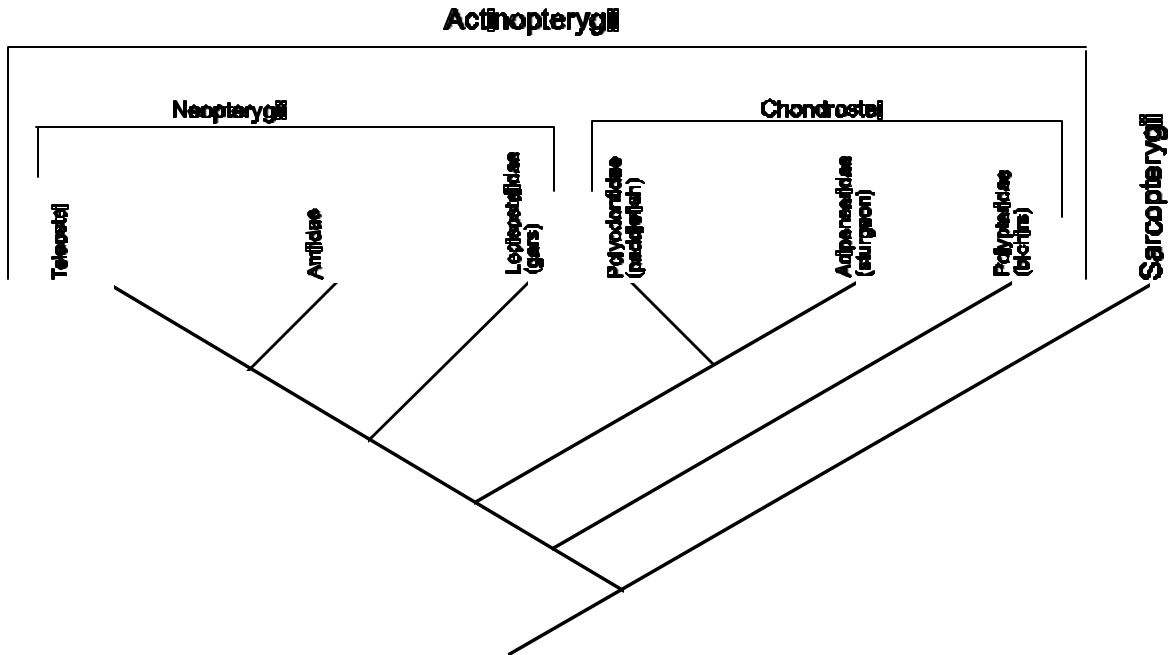


Osteichthyes - bony fish

- I. Origin, systematics and taxonomy, characteristics
 - A. Some dates
 - B. Systematics and taxonomy
 - C. Major characteristics
- II. Distribution and diversity
 - A. Sarcopterygii
 - B. Actinopterygii
- III. Trends in neopterygian evolution
 - A. locomotor efficiency
 - B. feeding efficiency
- IV. Adaptability: deep-sea fishes
 - A. the deep-sea environment
 - B. adaptations of deep-sea fishes
- V. Conservation
 - A. fresh-water fish
 - B. marine fish
 - C. coral reef fish
- I. Origin, systematics, taxonomy, characteristics
 - A. Some dates
 - 1. First fossils occur in Late Silurian
 - 2. Fossils abundant from Early Devonian; major radiation was underway by mid-Devonian
 - 3. by mid-Devonian, two major lineages diverged:
 - a. **Actinopterygii** (ray-finned fishes)
 - b. **Sarcopterygii** (lobe-finned fishes; gave rise to tetrapods)
 - 4. first **Neopterygii** (group including modern fish) had arisen by Late Permian
 - 5. most of ~400 teleost families established by Late Cretaceous
 - B. Systematics and taxonomy
 - 1. Because it includes the ancestors of tetrapods but not tetrapods, Osteichthyes is not a monophyletic group (but still very useful)
 - 2. Clear that two major lineages (Actinopterygii, Sarcopterygii) diverged by mid-Devonian

3. Actinopterygii = ray-finned fishes
 - a. good monophyletic group
 - b. highly diverse; we'll simplify major groups and relationships as follows
(note different from text):

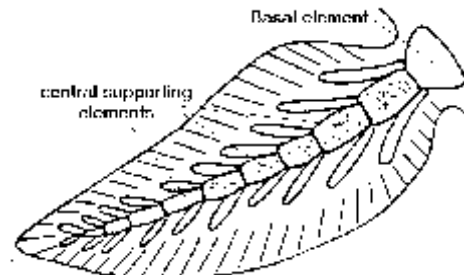


- 1) **Chondrostei** = paraphyletic group including “primitive” **bichirs**, **sturgeons**, and **paddlefish**
- 2) **Neopterygii** = monophyletic group including more “modern” forms
 - a) **bowfins** and **gars** retain some “primitive” characters
 - b) **Teoleostei** = modern teleosts, includes most of fish diversity
4. Sarcopterygii = lobe-finned fishes
 - a. because includes ancestor of tetrapods but not tetrapods, isn't a monophyletic group
 - b. relationships among two modern forms and current presumed sister group to tetrapods illustrated on earlier cladogram
 - c. two modern groups:

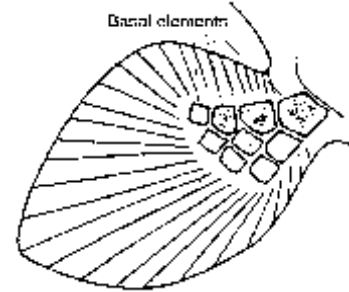
- 1) **Dipnoi** = lungfish
 - 2) **Coelocanthimorpha = Actinistia = Crossopterygii** = coelocanth
5. Summarize taxonomy we'll use (don't worry about ranks):
- a. Osteichthyes
 - 1) Sarcopterygii
 - a) Osteolepiformes (extinct sister group to tetrapods)
 - b) Dipnoi = lungfish
 - c) Coelocanthimorpha
 - 2) Actinopterygii
 - a) Chondrostei = bichirs, sturgeon, paddlefish
 - b) Neopterygii
 - i) "primitive Neopterygii" = bowfin, gar
 - ii) Teleostei = teleost fish

C. Major characteristics

1. Some shared, derived characteristics of Osteichthyes
 - a. unique pattern of dermal head bones, including mouth bones with rooted teeth
 - b. bony fin rays supporting fins
 - c. differentiation of branchial muscles
2. Shared, derived characteristics of Sarcopterygii:
 - a. fleshy pelvic and pectoral fins with
 - 1) single basal skeletal element,
 - 2) central supporting elements
 - 3) muscular lobes
 - b. differences in hard materials of scales, teeth
 - c. unique characteristics of jaws, gill supports, etc.



3. Shared, derived characteristics of Actinopterygii
 - a. pectoral fin with
 - 1) multiple enlarged basal elements,
 - 2) elements supporting fin rays don't extend into fin
 - b. single dorsal fin
 - c. unique arrangement, histology of scales
4. General features of Osteichthyes (doesn't matter whether primitive or derived)
 - a. fully calcified body skeleton
 - b. dermal armor is reduced to relatively thin, interlocking scales, usually of
 - 1) **elasmoid** type = lamellar bone only
 - 2) but also **ganoid** (gars) = lamellar bone + a form of enamel called ganoine
 - 3) **cosmoid** (Sarcopterygii) = two bony layers + dentine + enamel
 - c. bony operculum covers single gill opening
 - d. lung or swim bladder derived from the gut present in most (all?)



II. Distribution and diversity

A. Sarcopterygii: 7 living species

1. Dipnoi: 6 living species
 - a. size range 17" - 6.5'
 - b. strictly freshwater, found in Africa (5 spp), South America (1sp), Australia (1 sp) (Gondawanian distribution, best explained by continental drift)
 - c. in African and SA species, gills reduced; breathe air only; Australian species retains functional gills
 - d. African and SA species live in shallow waters, and can aestivate in burrows for long periods during dry season; Australian species lives in more open waters and can only survive limited periods of moderate habitat desiccation

2. Coelocanth (*Latimeria chalumnae*): see web pages
 - a. found off South Africa, Mozambique, Madagascar; recently one taken from Indonesia
 - b. seem to prefer relatively deep, cold waters with rocky, steep shores
 - c. grow to about 6', 140 lbs
 - d. ovoviviparous, with 20-65 developing eggs and 5-26 young born after gestation period of ~ 13 months/reproductive episode
 - 1) note combination of low reproductive rate and narrow habitat preferences make them vulnerable to over-exploitation

B. Actinopterygii

1. Chondrostei:
 - a. bichirs & reedfish = 11 living species; African fresh-water
 - b. sturgeons: ~ 27 species
 - 1) fresh and coastal marine waters of Europe, Asia, NA; many anadromous
 - 2) bottom feeders (but not scavengers), with fleshy barbels below jaw to help search bottom sediments for food
 - 3) unique rows of bony plates (5) along body
 - 4) largest fresh-water fish = beluga sturgeon (*Huso huso*) of SE Europe, said to reach length of 8 m and wt. of 2,865 lbs! – most famous of caviar sturgeons
 - 5) of course, sturgeons are source of caviar, but also used for
 - a) meat
 - b) oil
 - c) swim bladder used to produce isinglass = sheet of almost pure gelatin used for glues, waterproofing, and clarifying white wine
 - c. paddlefishes:
 - 1) 2 living species, one NA (mostly Mississippi river system) and one

Chinese

- 2) largely scaleless
- 3) elongate snouts make up 36 - 52% of total length
- 4) snout covered with electroreceptors used to detect swarms of zooplankton, upon which it filter feeds

