

Vert. Zoology – Lecture 7

Radiation of the Chondrichthyes

Chondrichthyes

- _____ skeleton
- Two major groups
 - Single gill opening on each side of the head
 - _____
 - Ratfish, rabbitfish, chimera
 - Long flexible tail, fish-like body, head with big eyes and buckteeth
 - Multiple gill openings on each side
 - _____
 - Sharks, skates, rays

Evolutionary Specializations of Chondrichthyes

- Their initial radiation from a common ancestor emphasized changes in teeth, jaws, and fins
 - Changes in feeding structures evolved at different rates within different lineages
 - In some lineages, a derived _____ is found with ancestral fins
 - In some lineages, derives _____ are found with ancestral dentition
- Different lineages developed similar but not identical modifications in feeding and locomotor structures
 - Similar selective forces acted on similar body forms and developmental mechanisms
 - An example of _____ evolution

Paleozoic Chondrichthyan Radiation

- Stem Chondrichthyans are identified by their teeth (3-cusped with little root development)
- Cladoselache – best known genus
 - Shark-like in appearance with large fins and mouth and 5 gill openings on each side of the head
 - Mouth was _____ opening
 - _____ - had multiple sites of upper jaw suspension
 - Gape was large and jaws extended well behind the rest of the skull
 - _____ teeth
 - useful for cutting through fish
 - as they were used, cusps broke off and edges grew dull
 - each tooth is a member of a tooth whorl

- directly behind each functional tooth is a series of developing teeth
 - Tooth replacement is rapid (about every 8 days in modern sharks)
- Body supported by a notochord with cartilaginous _____
- _____
- Body had 2 dorsal fins, paired pectoral and pelvic fins, & forked tail
- Pectoral fins had little capacity for altering angle of contact with water
- Caudal fin is externally symmetrical but internally asymmetrical
- Skin had placoid scales only on fins, around the eyes and within the mouth, behind the teeth
 - Lack of _____ suggests increased buoyancy
- Placoid scales have an enamel-like substance and contain a pulp cavity (like teeth)
- _____
- Braincase, jaws, and jaw suspension similar to those of Cladoseleache
- Differed from Cladoseleache in some ways
 - Freshwater bottom-dwellers
 - Robust fins
 - Heavily calcified, cartilaginous skeletons
- Are at the base of the elasmobranch radiation

Early Mesozoic Elasmobranch Radiation

- Evolution involved changes in feeding and locomotor systems
 - _____ - looked like a shark except that its mouth was terminal (not underslung beneath a sensory rostrum)
 - Teeth
 - Anterior teeth had sharp cusps for piercing, holding, and slashing softer foods
 - Posterior teeth were stout, blunt versions for crushing shells of crustaceans and mollusks
 - Pectoral and Pelvic Fins
 - Pairs of fins supported on narrow stalks that allowed the fin to be rotated to different angles as the fin swam up or down
 - _____
 - Intrinsic fin muscles could curve the fin from front to back or from base to tip to change the shape of the fin
 - Allows fin to produce lift, aid in turning, or stabilize
 - Caudal and Anal fins
 - Caudal fin was altered by reduction of _____ (lower) lobe and addition of flexible ceratotrichia
 - _____ are keratin fibers that support the web of the fins
 - Anal fin was added

- Complete set of hemal arches that protected the arteries and veins running below the notochord
- Well developed _____
- Narrow, more pointed, dorsal fin spines closely associated with the leading edges of the dorsal fins (probably used for defense)
- _____ (indicating they all had internal fertilization)

The Extant Radiation – Sharks, Skates, & Rays

- Extant sharks have _____ or snout that overhangs the ventrally positioned mouth
- Extant sharks have developed solid, calcified vertebrae which constricted or even replaced much of the notochord
- Extant sharks have a thicker and more structurally complex enamel-like material on the teeth than seen in earlier groups
- Sharks
 - Pleurotremates
 - 360 species
 - Sharks with gill openings on the sides of the head
 - Come from two lineages
 - _____
 - 80 species including spiny dogfish, cookie-cutter shark, basking and megamouth sharks
 - Live in cold deep water
 - _____
 - 280 species including hornshark, nurse and carpet sharks, whale sharks, mackerel sharks, and hammerhead sharks
 - Live in shallow, warm, species-rich regions of the ocean
 - Carnivores
 - Skeleton
 - Cartilaginous vertebral centra are distinctive
 - Between central, spherical remnants of notochord fit into depressions on the opposing faces of adjacent vertebrae
 - The axial skeleton can flex from side to side with rigid central elements swiveling on ballbearing joints
 - Sharkskin body covering
 - Unique armor that is flexible yet very protective
 - _____ scales have a single cusp and a single pulp cavity
 - Size, shape, and arrangement reduce turbulence
 - More scales are added to skin as shark grows
 - Sensory Systems and Prey Detection
 - Mechanoreceptors of lateralis system

