PHYLUM: CHORDATA

SUBPHYLUM: VERTEBRATE (CRANIATA)

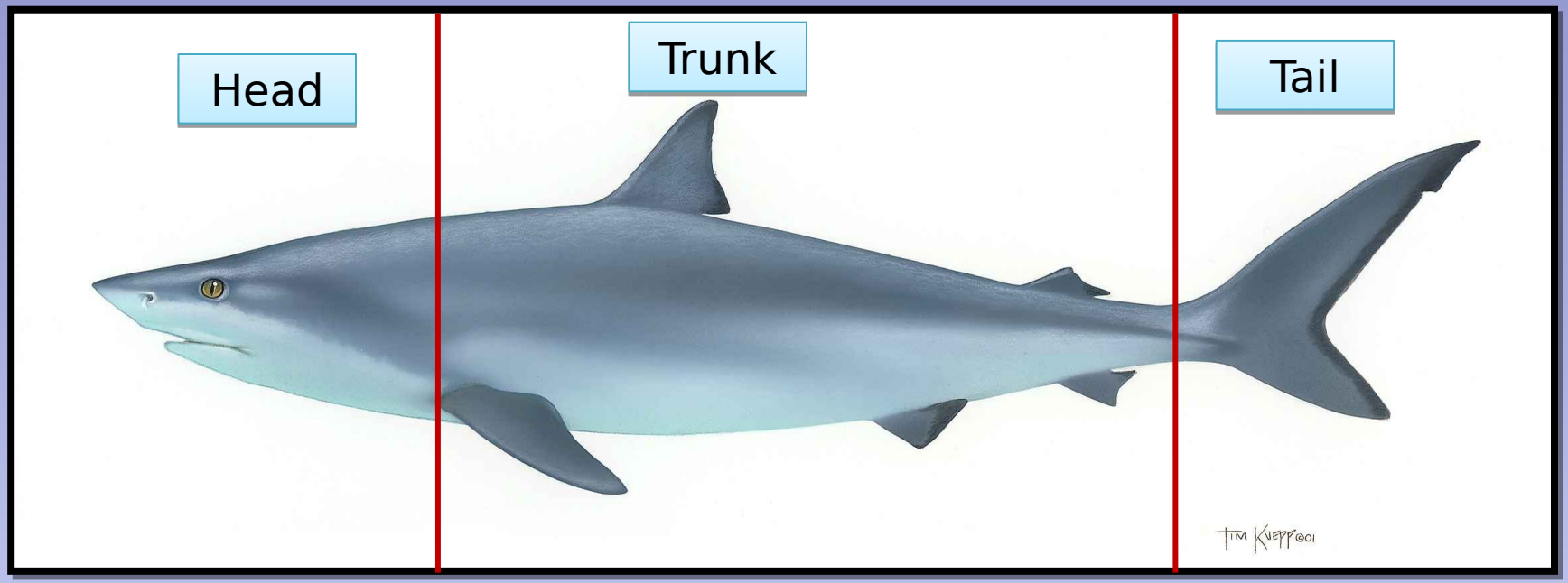
SUPERCLASIS: GNATHASTOMATA (JAWED FISHES)

CLASS I: CHONDRICHTYES (CARTILAGINOUS FISHES)

CLASS II: ACTINOPTERYGII (RAY-FINNED FISHES)

CLASS III: SARCOPTERYGII (LOBE-FINNED FIHES)

CLASS I: CHONDRICHTHYES
EXTERNAL FEATURES-MORPHOLOGY



Body Fusiform

Body dorsoventrally compressed

Median Fins

Heterocercal caudal fin

First Dorsal Fin

Free Rear Tip

Caudal Fin

Upper Lobe

Pre-Caudal Pit

Spiracle

Eye

Second Dorsal Fin

Snout

Placoid scales (Homologous mammalian teeth)

