Lecture 8

In the early Devonian, there were two major types of osteichthyans

- _____
  - Had fins containing bones and muscles from which the tetrapod limb was derived
- _____
  - Had fins primarily supported by rays
- The two groups have shared derived characters
  - Pattern of lateral line canals
  - Similar opercular and pectoral girdle dermal bone elements
  - Fins supported by bony dermal rays
  - _____ bone (bone replaces cartilage in the internal skeleton)
    - Agnathans, placoderms, and acanthodians also possess bone

'Osteichthyes'

- Osteo= bony, ichthys=fish
  - Named before people realized that other primitive fish had bony structures
  - Other fish names also misleading
    - _____= final bony fishes – but there has actually been a tendency for reduction of ossification, not an increase

Evolution of Sarcopterygii

- Primitive Sarcopterygii have
  - similar body shapes and size
  - two dorsal fins
  - an _____ lobe (fin area supported by the dorsal side of the vertebral column) on the heterocercal caudal fin
  - paired fins that were fleshy, scaled, and had a bony central axis
  - Jaw muscles of sarcopterygian fishes were massive compared to those of actinopterygians
  - Covered with _____, a dentine-like material, that spread across the sutures between dermal bones
- Phylogenetic relationships are still unclear
  - _____ are clearly a monophyletic group
  - Crossopterygii are paraphyletic or two separate lineages
  - Rhipidistians were recently split into several lineages
- Extant Sarcopterygii
  - Aquatic sarcoptergians dwindled in number in the late Paleozoic and Mesozoic
    - Remaining:
      - Dipnoans (lungfishes)
      - Actinistian Latimeria (coelacanths)

- Dipnoans
  - Distinguished by
    - Lack of articulated tooth-bearing premaxillary and maxillary bones
    - _____ (fusion of palatoquadrate to the undivided cranium)
    - Teeth scattered over the palate and fused into tooth ridges along the lateral palatal margins
    - Powerful adductor muscles from lower jaw to _____
  - Evolution during Devonian
    - Evolved a body distinct from other osteichyes
      - Medial fin fused around the posterior third of the body
      - Caudal fin became symmetrical (originally heterocercal)
      - Mosaic of small dermal bones of the skulls evolved a pattern of fewer larger element without the cosmine cover
        - _____ – appearance of juvenile characters in an adult
  - Australian lungfish
    - Restricted to fresh waters
    - Swims by body undulations or slowly walks on pectoral and pelvic appendages
    - Respires almost exclusively via its gills and uses its lung only when stressed
    - Reproductive Behavior-
      - Complex courtship w/ male _____
      - Selective about vegetation on which they lay eggs
      - No parental care
  - African lungfish
    - Gills are very small – drown if prevented from using _____
    - Males have filamentous and mobile paired appendages
      - These develop during the breeding season and are used to supply oxygen from the male's blood to the young in the nest cavity
    - _____ – similar to hibernation, increases likelihood of fossilization
      - Induced by drying of the habitat
      - When waters recede, the fish digs a vertical burrow in the mud
      - As drying proceeds, the lungfish becomes lethargic and breathes air from the burrow opening
      - Heavy _____ secretions condense and dry to form a protective envelope around its body

        - Metabolisms slows, and _____ protein is used as an energy source (usually for less than 6 months)
        - When rains return, the fish eats to regain its previous size
    - Actinistians
        - Hallmarks-
            - Fleshy, lobed fins (except for dorsal fin)
            - Symmetrical 3-lobed tail
            - Differ from other sarcopterygians in:
                - the head bones (lack a maxilla)
                - details of fin structure
                - presence of an unusual rostral organ
            - had been thought to be _____ until 1938
            - Based on observations of living coelocanths
                - Strong and aggressive
                - Have highly reflective eyes to see in dim light
                - Swim bladder is filled with fat
                - Has a rostral organ for _____
                - Is a predator
                - Swims with pectoral and pelvic appendages moved in the same sequence as tetrapods move their limbs
                - Are _____
                    - Internal fertilization must occur
                    - Males have no copulatory organ

- Evolution of Actinopterygii
    - Include a variety of diverse taxa
    - Early actinopterygians were small with a single dorsal fin and a _____ forked caudal fin
    - Early Actinopterygii had thick interlocking scales like sarcopteryians
        - Outer covering of _____ (from enamel), not cosmine
        - Distinct in structure and growth pattern
    - Parallel arrays of closely packed radial bones supported the bases of the fins
    - Early Actinopterygii had many bony rays that supported the fin membrane
        - These bony rays were derived from elongated scales aligned end to end
    - Early jaw was supported by _____ and closed by adductor mandibulae muscles
        - Originated in narrow enclosed cavity between maxilla and palatoquadrate and inserted toward the rear of the lower jaw
    - Near the end of the Paleozoic there were signs of change
        - Upper and lower lobes of caudal fin were nearly symmetrical
        - All fin membranes were supported by fewer bony rays
            - 1 ray each for dorsal and anal fins

