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The leaves of the sundews, *Drosera* subsp., trap insects to supplement their diet.

How plants work

Gail Summerfield

This series of articles is intended to open up that world and to start looking at plants from their point of view, rather than ours. It will look at the form of leaves, stems, roots and flowers, and relate this to their function. An understanding of how the plant works will give us much more chance of solving our gardening problems. The biological world is a complex system of interacting factors, so that solving a problem needs us to examine, evaluate, and then rule in or out any one of these factors in order to ascertain the most sensible and practical action to take.

As gardeners we love plants, collecting and arranging them to make a beautiful garden, but with a deeper knowledge about how plants grow and function we can push the boundaries much further. For many of us the mere mention of the word 'science' is enough to send us scuttling back to our comfort zone where we pull the shutters down and declare that this is not for us. However, in my experience, if we can peep into the world of botany we will find excitement and wonder. Knowing more about the plants we grow, and why and how they take the form they do, is like doing a jigsaw when one piece can transform the whole scene. If you ask any child what colour plants are, they will tell you 'green', and this is probably where we should start. The majority of our garden plants have green stems and leaves, the latter making up most of the surface area of the plant. As most gardeners will know, it is chlorophyll which accounts for the green colour, and the plant uses it to capture light-energy needed for the complex synthesis of sugars known as photosynthesis. Thus the greater the surface area of the leaves, the greater the plant's potential to produce the energy compounds which will support growth and reproduction. So it is in the plant's interest to have the biggest leaves it can, within the confines of its environment. Thus an alpine will have small leaves to cope with a windy and cold situation even though this reduces its capacity to photosynthesize, but often this will be counteracted by being evergreen, so maximizing the time available for sugar production.

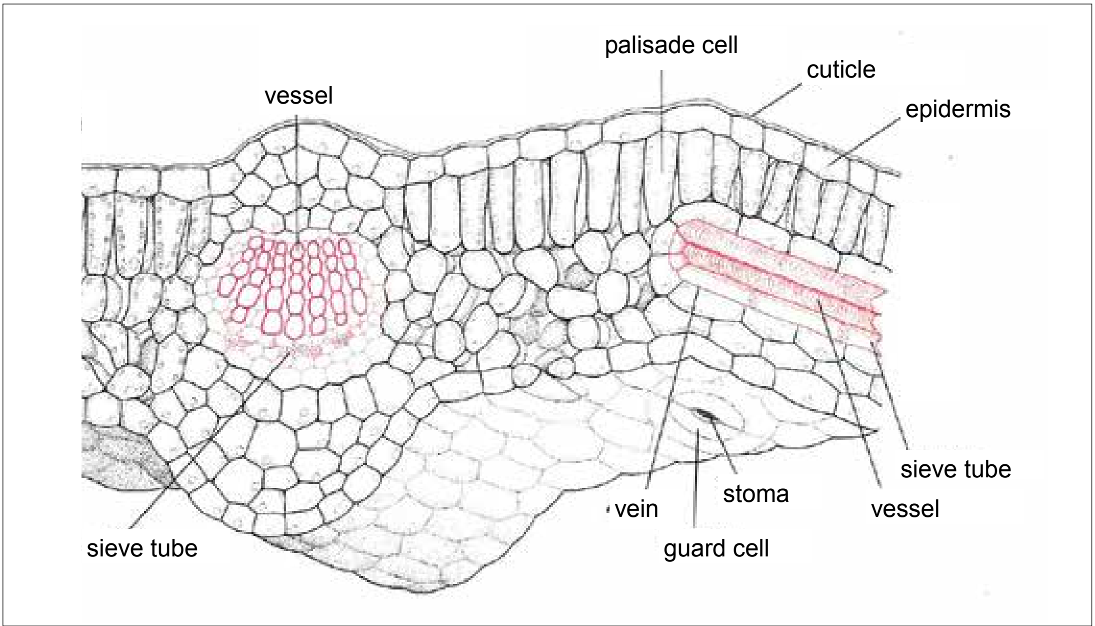

Fig. 1 Diagram of a transverse section of a leaf.

Neither can we expect to have vigorous growth from a plant whose leaves are predominated by areas where chlorophyll is sparse. In fact variegation is man made, and no plant in its right mind would relinquish the opportunity to maximize light-energy capture.

The shape and form of leaves is so diverse that we are able to use it as a means of identification. As botanists love to invent names for any and every bit of the plant there are a huge range of unmemorable terms for leaf shape, leaf tips and leaf bases. The glossary in *The Hillier Manual of Trees and Shrubs* may be helpful. The way leaves are arranged on the stem, phyllotaxy, can also help identification; for example, although the winter stems of *Cornus* and *Salix* look similar, it is easy to tell them apart by their phyllotaxy – the *Cornus* has leaves in opposite pairs whilst the Salix leaves are arranged alternately up the stem. If no leaves are present, then the arrangement of the buds will be the same, since buds occur in the axils of the leaves. Similarly the dimensions of a leaf may help identify a plant, but beware, the leaf size may vary depending on the time of year – winter pansies have much smaller leaves in the winter and the leaves expand dramatically in the early weeks of spring as days get longer.

