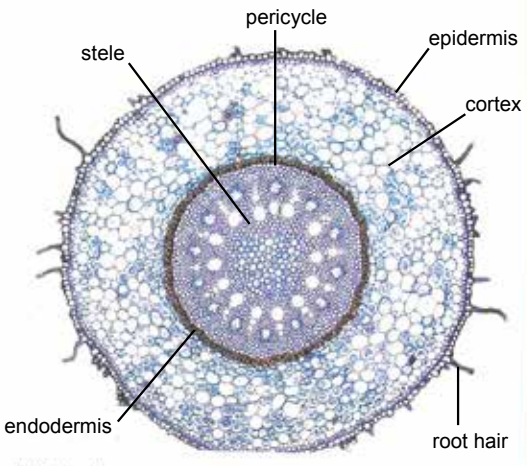

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Fig. 1 Transverse section through a root

How plants work part two – roots

Gail Summerfield

"The answer lies in the soil' is what Kenneth Williams used to say, but many an amusing remark contains solid common sense. In our gardens, the soil is the key to the problems we encounter with the majority of plants we grow. Plants need to have the maximum contact with the medium in which they are growing, and it is their roots which make this connection.

The main functions of the roots are absorbing water and nutrients, providing anchorage, and supporting the aerial parts of the plant. Fig. 1 shows how the internal structure of the root provides these functions. A slice of carrot shows its structure quite well (fig. 2). As the soil will support the growing roots there is less need for a skeletal network with strengthening tissue. So the cells which conduct the water and nutrients are situated in a central stele surrounded by a cortex of packing cells, enclosed by a single layer of epidermal cells, some of which have developed into root hairs. Such a system gives flexibility to the root when it is penetrating the soil. In addition the root has a cap of cells which protect the growing tip of actively dividing cells as the root forces its way through the soil. Also visible is a 'necklace' of strengthened cells known as the endodermis which acts as a control mechanism in the process of water uptake. Just inside the endodermis is a layer of cells, the pericycle, from which the secondary roots arise. This means that the young root is well developed before it emerges into the soil.

As gardeners we often take our soil for granted because most ornamental plants will survive in the 'average' garden soil. Unfortunately we also take this view in respect of the growing media we buy, being tempted by the three-for-a-tenner offers. Very few of us really know what kind of soil we have, let alone understand the properties of such a soil. If you are unsure there is a useful Cranfield University website which will give you this information if you live in England or Wales[1].

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Fig. 2 Transverse section of a carrot root

[1]Google LandIS – click on 'MAPPING' – under Soilscapes click ' Launch Soilscapes' – accept the terms and conditions – click ' Search' – enter your postcode – click 'View soil information' on the map. As you move the cursor over the map soil information will appear in the right-hand column.

Fig. 3 Root hairs

Fig. 4 Mycorrhiza

For a plant, the soil is an essential source of water and nutrients without which it is unable to complete its life cycle, and its root provides the means to absorb these nutrients. Before these chemicals can enter the root they must be in small enough chunks to get through the cell walls, which is made possible by their being dissolved in water and present as tiny charged particles or ions. The greater the surface area in contact with the soil water the greater the chance of effective mineral uptake. Behind the root tip is an area of specialized cells, the root hairs (fig 3), which are single cells with fingers stretching out into the soil amongst the soil particles. You may remember at primary school growing a runner bean on blotting paper, and a little way back from the root tip there was an area of fluff – the root hair region. Transplanting will inevitably damage these hairs making the plant less able to absorb water and nutrients, so that applying an abundance of water (watering in), will reduce the plant's stress and aid a complete recovery. Any action we can take, such as growing plants in modules so that the roots are intact when moved, will be beneficial. When transplanting bare-rooted seedlings, holding the plant by the leaves will help to avoid any further damage.

Most of us know when a plant is unhappy, but working out why is much more difficult. To a large extent this is educated guesswork as there are so many variables; in fact for most of us carrying out controlled experiments would be a lifetime's work. There are, however, some basic principles to consider. First, a deficiency of an essential nutrient may be caused by a change in the acidity of the soil which 'locks up' the nutrient in an insoluble form. This is the case with iron, and an application of an available form of iron (sequestrene), will solve the problem. If you have clay soil, there is also the possibility of a reduction in available nutrients caused by competition from other ions (ion antagonism), so a balanced fertilizer should be applied. Second, the soil or media may be waterlogged, so that spaces which should contain air are filled with water, thus suffocating the plants. The process whereby the roots take in nutrients needs energy, which is released when sugars are broken down in oxygen-rich or aerobic conditions. So we should always ensure that oxygen is present in the soil by improving the drainage with grit, perlite or bulky organic matter.

