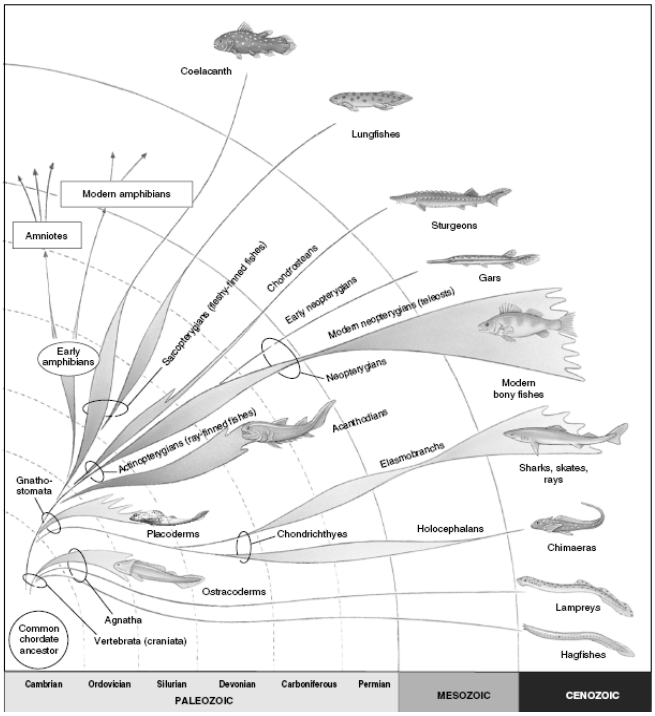


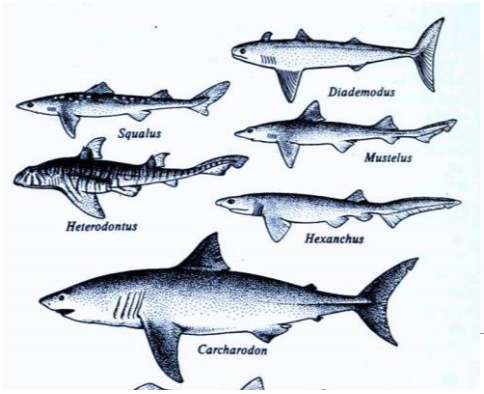
Class Chondrichthyes

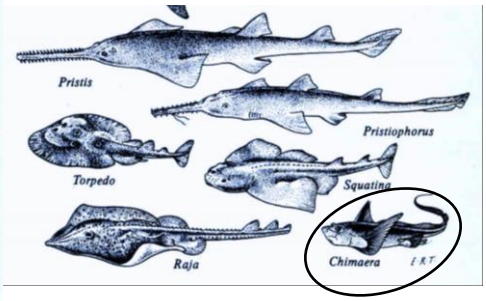
(Cartilageous fishes)

subclass elasmobranchi (sharks, skates and rays)

subclass holocephali (chimaeras)

- What ensures them to be secure in aquatic community?
- Apomorph character in skeleton!!!!!!!!!!!!!!!!!!!!





The most important charactristics of Chondricthyes

1. Large (average about 2 m), **body fusiform,** or dorsoventrally depressed, with a **heterocercal** caudal fin (diphycercal in chimaeras); paired pectoral and pelvic fins, two dorsal median fins; pelvic fins in male modified for **"claspers"**

2. **Mouth ventral;** two olfactory sacs that do not open into the mouth cavity in elasmobranchs; nostrils open into mouth cavity in chimaeras; **jaws** modified from pharyngeal arch

3. Skin with **placoid scales** or naked in elasmobranchs; skin naked in chimaeras; teeth of modified placoid scales and serially replaced in elasmobranchs; teeth modified as **grinding plates** in chimaeras

4. **Endoskeleton entirely cartilaginous;** notochord persistent but reduced; vertebrae complete and separate in elasmobranchs; vertebrae present but centra absent in chimaeras; appendicular, girdle, and visceral skeletons present; **cranium Sutureless**

5. Digestive system with J-shaped stomach (stomach absent in chimaeras); **intestine with spiral valve;** often with large oil-filled liver for buoyancy

6. Circulatory system of several pairs of aortic arches; dorsal and ventral aorta, capillary and venous systems,hepatic portal and renal portal systems; four-chambered heart with sinus venosus, atrium, ventricle, and conus arteriosus.

7. Respiration by means of five to seven pairs of gills leading to exposed gill slits in elasmobranchs; four pairs of gills covered by an operculum in chimaeras

8. No swim bladder or lung 9. Opisthonephric kidney and rectal gland; blood isosmotic or slightly hyperosmotic to sea water; **high concentrations of urea and trimethylamine oxide in blood**

10. Brain of two olfactory lobes, two cerebral hemispheres, two optic lobes, cerebellum, medulla oblongata; 10 pairs of cranial nerves; **three pairs of semicircular canals**

11. Senses of smell, vibration reception (lateral line system), vision, and electroreception well developed; inner ear opens to outside via endolymphatic duct

12. Sexes separate; gonads paired; reproductive ducts open into cloaca (separate urogenital and anal openings in chimaeras); oviparous, ovoviviparous, or viviparous; direct development; **fertilization**

وجه تمایز ماهیان غضروفی با دهان گردان

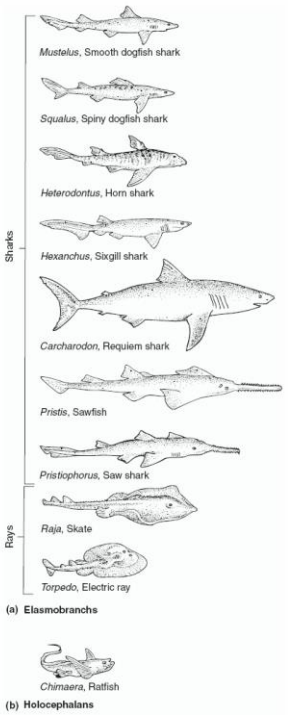
– بدن‌شان پوشیده از فلس است.

– دو زوج باله طرفی دارند.

– آرواره‌های قابل تحرک دارند که به جمجمه متصل شده.

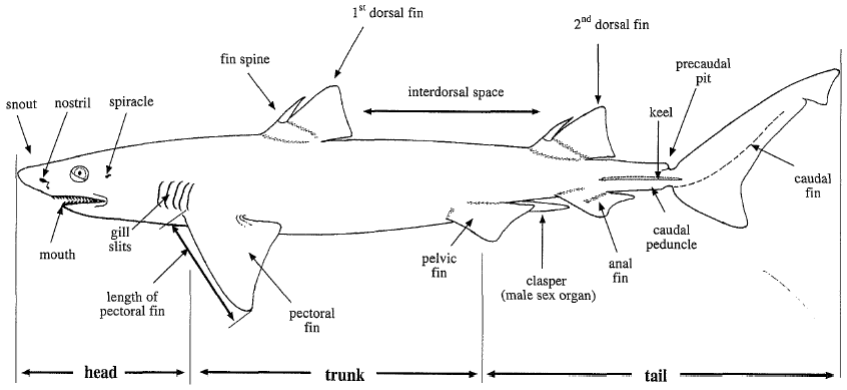
– دندان‌های آن‌ها مینا دارد و مجرای نیم دایره گوش داخلی 3 عدد است.

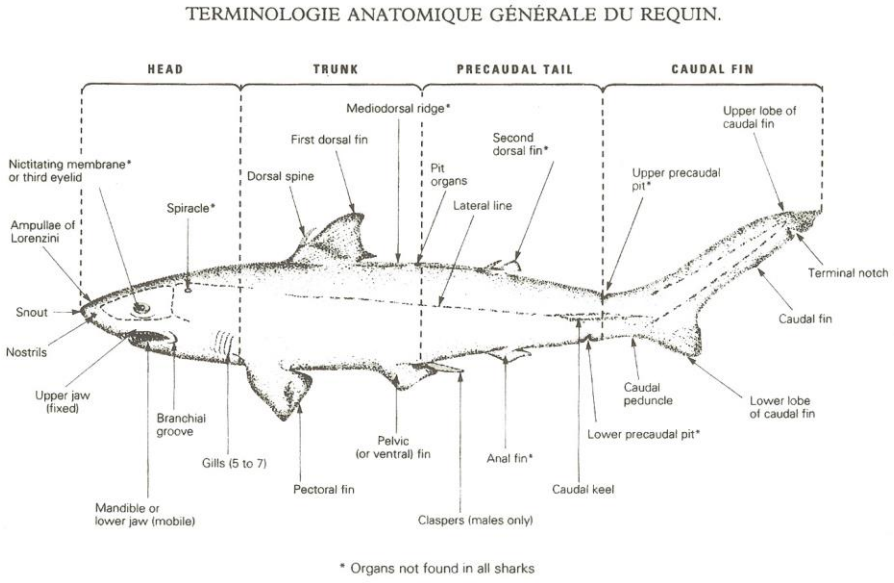
Subclass elasmobranchii



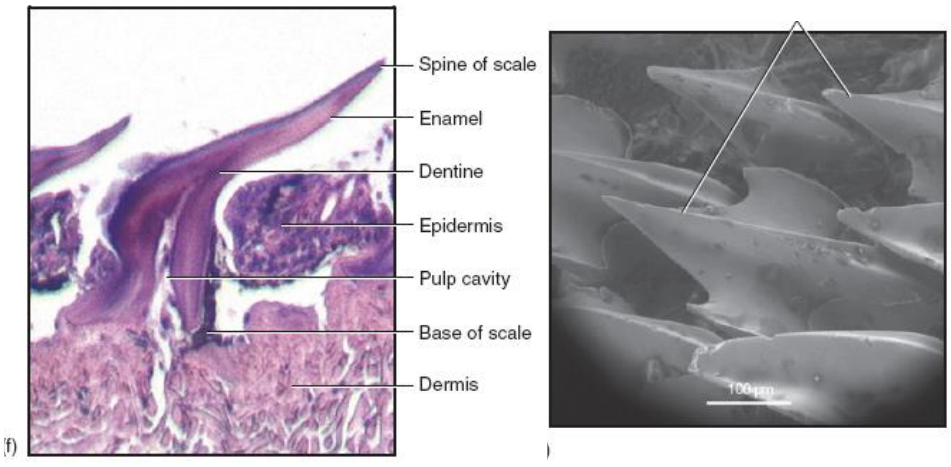
Morphological character

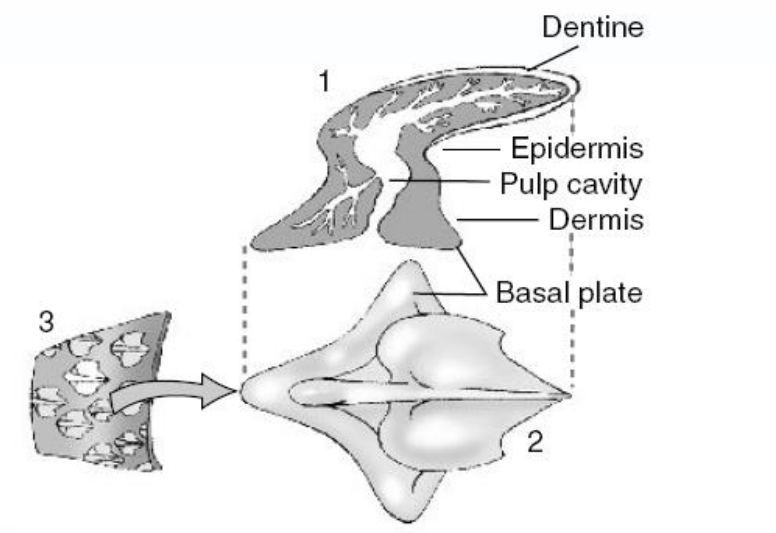
ویژگی های مورفومتریک(اندازه گیری)، مریستیک(شمارشی)، تشریحی (شکل و نوع و بود و نبود)، رنگ بندی، کاریوتایپ(تعداد و شکل کروموزوم ها) و بیوشیمیایی(پروتئین ها و DNA)



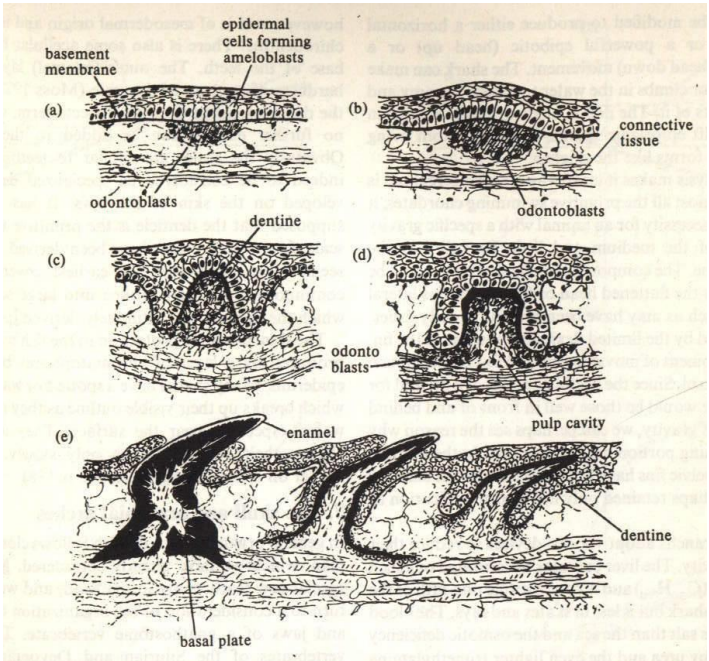

TERMINOLOGIE ANATOMIQUE GÉNÉRALE DU REQUIN.
HEAD
TRUNK
PRECAUDAL TAIL
CAUDAL FIN
Mediodorsal ridge*
First dorsal fin
Second dorsal fin*
Upper lobe of caudal fin
Nictitating membrane* or third eyelid
Dorsal spine
Pit organs
Upper precaudal pit*
Spiracle*
Lateral line
Ampullae of Lorenzini
Terminal notch
Snout
Caudal fin
Nostrils
Upper jaw (fixed)
Caudal peduncle
Lower lobe of caudal fin
Branchial groove
Pelvic (or ventral) fin
Lower precaudal pit*
Gills (5 to 7)
Anal fin*
Pectoral fin
Caudal keel
Mandible or lower jaw (mobile)
Claspers (males only)
* Organs not found in all sharks

Skin


Spine of scale
Enamel
Dentine
Epidermis
Pulp cavity
Base of scale
Dermis
100 µm


Dentine
1
Epidermis
Pulp cavity
Dermis
Basal plate
3
2

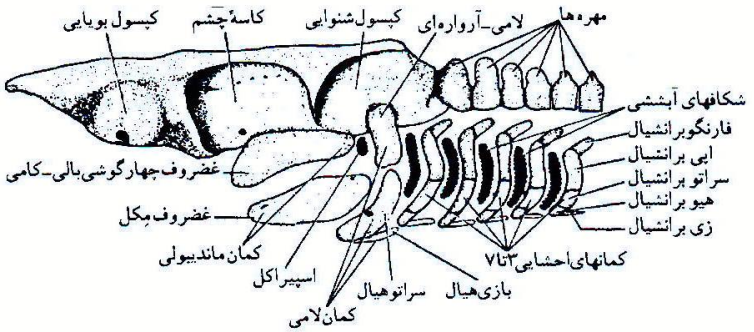
(a) Placoid


epidermal cells forming ameloblasts
basement membrane
(a)
odontoblasts
(b)
connective tissue
odontoblasts
dentine
(c)
(d)
odonto blasts
pulp cavity
(e)
enamel
dentine
basal plate

