**Ecophysiology** (from [Greek](https://en.wikipedia.org/wiki/Ancient_Greek) οἶκος, *oikos*, "house(hold)"; φύσις, *physis*, "nature, origin"; and -λογία, [*-logia*](https://en.wikipedia.org/wiki/-logy)), **environmental physiology** or **physiological ecology** is a [biological](https://en.wikipedia.org/wiki/Biology" \o "Biology)[discipline](https://en.wikipedia.org/wiki/List_of_academic_disciplines) that studies the adaptation of an [organism](https://en.wikipedia.org/wiki/Organism)'s [physiology](https://en.wikipedia.org/wiki/Physiology) to environmental conditions. It is closely related to [comparative physiology](https://en.wikipedia.org/wiki/Comparative_physiology) and [evolutionary physiology](https://en.wikipedia.org/wiki/Evolutionary_physiology).

Plants[[edit](https://en.wikipedia.org/w/index.php?title=Ecophysiology&action=edit&section=1" \o "Edit section: Plants)]

*Further information:*[*Plant perception (physiology)*](https://en.wikipedia.org/wiki/Plant_perception_(physiology))*and*[*Plant stress measurement*](https://en.wikipedia.org/wiki/Plant_stress_measurement)

Plant ecophysiology is concerned largely with two topics: mechanisms (how plants sense and respond to environmental change) and scaling or integration (how the responses to highly variable conditions—for example, gradients from full sunlight to 95% shade within tree canopies—are coordinated with one another), and how their collective effect on plant growth and gas exchange can be understood on this basis.

In many cases, [animals](https://en.wikipedia.org/wiki/Animal) are able to escape unfavourable and changing environmental factors such as heat, cold, drought or floods, while [plants](https://en.wikipedia.org/wiki/Plant) are unable to move away and therefore must endure the adverse conditions or perish (animals go places, plants grow places). Plants are therefore [phenotypically plastic](https://en.wikipedia.org/wiki/Phenotypic_plasticity) and have an impressive array of [genes](https://en.wikipedia.org/wiki/Gene) that aid in adapting to changing conditions. It is hypothesized that this large number of genes can be partly explained by plant species' need to adapt to a wider range of conditions.

**Food**[[edit](https://en.wikipedia.org/w/index.php?title=Ecophysiology&action=edit&section=2" \o "Edit section: Food)]

*See also: [Photomorphogenesis](https://en.wikipedia.org/wiki/Photomorphogenesis" \o "Photomorphogenesis) and [Photoperiodism](https://en.wikipedia.org/wiki/Photoperiodism" \o "Photoperiodism)*

As with most abiotic factors, light intensity (irradiance) can be both suboptimal and excessive. Light intensity is also an important component in determining the temperature of plant organs (energy budget).The light response curve of net photosynthesis ([PI curve](https://en.wikipedia.org/wiki/PI_curve)) is particularly useful in characterising a plants tolerance to different light intensities.

Suboptimal light (shade) typically occurs at the base of a plant canopy or in an understory environment. [Shade tolerant](https://en.wikipedia.org/wiki/Shade_tolerant) plants have a range of adaptations to help them survive the altered quantity and quality of light typical of shade environments.

Excess light occurs at the top of canopies and on open ground when cloud cover is low and the sun's zenith angle is low, typically this occurs in the tropics and at high altitudes. Excess light incident on a leaf can result in [photoinhibition](https://en.wikipedia.org/wiki/Photoinhibition" \o "Photoinhibition) and [photodestruction](https://en.wikipedia.org/wiki/Photodestruction" \o "Photodestruction). Plants adapted to high light environments have a range of adaptations to avoid or dissipate the excess light energy, as well as mechanisms that reduce the amount of injury caused.

