

AMPHIBIAN LIFE CYCLES

ANURA (Greek) / SALIENTIA (Latin): Frogs

Nearly worldwide except few above Arctic Circle and none in Antarctica; 45 families, 5450+ species.



URODELA / CAUDATA: Salamanders

Mostly north temperate; Plethodontidae to the Amazon Basin; 9 families, 560+ species (378 of which belong to the Plethodontidae)



GYMNOPHONA / APODA: Caecilians

Worldwide in tropics except Madagascar and Oceania; 6 families, ca. 170 species



2009

SEASONALITY

Primary Cues: Induce production and release of reproductive hormones and responsiveness of target organs

- Temperature
- Moisture
- Day Length

Some amphibians, especially in temperate zones, have definite reproductive seasons (late winter/early spring, summer, fall), especially in temperate zones

Some amphibians, especially in aseasonal tropical environments, breed year-round, although breeding may be more intense in periods of greater or lesser precipitation or, possibly, longer day length

Most species breed once a year, but some breed only every other year

MATE ATTRACTION and RECOGNITION

ANURA

Females attracted to species-specific call of males

Primary recognition by females associated with call of male; primary recognition by males associated with female behavior



URODELA

Recognition based on olfactory cues and courtship rituals



GYMNOPHONA

Unknown

FERTILIZATION

EXTERNAL

- 1. Most frogs: Amplexus - Inguinal (waist; ancestral), Axillary (behind front legs), cephalic; others (e.g., no amplexus)
- 2. A few salamanders (Cryptobranchidae, Hynobiidae)

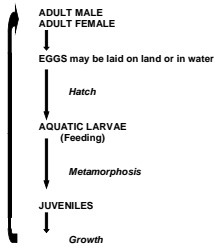
INTERNAL

- 1. A few frogs (*Eleutherodactylus jasperi* and *E. coqui* [Brachycephalidae] in Puerto Rico; *Mertensophryne miranotis* [Bufonidae] in Africa; some *Nectophrynoides* [Bufonidae] in Africa), *Ascaphus* [Leiopelamidae]
- 2. Most salamanders - Spermatophores
- 3. Caecilians - phalodeum (modified cloaca)



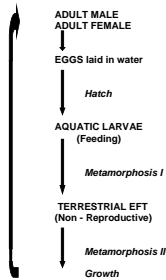
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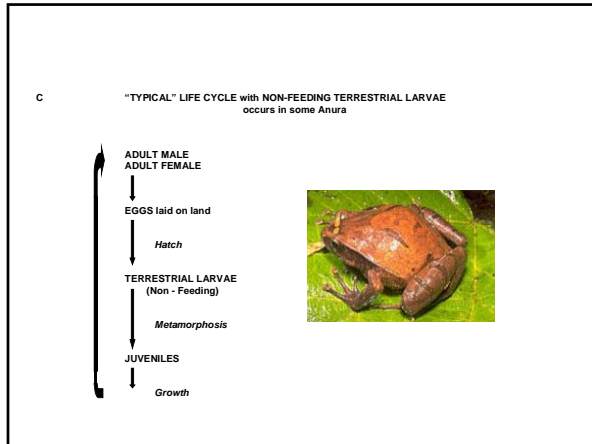
"TYPICAL" LIFE CYCLE - occurs in Anura, Urodela, Gymnophiona

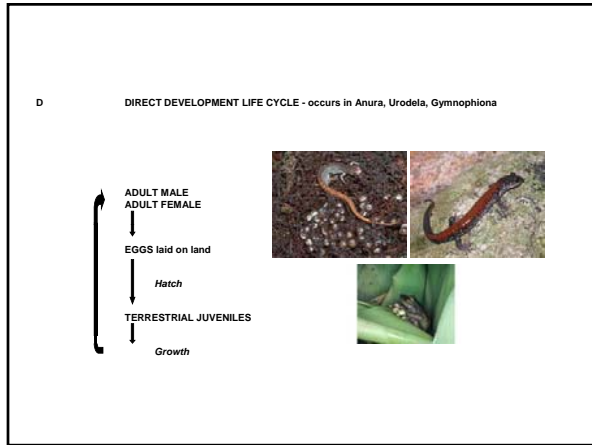


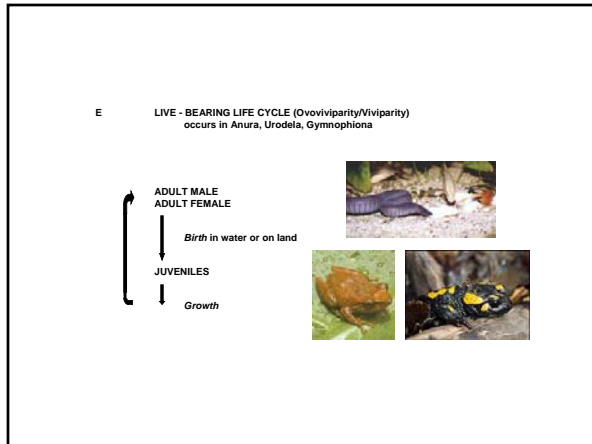
B

Notophthalmus viridescens (Salamandridae) LIFE CYCLE
High - Elevation Populations









