Photosynthesis

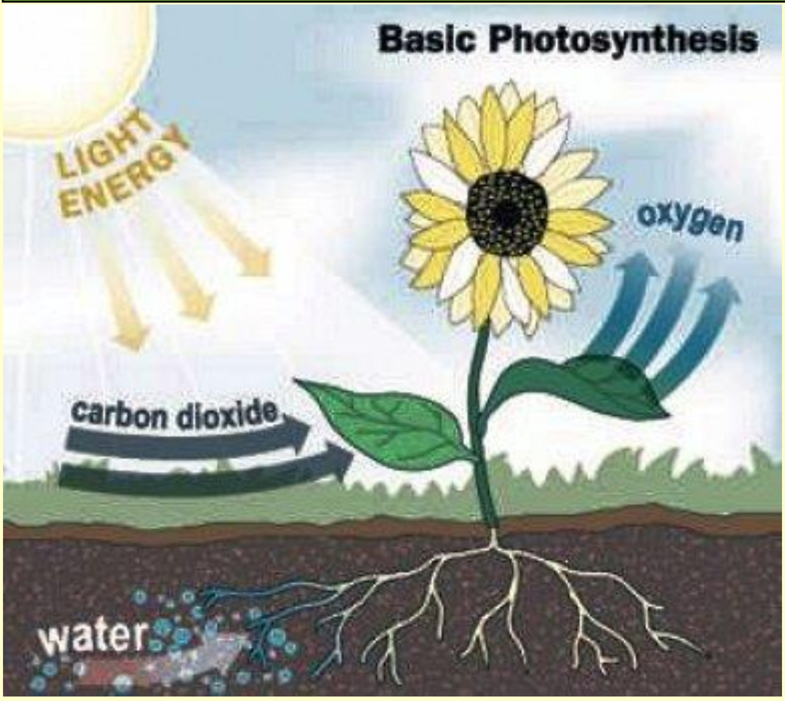
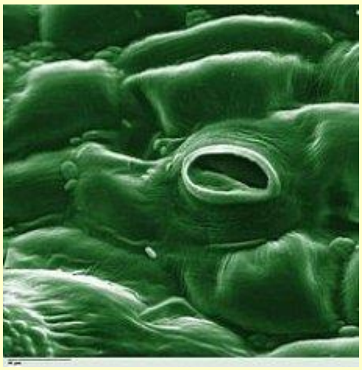


Photo: https://en.wikipedia.org/wiki/Photosynthesis

One of nature's many miracles is the process of photosynthesis by which plants utilise the power of sunlight to convert water and carbon dioxide into sugars/starches which are food for the plant. Water comes primarily via the plant roots, carbon dioxide from the air, the green leaf pigment called chlorophyll is a catalyst and, vitally for mankind, the reaction by-product is oxygen which is released into the air via pores (stomata) concentrated on the undersides of the plant leaves. An important consequence of the photosynthesis mechanism is that it opens the stomata to release the oxygen. In doing this it also opens up a pathway by which water is lost from the plant in a process known as transpiration.

When a plant is short of water, it will be appreciated that it would be to its advantage to be able to close the stomata to limit transpiration but this is basically rendered impossible by the need to release oxygen during photosynthesis. In short, a perfect example of the fabled "Catch 22" in the world of plants which is referred to by botanists as "the Photosynthesis-Transpiration Compromise". Gardeners will be familiar with the phenomenon of drooping plant leaves after an extra hot day when



Stoma in a tomato leaf shown via colorized scanning electron microscopeimage
Photo: https://en.wikipedia.org/wiki/Transpiration

water loss exceeded the plant's ability to replenish it followed by their recovery by the following morning after a night when photosynthesis did not take place and leaf stomata were closed preventing further transpirational water loss. In situations where there is excessive prolonged water loss by transpiration, leaf scorch will finally occur where generally the extremes of the leaf will desiccate. Evergreens such as rhododendrons and camellia in the winter when the ground is frozen and the plant is exposed to cold, drying wind can suffer leaf scorch because water can't be transported from the roots. (Incidentally, a rhododendron is thought by many authorities to attempt to lower the evaporating surface area of the leaf by rolling it up during very cold conditions. The leaf curling occurs but exactly why remains debatable:http://www.arnoldia.arboretum.harvard.edu/pdf/articles/1990-50-1-why-do-rhododendron-leaves-curl.pdf.)

