Fig. 2a

©John Summerfield

Fig. 2b

©John Summerfield

How plants work part three – stems

Gail Summerfield

While pondering on the content of this article I realised that gardeners interfere more with the growth of the stem than with any other part of the plant. The creation of a permanent framework relies on our manipulation of the growth of the stem, while the majority of cuttings require the presence of stem tissue for success. I certainly get the most satisfaction from the tasks of propagation and pruning, both of which would be pretty tedious if I grew only herbaceous perennials.

An effective stem should be structurally capable of withstanding the stresses caused by wind, animals or temperature. It should also have an effective plumbing system to enable water and nutrients to reach all the aerial parts of the plant while at the same time transporting all round the plant the sugars synthesised in the leaves. In addition, the hormones which influence the behaviour of the plant must use the stem as a means of transport.

> If a gardener understands the internal anatomy of the stem at various times of year s/he will know when to take cuttings and what size they should be.

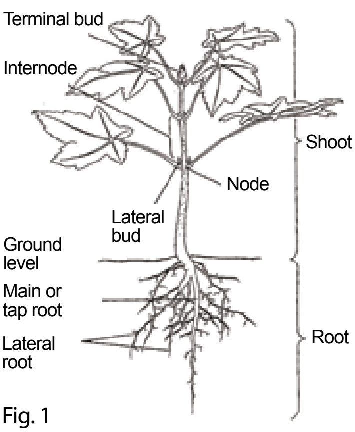

Fig. 1

©DG Mackean

Fig. 1 is a diagrammatic representation of the form of a 'typical' plant. The stem forms the main framework, with a series of leaves arising from it at the nodes. In the axil of each leaf there is a bud which can develop in the event of accidental or deliberate injury. The terminal bud sits at the apex of the stem; it is the source of the growth hormone auxin which influences the shape of the plant. When we pinch out the terminal bud the domination which it has over the lateral buds ceases as auxin is no longer present to inhibit growth, so the buds develop, elongating their stems and forming side shoots. This influence over the axillary buds depends on the type of plant and the distance the bud is from the source of auxin. To see this effect, compare the growth habit of *Pyrus salicifolia* 'Pendula' (fig. 2a) with that of the culinary pear (fig. 2b); our culinary pear trees show a strong apical dominance while the weeping pear shows virtually none, growing in all directions and sending out side shoots at any point on the stem.

Natural selection has resulted in a range of adaptations of the stem. Plants like *Primula* have stems with short internodes giving a rosette habit which keeps them close to the ground, away from wind and animal damage. On the other hand, climbers such as Clematis have stems with long internodes enabling them to climb up other plants and so maximise the light getting to their leaves. Most deciduous trees have the capacity to arrange their leaves in such a way as to make a complete canopy cover, providing each tree with an efficient light-capture system, necessary for photosynthesis.

Bulbous plants show a range of stem adaptations enabling them to remain in the soil in a dormant form. In true bulbs such as *Allium*, *Narcissus* and *Tulipa* (fig. 3), the stem has contracted to form a semi-spherical disc at the base (the basal plate), off which the leaves arise. When the bulb has flowered and the aerial leaves have died down, the remaining leaves are seen as fleshy leaf-bases, in the axils of which are buds. It is possible to take 'cuttings' of the bulb either by cutting it into wedges, each with a piece of stem and several leaf bases with the buds trapped between them, or by slicing off two leaf bases along with a portion of the stem. If you have left a cut onion in the fridge for a long time you will have seen the development of the axillary buds. The corms from which *Crocosmia*, *Crocus* or *Gladiolus* grow (fig. 4) consist largely of the swollen stem with the leaves represented by the papery outside casing. The buds are where these leaves come off the stem. Leaving a corm unplanted for a length of time will result in the development of a series of buds around the corm. In the case of the potato (fig. 5), the stem swells to produce a storage organ rich in carbohydrates, ready to sustain the fast-developing plant in spring. The 'eyes' are vestigial leaves with buds in their axils. The term 'seed' potatoes is a botanical misnomer.

In the environmental conditions in which cacti survive, their stems have become green water-storage organs with much-reduced leaves present as spines. Nevertheless, there will be a bud in the axil of each spine. The leaves of Butchers Broom (*Ruscus*) are actually adapted stems, known as cladodes, with the vestigial leaves and buds to be found on the surface of the 'leaf'.

