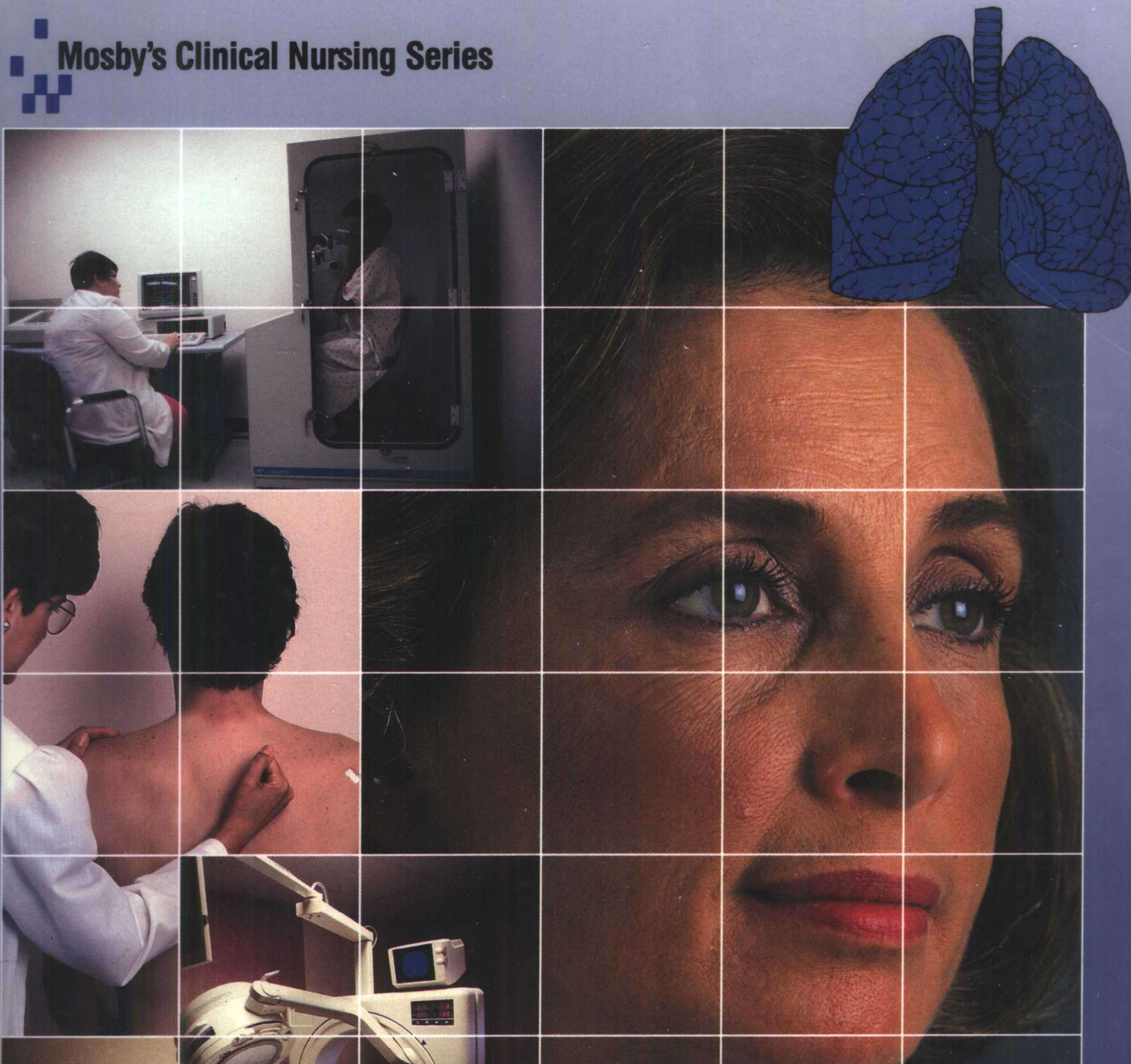
RESPIRATORY DISORDERS

Mosby's Clinical Nursing Series



Susan F. Wilson June M. Thompson

RESPIRATORY DISORDERS

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The authors and publisher have made a conscientious effort to ensure that the drug information and recommended dosages in this book are accurate and in accord with accepted standards at the time of publication. However, pharmacology is a rapidly changing science, so readers are advised to check the package insert provided by the manufacturer before administering any drug.

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PREFACE

Respiratory Disorders is the second volume in *Mosby's Clinical Nursing Series*, a new kind of resource for practicing nurses.

The *Series* is the result of the most elaborate market research ever undertaken by The C.V. Mosby Company. We first surveyed hundreds of working nurses to determine what kind of resources practicing nurses want in order to meet their advanced information needs. We then approached clinical specialists—proven authors and experts in 10 practice areas, from cardiovascular to ENT—and asked them to develop a common format that would meet the needs of nurses in practice, as specified by the survey respondents. This plan was then presented to 9 focus groups composed of working nurses over a period of 18 months. The plan was refined between each group, and in the later stages we published a 32-page full-color sample so that detailed changes could be made to improve the physical layout and appearance of the book, section by section and page by page.

The result is a new genre of professional books for nursing professionals.

Respiratory Disorders begins with an innovative Color Atlas of Respiratory Structure and Function. This is not a mere review of anatomy and physiology taught in undergraduate curriculums; it is actually a collection of highly detailed full-color drawings designed to explain how respiratory problems develop. Every effort was made to explain pulmonary structure and function in a way that rationalizes nursing interventions.

Chapter 2 is a pictorial guide to the nurse's assessment of the respiratory system. Clear, full-color photographs show proper position and technique in sharp detail, aided by concise instructions, rationales, and tips.

Chapter 3 presents the latest in diagnostic tests, again using full-color photographs of equipment, techniques, monitors, and output. A consistent format for each diagnostic procedure gives nurses information about the purpose of the test, indications and contraindications, and nursing care associated with each test, including patient teaching.

Chapters 4, 5, and 6 present the nursing care of patients experiencing noninfectious respiratory disorders, infectious respiratory diseases, and major surgical and therapeutic interventions, respectively. Each disease is presented in a format that you invented to meet your advanced practice needs. Information on pathophysiology answers questions nurses often have. A unique box alerting nurses to possible complications provides this information to health professionals in the best position to observe, respond to, and report dangerous changes in patient conditions. Definitive diagnostic tests and the physician's treatment plan are briefly reviewed to promote collaborative care among members of the health care team.