**Temperature**[[edit](https://en.wikipedia.org/w/index.php?title=Ecophysiology&action=edit&section=3" \o "Edit section: Temperature)]

*See also:*[*Plant adaptations to wildfires*](https://en.wikipedia.org/wiki/Fire_ecology#Immediate_Biotic_responses_and_adaptations)

In response to extremes of temperature, plants can produce various [proteins](https://en.wikipedia.org/wiki/Protein). These protect them from the damaging effects of ice formation and falling rates of [enzyme](https://en.wikipedia.org/wiki/Enzyme) catalysis at low temperatures, and from enzyme [denaturation](https://en.wikipedia.org/wiki/Denaturation_(biochemistry)) and increased [photorespiration](https://en.wikipedia.org/wiki/Photorespiration) at high temperatures. As temperatures fall, production of [antifreeze proteins](https://en.wikipedia.org/wiki/Antifreeze_protein) and [dehydrins](https://en.wikipedia.org/wiki/Dehydrin" \o "Dehydrin)increases. As temperatures rise, production of [heat shock proteins](https://en.wikipedia.org/wiki/Heat_shock_protein) increases. Metabolic imbalances associated with temperature extremes result in the build-up of [reactive oxygen species](https://en.wikipedia.org/wiki/Reactive_oxygen_species), which can be countered by [antioxidant](https://en.wikipedia.org/wiki/Antioxidant) systems. [Cell membranes](https://en.wikipedia.org/wiki/Cell_membrane) are also affected by changes in temperature and can cause the membrane to lose its [fluid properties](https://en.wikipedia.org/wiki/Fluid_mosaic#Structure_and_the_Fluid_mosaic_model) and become a gel in cold conditions or to become leaky in hot conditions. This can affect the movement of compounds across the membrane. To prevent these changes, plants can change the composition of their membranes. In cold conditions, more [unsaturated fatty acids](https://en.wikipedia.org/wiki/Fatty_acid#Unsaturated_fatty_acids) are placed in the membrane and in hot conditions more [saturated](https://en.wikipedia.org/wiki/Saturation_(chemistry)) fatty acids are inserted.

[](https://en.wikipedia.org/wiki/File:Leaf_temperature-_infrared_image_of_tomato_leaves.jpg)

Infrared image showing the importance of transpiration in keeping leaves cool.

Plants can avoid overheating by minimising the amount of sunlight absorbed and by enhancing the cooling effects of wind and [transpiration](https://en.wikipedia.org/wiki/Transpiration). Plants can reduce light absorption using reflective leaf hairs, scales, and waxes. These features are so common in warm dry regions that these habitats can be seen to form a ‘silvery landscape’ as the light scatters off the canopies.[[1]](https://en.wikipedia.org/wiki/Ecophysiology#cite_note-Lee2010-1) Some species, such as *Macroptilium purpureum*, can move their leaves throughout the day so that they are always orientated to avoid the sun (*[paraheliotropism](https://en.wikipedia.org/w/index.php?title=Paraheliotropism&action=edit&redlink=1" \o "Paraheliotropism (page does not exist))*).[[2]](https://en.wikipedia.org/wiki/Ecophysiology#cite_note-Plant_Ecology-2) Knowledge of these mechanisms has been key to [breeding for heat stress tolerance](https://en.wikipedia.org/wiki/Breeding_for_heat_stress_tolerance) in agricultural plants.

Plants can avoid the full impact of low temperature by altering their [microclimate](https://en.wikipedia.org/wiki/Microclimate). For example, *[Raoulia](https://en.wikipedia.org/wiki/Raoulia" \o "Raoulia)* plants found in the uplands of New Zealand are said to resemble ‘vegetable sheep’ as they form tight cushion-like clumps to insulate the most vulnerable plant parts and shield them from cooling winds. The same principle has been applied in agriculture by using [plastic mulch](https://en.wikipedia.org/wiki/Plastic_mulch) to insulate the growing points of crops in cool climates in order to boost plant growth.[[3]](https://en.wikipedia.org/wiki/Ecophysiology#cite_note-3)

**Water**[[edit](https://en.wikipedia.org/w/index.php?title=Ecophysiology&action=edit&section=4" \o "Edit section: Water)]

*See also:*[*Moisture stress*](https://en.wikipedia.org/wiki/Moisture_stress)

Too much or too little water can damage plants. If there is too little water then tissues will dehydrate and the plant may die. If the soil becomes waterlogged then the soil will become anoxic (low in oxygen), which can kill the roots of the plant.

