

Retrogressive Metamorphosis

Metamorphosis Gr., meta = after + morphe = form + osis = state) is the shape change in form during post-embryonic development and in many cases, signals a dramatic change in habitat of the animal such as pelagic to benthic existence.

Metamorphosis of the ascidian larva is unique and begins almost explosively. It involves transformation of an active non-feeding, pelagic, lecithotrophic (i.e., that feeds on its own yolk reserves) and tailed larva having many advanced features such as axial notochord, dorsal neural tube and special sense organs, into an inert, sedentary or sessile, simple (primitive) and plankotrophic filter feeding adult with only a pharynx with stigmata and endostyle, both indicating the chordate features of adult ascidian.

This type of metamorphosis which shows degenerative or retrogressive changes from larva to adult is called retrogressive metamorphosis.

It involves the following three types of changes:

- (i) Retrogressive,
- (ii) Progressive and
- (iii) Molecular changes.

(i) Retrogressive Changes:

These changes involve destruction and disappearance of some of the larval structures such as follows:

- a. Long tail of larva with caudal fin shortens and finally disappears.
- b. Caudal muscles, nerve cord and notochord disappear as they break down and are consumed by phagocytes.
- c. Larval sense organs (the ocellus and the otolith) are lost and sensory vesicle is transformed into an adult cerebral ganglion.
- d. Adhesive papillae disappear completely.
- e. Anterior region between point of attachment (adhesive papillae) and mouth shows rapid growth, while original dorsal side with atriopore stops growth. This causes shifting of mouth through 90°. Therefore, the final branchial and atrial apertures in the adult represent the original anterior and dorsal sides of the larva.

(ii) Progressive Changes:

Some larval structures necessary for survival become more elaborated and specialised in each adult, such as:

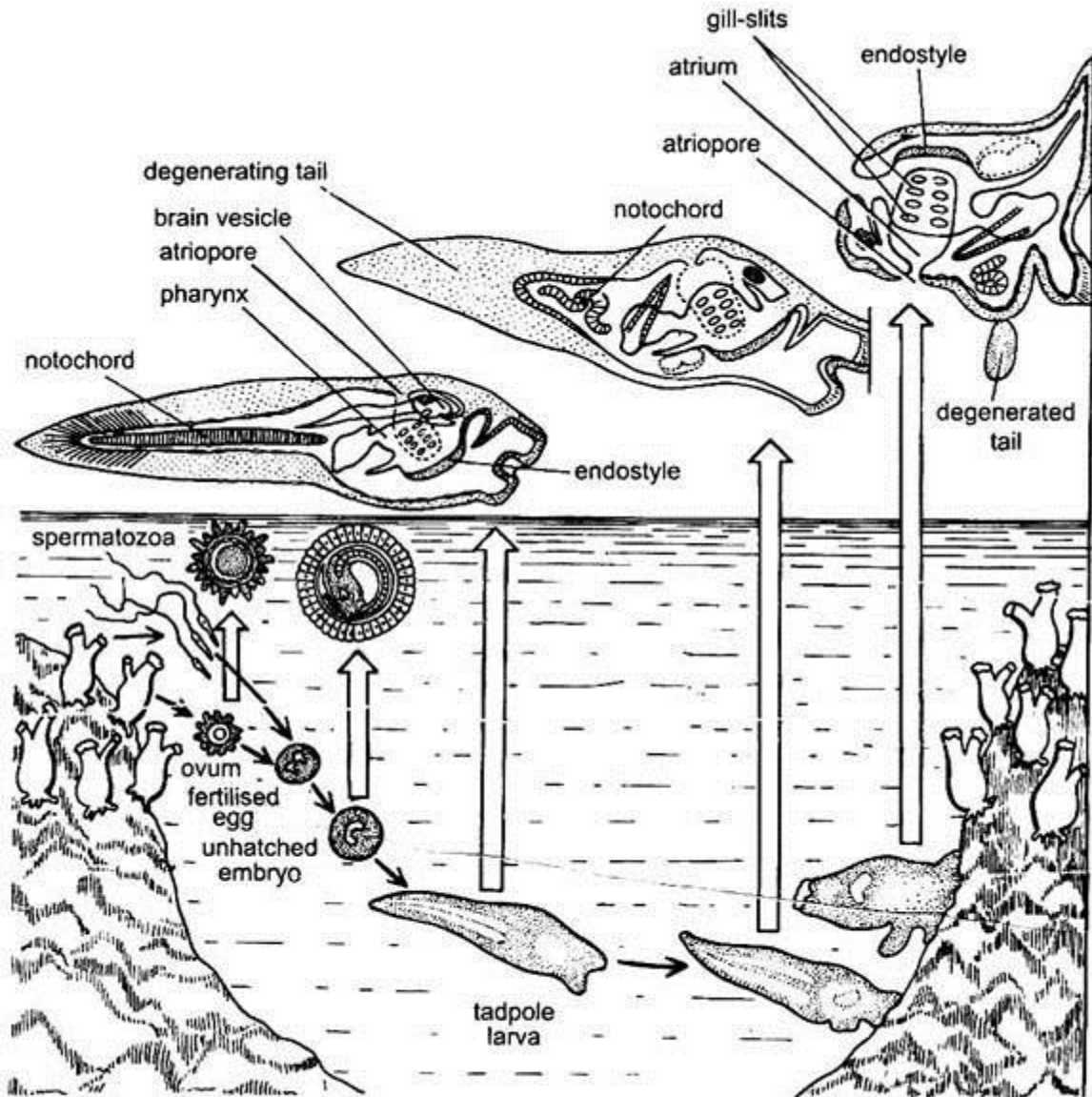


Fig. 35.4. Life cycle of a simple ascidian, showing retrogressive metamorphosis of tadpole larva, later its attachment with the solid substratum.

- a. Due to loss of tail, the trunk becomes pear-shaped and four larger ectodermal ampullae grow out of its four corners. These ampullae firmly anchor the metamorphosing tadpole to the substratum and also serve for respiration as a blood-like fluid keeps circulating through them. Soon two more smaller ectodermal ampullae appear dorso-laterally.
- b. Anterior region between point of attachment (adhesive papillae) and mouth exhibits rapid growth, while original dorsal side with atriopore stops growth. This causes shifting of mouth through 90°. The body too rotates so that general form of the adult sessile organism is assumed.

- c. Adult neural glands and nerve or cerebral ganglion are formed by the neural tube and trunk ganglion come to lie mid-dorsally between mouth and atriopore. The trunk ganglion itself persists as visceral nerve.
 - d. With the absorption of its test covering, the mouth becomes functional and filter-mode of feeding by incoming ciliary water currents.
 - e. Pharynx greatly enlarges, develops blood vessels and stigmata multiply rapidly, forming the branchial sac.
 - f. Stomach enlarges, intestine elongates and gets curved and liver develops.
 - g. Atrial cavity becomes more extensive.
 - h. Circulatory system with heart and pericardium develops.
 - i. Gonads and gonoducts develop from larval mesodermal cells.
 - j. Test or tunic spreads to cover entire animal, becomes thick, tough and vascular and attaches the animal by forming a foot if necessary.
- Thus, foregoing metamorphic changes mark the beginning of a sedentary, actively feeding, sexual adult life which soon starts producing gametes, first ova and later sperms.

(iii) Molecular Changes:

Manket and Cowden (1965) studied the molecular changes which take place during metamorphosis. They studied the metabolism of protein and nucleic acid and pointed out that some protein synthesis occurs throughout the development but with the outset of metamorphosis, extensive degradation of proteins begins followed by rapid synthesis of new proteins.

