UNIVERSITAS INDONESIA

Veritas, Probitas, Iustitia

FMIPA

BIOLOGI

Fish Diversity

Department of Biology, Faculty of Mathematics and Natural Sciences, Universitas Indonesia

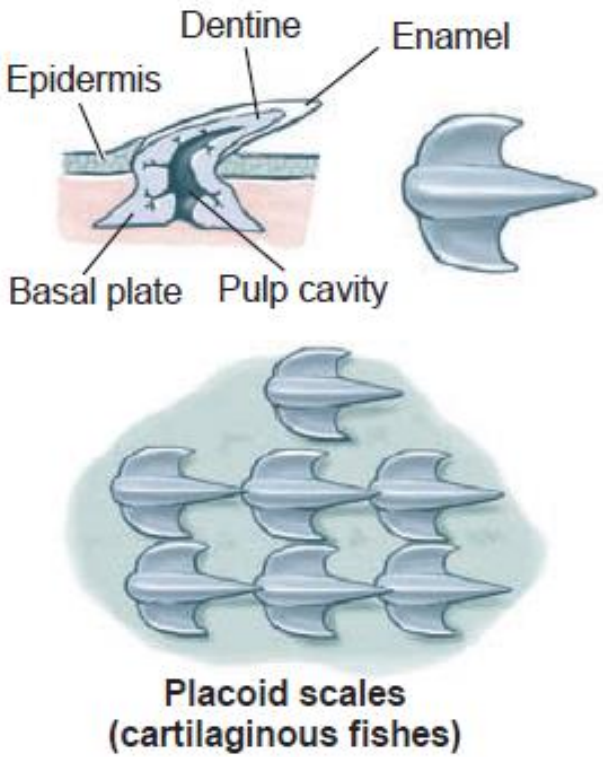
Outline

- Ancestry and relationships of major groups of fishes.
- Living jawless fishes.
- Chondrichtyes fishes.
- Osteichthyes fishes.

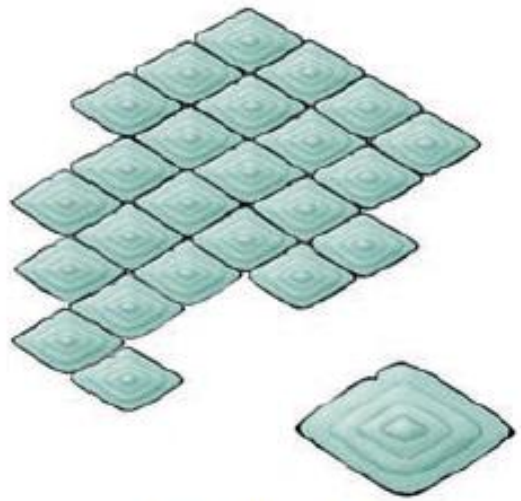
An Overview of Fish

- Fish can be roughly defined (and there are a few exceptions) as cold-blooded creatures that have backbones, live in water, and have gills.
- The gills enable fish to “breathe” underwater, without drawing oxygen from the atmosphere.
- No other vertebrate but the fish is able to live without breathing air. One family of fish, the lungfish, is able to breathe air when mature and actually loses its functional gills. Another family of fish, the tuna, is considered warm-blooded by many people, but the tuna is an exception.

Types of Scales

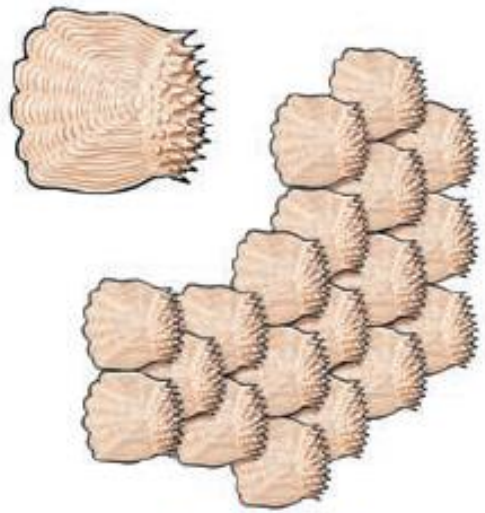


Placoid scales
(cartilaginous fishes)



Ganoid scales
(nonteleost bony fishes)

Cycloid scales
(teleost fishes)

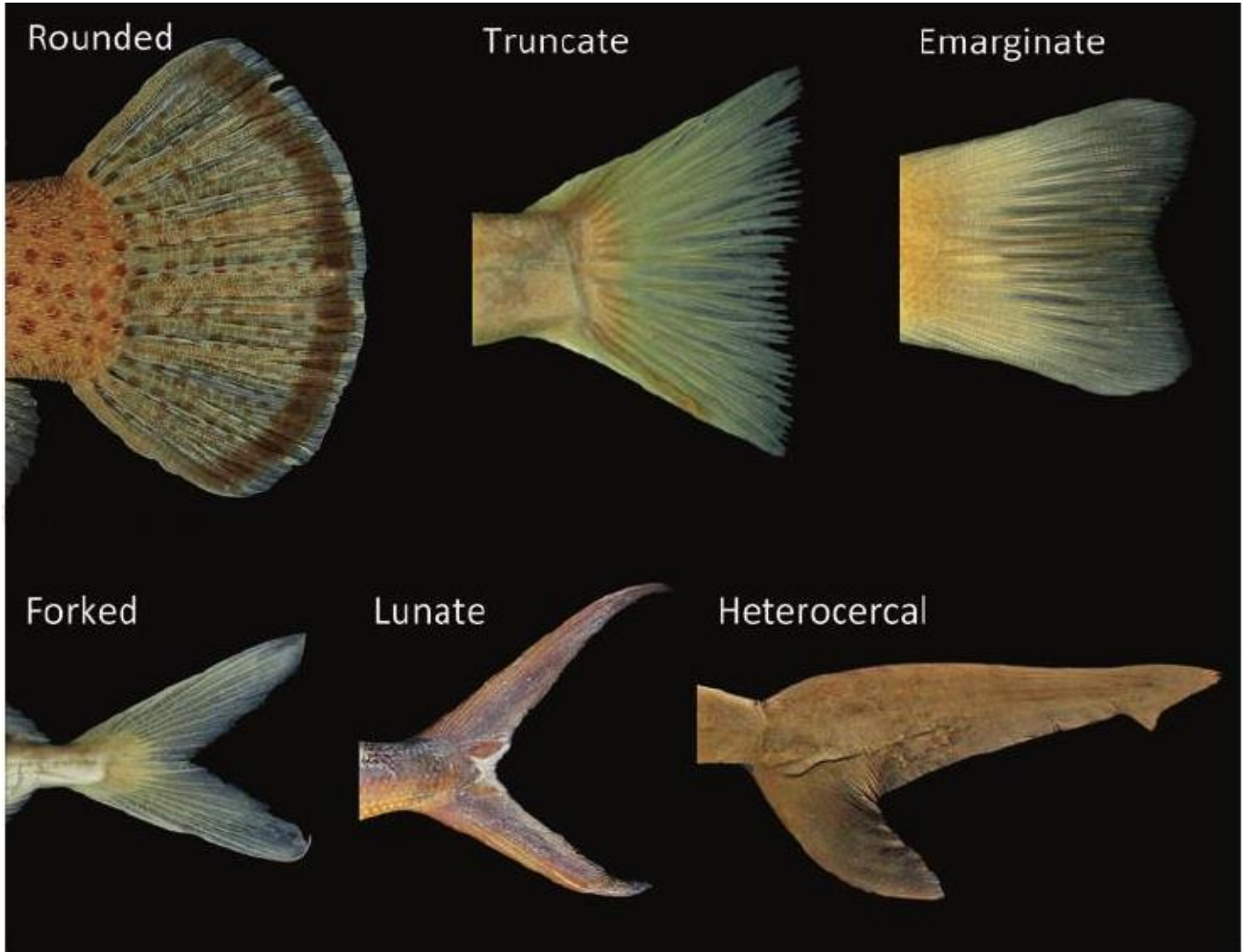


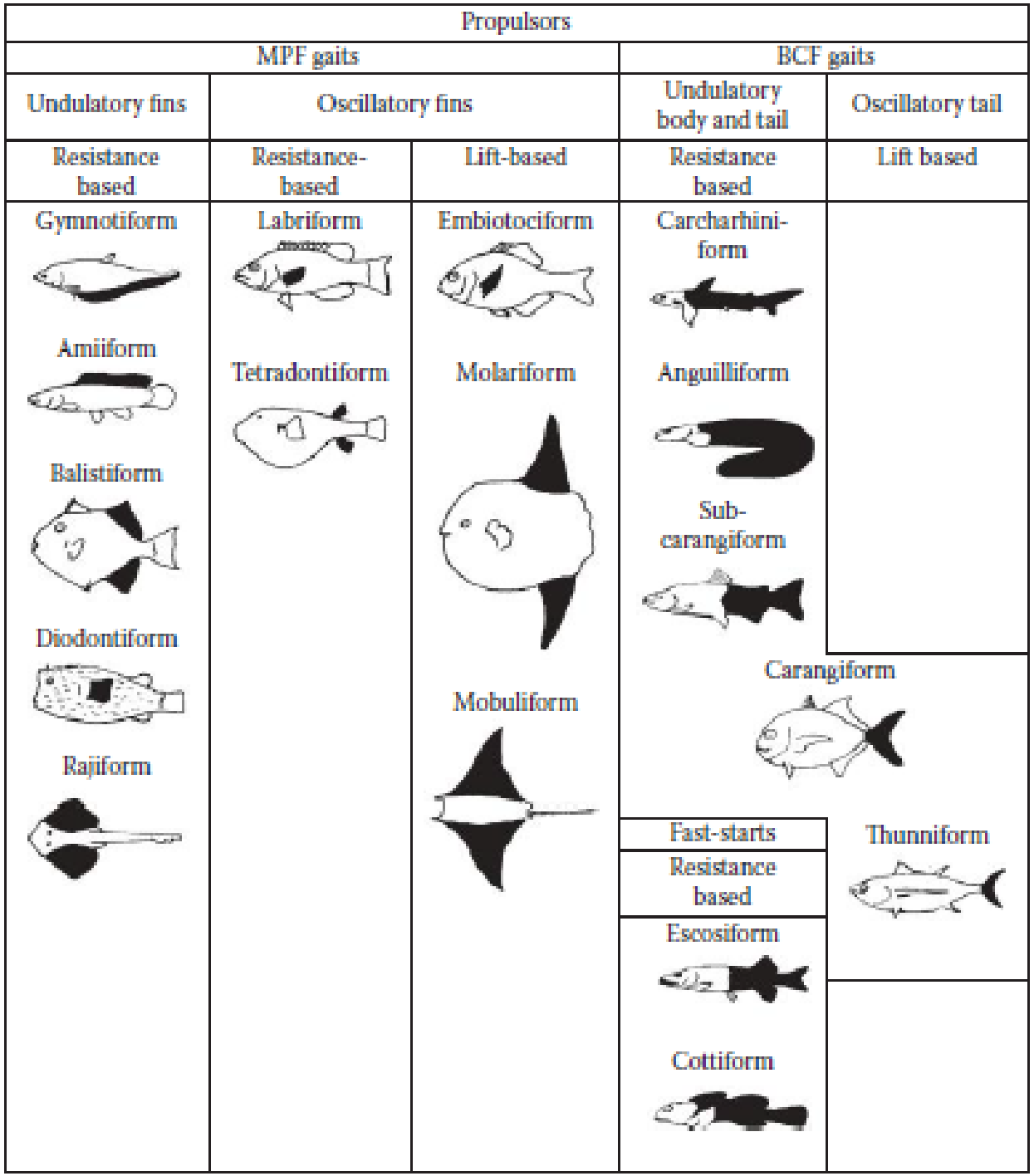
Ctenoid scales
(teleost fishes)

Fins and Locomotion

- Fish are propelled through the water by fins, body movement, or both.
- A fish can swim even if its fins are removed, though it generally has difficulty with direction and balance.
- Many kinds of fish jump regularly. Those that take to the air when hooked give anglers the greatest thrills. The jump is made to dislodge a hook or to escape a predator in close pursuit, or the fish may try to shake its body free of plaguing parasites.