Subterminal Notch

Mouth

Rear Margin

Nostril

Gills

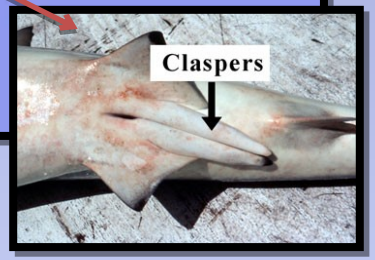
(5-7 pairs

Pectoral Fin

Anal Fin

Lower Lobe

Pelvic Fin

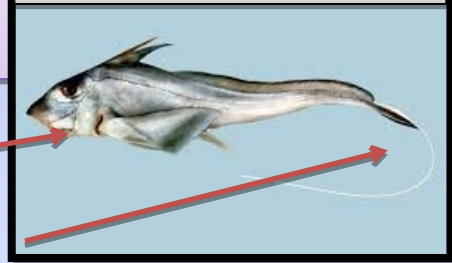


Median fin

Paired Fins
It is the first time seen in cartilaginous fish

Anal fin is not found in *Squalus*

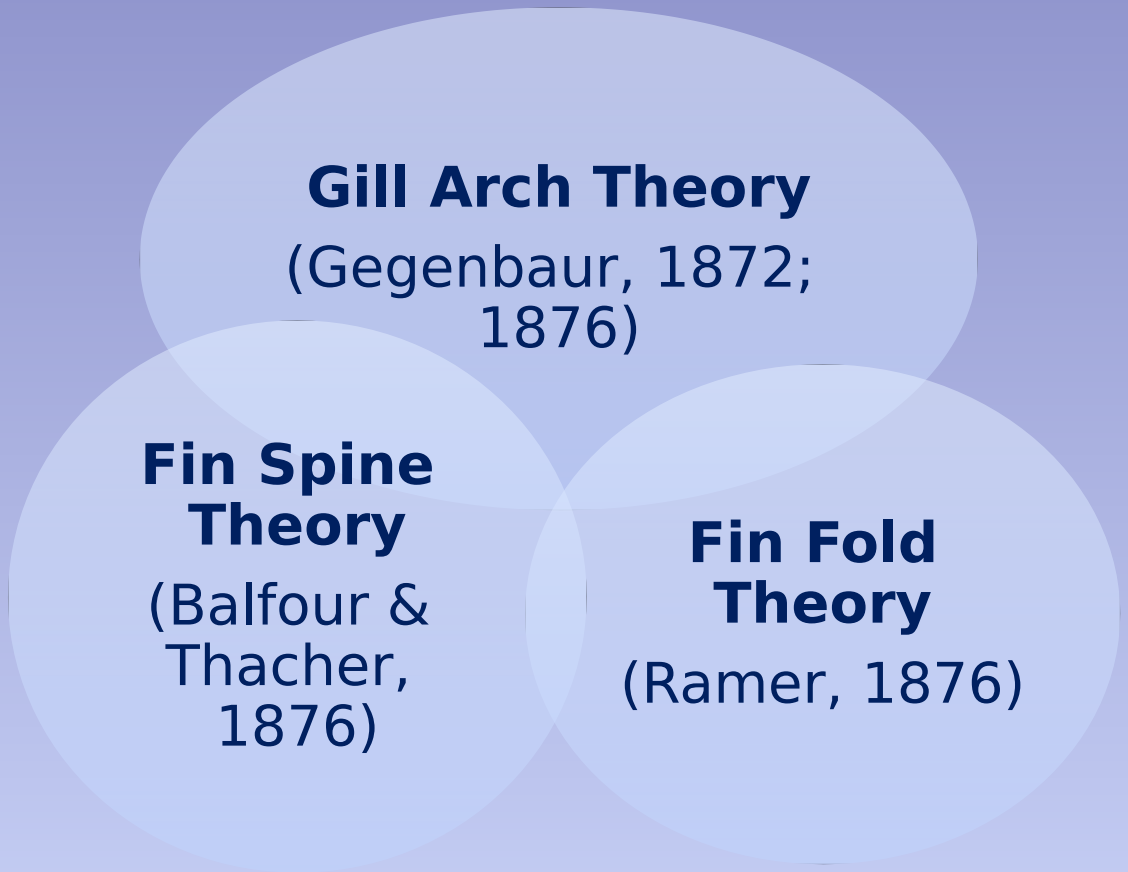
Chimaeras



Teeth covered with enamel

Operculum
Diphycercal

How did the paired fins occur? Development of Paired Fins



NO CLEAR ANSWER-MAY BE MORE THAN ONE OF THESE THEORIES COULD BE ACCURATE (CONVERGENT EVOLUTIONS)

Gill ArchesTheory

- Posterior gill arches became modified to form pectoral and pelvic girdles
- That modified gill rays formed the skeleton of fins.
- If we think the position of pectoral and pelvic fins

NOT ACCEPTABLE

Fin Fold Theory

- A continuous thickening of the ectoderm.
- Paired fins arose within a paired but continuous set of **ventrolateral folds** in the body wall.
- Interrupted at intervals.
- **Intermediate ones were lost.**
- **Remaining portions supposedly evolved into pectoral and pelvic fins.**

