

## Chapter 23: External Respiration

1. Fig 23.1 Generalized features of animal gas exchange
  - A. Convection
    - a. Ventilation
    - b. Diffusion

## Surface Area to Volume Ratio

1. Limitations imposed by the surface area of three dimensional structures lead to evolution of ... (next slide)

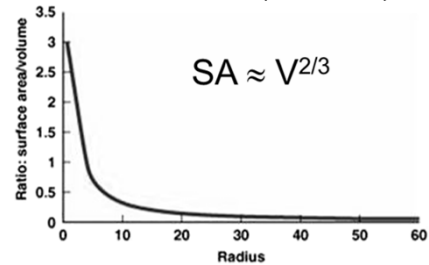


Fig 23.2 specialized breathing structures

1. Gills (evaginations)
  - A. External
  - B. Internal
2. Lungs (invaginations)
3. Cutaneous
4. Tracheae

1. Ventilation of respiratory surfaces reduces the formation of static boundary layers
  - A. Nondirectional
2. Passive ventilation
  - A. Nondirectional
3. Active ventilation
  - A. Tidal
  - B. Unidirectional

Figure 23.3 Tidal gas exchange

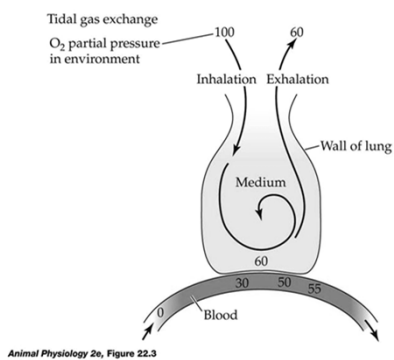
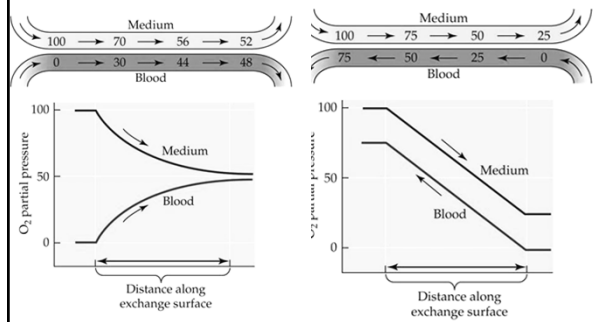
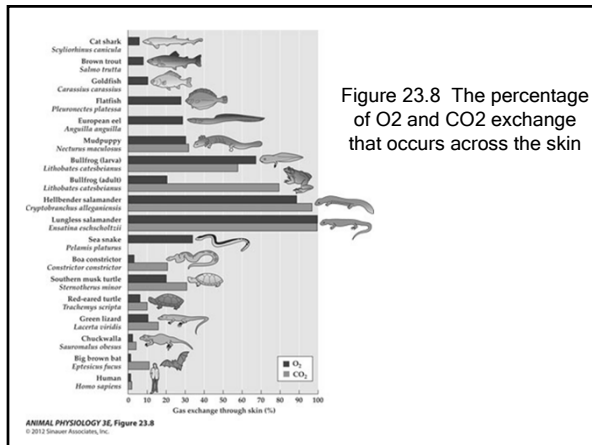
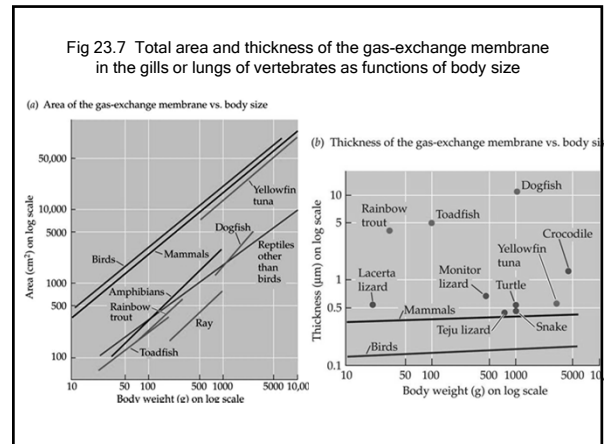
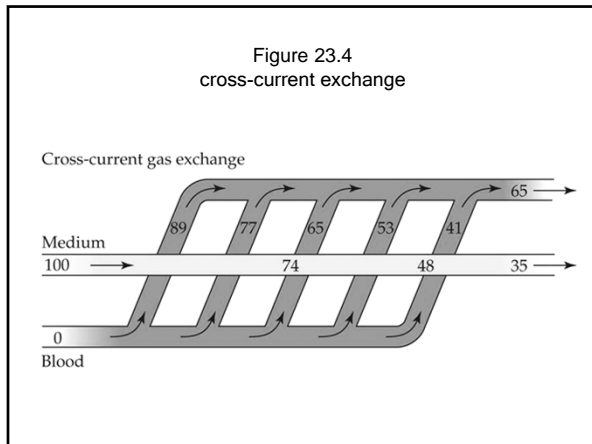


