The Respiratory System

Chapter 13: To Breathe or Not to Breathe ... that is a stupid question!
Respiratory Anatomy

Organs include:

- **Conducting zone organs** (purify, humidify, warm)
  - Nose
  - Pharynx
  - Larynx
  - Trachea
  - Bronchi/bronchioles of the lungs

- **Respiratory zone organ** (gas exchange)
  - Alveoli of the lungs
Respiratory Anatomy

The Nose

- **External nares** (the nostrils) pass through the nasal cavity to the internal nares and are divided into two areas by the nasal septum.
Respiratory Anatomy

The Nose (mucus linings)

• **Olfactory mucosa** (superior part of nasal cavity) function in the sense of smell.

• **Respiratory mucosa** (all the rest of the nasal lining) function in…
  – warming air,
  – producing mucus to trap antigens,
  – and using ciliated cells to move trapped debris back to the digestive tract for digesting (yum!).

*runny nose*
Respiratory Anatomy

The Nose (other divisions)

- **Conchae**: three lobes on the mucus lining; produces increased surface area and air turbulence (all the better to warm and moisten the air, my dear)
- **Palates**: two areas that divide the nasal and oral cavities; hard palate (divided by bone)* and soft palate (divided by muscle)
- **Paranasal sinuses**: ring of sinuses in the skull that lighten the skull, resonate for speech, and produce mucus*. 
Respiratory Anatomy

The Pharynx (throat): 13 cm long muscular passage that connects the nasal and oral cavities. Allows food and air to pass.

• Superiorly: nasopharynx (auditory tubes, pharyngeal tonsils)
• Medially: oropharynx (palatine* & lingual tonsils)
• Inferiorly: laryngopharynx (end with epiglottis)
Respiratory Anatomy

The Larynx (voice box): formed with eight hyaline cartilages and one elastic cartilage (epiglottis); directs food and air, speech.

- **Thyroid cartilage**: largest of the eight, shield shaped, called the Adam’s apple.
- **Epiglottis**: divides the pharynx and larynx; opens to allow air to pass to the larynx and closes with the motion of the larynx to allow food to travel to the esophagus.
- **Vocal folds (vocal cords)**: flaps in the mucosal lining that vibrate as air passes over them, producing sounds.
Respiratory Anatomy

The Trachea (windpipe): about 12 cm (to midchest), reinforced with C-shaped hyaline cartilage and surrounded by ciliated mucosa.

- **Ciliated mucosa**: moves mucous back towards the epiglottis so it can be swallowed or spit out (yum, again!). Cilia are damaged by smoking so coughing is the only way to transport the mucus out hence “the smoker’s cough”.

- **Hyaline cartilage**: rigid (keeps the pipe open even with pressure changes), but flexible (so we can swallow chunks of food). *tracheostomy
Primary Bronchi (bronchus singular): the division of the trachea.

- Right bronchus is wider, shorter and straighter, therefore more susceptible to infection.
Respiratory Anatomy

The Lungs: paired, largest organs of the thoracic cavity

• Pleura (surface linings)
  – Pulmonary (visceral) pleura: lines the outer surface of each lung.
  – Parietal pleura: lines the thoracic cavity around the lungs. The tight connection between these two pleura are necessary for breathing.
  – Pleural fluid: serous fluid between the pleura that allow the two walls to slide past each other with limited friction. *Pleurisy
Respiratory Anatomy

The Lungs

- **Passageways** (connecting conducting zone structures with respiratory zone structures)
- **Bronchioles**: bronchi branch like trees to form increasingly smaller bronchioles (CZS).
- **Alveoli** (air sacs): terminal branches of the bronchioles (respiratory bronchioles, alveolar ducts, alveolar sacs then alveoli); millions of them; the bulk of the lungs; make the lungs soft, spongy and light weight (RZS). *gas exchange!*
Respiratory Anatomy

The Lungs

• The Respiratory Membrane (air-blood barrier)
• **Simple squamous epithelium**: lines the alveoli; thinner than tissue paper; externally covered with capillaries (gas exchange via diffusion); surface area of a healthy man is 50–70 m² (40x more than integumentary surface)
• **Simple cuboidal epithelium**: produce a lipid surfactant which lessens the surface tension of water and causing the alveoli to not stick together and collapse.
• **Macrophages**: final line of respiratory defenses (wander the alveoli gobbling up antigens).
Respiratory Physiology

• The major function of the respiratory system is ... respiration.
  – 1. pulmonary ventilation (breathing)
  – 2. external respiration (gas exchange at the lung)
  – 3. respiratory gas transport
  – 4. internal respiration (gas exchange at the tissue)

  – Chemical respiration happens in the mitochondria of each specific cell.
Respiratory Physiology

Pulmonary Ventilation (Breathing)

• Rule: “Volume changes lead to pressure changes, which lead to the flow of gases to equalize the pressure.”

• Inspiration: air flow into the lungs

•Expiration: air flow out of the lungs
Respiratory Physiology

Pulmonary Ventilation (Breathing)

• Inspiration:
  – diaphragm contracts (superior-inferiorly the thoracic cavity expands),
  – intercostals contract (anteroposteriorly and laterally the thoracic cavity expands),
  – larger space in the cavity decreases air pressure causing a vacuum,
  – air is sucked in until intrapulmonary pressure equals atmospheric pressure.
Respiratory Physiology

Pulmonary Ventilation (Breathing)

- Expiration:
  - Inspiratory muscles relax
  - Thoracic cavity decreases
  - Intrapulmonary pressure increases past atmospheric pressure
  - Air is forced out of the lungs until it is equalized with atmospheric pressure.
Respiratory Physiology

Pulmonary Ventilation (Breathing)

• Intrapleural pressure: pressure between pleura is always negative (less than atmospheric pressure) in order to keep lungs from collapsing.

