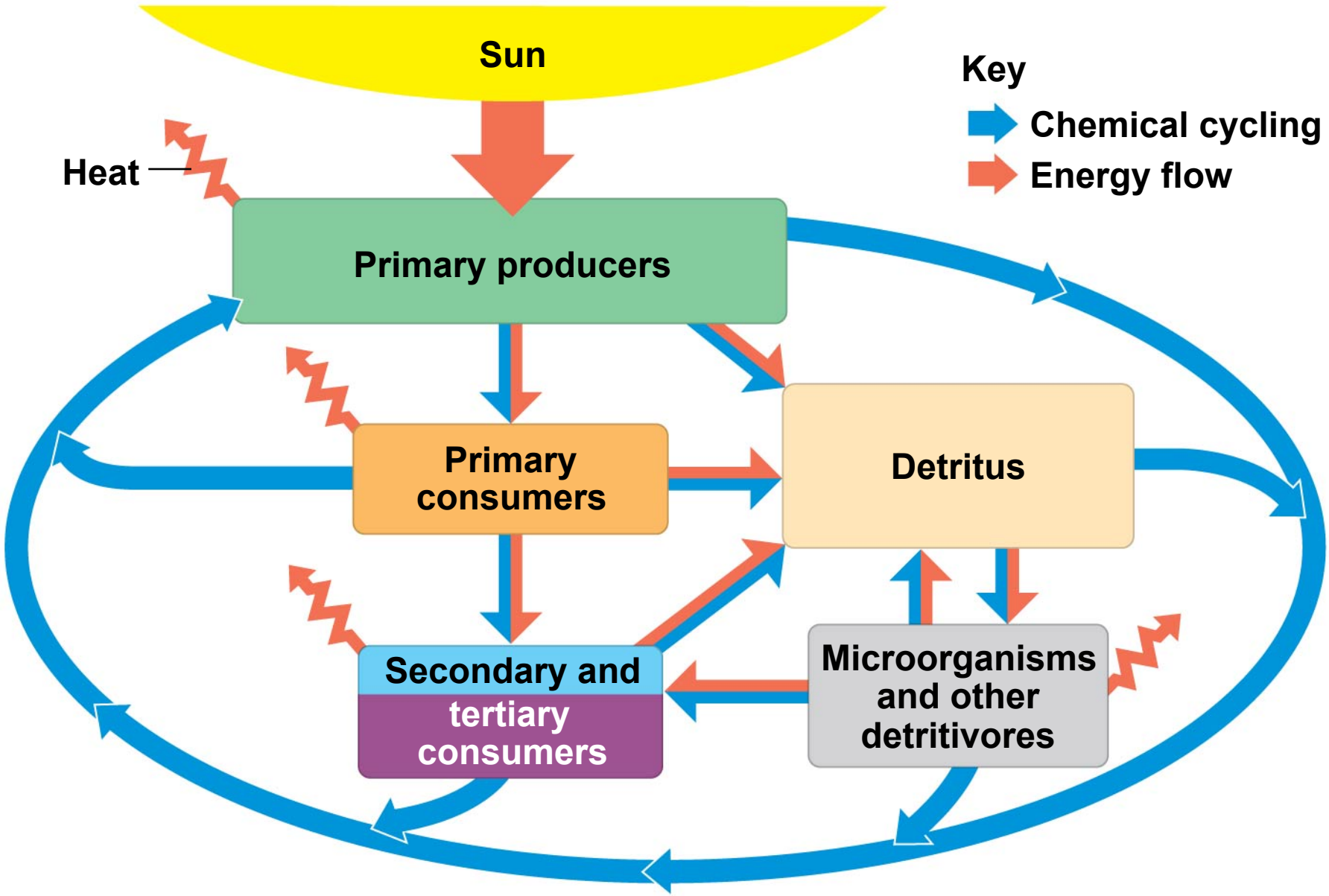


Measures of Production

GPP: Gross Primary Production

(energy converted to chemical energy of organic compounds in a given amount of time)

NPP: Net Primary Production

(includes only GPP not used for respiration in the producers)