Types of Caudal Fins



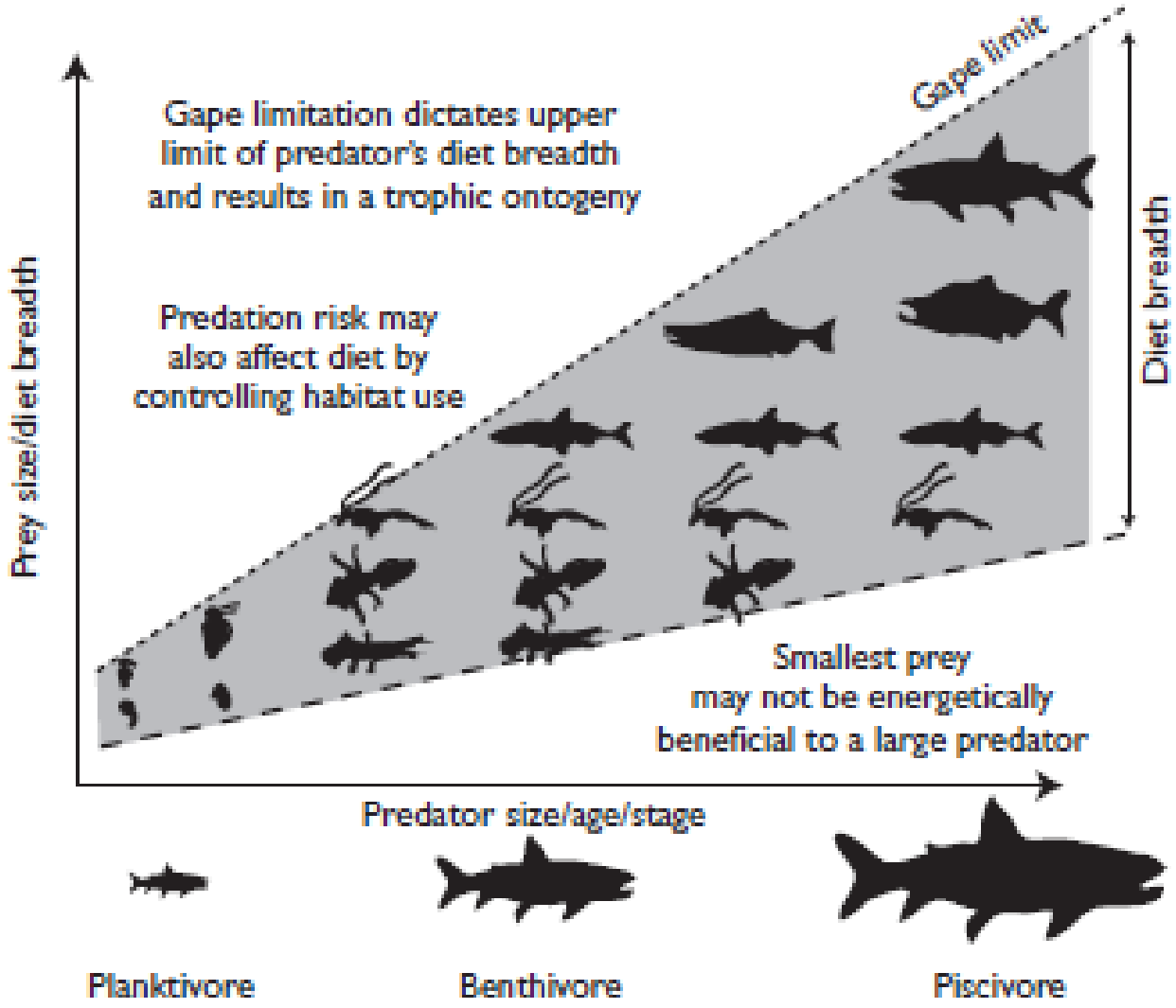


Fishes propel themselves through water in two very different ways,

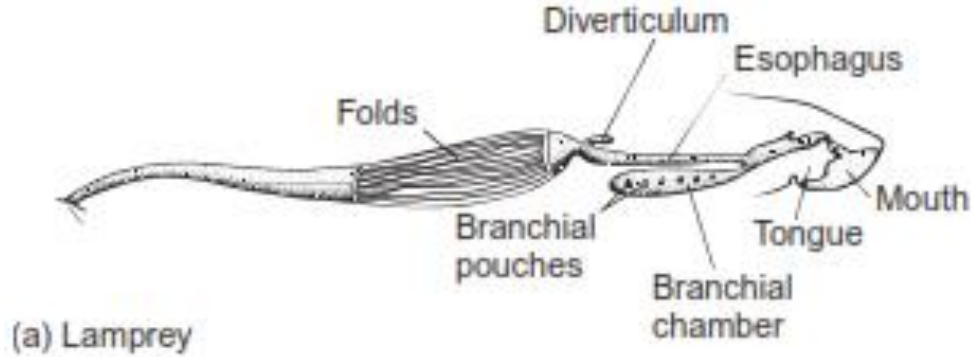
1. The median and paired fins (MPF)
2. The body and/or caudal fins (BCF)

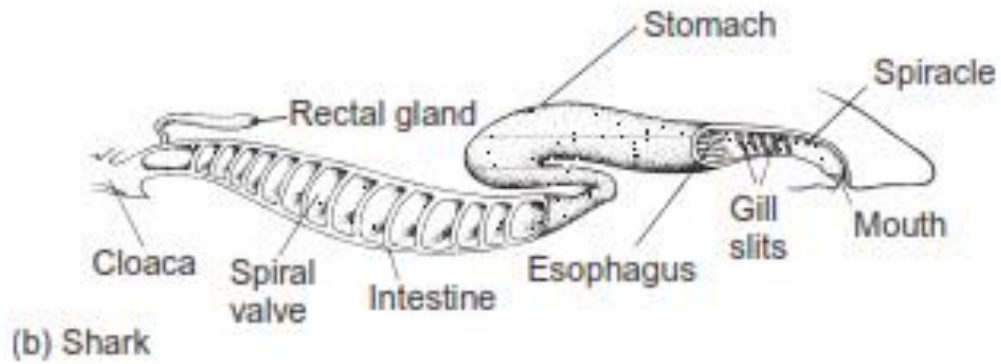
Nutrition and The Digestive System

- Many fish are strictly herbivores, eating only plant life. Many are purely plankton eaters. Most are carnivorous (in the sense of eating the flesh of other fish, as well as crustaceans, mollusks, and insects) or at least piscivorous (eating fish).
- The fish digestive tract is similar to that of other vertebrates. An enlargement, called the stomach, stores large, often infrequent, meals. The small intestine, however, is the primary site for enzyme secretion and food digestion. Sharks and other elasmobranchs have a spiral valve in their intestine, and bony fishes possess outpockets of the intestine, called pyloric ceca, which increase absorptive and secretory surfaces.

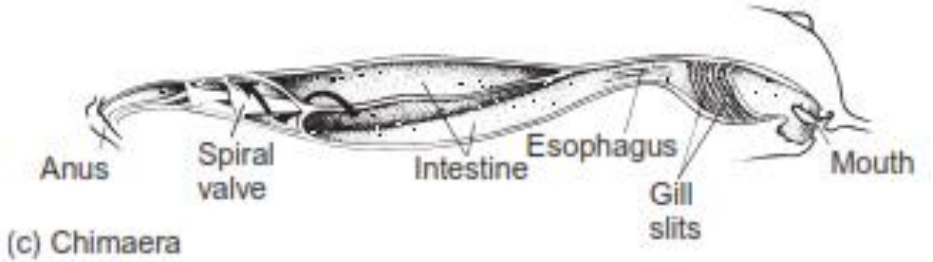


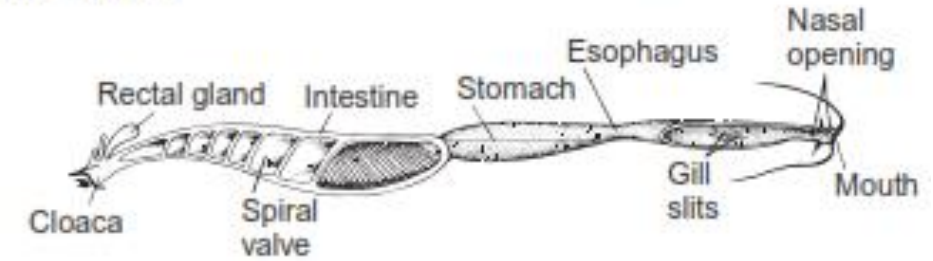
Size of food as well as dietary breadth increases with growth.

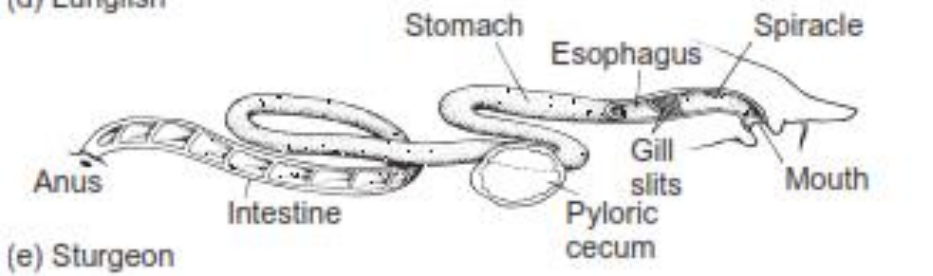


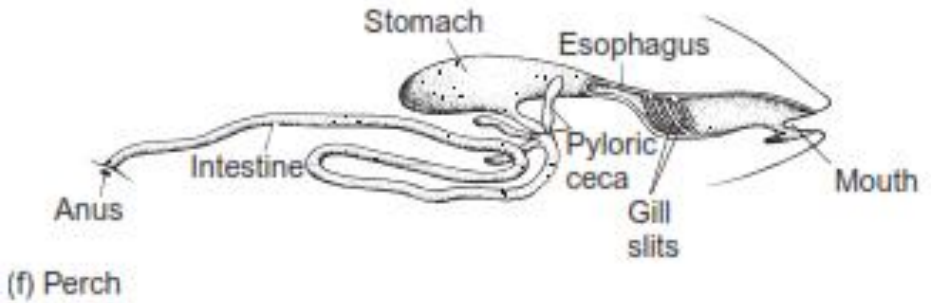


Digestive tracts of selected fishes.
(a) Lamprey. (b) Shark. (c) Chimaera. (d) Lungfish. (e) Sturgeon. (f) Perch. When a spiral valve is absent, the intestine is often lengthened, as in the perch.



