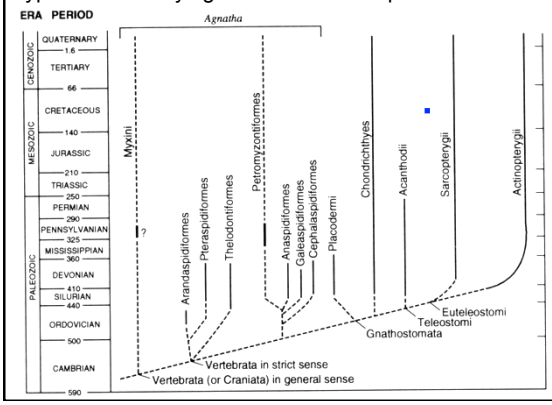
Ancient Bony Fishes

Hypothesized Phylogenetic Relationships



Superclass Gnathostomata - jawed fishes

Class Placodermi (plate-skinned) extinct

Class Acanthodii (spiny sharks)

Class Chondrichthyes

Class Sarcopterygii living

Class Actinopterygii

Grade **Teleostomi** ("perfect mouth")
= Osteichthyes ("bony fishes")

- Class Sarcopterygii: "lobed fins"

- Class Actinopterygii: "ray fins"

Teleostomi (Osteichthyes)

- appeared 425 mya during the Silurian
- probably evolved initially in freshwater
- dominant by 380 mya
- Ostracoderms had just died out
- Acanthodians, placoderms, elasmobranchs were radiating at the same time
  - so origins of bony fishes unclear

Characteristics of bony fishes

- jaws
- true bony skeleton (can be secondarily lost)
- bony operculum covering gill arches
- 3 semicircular canals, 3 otoliths
- paired fins
- lungs or swimbladders (sometimes lost in benthic forms)
- lepidotrichia replace ceratotrichia during ontogeny

Teleostomi (bony fishes)

Class **Sarcopterygii** (lobed fins)

Subclass Coelacanthimorpha (coelacanths)

Subclass Dipnoi (lungfish)

Dipnomorphs

Tetrapodamorphs (extinct - probably gave rise to tetrapods)

Class **Actinopterygii** (ray fins)

Subclass Cladistia 

Subclass Chondrostei 

Subclass Neopterygii 

Sarcopterygii (lobed fins)

- appeared 400+ mya
- marine and freshwater
- lobed fins: series of bony elements link fins to pelvic and pectoral girdle (like tetrapods)
- jaw suspension is autostylic (firmly attached to cranium)

Class Sarcopterygii (Sarcopterygians) = lobe-finned fishes

1. **Coelacanthimorpha**

2. **Dipnoi** - lungfishes

Sarcopterygii (2 living spp.)

Subclass Coelacanthimorpha (Actinistia)

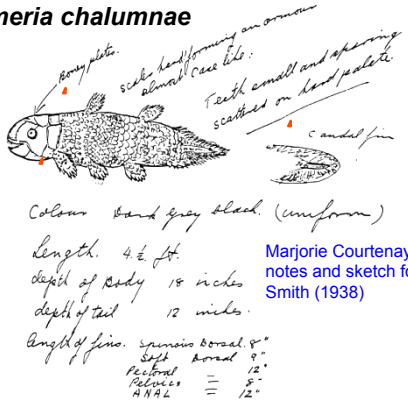
Order **Coelacanthiformes**

Family **Latimeridae**

Coelacanth ("hollow spine")

- all fins lobed, except 1st dorsal
- large swim bladder filled with fat
- bottom oriented predators, 100-250 meters
- electrical senses
- disappeared from fossil record 65 mya
- *Latimeria chalumnae* found off South Africa in 1938