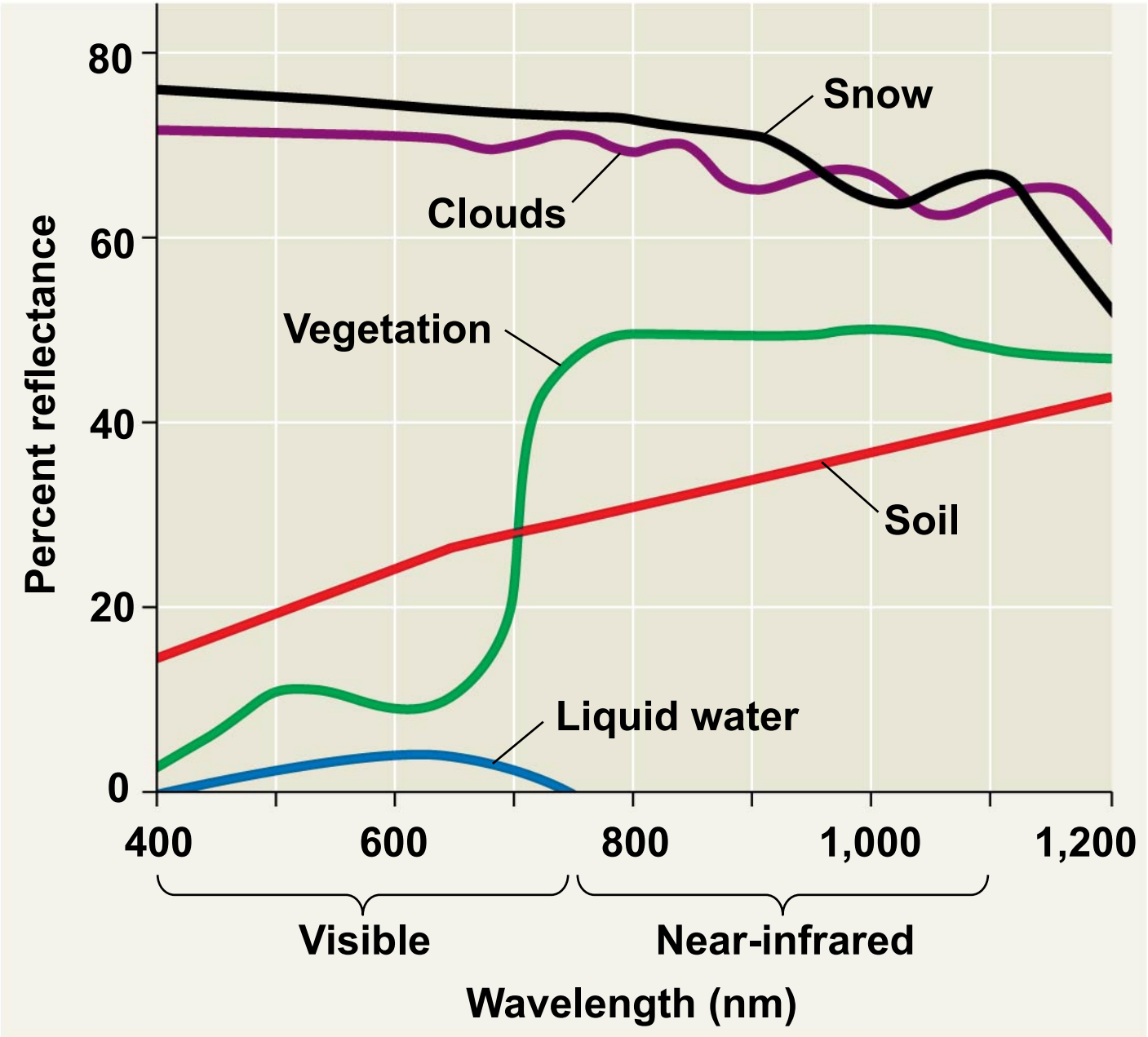
$$NPP = GPP - R_a$$

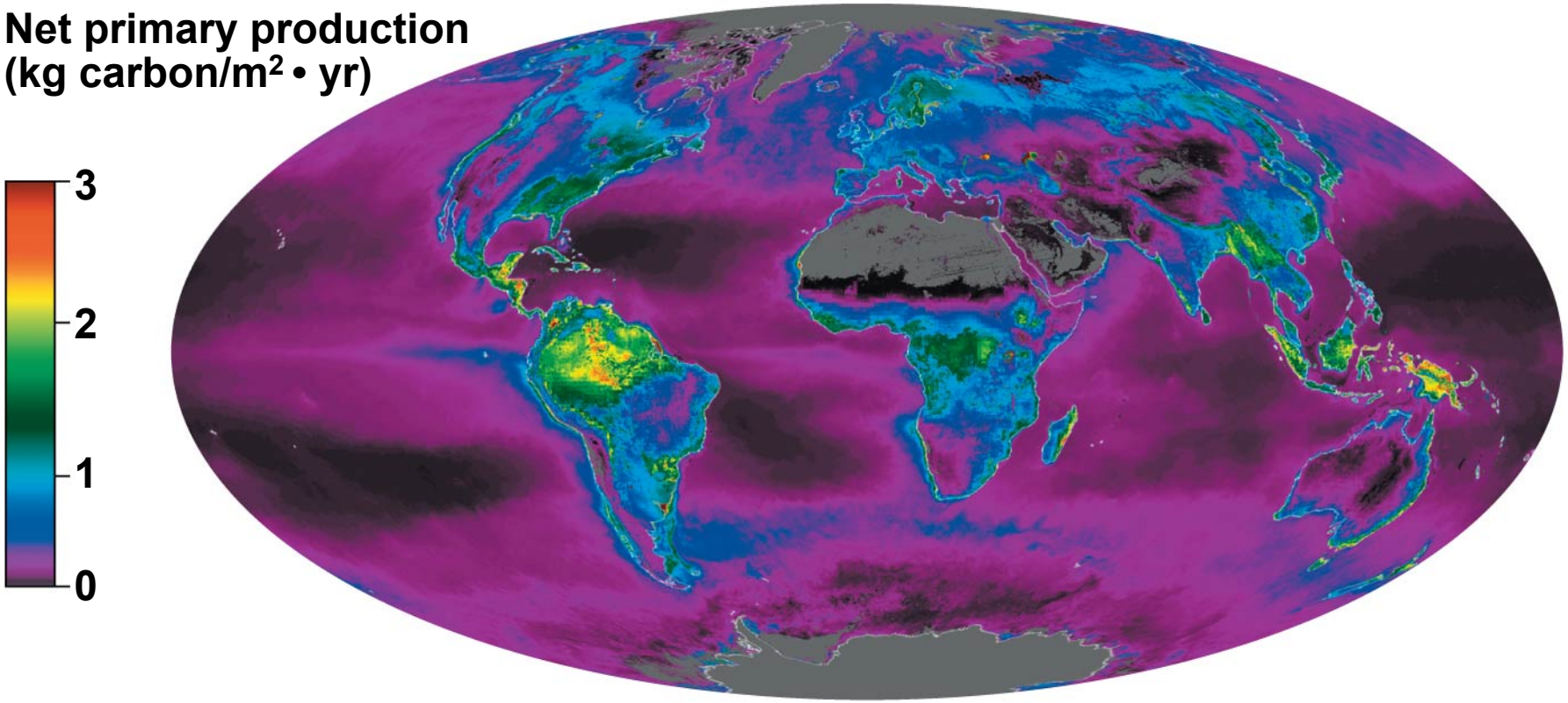
NEP: Net Ecosystem Production

(total accumulation of biomass)

