# Evolutionary trees to know:

![How “fish” relate to other vertebrates](data:application/pdf;base64,)

How “fish” relate to other vertebrates

![Major groups within Chondrichthys](data:application/pdf;base64,)

Major groups within Chondrichthys

![Major groups within Actinopterygii](data:application/pdf;base64,)

Major groups within Actinopterygii

# Evolutionary terms to know:

Monophyly

Clade

Paraphyly

Grade

![Fish anatomical terms to know](data:application/pdf;base64,)

Fish anatomical terms to know

# Focal taxonomic groups ( groups you need to be able to photo ID and place in a phylogeny)

**Cyclostomata** (jawless fish)  
No vertebral central, no pectoral / pelvic fins with endoskeletal support, gill openings pores rather than slits, elongated body

* **Myxini** (hagfish)   
  12 pairs of gill openings, mucous glands lateroventraly along the body, Paired of sensing tentacles
* **Hyperoartia** (lamprey)  
  7 pairs of gill openings, single mediodorsal nostral, funnel-shaped mouth surrounded by oral disk

**Gnathostomata** (jawed fish)

* **Chondrichthys** (cartilagenous fish; Fig. [2](#fig:Chondrichthys))  
  Cartilagenous endoskeleton, placoid scales, no swim bladder
  + **Holocephali** (Chimaera)  
    Operculum over 4 gill arches, teeth are grinding plates, no cloaca (anal and urogenital openings separate)
  + **Elasmobranchii**  
    Heterocercal tail, internal fertilization via claspers
    - **Selachii** (Sharks)  
      Heterocercal tail, 5-7 exposed lateral gill slits anterior to pectoral fins
    - **Batoidea** (Skates & Rays)  
      Dorsoventrally flattened body, expanded pectoral fins fused to the head
* **Osteichthyes** (bony fish)  
  endoskeletons composed (at least partially) of ossified tissue
  + **Actinopterygii** (ray-finned fish; Fig. [3](#fig:Actinopterygii))  
    raylike supports in fins, radial bones of pectoral girdle all attached to the scapulocoracoid complex
    - **Acipenseriformes**  
      Heterocercal tail, only dermal bones of head and pectoral girdle ossified
      * **family ACIPENSERIDAE** (sturgeons)  
        Robust body armed with 5 longitudinal rows of large bony plates, pronounced snout with 4 sensitive barbels, largest freshwater fish
      * ***Scaphirhynchus platorynchus*** (shovel-nosed sturgeon)  
        highly endangered, 4 lobes on lower lip, fringed barbels on front of mouth
      * **family POLYODONTIDAE** (paddlefish)  
        paddle/spatula-like snout, virtually naked skin, greatly extended operculum
      * ***Polyodon spathula*** (American paddlefish)  
        grows up to 7 ft, filter-feeder
    - **Lepisosteiformes** (gars)  
      elongate jaws with teeth, elongate body with dorsal and anal fins located caudally, abbreviated heterocercal tail, swim bladder can be used for respiration
      * ***Lepisosteus oculatus*** (spotted gar)  
        olive brown to black, spots on body, head, and fins
    - **Amiiformes** (bowfin)  
      swim bladder can be used for respiration, round snout
      * ***Amia calva*** (bowfin)  
        body nearly cylindrical, long dorsal fin, abbreviated heterocercal tail, gular plate
    - **Elopomorpha**  
      Leptocephalus larvae
      * **Anguilliformes** (eels)  
        body elongate, lack pelvic fins, pelvic girdle is often absent and when present is remote from skull
      * ***Anguilla rostrata*** (American eel)  
        long anal and dorsal fins
    - **Cypriniformes**  
      Kinethmoid bone for jaw protrusion
      * **family CATOSTOMIDAE** (suckers)  
        Pelvic fins abdominal, 1 dorsal fin, dorsal fin rays 10 or more, large mouth suckers ventral
      * ***Carpiodes velifer*** (highfin carpsucker)  
        Long sickle-shaped dorsal fin, projection on lower lip
      * ***Hypentelium etowanum*** (Alabama hogsucker)  
