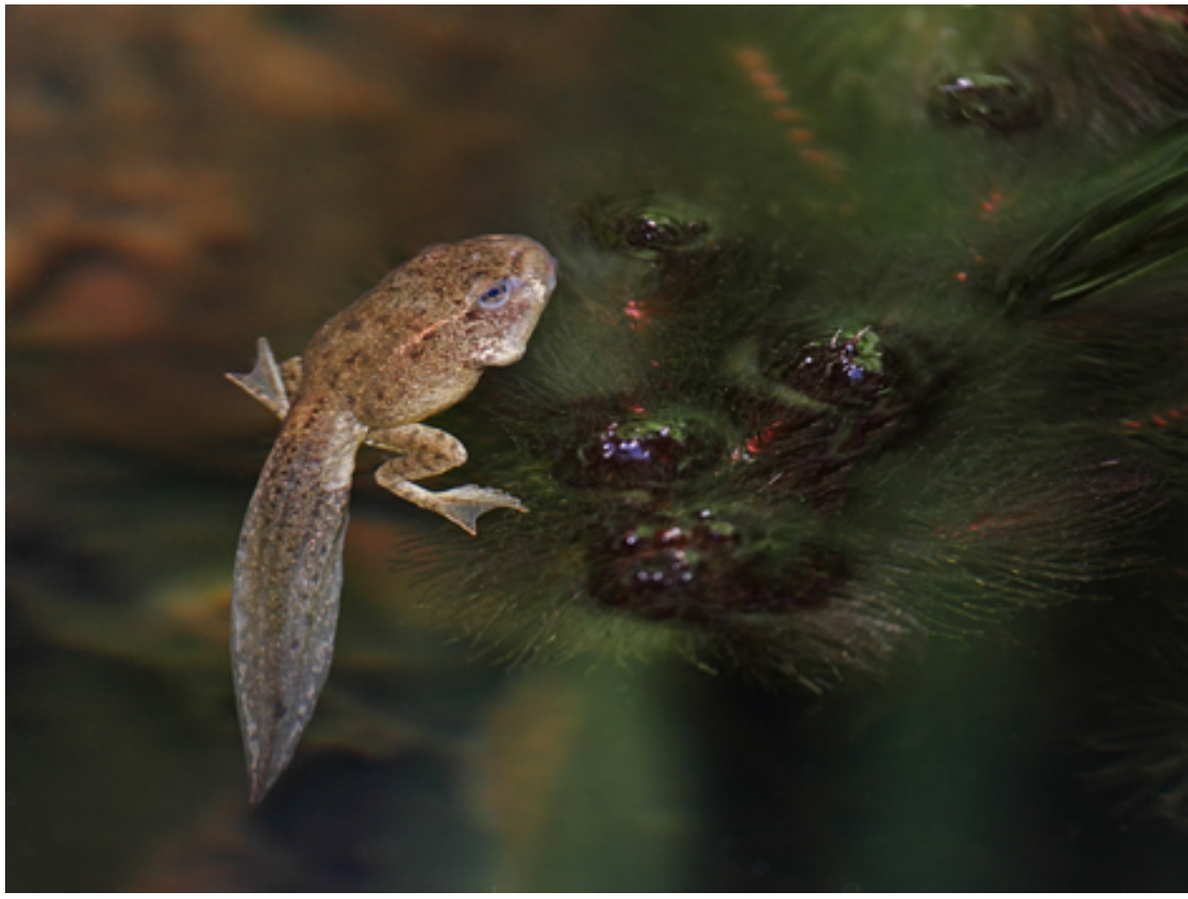
