Metamorphosis in frog and its hormonal regulation

ZOOLOGY DEPARTMENT
RTU

What is metamorphosis?

- ‘It is a biological process by which an animal physically develops after birth or hatching, involving a prominent change in the animal’s body structure through cell growth and differentiation’.
- In other words,
- ‘Metamorphosis is a post-embryonic extension of the developmental potential and involves dramatic changes in habit, habitat, morphology, physiology and behaviour of larva so that it is transformed into the adult having entirely different habitat and structure’.
- To compensate deficiency of yolk in egg, frog develops indirectly through an intermediate free living stage, Tadpole.

Change in frog tadpole during metamorphosis

Eggs

Tadpoles

Froglet with two limbs

Froglet with 4 limbs

A young frog

An adult frog

Tadpole features

- **Oral sucker stage**:
- At this stage, a pair of oral sucker is present on the ventral side of the head which help the larva to attach to any object for couple of days.
- Limb buds, tail or any other external body parts are indistinct.
- Does not feed or move.

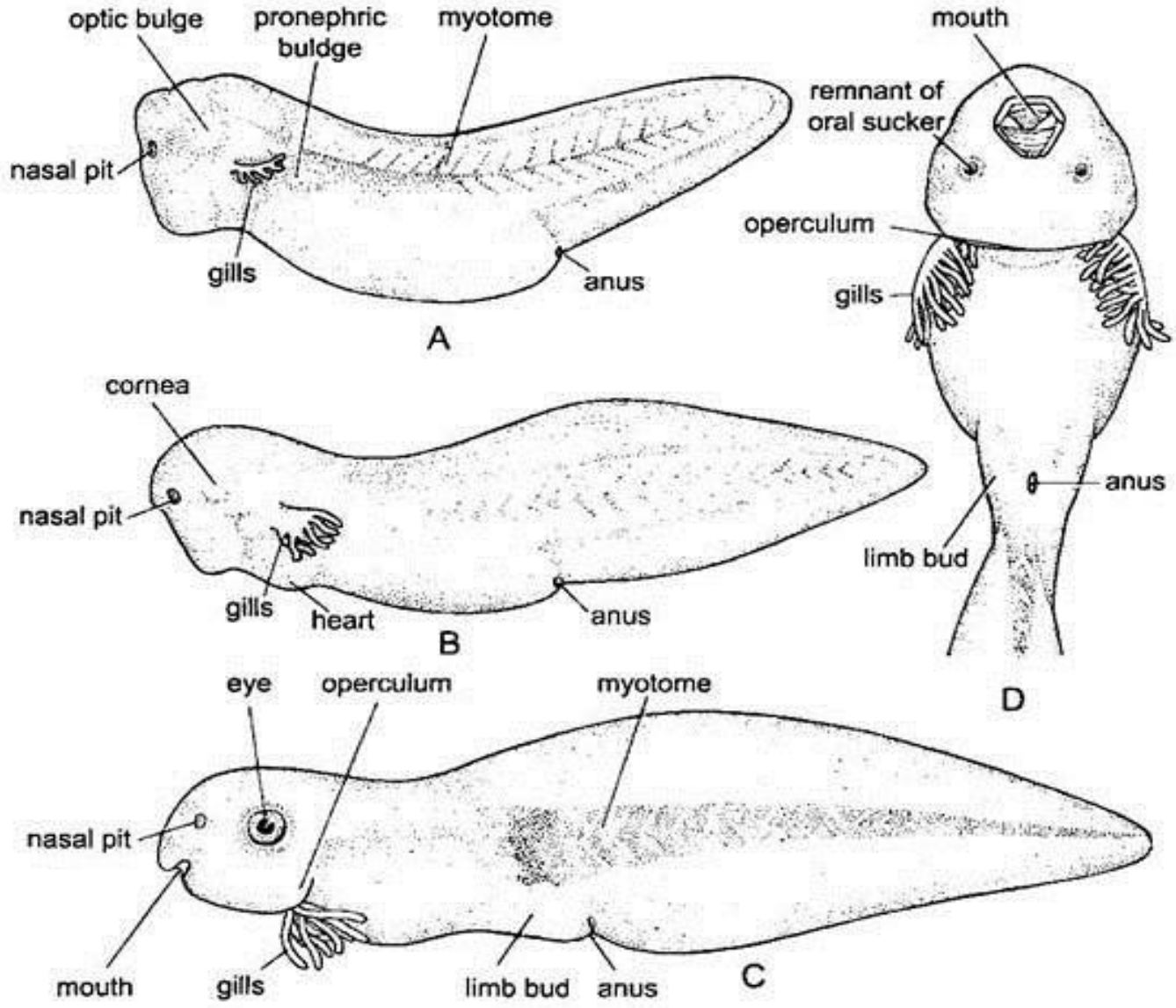


Fig. 37.11. Frog. Different stages of tadpole after hatching.

External gill stage

- The buds of hind limbs come out, and tail starts developing with dorsal and ventral fins.
- Three pairs of external gills come out on lateral sides called spiracles.
- The eyes become functional.
- Horny jaws develop with teeth for herbivorous mode of feeding.
- Grows to 40-50mm size after swimming about for 3-4 weeks at 26-28 degree C temperature.