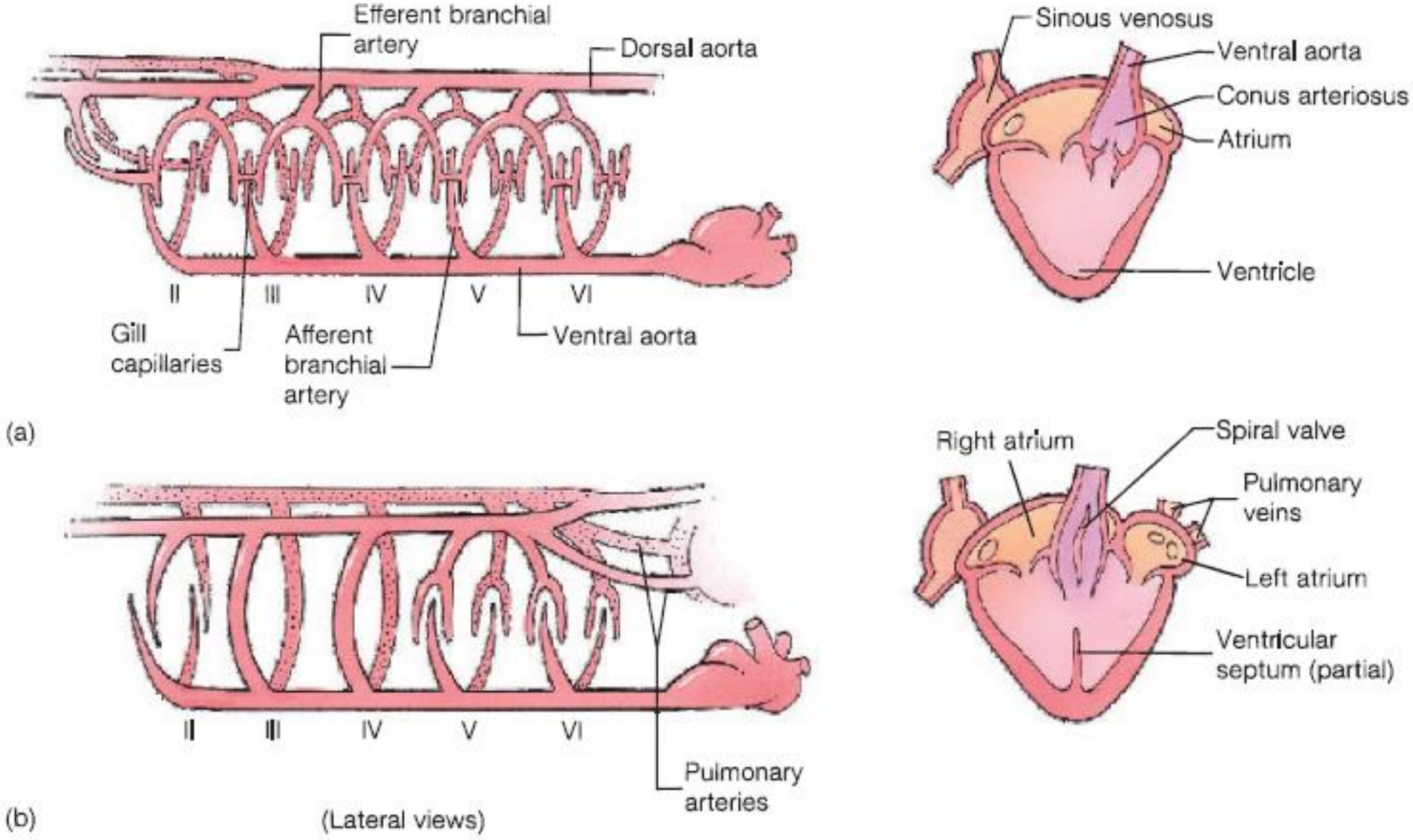






Circulation and Gas Exchange

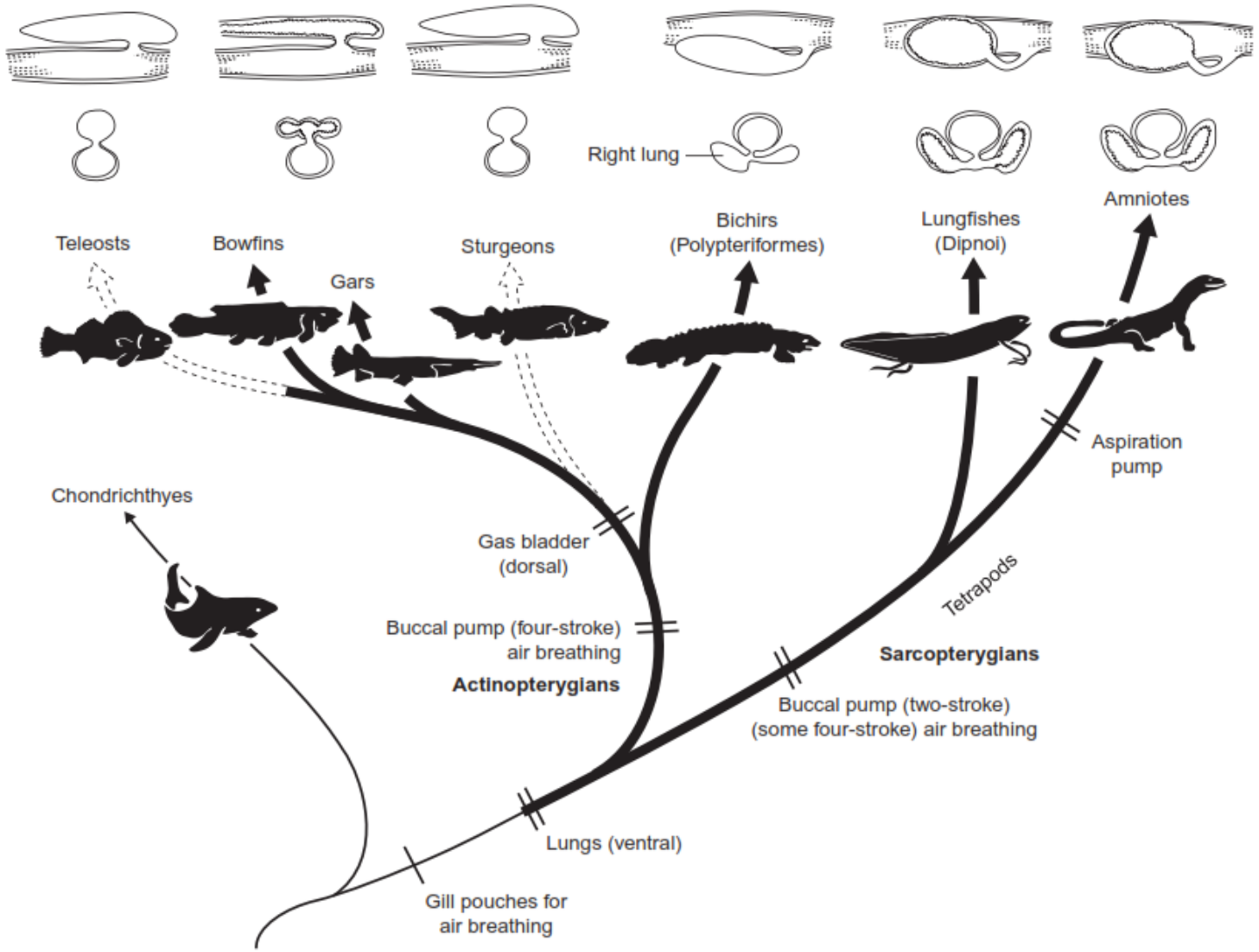
- In fishes, blood flows from the venous system through the sinus venosus, the atrium, the ventricle, the conus arteriosus, and into the ventral aorta. Five afferent vessels carry blood to the gills, where the vessels branch into capillaries. Blood is collected by efferent vessels, delivered to the dorsal aorta, and distributed to the body.



Circulatory System of Fishes. Diagrammatic representation of the circulatory systems of *(a)* bony fishes and *(b)* lungfishes. Major branches of arteries carrying blood to and from the gills are called branchial arteries (or embryologically, aortic arches) and are numbered with Roman numerals. They begin with II because aortic arch I is lost during embryological development.

Swim Bladders and Lungs

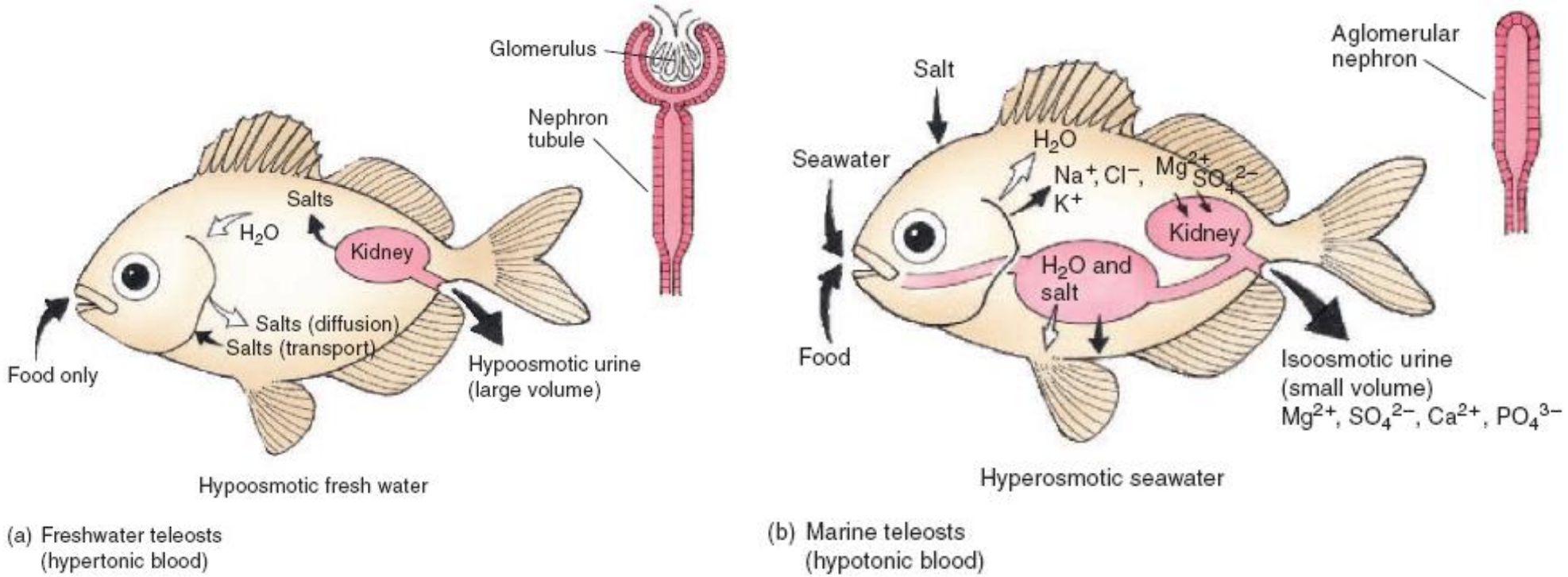
- Lungs are elastic bags that lie within the body. Their volume expands when air is inhaled and decreases when air is exhaled. Embryologically, lungs arise as endodermal outpocketings from the pharynx.
- Swim bladders differ from lungs in three ways. First, swim bladders are usually situated dorsal to the digestive tract, whereas lungs are ventral. Second, swim bladders are single, whereas lungs are usually paired. *Neoceratodus, the* Australian lungfish, is an exception, because as an adult it has a single lung dorsal to the digestive tract; however, its trachea originates ventrally from the digestive tract. Its embryonic lung arises initially as a paired primordium, suggesting that the single lung of *Neoceratodus* is a derived condition. Third, in swim bladders, returning blood drains to the general systemic circulation (cardinal veins) before entering the heart. In lungs, venous return enters the heart separately from the general systemic circulation.



