ASEXUAL PROPAGATION

Additional Techniques

Elizabeth L. King
Asexual Propagation

Additional Techniques

Compiled and written by:

Copyright and Terms of Use

© Department of Training and Workforce Development 2016 (unless indicated otherwise, for example ‘Excluded Material’).

The copyright material published in this product is subject to the Copyright Act 1968 (Cth), and is owned by the Department of Training and Workforce Development or, where indicated, by a party other than the Department of Training and Workforce Development. The Department of Training and Workforce Development supports and encourages use of its material for all legitimate purposes.

Copyright material available on this website is licensed under a Creative Commons Attribution 4.0 (CC BY 4.0) license unless indicated otherwise (Excluded Material).

Except in relation to Excluded Material this license allows you to:

- Share — copy and redistribute the material in any medium or format
- Adapt — remix, transform, and build upon the material for any purpose, even commercially

provided you attribute the Department of Training and Workforce Development as the source of the copyright material. The Department of Training and Workforce Development requests attribution as: © Department of Training and Workforce Development (year of publication).

Excluded Material not available under a Creative Commons license:

1. The Department of Training and Workforce Development logo, other logos and trademark protected material; and
2. Material owned by third parties that has been reproduced with permission.

Permission will need to be obtained from third parties to re-use their material.

Excluded Material may not be licensed under a CC BY license and can only be used in accordance with the specific terms of use attached to that material or where permitted by the Copyright Act 1968 (Cth). If you want to use such material in a manner that is not covered by those specific terms of use, you must request permission from the copyright owner of the material.

If you have any questions regarding use of material available in this product, please contact the Department of Training and Workforce Development.

Training Sector Services
Telephone: 08 6212 9789
Email: sectorcapability.ip@dtwd.wa.gov.au
Website: www.dtwd.wa.gov.au
ACKNOWLEDGEMENTS

The author wishes to acknowledge the contribution made to this text by Mrs Christine Cooper, A/Senior Lecturer, Department of Horticulture, South Metropolitan College of TAFE, Murdoch Campus; Mr Lance Dungate, Lecturer in Horticulture, South Metropolitan College of TAFE, Murdoch Campus, who read the draft; Mr Peter Coppin, Department of Agriculture Stoneville Fruit Research Station for his assistance with Chapter 9 and Mrs Veronica Winterbourne and staff of Huntingdale Plant Production for their assistance with Chapter 10.

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system or transmitted in any form or by any means, electronic, mechanical, photocopying, recording or otherwise, without the prior written permission of Training Publications.

Whilst every effort has been made to ensure the accuracy of the information contained in this publication, no guarantee can be given that all errors and omissions have been excluded. No responsibility for loss occasioned to any person acting or refraining from action as a result of the material in this publication can be accepted by Training Publications.

Published by and available from

Training Publications of Western Australia

Prospect Place West Perth WA 6005
TELEPHONE: (08) 9227 3360  FAX: (08) 9227 3298
EMAIL: TPWA@prospectpl.training.wa.gov.au
Contents

INTRODUCTION

CHAPTER ONE  ASEXUAL PROPAGATION

1.1 Asexual Propagation
1.2 Natural Structures
1.3 Artificial Asexual Propagation

CHAPTER TWO  HYGIENE

2.1 Hygiene

CHAPTER THREE  SELECTION OF PLANT MATERIAL

3.1 Plant Selection

CHAPTER FOUR  HARDWOOD CUTTINGS

4.1 Hardwood Cuttings
4.2 Advantages
4.3 Disadvantages
4.4 Commercial Uses
4.5 Recognising Suitable Material
4.6 Callusing
4.7 Procedure
4.8 Evergreen Material
4.9 Conifers
CHAPTER FIVE | ROOT CUTTINGS

5.1 Root Cuttings
5.2 Advantages
5.3 Disadvantages
5.4 Commercial Uses
5.5 Recognising Suitable Material
5.6 Procedure

CHAPTER SIX | LEAF CUTTINGS

6.1 Leaf Cuttings
6.2 Advantages
6.3 Disadvantages
6.4 Commercial Uses
6.5 Recognising Suitable Material
6.6 Procedures

CHAPTER SEVEN | LAYERING

7.1 Layering
7.2 Advantages
7.3 Disadvantages
7.4 Commercial Uses
7.5 Recognising Suitable Material
7.6 Procedures for Ground Layering
7.7 Aerial Layering

CHAPTER EIGHT | SEPARATION AND DIVISION

8.1 Separation and Division
8.2 Advantages
8.3 Disadvantages
8.4 Commercial Uses
8.5 Recognising Suitable Material
8.6 Timing
8.7 Procedures for Division
8.8 Procedures for Separation
CHAPTER NINE  BUDDING AND GRAFTING

9.1  Budding and Grafting
9.2  Advantages
9.3  Disadvantages
9.4  Commercial Uses
9.5  Compatibility
9.6  Timing
9.7  Grafting Techniques
9.8  Budding Techniques

CHAPTER TEN  MICRO-PROPAGATION

10.1  Micro-propagation
10.2  Advantages
10.3  Disadvantages
10.4  Commercial Uses
10.5  Deflasking and Transplanting Plantlets
10.6  Procedure
Introduction

This book has been written as the sequel to Introduction to Propagating Seeds and Cuttings.

It is primarily intended as the additional text for the second of the two propagation subjects for horticulture students doing the Certificate of Horticultural Practice with TAFE in Western Australia. However, other providers of allied courses and users such as home gardeners are reminded that two books should be used together.

Topics that are common to all aspects of propagation, including hygiene, plant selection, containers, growing media, record keeping and the care of stock plants are covered in detail in the first book but are only mentioned in book two when relevant.

Introduction to Propagating Seeds and Cuttings covers:

- the general procedures and requirements for successful commercial sexual and asexual propagation
- seeds and seedlings
- softwood and semi-hardwood cuttings.

Asexual Propagation covers a wide variety of additional asexual techniques used by horticulturists. As with the other book, the procedures given are those generally accepted by horticulturists. It should be remembered that many propagation nurseries are highly specialised and develop some of their own procedures for certain aspects of propagation. Very few propagators are likely to use all these methods in their work but the texts cover most common procedures.
Chapter One

Asexual Propagation

1.1 ASEXUAL PROPAGATION

Many plants have evolved to be able to reproduce by vegetative or asexual means as well as by seeds. Since the time of the earliest cultivators, gardeners and farmers have known that pieces of some plant material cut off and put into the soil could grow into a new plant. Techniques were refined by gardeners and many plants were found to be relatively easy to propagate asexually. In the latter half of this century, propagation of plants in very large numbers by asexual means has become a very precise scientific procedure, especially for the many plants which are not easy to propagate in commercial quantities by these methods.

Natural Asexual Reproduction:

During their life cycle, many plants develop a number of structures which reproduce the plant vegetatively and can be used by horticulturists as well. These structures are generally developed to:

- Spread the plant outwards from an ageing central area where old tissue and depleted soil do not allow for such vigorous growth as around the margins. Many herbaceous perennials spread out with structures such as rhizomes, runners, stolons, layers, offsets and clumps. In the dormant season induced by extremes of climate, vegetative growth may disappear or be no more than just a few leaves near the surface.
• Store food reserves during adverse seasons. These structures include bulbs, corms, tubers and thickened rhizomes. Some plants developed these structures to survive very cold winters when growth is not possible. Others developed similar structures to survive hot, dry summers when growth would not survive water stress. Above-ground vegetative growth dies back completely in many of these plants during the dormant phase.

1.2 NATURAL STRUCTURES

When the plant grows from a seedling, these vegetative structures develop as the plant reaches maturity, and mature as the plant completes its life cycle towards dormancy. These include rhizomes, runners, stolons, bulbs, tubers and corms. Some examples of these structures are discussed in detail:

Bulbs - Onions, Daffodils, Dutch Iris

When the plant grows from a seedling, most of the carbohydrate is used to produce energy to develop the bulb. The plant will not flower until the bulb has reached its mature size, which may take two or three seasons.

After flowering, the carbohydrates produced in the leaves by photosynthesis are concentrated in the storage structure of enlarged leaf bases; that is, the bulb, and by the time the above-ground part of the leaves dies down, the bulb has sufficient food stored to survive and produce a flower the following season. A large bulb then produces offset bulblets from the axillary buds in its stem base. As these grow larger, they can be used for asexual propagation. (Refer. 9.8)

![Diagram of a bulb showing dry and scaly leaf bases, fleshy leaf bases, next year's terminal bud, axillary bud, stem, bulb, and shrivelled roots.]

Fig. 1.1 Asexual Reproduction in a Bulb
Corms - Gladiolus, Freesia, Guildford Grass

A corm is similar in that the storage structure has to develop before flowers can be produced. However, a corm is a storage stem. Each year, a new corm develops on the top of the old corm as the plant reaches the flowering stage and it matures as the leaves die down. Vigorous corms also produce cormlets from the axillary buds on the side of the parent corm and these can be used for asexual propagation.

Fig. 1.2 Asexual Reproduction in a Corm

Stolons, Runners and Layers

These are types of structures which develop when a maturing plant produces a long above-ground stem which touches the soil surface, and roots down. The axillary buds in the node at this point then develop into vegetative shoots and a new plant is formed which may be used for asexual propagation.
1.3 ARTIFICIAL ASEXUAL PROPAGATION

By utilising the capacity of the meristem tissue, particularly in stems, to divide and produce more cells, rooting can be induced in cuttings in controlled conditions so that new independent plants are produced. As well as softwood and semi-hardwood cuttings, cuttings can also be taken from hardwood material.

Leaves and roots from only a limited number of species can be used for propagation.

Stems which take root when they touch the soil are called layers and these can be specially set-up, then removed later and grown-on.

Natural structures such as rhizomes, offsets, stolons etc. can be taken from the parent stock plant and either potted-on or planted out directly in a new location.

Grafting is a specialised technique for certain genera where the prepared stem of one plant is fastened on the top of a prepared stem of a suitable rootstock of the same genus, so that the cambium of both pieces is in contact and grows together. Budding is a variation in which only the bud is placed under the bark of the rootstock.

The newest type of asexual propagation is micro-propagation or tissue culture, where the meristematic cells are cultured and divided in a laboratory.
Chapter Two

Hygiene

2.1 HYGIENE

This topic is covered in detail in the first book, *Introduction to Propagating Seeds and Cuttings*. This chapter serves as a reminder of the main points.

Hygiene

- It is essential to practise good nursery hygiene to ensure that as high a percentage as possible of material used produces good quality plants for sale.

Accreditation

- Accredited nurseries and suppliers of various types of growing media comply with very strict guidelines to prevent the introduction and spread of diseases, particularly *Phytophthora cinnamomi*.

Chemicals, or Not?

