Lecture Outline: Respiratory System
Hole’s HAP [Chapter 19]

I. Introduction
Respiration is the process of exchanging gases between the atmosphere and body cells.

Respiration consists of:
Ventilation –

External Respiration –

Transport –

Internal Respiration –

Cellular Respiration –

II. Organization
1. Conducting division

2. Respiratory division

III. Functions
1. Gas exchange

2. Conducting passageway

3. Protection of respiratory surfaces

4. Sound production

5. Sense of olfaction
IV. Components

1. Upper respiratory system
   - nose, nasal cavity, paranasal sinuses, pharynx

2. Lower respiratory system
   - larynx, trachea, primary bronchi, lungs

A. Nose and nasal cavity
   Nose –
   
   External nares –
   
   Vestibule – space within flexible area, coarse hairs
   
   Nasal septum – perpendicular plate of ethmoid and vomer
   
   Nasal conchae – superior, middle, inferior
   
   meatuses –
   
   Hard palate –
   
   Soft palate –
   
   Olfactory region – extends from superior nasal conchae
   
   Internal nares – nasal cavity opens into nasopharynx

B. Sinuses

C. Pharynx
   1. Nasopharynx –
   
   2. Oropharynx –
   
   3. Laryngopharynx –
D. Larynx –
    Cartilages
    1. Thyroid – shield, hyaline cartilage
    2. Cricoid – hyaline cartilage
    3. Epiglottis –

    4. Three pairs of smaller cartilages:
       - arytenoid
          - cuneiform

    Vocal cords
    Vestibular folds
    - false vocal cords

    Vocal folds
    - true vocal cords

E. Trachea
    Length is about 11 cm, open tube

    Histology
    Mucosa –
    Submucosa –
    Cartilages –

    Heimlich maneuver – abdominal thrusts
    Tracheostomy –
F. Bronchi
   Trachea bifurcates into 2 primary bronchi

   Primary bronchi
     Right primary bronchus – larger in diameter, more vertical
     Left primary bronchus

   Branching
     Primary bronchi → (intrapulmonary bronchi) secondary bronchi
       → _____________________ → bronchioles →

       _____________________

G. Alveoli
   Approximately 300 million total

   Sacs composed of 2 cell types:
     - Simple squamous epithelium (__________)
     - Septal cells (__________) →

   Macrophages

   Capillaries surrounding alveoli:
     RV → pulmonary arteries → capillaries
       → _____________ → LA

H. Lungs –
   1. Location:

   2. Characteristics:
      Apex – superior end
      Base – concave inferior end, rests on diaphragm
      Hilus –
      Cardiac notch – indentation on left lung
3. Lobes – supplied by lobar bronchi

   Right lung –

   Left lung –

4. Pleural membranes (serous)

   Parietal pleura

   Visceral pleura

   Pleurisy –

   Pneumothorax –

   Hemothorax –

V. Respiratory Mucosa

   1. Respiratory epithelium

      PSCCE with Goblet cells –

      Stratified Squamous –

      PSCCE –

      Cuboidal cells with cilia –

   2. Lamina propria –

   3. Respiratory defense system

      - mucus escalator – cilia beat upward

      - filtration – traps particles in mucus

      - alveolar macrophages –
**VI. Breathing Mechanism**

Breathing is the movement of air from outside the body into the bronchial tree and alveoli

- air movements of inspiration and expiration
- changes in the size of the thoracic cavity due to ________________

Lungs at rest have an internal pressure equal to the outside pressure of the thorax

1. Inspiration
   - intra-alveolar pressure decreases to about ________________ as the thoracic cavity enlarges
   - atmospheric pressure forces air in the airways
   - shape of thorax changes by contraction of sternocleidomastoid and pectoralis minor muscles

2. Expiration
   - due to elastic recoil of the lung tissues and abdominal organs
   - maximal expiration is due to contraction of abdominal muscles and intercostal muscles

3. Boyle’s law
   Inverse relationship between __________ and __________

Pressure and airflow – air flows from high to low pressure

Diaphragm flattens as it contracts
   During inhalation:
   → increase volume of thoracic cavity
   →
Pressure changes
Atmospheric pressure (1 atm) = 760 mmHg

Inhalation               Exhalation

Intra-alveolar pressure

Intra pleural pressure

4. Respiratory Cycle
   = inhalation + exhalation

   Tidal Volume – amount of air inhaled or exhaled

   __________ ml at rest

   Eupnea –

5. Respiratory muscles
   Inspiration – diaphragm, external intercostals

   Expiration – passive process

   Hyperpnea –

   Inspiration – scalenes + same as above

   Expiration – internal intercostals and abdominal muscles

6. Respiratory rate
   Adults

   Children
7. Respiratory Volumes
   A. Resting tidal volume =
   B. Expiratory reserve volume =
   C. Residual volume =
   D. Inspiratory reserve volume
   E. Vital capacity

