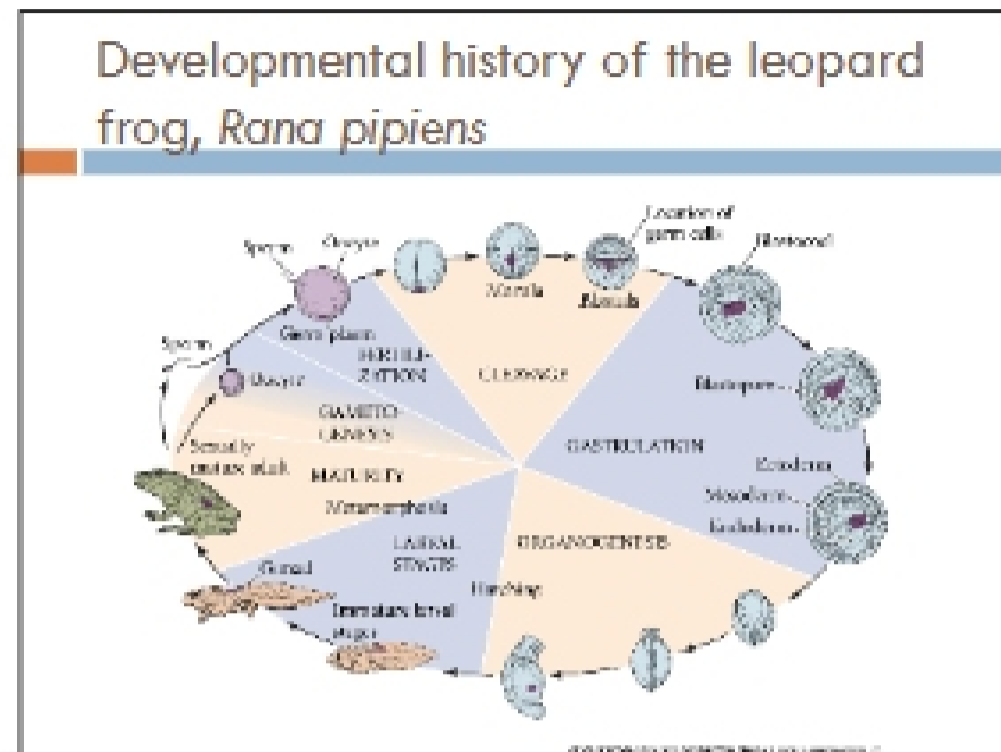
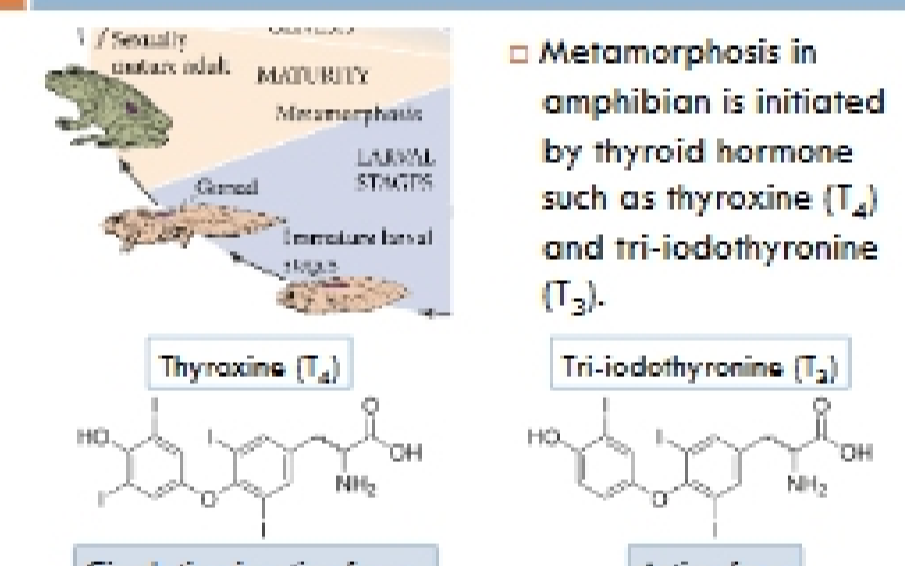