You might ask what is the use of all this information? I would argue that a knowledge of the morphology of the plant reduces the likelihood of our making some fundamental mistakes. For example, pruning shrubs by light trimming of the shoots results in the development of buds close to the cut and the loss of structural form. Again, we often hear people say "I just broke off a bit and stuck it in the ground and it grew". Well, it may have done, but then a high proportion of some genera will not and, if they do, we get a miserable, straggly plant. Understanding the morphology of plants enables us to take strong, compact cuttings and have a well-shaped final specimen.

The growth of a plant from seed and its development into a mature plant can take from a matter of weeks, in the case of some ephemeral weeds such as hairy bittercress, to many years for an oak

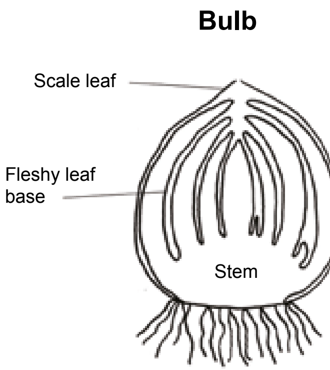

Fig. 3

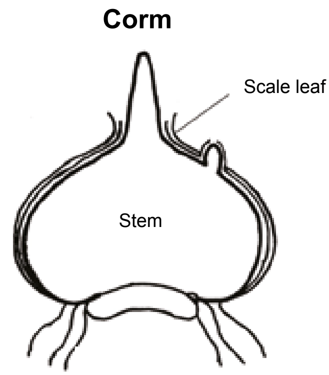

Fig. 4

tree. In every case, it is the stem which is crucial for the plant's survival. To reproduce, bittercress, with its delicate frost-sensitive stems, relies on producing copious quantities of seed which it scatters far and wide. In contrast, in our climate trees and shrubs live for many years and set seed annually; they depend on their ability to survive winter, making a framework from which they can develop in the spring, and should conditions be unsuitable for flowering they can sit tight and wait until the following season.

Flowering plants are divided into monocotyledons and dicotyledons. The majority of the plants we grow are dicots. Fig. 6 gives us a closer look at typical young stems in cross section, comparing dicotyledons and monocotyledons. Both have an outer epidermal layer, but the dicot has a distinct ring of vascular bundles whereas the monocot bundles are simpler and scattered throughout the packing tissue of the stem; they do not contain any actively dividing tissue and are said to be 'closed'. Both structures provide the young plant with the strength to support the rest of the plant, but the dicot has the added ability to join the vascular bundles into a ring of conductive tissue (fig. 7) which maintains the strength and increases the translocation capacity of the stem. In addition, the ring can be strengthened by the deposition of lignin in some of the cells, which protects the soft tissues from low winter temperatures. This process is known as secondary thickening and it limits the type of cuttings we can take and the time when we should take them.

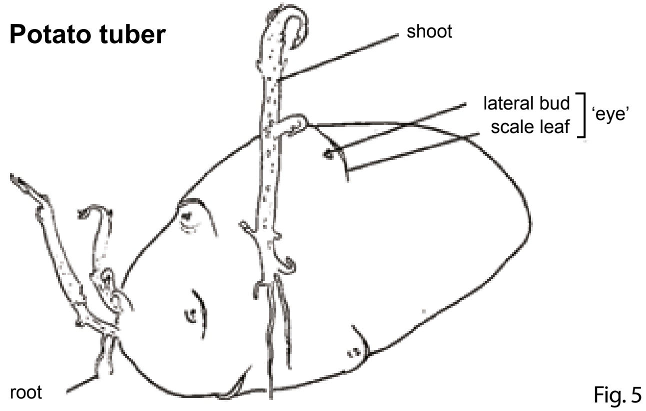

Fig. 5

Further examination of the dicotyledon vascular bundle (fig. 8) shows an outside protective layer of sclerenchyma cells strengthened with lignin, inside which is the phloem which transports the sugars. The innermost tissue is xylem, through which water and mineral nutrients are conducted. Plant hormones are thought to travel in the packing tissue (parenchyma) which is adjacent to the vascular ring. Sandwiched between the phloem and xylem is the cambium – a narrow layer of brick-like cells which are continuously dividing. Such cells are undifferentiated, but when a cutting is taken they have the capacity to develop into all the tissues necessary to make a new root. When we take a cutting, we do so by making a cut just below the node where there will be a concentration of growth hormones. As a tree matures, a ring of cells outside the vascular tissue begins to divide to produce cells which will eventually form the bark of the tree. Damage by animals or over-zealous strimmers to the outside layers of the stem will impair growth and may result in death.

