In the Name of God

Plant Propagation

M. Gholami

Definition of Propagation

- What is propagation?
  - *Propagation is the natural mechanism by which plants regenerate.*
  - *Propagation is most often by seeds produced by a plant*
  - *or by plant parts like vines, roots, tubers, stem cuttings etc..*

Vegetative Propagation

- Asexual propagation (vegetative propagation) = reproduction of plant material from vegetative organs (leaf, stem, root, bud) so that the offspring will contain the exact characteristics of the parent plant with regards to genotypes and health status.

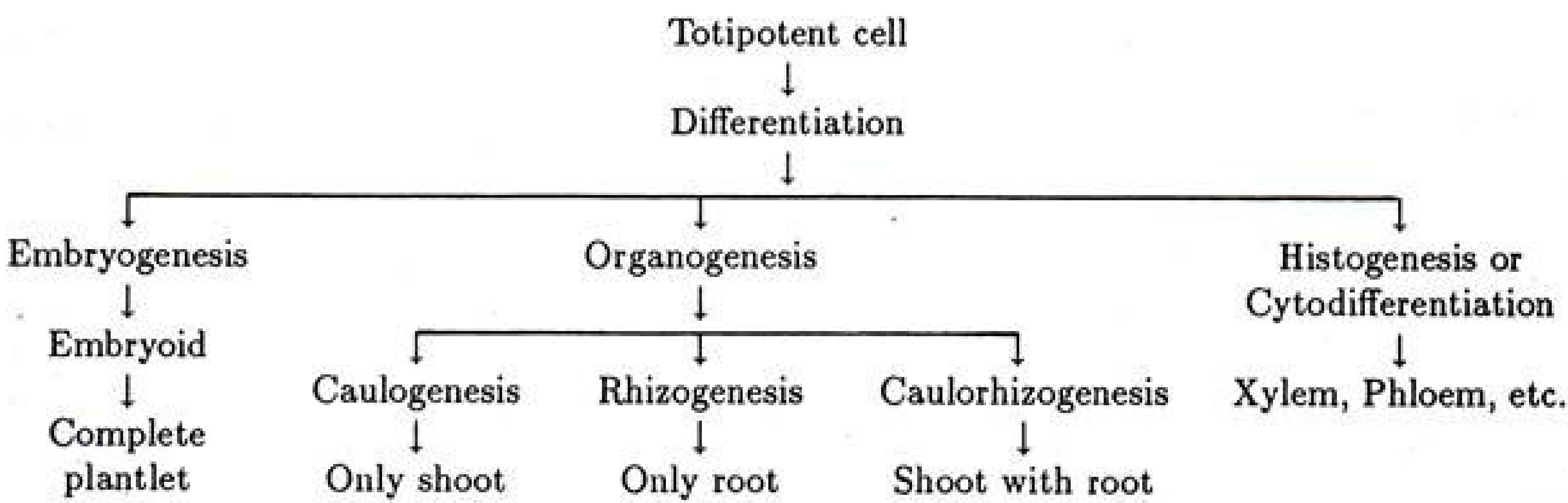
Updated slide

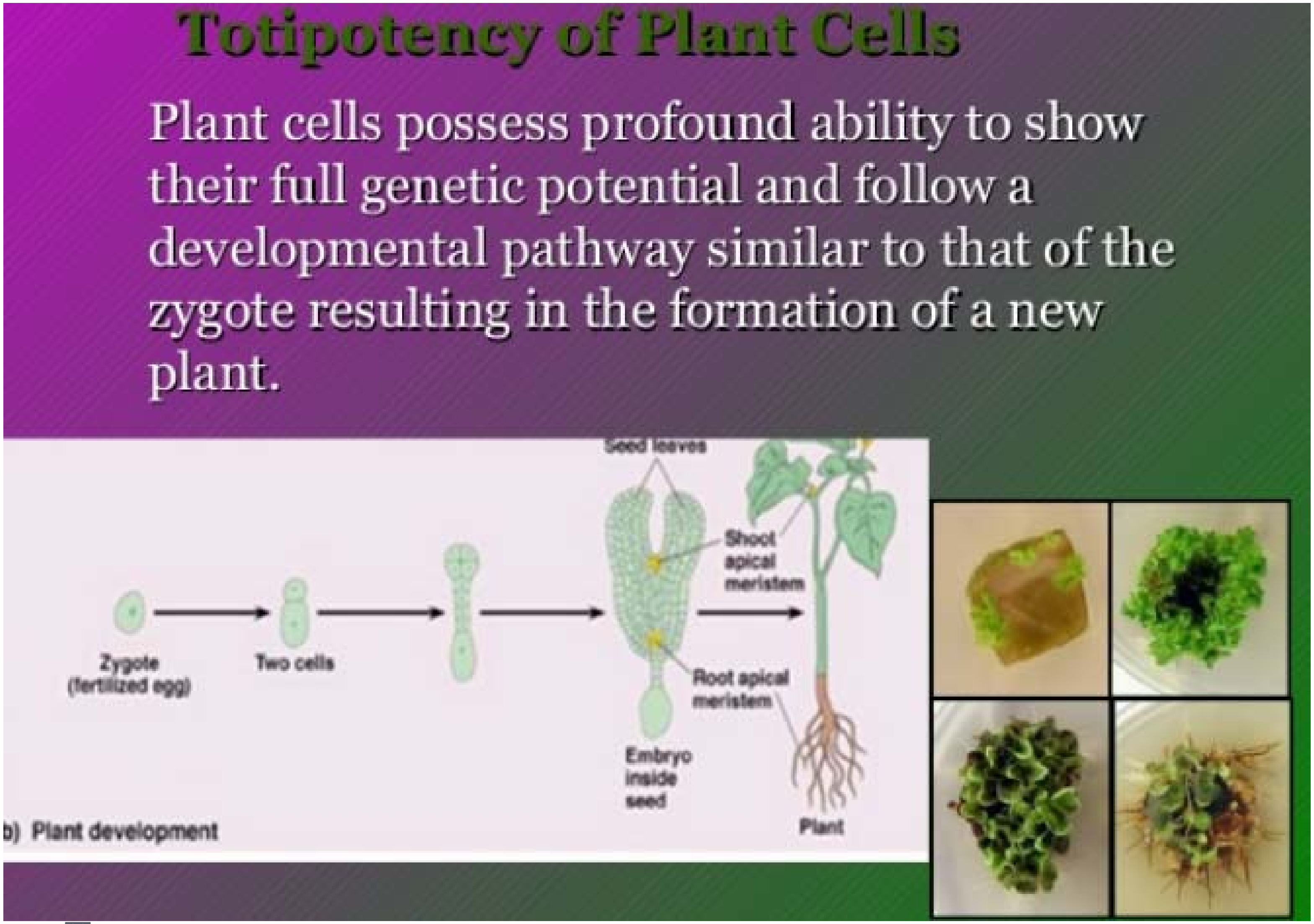
Concepts important in asexual propagation:

Totipotency
Differentiation
Dedifferentiation
Meristems (undifferentiated cells!)
  Primary "Apical" (root - shoot tips)
  Secondary "Lateral" (vascular-cork cambiums)
Adventitious

Plant growth hormones **1+1=2**
  Auxins Greek origin "means to grow"!
  Cytokinin compound promotes cell division. Highest concentrations found in root, young leaves, developing fruit

- همچنان که گیاه رشد و نمو میکند، سلولهای مریستمی برنامه ریزی می شوند تا به سلول های ویژه ای تمایز یابند که ساقه، برگ، ریشه و در نهایت گل و اندام های زایشی را تولید کنند. پیشرفت این مراحل (ontogenetic) در زندگی گیاه (چرخه زندگی) به مراحل رویانی (embryonic)، نونهالی (juvenile) و بالغی (adult/ mature) موسوم است.



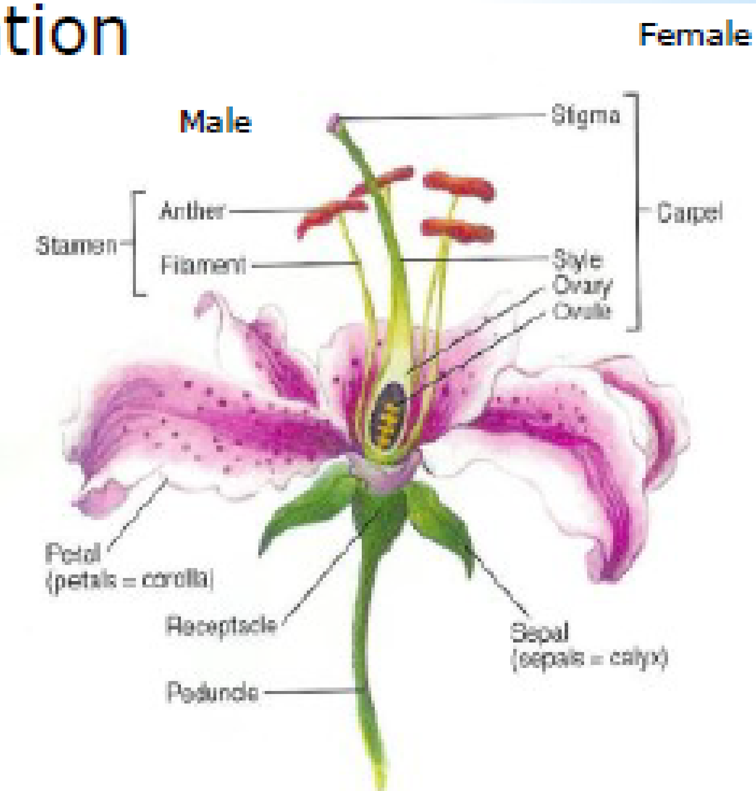


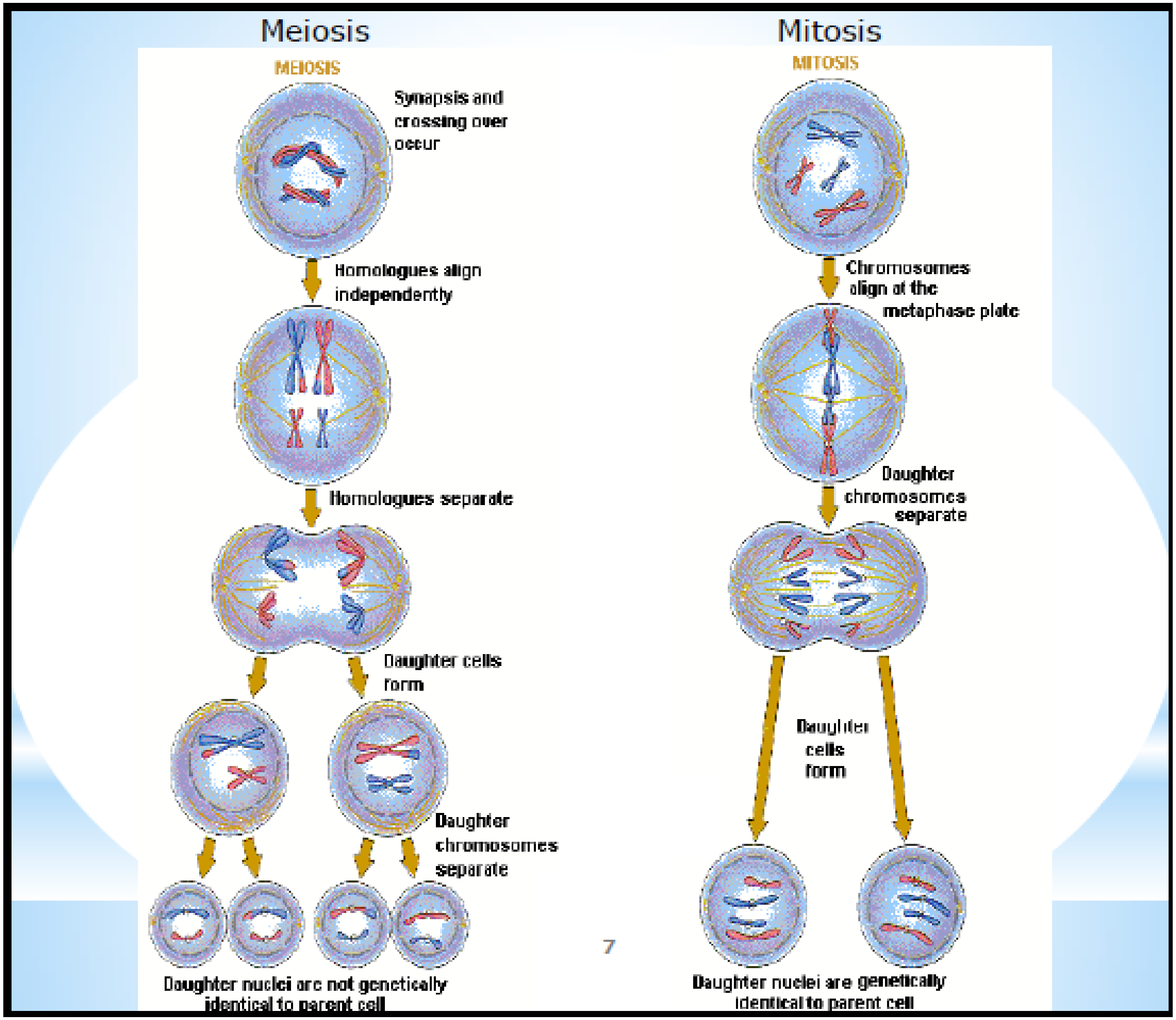
TOTIPOTENCY IS THE GENETIC POTENTIAL OF A PLANT CELL TO PRODUCE THE ENTIRE PLANT. IN OTHER WORDS, TOTIPOTENCY IS THE CELL CHARACTERISTIC IN WHICH THE POTENTIAL FOR FORMING ALL THE CELL TYPES IN THE ADULT ORGANISM IS RETAINED.

Sexual vs. Asexual

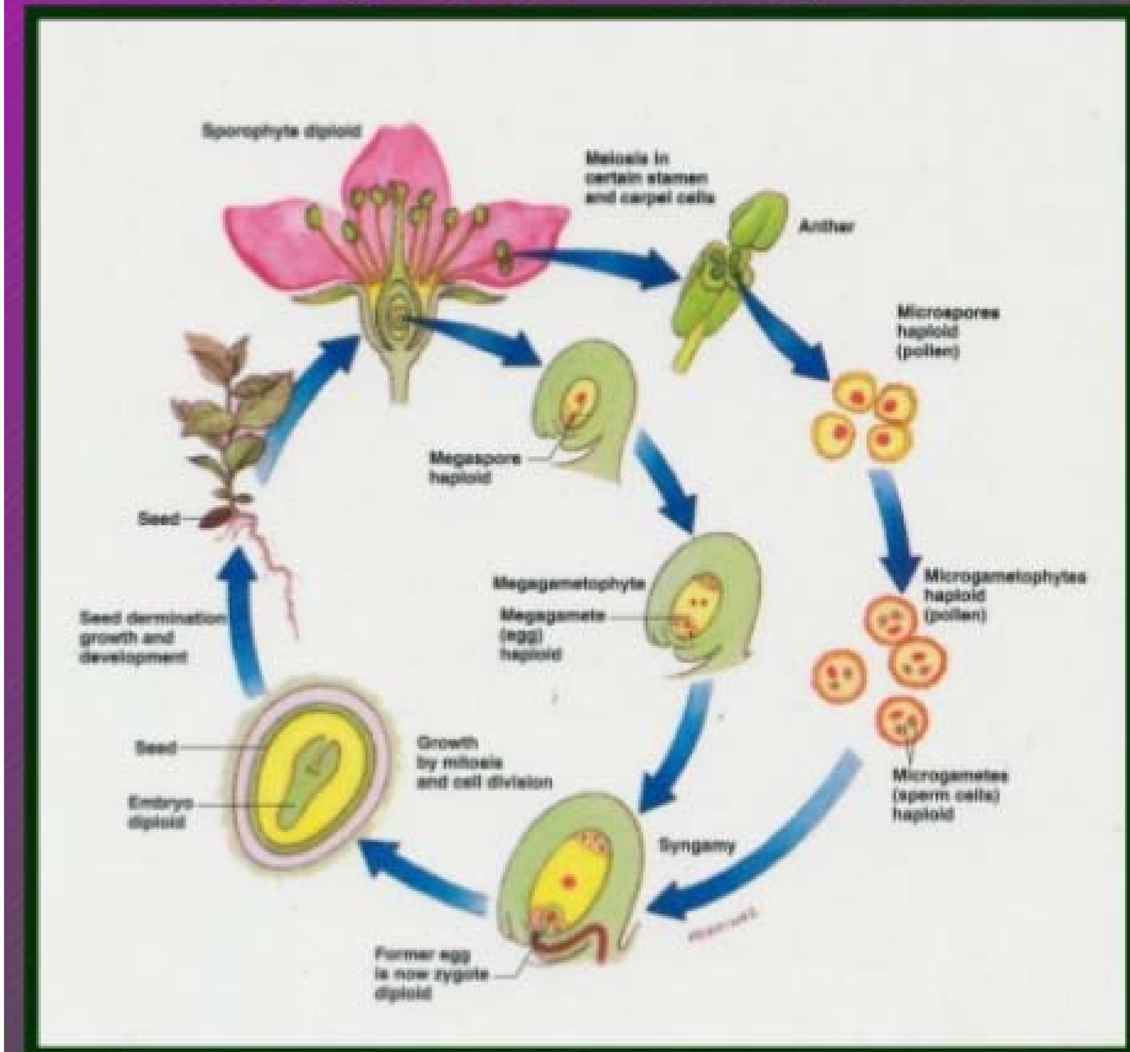
Sexual propagation

- end result is a seed




Meiosis
MEIOSIS
Synapsis and crossing over occur
Homologues align independently
Homologues separate
Daughter cells form
Daughter chromosomes separate
Daughter nuclei are not genetically identical to parent cell
Mitosis
MITOSIS
Chromosomes align at the metaphase plate
Daughter chromosomes separate
Daughter cells form
Daughter nuclei are genetically identical to parent cell

Angiosperm Life Cycle



واریته
CULTIVATED VARIETY
(CULTIVAR) رقم

Reasons for Sexual Propagation

- Create new varieties
- Create resistance to insects and disease
- Create new flower and/or foliage color
- Create new form and texture

Seed Storing

- Keep cool and dry
- Warm and moist conditions are the greatest enemies of stored seed
- Keep seed in paper verses plastic bags

Germination of Seeds

- Viability
- Purity percentage
- Germination percentage
- Pure live seed = Purity % x Germination %

Breaking Dormancy

- Stratification – exposing the seed to cold
- Scarification – abrading the seed coat
- Soaking – use moderately warm, not boiling, water
- Acid Soak – tough seed coats require mild acid solution to soften the seed coat

Germination Requirements

- Optimum temperature range
- Light requirement
- Moisture requirement
- Information charts exist for most plants

What Happens Next?