- Some hygiene practices depend on the use of disinfectants to clean benches and equipment, and the use of fungicides to control diseases.

- Other non-chemical practices relate to the design of structures, pasteurising growing media, processing of material and the environment for propagation.
Structures

- Structures must be designed to provide the best environment for propagation, that is, correct light quality and intensity, temperature control, humidity, watering and airflow.
- Structures must be easy to clean and well-drained.

Equipment

- All equipment must be kept clean, and disinfected as often as required for the propagation procedure.
- All secateurs, knives etc. must be kept sharp and disinfected.

Plant Material

- Plant material should only be selected from stock free of pests and diseases, and kept free of contamination until used.
- Dead leaves, weeds etc. should be removed promptly from the propagation area, and fungicides used when necessary.

Growing Media

- Propagation media should come from accredited suppliers and should be pasteurised with steam or drenched with fungicide to prevent disease organisms reaching the propagation material.

Personnel

- Only personnel involved with propagation should enter the propagation area. Staff should wash their hands thoroughly before handling plant material.
Selection of Plant Material

3.1 PLANT SELECTION

This topic is covered in detail in *Introduction to Propagating Seeds and Cuttings*. A summary of the main points relevant to asexual propagation is included here.

Choice of Cultivar

- The plant selected should have the most desirable characteristics available. It should be accurately labelled.

Health

- The plant should be growing well with no indication of pests or disease, water stress, nutrient deficiencies or weak, unhealthy growth.

Plant Variety Rights

- The propagator must ensure that the plants being propagated are not covered by a licence belonging to another nursery. It is a criminal offence to propagate for sale plants covered by PVR without the appropriate licence for that plant.
Preparation of Stock Plants

• Plants used to produce material for propagation should be grown in a suitable location, kept well watered, fertilised, free of weeds, free of pests and diseases, and pruned correctly where appropriate to promote the growth of suitable material at the right time of the year.

Collection of Material

• Material for asexual propagation should be collected just before it is needed for propagation. Secateurs and containers should be disinfected and the material wrapped in damp newspaper until required.
Chapter Four

Hardwood Cuttings

4.1 HARDWOOD CUTTINGS

Most hardwood cuttings are prepared from mature wood usually one to two years old taken mostly from deciduous plants in winter. The leafless cuttings are not subject to the same stress that can be experienced by leafy cuttings transpiring and suffering water stress.

Historically, hardwood cuttings were used to propagate many deciduous trees and shrubs. Nowadays, they are more commonly used as an economical way of producing large quantities of root stocks of plants such as fruit trees, grape vines and roses. Desirable varieties are then grafted or budded onto the rootstock.

However, there are some evergreen plants which also grow well from hardwood cuttings taken during winter in their time of least active growth. Conifers are also treated in a similar way because a growth regulating compound for hardwoods is required.

4.2 ADVANTAGES

- They are easy to prepare.

- The cutting material does not deteriorate quickly and may be stored in damp peat or newspaper in a cool room for weeks until a suitable time for propagation.

- Prepared cuttings do not deteriorate quickly like softer leafier cuttings.

- Some may be taken from pruned material.

- They are easy to strike without elaborate equipment.
• They can be used to produce a large quantity of rooted cuttings for root stocks.

• They can be used when only a few plants are required.

• They are a useful method for home gardeners.

4.3 DISADVANTAGES

• Unless part of pruning, taking a quantity of hardwood cuttings can remove a large part of the maturing wood on stock plants which is more demanding than taking semi-hardwood cuttings.

• Historically, hardwood cuttings were very important for propagating many trees and shrubs because the conditions needed to strike semi-hardwood cuttings successfully in reasonable numbers were not available. With present technology, it is faster to propagate many woody plants commercially by semi-hardwood cuttings.

4.4 COMMERCIAL USES

Hardwood cuttings can be used to propagate many types of deciduous trees and shrubs and some evergreen shrubs which are dormant in winter.

The main commercial use is in the production of root stocks. Roses, grapevines and many fruit trees such as plums are budded or grafted onto rootstocks grown from hardwood cuttings. (Some rootstocks used are seedlings rather than hardwood cuttings.)

_Hibiscus_ and _Bougainvillea_ are evergreen shrubs propagated by hardwood cuttings taken in winter when growth is least active.

Conifers are propagated using Hardwood or No. 3 growth regulating compound.
4.5 RECOGNISING SUITABLE MATERIAL

In woody, deciduous perennials, new growth in the spring is soft and usually bends easily and may break. (Think how easy it is to break young fuchsia and rose shoots.) As the wood matures over a few months of the spring and summer, it will become more whippy but still flexible enough to bend. It usually darkens in colour, often to a reddish-brown. This is termed semi-hardwood and is extensively used for propagation.

At the end of the growing season, the wood becomes dormant. In the following spring, the terminal bud breaks, leaving a girdle scar at the end of the previous year's growth. When bent, hardwood will break in a ragged tear. After a couple of years, the wood becomes much harder and is often grey in colour. Refer Figures 13.2 and 13.3 in Introduction to Propagating Seeds and Cuttings.

Hardwood cutting material is in its first or second winter. When it is older - that is, grey, woody and ringed with girdle scars - it is unlikely to root.

Hardwood material is generally about the diameter of a pencil or slightly larger, but this also depends on the species. There should be at least two nodes with undamaged dormant buds per cutting. There should not be any indication of pest damage or disease present.

Only plants with known desirable characteristics should be used. Plants that have been well-grown in good light conditions and not allowed to make excessive soft growth will produce the best hardwood cuttings. The plants should not have been stressed by summer drought. By the winter, hardwood material that has been properly grown should have a large amount of carbohydrate as starch stored in the stem tissue from the previous summer. This will be used to develop callus tissue and root growth before leaf growth starts in the spring.

4.6 CALLUSING

Taking Cuttings

There are specialised differences among various genera and species but, as a guideline:

- **Thickness** - cuttings are generally about 8 - 10 mm in thickness, about the size of a pencil. Thin cuttings will have insufficient carbohydrate.
• **Length** - cuttings will generally be between 200 and 300 mm long. Cuttings need to have at least two nodes with healthy auxiliary buds. The number and length will depend upon the internodal length normal for that species. Long cuttings waste material and those that are too short may run out of carbohydrate for energy before the roots are established.

Cuttings are cut just beneath a node. There should not be any wood older than its second winter. The ring of vascular tissue formed in older wood will have a hardened outer protective layer of sclerenchyma tissue which can prevent the development and growth of root initials. (Refer Figure 9.2.)

Softer tip growth should also be discarded from the material.

The cut ends of cuttings of sappy plants like frangipani and poinsettia need to be dried first to avoid rotting, before placing in the media.

**Timing**

Material is collected in the winter during the dormant phase for the species.

**Polarity**

Polarity refers to planting the cutting the right way up, to correspond with the way it grew on the plant. (It is relatively easy to plant a leafless cutting upside down.)

Nodes and leaf scars are not always so obvious in some species as in others. If planted upside down, the cutting would die as the top end cannot form callus, and shoot growth would initially be directed downwards before turning up.

Cutting material is usually prepared so that there is a cut straight across under a node at the base or proximal end of the cutting. The cut at the top or distal end of the cutting should be just above a bud and sloping to shed off water and visibly distinguish the ends of the cutting.
Formation of Callus

Callus protects the base of the cutting, absorbs moisture and protects the root initials in their early development. The sooner that callus is formed, the sooner the cutting is likely to produce roots and become independent. If shoot growth is initiated too early, the cutting’s
supply of carbohydrate will be used up too quickly. Early shoot growth may not be strong enough to survive until the plant is independent.

Several factors affect the development of callus tissue:

- temperatures at the base and top of the cutting
- moisture
- protection from too much heat, cold and drying wind.

The development of callus and roots is encouraged by warm, moist conditions around the base of the cutting.

Cuttings are struck in a callusing box, which is a shallow box made of wood or polystyrene, lined with newspaper and filled with moist, coarse sand. The box is placed over bottom heat to warm the base of the cutting. The top of the cutting is kept cooler but moist, to prevent it drying out. Cuttings may also have the tops covered with newspaper to exclude light, which also decreases the chances of shoot growth developing.

4.7 PROCEDURE

**Selection:** Choose material of suitable age and thickness from a dormant plant.

**Transport:** Carry the selected material in a hygienic container to the propagation area.

**Preparation:** Check the polarity by looking at the position of the buds and the leaf scars. Prepare the cutting so that there is a clean cut straight across under a node, and a sloping cut above a bud at the top of the cutting. Use disinfected sharp secateurs or knife.

Remove the buds from the lower half of the cutting.

Trim the base of the cutting with a sharp knife if there is any bruised or damaged tissue from the cut.
The base of the cutting may be wounded to expose a little of the cambium at the base.

This removes the sclerenchyma tissue, making it easier for callus and root initials to form. (Refer Figure 9.2.)

Treat with hormone preparation for Hardwood.

(i) Wounding

(ii) Callusing

(iii) Rooting

Fig. 4.3 Root Development
Storage: With some species, it is sometimes better practice to keep the cuttings until later in the winter before callusing. Prepared material is taken at the correct stage but is wrapped and stored in cool, moist, dark conditions in a cool room, and remains dormant for some weeks. With this method, the rooted cuttings will be coming into growth at the normal time for budbreak in the spring rather than earlier.

Callusing: Some species will develop callus and roots when lined-out in open ground or field conditions, or in a callus box without bottom heat. Others strike better when there is bottom heat under or in the callus box itself.

To save space in the callus box, cuttings are tied into bundles with the bases level. The bundles are placed in the callusing box with a bottom heat temperature of 24°C. The cuttings need to be watered but do not need mist. Use a fungicidal drench. About half of the cutting is buried in the media. Label the cuttings. The tops should be kept cool in normal winter temperatures, but not allowed to dry out in the wind or on sudden warm days in late winter. Bottom heat speeds up the formation of callus, but the cooler temperatures around the top of the cutting discourage premature bud burst.
Lining-Out: After a few weeks, when callusing is present but before roots have started to develop, the cuttings are removed from the callusing box. They can be potted-on into individual pots or put out in rows (lining-out) in a nursery situation, depending upon the plant and its eventual use. Do not damage the callus when handling.

Plants lined-out in rows are usually about 200 mm apart with about 900 mm between the rows, depending on the species.

Growing-On: The cuttings are then grown-on so that roots are established enough to support either shoot growth or grafted or budded material when required.

Direct Planting: Some species which callus and root easily may be planted directly out into rows. The bottom of the trench is usually lined with sand to prevent the base of the cutting becoming too wet, and rotting.
4.8 EVERGREEN MATERIAL

There are a number of evergreen plants which will strike from hardwood cuttings which are taken in winter at a time when activity in the stems is at a minimum. These are evergreen tropical and subtropical plants which respond to warm, moist conditions. (Some of them tend to lose some of their leaves at the limit of their tolerance to cold, as happens with hibiscus and bougainvilleas in the Perth Hills.)