Evolution of gas bladders.
Lungs, ventral in position, evolved in the common ancestor to actinopterygians and sarcopterygians. Swim bladders in actinopterygians may have evolved independently, or they may have been modified from earlier lungs. Some gas bladders are respiratory in function. Above the dendrogram outlining the evolutionary rise of each group, there are sagittal (top) and cross-sectional (bottom) views of the lung and its connection to the digestive tract.

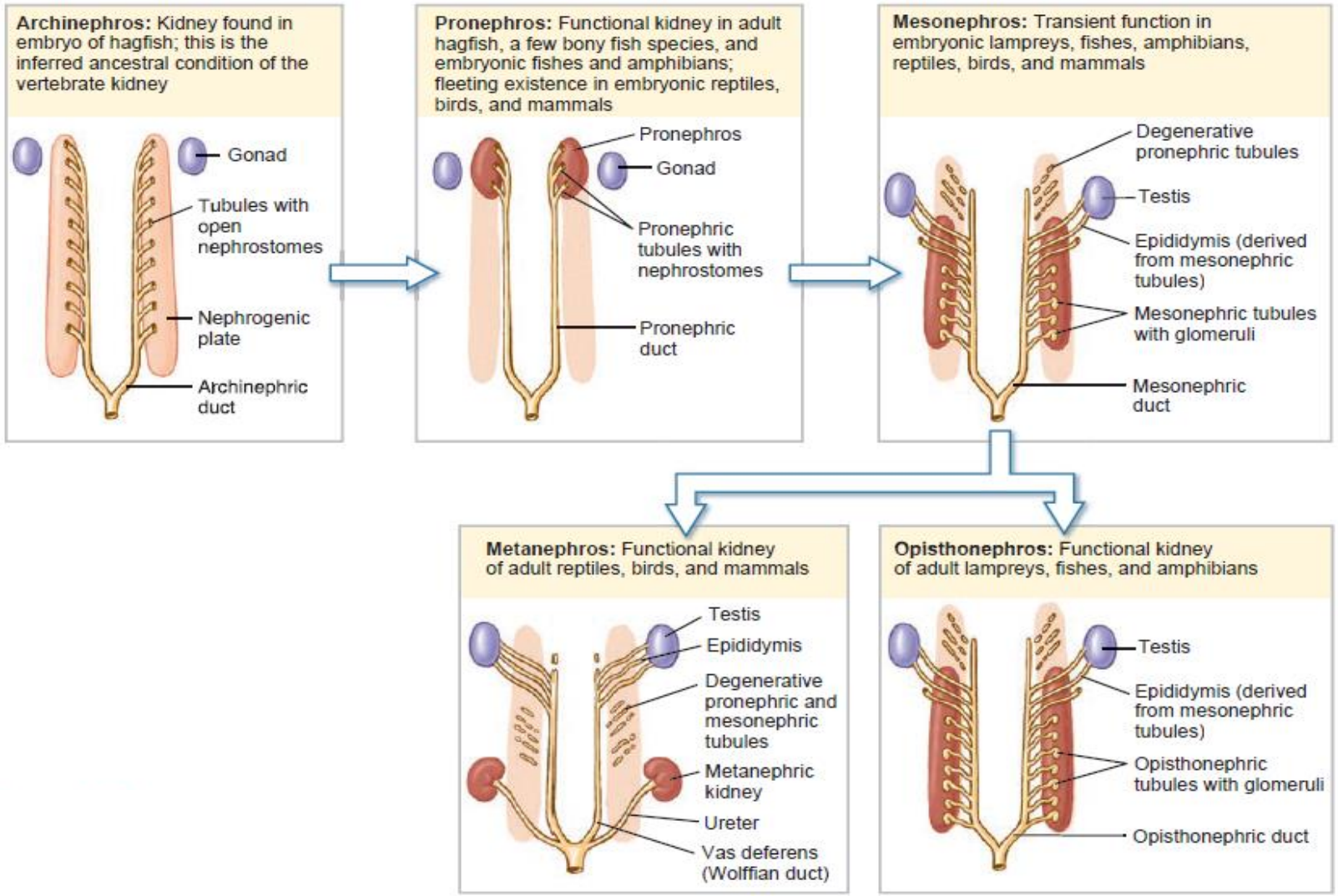
Excretion and Osmoregulation

- Diadromous: fishes that regulary move between freshwater and salt water.
- Anadromous: spent their adult phase of their lifecycle in salt water but move up streams and rivers to spawn (Pacific Salmon → *Oncorhynchus* spp.)
- Catadromous: spent their adult phase of their lifecycle in freshwater but spawn in salt water (some species Eel & Lampreys)



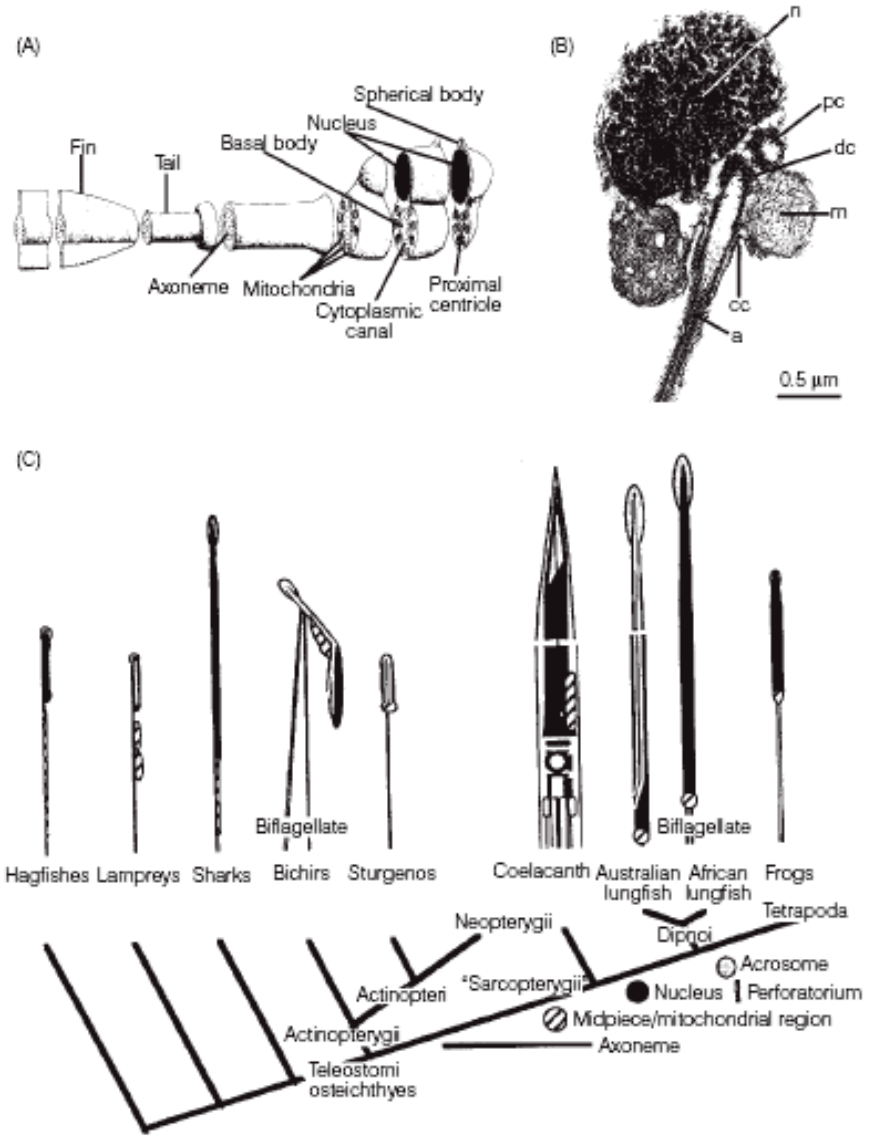
Osmoregulation by *(a)* Freshwater and *(b)* Marine Fishes. Large arrows indicate passive uptake or loss of water or electrolytes (ions) through ingestion and excretion. Small, solid arrows indicate active transport processes at gill membranes and kidney tubules. Small, open arrows indicate passive uptake or loss by diffusion through permeable surfaces.

Types of Kidney



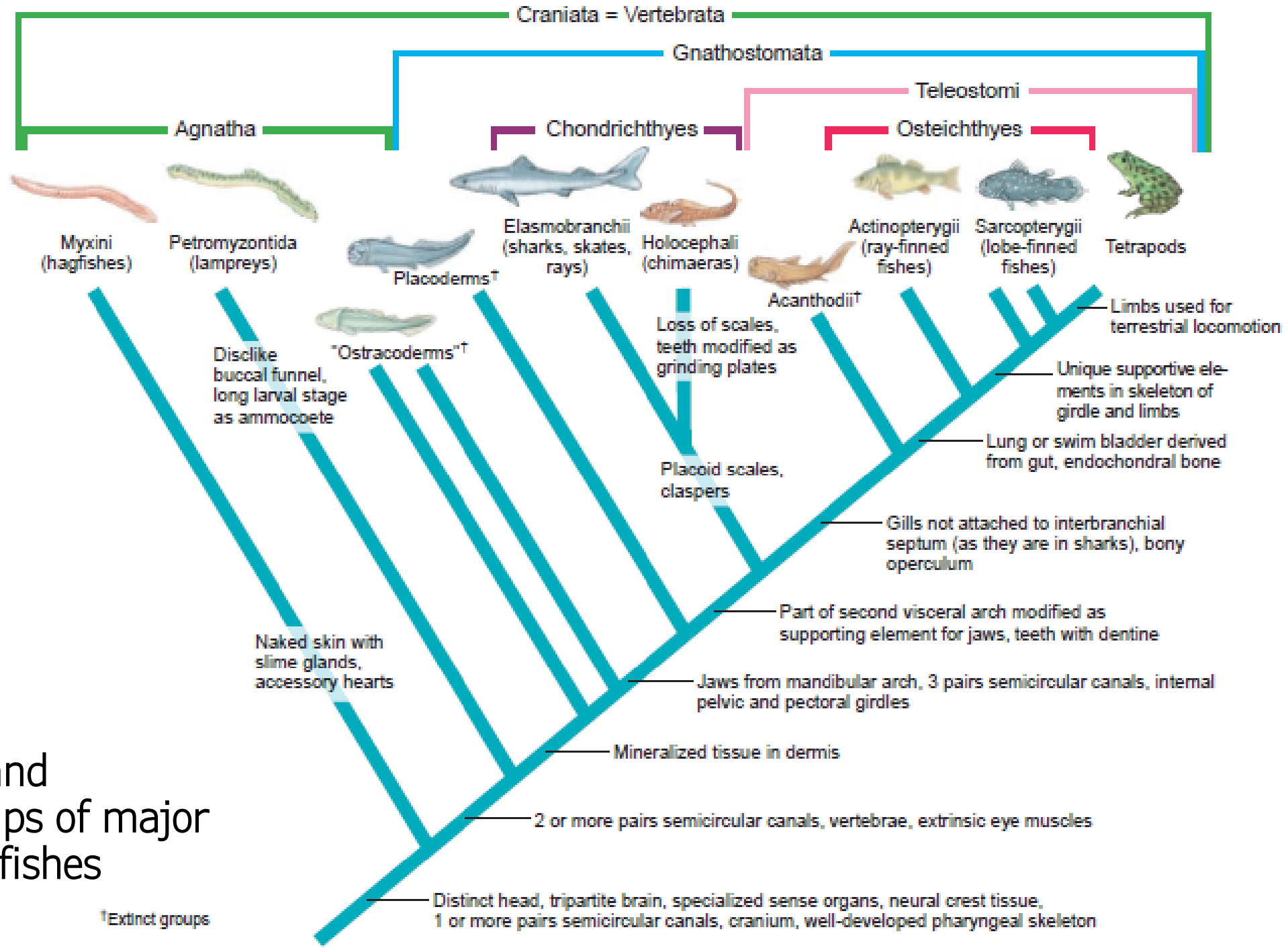
Reproduction and Development

- Modes of reproduction:
  1. Oviparity → lay undeveloped eggs, external fertilization (90% of bony fish), internal fertilization (some sharks and rays)
  2. Ovoviviparity → internal development (without direct maternal nourishment); advanced at birth (most sharks + rays); larval birth (some scorpion forms-rockfish)
  3. Viviparity → internal development (direct nourishment from mother); fully advanced at birth (some sharks, surf perches)



