Physiology and Cultivation of Algae and Cyanobacteria

4.

Biogechemical role of algae

- Energy flow in the environment
- Limiting nutrients
  - Liebig's Law of the Minimum
  - $\mu = \mu_{max}$ [LM] / [LM] + K_m
- Cycles of nutrients
  - Phosphorus
  - Nitrogen
  - Sulphur
  - Carbon & Oxygen
- environmental factors

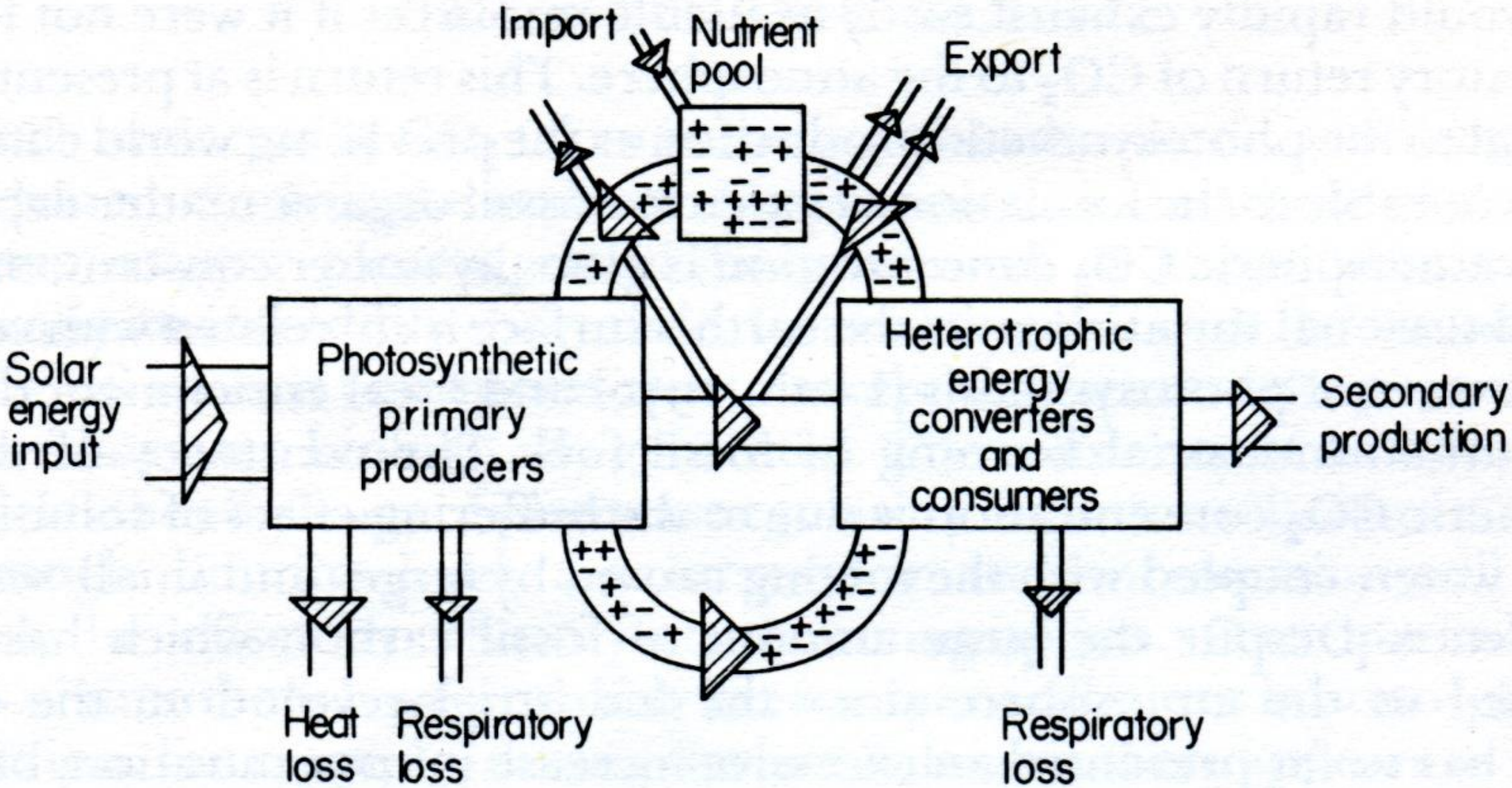

Figure 9.2 The relationship of the ecosystem nutrient cycle to energy flow. After E. P. Odum, *Fundamentals of Ecology*, 3rd. Edn., Saunders, Philadelphia, 1971, p. 87.