- Select the cutting material from wood from the previous season’s growth. It should be quite firm. Softer tip growth should be removed.

- Prepare the cuttings as though they were semi-hardwood cuttings, but treat with Hardwood hormone preparation.

- Place the cuttings in a warm environment with bottom heat and misting. The leaves mostly drop off and need to be removed.

- Cuttings can also be taken in spring and autumn if controlled environment and condition are available.

Callusing is fairly quick. Examples include Hibiscus, Bougainvillea and Acalaphya.

4.9 CONIFERS

Many conifers are difficult to strike vegetatively but that is the only way to propagate the cultivars. Many species can be grown from seed, though those from cold climates need to be stratified, and may not produce viable seed except in cold areas. Pinus are grown from seed for commercial plantations.

Chamaecyparis, Juniperus, Thuja and Cupressus, which are the most common genera in Western Australia, are among the easier to strike. Some of the genera, such as Abies and Picea, which are seldom grown in Perth because it is too hot, are more difficult. Some of the prostrate junipers such as Juniperus ‘Blue Rug’ will self-layer easily.

Some of the special cultivars are grafted including Cupressus macrocarpa ‘Greenstead Magnifica’ and Cupressus macrocarpa ‘Conebearii’, and the Cedrus, particularly Cedrus atlantica glauca. Sometimes this is to ensure a stronger rootstock, but it can also be for special effects such as a weeping standard of Cupressus macrocarpa ‘Greenstead Magnifica’.
Conifer Hardwood Cuttings

Cuttings are taken from late autumn to late winter. The cuttings may be stem cuttings or have a heel - a small portion of the stem still attached to a small side shoot which has been pulled off. Before the development of rooting compounds, heeled cuttings were needed to obtain a strike. The material in the heel may contain additional carbohydrates and rooting hormones, and may also be more resistant to rotting than the base of a normal stem cutting.

Fig. 4.5 Conifer Cutting with a Heel

The base of tip cuttings can be wounded to increase the amount of cambium exposed to rooting compound and the growing media.

In a commercial situation the base of the cutting must be treated with a Hardwood hormone preparation to obtain reasonably reliable rooting.

Cuttings are then placed over bottom heat with mist. Even then, rooting can be quite slow.
Chapter Five

Root Cuttings

5.1 ROOT CUTTINGS

Most plants cannot be propagated from their roots. Roots do not generally produce buds, but buds are needed to produce vegetative growth for a new plant. Most underground structures which are used for propagation are either stems; for example, rhizomes, stem tubers, bulbs, corms etc., or food and water storage tissue attached to a stem, as in a dahlia tuber.

Only a very few roots produce buds on their surface, of which the most well known is the sweet potato which produces buds on an adventitious root storage tuber.

The Stele

All roots have a central structure called the stele, which is surrounded by storage tissue. Within the stele are the vascular bundles which translocate water, nutrients, carbohydrates, growth regulators, etc., and in dicotyledonous plants, cambium cells from which lateral roots are initiated as the root grows.

Monocotyledonous plants do not have cambium in their roots except at the root tips, so cannot develop adventitious buds in pieces of root.
In a few dicotyledonous plants, this cambium, if it is damaged, is also able to divide and differentiate into adventitious buds which develop into vegetative growth. Some plants, including some stone fruit trees and poplars, will sucker from the roots if the roots are damaged by cultivation, road and drainage work etc., and if the cambium is exposed to the soil.

There are some plants which are capable of producing shoots from root cuttings because cutting up the root is equivalent to 'damaging' the root and the cambium is exposed to the cutting media.

5.2 ADVANTAGES

- Root cuttings provide an additional means of propagating a limited number of species so that they will be true to the characteristics of the stock plant.

- They are useful for fleshy-rooted herbaceous perennials.
5.3 DISADVANTAGES

- Root cuttings are only possible with a limited number of dicotyledonous plants, many of which may be able to be propagated more easily and economically by other means.

- The stock plant must be disturbed or dug up to obtain the cuttings, so the horticulturist must also care for the stock plant after the cuttings are taken.

- They cannot be used for grafted plants as the cutting will produce the root stock.

- They should not be used for variegated plants as some may revert to green.

- It is a tedious and time-consuming method.

5.4 COMMERCIAL USES

Root cuttings were used more in the past before the development of techniques using bottom-heated beds, fogging and growth regulators which ensured the successful raising of many more plants by stem cuttings.

Root cuttings can be used for many herbaceous perennial or cottage plants with fleshy roots; for example, Stokesia laevis, but a lot of those with fleshy roots are not those grown most readily in Western Australia; for example, perennial phlox and oriental poppies.

Other plants which may be grown from root cuttings include Paulownia tomentosum (powton tree), Liquidambar styraciflua, Lagerstroemia, Tetrapanax papyriferum (rice paper tree), Acanthus mollis, and Wisteria sinensis, but the technique is not often used commercially.

5.5 RECOGNISING SUITABLE MATERIAL

Plants that may be suitable for propagation by root cuttings are those which are known to sucker (that is, produce shoots from damaged roots) and those which have fleshy roots. The latter are more likely to have a good store of carbohydrate to maintain the cutting until root and shoot growth have developed.
So that the shock of removal of some of the root system is minimised, root cuttings are taken when the stock plant is dormant, but just before growth starts again. This is usually in late winter/early spring. Once the cuttings are taken, the stock plant must be replanted promptly, watered and given appropriate aftercare.

The stock plant may be prepared in advance for a larger number of suitable root cuttings. The old roots and shoots are trimmed off in the dormant season and the plant grows new roots during the following growing season. These fresh maturing roots are used for cuttings in the next dormant season. This procedure, which involves time and labour, would only be warranted commercially if the plant could only be grown from root cuttings.

5.6 **PROCEDURE**

**Selection:** Select an appropriate species and carefully dig up the stock plant. Shake off excess soil and trim off suitable pieces of roots and put in a bucket lined with damp newspaper to keep the pieces moist. Note the polarity of the cutting material. Replant the stock plant.

**Transport:** Take the roots to the propagation area without allowing them to dry out or be contaminated.

**Preparation:** Sterilise the surface of the bench. Wash the root pieces to remove soil and dip the roots in a 1% solution of sodium hypochlorite, to remove any contamination and rinse. Sterilise the blade of a sharp knife to prepare the cuttings.

Small roots are placed in trays while the larger roots are placed in pots. The containers should be filled with suitable moist cutting media, watered and tamped down.

Roots are cut up into lengths and treated according to their diameter. Discard any damaged roots, small laterals and the thin ends of roots.
**Small Delicate Roots:**

- These are cut into lengths measuring 25-30 mm; for example, perennial wallflower.
- Place the roots horizontally on a prepared tray so that they are not touching. Firm into the media, label and cover with about 10 mm of media so that the roots are covered. Water well, using a fungicide.

Fig. 5.2 Propagation of Small Fine Roots

**Fleshy Roots and Young Woody Roots:**

- These must be cut with care to ensure the polarity of the cuttings is maintained.
- The end of the piece of root closest to the stem is the *proximal* end.
- The end of the piece of root furthest away from the stem is the *distal* end.

Fig. 5.3 Fleshy Roots of *Stokesia laevis*
To ensure polarity, always make a flat cut straight across at the proximal end, and a sloping cut of approximately $45^\circ$ at the distal end.

- Prepare cuttings about 50 - 60 mm long.
- The use of growth regulating substances is not recommended.
- Dibble into prepared pots of media so that the flat end (proximal end) is level with the surface of the media and the cutting is vertical. The tops of the cuttings may then be lightly covered with grit to protect them.
- Label.
- Water the cuttings, using a fungicide.

**Fig. 5.4** Root Cuttings

**Growing-On:** The trays and pots of cuttings are then placed in a glasshouse and kept warm and moist but not allowed to become wet. Shoots develop from the cambium in the stele of the cutting. In some cuttings, adventitious roots develop from the base of the new shoot and the original root cutting withers away. When the shoots are developed, they are potted-on to be grown-on for planting out or sale.
Chapter Six

Leaf Cuttings

6.1 LEAF CUTTINGS

Leaf cuttings are only used to propagate a small range of species, especially those from the family GESNERIACEAE which generally produce rosettes of leaves without much stem tissue for cuttings.

Fig. 6.1 Meristem Tissue in a Young Shoot
Leaves are formed when the meristem in a developing vegetative bud divides and differentiates into leaves and young stem. After differentiation, the meristem in some leaves remains active as a strand of tissue in the vascular bundle in the petiole and into the midrib and lateral veins of the leaf. On some leaves, small plantlets will develop naturally as in *Tolmia*. In certain other plants, if the leaf is ‘wounded’, the meristem is able to divide and produce adventitious buds which can develop into new plantlets.

Most cuttings are made just from the leaf - these are termed *leaf cuttings*. Some though, are from the leaf, its axillary bud and just enough stem to help to support the cutting in the media - these are termed *leaf bud cuttings*.

When placed in media in suitable conditions, adventitious roots develop where the cambium is in contact with the media, followed by the development of adventitious buds and shoots. The leaf provides the carbohydrate for energy while the roots and buds develop. The original leaf then withers away. Care must be taken that, if it begins to decay, it does not affect the plantlets with fungal diseases before they reach the size to be potted-on.

### 6.2 ADVANTAGES

- Leaf cuttings are one of the best ways to propagate some of these species in reasonable numbers as each leaf may produce many plantlets.

- Some species are difficult to propagate by any other method except to obtain small numbers, for example, cutting up rhizomes of cleopatra begonias, or the division of larger specimens.

- Plantlets have a better growth form for tube stock and small containers prepared for sale than those from divided rhizomes.

### 6.3 DISADVANTAGES

- Leaf cuttings are only possible with a limited number of species.

- They require specialised conditions, especially with relation to humidity.

- They require careful attention to hygiene, as leaf cuttings are very susceptible to fungal infections.
• Some cultivars of *Sansevieria* and *Saintpaulia* are chimeras and revert to the original parent. (Ref. 6.6.)

• Some of the newest and best hybrids of *Saintpaulia* are now propagated in large quantities by micro-propagation.

### 6.4 COMMERCIAL USES

Leaf cuttings are used mostly for a number of popular indoor plants:

• *Saintpaulia* (African Violet), *Gloxinia* and *Streptocarpus* from the GESNERIACEAE.

• Some of the begonias, particularly the rex and cleopatra types.

• *Tolmiea menziesii* (piggyback plant) produces plantlets on the leaves as part of the normal growing process.

• Large *Ficus* cultivars can be propagated from rolled leaf bud cuttings.