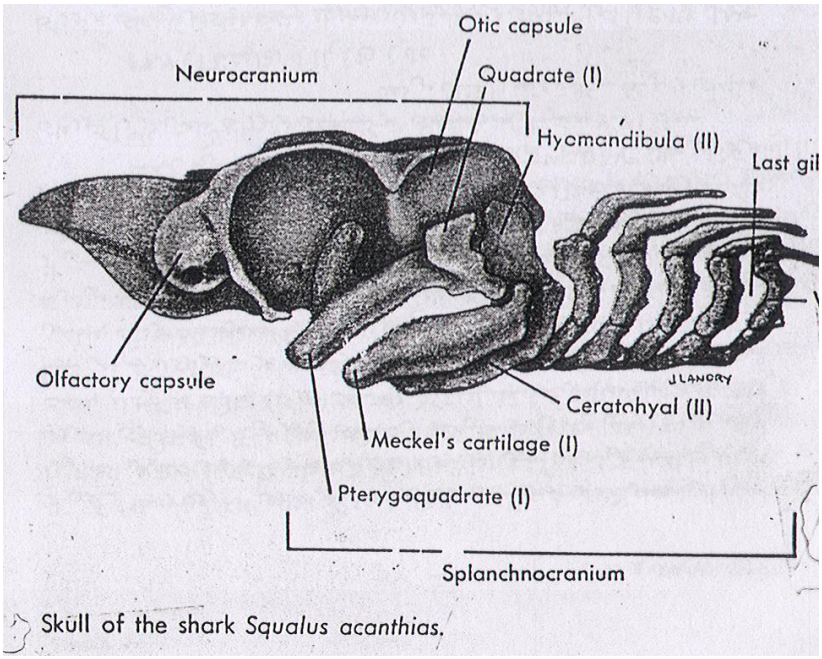
Skelton

نوتوکورد، مهره ها و ستون مهره ها، کمربند ها

اسکلت سری (Cephalic skeleton)

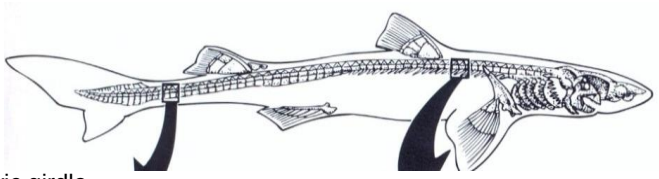


شکل ۳-۳ این طرح ارتباط کمانهای احشایی را به جمجمه، ستون مهره‌ها و شکافهای برانشی ، الاسموبرانش نشان می‌دهد.



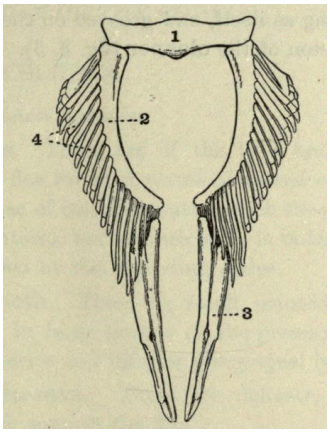
Skull of the shark *Squalus acanthias*.

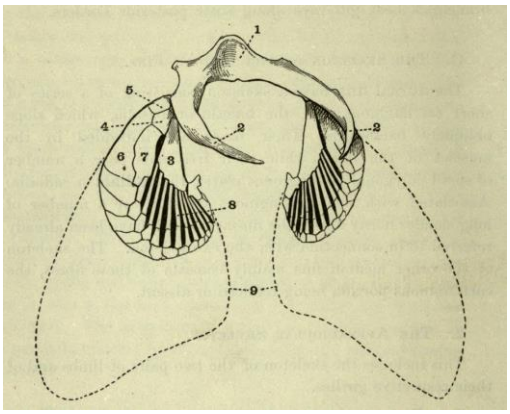
Apendicular skeleton



1. pelvic girdle.
2. basi-pterygium.
3. clasper.
4. radialia.

2,1. (scapular portion) pectoral girdle
3-5, ptrygium, 6,7,8 radials





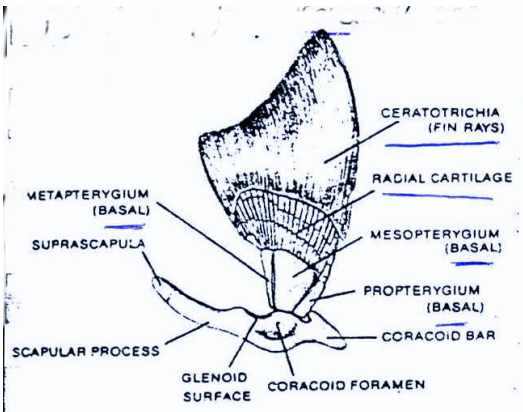


Figure 64 Left lateral view of the pectoral girdle and fin.

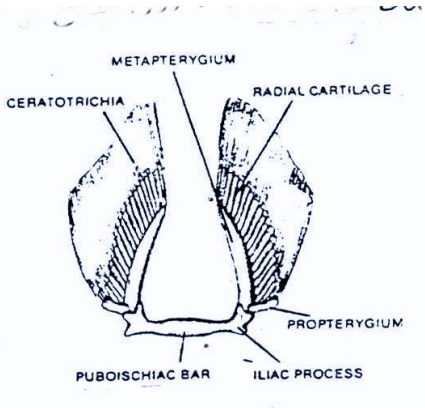
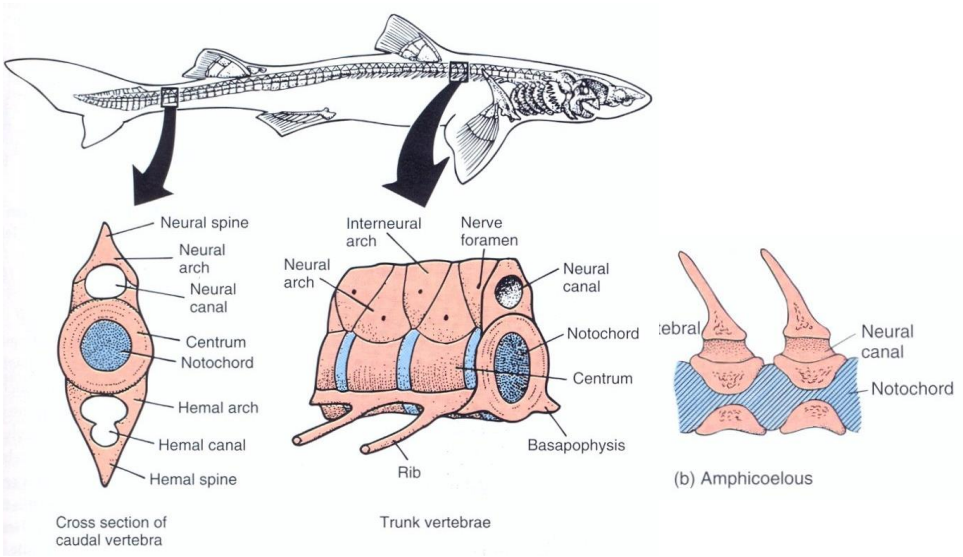
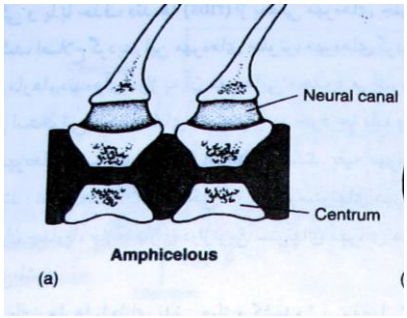
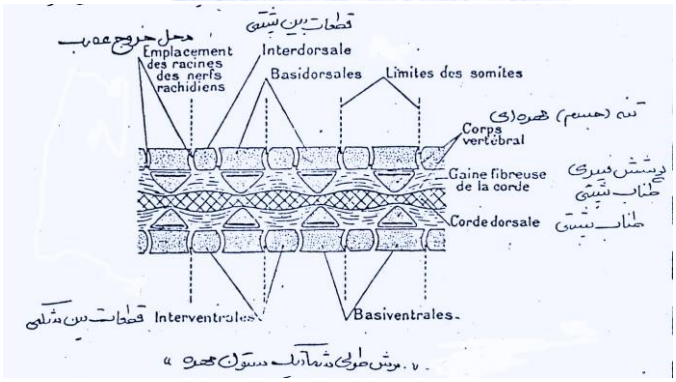


Figure 65. Dorsal view of the pelvic girdle and fins of a female shark. Kistley, 1981

اسکلت تنه (Axial skeleton)



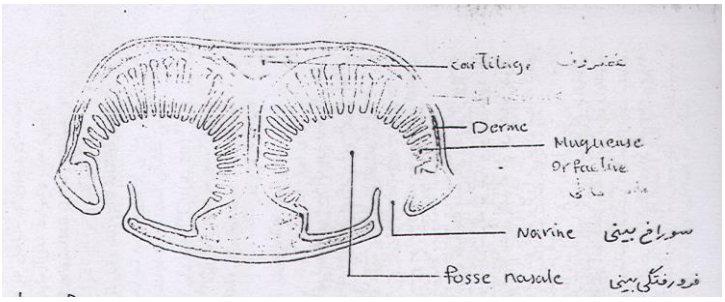




How does a shark catch the pray?

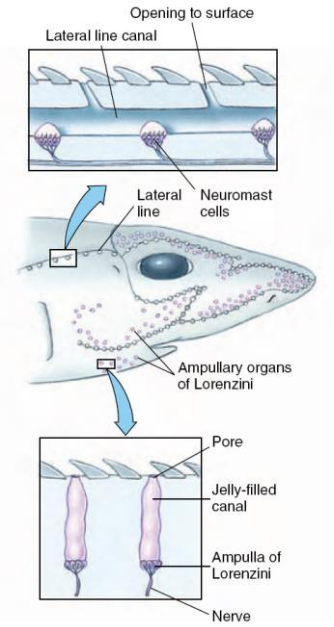
- Step one

  Olfactory organ



Step two

- Lateral line system



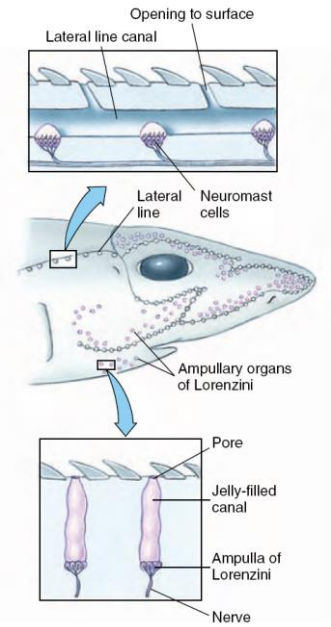
Step three

- Vision
- tapetum lucidum
- دوربینی ، تحدب عدسی در این جانوران خیلی زیاد نیست

- چشم پینه‌ای یا چشم سوّم: در سقفDiencephalon قرار گرفته است

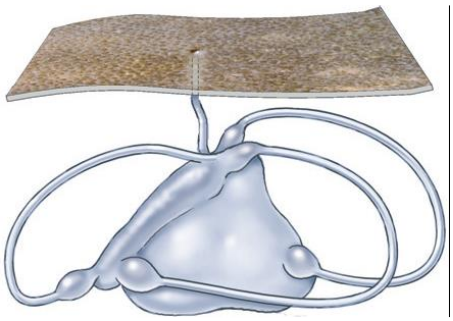
Step four

- Ampullae of Lorenzini

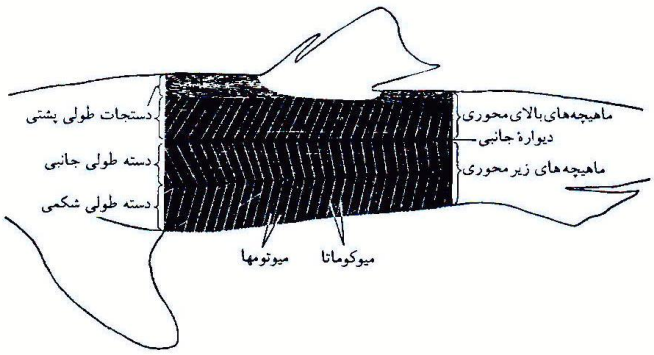


ears

- در ماهیان غضروفی گوش میانی و خارجی وجود ندارد
- مجرای Endolymphatic

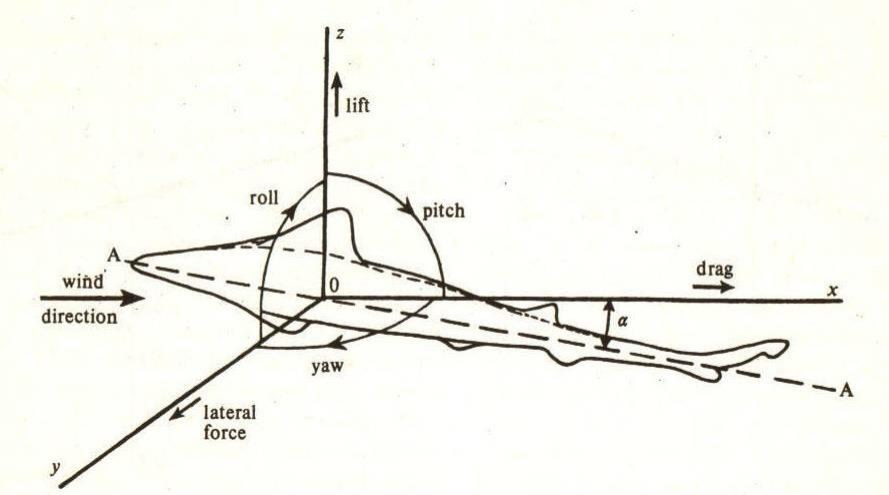


Muscles



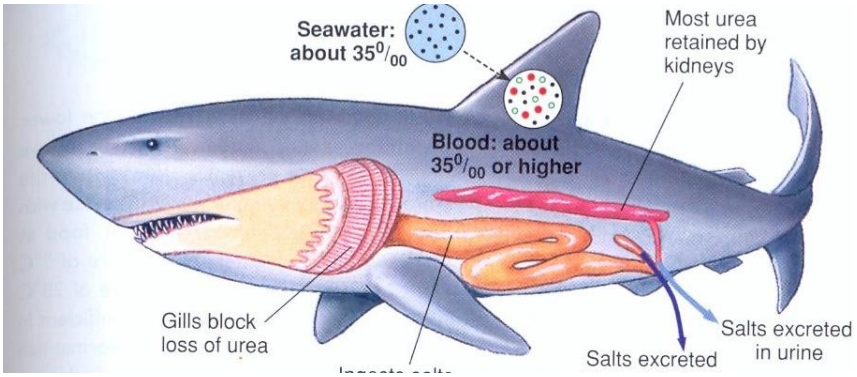
شکل ۵.۳ نمای جانبی بخشی از دیوارهٔ بدن سگ‌ماهی (*اسکوآلوس آکانثیاس*[۳]) که فرم زیگزاگی میوتوم‌ها را نشان می‌دهد. پوست این بخش برای نمایش ماهیچه‌های زیر آن برداشته شده است.