8. Alveolar ventilation
   Minute ventilation – tidal volume multiplied by breathing rate
   -
   Alveolar ventilation rate – major factor affecting concentrations of oxygen and carbon dioxide in the alveoli
   -
   - tidal volume minus physiologic dead space then multiplied by breathing rate

9. Nonrespiratory air movements
   Coughing
   Sneezing
   Laughing
   Crying
   Hiccuping
   Yawning
   Speech
VII. Control of Respiration

1. Respiratory centers in medulla oblongata
   - respiratory rhythmicity center = controls basic rhythm of respiration

2. Pontine respiratory group – formally called ______________ and ______________ centers in Pons
   Apneustic center – lower pons
     - increases inspiration =
   Pneumotaxic center – superior pons
     - coordinates transition between inspiration and expiration

3. Respiratory reflexes –
   A. Chemoreceptors – sensitive to _______, _______, and ________ in blood
     - stimulate respiratory centers →
     Central chemoreceptors – located in medulla oblongata
       - sensitive to ______ and ________ changes in CSF
     Peripheral chemoreceptors in carotid and aortic bodies
   B. Baroreceptors
     - carotid and aortic sinus detect stretching in vessel walls and blood pressure is adjusted
     Hering-Breuer reflex
       - stretch receptors in lungs prevent over-inflation
         - inhibitory impulses to respiratory center in medulla oblongata →
Factors affecting breathing

- decreased blood oxygen concentration stimulates peripheral chemoreceptors in the carotid and aortic bodies
- motor impulses travel from the respiratory center to the diaphragm and external intercostal muscles
- inhibitory impulses from receptors to respiratory center prevent over-inflation of lungs

VIII. Alveoli

- gas exchanges between the air and blood occur within the alveoli

Alveolar pores =

1. Respiratory membrane
   2 cell layer thickness
   
   Simple squamous epithelium –

   Endothelium –

   RDS – Respiratory Distress syndrome = not enough surfactant produced

2. Diffusion through respiratory membrane
   - gases are exchanged because of differences in ________________

A. Dalton’s law and partial pressure
   - pressure exerted by a particular gas in a mixture of gases is directly related to the concentration of that gas in the mixture and to the total pressure of the mixture
Atmospheric pressure –

760 mmHg =

Partial pressure of individual gas = % of that gas in atmosphere times total pressure of system

Ex. $pO_2$

B. External respiration
- $pCO_2$ is greater in capillary surrounding alveoli than in alveoli
- $CO_2$ diffuses from blood $\rightarrow$
- $O_2$ diffuses from alveoli $\rightarrow$

C. Internal Respiration
- $pCO_2$ is greater in tissues & tissue fluid than in capillaries $\rightarrow CO_2$ diffuses to blood
- $O_2$ diffuses into tissues

3. Oxygen Transport
- Most oxygen binds to hemoglobin to form oxyhemoglobin
- Oxyhemoglobin releases oxygen in the regions of body cells
- Much oxygen is still bound to hemoglobin in the venous blood

A. Oxygen
Hemoglobin (Hb) bound = 98.5%

Oxygen dissolved in plasma = 1.5%
B. Oxygen Release
Amount of oxygen released from oxyhemoglobin increases as:
- partial pressure of carbon dioxide increases
- the blood pH decreases
- blood temperature increases

Each Hb can carry 4 molecules of O2

If all Hb carry 4 molecules, then ______ saturated.

If Hb average 2 molecules, then ______ saturated.

Factors that affect oxygen dissociation curve:
1) $pO_2$

2) pH - ____acid environment (____pH) 
   $\Rightarrow$ O2 dissociates more readily from Hb

3) Temperature - ____temperature $\Rightarrow$ ____ O2 released from Hb

4) fetal Hb - binds more O2 than adult Hb

4. Carbon Dioxide Transport
- dissolved in plasma
- combined with hemoglobin
- in the form of bicarbonate ions

A. Dissolved in plasma: ______

B. Combines with globin part of Hb: ______
   - called carbaminothegoglobin

   \[ \text{CO}_2 + \text{Hb} \leftrightarrow \text{Hb} \text{ CO}_2 \]

C. Most transported as bicarbonate ions: ______

   \[ \text{CO}_2 + \text{H}_2\text{O} \leftrightarrow \text{H}_2\text{CO}_3 \leftrightarrow \text{H}^+ + \text{HCO}_3^- \]
5. Chloride Shift
   - bicarbonate ions diffuse out of RBCs

   When blood reaches lungs, all reactions are reversed:
   - Cl\(^-\) moves out of RBC;
   - HCO\(_3^-\) moves into RBC;
   - H\(_2\)CO\(_3\) forms \(\leftrightarrow\) CO\(_2\) + H\(_2\)O
   - CO\(_2\) diffuses into alveoli

Life-Span Changes
Clinical Applications