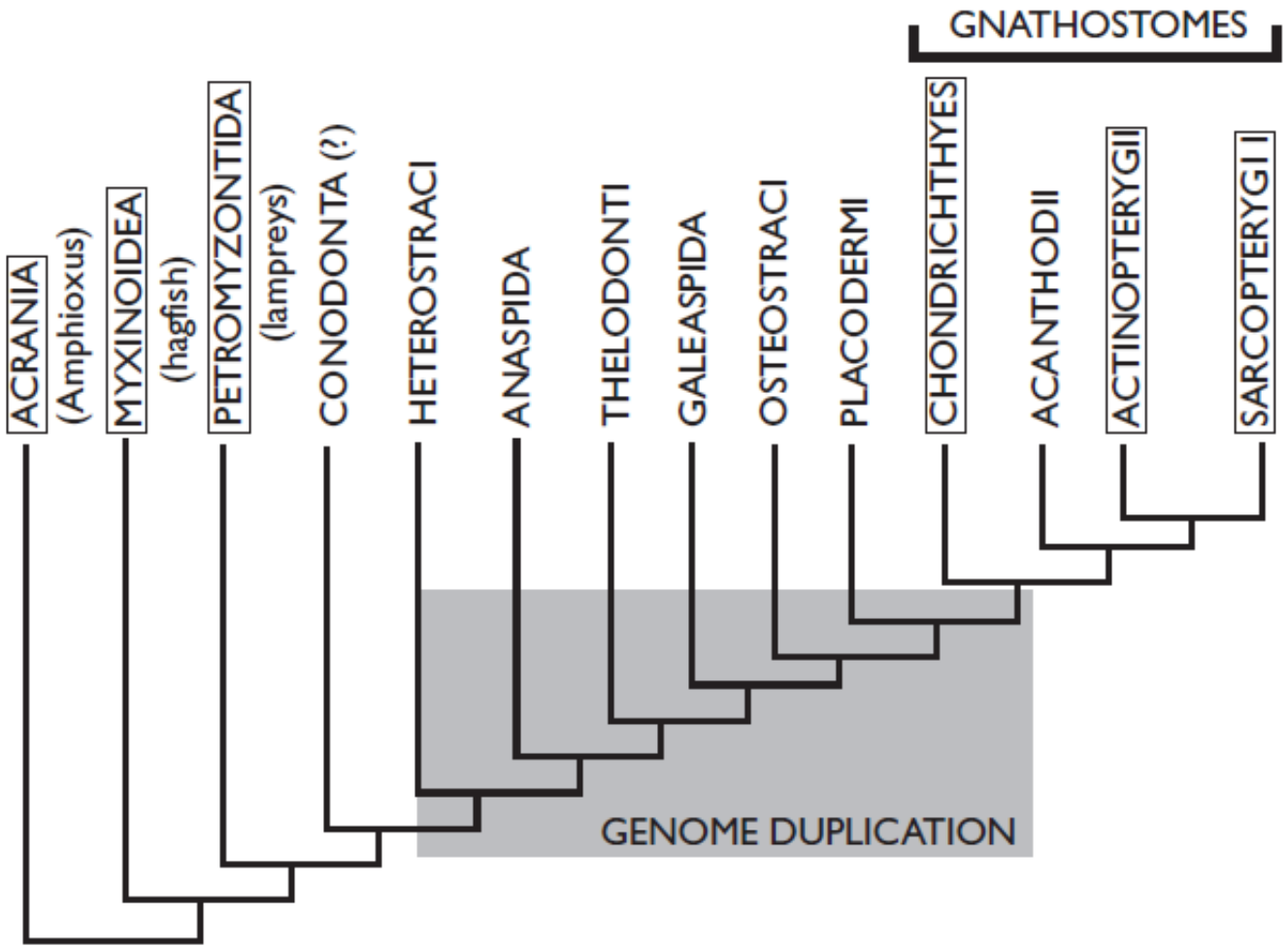
Fish sperm and their utility in constructing phylogenies. (A) Schematic diagram of the sperm of the percichthyid *Macquaria ambigua*; the entire structure is about 5 mm long. (B) Longitudinal section of the sperm of the Coral Trout, *Plectropomus leopardus* (Serranidae); a, axoneme; cc, cytoplasmic canal; dc, distal centriole; m, mitochondrion; n, nucleus; pc, proximal centriole. (C) Schematic diagrams of spermatozoa of nonneopterygian fishes and a cladogram based on sperm characteristics;