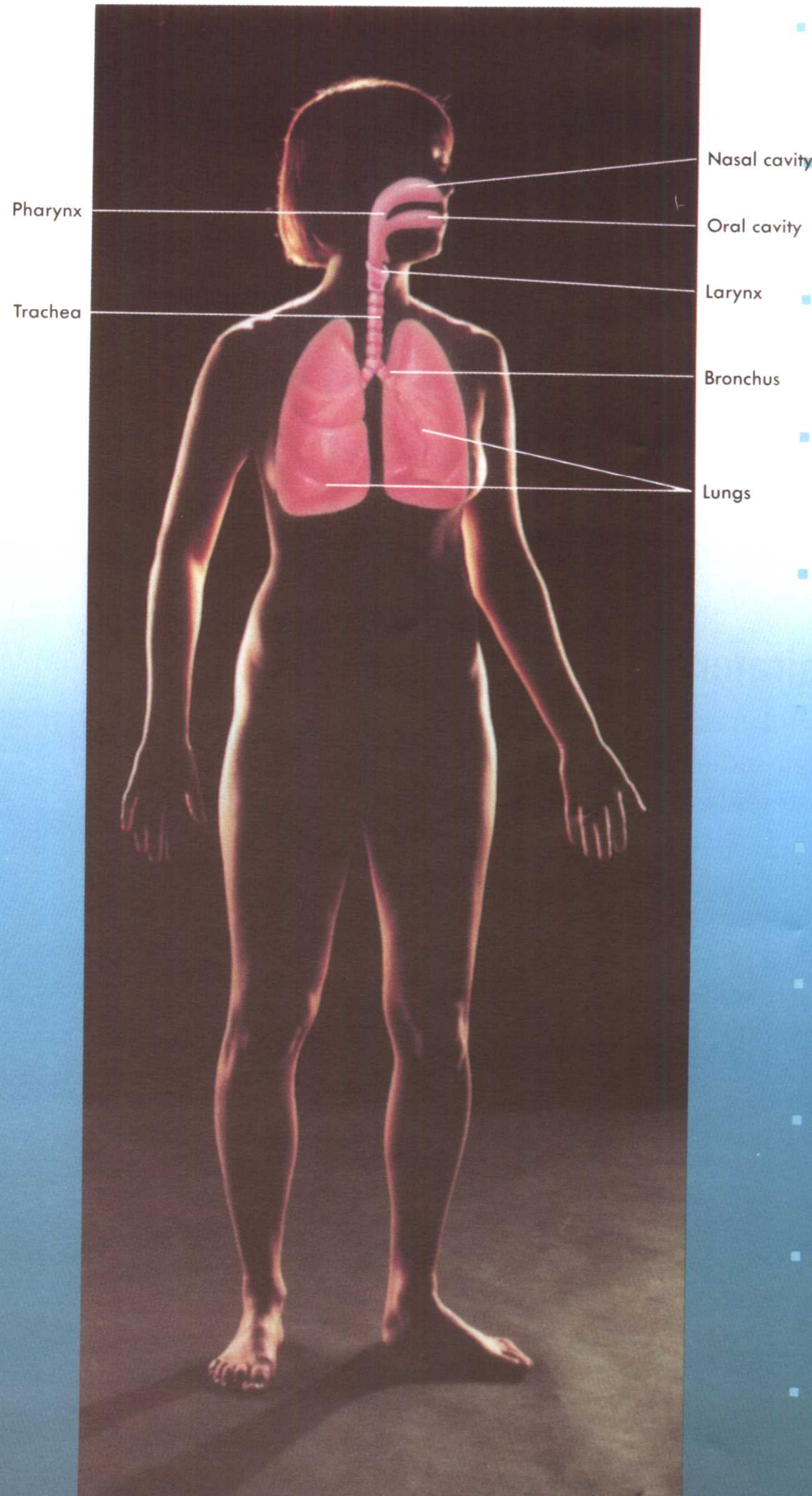
The heart of the book is the nursing care, presented according to the nursing process. These pages are bordered in blue to make them easy to find and use on the unit. The nursing care is structured to integrate the five steps of the nursing process, centered around appropriate nursing diagnoses accepted by the North American Nursing Diagnostic Association (NANDA). The material can be used to develop individualized care plans quickly and accurately, and it meets the standards of nursing care required by the Joint Commission on the Accreditation of Hospitals (JCAH). By facilitating the development of individualized and authoritative care plans, this book can actually save you time to spend on direct patient care.

In response to requests from scores of nurses participating in our research, a distinctive feature of this book is its use in patient teaching. Background information on diseases and medical interventions enables nurses to answer with authority questions patients often ask. The illustrations in the book, particularly those in the Color Atlas and the chapter on Diagnostic Studies, are specifically designed to support patient teaching. Chapter 7 consists of 14 Patient Teaching Guides written at a ninth-grade level so they can be copied, distributed to patients and their families, and used for self-care after discharge. Patient teaching sections in each care plan provide nurses with checklists of concepts to teach, promoting this increasingly vital aspect of nursing care.

The book concludes with a concise guide to respiratory drugs and, inside the back cover, a resource section, printed on yellow paper, that directs you to organizations and other resources on respiratory health for nurses and patients.

This book is intended for medical-surgical nurses, who invariably care for patients with acute respiratory disorders. Critical care nurses in our survey and focus groups also expressed a need for the book. We expect that students will find the book an indispensable help in developing clinical skills and judgment in caring for patients with respiratory disorders, as it will also be for nurses returning to practice after a hiatus, nurses seeking advanced certification, and nurses transferring to medical-surgical or critical care settings.

We hope this book contributes to the advancement of professional nursing by serving as a first step toward a body of professional literature for nurses to call their own.


Pharynx
Trachea
Nasal cavity
Oral cavity
Larynx
Bronchus
Lungs

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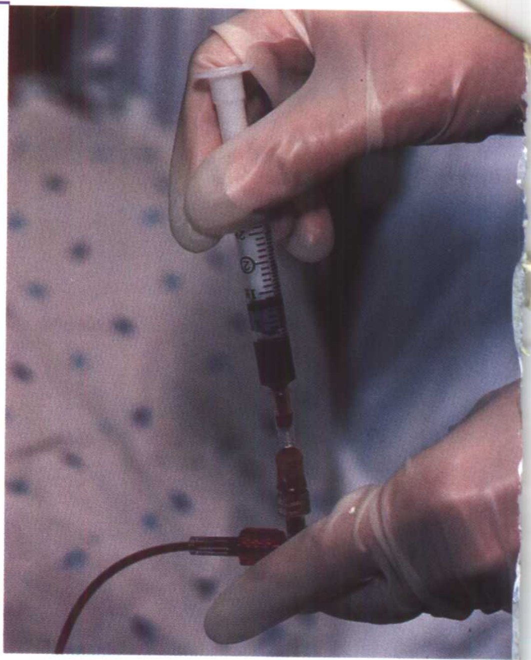