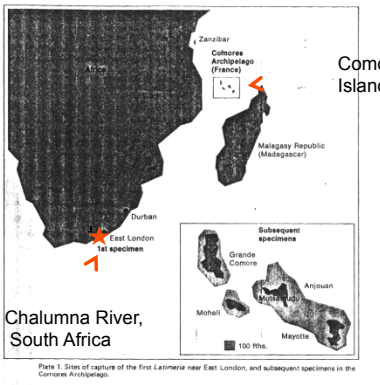
Latimeria chalumnae



Marjorie Courtenay-Latimer's notes and sketch for J. L. B. Smith (1938)

Coelacanth

Pre-dating the dinosaurs by millions of years and once thought to have gone extinct with them, 65 million years ago, the Coelacanth with its missing link "proto legs" was discovered alive and well in 1938!



Comoros Islands

Chalumna River, South Africa

Plate 1. Sites of capture of the first *Latimeria* near East London, and subsequent specimens in the Comores Archipelago.

Coelacanth footage #1

Coelacanth footage #2

Coelacanths are **live-bearers**

The largest coelacanth ever captured

Maputo Museum photo of the Mozambique female before dissection.
The fish was 178 cm in length and 98 kg.

- live 40-50 yr
- mature at 15 yr
- 3 yr gestation!

Latimeria menadoensis

BIG NEWS:

2nd species of coelacanth found off Indonesia in 1999!

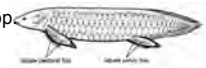
-- found and photographed in a fish market

Sarcopterygii

Subclass Dipnoi ("double breath") lung fish

Order Ceratodontiformes (3 families)

- evolved 400 mya, first in marine, moved to freshwater – all living representatives now FW
- once an abundant group
- functional lungs (evolved in stagnant waters?)
- massive tooth plates - made excellent fossils
  - teeth are attached to interior bones, not jaw bones
- estivation: state of reduced metabolism during dry-out
- heart intermediate between fish and tetrapods
- larvae have external gills in some spp

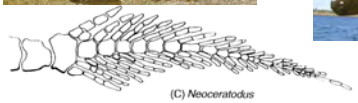


3 families of lungfish

- Australian (Ceratodontidae): heavy lobed fins, facultative air breather (1 species)
- African (Protopteridae): fins reduced to filaments, *obligate air breather* with estivation (first classified as an amphibian) (4 species)
- South American (Lepidosirenidae): fins reduced to filaments, *obligate air breather* (1 species)

Australian lungfish: Ceratodontidae

oldest living vertebrate? identical fossils from 140 million years ago

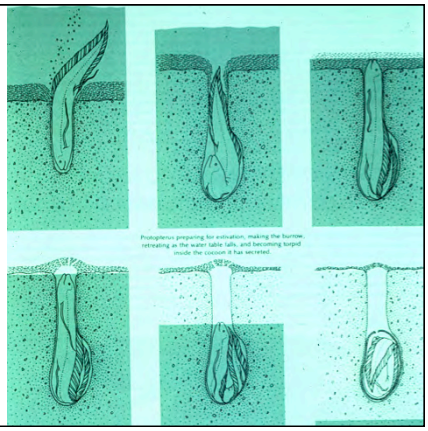


African lungfish: Protopteridae

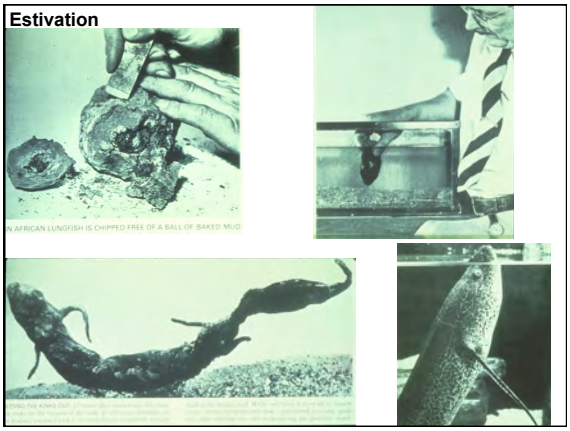
- juveniles have external gills – but are not amphibians!

