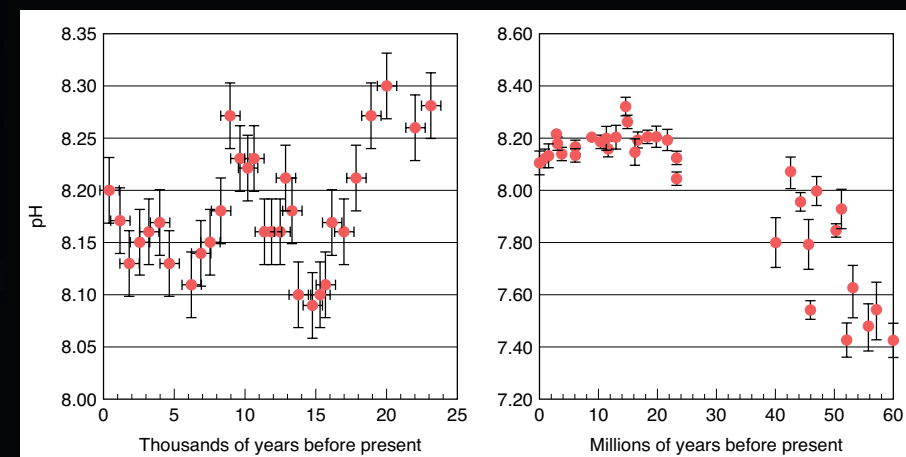




**COVER PHOTO:** Atmospheric CO<sub>2</sub> dissolved in the ocean creates carbonic acid, which alters the ability of marine organisms to make shells, skeletons, and other structures from calcium carbonate (CaCO<sub>3</sub>) (see Box 9-1). The lower photo on the front cover shows a pencil urchin grown for 60 days in seawater equilibrated with current atmospheric CO<sub>2</sub> level of 400 parts per million by volume (ppmv). The upper photo shows an urchin grown in seawater equilibrated with a possible future CO<sub>2</sub> level of 2850 ppmv. Calcium carbonate spines in the lower urchin form a regular, radial array. The urchin grown in elevated CO<sub>2</sub> has an irregular array of spines.



The boron isotope ratio in fossilized marine animals provides a record of ocean pH and how it has changed over time. Ocean surface water pH has decreased by 0.1 unit since the dawn of the industrial age. Increased atmospheric CO<sub>2</sub> will likely change the balance of the marine ecosystem in the future.



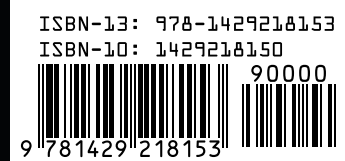
Equatorial Pacific Ocean surface pH deduced from <sup>11</sup>B/<sup>10</sup>B ratio in fossil shells. [Data from M. R. Palmer and P. N. Pearson, *Science* **2003**, 300, 480; *Nature* **2000**, 406, 695.]



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COVER PHOTO CREDIT: Photos by Tom Kleindinst, Woods Hole Oceanographic Institution, kindly provided by J. B. Ries, University of North Carolina, Chapel Hill. See J. B. Ries, A. L. Cohen, and C. C. McCorkle, *Geology* **2009**, 37, 1131.

COVER DESIGN: Vicki Tomaselli



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Daniel C. Harris