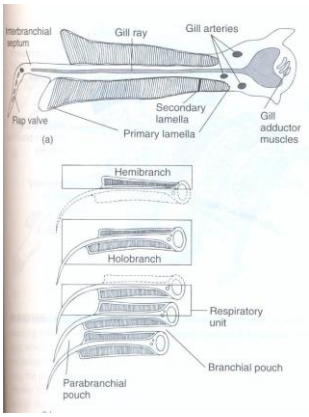
motion

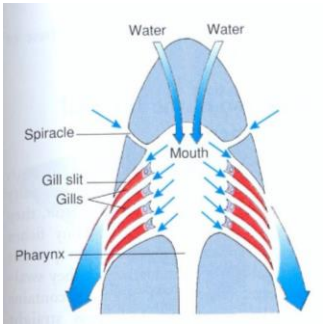


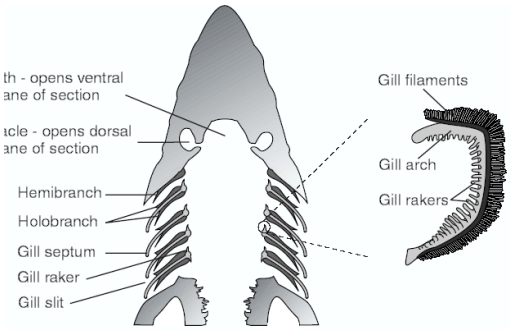
Respiration

ساختار آبشش ها وتنفس، نقش اسپیراکل ها در کوسه و سفره ماهی،







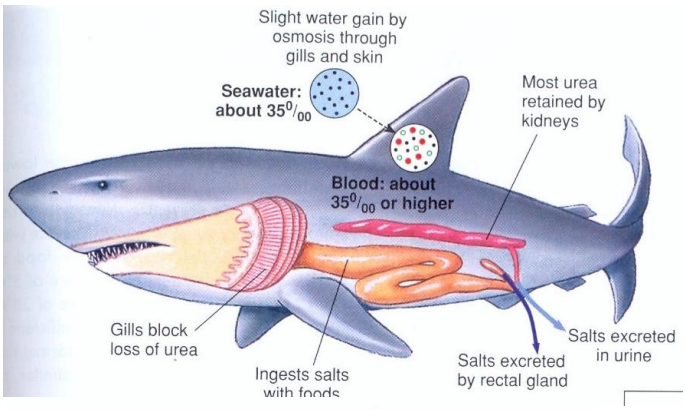


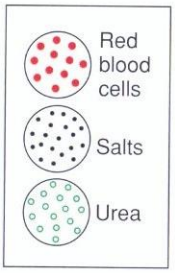
ورود آب به دستگاه تنفس:

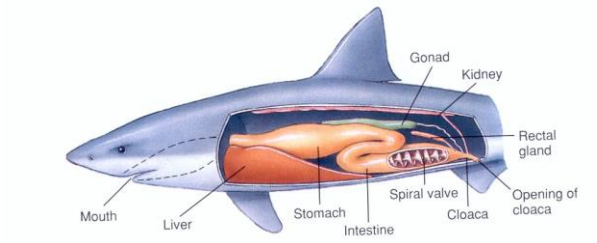
۱- Ram ventilation

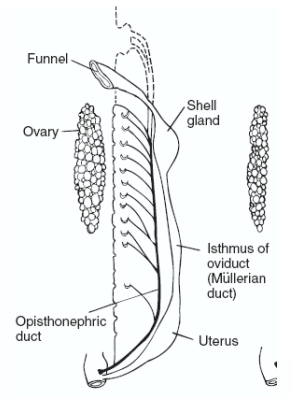
۲- پمپ دهانی- حلقی

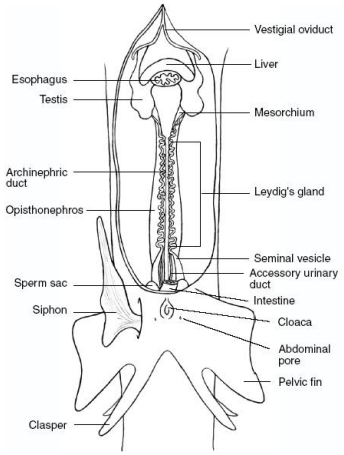
دستگاه دفعی: کلیه های مزونفروس(اپیستو نفریک)، غده rectal ، آبشش ها و پوست بدن



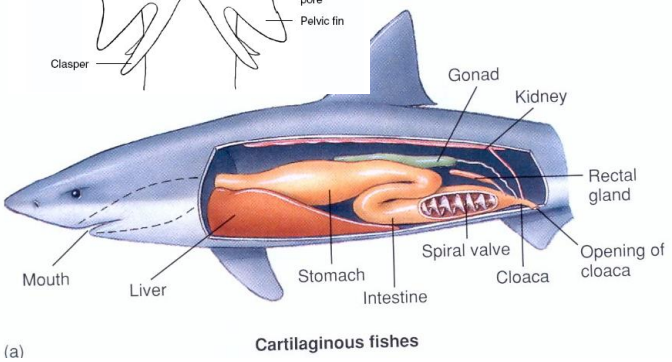




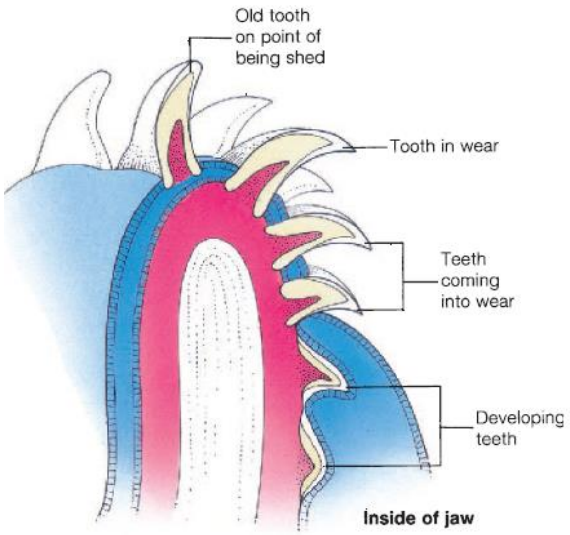




سیستم تناسلی و جفت گیری، تولید مثل و سیکل زندگی: برخی زنده زا (نوزاد در رحم از طریق اسپیراکل مواد آبکی دریافت می کند و در برخی کیسه زرده و پرز های رحم حالتی مثل جفت ایجاد می کنند) و برخی تخمگذارند. لقاح در همه آنها داخلی و تخم پرزرده است. رشد مستقیم است.



Digestive system



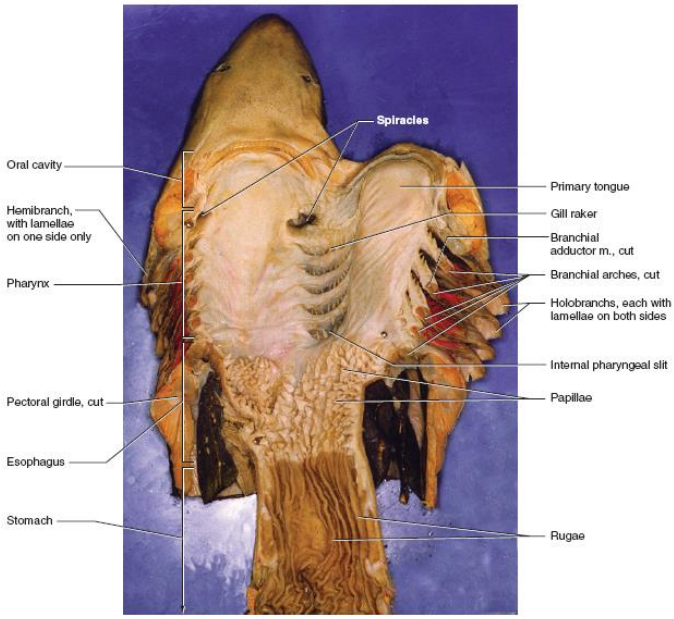
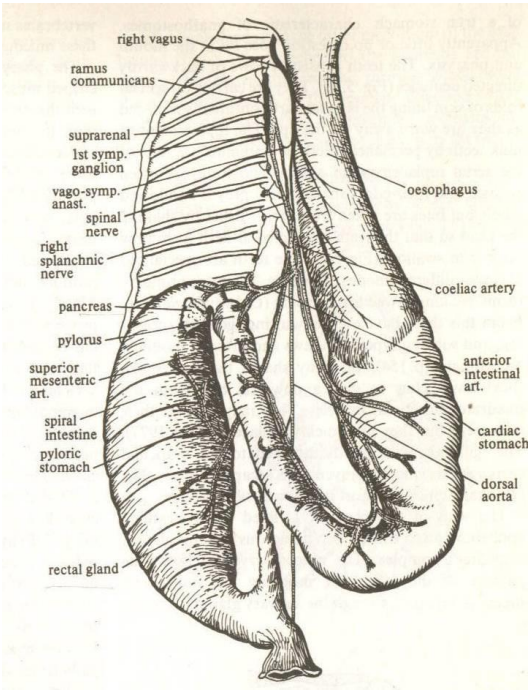
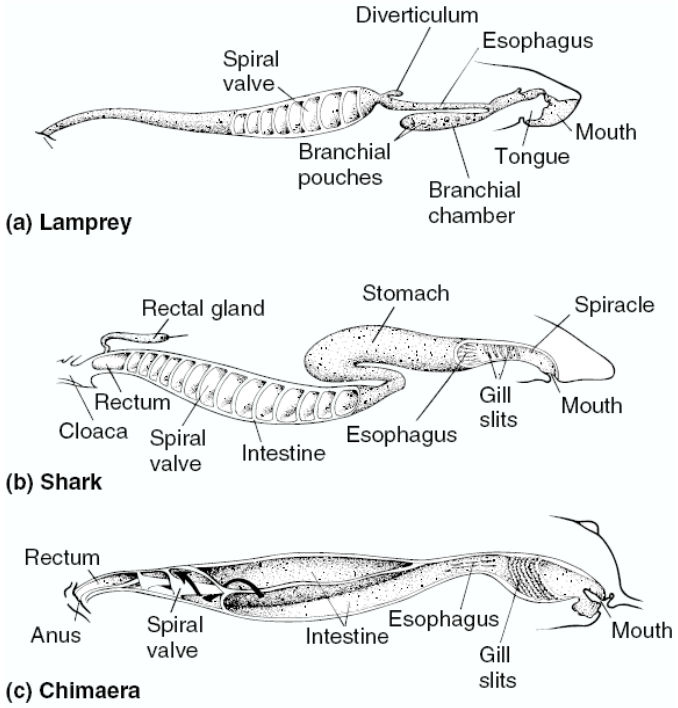


FIGURE 3.22 Anterior portion of the shark in ventral view. The right side visceral arches have been cut through to reflect the floor of the oral cavity and pharynx. The esophagus and stomach have also been cut and reflected.





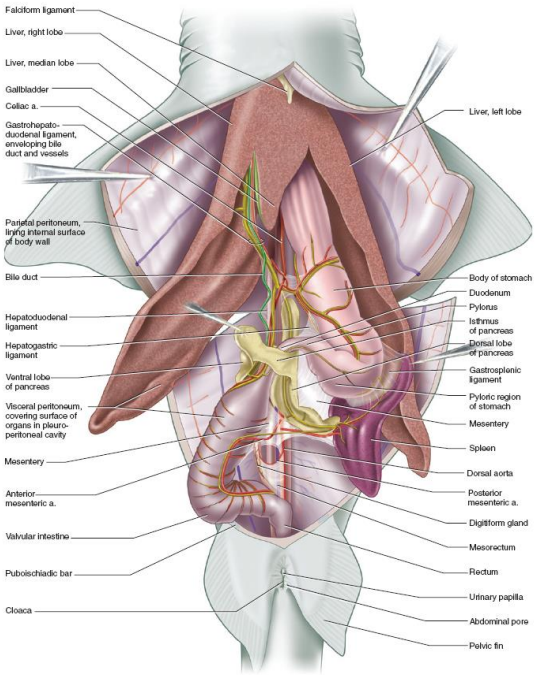


FIGURE 3.24 Pleuroperitoneal cavity of the shark in ventral view, showing viscera and vessels.

Reproductive system

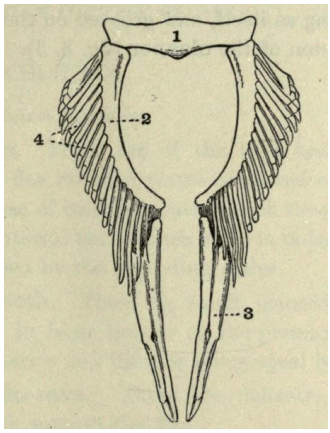
- Oviparous
  - Mermiad's purse

Reproductive system

- Oviparous
  - Mesraid's purse
- Viviparous
  - Placenta or uterin milk
- Ovoviviparous

Mating

- Clasper



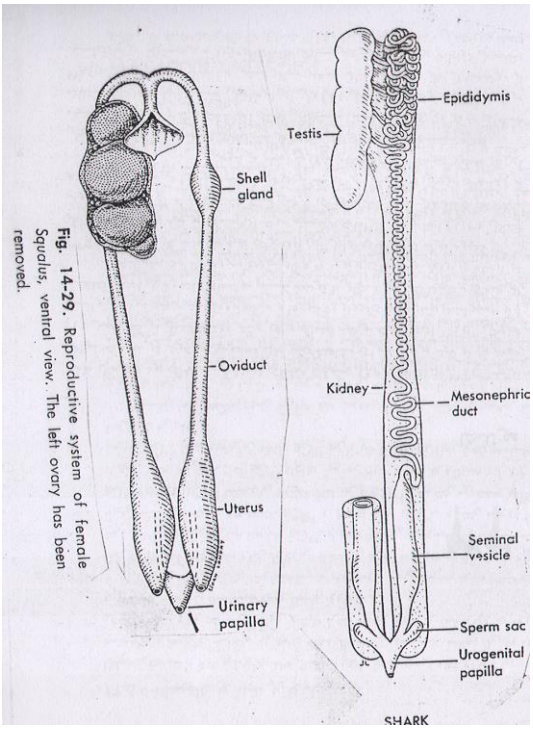
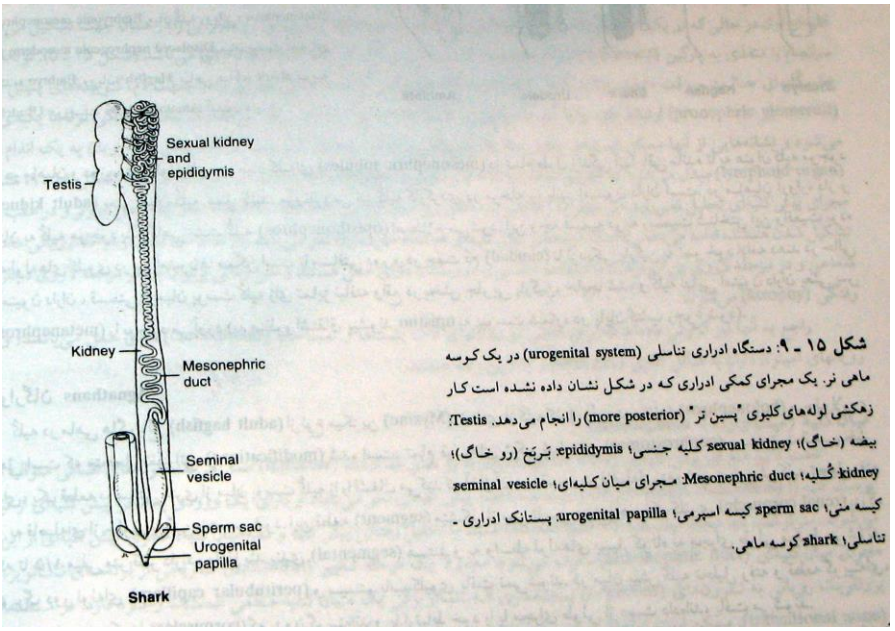
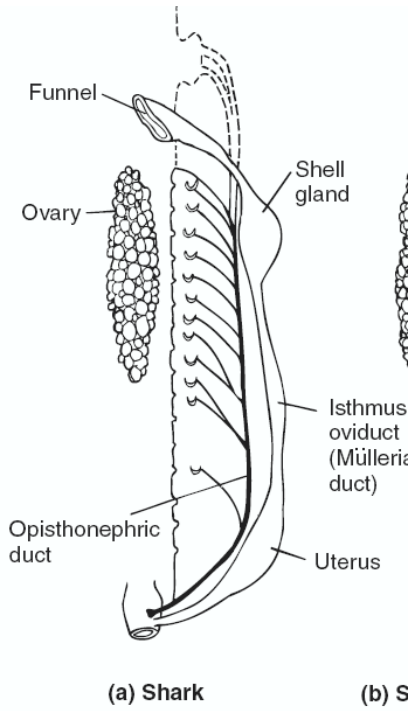


Fig. 14-29. Reproductive system of female Squalus, ventral view. The left ovary has been removed.



