Totipotency, Dedifferentiation and Redifferentiation.

Plants exhibit remarkable developmental plasticity. This is manifested in their high regeneration capacity. All multicellular organisms, including higher plants and animals, are derived from a single-celled zygote through successive mitotic divisions and differentiation. Most of the cells differentiate into specific cell types and lose the potentiality to reconstitute a new organism in animals. However, all living plant cells retain the potential to revert to the meristematic state and form new plants on exposure to favorable conditions. Plant tissue culture has considerably enlarged the scope of regeneration of plants from highly differentiated and structurally and functionally specialized cells of leaves, roots, stems, floral parts, and endosperm. The potentiality of differentiated and specialized cells to form complete plants like the zygote is referred to as **Cellular Totipotency**. The term was probably coined by T.H. Morgan (1901). However, it was the famous German plant physiologist, Göttlieb Haberlandt, who in his famous address to the German Academy in 1902 introduced the concept of cellular totipotency.

The totipotency of plant cells is now well established. Somatic embryogenesis is believed to be the definitive proof of the totipotency of somatic plant cells. Generally, totipotency is achieved by plant cells through three basic cellular mechanisms i.e. **differentiation, dedifferentiation, redifferentiation**.

Differentiation:

During the early developmental stage every cell has equal potential to develop into the whole plant but during further development depending upon the position and hormonal exposure every cell enters in a specific fate. ”After specification of fate, the embryonic cell enters in a specialized form of the cell this process known as differentiation.”

Figure: Differentiation

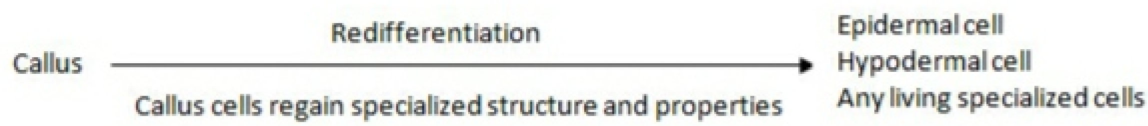
Dedifferentiation:

It is the process of conversion of the differentiated form of cell i.e. specialized cells into undifferentiated embryo-like cells. Plant regeneration from differentiated cells is generally preceded by the cells becoming meristematic, followed by divisions to form an unorganized callus. The phenomenon of mature cells reverting to a meristematic state is termed **dedifferentiation**. For example, when a wounded piece of explants is placed on an artificially designed growth medium in sterile, optimized in vitro condition then the specialized form of cells in explant tissue converts into an unorganized, undifferentiated mass of cells which are totipotent known as a callus. The callusing phase may be very brief or long, depending on the system.

The term “dedifferentiation” has many definitions: “process by which mature or specialized cells lose their differentiated character and rejuvenate” (Bloch, 1941); “a process in which tissues that have undergone cell differentiation can be made to reverse the process so as to become a primordial cell again” (Hale et al., 2005); “involves a terminally differentiated cell reverting back to a less differentiated stage from within its own lineage” (Jopling et al., 2011); “its distinguishing feature is the withdrawal from a given differentiated state into a ‘stem cell’-like state that confers pluripotentiality” (Grafi, 2004). The common in these definitions is that, contrary to differentiation, dedifferentiation increases the developmental potency of cells.

Redifferentiation:

It is the process of the conversion of undifferentiated and unorganized (callus) cells into specialized forms of plant cells under specific environmental conditions. Thus, regeneration of plants from callus or, sometimes, directly from the pre-existing meristematic cells (like stem cells) is termed **re-differentiation**.



In tissue cultures, cellular totipotency may be expressed via organogenesis (shoot differentiation) or embryogenesis (adventive embryony). In more than 75 % of the plant species for which plant regeneration from protoplasts has been achieved, especially those belonging to the most successful families (Solanaceae, Asteraceae, Brassicaceae, and Fabaceae), it occurred via organogenesis.