**CHAPTER 18,
POSTEMBRYONIC
DEVELOPMENT:
METAMORPHOSIS &
REGENERATION**

ZOO3603 12/1/09



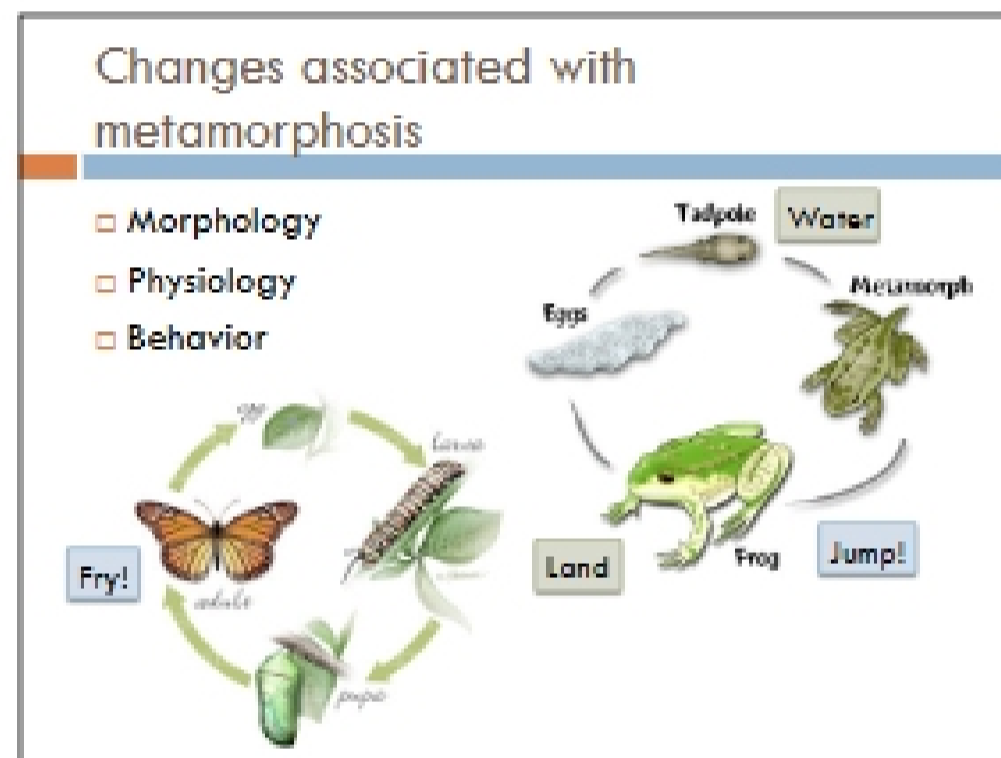
Metamorphosis & thyroid hormones in amphibian



Metamorphosis is initiated by thyroid hormones such as thyroxine (T_4) and tri-iodothyronine (T_3).

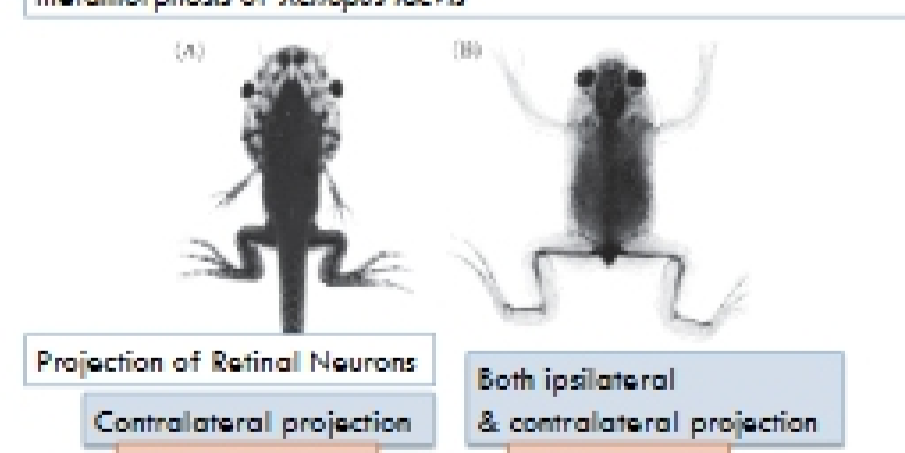
Thyroxine (T_4)
Circulating inactive form