شکل ۱۵ ـ ۹: دستگاه ادراری تناسلی (urogenital system) در یک کوسه ماهی نر. یک مجرای کمکی ادراری که در شکل نشان داده نشده است کار زهکشی لوله‌های کلیوی "پسین تر" (more posterior) را انجام می‌دهد. Testis: بیضه (خاگ)؛ sexual kidney: کلیه جنسی؛ epididymis: بَربَخ (رو خاگ)؛ kidney: کُلیه؛ Mesonephric duct: مجرای میان کلیه‌ای؛ seminal vesicle: کیسه منی؛ sperm sac: کیسه اسپرمی؛ urogenital papilla: پستانک ادراری ـ تناسلی؛ shark: کوسه ماهی.

female



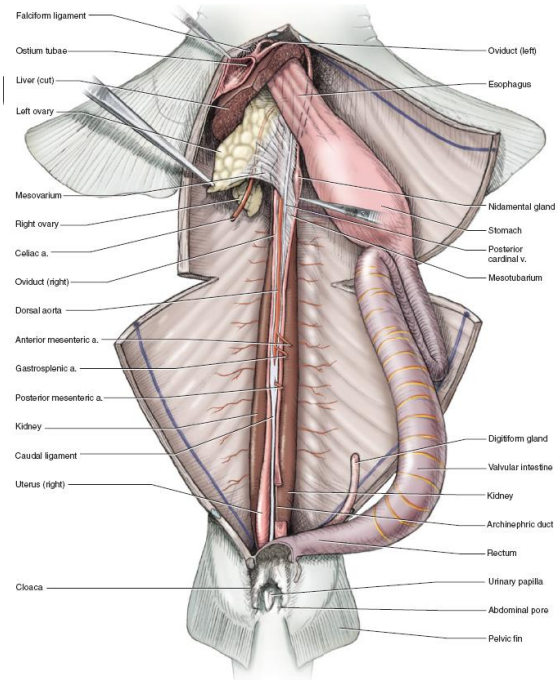
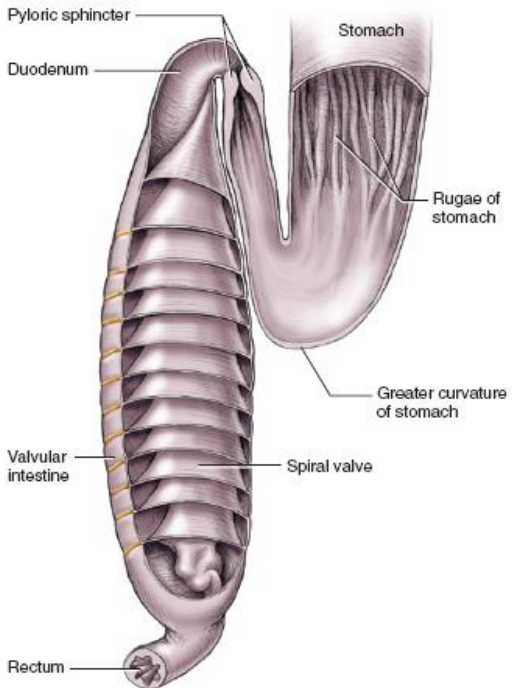
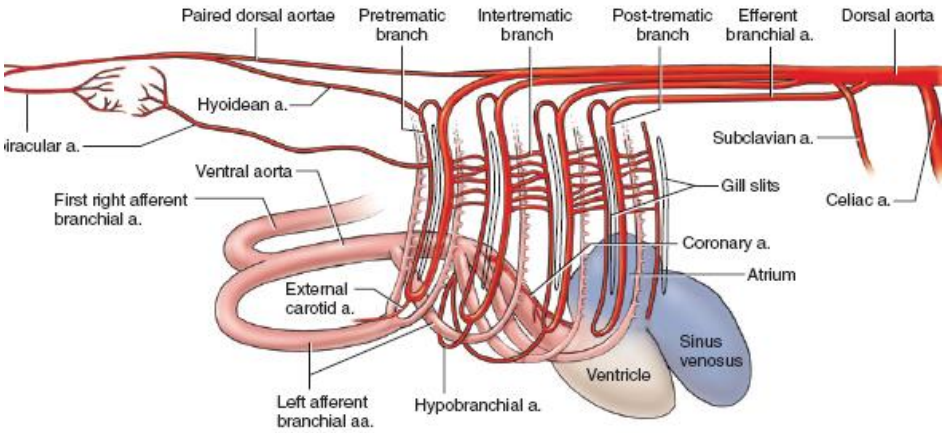
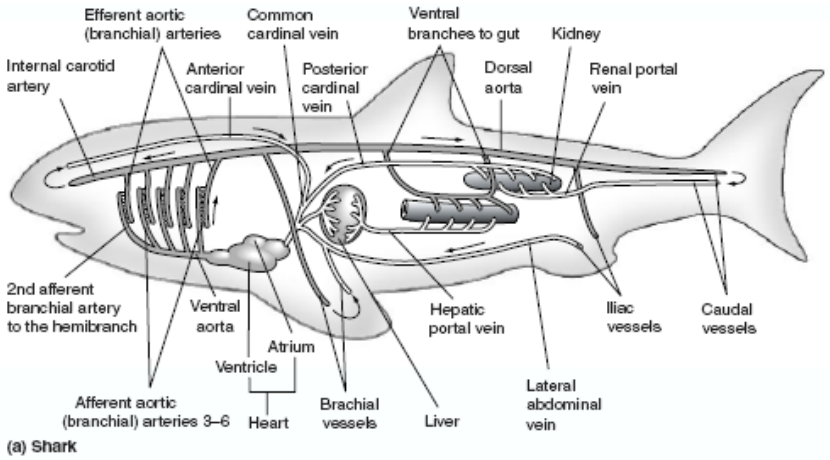


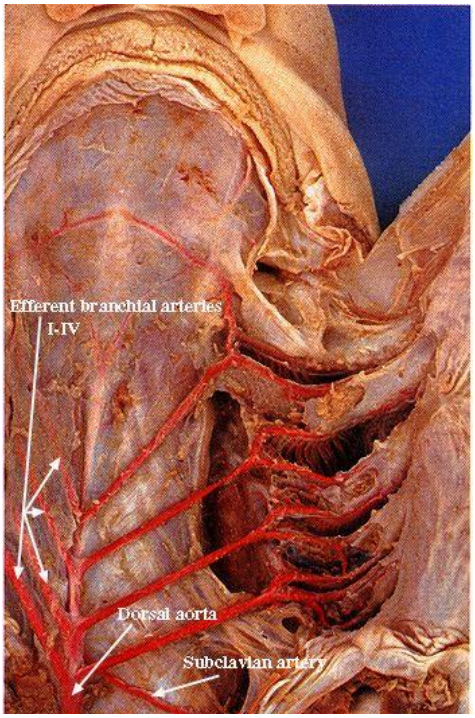
FIGURE 3.34 Pleuroperitoneal cavity in ventral view, showing the urogenital system of the female shark. Much of the viscera has been removed. The left ovary is reflected to the right.



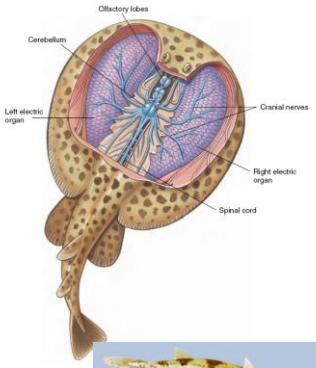
Circulatory system

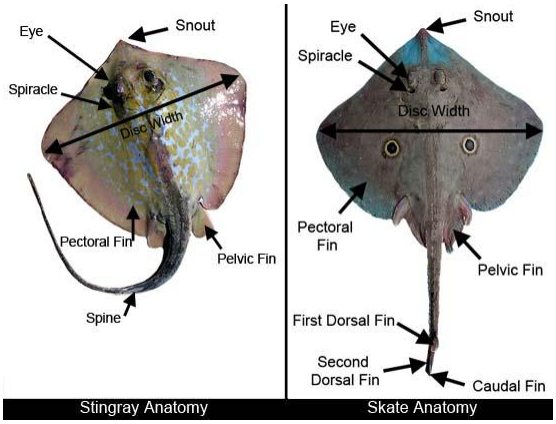




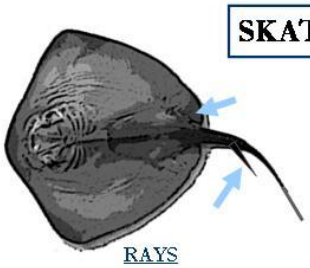


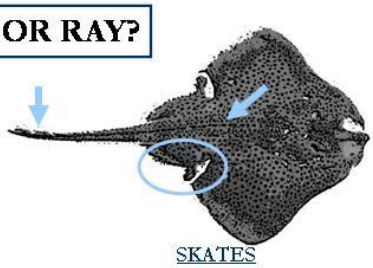
مورفولوژی انواع سفره ماهیان (Batoid fish) سپرماهی الکتریکی، اره ماهی





SKATE OR RAY?



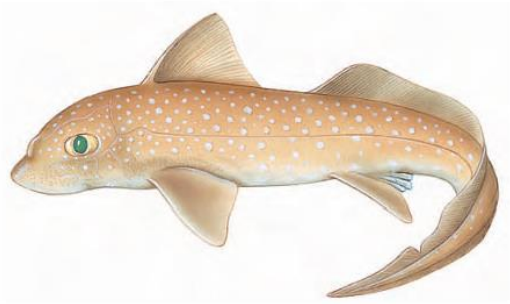


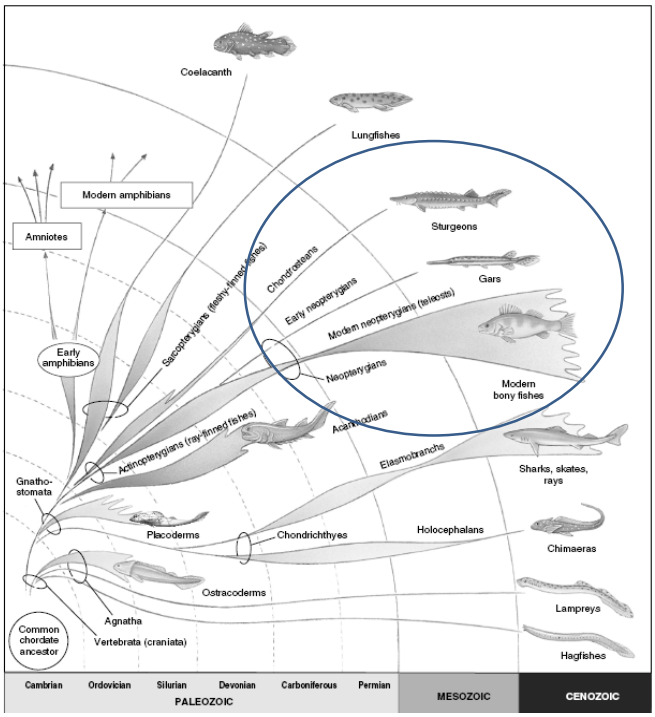
RAYS (Order Myliobatiformes)	vs.	SKATES (Order Rajiformes)
▪ No thorns (or bucklers) along the midline of the back.		▪ Most have enlarged thorns along the midline of the back extending onto the tail.
▪ Each pelvic fin has only one lobe.		▪ Pelvic fins have two lobes (bilobate).
▪ Tail is very slender and whip-like with a stinging spine midway along its length and usually without a dorsal fin. When a dorsal fin occurs, it is near the base of the tail. The caudal fin is either reduced and contiguous or absent.		▪ Tail relatively stocky without a stinging barb, and usually with two small dorsal fins near its tip. The caudal fin is tiny, when present.
▪ Mature males do not have malar or alar spines.		▪ Mature males have enlarged spines near the eyes (*'malar spines'*) and pectoral wingtips (*'alar spines'*).
▪ Give live birth (viviparous reproduction)		▪ Lay eggs (oviparous reproduction)

Rhynchobatus djeddensis (Forsskal, 1775)

مورفولوژی هلوسفال ها (شیمر ماهیان) (موش ماهی)، سرپوش آبششی کاذب، اسپیراکل و کلوآک ندارند، به جز در محل های خاص پولک ندارند، باله ای سینه ای بزرگ و نقش آن در حرکت،

کف زی اند و و دندان های کوچک و پهن دارند که برای آسیا کردن جانوران کوچک مثل نرم تنان است، آویختگی هلواستایلی



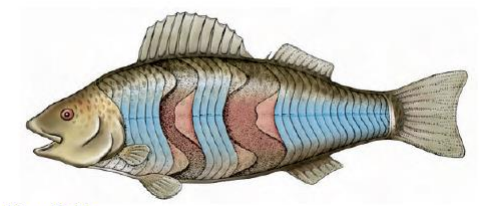


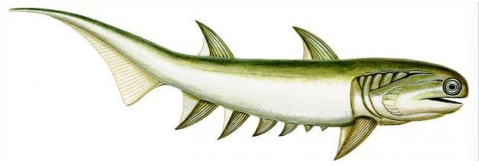
ماهیان استخوانی (Osteoicthyes)

رده ماهیان باله شعاعی (Actinopterygii)

رده باله گوشتی (Sarcopterygii)

Acanthodii





ماهیان استخوانی (Osteoicthyes)

رده ماهیان استخوانی در حال حاضر به ۳ زیررده تقسیم می‌شود که عبارتند از:

۱ - Actinipterygia
۲ -Sarcopterygia
۳ -Acanthodii

Actinipterygia به سه تحت‌رده یا دون‌رده تقسیم می‌شود. (پائین‌تر از Subclass):

۱- Chondrostei
۲- Holostei
۳- Teleostei

Evolutionary key factors

- Specialization of jaw musculature and skeletal elements involved in feeding
- Swim bladder
- operculum

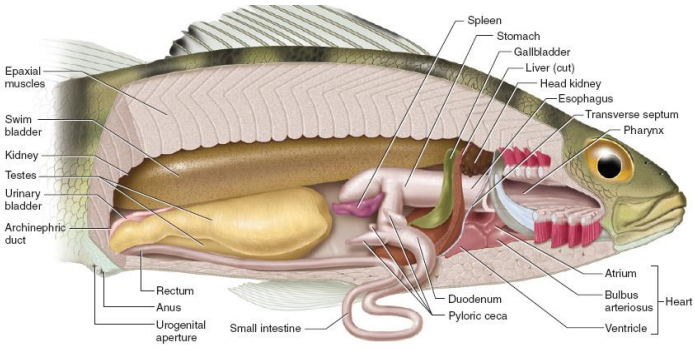
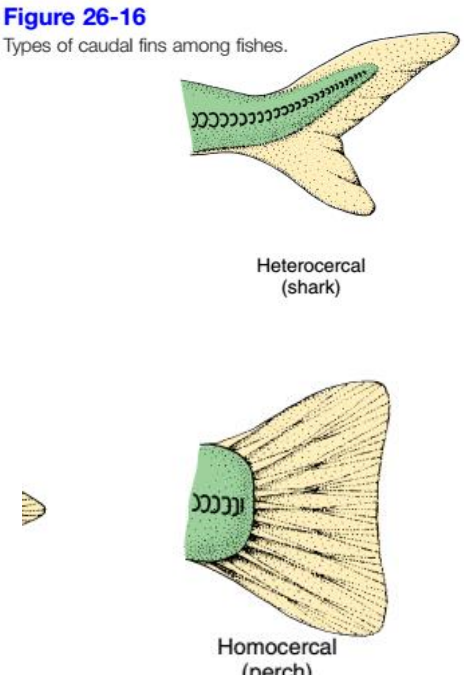


FIGURE 4.8 Cutaway view of the male perch in right lateral view, to reveal structures of the pharynx and pleuroperitoneal cavity.