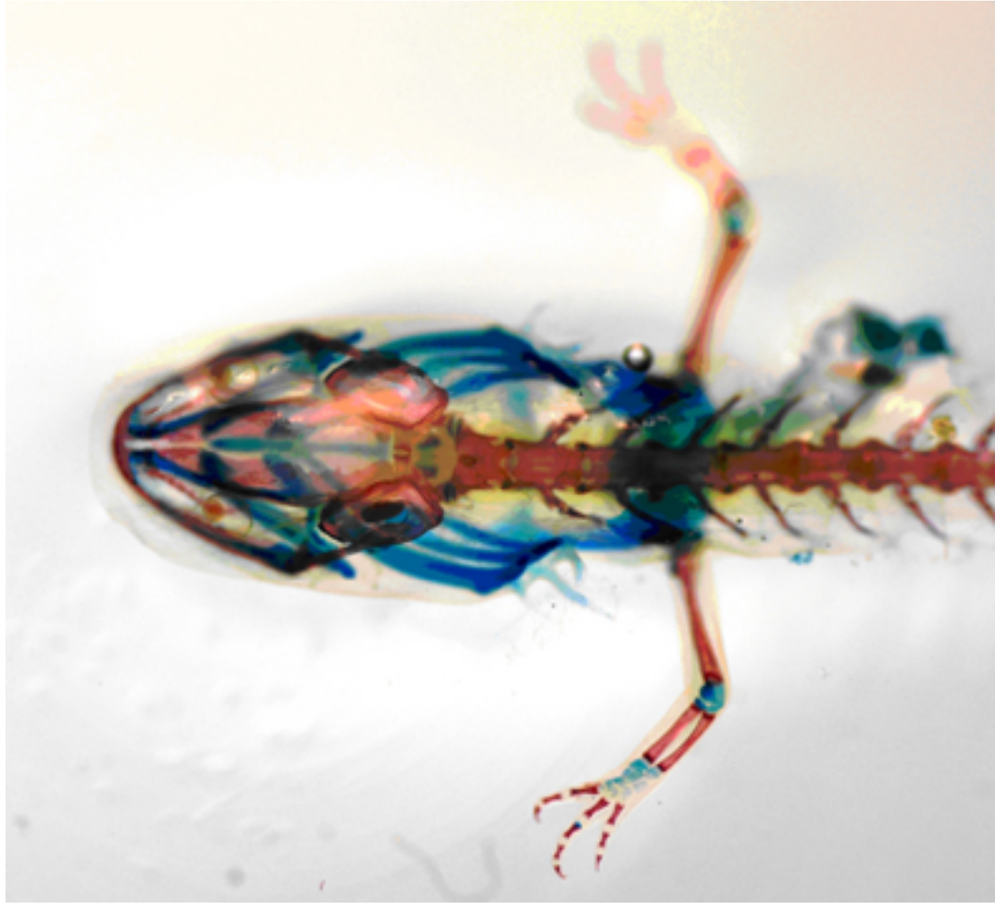
Amphibian Physiology

