Lecture 3 Ichthyology – Chpt 3 Helfman et al.
Skeleton, Skin and Scales

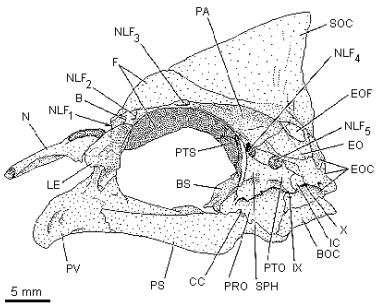
- **Skeleton, Skin and Scales**
- Skulls (3 major types)
- Agnatha (Cyclostomata) – no jaws
- Chondrichthyes – single cartilaginous structure
- Bony fish

Lecture 3 Ichthyology – Chpt 3 Helfman et al.
Skeleton, Skin and Scales

- **Skeleton, Skin and Scales**
- Dermal v Cartilage replacement bones
- Skull (Cranium)
- Neurocranium v. Chondrocranium
- Dermatocranium
- Branchiocranium
- Gill arch supports

Skeleton, Skin and Scales

Neurocranium
- Ethmoid region
  - Lateral ethmoids (**LE**)
  - Ethmoids
  - Vomer (**PV**)
  - Nasals (**N**)
- Orbital Region
  - Pterosphenoids (**PTS**)
  - Basisphenoids (**BS**)
  - Frontals (dermal) (**F**)
  - Infraorbitals (dermal)
  - Lachrymal
- Otic Region
  - Sphenotics (**SPH**)
  - Pterotics (**PTO**)
  - Proortics (**PRO**)
  - Epiotics (**EO**)
  - Posttemporal
  - Parietals (dermal) (**PA**)
- Basicranial Region
  - Exoccipitals (**EOC**)
  - Basioccipitals (**BOC**)
  - Supraoccipitals (**SOC**)
  - Parasphenoid (dermal) (**PS**)

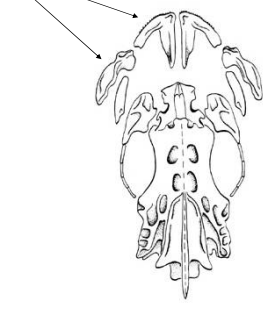


Branchiocranium

Mandibular Arch (Upper jaw) – all dermal bone
- Chondrichthyes = All palatoquadrate cartilage
- Bony Fish - Premaxillae, Maxillae & Supramaxilla

Lower jaw
- Chondricthyes = all Meckel's cartilage
- Bony - Dentary and Angular

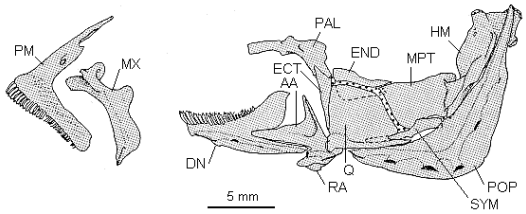
Types of Teeth (on jaws and pharyngeal jaws);
- Canine - large conical; Villiform - small, fine; Molariform - crushing, pavement type; Cardiform - fine, pointed; Incisor - large w/ flattened cutting; Fused (beaks) – parrotfish; Triangular cutting – sharks; Pharyngeal – cyprinids and cichlids etc
- Palatine Arch - often part of suspensorium (Next slide)



Branchiocranium (5 arches)

Palatine Arch - often part of suspensorium

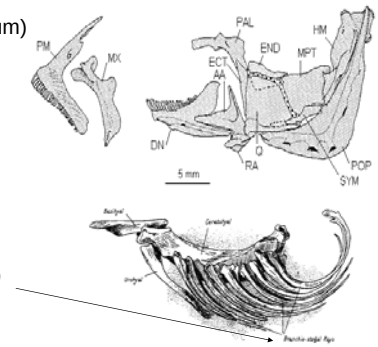
- Palatines (PAL)
- Ectopterygoids (ECT)
- Enopterygoids (END)
- Metapterygoids (MPT)



Branchiocranium (5 arches)