Phosphorus

- PO_4^{3-}
- membranes, coenzymes, DNA, RNA, ATP
- orthophosphate; metaphosphate (polyphosphate); “organic” phosphate

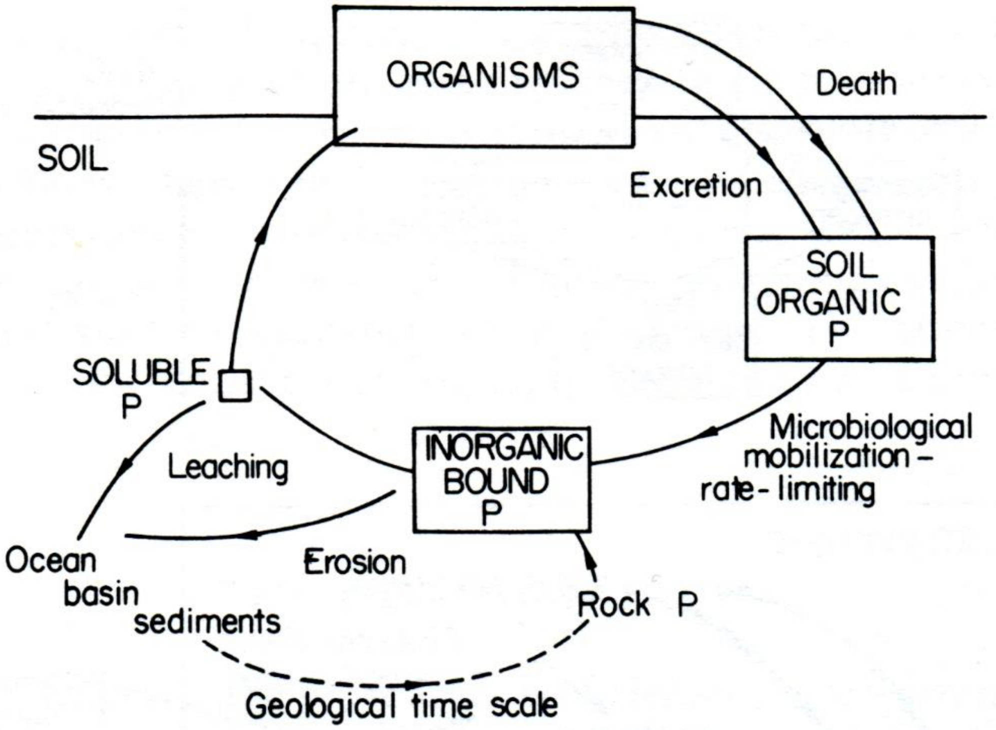

Figure 9.5 The local cycle of phosphorus. Both the organic and inorganic pools of soil phosphorus are essentially rather immobile with the result that the mobilization of organic P into the plant-available phosphate form is rate-limiting to the cycle, and also that the leaching loss of soil P is fairly slow. In many cases it is physical loss by soil erosion which removes P from natural ecosystems and agricultural land. Loss by these two mechanisms is only counteracted on a geological time-scale when ocean basin sediments become elevated to form new land surfaces. Soil P is normally very insoluble but the addition of fertilizer P causes a great increase in the rate of leaching to ground water or water courses.

Nitrogen

- diazotrophs
  - N-fixation (N_2 >> NH_3)
  - assimilation (NO_3^-&NH_4^+ >> organic N)
  - mineralization (organic N >> NH_4^+)
  - nitrification (NH_4^+&NO_2^- >> NO_3^-)
  - denitrification (NO_3^- >> NO, N_2O, N_2)
- nitrogenase; MoFe(V)-protein; PS I;
- *Nostoc*, *Anabaena*, *Trichodesmium*, *Katagnymene*