        Cylindrical body, very pronounced ventral sucker, top of head between eyes flat or concave
      * **family CYPRINIDAE** (minnows and carp)  
        no teeth on jaws, modified teeth on gill arches, fin rays soft and flexible, pelvic fins abdominal
      * ***Cyprinella venusta*** (black-tail shiner)  
        large black spot at base of caudal fin
      * ***Pimephales vigilax*** (bullhead minnow)  
        blunt snout, leading ray stout and detached from first principle ray, light tail spot
      * ***Notropis ammophilus*** (orangefin shiner)  
        8 dorsal rays, prominant orange fins
    - **Siluriformes** (catfish)  
      Single spinous ray at beginning of dorsal and pectoral fins, adipose fin, pectoral girdle modified to form locking mechanism for pectoral fin spine
      * ***Ictalurus punctatus*** (channel catfish)  
        caudal fin forked, 9 pelvic rays, deeply forked tail
      * ***Ameiurus nebulosus*** (brown bullhead)  
        8 pelvic rays, caudal fin not deeply forked, white or yellow chin barbels
    - **Esociformes**  
      Elongate body, tootless maxilla, posterior dorsal and anal fins
      * ***Esox niger*** (chain pickerel)  
        duckbill-like snout, snout longer than postorbital length of head, abdominal pectoral fins
    - **Percopsiformes**  
      ctenoid scales, spines on medial fins reduced or lost
      * ***Aphredoderus sayanus*** (pirate perch)  
        anus anterior between pectoral fins in adults (not in juveniles)
    - **Cyprinidontiformes**  
      unlobed caudal fin, low-set pectoral fins
      * **family POECILIIDAE** (live-bearers)  
        small fins, caudal fin rounded, mouth small and directed upward, males have anal fin displaced forward with gonopodium formed from 3 anal rays, elaborate reproductive strategy
      * ***Gambusia affinis*** (western mosquito fish)  
        6 dorsal fin rays
      * **family FUNDULIDAE** (killifish)  
        elongate body somewhat laterally compressed with head dorsoventrally flattened, mouth small and turned upward, lower jaw extends beyond upper
      * ***Fundulus olivaceus*** (black-spotted topminnow)  
        Dorsal fin origin posterior from anal fin origin, prominant black stripe with dorsal spotting
    - **Atheriniformes** (silversides)  
      2 dorsal fins well separated (first with weak spines), anal fin longer than second dorsal fin, elongate and slightly compressed body
      * ***Labidesthes sticculus*** (brook sliverside)  
        origin of first dorsal fin near origin of anal fin
    - **Centrarchiformes**  
      2 dorsal fins, 3 or more spines on anal tail, siny dorsal fin confluent with soft dorsal fin
      * ***Lepomis cyanellus*** (green sunfish)  
        maxilla reaches beneath eye, pectoral fin short and rounded
      * ***Micropterus salmoides*** (largemouth bass)  
        large mouth with lower jaw projecting, smaller spiny dorsal fin separated by notch from the second dorsal fin
    - **Perciformes**  
      spines in dorsal and anal fins
      * **family COTTIDAE** (sculpins)  
        skin mostly naked, high eyes directed upward, body robust with large head
      * ***Cottus carolinae*** (banded sculpin)  
        mottled brown with dark vertical banding, broad head, body narrows caudally
      * **family PERCIDAE** (perches and darters)  
        two dorsal fins, dorsal fins separated bya space, 2 anal spines
      * ***Ammocrypta meridiana*** (southern darter)  
        elongate body, blunt snout, caudal fin truncate
  + **Sarcopterygii**  
    radial bones of pectoral girdle not all attached to the scapulocoracoid complex
    - **Actinistia** (lobe-finned fish)  
      skull divided anteriorly and posteriorly, widely distributed 400 million years ago
    - **Dipnoi** (lung fish)  
      elongated and laterally compressed body, respire by gills and lungs