Introduction to Fish Biology

About 25,000 species of fish have been described

this is the most numerous group of vertebrates

approximately 45%-50% of all vertebrate species are fish

dominant life form in almost all aquatic systems

many diverse adaptations to life -

a very interesting group for biologists

the potential of many species as a food source -

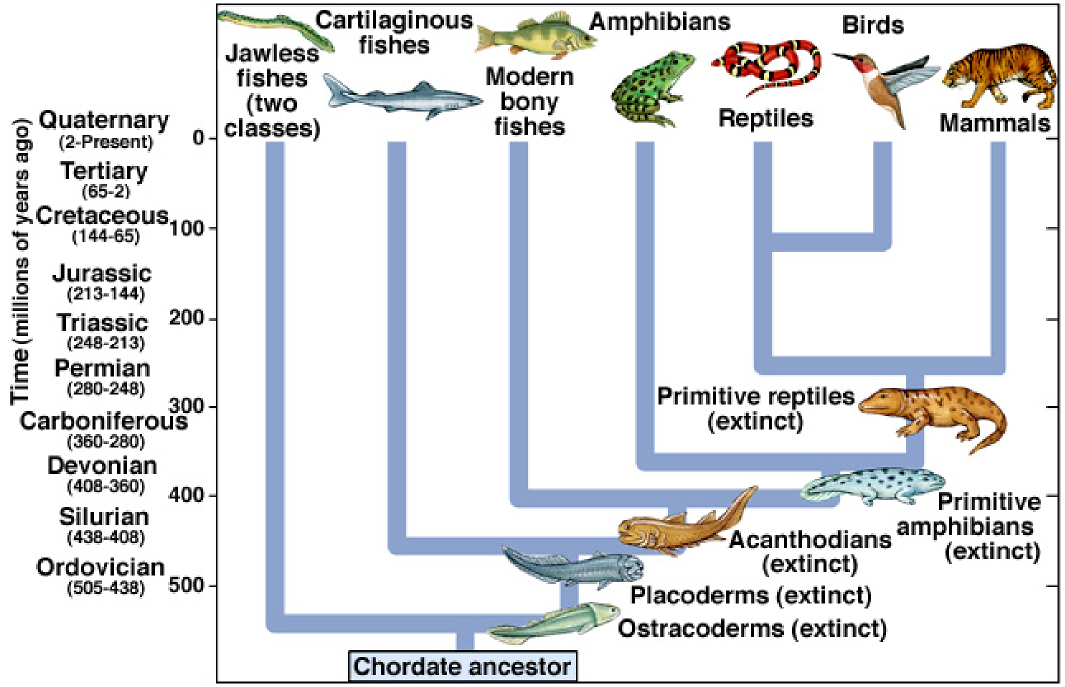
a valuable resource worth studying for knowledge of management and harvest strategies

