CELL DIFFERENTIATION

DR POONAM KUMARI
DEPT OF ZOOLOGY
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The normal process by which a less specialized cell develops or matures to become more distinct in form and function.

Differentiation in refers to the normal process by which a less specialized cell undergoes maturation to become more distinct in form and function. It is also called cell differentiation. For example, a single-celled zygote develops into a multicellular embryo that further develops into a more complex multisystem of various cell types of a fetus. The cell size, shape, polarity, metabolism and responsiveness to signals change dramatically such that the less specialized cell becomes more specialized and acquires a more specific role.

Process and Steps of Cell Differentiation

A cell capable of differentiating into any type of cell is known as "totipotent". For mammals, totipotent includes the zygote and products of the first few cell divisions. There are also certain types of cells that can differentiate into many types of cells. These cells are known as "pluripotent" or stem cells in animals (meristemic cells in higher plants).

While this type of cell can divide to produce new differentiated generations, they retain the ability to divide and maintain the stem cell population making them some of the most important cells.

Examples of stem and progenitor cells include:

Hematopoietic Stem Cells - These are from the bone marrow and are involved in the production of red and white blood cells as well as the platelets.

Mesenchymal Stem Cells - Also from the bone marrow, these cells are involved in the production of fat cells, stromal cells as well as a given type of bone cell.

Epithelial Stem Cells - These are progenitor cells and are involved in the production of certain skin cells.

Muscle Satellite Cells - These are progenitor cells that contribute to differentiated muscle tissue.

The process of cell differentiation starts with the fertilization of the female egg. As soon as the egg is fertilized, cell multiplication is initiated resulting in the formation of a sphere of cells known as the blastocyst. It is this sphere of cells that attach to the uterine wall and continues to differentiate.

As the blastocyst differentiates, it divides and specializes to form a zygote that attaches to the womb for nutrients. As it continues to multiply and increase in size, the differentiation process results in the formation of different organs.

Specification and Determination

During the differentiation process, cells gradually become committed towards developing into a given cell type. Here, the state of commitment may be described as "specification" representing a reversible type of commitment or "determination" representing irreversible commitment.

Although the two represent differential gene activity, the properties of cells in this stage is not completely similar to that of fully differentiated cells. For instance, in the specification state, cells are not stable over a long period of time.

There are two mechanisms that bring about altered commitments in the different regions of the early embryo.

These include:

- Cytoplasmic localization
- Induction

Cytoplasmic Localization - This occurs during the earliest stage of embryo development. Here, the embryo divides without growth and undergoes cleavage divisions that produce blastomeres (separate cells). Each of these cells inherit a given region of the cytoplasm of the original cell that may contain cytoplasmic determinants (reuratory substances).

Induction - In induction, a substance secreted by one group of cells causes changes in the development of another group. During early development, induction

tends to be instructive in that tissue assumes a given state of commitment in the presence of the signal.

Cell Differentiation Significance

As mentioned cell differentiation is a process through which a generic cell evolves into a given type of cell (cell type) and ultimately allowing the zygote to gradually evolve in to a multicellular adult organism.

Cell differentiation is an important process through which a single cell gradually evolves allowing for development that not only results in various organs and tissues being formed, but also a fully functional animal.

While it plays a significant role in embryonic development, the process of cell differentiation is also very important when it comes to complex organisms throughout their lives. This is because of the fact that it causes changes in size, shape, metabolic activities as well as signal responsiveness of cells. In cell differentiation, gene expression is particular important given that there are vital control systems that only ensure certain differentiation. Here, the process proves beneficial by controlling certain activities to guarantee both normal functioning tissues and organs, but also a full functional animal.

Knowledge of cell differentiation has also influenced stem cell research. Today, scientists and researchers are working to determine the best way they can use stem cells for the purposes of regenerating and repairing cellular damage. Stem cells are important in that they can develop to any cell type. This makes them very special in that they can differentiate and be used for given treatment purposes. A good example of this is with cells among the older adults. In older years, many of the cells experience wear and tear. As a result, they lose their ability to divide or repair themselves.