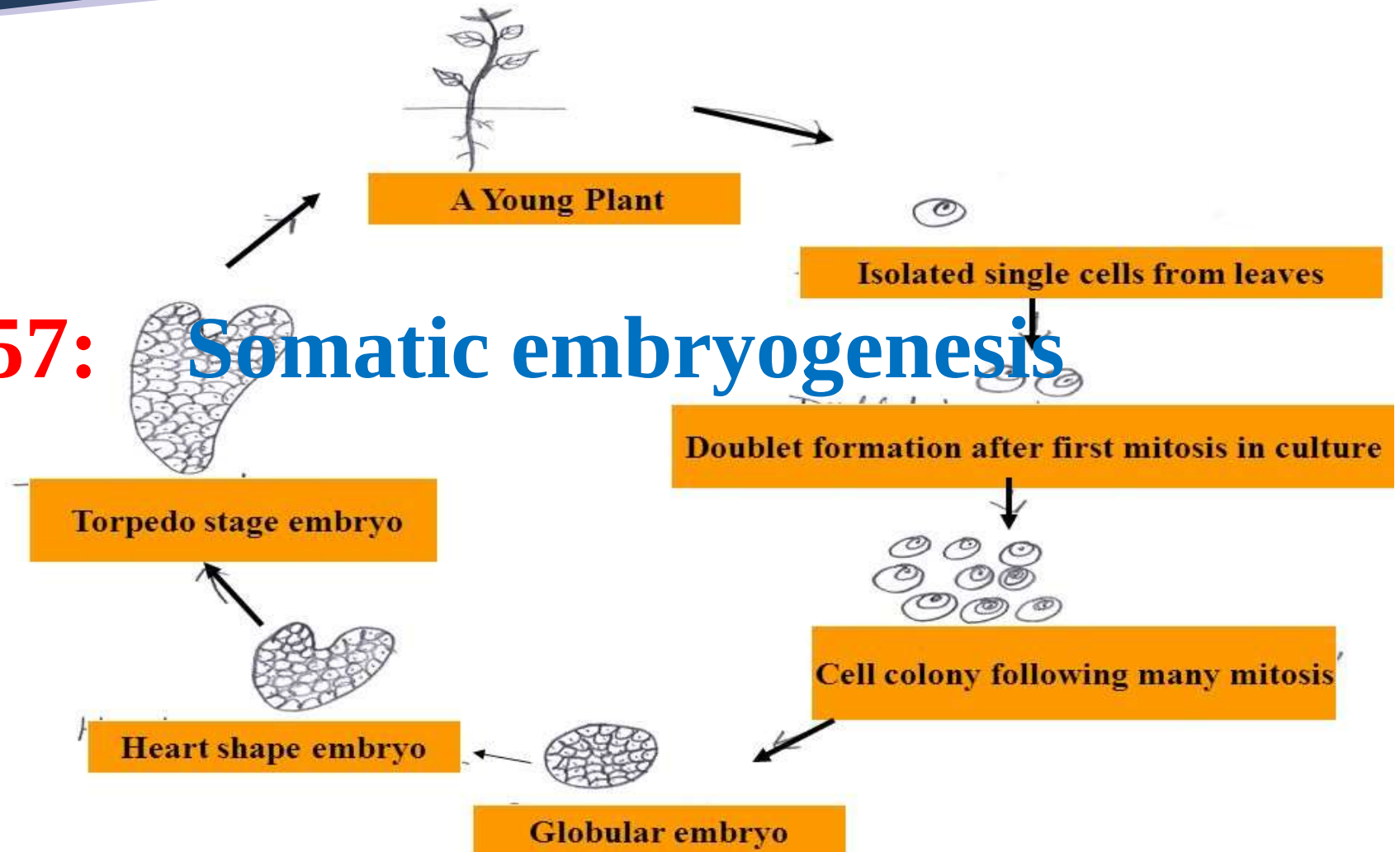




Section 57: Somatic embryogenesis



Somatic Embryogenesis (SE)

Somatic Embryogenesis (SE) is a remarkable developmental process of contemporary biology enabling non-zygotic plant cells (somatic cells), including haploid cells, to differentiate into embryos and to regenerate fertile plants (Rose et al., 2010)

his is the asexual process, utilizing the intrinsic totipotency of non-germ cells, which involves dedifferentiation of a non-zygotic cell and subsequent redifferentiation resulting in the production of all cells characteristic to regenerate full plants (Sahrawat et al., 2003)

he first observation of somatic embryo formation in *Daucus carota* cell suspensions was reported by Steward et al (1958)

SE in vitro is referred to as indirect and direct, to the presence or absence of a phase of callus development respectively (Rout et al., 2006).