Embryological Significance of Ascidian Tadpole:

The presence of a tadpole larva in the life history of Herdmania and other ascidians is significant in the following ways:

a. Taxonomic Significance:

The tadpole larva possesses true chordate characters such as notochord and dorsal tubular nerve cord, which are lacking in the adult. Thus, the ascidian larva provides the clue for including the ascidian under the phylum Chordata. Without tadpole larva, the true nature and taxonomic position of degenerate sedentary adult ascidians would have remained uncertain.

b. Phylogenetic Significance:

On the basis of recapitulation, the ascidian larva possessing the chordate features is considered as the relic of the free-swimming ancestral vertebrates.

c. Dispersal:

The adult ascidians being sedentary, the free-swimming habit of the larva provides the only means of dispersal of the species. It also provides chances of selecting better sites regarding food and protection, thus, ensuring survival of the race.

d. Embryological Significance:

Ascidians provide best example of mosaic eggs with a well-organised, pre-patterned and well differentiated ooplasm and highly determinate type of development. Moreover, ascidians are the only chordates exhibiting true retrogressive metamorphosis.

The egg cortex in case of ascidians is the site of morphogenetic patterning related to polar, bilateral and general organisation of developing egg. Besides this, cleavage in ascidians tends to segregate cytoplasmic territories, having different biological, histochemical and biochemical properties.

Retrogressive Metamorphosis in Urochordates



Metamorphosis is a change from the juvenile to adult stage in which larval stage is quite different from the adult stage. In retrogressive metamorphosis the larva possesses advanced characters which are lost during the development and the adult is either sedentary or degenerated with primitive characters. Urochordate adults, being sedentary show degenerative characters while the free swimming tadpole larva shows advanced chordate characters which are lost during metamorphosis. Parasitic crustaceans, like *Sacculina* and copepod parasites and stylopids and scale insects (Insecta) also show retrogressive metamorphosis.

Retrogressive Metamorphosis in *Herdmania*

The tadpole larva of *Herdmania* is only 1-2 mm long when it hatches out of the egg. It does not feed and hence has only 3 hours of survival during which it has to swim about in search of a suitable substratum for attachment. The larva needs advanced features for its free swimming existence, which is so necessary for dispersal of the population to distant places which the sedentary adult has no means to do.

The advanced Chordate characters of the larva

- There is a rod-like notochord in the tail to which are attached muscle bands for swimming.

- There is a dorsal hollow nerve cord which is enlarged to form brain at the anterior end. A photoreceptor ocellus and a balancing organ, the statocyst are attached to the brain.
- There are only two pairs of gill slits in pharynx but the mouth is closed by a membrane and intestine is rudimentary.
- Endostyle on the ventral side of pharynx is very well developed which functions like thyroid gland and helps in metamorphosis.
- Heart is on the ventral side of gut but is non-functional.
- The larva possesses on the anterior end three ectodermal adhesive papillae which help in firm attachment on the substratum.

Changes during metamorphosis

- Larva attaches to the substratum with the help of chin warts, head downward and tail up.
- Rapid growth takes place between the chin warts (adhesive papillae) and mouth and almost no growth on the opposite side of body.
- Due to rapid growth on one side, body starts rotating in such a way that mouth gradually migrates to the upper side.
- Meanwhile pharynx enlarges and stigmata increase in numbers.
- Intestine becomes functional and atrial opening is formed on the opposite side of oral aperture.
- Both tail and notochord are gradually absorbed in the body during metamorphosis.
- The hollow nerve cord is reduced into a solid nerve ganglion on the dorsal side.
- Sense organs, namely ocellus and statocyst are lost.

When the metamorphosis is over, *Herdmania* is transformed into a bag-like sedentary animal attached to the rock by a foot and having branchial and atrial openings for inlet and outlet of water respectively. Pharynx becomes enormously enlarged with a large number of stigmata for filter feeding and digestive system becomes well developed. However, other advanced chordate characters of the larva are degenerated into simple structures, due to which it is called retrogressive metamorphosis.