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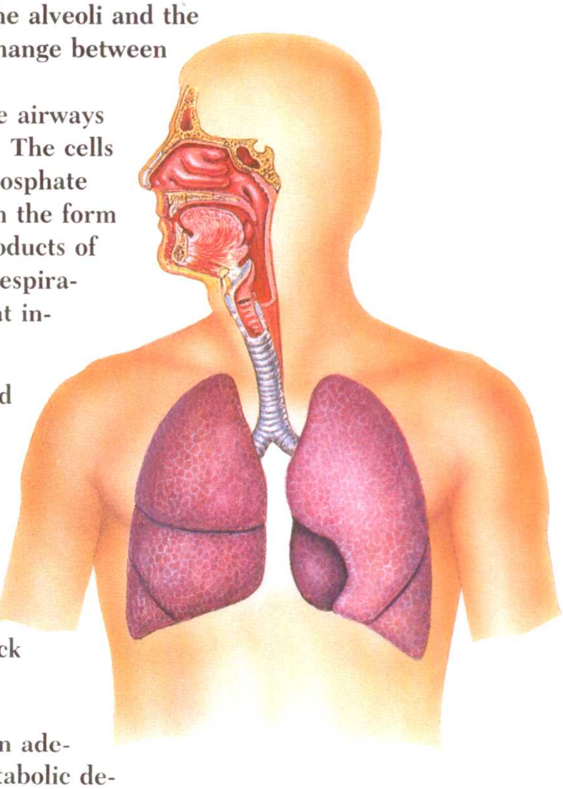
CHAPTER 1

Color Atlas of Respiratory Structure and Function

The respiratory system continually obtains oxygen from the environment, delivers oxygen to the body's cells, removes carbon dioxide from the cells, and expels carbon dioxide into the environment. During quiet activities, the average adult keeps this cycle going with about 15 respirations per minute. With each breath, an adult moves about 500 ml in and out of the lungs (tidal volume) for a total of about 18,925 liters of air every day. However, this half-liter is only about 12% of the maximum breathing capacity. With strenuous activity, respirations double and the volume of air with each breath increases more than five times.

The respiratory system is intimately related to the cardiovascular system. Respiration transpires on two levels: external and internal. *External respiration* is the exchange of gases between the alveoli and the pulmonary capillaries. *Internal respiration* is gas exchange between peripheral capillaries and the cells.

Although respiration is considered the work of the airways and lungs, every living cell is engaged in respiration. The cells require oxygen, which combines with adenosine diphosphate (ADP) and simple sugars (CHO) to produce energy in the form of adenosine triphosphate (ATP). The chemical byproducts of cellular metabolism are carbon dioxide and water. Respiratory physiology is, consequently, a complex event that involves four distinct phases:



- *Ventilation*—movement of air between body and environment and distribution of air within the tracheobronchial tree to alveoli
- *Alveolar diffusion and perfusion*—gas exchange across the alveolar-capillary membrane into the pulmonary blood supply
- *Transportation of respiratory gases*—the movement of oxygen and carbon dioxide through the circulatory system to peripheral tissues, and back across the alveolar-capillary membrane
- *Control of ventilation*—the neuromuscular and chemical regulation of air movement to maintain adequate gas exchange in response to changing metabolic demands

Each of these four phases is addressed in this chapter.

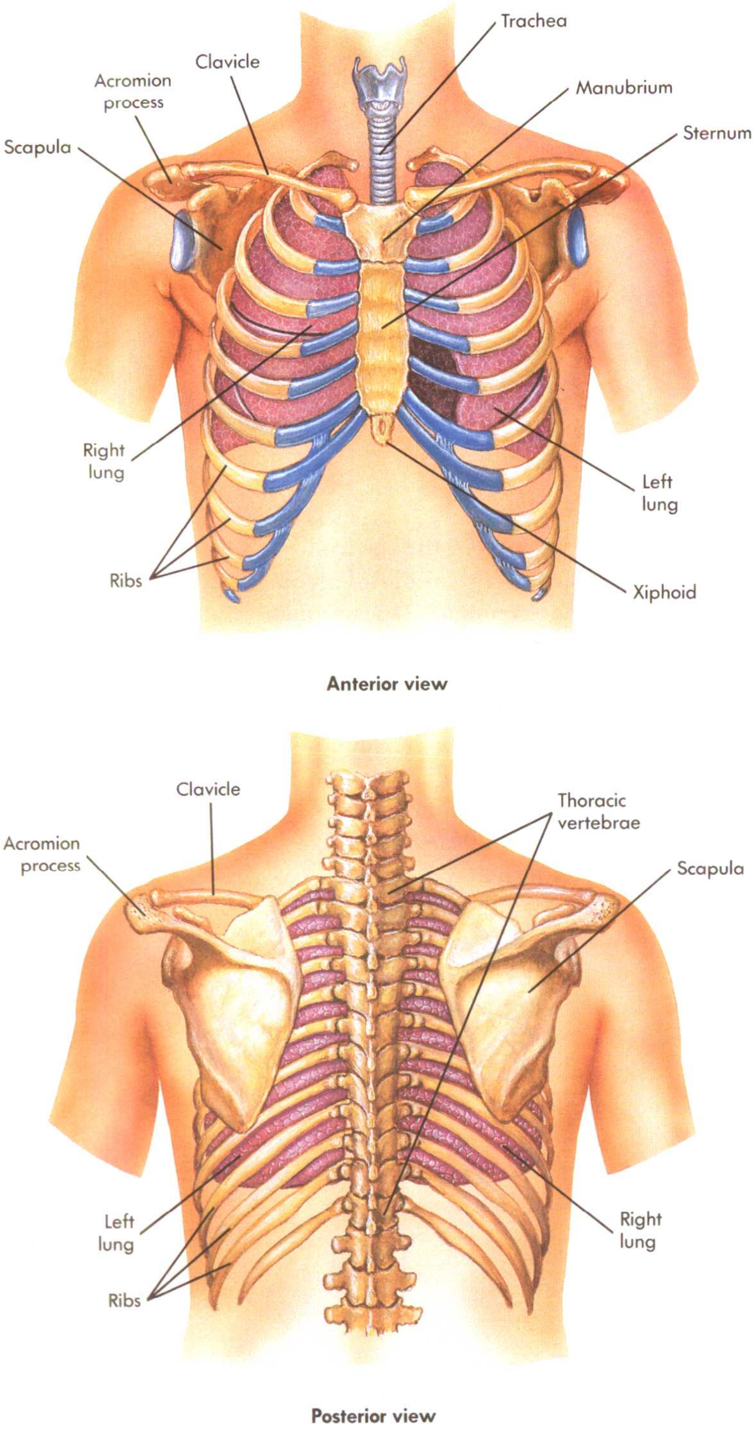


FIGURE 1-1
Skeletal structures of the chest.

VENTILATION

Ventilation is the mechanical process of moving air into and out of the lungs to deliver oxygen to the alveoli, where gas exchange occurs, and to expel carbon dioxide. The muscles of respiration must exert enough force to overcome resistance in the respiratory system to move the chest wall and expand the lungs. The volume of air entering the respiratory system is determined by anatomic properties of the chest wall, thoracic cavity, upper airways, and lower airways.

