

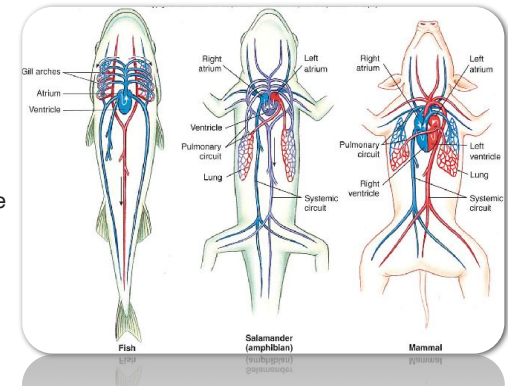
# circ./gas ex.

chapter 42

## gas exchange

- Gas exchange (respiration?)
  - respiratory medium
  - atmosphere is ~21% O<sub>2</sub> (by volume).
    - P<sub>i</sub> of O<sub>2</sub> = ~160mmHg
    - P<sub>i</sub> of CO<sub>2</sub> = ~0.23 mmHg
  - Dalton's Law
- respiratory surface (Fick's Law)
  - CO<sub>2</sub> and O<sub>2</sub> move by diffusion.
  - moist, thin, large surface area
  - complexity of respiratory surface
    - size of the organism
    - aquatic or terrestrial
    - metabolic demands

$$\text{rate of diffusion} = k \times A \times \frac{(P_2 - P_1)}{D}$$



## skin?

- simpler organisms
  - Gas exchange occurs over the entire surface area
  - sponges, cnidarians, and flatworms
- cutaneous breathing (amphibians, earthworms)
  - moist skin
  - highly vascularized
  - high SAV ratio



## gills

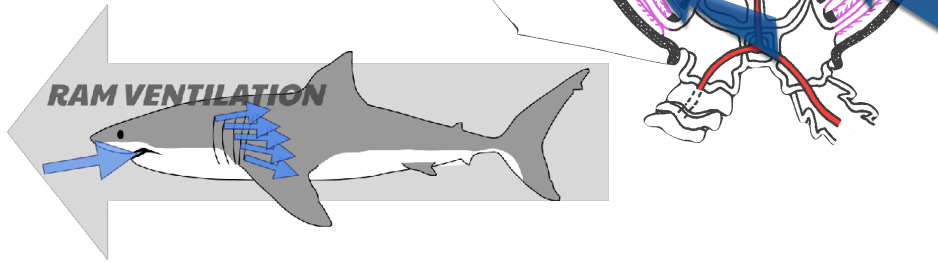
- aquatic respiratory organs
  - surface area of gills > rest of the body
- Water as a respiratory medium:
  - moisture?
  - O<sub>2</sub> concentrations low in H<sub>2</sub>O
  - gills must be very efficient



## gills

- **Ventilation**

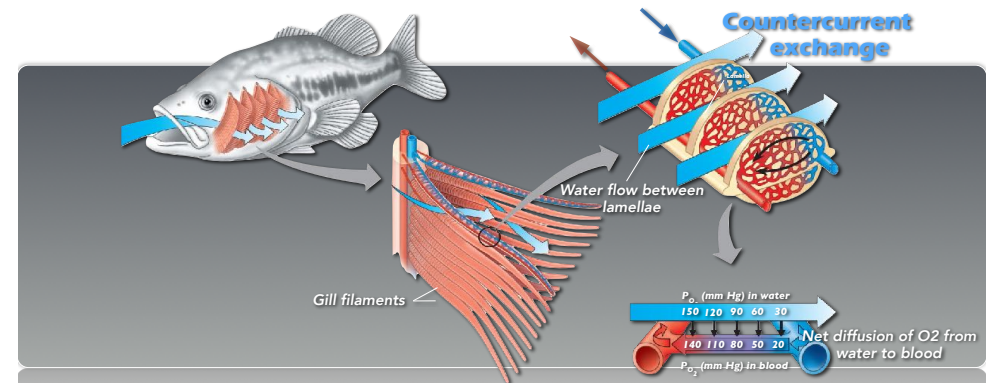
- necessary in water
- Crayfish and lobsters
- energy associated with ventilation?
  - RAM ventilation