A number of succulents also produce plantlets naturally on their leaves or can be induced to do so fairly readily - *Crassula*, *Bryophyllum*, *Sedum* and *Kalanchoe*. Some ferns also produce plantlets in the fronds which can be removed carefully and grown-on - *Asplenium bulbiferum* and *Hemionitis*.

Leaf bud cuttings are used particularly where there is a limited amount of suitable stock available for semi-hardwood cuttings; for example, to propagate a new camellia hybrid or one that is slow growing.

### 6.5 RECOGNISING SUITABLE MATERIAL

Leaves should be healthy and free of any disease or damage from pests. Leaves should be just mature. Very young leaves will not be sufficiently developed and old ones lack the vigour required. Only mature healthy leaves will have sufficient carbohydrate to provide for the developing plantlets.

Some of the leaves are covered in fine hairs (African Violets and, to a lesser extent, some of the begonias) and others, like the begonias, are quite delicate and easily damaged so they must be handled carefully to avoid bruising.
Leaves may be available for much of the year if the stock plants are maintained in glasshouses. The stock plants may be prepared in advance by removing all the old or damaged leaves, and encouraging new growth by trimming, repotting, fertilising etc. to encourage the development of vigorous new leaves.

6.6 PROCEDURES FOR LEAF CUTTINGS

Preparation:

Depending on the type, leaf cuttings are usually placed in trays of a free-draining peat/perlite mix.

Some larger cuttings are placed in pots, especially the rolled leaf bud cuttings.

Hygiene is particularly important, so the containers and the tools used must be disinfected. Media should be pasteurised and fungicidal drenches used. The leaves should be dipped in 1% solution of sodium hypochlorite, and rinsed.

Soft leaves should be collected from stock plants just before the cuttings are ready to be used, and the leaves should be protected carefully in a container such as a sterilised ice-cream container.

Environment:

The conditions are similar to those for softwood and herbaceous cuttings. Soft leaves need to be placed in a warm environment with bottom heat and fogging rather than misting. Misting allows too much water to collect on the leaves which may allow disease to become established, especially on soft, hairy leaves. Fogging keeps the humidity high without the leaves becoming too wet.

Trays may be watered by capillary methods to keep the amount of water on the leaves to a minimum.

Some leaves may be placed in a wet tent or high humidity cabinet which maintains a very high humidity in a smaller area of a glasshouse.
Leaf Cuttings - Soft Leaves:

*Leaf blade only; or leaf blade with a short length of the petiole*

- using a dibbler, insert the petiole and/or the base of the leaf into the media so that the leaf is at an angle to shed water.

- arrange the leaves in neat rows in the tray.

- label.

- water, including a fungicide.

- place in a controlled environment.

- the plantlets develop from the cut edge of the leaf blade or the base of the petiole.

Examples: African violet and peperomia.

![Leaf cutting with petiole in a container of media and Plantlet forming at base of petiole](image)

Covered with media

Adventitious roots

**Fig. 6.2 Leaf Cuttings**

**Large leaf blade**

- place a large begonia leaf upside-down on a disinfected surface.

- with a sterilised scalpel blade, make several tiny cuts through the lateral veins, as shown in Figure 6.3.

- place the leaf right-side-up on the media, and pin down or weigh down with clean gravel so that the cut surfaces are in contact with the media. Growth is initiated in the cut areas where the cambium touches the media.
• Label.
• Water, including a fungicide.
• Place in a controlled environment.

Fig. 6.3(a) Underside of prepared Begonia leaf

Fig. 6.3 (b) Large leaf blade pinned down
Leaf Section

- *Streptocarpus* and Rex begonia can be cut into two or three sections or cut in half lengthways. The leaf cuttings are then placed in rows in a tray and treated as above.

- Very large begonia leaves may be cut into triangular wedges and these dibbled into the media in rows so that the cut edges of some of the lateral veins are in the media. The trays are then treated as above.

Maintain polarity of wedge

Fig. 6.4 Leaf Segments

Leaf Cuttings - Tougher Leaves

*Leaf Section*

- Firm leaves such as *Sansevieria* may be cut into 7.5 - 10 cm lengths and placed into pots of cutting media.

- Place in a sheltered house, although these leaves to not need the precise conditions of begonia and African violet leaf cuttings.

- Three points to note about *Sansevieria*:
  - It is advisable to allow *Sansevieria* to dry out for a day or so before propagating.
  - The leaf pieces have polarity, and roots and buds will only come from the base or proximal end of the leaf cutting, so don’t plant the cuttings upside down.
Variegated *Sansevieria* will lose its variegation if propagated from leaf cuttings. This type of plant is called a *chimera*. Only the green tissue is capable of division and genetically it does not carry the variegated characteristics. Variegated cultivars must be obtained by division of a large stock plant.

![Leaf cuttings in a pot with a plantlet forming](image)

**Fig. 6.5 Leaf Cuttings of Sansevieria**

**Leaf Bud Cutting**

- This is a type of stem cutting in that there is some stem tissue, one leaf and its axillary bud. The leaf provides carbohydrate and support until roots and shoots develop.

- However, because the cutting is so small, the growing conditions are closer to that of a leaf cutting than a much longer stem cutting with more stored material and several leaves.

- The leaf bud cuttings are dilled into a tray or pot (depending upon their size) and kept in a closely controlled environment until roots and shoots form.
• Leaf bud cuttings can be used for hardy shrubs, especially camellias. Semi-hardwood rooting hormone is used and rooting can take some time to establish.

• Leaf bud cuttings can also be used for a number of house plants such as Scindapsus and Hoya which root easily from each node.

• Large leaved plants such as Ficus can be propagated with rolled leaf bud cuttings. The leaf is rolled up - with the upper surface to the outside - to prevent moisture loss. The leaf blade is held in position with a rubber band. The cutting is then dipped in a rooting preparation and placed in a pot of peat/perlite mix. A short cane may be inserted for support and tied to the leaf with soft twine. Plantlets will appear from the base of the cutting.

Fig. 6.6 Leaf bud cutting of Camellia

Fig. 6.7 Rolled leaf bud cutting - Ficus
Succulents

A number of succulents, especially of the CRASSULACEAE, form plantlets on their leaves without any special treatment. *Bryophyllum* develop the shoots while the leaves are still on the plant. Many of the *Sedum* and *Echeveria* will develop plantlets at the base of the leaf if the leaf falls or is knocked off the parent plant.

These plants can be readily propagated by placing the leaves on a tray of media which contains more coarse sand than typical cutting media. They do not want to be too wet as the leaves are water storage organs.

Small plantlets are then grown-on in the slightly drier conditions appropriate to the species.

![Diagram of plantlet formation](image)

**Fig. 6.8 Plantlets on succulents**

Bulb Scales

The bulb scales of *Lilium* can be separated from the main bulb and planted in cutting media. Small bulblets will appear along the base of the bulb scale and can be potted-on until the bulblets develop to flowering size.
Potting-on the Plantlets

Plantlets formed either naturally or from leaf cuttings cannot stay on the leaf for very long without needing to be put out in trays to develop stronger root systems.

The plantlets may be quite small and are often crowded as more than one may develop at any one place on the leaf. It is important to separate them as soon as they are large enough to handle.

They should be planted out into trays of growing-on media and returned to carefully controlled conditions to begin to grow-on. As the leaves develop, care must be taken to avoid fungal diseases, especially on those plants with soft, hairy leaves.

When further developed, the plants are ready to pot-on to grow for sale.
Layering

7.1 LAYERING

Layering occurs when adventitious roots develop at a node or along the internode of a plant stem that is in direct contact with growing media. Historically, layering has been a popular method of propagating many plants because it works without the use of special structures such as a heated glasshouse.

Layering happens naturally in many plants which develop horizontal stems intended to spread the plant out from its centre to fresh soil and more space for growth. These include ground cover and prostrate plants, many herbaceous perennial or cottage plants, turf grasses and some perennial weeds. It also happens naturally in many spreading shrubs with branches that may bend down to soil level and develop roots at the point of contact.

The Layering Process (Why Does Layering Work?)

In the normally growing stem, there is ongoing translocation of:

- water and nutrients from the roots to the leaves in the xylem, and
- carbohydrates (sugars and starches) and growth regulating compounds from the leaves and shoot tips to the stems and the roots in the phloem.
In the various types of layers, this flow is interrupted by some type of *stem treatment* or *stem wounding* at the place where rooting is required. Stem treatment confines roots to a smaller area rather than all along a stem. Some plants will not root without stem treatment. Stem treatment ensures that:

- The carbohydrates and growth regulators accumulate above the point where the phloem has been cut or partly cut and this encourages rooting as the accumulated sugars in the phloem allow the production of more energy to produce the roots.

- Water and nutrients continue to reach the tip of the layer through the xylem, which must not be damaged.

- The cambium is exposed to the media which initiates roots from the dividing cells on the shoot side of the wound.

When the roots are developed, the layer is cut from the parent plant and potted-up to grow-on and harden-off, ready for final transplanting.

### 7.2 ADVANTAGES

- There are some plants which root more easily from layers than from cuttings; for example, trench layering for apple rootstocks, and aerial layering for *Magnolia grandiflora*.

- Special propagation structures and equipment are not required.

- If the layer does not take, the stem remains part of the plant, not wasted, which is important if the plant is small or rare.

- Useful for a few ‘extra’ plants where the stock plants are already part of a parks and gardens display. Can be used to extend ground covers over a larger area.

- Observant horticulturists can obtain extra plants by utilising self-layering in many plants.

- Useful for home gardeners.
7.3 DISADVANTAGES

On a commercial basis, there are several disadvantages, which have lead to this method being less common in recent years.

- There is a high labour cost per saleable plant produced.
- A large area is needed to produce plants in the stock garden.
- Stock plants need to be prepared for the best production of layers.
- Cutting material can be brought in from other areas, while layers need to be at or near the propagation nursery for monitoring.
- Only a few plants can be produced from each stock plant at a time, that is, a low reproduction percentage from each stock plant.
- Modern techniques for cuttings using growth regulators and controlled environments have increased the success rate from plants previously difficult to propagate by cuttings.
- Producing saleable plants by layering is slower than by cuttings in many species.
- Plants from cuttings may have a better growth form than those from layers of the same species.

7.4 COMMERCIAL USES

In horticulture, ground layers are mainly used in parks and gardens situations where a few more plants from an existing stock plant are needed. Ground layers are less likely to be used in commercial propagation except for trench layering of some fruit tree stocks, but aerial layering is still an important way of propagating certain plants such as Ficus.

7.5 RECOGNISING MATERIAL

There are two main types of artificial layers:

- Aerial layers, in which rooting is induced in an above-ground stem by treating the stem and packing it in rooting media.
• Ground layers, in which rooting occurs in stems that are treated and covered by growing media.