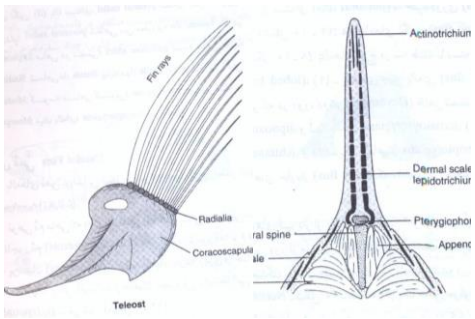
Characteristics of Class Actinopterygia

1. **Skeleton with bone of endochondral origin;** caudal fin heterocercal in ancestral forms, usually **homocercal** in advanced forms; skin with mucous glands and embedded dermal scales; scales **ganoid** in ancestral forms, scales **cycloid, ctenoid** or absent in advanced forms



Characteristics of Class Actinopterygia

2. Paired and median fins present, **supported by long dermal rays (lepidotrichia)**; muscles controlling fin movement within body




A


B


C


D

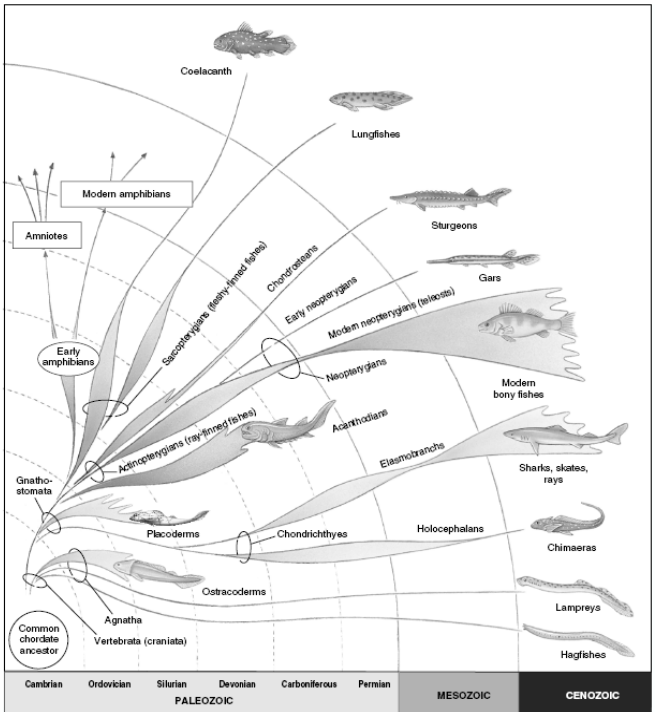
3. Jaws present; teeth usually present with enamaloid covering; olfactory sacs do not open into mouth; spiral valve present in ancestral forms, absent in advanced forms

4. Respiration primarily by gills supported by arches and covered with an **Operculum** (evolutionary key factor)
5. **Swim bladder** often present with or without a duct connecting to esophagus, usually functioning in buoyancy (evolutionary key factor)

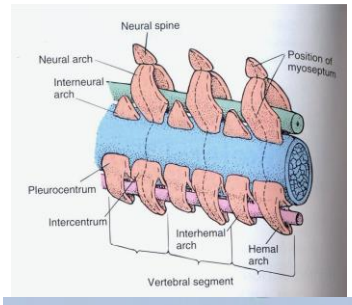
6. Circulation consisting of a heart with a sinus venosus, an undivided atrium, and an undivided ventricle; single circulation; typically four aortic arches;nucleated erythrocytes

7. Excretory system of paired opisthonephric kidneys; sexes usually separate; fertilization usually external; larval forms may differ greatly from adults

8. Nervous system of a brain with olfactory lobes, small cerebrum, optic lobes, and cerebellum; 10 pairs of cranial nerves; three pairs of semicircular canals



Condros tei یا ماهیان غضروفی – استخوانی (ماهیان خاویاری) : بخشی از اسکلت غضروفی و بخشی استخوانی، بدنی کوسه مانند و دم هتروسرک دارند. فلس های گانوئیدی در نزدیک دم دارند. جسم مهره ای ندارند. نمونه هایی مثل فیل ماهی، ازون برون و قره برون و ... در دریای خزر دیده می شود.

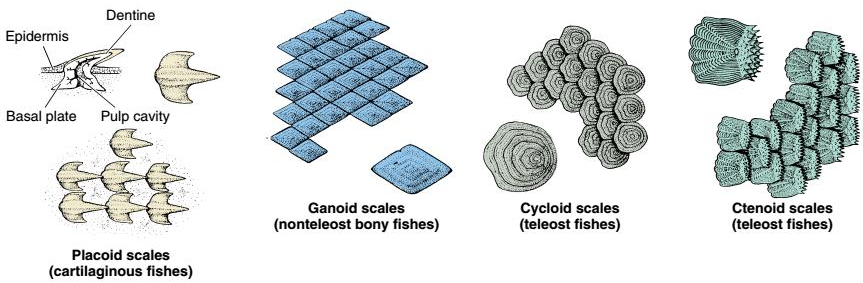


Neopterygians

- Holostei (early)
- Teleosei (modern)

Holostei: شامل ماهیان باله کمانی و گار ماهیان یک گروه قدیمی چند جنس، دارای فلس های گانوید

Scales



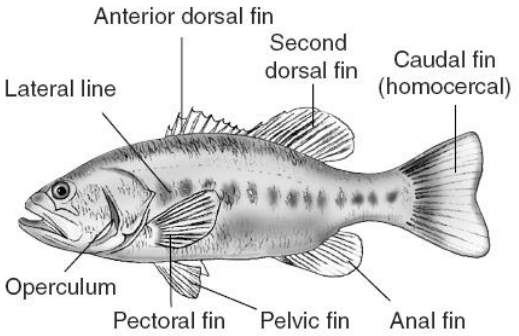
a)

b)

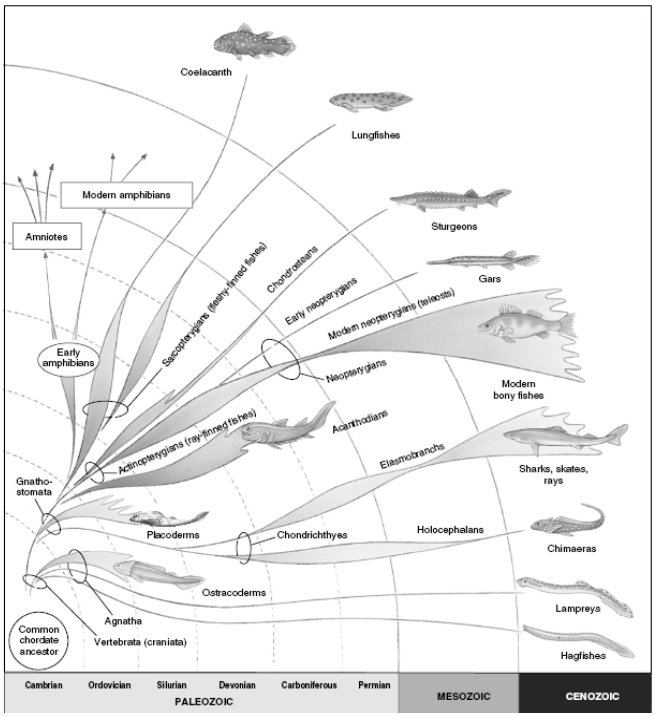
Teleostei شامل سایر ماهیان استخوانی امروزی:

مورفولوژی خارجی، شعاع های باله ای،

تنوع در شکل- زیستگاه و عملکردها



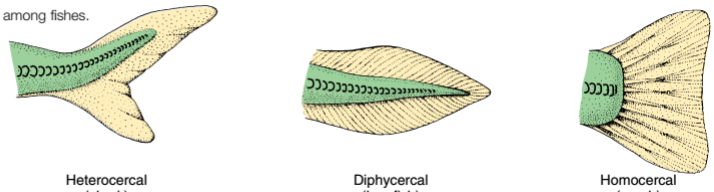
(b) Largemouth bass



Morphological traits help to diversify

- Scale
- Homocercal tail
- Pharyngeal jaws
- Swim bladder

Figure 26-16
Types of caudal fins among fishes.



skin

- Iridocyte
- chromatophore

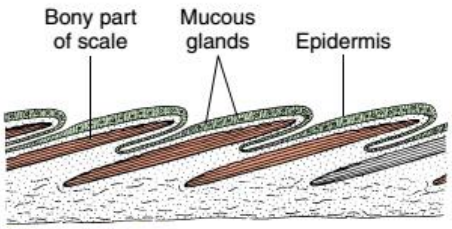
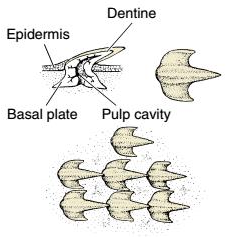


Figure 26-17
Section through the skin of a bony fish, showing the overlapping scales (*red*). The scales lie in the dermis and are covered by epidermis.

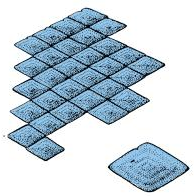
C

B

Scales

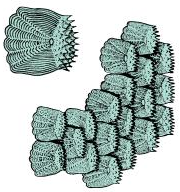


Placoid scales
(cartilaginous fishes)

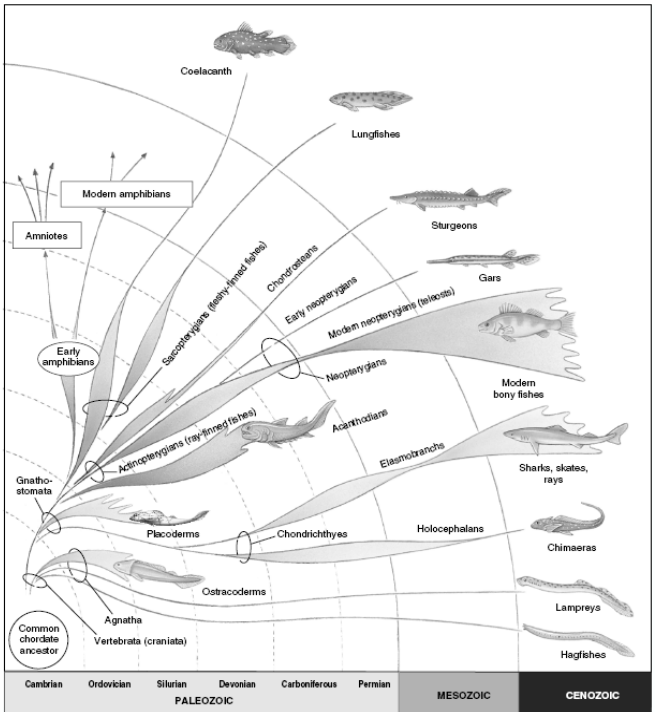


Ganoid scales
(nonteleost bony fishes)

Cycloid scales
(teleost fishes)



Ctenoid scales
(teleost fishes)



External morphology

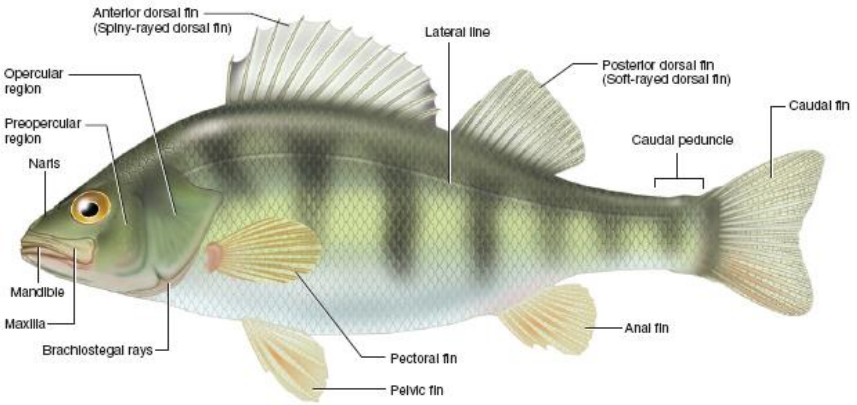
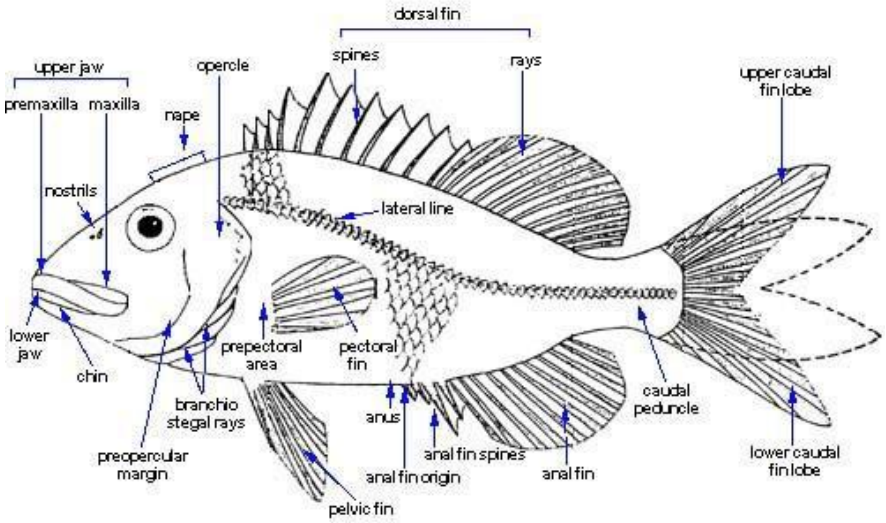


FIGURE 4.3 External features of the perch in left lateral view.



