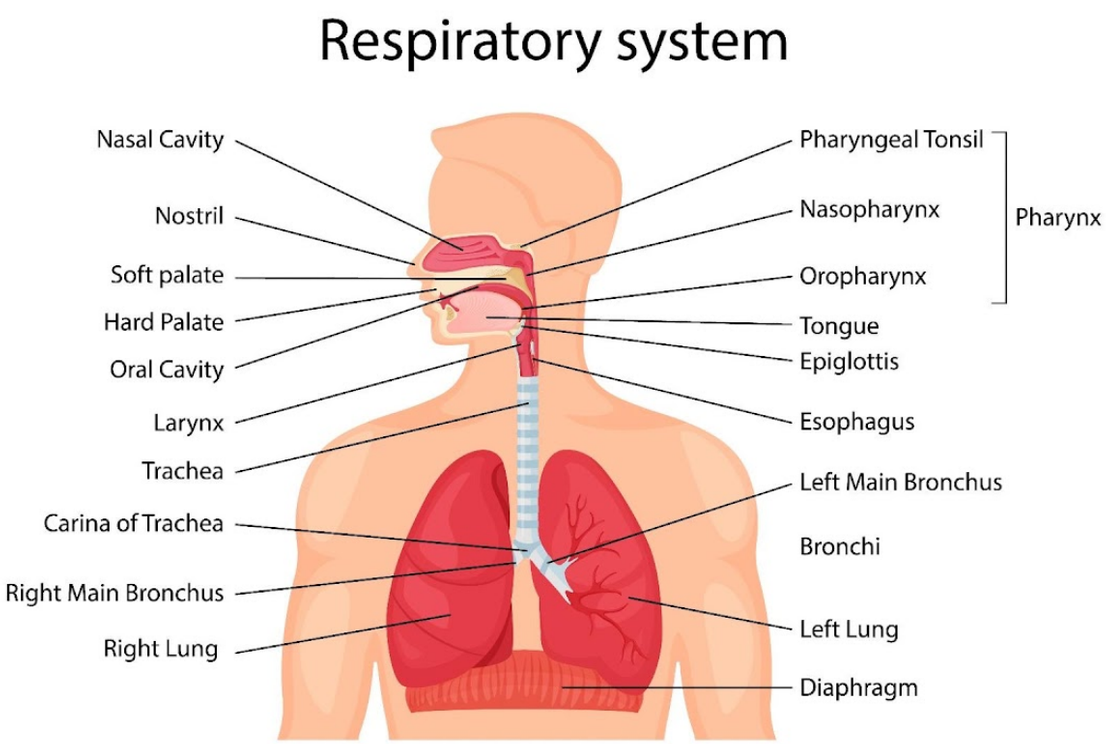
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Respiratory System

Anatomy & Physiology

Nose, pharynx, larynx, trachea, lungs and thoracic structures

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Respiratory System - illustration 1

RESPIRATORY SYSTEM - APPLIED ANATOMY

1. Introduction

The respiratory system is a group of organs responsible for breathing and the exchange of gases between the body and the external environment.

It supplies oxygen to the body and removes carbon dioxide produced during cellular metabolism.

Main Functions

1. Supplies oxygen to the blood.
2. Removes carbon dioxide from the body.
3. Helps maintain acid-base balance.
4. Produces voice and speech.
5. Provides the sense of smell.
6. Filters, warms and humidifies inspired air.
7. Protects the body against inhaled microorganisms and foreign particles.

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2. Parts of the Respiratory System

The respiratory system is divided into two major parts.

A. Upper Respiratory Tract

- Nose and nasal cavity
- Paranasal sinuses
- Pharynx

B. Lower Respiratory Tract

- Larynx
- Trachea
- Bronchi
- Bronchioles
- Lungs and alveoli

Note: Some textbooks classify the larynx differently. The above division is commonly used in nursing education.

3. Nose and Nasal Cavity

Definition

The nose is the primary external organ of the respiratory system through which air enters and leaves the body.

Location

It is situated in the centre of the face, above the mouth and between the two orbits.

Parts of the Nose

1. External Nose

- Root: Upper part between the eyes.
- Bridge: Bony upper portion.
- Apex: Tip of the nose.
- Nostrils (Na res): Two external openings.
- Alae: Lateral expanded portions surrounding the nostrils.

2. Nasal Cavity

The nasal cavity extends from the nostrils to the posterior nasal openings called choanae.

It is divided into right and left halves by the nasal septum.

Nasal Septum

The nasal septum separates the two nasal cavities.

It consists of:

- Perpendicular plate of ethmoid bone.

- Vomer bone.
- Septal cartilage.

Nasal Conchae

There are three pairs of nasal conchae:

1. Superior nasal concha.
2. Middle nasal concha.
3. Inferior nasal concha.

They increase the surface area of the nasal cavity and create airflow turbulence.

Functions of the Nose

1. Provides a passage for air.
2. Filters dust and foreign particles.
3. Warms inspired air.
4. Humidifies inspired air.
5. Contains olfactory receptors responsible for smell.
6. Contributes to voice resonance.

Clinical Importance

- Epistaxis: Bleeding from the nose.
- Rhinitis: Inflammation of the nasal mucosa.
- Sinusitis: Inflammation of the paranasal sinuses.
- Deviated nasal septum: Displacement of the nasal septum.