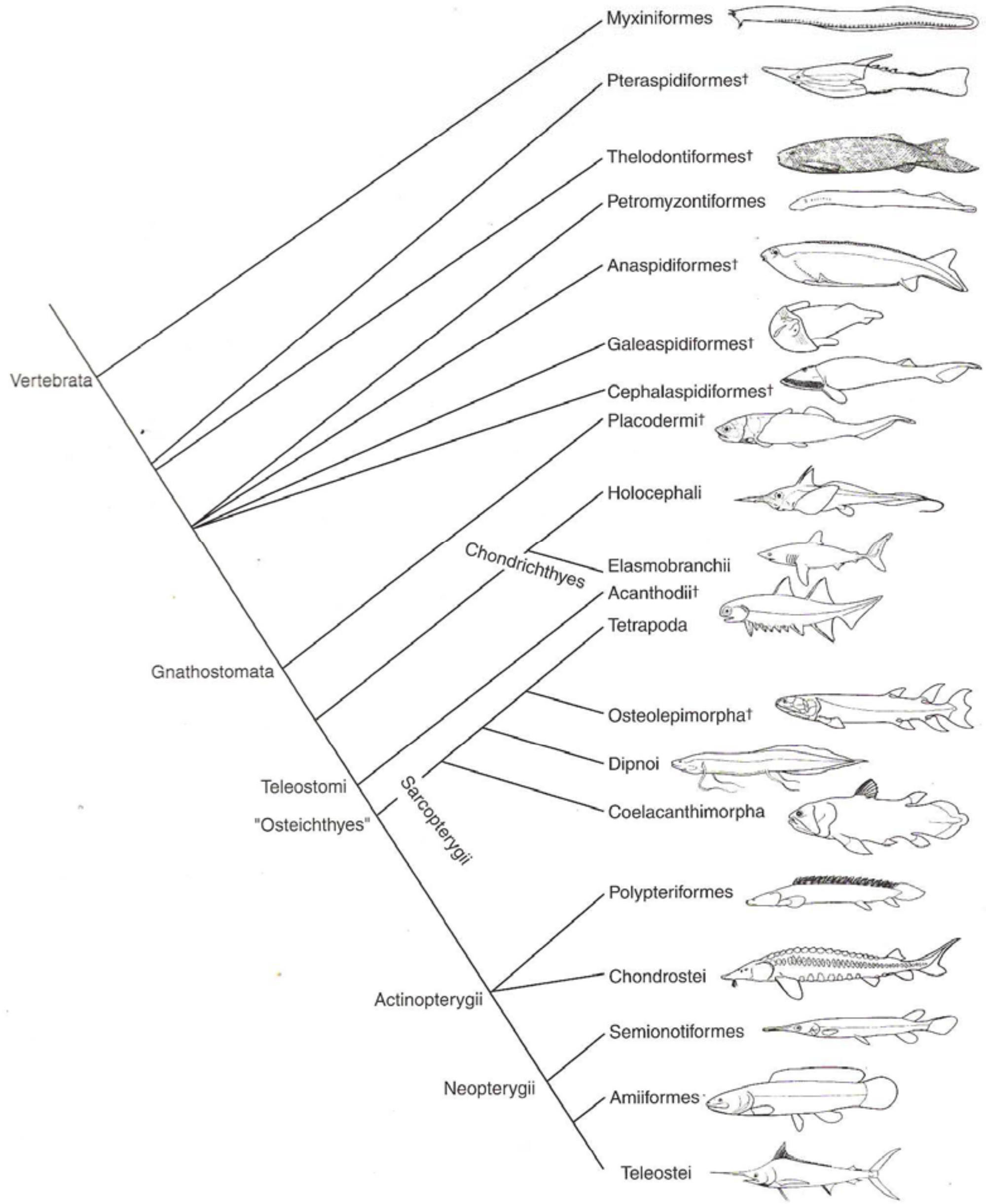
Common characteristic of fishes

- cranium
- backbone,
- live in water,
- possess gills throughout life,
- they either have or are descended from ancestors that had scales or armor derived from dermal tissue