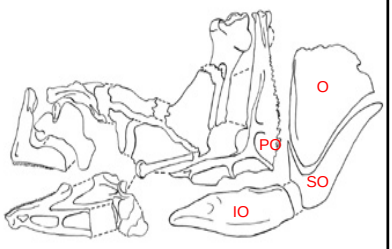
Hyoid Arch (Suspensorium)

- Hyomandibula (HM)
- Symplectic (SYM)
- Quadrate (Q)
- Hyoid complex
  - Hypohyal
  - Ceratohyal
  - Epihyal
  - Interhyal
  - Brachiostegal Rays (D)

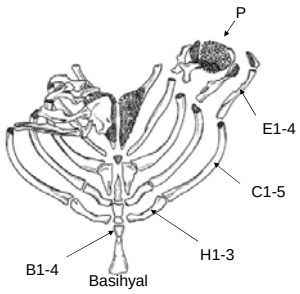


Branchiocranium (5 arches)

- CONTINUED
- Opercular (all dermal)
- Opercle (O)
- Subopercle (SO)
- Preopercle (PO)
- Interopercle (IO)



Branchiocranium (5 arches)



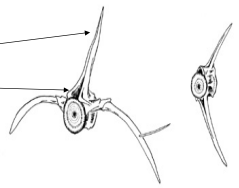
BRANCHIAL ARCH Arch

- Basibranchials (B1-B4)
- Hypobranchial (H1-H3)
- Ceratobranchial (C1-C5) = lower pharyngeal jaws
- Epibranchials (E1-4)
- Pharyngobranchials (P) = upper pharyngeal jaws

Chapt 3 Helfman et al.

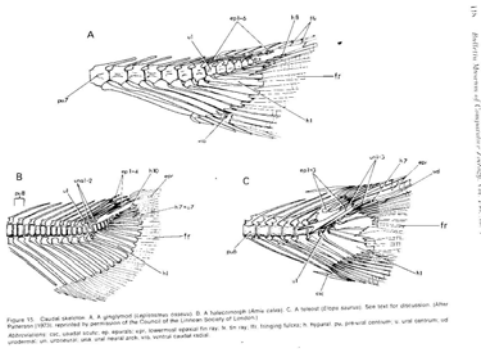
Skeleton, Skin and Scales

- Post Cranial Notochord
- Vertebrae - precaudal (end of body cavity; bearing ribs) vs. caudal (posterior - first w/ haemal spine);
- Neural Spine
- Neural arch - neural canal
- Parapophyses
- Haemal arch - Haemal canal
- Ribs
- Intermuscular bones



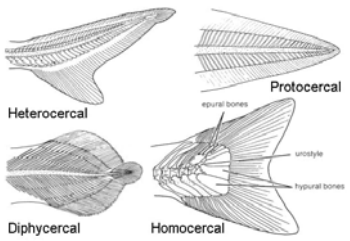
Skeleton, Skin and Scales

- Caudal Complex – discuss bones in detail later



Skeleton, Skin and Scales

- Types of fins
- Protocercal - primitive undifferentiated (lancelets, agnathans...)
- Heterocercal - unequally lobed (Chondricthyes, sturgeons, gars)
- Homocercal - equally lobed ----urostyle
- Leptocercal or Diphycercal - like Proto; secondarily derived in lungfish, coelacanth & rattails

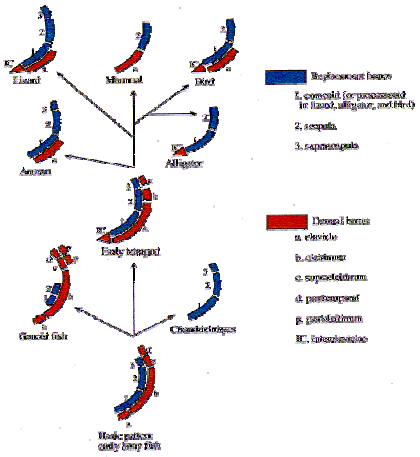


Skeleton, Skin and Scales

Appendicular Skeleton – Pectoral Girdle

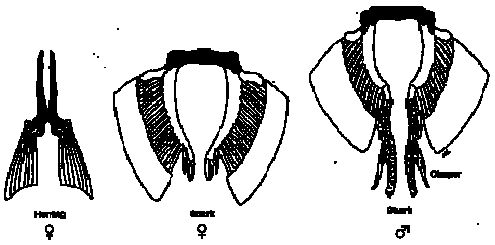
- 3 Dermal - Posttemporal, supratemporal and supracleithrum
- 3 Cart - Cleithrum, scapula and coracoid
- Radials (Cart) - support fins rays