Tri-iodothyronine (T_3)
Active form



Morphological changes: Growth of new structures

Eye migration and associated neuronal changes during metamorphosis of *Xenopus laevis*



(A) Projection of Retinal Neurons
Contralateral projection
Wide, but not 3D

(B) Both ipsilateral & contralateral projection
3D, but narrow

Cell death during metamorphosis

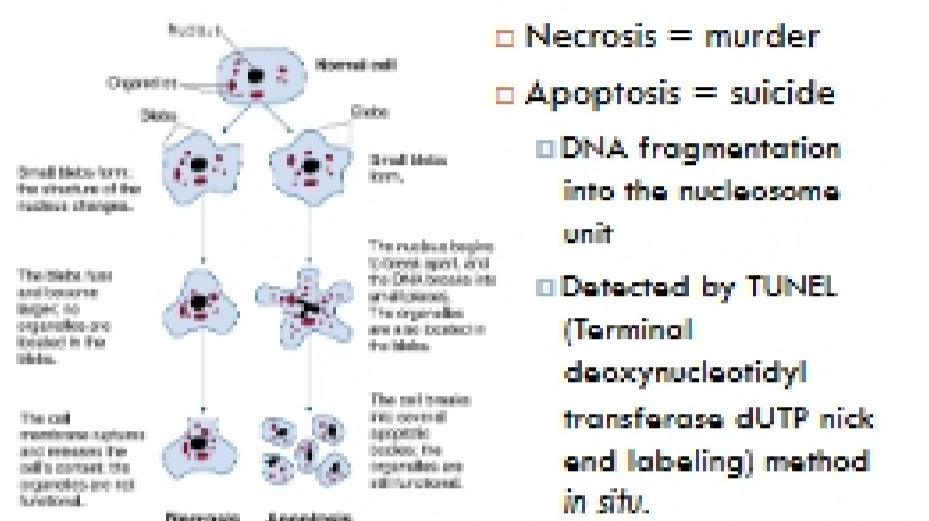
- Paddle-like tail
- Oxygen-procuring gills
- Conversion of red blood cells
 - Tadpole red blood cells

Regress by apoptosis

Cell death

- Apoptosis (program cell death)
- Necrosis

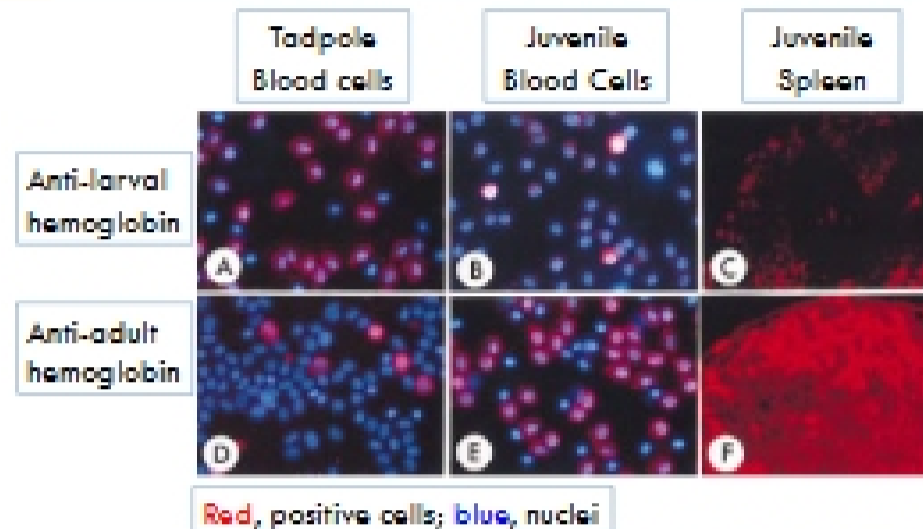
Necrosis and Apoptosis



- Necrosis = murder
- Apoptosis = suicide
- DNA fragmentation into the nucleosome unit
- Detected by TUNEL (Terminal deoxynucleotidyl transferase dUTP nick end labeling) method *in situ*.