South American lungfish: Lepidosirenidae

Estivation



Estivation

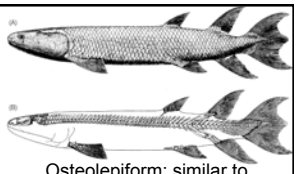


Sarcopterygii
Subclass Dipnoi

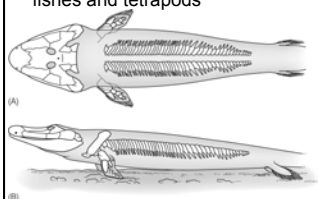
Tetrapodamorpha

Elpistostegalian:

Tiktaalik roseae – the "missing link" between fishes and tetrapods

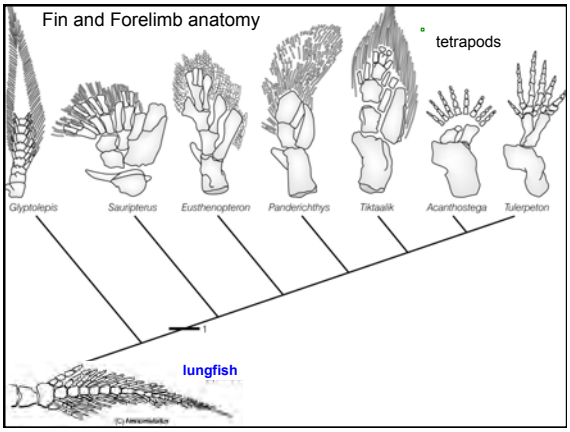


Osteolepiform: similar to early tetrapod ancestor



Fin and Forelimb anatomy

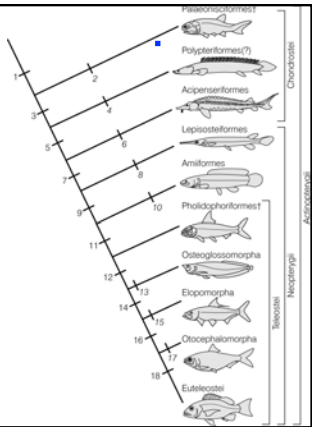
tetrapods



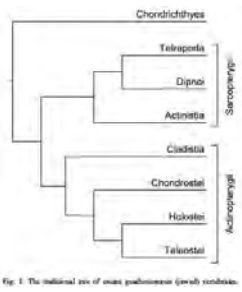
Next group:

Class **Actinopterygii**
("ray fins")

see Fig. 11.23 for details

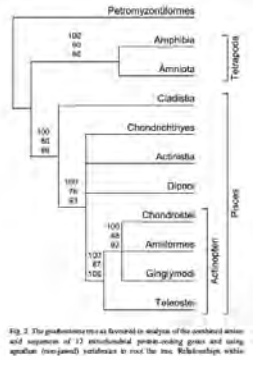


"Traditional" phylogeny



Arnason et al. 2004

Tree favored by molecular data



Gnathostomata

Class **Actinopterygii** ("ray fins")

Subclass Cladistia
Order Polypteriformes (bichirs)

Subclass Chondrostei ("cartilage bone")
Order Acipenseriformes (sturgeons & paddlefish)

Subclass Neopterygii ("new fins")
Order Lepisosteiformes (gars)
Order Amiiformes (bowfin)

Division Teleostei (modern bony fish)