- Seed imbibes water and swells
- Seed coat splits
- Radical appears
- Seed leaves appear
- First true leaves appear

Sexual (Seed) Vs Asexual (Vegetative) Reproduction

Cross pollination ensures variation

More resistant to disease.

Dispersal reduces competition.

Seeds can remain dormant and survive unfavourable conditions

Sexual reproduction favours evolution

New plants well developed before separating from parent

Retain parental genotype.

New plants obtained in a shorter time.

Only one parent needed.

Sure of establishing new daughter plant

Sexual Vs Asexual Reproduction (2/2)

- Seed production - complex.
- A lot of seed produced - few new plants obtained.
- Pollination + dispersal depend on external agents.
- Seeds + fruits eaten by animals

- Grow in clumps - competition for minerals, light, space.
- Susceptible to disease - all genetically similar - clones

Cloning

clone: all offspring genetically identical - produced asexually i.e. all have come from one original parent e.g. King Edward potato.

Clones are produced by mitosis.

All the offspring from the various methods of vegetative reproduction (both natural and artificial) mentioned above are examples of clones.

WHAT HAPPENS?

Part of the plant becomes separated from the parent plant and grows into a new plant.

New plants generally develop from an axillary bud of the parent plant.

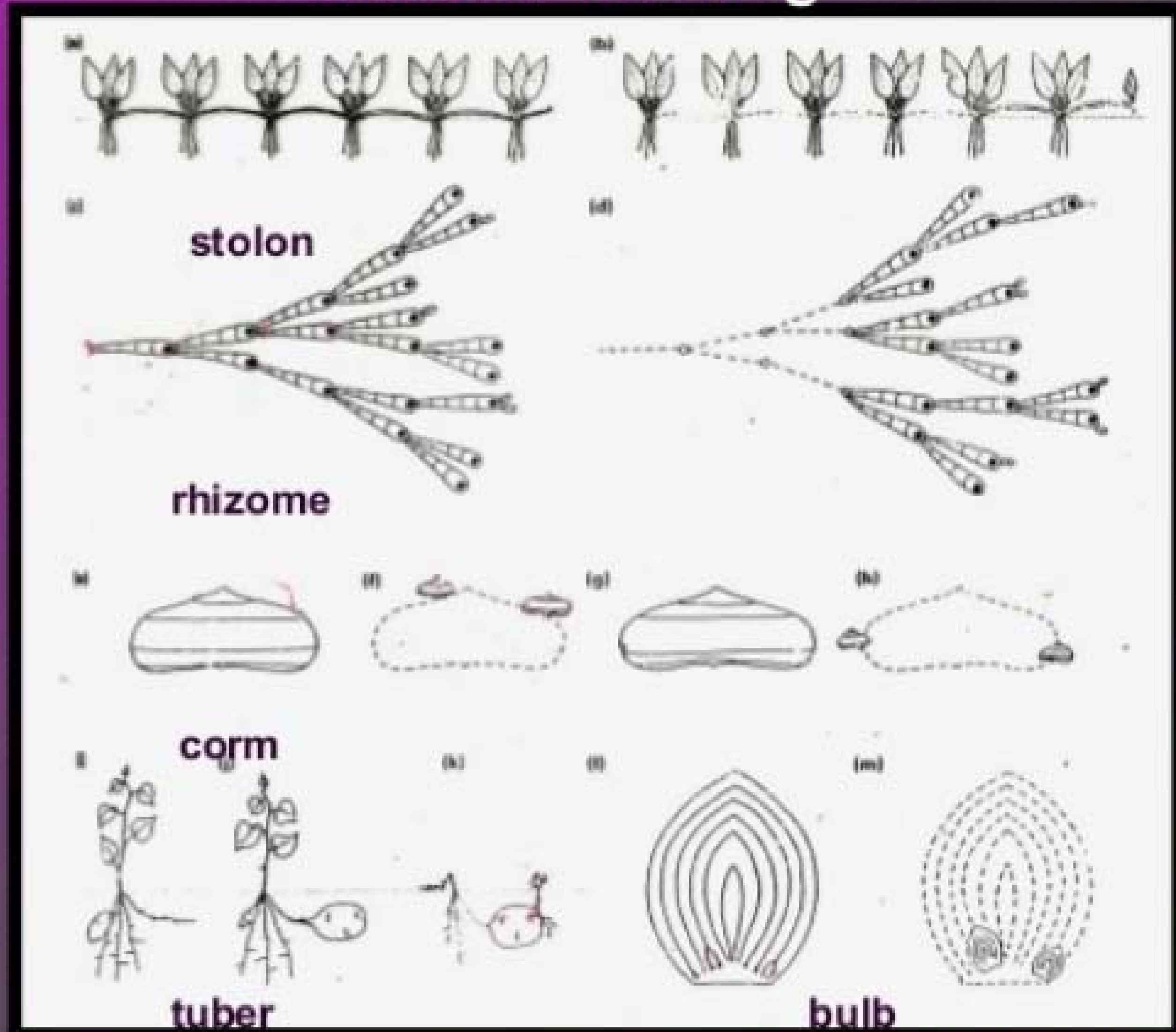
Parts of the parent plant are specially modified for the purpose.

Methods of Asexual Propagation

- Cuttings
- Layering
- Grafting
- Offsets
- Separation
- Division

What's the biology involved?

Natural Cloning



VEGETATIVE PROPAGATION

vegetative propagation: reproduction not involving seed

Two types:

Natural e.g. rhizomes, corms, tubers, bulbs,

Artificial - used by gardeners to propagate plants e.g. cuttings, layering, grafting, and budding.

When is it appropriate to use vegetative propagation

- When the species in question:
  - is an out breeder; (*outbreeding* depression is when progeny resulting from crosses between genetically distant individuals (outcrossing) exhibit lower fitness in the parental environment than either of their parents)
  - is dioecious;
  - has recalcitrant seeds;
  - has low germination rates;
  - flowers and fruits erratically and;
  - to capture their genetic diversity.

Rationale for vegetative propagation….1

- *Maintaining superior genotypes*
  - Most tropical tree species are outbreeders implying that through the recombination of genes during sexual reproduction, many important characteristics might disappear. If a superior individual tree has been identified by farmers or researchers, its genetic information can be 'fixed' through vegetative propagation, thus allowing the reproduction of the same superior individual in the next generation

CREATION OF A CULTIVAR

Variation in Allanblackia fruits

Anticipated earlier fruiting, smaller trees and uniform quality *Allanblackia* fruits

RATIONALE FOR VEGETATIVE PROPAGATION….2

- *Problematic seed germination and storage*
  - Some tree species produce seedless fruits (e.g. banana) and need to be propagated vegetatively, others bear fruit very scarcely or erratically (*Prunus africana)* or seeds difficult to gereminate *(Allanblackia spp)*.
  - In these cases, vegetative propagation might be a suitable and cheaper alternative to seedling production.

Rationale for vegetative propagation….3

Shortening time to flower and fruit

- Most vegetative progaules originate from scions or cuttings from mature trees, and maintain the characteristics of maturity after grafting or rooting.

Flowering *Allanblackia* graft

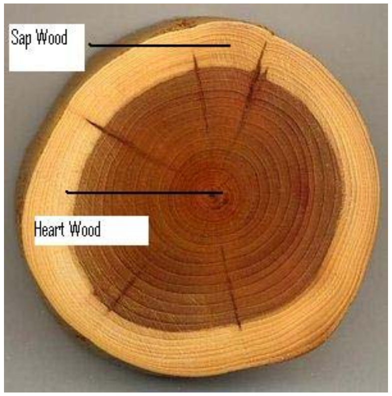
Rationale for vegetative propagation….4

- ***Combining more than one genotype in one plant***
  - Grafting is a unique way of combining desired characteristics from two or more plants into a single one.
  - Graft scions with particular fruit characteristics onto rootstocks with other desirable characteristics:
    - disease resistance and adaptability to environmental constraints.
  - Another possibility is the grafting of more than one cultivar or species onto the same stem, for example *Irvingia gabonensis* (sweet fruits) grafted to an *Irvingia wombolu* (bitter fruits) rootstocks and a male AB pollinator branch grafted to a female tree.

RATIONALE FOR VEGETATIVE PROPAGATION….5

- *Uniformity of plantations*
  - For many commercially grown species, *Irvingia spp*, *Dacryodes edulis*, *Cola spp*, *Allanblackia spp*. etc. uniformity of growth form or fruiting season is important economically.

CONTROL VEGETATIVE OR MORPHOLOGY CHARACTERISTICS 6



Plant Propagation

Vegetative propagation of importance to agriculture, horticulture and forestry since it provides:

1. For the production of uniform material for crop planting,
2. For the multiplication of good quality or superior trees, ornamentals, vegetables etc.

VEGETATIVE PROPAGATION

- Asexual – Not involving flowers or fusion of egg and sperm
- Accomplished through mitosis:
  - Nucleus contains genetics for entire plant
  - Cells genetically identical
  - Cells can still differentiate
  - Capable of becoming any kind of cell
- Due to:

VEGETATIVE PROPAGATION METHOD…1

Cuttings: severed uninodal leafy shoot or root fragments usually place into a suitable rooting substrate and kept under high humidity in propagators until adventitious roots and shoots are formed respectively.

Cuttings - techniques

Stem cuttings

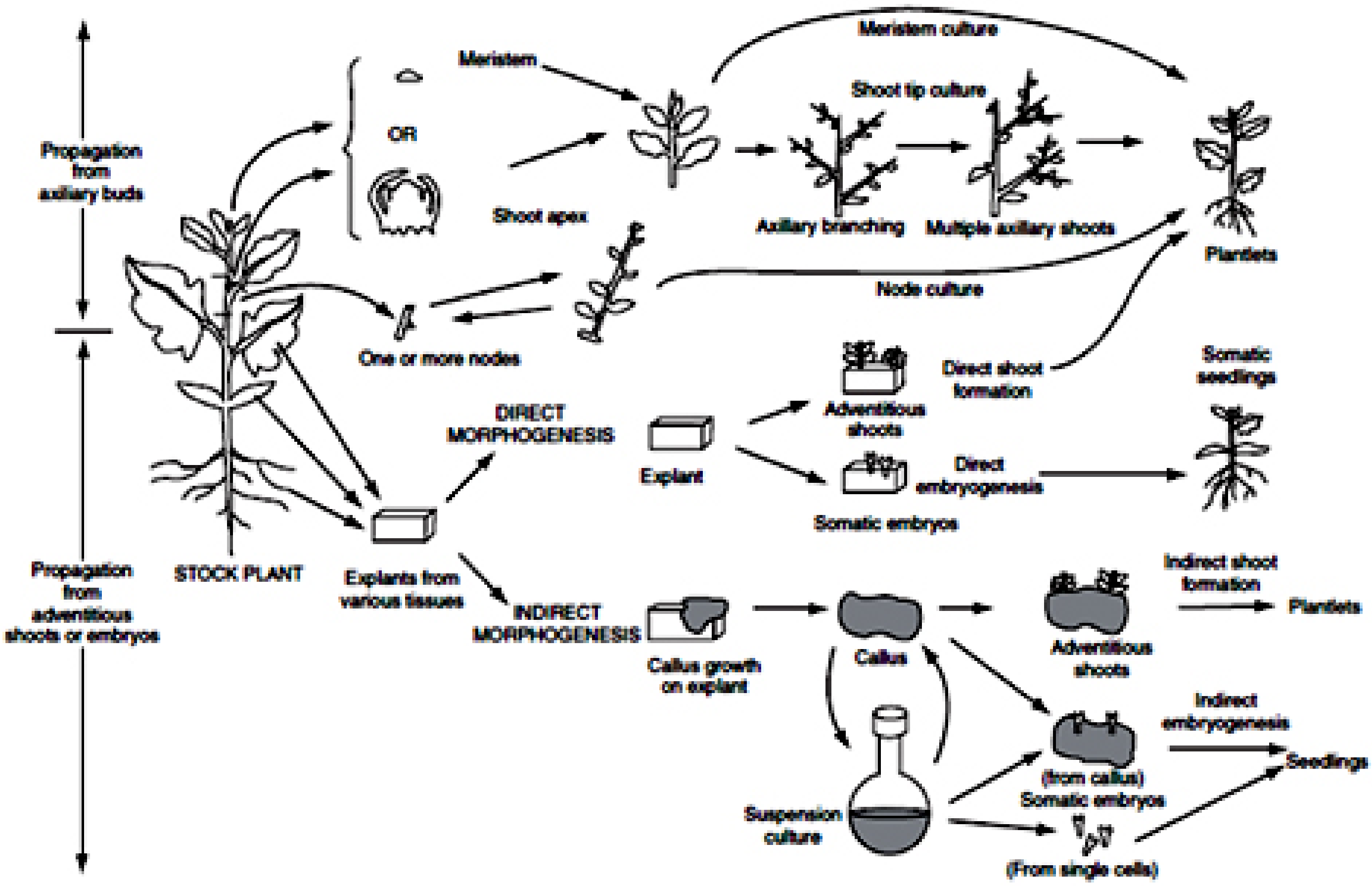
- Hardwood (last years wood)
- Semi-hardwood (Current wood/mature wood)
- Softwood (succulent new growth)
- Herbaceous (anytime plant is active)

Leaf cuttings

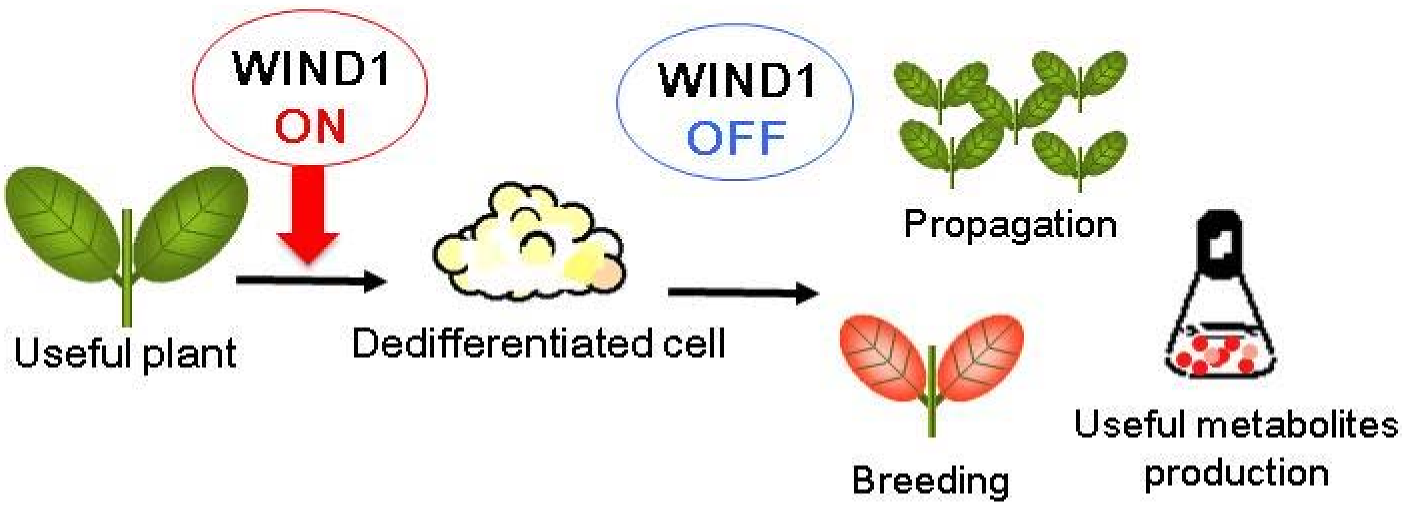
(needs to grow **stem/root**

Root cuttings

- Totipotency – ability of *mature cell* to return to *embryonic state* and produce *whole new individual*

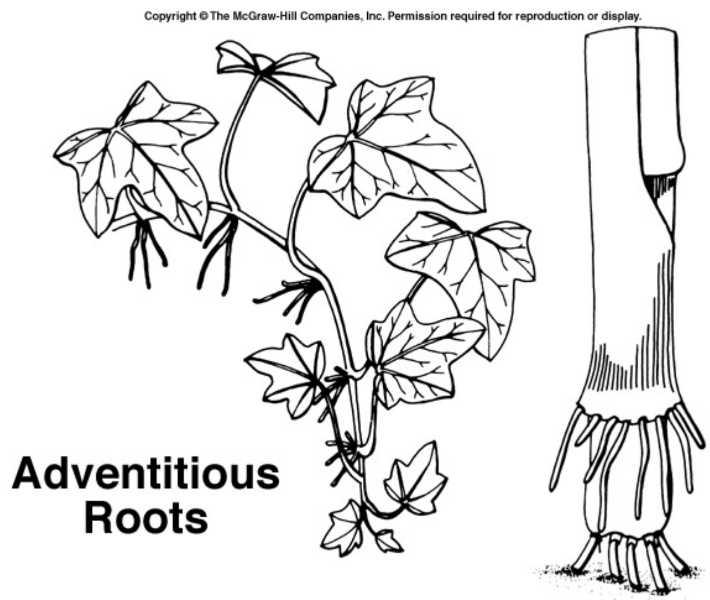


- **Dedifferentiation** is an important biological phenomenon whereby cells regress from a specialized function to a simpler state reminiscent of stem cells. Stem cells are self-renewing cells capable of giving rise to differentiated cells when supplied with the appropriate factors.