Figure 23.4

Cocurrent Gas Exchange

Countercurrent Gas Exchange

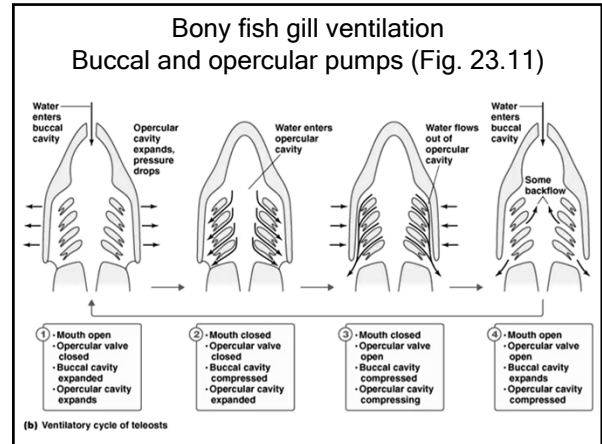
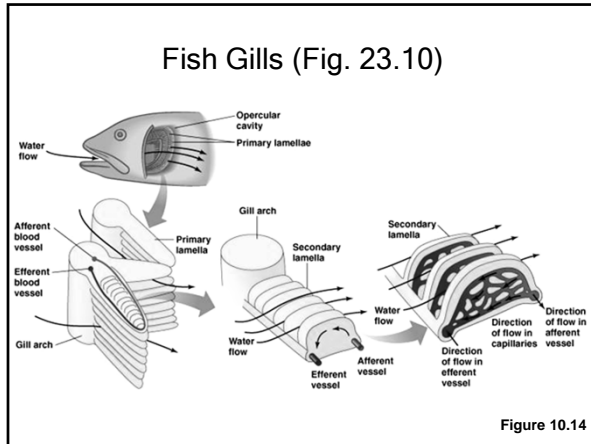




- ### Ventilation and Gas Exchange
1. Different physical properties of air and water
  2. Tidal versus unidirectional flow
  3. Differences
    - A. Density
    - B. Viscosity
    - C. Solubility

- ### Ventilation and Gas Exchange
1. Work of respiration
    - A.  $[O_{air}]$  30x greater than  $[O_{water}]$
    - B. Water requires 50x energy for movement
  2. Advantages in Breathing Water
    - A. Venting CO<sub>2</sub>
    - B. Evaporation is an issue for air breathers

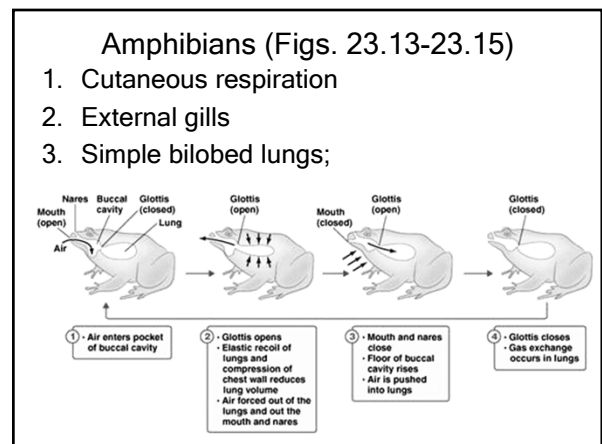
- ### Ventilation of Gills
1. to replenish oxygen
    - A. move gill through water
    - B. move water over gill
  2. Moving gill through the water limited to smaller organisms
  3. Moving water over gill
    - A. ciliary action (some invertebrates)
    - B. mechanical pump
  4. Fish use countercurrent exchange



- ### Gill Ventilation
1. Buccal and opercular pumps (Fig. 23.12)
  2. Ram ventilation
    - A. Continuous swimming, with mouth open
    - B. large, fast-swimming pelagic fish
    - C. Most fish pump at low speed
    - D. Switch to ram ventilation at high speed

- ### Air Breathing Fish Air-breathing fish (Fig. 23.12)
1. Several hundred species of bony fish
  2. Live in oxygen poor environments
  3. Use various vascularized tissues
  4. Vertebrate lungs are outpocketings of the esophagus

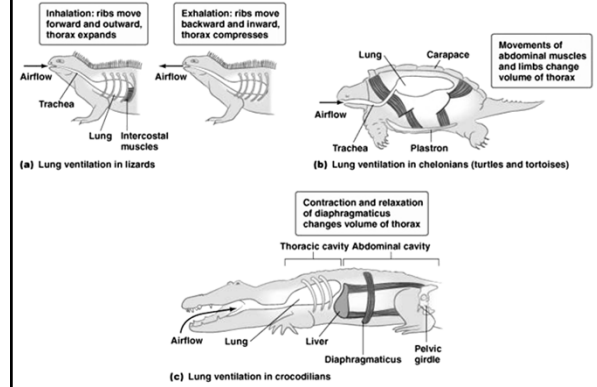
- ### Water to Land
1. More  $O_2$  in air than in water
    - A. Water = 0.5 - 1%
    - B. Land = ~ 21%
  2. Mollusks, arthropods, and fish
  3. Two problems at gills
    - A. no support
    - B. evaporation