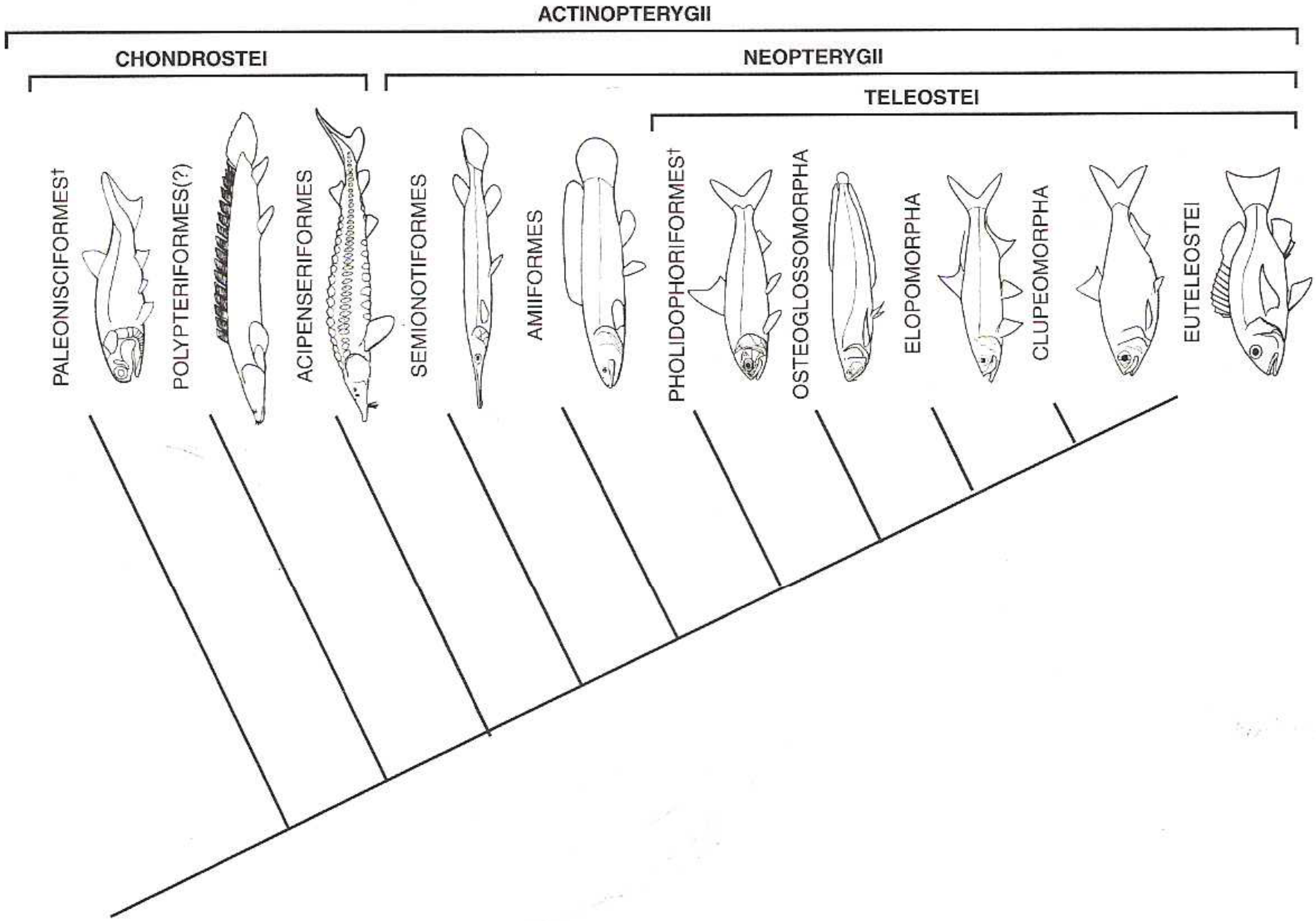
Fish Phylogeny -

several diverse evolutionary lines are lumped together and commonly called fishes

