Federal University Wukari,
Faculty of Pure and Applied Sciences,
Department of Biological Sciences.
BIO 101 Lecture Notes

PLANT REPRODUCTION

The process by which living organisms produce their offsprings for the continuity of the species is called reproduction. It is a characteristic of all living things.

The modes of reproduction vary according to individual species and available conditions. It may be simply by division of the parent cell as in unicellular organisms, by fragmentation of the parent body, by formation of buds and spores, or it may be very elaborate involving development of male and female reproductive organs (stamens and pistils).

Irrespective of the mode of reproduction, all organisms pass on their hereditary materials to their offsprings during the process of reproduction.

Modes of Reproduction

The various modes by which plants reproduce are of three types –

a. Vegetative b. Asexual c. Sexual

In vegetative and asexual modes of reproduction, offsprings are produced from a vegetative unit formed by a parent without any fusion of gametes or sex cells.

- A single parent is involved.
- Offsprings are genetically identical to the parent.

a. Vegetative reproduction may be of the following types:

i. Vegetative reproduction: It involves formation of new plantlets from vegetative (somatic) cells, buds or organs of the plant. In this case, a vegetative part of the plant (root, stem, leaf or bud) gets detached from the parent body and grows into an independent plant. It is similar to asexual reproduction in that it also requires only mitotic division, no gametic fusion is involved, and newly-formed plants are genetic clones of the parent plant.

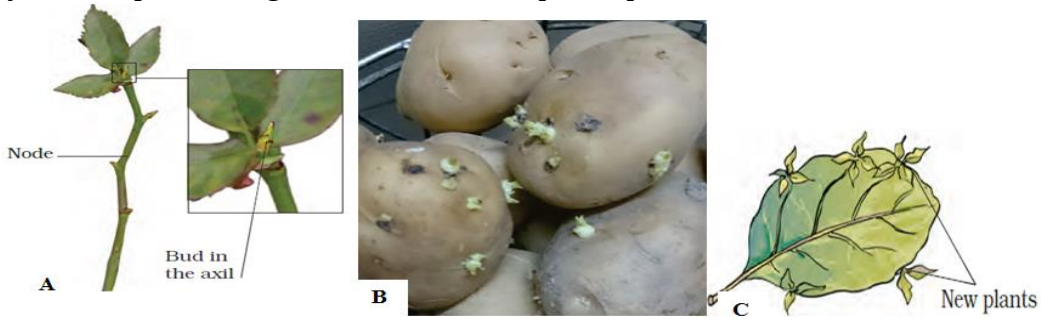


Figure 1: **A.** Stem-cutting of rose, **B.** Potato plant sprouting from an 'eye', **C.** Leaf of *Bryophyllum* with buds in the margin.

NB:
Vegetative reproduction can be natural (as outlined above) or artificial. Artificial methods include; cutting (eg., Rose, Croton, Sugarcane), layering (eg., strawberry, grapevine) and grafting (eg., citrus, mango, apple)/

Advantages of vegetative reproduction

i. Rapid means of reproduction and spread.
ii. Offsprings identical to parent. The desired varieties can thus be preserved genetically for use.
iii. Food storage organs allow perennation or survival in adverse conditions.
iv. Improved varieties of ornamental plants and fruit trees can be multiplied easily.
v. Vegetative propagation is a quicker, easier and a less expensive method of multiplying plants.

Disadvantages of vegetative reproduction

i. Overcrowding and competition for space unless separated artificially.
ii. New varieties cannot be produced by this method except by mutation.
iii. Diseases typical of the species are rapidly transmitted and can be detrimental to a crop.

ii. Fragmentation: In filamentous algae, an accidental breaking of the filament into many fragments, each fragment having at least one cell, may give rise to a new filament of the algae by cell division e.g. *Spirogyra*.