4. Paranasal Sinuses

Definition

Paranasal sinuses are air-filled spaces present within certain skull bones and connected to the nasal cavity.

Types of Paranasal Sinuses

1. Frontal sinuses: Located in the frontal bone.
2. Maxillary sinuses: Located in the maxillary bones.
3. Ethmoidal sinuses: Located in the ethmoid bone.
4. Sphenoidal sinuses: Located in the sphenoid bone.

Functions

- Reduce the weight of the skull.
- Help warm and humidify inspired air.
- Produce mucus.

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- Contribute to voice resonance.

5. Pharynx

Definition

The pharynx is a muscular, funnel-shaped tube that acts as a common passage for air and food.

Location

It extends from the base of the skull to the level of the sixth cervical vertebra (C6), where it continues as the oesophagus.

Length

Approximately 12-14 cm in adults.

Three Parts of the Pharynx

1. Nasopharynx
   - Uppermost part.
   - Located behind the nasal cavity.
   - Carries air only.
   - Contains the openings of the auditory (Eustachian) tubes.
   - Contains the pharyngeal tonsil (adenoid).
2. Oropharynx
   - Middle part.
   - Located behind the oral cavity.
   - Extends approximately from the soft palate to the upper border of the epiglottis.
   - Acts as a passage for both air and food.
   - Contains the palatine tonsils.
3. Laryngopharynx (Hypopharynx)
   - Lowest part.
   - Located behind the larynx.
   - Extends approximately from the epiglottis to C6.
   - Directs air towards the larynx and food towards the oesophagus.

Functions of the Pharynx

1. Provides a passage for air and food.
2. Helps in swallowing.
3. Participates in speech resonance.
4. Provides immune protection through tonsils.

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Clinical Importance

- Pharyngitis: Inflammation of the pharynx.
- Tonsillitis: Inflammation of the tonsils.
- Adenoid enlargement: Enlargement of the pharyngeal tonsil.

6. Larynx (Voice Box)

Definition

The larynx is a hollow, cartilaginous organ that connects the pharynx to the trachea.

Location

It is situated in the anterior neck, approximately opposite C3-C6 vertebrae.

Main Functions

1. Produces voice.
2. Maintains an open airway.
3. Protects the lower respiratory tract during swallowing.
4. Helps in coughing and expelling foreign particles.

Cartilages of the Larynx

The larynx consists of nine cartilages.

A. Three Unpaired Cartilages

1. Thyroid cartilage: Largest cartilage; forms the Adam's apple.
2. Cricoid cartilage: Complete ring-shaped cartilage below the thyroid cartilage.
3. Epiglottis: Leaf-shaped elastic cartilage that helps protect the airway during swallowing.

B. Three Pairs of Cartilages

1. Arytenoid cartilages.
2. Corniculate cartilages.
3. Cuneiform cartilages.

Vocal Cords

The larynx contains two pairs of folds:

- Vestibular folds (false vocal cords): Help protect the airway.
- Vocal folds (true vocal cords): Produce sound through vibration as air passes through them.

The opening between the true vocal folds is called the glottis; more precisely, the glottis includes the vocal folds and the opening between them.

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Clinical Importance

- Laryngitis: Inflammation of the larynx.
- Hoarseness: Change in voice quality.
- Laryngeal obstruction: Blockage of the airway.
- Tracheostomy: Surgical opening into the trachea to establish an airway.

7. Trachea (Windpipe)

Definition

The trachea is a flexible, air-conducting tube that connects the larynx to the main bronchi.

Location

It begins at the lower border of the cricoid cartilage at C6 and descends through the neck into the thoracic cavity.

Length and Diameter

- Length: Approximately 10-12 cm in adults.
- Diameter: Approximately 2-2.5 cm.

Structure of the Trachea

The trachea is supported by approximately 16-20 C-shaped rings of hyaline cartilage.

These rings:

- Prevent the trachea from collapsing.
- Maintain an open airway.
- Allow flexibility during neck movement.

The posterior wall contains the trachealis muscle, which allows adjustment of the tracheal diameter.

Layers of the Trachea

1. Mucosa: Contains ciliated epithelium and goblet cells.
2. Submucosa: Contains connective tissue, blood vessels and glands.
3. Cartilaginous layer: Contains C-shaped cartilage rings.
4. Adventitia: Outer connective tissue layer.

Carina

The trachea divides into the right and left main bronchi at approximately the level of the sternal angle (T4-T5).

The internal ridge at this division is called the carina.

Functions

1. Conducts air towards the lungs.
2. Filters inhaled particles through mucus and cilia.
3. Helps remove foreign particles through the mucociliary escalator.

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4. Maintains an open airway.

Clinical Importance

- Tracheitis: Inflammation of the trachea.
- Tracheal obstruction: Blockage of the airway.
- Tracheostomy: Surgical creation of an opening into the trachea.
- Endotracheal intubation: Insertion of a tube into the trachea to maintain an airway.

8. Bronchi and Bronchioles

Bronchi

The trachea divides into two main bronchi.

Right Main Bronchus

- Shorter, wider and more vertical.
- Divides into three lobar bronchi.
- Supplies the right lung.