Somatic embryogenesis follows similar developmental process to that of zygotic embryogenesis, progressing from the globular to heart, torpedo and finally cotyledonary stage, or to scutellar and coleoptilar in the case of monocots (Ipecki and Gozukirmizi, 2003)

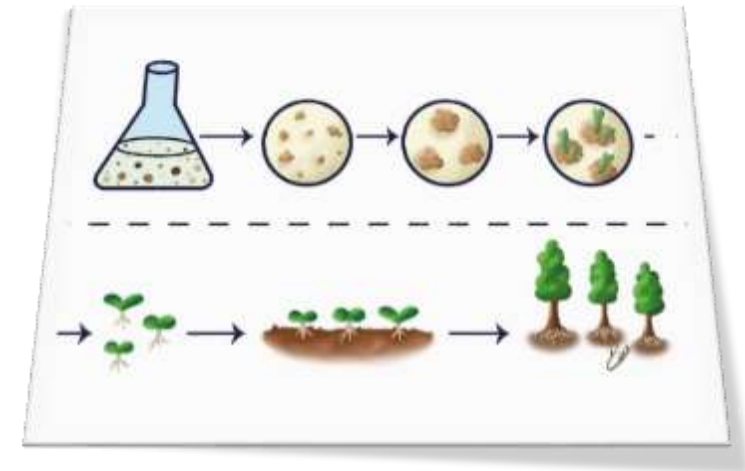
Importance of Somatic Embryogenesis (SE)