$$NEP = GPP - R_T$$

Technique





Results

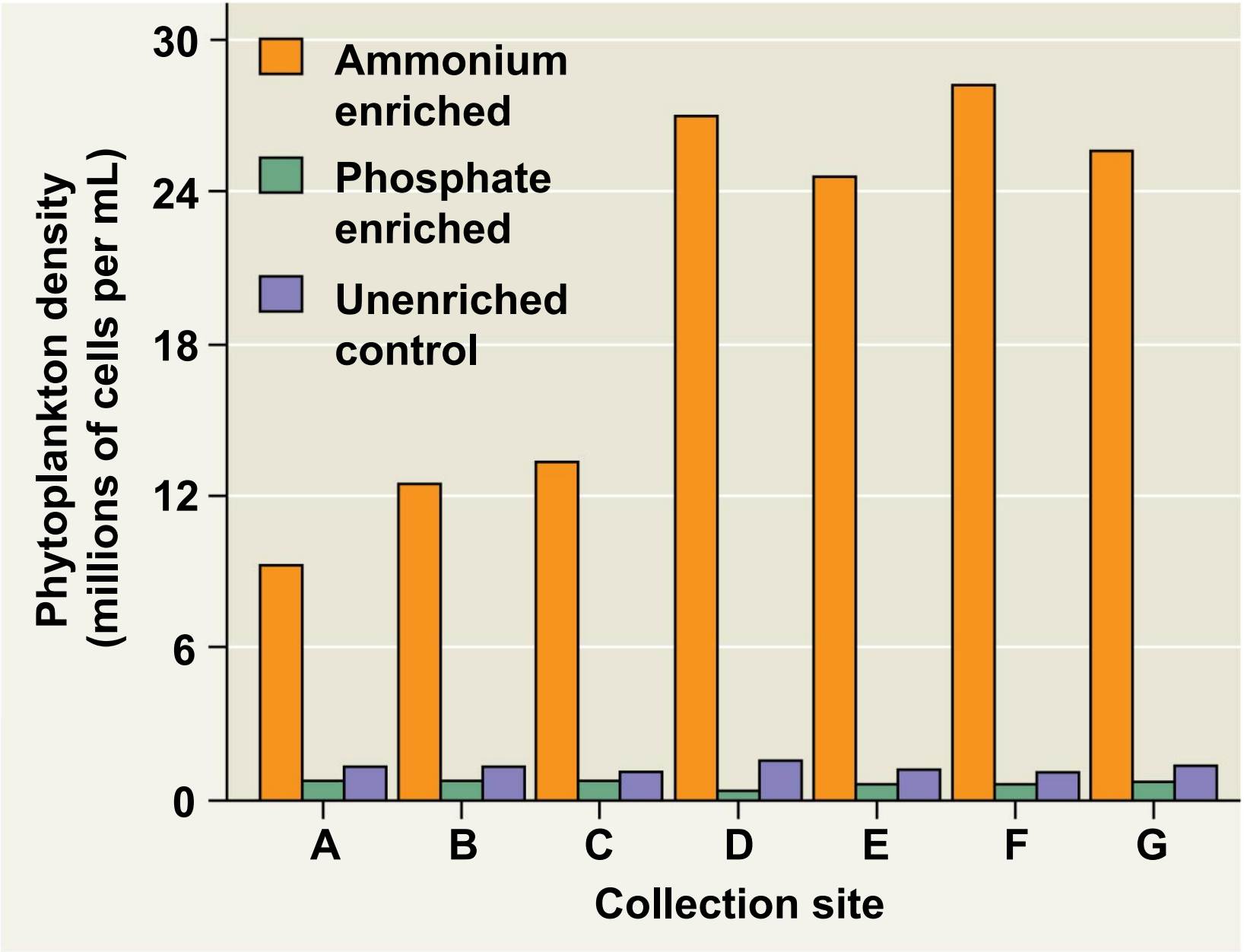
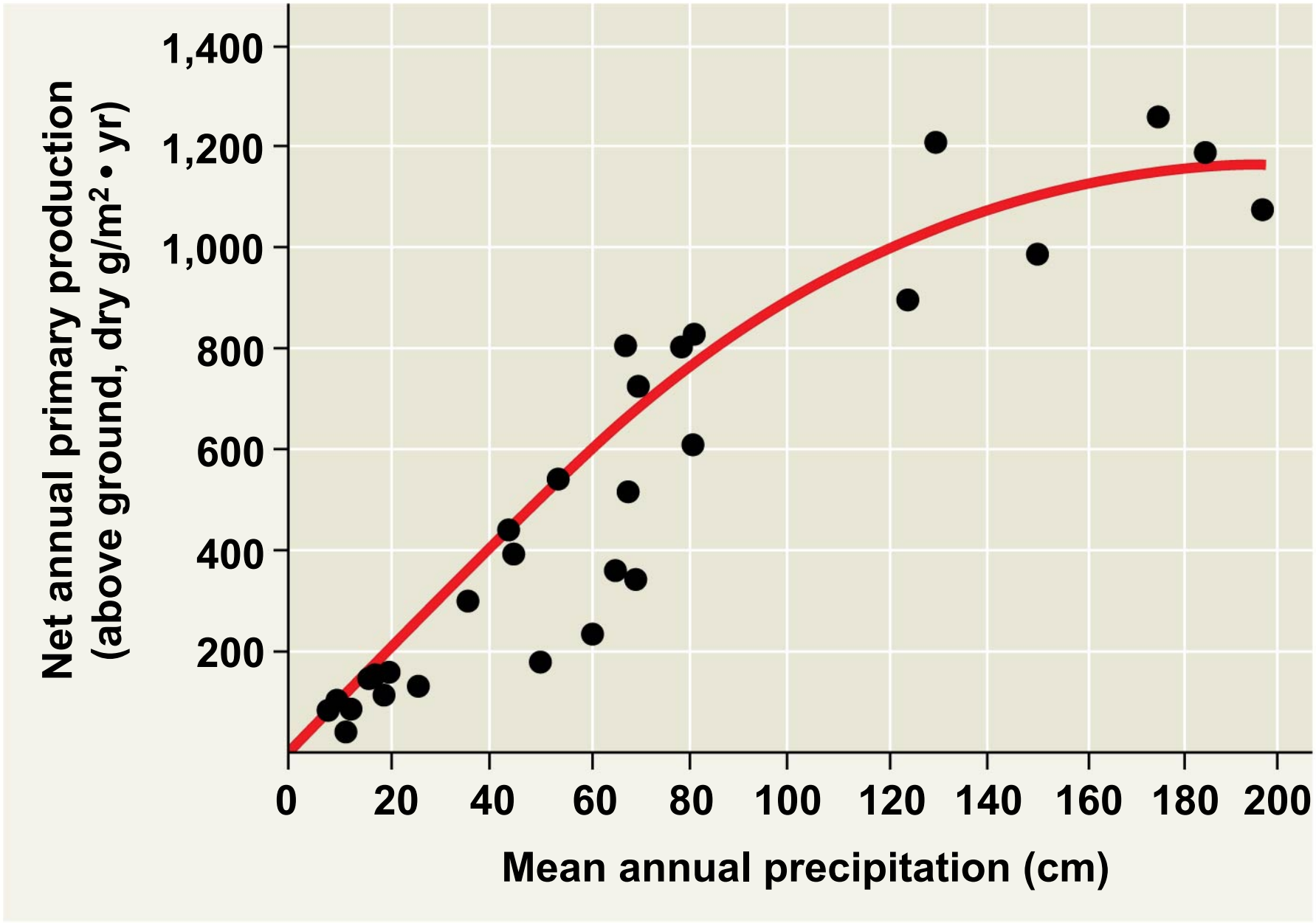