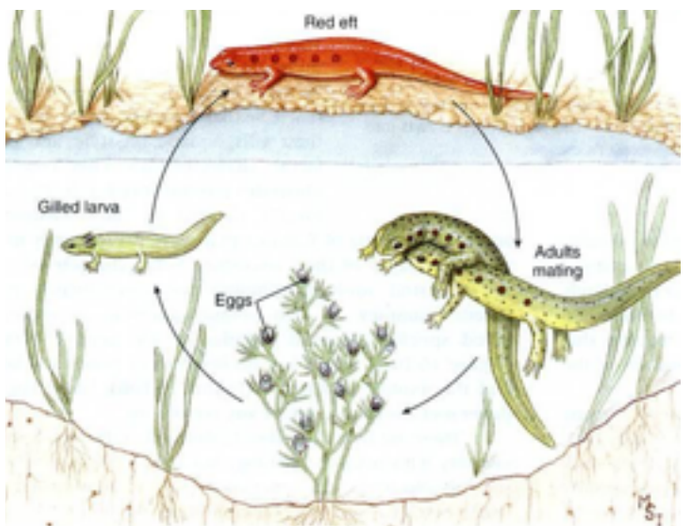


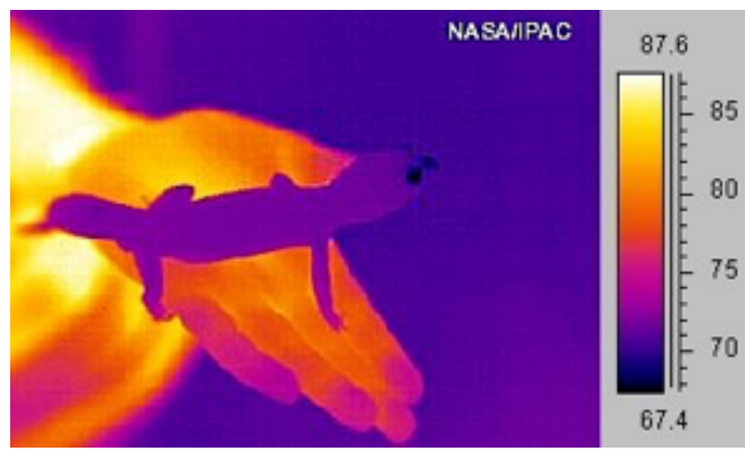


What is Physiology?

- The study of **chemical** and **physical processes** in the organism

- Aspects of the physiology can be informative for understanding organisms in their environment
  - Thermoregulation
  - Water Regulation
  - Development

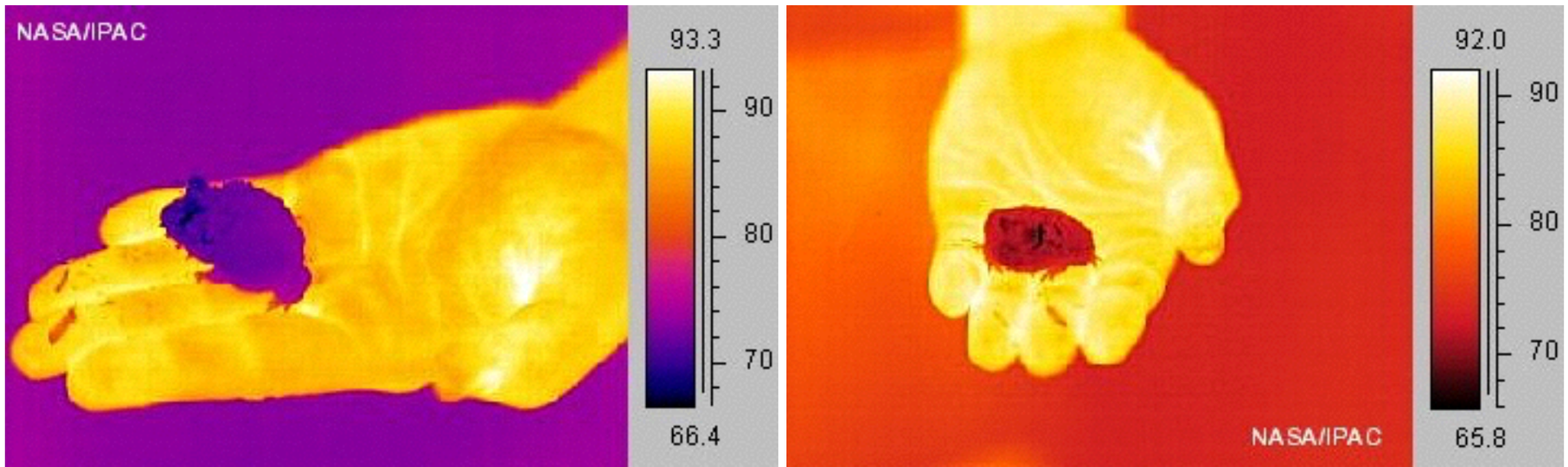




Thermoregulation

- All amphibians and reptiles are **ectotherms**
  - Their body temperature is governed by the environment.
- Changes in temperature have cascading effects throughout the body
  - Brain function
  - Muscle function
  - Digestive function