CHEST WALL

The bony structures of the chest form a protective, expandable cage around the lungs and heart (Figure 1-1). The ribs attach to the sternum with costal cartilage, allowing the rib cage to expand and providing a substantial degree of elasticity to the chest wall.

In adults the transverse diameter of the chest is normally greater than the anteroposterior diameter (see Figure 2-3, page 24). At birth these two dimensions are roughly the same, giving the newborn's chest a round appearance. The chest and head circumference are about equal until age 2 years. The chest wall is more cartilaginous in infants and young children, often with a more prominent xiphoid process. The anteroposterior diameter of the chest wall is often increased in older adults, even those who have normal respiratory function. This change evolves from loss of muscle strength in the thorax and diaphragm and an increased dorsal curve of the thoracic spine.

The muscles of ventilation are shown in Figure 1-2. Inspiration, the active phase of ventilation, is initiated by contractions of the primary muscles of ventilation—the diaphragm and intercostal muscles. When the work of breathing increases, accessory muscles—the scalene, sternocleidomastoid, and abdominal muscles—actively assist respiration.

Expiration during quiet breathing is a passive event resulting from lung recoil. When movement of air out of the lungs is impeded, expiration becomes active. Table 1-1 describes the muscle physiology of ventilation.

• • •

Respiratory distress is often immediately evident from the appearance of the chest wall and exaggerations or aberrations in respiratory patterns. Chronic hyperinflation causes a barrel chest appearance characterized by enlarged anteroposterior diameter, a rib angle that is more horizontal, a prominent sternal angle, and a kyphotic spine. It is the hallmark of long-standing pulmonary disorders, particularly asthma, emphysema, and cystic fibrosis, and is accompanied by prolonged expiration and diaphragmatic depression.

Use of accessory muscles during rest is associated with several acute and chronic pulmonary disorders. Marked retraction of the intercostal muscles and prominent contraction of the sternocleidomastoid muscles are often seen in acute respiratory distress.

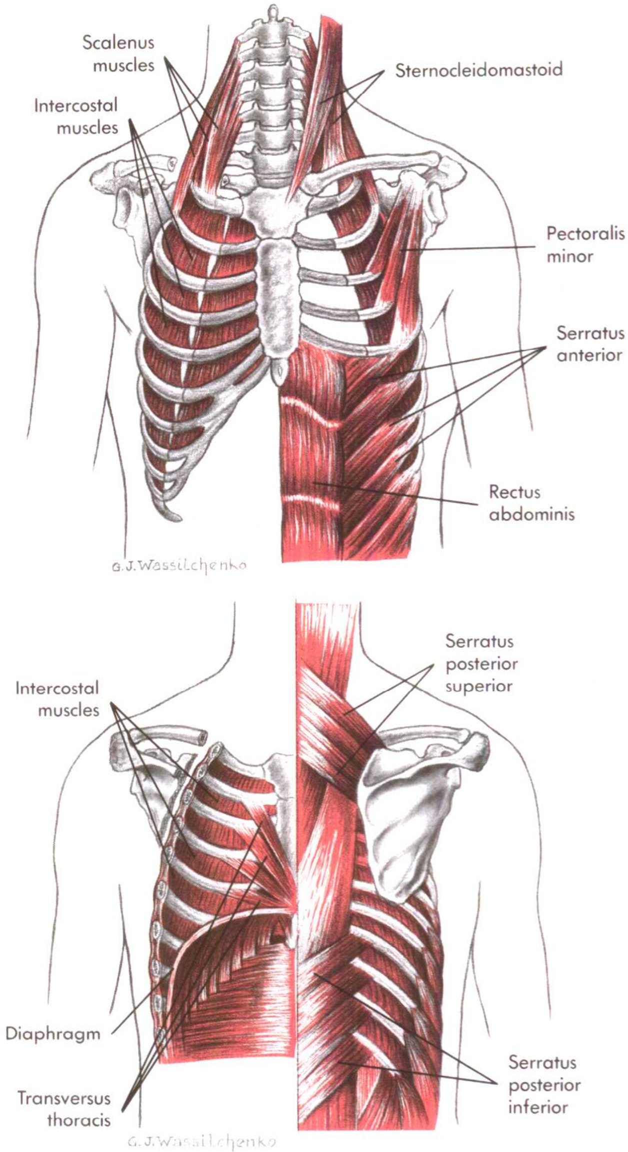
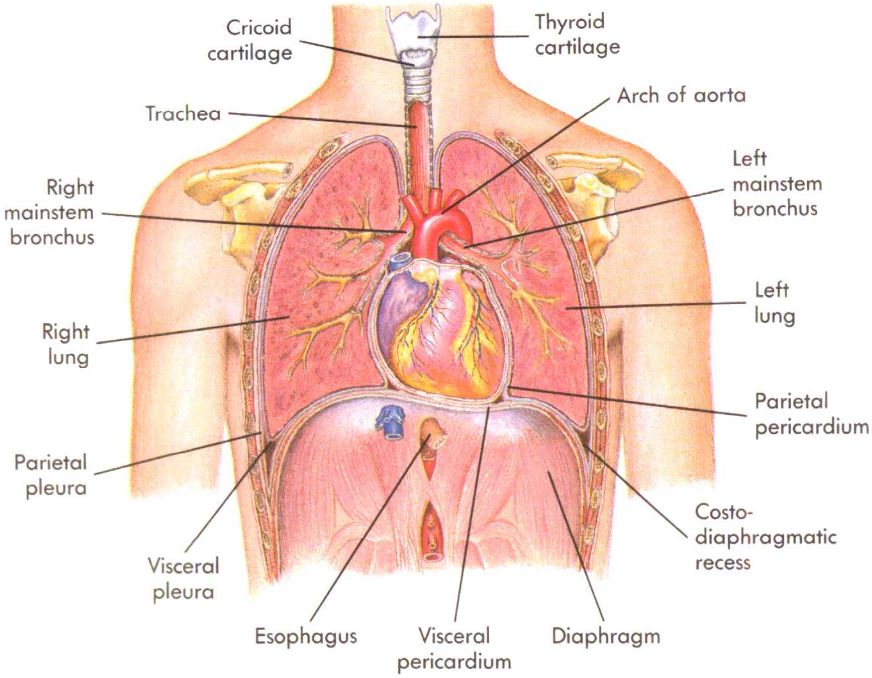


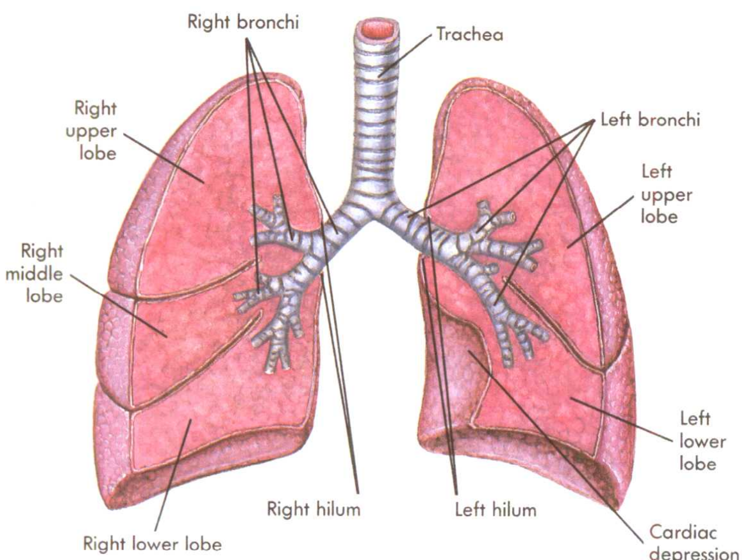
FIGURE 1-2
Muscles of the chest.