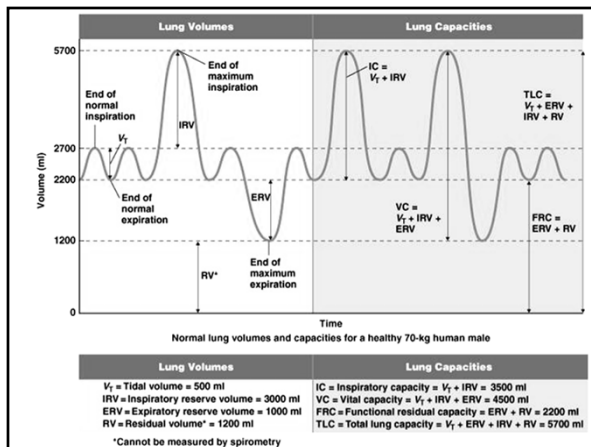
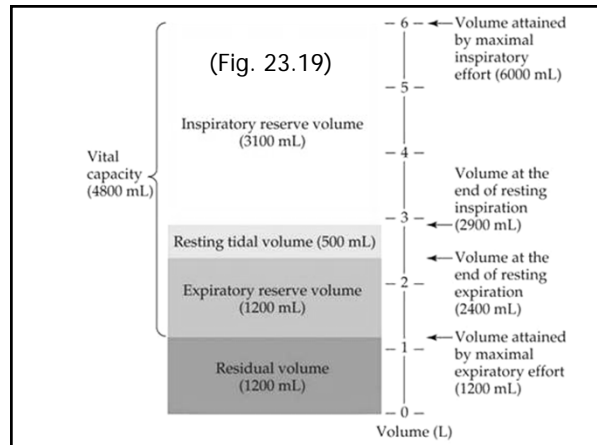
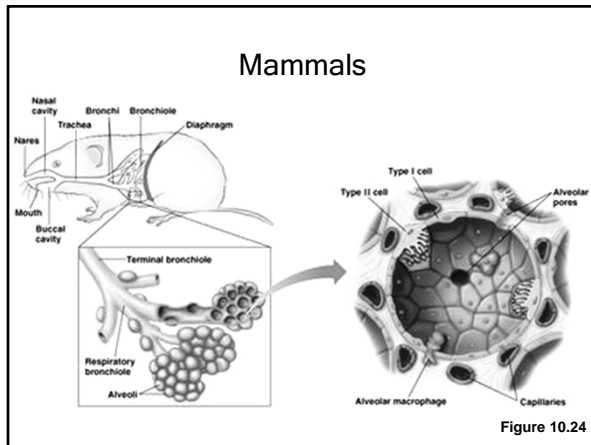
## Reptiles

- Most have two lungs
- Can be simple or highly divided
- Ventilation
  - Tidal
  - Suction pumps
  - separate feeding and respiratory muscles
- inspiration and expiration
- several mechanisms to change the volume

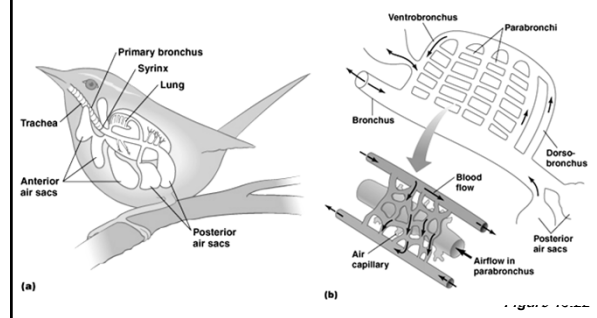
## Reptile Ventilation



## Mammals

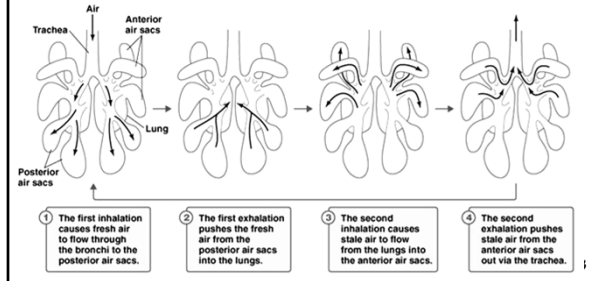


## Birds (Fig. 23.22)



### Bird Ventilation (Fig. 23.22)

1. two cycles
2. unidirectional air flow



### 2. Insects and arachnids (Fig. 23.29)

1. Combine "circulation" and gas exchange
2. tracheal system, tracheoles, spiracles
3. Gases diffuse in and out

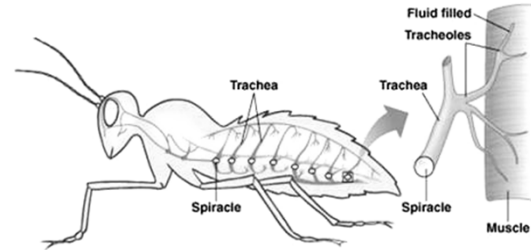


Figure 10.16