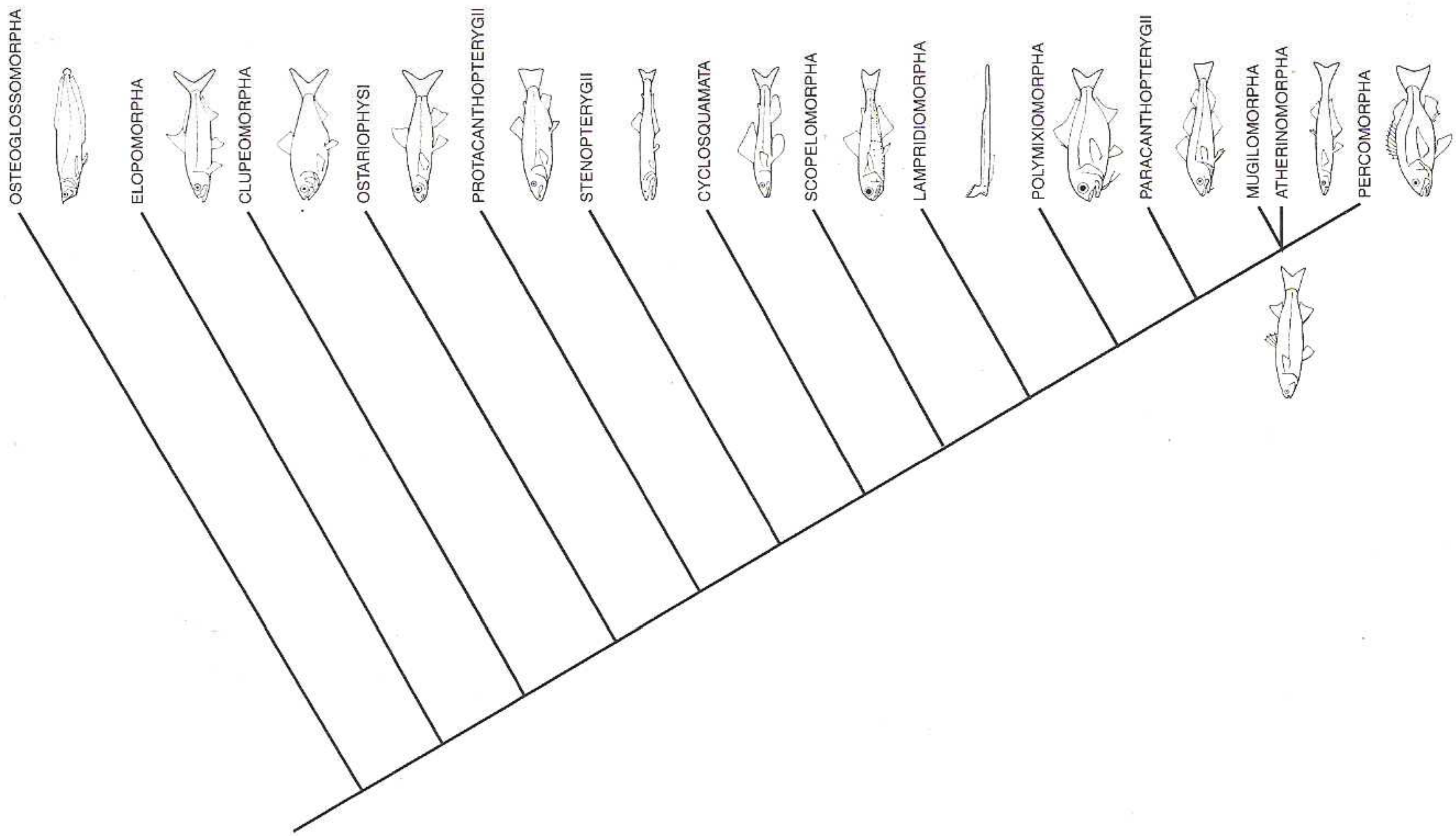




Hypothesized phylogenetic relationships among living and selected extinct (†) fish groups.
Mostly after Nelson 1994 (see Chaps. 11, 13).



Phylogenetic relationships among actinopterygian fishes (see Fig. 11.13).



Phylogenetic relationships among living teleosts (see Fig. 14.1).

Fish Classification

Phylum Chordata

have notochord at some time in their lives, have a post-anal tail at some time, dorsal tubular nerve cord, have gill slits, pharyngeal basket,

Subphylum Vertebrata (or Craniata)

all groups have vertebrae surrounding nerve cord, cranium

Superclass Myxinomorphi

Class Myxini – hagfishes

Superclass Petromyzontomorphi

Class Cephalaspidomorphi – lampreys and extinct relatives

lampreys and hagfishes formerly lumped into Class Agnatha

based on superficial similarities: no jaws, skel. of cartilage, persistent notochord

All groups from this point on have jaws and paired appendages

Superclass Gnathostomata – jawed vertebrates

Class Chondrichthyes - cartilaginous fishes

sharks, skates, rays,

jaws, paired appendages, skeleton of cartilage,

All groups from this point on have a skeleton with bone

Grade Teleostomi (formerly “Osteichthyes”)

Class Sarcopterygii – lobe-finned fishes and tetrapods

fish in this class include coelacanths, lungfishes, and extinct relatives

tetrapods include amphibians, reptiles, birds, and mammals

Class Actinopterygii – ray-finned fishes – all other fishes

Classes Myxini, Cephalaspidomorphi, Chondrichthyes, Sarcopterygians (excluding tetrapods) and Actinopterygians are collectively called fishes

all fish are vertebrates with gills throughout life and live almost exclusively in water and lack four legs

