CSIR NET Life Science Unit 5

Limb Regeneration

For gaining insight into the cellular mechanism of growth and pattern formation in developmental biology, the vertebrate limb has proven to be a valuable model system. Cell behaviours in limb patterning guide studies of the molecules involved in pattern formation. Invertebrate paired forelimb and hindlimb appear in the larval stage and they are derived from somite and lateral plates epidermal, ectodermal, and mesodermal lines.
The process of limb development is started by thickening of lateral plate of mesoderm which is found just beneath the epidermis area presumptive as limb area, which may lie either behind the branchial region for the formation of forelimb or may lie just in front of the anus for the formation of the hind limb. Limb formation begins at a special region which is known as the limb field; this region is the specific region that is known for the expression of HOX gene, Tbx genes Tb*5 for forelimb and Tb*4 for the hind limb. Mesenchymal cells from the lateral plate's mesoderm proliferate to the points and above side ectoderm bulge out, this bulge known as limb bud. After some time when limb bud has grown, the length of bud exceeds and differentiation of breath and other subordinate parts occur. The distal part of the limb bud is flattened and is broad, and it becomes the circular hand or footplate; thereafter, it becomes pentagonal.
Projections indicate the rudiments of digits mesodermal and ectodermal cells of these sections die and are engulfed by macrophages. Tips bend towards and are further differentiated after rotation of limb rudiments.

Regeneration of limbs in vertebrates:

• Regeneration is also defined as the reactivation of restoring missing tissue development in later life. For instance, the phenomenon of limb regeneration in starfish.

• Animals have the ability to extensive damage repair incurred by the body by a natural condition or by accident. The natural ability of animals to repair, replace and restore damaged parts of the body or to reform the entire body and form small fragments during the post-embryonic phase is known as regeneration.

• The capacity of regeneration found in amphibians to regenerate the heart, jaws, tails, and lens wake interest in knowing the regeneration in vertebrates. This process is commonly divided into four sequential steps:

1. In the first stage of regeneration, wound epidermis is formed in which the site of amputation is covered by epithelial cells.
2. After amputation, dedifferentiation or disorganization of mesenchymal cells occurs near the wound.
3. Undifferentiated cells form a mass which is known as blastema. This is formed primarily by the dedifferentiation of cells in the surrounding tissues.
4. At the final stage, dedifferentiated cells proliferate and redevelopment occurs in this process correct pattern is formed in blastema which results in regeneration in an amputated portion of the organ. The redevelopment stage of regeneration is usually under the control of highly complex genes.