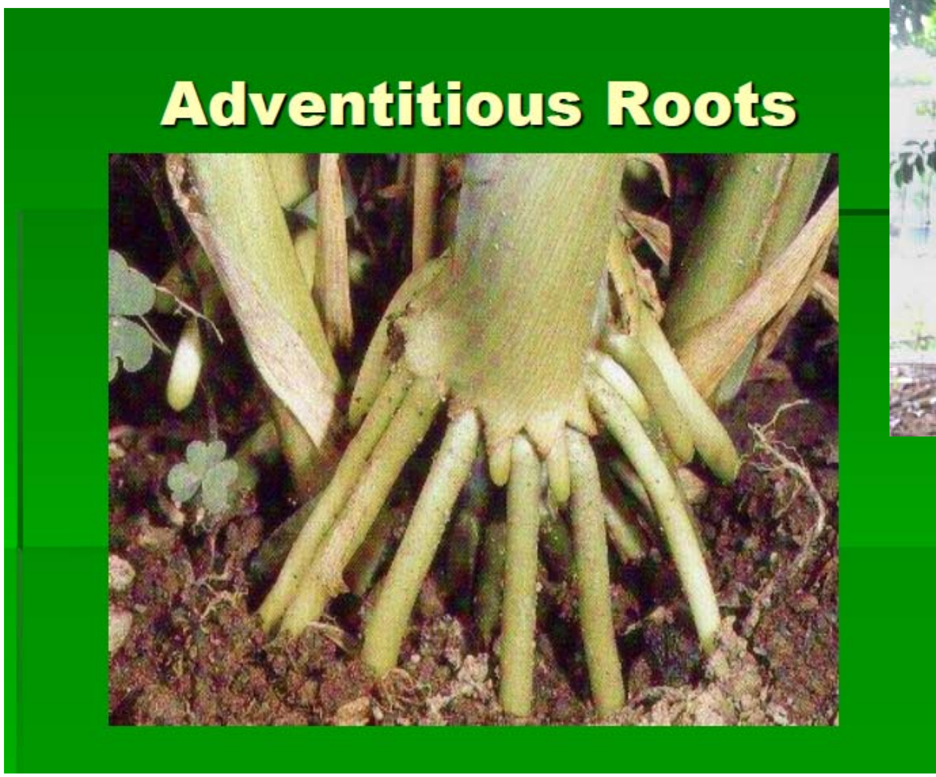


VEGETATIVE PROPAGATION

- Mitosis produces:
  - Adventitious roots
  - Adventitious shoots
  - Callus



تشکیل ریشه نا بجا



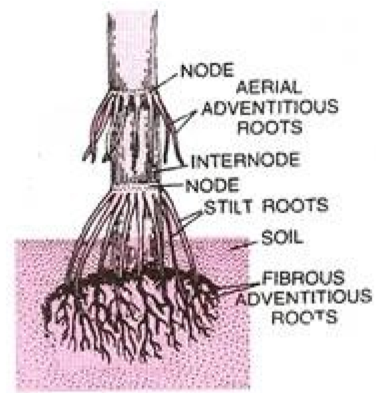


Fig. 5.14. Stilt roots of Maize.

Adventitious root formation on stems

Adventitious roots
Preformed and wound-induced

دو نوع ریشه نابجا

- ریشه های پیش تشکیل شده
- ریشه های زخم

- **ریشه های پیش تشکیل شده** به طور طبیعی روی ساقه گیاه مادری تشکیل می شوند اما تا زمانی که ساقه قطع نشود، بیرون نمی آیند.

- **ریشه های زخم** فقط پس از قلمه گیری ایجاد می شوند که واکنشی در برابر اثر زخم می باشد

Preformed (latent)

- Root primordia are pre-formed but lie dormant
- Emerge in response to environmental conditions
- Easy to root species
  - *Salix* (Willow)
  - *Hydrangea*
  - *Populus* (Poplar)
  - *Ribes* (Currant)

Wound induced

- Develop only after the cutting is taken
- In response to wounding
- De novo = “anew”
- Direct – cells in close proximity to the vascular system (easy-to-root taxa)
- Indirect – from callus (difficult-to-root taxa)

۳ مرحله فرایند بهبودی و باززایی:

- مردن سلول های آسیب دیده، تشکیل یک صفحه بافت مرده، مسدود شدن زخم با ماده ای چوب پنبه ای (سوبرینی)، محافظت از از سطح بریده شده در برابر از دست دادن آب و ورود عوامل بیماری زا

- شروع به تقسیم سلول های زنده پشت این صفحه پس از چند روز، تشکیل لایه ای از سلول های پارانشیمی (کالوس)

- شروع به تقسیم و آغازیدن ریشه های نابجا در سلول های معینی در نزدیکی لایه زاینده آوندی و آوند آبکش

تغییرات ساقه در حین آغازیدن ریشه (مرحله سوم)

- ۱- نامتمایز شدن برخی سلول های تمایز یافته خاص
- ۲- تشکیل آغازنده های ریشه از برخی سلول های نزدیک به دسته های آوندی که اکنون پس از نامتمایز شدن به حالت مریستمی درآمدند
- ۳- نمو بیشتر این آغازنده های ریشه و تبدیل آنها به سرآغازه های ریشه (پریموردیا)
- ٤- رشد و بیرون آمدن سرآغازه های ریشه از میان بافت ساقه به سمت خارج، تشکیل ارتباط آوندی بین سرآغازه ریشه و بافت هادی خود قلمه

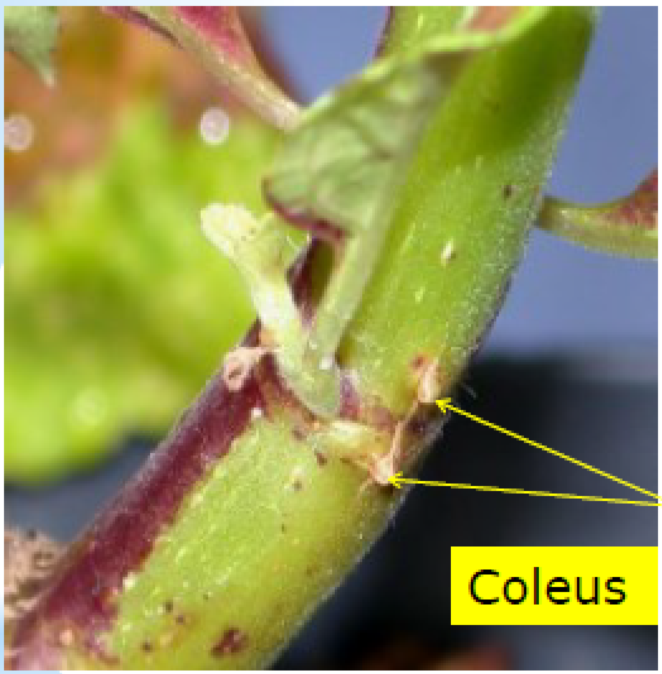
- در گیاهان علفی ریشه های نابجا از نزدیک**معمولا** قسمت بیرونی دسته های آوندی و از بین دسته های آوندی منشا می گیرند

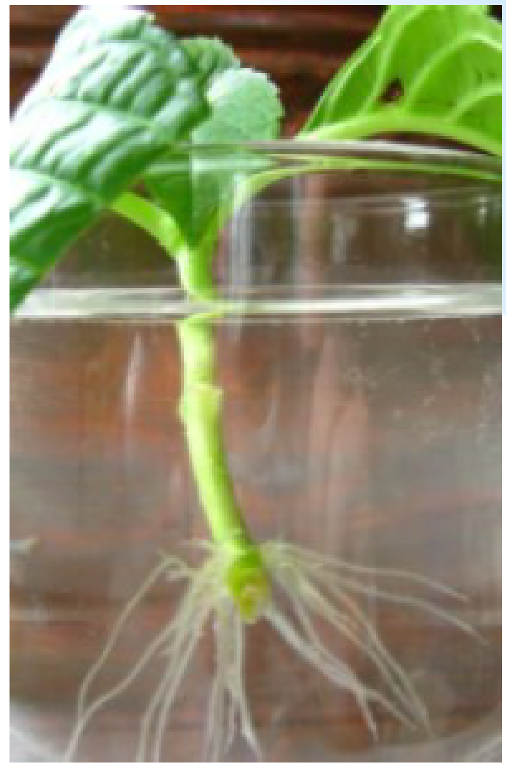
- در گیاهان چندساله چوبی ریشه های نابجا **معمولا** از سلول های پارانشیمی زنده که بیشتر در آوند آبکش ثانویه جوان هستند منشا می گیرند

- **آغازنده های ریشه های پیش تشکیل شده یا نهفته** به طور طبیعی تا زمانی که ساقه قطع نشود و در شرایط محیطی مناسب برای توسعه بعدی و رویش سرآغازه ها قرار داده نشوند، بیرون نمی آیند.
- منشا این آغازنده های ریشه پیش تشکیل شده همانند تشکیل ریشه های نابجای نو می باشد

Emerging preformed root initials of *Hedera helix*

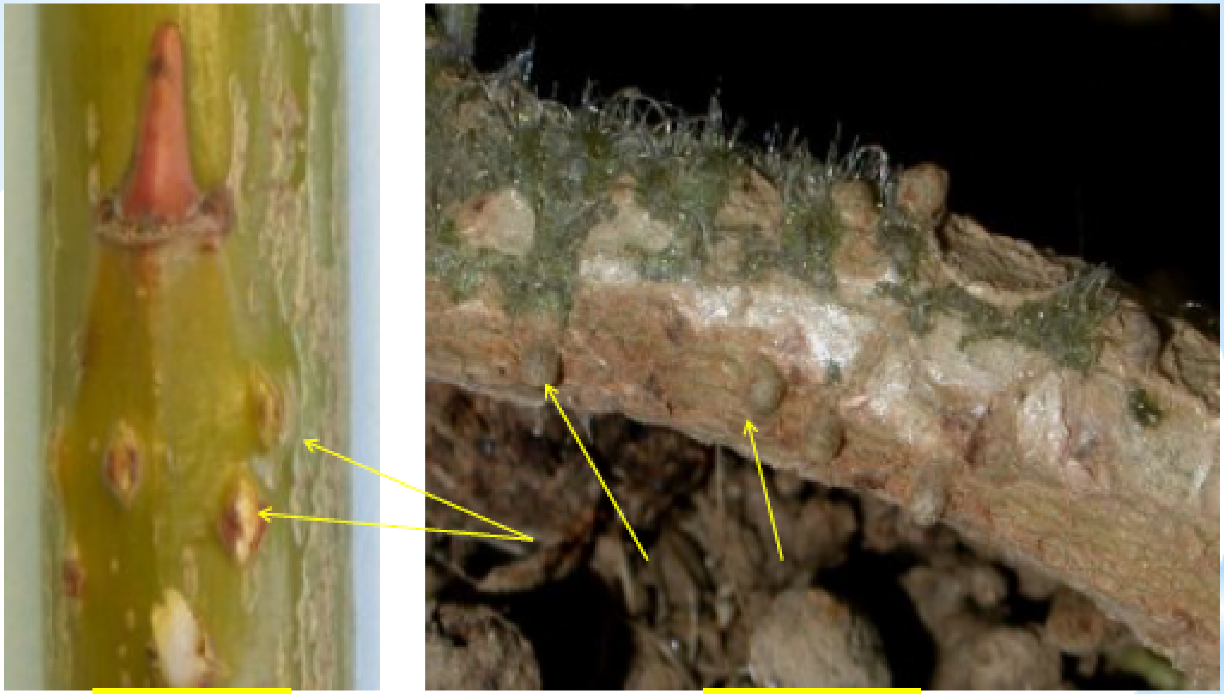
Preformed root initials





Hydrangea

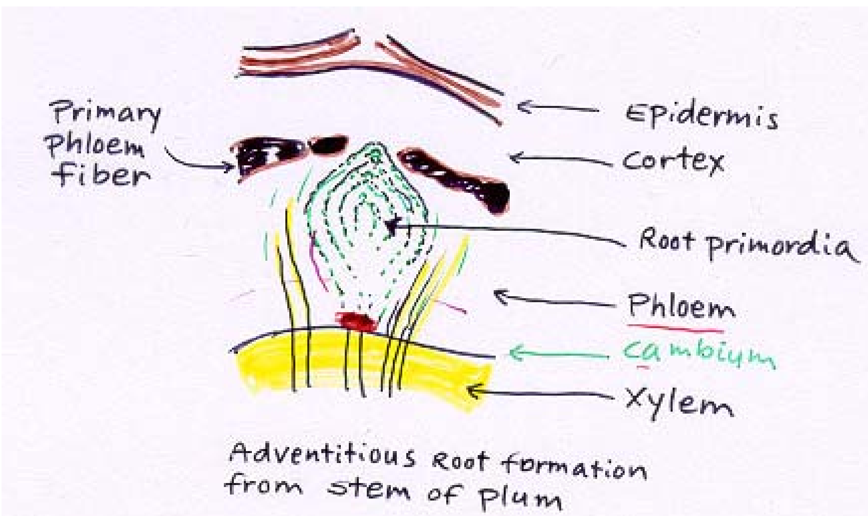
Preformed root initials

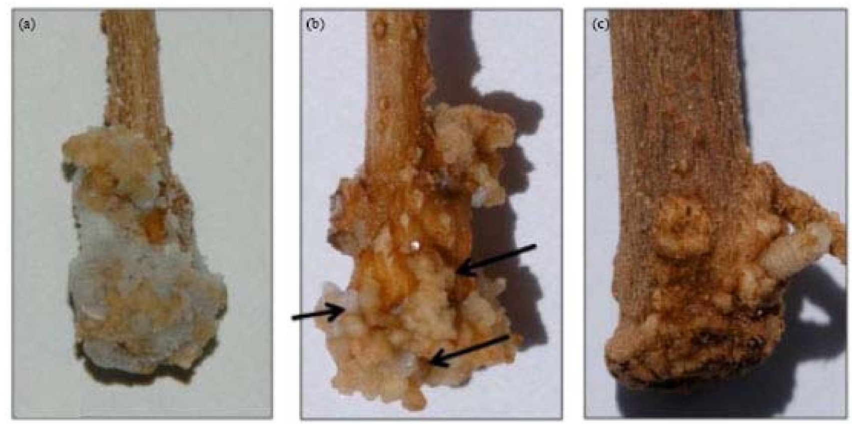


Willow Tomato

پینه (کالوس) (CALLUS)

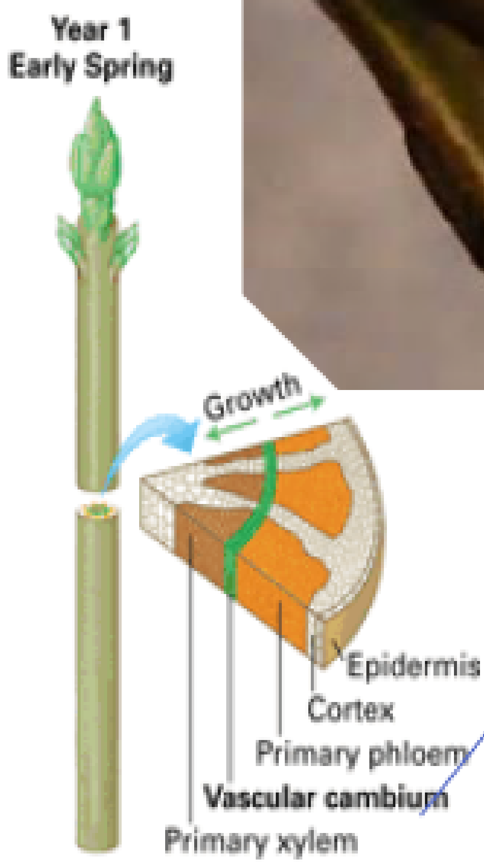
توده ای نامنظم از سلول های پارانشیمی که در حالات مختلف چوبی شدن قرار دارد. پینه از سلول های جوان ناحیه آوندی لایه زاینده به دست می آید. گرچه سلول های مختلف کورتکس و مغز هم ممکن است به تشکیل پینه کمک کنند



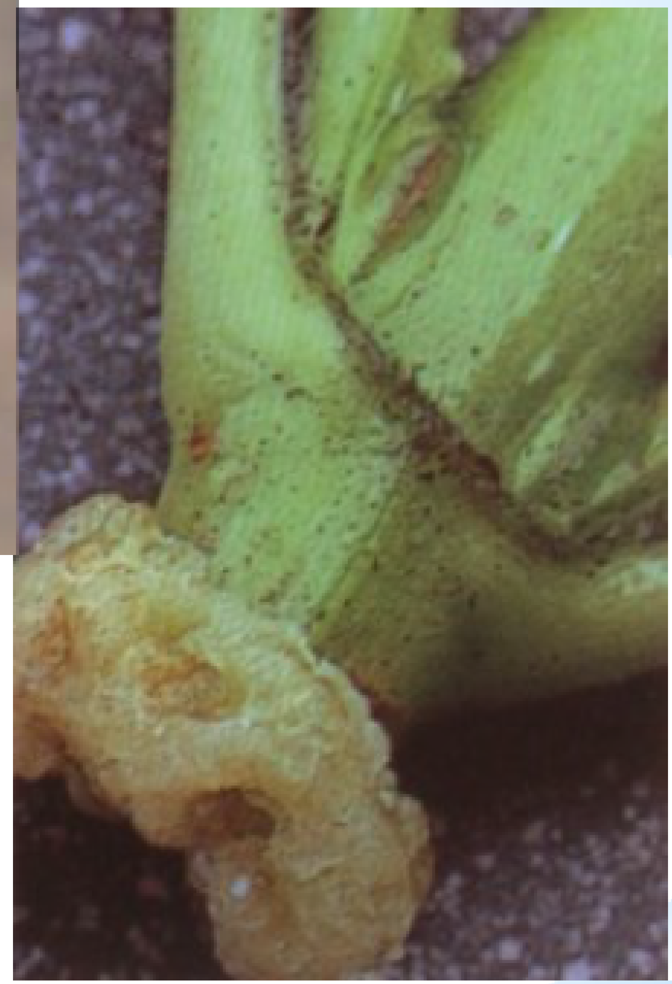


- اغلب اولین ریشه ها از **میان پینه** بیرون میزنند و این باعث شده تصور شود پینه اساس ریشه زایی است. در بیشتر گیاهان تشکیل پینه و ریشه با آن که هر دو حاصل تقسیم میتوز هستند ولی مستقل از هم هستند
- در قلمه های سخت ریشه زا منشا ریشه های نابجا پینه است.