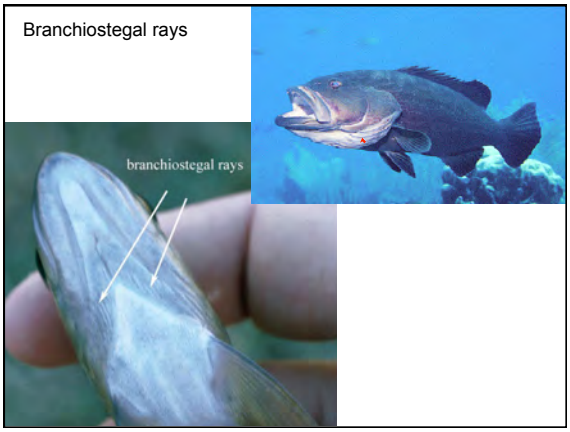
Class Actinopterygii

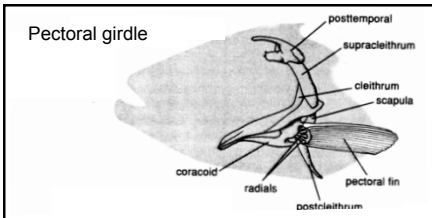
- first appeared 425 mya
- dominant freshwater fishes about 340 mya
- began to invade salt water about 340 mya

Characters of Class Actinopterygii
-- many and diverse and changing

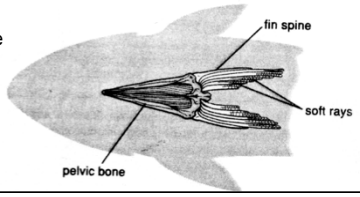
Most Actinopterygii have:
- fins attached to body via fin rays
- branchiostegal rays
- distinct pelvic and pectoral girdles
- bony skeleton

Branchiostegal rays





Pelvic girdle



Class Actinopterygii ("ray fin")

- Subclass Cladistia
  Order Polypteriformes (bichirs)

- Subclass Chondrostei
  Order Acipenseriformes (sturgeons & paddlefish)
  Order Palaeonisciformes - extinct

- Subclass Neopterygii
  Order Lepisosteiformes
  Order Amiiformes
  Division Teleostei (modern bony fish; w/ 40 orders!)

Subclass Cladistia, Order Polypteriformes
(sometimes placed in order Brachiopterygii)

- ancient group & unclear what other group they are mostly closely related to
- probably sister group to all other Actinopterygians

Characters:
- dorsal fin with 5-18 finlets
- lobed pectoral fins
- lungs
- skeleton partly cartilaginous
- spiral valve intestine
- heavy ganoid scales
- spiracles (exhale air through them)
- no brachiostegals

Order Polypteriformes

Family Polypteridae: bichirs (*"bih-shears"*)

- 10 spp., all freshwater, Africa
- larvae with external gills

Bichirs (& reedfishes)

-- note the finlets

Subclass Chondrostei

- first appeared about 425 mya
- order Palaeonisciformes gave rise to the Neopterygii

Characters of modern chondrosteans:

- cartilaginous skeleton (secondarily derived)
- heterocercal tail
- spiral valve intestine
- heavy ganoid scales
- spiracles
- one brachiostegal

Order: Palaeonisciformes (extinct)

- fin rays
- changes in jaw bones and musculature
- lighter, more flexible scales
- Devonian (about 400 mya)

Order: Acipenseriformes

Families:

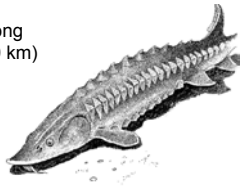
Acipenseridae (sturgeons, 25 spp.)

freshwater/anadromous

Polyodontidae (paddlefishes, 2 spp.)

freshwater

- big: paddlefish up to 5-m long & sturgeons up to 8.5 m and 1300 kg!
- North America & Eurasia
- live in temperate & arctic rivers (long upstream migrations -- up to 2500 km)
- live up to 150 years of age!



white sturgeon (*Acipenser transmontanus*)

- largest freshwater fish in North America
- 6.1 m (20 feet)!
- 800 kg (1800 pounds)!

