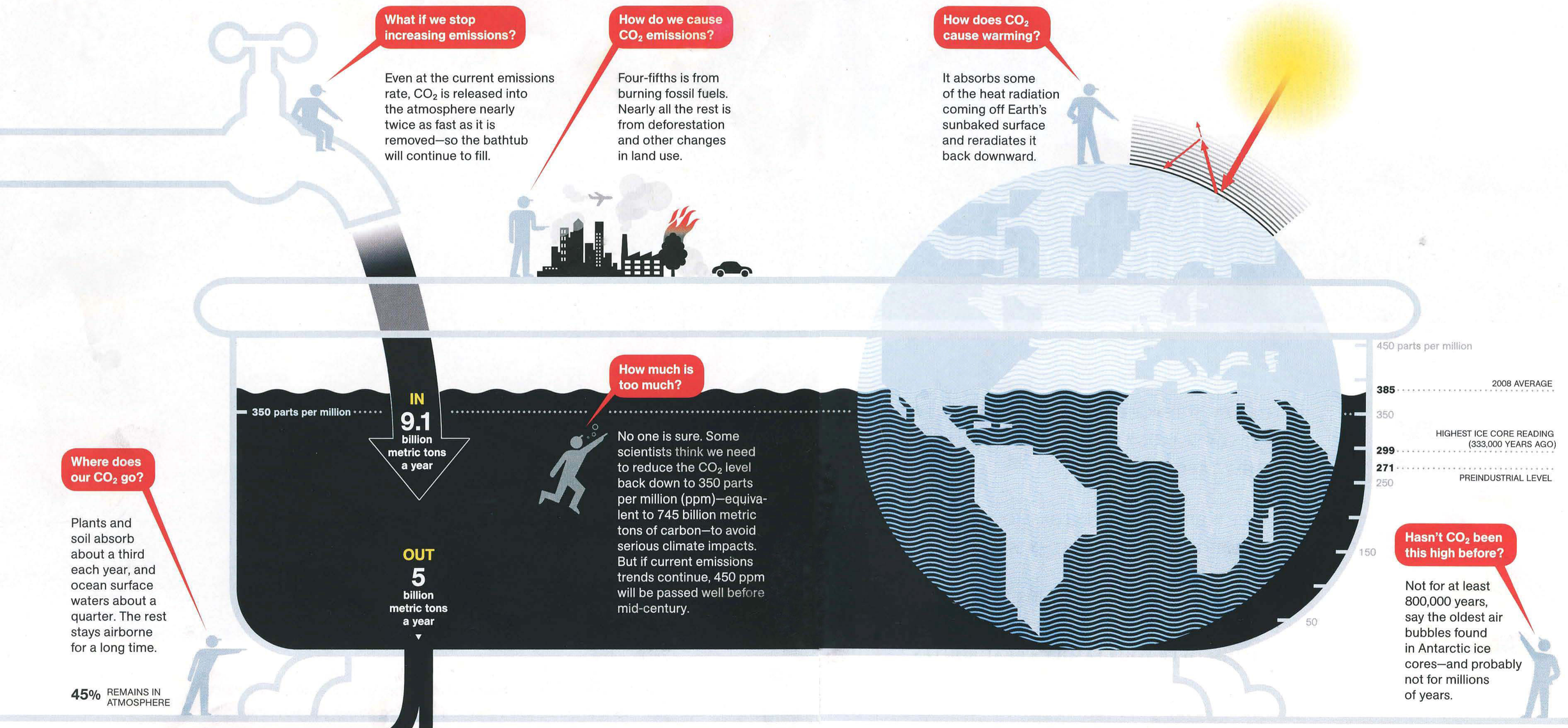
The Carbon Bathtub

It's simple, really: As long as we pour CO_2 into the atmosphere faster than nature drains it out, the planet warms. And that extra carbon takes a long time to drain out of the tub.

A fundamental human flaw, says John Sterman, impedes action on global warming. Sterman is not talking about greed, selfishness, or some other vice. He's talking about a cognitive limitation, "an important and pervasive problem in human reasoning" that he has documented by testing graduate students at the MIT Sloan School of Management. Sterman teaches system dynamics, and he says his students, though very bright and schooled in calculus, lack an intuitive grasp of a simple, crucial system: a bathtub.

