Respiratory System
Chapter 22

Main Functions of Respiratory System
Supplies \( O_2 \) and removes \( CO_2 \)
Joins kidney to Regulate pH of blood
Produces sounds for speech
Defends against microbes

Human Respiratory System: It has 4 main Phases.
A) Breathing or Pulmonary Ventilation
B) External Respiration – exchange of gases between lungs and blood
C) transport of gases in blood
D) Internal Respiration - exchange of gases between blood and tissues.
Structure of human respiratory system is well documented in images in text book and lab manual

Organization of Respiratory system

Upper Airways: external nares \( \rightarrow \) nasal cavity \( \rightarrow \) internal nares \( \rightarrow \) nasopharynx \( \rightarrow \) oropharynx \( \rightarrow \) laryngopharynx \( \rightarrow \) larynx
Lower Airways: trachea \( \rightarrow \) bronchi \( \rightarrow \) bronchioles \( \rightarrow \) terminal bronchioles \( \rightarrow \) respiratory bronchioles \( \rightarrow \) alveolar ducts \( \rightarrow \) alveoli (main portion of gas exchange)
Conducting zone: From external nares \( \rightarrow \) terminal bronchioles
Respiratory Zone: respiratory bronchioles \( \rightarrow \) alveolar ducts \( \rightarrow \) alveoli (main portion of gas exchange)

Provides a low resistance path to alveoli
Bronchioles are the main site of air flow regulation by ANS and hormones. Bronchodilation increases ventilation and bronchoconstricition decreases it.

Macrophages, mucous and cilia lining it defend against microbes and harmful particles
In chronic smokers cilia get damaged leading to mucous accumulation and chronic coughing
Paranasal Sinuses do same function as nasal mucosa.

Larynx

Larynx = the sound box: is supported by 8 cartilages.

Thyroid – is large shield like, curved cartilage that forms the front and side walls of larynx.
Cricoid – is another single cartilage; it is 2nd largest cartilage in larynx; is ring like anteriorly narrow but broad posteriorly, lies inferior to thyroid.
3 pairs of cartilages are present in larynx.
Most important is Arytenoid Cartilages. Most laryngeal muscles get attached to this pair and move them. In turn these arytenoids cartilages move the true vocal cords that produce the sound.

Glottis is the vocal folds and gap between them. Vestibular folds lie lateral/superior to true vocal cords.

Pitch of Sound – Larynx produces high pitch sounds by making vocal folds tenser.

The volume of the sound is controlled by regulating the amount of air forced out through glottis.

Trachea

Trachea = Windpipe: lies anterior to food pipe, esophagus. It has incomplete C-shaped cartilages to make its wall non-collapsible. Trachea inferiorly divides into 2 Bronchi.
Main = Primary bronchus \( \rightarrow \) lobar = secondary bronchus \( \rightarrow \) segmental = tertiary bronchus \( \rightarrow \) \( \rightarrow \) terminal bronchioles \( \rightarrow \) respiratory bronchioles \( \rightarrow \) alveolar ducts \( \rightarrow \) alveoli.
Lungs

Bronchi enter lungs. Left lung has 2 lobes and right lung has 3 lobes.

Each primary bronchus entering respective lung divides into secondary bronchi that carry air to different lobes.

Secondary bronchi divide into tertiary bronchi that carry air to different segments of lobes. The bronchi divide further divide and have cartilaginous rings to support them.

Ultimately they produce fine tubes without rings – Bronchioles.

terminal bronchioles → respiratory bronchioles → alveolar ducts → alveoli.

Breathing

Breathing: 2 Phases of Breathing are Inspiration and Expiration. When air enters the lungs it is inhalation and when it leaves the body it is exhalation. During inspiration rib cage moves up and out and diaphragm, a muscular sheet, moves down. It reduces pressure around lungs. As a consequence Lungs expand. During expiration rib cage moves down and in and the diaphragm moves up. The respiratory route air passes through is: Nostrils → nasal cavity → Pharynx → Larynx → Trachea → Bronchi (with cartilaginous rings) → Bronchioles (without rings) → Alveoli (air sacs) in inspiration. It is reverse for expiration.

Breathing – Muscles involved

Normal Breathing: main muscles are diaphragm and external intercostals. Scalenes keep 1st and 2nd ribs steady.