If we look a little closer, Fig. 1 shows a transverse section of a typical leaf. On both the upper and lower surfaces there is a layer of brick-like cells, the epidermis, which basically acts like a box to contain the internal cells of the leaf. Overlying the upper epidermis in particular is the cuticle, an inert substance similar to the one that makes up our hair and nails. Its function is the protection of the cells in the leaf from excessive rain, heat and cold. Many of the evergreens we grow have waxy or shiny leaves making them resistant to freezing temperatures, while in plants such as *Camellia*, which thrives in areas of high rainfall, the cuticle protects the cells from waterlogging. Deciduous plants have no need for this level of protection as they simply discard their leaves in winter.

Fig. 2 Upper and lower sides of a primula leaf.

Chlorophyll needed to capture light-energy is present within the palisade cells in structures called chloroplasts. It makes sense for these cells to be near the upper surface of the leaf where there is maximum exposure to light and this proves to be the case. The number of layers of these brick-like cells varies depending on the amount of light the plant has access to in its native environment – plants which grow well in shade often have more than one row of palisade cells.

Photosynthesis combines water (H_2O) and carbon dioxide (CO_2) to make glucose ($C_6H_{12}O_6$) and produces oxygen (O_2) as a waste product. The layer of cells known as the spongy mesophyll is responsible for the exchange of oxygen and carbon dioxide into and out of the leaf. Access to the atmosphere is provided by specialist cells situated in the lower epidermis called stomata, which can open and close to allow the free exchange of gases. The mesophyll cells which surround the air spaces in the lower part of the leaf have a film of water around them. Water vapour escapes into these spaces and evaporates from the leaf through the open stomata. In most cases the stomata remain open during the day and close at night. So on a windy or warm day the speed at which water vapour leaves the leaf increases. Growing plants close together will reduce water loss as the shelter increases the humidity of the atmosphere outside the leaf and slows down the loss of water vapour through the stomata. Watering plants in the evening allows them to replenish the water lost during the day while the stomata are closed at night, hence a plant such as *Ligularia przewalskii* which can wilt during sunny days will regain its turgidity by the morning. The evaporation of water from the leaf produces a cooling effect when temperatures are high and protects the cells within the leaf. In one group of plants, members of families which live in areas of high daytime temperatures such as *Agave americana* (fig. 3), the stomata close in the day and open at night to conserve water.

In order for the leaves to carry out their functions, it is important that water can reach all the cells of the leaf and in turn the cells can export sugars to the rest of the plant. This is the function of the veins. Confronted with a leaf from a grass and one from a primula (fig. 2) most people would be able to identify two distinct forms of venation, which is reflected in the construction of the vascular bundles which make up the veins of the leaf, those of the grass being much simpler. Vascular bundles in plants with a network of veins like the primrose have a more complex construction than those in the grasses where the veins are parallel. The venation of the leaf is one of the key identifying features. In addition there are some plants which have adapted the internal structure of the vascular bundles to reflect a different pathway for the synthesis of sugars. The grass family, the *Poaceae*, is a good example of this, with genera being referred to as warm or cold season. The production of sugars in the warm-season grasses is much more efficient, resulting in large plants with a large photosynthetic capacity. Most sub-tropical grasses are warm season whilst the temperate ones are cold season. Propagation of the warm-season grasses should be carried out in May and June while cool-season grasses can be split at any time.

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Fig. 3 The stomata in the leaves of *Agave americana* 'Variegata' close in the day to conserve water.

The story doesn't stop there because plants have adjusted to their environment, resulting in some interesting adaptations. Water loss in plants from arid regions can be controlled by a dense mat of hairs which traps the water vapour within them, or in extreme cases the leaves have been reduced to spines leaving the swollen stems to carry our the photosynthetic work. Aquatic plants need less physical support but some form of buoyancy aid, which comes from very large air spaces in the tissues. In the pea family, competition for light has resulted in the replacement of some of the leaflets with tendrils, making it possible to climb. In insectivorous plants such as the sundew, *Drosera* subsp. (title image), which live in nutrient-deficient soils, the leaves have been adapted to enable the plant to supplement its nutrient requirements with the insects caught in leaf traps.

And so the story goes on – when, or if, we sit down with a cup of coffee in our garden, we will be surrounded by plants from around the world, all with their secrets, and it is our task as gardeners to interpret the clues that their form and structure give us.

Good luck and happy botanising!

Gail Summerfield is a botanist and former lecturer in horticulture. In 1985 she started Westshores Nurseries, which has specialised in ornamental grasses for the past 21 years.