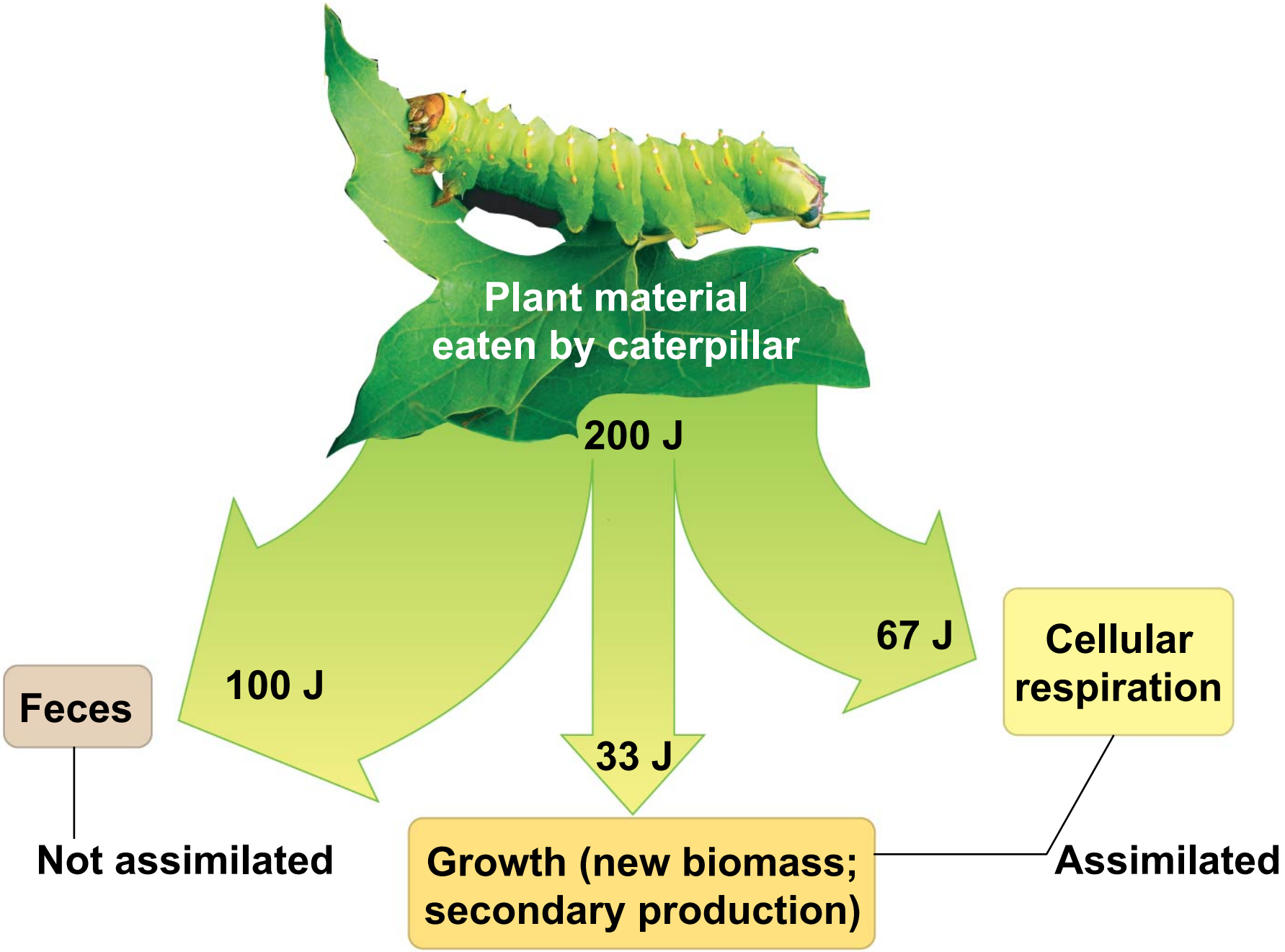
Table 42.1 Nutrient Enrichment Experiment for Sargasso Sea Samples

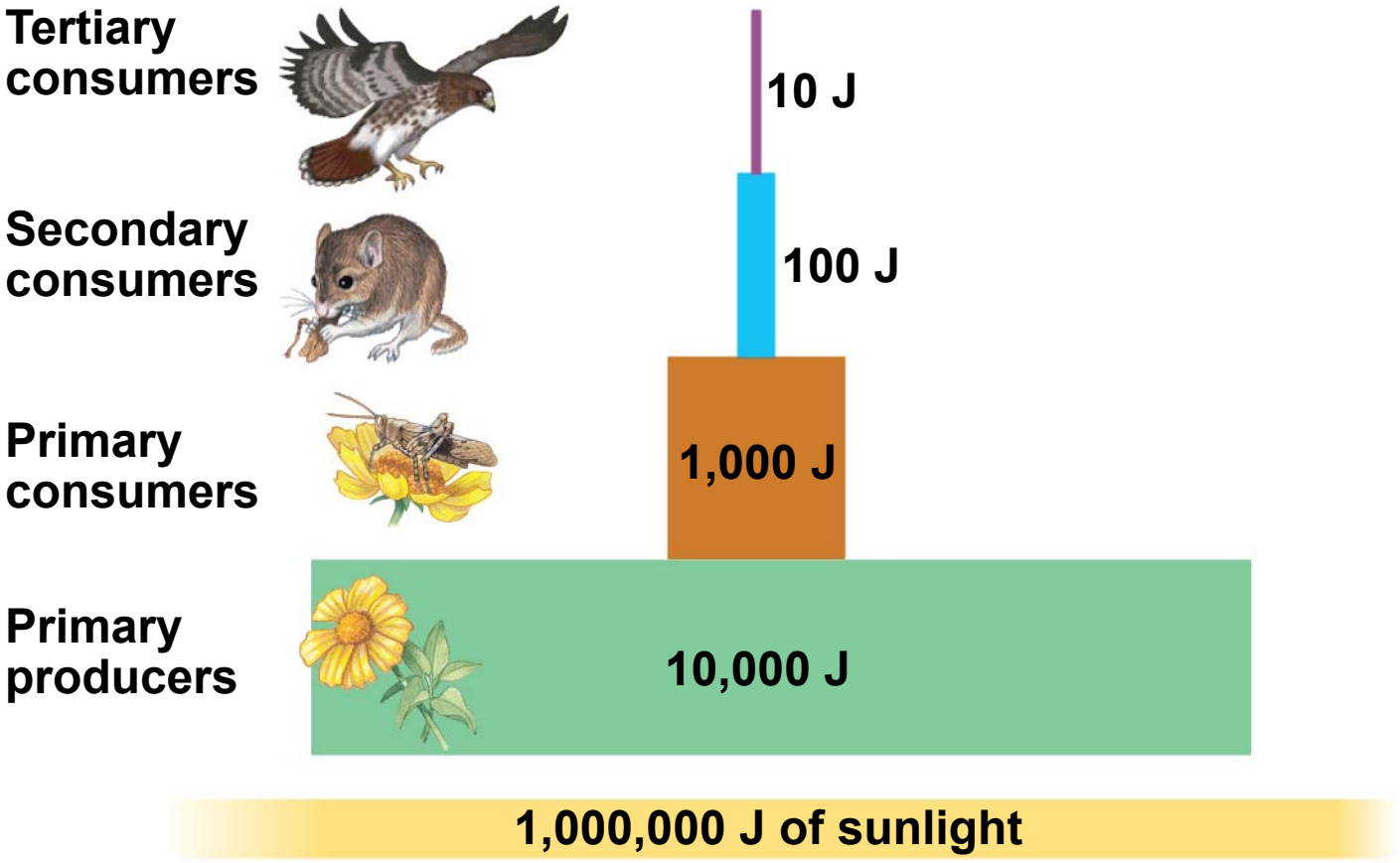
Nutrients Added to Experimental Culture	Relative Uptake of ^{14}C by Cultures*
None (controls)	1.00
Nitrogen (N) + phosphorus (P) only	1.10
N + P + metals (excluding iron)	1.08
N + P + metals (including iron)	12.90
N + P + iron	12.00

