbon Dioxide Information Analysis Center. Graphic by

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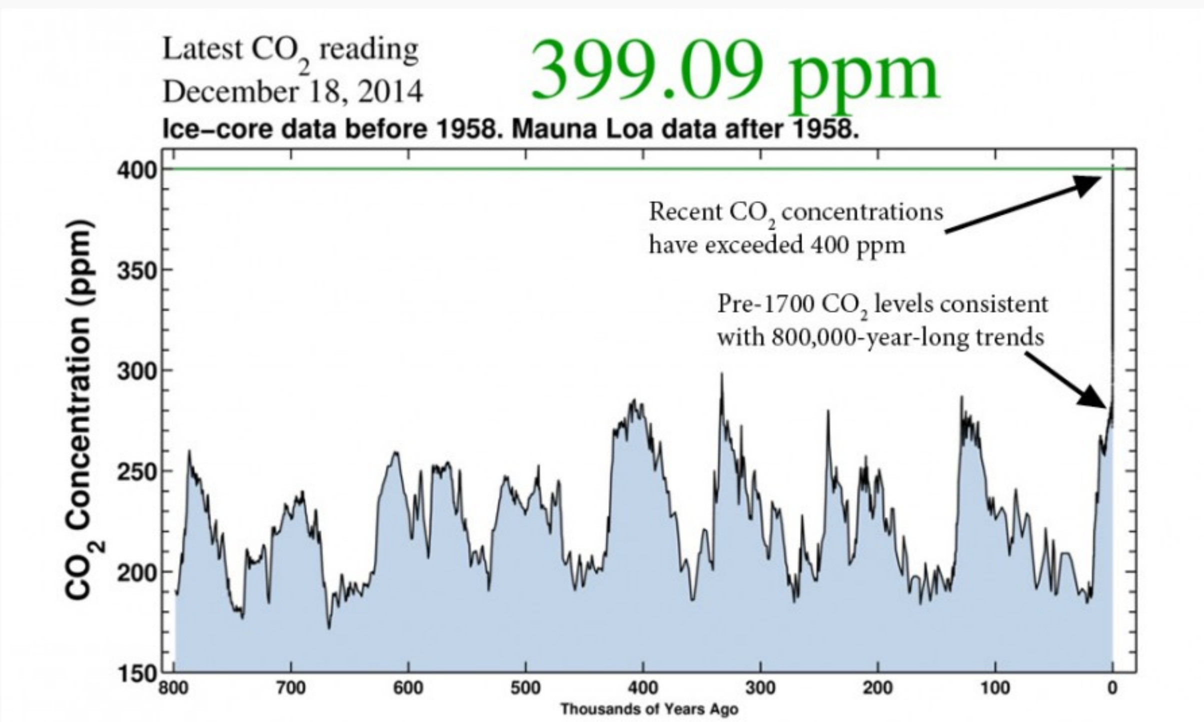



800,000-year-long history of Earth's atmospheric carbon dioxide concentration. Data made available by the Scripps Institution of Oceanography at the University of California – San Diego.

Though the unprecedentedly high concentration is startling enough, it's the speed at which it has risen that is making the effects of climate change dangerously unpredictable.

At it's most rapid accumulation rate in the ice core data, $CO_2$ levels in the atmosphere increased by about 75 ppm over 25,000 years. Twice that amount has been added to the atmosphere today since the effects of the Industrial Revolution just 200 years ago.

In other words, the atmosphere is accumulating $CO_2$ more than 200 times faster than it ever has in the last million years — all at a time when it should be starting to decrease. And as the human population grows, it's expected to accelerate to almost 700 times faster than pre-human rates in just another century without mitigation.[2]

But how do we know $CO_2$ levels are rising because of humans?

Though $CO_2$ is released in massive doses naturally during volcanic activity — up to 500 million tons of it each year — that's less than 2 percent of the 30 billion tons humans emit annually burning fossil fuels.[3]