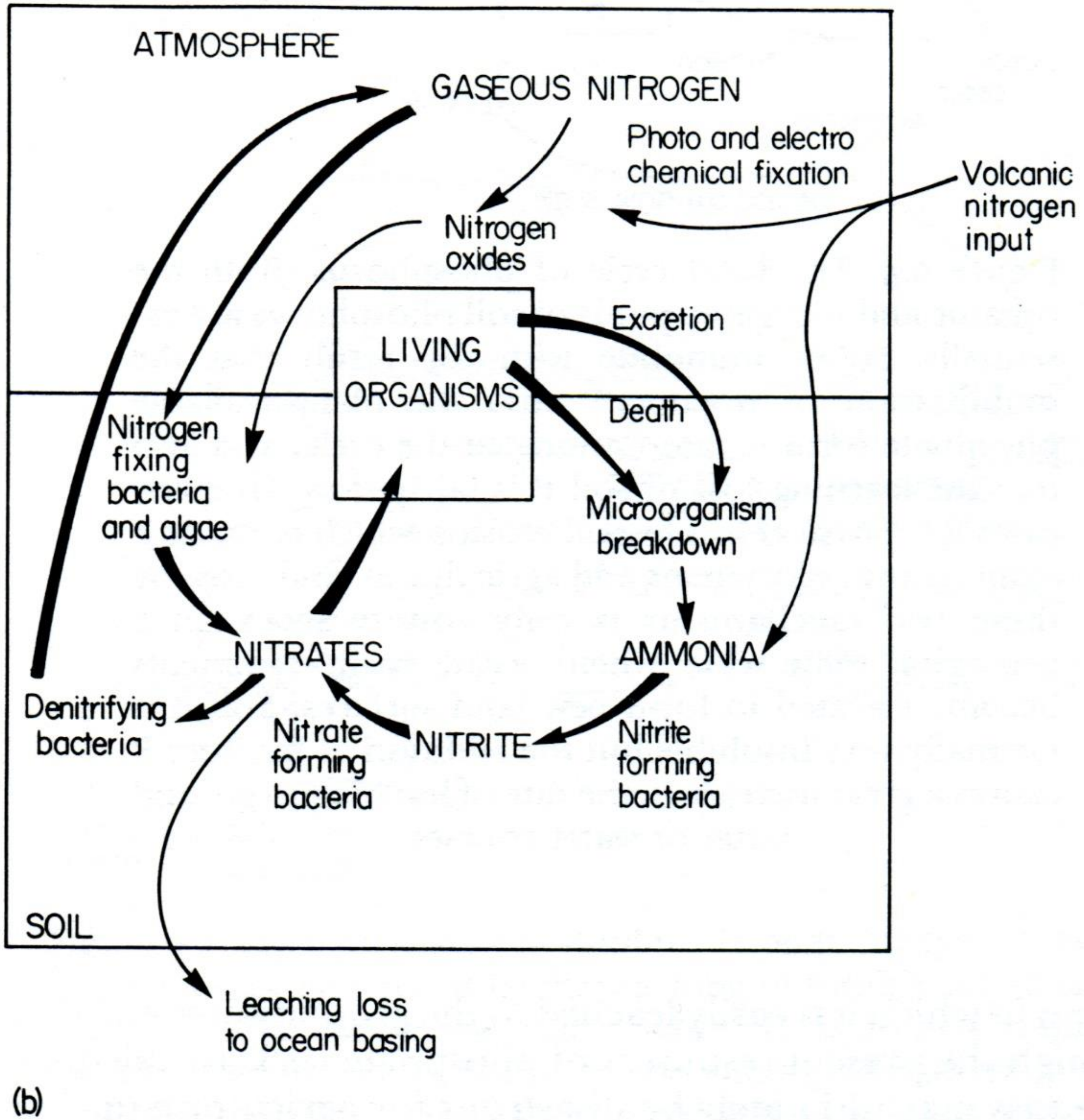

Figure 9.4 The nitrogen cycle. (a) Major relationships between the very large atmosphere pool of gaseous nitrogen and the biosphere. (b) The complex interrelationships of the soil-based portion of the cycle.

Silicon

- $[Si(OH)_4]$; $(SiO_2 \, . \, nH_2O)$
- silica-forming organism
  - Chrysophyceae
  - Bacillariophyceae
  - Dictyochlorophyceae
- cell wall; sediments

Sulphur

- aminoacids (Cys, Pro, cystine)
- SO_2, SO_4^{2-}, H_2S,
- APS (adenosine-5'-phosphosulphate)
- PAPS (3'-phosphoadenosine-5'-phosphosulphate)
- DMS (dimethyl sulphide)
- DMSP (dimethylsulphonium propionate)