Table 1-1

MUSCLES OF RESPIRATION

	Action	Result
Quiet Breathing	Diaphragm begins contraction	Lower ribs rise up and out to increase transverse and lateral intrathoracic space.
	Diaphragm completes contraction	Diaphragm moves downward 3-5 cm (from 10th-12th rib) and compresses abdomen.
	External intercostals contract	Increases anteroposterior diameter of thoracic cavity.
	Internal intercostals contract	Decreases transverse diameter of rib cage.
Increased Effort Breathing	Scalene muscles contract	Elevates 1st and 2nd ribs during inspiration to enlarge upper thorax and stabilize chest wall.
	Sternocleidomastoid muscles contract	Elevates sternum during inspiration and slightly enlarges thoracic cavity.
	Abdominal muscles contract	Compresses lower ribs to assist forced expiration.





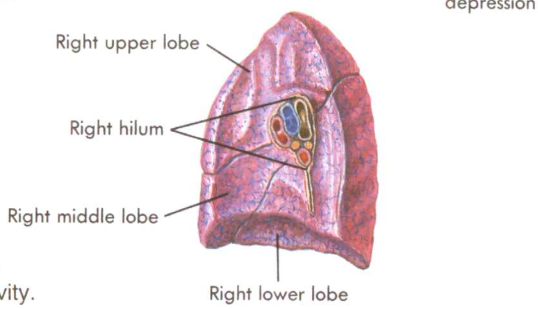


FIGURE 1-3
Thoracic cavity.

THORACIC CAVITY

The thoracic cavity is divided into right and left pleural cavities separated by the mediastinum (Figure 1-3). The **mediastinum** is the centrally located area, containing the heart, aorta, major blood vessels, lower trachea, large bronchi, part of the esophagus, thymus, lymph nodes, and numerous major nerves, including the phrenic nerve, the cardiac and splanchnic branches of the sympathetic nervous system, and the laryngeal and vagus branches of the parasympathetic nervous system. At the center of the mediastinum are the right and left **hilum** where the mainstem bronchi and the pulmonary vessels enter the lungs (Figure 1-3).

Lining each pleural cavity is a two-layered membrane, the **pleura**, that forms a closed protective sac surrounding each lung. The visceral, or pulmonary, layer lines the outer wall of each lung, and the parietal pleura lines the chest wall and upper surface of the diaphragm. The visceral and parietal pleurae join at the hilum to form a sheath around the bronchi. Serous lubricating film in the space between the pleural layers permits them to slide together without friction, facilitating lung movement.

The lungs fill the pleural cavities, extending to about 4 cm above the first rib anteriorly and to the level of the first thoracic vertebra (T1) posteriorly. Their medial surface is concave, forming a cradle around the mediastinum. On deep inspiration the lower lung borders descend to about T12 and on forced expiration rise to about T10 (Figure 1-4).

• • •

Increased pressure within the thoracic cavity can interfere with lung expansion. This can result from pleural effusion, hemothorax or pneumothorax, empyema, pulmonary edema, or space-occupying lesions within the thoracic cavity.