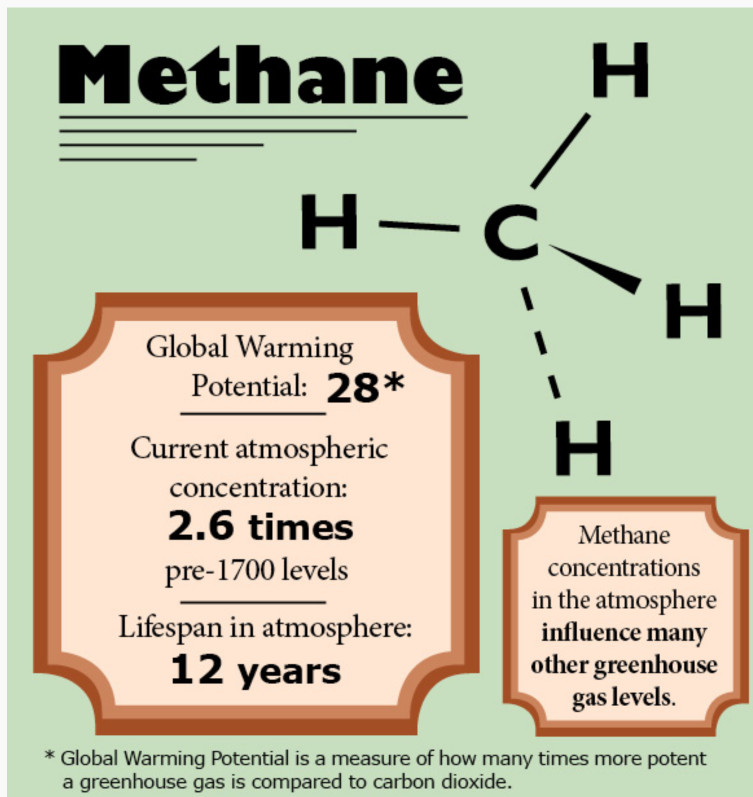
Because $CO_2$ molecules from different sources have unique isotopic signatures,[4] scientists can identify where $CO_2$ in the atmosphere comes from, and the exact amount we know we burn in fuel consumption each year matches the amount in the atmosphere that bears the human signature.

The second most abundant greenhouse gas in the atmosphere is methane ($CH_4$), an important player in the nitrogen cycle crucial to plant and microbial life.

It's also a waste product of most livestock digestion, and with U.S. dependence on a heavily meat-based diet, livestock production is one of the country's leading contributors to climate change.

In fact, new data from a methane-detecting satellite suggests methane release by livestock has been vastly under reported and may actually account for 30 percent of all anthropogenic greenhouse gas emissions worldwide.[5]

A far more potent greenhouse gas, nitrous oxide ($N_2O$) is a component of nitrogen fertilizer used in agriculture. Fertilizer use accounts for 75 percent of $N_2O$ in the atmosphere today.[6]



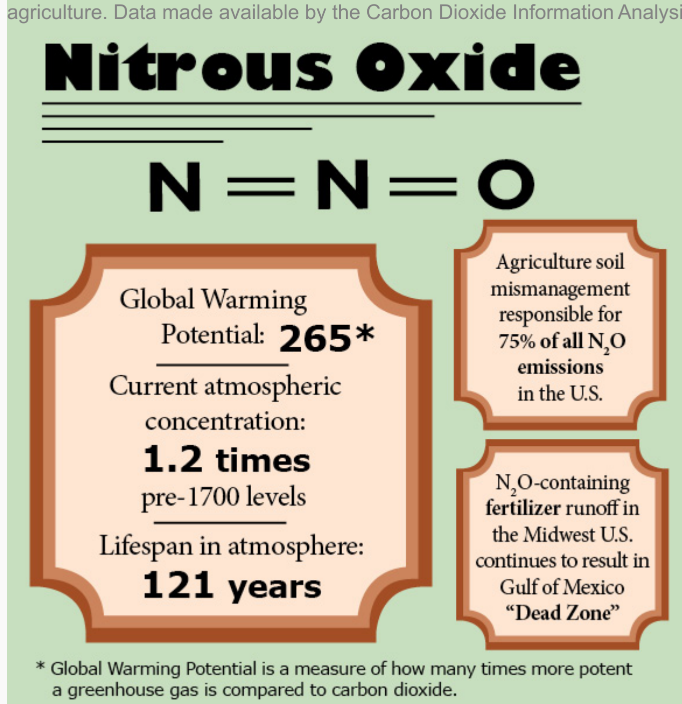
Methane is the second most abundant greenhouse gas in the atmosphere. It is primarily released as a byproduct of livestock digestion. Data made available by the Carbon Dioxide Information Analysis Center. Graphic by Will Beaton.

Fertilizer runoff in North America also leads to nitrogen buildup in the Gulf of Mexico, resulting in nitrogen-feeding algal blooms proliferating and using up all the dissolved oxygen in the sea. The Gulf "Dead Zone," which continues to prevent the habitation of virtually all marine life, covered 8,400 square miles at its largest a few years ago.[7]