Optimal functions occur at T_O



Amphibian Thermoregulation

- Amphibians, for the most part do not bask to warm their bodies
  - Salamanders - no evidence
  - Frogs - perhaps *R. catesbiana*?
- However, some amphibians will move to accommodate changes
  - Salamanders - Movement between underground (cold nights) and cover objects at the surface (warm days)
  - Frogs - Movement between middle of the pond (cold nights) and the shore (warm days)

Amphibian Thermoregulation

- **Plethodontids** are especially adept for life at cold temperatures
    - Lungless
    - Cold water carries more oxygen (even in moist soils)
    - Specialized feeding structures
        - Gets around the “cold muscle” problem

Overwintering

Moving to Warm Habitat

- Frogs - hibernate
  - Terrestrial hibernators (e.g. *Bufo*, *Scaphiopus*)
  - Aquatic hibernators (e.g. *Rana catesbeiana, Rana clamitans, Rana pipiens*, etc.)
- Salamanders - reduced activity
  - Underground burrowers (e.g. *Plethodon*, *Ambystoma, N. viridescens* red-eft)
  - Active in aquatic habitat (e.g. *N. viridescens* adults)

Overwintering

Freeze Tolerant Frogs

- Some species are specially adapted to freeze
  - *Pseudacris crucifer*
  - *Hyla versicolor*
  - *Rana sylvatica*
- Possess large carbohydrate stores in their liver, which is converted to glucose or glycerol in the winter, serving as an antifreeze
- Allows a head-start before other frogs come out of hibernation at the bottom of ponds

Water Regulation

- Proper water balance is one of the most critical factors in **habitat choice**.
- However, the fact that amphibians are “shackled” to the water is largely overblown; there are important…
    - adaptations for very dry conditions
    - adaptations for very wet conditions

Dry Condition Adaptations

- Moist skin is a huge vector for water loss in terrestrial amphibians
    - Habitat choice
    - Skin anatomy
        - Warty skin (*B. americanus*)
        - Mucus *(P. glutinosus*)
    - Water storage in urinary bladder
- Many amphibians can take up water through the skin
- Adaptations NOT seen in CT:
    - Cocoon frogs
    - “Waterproof” frogs