Left Main Bronchus

- Longer, narrower and more horizontal.
- Divides into two lobar bronchi.
- Supplies the left lung.

Branches of the Bronchial Tree

1. Main bronchi.
2. Lobar (secondary) bronchi.
3. Segmental (tertiary) bronchi.
4. Smaller bronchi.
5. Bronchioles.
6. Terminal bronchioles.
7. Respiratory bronchioles.
8. Alveolar ducts.
9. Alveolar sacs and alveoli.

Bronchioles

Bronchioles are small branches of the bronchial tree that do not contain cartilage.

Their walls contain smooth muscle, which regulates airflow.

Functions

- Conduct air into deeper parts of the lungs.
- Distribute air to different lung regions.
- Regulate airflow through smooth muscle contraction and relaxation.

9. Lungs

Definition

The lungs are a pair of spongy, elastic organs located within the thoracic cavity and responsible for gas exchange.

Location

They occupy the right and left sides of the thoracic cavity, separated by the mediastinum.

Shape

Each lung is cone-shaped and has:

- Apex: Upper pointed part extending slightly above the first rib.
- Base: Lower concave surface resting on the diaphragm.
- Surfaces: Costal, mediastinal and diaphragmatic.
- Borders: Anterior, posterior and inferior.

Right Lung

The right lung is larger and heavier than the left lung.

It has:

- Three lobes:Upper lobe.Middle lobe.Lower lobe.
- Two fissures:Horizontal fissure.Oblique fissure.

Left Lung

The left lung is smaller because of the position of the heart.

It has:

- Two lobes:Upper lobe.Lower lobe.
- One oblique fissure.
- Cardiac notch: Indentation for the heart.
- Lingula: Tongue-shaped projection of the upper lobe.

Comparison of Right and Left Lungs

Feature Right Lung Left Lung

Size Larger Smaller

Lobes 3 2

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Fissures 2 1

Shape Wider and shorter Narrower and longer

Cardiac notch Absent Present

Lingula Absent Present

Surfaces of the Lungs

1. Costal surface: Faces the ribs.
2. Mediastinal surface: Faces the mediastinum.
3. Diaphragmatic surface: Rests on the diaphragm.

Hilum of the Lung

The hilum is a depression on the mediastinal surface through which structures enter and leave the lung.

It transmits:

- Main bronchus.
- Pulmonary artery.
- Pulmonary veins.
- Bronchial vessels.
- Lymphatic vessels.
- Nerves.

These structures collectively form the root of the lung.

10. Bronchopulmonary Segments

Definition

A bronchopulmonary segment is a structurally and functionally distinct subdivision of a lung lobe supplied by a segmental bronchus and a corresponding branch of the pulmonary artery.

Number

- Right lung: Usually 10 segments.
- Left lung: Usually 8-10 segments, with anatomical variation.

Clinical Importance

- Helps identify localized lung disease.
- Allows surgical removal of an affected segment.
- Helps interpret radiological findings.

11. Alveoli

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Definition

Alveoli are tiny, thin-walled air sacs located at the ends of the respiratory passages where gaseous exchange takes place.

Structure

- Made of simple squamous epithelial cells, mainly type I pneumocytes.
- Type II pneumocytes produce pulmonary surfactant.
- Surrounded by a dense network of pulmonary capillaries.
- Contain alveolar macrophages that remove foreign particles.

Important Cells

Type I Pneumocytes

- Form most of the alveolar surface.
- Allow diffusion of oxygen and carbon dioxide.

Type II Pneumocytes

- Produce surfactant.
- Reduce surface tension.
- Help prevent alveolar collapse.

Alveolar Macrophages

- Engulf microorganisms and foreign particles.
- Provide local immune defence.

Functions

1. Exchange oxygen and carbon dioxide.
2. Allow oxygen to enter the blood.
3. Allow carbon dioxide to leave the blood.
4. Surfactant helps keep alveoli open.

12. Pleura

Definition

The pleura is a thin, double-layered serous membrane that surrounds each lung.

Layers of Pleura

1. Visceral Pleura
   - Covers the surface of the lungs.
   - Extends into the lung fissures.
2. Parietal Pleura

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- Lines the inner surface of the thoracic cavity.
- Covers the diaphragm and mediastinum.

Pleural Cavity

The pleural cavity is the potential space between the visceral and parietal pleura.

It contains a small amount of pleural fluid.

Functions

1. Reduces friction during breathing.
2. Allows smooth movement of the lungs.
3. Helps maintain the mechanical coupling of lungs to the chest wall.

Clinical Importance

- Pleurisy: Inflammation of the pleura.
- Pleural effusion: Excess fluid accumulation in the pleural cavity.
- Pneumothorax: Presence of air in the pleural cavity.
- Hemothorax: Accumulation of blood in the pleural cavity.

13. Thoracic Cage

Definition

The thoracic cage is the bony and cartilaginous framework that surrounds the thoracic cavity and protects the heart, lungs and major blood vessels.

Components

1. Sternum.
2. Twelve pairs of ribs.
3. Twelve thoracic vertebrae.
4. Costal cartilages.

Sternum

The sternum is a flat bone located in the middle of the anterior chest wall.

It consists of three parts:

- Manubrium.
- Body.
- Xiphoid process.

Ribs

There are 12 pairs of ribs.