*^{14}C uptake by cultures measures primary production.

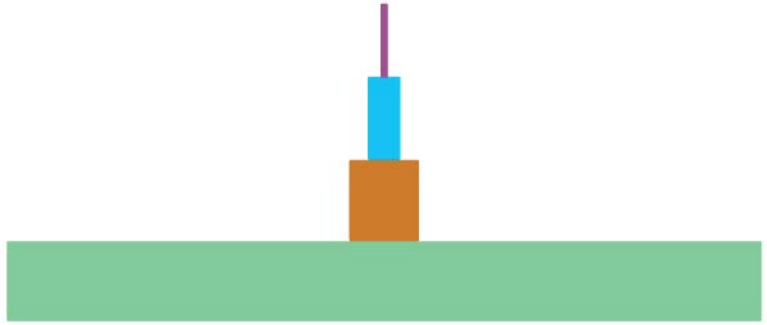
Source D. W. Menzel and J. H. Ryther, Nutrients limiting the production of phytoplankton in the Sargasso Sea, with special reference to iron, *Deep Sea Research* 7:276–281 (1961).







Trophic level	Dry mass (g/m^2)
Tertiary consumers	1.5
Secondary consumers	11
Primary consumers	37
Primary producers	809

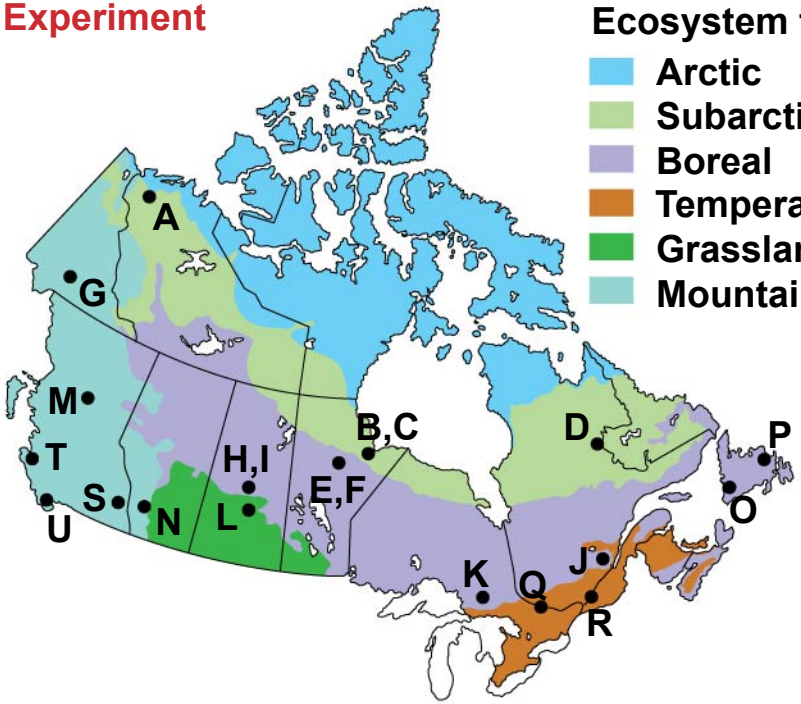


(a) Most ecosystems (data from a Florida bog)

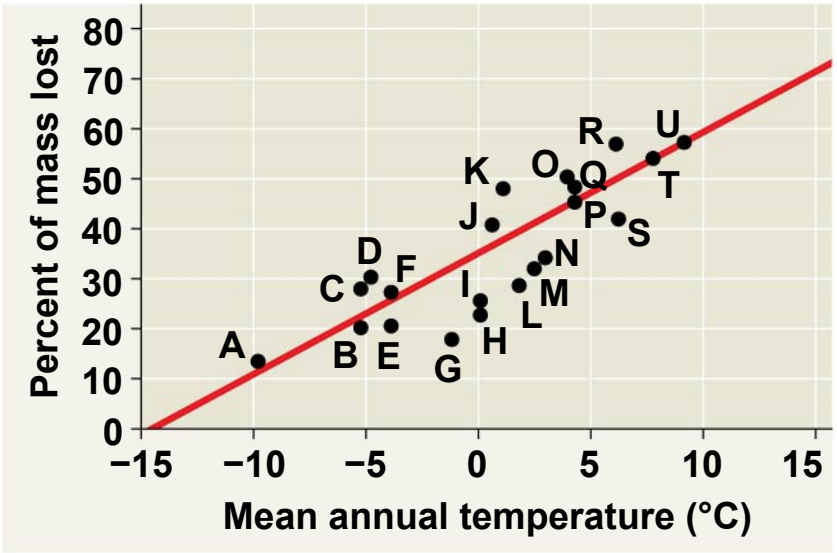
Trophic level	Dry mass (g/m^2)
Primary consumers (zooplankton)	21
Primary producers (phytoplankton)	4