Skeletal system

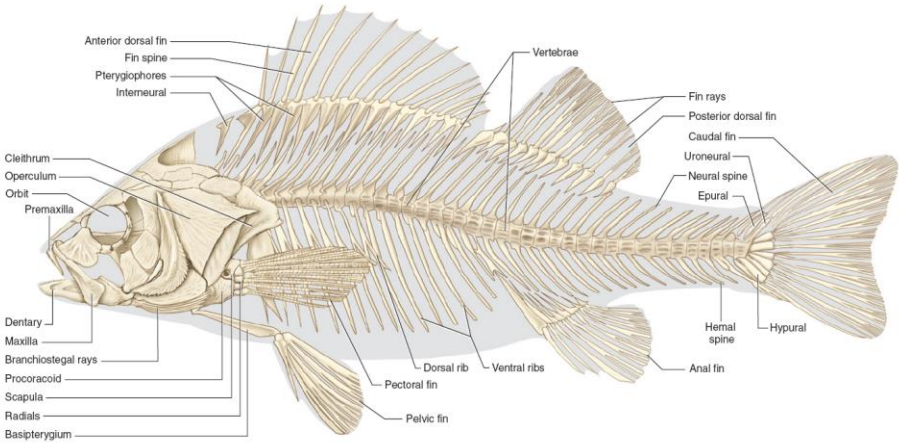
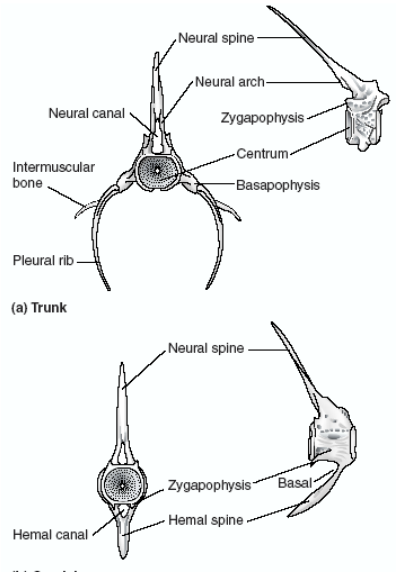
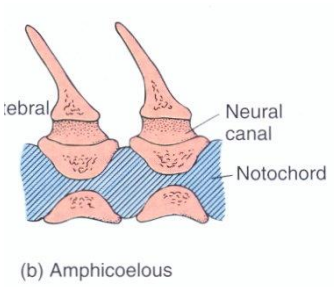


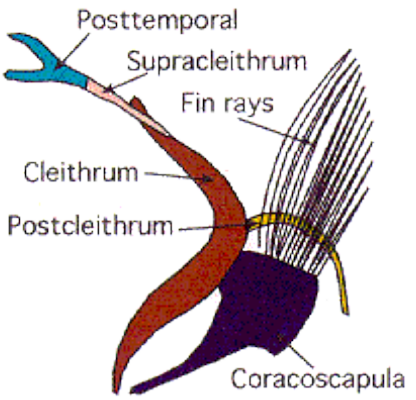
FIGURE 4.1 Skeleton of the perch in left lateral view.

Axial skeleton



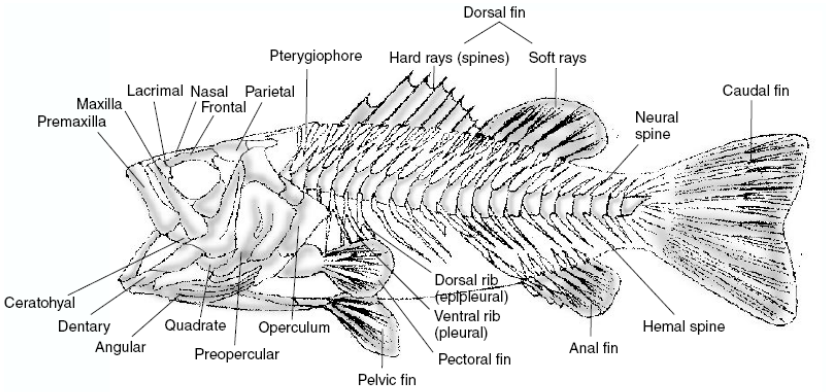


Limbs skeleton



Teleost pectoral girdle and fin (left half)

Skull



Lateral view of the skeleton of a bony fish (Teleostei). Note the position of the paired and unpaired fins and the hyostylic method of jaw suspension.

Visceral skeleton

- Gill slites

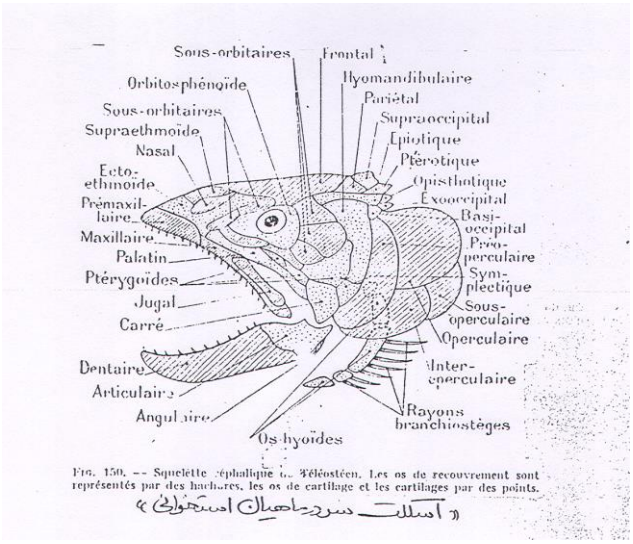


Fig. 150. — Squelette céphalique d'un Téléostéen. Les os de recouvrement sont représentés par des hachures, les os de cartilage et les cartilages par des points.

« اسکلت سر ماهیان استخوانی »

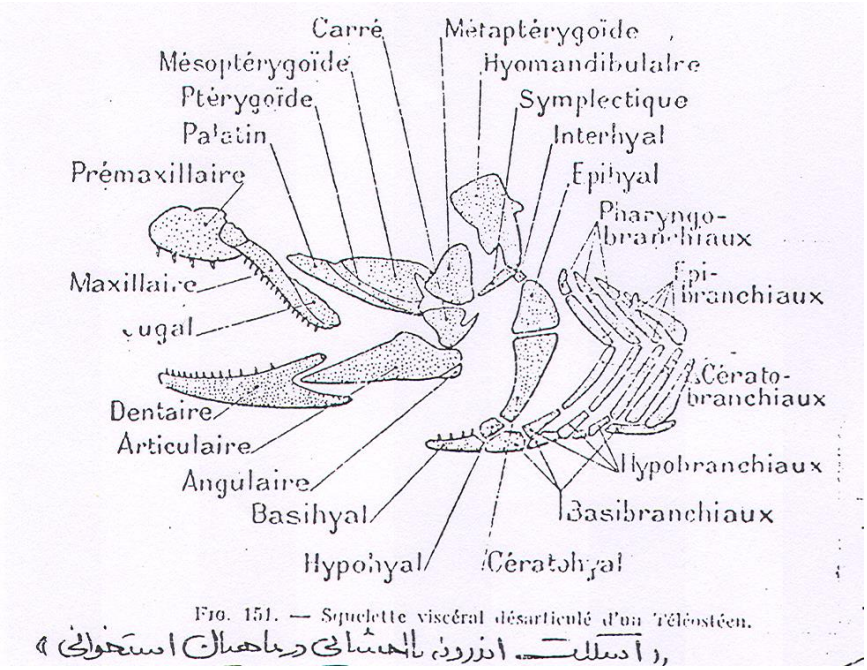
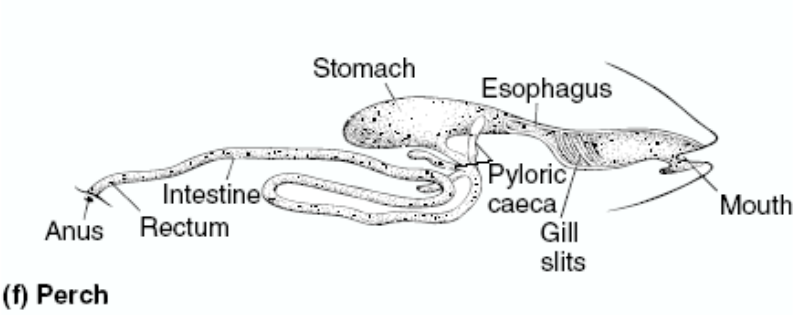


Fig. 151. — Squelette viscéral désarticulé d'un Téléostéen.

« اسکلت احشائی ماهیان استخوانی »

تغذیه : متنوع، گوشتخوار، گیاه خوار و پالوده
خوار با سبک و ابزار های متنوع



(f) Perch

Digestive system

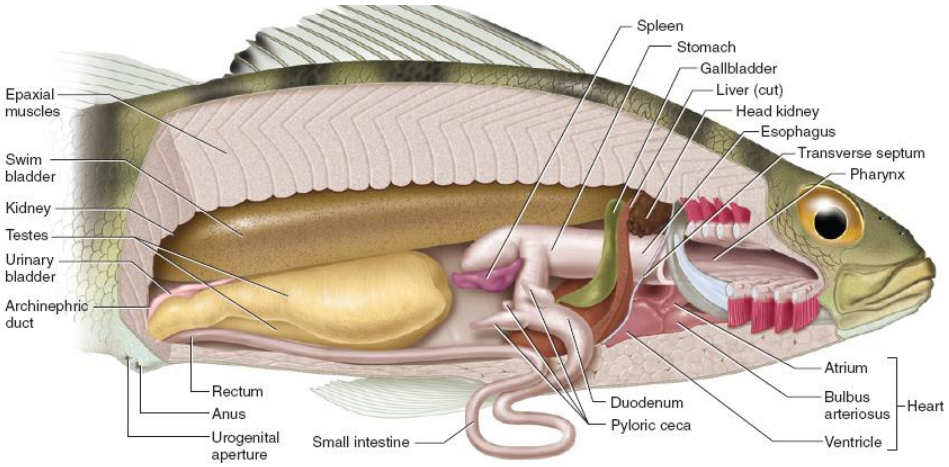


FIGURE 4.8 Cutaway view of the male perch in right lateral view, to reveal structures of the pharynx and pleuroperitoneal cavity.

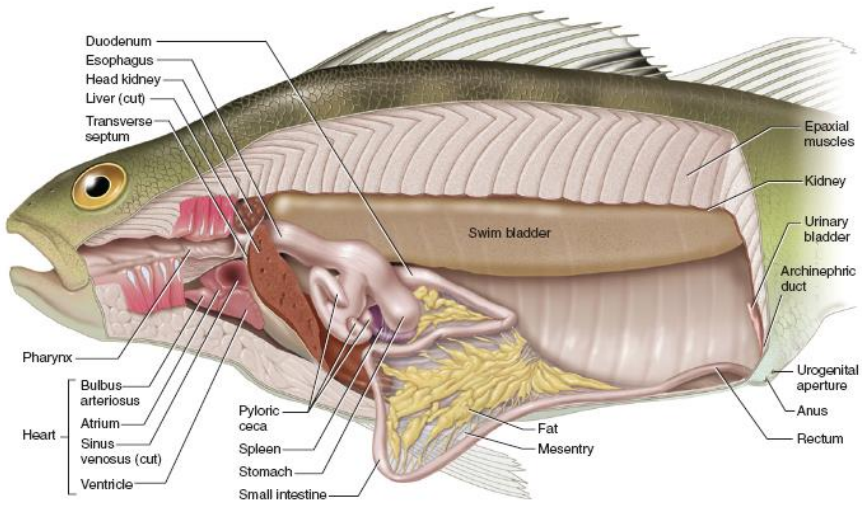


FIGURE 4.9 Cutaway view of the female perch in left lateral view, to reveal structures of the pharynx and pleuroperitoneal cavity. Ovary has been removed.

Swim bladder

- **Physostomatus**
- **physoclistous**

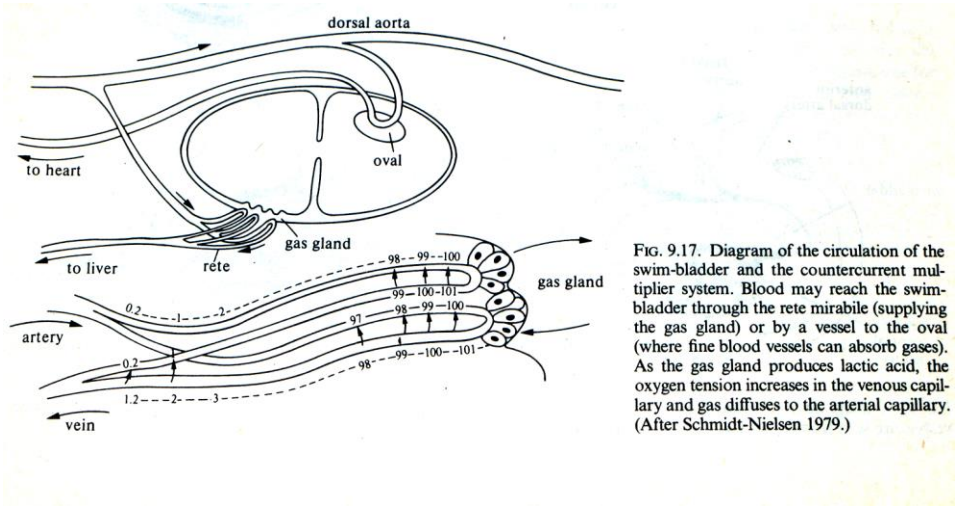


FIG. 9.17. Diagram of the circulation of the swim-bladder and the countercurrent multiplier system. Blood may reach the swim-bladder through the rete mirabile (supplying the gas gland) or by a vessel to the oval (where fine blood vessels can absorb gases). As the gas gland produces lactic acid, the oxygen tension increases in the venous capillary and gas diffuses to the arterial capillary. (After Schmidt-Nielsen 1979.)

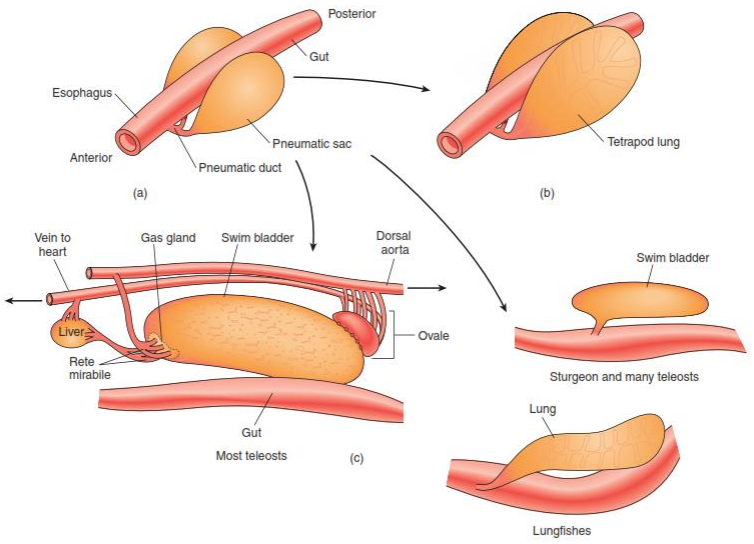
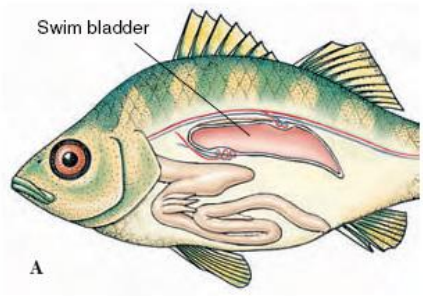
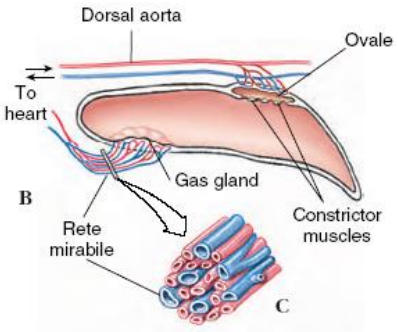


FIGURE 18.17

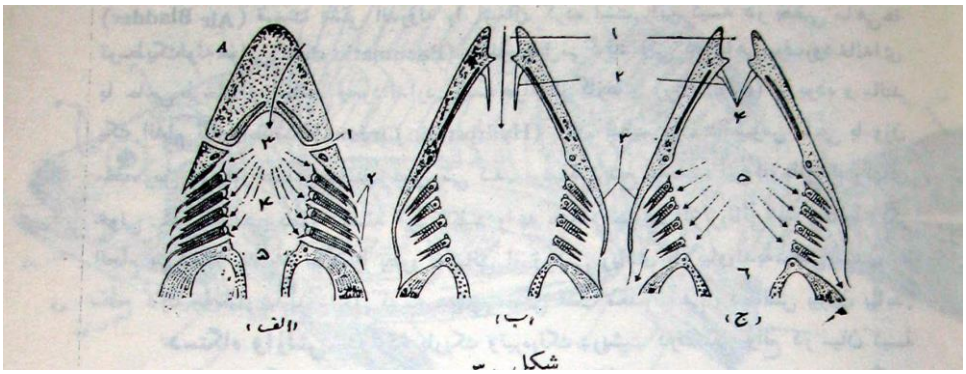
Possible Sequence in the Evolution of Pneumatic Sacs. *(a)* Pneumatic sacs may have originally developed from ventral outgrowths of the esophagus. Many ancient fishes probably used pneumatic sacs as lungs. *(b)* Primitive lungs developed further during the evolution of vertebrates. Internal compartmentalization increases surface area for gas exchange in land vertebrates. *(c)* In most bony fishes, pneumatic sacs are called swim bladders, and they are modified for buoyancy regulation. Swim bladders are dorsal in position to prevent a tendency for the fish to "belly up" in the water. Pneumatic duct connections to the esophagus are frequently lost, and gases transfer from the blood to the swim bladder through a countercurrent exchange mechanism called a rete mirabile. The ovale, at the posterior end of the swim bladder, returns gases to the bloodstream.