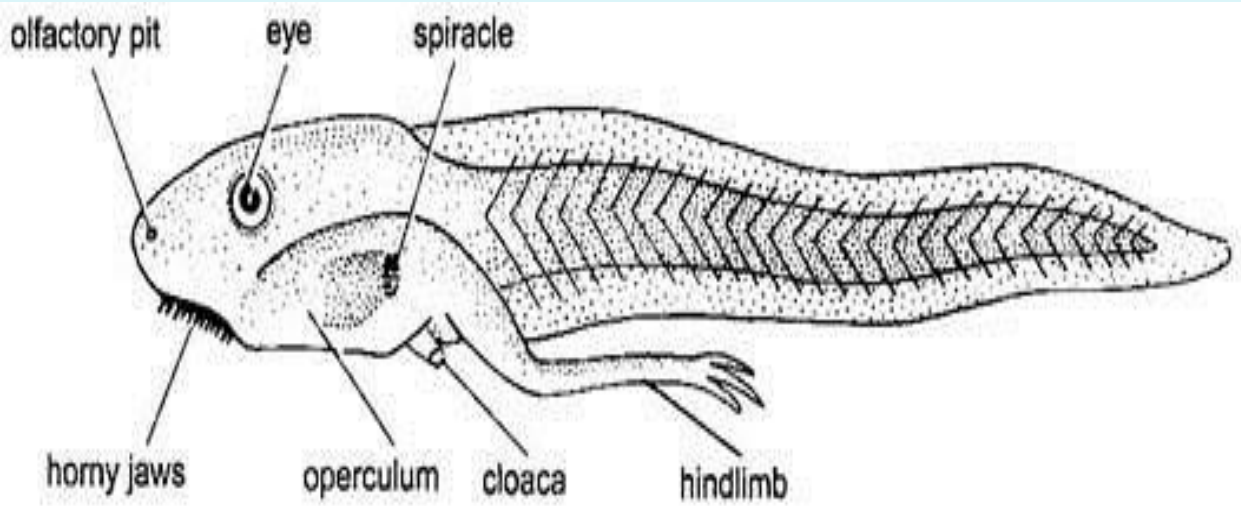


Fig. 37.12. Frog. Tadpole larva with hindlimbs.

Internal gill stage

- Fish-like appearance with well developed internal gills covered with operculum and have spiracles.
- Fish-like two chambered venous heart.
- Excretion ammonotelic (excretes ammonia as wastes), nephrostomes connected to nephrones.
- Well developed tail with dorsal and ventral fins.
- Well developed hind limbs.
- Eyes and lateral line system well developed.
- Alimentary canal elongated for herbivorous mode of feeding and digestion.

Changes during metamorphosis from tadpole to adult:

- 1. Retrogressive changes:
- Disappearance of tail.
- Loss of gills, gill chambers and operculum.
- Loss of lateral line system.
- Lungs are formed
- Horny jaws replaced by bony structures.

2.Progressive changes:

- Hind limb and pelvic girdle fully formed.
- Fore limbs are formed below the opercula.
- Eyes become enlarged, protrucible and nictitating membrane is formed.
- Maxillary and Vomarine teeth are fully formed on the upper jaw.
- Middle ear and tympanum is fully formed.

3. Physiological changes:

- Shortening of alimentary canal occurs due to change in herbivorous to carnivorous habit.
- Fish-like heart changes to three chambered heart and plan of circulatory system changes due to change in respiratory system accordingly.
- Nephrostomes get disconnected from nephrones, and mode of excretion changes from ammonotelic to ureotelic.
- Liver function changes due to change in feeding habit.
- Increase in carbohydrate metabolism occurs.
- Endocrine function of pancreas begins, insulin is secreted.
- Visual pigments of tadpoles are porphyropsin (retinene 2), while during metamorphosis there is a shift to the use of rhodopsin (retinene 1).
- The reduction of the gills and tail is affected by autolysis of the component tissues of these organs, with active participation of amoeboid macrophages, which phagocy tose the debris of the disintegrating cells.

Continued
Physiological changes

- Biochemical metamorphic alterations may be considered to have direct adaptive value or to serve as a basis for morphological, chemical or other changes which have adaptive value relating to the transition from water to land. Shift from ammonotelism to ureotelism, increase in serum albumin and proteins, alterations in the properties and biosynthesis of haemoglobin are the important adaptive changes.
- Development of digestive enzymes also contributes to the success of the differentiation. Major modifications occur in water balance, visual pigments, pigmentation, and tail metabolism, which aid in adjustment to land.

