

Adaptations to Aquatic Environments

Aquatic plants evolved from terrestrial plants. Like whales and other marine mammals, aquatic plants evolved from land back to aquatic habitats. Aquatic plants modified terrestrial features to withstand emerged, submerged, or floating conditions.

Types of Challenges

Emergents:

Aeration of Roots:

- Formation of aerenchyma: large open spaces between cells, which is important to carry oxygen down to the root zone.
- Formation of prop roots (Red Mangrove)
- Formation of pneumatophores (Black Mangrove)
- Anaerobic respiration: plants will form ethylene, then more aerenchyma tissue and adventitious tissue. The plant elongates and forms fatty acids from the ethylene. Ethylene is a common gas in swamps due to decay.

Reproduction: Sexual reproduction is rare, more commonly used methods are:

- Fragmentation, pieces break off and float away to another location where they get embedded in the substrate.
- Rhizomes: underground stems send up shoots to start a new plant.
- Stolon: same as rhizomes except these are above ground stems which form into shoots and start a new plant.

Seed germination: Plants have different strategies for seeds:

- Timing of seed production to occur during the non-flood season either by delayed or accelerated flowering.
- Production of buoyant seeds that float on high unflooded ground.
- Seeds germinate while still attached to the plant.

Photosynthesis: Gas exchange: As the water gets deeper, the wavelength of light gets shorter until its gone. The red and blue wavelengths are lost, and the green (not so good for photosynthesis) remains. Adaptations include:

- Wetland plants often use C4 biochemical pathway of photosynthesis instead of C3.
 - C4 provides a possible pathway for recycling CO₂ from cell respiration
 - plants using C4 have low photorespiration rates and the ability to use even the most

intense sunlight efficiently.

-C4 plants more efficient than C3 plants in rate of carbon fixation and amount of water used per unit carbon fixed.

Salinity:

- Barriers prevent or control the entry of salts -root and leaf cell membrane act like ultra-filters.
- Organs specialized to excrete salts -selectively remove certain ions from the vascular tissue of the leaf.

Submerged plants:

Reproduction:

- *Vallisneria* produce a coiled peduncle (female), which straightens out so the stigma can reach above the water surface. The spathe (male) also straightens out so its petals float on the surface. Its three leaves and anthers form a sailboat. The spathe floats along until hopefully it bumps into a stigma.
- *Ceratophyllum*: uses a strategy of hydrophily: the male releases pollen into the water where it floats until it sinks again, hopefully landing on a female plant.
- A chinese lotus can lay dormant for over 1,000 years.

Photosynthesis:

Algal blooms can block the sunlight and nutrients to submerged plants.

Aeration of Roots -

Oxygen is transmitted from the leaves to the roots and rhizomes by lacunae (air spaces forming channels in leaves, stems, and roots). Lacunae also have a structural role.

Lacunae take up about 60% of the plants volume.

An experiment was done to demonstrate the oxygen gradient in plants. It was found that a plant has 20% oxygen in its leaves, 15% in its stem, 10% in the root parts, and only 2-5% in the root hairs. The oxygen is taken in from the air by photosynthesis and travels through the plant and out the root hairs.

When low oxygen levels are present, plants use other mechanisms to adjust for respiration. Aquatic plants can respire anaerobically. This has been shown experimentally by bubbling N₂ or O₂ into the water with rhizomes, and then measuring the ethanol production. At <3% O₂, ethanol is produced by Typha, Scirpus, Nuphar, and others. Some aquatic plants have developed air roots along their stems for respiration in water. Aquatic trees have developed pneumatophores, which are extensions of the root system reaching above the water level. Pneumatophores take in oxygen through small holes at their tips.

Other challenges that aquatic plants must adapt to include: flooding, desiccation (drying out) nutrient uptake, and vegetative reproduction.