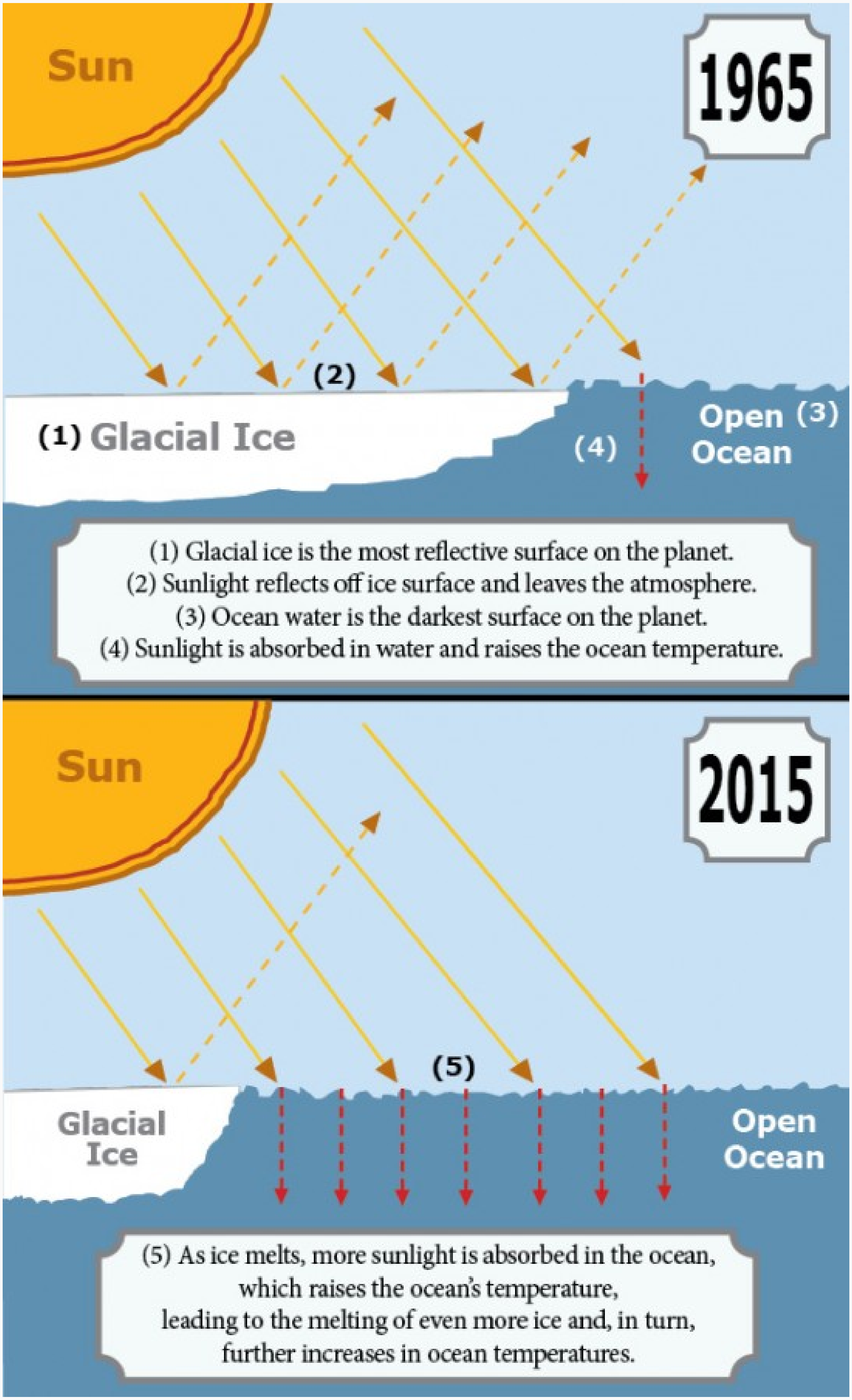
Today, it is estimated that 70 percent of the nitrogen contributing to the Dead Zone comes from fertilizer runoff from farms of the American Midwest.[8]

But what's the significance of increasing global temperature as a result of greenhouse gas emissions? How might the melting ice caps affect our way of life?

Nitrous Oxide enters the atmosphere through the use of nitrogen fertilizer in agriculture. Data made available by the Carbon Dioxide Information Analysis




Center. Graphic by Will Beaton.




Positive feedback loops — like the melting of polar ice caps in response to rising sea temperatures — often amplify the effects of climate change. Graphic by Will Beaton.

The warming of the ocean and the melting of the ice caps are two symptoms of one event. As such, their relationship affects more than just polar bear habitats — the more ice that melts, the warmer the planet will get, and the more unpredictable global climate will become.

A study published this month shows that the warming of ocean water also is triggering the release of massive stores of methane hydrates off the coast of Washington. The authors say these warming underwater reserves are emitting as much greenhouse methane as did the BP Deepwater Horizon oil spill — each year. Similar reserves have yet to be monitored.[9]

The global climate system is so vast and complex that human beings will likely never be able to fully predict its behaviors.

Reading the secrets of our atmospheric past in the ice, however, has shown that humans influence the natural factors that regulate climate change more drastically and with more speed than anything has in the last million years — making the actions of our species today some of the most important elements in influencing the future of planet Earth.

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