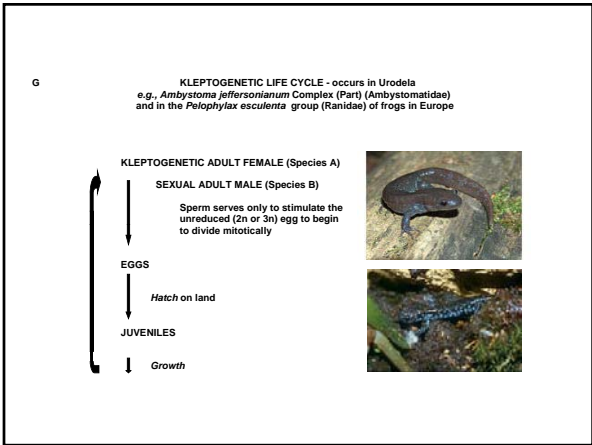
F **PARTHENOGENESIS**

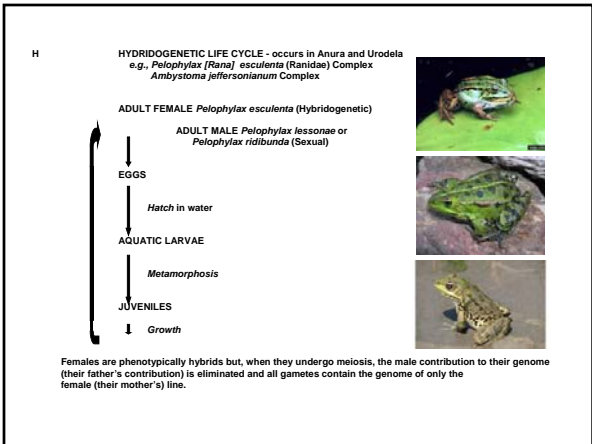
Parthenogenesis is a form of unisexual (*not* asexual) reproduction. All individuals in a population or a species are female, and all are reproductive as adults.

Females produce eggs which develop mitotically without fertilization.

Parthenogenesis may be obligate (permanent) or facultative (individuals belonging to a population or an entire species may reproduce parthenogenetically but, in response to environmental cues, may begin to produce both male and female offspring which reproduce sexually).

Known to occur in many invertebrates, as well as some fishes, lizards and snakes. Suspected in salamanders (*Ambystoma jeffersonianum* complex [Ambystomatidae]) and frogs (XXX esculenta complex [Ranidae]). Has been artificially induced in mammals (rabbits) and birds (turkeys).





HETEROCHRONY

"Shape arises from differential growth within a structure" (Vitt and Caldwell 2008, p. 37).

Heterochrony is a change in the timing and/or rate of growth of a trait relative to that in the ancestral taxon.

Several patterns of heterochrony are recognized (Reilly et al. 1997) and two are emphasized here:

- 1. Paedomorphosis
- 2. Paedogenesis

Both occur in taxa in which sexual maturity is achieved while larval characteristics are retained.

PAEDOMORPHOSIS

This is an *interspecific* process and reflects change over evolutionary time. Comparison is made between the paedomorphic taxon and its immediate non-paedomorphic ancestor. It is irreversible in the short term (i.e., full metamorphosis does not occur).

Examples include salamanders in the families Siren and Proteidae, and *Ambystoma mexicanum* (the Axolotl; Ambystomatidae). It also occurs in several genera of salamanders in the family Plethodontidae.

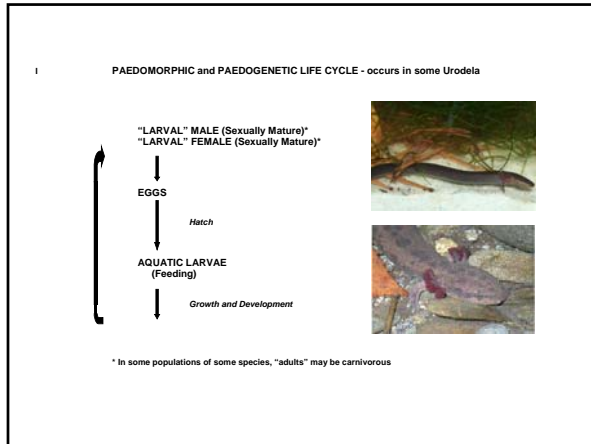
Caecilians and salamanders in the families Amphiumidae and Cryptobranchidae, as well as some species in the family Salamandridae, exhibit some paedomorphic traits although their morphology is not so fully larval as the taxa cited above.