Statistics on fishes

Numbers of species

hagfish - 70 spp – all marine scavengers and predators

lampreys - 38 spp – freshwater and marine,
parasitic and filter feeders

within the Chondrichthyes

sharks - 403 spp - mostly large marine pred, a few in freshwater

rays and skates - 534 spp. - mostly marine, 30 in freshwater

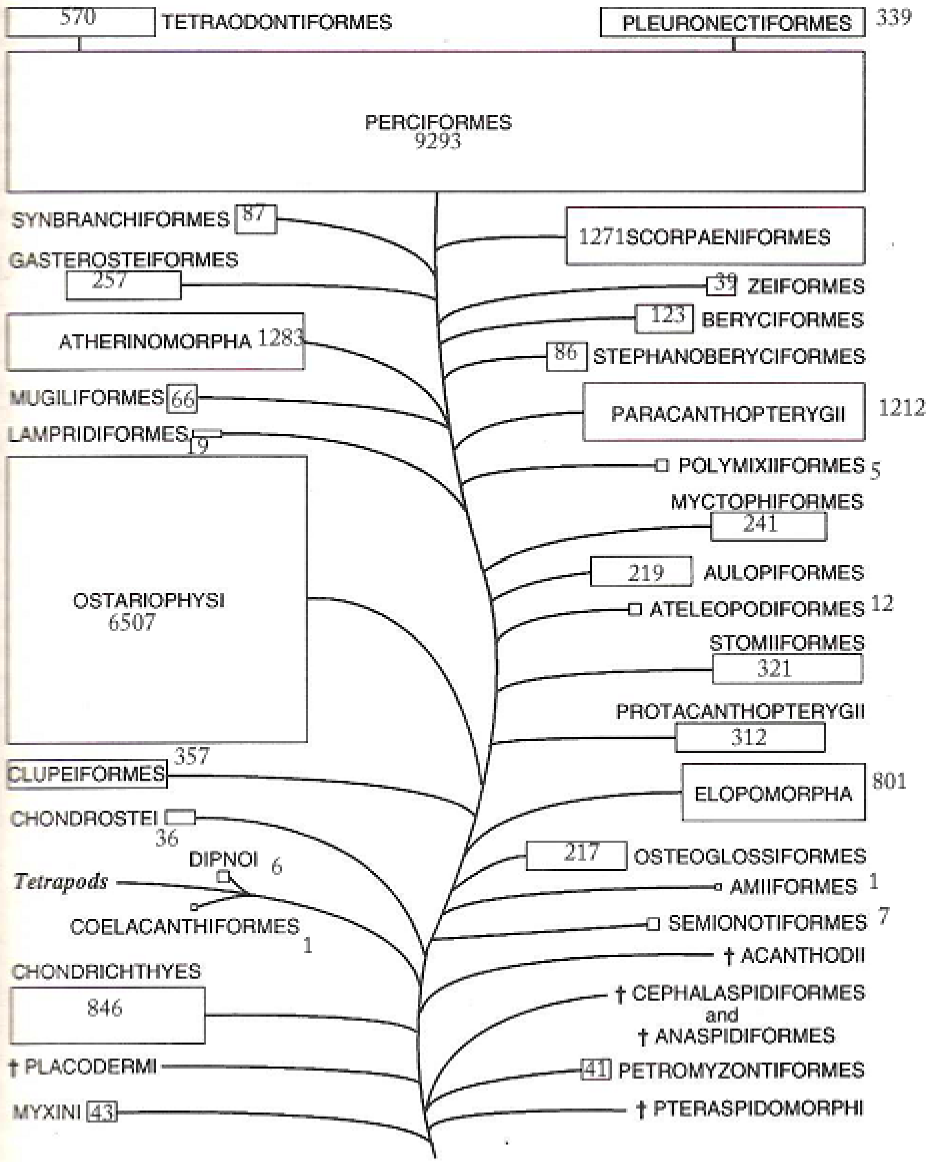
chimaeras - 33 sp – all marine, most in deep water

Teleostomes (*“Osteichthyes”*) – about 24,000 spp and 40% of all vertebrates within this group