The ability of plants to access water depends on the structure of their roots and on the [water potential](https://en.wikipedia.org/wiki/Water_potential) of the root cells. When soil water content is low, plants can alter their water potential to maintain a flow of water into the roots and up to the leaves ([Soil plant atmosphere continuum](https://en.wikipedia.org/wiki/Soil_plant_atmosphere_continuum)). This remarkable mechanism allows plants to lift water as high as 120 m by harnessing the gradient created by [transpiration](https://en.wikipedia.org/wiki/Transpiration) from the leaves.[[4]](https://en.wikipedia.org/wiki/Ecophysiology#cite_note-4)

In very dry soil, plants close their stomata to reduce transpiration and prevent water loss. The closing of the stomata is often mediated by chemical signals from the root (i.e., [abscisic acid](https://en.wikipedia.org/wiki/Abscisic_acid" \o "Abscisic acid)). In irrigated fields, the fact that plants close their stomata in response to drying of the roots can be exploited to ‘trick’ plants into using less water without reducing yields (see [partial rootzone drying](https://en.wikipedia.org/wiki/Partial_rootzone_drying)). The use of this technique was largely developed by Dr Peter Dry and colleagues in Australia[[5]](https://en.wikipedia.org/wiki/Ecophysiology" \l "cite_note-5)[[6]](https://en.wikipedia.org/wiki/Ecophysiology#cite_note-6) (see [nominative determinism](https://en.wikipedia.org/wiki/Nominative_determinism)).

If drought continues, the plant tissues will dehydrate, resulting in a loss of [turgor pressure](https://en.wikipedia.org/wiki/Turgor_pressure) that is visible as [wilting](https://en.wikipedia.org/wiki/Wilting). As well as closing their stomata, most plants can also respond to drought by altering their water potential ([osmotic adjustment](https://en.wikipedia.org/w/index.php?title=Osmotic_adjustment&action=edit&redlink=1)) and increasing root growth. Plants that are adapted to dry environments ([Xerophytes](https://en.wikipedia.org/wiki/Xerophytes)) have a range of more specialized mechanisms to maintain water and/or protect tissues when desiccation occurs.

Waterlogging reduces the supply of oxygen to the roots and can kill a plant within days. Plants cannot avoid waterlogging, but many species overcome the lack of oxygen in the soil by transporting oxygen to the root from tissues that are not submerged. Species that are tolerant of waterlogging develop specialised roots near the soil surface and [aerenchyma](https://en.wikipedia.org/wiki/Aerenchyma" \o "Aerenchyma) to allow the diffusion of oxygen from the shoot to the root. Roots that are not killed outright may also switch to less oxygen-hungry forms of cellular respiration.[[7]](https://en.wikipedia.org/wiki/Ecophysiology#cite_note-7)Species that are frequently submerged have evolved more elaborate mechanisms that maintain root oxygen levels, perhaps most notable being the dramatic aerial roots seen in [Mangrove](https://en.wikipedia.org/wiki/Mangrove) forests.

However, for many terminally overwatered houseplants, the initial symptoms of waterlogging can resemble those due to drought. This is particularly true for flood-sensitive plants that show drooping of their leaves due to [epinasty](https://en.wikipedia.org/wiki/Epinasty" \o "Epinasty) (rather than wilting).

**CO2 concentration**[[edit](https://en.wikipedia.org/w/index.php?title=Ecophysiology&action=edit&section=5" \o "Edit section: CO2 concentration)]

CO2 is vital for plant growth, as it is the substrate for photosynthesis. Plants take in CO2 through [stomatal](https://en.wikipedia.org/wiki/Stomatal" \o "Stomatal) pores on their leaves. At the same time as CO2 enters the stomata, moisture escapes. This trade-off between CO2 gain and water loss is central to plant productivity. The trade-off is all the more critical as [Rubisco](https://en.wikipedia.org/wiki/Rubisco" \o "Rubisco), the enzyme used to capture CO2, is efficient only when there is a high concentration of CO2 in the leaf. Some plants overcome this difficulty by concentrating CO2 within their leaves using [C4 carbon fixation](https://en.wikipedia.org/wiki/C4_carbon_fixation)or [Crassulacean acid metabolism](https://en.wikipedia.org/wiki/Crassulacean_acid_metabolism" \o "Crassulacean acid metabolism). However, most species used [C3 carbon fixation](https://en.wikipedia.org/wiki/C3_carbon_fixation) and must open their stomata to take in CO2 whenever photosynthesis is taking place.