Sharks – coracoid (3), scapula (6), suprascapula (2)



Skeleton, Skin and Scales

Appendicular Skeleton -Pelvic Girdle - not attached, usually free floating
- Chondricthyes - ceratotrichia, 3 layers radials below
- Lepidotrichia (bony fish derived from scales) - Primitive = three radials, Advanced = 1 interneural (dorsal fin) or interhyal (anal fin) bone
- Spines - hard, pointy, enbranched, solid
- Rays - soft. segmented, bilateral



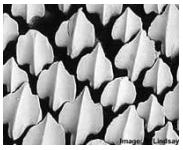
Skeleton, Skin and Scales

Integumentary - Skin and Skin derivatives
- Epidermis - Stratum germinativum - lowest layer
- Dermis - Stratum laxum (upper) and Statum compactum (lower)
- Mucus (Mucin = glycoprotein)
- Photophores
- Chromatophores

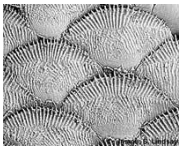
Scales
- **Placoid** - Chondrichthyes; hard enamel outer=vitrodentine; Dentine cap
- **Cosmoid** - Fossil crossopterygians & lungfish - Layer cosmine/pore system
- **Ganoid** - fossil and Chondrostei - Cosmine replaced by dentine and surface has ganoine - a calcified non-cellular material without canals
- **Cycloid and Ctenoid** - completely dermal; no enamel; (except ctenii - posterior border teeth)

External Anatomy
Scales

cosmoid



placoid



ctenoid

ganoid

cycloid

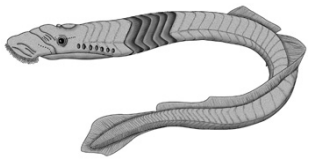
Skeleton, Skin and Scales

-
- Muscles and Soft Anatomy

- **Muscles -** Remember = think of fish as neutrally buoyant (many not) but water 800X denser than air - power needed to get thru it.
- Large muscles associated with head and tail; smaller muscles associated with jaws, branchial arches and fins;

Skeleton, Skin and Scales

- Types of Muscle
  - **Skeletal**=striated
  - **Smooth** = non-striated, associated w/ digestive tract and also swim bladder and reproductive and excretory tracts and lens muscle of eye
  - **Cardiac** = non-skeletal but striated
- Jawless fish = simple striated; no paired appendages or jaws; no septa



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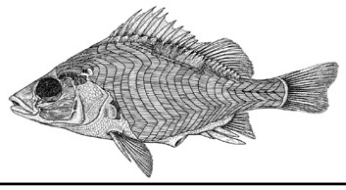
Jawed Fish = Epaxial (upper) vs Hypaxial (lower) = divided along septum; vs red.

Trunk muscles = series of blocks = myotomes or myomeres; seperated connective tissues called myosepta; myotomes resembles letter W on side - lamprey slight angle of flex; bony/sharks = bends are sharper.

Bony fish:
- 2 myomeres per vertebral sentrum - can span 3 to 12 intervertrebral joints;
- Each myotome divided into 4 or more portions by myosepta
- Vertical septum = bilateral left and right halves
- Horizontal septum (2 layers tendons) divide into hypaxial and epaxial



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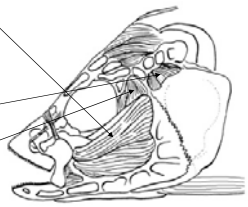
Skeleton, Skin and Scales

- White vs Red Muscle
- White = short duration/ quick fatigue; bursts of power (escape/capture prey); lack of myoglobin and little vascularization; little lipid, low mitochondrial, large diameter and have an anaerobic glycolysis system - trout use 50% stored glycogen in 15 seconds - glycogen to lactate - takes up to 18 hours for recovery
- Red = thin (small diameter) lateral; sustained swimming; hard to fatigue at slow cruising speeds; abundant myoglobin and mitochondrial (16 to 35%); small diameter; large many mitochondria; some sharks, tunas. Operates aerobically with oxidative enzyme system recovers in < 1 hr.