Wounding a cutting

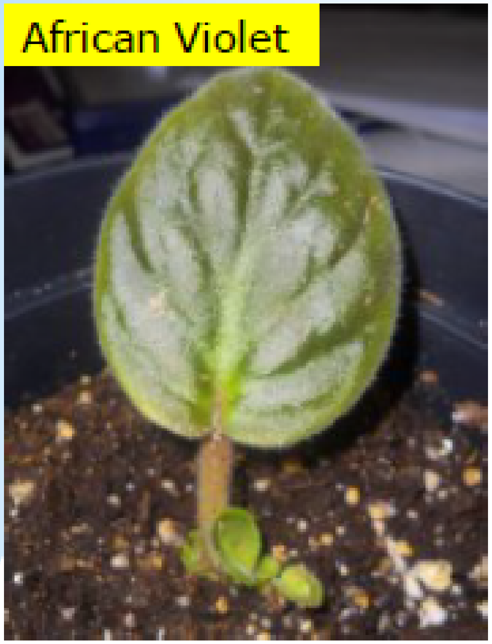


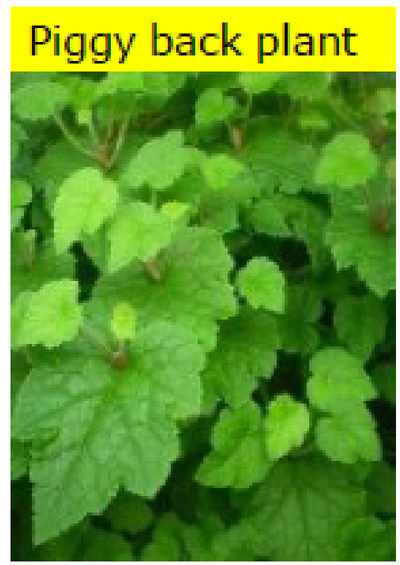
Response to wounding



Leaf cuttings

adventitious buds
AND adventitious roots needed





منشا شاخه و ریشه جدید در قلمه برگ:

- مریستم های اولیه (پیش تشکیل شده): سلول هایی که به طور مستقیم از سلول های رویانی منشا گرفتند و همیشه به حالت مریستمی هستند و فعالیت مریستمی آنها متوقف نمی شود

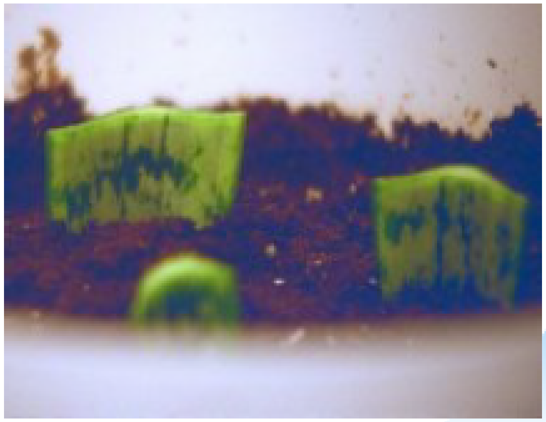
- مریستم های ثانویه (زخم): سلول هایی که متمایز شده اند ولی دوباره به ناحیه های مریستمی جدید متمایز می شوند که منتج به باززایی اندام های گیاهی جدید می شود

2) In plants like bryophyllum adventitious root are grow on leaves this buds are dormant till they are attached to the plant

3) This plantlets are detached from parent plant to continue their growth

Leaf

- Limited number of species
- Leaf blade or leaf blade and petiole
- Original leaf not part of new plant
- *Sansevieria* Leaf only
- Insert vertically – observe polarity
- Roots form at base



Leaf

- Begonia - Leaf only
- Fleshy leaves – cut veins underside
- Roots form at vein cuts
- African violet – leaf only, leaf plus petiole, portion of leaf blade

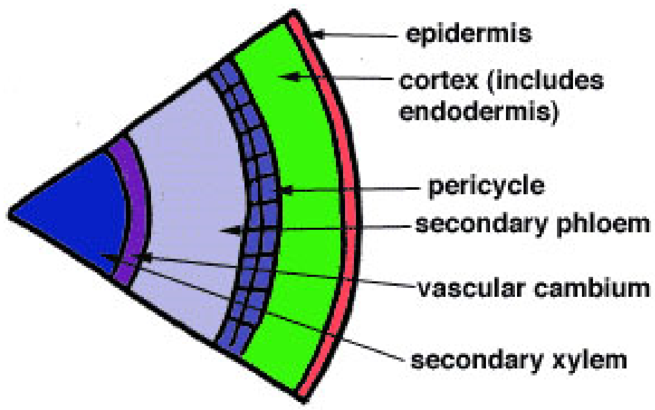
- آغازیدن ریشه و نمو آن مستقل از تشکیل جوانه نابجا و شاخساره است
- ریشه های نابجا بسیار آسان تر از جوانه های نابجا روی برگ تشکیل می شوند

Root

- Young plant in late winter
- Maintain correct polarity or horizontal
- 1″ – 2″ deep
- Cutting size depends on type of roots
- Japanese anemone, Daphne, Trumpet vine, Forsythia

- در ریشه های جوان جوانه های جانبی ممکن است به صورت درون زا در سلول های پریسیکل در نزدیکی بافت های زاینده آوندی برخیزند

- در ریشه های مسن جوانه ها ممکن است به صورت برون زا در یک رشد پینه مانند از لایه چوب پنبه ساز برخیزند یا ممکن است به شکل پینه از پرآوری بافت شعاعی پدید آیند.
سرآغازه های جوانه ممکن است از پینه زخم هم حاصل شوند که از انتهای بریده شده یا سطح آسیب دیده ریشه ها پرآوری می کنند.



- ✓ **باززایی مریستم های جدید ریشه روی قلمه ریشه اغلب مشکل تر از تولید جوانه های نابجا است.**
- ✓ **ریشه های جدید ممکن است نابجا نباشند بلکه از آغازنده های ریشه نهفته ای که روی ریشه های فرعی قدیمی وجود دارد حاصل شوند**
- ✓ **معمول ترین نوع در قلمه ریشه ابتدا تولید شاخساره نابجا است. پس از آن ریشه ها اغلب از پایین شاخه جدید و نه از قطعه ریشه اصلی ظاهر می شوند**

عوامل مؤثر در باززایی گیاهان از قلمه

- 1- شرایط محیطی و فیزیولوژیکی گیاهان مادری
- (عدم تنش، تاریک رویی، افزایش دی اکسید کربن، مواد غذایی معدنی، طوقه برداری)
- ۲- بازجوان سازی و آماده سازی گیاهان مادری
- (نگهداری قلمه ها، آبشویی برای حذف بازدارنده_ها)
- ۳- شرایط محیطی حین ریشه زایی
- (روابط آبی، نور، فتوسنتز، محیط کشت)

1- شرایط محیطی و فیزیولوژیکی گیاهان مادری

- قلمه گیری در صبح (گیاه شاداب)

تاریک رویی حذف نور به طور کامل است
پاتاریکی نور را به صورت موضعی حذف می کند
سایه دهی رشد گیاه در شرایط نور کاهش یافته است.

- تاریک رویی حساسیت ساقه به اکسین را افزایش می دهد، با تغییر در مواد فنولیکی همراه است، باعث تغییراتی تشریحی در بافت شاخه می شود که ممکن است پتانسیل آغازیدن سرآغازه ریشه را به دلیل سلول های پارانشیمی تمایز نیافته افزایش دهد، تولید لیگنین کاهش می یابد

- کاهش در میزان نیتروژن گیاه مادری و کاهش رشد و تجمع کربوهیدرات، انتخاب شاخه های قوی با کربوهیدرات فراوان، هر نوع بستن ساقه انتقال کربوهیدراتها و هورمون ها را مسدود میکند

۲- بازجوان سازی و آماده سازی گیاهان مادری

- **قابلیت تولید ریشه نابجا در قلمه با افزایش سن گیاه پس از کاشت بذر و یا به عبارت دیگر تغییر مرحله گیاه از نونهالی به بلوغ کاهش می یابد**

(افزایش تولید بازدارنده ها، کم شدن مقدار مواد فنولیک)

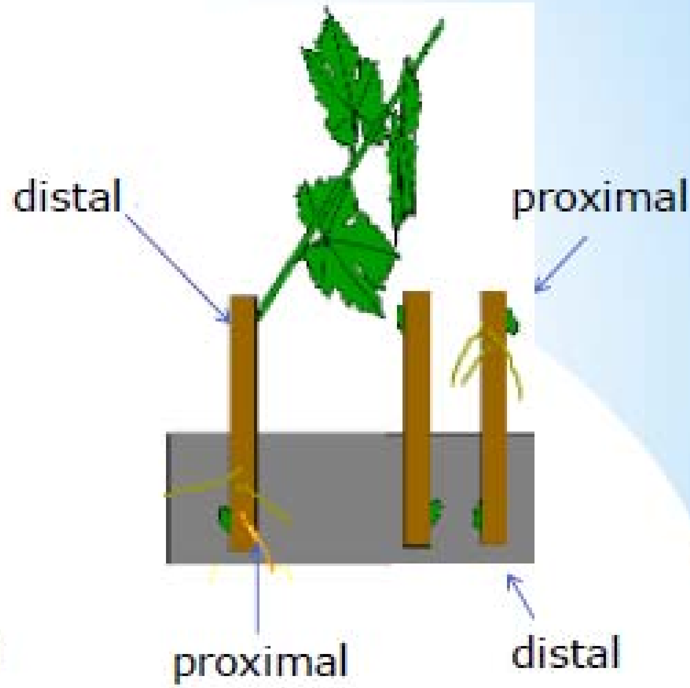
- **تولید شاخه از ریشه و تهیه قلمه از آنها**
- **تولید شاخساره از محل تورم تنه**
- **پیوند شکل های بالغ روی نونهال و تیمار دمایی (تبدیل به گیاه نونهال)**
- **حلقه زنی، طوقه برداری، هرس شدید، تاریک رویی، محلول پاشی جیبرلین، کشت بافت و ....**

Polarity - A cutting has different properties in opposite ends

Buds and leaves - Affect root formation

Plant Growth Hormones – influence root initiation

Auxins – natural IAA (Indole-Acetic Acid)



- وجود حداقل یک جوانه روی قلمه برای تولید ریشه ضروری است.
- یک قلمه بدون جوانه حتی اگر با مواد سرشار از آکسین تیمار شئد، ریشه نمیدهد
- در نخودفرنگی حذف جوانه پس از ۴ روز در تشکیل ریشه اختلالی ایجاد نکرد.

- اگر قلمه چوب سخت در اواسط زمستان در دوره استراحت جوانه ها گرفته شود، جوانه هیچ اثر محرکی روی ریشه دهی ندارد. (برخلاف اول پاییز و آخر زمستان)

- **اثر برگها بر تولید کربوهیدرات ها و کمک به تشکیل ریشه ثابت شده است.**
- **برگها و جوانه ها تولید کننده های هورمون آکسین هستند**
- **پیوند بخش برگدار یک کلون آسان ریشه زا روی یک کلون سخت ریشه زا و استفاده از این ترکیب به عنوان قلمه موجب تولید آسان ریشه شد.**

ماده پیشنهادی به عنوان ریزوکالین:

- مواد اختصاصی مانند اورتو دی هیدروکسی فنل
- مواد غیر اختصاصی مانند اکسین
- آنزیم های اختصاصی که در بافت های خاص مانند پریسیکل یا لایه زاینده تولید می شوند مانند پلی فنل اکسیداز

مراحل تشکیل و نمو ریشه

- 1- **مرحله آغازیدن: تشکیل مریستم ریشه**

الف: مرحله فعال اکسین، نیاز مرتب به اکسین

ب: مرحله غیرفعال اکسین: عدم نیاز به اکسین

- ۲- **مرحله رشد و طویل شدن ریشه: عدم واکنش به اکسین**

Auxins

IBA – Indole-butyric acid

NAA – Napthalene acetic acid

Indole-butyric acid

Napthalene acetic acid

Liquid concentrate

Willow water IBA, Salicylic acid

Powder

Indole-butyric acid

Cytokinins – greatest effect on buds and shoots from leaf cuttings

High auxin to cytokinin ratio favors **rooting**
High cytokinin to auxin ratio favors **shoot/bud**

- گونه هایی که سایتوکنین فراوانی دارند مشکل تر از آنهایی که سایتوکنین آنها کم است ریشه دار می شوند.
- معمولا به کارگیری سایتوکنین ها از آغازیدن ریشه در قلمه های ساقه جلوگیری میکند ولی اثر سایتوکنین در اغازیدن ریشه به مرحله خاص آغازیدن و غلظت دارد.
- اثر تحریکی آنها بر ریشه زایی می تواند به بازجوان سازی و جمع آوری کربوهیدرات ها مربوط باشد.
- افزودن سایتوکنین با غلظت زیاد به قللمه های برگ تشکیل جوانه نابجا را به حداکثر میرساند ولی کیفیت ریشه ها را کاهش می دهد

Factors affecting success with cuttings:

- Nutrients in mother plant
- Immature material
- Water stress
- Lateral and terminal shoots
- Flowering or vegetative growth
- Seasonal timing

- **جیبرلین ها در غلظت زیاد از تشکیل ریشه نابجا جلوگیری می کنند**
- **کند کننده های رشد شاخساره برای افزودن ریشه زایی استفاده می شوند**

مکانیسم اثر کندکننده های رشد:

- جلوگیری از تولید جیبرلیک اسید
- کاهش رشد شاخساره و رقابت

- اتیلن می تواند روی تشکیل ریشه اثر افزایشی یا کاهشی داشته باشد یا بی اثر باشد.

Factors affecting success with cuttings:

- Rooting medium

Organic		Inorganic
Peat moss Compost Sphagnum moss	+	Sand Perlite Vermiculite

- Wounding (sanitize tools)
- Treating with auxins
- Enclosures
- Bottom heat
- Care after rooting

Cutting techniques

- Ways to improve rooting of cuttings
  - Proper rooting medium
  - Wounding
    - Stripping
    - Girdling
  - Auxins
    - IBA best or a combination of IBA & NAA
    - K-IBA (talc or water solution) for softwood & semi-hardwood

Rooting from Cuttings

- Rooting media should be about 4 inches deep.
- Best time of day to take cuttings is early morning because plants have more moisture.

Rooting from Cuttings

- The three main types of cuttings are….
  - Stem
  - Leaf
  - Root

STEM CUTTINGS

- The taking of a piece of stem to reproduce plants.
- Use a rooting hormone with fungicide to….
  - Speed up root development.
  - Prevent root rot.

Types of Stem Cuttings

Segments of stems containing buds are used to produce new plants. There are several types:

- **Softwood**
- **Semi-hardwood**
- **Hardwood**
- **Herbaceous**

Softwood cuttings are taken from woody plants when growth is still relatively soft and succulent before tissues have matured and become woody.

Softwood cuttings usually root easier and faster than other types of stem cuttings, taking about 6 weeks. Softwood cuttings should be taken during the summer months when plants are still growing. The stems should be hardened enough to “snap” when bent.

- **Semi-hardwood cuttings** **differ from softwood cuttings only in the maturity of the wood. They are collected later in the growing season when the lower portion of the cutting has become lignified (woody).**

- Semi-hardwood cuttings of evergreen species are generally taken from new shoots 6 to 9 weeks after a flush of growth when the wood is partially matured. This can be any time from mid-spring to the end of the growing season.

- **<u>Hardwood cuttings</u> are taken in the dormant season when tissues are fully matured and lignified through their entire length. This may be after leaves have dropped in deciduous species.**

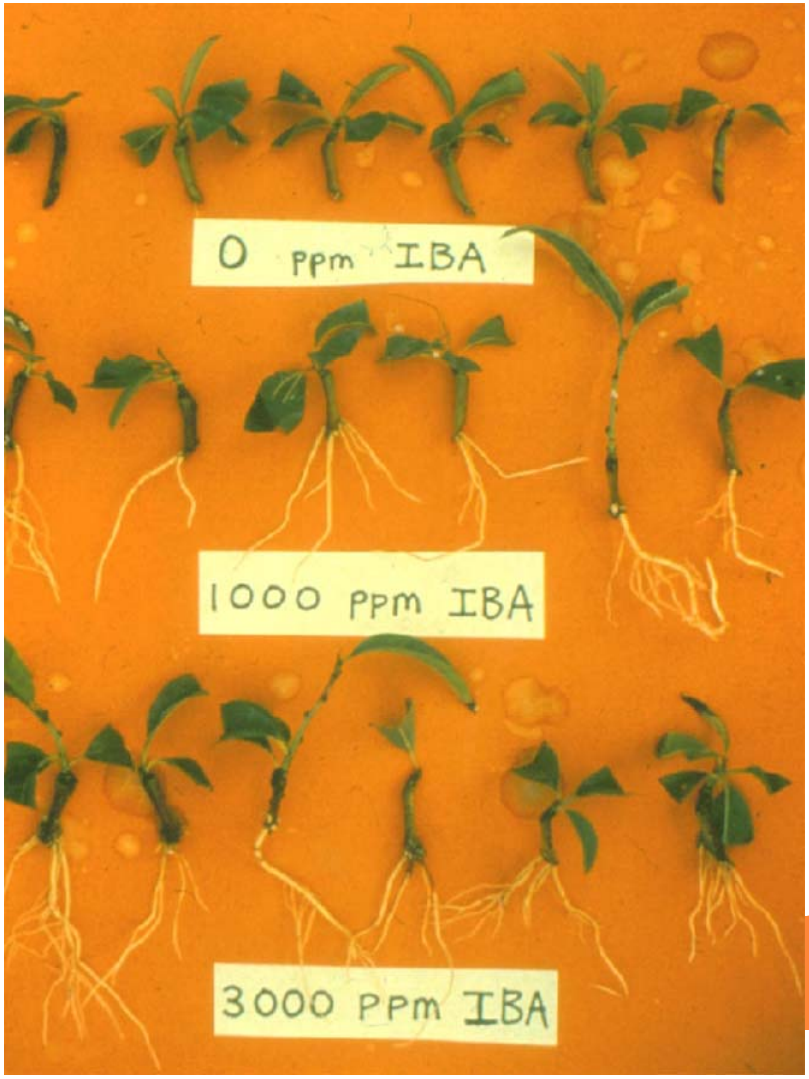
- Cuttings should be planted upright with the top 2 – 3 buds above the medium. Hardwood cuttings vary in length from 4 to 20 inches with at least two nodes included in the cutting. The diameter of the cutting may range from ¼ to 1 inch depending upon the species.

- **<u>Herbaceous cuttings</u> are made from succulent, herbaceous (non-woody) plants such as geraniums, chrysanthemums, coleus, and carnations.**
- Herbaceous cuttings are typically 3 to 5 inches in length with leaves retained at the upper end. Most florists' crops are propagated by herbaceous cuttings.

SOFTWOOD CUTTINGS-PEACH

- Actively growing shoots are used
- Softwood cuttings are taken during spring and summer



Leaf Cuttings

- The use of leaves and sections of leaves to reproduce plants.
- Done from herbaceous plants.
- Veins must be cut!!!