• Chest wound or pleural rupture causes air to flow rapidly into the pleural space pulling the linings apart and collapsing the lung.
Respiratory Physiology

Pulmonary Ventilation (Breathing)

• Nonrespiratory air movements: move air into or out of intrapulmonary cavity in a way that can change respiratory rhythms.

• Examples:
  – Cough
  – Sneeze
  – Crying
  – Laughing
  – Hiccups
  – yawn
Respiratory Physiology

Pulmonary Ventilation (Breathing)

- Respiratory volumes/capacities
- **Tidal volume (TV):** normal breathing (500ml).
- **Dead space volume:** air that does not make it to the alveoli, but are trapped in the conducting zone (150ml).
- **Functional volume:** air that does make it to the alveoli; used in gas exchange (350ml).
Respiratory Physiology

Pulmonary Ventilation (Breathing)

- Respiratory volumes/capacities
- **Inspiratory reserve volume (IVR):** air taken forcibly over the tidal volume amount (2100-3200ml).
- **Expiratory reserve volume (ERV):** air released forcibly after tidal volume amount (1200ml).
- **Residual volume:** remaining air after ERV; allows gas exchange between breaths.
- **Vital capacity (VC):** the total amount of exchangeable air (4800ml) = TV + IRV + ERV
Respiratory Physiology

External Respiration

• Gas exchange in the lungs at the respiratory membrane. Follows the rule of diffusion (high to low).

• Oxygen levels are high in alveoli so they diffuse to the capillaries.

• Carbon dioxide levels are high in the capillaries so they diffuse to the alveoli.
Respiratory Physiology

Gas transport in the blood

- **Oxygen**: most attaches to hemoglobin in RBCs to form oxihemoglobin $\text{HbO}_2$ - some is dissolved in the plasma.

- **Carbon dioxide**: most is in plasma as bicarbonate (used in the blood pH buffer system) - some is attached to hemoglobin in RBCs.
Respiratory Physiology

Internal respiration

- Gas exchange in the tissues. Follows the rule of diffusion (high to low).
- Oxygen levels are high in capillaries so they diffuse to the tissues.
- Carbon dioxide levels are high in the tissues so they diffuse to the capillaries. (see p 417)
- Hypoxia: impaired oxygen content in tissues due to anemia, pulmonary disease, obstruction, carbon monoxide poisoning.
Respiratory Physiology

Respiratory control mechanisms

1. Neural regulation
   a) **Respiratory muscles (diaphragm and intercostals):** are regulated by phrenic and intercostal nerve impulses.
   b) **Medulla:** self-exciting inspiratory center that sets the rhythm of breathing.
   c) **Pons:** smoothes out the breathing rhythm
   d) **Stretch receptors:** in bronchioles and alveoli; send messages to medulla via the vagus nerves when inhalation should stop and exhalation should start.
Respiratory Physiology

Respiratory control mechanisms

2. **Physical factors**: talking, coughing, exercise, fever change breathing depth and rate.

3. **Volition (conscious control)**: singing or swimming or pouting as a child, but involuntary controls take over (drowning).

4. **Emotional factors**: gasping or panting from fright or extreme distress or sadness. These are all reflex actions of the hypothalamus.
Respiratory Physiology

Respiratory control mechanisms

5. **Chemical factors**: most important control factor; controls levels of oxygen and CO\textsubscript{2}.
- Controlling CO\textsubscript{2} levels is more important than O\textsubscript{2} levels.
- Increased CO\textsubscript{2} levels also increases acidity (lowers pH) due to a build up of carbonic acid.
- The result is hyperventilation, releasing CO\textsubscript{2}.
- Too much hyperventilation results in increased basicity (alkalinity-high pH).
- The result is hypoventilation or apnea, accumulating CO\textsubscript{2} in the blood.
Respiratory Disorders

Chronic Obstructive Pulmonary Diseases (COPD)

• We will look at two: emphysema and chronic bronchitis
• They have four commonalities:
  1. History of smoking
  2. Dyspnea: laborious breathing
  3. Chronic pulmonary infections with coughing
  4. Hypoxic: respiratory acidosis from carbonic acid build up which leads to respiratory failure.
Respiratory Disorders

Chronic Obstructive Pulmonary Diseases (COPD)

- **Emphysema (pink puffers):** the inability to exhale effectively due to enlarged alveoli, chronic inflammation, fibrosis of the lungs, decreased elasticity and collapsing of the lungs during exhalation.

- **Chronic bronchitis (blue bloaters):** inflamed respiratory mucosa produces excessive amounts of mucous. This impairs gas exchange and increases pneumonias.
Respiratory Disorders

- **Infant respiratory distress syndrome (IRDS):** lungs develop last and often don’t work well at birth especially if delivered premature.
- **Cystic fibrosis (CF):** genetic disease predominantly of Anglo decent. Causes incredible amounts of mucous build up in respiratory and digestive organs; sufferers die young.
- **Sudden infant death syndrome (SIDS):** believed to be heart rhythm malfunction.
- **Asthma:** chronically inflamed, hypersensitive bronchial tubes.