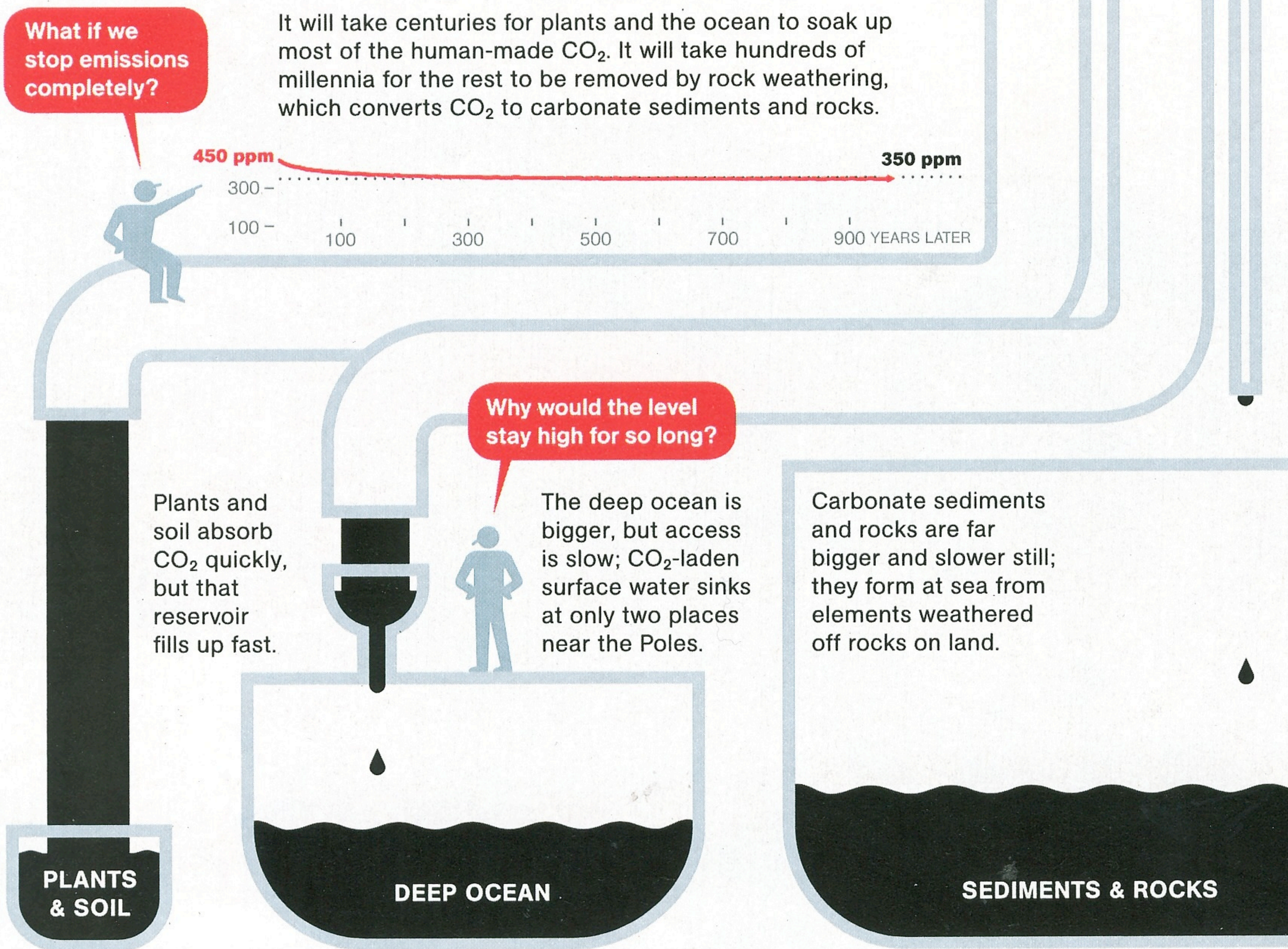
In particular, a tub with the tap running and the drain open. The water level can stand for many quantities in the modern world. The level of carbon dioxide in Earth's atmosphere is one. A person's waistline or credit card debt—both of which have also become spreading problems of late—are two more. In all *(Continued on next page)*



*PERCENTAGES DO NOT ADD UP TO 100 BECAUSE OF ROUNDING.

GRAPHIC: NIGEL HOLMES. SOURCES: JOHN STERMAN, MIT; DAVID ARCHER, UNIVERSITY OF CHICAGO; GLOBAL CARBON PROJECT

THE BIG IDEA (continued)



three cases, the level in the tub falls only when the drain runs faster than the tap—when you burn more calories than you eat, for instance, or pay off old charges faster than you incur new ones.

Plants, oceans, and rocks all drain carbon from the atmosphere, but as climatologist David Archer explains in his book *The Long Thaw,* those drains are slow. It's going to take them hundreds of years to remove most of the CO_2 that humans are pouring into the tub and hundreds of thousands of years to remove it all. Stopping the rise of CO_2 will thus require huge cuts in emissions from cars, power plants, and factories, until inflow no longer exceeds outflow.

Most of Sterman's students—and his results have been replicated at other universities—didn't understand that, at least not when the problem was described in the usual climate jargon. Most thought that simply stopping emissions from rising would stop the rise of CO_2 in the atmosphere—as if a tap running steadily but rapidly would not eventually overflow the tub. If MIT graduate students don't get it, most politicians and voters probably don't either. "And that means they think it's easier to stabilize greenhouse gases and stop warming than it is," Sterman says.

By 2008, the level of CO_2 in the tub was 385 parts per million (ppm) and rising by 2 or 3 ppm each year. To stop it at 450 ppm, Sterman says, a level many scientists consider dangerously high, the world would have to cut emissions by around 80 percent by 2050. When diplomats convene in Copenhagen this month to negotiate a global climate treaty, Sterman will be there to help, with software that shows immediately, based on the latest climate-model forecasts, how a proposed emissions cut will affect the level in the tub—and thus the temperature of the planet. His students are generally much better at bathtub dynamics by the end of his course, which gives him hope. "People can learn this," he says. *—Robert Kunzig*

Tub Dynamics To experiment with the effects of different emissions cuts, go to **ngm.com/bigidea.**

GRAPHIC: OLIVER UBERTI, NG STAFF. CHART SOURCE: SUSAN SOLOMON, NOAA