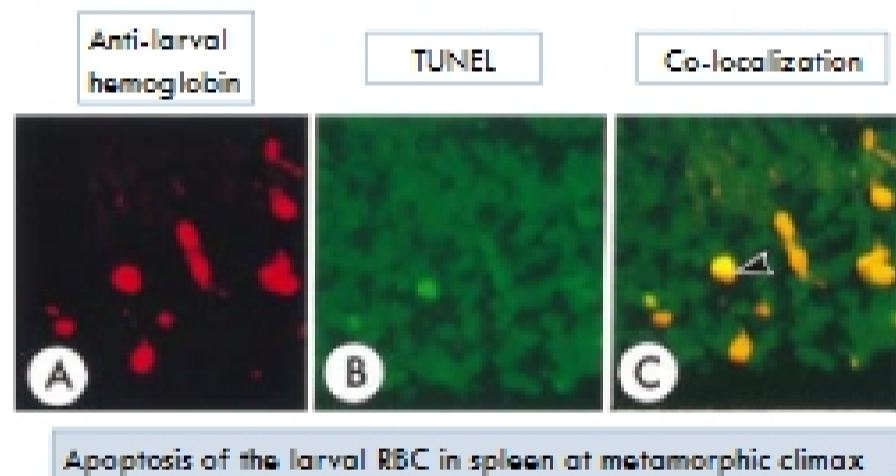
Chen et al., *Journal of Cell Biochemistry* 2017;134:1841-1851 (2017)

Cell death during metamorphosis: Conversion of red blood cells



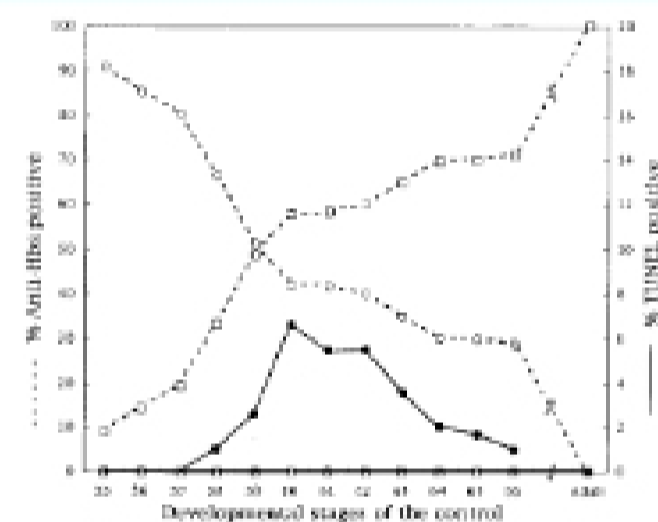
Samal & Weisberg, *Int. J. Dev. Biol.* 44: 373-382 (2000)

Cell death during metamorphosis: Conversion of red blood cells



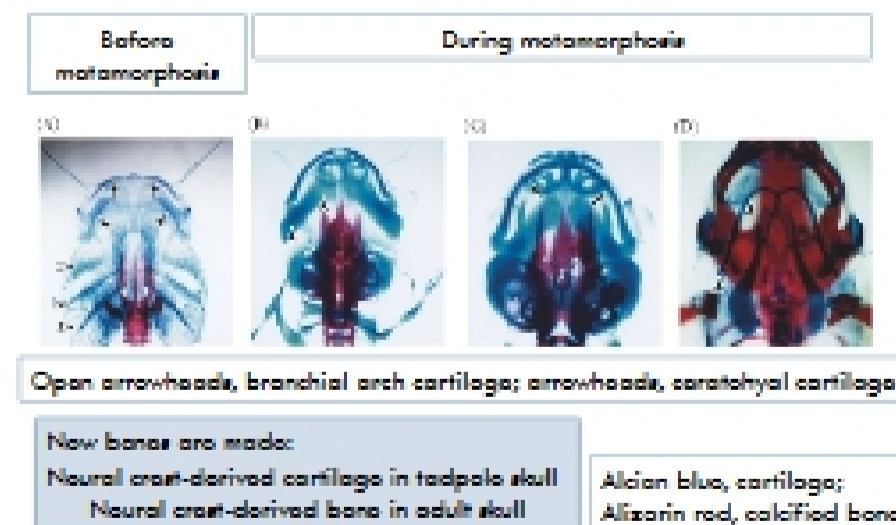
Samal & Weisberg, *Int. J. Dev. Biol.* 44: 373-382 (2000)

