Lecture 12

Salamanders, Anurans, Caecilians (up to modes of reproduction)

Extant amphibians

- Lissamphibia
- Tetrapods with _____, _____ skins
- Most have four well-developed limbs (a few salamanders and all _____ are limbless)
- Includes three distinct lineages
  - _____ (frogs)
    - Lack tails
    - Have hindlimbs that are long
    - Have short, stiff bodies that don't bend when they walk
  - _____ (salamanders)
    - Have long tails
    - Have forelimbs and hindlimbs of equal size
    - Move with lateral undulations
  - _____ (caecilians)
    - Have short tails
    - Have no limbs
    - Move by serpentine locomotion
- Have many derived characters in common
  - Moist permeable _____
    - Paleozoic nonamniote tetrapods often had dermal armor
    - Permeable unadorned skin is a shared derived character
  - _____
    - Eat almost anything they can catch and swallow
    - Tongue is broad, flat, and relatively immobile, but some terrestrial amphibians can protrude from the mouth to capture prey
    - Size of the head is an important determinant of the maximum size of prey that can be taken
      - Sympatric species of salamanders frequently have different head sizes, suggesting that this feature reduces competition
      - Lepidobratrachus feeds largely on other _____ and has a huge mouth
  - Operculum-plectrum complex
    - Two bones involved in transmitting sounds to the inner ear
  - Green rods
    - Distinct type of _____ cells
  - _____ teeth
    - Teeth in which the crown and base are composed of dentine and are separated by a narrow zone of uncalcified dentine or fibrous connective tissue

- Body form

  - Probably evolved from salamander-like starting point
  - Salamanders and caecilians swim as fishes do
  - _____ have inflexible bodies and swim with simultaneous thrusts of the hind legs
  - Some paleontologists have proposed that the anuran body form evolved because of the advantages of that mode of _____
  - An alternative hypothesis traces the anuran body form to the advantage gained by an animal that could rest near the edge of the water and _____ _____ with a rapid leap followed by locomotion on either land or water
- Age
  - Oldest fossils of amphibians are _____ of anurans and salamanders of the Permian
  - Examples of frogs, salamanders, and caecilians have all been found from the _____, suggesting that each of these groups has existed for some time

Salamanders – Urodela

- Have the most generalized body form and locomotion of amphibians
- Elongate
- All but a few species have 4 functional legs
- Walking-trot gait is probably similar to that employed by earliest tetrapods
  - Combines lateral bending of fishes with leg movements
- Almost entirely limited to the northern hemisphere
- Paedomorphosis is widespread
  - Retention of larval characters including :
    - larval tooth and bone patterns
    - absence of _____
    - retention of a functional _____ _____ system
    - retention of external gills
- Aquatic forms
  - Cryptobranchidae –
    - Do not retain external gills, but have other larval characteristics
  - Mudpuppies-
    - Retain external gills, and live in lakes and streams
  - Congo eels-
    - Have well developed lungs and can estivate for up to 2 years
- Several lineages have adapted to life in _____
  - Constant temperature and moisture are good for salamanders
  - Food is supplied by cave-dwelling _____
  - Texas blind salamander is highly specialized
    - Blind, white, with external gills, extremely long legs, and flattened snout used to probe underneath pebbles for food
- _____ salamanders
  - Some have aquatic larvae that lose their gills at metamorphosis

- Most fully terrestrial salamanders include species in which the young hatch from eggs as miniatures of _____ with no aquatic larval stage

- Feeding specializations of Plethodontid Salamanders
  - Plethodontidae is characterized by the absence of lungs
  - Contains more species and geographic distribution than any other lineage of salamanders
  - Many have evolved specializations of hyobranchical apparatus that allow them to protrude the _____ to capture prey
    - This has not evolved in salamanders with lungs, because the hyobranchial apparatus is essential in respiration
      - Salamanders lack ribs, so they cannot expand and contract the rib cage to move air in and out of the lungs
      - A sturdy _____ apparatus is essential for buccal pumping to force air from the mouth into the lungs
      - Tongue protrusion requires that the hyobranchial apparatus instead be elongated and lightened
      - Reliance on the _____ instead of the lungs for gas exchange may have been a necessary first step in the evolution of tongue protrusion in plethodontids