Family Acipenseridae: sturgeons

- 4 barbels (for taste & feel)
- 5 rows of scutes for armor
- elongated snout
- protrusible mouth
- single dorsal fin

many species are currently endangered because of caviar harvest & dams

Caviar from sturgeon

Prone to overfishing

- long lived (100+ yr)
- late maturity (up to 30 yr)
- females may spawn only every 3-5 yr or longer

Valuable!

female beluga sturgeon: (captured in Russia, 1924)

- 1,227 kg (2,700 lb.)
- yielded 245 kg (540 lb.) of caviar
- if eggs qualified as grade OOO Malossol caviar, which sells on the internet for as much as $165/oz ($5,808/kg)…
- the fish would be worth nearly $1,423,000!!

Family Polyodontidae: paddlefishes

- no bony scutes (virtually naked)
- midwater (not benthic)
- paddle-like snout
- planktivores
- 1 sp. in North America, 1 in China

- electroreception organs (ampullary organs) on paddle

Subclass Neopterygii

- first appeared about 345 mya
- radiated 290-190 mya, and most extensively 80-65 mya

Shared characters of modern neopterygians
(intermediate between chondrosteans and teleosts)
Lepisosteiformes (gars) & Amiiformes (bowfin):

- heterocercal tail
- spiral valve intestine
- ossified skeleton
- functional lungs / gas bladder

Otherwise very different from each other

Ganoid (Chondrostei, Lepisosteiformes)

Ctenoid (Teleostei)

Cycloid (Teleostei, Amiiformes)

Lepisosteiformes: gars (7 spp.) (AKA Ginglymodii)

- evolved about 200 mya

Characters

- large swimbladder also used as lung
- ganoid scales
- spiral valve intestine
- toxic eggs (laid on aquatic plants)
- North America, Central America, and Cuba
- ambush predators, primarily freshwater

Alligator gar

impale prey on teeth rather than suction feed

Alligator gar

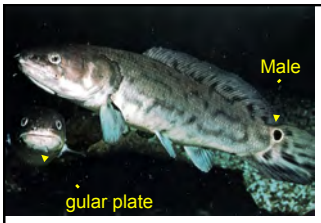
8’ 2”, 245 lb.

??

Amiiformes, family Amiidae (bowfin)

-- single species, *Amia calva*

- once abundant group coexisted w/ dinosaurs
- North America
- large lung
- spiral valve intestine
- cycloid scales
- more closely related to Teleostei than gar



“Gar-Like” Traits

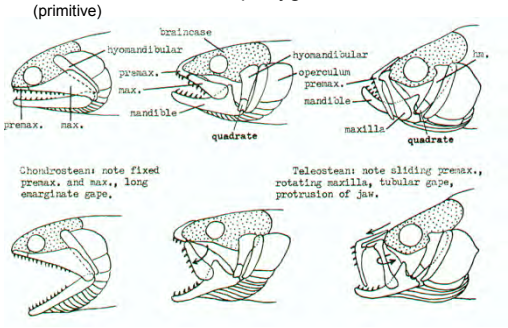
- abbreviated heterocercal tail
- vascularized swimbladder
- spiral-valve intenstine

“Teleost-Like” Traits

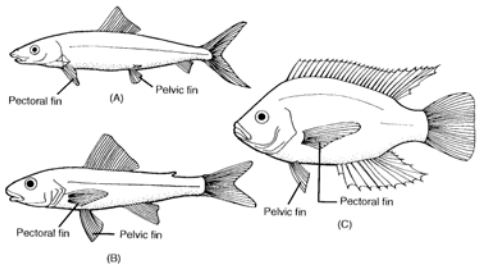
- cycloid scales
- amphicoelous vertebrae
- suction feeders
- parental care

Evolution of protrusible jaws:

Chondrostean → Neopterygian/Teleost
(primitive)



Evolution of paired fin location in teleosts



Division Teleostei (perfect bone)

- >95% living species = 400+ families
- arose 200 mya
- common genera of today existed 40-70 MYA
- evolved from several lines
- 4 subdivisions

Primitive teleosts - Next Lecture