Ancestry and relationships of major groups of fishes



†Extinct groups

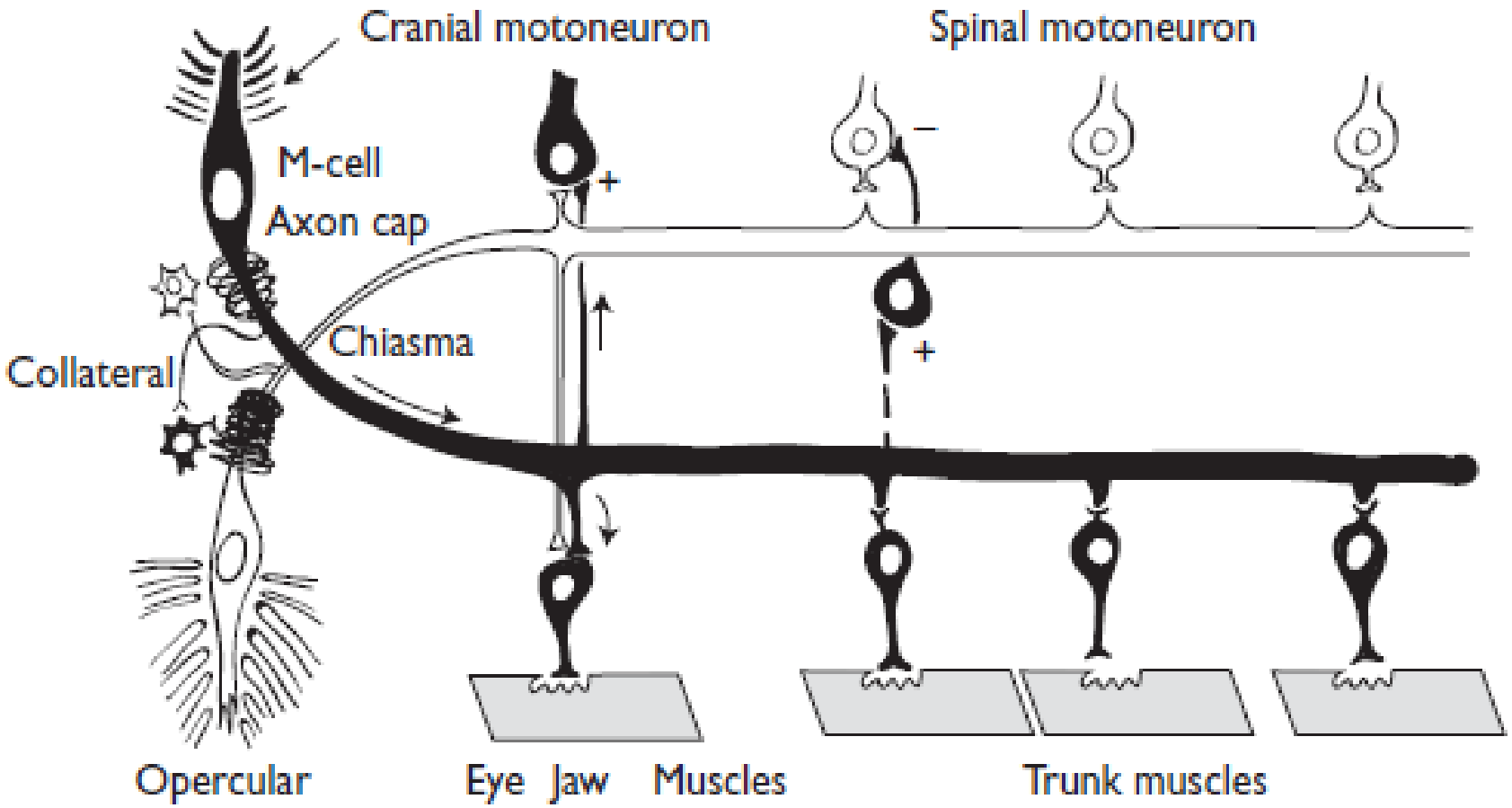
Genome Duplication in Fishes



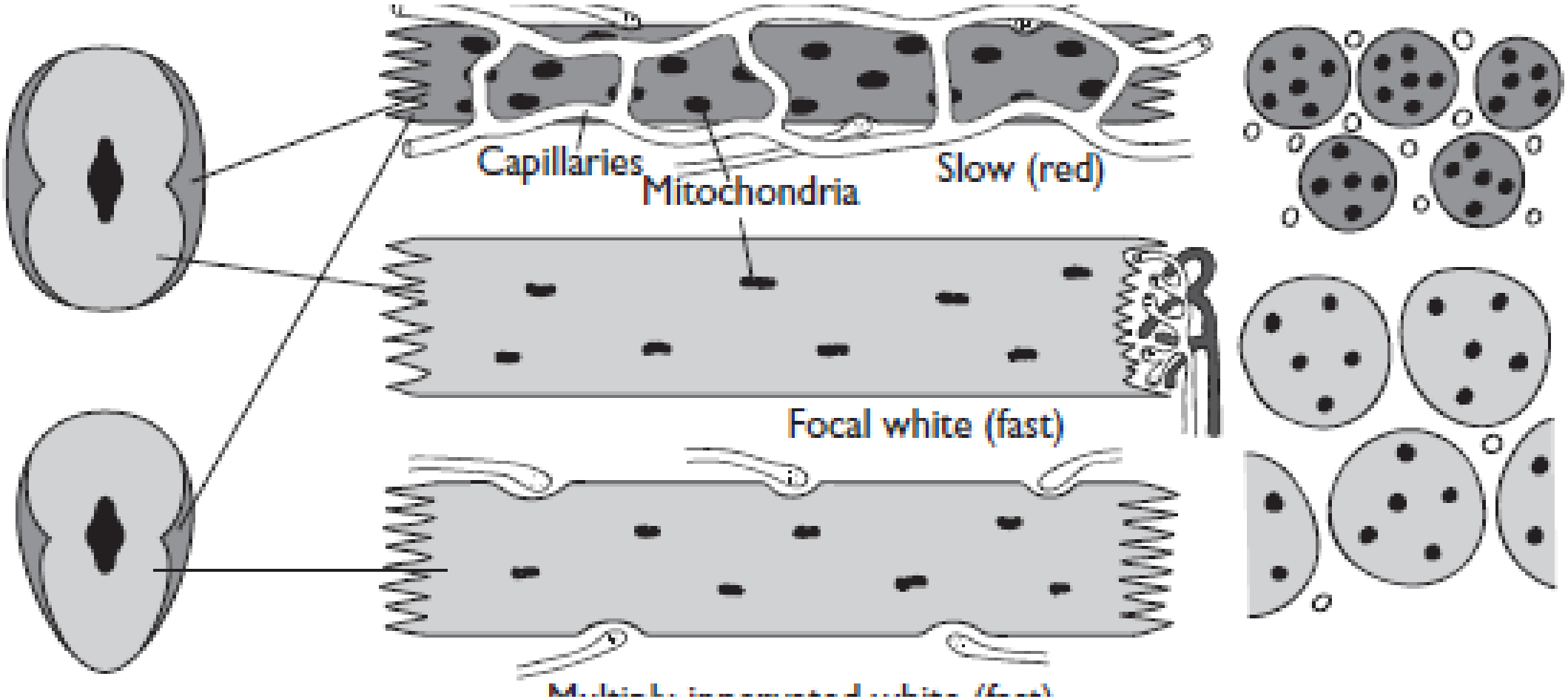
Fishes Phylogenetics

- The class Pisces is not monophyletic.
- Common ancestry characteristics:
  1. The hind brain → lampreys, there are paired large Mauthner neurons found in relation to nerve VIII.
  2. The myotomal muscles along the body.

Mauthner System

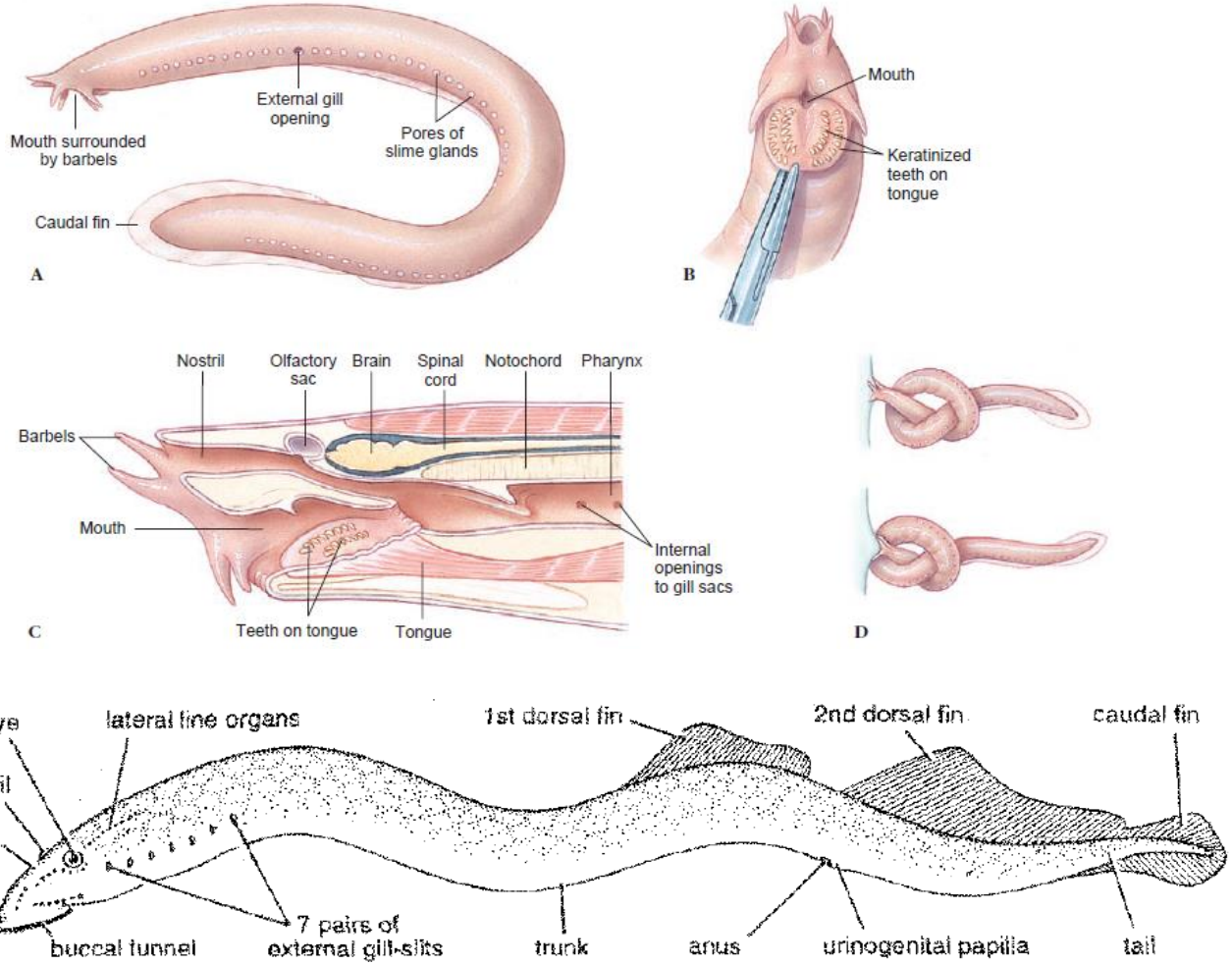


Myotomal Muscle



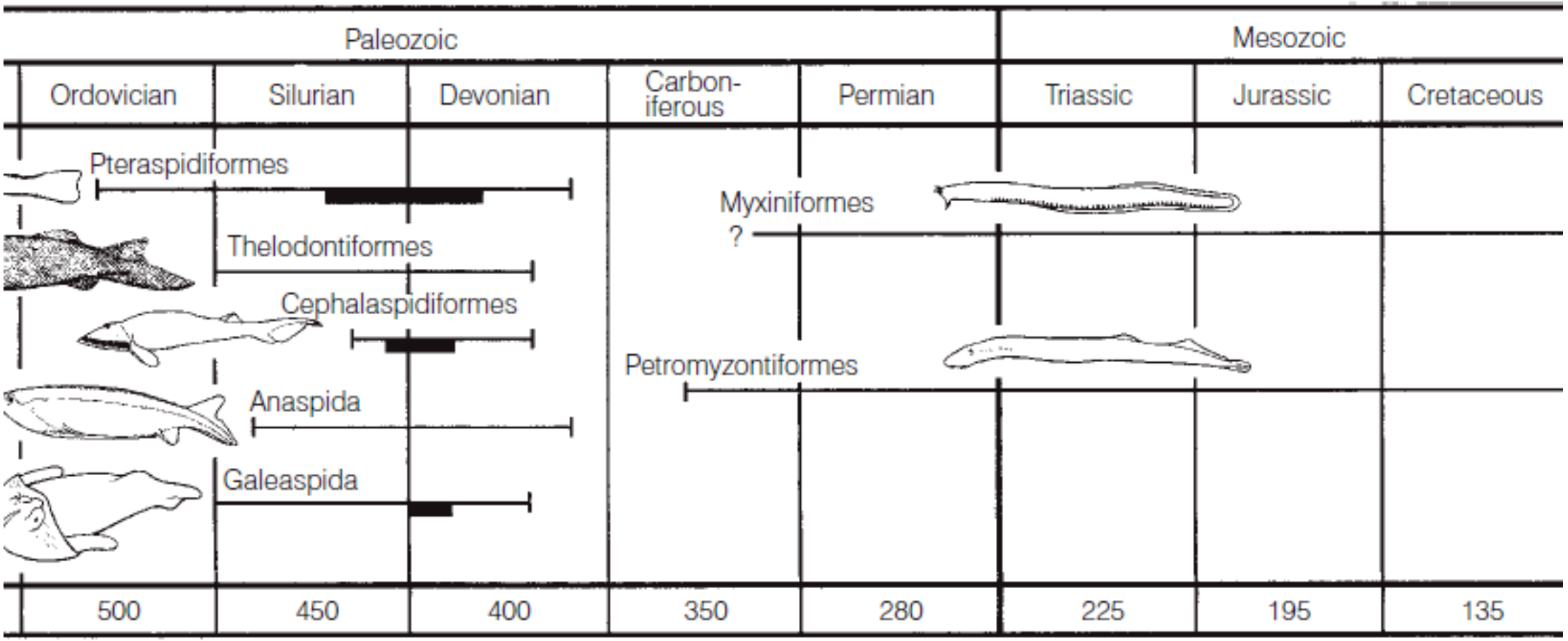
Living Jawless Fishes

- Living jawless fishes include approximately 108 species divided between two classes:
  1. Myxini (hagfishes) with about 70 species
  2. Petromyzontida (lampreys) with 38 species



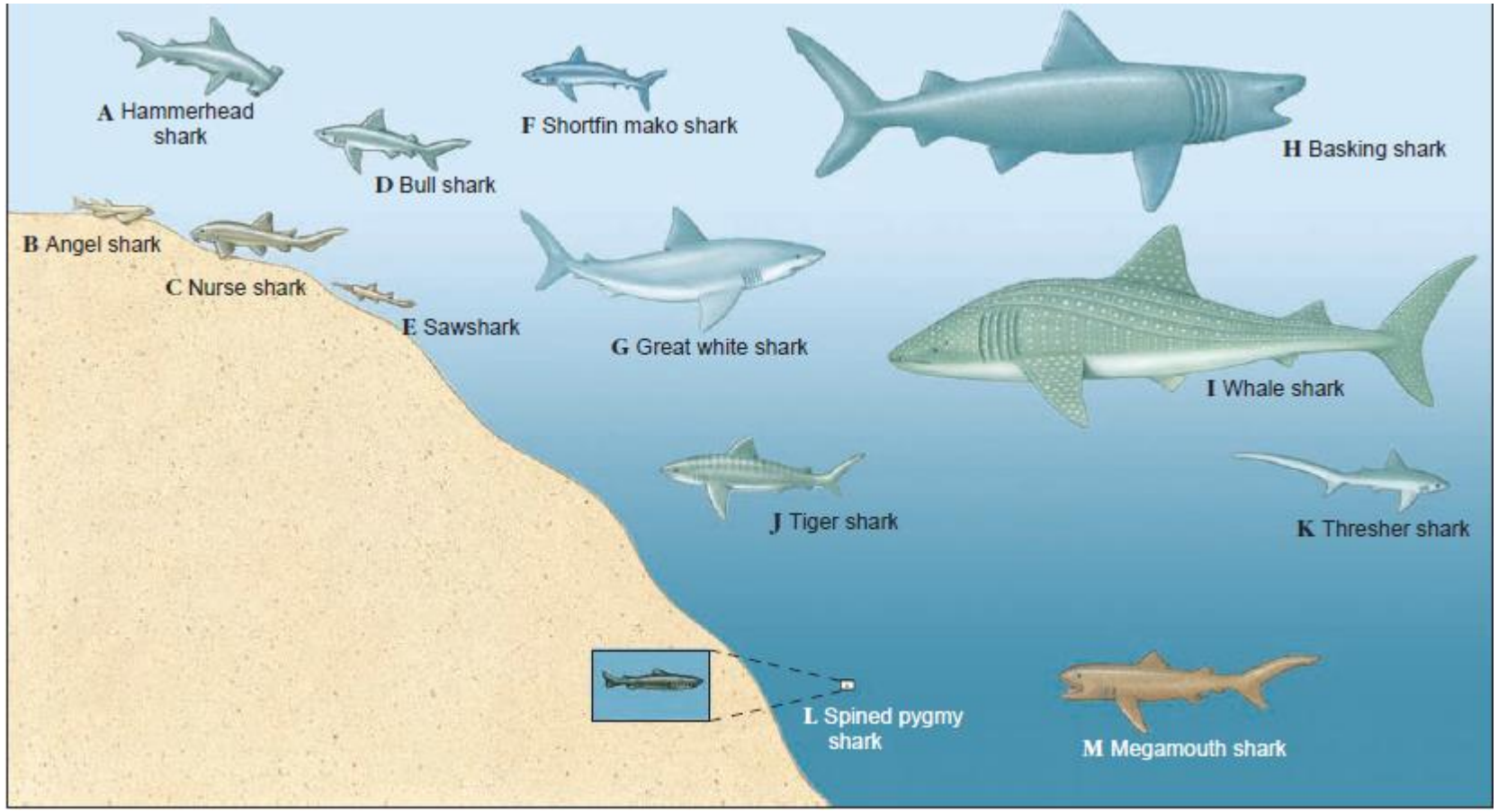
Sea lamprey *Petromyzon marinus*.