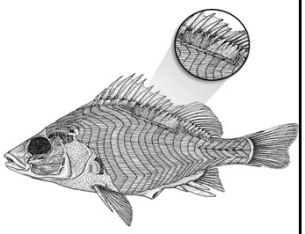
Mouth muscles

- Adductor mandibulae (A1 A2 A3) = cheek muscles - close jaws;
- Levator arcus palatini - post orbital part of cheek,
- Dilator operculi, adductor operculi , levator operculi - insert on opercle
- Adductor arcus palatini, adductor hyomandibulae



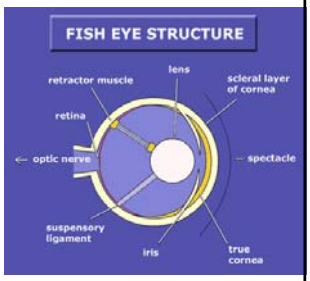
Fin muscles

- Fins: Unpaired fins – dorsal/anal = Carinal muscles (5 different types)
  - Protractors - erect fins
  - Retractors - depress fins
  - Lateral inclinators - soft rays anal/dorsal
- Paired fins – pectoral and pelvics - major types
  - Abductors - pulls ventrally/cranial
  - Adductor - pulls dorsally/caudal
- Caudal musculature = asymmetrical - 5 flexors 2 others; attach to heads of lower caudal fin rays and hypural skeleton to fin rays of dorsal portion of caudal;



Eye Muscles

- Eyes - 3 pairs; 2x dorsal oblique, 2x dorsal rectus, 2x medial rectus
- Suspensory ligament and retractor lentis muscle - focus eye
- Eye Muscles evolved into electric organ in electric stargazer and heater organs in 2 groups scombroid



Weird Muscle

Counter current heat exchange system part of heat retention

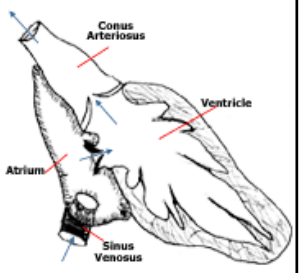
- Pink - intermediate to red and white
- Antarctic notothenoids - no hemoglobin; =yellow muscle in heart (sim. to red)
- Muscles have also become electric organs but will not discuss here.

Cardiovascular system: Heart to Gills to Body

Heart = Heart (all fish) four chambers (posterior to anterior): 1) Sinus venosus, 2) atrium, 3) ventricle, 4) conus arteriosus

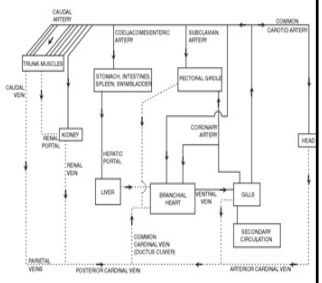
Chondricthyes & lungfish = bulbous arteriosus

Lungfish - partition atr/ven



Cardiovascular system: Heart to Gills to Body

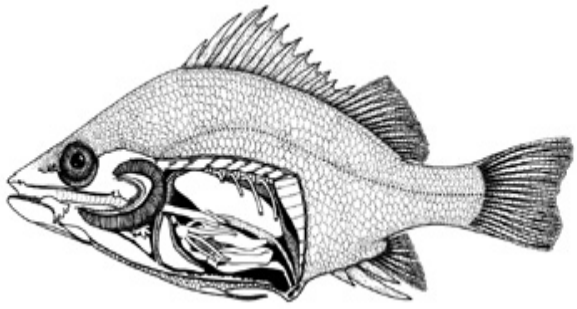
- Blood flow= Sinus venosus, atrium, ventricle and conus arteriousus. Venous (unoxygenated) blood collects in sac-like sinous venosus from liver via hepatic sinuses and from other regions of body from common cardinal veins. Ducts of Cuvier laterally.
- Ventricle = principal propulsive chamber; two myocardial layers w/ inner = 75% cardiac mass and avascular = metabolic limitations on cardiac performance
- Conus arteriousus = straight muscular tube w/ one-way valves (backflow). Continues anteriorly as non-muscular ventral aorta.
- Ventral Aorta - Afferent branchial arteries (deoxygenated blood to gills) - Efferent branchial arteries (oxygenated blood from gills to body; one per arch - hemi/holobranch)
- Dorsal aorta - caratoids and cardinals lead to the brain - dorsal aorta to rest of body - subclavian (pectoral girdle) - coeliaco-mesentteriac (viscera) - renal (kidneys) - postcardianal veins - in tunas (Cutaneous arteries)