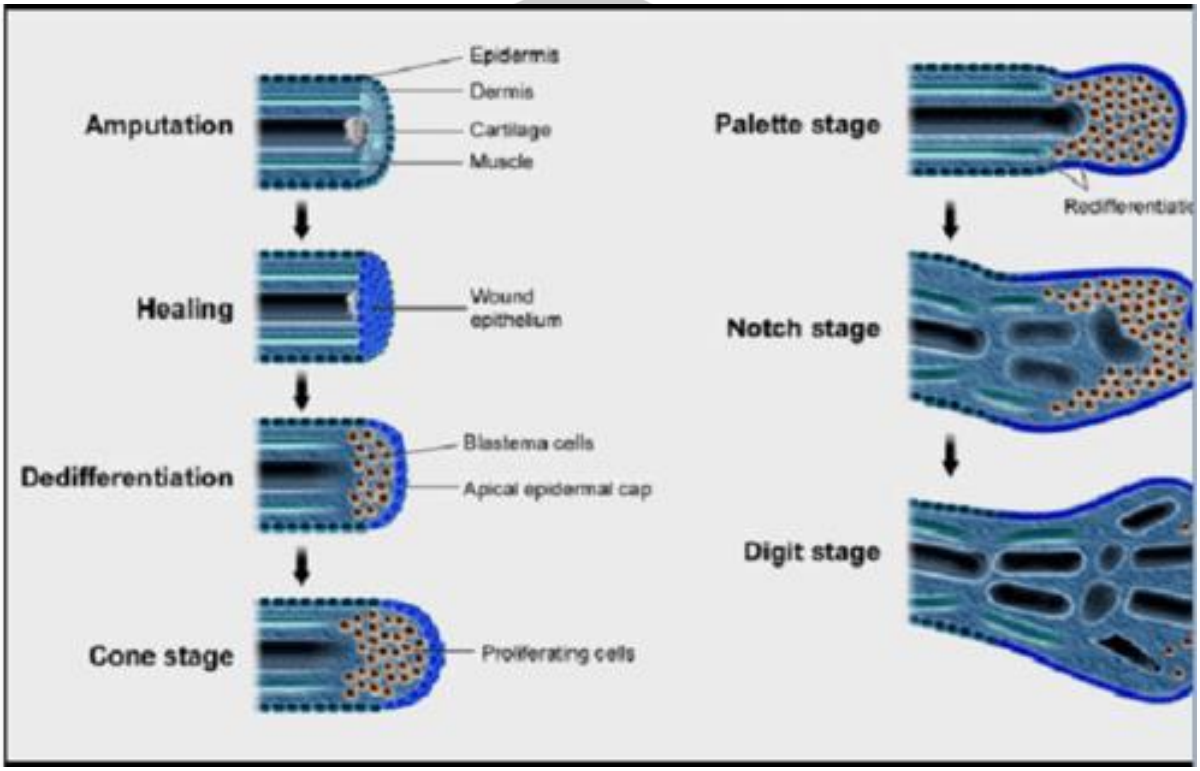

Fig. Limb regeneration process

The regeneration process was first discovered by Trembley in Hydra. Mainly, this process is known to have two functional types: -The regeneration process was first discovered by Trembley in Hydra. Mainly, this process is known to have two functional types: -

• Reparative regeneration process-In this process of regeneration, multicellular organisms have the power to only repair certain damaged cells of the body. It is the common process found in both vertebrates and invertebrates.

• Restorative regeneration process-In this process of regeneration, multicellular organisms have the ability they can redevelop severely damaged body parts or they may form the whole body from a small segment. This process is commonly found in invertebrates. Restorative regeneration may occur by epimorphosis or morphallaxis. This process is a known feature in some groups of organisms, examples are given below.

• Certain animals have autotomy; some parts of their body is broken off by the threat of an enemy or predators. This is also known as the self-mutilation phenomenon of the body. The organism may lose a tail, viscera of arm and tail such as in Lizard.

• Another process is known as climatic regeneration, wherein the whole body can be developed from any fragment of the body. This process is observed in coelenterate (Hydra), Sponges (Scypha) and flatworms (Planaria).

Regeneration Mechanism:

The primary mechanisms of regeneration found in animals are

• **Morphallaxis:**
• In this process, reconstruction of the entire animal occurs from a small fragment by recognizing the existing cell. • After regeneration, the organism is smaller than the original size, after growth, it attains normal size.

• In morphallaxis in the process of regeneration, repatterning of existing tissue occurs.

• Such a type of regeneration process is a characteristic trait in Hydra; when cut in half, the half portion containing the head regenerates a new basal disc and the other half cut portion which contains the basal disc regenerates a new head and it grows and attains normal size after some time. No cell division is required in this process.