Cell death during metamorphosis: Conversion of red blood cells



Samal & Weisberg, *Int. J. Dev. Biol.* 44: 373-382 (2000)

Remodeling during metamorphosis: Changes the skull in *Xenopus*

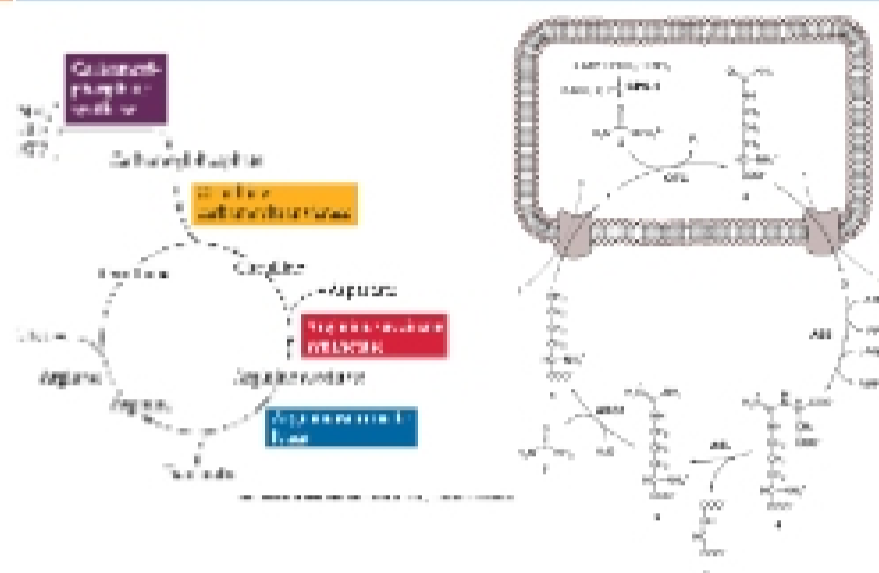


Biochemical Re-specification: Development of urea cycle during anuran metamorphosis

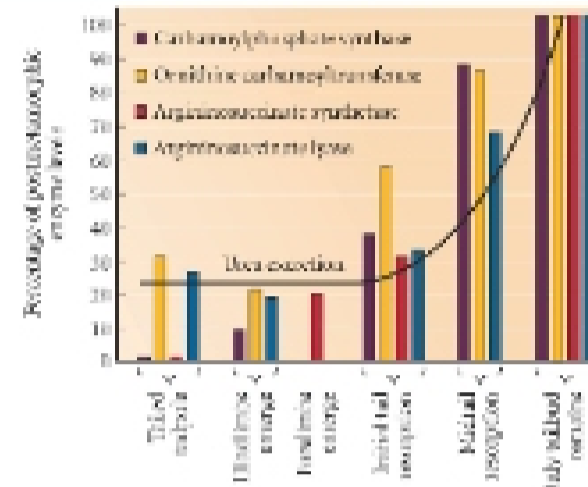
- Ammonotelic, excreting ammonia in most freshwater fish including tadpoles.
- Ureotelic, excreting urea in most terrestrial vertebrates including many of adult frogs.

