

Respiratory System

Main Functions of Respiratory System

1. Supplies O₂ and removes CO₂
2. Joins kidney to Regulate pH of blood
3. Produces sounds for speech
4. Defends against microbes

Respiratory System

5. Respiration is the liberation of chemical energy by the oxidation of food. The released chemical energy is stored as ATP molecules. Most organisms need O₂ for respiration and release CO₂ as waste product. Respiration takes place inside cells.
6. $\text{Glucose} + 6 \text{O}_2 \rightarrow 6\text{CO}_2 + 6\text{H}_2\text{O} + \text{ATP (energy)}$

Human Respiratory System: Has 2 portions: respiratory and conducting zone.

7. **Conducting Zone:** external nares → nasal cavity → Nasopharynx → Oropharynx → Laryngopharynx → larynx → trachea → bronchi → bronchioles → terminal bronchioles. Conducting Zone provides a low resistance path to respiratory zone.
8. **Respiratory Zone:** exchange of O₂ and CO₂ takes place in respiratory zone. It has respiratory bronchioles → alveolar ducts → alveoli (main portion of gas exchange).
9. Bronchioles are the main site of air flow regulation by ANS and hormones. Bronchodilation increases ventilation and bronchoconstriction decreases it.
10. Macrophages, mucous and cilia lining it defend against microbes and harmful particles
11. In chronic smokers cilia get damaged leading to mucous accumulation and chronic coughing
12. **Nose** has vestibule, respiratory region and olfactory region. Nose has 5 cartilages: median septal cartilage, 2 lateral cartilages and 2 alar cartilages. External Nares = nostrils → Nasal vestibule → Nasal Cavity (has 3 nasal Conchae having Superior meatus, middle meatus and inferior meatus) → internal naris = nostril).
13. **Pharynx:** common passage for food and air; is supported by Superior, middle and inferior Constrictor muscles
 - a. Nasopharynx: Superior part of pharynx, has opening of auditory tube and pharyngeal tonsil
 - b. Oropharynx : Middle part of pharynx, communicates with mouth cavity
 - c. Laryngopharynx: Inferior part of pharynx, communicates with larynx and esophagus
14. **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 anterior side narrow but broad on posterior side, lies inferior to thyroid. 3 pairs of cartilages are present in larynx. Most important are triangular Arytenoid Cartilages made of hyaline cartilage. Small horn shaped corniculate cartilages, (made of elastic cartilage) are present at the end of arytenoids cartilages. A pair of club shaped (elastic cartilage) cuneiform cartilages, are present anterior to corniculate cartilages. Larynx manipulates sound and volume by rocking thyroid cartilage against cricoid cartilage. Arytenoids cartilages move the vocal folds closer to produce the sound.

15. **Glottis** is the gap between the vocal folds. Vocal folds are triangular pieces of mucous membrane with some skeletal muscle fibers in them. They are attached to thyroid cartilage on anterior side and to arytenoids on posterior side. They vibrate to produce the basic sound. Vesicular folds lie superior to vocal folds. Normally they do not produce any sound but help to resonate sound.
16. **Pitch of Sound** – Larynx produces high pitch sounds when glottis is narrow and low pitch deep sounds when glottis is wide.
17. The **volume of the sound** is controlled by regulating the amount of air forced out through glottis.
18. **Trachea = Windpipe:** lies inferior to cricoid cartilage and anterior to esophagus. It has incomplete C-shaped cartilages to make its wall non-collapsible. Trachea inferiorly divides into 2 Bronchi. At the bifurcation a transverse ridge of cartilage, Carina, is present.
19. Primary bronchus → secondary bronchus → tertiary bronchus → terminal bronchioles → respiratory bronchioles → alveolar ducts → alveoli.

Lungs

20. Bronchi enter lungs. Left lung has 2 lobes and right lung has 3 lobes. Right primary bronchus is short and wide. Left primary bronchus is long and narrow. 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.
21. Tissues linings: Non-keratinized squamous epithelium lines vestibule, Oropharynx, Laryngopharynx, and upper larynx above glottis. Pseudostratified columnar epithelium lines main nasal cavity (respiratory region), nasopharynx, and lower part of larynx below glottis, trachea and bronchi. Simple columnar epithelium lines the bronchioles. Simple squamous epithelium lines alveolar ducts and alveoli.
22. **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).

Breathing or External Respiration

Alveoli are the seat of exchange of O_2 / CO_2 between lungs and blood. O_2 from its higher concentration in alveoli moves to blood and CO_2 from its higher concentration in blood moves to alveoli. Both gases move by diffusion.

Internal Respiration

23. **Blood-tissue gas exchange:** Pulmonary veins carry O_2 to heart and arteries carry O_2 to body tissue via blood capillaries with thin walls. O_2 enters interstitial fluid and finally into cells. Mitochondria use O_2 and produce CO_2 which leaves cells and enters into blood capillaries through interstitial fluid. Capillaries join to form veins which carry CO_2 to heart which sends the blood to lungs for gas exchange.

Gas transport in blood

24. Oxygen – 99% of O₂ binds with hemoglobin inside RBC's and travels as Oxyhemoglobin. Carbon Dioxide – Most of CO₂ travels as bicarbonate = HCO₃⁻ ions. Some CO₂ molecules combine with hemoglobin.
25. **Respiratory Centers** lie in Medulla and Pons.
26. **Regulation of breathing:** Breathing is regulated by respiratory centers present in Brain Stem. The center is more sensitive to changes in CO₂ concentration than O₂ concentration. Centers use the pH of cerebrospinal fluid and inputs from receptors inside Carotid and Aortic bodies.

Lung disorders

27. **Lung cancer:** SO₂ sulfur dioxide, CO carbon monoxide and O₃ like pollutants damage lungs but the worst is tobacco smoke which 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 many times more common in smokers than non-smokers.
28. **Emphysema:** In addition tobacco smoke inactivates cilia lining the lung passages so that harmful particles remain in lungs and make alveoli inelastic. This enlargement of alveoli due to broken walls and loss of elasticity is called.
29. **Chronic Bronchitis** is the constant irritation of lungs by inhaled irritants and leads to formation of excessive mucus and is the cause of smoker's cough.