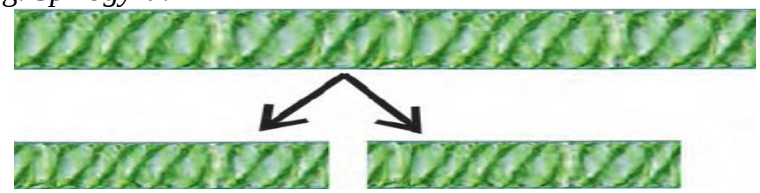


Figure 2: Fragmentation in *Spirogyra* (an alga).

iii. Fission: It occurs in unicellular organisms like bacteria and yeasts where the content of the parent cell divides into 2, 4 or 8 daughter cells and accordingly the fission is known as binary or multiple fission. Each newly formed daughter cell grows into a new organism.

iv. Budding: It also occurs in unicellular plants. A bud-like outgrowth is formed on one side of the parent cell and soon it separates and grows into a new individual e.g. in yeast.

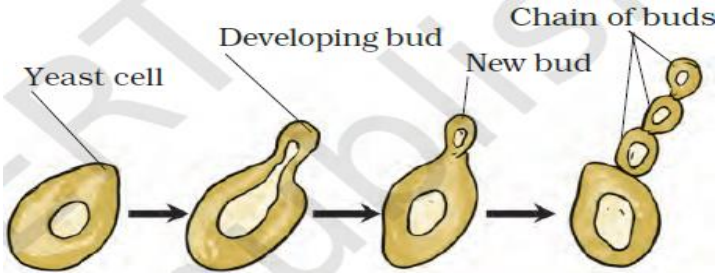


Figure 3: Reproduction in Yeast by budding.

b. Asexual reproduction takes place by asexual spores which may be flagellate or nonflagellate; **Spore formation**: In lower plants including bryophytes and pteridophytes, special reproductive units develop asexually on the parent body. These are called spores. They are microscopic and covered by a protective wall. When they reach suitable environment they develop into a new plant body e.g. in bread moulds, moss, fern.

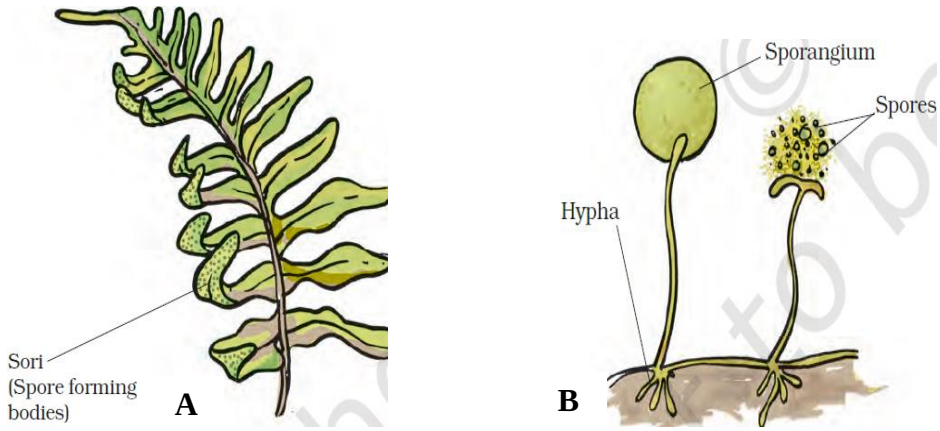


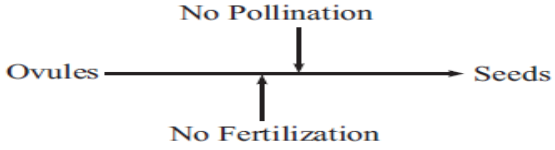
Figure 4: Reproduction through spore formation; **A.** Fern, **B.** Fungus.

NB: In higher plants like pea, maize and gymnosperms, asexual reproduction is always heterosporous. Here, spores are produced after meiosis. The small male spores called microspores give rise to male gametophyte. The large female spores are called megaspores, and they give rise to female gametophytes.

c. Sexual reproduction involves fusion of male and female reproductive cells (gametes) which are haploid and are produced by male and female reproductive organs. This fusion is known as fertilization and results in the production of a zygote (diploid). Further development of zygote gives rise to a new individual which is diploid.

