Environmental Factors & Adaptations (text pp. 61-131)

MINERAL NUTRIENTS

I. Nutrient cycles

A. Importance and relative abundance of macronutrients

Macronutrient	**Absorbed as**	**Function in plant**
C	CO_2	skeleton of all organic compounds
H	H_2O	part of organic skeleton
O	H_2O or O_2	organic compounds, e- acceptor in cellular respiration
N	NH_4^+, NO_3^-	amino acids, nucleotides, chlorophyll, coenzymes
P	$H_2PO_4^-$, HPO_4^{-2}	nucleotides, phospholipids
S	SO_4^{-2}	amino acids, coenzyme A

- C, H, O, and S are relatively abundant in the biosphere (**Table from Wetzel 2001**)
- N & P often are limiting to plant growth (N & P most frequently)
- In aquatic systems, C:N:P ratio is an important parameter for determining nutrient limit to plant growth
  - in plant material ratio is typically 40:7:1; in freshwaters about 1200:23:1 (global average)

B. Nitrogen cycle (**Fig**)

Nitrification (conversion from NH3 to nitrite, nitrate) – carried out by *Nitrosomonas*, *Nitrobacter*
Assimilation (uptake of nitrate & conversion to organic N)
Ammonification (conversion from organic N to ammonia)
Denitrification (conversion from nitrite, nitrate to N2) – carried out by *Thiobacillus*, *Paracoccus*, et al.
nitrate → nitrite → nitric oxide → nitrous oxide → N2
N fixation (conversion from N2 to ammonia) – carried out by *Rhizobium* and others

C. Phosphorus Cycle (**Fig**)

- virtually all phosphates in the biosphere are in solid form (exception is phosphine gas)
- mechanisms for cycling are uptake, decay, and precipitation/dissolution
- phosphates generally become locked up in aquatic sediments because of insolubility of oxidized phosphate compounds (such as Ferric Phosphate) and co-precipitation with carbonates at higher pH

II. Redox and nutrition/nutrients

A. Nitrogen

1. Reduction can result in immobilization or loss
   a. under low NO_3 conditions, transformation (reduction) usually is to NH_4, resulting in immobilization or recycling of N within the sediments (ammonification)
   b. under high NO_3 conditions, transformation (reduction) usually is to N_2, resulting in loss of N from the sediments (denitrification)

B. Manganese

Reduction leads to increased availability of Mn^{2+} to plants

- this leads to interference with enzymes and nutrient uptake

C. Iron

Reduction leads to increased availability of Fe^{2+} to plants

- this leads to interference with production of chlorophyll

Oxidation also may lead to reduced nutrient uptake because of the thick plaque that may form on roots

D. Sulfate

Reduction leads to sulfides that may:

- interfere with photosynthetic enzymes,
- reduce cellular respiration within roots, and
- the capacity for anaerobic metabolism by interfering with ADH

E. Carbon (CO_2 and detritus)

Reduction produces methane, which is not known to be harmful to plants, but is a greenhouse gas

III. Symbioses

A. Mycorrhizae

1. Ectomycorrhizae
   - found in some spp of woody plants in northern peatlands

2. Endomycorrhizae

   a. Arbuscular Mycorrhizae (AM)
   - found in numerous spp of herbaceous macrophytes

   b. Ericaceous mycorrhizae
   - found only in plants of the Ericaceae
   - believed primarily to augment N availablity

   c. Orchidaceous mycorrhizae
   - found in various orchid spp
   - supply carbon to germinating seedling, in addition to other nutrients

B. Nitrogen fixing bacteria

1. Reside in nodules within the roots of Legumes and other assorted spp.
   Alnus and *Myrica* are notable wetland shrubs
2. Convert atmospheric N_2 into organic nitrogen

IV. Carnivory

A. Adaptation to acquire extra nutrients from digestion or decomposition of capture invertebrates
- plant generally are found in nutrient-poor areas

B. Various forms of traps for capturing prey
1. Pitfall traps (Pitcher plants)
2. Snap traps (Venus' Flytrap)
3. Adhesive traps (Sundews or Butterworts)
4. Bladder traps (*Utricularia*)

V. Nutrient Translocation

More than 70% of aquatic monocots rely strongly on asexual reproduction and perenniation to maintain their populations
- recycling of nutrients by translocation to roots/rhizomes during periods of dormancy and/or during the process of senescence and production of new shoots increases productive efficiency