Single Node Cuttings

Double-Eye Single Node Cutting (DE)

- Healthier than SE
- Less disease attacks

Single-Eye Single Node Cutting (SE)

- Largest no. cuttings/plant
- Slower development
- Higher mortality

Root Cuttings

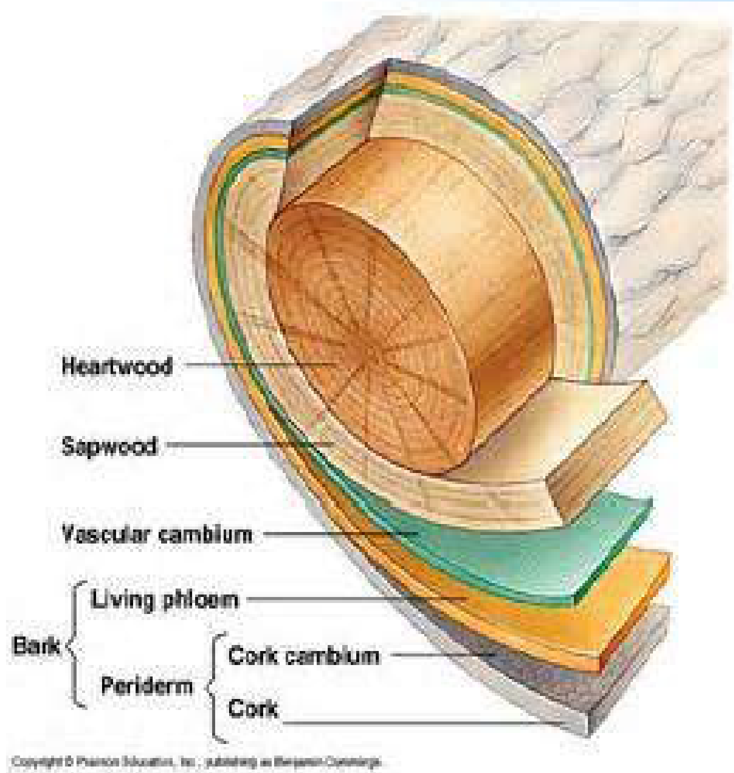
- The use of roots to reproduce plants.
- Should be spaced 3 inches apart in the rooting area.

Procedure

- Gather Materials
- Prepare Rooting Media
- Remove Cuttings from Stock
- Prepare Cuttings
- Apply Rooting Hormone
- Place Cuttings in Media
- Label Cuttings
- Follow Proper Safety and Sanitation Procedures

Grafting Terms to Know

- Scion
- Rootstock
- Vascular cambium
- Callus bridge



Cutting techniques

- Disease prevention while taking cuttings
  - Start with disease-free stock plants
  - Apply fungicides
    - In auxin talc or solution
    - Drench medium after sticking
  - Sterilize workspace/tools
    - Bleach (10%) Water (90%)

The Biology of Grafting

- <u>**Natural grafting**</u>
  - **Bracing of limbs in commercial orchards to support weight of fruit**
  - **Root grafting in woods is prevalent (CHO's of upper canopy trees provide support for understory trees). This grafts only occur between trees of the same species**
  - **Problems with root grafting include: transmission of fungi, bacteria and viruses between plants (Dutch Elm Disease spreads this way)**

THE BIOLOGY OF GRAFTING

- **Formation of the graft union**
  - **A "de novo" formed meristematic area must develop between scion and rootstock for a successful graft union**
- **3 events**
  - **1) adhesion of the rootstock & scion**
  - **2) proliferation of callus at the graft interface = callus bridge**
  - **3) vascular differentiation across the graft interface**

THE BIOLOGY OF GRAFTING

- **Steps in graft union formation**
  - **1.) lining up of the vascular cambium of rootstock and scion. Held together with wrap, tape, staples, nails or wedged together**
  - **2.) wound response**
    - **Necrotic layer 1 cell deep forms on both scion and stock**
    - **Undifferentiated callus tissue is produced from uninjured parenchyma cells below the necrotic layer**
    - **Callus forms a wound periderm (outer "bark") which becomes suberized to prevent entry of pathogens**
    - **Necrotic layer dissolves**

The Biology of Grafting

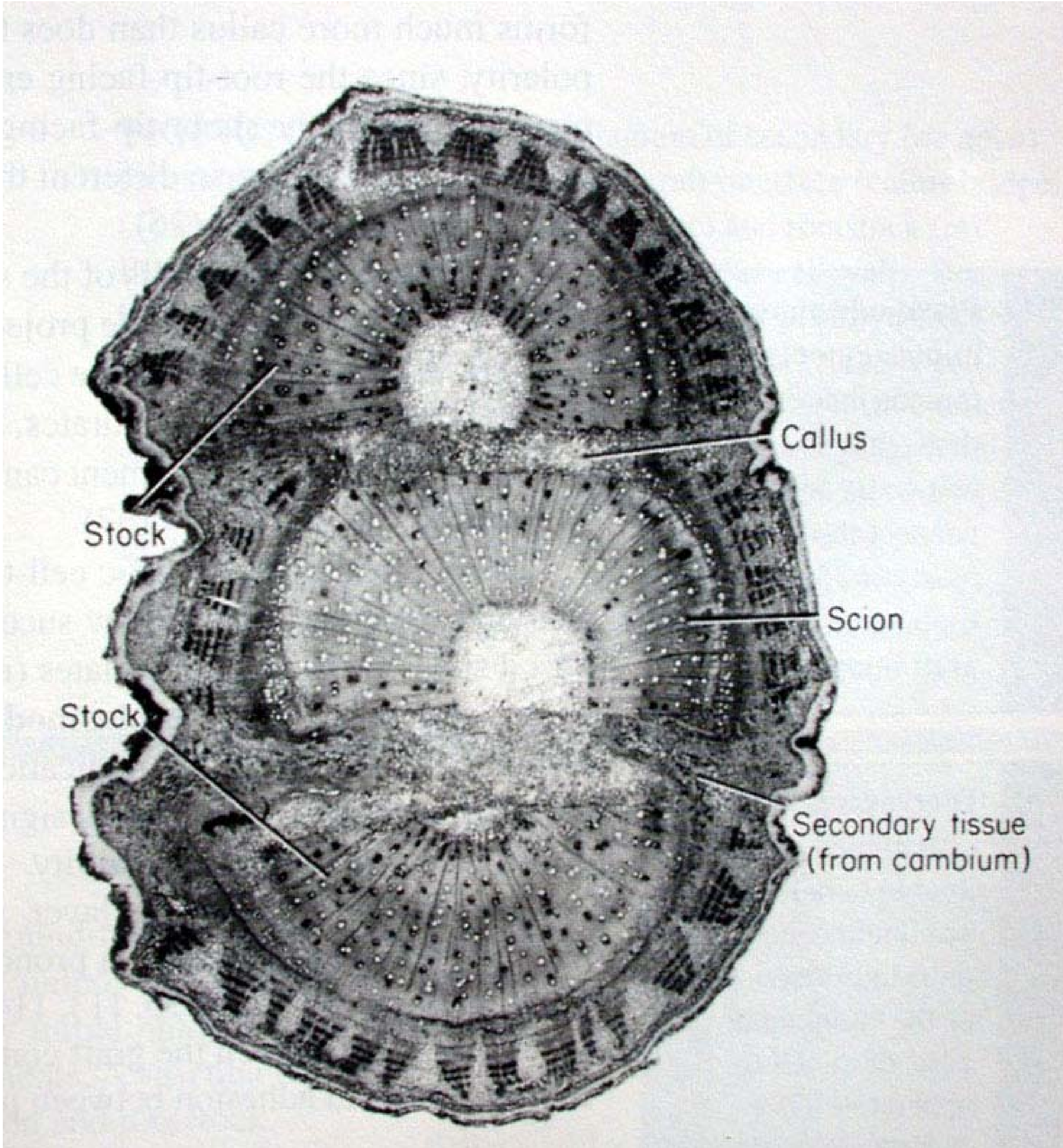
- **3.) callus bridge formation**
  - **Callus proliferates for 1 - 7 days**
  - **Callus mostly comes from scion (due to basal movement of auxins and CHO's, etc.)**
  - **An exception to this is on established rootstock which can develop more callus than that from the scion.**
  - **Adhesion of scion and stock cells with a mix of pectins, CHO's and proteins. Probably secreted by dictyosomes which are part of the Golgi bodies in cells.**

The Biology of Grafting

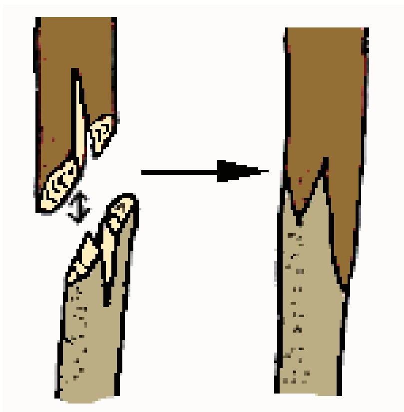
- **4.) Wound-repair :**
  - **First the <u>xylem</u> and then the <u>phloem</u> is repaired**
  - **Occurs through differentiation of vascular cambium across the callus bridge**
  - **Process takes 2 - 3 weeks in woody plants**
- **5.) Production of 2º xylem and phloem from new vascular cambium in the callus bridge**
  - **Important that this stage be completed before much new leaf development on scion or else the leaves will wilt and the scion may die**

The Biology of Grafting

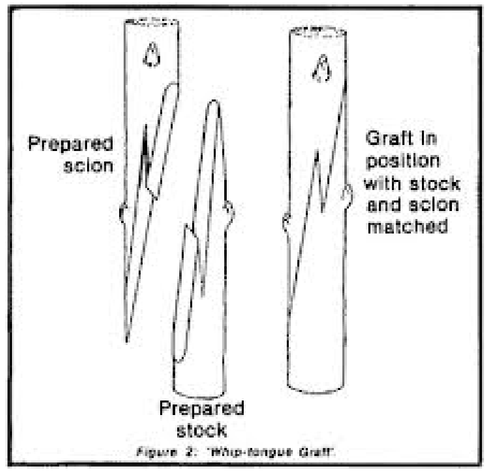
- Some water can be translocated through callus cells but not enough to support leaves
- Cell-to-cell transport via plasmodesmata = symplastic transport (links cells membranes)
- Apoplastic transport is between adhering cells

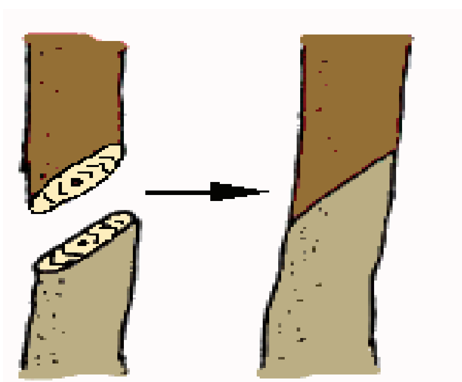

Callus
Stock
Scion
Stock
Secondary tissue
(from cambium)

Grafting Methods



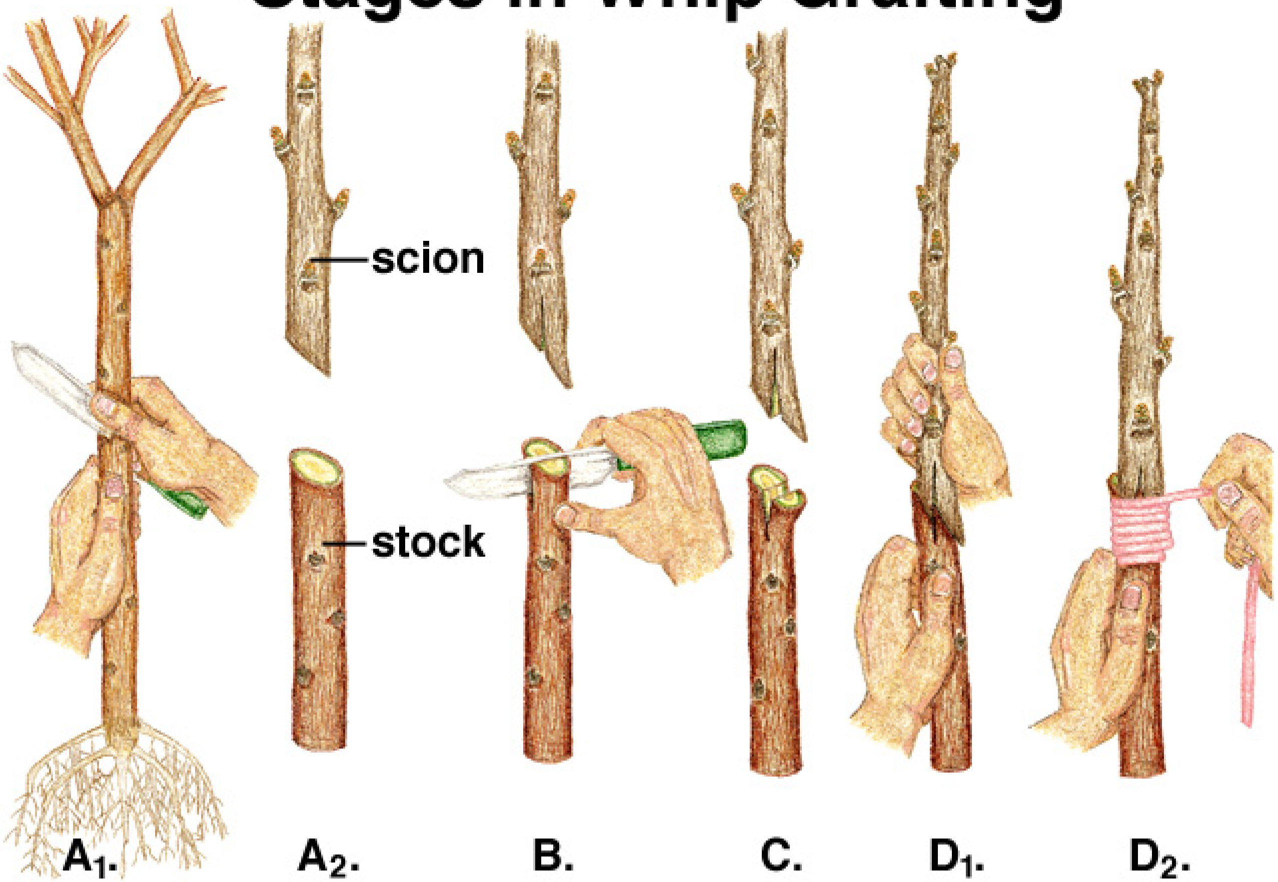
whip & tongue graft

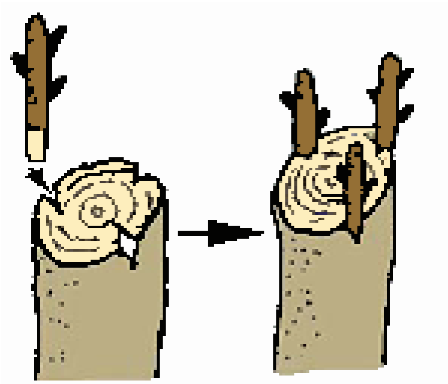




splice graft

Stages in Whip Grafting





notch graft

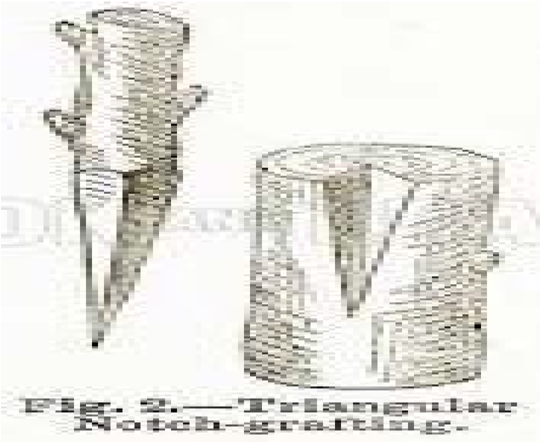
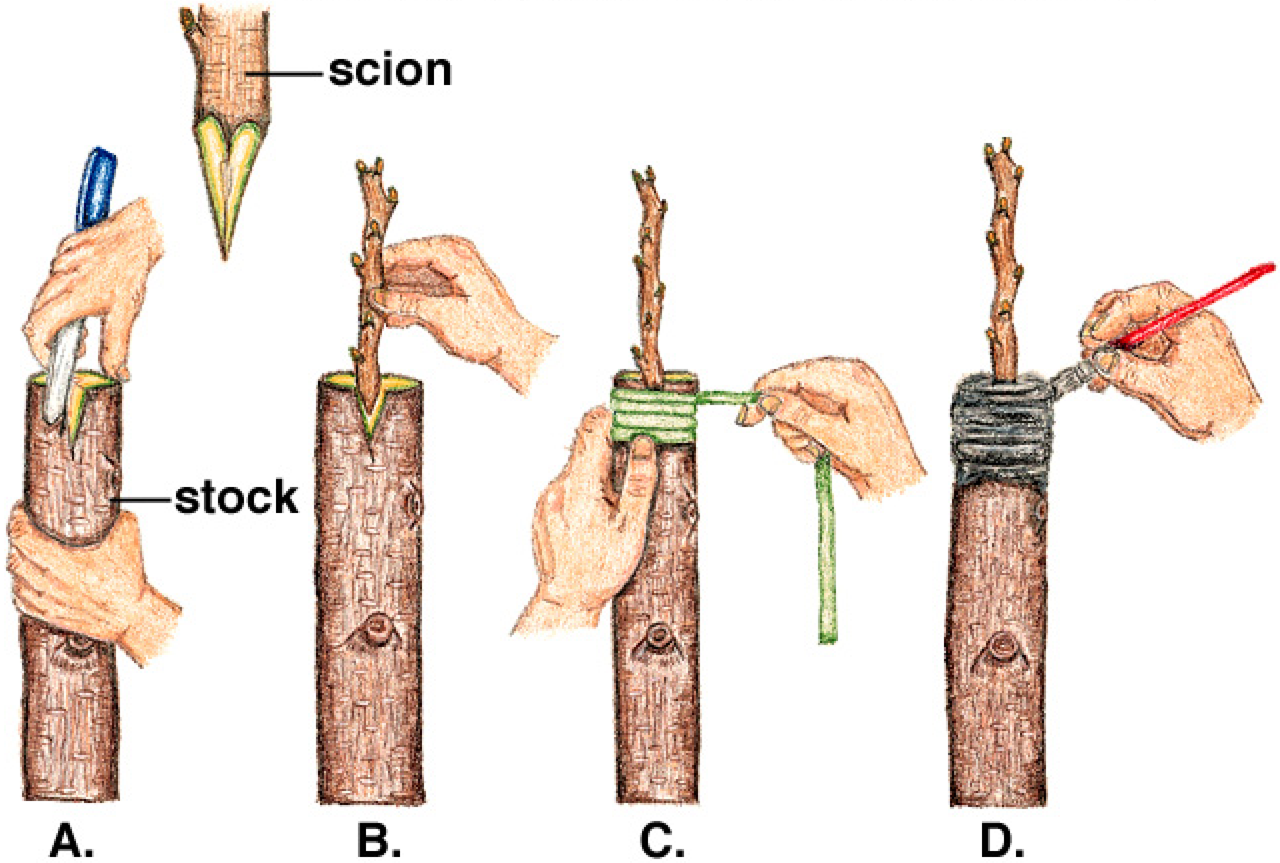
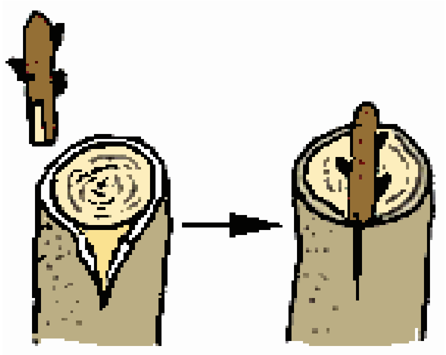


Fig. 2.—Triangular Notch-grafting.