In this case, at some stage of the life history, meiosis is involved and the offsprings are not genetic clones of their parents, but are genetically different and generally exhibit mixed characters of their parents.

NB: Apomixis - This is a unique mechanism of asexual reproduction in certain plants (e.g. Dandelions) which produce seeds without pollination and fertilization. Since there is no fusion of male and female gamete, any somatic cell of ovule which is diploid, gives rise to the embryo and then ovule matures into a seed. The seeds are then dispersed. The interesting fact is that apomixis is an **asexual process** but disperses its seeds like those of plants that undergo sexual reproduction.



Reproduction in Lower Plants

1. *Chlamydomonas*:

It is a haploid unicellular alga found in fresh water ponds. The plant body is pear-shaped with two flagella attached at the narrow end.

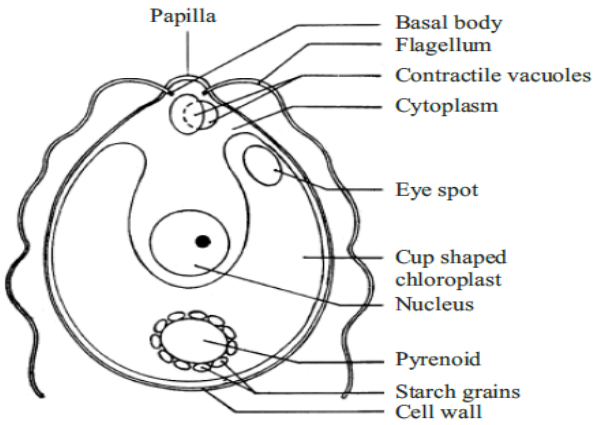


Figure 5: A *Chlamydomonas* cell

A. Asexual Reproduction

1. Asexual Reproduction by Zoospores:

- If plenty of water is available for free swimming, *Chlamydomonas* reproduces by flagellate thin-walled spores, called zoospores.
- *Chlamydomonas* cell loses flagella and becomes non-motile.
- Its protoplasm (cytoplasm and nucleus) divides mitotically and forms 2-16 daughter protoplasts, each of which develops ***flagella***, and is called a zoospore.
- The parent cell wall is ruptured and zoospores are released.
- Each zoospore develops a cell wall and grows into an adult cell.
- After release of zoospores the parent cell does not exist, any more.

2. Asexual Reproduction by Aplanospores:

- If a thin-film of water is available where swimming is not possible, *Chlamydomonas* produces thin-walled, ***non-flagellate*** daughter protoplasts, called aplanospores.
- The parent cell loses flagella and becomes highly extended. Its protoplast divides repeatedly to produce 100 or more daughter protoplasts, each of which is called an aplanospore.
- The whole structure containing groups of non-motile aplanospores resembles a non-motile Colonial alga, called Palmella, and so this is called palmella stage of *Chlamydomonas*.
- If plamella-stage is flooded with water, each aplanospore develops flagella, comes out of the parent cell wall and grows into a normal independent plant.

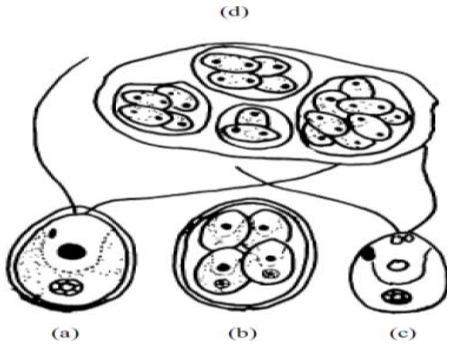


Figure 6: Asexual reproduction in *Chlamydomonas*. **a.** Muture cell, **b.** 4 daughter cells (zoospores formed by asexual reproduction), c. Zoospore after escape from parent cell, **d.** Palmella stage of *Chlamydomonas*.