2. Neopterygii

a. "primitive" neopterygians

- 1) bowfin: 1 species, from large rivers of E. NA
- 2) gars: 7 species; mostly freshwater from eastern NA south to about Costa Rica, but sometimes found in brackish coastal waters
 - a) uniquely elongated snout: elongation is between eyes and nose (rather than in front of nose, as in paddlefish and other beak fish), so nostrils at tip of "beak"
 - b) lurking ambush predators, with dorsal and anal fins displaced posteriorly to increase thrust
 - c) ganoid scales not found in many/any other groups

b. Teleostei = teleost fish: everyone else

- 1) ~20,800 species
- 2) worldwide, in virtually every type of aquatic habitat
- 3) two largest groups:
 - a) catfish & minnows: just over 6,000 species
 - b) perches: ~ 7,800 species

III. Functional trends in Neopterygii evolution: what features make this group so spectacularly successful in terms of taxonomic, ecological diversity? Looking across neopterygian lineages, we see the same kinds of changes taking place repeatedly (convergent evolution):

A. increasing locomotor efficiency

1. **swim bladder** provides precise buoyancy regulation

2. symmetrical, more flexible caudal fin provides better forward thrust and maneuverability
 3. fins released from need to control lift (because of a and b):
 - a. can be folded to body during rapid locomotion, reducing drag
 - b. can be modified to serve a variety of other functions
 4. reduction in dermal armor to thin scales reduces weight, increases flexibility of body, fins, etc.
- B. increased complexity and efficiency of feeding apparatus (face, jaws, skull and associated musculature)
1. increase in the number of mobile joints between the bones of the jaws, face, etc.
 2. increase in both
 - a. subdivision of muscles (to control increased number of joints → precision of movement) and
 - b. size (and, therefore, strength) of jaw-closing muscles
 3. mobile, tooth-bearing **pharyngeal jaws**
 4. results include
 - a. highly protrusible jaws provide very strong, directional suction for feeding from a variety of places relative to fish's mouth (i.e., above, in front, below, to side, etc.)
 - b. flexibility of joints permits mouth to close while buccal cavity still expanded: trap prey inside mouth
 - c. pharyngeal jaws help trap food in mouth, and provide very strong grinding surfaces for dealing with a wide range of food types
 - d. mobile jaws with fine motor control permit delicate movements and manipulation of environment (for feeding and for other functions – jaws become like our hands)
 5. Net result has been huge radiation into numerous ecological niches and

virtually every aquatic habitat

IV. Example of adaptability of bony fish – deep sea fishes (pp. 157-162)

A. The deep-sea environment

1. terms:
 - a. epipelagic zone = upper waters where photosynthesis takes place
 - b. mesopelagic zone = waters between 100 - 1000 m
 - c. bathypelagic zone = waters below 1000 m
2. most important feature of deep-sea environment is lack of food
 - a. water is too deep for light to penetrate, so no PSN
 - b. only food is detritus “rain” from surface waters; this declines rapidly with depth – e.g., phytoplankton abundance drops from 500mg/m³ to 0.5m/m³ at 10,000 m
3. productivity (and therefore species diversity) in deep-sea environments is greatest in tropical regions in areas of upwelling

B. Adaptations of deep-sea fish

1. 5 orders of fish have species adapted to deep-sea environments
2. in general, as depth increases, get decrease in size, abundance, and diversity of fish
 - a. ~ 800 species of mesopelagic fish
 - b. ~ 150 species of bathypelagic fish
3. because food is limited, many adaptations of deep-sea fish are related to obtaining and conserving energy:
 - a. species generally adopt “low energy” habits – e.g., little long-distance movement, sit-and-wait predation
 - b. because locomotion is limited, axial skeleton and muscle mass are both reduced
 - c. because no light (or very limited light) is present, most have bioluminescence produced by photophore organs; this can serve to

- 1) lure prey
- 2) identify species and gender (very important when densities are low)
- d. jaws are generally very large relative to body size & guts hugely distensible
– this allows individuals to take and store whatever prey they encounter
4. on your own, read adaptations for reproduction in anglerfish (p. 162)

V. Conservation

A. Fresh-water fish (p. 155)

1. ~ 40% of fish species live in fresh water habitats
2. nearly all have been affected by habitat alteration, degradation (including introduction of exotic species), and loss
3. in US alone, ~ 20% of 800 species of native freshwater fish are currently facing some significant threat (see fig. 6-16 p. 156).
4. worldwide scope of the problem is probably greater

B. Marine fish (p. 157)

1. biggest problem that we know about (for obvious reasons!) is with commercially valuable fish
2. one major problem is that it's hard to predict future stock size based on current stock size (abundant juveniles may not produce abundant adults; sometimes a small breeding population can produce a relatively large adult population) – so managing commercial fisheries well is difficult
3. overfishing is a huge problem, partly because of difficulty in managing stocks and partly because of socioeconomic issues

C. Coral reef fish

1. coral reef fish (confined to warm, shallow tropical waters) are the most diverse group of vertebrates on earth
2. diversity depends on the structural integrity of coral reef systems
3. problem is that coral reefs are
 - a. being destroyed directly by human activity (mined for limestone, broken up for harvest, blown up by people collecting for the exotic pet trade, etc.)

- b. dying for other reasons – e.g., increasing water temperature has caused large-scale deaths of some reefs world wide