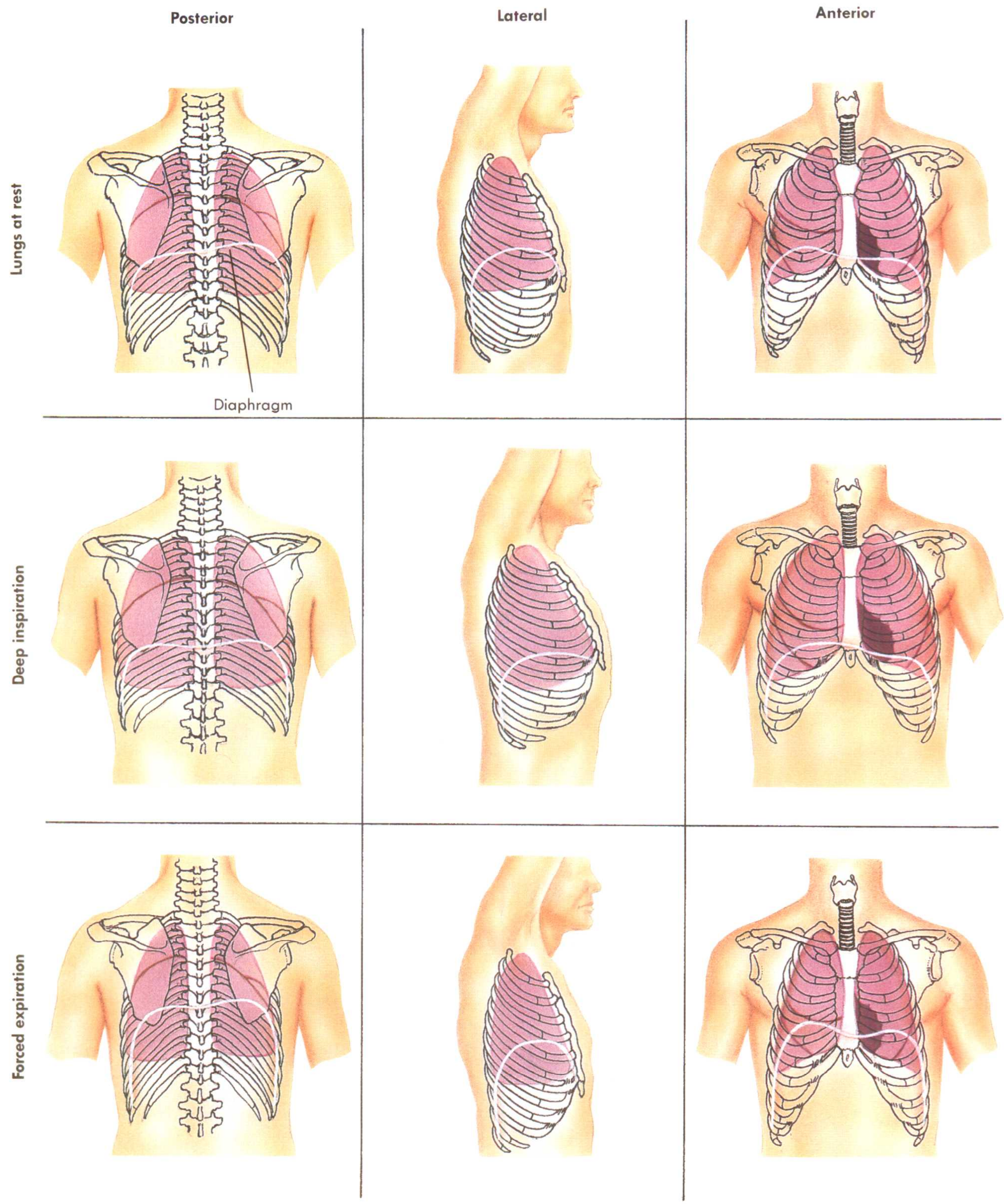


FIGURE 1-4
Movement of the lungs during rest, deep inspiration, and forced expiration. The lung tissue is drawn as transparent here to show the movement of the diaphragm (white line) during the three phases of respiration. As the diaphragm moves the inner portion of the lung tissue follows the movement of the diaphragm, while the outer portion of the lung falls below the diaphragm.

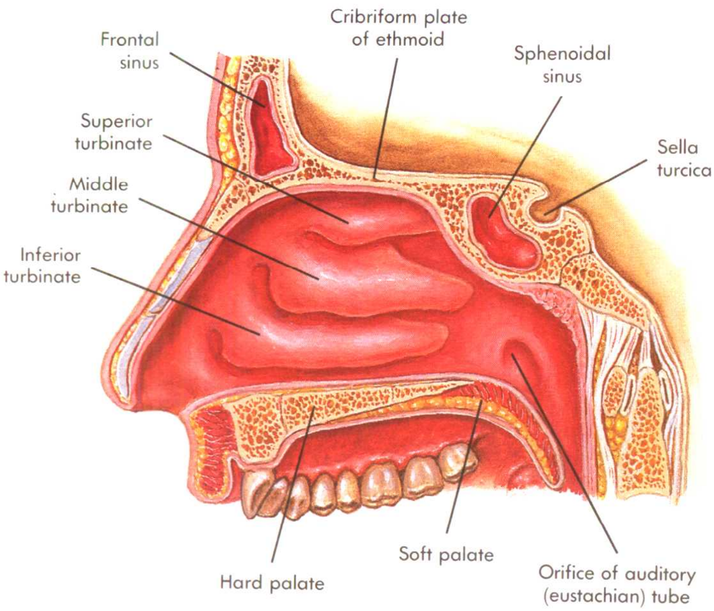


FIGURE 1-5
Cross-section of the nose and nasopharynx.

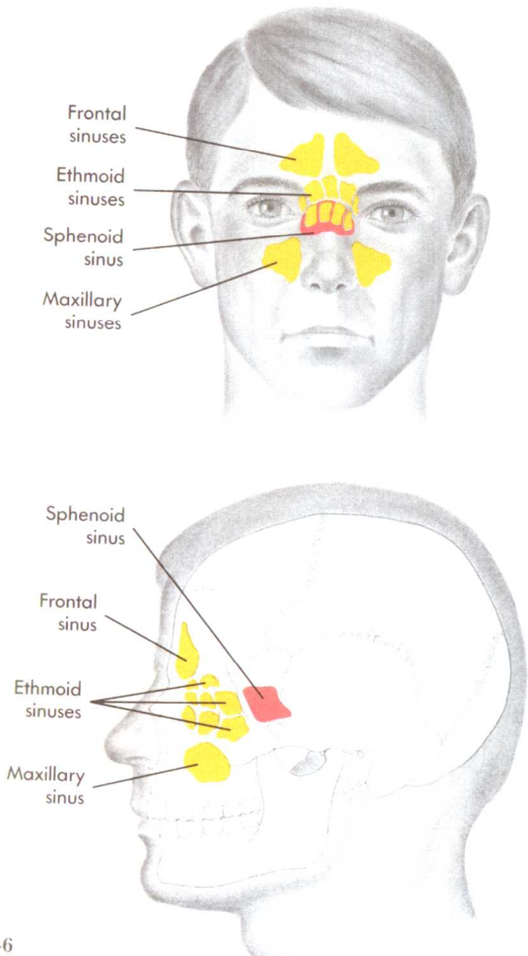


FIGURE 1-6
Paranasal sinuses in the adult.

UPPER AIRWAY STRUCTURES

Nasal passages
Sinuses
Pharynx
Larynx
Upper trachea

UPPER AIRWAY

The upper airway consists of the nasal passages and sinuses, pharynx, larynx, and upper trachea. In addition to conducting air to the lower airway, the primary functions of the upper airway are to protect the lower airway from foreign material and to warm, filter, and humidify inspired air. Both tasks are aided by a mucous membrane made of pseudostratified ciliated epithelium that lines all upper airway structures. In the nose, sinuses, and part of the pharynx this membrane is primarily columnar, changing to squamous cells in the pharynx. Goblet cells throughout the epithelium produce debris-trapping mucus, which drains into the nasopharynx for swallowing or expectoration (see Figure 1-11).

Nasal Passages

Air enters the nares, passes over the coarse nasal hairs (vibrissae) lining the vestibules, and enters the nasopharynx. The cribriform plate at the roof of the nose houses sensory endings of the olfactory nerve. Numerous small, fragile arteries and veins intertwine through the mucous membrane.

The curved **turbinates,** which form the lateral walls of the nasal passages, provide a larger surface area in which to warm, humidify, and filter inspired air (Figure 1-5). Each turbinate has a meatus for drainage into the nose. The nasolacrimal duct drains into the inferior turbinate meatus, while the paranasal sinuses drain into the medial and superior turbinate meatus.

In addition to the olfactory nerve, the nose is innervated by sensory fibers of the trigeminal nerve.

Paranasal Sinuses

The hollow, paired, but rarely symmetric sinuses (Figure 1-6) produce additional mucus for the nasal passages. Drainage from the maxillary and frontal sinuses is through the medial meatuses. The ethmoid sinuses open into both the medial and superior meatus, and the sphenoid sinuses drain into the superior meatus. The paranasal sinuses also provide resonance during vocalization and lighten the weight of the skull.

At birth the maxillary and ethmoid sinuses are present but are quite small. Frontal sinuses form by age 7 or 8 years, and the sphenoid sinuses develop completely by puberty.

Only the maxillary and frontal sinuses are directly accessible for examination, because the ethmoid sinuses lie behind the frontal sinuses, and the sphenoid sinuses are posterior to the ethmoids.

Pharynx

The pharynx is about 13 cm long and is divided into three parts (Figure 1-7). The entire area contains numerous sensory fibers from the glossopharyngeal and facial nerves.

