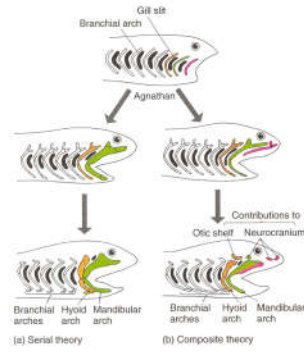


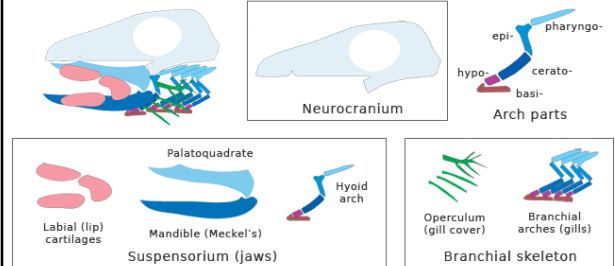
## Evolution of Jaws

- Earliest forms
  - No jaws
  - Cartilage cranium
  - 8 Cartilage arches support gill slits
- Derived forms
  - Jaws
  - Bony cranium
  - 5 arches support gills
- Two theories
  - Serial
  - Composite



**FIGURE 7.7** Serial and composite theories of jaw development. (a) The serial theory holds that jaws arise completely from one of the anterior branchial arches. Elements may be lost within it, but other elements from other arches do not contribute. (b) In the composite theory, the mandibular arch is formed from elements of several adjacent arches that also contribute to the neurocranium.

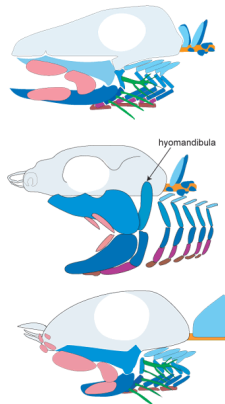
## Derived Fish Skull Components



- Neurocranium –
- Suspensocranium (suspensorium) –
- Branchial Skeleton –

## Jaw suspension

- Autostylic
  - Palatoquadrate articulated with neurocranium
  - Hyoid arch not involved in jaw suspension
  - Hyomandibula -> inner ear bones
  - All non-fish vertebrates
- Hyostylic
  - Palatoquadrate hangs from ethmoid and hyomandibula
  - Hyomandibula attached to upper and lower jaws
  - Modern sharks and teleost fishes
- Holostylic
  - Palatoquadrate fused with neurocranium, no hyomandibula in hyoid arch
  - Chimera



## Jaw Protrusability and Feeding

- Suction feeding
- Ram feeding
- Suction feeding and Jaw Protrusion



### Feeding Habits and Gut Morphology

- Feeding Guilds
  - Detritivores
  - Herbivores
  - Carnivores
  - Omnivores
- Most fish euryphagous carnivores, ontogenetic shifts common
- Digestive tract anatomy
  - Low quality prey –
  - High quality prey –

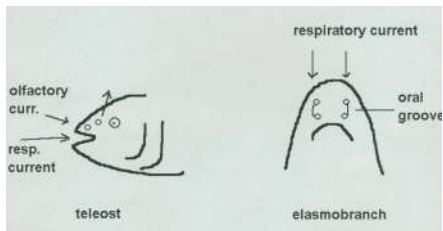
### Digestive Tract

- Esophagus
- Stomach
- Small intestines
  - Pyloric caeca



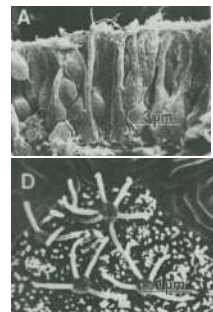
### Chemoreception

- Olfactory reception
- Taste



### Sensory Epithelium

- Composed of:
  - receptor neurons: high densities
    - 25,000/mm<sup>2</sup> in salmonids
    - 500,000/mm<sup>2</sup> in cyprinodontids
  - supporting cells
  - basal cells
- Receptor neurons:
  - ciliated – 8 cilia
  - microvillous – 80 microvilli



### Taste

- Taste buds
  - Detection limits:
    - *Pimephales* - p-chlorophenol <math><0.0005\text{ ppm}</math>
    - *Oncorhynchus* - morpholine     - Catfish - amino acids  $10^{-7} - 10^{-9}\text{ ppm}</math>$
- Palatal organ:
- Elasmobranchs:
- Examples:

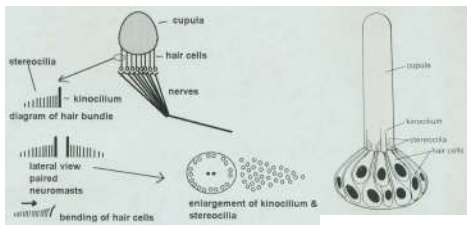


### Chemoreception Examples

- Salmon imprinting of natal stream, return migration
- Recognize smell of juveniles (Pheromone hypothesis) for parental care
- Kin recognition, mitigates aggressive interactions
- Schooling aggregation
- Schreckstoff
- Food location
  - Ion concentrations detected by gill parasite catfish
  - sharks