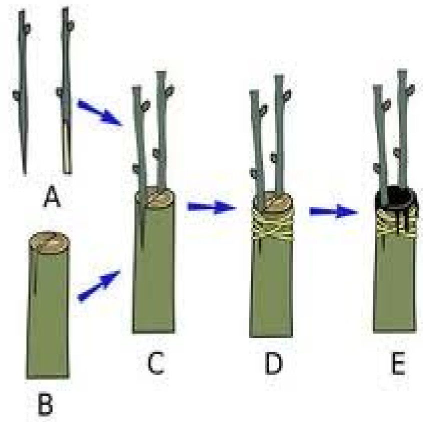
B
Notches/ small cut into wood

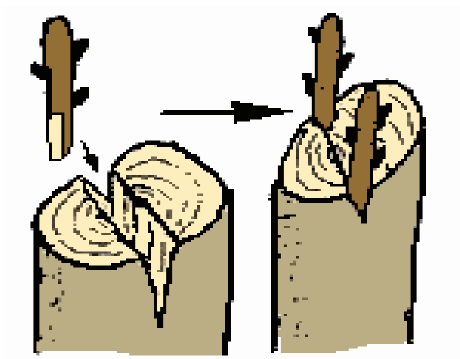
Grafts of Different Diameters



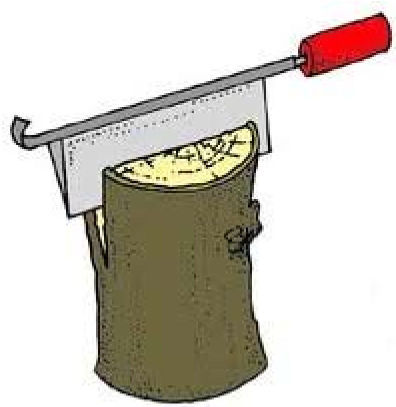


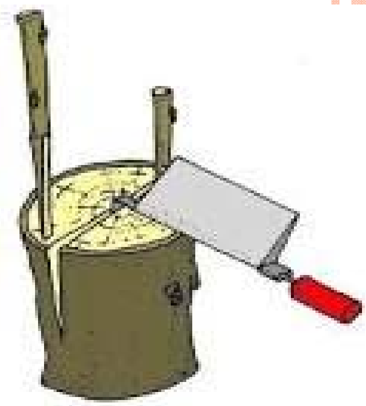
bark inlay graft



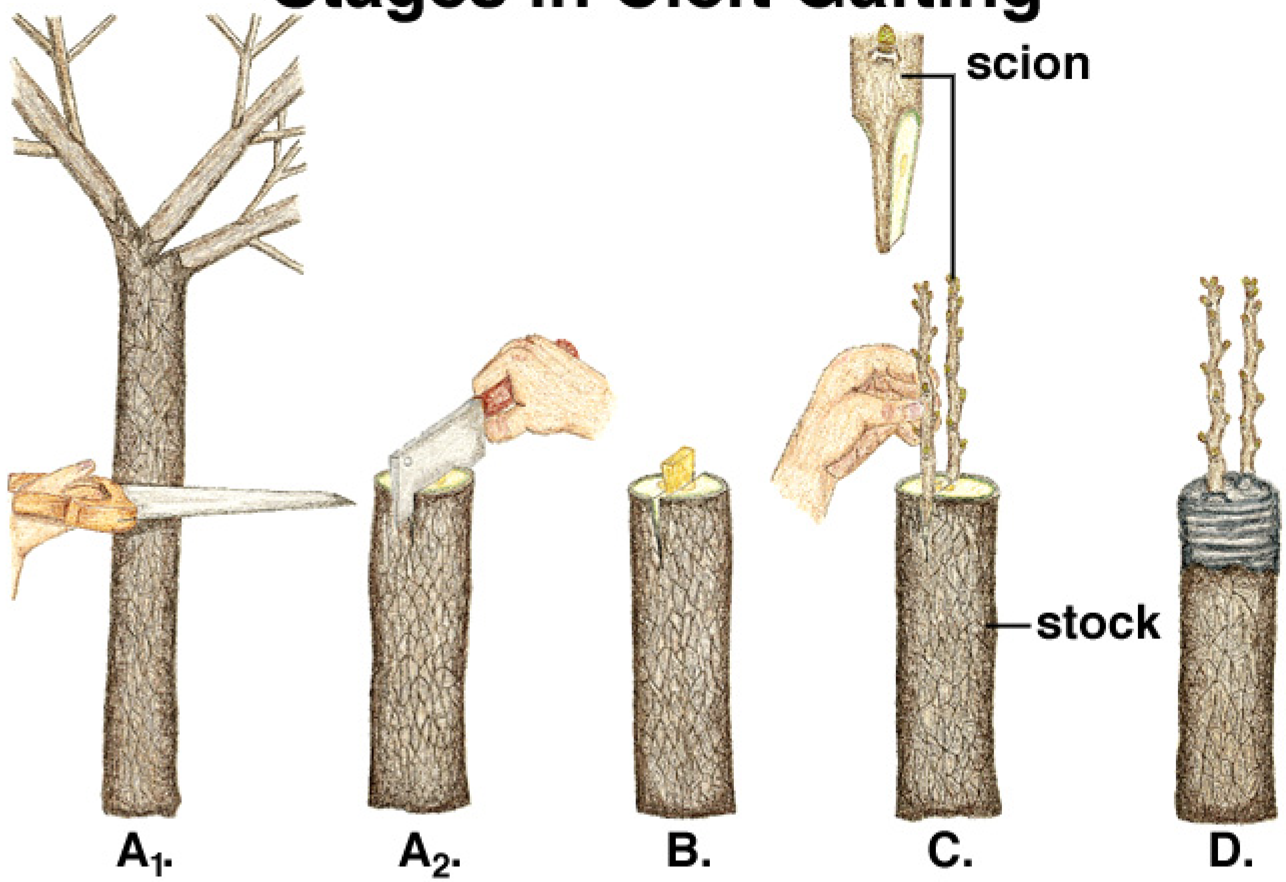


cleft graft



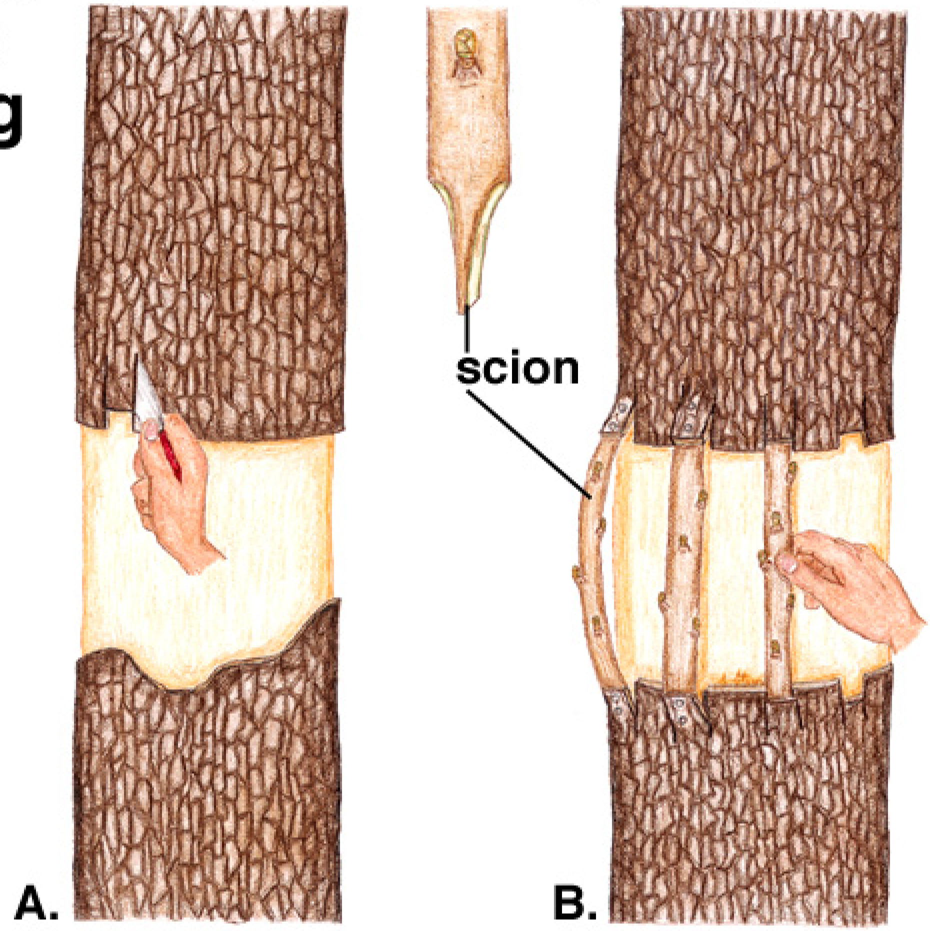


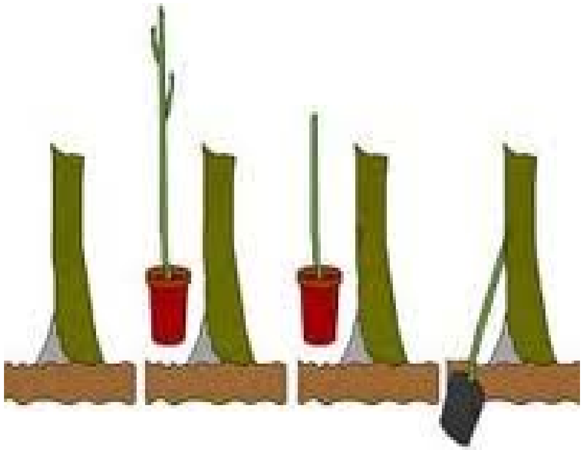
Stages in Cleft Gafting



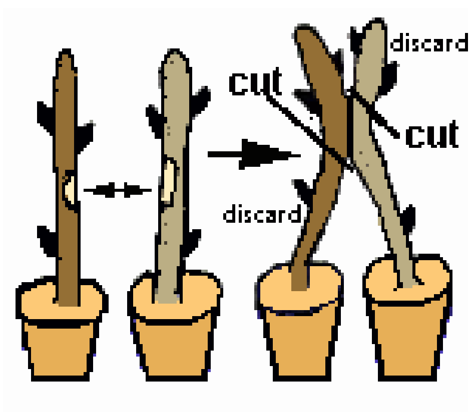
BRIDGE GRAFT

Bridge Grafting

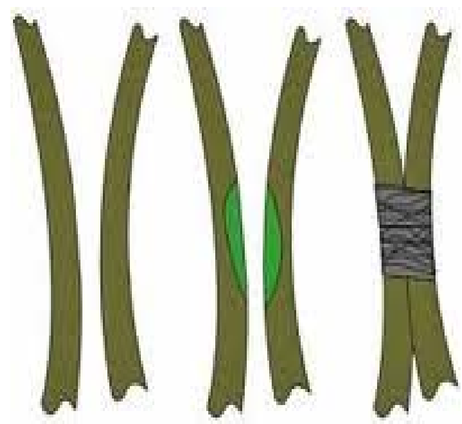




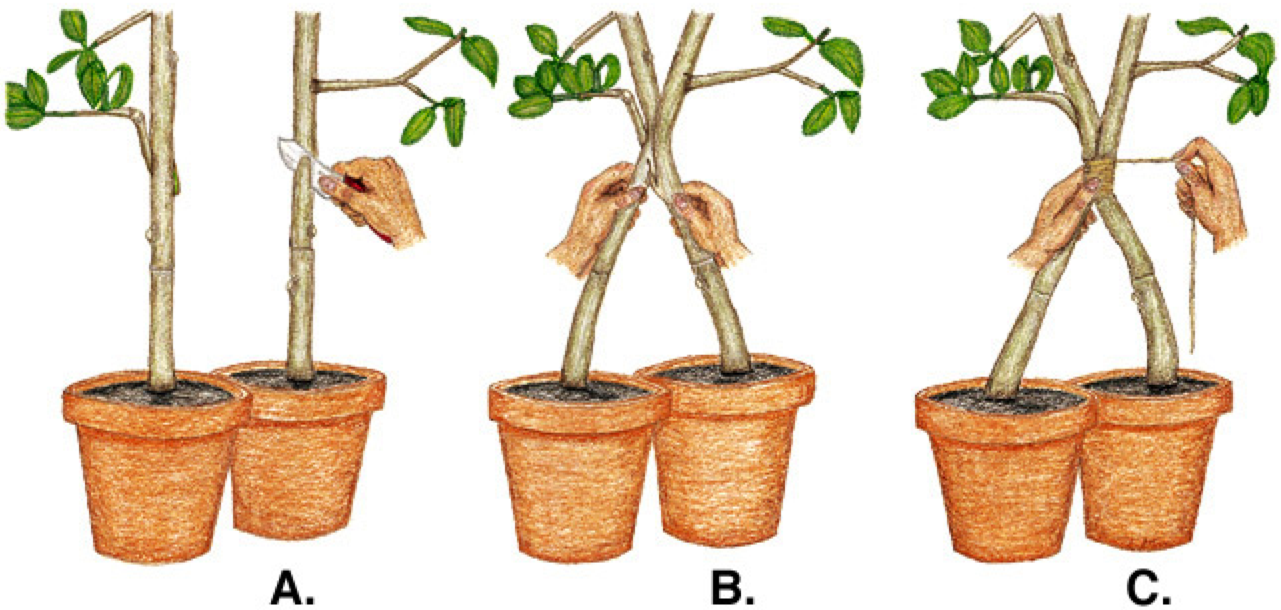
INARCHING GRAFT



approach graft



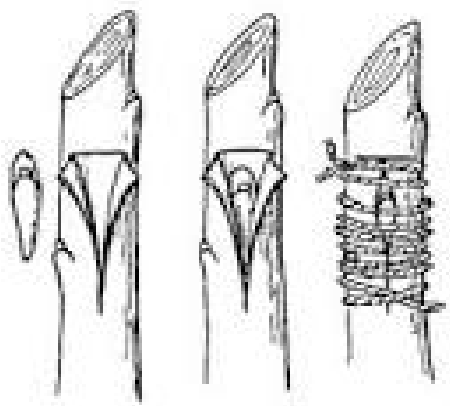
Approach Graft



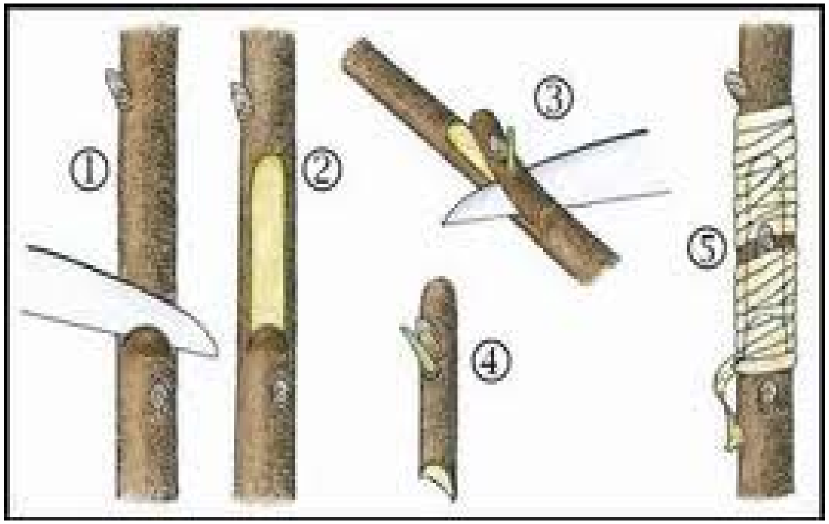
BUDDING

- A form of grafting when a bud is used.
- Faster or quicker than grafting.
- The 3 main methods are….
  - Patch budding.
  - T-budding.
  - Chip budding.

