Respiratory system

The organ system that exchanges gases between the air in the lungs and the blood

- In lungs, O_2 enters the blood and CO_2 exits the blood
- The two major parts are the airway passages and the lungs

Fig 22.2

Airway passages (the respiratory tract):

The passageways that carry air in and out of the lungs

- The airways also clean and warm the air
- Cells of passageways secrete mucus (to trap contaminant particles in air) and have beating cilia (hairs to propel mucus up away from lungs)

Figs 22.2 and 22.5

Airway organs:

- Nasal cavity = open air chamber behind nose
- Pharynx = The upper throat (behind the nasal and oral cavities)
  - √ Conducts air, food, and water
- Larynx (voice box) = A hollow cartilage structure at the junction of the trachea and the pharynx
  - √ Epiglottis = A cartilage flap that covers the windpipe when we swallow, to divert food and water into the esophagus
  - √ Vocal cords = Vibrating folds in the larynx that make the sounds when we speak
  - √ Thyroid cartilage (Adam's apple) = The largest part of the larynx cartilage
- Trachea (windpipe) = A tube that conducts air from the larynx down into the thorax, towards the lungs
- Primary (left and right) bronchi = tubes formed by branching of trachea
  - √ Each bronchus enters a lung

Figs 22.2, 22.4, 22.6, 22.7, and 22.9

Lungs

Two spongy elastic organs in the thoracic cavity that draw in air and exchange gases with blood

- Each bronchus branches repeatedly in lungs
- Bronchioles = The smallest branchings of the bronchi
- Alveoli = Round air sacs at the end of bronchioles where O_2 enters blood and CO_2 exits blood
    - √ Gases easily diffuse through the walls of the alveoli and the capillaries, which are both simple squamous epithelial tissue
- Air is drawn into lungs (inspiration) when we expanded them using the inspiratory muscles

Figs 22.2, 22.9, 22.10, 22.11, and 22.22

Inspiratory muscles

Muscles that expand the lungs to a larger size, which causes inspiration of air into the lungs

- Diaphragm = Dome shaped muscle under the lungs that expands the lungs downward
- External intercostal muscles = Muscles between the ribs that expand the lungs anteriorly and laterally
- (No muscles are needed for normal expiration: The elastic recoil of the lungs automatically contracts the lungs back to a smaller size, which causes expiration of air out of the lungs).

Figs 11.18, 22.2, 22.14, and 22.17; Table 11.7

Pleura

A fluid-filled double membrane (a serosa) between the lungs and the thoracic cavity wall

- Inner membrane attaches firmly to lungs
- Outer membrane attaches firmly to thoracic cavity wall
- Pleural fluid = fluid between inner and outer membrane of pleura
  - √ Creates a vacuum that holds lungs to thoracic cavity wall
  - √ Lubricates sliding of lungs along wall when breathing

Figs 22.14 and 22.16

Spirometry

Measurement of the volumes of air breathed

Fig 22.18 and 22.19

Tidal volume (TV)

The volume of air moved in and out of the lungs in each normal relaxed breath

- about 500 ml

Fig 22.18 and 22.19

Inspiratory reserve volume (IRV)

The maximum volume of air that can be forcibly inspired *after* a tidal inspiration

- about 3000 ml

Fig 22.18 and 22.19

Expiratory reserve volume (ERV)

The maximum volume of air that can be forcibly expired *after* a tidal expiration

- about 1100 ml

Fig 22.18 and 22.19

Vital capacity (VC)

The maximum volume of air that can be forcibly expired *after* a maximum inspiration (inspiratory reserve + tidal volume + expiratory reserve)

- about 4600 ml

Fig 22.18 and 22.19

Residual volume (RV)

Air volume that remains in lungs after a maximum expiration

- about 1200 ml

Fig 22.18 and 22.19

Gases always move in and out of blood by simple diffusion (molecules moving spontaneously from high to low concentration areas)

- In pulmonary loop capillaries…
  - √ O_2 enters the blood because the air in lungs has a higher O_2 concentration than the blood
  - √ CO_2 exits the blood because the lungs have a lower CO_2 concentration than the blood
- In systemic loop capillaries…
  - √ O_2 exits the blood because the tissues have a lower O_2 concentration than the blood
  - √ CO_2 enters the blood because the tissues have a higher CO_2 concentration than the blood

How oxygen is carried in the blood:

- O_2 enters the blood in the pulmonary loop and exits the blood in the systemic loop
- O_2 is carried on Fe (iron) atoms
- The iron atoms are part of hemoglobin protein
- The hemoglobin proteins are inside red blood cells

Figs 22.22, 22.23, and 22.25

How carbon dioxide is carried in the blood:

• CO_2 enters the blood from cells in the systemic loop. When CO_2 enters the blood, most of it becomes HCO_3^- (bicarbonate ion)

CO_2 -> HCO_3^- + H^+

√ For each CO_2 that becomes HCO_3^-, a hydrogen ion is created in the blood

√ The more CO_2 that enters the blood = The more H^+ in the blood

• In the pulmonary loop, HCO_3^- becomes CO_2 again. The CO_2 exits the blood into the lungs

HCO_3^- + H^+ -> CO_2

√ For each HCO_3^- that becomes CO_2, a hydrogen ion is removed from the blood

√ The breathing rate controls how fast HCO_3^- becomes CO_2, and therefore controls the blood's H^+ concentration

√ Normally, our breathing rate is set so that the amount of H^+ removed from the blood by breathing exactly balances the amount of H^+ that created in the blood by CO_2

- Hypoventilation (less than normal breathing) increases the blood's H^+ concentration. Hyperventilation decreases the blood's H^+ concentration.

Figs 22.22, 22.28, and 26.16

CO_2 + H_2O → H_2CO_3 → H^+ + HCO_3^-
(from cells) (carbonic acid) (bicarbonate)

Breathing control center of brain

The pons and the medulla (in the brain stem) control respiration rate (breaths per minute)

- Normal respiration rate = 12 -18 breaths per minute

  √ Brain sends impulses to contract diaphragm and external intercostal muscles

- Breathing rate changed when blood's CO_2 and O_2 levels change

  √ CO_2 high *or* O_2 low = breathing rate increases

  √ CO_2 low *or* O_2 high = breathing rate decreases

- Oxygen level measured by O_2 sensors in aorta and carotid artery

  √ The O_2 information is sent to the breathing control center

- CO_2 (not O_2) is the major determinant of breathing rate

- CO_2 level not directly measured by breathing control center; Brain uses H^+ level (blood pH) to estimate CO_2 level

  √ Because one H^+ is made for each CO_2 that enters blood

  √ High CO_2 = High H^+ = low blood pH = acidosis (acidic blood)

  √ Low CO_2 = Low H^+ = high blood pH = alkalosis (basic blood)

Figs 22.20, 26.16, and 26.18

Respiratory system disorders:

- Emphysema* = walls of alveoli break down
  - √ Passages collapse during expiration
  - √ Victims have difficulty exhaling

- Chronic bronchitis* = lower respiratory passages inflamed; produce excess mucus
  - √ Coughing, increased lung infections, gas exchange reduced
  - √ Victims tend to display cyanosis (blue color due to hypoxia (insufficient O_2))

- Lung cancer* = uncontrolled cell growth in bronchi or lungs
  - √ Cancer metastasizes (invades other tissues) rapidly
  - √ 90% of victims smoked
  - √ Only 7% of victims survive

- Asthma = easily inflamed bronchi
  - √ Inflammation often triggered by specific irritant (allergies)
  - √ Causes coughing and shortness of breath

(* respiratory disease associated with smoking)