## gills

- **countercurrent exchange.**

- maximizes diffusion gradient



## air breathing

- **terrestrial animals**

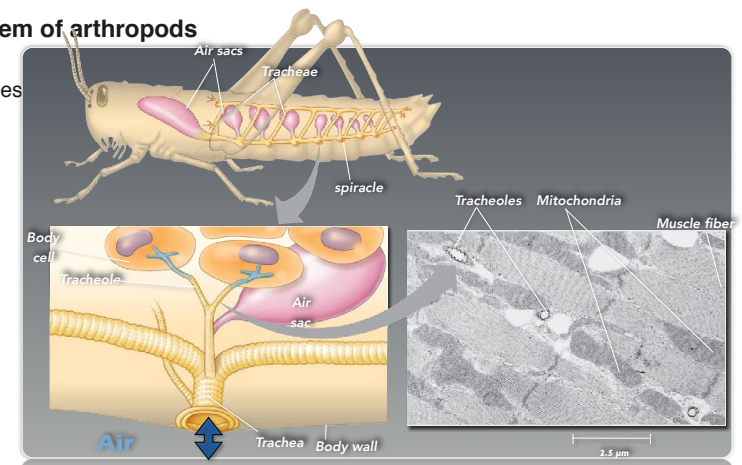
- air has many advantages over water.
  - more O<sub>2</sub>
  - ventilation?
  - less energy to ventilate
- problems:
  - water loss.



## tracheae

- **tracheal system of arthropods**

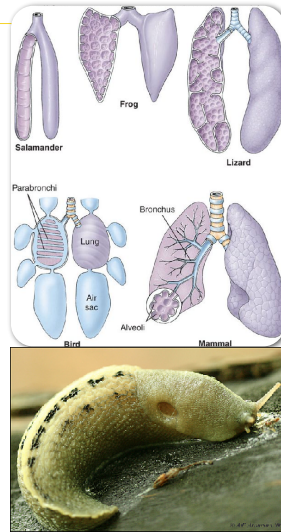
- ventilation
- flight muscles
- air sacs



# lungs

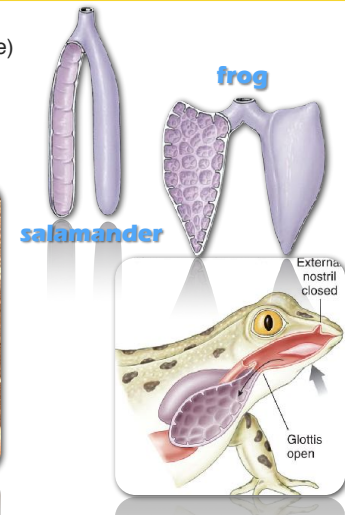
## • lungs

- interfaces with circulatory system
- closed circulatory
  - capillaries line respiratory surface.
- open circulatory
- spiders, terrestrial snails, and vertebrates.



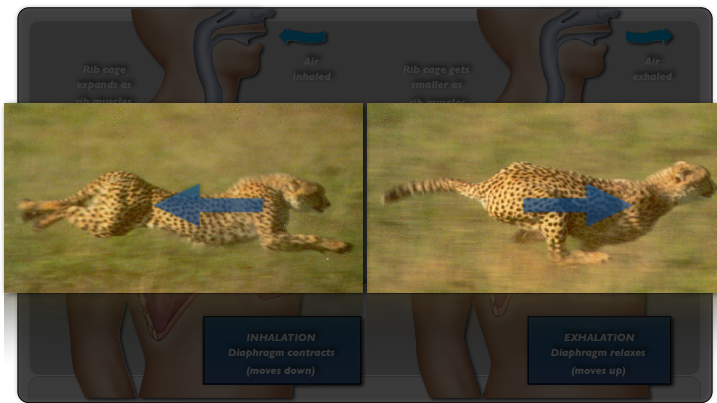
## • amphibians

- some lack lungs altogether (plethodontidae)
- skin breathing very important
- positive pressure breathing