B. Sexual Reproduction

Chlamydomonas reproduces sexually by isogamy, anisogamy or oogamy depending upon the species:

I. Sexual Reproduction by Isogamy

- Isogamy is exhibited by *Chlamydomonas eugametos* and *C. eherenburgii*.
- The male and female cells become non-motile by losing their flagella.
- The protoplasm of each cell divides mitotically into 32 - 64 daughter cells.
- Each daughter cell develops flagella and is released in water by the rupture of mother cell wall.
- Each of these cells acts as a gamete.
- The gametes are morphologically identical in structure but differ physiologically or chemically.
- Gametes released in water from two different mother cells fuse in pairs forming quadriflagellate zygotes (diploid).
- This is the only diploid stage in the life cycle of *Chlamydomonas*.
- The zygote develops a thick wall around itself and develops brown to black coloured pigmentation to tide over unfavourable conditions (zygospores).
- On the return of favourable conditions (temperature, food and water) the diploid nucleus of the zygote divides by meiosis and forms four haploid zoospores.
- Each zoospore grows into a new adult *Chlamydomonas* plant.

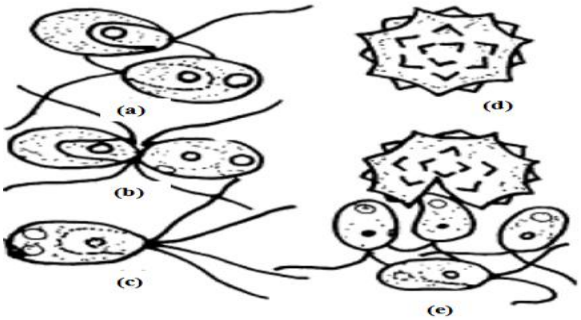


Figure 7: Sexual reproduction in *Chlamydomonas* by isogamy: **a.,b.c.** Free swimming gametes and fusion of gametes, **d.** A resting zygote (zygospore), **e.** 4 cells formed after meiosis of the zygote cell (zoospores).

II. Sexual Reproduction by Anisogamy

- Anisogany is exhibited by *Chalamydomonas braunii*.
- Male and female cells lose flagella and become non-motile.
- In male cell, protoplast divides repeatedly to produce 32 - 64 biflagellate gametes but in female cell, protoplast divides to produce 8 to 16 biflagellate gametes.
- Both male and female gametes are released in water.
- Larger female gametes lose flagella and become non-motile, and each one is fertilized by a smaller motile male gamete.
- After fertilization, the fusion product loses flagella, becomes spherical and develops thick wall to become a resting zygote.
- On return of favourable conditions of water, temperature and light, the zygote undergoes meiosis and produces four haploid zoospores each of which grows into an independent *Chlamydomonas* plant.

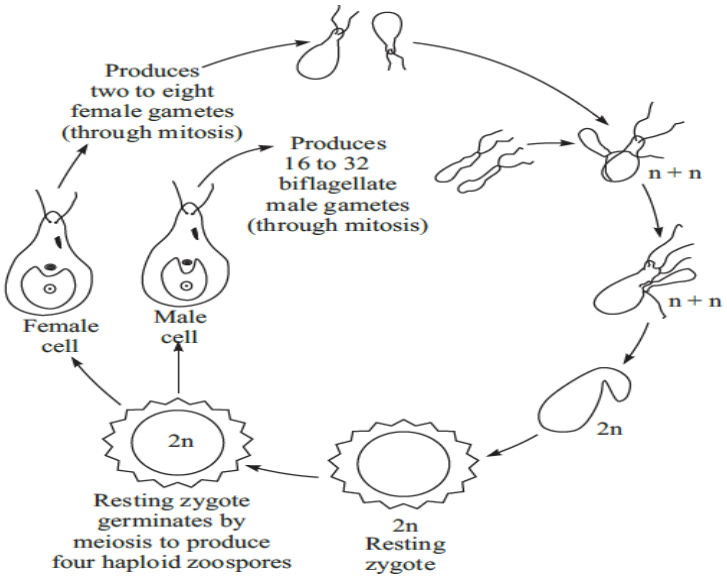


Figure 8: Sexual reproduction in *Chlamydomonas* by anisogamy.