Classification

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1. True ribs (1-7): Directly attached to the sternum through their own costal cartilages.
2. False ribs (8-10): Attach indirectly to the sternum through the cartilage of the rib above.
3. Floating ribs (11-12): Have no anterior attachment to the sternum.

Functions of the Thoracic Cage

1. Protects the heart and lungs.
2. Supports the upper body.
3. Provides attachment for respiratory muscles.
4. Helps in breathing movements.

14. Intercostal Muscles

Intercostal muscles are muscles located between adjacent ribs.

Types

1. External Intercostal Muscles
   - Elevate the ribs.
   - Help in inspiration.
2. Internal Intercostal Muscles
   - Interosseous part helps in forced expiration.
   - Interchondral part can assist inspiration.
3. Innermost Intercostal Muscles
   - Deepest layer of intercostal muscles.
   - Assist the internal intercostal muscles.

Nerve Supply

Intercostal muscles are supplied by the intercostal nerves (anterior rami of thoracic spinal nerves).

15. Diaphragm

Definition

The diaphragm is a dome-shaped musculotendinous structure that separates the thoracic cavity from the abdominal cavity.

It is the principal muscle of respiration.

Structure

It consists of:

1. Sternal part.
2. Costal part.
3. Lumbar part.

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These parts converge into a central tendon.

Major Openings

Opening

Vertebral Level

Structures Passing Through

Caval opening

T8

Inferior vena cava and branches of right phrenic nerve

Oesophageal hiatus

T10

Oesophagus, vagal trunks and associated vessels

Aortic hiatus

T12

Aorta, thoracic duct and often azygos vein

Nerve Supply

The diaphragm is supplied by the right and left phrenic nerves (C3, C4 and C5).

Functions

1. Main muscle of inspiration.
2. Increases the vertical diameter of the thoracic cavity.
3. Helps in coughing, sneezing and vomiting.
4. Assists in abdominal straining and defecation.

Important: During inspiration, the diaphragm contracts and moves downward. During expiration, it relaxes and moves upward.

16. Blood Supply of the Lungs

The lungs have two circulations.

A. Pulmonary Circulation

- Pulmonary arteries carry deoxygenated blood from the right ventricle to the lungs.
- Pulmonary capillaries surround the alveoli.
- Pulmonary veins carry oxygenated blood to the left atrium.

B. Bronchial Circulation

- Bronchial arteries supply oxygenated blood to the supporting tissues of the lungs and bronchi.
- Bronchial veins drain part of this blood into the azygos and hemiazygos venous systems.

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17. Nerve Supply of the Respiratory System

The respiratory system receives autonomic nerve supply.

Parasympathetic Supply

- Mainly through the vagus nerve.
- Causes bronchoconstriction.
- Increases bronchial gland secretion.

Sympathetic Supply

- Mainly through sympathetic pathways from the upper thoracic spinal segments.
- Causes bronchodilation.
- Reduces bronchial gland secretion.

Phrenic Nerve

- Arises from C3, C4 and C5.
- Supplies the diaphragm.
- Essential for normal inspiration.

18. Applied and Clinical Anatomy

Condition

Description

Asthma

Chronic inflammatory airway disease with variable airflow limitation

Pneumonia

Infection causing inflammation of lung tissue

Tuberculosis

Infectious disease commonly affecting the lungs

COPD

Chronic obstructive pulmonary disease causing persistent airflow limitation

Bronchitis

Inflammation of the bronchi

Emphysema

Destruction of alveolar walls with enlargement of air spaces

Pleurisy

Inflammation of the pleura

Pneumothorax

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Air accumulation in the pleural cavity

Pleural Effusion

Excess fluid in the pleural cavity

Atelectasis

Partial or complete collapse of lung tissue

Lung Cancer

Malignant growth arising in lung tissues

19. Importance of Respiratory Anatomy in Nursing

Knowledge of respiratory anatomy helps nurses to:

1. Assess respiratory rate, rhythm and depth.
2. Identify normal and abnormal breath sounds.
3. Perform chest examination and auscultation.
4. Understand oxygen therapy and airway management.
5. Assist in endotracheal intubation and tracheostomy care.
6. Position patients for improved ventilation.
7. Understand chest X-rays and other respiratory investigations.
8. Monitor patients with respiratory disorders.
9. Perform safe suctioning procedures.
10. Recognize signs of respiratory distress.

20. Important Examination Questions

Long Answer Questions

1. Describe the anatomy of the respiratory system with a labelled diagram.
2. Explain the structure of the lungs and differentiate between the right and left lungs.
3. Describe the anatomy of the larynx and its cartilages.
4. Explain the structure and functions of the trachea.
5. Describe the diaphragm, its openings and nerve supply.
6. Explain the pleura and its clinical importance.

Short Answer Questions

1. Write the functions of the nose.
2. Describe the three parts of the pharynx.
3. List the cartilages of the larynx.
4. Explain the structure of the trachea.
5. What are bronchopulmonary segments?

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6. Differentiate between the right and left lungs.
7. Describe the layers of the pleura.
8. Classify the ribs.
9. Write the nerve supply of the diaphragm.
10. Explain the structure of alveoli.