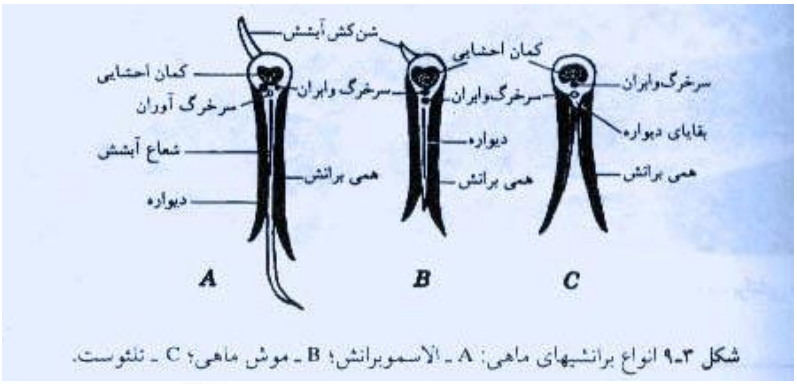




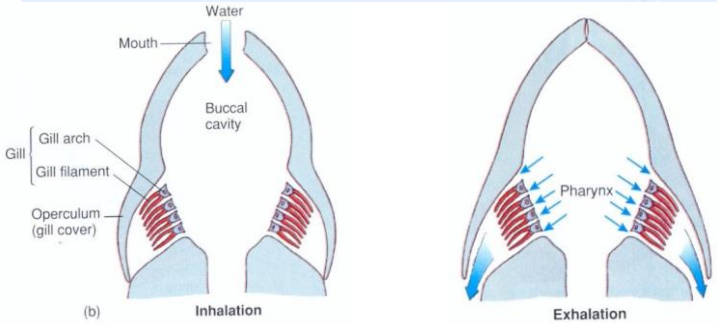
کیسه شنا ، نقش شناوری و تعادل ، نقش تنفسی و ارتباط آن با لوله گوارش و گردش خون و گاز های آن و شنوایی

Respiratpry system





شکل ۳-۹ انواع برانشیهای ماهی: A ـ لاسموبرانش؛ B ـ موش ماهی؛ C ـ تلئوست.



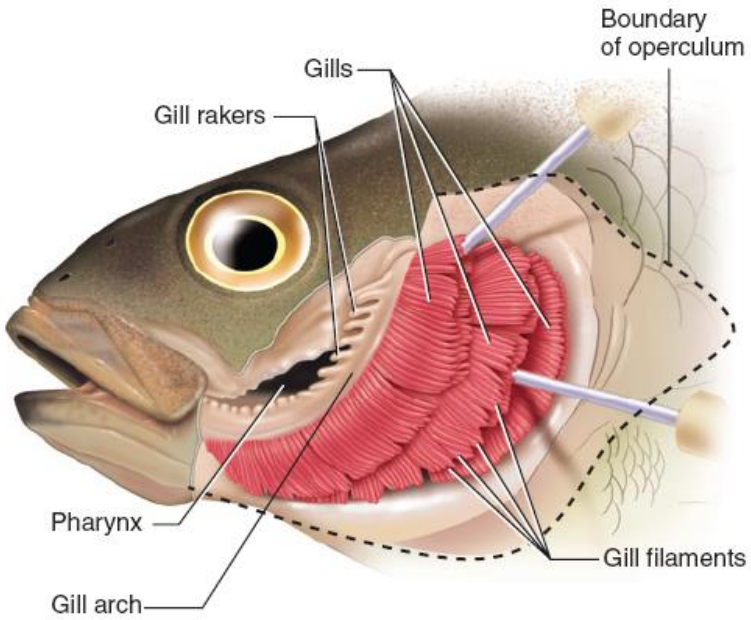
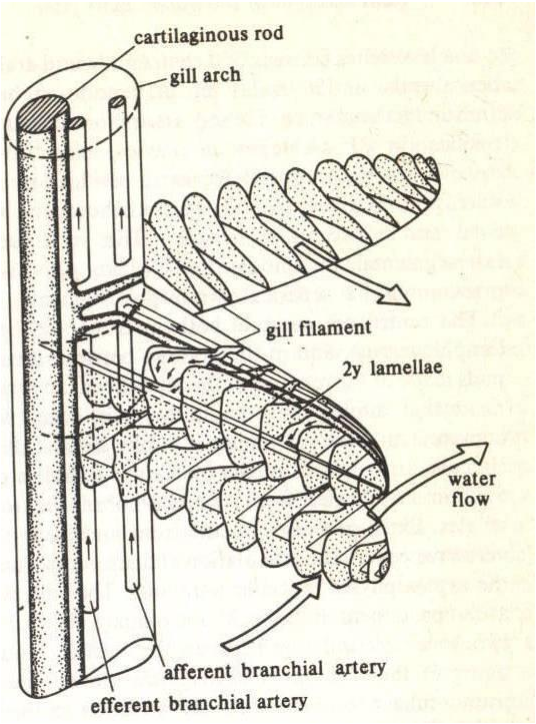
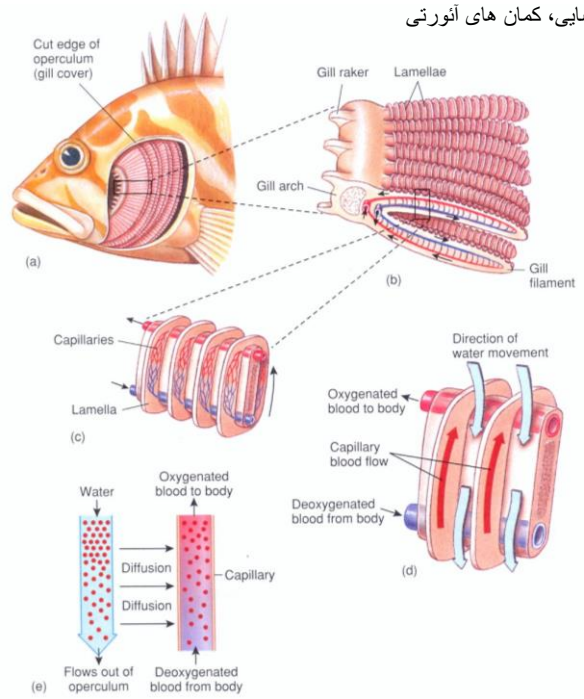


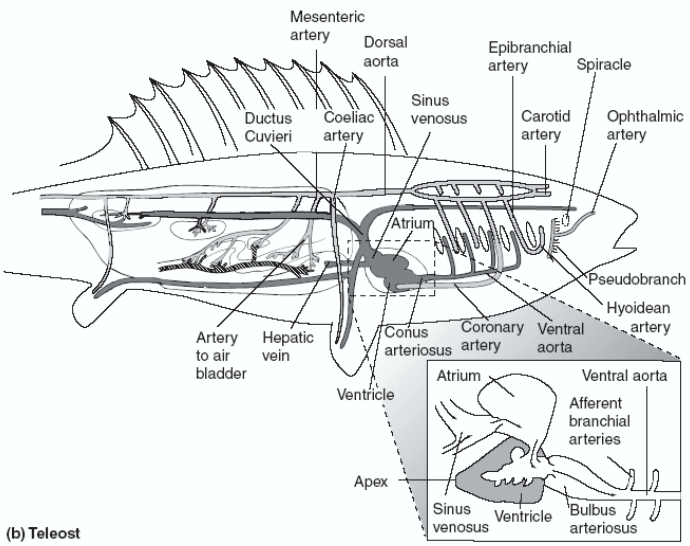
FIGURE 4.5 Gills of the perch in left lateral view.



تنفس: آبشش ها ، درپوش، raker، اسکلت احشایی، کمان های آئورتی



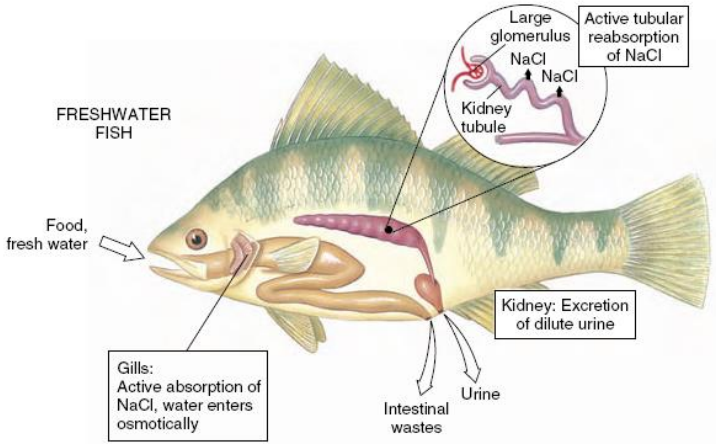
قلب و گردش خون: مشابه کوسه ماهیان



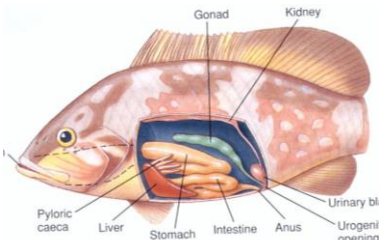
وسائل مورد نیاز برای گردش علمی

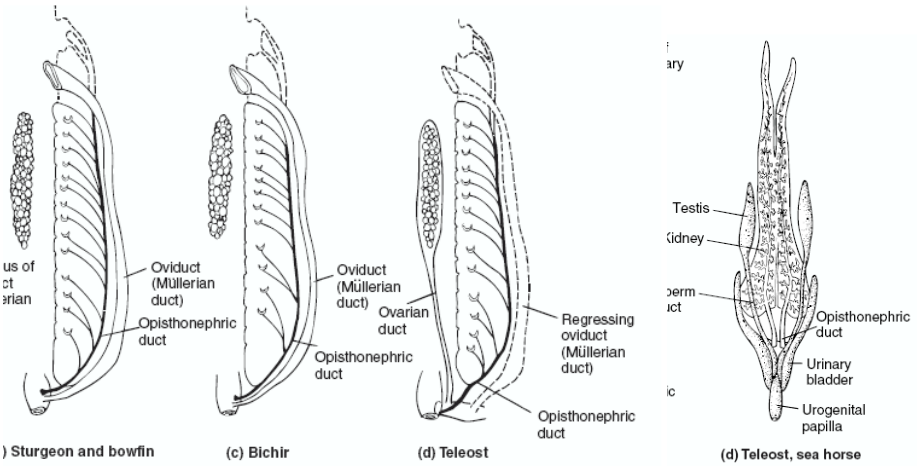
- دوربین دوچشمی
- کتاب راهنمای صحرایی پرندگان، پستانداران، مارها و حیات وحش ایران

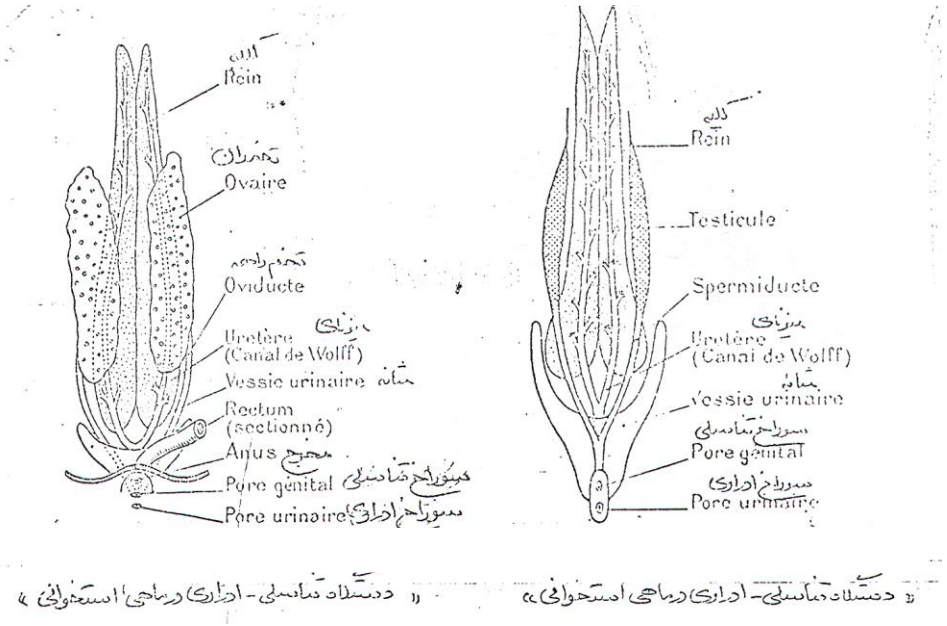
دستگاه دفعی: دفع به کمک کلیه
های مزونفروس، آبشش ها و غده
مخرجی (rectal)(نقش مثانه
دارد) و بعضا پوست بدن، در
نمونه های آب شیرین و دریازی ها



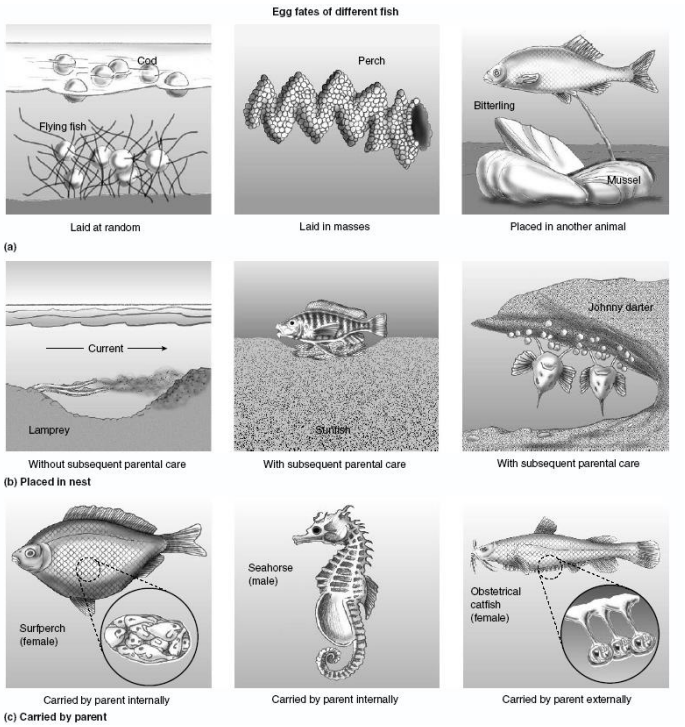
سیستم تناسلی و تولید مثل: اغلب جدا جنس، برخی
هرمافرودیت، سر نوشت مجرای مولر، بحث تغییر جنسیت