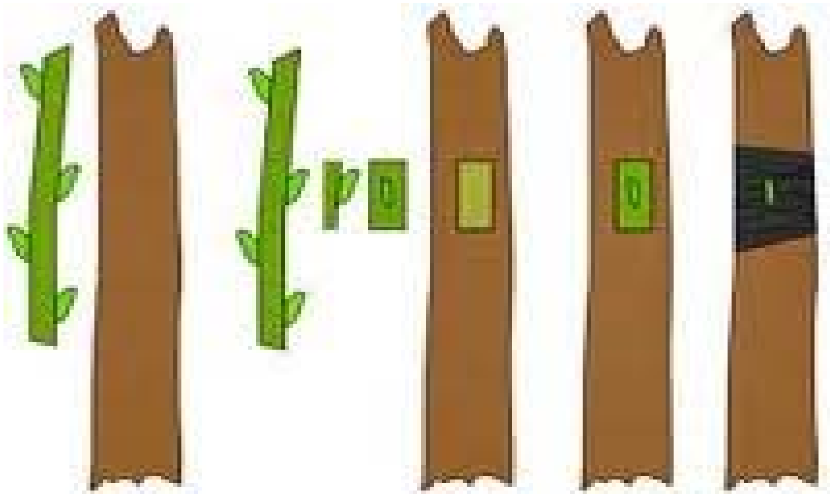
T-Budding



Chip Budding



Patch Budding



FACTORS INFLUENCING GRAFT UNION SUCCESS

- **Incompatibility**
- **Plant species and type of graft**
  - **Easy plants = apples, grapes, pears**
  - **Difficult plants = hickories, oaks and beeches**

  - **Gymnosperms are usually grafted scions**
  - **Angiosperms are usually budded scions**

FACTORS INFLUENCING GRAFT UNION SUCCESS

- **Environmental conditions following grafting**
  - **<u>Temperature</u>: effects callus production.**
    - **Depends on plant! (beech calluses better at 45ºF while grape is best at 75ºF)**
    - **Easy to control in a greenhouse but difficult in the field**
  - **<u>Moisture</u>: needed for cell enlargement in the callus bridge**
    - **Maintain using plastic bags over scion**
    - **Wrap with grafting tape, Parafilm, grafting rubbers and wax**
    - **Place union in damp peat moss or wood shavings for callusing**

Factors influencing graft union success

- **Growth activity of the rootstock**
  - **"T-budding" depends on the bark of the rootstock "slipping" meaning the cambial cells are actually dividing and separate easily from each other**
  - **"slipping" usually occurs in late spring or early summer**
  - **At certain periods of high growth in spring, plants (like walnut, maple and grape) can have excessive root pressure producing sap and "bleeding", forcing off the scion and an result in an unsuccessful graft**

FACTORS INFLUENCING GRAFT UNION SUCCESS

- **Art of grafting (especially with conifers)**

- **Virus contamination, insects and disease**
  - **Viruses cause delayed incompatibilities**
    - **Blackline in walnut and brownline in plum**
  - **Bacteria and fungi can enter the wound made during grafting**

FACTORS INFLUENCING GRAFT UNION SUCCESS

- **Plant growth regulators and graft union formation**
  - **Exogenous auxins have not proven beneficial**
  - **Endogenous auxin is needed in the scion to produce callus**
- **Post-graft (bud-forcing) methods**
  - **"crippling" or "lopping" = cutting halfway through the rootstock shoot on the side above the bud union and breaking over the shoot. This "breaks" apical dominance and the scion bud can elongate**

FACTORS INFLUENCING GRAFT UNION SUCCESS

- **Polarity in grafting**
  - **<u>Top-grafting</u>: proximal end of scion inserted into distal end of rootstock**
  - **<u>Root-grafting</u>: proximal end of scion inserted into proximal end of rootstock**
  - **Inverse scions in bridge grafts can remain alive but will not expand/grow**
  - **<u>Budding</u>: upright orientation of bud should be maintained**

Factors influencing graft union success

- Genetic limits of grafting
  - Monocots are harder than dicot. Why?
    - Lack vascular rings and have scattered vascular bundles instead
  - General rules:
    - The more closely related plants are (botanically), the better the chances for the graft to be successful
    - Grafting within a clone (no problems)
    - Grafting between clones within a species (usually no problems)
      - Problems can occur with *Pseudotsuga* (evergreen conifer) and *Acer rubrum* and *Quercus rubra* (deciduous angiosperm plants)

FACTORS INFLUENCING GRAFT UNION SUCCESS

- **Genetic limits of grafting**
  - **General rules:(continued)**
    - **Grafting between species within a genus (50/50 chance of success). Reciprocal interspecies grafts are not always successful**
    - **Grafting between genera within the same family (rather remote)**
      - ***Chamaecyparis* (cypress) on *Thuja* (arborvitae)**
      - ***Citrus* (citrus) on *Poncirus* (hardy orange)**
      - ***Pyrus* (pear) on *Cydonia* (quince)**
      - **In the Solanaceae (nightshade family) grafting between genera is not a problem! Tomato, tobacco, potato, pepper, petunia, morning glory, etc.**

FACTORS INFLUENCING GRAFT UNION SUCCESS

- **Genetic limits of grafting**
  - **General rules:(continued)**
    - **Grafting between families: *nearly* impossible!**
    - **The first known graft union between two different families was published in 2000. The families were two succulents:**
    - **Cactaceae and Capparaceae**

Graft Incompatibility

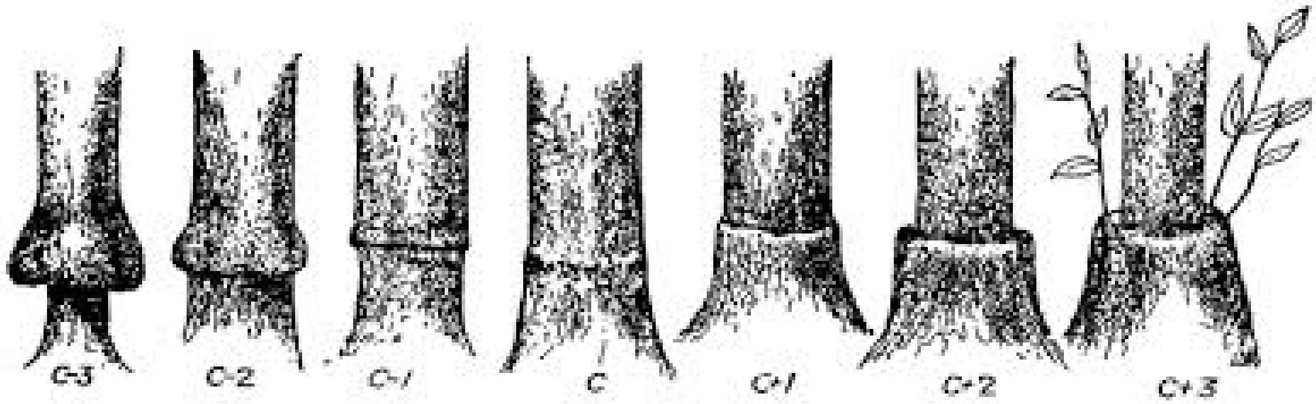
- <u>Compatibility</u> = ability of two different plants grafted together to produce a successful union and continue to develop satisfactorily
- <u>Graft failure</u>: caused by anatomical mismatching/poor craftmanship, adverse environment, disease and graft incompatibility

Graft Incompatibility

- **Graft incompatibility from:**
  - **Adverse physiological responses between grafting partners**
  - **Virus transmission**
  - **Anatomical abnormalities of the vascular tissue in the callus bridge**

GRAFT INCOMPATIBILITY

- **External symptoms of incompatibility**
  - **Failure of successful graft or bud union in high percentages**
  - **Early yellowing or defoliation in fall**
  - **Shoot die-back and ill-health**
  - **Premature death**
  - **Marked differences in growth rate of scion and stock**
    - **Overgrowth at, above or below the graft union**
    - **Suckering of rootstock**
    - **Breakage at the graft union**



C-3
C-2
C-1
C
C+1
C+2
C+3

Graft Incompatibility

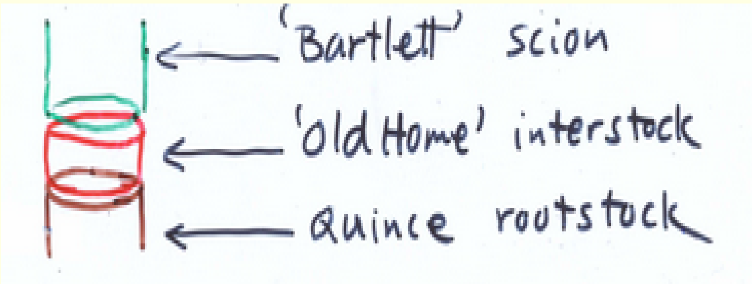
- **Anatomical flaws leading to incompatibility**
  - **Poor vascular differentiation**
  - **Phloem compression and vascular discontinuity**
  - **Delayed incompatibility may take 20 years to show up (often in conifers and oaks)**

Graft Incompatibility

- **Physiological and Pathogen-Induced Incompatibility**
  - **Non-translocatable = localized. Problem is fixed by using mutually compatible interstock(no direct contact between scion and stock)**
  - **Translocatable = spreads. Interstock does not solve the problem. Some mobile chemical causes phloem degradation. Ex: cyanogenic glucosides like prunasin is converted to hydrocyanic acid (from Quince to pear)**

3 types of incompatibility

1. Localized -lack of contact between cambium layers of stock and scion
   Bartlett pear scion o fquince rootstock-------> incompatible
   Use of 'old home' pear as interstock ---------> compatible
2. Translocated - translocatable 'substances' cause incompatibility ---results in phloem degeneration, necrotic tissues, etc.



   'Hale's Early' peach no 'Myrobalan B' plum rootstock --> incompatible
   use of interstock does not overcome incompatibility
3. Virus-induced - latent viruses become active when transmitted to scion from stock or vice versa
   -citrus quick decline, pear decline
   -stempitting virus from scion to rootstocks of 'Virginia Crap' apple

Graft Incompatibility

- **Pathogen-induced virus of phytoplasma induced**
- **<u>Tristeza</u> = viral disease of budded sweet orange that is grafted onto infected sour orange rootstock**

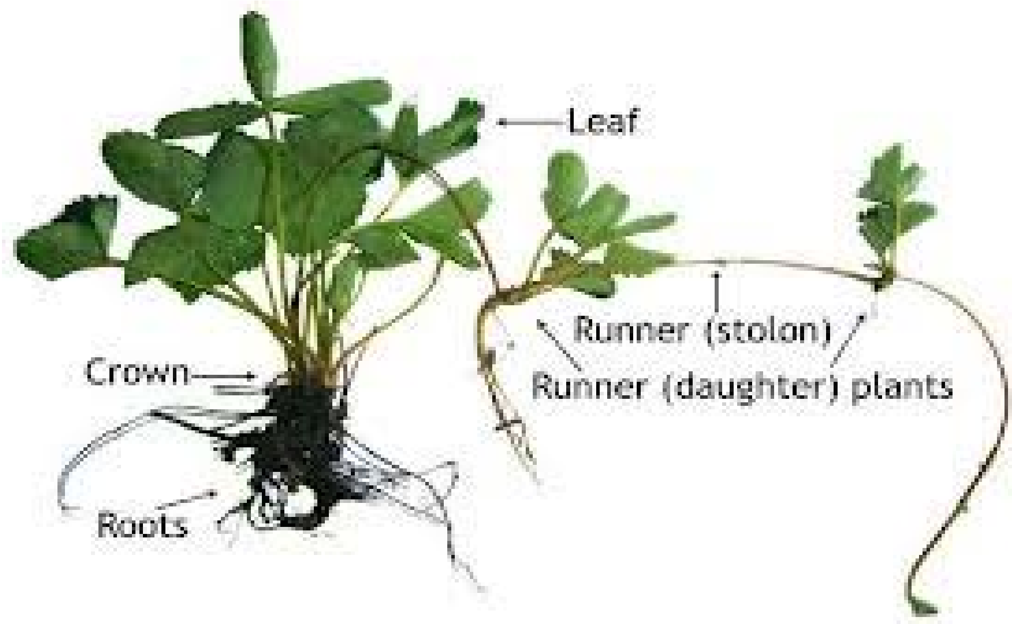
Graft Incompatibility

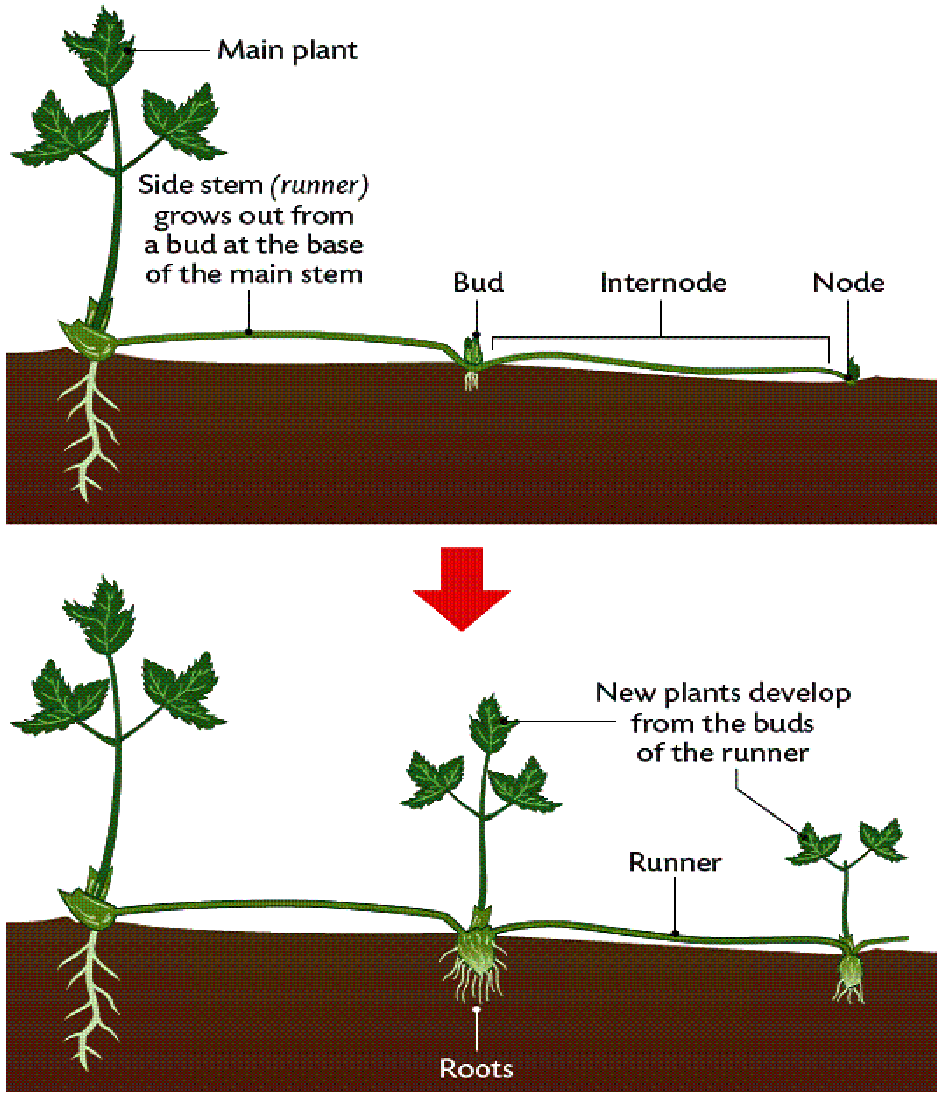
- **Predicting incompatible combinations**
  - **Electrophoresis test to look for cambial peroxidase banding (chestnut, oak and maple). Peroxidases produce specific lignins and the lignins must be similar for both scion and stock for the graft to be successful long-term.**
  - **Stain tissues at the graft union and examine microscopically**
  - **Magnetic resonance imaging (MRI) checks for vascular discontinuity**

Graft Incompatibility

- **Correcting incompatible combinations**
  - **Generally not cost-effective. Remove and top-work the rootstock**
  - **Bridge graft with a mutually compatible rootstock**
  - **Inarch with a seedling of compatible rootstock**

Runner



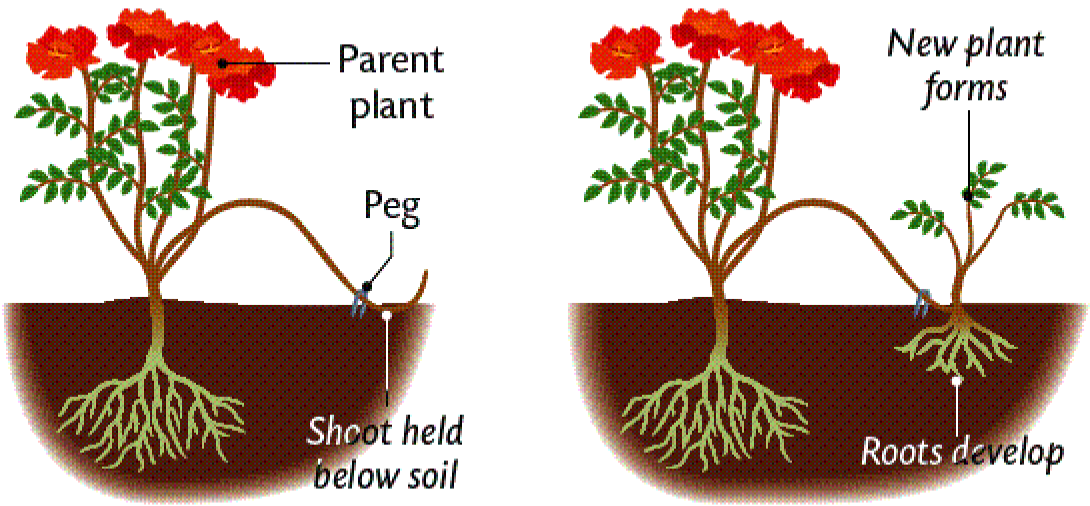


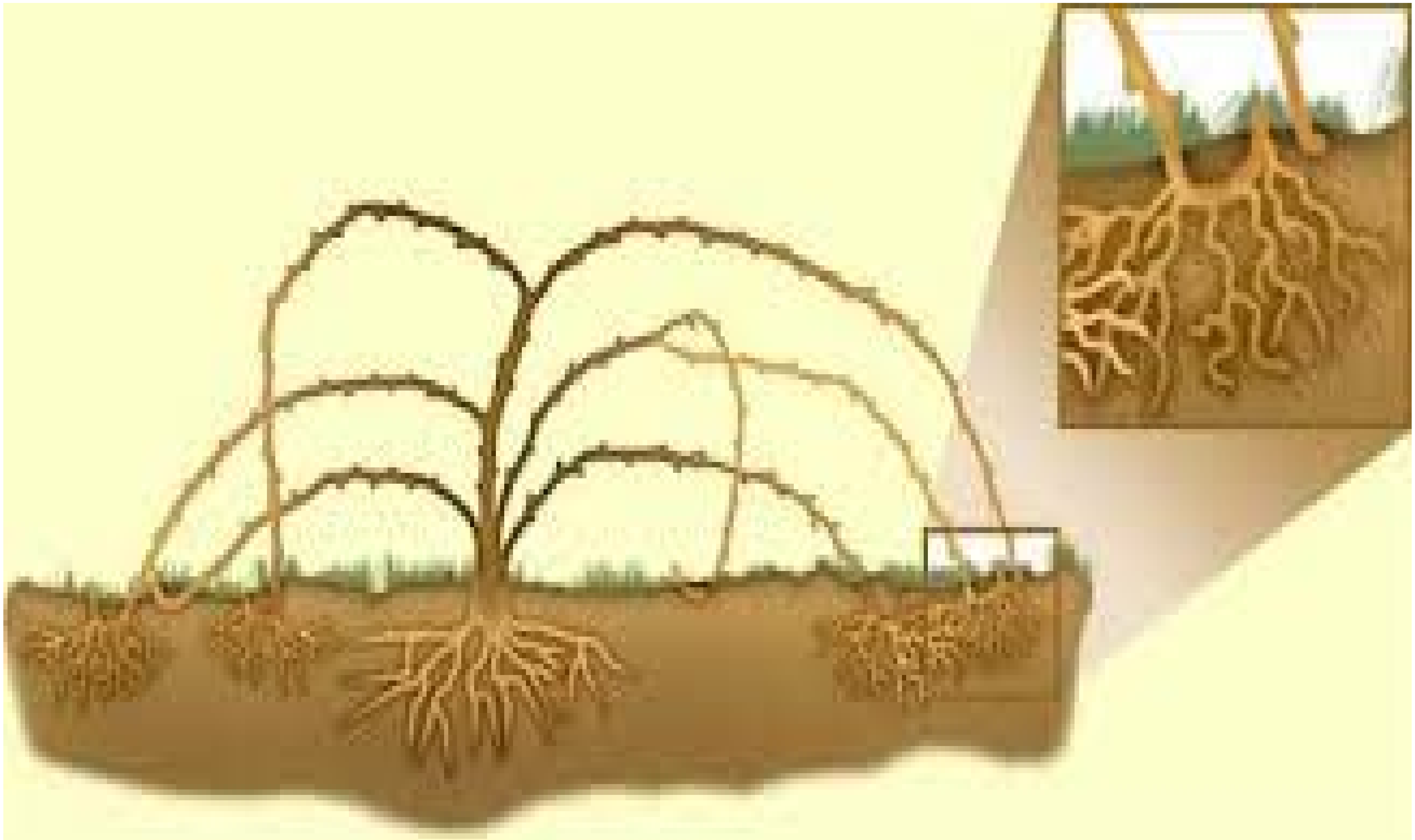
Main plant
Side stem (runner) grows out from a bud at the base of the main stem
Bud
Internode
Node
New plants develop from the buds of the runner
Runner
Roots

Sucker

LAYERING

- The rooting of plant parts while they are still attached to the "parent" plant.
- The types are….
  - Air Layering.
  - Trench Layering.
  - Mound Layering.