The **nasopharynx** lies directly behind the nasal cavities and is connected to the nose by two posterior nares. Two eustachian tubes lead from the middle ear into the nasopharynx. Near these openings are clusters of lymphoid tissue that make up the adenoids, or pharyngeal tonsils. At birth the nasopharynx is covered with columnar ciliated epithelium, but after age 10 years the epithelial cells become stratified and squamous.

The **oropharynx** is the posterior portion of the oral cavity that is visible when the tongue is depressed. Its primary landmarks are the uvula and the soft palate. The oropharynx houses two sets of tonsils: the palatine tonsils in the lateral wall and the lingual tonsils at the base of the tongue.

The **laryngopharynx** opens into the larynx and esophagus. Its main boundaries are the root of the tongue and the hyoid bone. The epiglottis projects upward into the laryngopharynx.

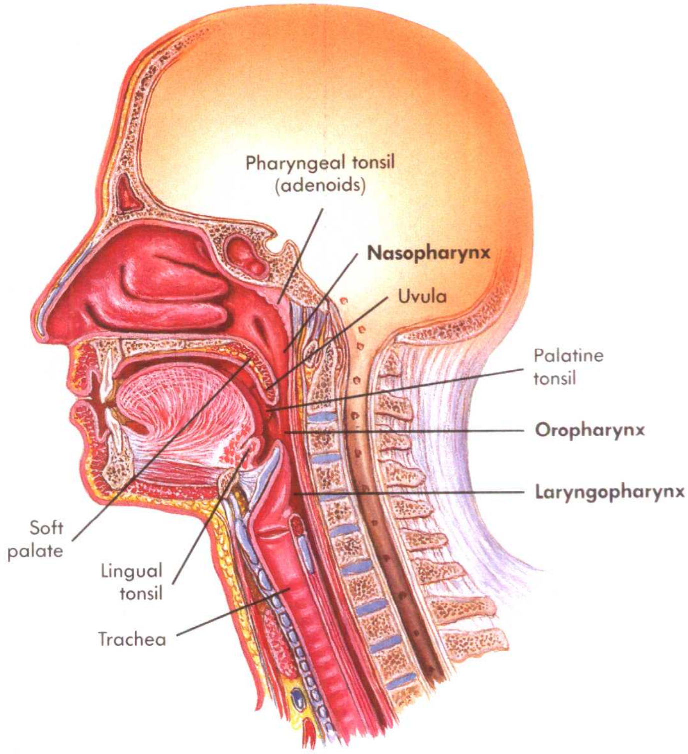


FIGURE 1-7
Cross-section of the pharynx and larynx.

Larynx

The larynx connects the upper airway to the trachea and houses the vocal cords (see Figure 1-7). It is a rigid tube formed by nine cartilages held together with striated muscles and ligaments. The narrowest point in children is the cricoid cartilage, the only portion of the larynx that forms a closed circle.

The leaf-shaped epiglottis cartilage resting atop the hyoid bone is attached in a hinge-like manner to the thyroid cartilage, which is the structure in the larynx. This permits the epiglottis to close over the trachea during swallowing to prevent aspiration of food.

The mucosa lining the larynx is very sensitive to stimulation by foreign particles. Two branches of the vagus nerve innervate the larynx, with the recurrent laryngeal nerve providing motor innervation and the super ior laryngeal nerve supplying some motor and all sensory innervation. Stimulation of this latter nerve initiates the cough reflex.

• • •

The hallmark antigenic response in the upper respiratory tract is mucosal edema with increased tissue sensitivity and copious mucus production. This occurs in response to invasion by pathogenic organisms or hypersensitivity to environmental agents. Blockage of the turbinate meatus, particularly the medial meatus, can lead to sinusitis.

Infants and young children are especially susceptible to complications from upper respiratory tract infections. The shorter, more vertical placement of the eustachian tubes in early childhood encourages bacterial transit to the middle ear, resulting in otitis media. Tonsillitis is also most common in young children. Significant edema of the larynx can completely block the airway in children.

Neurologic disorders affecting pharyngeal or laryngeal innervation can interfere with cough, swallow, or gag reflexes and lead to aspiration of food or secretions into the lungs.

The right lung conducts 55% and the left lung 45% of normal lung function.

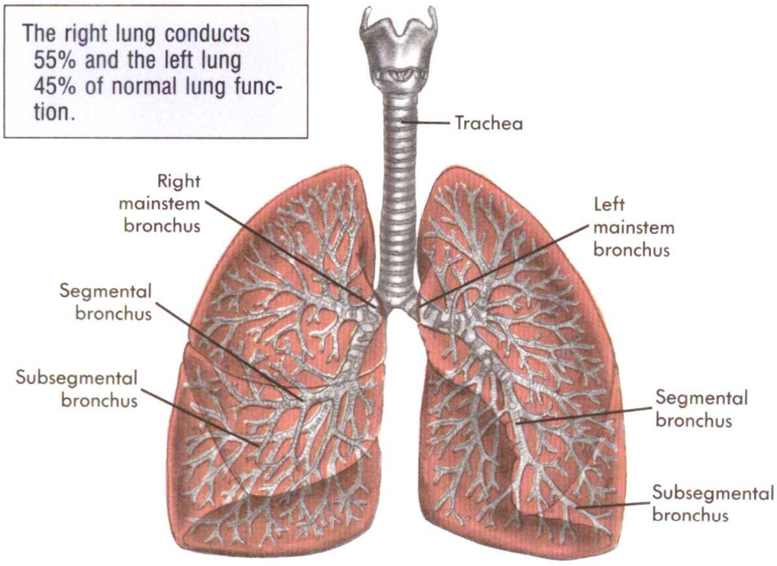


FIGURE 1-8
Trachea and lungs.

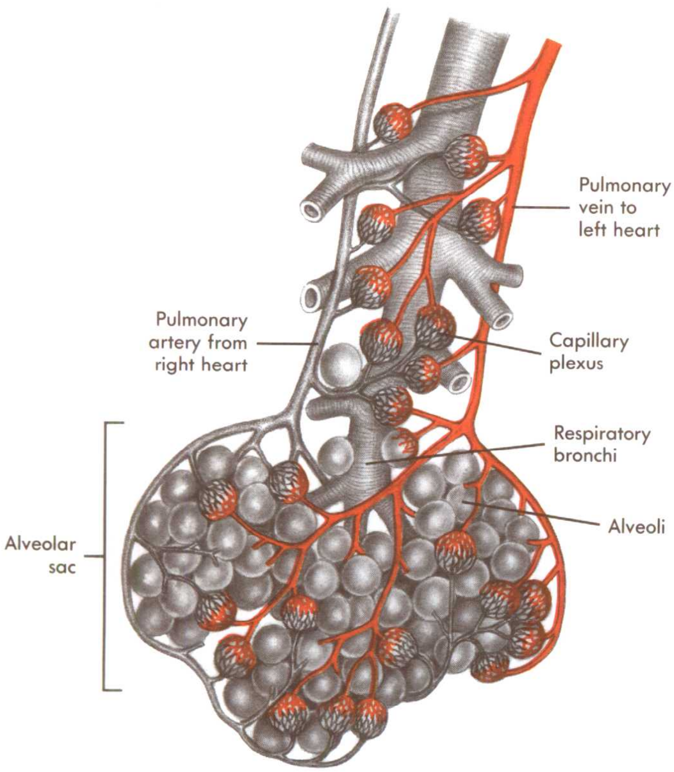


FIGURE 1-9
Structure of an acinus.