A little bottom heat in a propagator will increase the speed of division and speed up rooting in cuttings. Plant hormones auxin and cytokinin influence rooting of all cuttings. They are produced in response to "wounding" when a cutting is taken. Commercial hormone rooting powder contains chemically produced versions of these compounds; there's really no need to use it though it does speed up the process in subjects which are shy to root.

Evolution in specific environmental conditions has led to anatomical adaptations

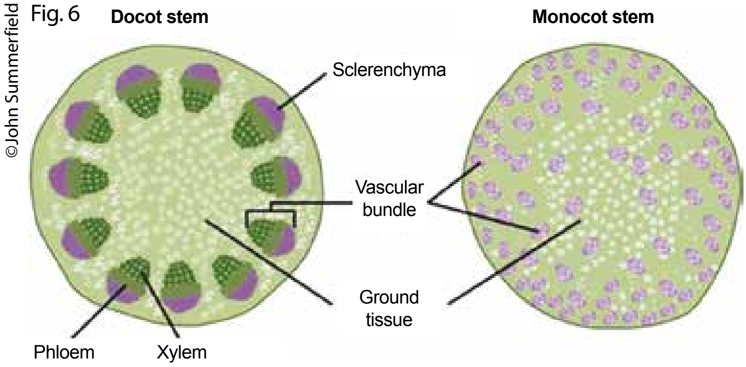

Fig. 6

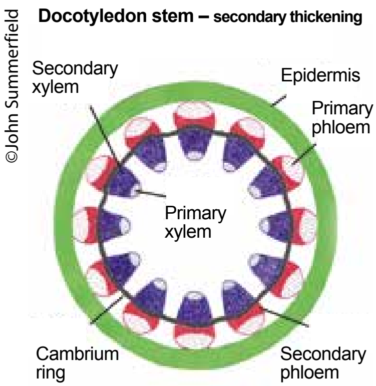

Fig. 7

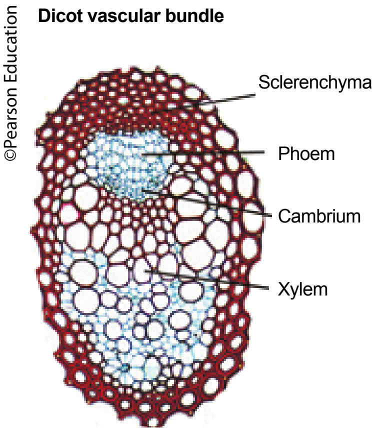

Fig. 8

of stems: for example, water plants incorporate large air spaces to give greater buoyancy whereas grass stems have a high silica content allowing them to grow tall and stand well throughout the year.

Knowledge of plant physiology is most useful when we want to take cuttings. It's generally best to take softwood cuttings of herbaceous and woody plants when new growth appears in spring and early summer. Our level of success will depend on the genus of plant, but softwood cuttings of shrubs such as *Forsythia*, *Weigela* and *Sambucus* and herbaceous plants such as *Symphyotrichum*, *Heleniums* or *Heuchera* are very quick to root. I find that taking basal stem cuttings is an effective way of increasing my stock without having to remove the whole plant from the soil, a task which becomes more onerous with each passing year. Rooting is quick, 4 to 6 weeks, and I have good strong plants by high summer.

As the season progresses, the vascular bundles of dicotyledons join up into a ring with strengthened tissue on the outside, so that the stems resist being gently pushed by a finger. The cuttings we take at this time will be semi-ripe. Take cuttings of deciduous shrubs in July/August, so that the leaves can provide sustenance for the developing roots, but leave evergreen shrubs until September/October. Once winter sets in, the secondary thickening process will be complete and the stems will lack any flexibility; cuttings taken at this stage are hardwood, they need to be much longer (15–20cms), and they can take three months to root. *Buddleja*, *Ribes* and *Rosa* are suitable subjects. For the more difficult subjects the use of rooting powder is recommended.

In conclusion, I would urge every gardener to pay attention to the morphology and anatomy of the stem before undertaking invasive surgery – to 'think plant'. It will make you a more successful gardener and will allow you to grow a wider range of plants in your garden conditions.

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 22 years.