Very Short Answer Questions

1. What is the voice box?
2. What is the windpipe?
3. How many lobes are present in the right lung?
4. How many lobes are present in the left lung?
5. Which muscle is the main muscle of inspiration?
6. Which nerve supplies the diaphragm?
7. What is the carina?
8. Which cells produce surfactant?
9. What is the functional unit of gas exchange in the lungs?
10. What is the name of the membrane covering the lungs?

21. Quick Revision Points

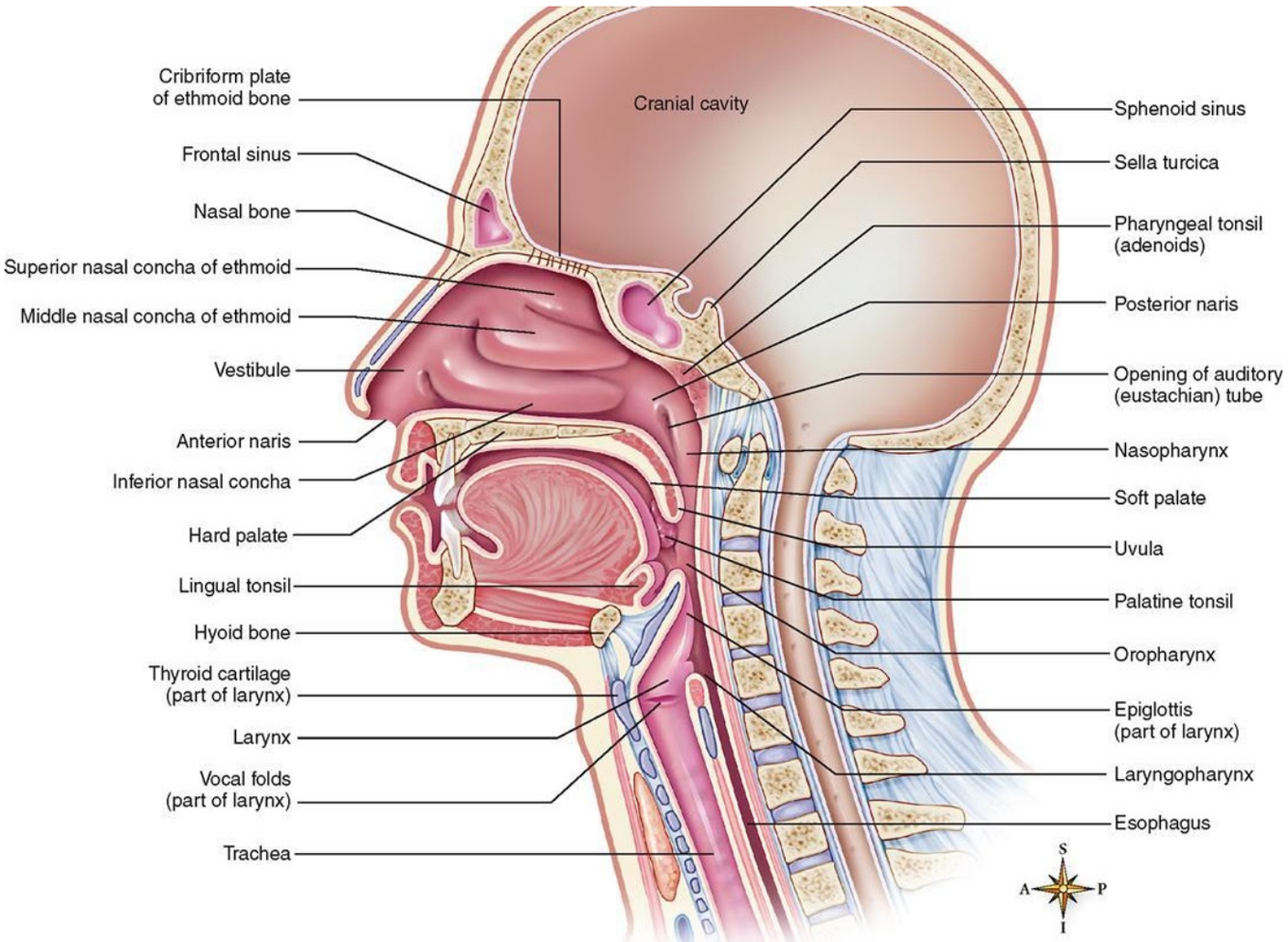
- Main function: Exchange of oxygen and carbon dioxide.
- Upper respiratory tract: Nose, nasal cavity, paranasal sinuses and pharynx.
- Lower respiratory tract: Larynx, trachea, bronchi and lungs.
- Pharynx: Common passage for air and food.
- Larynx: Voice box.
- Trachea: Windpipe.
- Tracheal cartilage: C-shaped hyaline cartilage rings.
- Carina: Ridge at the division of the trachea.
- Right lung: 3 lobes and 2 fissures.
- Left lung: 2 lobes and 1 fissure.
- Alveoli: Main sites of gaseous exchange.
- Type II pneumocytes: Produce surfactant.
- Pleura: Double-layered membrane around the lungs.
- Diaphragm: Principal muscle of inspiration.
- Phrenic nerve: C3, C4 and C5.
- Pulmonary artery: Carries deoxygenated blood to the lungs.

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- Pulmonary veins: Carry oxygenated blood to the left atrium.