In containers the problem is often misdiagnosed: a plant wilting through lack of oxygen is thought to need more water rather than less, and then by watering we exacerbate the problem. Third, for the plant to obtain a good supply of nutrients they have to be in soluble form. In free-draining, light soils this means that any application of water will leach out the nutrients such as calcium very quickly. Hence these soils need feeding regularly. Clay soils have a much greater capacity to hang on to the nutrients and some proprietary brands of media incorporate clay granules in the mix.

Many plants benefit from mycorrhiza, a relationship between the roots (rhiza) and a fungus (myco). Mycorrhiza may just be on the outside of the root (fig. 4), or in some cases like orchids, between the root cells. In every case they increase the surface area available for the absorption of water and nutrients, and in return the fungus receives sugars from the plant. The presence of mycorrhiza has been found to be widespread in a range of plants. However in plants grown in sterile media, mycorrhiza are absent; this may be the case with the mass-produced plants sold in the garden centres. To rectify this problem a product called Rootgrow, which contains the fungus necessary to form mycorrhiza with the plant, can be applied to the growing medium. Although it's expensive, and not really an option for general use in the garden, it can be very useful when growing plants in pots where it increases the speed of root development. When transplanting trees and shrubs we are advised to transfer them with a good root ball. The reasons for this are threefold: less risk of damage to the roots, less need for watering after transplanting and a greater chance of having the right mycorrhizal association for the plant.

When a seed germinates the first thing to emerge is the radicle, the primary root, which will provide the plant with the water and nutrients it needs to develop further. In fact some plants such as peonies take two seasons to be seen emerging from the pot: the radicle appears in the first season and the plumule (the shoot), in the next. Most of us are very impatient with our seeds, expecting them to germinate within a few weeks of sowing. So I expect, like me, you have discarded the compost from your seed trays feeling you have failed miserably, only to find a carpet of seedlings in amongst your other plants or on the edge of the compost heap!

The other reason for the emergence of the root is to anchor the plant in the soil. How much and what type of root system will develop depends on soil type, the availability of nutrients and environmental conditions. Patience is a virtue many

Fig. 5 *Iris germanica*

gardeners struggle to possess, particularly when it comes to trees, and we are tempted to buy the large specimen to get an instant effect. A standard tree which is container grown will have an established root system which has been fed on a regular basis, so it has no need to go searching for water and nutrients, neither is it used to the prevailing winds rocking it to and fro. So really, if we can, we should plant younger, field-grown specimens when they are dormant; they can then develop their own roots to cope with the conditions in which we put them in. Reducing the top growth of the tree with judicious pruning will reduce the

Fig. 6 Dandelion root

stress it suffers trying to get water and nutrients to the developing buds. If you need to support the tree the stakes should be on the side of the prevailing wind; short, angled stakes are now preferred as they allow the plant to move, encouraging the development of a strong anchoring root system. Some plants which grow in unstable media develop an extra system of anchorage in the form of prop roots, whilst bulbous plants such as *Iris germanica* (fig. 5) and C*rocus* spp. have special contractile roots which pull them down into the soil.

In the survival of the fittest, those plants which adapt most successfully to their environment will thrive and flourish. Many herbaceous plants overwinter in a dormant form from which they can awaken when conditions become more opportune for active growth. Herbaceous plants often use their roots to store sugars in preparation for the return to growth in spring. For example, this will take the form of swollen tap roots, in the case of carrots and parsnips, or as tubers in dahlias. As carrot and parsnips are biennials, the plants can devote their energy reserves in year one to produce vegetative growth including an effective storage organ, whilst using these food reserves to produce flowers and seeds in year two. Root tubers are usually a means by which the plant can survive in a dormant form, well down in the soil out of reach of freezing conditions. There are always exceptions, so plants like *Symphytum*, *Acanthus* and our friend the dandelion (fig. 6) have thick tap roots and cunningly wait for spring to show their faces.

Although there are only a few plants such as *Eryngium*, *Phlox* and *Primula* where we are advised to take root cuttings, all plants exhibit totipotency – the capacity to regenerate from any vegetative part of the plant. This is controlled by the redistribution of hormones, and the balance between them which stimulates either the production of roots or shoots. If a plant you buy has multiple shoots arising from the base it is likely it will have been produced by micropropagation, so treat it with extra care as it has spent most of its life in a very protected environment.

Unfortunately no discussion about how plants work can be either definitive or comprehensive, and when the topic under examination is hidden away under the soil there must be many unanswered questions. As gardeners we should always be asking these questions, and challenging some of the statements made in the gardening press. Give me a practical gardener any time, although I often feel I may score fairly low in this respect!

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.