Higher propagation rate

Suitable in suspension culture

Artificial seed production

Labor saving



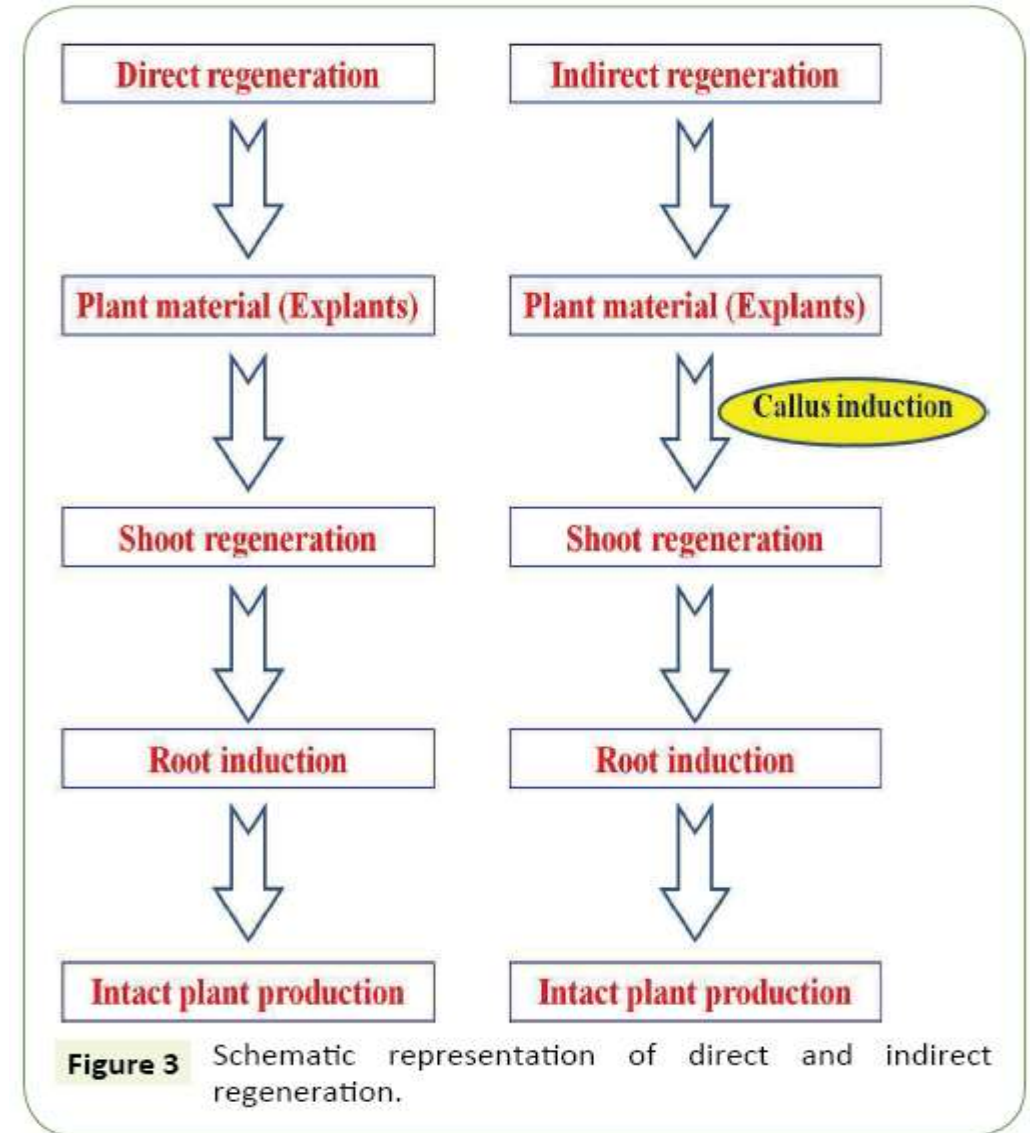
Two ways of somatic embryogenesis

1. Direct SE

when embryos are formed directly from explant tissue creating an identical clone without production of intervening callus. The explants capable of direct embryogenesis seem to carry competent or “**pre-embryonic determined cells**”(PEDCs). These cells are committed to Embryo development and need only to be released.

2. Indirect SE

when explants produced undifferentiated mass of cells(callus) which is maintained or differentiated into embryo. Specific growth regulators and culture conditions are required for callus formation and the redetermination of embryogenic development pattern called “**induced embryogenic determined cells**”(IEDCs).



Organogenesis Vs. Somatic embryogenesis

Somatic embryogenesis	Organogenesis
An artificial process in which a plan or embryo is derived from a single somatic cell	The series of organized integrated progresses which transforms an amorphous mass of cells into a complete organ in the developing embryo
The process which generates the embryonic callus from vegetative cell tissue	The process which generate plant organs including shoot and root from vegetative tissue
An artificial process occurs under laboratory condition	An natural process occurs in natural and it can also be induced artificially
Result in the formation of a somatic embryo	Results in the formation of a complete plantlet with shoot and root
The somatic embryos have no vascular connection with the maternal callus	The shoots and roots have a strong connection with their maternal tissue

Stages involved in SE

Regardless of the plant species, the various somatic embryogenesis protocols generally follow a similar process flow:

- a) Initiation of embryogenic cultures;
- b) Multiplication/ proliferation of embryogenic calli (undifferentiated phase);
- c) Maturation of somatic embryos (embryogenic phase) and
- d) Plant regeneration from these embryos

Initiation of embryogenic cultures:

Two mechanisms appear to be important for in vitro initiation of somatic embryogenesis: asymmetric cell division and control of cell elongation (De Jong et al., 1993, Emons, 1994).

Asymmetric cell division is promoted by plant hormones that alter cell polarity by interfering with the pH gradient or the electrical field around cells (Smith and Krikorian, 1990).

Stages involved in SE

Proliferation of embryogenic calli: Once formed, embryogenic cells continue to proliferate making pro-embryogenic masses.

Auxin is required for proliferation of pro-embryogenic masses but it is inhibitory for the development of somatic embryos (Filonova et al., 2000)

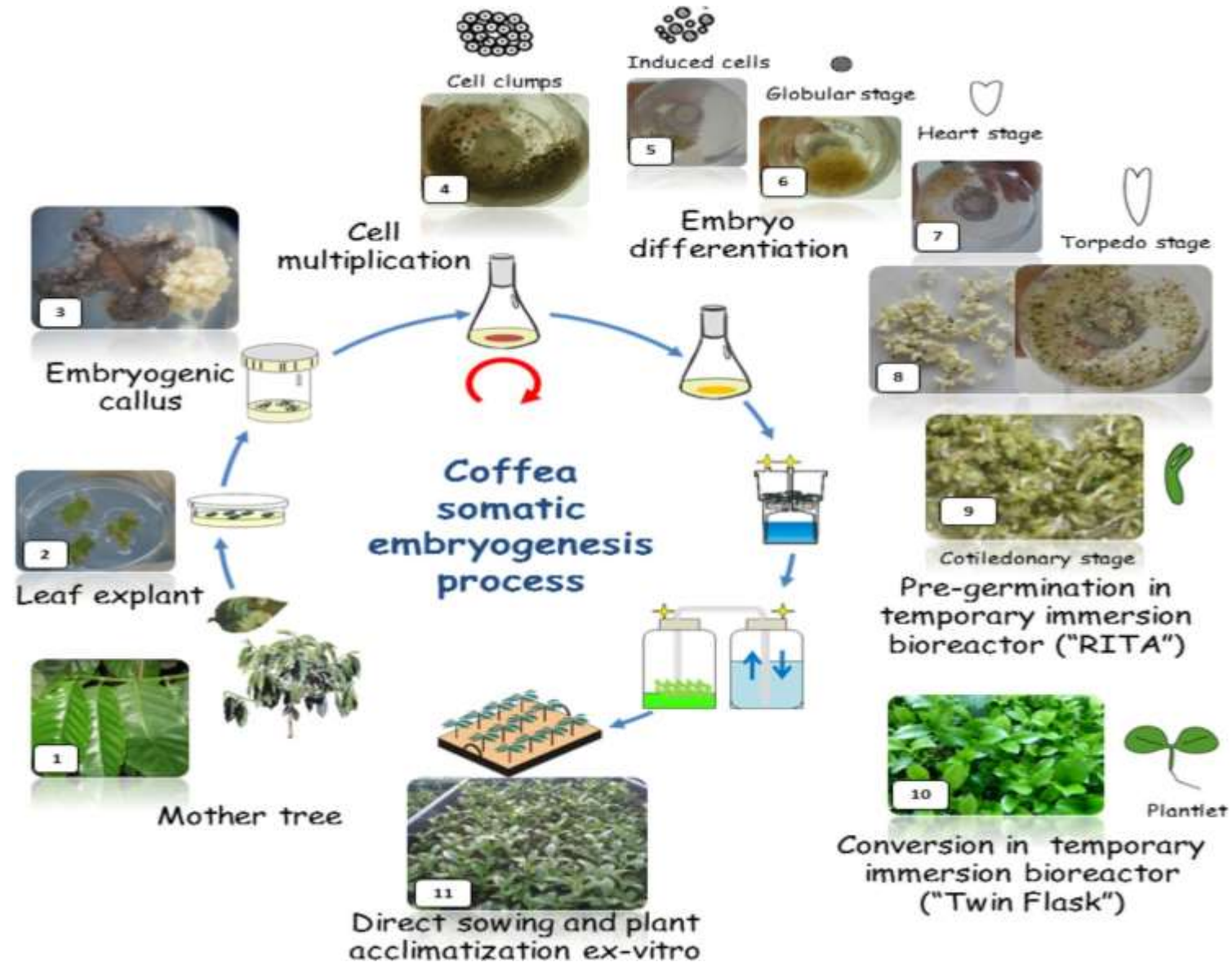
Proliferation rate of embryogenic calluses is higher in suspension cultures.