Stems for layering will be semi-hardwood or semi-mature, depending on the type of plant. Mature wood more than a year or so old may not root at all. Soft, immature stems may easily be damaged by being bent and covered in media. They are also more likely to rot or be damaged by soil-dwelling pests such as slugs and weevils.

Suitable semi-mature stems should:

• be flexible enough to bend without snapping

• have sufficient carbohydrate stored in the stem to use to develop roots

• have leafy shoots beyond the point of contact for continued production of sugars during rooting and when the layer is lifted and potted-on

• not be in flower.

7.6 PROCEDURES FOR GROUND LAYERING

Timing

Layers are usually done in the spring as the soil begins to warm up and root growth is most active. Deciduous plants are done in later winter. In Western Australia, it is essential to ensure that the soil around the layer remains moist in the summer. Many shrub layers may be ready to pot-on by the autumn, but some quick-rooting shrubs and herbaceous perennials may be ready sooner.

Simple Layering

For the most simple layering, take a suitable stem, bend it to the ground, and cover it with soil so that the terminal shoot with its leaves is exposed.

The more accepted general procedure is indicated below:

• Select a stem that can be held down to the soil without excessive force and select the most suitable place on the stem to make the layer.
- Remove the leaves around this area.

- Prepare the soil where the layer is to be made. It should be friable and should be enriched with organic matter to improve water retention in sandy soil.

- Make a slanting cut in the stem angled towards the tip of the layer to expose the cambium but not to cut through the xylem.

- Twist the tip of the layer slightly upright to expose the cut surface which may be kept open with a matchstick.

- Apply rooting hormone for semi-hardwoods.

![Diagram of layering process]

**Fig. 7.1 Preparing a stem for layering**

- Place the layer into a hole in the media and peg down to stop the layer lifting or twisting. The shoot may be staked upright for support. It is important for the tip to be as upright as possible so that any new vegetative growth will develop a good vertical form for the future plant.

- Cover the layer with media. Light must be excluded from the wounded stem area for roots to form.
Fig. 7.2 Development of Roots

- If desirable, remove the tip of the shoot to induce lateral branching close to the base of the new plant.

- The layer may also be fixed into a container of potting media which makes the removal of the rooted layer easier later.

- Ensure that conditions remain moist, aerated and warm around the new root zone. The parent plant will provide the shoot with water and nutrients, but the new roots will die if not kept moist.

- Look for the development of roots in the autumn or when vigorous shoot growth indicates an additional source of nutrients for the shoot. Do not detach from the stock plant until there is adequate root growth.

- Remove the rooted layer with minimal damage to the roots, pot-up and grow-on in sheltered conditions then harden-off just like a cutting-grown plant. The top of the shoot may have to be pruned if the quantity of leaf growth exceeds the capacity of the root ball to provide water.

The layer may be severed from the stock plant several weeks before lifting and allowed to develop further before disturbance, but conditions in a glasshouse or shadehouse should reduce stress and make this unnecessary.
Serpentine or Compound Layering

Long flexible stems on some climbers, ground covers and house plants will root in more than one place provided that between each layer there is stem tissue and leaves left above the soil to produce sugars for growth. The procedure is as for ground layering except that there are several layers located at every second or more nodes depending upon the length of the internodes. Once rooting takes place, the layer is cut up into the several small plants which are then grown on just like cuttings, for example, Lonicera (honeysuckle), Wisteria, Philodendron and Scindapsus.

Fig. 7.3 Compound Layering

Tip Layering

A tip layer is useful when the stem is not long enough to do a simple layer. In this case, the stem just before the tip is bent into the soil and the tip of the stem is just at the surface. By the time the layer has developed roots, the tip will have grown into a shoot.

Fig. 7.4 Tip layering
**Mound Layering (Stool Layering)**

Mound layering is a technique suitable for plants that develop sturdy vertical stems from the base. To get a reasonable number of layers per stock plant, also called a *stool plant*, preparation is necessary beforehand so it is a fairly slow procedure.

- Trim the stool plants nearly to ground level so that a crop of young shoots of the same age and size develop from the base (called the *crown*).

- These stems are progressively buried with good growing media, and kept moist. Once roots develop on these vertical stems, they can then be removed just above the crown and grown on in the usual way.

- The crowns are then exposed to air and light and a new crop of shoots develop. Historically, this was a very important way of propagating shrubs, and plants were grown especially for propagating in stool beds. The amenity value of the plant is lost during this process so these plants were grown separately.

- Small numbers of mound layers can be taken by covering only part of the crown.

Suitable local examples include hydrangeas, azaleas, fuchsias, cane fruit and any shrubs that produce new growth regularly from the base.
Fig. 7.5 Mound or stool layering

Trench Layering

This is another fairly slow technique particularly used to produce root stocks for fruit trees such as apples. The root stocks are grown as long, whippy stems which are then bent over, buried in a shallow trench and gradually covered with sawdust/media. Shoots and roots develop at the nodes on these buried stems. When established, the stems are carefully exposed and the new rooted shoots individually potted on as root stocks ready for grafting. The stock plants will produce more than one crop of layers.
Long whippy shoot

Shoot is pinned down in trench

Shoots form at nodes and trench is filled in gradually

Layer remains for further shoots

New rooted shoot

Ready to pot-on

Fig. 7.6 Production of apple rootstocks
7.7 AERIAL LAYERING

Aerial layering is a technique which induces rooting in an above ground stem. Aerial layering works because extra carbohydrate produced in the leafy shoot is concentrated at the treatment area. It is important that:

- the phloem is disrupted concentrating the carbohydrates
- the cambium is exposed to the media and,
- the xylem is not damaged, so that water and nutrients are still translocated to the top of the shoot. If the xylem is severed, the shoot has been ringbarked and will die.

Fig. 7.7 Two Methods of preparing aerial layers
Procedure

- Aerial layers are done in spring on stems of the previous season’s flush of growth.

- Locate a suitable stem for aerial layering. It should be mature but not old as old/hardwood stems are hard to root. It should be thick enough to withstand wounding. The tip of the shoot should be vigorous, healthy and well-shaped.

- Remove the leaves in the area to be covered.

- As shown in Fig. 7.7, a piece of the bark and the phloem tissue and cambium tissue are carefully peeled away (called girdling) leaving the xylem exposed,

or some propagators prefer to lift a strip of bark and soft tissue about 5 - 6 cm long, and wedge the strip open with a matchstick or sphagnum moss.

- Dust the cut edge with root promoting powder, generally softwood for Ficus and houseplants and semi hardwood for Camellia etc.

- Pack the area around the treated stem in about two handfuls of moist sphagnum and wrap firmly in black plastic. Secure this carefully to exclude water, insect pests, etc. Black plastic prevents algal growth in the damp moss and protects the developing roots from the light.

- Some propagators use clear plastic under the black plastic so the layer can be inspected more easily. Some propagators use aluminium foil instead of black plastic so that the root zone doesn’t become too hot in the late spring.

- Check for root development by opening the black plastic without disturbing the moss until the roots are visible. Then the layer is ready to be cut from the parent plant, potted-up and grown-on in the usual way.

- Sometimes the shoot may have to be pruned to maintain the balance between the size of the shoot and the root growth but proper care in a glasshouse can prevent this if it is likely to spoil the form of the shoot.
Aerial layering is particularly used for various cultivars and species of *Ficus*, but can also be used for *Camellia, Croton, Magnolia, Rhododendron, Daphne, Schefflera* and *Dracaena*. Many others which have been tried experimentally do succeed.

Aerial layering is also known as Chinese layering and marcottage.
Chapter Eight

Separation and Division

8.1 SEPARATION AND DIVISION

Separation and division are methods of propagating where the parent or stock plant is divided up into smaller vegetative parts. Herbaceous perennials, including many cottage plants, are suitable for division. Some of these plants produce structures such as tubers and rhizomes, while others develop new shoots in the leaf axils of compressed stems close to ground level, and these new shoots develop roots. The older central part of the plant becomes woody and will not produce good flowers. However, if the new shoots are not removed and thinned out, they often become too crowded to be really productive.

Separation describes the breaking up of clumps of bulbous plants. Many bulbs become crowded with the quantity of bulblets produced in the axils of the leaf bases.

8.2 ADVANTAGES

Because division and separation are easy, there are several advantages:

- They are easy methods which do not require special propagation conditions.

- In a parks and gardens situation, including home gardens, plants can be divided and replanted into fresh soil without the need for repotting, if the weather conditions are suitable and initial care is available.

- They are an easy way to increase the quantity of suitable plants already growing in a garden.
• Replacing old woody stock plants is simple.

• Separation is the main way of propagating fully dormant forms such as bulbs, corms and some tubers, which can be transported and sold dry or in packets of peat/sawdust (which allows them to be sold interstate).

• If required, relatively large plants can be obtained by using larger pieces for the division.

8.3 DISADVANTAGES

The disadvantages apply mainly to a wholesale/retail situation where a lot of plants have to be propagated for sale.

• It is a labour-intensive way of propagating. Some herbaceous perennials grow easily from seeds or softwood cuttings with less use of labour; for example, penstemons.

• Depending upon the species, there may not be many new plants propagated from each stock plant.

• The stock plants must be at least two or three years old to produce a lot of material so they take up a lot of space and time in a stock garden. This can be offset to some extent if the stock garden is also for display.

8.4 COMMERCIAL USES

• Division is not used much in commercial propagation nurseries. It is very useful though in parks and gardens situations, including home gardens where old perennials that no longer give a good display can be divided for regenerating and where only a few new plants are required.

• Separation of bulbs and corms is important commercially because bulbs multiply vegetatively by producing small bulblets which are separated from the main bulb and grown on.
8.5 RECOGNISING SUITABLE MATERIAL

There is some difference among the various species propagated by these methods, but generally:

- The material should look healthy without diseased or badly damaged stems or roots.

- There should not be any signs or symptoms of pests.

- Roots will either be missing, as in bulbs and corms etc. or at an early stage of development so that digging up and dividing does not damage the roots intended to provide for the plant during that growing season.

- Preferably, there should not be any sign of floral buds developing as some plants can be severely stressed if division takes place then. This is because the growth regulating chemicals in the plant have changed from vegetative growth to reproduction. Some divisions in flower will not grow at all.

8.6 TIMING

Some plants can be divided at a wide range of times (even in flower if necessary to save the plant), but there are others which are much more sensitive and need to be divided at the right stage according to their life cycle.

Some herbaceous perennials become completely dormant; for example bulbs, corms and tubers, and these are best separated at this stage as there is no active growth and no roots to be damaged.