Periods of Occurrence of Major Jawless Fish Taxa Based on The Fossil Record



Subclass Elasmobranchii

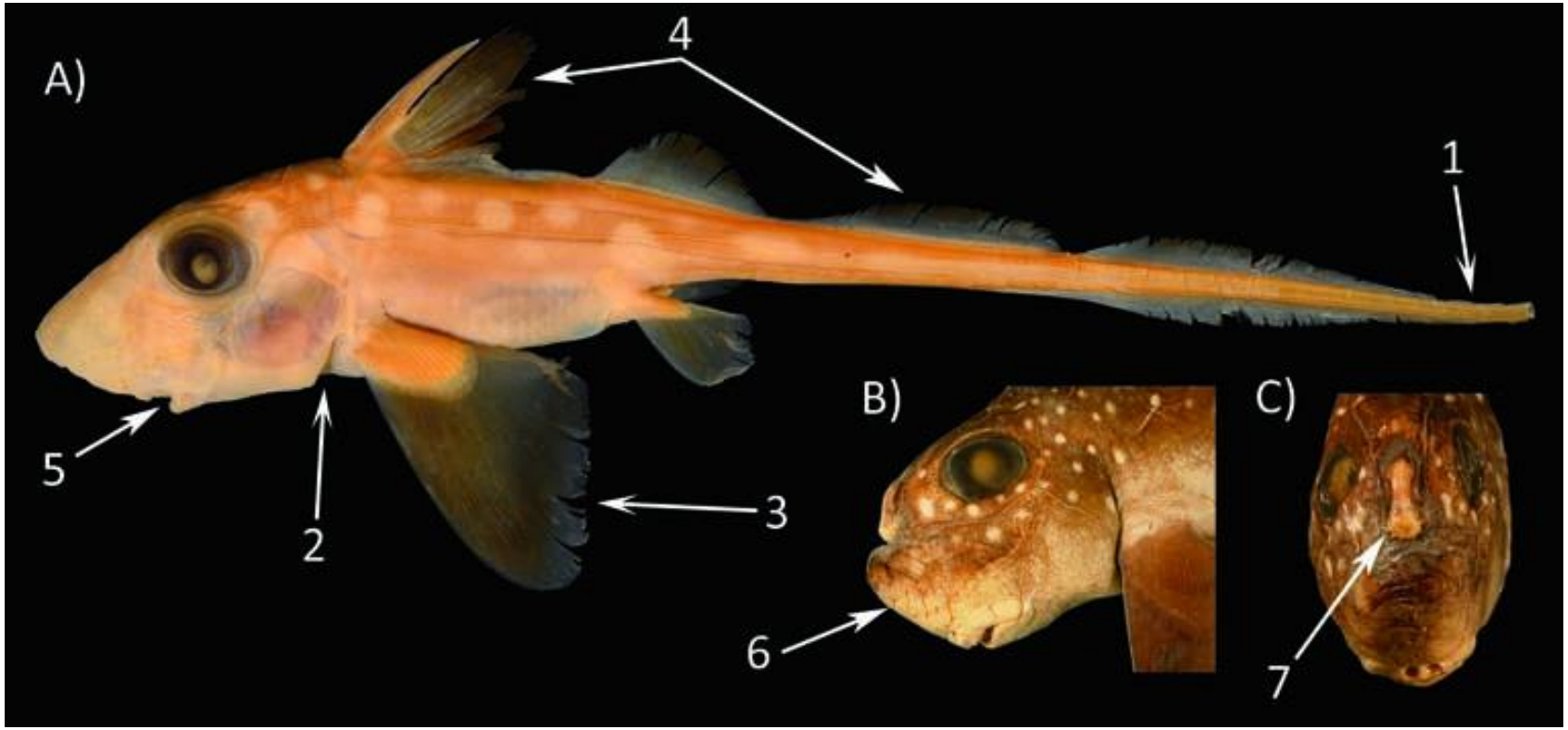
- The 13 living orders of elasmobranchs number about 937 species.



A, *Sphyrna;*
B, *Squatina;*
C, *Ginglymostoma cirratum;*
D, *Carcharhinus leucas;*
E, *Pristiophorus;*
F, *Isurus oxyrinchus;*
G, *Carcharodon carcharias;*
H, *Cetorhinus maximus;*
I, *Rhincodon typus;*
J, *Galeocerdo cuvier;*
K, *Alopias vulpinus;*
L, *Squaliolus laticaudus;* and
M, *Megachasma pelagios.*

Subclass Holocephali

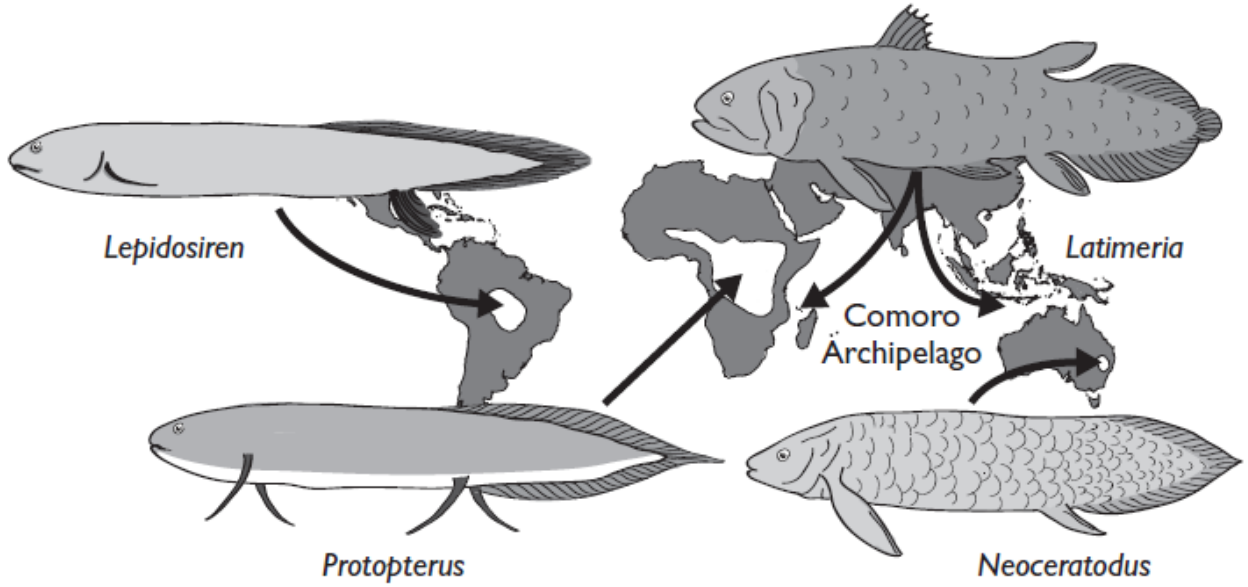
- The Chimaeriformes includes three families, six genera, and approximately 50 species of generally deep-sea predators.



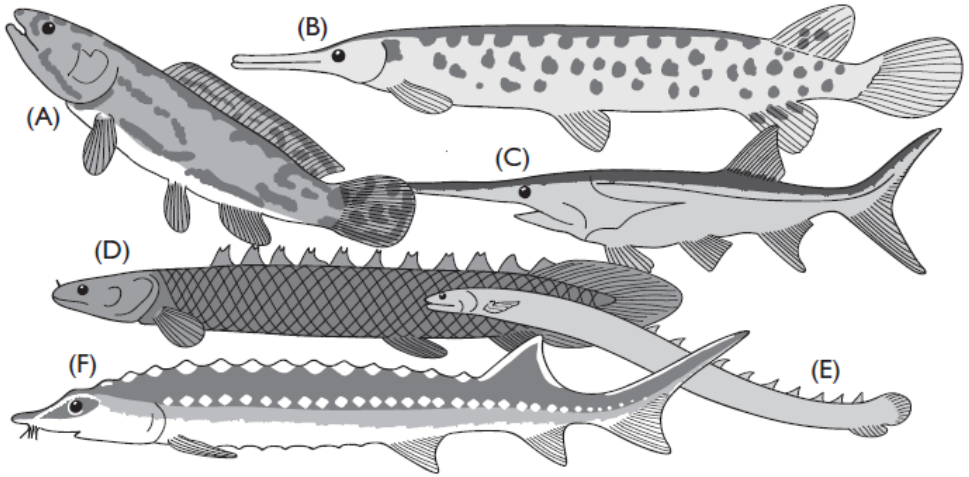
1. body elongate with a whip-like tail, body usually naked
2. one external gill opening, anterior to pectoral fin
3. pectoral fins broad and wing-like
4. two dorsal fins: the first high with an erectile spine, the second low with a long base
5. mouth inferior
6. conspicuous lateral-line canals on snout
7. males with a club-like clasper on top of head
8. pelvic claspers bi-lobed
9. spiracles absent

Class Sarcopterygii

- Sarcopterygians were common in fresh water during most of the Paleozoic, but today the only surviving sarcopterygians are three genera of lungfishes (dipnoans) living in tropical streams and rare coelacanths, confined to the deep waters of the Indian Ocean.



Class Actinopterygii



(A)Bowfin (*Amia*); (B) garpike (*Lepisosteus*); (C) paddle fish (*Polyodon*); (D) bichir (*Polypterus*); (E) reedfish (*Calamoichthys*); (F) sturgeon (*Acipenser*).

Chondrostei

- Share primitive characters → spiracles and a spiral valve.
- The paired lung-like septated swimbladder.

Holostei

- The skeleton is strongly ossified, the fins are more flexible, although with fewer fin rays than chondrosteans, and there is no spiracle.
- The heart has a large conus, and there is a reduced spiral valve in the intestine.

