14.7

OBJECTIVES

By the end of this spread you should be able to:

- discuss the advantages and disadvantages of vegetative propagation
- describe the main types of vegetative propagation
- explain the significance of perennating organs.

Fact of life

Most grasses propagate asexually by sprouting shoots and roots from underground runners. A small patch of grass can spread in this way to cover an acre or more.

Seeds without sex

Sexual reproduction in flowering plants produces seeds, but seeds can also be produced asexually. Some plants, such as many common species of dandelion (*Taraxacum* spp.), produce seeds without fertilisation. This type of reproduction is known as **apomixis**. It can occur in many ways but always results in offspring genetically identical with the parent. In dandelions, the bright yellow flowers attract insect pollinators, but the pollination is only a trigger for seed formation; it does not lead to fertilisation.

Apomixis ensures that a parent plant that is well adapted to a specific environment produces equally well adapted offspring. Only asexual reproduction can do this; sexual reproduction reshuffles genes. Dormancy and seed dispersal enable apomictic daughter plants to leave the specific habitat of the parent plant. Therefore, as long as there are similar habitats elsewhere, apomictic daughter plants have a good chance of surviving even if the parent's habitat is destroyed.

Vegetative propagation

The role of asexual reproduction

Sexual reproduction provides the genetic variety that plants need in order to adapt to ever-changing environments. But this variety comes at a high price. Parent plants must invest a lot of energy in pollen and seeds but very little chance of producing large numbers of viable offspring. Asexual reproduction is much less costly and gives a much better rate of return. It usually produces many offspring that are genetically identical with the parent, but this is no disadvantage if the offspring can find a habitat which is similar to the parent's. In fact, only asexual reproduction ensures that a plant that is well adapted to a specific environment will pass on its genetic secrets of success to the next generation.

The lack of variation associated with asexual reproduction may be a disadvantage to long-term survival in a changing world. Most flowering plants which, in evolutionary terms, have been around for a long time, adopt a mixed reproductive strategy: they use sexual reproduction, which produces variety, as well as asexual reproduction, which is more efficient.

Fragmentation and regeneration

Vegetative propagation is the most common form of asexual reproduction in flowering plants. It generally involves **fragmentation**, the separation of parts of the parent plant, and **regeneration** of those parts into new individuals. It is such a commonplace event that we tend to take it for granted. However, if a similar process happened in a person it would make headline news throughout the world (imagine the sensation created by a headline such as 'Child grows from man's finger!').

Vegetative propagation is not usually a haphazard process relying on accidental detachment of a plant part. It usually involves the development of highly specialised structures which bear little resemblance to the parent organ from which they developed. As table 1 shows, almost any plant organ may be adapted to vegetative propagation.

Perennation

In many seasonal plants, the organ involved in vegetative propagation is also used as a **perennating organ**; that is, an organ that enables the plant to survive the harsh conditions of winter. In temperate regions, the aerial parts of most **herbaceous perennials** (non-woody plants which live for several years) die back in the autumn. Their perennating organs, often swollen with food stores built up in the previous growing season, lie buried under a blanket of soil, protected from the worst of the winter cold. Perennating organs often fragment to produce the new generation in the following year. The food store enables the offspring to grow quickly as soon as light and temperature conditions become favourable. This is especially important for small woodland plants, such as bluebells, which must grow and flower before trees come into leaf and plunge them into shade.

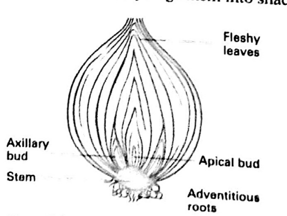

Figure 1 Longitudinal section of an onion bulb.

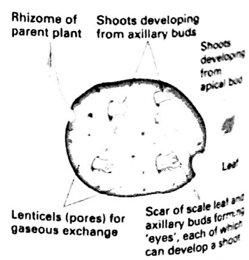

Figure 2 Well developed potato tuber

*Table 1 Organs of vegetative propagation. An asterisk (*) shows organs that may also be used for perennation. The table refers to **axillary buds** and **apical buds** from which new plants may develop. An axillary bud occurs in the axil of a leaf, that is, the angle between the upper side of a leaf and the stem. An apical bud occurs at the tip of a shoot.*