Diaphragm is prime mover (2/3rd of air) for pulmonary ventilation; it flattens for inspiration. Intercostal muscles move 1/3rd air.

Rib cage expands and draws parietal pleura out

Lungs expand and air pressure in lungs < air pressure outside

Air rushes in

Expiration takes place due to recoiling of ribs when muscles relax

Forceful Breathing:

Inspiration: sternocleidomastoid pulls sternum up, scalenes pull 1st 2 ribs up and help in deep inspiration

Expiration: Internal oblique – move rib cage in, Rectus abdominis, abdominal oblique muscles, latissimus dorsi pull ribcage down and cause faster expiration

Breathing and External Respiration

Breathing or Pulmonary Ventilation: is exchange of air between lungs and air outside

External Respiration: is exchange of O2 / CO2 between lungs and blood. O2 from its higher concentration in alveoli moves to blood and CO2 from its higher concentration in blood moves to alveoli. Both gases move by diffusion.

Lung Alveoli are the main seat of external respiration.

Internal Respiration

Internal Respiration is Blood-tissue gas exchange. Pulmonary veins carry O2 to heart and arteries carry O2 to body tissue via blood capillaries with thin walls.

O2 enters interstitial fluid and finally into cells. Mitochondria use O2 and produce CO2 which leaves cells and enters into blood capillaries through interstitial fluid.

Capillaries join to form veins which carry CO2 to heart which sends the blood to lungs for gas exchange.

Sensory Inputs for Breathing

Central Chemoreceptor: The center lies in medulla and is more sensitive to changes in CO2 concentration than O2 concentration. 70% stimulus is the pH of cerebrospinal fluid – directly affected by CO2 concentration.

Carotid and Aortic Chemoreceptors: 30% stimulus is regulated by impulses from receptors inside Carotid and Aortic bodies.

Regulation of Breathing
**Ventral Respiratory Group** = VRG lies in medulla and sets the basic rhythm of breathing.

**Dorsal Respiratory Group** = DRG lies posterior to VRG and receives inputs from carotid bodies – glossopharyngeal nerve, aortic bodies – vagus nerve, central chemoreceptors in medulla, PRG in pons and higher brain centers. It modifies the basic rhythm set by VRG. It sends instructions to spinal integrating centers. Spinal integrating centers send impulses to diaphragm, intercostal and other accessory muscles.

**Pontine Respiratory Group** = PRG lies in pons and receives inputs of higher brain centers to modify rhythm of breathing

**Lung Diseases**

**Lung disease**: Tobacco smoke carries more than 4000 chemicals attached to smoke particles. Many of these molecules are toxic and others are carcinogenic = cause cancer. So **lung cancer** is more common in smokers than non-smokers. It is # 1 cancer in the world.

**Emphysema**: Tobacco smoke inactivates cilia lining the lung passages so that harmful particles remain in lungs. It also breaks elastin protein of alveoli and make theme inelastic. Emphysema is enlargement of alveoli due to broken walls and loss of elasticity.

**Chronic Bronchitis** is the constant irritation of bronchi by inhaled irritants and leads to formation of excessive mucus and is the cause of smoker’s cough.

Recap 1 Respiratory System

1. During breathing in air from nasal cavity enters nasopharynx through-----
2. The part of pharynx communicating with nasal cavity is ----; with mouth is ---and with larynx is

Recap 2 Respiratory System

1. Main functions of respiratory system include: making ------available to tissues; production of---------for communication; and eliminating ----------from body.
2. The paths of food and air cross in -------------
3. Trachea is --------and esophagus is ---------in neck.
4. Stratified simple epithelium lines ------- and Pseudostratified columnar epithelium lines --------
5. During inspiration rib cage moves ------and ----and diaphragm gets -----
6. External nares to larynx is --------, from trachea to alveoli form ---------------
7. From external nares to terminal bronchioles is -------zone and respiratory bronchioles to alveoli form ---------zone of respiratory system.
8. Respiration is exchange of gases between blood and lungs.
9. Most of CO2 travels in blood as --------, most oxygen travels as---------
10. DRG receives sensory input from -- ------ --- and ------- chemoreceptors.
11. -------- determines the basic rhythm of breathing.
12. In chronic smokers alveoli walls become inflexible and coalesce together, a condition called ------