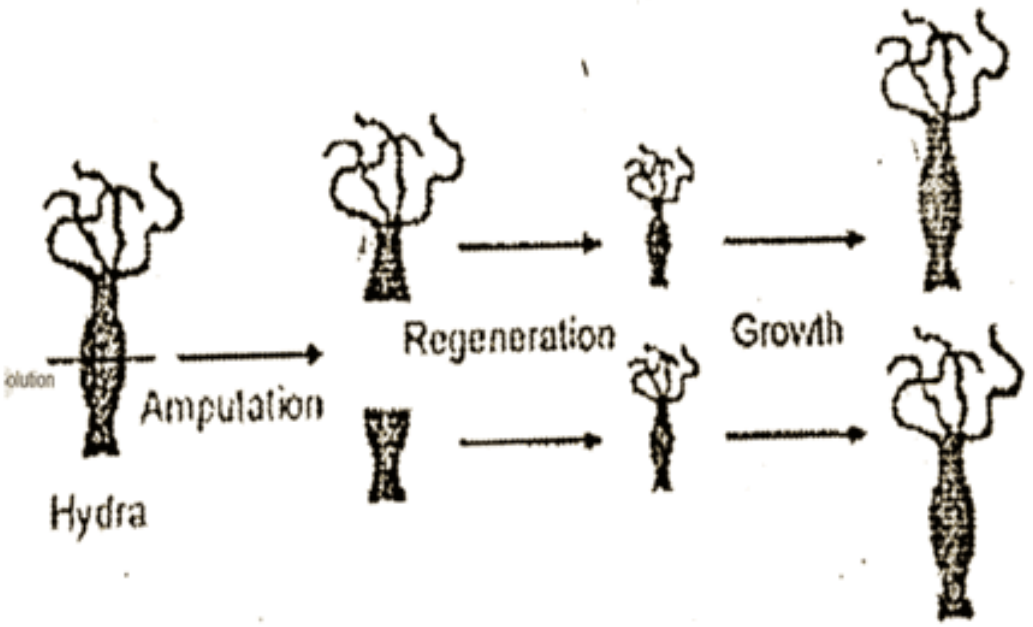

Fig. Process of Morphallaxis in Hydra

B) Epimorphosis:

• In this process, the replacement of lost organs of the body occurs by the proliferation of new cells from the surface of the injured part.

• In the process of epimorphosis, dedifferentiation of the adult cell occurs from an undifferentiated mass or bunch of cells which is known as blastema then adult cells become respecified.

• When an adult salamander is amputated, all the remaining cells are capable to form a new limb; all differentiated cells are arranged in proper order and then undergo dedifferentiation, i.e. newly undifferentiated cells form the missing structure.

• Some examples of epimorphosis include appendage regeneration in arthropods, starfish arms, salamanders limbs, and lizard tails.

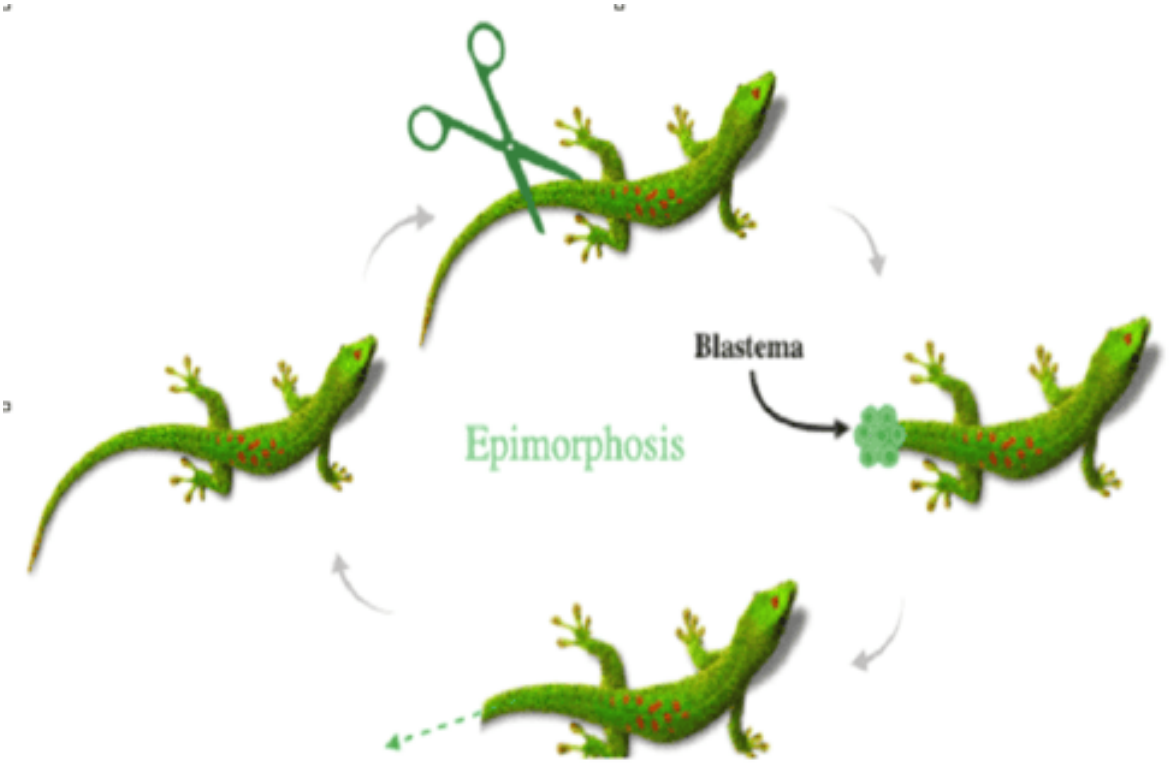

Fig. Epimorphosis in salamander