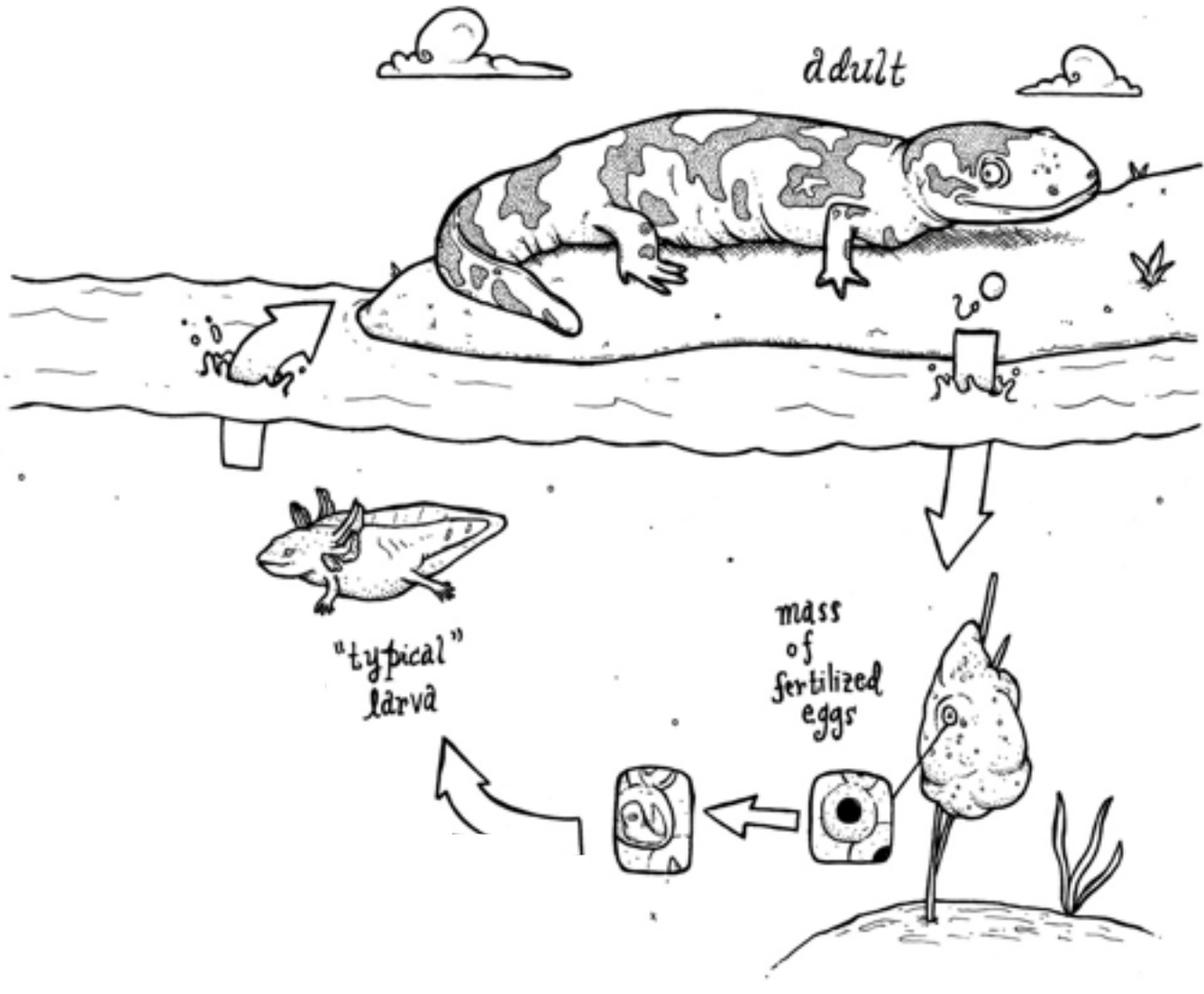
Wet Condition Adaptations

- Smooth skin makes drinking via skin slower
- Fluctuating blood ion concentrations
  - Keep blood ion concentration low, so water flows out (opposite is true for terrestrial species)
  - Excrete nitrogenous waste via ammonia, which is toxic but very water soluble
- Secreting fungicidal chemicals and antibacterial agents to keep the skin clean and healthy