III. Sexual Reproduction by Oogamy

- Oogamy is exhibited in *Chlamydomonas coccifera* and *C. ooganum*.
- In this case, female and male cells lose flagella and become non-motile.
- All the contents of female cell act as female gamete or egg, but the protoplasm of male cell divides to produce 32-64 biflagellate gametes.
- The biflagellate gametes are liberated in water and swim around in search of female gamete.
- Two or more flagellate gametes enter each female cell having non-motile egg, but only one fertilizes the egg and others degenerate, contributing nutrition to the young zygote.
- The fusion product of egg and a motile gamete is called zygote and it develops a thick, pigmented wall to enter into resting phase.
- On return of favourable conditions of water, temperature and light, the zygote undergoes meiosis to produce four haploid biflagellate zoospores, each of which on liberation from zygote, grows into an independent plant of *Chlamydomonas*.

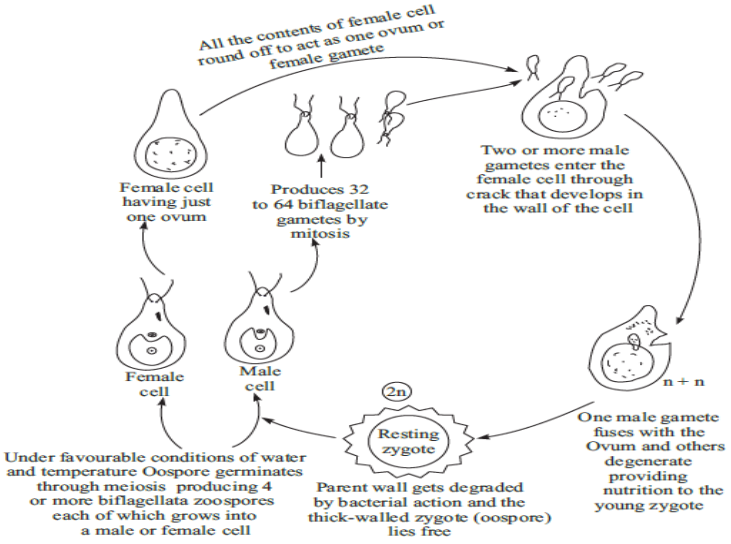


Figure 8: Sexual reproduction in *Chlamydomonas* by oogamy.

2. *Spirogyra* (A Multicellular, Filamentous Alga)

Structure

- It is a free floating alga found in fresh water ponds.
- The body has a row of cylindrical cells joined end to end.

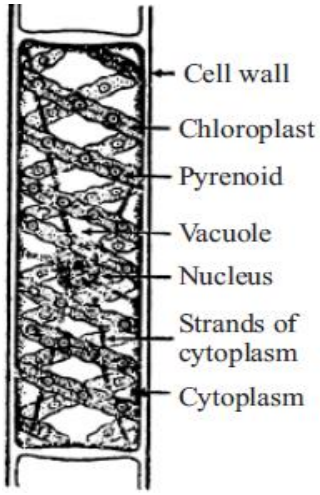


Figure 9: *Spirogyra*: Single cell from a filament

Reproduction

A. Vegetative Reproduction by fragmentation:

- The filament breaks into small fragments, at the point of transverse septum following a physico-chemical change.
- Each fragment having at least one complete cell grows into a new filament by repeated mitotic cell division.