  - Modifications of the respiratory system and hyobranchial apparatus appear to be linked with other characteristics
    - Bolitoglossine plethodontids
      - Can project the tongue a distance equivalent to the head length plus the _____ length
      - Can pick off _____ prey
      - This requires fine _____ discrimination of distance and direction
        - Eyes are placed more _____ on the head
        - Eyes have a large number of nerves to the visual centers of the brain with complete dual projection of the binocular visual fields to both hemispheres of the brain
      - Do not have _____ larvae, and morphological specializations of adults appear during embryonic development
        - Aquatic larval salamanders employ suction feeding, which requires the hyobranchial apparatus

- Social Behavior of Plethodontid Salamanders
  - Plethodontid salamanders have a _____ groove that extends ventrally from each external naris to the lip of the upper jaw

- These grooves are an important part of the chemosensory system of plethodontids
- As a plethodontid moves about, it presses its snout against the substrate to pick up chemicals which are drawn upward to the vomeronasal organ
- How is chemoreception important?
  - Males defend _____ that are used for feeding and reproduction
  - Males mark substrate with _____
  - A salamander can distinguish between substrates it has marked and and those marked by _____
  - A salamander can also distinguish between the scent of a salamanders that they have encountered in the past and those they have not, and they can react differently to those scents
  - Male salamanders can learn to recognize and ignore the scent of a male in adjacent territories and yet recognize and attack strange intruders
  - Learning not to respond to the presence of a _____ may allow a salamander to forage more effectively and avoid injuries from territorial encounters – _____ _____ recognition
    - Injuries:
      - Salamanders bitten on the snout have reduced success in _____ _____
      - Bites to the tail may cause _____ (breaking off) and loss of stored fat

Anurans

- Anurans include 27 families with 4300 species and occur on all continents except Antartica
- Specialization of the body for jumping is the most conspicuous skeletal character
  - Bones of hindlimbs form a lever system that can catapult an anuran into the air
    - Hindlimbs are elongate and tibia and fibula are fused
    - Powerful pelvis is strongly fastened to the vertebral column
    - _____ is elongate and reaches far anteriorly
    - Posterior vertebrae are fused into a solid rod called the _____
    - Strong forelimbs and flexible pectoral girdle absorb the impact of landing
    - Eyes are large and placed forward on the head for binocular vision
  - Muscles of hindlimbs
    - _____ muscle operates at the length that produces maximum force during the entire period of contraction

        - Muscle shortens faster and generates more power than muscles from most other animals
        - Intracellular physiological processes of muscle contraction continue at the maximum level throughout the contraction
- Distinguishing Anurans
    - _____ have long legs and move by jumping
        - Semiaquatic forms are moderately streamlined and have webbed feet
    - _____ have stout bodies and make short hops instead of long leaps
        - Have blunt heads, _____ bodies, relatively short legs, little webbing between toes
        - Spadefoot toads take their name from a _____ structure on the hind foot used for digging
        - Horned frogs have extremely large heads and mouths
            - Feed on small vertebrates
            - Tadpoles of horned frogs are _____
        - Frogs that _____ headfirst have pointed heads, stout bodies, and short legs
        - Arboreal frogs
            - Large heads and eyes, slim waists, long legs
            - Tree frogs have large toe disks
                - Surfaces of toe pads consist of an epidermal layer with peg-like projections separated by spaces or canals
                - _____ glands distributed over the disks create a watery mucus that forms a layer of fluid between the toe and the surface it rests on, holding the toe pad and the surface together
                - When a frog moves forward its pads are peeled loose (can't stay up facing downward)
                - Adhesion and detachment of the pads alternate as a frog walks across a leaf.
- Locomotion and natural history
    - Short-legged species that move by hopping are frequently wide-ranging predators that cover large areas as they search for food
        - This behavior makes them conspicuous to predators
        - Short legs prevent them from fleeing rapidly to escape
        - Many of these have defensive _____ that are released from glands in the skin when they are attacked