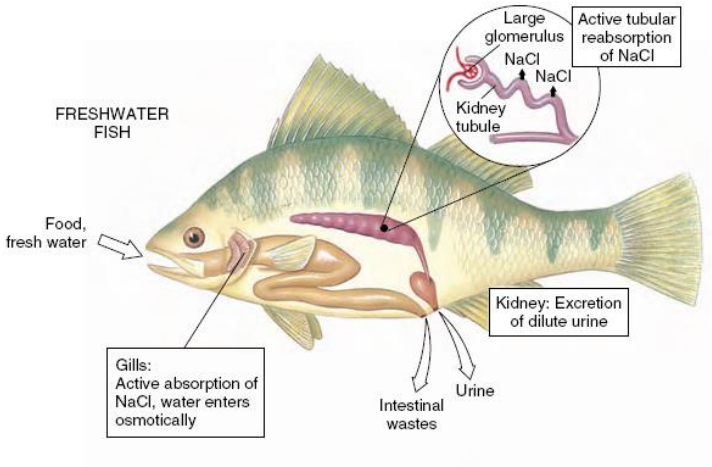


« دستگاه تناسلی - ادراری ماهی استخوانی »



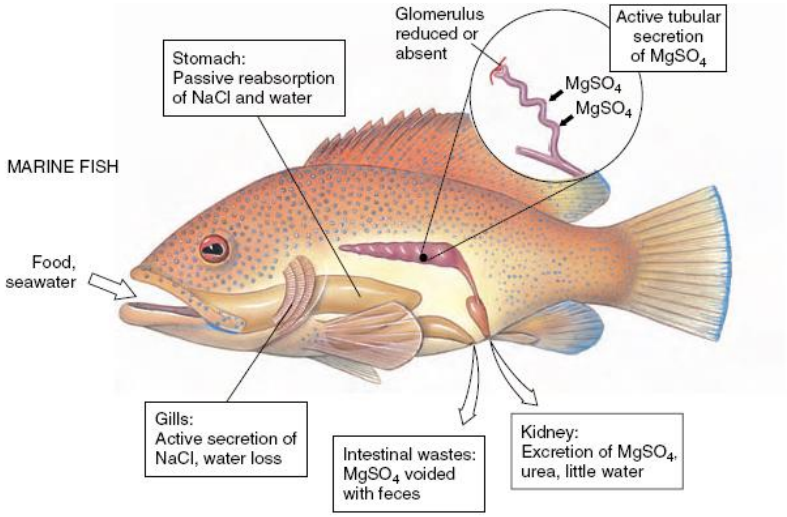
Osmoregulation

- fresh water



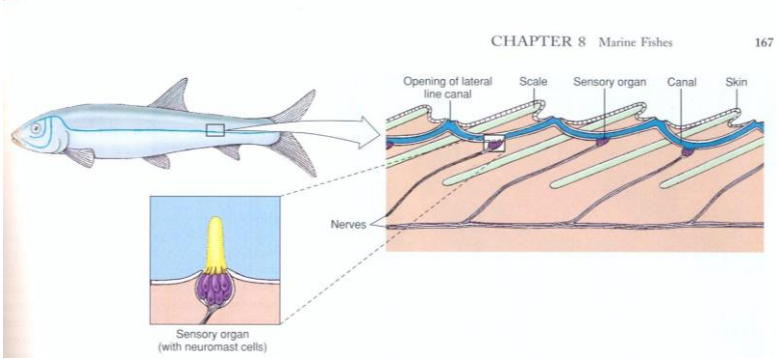
Osmoregulation

- Sea water



Sense organ

- Vision
  - Deep sea more than 1000 m depth
  - Mesophagic
  - Shallow water
- Lateral line



Sense organ

- Hearing
  - Webber
  - Making sound (stridulation, phonation)
- Light organ
  - Luminecent

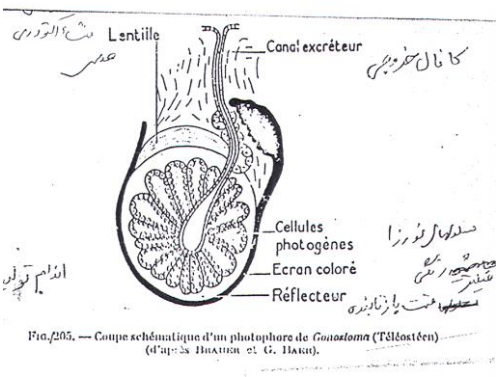
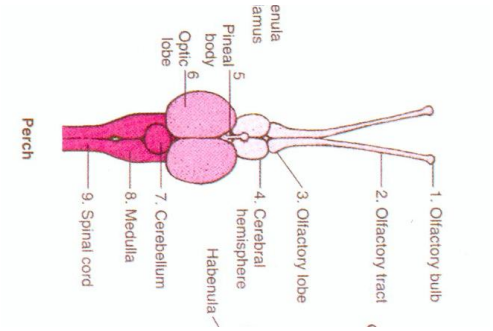


Fig. 205. — Coupe schématique d'un photophore de *Gonostoma* (Téléostéen) (d'après Brauer et G. Hahn).

Sense organ

- Electric organ
- Olfactory



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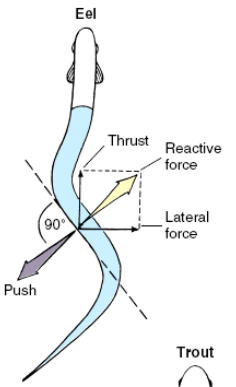
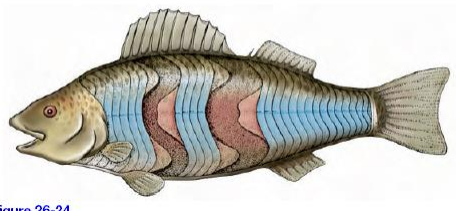
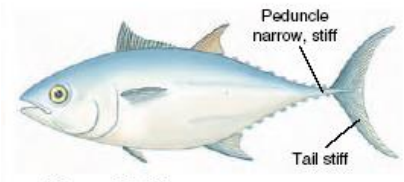
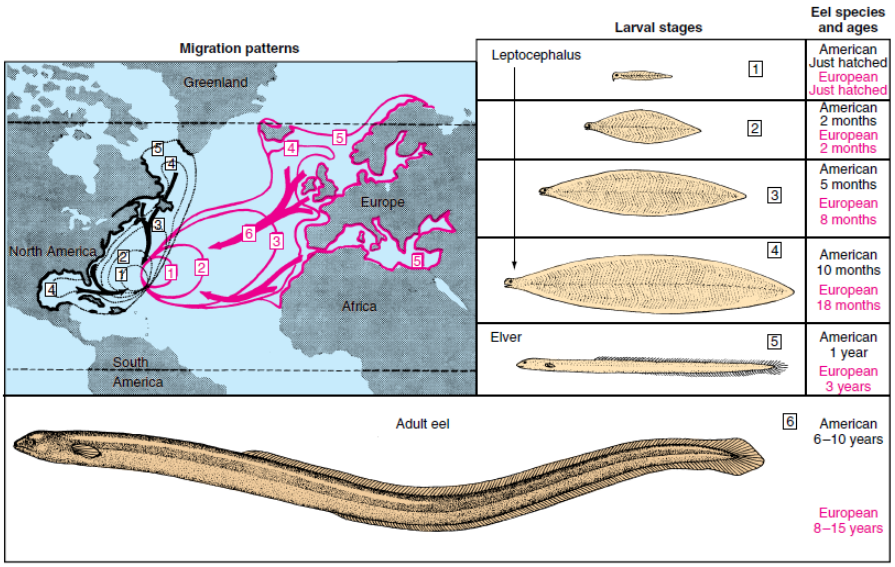




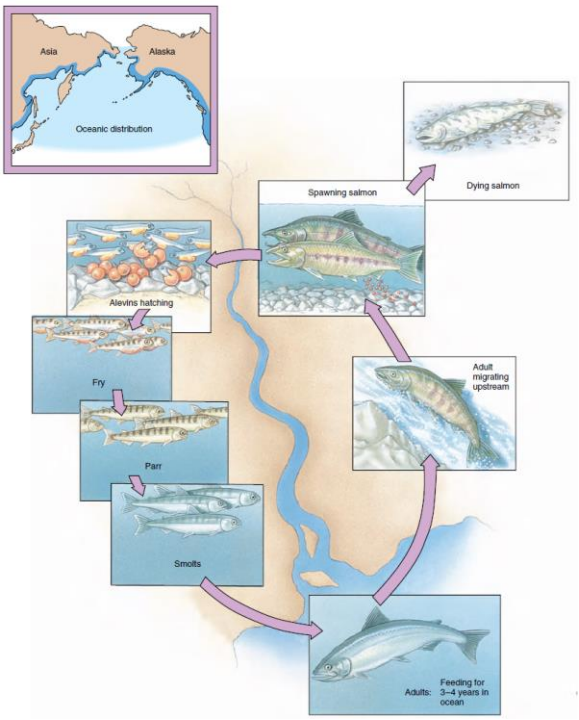
CHAPTER 26 Fishes 525

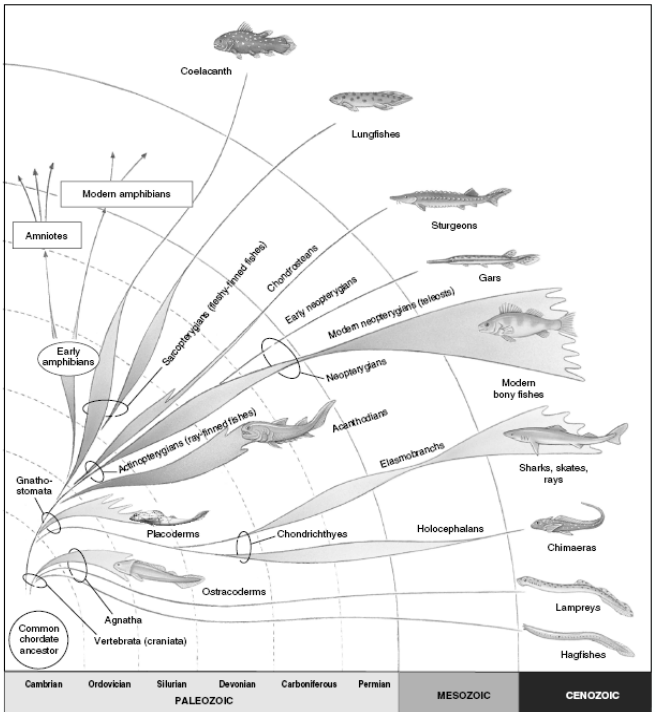


مهاجرت در مارماهی آمریکا و اروپا که catadromus (ساکن اصلی رودخانه ها) هستند



مهاجرت در ماهی آزاد که در اصل anandromous هستند.





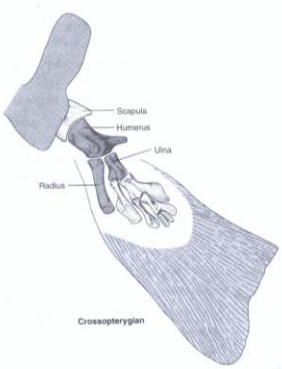
Sarcopterygians

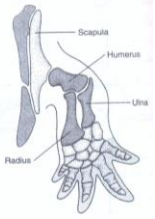
زیر رده ماهیان دوتنفسی

Bichirs: یک گروه قدیمی دارای دوجنس، دارای فلس های گانوییدی و شش

زیر رده ماهیان باله گوشتی:

راسته ماهیان باله لوب دار (Crossopterigii)(سلاکانت ها): مثل نمونه های Latimeria : نفوذ اسکلت و عضله در باله ها (استخوان هایی معادل برخی بخش های اسکلت دست در چهار پایان)، حرکت به کمک باله ها روی بستر، اهمیت مطالعه آن از این نظر است که می تواند رابط ماهیها با چهارپایان باشد.





Characteristics of subclass Sarcopterygia

1. **Skeleton with bone of endochondral origin**; caudal fin **diphycercal** in living representatives, heterocercal in ancestral forms; skin with embedded dermal scales with a layer of dentine-like material, **cosmine,** in ancestral forms

2. Paired and median fins present; paired fins with a single basal skeletal element and short dermal rays; muscles that move paired fins located on limb

3. Jaws present; teeth are covered with true enamel and typically are crushing plates restricted to palate; olfactory sacs paired, may or may not open into mouth; intestine with spiral valve

4. Gills supported by bony arches and covered with an **operculum**

5. **Swim bladder** vascularized and used for respiration and buoyancy (fat-filled in the coelacanth)

6. Circulation consisting of heart with a sinus venosus, two atria, a partly divided ventricle, and a conus arteriosus; **double circulation** with pulmonary and systemic circuits; characteristically five aortic arches

7. Nervous system with olfactory lobes, a cerebrum, a cerebellum, and optic lobes; 10 pairs of cranial nerves; three pairs of semicircular canals

8. Sexes separate; fertilization external or internal

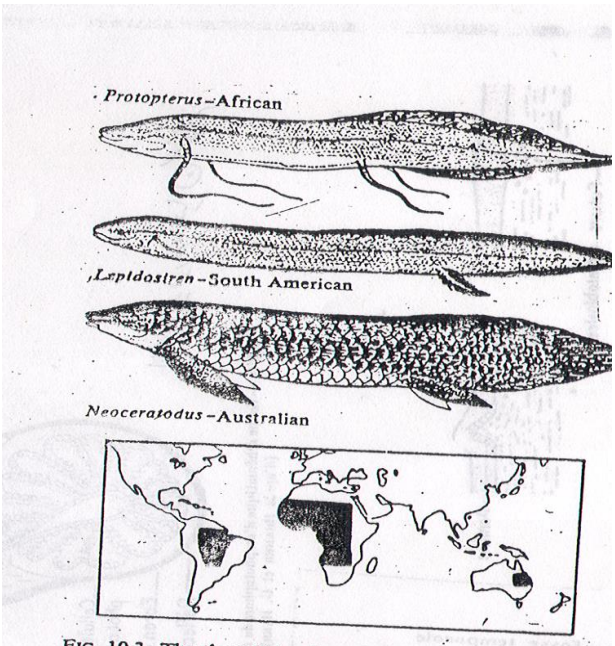
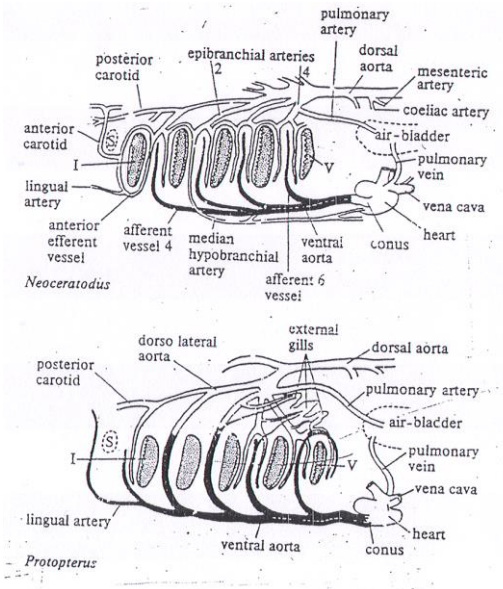


FIG. 10.3. The three living lung fishes and their distribution. (From Norman 1931.)



. 10.7. Branchial circulation of A *Neoceratodus* B *Protopterus*. *S*. position of closed spiracle; *I–V* branchial slits. The gills are present on the hyoid next four branchial arches. (From Goodrich).)