

Neoteny

Neoteny refers to the retention of a larval or embryonic trait in the adult body. It was Kollmann (1882) who coined the term neotenie (neoteny) for the phenomenon of retention of larval characters beyond the normal period and attainment of sexual maturity. Familiar examples are retention of embryonic cartilaginous skeleton in adult in Chondrichthyes; and the larval gills in some adult salamanders.

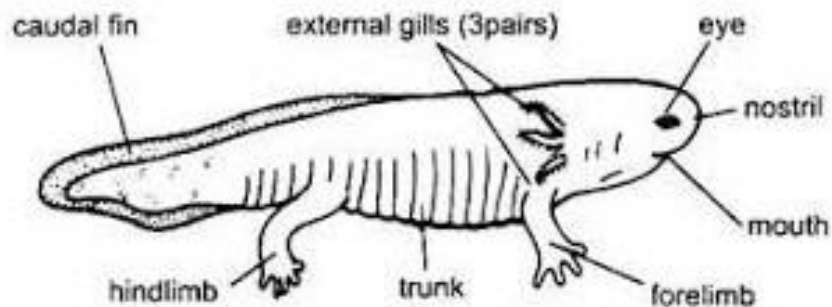
Types of Neoteny: (1) Partial neoteny and (2) Total neoteny

Partial neoteny: In this type there is simple retardation of metamorphosis beyond the normal period due to temporary changes in surrounding habitat or some sudden physiological disorder. Examples of partial neoteny are mostly found in anurans like the tadpoles of *Rana esculanta*, *Rana temporaria*, *Bufo vulgaris*, *Alytes obstetricans*, *Hyla arborea*, *Bombinator pachypus*, etc. In *Rana esculanta* most of the tadpoles remain in the larval stage for one or two years after which they metamorphose. It may be noted that in partial neoteny there is simple retardation of metamorphosis and the larvae do not attain sexual maturity.

Total neoteny: In this category the animals retain larval characters but become sexually mature. The larval characters retained are external gills, tail fin, ill-developed eyes, ill-developed dorsal fin and weak limbs. Animals exhibiting total neoteny normally do not metamorphose and remain as sexually mature larvae. In some cases, however, such larvae may undergo metamorphosis under favourable conditions as the axolotl larva. Total neoteny is observed in urodels only.

Axolotl. Classical and most informative examples of neoteny among Amphibia (vertebrates) are furnished by *Ambystoma* (or *Amblystoma*). *A. mexicanum* lives in Lake Xochimilco in the highlands of Mexico and the closely related *A. tigrinum* (tiger salamander) in high altitudes of

Colorado (North America). Ordinarily they go through typical gilled aquatic larval stages, then metamorphosis, to transform into adult air-breathing land forms. However, under certain circumstances, the larvae do not metamorphose, retain their gills and aquatic habitat but become sexually mature. This sexually mature but morphologically immature, larval Stage with external gills is called an axolotl. The name was given by natives of Mexico who captured them for food. In Aztec axolotl means "servant of water".



Environmental factors affecting neoteny.

Environmental factors affect metamorphosis in several ways. Abundance of food, cold temperature or insufficient iodine (a component of thyroxine hormone that induces amphibian metamorphosis) may cause failure of metamorphosis and retention of larval features. This is indicated by the fact that drying up of swamps, lack of food and rise in temperature in surrounding water induce axolotls to metamorphose. When experimentally treated with thyroxine or TSH, these axolotls lose their gills, assume lungs and become adult air-breathing native tiger salamanders. The genetic basis for metamorphosis seems to be multifactorial, variable and subject to selective pressure. Genes for transformation have become suppressed in neotenic populations but not entirely absent for there is occasional appearance of metamorphosed

individuals. The cause of neoteny among amphibians has not been properly understood. Various extrinsic and intrinsic factors are supposed to be responsible for such an unusual phenomenon.

Extrinsic factors

- (1) Abundance of food and other favourable requisites in the aquatic life is the cause of retention of larval features.
- (2) Deepwater and coldness inhibits the secretion of thyroxin.
- (3) Saline nature of water is responsible for neoteny.
- (4) Low temperature is responsible for the arrest of metamorphosis.

Intrinsic factors

Metamorphosis is primarily influenced by-

- (i) varying threshold levels of thyroxin and its analogues and
- (ii) by the degree of responsiveness of the larval tissues to the hormones. During early premetamorphic stage in amphibian development, the level of thyroxin is kept very low in the body by genetic mechanism.

Several factors can influence the occurrence and extent of neoteny in organisms. These factors can be genetic, environmental, or a combination of both. Here are some key factors affecting neoteny:

- **Genetic Variation:** Genetic mutations or variations can directly impact the expression of neotenic traits. Changes in genes responsible for regulating development, growth, and maturation processes can result in the retention of juvenile characteristics into adulthood.

- **Heterochrony:** Heterochrony refers to changes in the timing or rate of developmental events during an organism's life cycle. Alterations in the timing of developmental processes, such as delayed maturation of certain features or prolonged growth periods, can lead to neotenic traits.
- **Hormonal Regulation:** Hormones play a crucial role in regulating various aspects of development and maturation. Changes in hormone levels or their signaling pathways can influence the rate and timing of developmental transitions, potentially leading to neoteny.
- **Environmental Conditions:** Environmental factors, including temperature, humidity, resource availability, and social interactions, can influence developmental trajectories. Favorable environmental conditions may promote the retention of juvenile traits by reducing selective pressures for rapid maturation or by providing opportunities for continued growth and development.
- **Selective Pressures:** Selective pressures imposed by the environment or by interactions with other organisms can shape the prevalence and degree of neoteny within a population. For example, if juvenile traits confer a survival or reproductive advantage in certain environments, individuals exhibiting neotenic characteristics may be more likely to thrive and pass on their genes to future generations.
- **Artificial Selection:** In domesticated animals and plants, humans have intentionally selected for traits associated with neoteny through breeding practices. For example, dogs exhibit a wide range of neotenic features compared to their wild ancestors, as certain traits such as docility, reduced aggression, and cuteness have been favored by humans during the process of domestication.

- **Developmental Plasticity:** Some organisms exhibit developmental plasticity, the ability to adjust their developmental trajectories in response to environmental cues. Environmental factors experienced during critical periods of development can influence the expression of neotenic traits by altering gene expression patterns or developmental pathways.
- **Epigenetic Mechanisms:** Epigenetic modifications, such as DNA methylation and histone modifications, can regulate gene expression without altering the underlying DNA sequence. Changes in epigenetic regulation during development or in response to environmental stimuli can affect the expression of neotenic traits.

Overall, neoteny is a complex phenomenon influenced by a combination of genetic, environmental, and developmental factors. Understanding the mechanisms underlying neoteny can provide insights into the processes of development, evolution, and adaptation in diverse organisms.

Significance of neoteny. Weismann (1875) thought neoteny to be a case of retarded evolution or atavism, that is, reversion to ancestral condition. However, this is now regarded to be of secondary specialization, a physiological adaptation of advantage. This is also proved by the great heterogeneity of all neotenuous perennibranchiate forms.