        - Dermal armor was_____
    - In the late Permian, neopterygians had a new jaw mechanism
        - Short maxilla with posterior end freed from other bones of the cheek
        - Cheek was no longer solid, so hyomandibula could swing out _____ when mouth opened
            - Increased volume allowed _____ of prey
        - Crushing power increased
            - adductor muscle expanded
            - _____ process
                - Extra lever arm developed at site of insertion of adductor

    - In the late Triassic, neopterygians had additional changes
        - Bones of operculum were connected to the mandible so that expansion of the orobranchial chamber aided in opening the mouth
        - Anterior, articulated end of the maxilla developed a _____ joint with the neurocranium (helped grasp prey)
        - Folds of _____ covering the maxilla changed the shape of the gape from a semicircle to a circular opening
            - Increased suction
            - Reduced likelihood of prey escaping to side

- Specializations of Teleosts
    - locomotion
        - Caudal fin is supported by a few enlarged hemal spines called _____ bones
            - They articulate with the tip of the vertebral column
        - Number of hypural bones decreased during the transition from actinopterygians to the more derived teleosts
        - _____- modified posterior neural arches
            - Add support to the dorsal side of the tail
            - Caudal fin is therefore reinforced but flexible
        - Homocercal tail- upper and lower lobes of same size
            - Allows swimming horizontally without use of paired fins to adjust elevation
        - _____ fins- no longer needed to control lift
            - Became more flexible, mobile, and diverse in shape, size, and position
        - Improvements in locomotion were accompanied by reductions in armor
    - Jaws
        - Suction

- A rapid approach by a predator pushes a wave of water toward the prey that could push prey away from the grasp of the predator
- This problem may be dealt with by increasing the volume of the _____ chamber and creating a flow of water that carries prey into the mouth

- Mobility of skeletal elements
  - _____ jaws - Mobility allows grasping margins of the jaws to be extended from the head
    - Involve complex ligamentous attachments that allow ascending processes of the premaxilla to slide forward on top of the cranium without dislocation
      - Opening the lower jaw may protrude the premaxillae through ligamentous ties between the mandible and posterior tip of the premaxillae
    - Since no muscles are in position to pull the premaxillae forward, they must be pushed by leverage from behind
      - _____ can be provided by complex movements of the maxillae, which become isolated from the rim of the mouth by long posterior projections of the premaxillae
    - Advantage of protusible jaws
      - May enhance the hydrodynamic efficiency of the circular mouth opening of primitive teleost
      - May aid in _____ prey
      - May allow for eating from substrate while keeping the body horizontal
      - Shooting out the jaws in front of the head increases _____ velocity by 39 to89 percent in the last moment of approach

- Pharyngeal Teeth
  - Ancestrally, ray-finned fishes had tooth plates in the pharynx
    - Trend was for fusion of tooth plates to one another and to a few gill arch elements above and below the esophagus
    - Consolidated pharyngeal jaws were not mobile, ancestrally
  - In ostariophysan minnows and suckers, primary jaws are protrusible, but _____

- Allow for feeding on plant materials
- In neoteleostei, muscles associated with branchial elements supporting pharyngeal jaws have undergone radical _____
  - Movements of pharyngeal jaw tooth plates are completely unrelated to movement of primary jaws, and upper and lower tooth plates move independently of one another
  - Many separate systems, so some of the most extensive adaptive radiations have been in fishes with protrusible primary jaws and specialized mobile pharyngeal jaws

Extant _____ – Ray-finned fishes

- 24,000 species described so far
  - Cover habitats that make up 73% of the planet
  - Have high rates of _____
    - Groups become isolated in lakes and within a relatively short time, become reproductively isolated
- Some of the phylogenetic relationships are uncertain

Primitive Neopterygians

_____ (birchirs)

- Most primitive surviving lineage of actinopterygian fishes
- 11 species of elongate, heavily armored fishes
- less than a meter, heavily armored, slow-moving, with heterocercal tails
- Full complement of dermal and edochondral bones, plus thick, interlocking, multilayered scales
- Larval forms have external gills
- All are predatory, and jaw mechanics provide model of original actinopterygian condition
- Have unique flag-like dorsal finlets and fleshy bases of pectoral fins

_____ (sturgeons & paddlefish)

- Large, active, benthic
- Lack endochondral bone and have lost much of dermal skeleton of primitive actinopterygians
- Strongly heterocercal tail
- Rows of enlarge armor-like scales along the body
- Sturgeon: Mode of jaw protrusion useful for suction feeding
- Paddlefishes: Strains crustaceans from water using modified gill rakers as strainers

_____ (gars)

- Predators of warm temperate fresh and estuarine waters

- Elongate body, jaws, and teeth are specialized features
- Interlocking multilayered scales are similar to those of many Paleozoic and Mesozoic actinopterygians
- Swims alongside prey and attacks with needle-like teeth
- Only alligators can get through thick armor of a gar