LOWER AIRWAY

LOWER AIRWAY STRUCTURES

The lower airway is formed by serial branching, giving it a tree-like shape. The trachea, mainstem bronchi, segmental bronchi, subsegmental bronchioles, terminal bronchioles, and gas exchange units form the lower airway.

The lungs are spongy, highly elastic organs. They are paired but not symmetric. The right lung is composed of three lobes and ten bronchopulmonary segments, whereas the left lung has two lobes and nine bronchopulmonary segments.

Trachea and Bronchi

The trachea and bronchi are made up of C-rings of cartilage held together with fibromuscular tissue (Figure 1-8). Lined with ciliated epithelium interspersed with mucus-producing goblet cells, the cilia sweep foreign particles upward toward the pharynx (see Figure 1-11). The **carina,** located at about the level of T5, marks the point where the trachea divides to form the two mainstem bronchi.

The right mainstem bronchus is about 5 cm shorter than the left bronchus and nearly vertical. In contrast, the left bronchus lies more horizontally. The mainstem bronchi divide into lobar bronchi, 3 on the right and 2 on the left. Within a short distance the lobar bronchi branch into 19 segmental bronchi, 10 on the right and 9 on the left. The segmental bronchi divide to form numerous subsegmental bronchioles.

Bronchioles

The structure of bronchioles differs considerably from that of the larger airways. The bronchioles have no cartilage and the mucosa has no goblet cells or submucosal glands. Rather, the bronchiole comprises a concentric ring of smooth muscle with two sets of muscle fibers. The inner walls are lined with mucosa.

Subsegmental bronchioles end in terminal bronchioles, which conduct air to the alveolar ducts. Terminal bronchioles are lined with epithelium and Clara cells (see Figure 1-11). Together, both lungs contain about 35,000 terminal bronchioles, which further divide into terminal respiratory units (*acini*) where gas exchange occurs.

The lungs in the adult contain about 600 million alveoli.

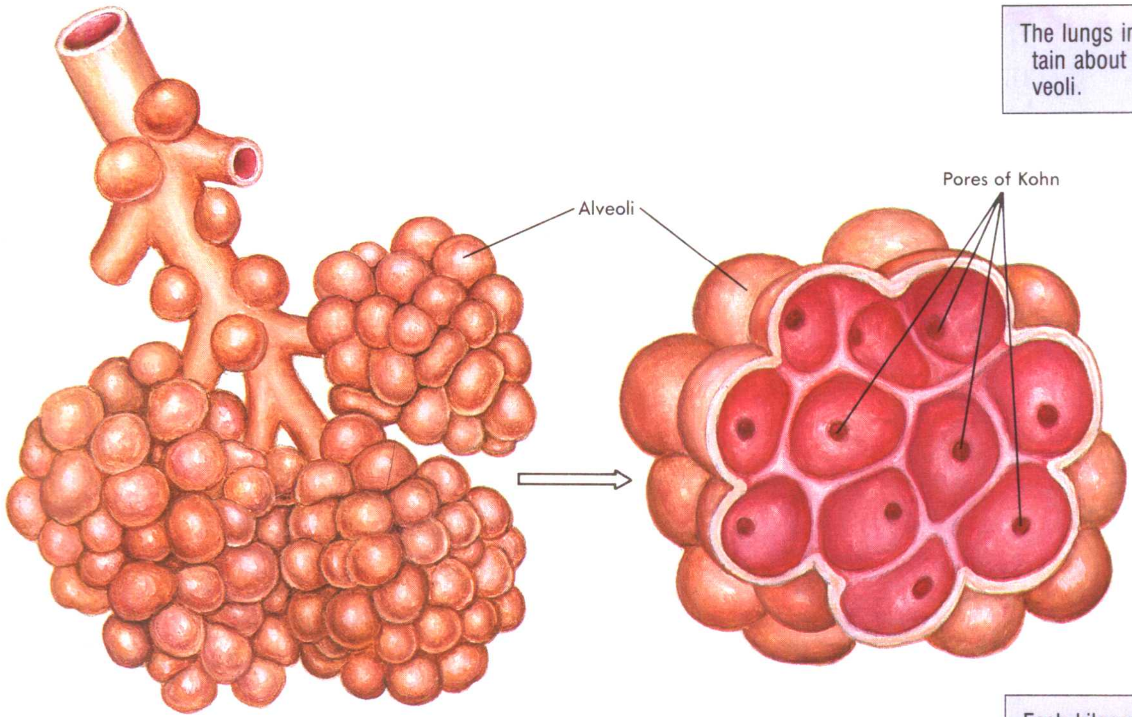


FIGURE 1-10
Structure of alveoli and the pores of Kohn.

Each kilogram of body weight requires about 1 square meter of lung surface to meet the body's metabolic needs. In the average adult, this translates to a lung surface equivalent to a regulation size tennis court.

Gas Exchange Units

Acini, arranged in clusters throughout the lungs, are composed of respiratory bronchioles, alveolar sacs, and alveoli (terminal air sacs) (Figure 1-9). Each acinus has a network of pulmonary arteries and veins. A flattened, one-cell-thick layer of epithelium covers the surface of the acini.

The **alveolar sacs** (Figure 1-10) are formed by a five-layered epithelial membrane containing type II cells. These specialized cells secrete **surfactant,** a lipoprotein that coats the membrane surface to decrease the surface tension of the alveoli so the lungs can inflate easily. The alveolar membrane forms the division between the alveolar space and the pulmonary capillary.

Tiny openings called the **pores of Kohn** connect the alveoli (Figure 1-10). These pores allow even air distribution throughout the acinus so all alveoli have the same gas concentration. Consequently, these pores also provide collateral ventilation if a small airway becomes obstructed.

• • •

Aspiration of foreign particles into the right lung is more common, owing to the nearly vertical position of the right mainstem bronchus. The smaller airways of the lower respiratory tract are easily obstructed by accumulations of mucus or foreign particles. Constriction of the bronchioles, as occurs in asthma, narrows the airways and compromises ventilation. If production of surfactant is insufficient or absent, as occurs in hyaline membrane disease and adult respiratory distress syndrome, the alveolar sacs fail to inflate.