Sarcopterygians - lobefins - fleshy bases on paired fins

lungfishes - 6 spp – all in freshwater, one in Australia,
one in South America, and four in Africa

coelacanth - 2 spp - Latimeria - only in Indian Ocean
once thought extinct - 1938 fisherman captured one



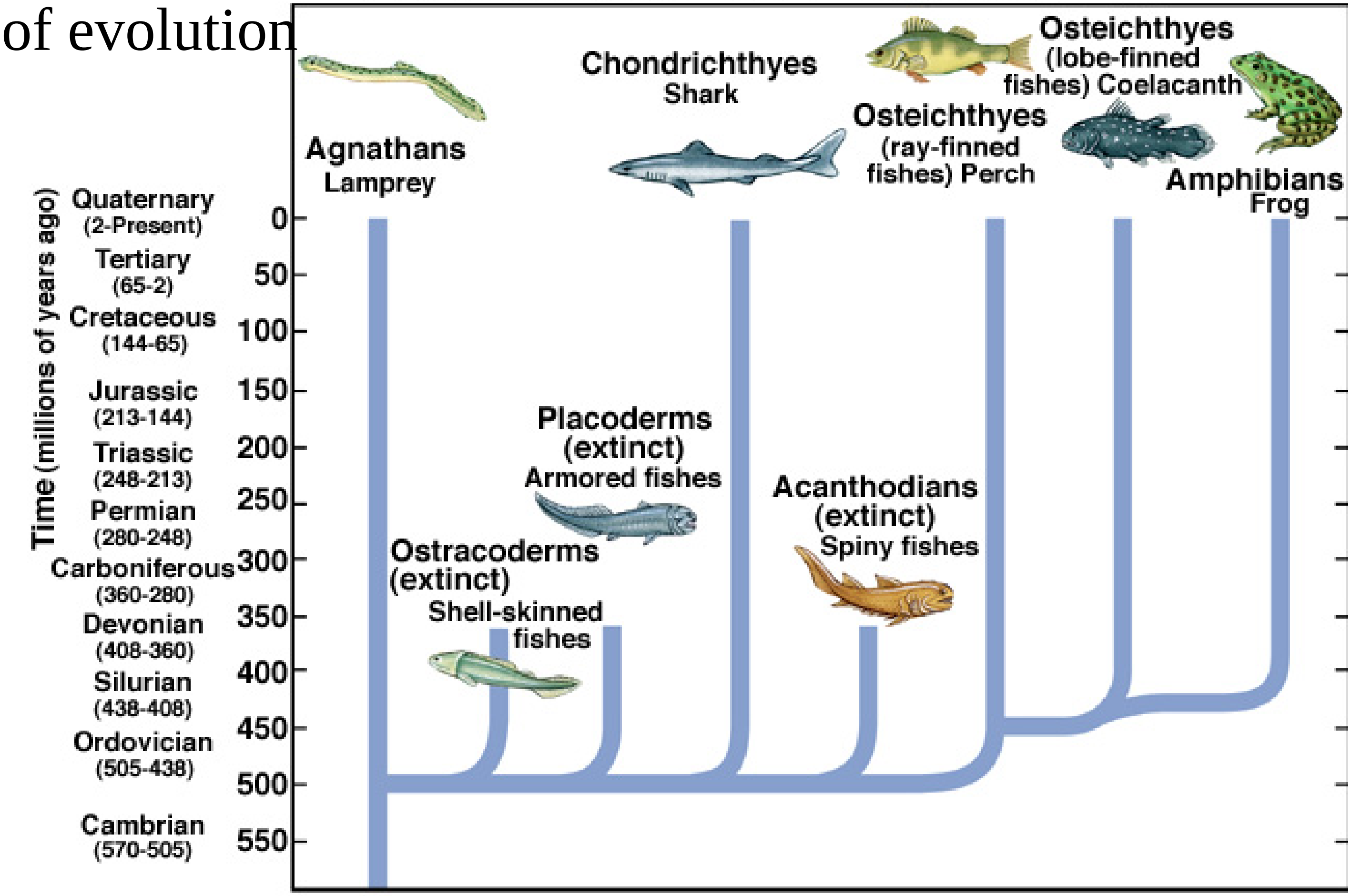
Generalized diagram of relationships of the major groups of extant fishes showing the relative number of recognized species in the groups by size of the blocks. Some major extinct groups shown by dagger and name only. Such a diagram is useful in plotting other information (e.g., to give a visual impression of the proportion of fish species in the various groups in specific geographic areas, in freshwater, or possessing or lacking some feature or body part).