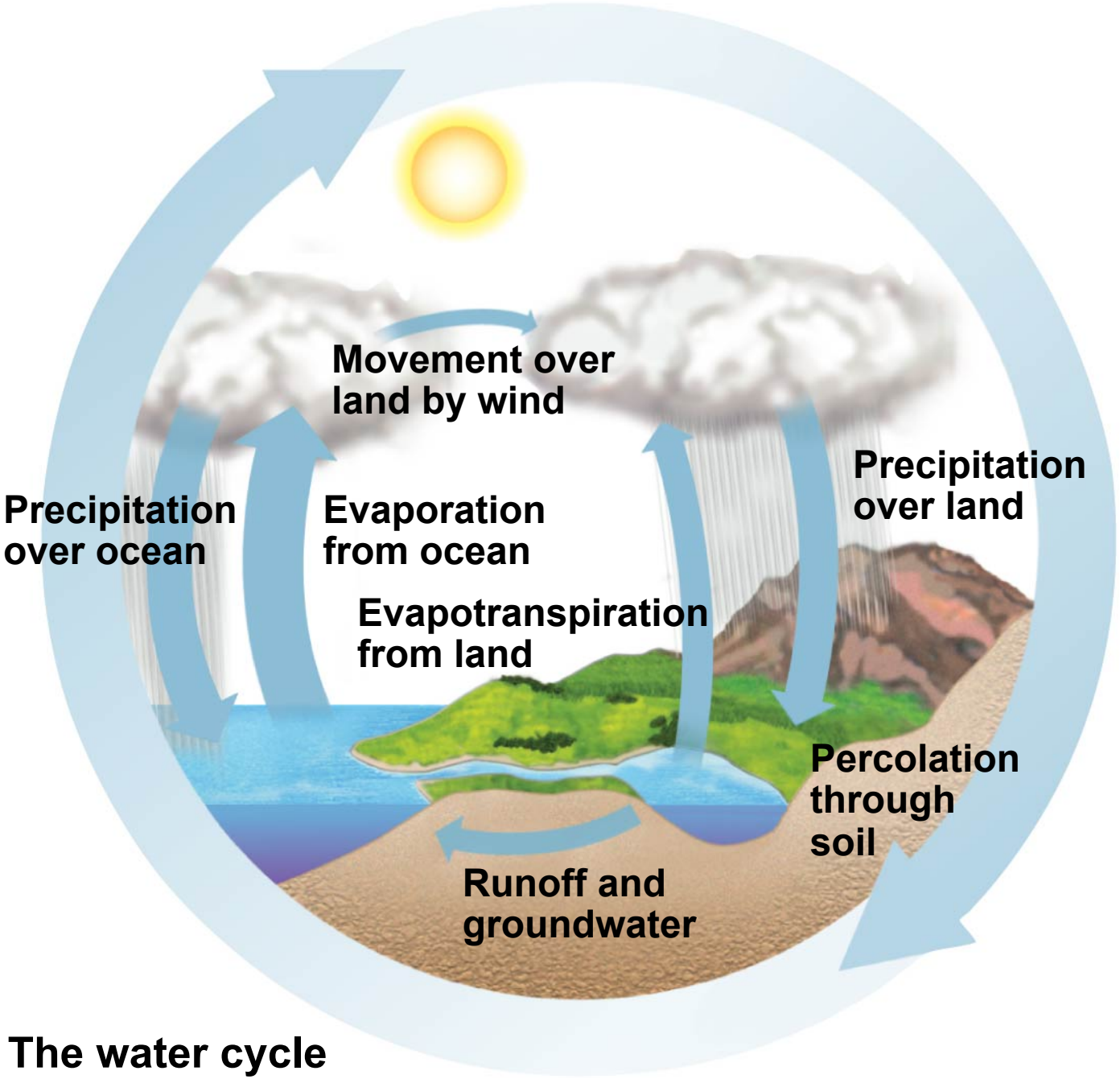
(b) Some aquatic ecosystems (data from the English Channel)