Many herbaceous perennials have a period of reduced growth induced by the weather, even though some leaves may not totally disappear. At this stage of growth, many of the roots also die off, leaving just enough to maintain the plant. This is the time to divide. If division is left until the new growth starts, the active new roots will also be damaged, and while the plant may survive it will take much longer for it to recover to full flowering potential than if it had been divided when it was semi-dormant.
Not all plants are dormant at the same time though. In Western Australia, some herbaceous perennials are dormant in the summer so are best divided just before the autumn rains bring rapid growth. These are plants which flower in winter and early spring, having made growth during the milder days of the winter and become semi-dormant with the heat of the summer. These include bearded irises and native herbaceous plants such as kangaroo paws (Anigosanthis) and native irises (Patersonia), which should be divided in March.

Many of the cottage perennials flower in the late spring and summer and their main flush of growth is from late winter and early spring before the summer heat. During autumn and winter, their top growth is reduced but new shoots are developing around the main clump of the plant. These are best divided in the winter and early spring. If they are left too late, then the shoots will have begun to form the inflorescences and will not adjust to being dug up and divided so well as they do while still in the early vegetative stage. These include such perennials as daylilies, golden rod (Solidago), obedient plant (Physostegia), michaelmas daisies and Shasta daisies.

8.7 PROCEDURES FOR DIVISION

Clumping Plants

The division of a perennial clump may be done on-the-spot in the garden if that is what is required, or the clump may be taken to a propagating area so that the small plants can be potted-up.

Selection: Choose a plant that is large enough to have suitable young shoots developing around it. Dig the clump out carefully to minimise damage to the roots and new shoots. This may be a fairly easy task or, in the case of some very vigorous perennials, it may take a great deal of energy and dedication to the task in hand! Sometimes shoots for division can be taken off the side of a big clump, but it should be remembered that the centre of the clump may not be very productive and it might be better gardening practice to remove the entire clump and replace it.

Some plants for division may be in containers, so they should be removed from the containers, ready for division.
**Replanting:** If the plant is to be divided up in the garden, the gardener may work off a sheet of plastic or on a clean path. If it is warm, then it is better to work in the shade. The required divisions are taken off and replanted where required as quickly as possible into soil properly prepared with compost and slow-release fertiliser, etc. Plants should be set at the same level as before. (The soil mark can be seen as the change in colour and texture between the stem and the roots.) Water in thoroughly and provide proper after-care. Old material is discarded.

**Transport:** If the clump of plant material is to be taken to the propagation area to be grown-on, shake off the loose soil and discard any loose old material to reduce the weight. It should be transported as quickly as possible in a wheelbarrow or on a trolley. The plant should be wrapped or covered in wet newspaper and kept in the shade to prevent damage to the young shoots and roots.

**Labelling:** If more than one species is being divided, make sure that each is clearly labelled because dormant plants are not always easy to identify. This is particularly important where there may be different coloured cultivars of the same species.

**Hygiene:** A plant ready for division will still have soil attached so it may carry pests or diseases into the propagating area even if the plant does not appear to be affected. Division can be done in the potting-on area. The divisions may be gently washed clean of soil, but remember that washing may also damage the root hairs.
**Procedure**

- Examine the clump and locate the young, vigorous shoots.
- Depending on the plant, pull the divisions apart or cut these from the old stem with clean, sharp seateurs or a knife.
- Remove any damaged growth and old leaves.
- Trim back any excessive leafy growth to balance the shortened roots.
- Keep the selected divisions moist in damp newspaper on a bench until ready to pot-on.
- Pot-up in tubes or pots, depending upon the size of the division. Some new shoots may have a well established root system, while others may have only a few new roots developing.
- Containers should be placed in sheltered conditions for a few days until established, then gradually hardened-off.
**Rhizomes**

These are storage stems which develop underground and have nodes, internodes and leaves modified as leaf scales and buds. They develop adventitious roots. Some are quite thin while others are enlarged. All kinds are able to store carbohydrate and water for adverse seasons. Rhizomes can be lifted and cut up for propagation. These must be healthy buds on the pieces used so that new shoots can develop; for example, bearded iris, ginger, michaelmas daisy, mint and hybrid couch grasses. Rhizomes must be set just under the surface. Otherwise the procedure is as above.

**Fig. 8.2 Dividing the rhizomes of a bearded iris**

**Tubers**

The most common examples of these are dahlias and ranunculas. The tubers are lifted at the end of the autumn when flowering is complete and the leaves and stems have died down. They should be cleaned of soil, dead leaves and old stem tops, and any damaged tubers should be discarded. The tubers may be dusted with fungicide before storing until the next growing season.

Each dahlia crown may be cut with a sharp knife into several pieces, depending upon its size. Each division must have a vigorous tuber or tubers for food storage and healthy buds on the stem section.
8.8 SEPARATION

This term refers to a special type of division where the material for propagation is separated from the parent plant. It is generally used to refer to bulbs and corms, but also includes plantlets that form on stems.

Bulbs and Corms

Bulbs like jonquils and daffodils naturally produce bulblets or offsets from adventitious buds on the basal plate (Ref. Fig. 1.1). These become crowded around the parent bulb and need to be separated to grow on to maturity. Corms produce cormlets on the mother corm which wither away each season (Fig. 1.2) and some like freesias also produce cormels along the main flowering shoot after flowering. Cormlets and cormels both need to be separated to grow on or they become too crowded to develop.
Commercially, bulbs can be separated to grow on for sale, but there are also additional techniques used by the large bulb growers in the Eastern States to greatly increase the number of bulbs. These techniques (scooping and scoring) involve cutting the basal plate of a bulb so that the cambium tissue initiates many tiny bulblets which can be grown-on. Only specialist hobby growers are likely to use these techniques in Western Australia as the majority of our bulbs for retail sale come from the Eastern States.

**Plantlets**

These are very easy to propagate as they are easy to see attached to the stem of the mother plant. They readily produce adventitious roots and will root if in contact with growing media. They need to be potted-on and kept in sheltered conditions only until the root system is established; for example daylilies (*Hemerocallis*), crucifix orchids, spider plant (*Chlorophytum*), and strawberries (Ref. Fig 1.3).
Fig. 8.5 Plantlets on Chlorophytum Cosmossum Variegatum
Chapter Nine

Budding and Grafting

9.1 BUDDING AND GRAFTING

Budding and grafting describe a number of techniques where the bud or stem of a desirable cultivar is attached to another plant, usually of the same genus, which forms the rootstock.

![Diagram of a saddle graft showing polarity and labelings.]

Fig. 9.1 Polarity in a saddle graft

Scion

The top part of the graft or bud is called the scion. It is chosen because it has desirable characteristics which may include:

- Yield, size and flavour - any fruit, vines or nuts.
- Earlier or later fruiting time - marketability of produce.
• Lower requirement for chilling - low-chill stone fruits can be grown in areas not previously suitable for stone fruit.

• Size, fragrance and colour of flowers - roses.

• Desirable growth form - weeping standards, variegated and special colour forms of ornamental trees and shrubs which often don’t produce good root systems.

Selecting the Scion

Scion wood must be selected carefully:

• The scion must be collected from a correctly labelled cultivar.

• For grafting, it is a small shoot which must have several healthy vegetative buds from which the new growth can develop. It should not be too succulent, and will probably come from the lower part of the shoot.

• For budding, it is a healthy vegetative bud taken from a healthy stem section, called a budstick.

• For grafting in winter, the wood is generally about a year old; that is, it grew in the spring of the year prior to grafting taking place.

• For budding in summer, the budstick will have developed buds since the spring flush of growth.

• There must not be any visible signs or symptoms of pests and disease.

• Ensure that the polarity of the shoot is maintained, especially on deciduous shoots with small buds.
Stock

The bottom part is called the stock (also termed rootstock and understock). This part of the plant produces only the root system. It should not be allowed to produce any shoot growth once the graft has taken. Root stocks are chosen for a number of reasons, including such desirable characteristics as the ability to:

- Resist soil-borne pests and diseases, especially nematodes and Phytophthora cinnamomi. This is particularly important when old vineyards are replaced with new cultivars which need resistant rootstocks.
- Tolerate drought, especially in sandy soil.
- Tolerate salt.
- Support productive growth for many years.
- Produce a sturdy stem for standards.
- Produce a sturdy root system for variegated plants which often do not produce good root systems.
- Produce - when desirable - a shorter, sturdier but still productive plant, for example, dwarfing rootstocks for fruit trees.
- Prevent a scion suckering on its own roots.
- Give a much sturdier plant than one grown from a cutting of the scion.

Selecting the Stock

The stock plants may be developed from:

- hardwood cuttings; for example, roses and grapevines
- suitable seedlings; for example, peaches, nectarines, citrus fruit
- trench layers; for example, apples.
Like the scion, the wood must be correctly identified and free from pests and diseases.

It must also be easy to propagate and be reliable, as rootstocks are often needed in large quantities for plants such as fruit trees and roses.

Some rootstocks are budded or grafted while dormant in winter without being rooted. They are easier and quicker to handle then, especially where there is plenty of budwood. They are then callused and ready to grow-on in the spring.

Rootstocks from cuttings and layers will be about one year old when ready for grafting in the winter and about six months old when budded in summer. Seedlings may be of various ages, depending upon the budding or grafting method chosen and the time of the year.

**The Graft Union: The budding and grafting process**

Within a dicot stem the vascular bundles are arranged in a ring. In shrub and tree stems, the bundles are linked by a thin line of cambium cells which divide to produce additional phloem and xylem as the stem increases in girth. The vascular bundles then merge into rings of phloem, cambium and xylem.

![Diagram of Cambium in Young Dicot Stem](image)

*Fig. 9.2 Cambium in Young Dicot Stem*
Monocot plants cannot be grafted as they do not have a ring of cambium which can be matched up in the stock and the scion.

With grafting and budding, the cambium of the stock plant is exposed and the cambium of the scion is placed firmly in contact by a variety of techniques. Given the correct conditions, the graft or bud begins to take. The cambium divides to form callus tissue so that the two are fused together. It is vital that the vascular bundles of the stock and the scion line up so that the phloem, cambium and the xylem match up. The cambium divides to produce new phloem and xylem. Then the xylem continues to function, taking water and nutrients into the new shoot and the phloem translocates growth regulators and carbohydrates from the shoot tips and the leaves as they form. As secondary growth develops, the stem thickens over the graft union, making a sturdy plant.

![Diagram of grafting process]

**Fig. 9.3** The Process of Grafting
9.2 ADVANTAGES

Some plants are only propagated by one of the methods of budding and grafting. Budding and grafting are specialised skills though they become less tricky with practice and skilled propagators can bud over 2000 roses per day, with a high success rate.

- It is the only way to propagate some plants which will not grow easily from cuttings, layers etc.

- It is the method of propagating roses, grapevines and fruit trees commercially to ensure that the cultivars are true to name. Seedlings would be too variable.

