

# Regeneration

# Concept of the regeneration

- ☐ You might have seen a house lizard without tail. After some days the tail develops again from the remaining part. This process of development of missing part or structure is due to regeneration.
- ☐ Our body also lose some of the cells and replaced by new ones.
- ☐ It is post embryonic developmental process.
- ☐ “Regeneration can be defined as the ability of living organisms to replace damaged or lost parts of the body or to reconstitute the whole organism from small fragments of the body”.
- ☐ Regeneration is carried out by specialized cells called stem cells.

- ❑ Regeneration was first reported in *Hydra* by Tremble in 1740.**
- ❑ T.H. Morgan studied regeneration in *Planaria*.**
- ❑ Limb and tail regeneration in Salamanders was described by Spallanzani.**
- ❑ The regenerative capacity is present in different animal kingdom but with varying degree.**
- ❑ In lower animal kingdom as sponge, coelenterate, flat worm the regenerative capacity is very high. In higher kingdom the regeneration is higher in embryonic and larval stage. In adult stage it is restricted to certain parts or organs.**

## Mode of regeneration

There are three major ways (types) of regeneration:

### 1. Epimorphosis:

- ☐ Regeneration of some lost or damaged part.
- ☐ This type of regeneration occurs by proliferation of new cells from the surface of the injured part.
- ☐ In this type of regeneration, first the adult structure at the lost or damaged part dedifferentiate, and then proliferate to increase the number of dedifferentiated cells and form blastema.
- ☐ This blastema grows and forms distal structures.
- ☐ Cells in the blastema redifferentiate to form rudiment of lost part.
- ☐ **Example: Limb regeneration in salamander. Tail regeneration in lizard.**

## 2. Morphallaxis:

- ❑ Regeneration occurs mainly by the repatterning of the existing tissues. Very less new growth.
- ❑ In this type of regeneration each part of the body remodel into new organism.
- ❑ **Example:** If the Hydra cut into smaller pieces, each segments with specialized interstitial cells grow into complete organism.

### 3. Compensatory regeneration:

- ❑ This type of regeneration occurs when some of the part of any organ damage and it regenerates by the proliferation of existing tissue.
- ❑ In this the cells divide, but do not undergo dedifferentiation.
- ❑ Similar cells are produced but do not form a mass of undifferentiated tissue.
- ❑ **Example:** Regeneration in the mammalian liver.

## **Autotomy:**

It is the process of detachment of the body part when being threatened by the predators. This lost part then regenerate. This process is also called self mutilation.

## **Example:**

1. Crabs break off their leg on approaching of the enemy
2. Holothurians throw off their internal viscera.
3. Starfish breaks off an arm
4. Lizards detach their tail.

**Heteromorphic regeneration:** After regeneration the different organ develops from the lost or removed structure. The phenomenon is also called heteromorphosis.

Example: In *Palinurus* (shrimp), if the eye is removed from eye stalk then new eye will regenerate. But if it is removed along with optic ganglion, antenna like structure develop in place of eye.

**Super regeneration:** Development of supernumerary organs or parts as a result of regeneration, termed as super regeneration.

Example: When incision made in the planaria head, two head will develop.



## Regeneration across different animal kingdoms:

Animal Kingdom	Regeneration part
Sponge, Coelenterate, Flatworm	Whole body reconstituted from smaller body fragment containing special cells.
Annelida	In some annelids as earthworm regeneration in the anterior posterior end
Arthropoda	Limb regeneration in some Arthropoda as Insects, Spiders, Crustaceans.
Mollusca	Eye and head (Snail), arms (Squids)
Echinoderms	Arms (shows Autotomy)
Fish	Tail (Lamprey), Fin (some fishes)
Amphibia	Limbs, tail, external gills, jaws, eye lens and retina (Urodel amphibia as salamander newt, axolotl larvae) Tail and limb (larva of frog and toad)
Reptiles	Tail (Lizards) shows autotomy
Aves	Part of beak
Mammals	Compensatory regeneration. Some tissues as skin, liver and kidney.

## Mechanism of Salamander limb regeneration

**Salamander limb regenerates in the following stages:**

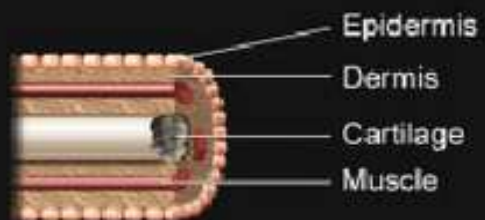
**(1) Wound healing:** After amputation of limb, the epidermal cells surrounding the wound migrate and spread over the exposed surface. This stops the bleeding. This is known as wound healing. This layer of epidermis proliferate to form apical ectodermal cap.

**(2) Blastema formation:** After some days cells below the epidermis start dedifferentiation. These dedifferentiated cells accumulate inside the epidermis. Due to this accumulation a bulge or outgrowth form termed as blastema.

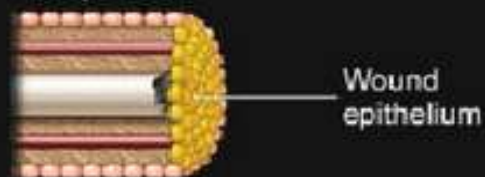
**(3) Redifferentiation and morphogenesis:** The blastema cells continue to divide. The specific pattern and axis (dorsal-ventral, anterior-posterior) will form in the growing blastema. Thus the cells of the blastema redifferentiate develop into different structure of the limb. Edge grows out into new digits.

**(4) Growth:** New blood and nerve supply develops in the growing limb. The regenerated limb increases in size and attain the normal length.

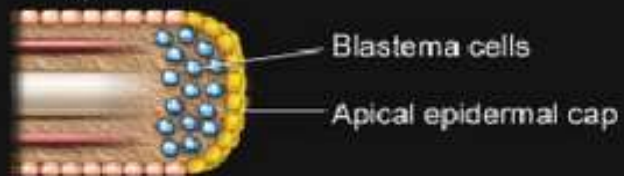
## Amputation



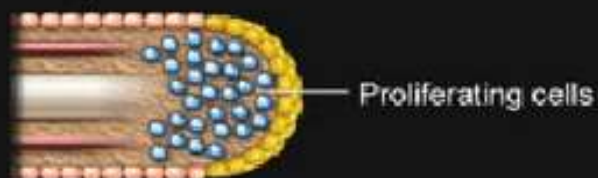
## Healing



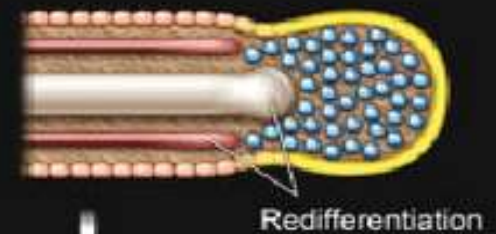
## Dedifferentiation



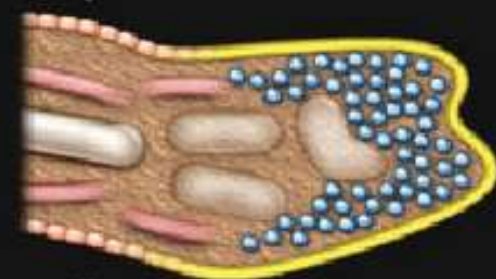
## Cone stage



## Palette stage



## Notch stage



## Digit stage