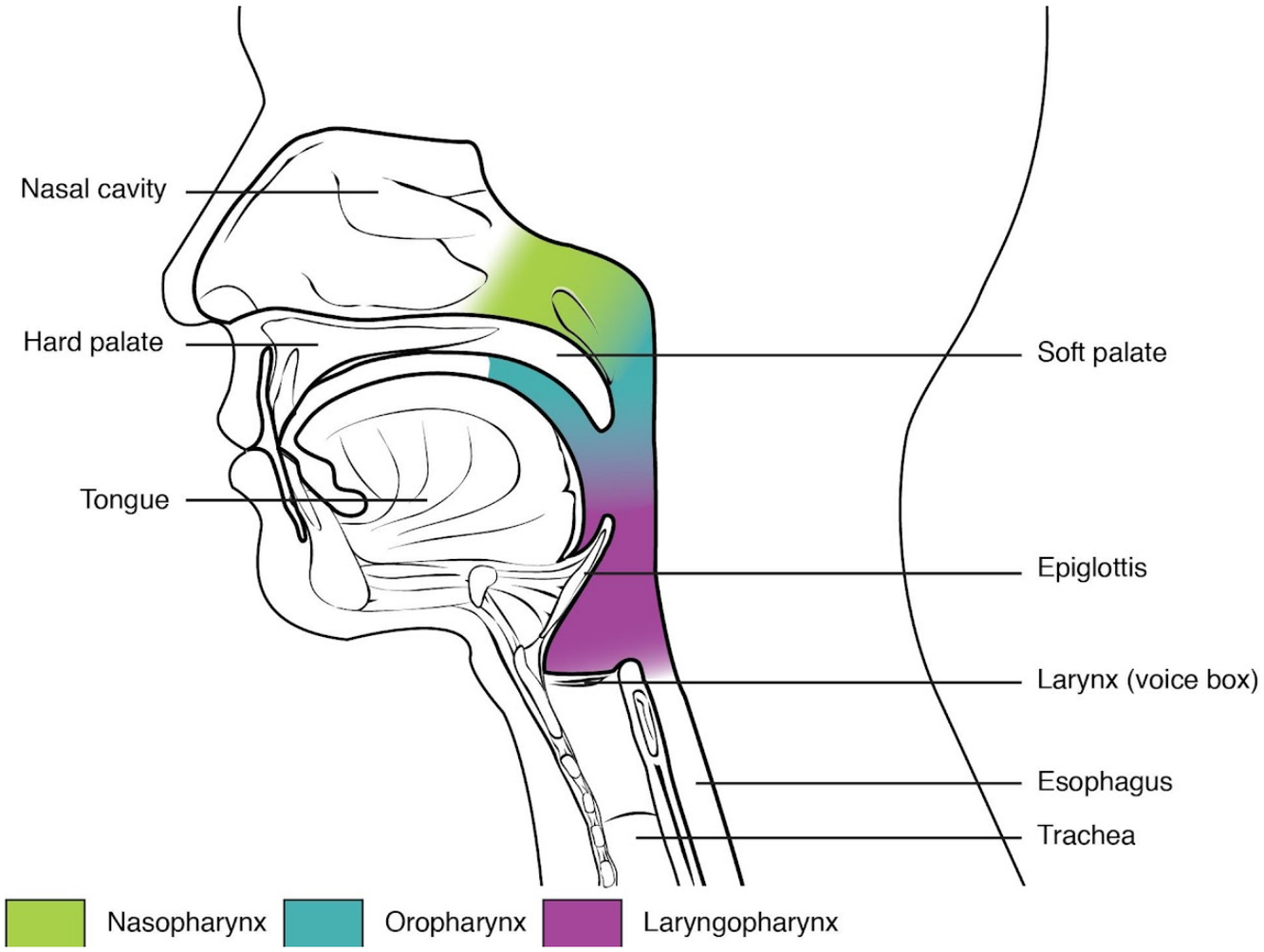
Conclusion

The respiratory system is essential for maintaining oxygen supply and removing carbon dioxide from the body. Knowledge of its anatomical structures, including the nose, pharynx, larynx, trachea, bronchi, lungs, pleura and diaphragm, forms an important foundation for nursing assessment and respiratory patient care.



