

## 73% of earth is covered with water

Table 3.1 Amounts of Water in the Various Reservoirs on Earth

Reservoir	Percent of Total	Sphere Depth <sup>a</sup> (m)
Oceans	97.41	2685
Polar caps and ice	1.94	53
Ground water	0.64	18
Lakes	0.01	0.3
Atmosphere	0.001	0.03

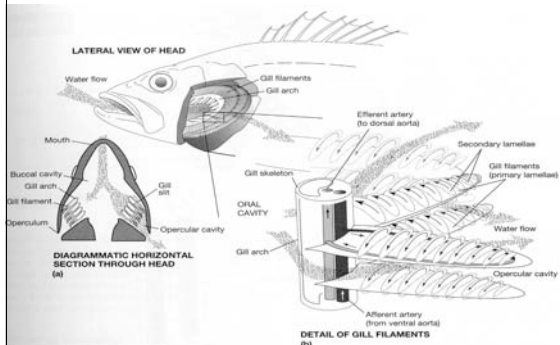
<sup>a</sup>This is the depth the water would have if the Earth's surface were perfectly smooth, and the water were spread uniformly over it. (Although the volume of the oceans is accurately known, estimates of ground water and Antarctic ice vary.)

Yet.....  
40% of teleosts are freshwater

## Things about Water (p74)

- Density
- Viscosity
- Oxygen Content
- Heat Capacity and Conductivity
- Electrical Conductivity

## Getting Oxygen from Water



## Getting Oxygen from Air (if you're a fish)

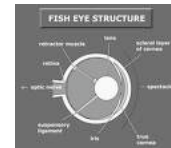
- If the environment is very low-oxygen, gills aren't enough
  - Large lips for gulping
  - Labyrinths-vascularized chambers at the rear of the head into which air can be sucked for gas exchange
  - **Facultative** vs. **Obligate** air breathers

## Adjusting Buoyancy

- Fish that can hover generally have swim bladders
  - They can adjust air volume as they swim up and down to maintain neutral buoyancy
  - They can maintain their position with a little backpedaling by the pectorals and a gentle undulation of the tail
  - Marine fish have smaller swim bladders---why?
- Cartilaginous fish use a large volume of light liver oil instead and nitrogenous compounds
  - Liver up to 25% body weight
- Deep Sea fish use lipids in either a bladder or dispersed

## Vision

- As light passes from air to water, it gets bent such that things underwater appear closer than they are
- There is not much difference in the bending between water and the cornea, so in fish, the cornea can handle most of the focusing and the lens is spherical and moves back and forth



- Light is bent much more when it passes from air through the cornea

## Taste



- Fish have taste buds in the mouth and around the head and anterior fins
- They also have receptors for a sort of general chemical sense to detect substances slightly soluble in water
- Olfactory organs detect substances completely soluble in water
  - Sharks and salmon can detect odors at concentrations of less than 1ppb

## Mechanoreceptors: touch/water displacement

- Basis for senses of sound, touch, pressure, and motion
- Inner ear detects changes in speed and direction of motion
- Gravity sensors in the fish inner ear allow it to distinguish up from down

## The Neuromasts

Hair cells:



- These are the mechanoreceptors (hair cells plus support cells)
- Found on the surface of the head and body of fish and amphibians
- In jawed fish these are located in canals along the head and running the length of the body: the **lateral line system**
  - Air isn't dense enough to stimulate these cells so terrestrial verts lack these

## Electric Discharge

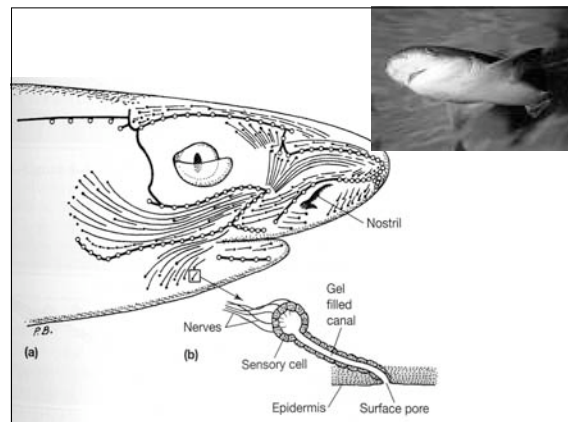
- The electricity comes from **electrocytes** which are muscle cells modified to generate ion current flow rather than contract
- They're arranged in stacks so charge can build up
- Some rays, electric catfish, and eels use electricity to stun prey or deter predators
- A few use the signals for communication
- Most electric fish are in African and South American freshwater systems



## Electroreception

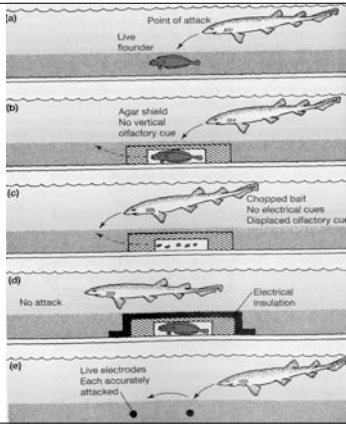


- Sharks and rays can detect electric fields via the **ampullae of Lorenzini** on their heads or pectoral fins
- Surface pore connected to a receptor and filled with electrically conductive gel
- Work like voltmeters, detecting change in electric potentials
  - Good down to at least 0.01microvolts/cm---as good as the best voltmeter we can build
- Gel can also detect temperature gradients of  $<.001^{\circ}\text{C}$
- Sharks can also use the sense the earth's magnetic field and even voltages created by currents moving ions



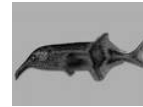
### Electrolocation Capacity of Sharks

- Detects live flounder
- Detects flounder when smell is shielded by agar
- Follows displaced olfactory cues, misses chopped bait
- Unaware of entirely shielded flounder
- Shark attacks electrodes (no smell necessary)



### Teleost Electrolocation

- The knifefishes of South America and the Elephant Fishes of Africa use electrical discharge to communicate and electrical fields to “see”
- Their electroreceptors are modified lateral line organs sensing distortion



- Several amphibians and the monotremes can find prey this way to

### Internal Environment

- Vertebrate Kidney
  - Removes excess water, salts, waste materials, foreign substances
- Regulation of Fluids
  - Seawater concentration is ~1000 millimoles/kg
  - Isosmolar, hyposmolar, hyperosmolar
  - Stenohaline, euryhaline

### Fluid/Salt Balance: Freshwater Organisms

- Teleosts
- Amphibians

### Fluid/Salt Balance: Marine Organisms

- Teleosts
- Hagfish
- Cartilaginous Fish
- Coelocanth
- Sharks/Rays in Freshwater
- Marine Amphibians



### Temperature

- Influence on Standard Metabolic Rate (SMR)
- Ectotherm vs. endotherms
- Regional Heterothermy
- Surface to Volume Ratio and temperature