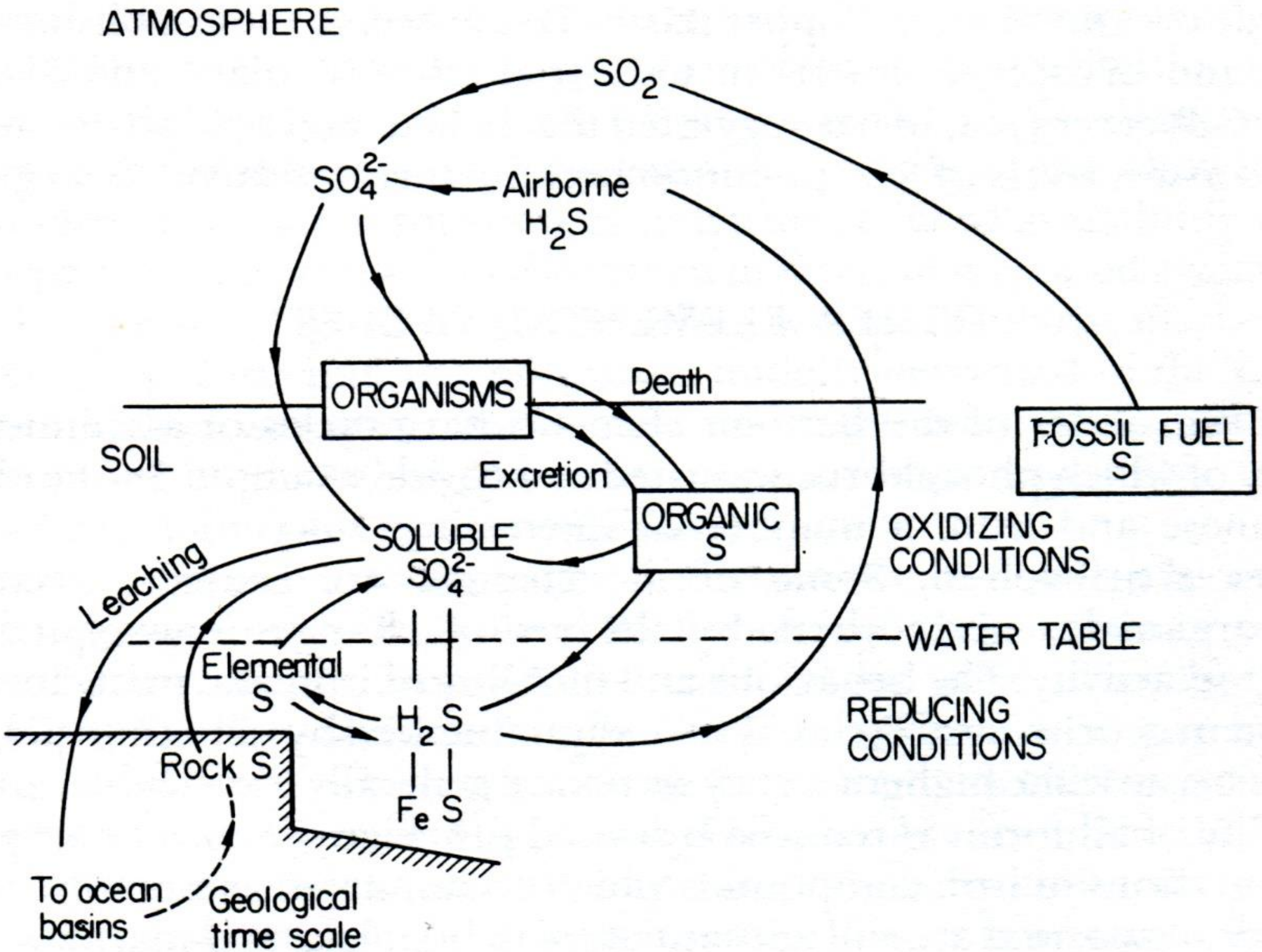

Figure 9.6 The hybrid cycle of sulphur. Though the cycle is essentially local it may be opened by the leaching of soluble sulphate into a reducing zone below the water table. If hydrogen sulphide is produced it may be liberated to the atmosphere where it rapidly oxidizes to sulphate. The conversion of organic sulphur to the plant-available sulphate and the various interconversions of sulphur in wet soil are all bacterially mediated processes.