Plant Productivity in a Warming World

The concentration of [CO2 in the atmosphere](https://en.wikipedia.org/wiki/Carbon_dioxide_in_the_Earth%27s_atmosphere) is rising due to [deforestation](https://en.wikipedia.org/wiki/Deforestation) and the combustion of [fossil fuels](https://en.wikipedia.org/wiki/Fossil_fuels). This would be expected to increase the efficiency of photosynthesis and possibly increase the overall rate of plant growth. This possibility has attracted considerable interest in recent years, as an increased rate of plant growth could absorb some of the excess CO2 and reduce the rate of [global warming](https://en.wikipedia.org/wiki/Global_warming). Extensive experiments growing plants under elevated CO2 using [Free-Air Concentration Enrichment](https://en.wikipedia.org/wiki/Free-Air_Concentration_Enrichment) have shown that photosynthetic efficiency does indeed increase. Plant growth rates also increase, by an average of 17% for above-ground tissue and 30% for below-ground tissue.[[8]](https://en.wikipedia.org/wiki/Ecophysiology#cite_note-8)[[9]](https://en.wikipedia.org/wiki/Ecophysiology#cite_note-9) However, detrimental impacts of global warming, such as increased instances of heat and drought stress, mean that the overall effect is likely to be a reduction in plant productivity.[[10]](https://en.wikipedia.org/wiki/Ecophysiology#cite_note-Parry2007-10)[[11]](https://en.wikipedia.org/wiki/Ecophysiology#cite_note-11)[[12]](https://en.wikipedia.org/wiki/Ecophysiology#cite_note-12) Reduced plant productivity would be expected to accelerate the rate of global warming. Overall, these observations point to the importance of avoiding further increases in atmospheric CO2 rather than risking [runaway climate change](https://en.wikipedia.org/wiki/Runaway_climate_change).

**Wind**[[edit](https://en.wikipedia.org/w/index.php?title=Ecophysiology&action=edit&section=6)]

*See also:*[*wind pollination*](https://en.wikipedia.org/wiki/Wind_pollination)*and*[*seed dispersal*](https://en.wikipedia.org/wiki/Seed_dispersal)

The main impact of wind on plants is through its influence on the canopy, which in turn influences the way leaves regulate moisture, heat, and carbon dioxide. When no wind is present, a layer of still air builds up around each leaf. This is known as the [boundary layer](https://en.wikipedia.org/wiki/Boundary_layer) and in effect insulates the leaf from the environment, providing an atmosphere rich in moisture and less prone to convective heating or cooling. As wind speed increases, the leaf environment becomes more closely linked to the surrounding environment. It may become difficult for the plant to retain moisture as it is exposed to dry air. On the other hand, a moderately high wind allows the plant to cool its leaves more easily when exposed to full sunlight. Plants are not entirely passive in their interaction with wind. Plants can make their leaves less vulnerable to changes in wind speed, by coating their leaves in fine hairs ([trichomes](https://en.wikipedia.org/wiki/Trichomes" \o "Trichomes)) to break up the air flow and increase the boundary layer. In fact, leaf and canopy dimensions are often finely controlled to manipulate the boundary layer depending on the prevailing environmental conditions.[[13]](https://en.wikipedia.org/wiki/Ecophysiology#cite_note-13)

In areas where very strong winds are common, plants respond by reducing their above ground growth (known as dwarfing) and by strengthening their stems. Trees have a particularly well-developed capacity to reinforce their trunks when exposed to wind. In the 1960s, this realisation prompted arboriculturalists in the UK to move away from the practice of staking young [amenity trees](https://en.wikipedia.org/wiki/Amenity_tree) to offer artificial support.[[14]](https://en.wikipedia.org/wiki/Ecophysiology#cite_note-14) In the most extreme cases, plants can be mortally damaged or uprooted by wind. This is a particular problem for agriculture in hurricane-prone regions, such as the banana-growing Windward Islands in the Caribbean.[[15]](https://en.wikipedia.org/wiki/Ecophysiology#cite_note-15) When this type of [disturbance](https://en.wikipedia.org/wiki/Disturbance_(ecology)) occurs in natural systems, the only solution is to ensure that there is an adequate stock of seeds or seedlings to quickly take the place of the mature plants that have been lost- although, in many cases a [successional](https://en.wikipedia.org/wiki/Ecological_succession) stage will be needed before the ecosystem can be restored to its former state.