Experiment

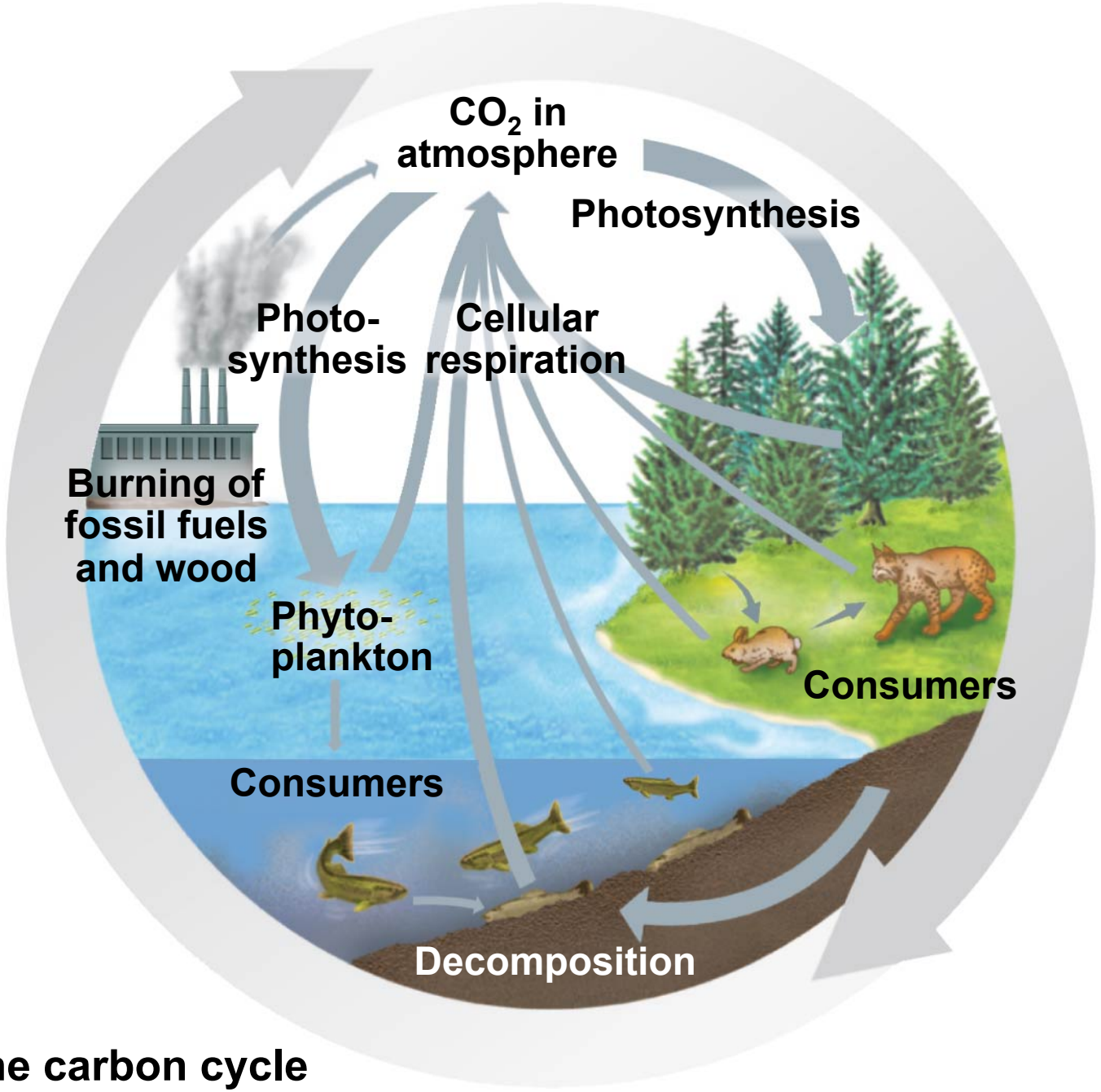


Results

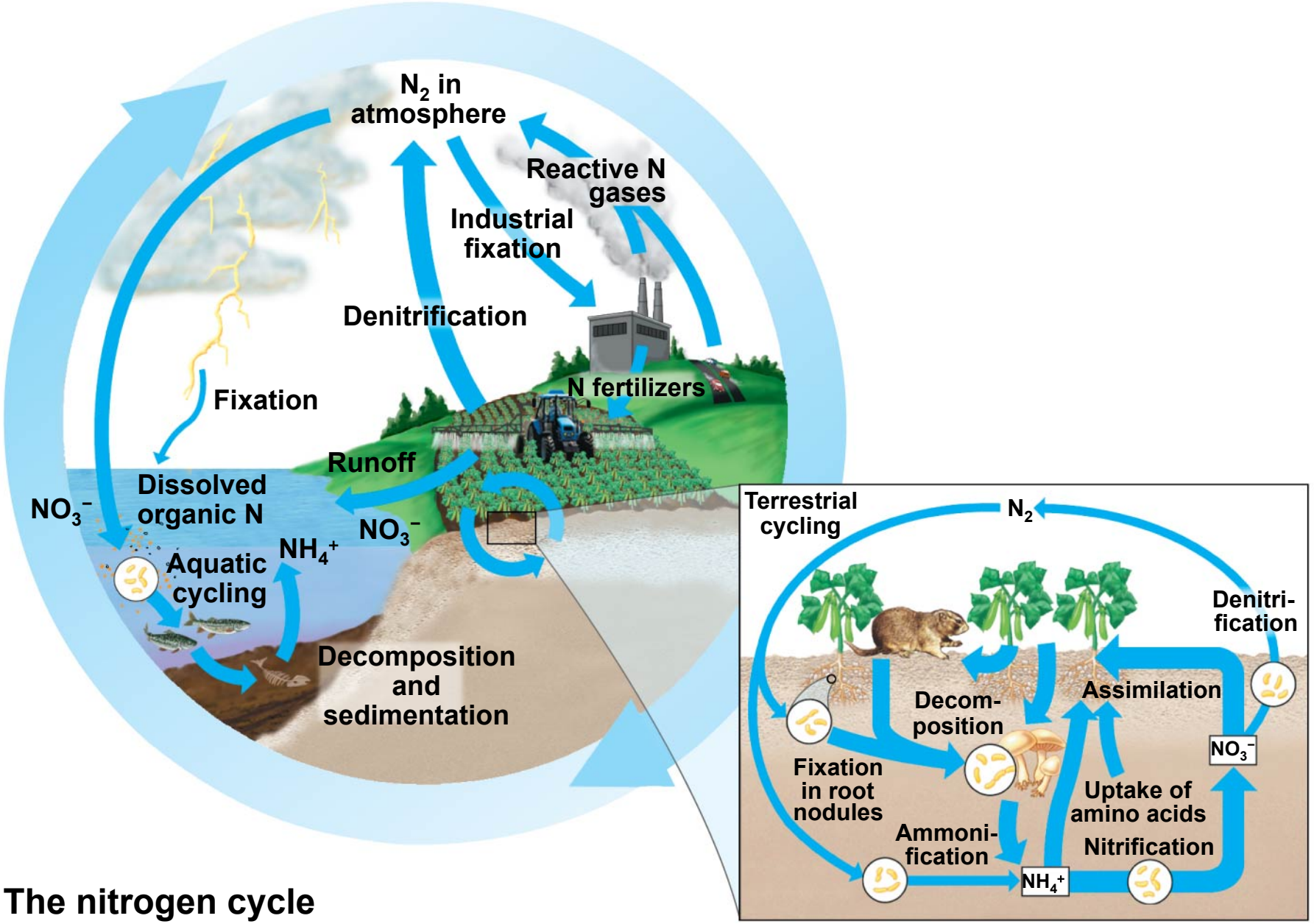




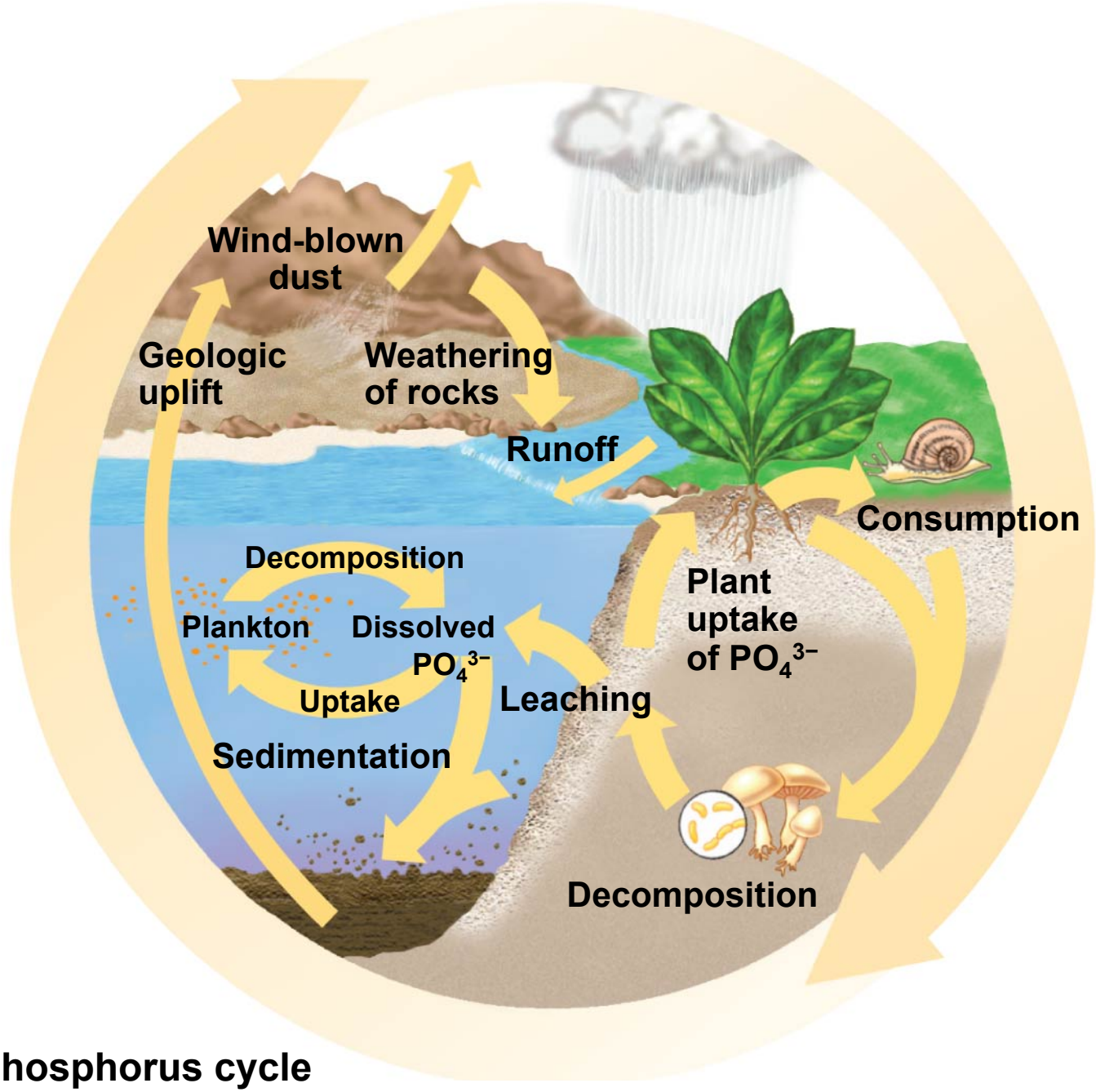
The water cycle



The carbon cycle



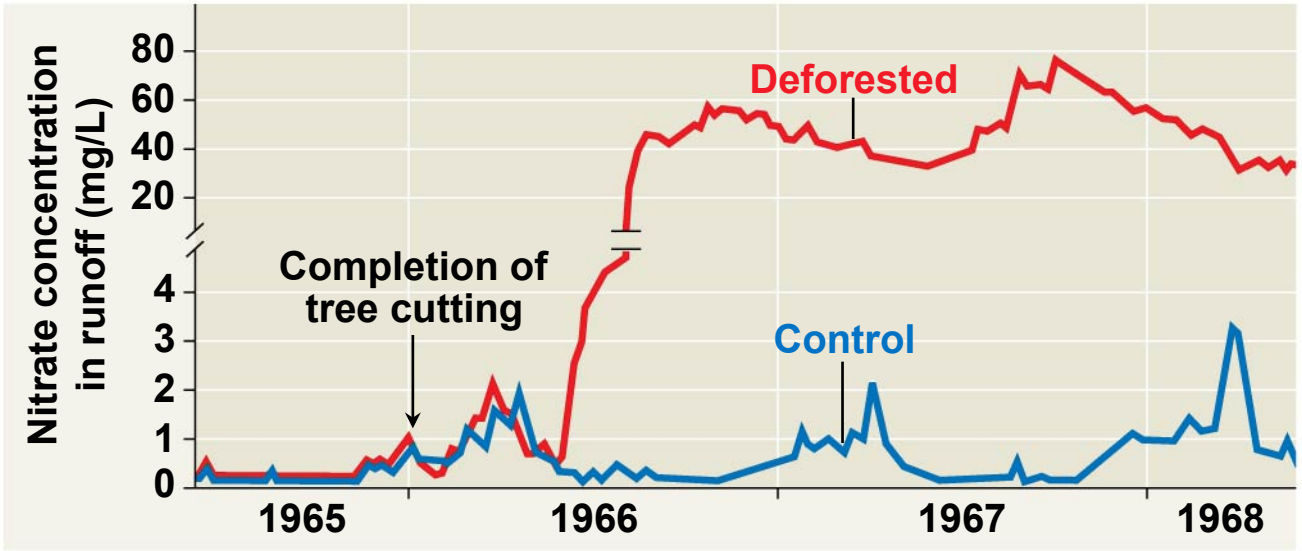
The nitrogen cycle



The phosphorus cycle

(a) Concrete dam and weir