B. Sexual Reproduction: It takes place by scalariform and lateral conjugation.

✓ **Scalariform Conjugation**

- Conjugating filaments give a ladder-like appearance.
- Two filaments come to lie very close to each other so that the cells of the two filaments pair septum to septum and face to face.
- The pairing cells of the two filaments form a contact with the help of a tube called the conjugation tube.
- Cytoplasmic contents of each cell round off to act as a gamete.
- Gamete from one cell (male) passes to the other cell (female) through the conjugation tube, by amoeboid movement.
- The contents of two gametes fuse in the female cell and form a diploid zygote.
- After the sexual fusion of gametes, all the cells of male filament are empty whereas each cell of the female filament has one thick-walled diploid zygospore.
- The zygospore develops a thick wall around itself and develops dark brown to black pigment to tide over the unfavourable period.
- On the return of favourable conditions, the diploid nucleus divides by meiosis into four haploid nuclei.
- Three of these nuclei degenerate.
- On germination, wall of the zygospore ruptures and a small tube like structure, containing one haploid nucleus comes out.
- The small tube develops into a long filament by repeated mitotic cell divisions.

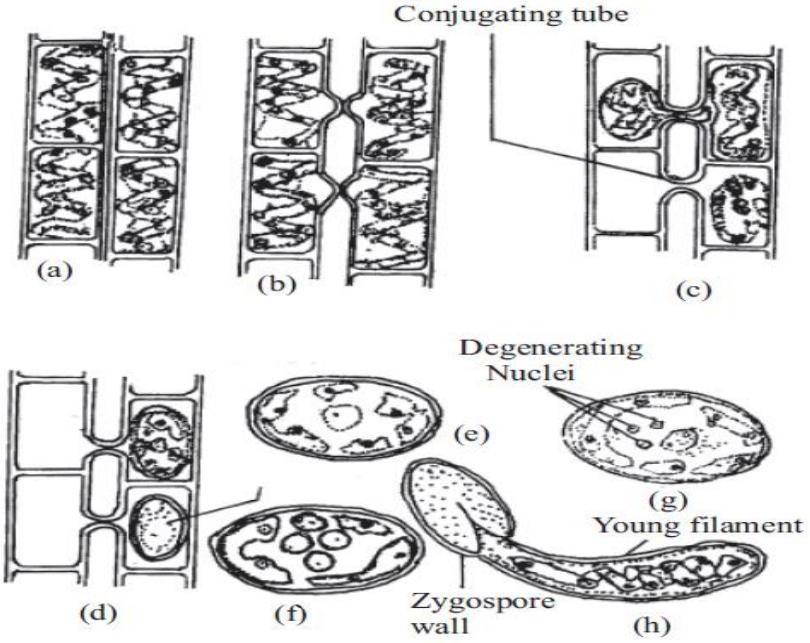


Figure 10: Sexual reproduction in*Spirogyra* – Scalariform conjugation. **a.** 2 filaments lie close, **b.** Formation of conjugation tube, **c.** Transfer of gamete from the donor to the recipient cell, **d.** Zygospore within recipient cell, **e.** Zygospore released from female cell, **f.** Meiotic division in zygospore produces 4 haploid nuclei, **g.** 3 haploid nuclei degenerate, **h.** Formation of young filament.

- ✓ **Lateral Conjugation**

- In this case, cells of only one filament are involved in conjugation wherein, male and female cells are arranged in alternate pairs i.e., two male cells alternate with two female cells all along the length of a filament.
- Conjugation tube is formed lateral to the septum separating a male and a female cell.
- Protoplasm of male cells migrate into female cells.
- After fertilization, a filament would show two empty cells alternating with two cells each having thick-walled diploid zygospore.
- The zygospore under favourabe conditions, germinates as in scalariform conjugation to produce only one independent plant, because 3 haploid nuclei after meiosis, degenerate.

Reproduction in Angiosperms (Flowering Plants)

- Angiosperms reproduce both by vegetative as well as by sexual methods.
- Sexual reproduction occurs by fusion of male and female gametes produced in the flower.
- Thus, flower represents the reproductive unit of a flowering plant – ***The structure and role of flower in sexual reproduction will be discussed next semester***.
- Angiosperms can be classified as annuals, biennials and perennials depending upon the time they take to complete the life cycle including flowering, fruiting, and death.

i. Annuals: The plants which complete their life cycle (flowering to seed formation) within one season are called annuals eg. Pea.

ii. Biennials: Plants which complete their life cycle in two seasons are called biennials. In the first season these plants remain in the vegetative state, and in the second season, they produce flowers, fruits, and seeds and then die e.g. Radish.

iii. Perennials: Plants which live for several years are termed perennials. Their vegetative stage may last from one to a few years after which they produce flowers, fruits, and seeds every year e.g. Mango, Neem.