    - Species of frogs that move by jumping are usually sedentary predators that wait in ambush for prey to pass their hiding places
        - These species are usually _____ colored and lack chemical defenses

- If they are discovered by a predator, they rely on a series of rapid _____ to get away
- Anurans that forage widely encounter different types of prey than those that wait in one spot
  - Differences in dietary habits may be associated with differences in locomotor mode

- Feeding
  - Aquatic anurans use _____ to engulf food in water
  - Most species of semiaquatic and terrestrial anurans have sticky tongues that can be flipped out to trap prey and carry it back to the mouth
    - Most use a catapult-like mechanisms to project the tongue
    - As the mouth is opened, contraction of the _____ muscles causes the front of the tongue to stiffen while contraction of a short muscle at the front of the jaws provides a fulcum
    - The stiffened tongue rotates forward over the _____ and flips out of the mouth
    - Inertia causes the rear portion of the tongue to elongate as it emerges
    - After trapping the prey, the tongue is drawn back into the mouth by the _____ muscle

Caecilians

- Legless, burrowing or aquatic amphibians
- Occur in _____ habitats around the world
- Eyes of caecilians are covered by _____ (or bone and skin), or lack eyes entirely
- Annuli (dermal folds) encircle the body
  - Primary annuli overlie vertebrae and myotomal septa and reflect body segmentation
- Many species have dermal _____ in pockets of the annuli
- Have a pair of protrusible _____, one on each side of the snout between the eye and nostril
  - _____ muscles have become the muscles for the tentacle
  - the Harderian gland lubricates the channel of the tentacle
  - Tentacle is probably a sensory organ that allows chemical substances to be transported to the _____ organ
- Earliest known fossil is from Jurassic
  - combination of ancestral and derived characters
    - four legs
    - fossa for chemosensory tentacle
- Feed on small or elongate prey
  - Tentacle may allow them to detect the presence of prey when they are underground

- Reproduction
  - Females of some species of caecilians brood their eggs
  - Other species give birth to live young
  - Embryos of terrestrial species have long _____ gills
  - Embryos of aquatic species have _____ gills

Diversity of Life Histories of Amphibians

- Most species of amphibians lay eggs
  - Eggs may be deposited in water or on land
    - Hatch into aquatic larvae or into miniatures of the terrestrial adults
  - Adults of some species of frogs carry eggs in _____ sacs, or even in the _____
  - In some species the females retain the eggs in the _____ and give birth to metamorphosed young
  - Many amphibians have no parental care of their eggs or young
  - Many parents remain with the eggs and sometimes with hatchlings and transport tadpoles from the nest to water
  - In a few species, an adult _____ the tadpoles

- Population ecology of amphibians
  - Hard to study
    - Fluctuation in _____ appears to be a normal feature
      - In a year of drought the reproductive output of a population may die
      - In a good year, survival may be unusually high, and a large number of individuals may be added to a population
    - Many species live in _____ in which individuals move among local populations that are centered around breeding sites
      - A limited study might conclude that a species was vanishing, whereas a broader analysis would show that the _____ population of the species had not changed

Caecilian life history

- Internal fertilization was accomplished by a male _____ organ that is protruded from the cloaca
- Some lay eggs
  - The female may coil around the eggs, remaining with them until they hatch
- _____ is widespread (75% of species)
  - At birth, young are 30 to 60% of their mother's body length
  - Initial growth of fetuses is supported by yolk contained in the egg at the time of fertilization,
  - Additional energy must be supplied by the mother

