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# Extreme environments

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# 13

## OM13.1 MANGROVES

Mangroves are shrubs or trees that grow in intertidal zones in **tropical** and subtropical climates (**Figure OM13.1-1**). Although mangrove species are all adapted to the extreme conditions presented by intertidal zones and look superficially similar, these plants come from 15 diverse families: they are an example of **convergent evolution**. Some adaptations are common to many species – for example **stilt roots** that support the tree as water levels rise and fall with tides. However, species differ widely in the mechanisms by which their roots – usually growing in anoxic, saline mud – are aerated, and by which they tolerate high salt concentrations. In some species, oxygen supply to roots via aerenchyma from aerial parts is supplemented at low tide by **lenticels** in the bark of stilt roots that can extend meters beyond the trunk. (Lenticels are pores in the bark of woody species that allow aeration of the internal tissues.) Other mangrove species have pneumatophores, or “breathing roots” that extend upwards from the root system into air at low tide and into aerated water at high tide. Mangrove species also differ in their mechanisms of salt tolerance. In some families, specialized cell layers at the root surface largely prevent the entry of sodium, whereas in other families salt is sequestered in leaves for extrusion via leaf glands. Mechanisms of salt tolerance are discussed in Section 13.5.

(A)



**Figure OM13.1-1 Mangroves.** (A) Pneumatophores of *Avicennia marina* in South Australia. (B) Stilt roots of *Pelliciera rhizophorae* in Costa Rica. (C) A mangrove swamp in Okinawa, Japan. Stilt roots are visible in the foreground. (A, from “Pneumatophore overkill – grey mangrove” by Peripitus. Licensed under CC BY SA 3.0 via Wikimedia Commons. B, from “Pelliciera rhizophorae” by Fabsiar. Licensed under CC BY SA 4.0 via Wikimedia Commons. C, from “Mangrove swamp, Iriomote Island, Okinawa, Japan” by Anagounagi. Licensed under CC BY SA 4.0 via Wikimedia Commons.)

(B)



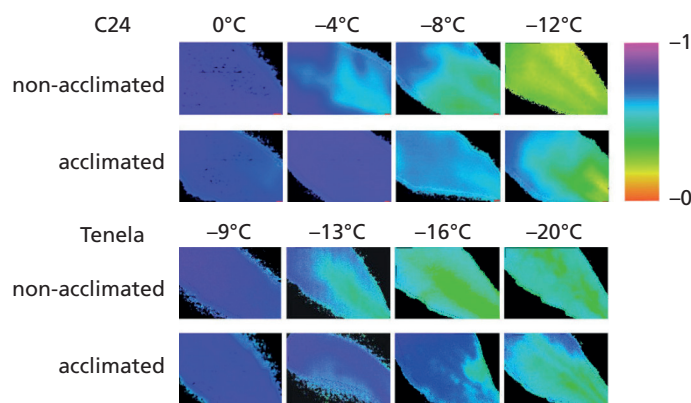
(C)



Mangrove swamps are exceptionally biodiverse habitats, providing shelter and food for numerous species of crustacea, fish, reptiles, and birds (among others), livelihoods for small-scale fishing enterprises, and protection of coastlines from erosion. They are under threat of destruction from the global rise in demand for timber, marine farming, and land reclamation, and from pollution, commercial over-fishing, and increases in sea level and temperature. It is estimated that 35–50% of global mangrove habitat was lost in the 20 years between 1980 and 2000.

## OM 13.2 USE OF FLUORESCENCE TO MONITOR LOW-TEMPERATURE DAMAGE AND ACCLIMATION

Stress conditions including freezing can reduce photosystem efficiency by decreasing the capacity of PSII (photosystem II) to dissipate excess excitation energy as heat and fluorescence, thus exposing the photosynthetic apparatus to damage (see Section 4.2). Measurements of fluorescence emission on leaves in different light conditions enable the capacity for dissipation of excitation energy from PSII to be estimated. Here, the effects of temperature reductions on so-called  $F_v/F_m$  values (see Online Material 4.5) for non-acclimated and acclimated (4°C for 14 days) plants are compared for two different *Arabidopsis* accessions (**Figure OM13.2-1**). Values of about 0.8 are observed for non-stressed conditions in the leaves of most species (dark blue). As temperature is decreased,  $F_v/F_m$  values decrease (pale blue to red). The non-acclimated plants show reduced  $F_v/F_m$  values at higher temperatures than is the case in acclimated plants. The values also show that the cold-adapted accession Tenela (from Finland) has a much greater intrinsic capacity for freezing tolerance than the accession C24 (from Portugal).



**Figure OM13.2-1 Use of chlorophyll fluorescence values to monitor low-temperature damage to leaves.** Leaves of the *Arabidopsis* accessions C24 and Tenela were frozen to the temperatures indicated by reducing the temperature by 2°C per hour. They were then slowly thawed prior to fluorescence imaging. Non-acclimated leaves were taken from a greenhouse; acclimated leaves were from plants held at 4°C for 14 days prior to the experiment. *Blue* indicates values of  $F_v/F_m$  commonly seen in unstressed leaves; *green* and then *yellow* indicate increasing levels of stress. (From Ehlert B and Hincha DK (2008) *Plant Methods* 4:12. CC BY 2.0.)

Rapid freezing down to -4°C can kill *Arabidopsis* plants grown at warm temperatures, but prior exposure to temperatures around 4°C for 2 days or more enables them to tolerate temperatures down to -10°C or lower (see Figure OM13.2-1). There is considerable variation between *Arabidopsis* accessions in their capacity to acclimate to freezing conditions. Accessions from the northernmost part of the range of this species, in Scandinavia, survive the winter under the snow at sub-zero temperatures whereas accessions from regions that do not normally experience freezing have a much lower capacity to acclimate to freezing conditions. In general, there is huge variation between species in the capacity for acclimation to low temperatures. Whereas many species native to **temperate zones** can undergo acclimation to low temperature, many plants native to the tropics cannot acclimate to low temperatures and may be killed by exposure to temperatures that are well above freezing.