The Evidence Supporting The Accuracy of Fin Fold Assumptions

1. Similar skinfolds in *Amphioxus*

2. Fins-like extensions between the pectoral and ventral fins in the *Climatius* (Living in Devonian)

3. The base section of the *Cladoselache* (lived in Late Devon) has got paired fins supported by wide and parallel rays

4. The presence of skinfolds in the appearance of the fin in some sharks embryos (*Scyllum*) living today

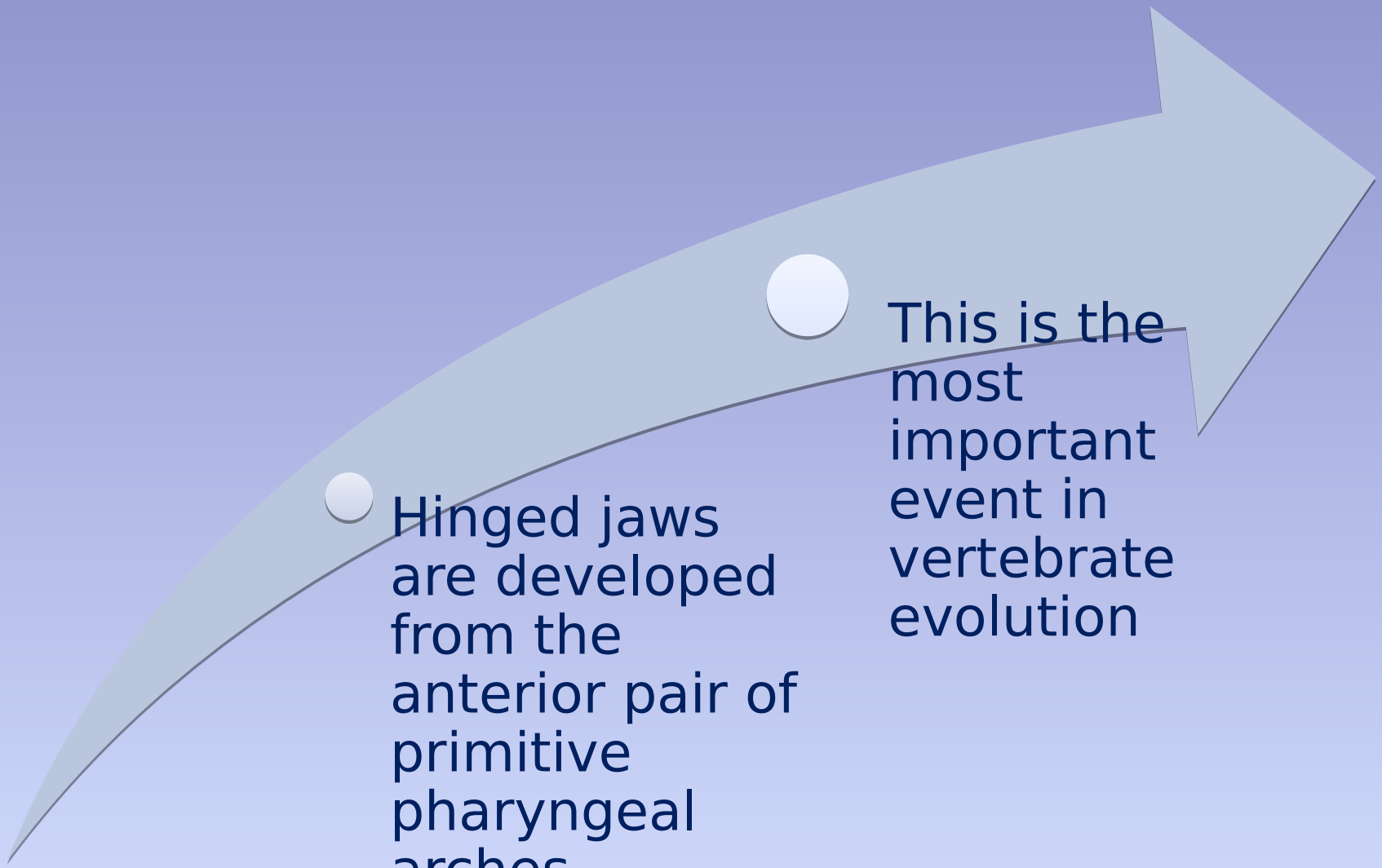
Fin Spine Theory

Spiny sharks (Acanthodians) possessed as many as **seven pairs of spiny appendages along their trunks**

anterior pair develop into **pectoral fins**; posterior pair develop **pelvic fins**

In some forms, a flesy weblike membrane was attached to each spine.

Development of Hinged Jaws



Permitted the capture and ingestion of a much wider array of food than was available to the jawless fishes

Permitted the development of predatory life styles

Selectively capture more food

Occupy more niches than jawless fishes

THUS

More likely to survive and leave offspring

Defensive purposes

SKELETAL SYSTEM

- Body made of cartilage
- They do not have ribs and bone narrow

EXOSKELETON: Scale (Placoid) and Rays of fins

ENDOSKELETON

a. Axial Skeleton: Head, vertebrae; reduced notochord

b. Appendicular Skeleton: Median (dorsal; anal; caudal) and lateral (paired: pectoral and pelvic) fins

Except for the ventral lobe of the caudal fin, others are not associated with the vertebrae

MUSCULAR SYSTEM AND MOVEMENT

Movement provided by myotomes.

- **Well-developed muscular caudal fin propels them through the water**
- **Paired pectoral fins enable steering**
- **Dorsal fins provide stability**

They haven’t got swim-bladder
They have to move continuously because of not submerged

DIGESTIVE SYSTEM

MOUTH → PHARYNX → ESOPHAGUS (SHORT) → STOMACH → SMALL INTESTINE → CLOACA → ANUS
(Spiral valve)