_____ (bowfins)

- Head skeleton shows modifications of the jaws as a suction device
- Prey on almost any animal smaller than themselves
- Scales are thin, tail is heterocercal

Teleosteans

_____

- Restricted to tropical fresh waters
- Predatory
- Unique bony characters of the mouth and mechanics of the jaws

_____

- Has specialized leptocephalous larval form that spend a long time adrift at the ocean surface
- Most are eel-like and marine
- American eel is catandromous
    - Lives and feeds in rivers and streams
    - At sexual maturity, goes to sea to spawn and die

_____ (herrings, shad, sardines)

- Specialized for feeding on minute plankton gathered by specialize mouth and gill straining apparatus
- Silvery, mostly marine schooling fishes

_____

- Thousands of species
- Two main groups: Ostariophysi and Salmoniforms
- Ostariophysi
    - Predominant fishes of fresh waters
    - Many have protrusible jaws and obtain food in multiple ways
    - Pharyngeal teeth act as second jaws
    - Many have fin spines or special armor for protection
    - Diverse reproductive habits, but most lay sticky eggs or guard eggs to prevent their movement
    - Have _____ apparatus
        - Small bones connect the swim bladder with the inner ear
        - Swim bladder is used as an amplifier and bones as conductors to enhance hearing sensitivity
    - Have fright or alarm substance in the skin

        - Chemical signals are released into water when the skin is damaged, and they produce a fright reaction in nearby fishes
        - Cause rush for cover or formation of a tighter school
- _____
    - Include anadramous salmon, and freshwater trout
- Lots of other fish belong in Euteleostei
    - Marine mesopelagic lanternfishes, flying fishes, snappers, barracudas, etc.

Locomotion in Water

- Results from anterior to posterior sequential contractions of the muscle segments along one side of the body and simultaneous relaxation of those of the opposite side
- A portion of the body momentarily bends, the bend is propagated posteriorly, and a fish oscillates from side to side as it swims
- Most of the power for swimming comes from muscles in the _____ region of the fish
- Classfications of motions:
    - _____- typical of highly flexible fishes capable of bending into more than half a sinusoidal wavelength
    - _____- undulations limited mostly to the caudal region, the body bending into less than half a wavelength
    - _____- body is inflexible, undulation is limited to the caudal fin

- Specializations
    - Overcome gravity by producing lift – generate buoyancy
    - Overcome drag-
        - Fishes swim forward by pushing backward on the water
        - Undulations produce an active force directed backward
            - They also produce a lateral force
            - The overall reactive force is _____ and at an angle to the side
        - Speed: Anguilliform and carangiform swimmers increase speed by increasing _____ of undulations
            - An eel's long body limits speed because it induces drag from the friction on the water on the elongate surface of the fish
            - Fishes that swim rapidly are shorter and less flexible
        - Drag:
            - Comes in 2 forms
            - _____ drag- from friction between the fish's body and the water
                - Relatively constant over a range of speeds
                - Affected by surface _____

    - Higher with _____ body (large SA/mass ratio)
    - Drag is minimized by small scales and _____
- _____ drag- pressure differences created by the fish's displacement of the water
    - Is low at slow speeds and increases rapidly with increasing speeds
    - Influenced by body _____
    - Higher with _____ body (displace a large volume of water as it moves forward).
    - Minimum drag occurs when maximum width is about ¼ of length and is situated about 1/3 of the length from the leading tip

Freshwater Teleost Reproduction

- Produce and care for a relatively small number of large, yolk-rich _____ eggs
    - Lay adhesive eggs in gravel or sand
        - Flowing water would otherwise carry away the eggs
    - Eggs hatch into babies that have body forms and behaviors similar to those of adults

Freshwater Teleost Conservation

- 40% of fish live in fresh waters
- All of these are threatened
    - Draining, damming, canalization, and diversion of rivers destroy habitat
    - Fresh waters are polluted by silt and _____of human origin

Marine Teleost Reproduction

- Mot marine teleosts release large numbers of small, buoyant, transparent eggs into the water
- Eggs are fertilized externally and left to develop and hatch while drifting in the open sea
- Have little yolk reserve and begin feeding on _____ soon after hatching
- Advantages to spawning palagically:
    - Reduction of some types of _____ on fertilized eggs
        - Predators that would capture the eggs may be abundant in the parental habitat but relatively absent from pelagic area
    - High biological _____ of the pelagic environment
        - Microplankton are abundant where nutrients and sunlight are found
        - It could be advantageous to produce larvae that can take advantage of this energy source
    - Increased chances of colonizing any suitable adult habitat in a large area

- A species that is widely dispersed is not vulnerable to local environmental changes

Marine Teleost Conservation

- Weather-related events, such as temperature extremes can kill large numbers of eggs or young fish
- Ocean currents can be changed by wind and el Nino phenomenon
- Numbers increase or decrease dramatically by chance, and overfishing the wrong year can have devastating results