# Cellular differentiation and Totipotency

The potential of a cell to grow and develop into a multicellular or multiorganed organism is termed as cellular totipotency. Since the potential lies mainly in cellular differentiation this indicates that all genes responsible for differentiation are present within individual cells and many of them that remain inactive in differentiated tissues or organs are able to express only under adequate culture conditions. The development of an adult organism from a single cell (zygote) is the result of the integration of cell division and cell differentiation. Isolated cells from differentiated tissues are generally non-dividing and quiescent. To express totipotency the differentiated cells first undergo dedifferentiation and then redifferentiation. The phenomenon of mature cells of explant reverting to a meristematic state and forming undifferentiated callus tissue is termed as dedifferentiation, whereas the ability of dedifferentiated cells to form a whole plant or plant-organ is termed redifferentiation. These two phenomena of dedifferentiation and redifferentiation are inherent in the capacity of a plant cell, and thus giving rise to a whole plant. During the process of redifferentiation cells of callus undergo cellular differentiation or cytodifferentiation.

Cytodifferentiation can be studied under different headings –

### (A) Vascular differentiation (xylogenesis & phloem differentiation)

Xylogenesis is the differentiation of parenchyma into cells that have localised Secondary wall thickening as seen in the xylem of vascular plants. *In vitro* and *in vivo*, the main emphasis in plant cytodifferentiation has been laid on vascular tissue differentiation (xylem, phloem), particularly the xylem elements. In an intact plant, tissue differentiation goes on in a fixed manner that is characteristic of the species and the organ, while callus cultures which lack vascular elements offer a valuable system for the study of the effect of various chemicals and physical factors on vascular tissue differentiation. Two substances, auxins and sucrose, have a major effect on vascular tissue differentiation, while cytokinins and gibberellins promote differentiation into xylem tissue (xylogenesis). Generally, auxin at low concentration (0.05 mg/l) stimulates xylogenesis and there is an inverse relationship between the auxin concentration and degree of xylem differentiation. Further, it has been observed that the effect of auxin on vascular tissue differentiation seems to be closely dependent on the presence of sugars. Varying the sucrose concentration in the presence of a low concentration of auxin could change the relative amounts of xylem and phloem formed in callus cultures. In studies on *Syringa*, keeping the concentration of IAA

auxin at 0.05 mg/l constant and sucrose level at 1% induced little xylem formation; 2% sucrose favoured better xylem formation with little or no phloem; 2.5-3.5% sucrose resulted in both xylem and phloem differentiation and with 4% sucrose, phloem was formed with little or no xylem. Besides sucrose, other sugars such as glucose, fructose, maltose and trehalose have also been used to stimulate vascular differentiation. The role of cytokinins and gibberellins in xylem differentiation has also been reported. Besides light and temperature, physical factors have a pronounced effect on vascular differentiation.

**(B) Organogenic Differentiation**

In nature, totipotentiality of somatic cells has been observed in several taxa where stem, leaf and root pieces are able to differentiate into shoots and roots. *In vitro* studies have indicated that totipotentiality is not restricted to few species; most plant species if provided with appropriate conditions would show differentiation. For the regeneration of a whole plant from a cell or callus tissue, cytodifferentiation is not enough and there should be differentiation leading to shoot bud or embryo formation. This may occur either through organogenesis or somatic embryogenesis. In organogenesis, a monopolar structure that has a connection with the pre-existing vascular tissue within the callus, while in embryogenesis a bipolar structure with no vascular connection with the maternal callus tissue or explant is formed.

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