Maturation of somatic embryos: Synthetic auxins, such as 2, 4-D is very effective during initiation and proliferation of embryogenic cultures as compared to natural auxins.

During the maturation, cotyledons expand by depositing storage materials (Thomas, 1993; Yeung, 1995). The synthesis and deposition of storage and late embryogenesis abundant (LEA) proteins during somatic embryogenesis are regulated through ABA and water-stress induced gene expression (Dodeman et al., 1997).

Regeneration of plants: Mature embryos having accumulated enough storage materials and acquired desiccation tolerance at the end of maturation and develop into normal plants.

Flow diagram of coffee SE process



Factors affecting SE

- 1. Genotype:** All the cultivars of a crop are unable to regenerate through somatic embryogenesis due to genetic variability (Vasil,1987).
 - Cultivar plays the major role in somatic embryogenesis competency, out-weighting other factors such as explant source, donor plant conditions and even media composition
 - Plant **epigenetics** revealed heterochromatin to be marked by methylation of cytosine and histone H3 (Bender,2004).
 - Involvement of **siRNAs** in the condensation of chromatin (Baurle et al., 2007) and **DNA methylation** patterns are heritable which can be maintained across mitosis (Henderson and Jacobsen, 2007).
- 2. Explant:** Currently two explants are commonly used to culture embryos in *Triticum aestivum* i.e. immature inflorescence(Jones, 2005) and scutellar tissue from immature embryos (Maës et al., 1996).
- 3. Plant growth regulators:** Auxin , Cytokinin, Gibberellic acid (GA), Absciscic acid (ABA), Polyamines, Phytosulfokine, and Phenolic compounds
- 4. Calcium-mediated signal transduction**
- 5. Proteins in somatic embryogenesis**
- 6. Genes during somatic embryogenesis:** Housekeeping genes, Hormone responsive gene, somatic embryogenesis receptor kinase genes, homeobox gene

Application of SE

To speed up the [clonal propagation](#)

To automate large scale production of embryos in bioreactors

Direct development into complete plantlet without the need of a rooting stage

Production of **synthetic seed/artificial seed**

Production of [secondary metabolites](#) in species where embryos are the reservoir of important biochemical compounds

To overcome the [problem of embryo abortion and dormancy and self sterility](#) in plant

Advantages and disadvantages of S

Advantages:

Somaclonal variation

Germplasm conservation

Disease free planting materials

Labour saving

High propagation rate

Lack of material is not a limiting factor for experimentation

Disadvantages:

Confined to few species

Somatic embryo show very poor germination because of their physiological and biological immaturity

Instability of culture in long term cultures

Conclusion

SE is an efficient plant generation system and potential genetic transformation tool

Indirect SE reduces the breeding cycle and produce virus free plant

Cross-linking between phytohormone and transcription factors is likely to play an important part in somatic embryogenesis

But mechanism of plant embryogenesis is unclear and comprehensive work in future is necessary to be studied with the interaction of various factors for entire picture of regulatory mechanism of embryogenesis to be transplanted



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*Thank
you*