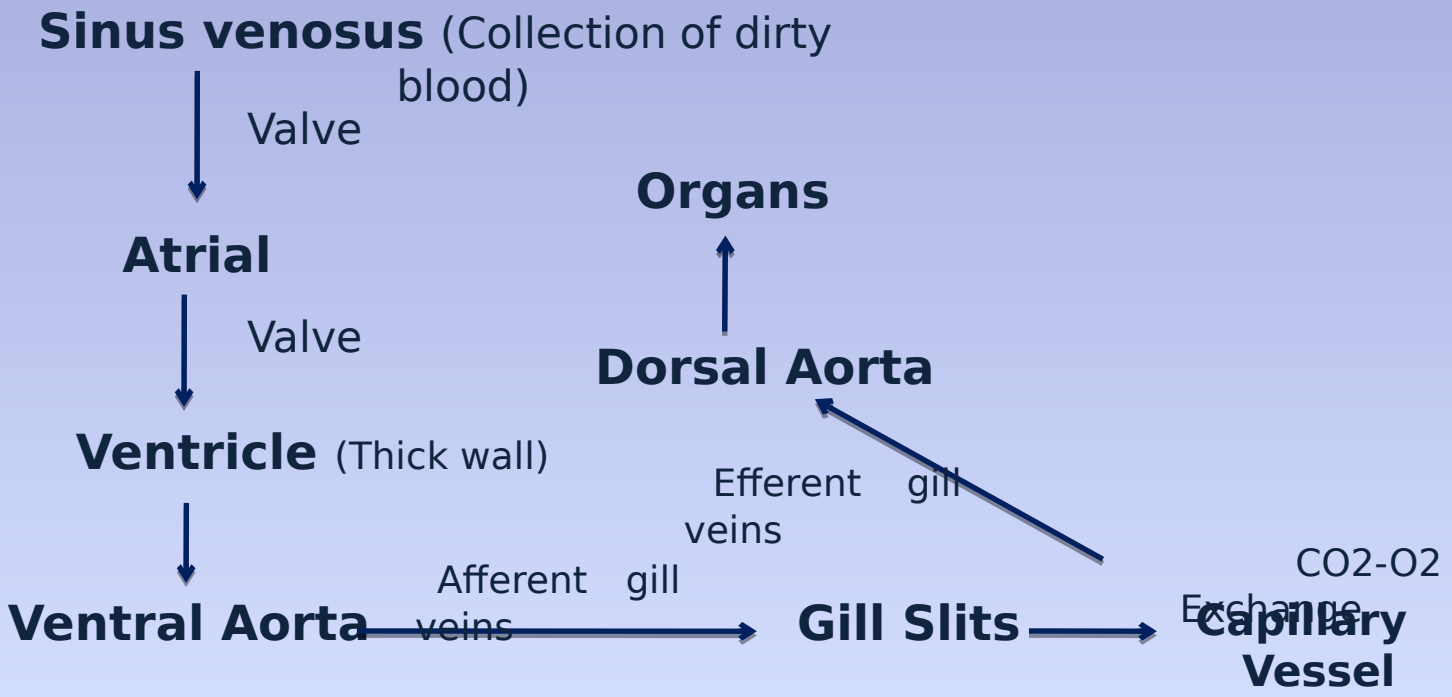
- Width and ventral position
- Jaws with polyphyodont teeth (rolled backward and renewed
- Foods are mostly swallowed

- The openings on both sides of the pharynx are connected to the gill slits and the spiracle.
- **No mouth and pharynx digestion.**
- **of**

- **Muscular J-shaped stomach**
- **Liver Functions:** Storage of nutrients; degradation of red blood; hydrostatic organs

CIRCULATORY SYSTEM

Two chambered heart consist of sinus venosus, atrium, ventricle and conus with three rows of valves



RESPIRATORY SYSTEM

- **Gill-breathing (5-7 pairs of gills)**
- **No swim-bladder**
- **Spiracles** do not have the ability to clean the blood.

There are numerous gill filaments surrounded by abundant capillaries on the gill.

Mouth open and water enter

↓

Mouth closed

↓

The mouth base is folded upwards.