- Ampullae of Lorenzini
- Olfactory apparatus
- Vision
 - Rod-rich retina and cells with crystals of guanine that are located just behind the retina in the choroid layer which reflect light to increase the chance that it will be absorbed.
- _____ are proportionally heavier than those of other fishes, due to the many sensory systems
- Steps towards prey
 - _____ – useful over long distances
 - Lateralis system- good directionality
 - Vision used to identify prey
 - _____ used so that eyes can be closed during attack
- Jaws
 - _____ (mobility within the head skeleton) allows consumption of large food items (or small)
 - Enlarged hyomandibular cartilage which braces the posterior portion of the palatoquadrate and attaches firmly but movably to the otic region of the cranium
 - A second connection to the chondrocranium is via paired palatoquadrate projections to either side of the braincase just behind the eyes and attached to the braincase by elastic ligaments.
 - This permits multiple jaw positions, each appropriate to different feeding opportunities
 - Muscles from the pectoral girdle swing the _____ laterally and anteriorly to increase the distance between the right and left jaw articulations and thereby increase the volume of the orobranchial chamber.
 - This increase is not possible with an amphistylic jaw suspension because the palatoquadrate is tightly attached to the chondrocranium
- Feeding
 - Protrusion of the jaw drops the mouth away from the head to allow a shark to bite an animal larger than itself
 - The shark opens its mouth and sinks its upper and lower teeth deeply into the prey
 - As the jaws reach maximum penetration, the shark throws its body into lateral undulations which results in violent side-to-side shaking of the head
 - This turns the upper teeth into saws to sever a large piece of flesh from the victim

- A shark holds a seal tightly in its jaws until it is no longer bleeding and then bites down to remove a large chunk of flesh...it then returns to the floating carcass for additional bites
- Sharks often seize and release sea lions until they die from blood loss, and they may reject prey after the first bite
- Reproduction
 - Internal fertilization is universal
 - _____ of males have a solid skeletal structure that may increase their effectiveness
 - During copulation, a clasper is bent at 90 degrees to the long axis of the body, so the dorsal groove of the clasper lies directly under the cloacal papilla from which sperm are emitted
 - The clasper is inserted into the female's cloaca, where it is locked in place by barbs, hooks, and spines near the clasper's tip
 - Males of small species may wrap around females; large species swim side by side with bodies touching or enter copulation in a sedentary position
 - Elasmobranchs adopted a reproductive strategy favoring the production of a small number of offspring that are retained, protected, and nourished for varying periods
 - Oviparous elasmobranch fish have large eggs with yolks that provide food for the zygote for 6 to 10 months
 - The egg is surrounded by a proteinaceous case produced by the _____ gland at the anterior end of the oviduct
 - Ovoviviparous – prolonged retention of fertilized eggs
 - _____
 - Reduction in rudimental gland's shell production
 - Inorganic ions and gases are exchanged between mother's blood and offspring
 - Nutritional supplement is limited to yolk
 - _____
 - Nutritional supplement is not limited to yolk
 - Some have extensions of the oviduct walls that penetrate the mouth and gill

openings of young and secrete nutritive substance

- Some simply continue to ovulate, and the young feed on the new eggs
 - Some utilize a yolk sac placenta which allows the young to obtain nutrition from the maternal uterine bloodstream
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- Social behavior
 - Elasmobranchs have long been considered solitary and asocial
 - Field observations indicate that they aggregate in large numbers periodically
 - Some groupings seem to exhibit courtship behavior, others are not understood
 - Life History and Conservation
 - A female produces relatively few young in her lifetime
 - The strategy of providing more resources to ensure survival of fewer offspring has been a successful strategy until recently
 - Recently:
 - People eat sharks
 - Asians like shark fins for medicinal properties
 - Problems:
 - ---
 - Mature late in life
 - Have few young at a time
 - Don't reproduce every yearL
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- Skates and Rays
 - Hypotremates
 - 456 extant species
 - ---
 - Elongate but thick tail stalk supporting two dorsal fins and terminal caudal fin
 - May have specialized cells in tails that emit electric discharge
 - Oviparous – lay eggs
 - ---
 - Whip-like tail stalk with fins replaced by barbs
 - May have specialized gill muscles that produce electric discharge
 - Viviparous- give birth to young

- Both
 - Dorsoventrally flattened with greatly enlarged pectoral fins
 - Placoid scales are largely absent
 - Primarily benthic invertebrate feeders
 - May catch some small fish
 - Largest rays are plankton feeders
 - Dentition is sexually dimorphic
 - Males use teeth to hold or stimulate females during mating
 - Unlike sharks, teeth are mostly flat, crowned plates

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- 34 extant forms of chimeras
 - Soft anatomy more similar to sharks and rays than to any other extant fishes
 - Generally found deeper than 80 meters
 - Most appear to feed on shrimp, mollusks, and sea urchin
 - Locomotion is produced by lateral undulations of the body and fluttering movements of large, mobile, pectoral fins
 - Solidly fused crushing tooth plates grow throughout life
 - Ancestors?
 - Ptyctodontids
 - Postcranial characters such as fin spines, large paired appendages, claspers, and caudal development are strongly reminiscent of extant holocephalians
 - Iniopterygians
 - Had characteristics thought to link earliest sharks and holocephalians
 - Actually, they probably evolved in parallel with holocephalians