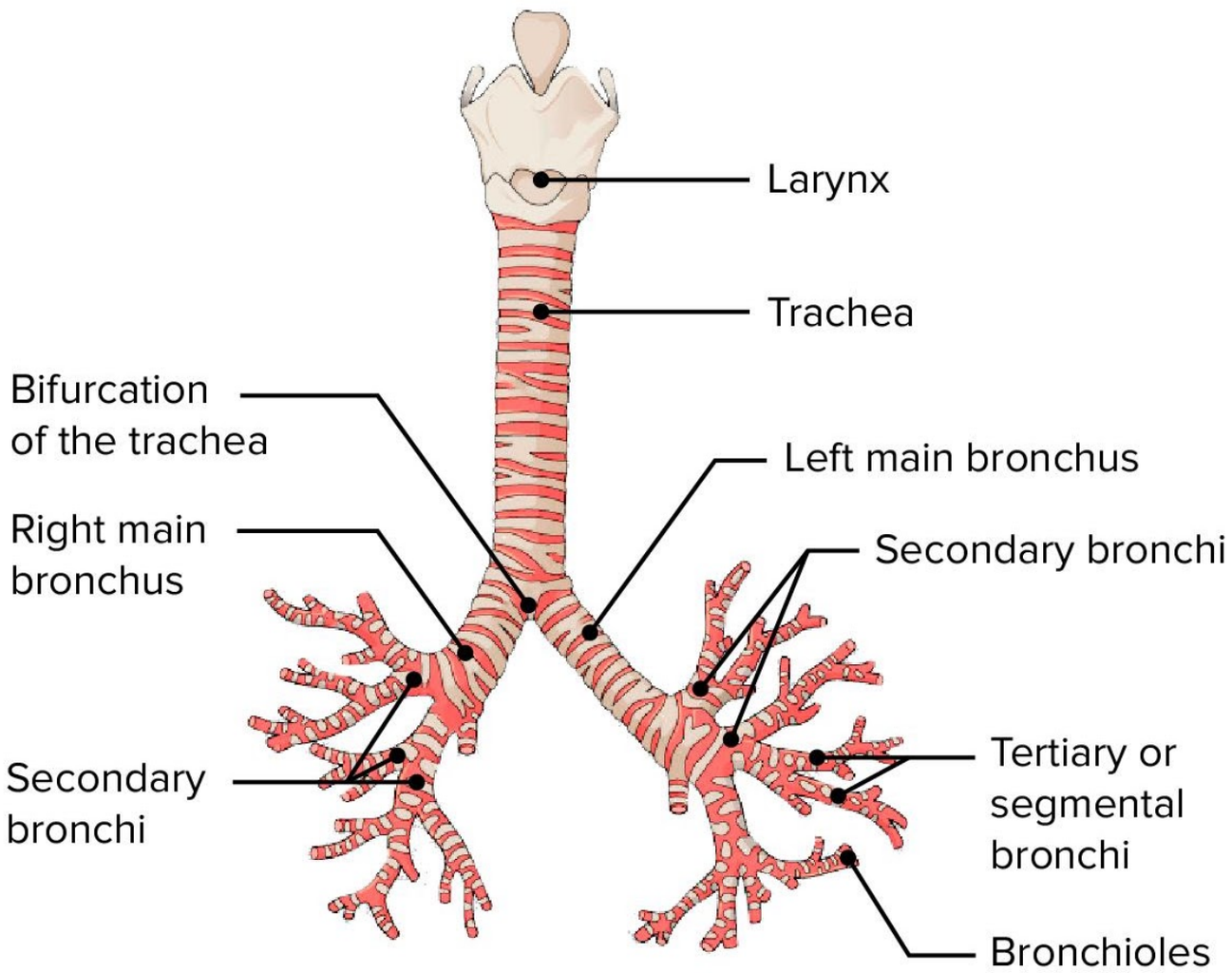
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Respiratory System - illustration 3

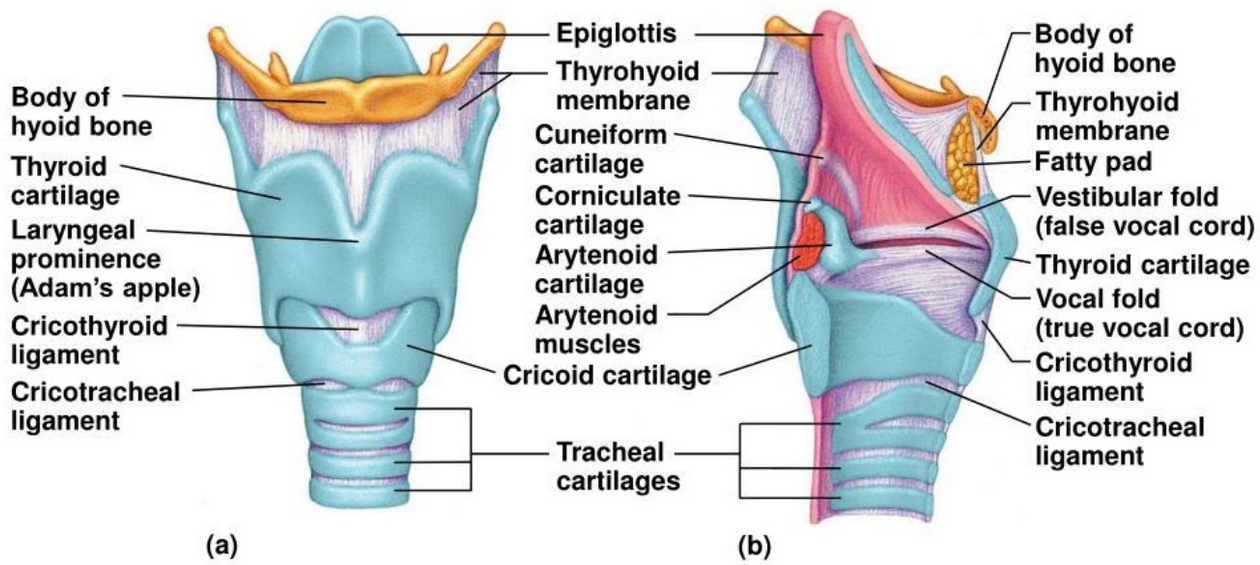
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Respiratory System - illustration 4