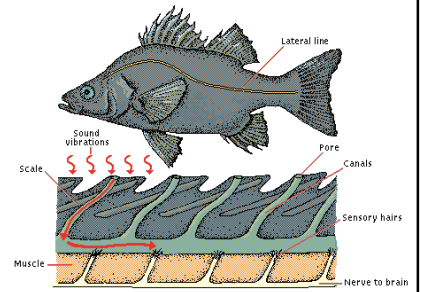
### Detecting sound, vibration and water movement

- Lateral line
  - Neuromasts –
  - Cupula –



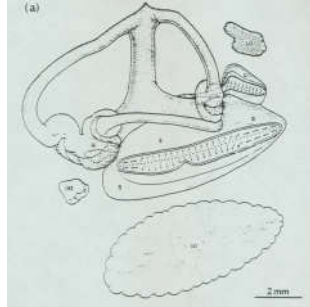
### Variability in lateral line

- Jawless fishes:
- Open vs Closed Canals:
- Habitat indicator



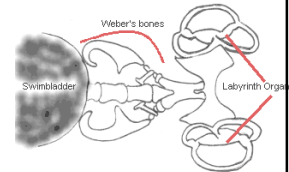
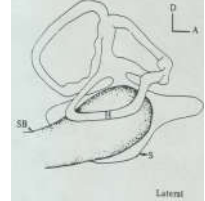
### Inner ear

- Embryologically related to the lateral line
- Two parts:
  - semicircular canals
  - otolith organs
- Perception



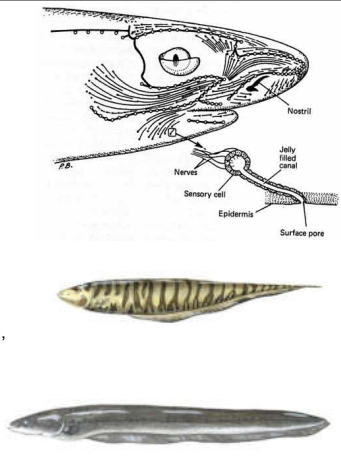
### Swim bladders and hearing

- Swim bladder as hearing receptor
  - Clupeidae - hollow ducts extend from gas bladder to inner ear
- Elephant fish have gas bubble in head
- Weberian apparatus
  - Otophysan fishes (e.g., catfish, minnow)
  - Connected to air bladder

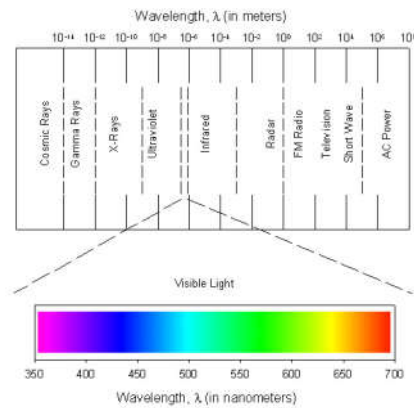


### Electroreception

- External pit organs on teleosts
- Ampullae of Lorenzini
- Weakly electric fishes - gymnotiformes
- Communication, prey detection, navigation



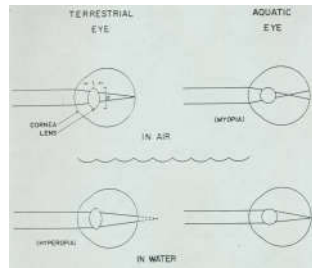
### Electromagnetic Spectrum



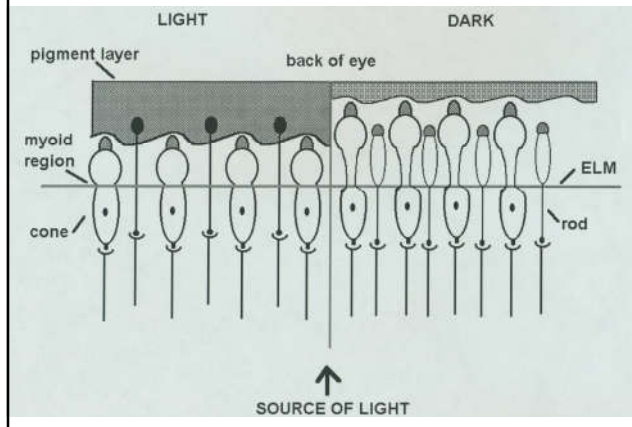
•In some ways, fish vision is better than our own.  
•UV, tetrachromic vision in some species

## Fish vs Terrestrial Eyes

- Focusing
- Pupils
- Other structures



## Rods, cones, photomechanical movement and light accommodation



## Reproduction

- Gender System
  - Gonochoeristic
  - Gynogenic
  - Hermaphroditic
    - Simultaneous
    - Sequential
      - Protandrous
      - Protogynous
- Sex determination
  - Genetic
  - Environmental
- Mating System
  - Promiscuous
  - Monogamy
  - Polyandry
  - Polygyny
- Secondary traits
  - Monomorphic
  - Dimorphic
    - Seasonally dimorphic
    - Permanently dimorphic
- Number of reproductive acts
  - Semelparous
  - Iteroparous

## Reproduction continued

- Site of fertilization
  - Internal
  - External
- Fate of Eggs
  - No parental care
    - Broadcast spawners
      - Pelagic
      - Benthic
    - Brood hiders
  - Eggs guarded
    - Substrate spawners
    - Nest builders
  - Bearers
    - Internal bearers
      - Ovovivipary
      - Vivipary
    - External bearers