↓

Water enters the pharynx cavity

↓

Water is thrown out from the gill slits and the spiracles opening

UROGENITAL SYSTEM (EXCRETORY AND REPRODUCTIVE)

- **Mesonephric or opisthonephric kidneys.**
- Kidney quite wide in male to carry the sperma.
- The appearence of kidney differs in male and female.
- Front region of the kidney is very narrow in female wherease quite wide in male to carry the sperma.
- Kidney canals are combined with the urogenital canal and opened out of the cloaca.
- Marine Elasmobranchs have developed an interesting solution to the physiological

It differs from other **vertebrate animals because of the large amount of urea in their blood.**

While 2% urea has a lethal effect for other living things, it is necessary to regulate the osmotic pressure in cartilaginous fish.

Both urea and trimethylamine oxide (TMAO) solutes combined with the blood salts, raised the blood solute concentration to exceed slightly that of seawater and eliminating an osmotic in equality between their bodies and surrounding seawater.

slightly more hypertonic.

This is one of the proofs that all vertebrates are an ancestor living in freshwater.

Excess salt in the body is excreted with **a rectal gland** for the osmotic pressure is regulated.

REPRODUCTIVE SYSTEM

- Sexes separate.
- In males, sperm develops in two long testes located on the anterior side of the body cavity.
- The females have two ovaries with a single structure appearance.
- During mating, the males spermatozoa are given to the female's cloaca with the help of Clasper, who acts as a copulation organ.
- Evacuation of sperma is controlled by adrenaline secretion.

- **All of them have internal fertilization**; but maternal support of embryos is highly variable.
- Some sharks and all skates lay large, yolk egss soon after fertilization-**oviparous**
- Some deposit their eggs in a keratinized capsule called **“Mermaid’s purse”.**
- Embryos are feeded from the yolk for a long period (6-9 months ; some of them 2 years).
- Many sharks are **ovovoviparous.** There is no shell in the eggs. The egg opens in the animal's body cavity (*Squalus acanthias*).
- Deep sea cartilaginous fish develop **viviparous reproduction.** In these, embryos receive food from the maternal bloodstream through a placenta or from nutritive secretions **“uterine milk”** produced by the mother.
- In some *Lamna* species, the older embryos in the uterus consume young embryos and unfertilized eggs. This is called **Prenatal Cannibalism**. They have t most two offsprings.

NERVOUS SYSTEM AND SENSE ORGANS

- Examined in three parts: Central, peripheral and autonomous
- CNS: Brain and spinal cord

  PNS: Brain and nerves affrenet from spinal cord

  ANS: Sympathetic; Parasympathetic nerves
- **Brain:** Forebrain, midbrain, hindbrain
- Unlike Cyclostomata forebrain and hindbrain divided into subregions.

Telencephalon (Cerebrum)]
Diencephalon] **Forebrain**

Mesencephalon (Midbrain)]
Metencephalon (Cerebellum)]
Myelencephalon (Medulla oblongata)] **Hindbrain**

- **Vestibular Organ**: Ear is found inside of the cranium. Function is to identify the voices and determine the balance with the direction of the fish.
- Each internal ear contains 3 semicircular canal. Unlike other vertebrate animals, **there is no Lagena**.
- **Skin:** Sensations such as touch and pain
- **Olfactory Organ:** Nostrils are well-developed for smelling.
- There are both scattered taste buds and some chemical sensory organs on the **pharynx.**
- **Vision Organs:** Eyes are well developed for eyesight (prey and predator)
- **Lateral Line System:** It extends from the back of the head to the end of the tail on both sides of the body. It consists of a channel under the skin and the pores that open out at certain intervals.
- There are also many sensory channels (Lorenzini bulb) on the head.

ORIGIN AND FOSSILS

The earliest known jawed vertebrates were the **spiny sharks (Acanthodians) in the Silurian period** (about 440 million years ago)

Placoderms which also possessed jaws and whose bodies were covered with dermal bony plates become the dominant fishes during most of the Devonian period

Placoderms were too specialized to be directly intermediate between Ostracoderms and modern groups of fishes.

Chondrichthyes are thought to have arisen from Pacoderm ancestors

Recent fossils finds from China indicate that existence of several different jawed fishes in the Silurian.