Development

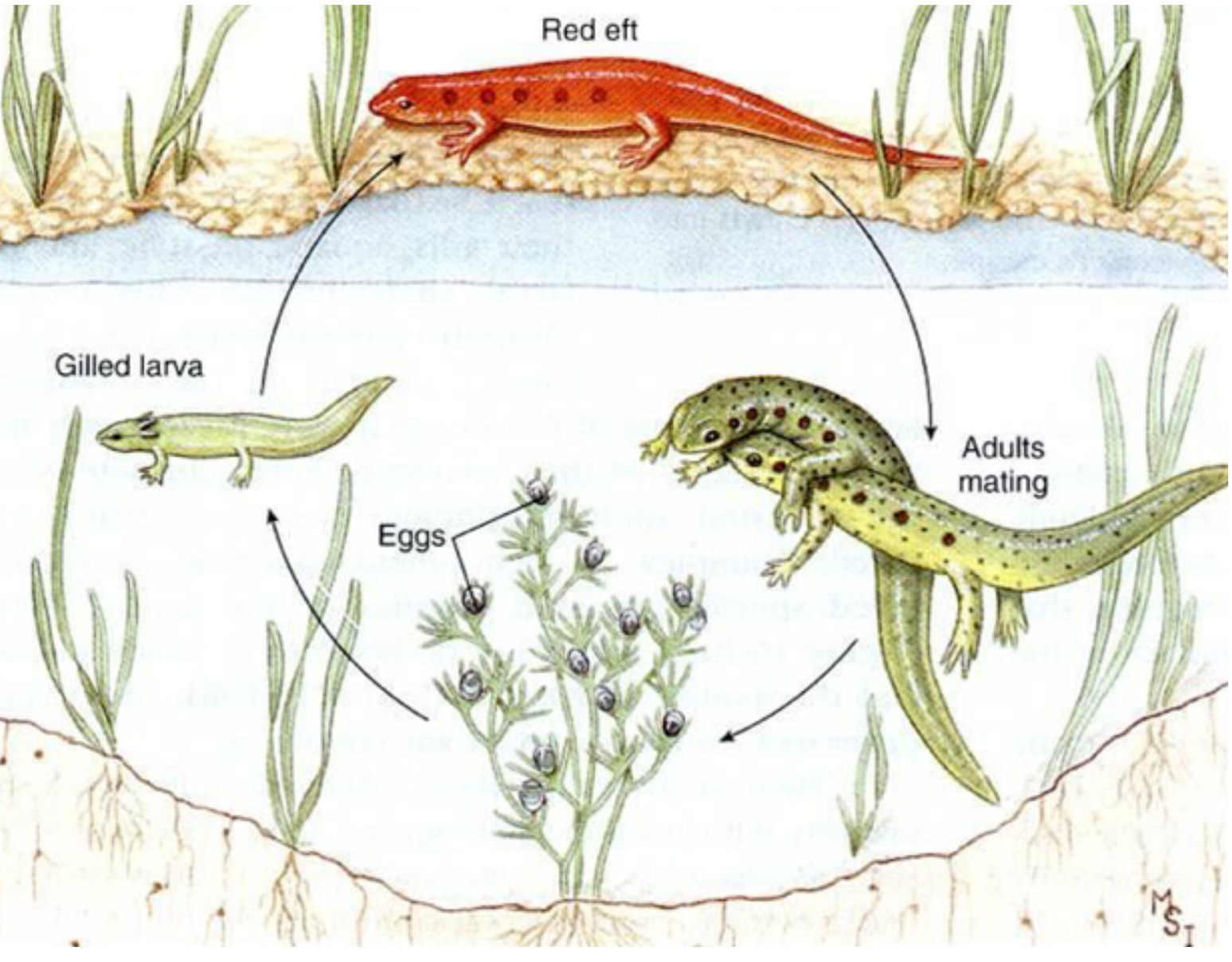
- **Ontogeny** is the process of creation and development of an organism; the growth of an organism from embryo to mature adult
    - “Normal development”
    - Regeneration
- Amphibians in CT have **four** different ontogenies

Ontogeny 1:
Egg, Aquatic Larvae, Adult



- All CT frogs
- All CT salamanders except for *Plethodon* and *Necturus maculosus*

Ontogeny 2:
Egg, Aquatic Larvae, Terrestrial Subadult, Aquatic Adult



- *Notophthalmus viridescens*
- "Adds another step"

Ontogeny 3: Egg, Terrestrial Subadult, Terrestrial Adult

- *Plethodon cinereus* and *Plethodon glutinosus* salamanders
- “Skips aquatic larvae”

Ontogeny 4:
Egg, Aquatic Larvae,
Sexually Mature Aquatic Larvae

- *Necturus maculosus*
- “Skips adult stage”

Limb Regeneration

- Salamanders
  - Appear to retain this ability throughout their lifespan
    - Tails
    - Limbs
  - They get **everything** back, bone, muscle, and nerves!
- Frogs
  - Tadpoles capable of regenerating tail, but adult frogs cannot regenerate
  - Can only regenerate the notochord