- Rootstocks of these plants (roses, grapevines and fruit trees) are more resistant to drought and live longer than roots on the cultivars. Grafting on special rootstocks suitable for Western Australian conditions extends the range of plants available here.

- Grafted plants - for example, roses - flower well in two-to-three years.

- Used for special effects such as weeping standards of various shrubs, including roses, Grevillea ‘Royal Mantle’ and Cupressus macrocarpa ‘Greenstead Magnifica’.

- Can be used to rework old fruit trees with new cultivars which may be better quality, more in demand, and ripen at a different time.

- Can be used to prevent problems with cross-pollination of fruit trees such as apples and plums as compatible cultivars can be put onto the one rootstock. This is called a multigraft and multigrafted fruit trees are available for home gardeners to save space.

9.3 DISADVANTAGES

- Grafting and budding are skills which require practice to ensure good contact between the meristematic tissues in the stock and the scion.

- The stock and the scion must be compatible; that is, from the same genus and very occasionally between genera in the same family, so there are limitations on the material which can be used.
9.4 COMMERCIAL USES

Various methods of grafting and budding are used to propagate:

- Almost all roses, except some of the intensively grown roses for floriculture.
- Wine and table grapevines.
- Avocados, mangoes, pecan nut trees, pome, stone and citrus fruit.
- Flowering fruit trees for ornamental display; for example, flowering peaches, almonds.
- Deciduous ornamental trees: many are grafted from selected specimens to ensure autumn colour; for example, *Liquidambar styraciflua*.
- A variety of special forms; for example, weeping standard roses, various weeping ornamentals.

9.5 COMPATIBILITY

For the graft to unite properly, the stock and the scion must be closely related. Plants that are not closely related either will not take or will only form weak unions which are liable to break. The stock and scion are mostly from different species within a genus - a cultivar with special characteristics onto a rootstock that is either a hardy species or a special rootstock cultivar; for example:

- Roses are best budded onto *Rosa 'Fortuniana'* rootstocks.
- *Prunus* (almonds, peaches, plums, nectarines) onto other *Prunus* rootstocks, with their own species preferred.
- *Malus* (apples) onto special *Malus* rootstocks.

Although there are not many examples that are used commercially, there have been some successful grafts between different genera within a family.

- Commercial *Citrus* spp are budded onto *Poncirus trifoliata* which is a closely related genus with no other commercial value. Both are RUTACEAE.
• *Prostanthera* (Mint Bush) are susceptible to *Phytophthora* and are grafted onto *Westringia fruticosa* which is resistant to *Phytophthora cinnamomi*. Both are LAMIACEAE.

Grafting between genera in different families is not considered possible because the tissues are not compatible enough to unite.

### 9.6 TIMING

Timing depends upon the species involved and the method being used. Some plants may be done by different methods at different times of the year; for example, grapevines can be budded or grafted onto rootstocks grown from hardwood cuttings struck from pruneings. Vines can be propagated while dormant or with green chip buds while actively growing in the early summer.

Most grafting of deciduous trees and shrubs, including fruit trees, is done in late winter when deciduous shoots of scion material are dormant but growth is timed to start as the graft takes, for example, plums, apples. These may also be done outside in a growing area or in the field in cool weather.

Evergreen material (*Citrus*) is done from late spring to summer when there is active growth and sap flow, but the budded plants need careful attention to prevent drying out in warm weather. The largest stock plants, budded in late spring, may be ready to sell in the following winter/spring, but those which are budded in the summer will not be ready for sale until the following year when about two years old.

Some roses may be budded in late spring if the rootstocks are well established and the budwood is ready which depends on the rose cultivar. Most roses though are budded in summer and grown-on to sell when at least a year to two years old. Many are budded in containers and sold when ready as container plants usually in flower. Roses to be sold bare rooted are left in the field until it is time to lift them in the early winter.

### 9.7 GRAFTING TECHNIQUES

Grafting is a very old technique, having been practised for hundreds of years, and there are now several main methods that are used commercially. Some of the other methods have been superseded by faster methods suitable for commercial propagation, though there are some plants which will only accept particular kinds of grafts.
Unless for some special purposes like the grafting of a standard or reworking, the graft union will generally be about 10 - 15 cm above the soil surface. If placed any lower it could be buried in mulch later and become prone to disease and damage. Graft unions that are higher can sometimes be unsightly because the bark of the stock and the scion are not the same, and the graft union can develop into a large lump, as usually happens with roses. However, there is a trend towards higher grafts (30 - 40 cm) in plants particularly prone to collar rot infection so the graft union is well above mulch and moist soil.

Tools used to collect and prepare the material that is, secateurs, budding knife, pruning knife and scalpel blades should be very sharp and disinfected to make clean, precise cuts. There are machines called grafting machines which can cut the stock and scion automatically for grafting. Many propagators do not like them because they can damage the material too much, so they are only economic if there is a lot of stock and scion material available from prunings.

In the past, grafts were sealed with wax but now they are usually bound with budding tape or Parafilm®. This is to prevent the graft union drying out, becoming too wet, or being invaded by pests and diseases. It also helps to keep the stock and the scion firmly together. When the graft takes, the wrapping is removed, though some of the newer tapes biodegrade with time, saving much labour removing the tape around the graft/bud union. However, they still need to be checked or the union can be strangled by the tape.

*Whip and tongue* grafts and *saddle* grafts are used when the stock and the scion are smaller or very nearly the same diameter and it is possible to match up the vascular bundles most of the way around the graft union.

*Cleft* grafts are used when the stock is much larger than the scion material. This is a very important technique used when the rootstocks of older but healthy fruit trees are regrafted with new cultivars. This is called *reworking*. These new scions will grow much faster on an established root system. Problems with cross-pollination can also be overcome by putting compatible cultivars on the same rootstock.

**Saddle Grafting**

The stock and the scion are cut, as shown in Figure 9.1. It is most important that the angle of the cuts match so that the saddle fits closely without too much space between the tissues. This is considered an easier method to prepare than whip and tongue grafting, but the latter, when done properly, is more reliable.
Whip and Tongue Grafting

This is a very common method of grafting:

- Select suitably sized stock and scion material. The scion should have at least three buds.

- Make a sloping cut on the stock and the scion so that the angle matches to obtain a good fit. The cuts must be neat without any ragged edges and should be just below a bud on the scion.

- Along each of the cut surfaces, make a short cut parallel to the length of the wood and about one third of the way along, as shown. The pieces form the tongues.

- Fit the tongues together. For a good graft, there should be a tight fit with the vascular bundles and therefore the cambium adjacent. There should not be any daylight between the scion and the stock. If so, the angle of cut was not precise enough. This takes considerable practice to get right.

- Bind the graft with budding tape or Parafilm®, which may need to be removed when the graft union has properly formed. Depending on the type of tape, labour can be reduced as some tapes are biodegradable.

![Diagram showing stock and scion with cuts](image)
Cleft Grafting

The prepared scion or scions are placed in the cleft in the prepared stock so that the cambium of the scion touches the cambium of the stock, as is shown in Fig. 9.5(a) and 9.5(b).

Fig. 9.5(a) Cleft grafting
Approach Grafting

This is a special type of grafting reserved for plants that are difficult to propagate; for example, grevilleas on a standard of *Grevillea robusta*. The scion is not detached from its stock plant but is brought to the rootstock - easiest if they are both in containers - and the graft carried out. This procedure is most likely to be successful when the plants are in active growth in the spring. If the graft is successful the scion is cut off, but if it is not successful the scion still remains as part of its parent plant.

- Position the containers so that the shoot and the rootstock are together and without any tension.
• The bark and the phloem of both are carefully removed with a knife or a scalpel if the bark is very thin. The two cambium layers are then bound together with film or tape. Both the plants should receive good care to prevent stress while the graft is taking place.

• If the graft is successful, the base of the scion just below the graft and the shoot of the stock just above the graft are cut off very neatly. The grafted plant will need care in a sheltered environment until the scion is entirely adapted to absorbing all the water and nutrients it needs from the rootstock.

Fig. 9.6 Approach grafting
Green Tip Grafting

This is a relatively new technique which is now being used commercially by some nurseries in Western Australia to propagate citrus, avocados and mangoes. It has been used overseas for some years and when properly done produces a well-formed plant in a much shorter time than conventional budding or grafting.

The stock is a seedling which is grown-on so as to be about 22 to 30 cm tall. These seedlings are usually grown in large tubes in a glasshouse to be ready in time for grafting in early spring.

The scion selected from a desirable cultivar is a very small apical or tip shoot which is ready to break dormancy in the spring and so contains two or three buds still very close together. The tip shoot must be removed before the shoot starts to expand - usually August or early September depending on the location and the weather. If the stock plants are ready, grafting can be done immediately, but if the stock plants are not ready, the tip shoots are kept moist and stored in the refrigerator for a few weeks and grafted in September.

The apical bud or tip shoot of the stock plant is cut out with a scalpel and the tip of the scion is prepared as a wedge graft and placed in the top of the seedling. This is very delicate work as the structures are very small, soft and easily damaged. The plants remain under close supervision in a glasshouse until the grafts take. Callusing may start within a fortnight. As they develop, the plants are potted-on and hardened-off for sale in the usual way.

When the graft takes, growth is very rapid and the tree has a much better form than that grown from a T-bud in the side of the stock. Plants are often ready for sale a year sooner provided they have been given the very best care.

9.8 BUDDING TECHNIQUES

- Budding is similar to grafting in that the scion is the bud with all its characteristics, and the bud is budded onto a rootstock with its own special characteristics.

- Budding is more economical than grafting as only one bud is needed per rootstock. New cultivars of a plant that can be budded; for example, a rose, can be multiplied much more quickly by budding than grafting.
• Budding is carried out from spring to summer when the new spring shoots have matured enough for the buds to be visible. A shoot with suitable vegetative buds is called a budstick. Growth of the stock must be active and the bark of the rootstock at the right stage to peel neatly and quickly for T-budding.

• Collect the budsticks when ready to begin budding. Remove any prickles or thorns to make handling easier. Remove the leaves to reduce transpiration but leave the petioles to help hold the bud. Keep the budsticks damp, wrapped in wet newspaper.

• Budding results in a very strong union forming. There is very little chance of the twisting and loosening that could occur with a graft.

• Budding results in a smaller wound than in grafting so there is less chance of infection.

• The same comments regarding compatibility and polarity also apply to budding.

There are several main types of budding: T-budding, inverted T-budding, chip budding, patch budding and micro budding.

T-budding and Inverted T-budding

These methods are so named because a shape like a capital T is cut into the rootstock to receive the bud. An inverted T is cut the other way up and many propagators prefer this because water is shed down the stem past the bud. An inverted T is also used when the sap is flowing freely.

Preparation of the Rootstock

• Remove any prickles or thorns in the way.