Alimentary Canal

- Anterior - Mouth - buccal cavity - pharynx - no salivary glands
- Posterior foregut - esophagous (striated and smooth muscle; taste buds, mucous) - stomach (mucous and pepsin/HCl secrete cells); some lost true stomach
- Midgut - intestine (columular epithelium and goblet cells) and pyloric caeca (finger like projections - absorprion or digestion); Length varies - correlated with diet;
- Hindgut - rectum - not well defined;
- Agnatha - have straight w/ typhlosole (fold)
- Chondrichthyes - spiral valve

Alimentary Canal



Other structures

- Liver - gall bladder - bile duct; stores fat; cod liver oil - vit A and D
- Pancreas - digestive enzymes
- **Gas Bladder**
  - 2 layer - Tunica externa (collagen) & tunica interna (muscle and epithelium);
  - Walls lined w/ guanine crystals (decrease permeability 40x)
- Physostomous - connection of esophagous/bladder by pneumatic duct
- Physoclistous - lose connection
- Gas gland - secretes lactic acid; lower pH, reduces solubility (1 pH = 50% O2)- raises partial pressure of O2
- Rete mirabile (wonder net)- counter current gas exchange system
- Oval - posterior dorsal resorptive area

Waste Land

- **Kidneys** - major excretion and osmoregulation; most nitrogenous wastes through the gills
- Pronephros - all larval fish; funnels that empty into body cavity;
- Mesonephros - Actinopterygii;
- Renal corpuscles - glomerulus surrounded by Bowman's capsule;
- Glomerulus receives blood; filter; waste's collect in Bowman's to mesonephric tubule (some resorption);
- Freshwater fish - have to secrete copious amounts of dilute urine;
- Saltwater fish - drink lots of water; secrete very concentrated salty urine.
- Metanephros - all higher vertebrates

Internal Anatomy

- **Gonads** - most fish are dioecious - two sexes
- Testes - usually paired; up to 12% body weight; claspers in Chond; - teste - vas efferentia - Leydig's gland - sperm duct - seminal vesicle
- Bony fish - lack seminal vesicles (or sperm sac)
- Overies -
- Gymnovarian - Chondrichtyes - shed eggs into body cavity - eggs enter funnel of oviduct; - Nidamental (shell) gland - membrane;
- Oviparous (egg laying) - horny membrane
- Viviparous - live bearing = uterus
- Cystovarian - Gars and most teleosts = ovary continuous w/ oviduct

Fish – Nervous Systems

- **Nervous systems** - Cerebrospinal system (CNS and peripheral); brains small (7.5% of comparable bird etc)
- Brain - 5 regions
- 1) Telencephalon - forebrain = smell; olfactory bulb; CN1 = olfactory
- 2) Diencephalon - correlation center; pineal structure
- 3) Mesencephalon - Midbrain - vision; CN2 = optic;
- 4) Metencephalon - hind brain; muscle tone equilibrium in swimming CN3 - oculomotor (somatic motor), Large median lobe = cerebellum - CN4 = trochlear (somatic motor)
- 5) Myelencephalon (medulla oblongata or brain stem) - relays sensory information - cranial nerves 5-10 (6 = abducens = somatic motor; 5=trigeminal mixed somatic/sensory for anterior head; 7=facial and 8=acoustic often fuse); 9=gloosopharyngeal (gill region); 10= vagus=lateral line and viscera)