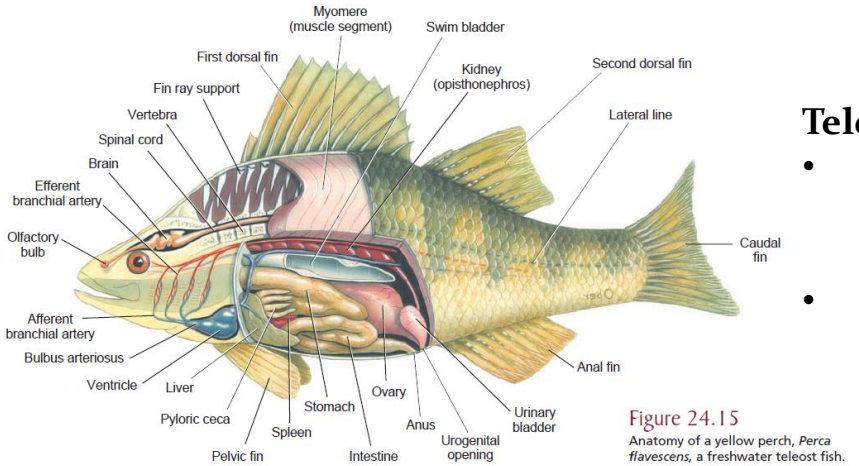
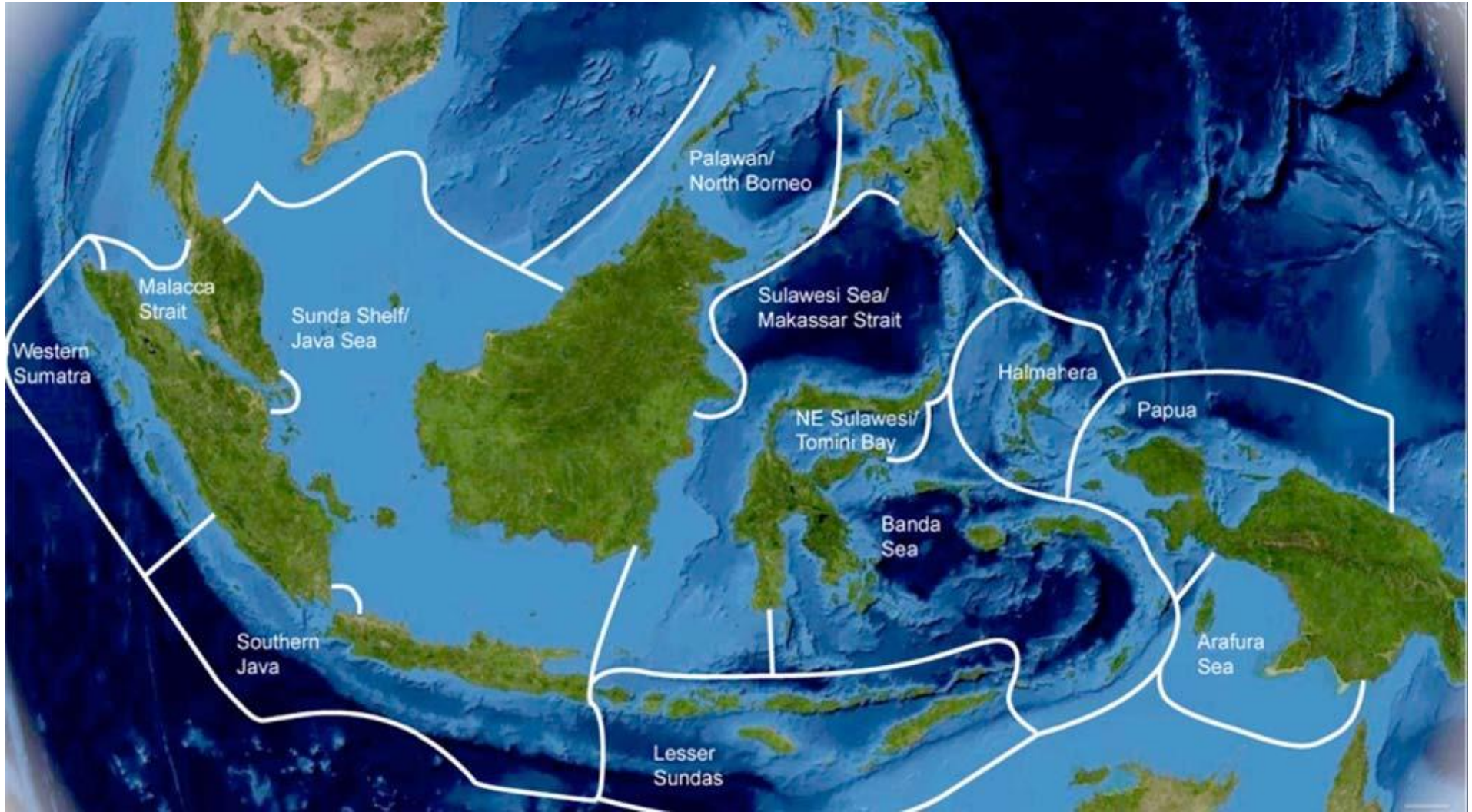


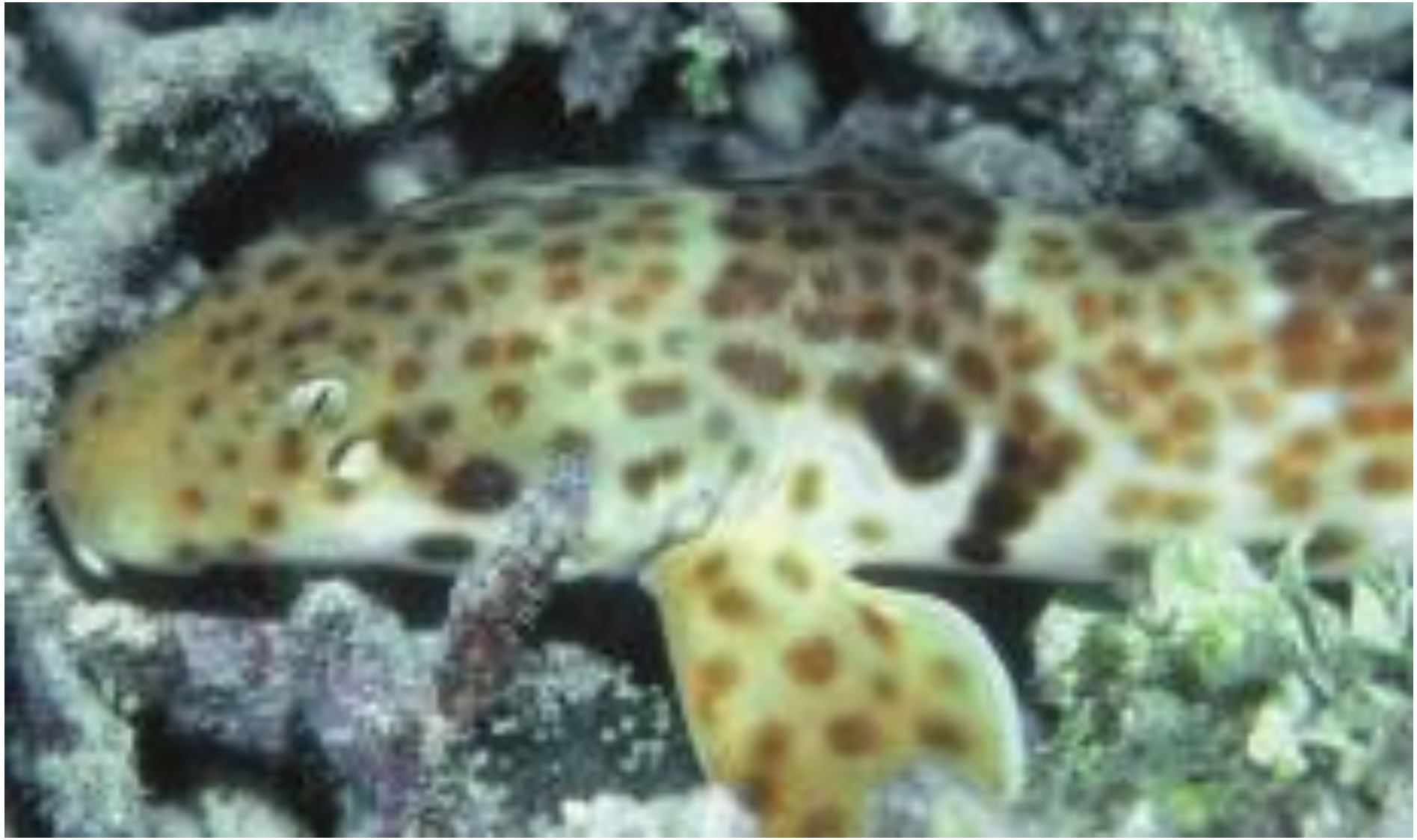
Figure 24.15
Anatomy of a yellow perch, *Perca flavescens*, a freshwater teleost fish.

Teleostei

- Generally more active, faster swimmers and more lightly built, with more flexible fins built from fewer fin rays.
- The heart has an elastic bulbus instead of the holostean contractile conus, and there are usually complex gut diverticula (pyloric ceca).

Conservation of Indonesian Waters





Corythoichthys sp., Raja Ampat Is. (G. Allen).

Hippocampus kampylotrachelos, Bali (A. Ogawa).

Application of DNA barcoding to detect mislabeling of fish fillet products from Jabodetabek's market

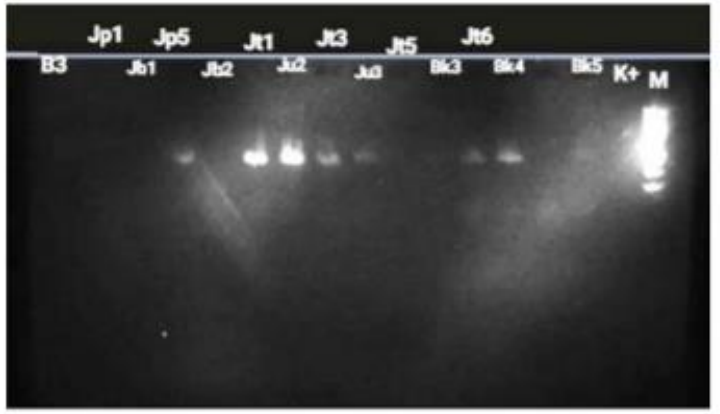


Figure 5. Electrophoresis Gel of B3, JB1, JB2, JU2, JU3, BK4, BK5, JP1, JP5, JT1, JT3, JT5, JT6.

Table 1. Species identified from samples.

Brand no.	Sample code	Species label on product	Species identified	Label	IUCN status
1	JS9, JU4, B4	Tilapia	*Oreochromis niloticus*	+	LC[a]
2	JB3, B1, BK1, JU2, T2, JP3, JS6, D2	-	*Prionace glauca*	—[*]	NT[b]
3	B2, D1	Tilapia	*Oreochromis mossambicus*	+	NT
4	T3, BK2, B3, T5, JP4, D3	Pangasius	*Oreochromis niloticus*	—	LC
5	B5	Dory	*Pangasianodon hypophthalmus*	—	EN[c]
6	JT4, BK4	Pangasius	*Diagramma picta*	—	NT
7	BK5, JT6, JS5	Pangasius	*Pangasianodon hypophthalmus*	+	EN
8	JT1	-	*Pangasianodon hypophthalmus*	—[*]	EN
9	JU3, T4	-	*Prionace glauca*	—[*]	NT
10	JP5	Pangasius	*Pangasianodon hypophthalmus*	+	EN
11	D4	Gindara	*Lepidocybium flavobrunneum*	+	LC

[*] Samples are non-labeled fish fillet
[a] Least Concern
[b] Near Threatened
[c] Endangered

+ : Correct Label
— : Mislabel