## • pulling air

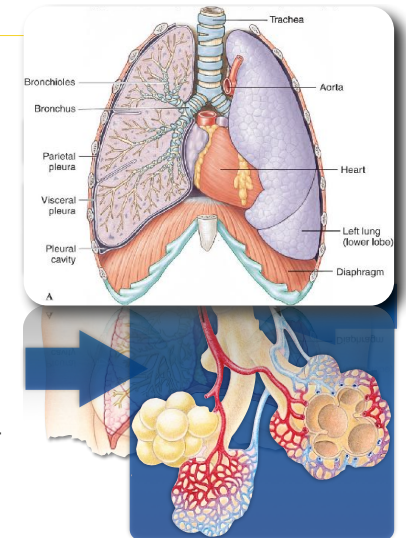
- negative pressure breathing (e.g. mammals and reptiles)
- visceral pump?



# humans

## • human lungs

- system of branching ducts
- nasal, sinus passages
  - warmed and humidified
  - olfaction.
- trachea
- bronchi
- bronchioles
- alveoli
- pleural cavity
  - thin space filled with fluid
  - surface tension, adhesion and cohesion of water
- diaphragm

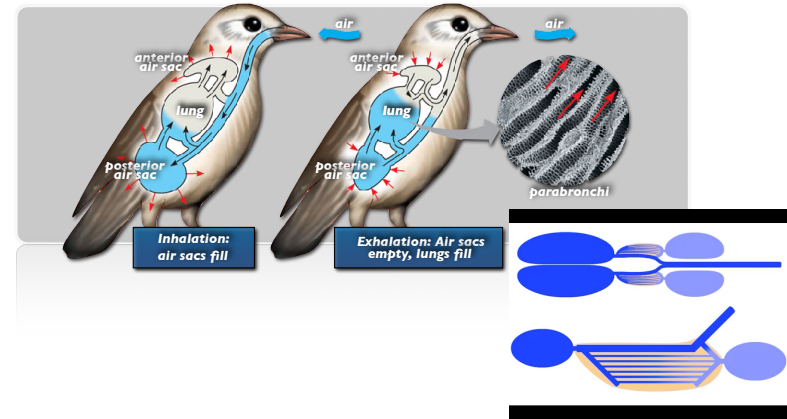


# lung volume

- **tidal volume**
  - (~500 mL)
- **vital capacity**
  - (3.4 L and 4.8 L)
- **residual volume**



- **Birds -- continuous breathing**
  - eight or nine air sacs; parabronchi



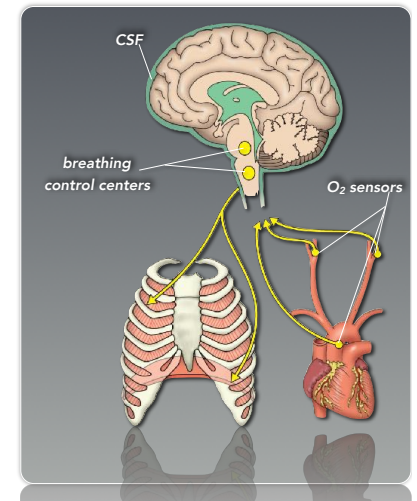
## • rate and depth of breathing

- autonomic regulation
- negative-feedback via stretch receptors
- breathing control centers
  - medulla oblongata and the pons
    - pH
    - hypercapnia?



## • O<sub>2</sub> levels?

- O<sub>2</sub> sensors in aorta and carotids
- **CO<sub>2</sub> and O<sub>2</sub> - negatively correlated.**
  - hyperventilation
  - removing CO<sub>2</sub>?



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• **respiratory pigments**

- hemocyanin
- hemoglobin
  - four subunits (heme groups)
- O<sub>2</sub> loading
  - bohr shift
- CO<sub>2</sub>
  - amino groups