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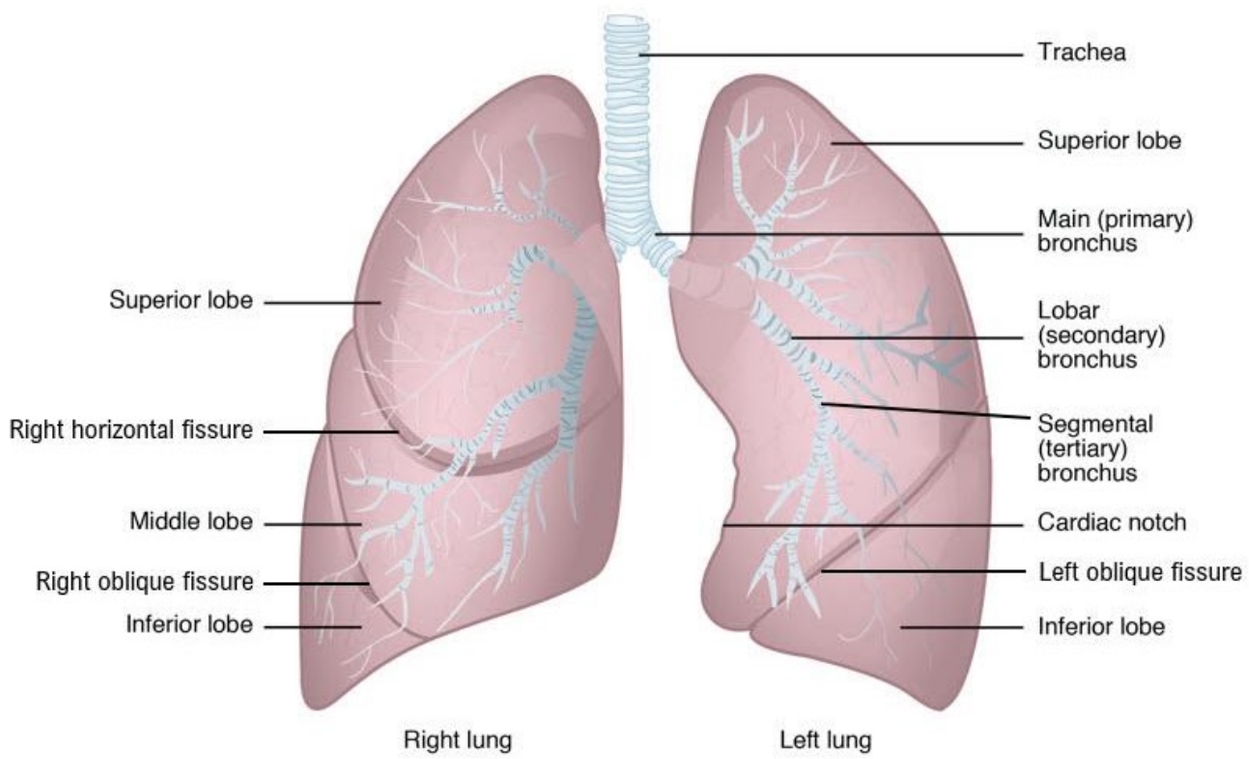
Figure 22.4a-b: The larynx, p. 836.



Human Anatomy and Physiology, 7e
by Elaine Marieb & Katie Hoehn

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Respiratory System - illustration 5



Respiratory System - illustration 6

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Quick Revision

- Airway overview: Nose -> nasal cavity -> pharynx -> larynx -> trachea -> main bronchi -> smaller bronchi -> bronchioles -> alveolar passages. The conducting zone ends at terminal bronchioles; the respiratory zone begins at respiratory bronchioles.

- Nose, pharynx & larynx:

- Trachea & bronchial tree: The trachea lies anterior to the oesophagus. C-shaped cartilage rings support it, with the open part posteriorly. It divides at the carina into main bronchi. The right main bronchus is generally wider, shorter and more vertical.

- Lungs, pleura & thorax: The diaphragm forms the muscular floor of the thorax. Intercostal muscles lie between ribs. Type I alveolar cells form a thin exchange surface; type II cells produce surfactant.

Examination questions

1. Trace air from nostril to alveolus.

2. Compare right and left lungs.

3. Distinguish visceral from parietal pleura.

Practice questions

Choose one best answer. The answer key and explanations follow the questions.

1. Which structure is the tracheal bifurcation?

A. Hilum
B. Carina
C. Glottis
D. Epiglottis

2. How many lobes does the left lung have?

A. One
B. Two
C. Three
D. Four

3. Which layer directly covers the lung?

A. Parietal pleura
B. Peritoneum
C. Visceral pleura
D. Pericardium

4. A patient aspirates a small object while upright. The nurse anticipates that it is more likely to enter which main bronchus?

A. Right main bronchus
B. Left main bronchus
C. Both bronchi are equally vertical

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D. Neither main bronchus can receive an aspirated object

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Answer key and explanations

1. B - Carina

The carina marks the division into right and left main bronchi.

2. B - Two

The left lung has superior and inferior lobes.

3. C - Visceral pleura

Visceral pleura adheres to the lung surface.

4. A - Right main bronchus

The right main bronchus is wider, shorter and more vertical. This anatomy makes entry of an aspirated object into it more likely.

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