Greenhouse Gas Mitigation: The Biology of Carbon Sequestration

The world is warming up. In fact, last year was the second warmest on record, continuing a decade-long trend of rising temperatures. The extra heat is having predictable effects: Permafrost is thawing, growing seasons are lengthening, birds are breeding earlier and at higher latitudes, glaciers are melting, and the additional meltwater and the expansion of oceanic water due to the increased temperature are raising sea levels.

Atmospheric scientists worldwide agree that global warming is largely caused by the increasing concentrations of greenhouse gases in Earth’s atmosphere. Chief among them is carbon dioxide (CO$_2$), a byproduct of fossil fuel, forest, and grassland combustion. The atmospheric concentration of CO$_2$ has nearly doubled over the last century. Clearly, our production of CO$_2$ has outpaced Earth’s capacity to remove and store it naturally.

This has led to proposals to remove it from the atmosphere in various ways. Carbon could be photosynthetically fixed in trees and litter by reforesting cleared areas. Done intelligently, reforestation would restore biodiversity and stabilize steep hillsides where landslides claim many lives each year, especially in the humid tropics. Although a significant amount of carbon could be sequestered by reforestation, the gain would be short term. How long it would remain locked up depends on which tissues grow fastest and how quickly they are subjected to harvest, herbivory, burning, or decay. Overall, the mean half-life of sequestered carbon is apt to be on the order of scores of years, yet only a few decades’ worth of CO$_2$ emissions could be stored through reforestation.

A much more ambitious scheme is to inject the gas into the deep sea. Earth’s sea floor is so vast, and appears so sterile, that it is tempting to dump the problem there and be done with it for all time. But the deep sea, far from being sterile, teems with life. The recent discovery of enormous squids at depths of 2000–5000 meters in the Atlantic, Pacific, and Indian Oceans is an eye-opener, for where large predators roam in significant numbers, there must be higher productivity of smaller animals to support them.

Equally important is what lies within the top few centimeters of the sea floor: dense populations of microorganisms whose diversity and functions are barely known. One group of Arachaea living in anoxic sediments fixes 80 percent of the methane produced in the world’s oceans. And guess what? Methane is second only to carbon dioxide as a significant amount of carbon could be sequestered by reforestation, the gain would be short term. How long it would remain locked up depends on which tissues grow fastest and how quickly they are subjected to harvest, herbivory, burning, or decay. Overall, the mean half-life of sequestered carbon is apt to be on the order of scores of years, yet only a few decades’ worth of CO$_2$ emissions could be stored through reforestation.

Reducing our reliance on fossil fuels through greater fuel efficiency (especially in transportation) and substituting solar and wind power can yield large, sustained contributions to mitigation. Over the long term, hydrogen generated by photovoltaic or wind-powered electrolysis of water could sustain an energy economy with greatly reduced greenhouse gas emissions.

Large-scale development of renewable energy sources can happen only when the true economic cost of the present alternatives, measured by their effects on ecosystem services, is appreciated. This appreciation will require leadership from two groups: scientists, who must educate themselves and the public, and politicians, who must generate the will to move us forward.

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