• Because budding is done in the warm weather, an active stock plant will already have produced some shoots. It is necessary to keep a proportion of these to photosynthesise, and translocate water, nutrients and sugars past the bud. If the bud is deprived of this sap flow it may die or remain dormant for a long time.
• The T cut is about 2-3 cm across and down.

• Lift the bark carefully, but do not allow it to dry out.

Preparation of the Bud

• Hold the budstick with the bud facing you.

• Slice through from just under the bud to just above it to include the bud and a piece of bark for support. The bud will be about 2 - 2.5 cm long. Do not allow the bud to become dry.

• Any wood included behind the bud may be flicked out as it may hinder callus development.

• Push the bud into the T shape so that it is firmly tucked under the flaps of bark, and the two layers of cambium are touching. Ensure the polarity of the bud and the stock.

• Wrap firmly with budding tape so that the bud is still exposed.

• The leafy shoots from the stock are progressively removed as the bud develops into a shoot. If these are trimmed too quickly, the stock plant will be stressed affecting the survival of the bud. The new shoot from the bud cannot provide sugars until it has developed healthy leaves.

• Care must be taken when the stock plant is finally trimmed off above the bud union not to damage the new wood formed by the new shoot or the stock may die back and affect the bud union.
Patch Budding

Patch budding is a special technique which is used particularly on nut trees (pecans and walnuts) which have thick bark which does not peel back as is needed for a T-bud. The propagator uses a special tool with parallel blades to cut a small rectangle of bark out of the scion wood around a bud. The same tool then cuts out a rectangle of bark in the stock plant and the bud is fitted into place and tied on in the usual way. Nut trees are usually budded in February and the buds begin to grow in the spring.
Chip Budding

This is a more difficult form of budding which may be carried out during dormancy. A chip of bark and tissue is cut from the rootstock, and a matching chip, including the bud is cut from the budstick. It is more difficult to cut the chips to match than to do T-budding. The fitted chip is then bound in tape as in other budding methods.

Chip budding is used on grapevines because the bark does not slip open easily enough for T-budding.
Micro Budding

This is a special type of budding used on citrus in late spring and summer. A microbud, which is just the bud with only the tiniest amount of bark around it, is inserted into the bark of the stock. This is a very economical way to utilise all the buds on a budstick, especially in citrus where the new wood is triangular and conventional buds would not fit properly into the T. The method used to insert the bud is the same as T-budding but, as the bud is from immature wood, there is no wood to flick from the back of the bud as with the usual T-budding. This is very fine work and has to be done with care and a very sharp blade. The plants need considerable aftercare but make good growth.
Shoots on the stock plant are gradually trimmed off as the bud takes and begins to grow. This may take several trimmings to avoid stressing the stock. It takes 2 - 3 years for a citrus tree to grow to a good saleable size for retail.
Chapter Ten

Micro-Propagation

10.1 MICRO-PROPAGATION

Micro-propagation, often known as tissue culture, is a relatively new method of asexual propagation that has only in recent years moved from purely research to commercial application on a large scale.

The processes of micro-propagation take place in a laboratory under strictly controlled hygienic conditions. Temperature and lighting are controlled to suit each stage of development of the plantlets.

Stages of Development

Establishment

The meristem of a vegetative bud is divided up and the cells are sealed in a plastic or glass container (called a flask) on a gel solution consisting of:

- agar - the support medium for the other ingredients
- sucrose - for energy
- macro- and micro-nutrients
- enzymes and vitamins
- plant hormones or growth regulating compounds for shoot and root initiation.

The sealed flasks are placed on shelves in controlled temperatures under artificial lighting to promote photosynthesis. The shoots develop first and adventitious roots develop on the base of the stems.
Multiplication

The cells divide and many vegetative cells develop. These clusters of plant growth (callus tissue) are further divided and transferred to a new flask with fresh medium. This may happen several times so that many plantlets have developed from the original meristem.

There is a limit to the number of times that the callus should be divided before genetic changes which are not desirable start to occur. Laboratories have to be aware of this or the plantlets being sold may lack vigour and not be true to type.

![Diagram of Multiplication Process]

(i) Establishment
(ii) Multiplication

Cells on agar for shoot initiation
Callus development

(iii) Pre-transplanting
(iv) Plants in agar solution for initiation of adventitious roots
Leaves developing from callus as plantlets form

Fig. 10.1 Stages in Micro-propagation

Pre-transplanting

As shoots and leaves develop, the plant material is divided again and transferred to a different medium with root promoting hormones. Intensity of lighting may increase as more leaves are produced. The small plants with some leaves, stem growth and roots grow-on in
laboratory conditions with controlled light and temperature until large enough to be handled and potted-on. At this stage, they are ready for transplanting or for sale in containers suitable for air freighting.

**Transplanting**

The plantlets are removed from the flasks (called *deflasking*) and grown-on in very sheltered conditions. The plantlets have been produced in totally sheltered conditions of 100% humidity in the flasks.

The main problem is to ensure that the plantlets adapt to growing in normal environmental conditions in a gradual way.

10.2 **ADVANTAGES**

- Many plants can be produced from the one meristem which is particularly important where there is a very limited supply of the particular stock plant; e.g. a new cultivar.

- Meristem tissue is free of disease, including viruses, and the sterile conditions in micro-propagation prevent the carrying and spread of pests and diseases.

- Commercial quantities of fashionable plants or new or rare cultivars can be produced quickly.

- Laboratories are specialised to produce large quantities of high quality plants for production nurseries to grow on for sale.

- Many plants can be produced in a much smaller area than would be required for cuttings.

- Sterile plants in flasks can be imported from interstate and overseas without risk of disease thereby avoiding expensive and time consuming quarantine procedures.

- Small micro-propagated plants have a better growth form than cuttings of the same species and so can be retailed as tube stock or used in terrariums.
10.3 DISADVANTAGES

- The equipment needed for micro-propagation is very specialised and very expensive so the production of commercial quantities of plantlets is concentrated in a few laboratories.

- If callus is subcultured too often, the quality of the plantlets will deteriorate and will not be uniform in growth form, size and vigour. To prevent this occurring, growth must be regularly re-initiated from fresh meristem from high quality stock plants.

- Plants can be lost if the deflasking and hardening-off stages are not carried out with care.

10.4 COMMERCIAL USES

Because micro-propagation is expensive, it can only be used where there is a definite commercial advantage or a real need for a large quantity of plants not easily propagated by other means; for example:

- The production of many indoor plants and ferns. Large quantities of small attractive plants can be produced quickly and the market can respond to the demand for new and fashionable cultivars.

- Plants such as kangaroo paws, which are susceptible to disease, are more disease-resistant because disease-resistant strains can be propagated in large quantities.

- Salt-tolerant varieties of some native plants useful for regeneration can be propagated in much larger quantities and more reliably than by any other method.

- Large quantities of cultivars used in production horticulture can be developed quickly; for example, new cultivars of grapevines, cultivars for floriculture and fashionable houseplants.
10.5 DEFLASKING AND TRANSPLANTING PLANTLETS

Flasks

Production nurseries generally do not produce the plantlets but buy them in from the laboratories. Flasks may vary with the supplier but a typical example used in Western Australia is illustrated in Figure 10.2. The flasks are made of slightly opaque plastic with a tight fitting lid. There is about 1.5 cm of rooting gel in the bottom and about 30 to 35 plantlets with some leaves and developed roots. As the plantlets keep on dividing, there may be more in some species.

The flasks must be kept in warm conditions with adequate but not high levels of light because the plantlets are very sensitive at this stage, having been developing in the flask in conditions of strictly controlled light intensity and duration, temperature and 100% humidity.

Remember, that when handling and locating the plantlets:

- They need some light to photosynthesise.
- The leaves are transpiring.
- The leaf tissue has developed in 100% humidity and has not yet developed a proper epidermis. It will take time to acclimatise to normal glasshouse conditions in air.
- The leaf tissue takes time to adapt to stronger light levels and avoid the risk of photo-respiration, whatever the species and its ultimate position when mature.
- The root system is not vigorous and may be very brittle as it has developed in solution, not in a growing media with air.

Preparation

The bench and all the equipment used for deflasking must be sterilised and the media either sterilised or treated with a fungicidal drench.
De-flasking

The flask is opened and the plantlets are gently separated and washed in a container of tepid to warm (not cold) water to remove as much of the rooting gel as possible. This is to ensure that the roots make proper contact with the media particles to absorb water, nutrients and oxygen. Care must be taken with the roots which may be tangled, as the plantlets are crowded in the flask. In some species, the roots are very brittle and the plantlet will be weakened or die if the roots are broken.

Keep the plantlets moist at all times in a container of water.

Grading and Transplanting

The plantlets are then graded. The largest may be advanced enough to go directly into tubes of growing-on media. These plantlets will have several leaves and a developed adventitious root system. After several days in controlled conditions, they will be ready to grow-on then harden-off for potting-on or sale elsewhere.

The remainder will consist of small plantlets with short roots which need extra time to develop an adequate root system. This material is dibbled in rows in trays of a peat-perlite media and kept in controlled conditions of high humidity, (approximately 90%), reduced light and temperatures of about 27°C until the roots are fully developed and the leaf area is greater. These conditions may be provided in a special growing house or in a mist tent for smaller quantities. The plantlets can then be tubed-up when more established.

Fig. 10.2
Flask of Plantlets Ready for Transplanting into Trays and Tubes
There may also be clumps of recently divided vegetative material with only root initials and these can also be divided and planted out into trays. Using the small pieces of less developed material is a balance between the cost of the flasks of plantlets and the space taken up by the trays, especially when thousands of plantlets are being grown.

Growing-on

When first deflasked, the plantlets need to be in a warm, moist environment with regular fogging to prevent the leaves drying out until they adapt to being in the air. Light levels need to be low to prevent photorespiration in the soft tissue. Bottom heat encourages the development of roots. Regular weekly drenching with fungicide is usually necessary to prevent any risk of disease in the humid conditions. As the plants develop, they can gradually be moved to conditions of brighter light appropriate for the species.

10.6 PROCEDURE FOR DEFLASKING

- Prepare media for trays and for growing on.
- Sterilise benches and equipment, including containers to hold the plantlets.
- Remove plantlets from flask and wash gently in tepid water to remove the agar gel.
- Carefully untangle the roots while washing off the agar.
- Grade the plantlets, separating those large enough to tube-up and keep moist.
- Tube-up the larger plantlets into tubes of growing on media containing some fertiliser.
- Dibble the smaller plantlets in close rows into trays of peat/perlite media.
- Place the tubes and trays into a mist tent or a glasshouse with very high humidity.
- Monitor the needs of the plantlets and gradually harden off according to the species.
- Treat media regularly with fungicide.

10.7