- Fetuses obtain energy by scraping material from the walls of the oviducts with specialized embryonic teeth
- Epithelium of oviduct _____ and forms thick beds of tissue
- When yolk supply has dwindled, fetuses bite the walls of the oviduct, stimulating secretion of creamy substance called _____ _____. They consume the milk, along with muscle and epithelial tissue

  - Gas exchange achieved by close contact between fetal gills and the walls of the oviducts
    - Gills are absorbed before birth, and _____ gas exchange may be important for fetuses late in development

Salamander life history

- Most groups of salamanders use internal fertilization
  - Occurs by transfer of a _____ (a packet of sperm)
  - The form of the spermatophore differs in various species
  - Consist of a sperm cap on a gelatinous base.
  - In Euteproctus
    - Male deposits a spermatophore on female's body, holds her with tail or jaws, uses feet to insert spermatophore into her _____
  - In Ranadon sibiricus
    - Male deposits a spermatophore on the _____, and female picks of the cap with her cloaca
    - Sperm are released as the cap dissolves, and fertilization occurs in the oviducts

- Salamander Courtship
  - Males of some species have elaborate sexual characters used for courtship
  - Pheromones are released primarily by _____
    - Pheromone delivery often involves physical contact
      - Male applies secretions to the nostrils or body of the female
        - Plethodontidae
          - Spread secretions from mental gland on the females skin
          - Abrades her skin with _____, inoculating female with pheromone
        - Desmognathus
          - Use specialized mandibular teeth to bite and stimulate the female
        - Salimandridae
          - Males rub the females snout, the hedonic glands on their cheeks, chin, or cloaca

- Triturus
  - Males transfer pheromones without physical contact between the male and female
  - Males perform elaborate courtship displays in which the male vibrates its tail to create a stream of water that _____ pheromones toward the female

- Salamander eggs and larvae
  - In most cases, salamanders that breed in water lay eggs in water
  - Eggs hatch into gilled aquatic larvae that transform into _____ adults (except in paedomorphic forms)
  - Some have no aquatic larval stage
    - Some plethodontids lay eggs beneath a log or rock near water, and the female remains with them until after they have hatched
      - Larvae take up an aquatic existence or move directly to terrestrial life

- Salamander viviparity
  - Four species give birth to live young
  - European Salamander
    - Embryos get all energy needed from egg _____
    - Larvae are released in water and have a 3 month aquatic stage
  - Alpine Salamander
    - Embryos are nourished by _____ secretions, like caecilians
    - Young are born fully developed

- Salamander Paedomorphosis
  - Small-mouthed salamander
    - Breed in autumn and winter
    - During the following summer some larvae metamorphose to become terrestrial juveniles
    - These become sexually mature by autumn and return to the ponds to breed when they are about a year old
    - Paedomorphic larvae remain in the ponds through the summer and mature and breed in the winter. Some metamorphose after breeding, but some remain in the ponds as permanently _____ adults

Anuran life history

- Mating systems
  - _____ breeding
    - Breeding season is very short (few days)

- Include many species of toads and other anurans that breed in _____ aquatic habitats such as vernal ponds
- Breeding congregations form as son as the site is available
- Males and females arrive in large numbers
- Mating success is approximately the same for all the _____

- _____ breeding
  - Breeding season extends for several months
    - Males arrive first at the breeding site
      - Males of some species establish _____
      - Males of other species establish nocturnal calling sites
    - Females come to the breeding site to breed
      - Just a few females arrive every day, and some males have no opportunity to breed
      - Females select males with which to breed based on frog _____

- Vocalizations
  - Advertisement calls-
    - Characteristics of the call identify the _____ and _____ of the calling individual
    - Many species are territorial, and males recognize one another by _____
    - An advertisement call is a conservative evolutionary character
      - Among related taxa there calls are very similar
    - A female's response to her own species' mating call is a mechanism for _____ recognition when multiple species breed simultaneously in one pond