**5.2: Stem cells and Tissue Engineering:**

**What are stem cells, and why are they important?**

* Stem cells are cells that have the remarkable potential to develop into many different cell types in the body during early life and growth.
* In many tissues additionally they serve as a sort of internal repair system, dividing essentially without limit to replenish other cells as long as the person or animal is still alive.
* When a stem cell divides, each new cell has the potential either to remain a stem cell or become another type of cell with a more specialized function, such as a muscle cell, a red blood cell, or a brain cell.
* Stem cells are distinguished from other cell types by two important characteristics.

1. First, they are unspecialized cells capable of renewing themselves through cell division,

sometimes after long periods of inactivity.

1. Second, under certain physiologic or experimental conditions, they can be induced to become tissue- or organ-specific cells with special functions.

In some organs, such as the gut and bone marrow, stem cells regularly divide to repair and replace worn out or damaged tissues. In other organs, however, such as the pancreas and the heart, stem cells only divide under special conditions.

**Scientists primarily worked with two kinds of stem cells from animals and**

**humans: embryonic stem cells and non-embryonic “somatic” or “adult” stem cells.**

Scientists discovered ways to derive embryonic stem cells from early mouse embryos

in 1981. The detailed study of mouse stem cells led to the discovery, of a method to derive stem cells from human embryos and grow the cells in the laboratory in 1998. These cells are called human embryonic stem cells.

The embryos used in these studies were created for reproductive purposes through in vitro fertilization procedures. When they were no longer needed for that purpose, they were donated for research with the informed consent of the donor.

In 2006, researchers made another breakthrough by identifying conditions that would allow some specialized adult cells to be “reprogrammed” genetically to assume a stem cell-like state. This new type of stem cell, called induced pluripotent stem cells (IPSCs), will be discussed in a later section of this document.

Stem cells are important for living organisms for many reasons. In the 3- to 5-day-old

embryo, called a blastocyst, the inner cells give rise to the entire body of the organism,

including all of the many specialized cell types and organs such as the heart, lung, skin,

sperm, eggs and other tissues. In some adult tissues, such as bone marrow, muscle, and

brain, discrete populations of adult stem cells generate replacements for cells that are lost

through normal wear and tear, injury, or disease.

Given their unique regenerative abilities, stem cells offer new potentials for treating

diseases such as diabetes and heart disease.

Scientists are already using stem cells in the laboratory to screen new drugs and to develop model systems to study normal growth and identify the causes of birth defects.

Stem cell research is one of the most fascinating areas of contemporary biology, but, as with many expanding fields of scientific inquiry, research on stem cells raises scientific questions as

rapidly as it generates new discoveries.

**5.3 CLONING:**

Cloning is the process of producing genetically identical individuals of an organism either naturally or artificially. In nature, many organisms produce clones through asexual reproduction. The term "cloning" generally applies to a process more technically known as somatic cell nuclear transfer.

*Example: What Somatic Cell Nuclear Transfer means is that the DNA from the cell of an adult animal (eg cows), called the "donor," is extracted from the cell (usually a skin cell taken in a biopsy) and inserted into an egg cell from another cow. The egg cell has had its nucleus removed so that it will read and duplicate the DNA of the donor cell. The newly created embryo is then jolted with electricity so that it starts multiplying, until it becomes a blastocyst (a small clump of cells that forms after an egg is fertilized), which is then implanted into a surrogate mother. The resulting newborn will be an identical genetic replica to the donor cow.*

**Plant Cloning:**

It is carried out through vegetative propagation and tissue culture.

Plant cloning is useful for rapid multiplication of genetically engineered, agronomically important and rare plants.

The important plants are first genetically changed through mutations, hybridisation or gene manipulation for incorporation of such traits as disease resistance, drought resistance, her­bicide tolerance, high yield, early maturing, food products (e.g., GMFs like vitamin A rich Rice, lysine rich pulse), etc.

Meristematic areas present at root and shoot apices are preferred for quick growth

Rapid cloning is then performed through tissue culture.

**Animal Cloning:**

Formation of one or more genetically identical animals from a single parent animal is called animal cloning. Budding in Hydra produces clones. Monozygotic twins (identical twins) are also clone of each other. They develop from one zygote by splitting of the early embryo. Dasypus novemcinctus (Armadillo) always produces a clone of 4-8 identical young ones of the same sex formed from a single zygote.

The World’s First Cloned Mammal (Fig. 6.46 & 6.47):

Wilmut and coworkers (1997), at Roslin Institute in Edinburgh (Scotland), produced the world’s first cloned mammal a sheep, named Dolly. It was a major development in animal cloning. They took cells from the udder of a six year old sheep. Unfertilized egg of another adult sheep was taken out.

The egg was denucleated. Nondividing nucleus of an udder cell was taken out and inserted in the denucleated egg. In nutrient me­dium the egg began to undergo cleavage. The young embryo was implanted in the uterus (womb) of a third sheep. The surrogate mother gave birth to normal healthy lamb, Dolly, on February 13, 1997. Subsequently, several cloning experiments have been performed successfully.