Vegetative structure	Example	Description	Comments on mechanism of vegetative propagation
Bulb* (figure 1)	Daffodil (*Narcissus*) Onion (*Allium*) Tulip (*Tulipa*)	Short stem with underground fleshy leaves	Each apical bud and axillary bud can develop into a new plant.
Corm*	*Crocus* *Gladiolus*	Enlarged, swollen, and usually rounded base of stem; covered externally with thin scales or leaves	Axillary buds may develop into new plants.
Offset	Water hyacinth (*Eichhornia*)	Short thickened horizontal branch of stem with tuft of leaves at apex and small roots below	Similar to runner, but shorter and stouter. Often breaks away from parent to form new daughter plant.
Rhizome*	*Iris*, mint (*Mentha*), couch grass (*Agropyron repens*)	Thick horizontal stem usually growing underground	Sends out shoots above and roots below to give rise to new plants.
Runner	Strawberry (*Fragaria*) and creeping buttercup (*Ranunculus repens*)	Thin lateral stem on the soil surface	A number of stems usually radiate from the parent plant. New plants develop along the runner where it puts down adventitious roots. Runner decays when the daughter plant becomes established.
Stolon	Blackberry (*Rubus*)	Slender stem	Stem grows diagonally upwards then bends to the ground, putting roots out at the tip and producing a bud which grows into a daughter plant.
Sucker	*Chrysanthemum* Raspberry (*Rubus idaeus*)	Branch of a stem	Initially grows underground then emerges to form a new plant, at first nourished by the parent plant.
Tiller	Grasses	Side shoot arising at ground level	Tillers normally remain connected to form a plant that can cover a very wide area. Occasionally tillers become detached and give rise to new individuals.
Tuber* (stem) (figure 2)	Potato (*Solanum tuberosum*)	Swollen stem	A single parent plant may produce many tubers. Each tuber may have several axillary buds, each of which can develop into a new plant, enabling very rapid asexual reproduction.
Tuber* (root)	*Dahlia*	Swollen fibrous root	New plants develop from axillary buds at the base of the old stem.

QUICK CHECK

1 Give one advantage and one disadvantage of vegetative propagation.

2 Distinguish between:

a a bulb and a corm

b a stolon and a runner

c a stem tuber and a rhizome.

3 Explain why perennating organs are particularly advantageous to small flowering plants such as bluebells that live in temperate woodlands.

Food for thought

Despite the disadvantages of asexual reproduction, some plants adopt it as their only means of reproduction. Although the offspring usually inhabit the same type of environment as the parent plant, some asexually reproducing species adapt to a changing environment. Suggest how they might do this.

14.3

OBJECTIVES

By the end of this spread you should be able to:

- describe how cuttings can be made
- explain how plants can be reproduced by micropropagation

Fact of life

In the 1870s the European stock of vines was nearly completely destroyed by the introduction of a root eating pest, *Phylloxera vastatrix*. Disaster was averted when it was discovered that the roots of North American vines resist attack (the pest was introduced from the USA). Nearly every European vine had to be pulled up and grafted onto a rooted cutting of an American vine. Every European vine is now grafted onto American roots. Traditional grafting involved knife-work and binding up; a new technique uses a stamping machine to cut a mortice and tenon in the scion and stock which lock together to form a new plant (figure 2).

Figure 1 Taking cuttings: a traditional method of vegetative propagation. A stem of busy lizzie (Impatiens sp.) was cut and placed in water for a week or two, and roots formed from the cut end, resulting in a new plant.

Commercial applications of vegetative propagation

Selective breeding and vegetative propagation

The cabbages, cauliflower, kale, Brussels sprouts, and broccoli that grace a greengrocer's stall all originated from a single species of wild mustard. Early varieties of these vegetables were produced by farmers selecting and breeding together plants with specific characteristics: for example, large fleshy flower clusters for cauliflowers, a large terminal bud for cabbages, and leaves for kale. Traditional forms of this **selective breeding** are usually slow and costly.

Once a plant with the desired characteristics has been bred, commercial growers usually use vegetative propagation (spread 14.7) to produce more of the same. Maintaining the same characteristics through seed production often involves a complex genetic breeding programme which needs to be managed carefully for each generation. In contrast, vegetative propagation ensures that the desirable qualities of a plant will be maintained from one generation to the next with little effort on the part of the grower. Barring a few mutations, this form of reproduction produces **clones**, plants genetically identical with each other and their parent. Vegetative propagation has other advantages to the commercial plant grower. It allows plants to be produced quickly, in very large numbers, and with the minimum expense and effort. It also allows the grower to produce offspring from sterile **hybrids** formed from a cross between two different species. Many commercial flowers, trees, and shrubs are sterile: they may be very healthy, but the only way of propagating new plants from them is vegetatively.

Cuttings and grafts

One of the most commonly used methods of vegetative propagation is taking a **cutting** (figure 1). A small piece of a healthy plant is removed and kept in water or compost until roots grow. Sometimes a **plant growth substance** (an auxin) is added to speed up root development. When the roots emerge, the plant is grown in soil in the normal way. The cutting may be a leaf, a healthy young twig, or a stem tip.

Grafting (figure 2) is a similar technique but in this case the cutting (a young twig or shoot referred to as the **scion**) is inserted into a branch or stem of another plant (referred to as the **stock**). Two plants are often bound together with tape or raffia to help them join together, and the joint is covered with wax to prevent evaporation and infection. Grafting is common in gardening and commercial growing, and is the mainstay of the wine industry in many regions of the world. The only way of producing certain vines is by grafting a scion chosen for its grape production onto a stock chosen for its efficient root system and its resistance to disease. The quality of the vine is determined by the genetic make-up of the scion and is not diminished by grafting.