Plant nutrition

Before focussing specifically on how woodland plants have adapted to life in the shade, it is useful to touch on some other aspects of plant nutrition to get a balanced view of a plant's needs. A more detailed introduction is provided in the literature, for example: https://en.wikipedia.org/wiki/Plant_nutrition. In short, a plant takes up a host of water-soluble minerals through it's roots which together contribute to general plant growth which includes the manufacture of green-coloured chlorophyll and so they also indirectly assist photosynthesis which provides the non-mineral food (sugars and starches), as was explained. The gardener needs to be aware of the Primary Macro-nutrients which are the main constituents of fertilizers and are the origin of the NPK reference which invariably appears on the pack. "N" refers to nitrogen which boosts growth and chlorophyll production – that is why using fertilizer rich in a soluble source of nitrogen such as urea will quickly green up grass. "P" is phosphorus which boosts root and flower growth. "K" is for potassium (from the old name of "kalium") and it's main function is in plant cell building and boosting disease resistance – special pre-winter feeds are often rich in potassium because more robust plant cells render them more resistant to the stresses imposed by winter conditions. It is important to note that applying individual fertilizer components is something which needs to be done with great care because applying an excess of one can basically induce symptoms of a deficiency of other components. This topic goes outside the remit of our garden website but you have been warned, so stick to proprietary fertilizers if you feel you need them! In addition there are other water-soluble nutrients from the soil called Secondary Macro-nutrients (calcium, magnesium & sulphur) and numerous micro-nutrients or "trace elements" which are talked about in the Wikipedia reference I provided. Optimal availability of the water-soluble minerals occurs in soils which are just on the acidic side of neutral (pH 6 to 6.5). The pH scale is commonly used to quantify how acid or alkaline a soil is and is explained succinctly in the following reference: https://en.wikipedia.org/wiki/Soil_pH.

Plant roots fulfil at least two vital functions – they stabilise it and provide conduits for transferring water and dissolved minerals from the soil to the plant. A well developed and healthy root system is clearly a pre-requisite for a good plant. The gardener traditionally would prepare a soil by digging in compost and manure before putting in a plant and would ensure that roots were "teased out" before planting in the case of pot-grown items. Then it was a case of watering in and invariably after some time, the plant would establish and grow away. This is thankfully still the case but nowadays a better understanding of how root systems develop can be used to help stack the odds for success even more in the gardener's favour especially when planting in less than ideal conditions such as under trees where soils can get very dry and nutrient-poor. In recent years the importance of symbiotic root- fungus relationships in the soil has been recognized. Whereas the physical length of plant roots themselves can be measured in terms of meters, effective extensions provided by fungi networking through the soil boost this by a factor of thousands if not more. In short, anything the gardener can do to boost the establishment of this underground symbiotic relationship will repay dividends above ground.

Mycorrhiza

The term given to the symbiotic relationship is "Mycorrhiza" and the nature of the fungal association can assume two basic forms. One which is common in species such as forest trees forms a sheath around the root from which threads or "hyphae"extend into the soil and these symbiotic couplings are called "Ectomycorrhizae". A more widespread fungal mechanism involves penetration of the root tissue by the fungus which in turn also sends hyphae into the soil; around 80% or more plant species accommodate these "Endo- or Arbuscular mycorrhizae". The Internet provides an extensive literature for more detailed reference on the topic. In general terms, fungi not only assist in actually feeding plants but also provide a degree of protection to roots from pathogenic soil fungi. Probably the first demonstration of the importance and power of mycorrhizae to the gardener was provided by David Austin who showed that the well-known problem of rose replant syndrome could often be avoided by treating roses with a mix including a range of suitable fungi – https://www.davidaustinroses.com/american/Advanced.asp?PageId=2153. In recent years, other commercial products have appeared such as "Rootgrow" and it is worth considering using the product when planting many shrubs, trees and plants

Enough said and let us now return to looking at how plants have adapted to cope with shade.