Carbon & Oxygen

- CO_2, H_2O, CO, O_2, HCN, CH_4, $CaCO_3$, CFC, HCFC
- photosynthesis
- oxidizing atmosphere
- coccoliths

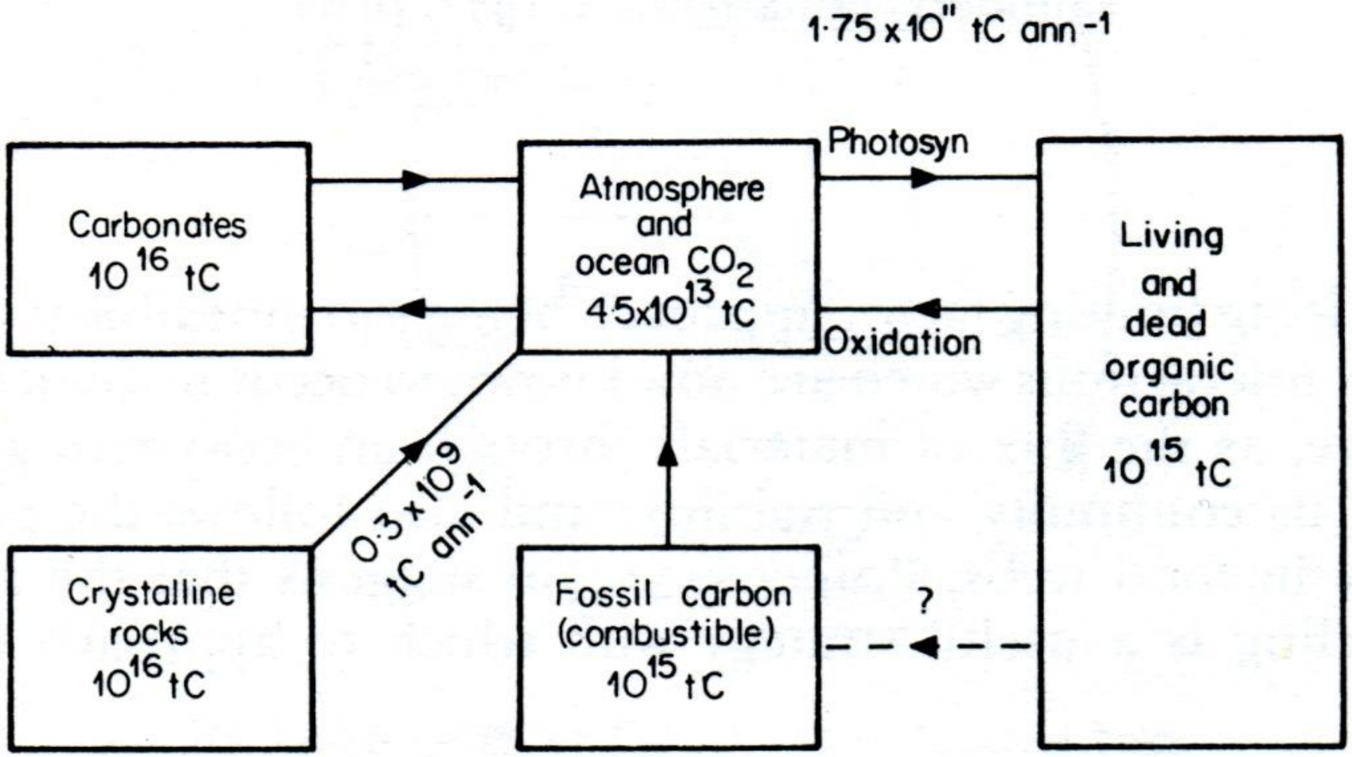

Figure 9.3 The global carbon cycle. Data from Nichiporovich (1969), Wassink (1968) and Revelle and Fairbridge (1957).

Algae & Men

- macroalgae (commerce - 42 countries)
    - food
        - *Laminaria* (China, N.,S.Korea, Japan, Philipines, Chile, Norway, Indonesia, U.S., India)
        - *Porphyra*, *Kappaphycus*, *Undaria*, *Euchema*, *Gracilaria*
        - **Nori** (*Porphyra yezzoensis*) – 13mil. t/y
- microalgae
    - carotenoids, pigmenst, proteins, vitamins, …
        - nutraceuticals, pharmaceuticals, animal feed additives, cosmetics, fertilizers
        - *Dunaliella*, *Haematococcus*, *Arthrospira*, *Chlorella*