Ammonotelic Ureotelic
T₃ in Liver

Major features of the urea cycle



The emergence of urea cycle enzyme activities

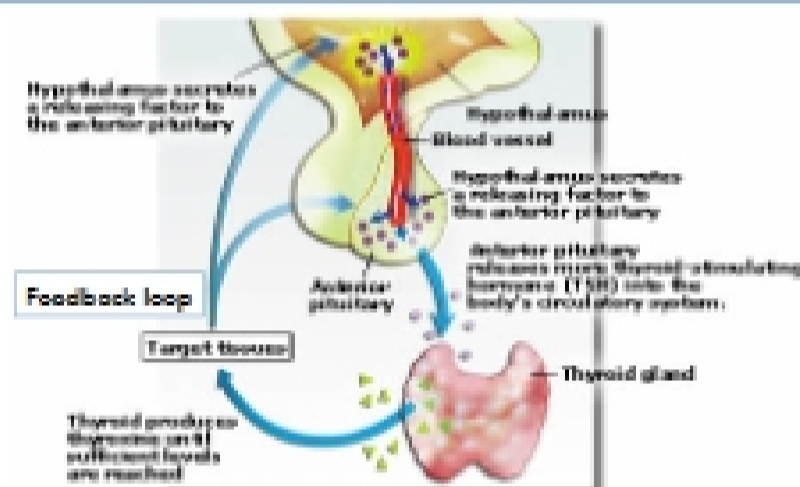


It correlates with metamorphic changes in *Rana catesbeiana*

Hormonal control of amphibian metamorphosis

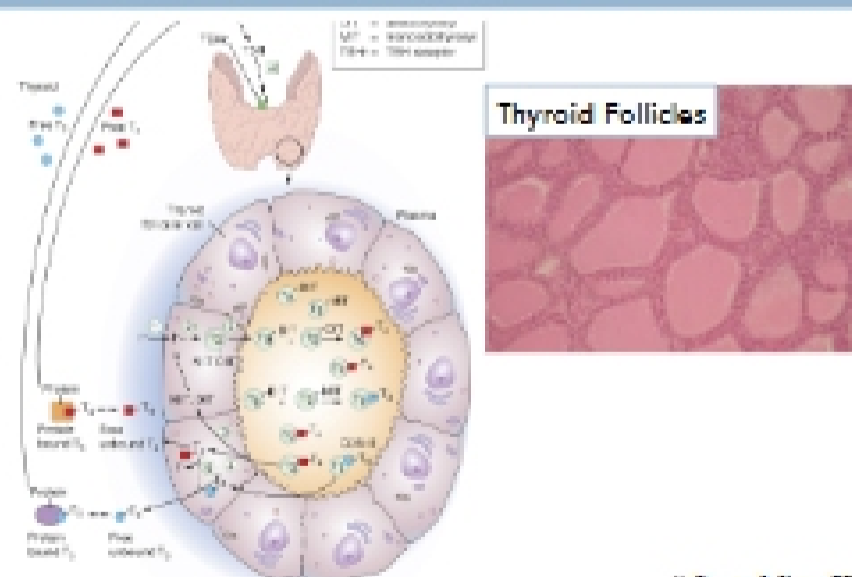
- Fed powdered horse thyroid glands
Premature metamorphosis.
- Removed or destroyed thyroid
Never metamorphosed
- Increasing amount of thyroid hormone regulates anuran metamorphosis.

Regulations of thyroid hormones



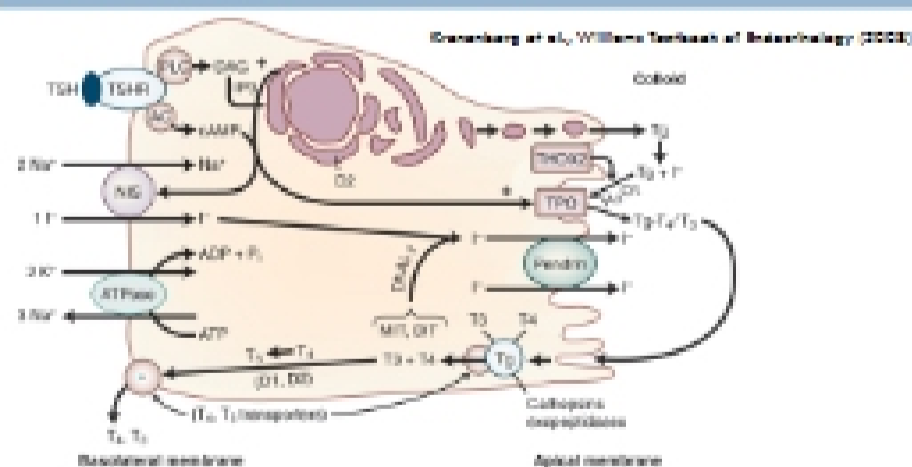
<http://www.oxfordjournals.org/abstract/doi/10.1093/oxfordjournals/physiol.a011111.a011111>

Hypothalamic-pituitary-thyroid axis and thyroid hormone synthesis



Alfonsi & Pines, 2004

Key aspects of thyroid iodine transport and thyroid hormone synthesis



NIS, Sodium-iodide symporter; T3, triiodothyronine; T4, thyroxine; Tg, thyroglobulin; TPO, thyroid peroxidase; TSHR, thyrotropin receptor. [Modified from Spitzweg C, Heufelder AE, Morris JC. Thyroid iodine transport.