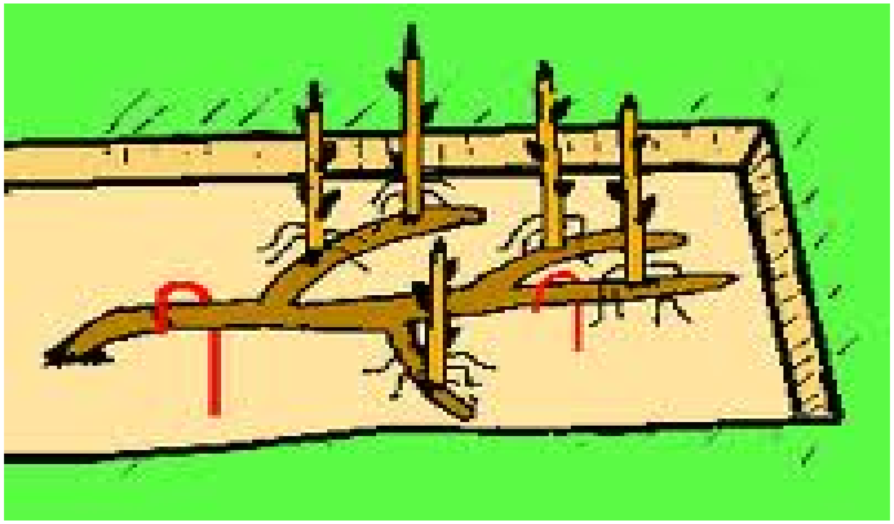

Parent
plant
Peg
Shoot held
below soil
New plant
forms
Roots develop



Simple Layering

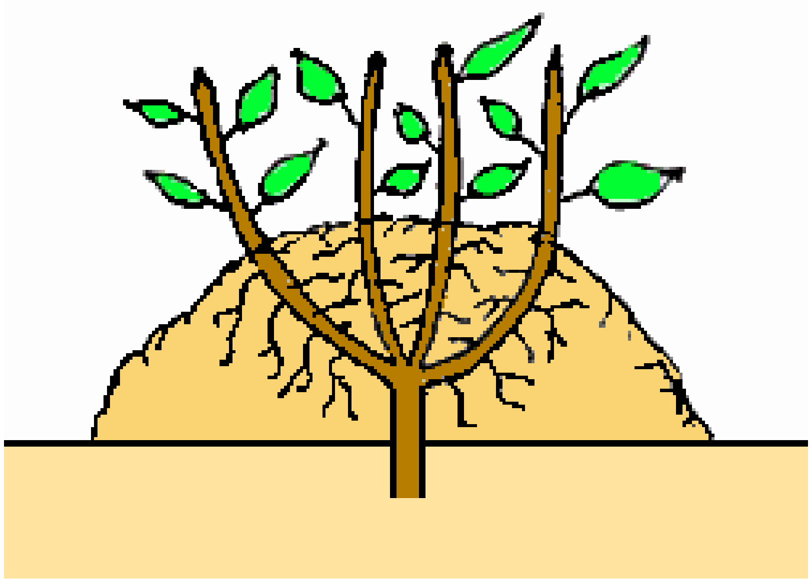
Trench Layering

- Mother plant is bent to the ground and buried.
- Plants form at each node on covered stem.



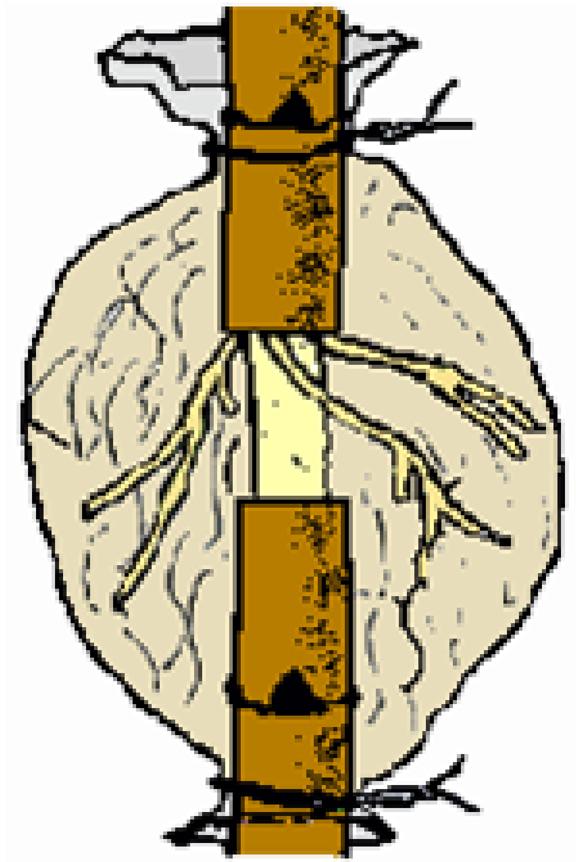
Mound Layering

- Rooted plant is cut off at the soil level.
- As the season progresses, soil is added to cover the growing shoots.
- After 1 year, the shoots are rooted and removed from the parent plant.

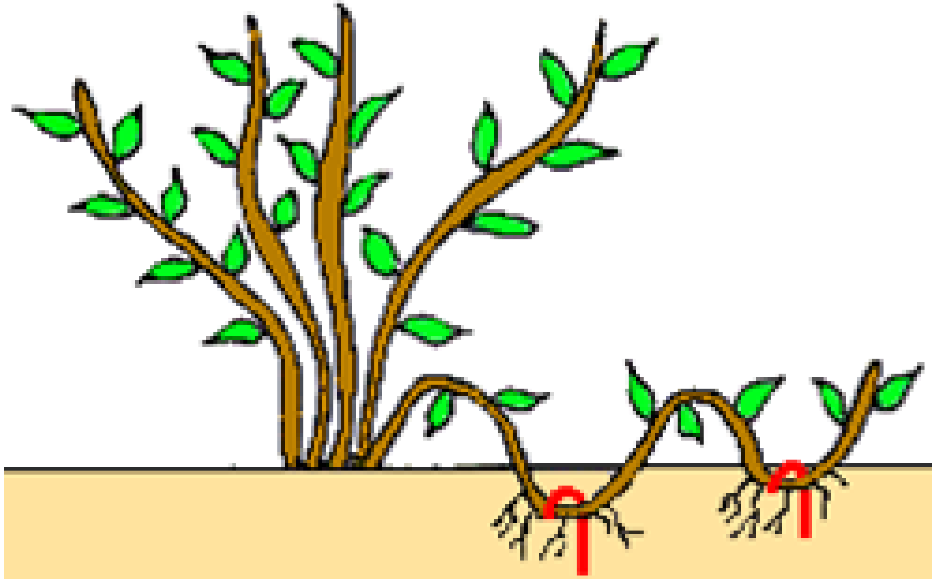


Air Layering

- Also called Chinese propagation.
- Area of plant is girdled and surrounded by a moist growing medium that is sealed in polyethylene film.



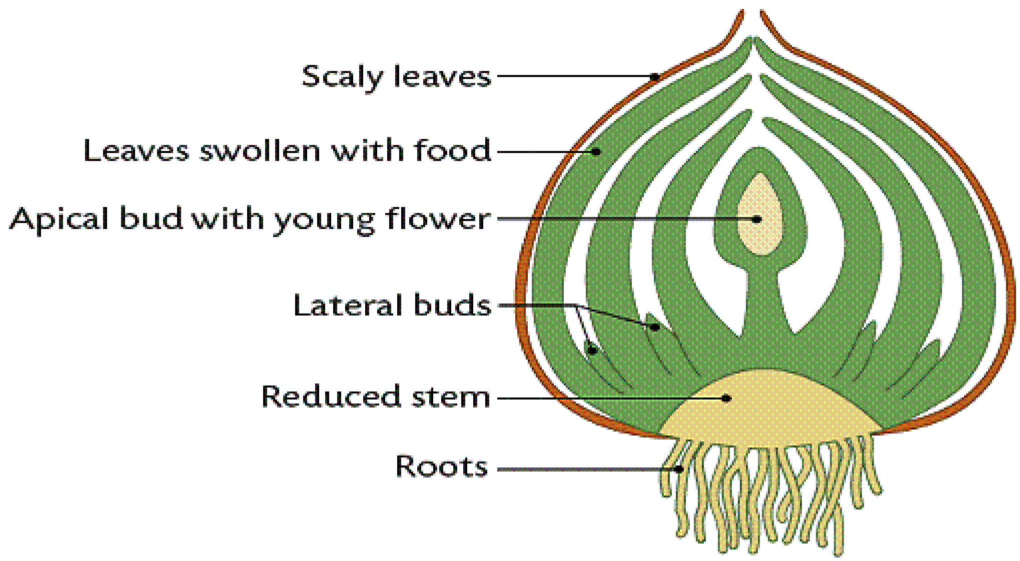
Compound Layering



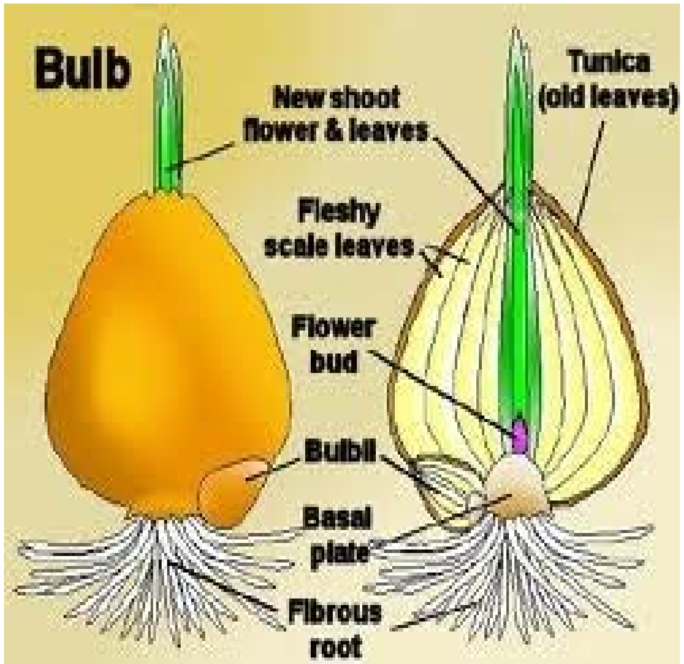
Division & Separation

- Cutting or pulling apart of….
  - Bulbs
  - Corms

•**Bulbs**: A bulb contains an **underground stem**. Leaves are attached to the stem. These leaves contain much stored food. At the centre of the bulb is an **apical bud**. Also attached are **lateral buds**. The apical bud will produce leaves and a flower while the lateral buds will produce new shoots. As the plant grows and develops it will form a new bulb underground.



SEPARATION

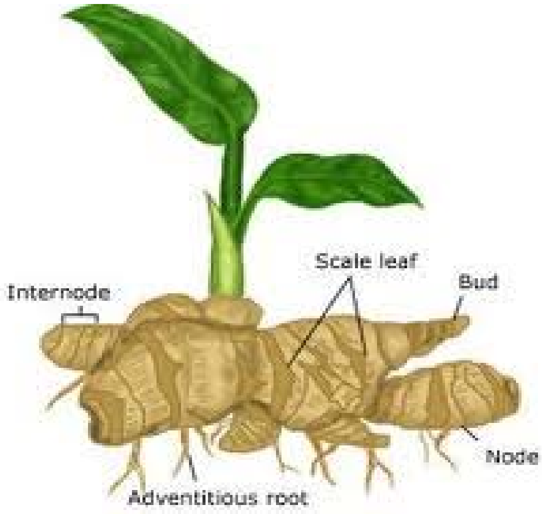


Bulb
New shoot
flower & leaves
Tunica
(old leaves)
Fleshy
scale leaves
Flower
bud
Bulbil
Basal
plate
Fibrous
root


Lily bulb
bulb scales

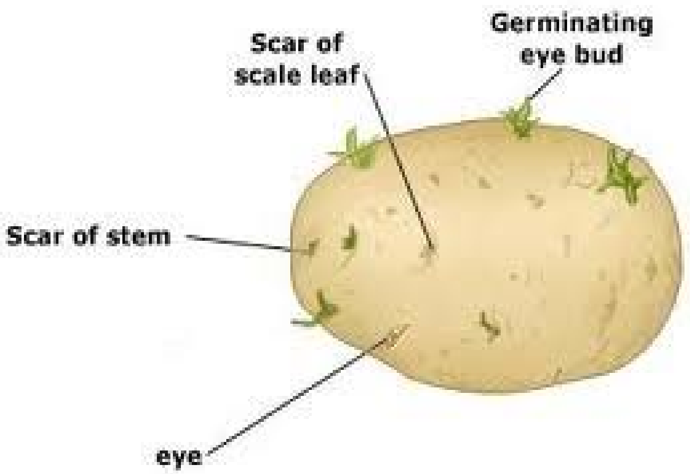
CORM

RHIZOME نیساگ



OFFSET (OFFSHOOT)

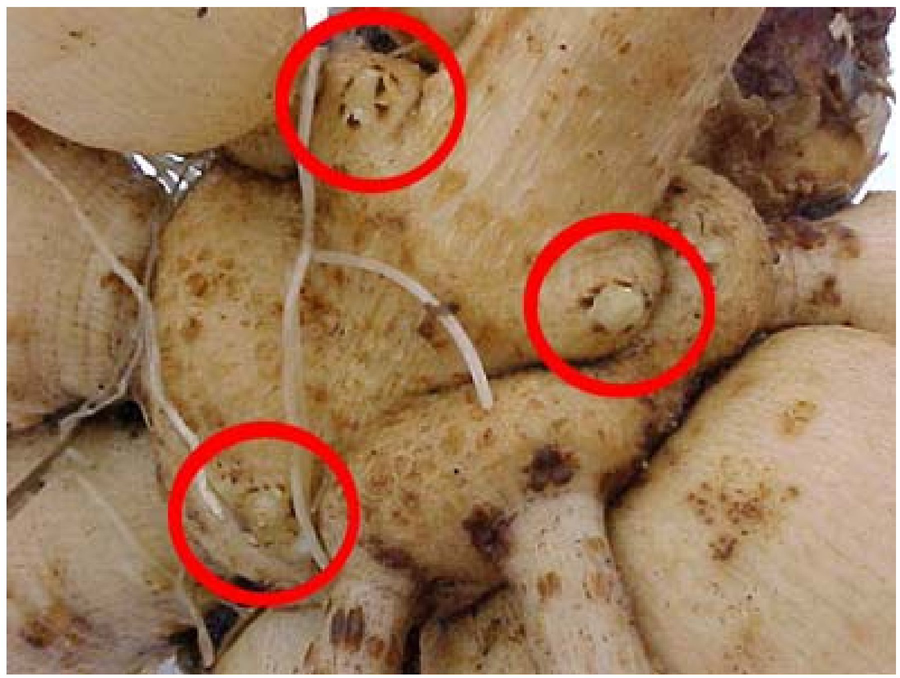
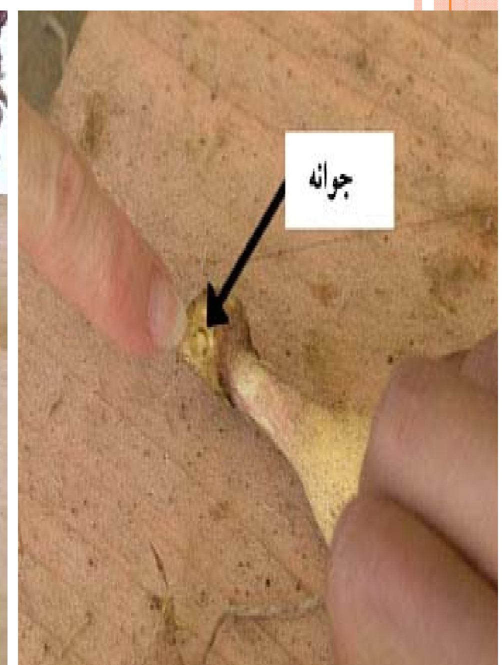
TUBER


Germinating
eye bud
Scar of
scale leaf
Scar of stem
eye


COMPOSITE
TUBER
MANY
LEAVES
CALADIUM
TUBER
INDIVIDUAL
TUBERS







جوانه

Crown