Will the effects of climate changes on ocean biological productivity reduce ocean CO_2 uptake?

PROBLEM: Biological productivity converts inorganic carbon into organic detritus that eventually sinks to the deep ocean. This process differs from uptake of inorganic carbon by chemical absorption and physical transportation to other parts of the ocean. The result is net removal of carbon from the surface layer, which permits an additional influx of CO_2 to the ocean surface waters. Ocean models by Sarmiento and Toggweiler (1984), Knox and McElroy (1984), and Siegenthaler and Wenk (1984) suggest that changes in biological productivity at high latitudes may have a strong influence on oceanic CO_2 uptake and, hence, on atmospheric CO_2 concentrations.

KNOWNS, UNKNOWNS, UNCERTAINTIES: The geographic distribution of marine productivity can influence oceanic source and sink properties. Of the 20 to 58 Pg Cyr^{-1} that have been estimated as net primary production (NPP) of the open ocean (DeVooys, 1979; Bolin et al., 1979; Dawes, 1981; and Chavez and Barber, 1987), the amount of marine particulate matter that sinks from the surface layer of the open ocean is estimated to be from 0.4 to about 22 Pg Cyr^{-1} (Eppley and Peterson, 1979; Broecker and Peng, 1982; Bolin et al., 1979; and Chavez and Barber, 1987). Net primary productivity in estuarine and coastal waters totals about 8 to 13 Pg Cyr^{-1} (Wollast and Billen, 1981; and Dawes 1981), and a relatively large fraction of this amount (1 to 5 Pg Cyr^{-1}) could be buried in coastal sediments. Decreases in nutrient supply and, hence, the decrease in biogenic carbon flux by as little as 5% (e.g., 0.02 to 0.25 Pg Cyr^{-1}) would increase the CO_2 content of the atmosphere by 8 ppmv. Support of this possibility is given by recent studies that show that the atmospheric CO_2 increase at the end of the last continental glaciation is correlated with decreases in marine photosynthesis at high latitudes (Sarmiento and Toggweiler, 1984; Knox and McElroy, 1984; and Siegenthaler and Wenk, 1984).

Will terrestrial ecosystems release or store carbon in response to changing climates?

PROBLEM: The terrestrial biota will certainly respond to changes in climate. Changed geographic distribution and extent of vegetation zones may reduce the amount of CO_2 sequestered in terrestrial ecosystems over long enough time periods for ecological succession to occur (decades to centuries). Over shorter time periods, ecosystem respiration and production rates will respond to climate change and will alter the amounts of CO_2 released by the terrestrial biota.