(b) Clear-cut watershed

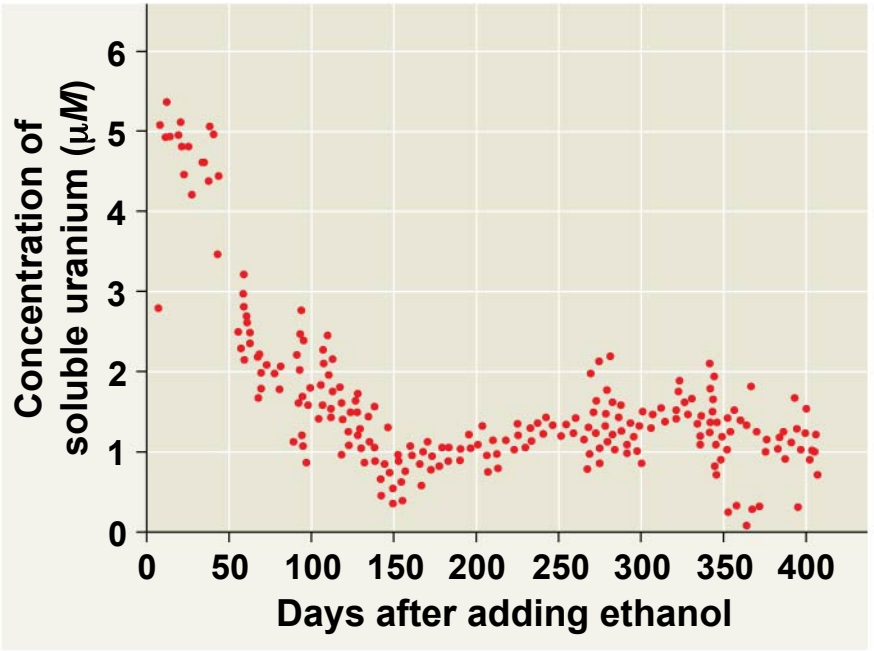


(c) Nitrate in runoff from watersheds

(a) In 1991, before restoration

(b) In 2000, near the completion of restoration

(a) Wastes containing uranium, Oak Ridge National Laboratory



(b) Decrease in concentration of soluble uranium in groundwater