Initiation of flowering

As the seed germinates a new plantlet emerges from it. The young plant grows vigorously and continues to grow till it attains a definite shape and size with its vegetative parts (roots, stem, leaves) well developed. This phase of the life cycle represents the young or the juvenile phase.

Then, at a certain point of time on completion of vegetative growth the plant switches over to its reproductive phase or adult phase and vegetative shoot apex transforms into a reproductive or floral apex and starts bearing flowers. This transition from vegetative to the flowering stage may take several years in trees but only a few weeks or days in annuals.

Differences between Juvenile and Adult Shoot

S/No.	Juvenile Shoot	Adult Shoot
1.	Small, soft stem bearing a few young leaves	Well developed branched stem bearing young as well as mature leaves
2.	Shape and size of leaves remain same	Shape and size of leaves differ
3.	Shoot does not respond to stimuli to produce flowers	Shoot respond to stimuli to produce flowers

Factors Affecting Flowering
Flowering in a plant is affected by temperature (vernalisation) and light (photoperiodism).
Vernalisation: Low temperature treatment which stimulates early flower formation in some plants is called vernalisation.
Photoperiodism: It is the biological response, in growth and flowering, to the duration of light and dark period received by a plant in a specific sequence.

Sex in flowers
Flowers may be bisexual (having both stamens and carpels) or unisexual (staminate or pistillate/carpellate).

Micropropagation
- The technique of plant tissues culture is utilised for propagation of plants. In this case, a small piece of tissue, organ or even a single cell is taken from a plant and is transferred to a sterilized container with nutrient medium in aseptic conditions.
- The tissue grows very-very fast into an unorganised mass, called callus (the callus can be maintained and multiplied for an indefinite period).
- When small portions of the tissue are transferred to another specialised medium with hormones, it induces differentiation and plantlets (little plants) are formed.
- The plantlets can be transplanted into pots and or soil by a gradual process and are grown to mature plants.

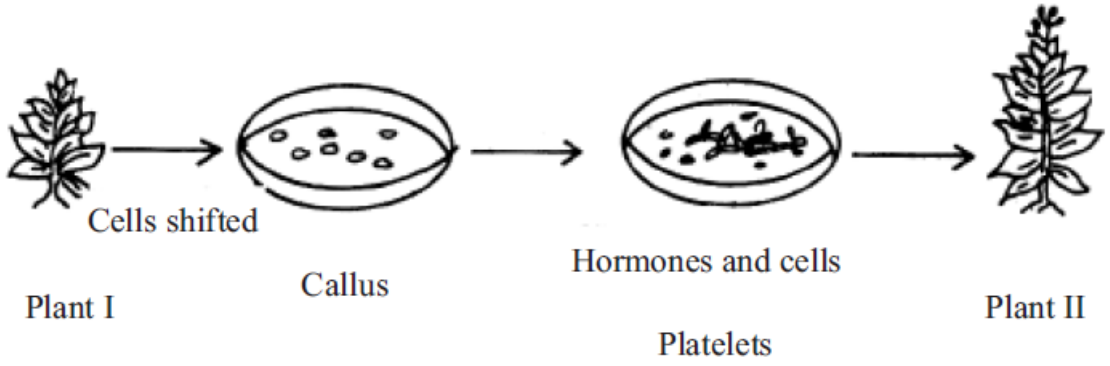


Figure 11: Steps in micropropagation

The **advantage** of micropropagation is that an indefinite number of identical plants can be obtained vegetatively starting from a small amount of parent tissue.