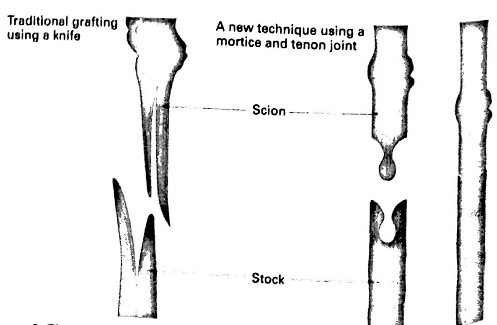

Figure 2 The methods of grafting.

Micropropagation

Micropropagation (sometimes called tissue culture propagation or cloning) refers to test-tube methods of culturing whole plants asexually from very small pieces of tissue (called **explants**) cut from the parent (figure 3).

It was realised at the start of the twentieth century that each non-reproducing body cell (**somatic cell**) of a plant has the potential to form a whole plant (a phenomenon called **totipotency**). However, the conditions that allow the cell to fulfil this potential were not discovered until the 1950s. These conditions are:

- a source of energy
- water
- a suitable nutrient medium, including mineral salts, vitamins, and growth regulators (spread 14.10)
- a suitable temperature (usually 15–30 °C)
- suitable light levels
- sterile conditions, which must be maintained until an independent plant is formed in order to exclude microorganisms that would find the culture medium an ideal place in which to grow.

The cultured cells divide by mitosis to form a **callus** (a hard mass of undifferentiated cells). By altering the balance of the growth regulators, cells in the callus can be made to differentiate into roots and shoots. The plantlet which develops is grown in another medium, usually agar based, to support the growing shoots, and then transferred to soil. The plants are grown in greenhouses under special environmental conditions until they are sufficiently robust for the market.

Some plants develop a well defined embryo-like structure during micropropagation. This structure is called a **somatic embryo** to distinguish it from the embryo in a seed. Somatic embryos have been encapsulated with nutrients in a polysaccharide gel to make artificial seeds.

By micropropagation, a single plant can produce thousands of clones, all genetically identical with each other and the parent plant. The commercial applications of micropropagation are already great: it is a viable alternative to conventional vegetative propagation for many plants. It allows enormous numbers of plants to be produced in a small space at a time convenient to the grower. It is an especially useful technique for propagating rare plants which cannot be propagated by traditional methods.

When combined with genetic engineering (spread 18.9), the potential uses of micropropagation are almost mind-boggling. However, micropropagation tempts growers to create **monocultures** (large areas of land with a single plant variety), giving an increased susceptibility to diseases and pests which can be transmitted rapidly from one plant to another. Also, some scientists fear that long-term micropropagation may result in genetically unstable plants, or in plants that are usually fertile becoming sterile. In the 1970s, micropropagated oil palms introduced into Malaysia turned out to be sterile. Although this particular problem has now been resolved, it is a warning that, in the future, we must use micropropagation with care.

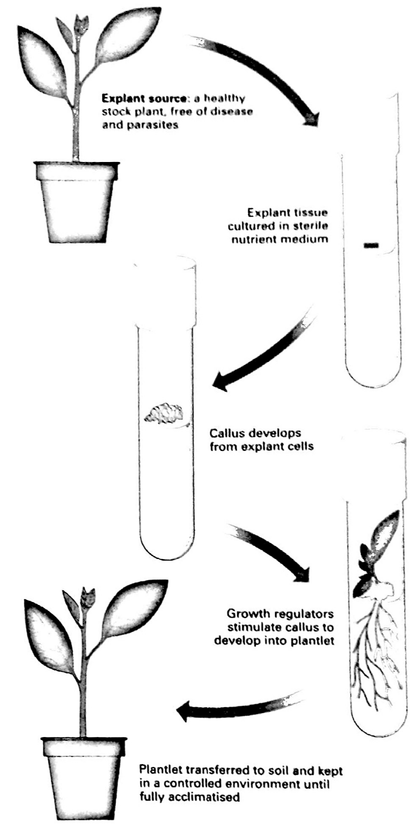

Figure 3 An outline of micropropagation. The conditions vary for each type of explant propagated. The culture medium and environmental conditions are usually changed several times during the process. Extreme care is taken at all times to keep things sterile.

QUICK CHECK

1 Give three advantages to agriculturists and horticulturists of propagating plants asexually.

2 What is a cutting?

3 What is totipotency, and why is it important for micropropagation?

Food for thought

Most crops are grown in monocultures: large areas of land with a single plant variety. Discuss the advantages and disadvantages of this form of agriculture. Suggest how the advantages could be maximised and the disadvantages reduced.