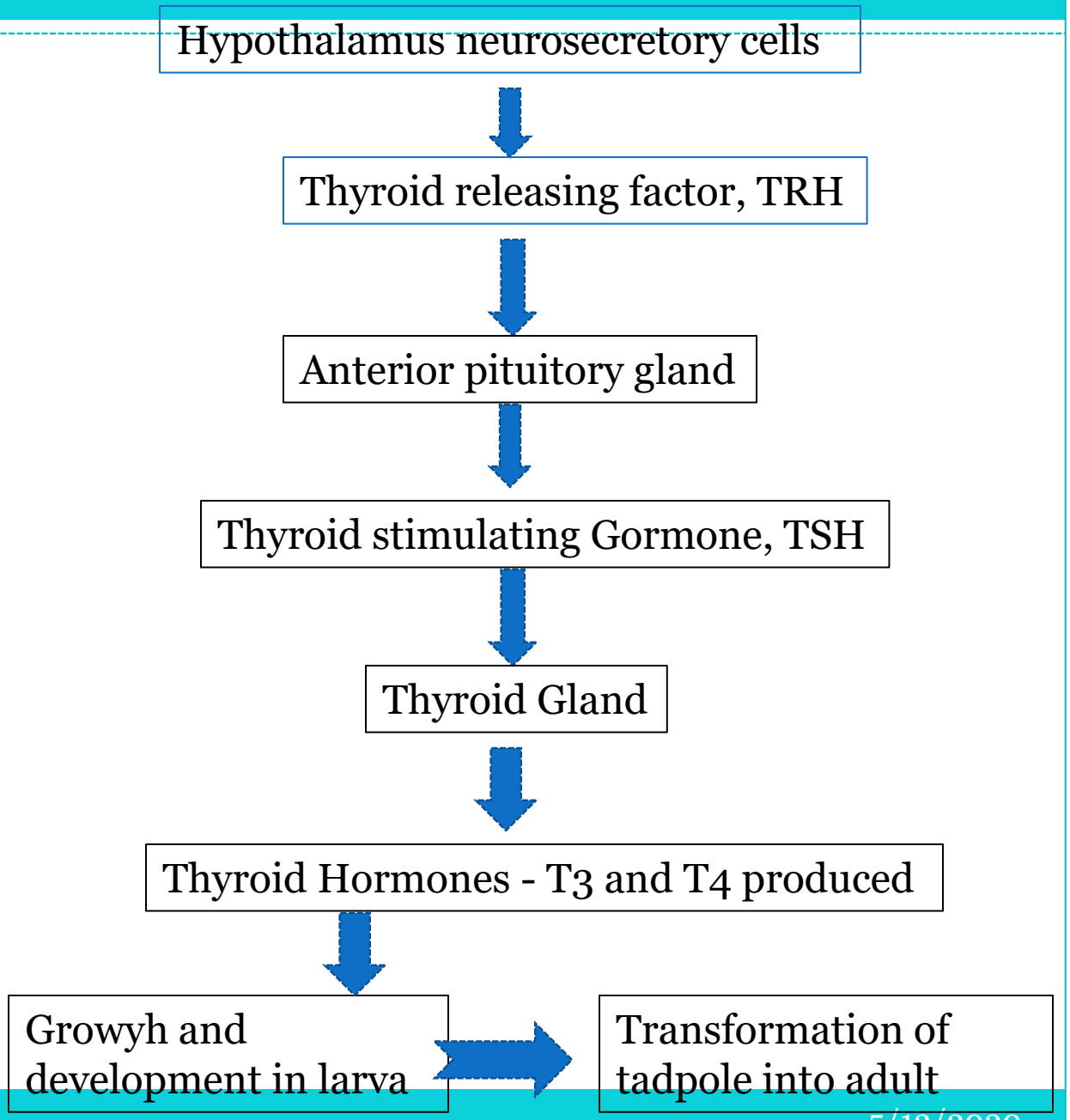
Hormonal Control of Amphibian Metamorphosis:

- During metamorphosis concurrent changes in all body parts suggest the existence of hormones released in large quantities from the thyroid gland of the animal. This indication was given by Gundernatsch (1912) when he fed some frog tadpoles on dried and powdered sheep thyroid gland and observed their metamorphosis precociously

Neuroendocrine control of metamorphosis

- The amphibian metamorphosis is under neuroendocrine control, involving neurosecretory cells in the brain (the hypothalamus) and two endocrine glands, the pituitary (anterior pituitary) and the thyroid.
- The trigger to metamorphosis may be an environmental signal affecting the larval brain through the nervous system, or there may be an endogenous 'clock' in the hypothalamus.
- In a way, hypothalamus integrates the information received from body with the environmental information.

Neurosecretory cells in the hypothalamus are stimulated to produce TRF or thyroid-releasing factor which stimulates the anterior pituitary gland to secrete a TSH or thyroid-stimulating hormone which causes orderly increase of thyroid secretion. Increase in thyroid hormone then trips the orderly sequence of tissue changes that transforms the tadpole larva into the frog.



Role of prolactin hormone

- Another anterior pituitary hormone, called prolactin is also found to be involved as an inhibitor in the overall control of metamorphosis.
- Developmental control is effected by a balance between inhibition and stimulation at the level of endocrine action.
- Thyroid hormones are also known to affect the process of protein synthesis at the levels of transcription and translation and to have a role in cell differentiation ,growth and development.