PAEDOGENESIS

This is an *intraspecific* process and reflects change over ecological time

Individuals *within* populations of a species retain larval characteristics while achieving sexual maturity, and may or may not metamorphose into a "fully adult" stage, depending on environmental conditions.

Examples include some, but not all, populations of *Ambystoma talpoideum*, populations of *Ambystoma tigrinum* in the Great Plains and at higher elevations in the Rocky Mountains, and *Ambystoma gracile* in northwestern United States and southwestern Canada.



PARENTAL CARE

Parental care occurs in Anura, Urodela, and Gymnophiona and there are a wide variety of types. Among these are:

- Construction of nests (e.g., *Physalemus* [Leiperidae], *Hyla boans* [Hylidae], many salamanders, some caecilians)
- Guarding of eggs, or eggs and larvae, by the male or female parent (e.g., some hylid frogs, *Pyxicephalus adspersa* [Pyxicephalidae], many salamanders, some caecilians)
- Carrying of the eggs on or in the body of a parent (e.g., *Alytes* [Alytidae], *Pipa Pipa* [Pipidae], *Gastrotheca* [Amphignathodontidae], live-bearing caecilians)
- Carrying of the tadpoles on or in the body of a parent (e.g., *Dendrobates* [Dendrobatidae], *Rhinoderma* [Cycloramphidae], *Rheobatrachus* [Myobatrachidae])
- Carrying of the eggs, tadpoles and, in a few species, newly metamorphosed young on the body of a parent (e.g., *Hemiphractus* [Hemiphractidae])

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REFERENCES

Duellman, W. E. and L. Trueb. 1986. *Biology of Amphibians*. McGraw-Hill Book Company, New York.

Reilly, S. M., E. O. Wiley and D. J. Meinhardt. 1997. An integrative approach to heterochrony: The distinction between interspecific and intraspecific phenomena. *Biological Journal of the Linnean Society* 60:119-143.

Vitt, L. J. and J. P. Caldwell. 2008. *Herpetology: An Introductory Biology of Amphibians and Reptiles*, 3rd Ed. Academic Press, Burlington, Massachusetts.

Wells, K. D. 2007. *The Ecology and Behavior of Amphibians*. University of Chicago Press, Chicago.

KEY TO SPECIES APPEARING ON SLIDES
Incomplete .. photo credits will be added

Slide	Image	Taxon
1	a	<i>Atelopus varius</i> (Bufonidae)
	b	<i>Plethodon jordani</i> (Plethodontidae)
	c	<i>Dermophis mexicanus</i> ("Caeciliidae")
3	a	<i>Anaxyrus americanus</i> (Bufonidae)
	b	<i>Anaxyrus bufo</i> (Bufonidae)
4		<i>Ascapheus montanus</i> (Leiopelmatidae)
5	a	<i>Pyxicephalus adspersa</i> (Pyxicephalidae)
	b	<i>Cryptobranchus alleganiensis</i> (Cryptobranchidae)
6	a	<i>Notophthalmus viridescens</i> (Salamandridae) - Adult
	b	<i>Notophthalmus viridescens</i> (Salamandridae) – Eft
7		<i>Plethodontohyla inguinalis</i> (Microhylidae)

KEY TO SPECIES APPEARING ON SLIDES
Continued

Slide	Image	Taxon
8	a	<i>Hemidactylium scutatum</i> (Plethodontidae)
	b	<i>Plethodon yonahlossee</i> (Plethodontidae)
	c	<i>Eleutherodactylus coqui</i> (Brachycephalidae)
9	a	<i>Typhlonectes natans</i> (Typhlonectidae)
	b	<i>Eleutherodactylus jasperi</i> (Brachycephalidae)
11	c	<i>Salamandra salamandra</i> (Salamandridae)
	a	<i>Ambystoma jeffersonianum</i> (Ambystomatidae)
	b	<i>Ambystoma laterale</i> (Ambystomatidae)
12	a	<i>Pelophylax esculenta</i> (Ranidae)
	b	<i>Pelophylax lessonae</i> (Ranidae)
	c	<i>Pelophylax ridibunda</i> (Ranidae)
16	a	<i>Siren intermedia</i> (Sirenidae)
	b	<i>Necturus maculosus</i> (Proteidae)

KEY TO SPECIES APPEARING ON SLIDES
Continued

Slide	Image ¹	Taxon
17	a	<i>Chiromantis xerampina</i> (Rhacophoridae)
	b	<i>Chiromantis xerampina</i> (Rhacophoridae) – Egg Mass
	c	<i>Ambystoma maculatum</i> (Ambystomatidae)
	d	<i>Alytes cisternasii</i> (Alytidae)
	e	<i>Gastrotheca piperata</i> (Amphignathodontidae)
	f	<i>Pipa pipa</i> (Pipidae)
	g	<i>Dendrobates pumilio</i> (Dendrobatidae)
	h	<i>Rhinoderma darwinii</i> (Cycloramphidae)

¹ a and b – top left and right, respectively, etc.