Actinopterygians - ray finned fishes –
- Cladistians – bichirs (16) – all freshwater
- Chondrosteans - sturgeons (25), paddlefish (2) mostly freshwater
- Neopterygians -
  - Amiiformes - bowfin (1) freshwater
  - Semionotiformes - gars (7) mostly freshwater
  - Teleosteans - most species
    - every aquatic habitat
      - lakes, streams, desert springs, caves, seas from pole to pole, deep seas both off and on the bottom,
    - within this group there is gradation in body forms from primitive to advanced (soft-rayed, spiny rayed)
    - most of our familiar species here
      - tarpon, eels, shad, salmon, piranhas, minnows, suckers, cod, topminnows, silversides, sea horses, mullets, perch, bass, gobies, remoras, scorpionfish, sculpins, flounders, puffers, boxfish, etc.

The major lineages of fishes are very old

- The agnathans have a history that goes back 500 my
- by 400 mya all the major lineages were present

So modern groups that are called fishes, at the class level are very distantly related and separated by approximately 400 my of evolution



Within all this diversity
- 58% are marine
- 41% are freshwater
- 1% euryhaline
  - within euryhaline species
  - anadromous - move upstream to spawn - mostly in temperate zones
  - catadromous - move downstream to spawn – mostly in tropics

Questions
- Why is there so much diversity in freshwater?
- Why do species move into alternate habitats to spawn?
- Why are there anadromous forms in the temperate zones and catadromous forms in the tropics?

Most marine species are coastal

only 13% of all fish species live exclusively in open ocean

44% live in less than 200m of water, near the coast

In both freshwater and marine fish groups, most species are found in the tropics

In spite of diversity - we don't have any trouble recognizing most things that are fish -

One thing that all fishes have in common is that they live in water and living in water imposes some constraints on them that they must live within - the properties of water limit the number of morphological, physiological, and ecological options for fishes

Water is dense - 800 x air

benefits - 1. buoyancy - little or no effect of gravity

2. allows more force to be exerted on it

costs - resists movement

most fish are streamlined - those that must move quickly, or over long distances

most fish have a large proportion of the body as muscle for locomotion -

Water is almost incompressible

- moving through air involves compression and displacement
- moving through water - all displacement
  - this produces turbulence and drag
- benefits -
  1. displacements are detectable -
     - gives long-distance sense of touch
     - allows fish to detect other fish and prey
  2. allows for suction feeding and forceful ventilation
     - water can be sucked into, and pumped out of mouth

Slight compressibility of water -

sounds move further and faster - 4x faster than air

fish don't have external ears, but nearly all fish can hear

a fish body is nearly the same density as water

sound waves pass readily through fish bodies

use internal structures (otoliths) of different density and swim bladders to intercept sound waves

all hear and many can make sounds and use them for communication

Water is a good solvent -
- dissolved solutes necessary for aquatic life as nutrients
- creates a problem -
  - fish must resist being dissolved themselves - having their solutes lost by diffusion, or in conditions of high salinity losing their water through osmosis - later
  - one additional factor makes this problem a special problem -
    - oxygen is not very soluble in water
      - air is 21% O_2
      - water is 0.8% O_2 (8ml/l, or 12.8 mg/l) max.
        - solubility decreases with increases in temperature and salinity
        - can limit fish activities,
        - to compensate, fish have a large portion of the surface area of their bodies very permeable - the gills
          - for extracting oxygen, but also provides an easy entry and exit point for solutes and water

Water has low light penetration

- 1000 m max (pure water)
- most fish in lighted zone (productive zone)
- most fish live in a relatively murky and dark environment
  - compensate through highly developed sense of touch, smell, some have electric organs (fields that can be used to detect movements) or electric sense to detect the weak electric charge of other living things,
  - some make their own light

The biology of fishes is the biology of active living organisms in water. The properties of water limit and shape the biology of fishes.