Respiratory System Anatomy and Physiology

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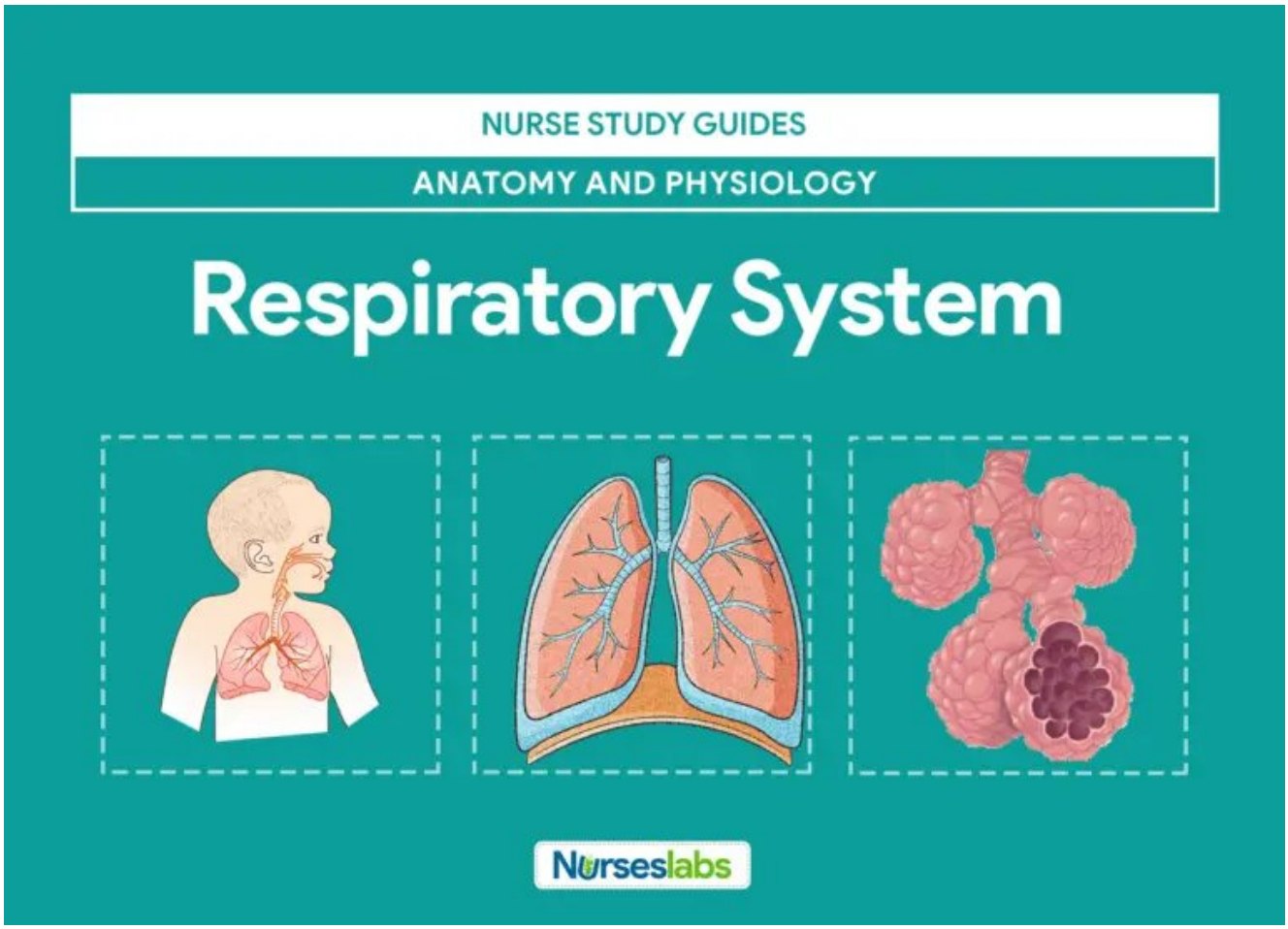


The trillions of cells in the body require an abundant and continuous supply of oxygen to carry out their vital functions. We cannot "do without oxygen" for even a little while, as we can without food or water.

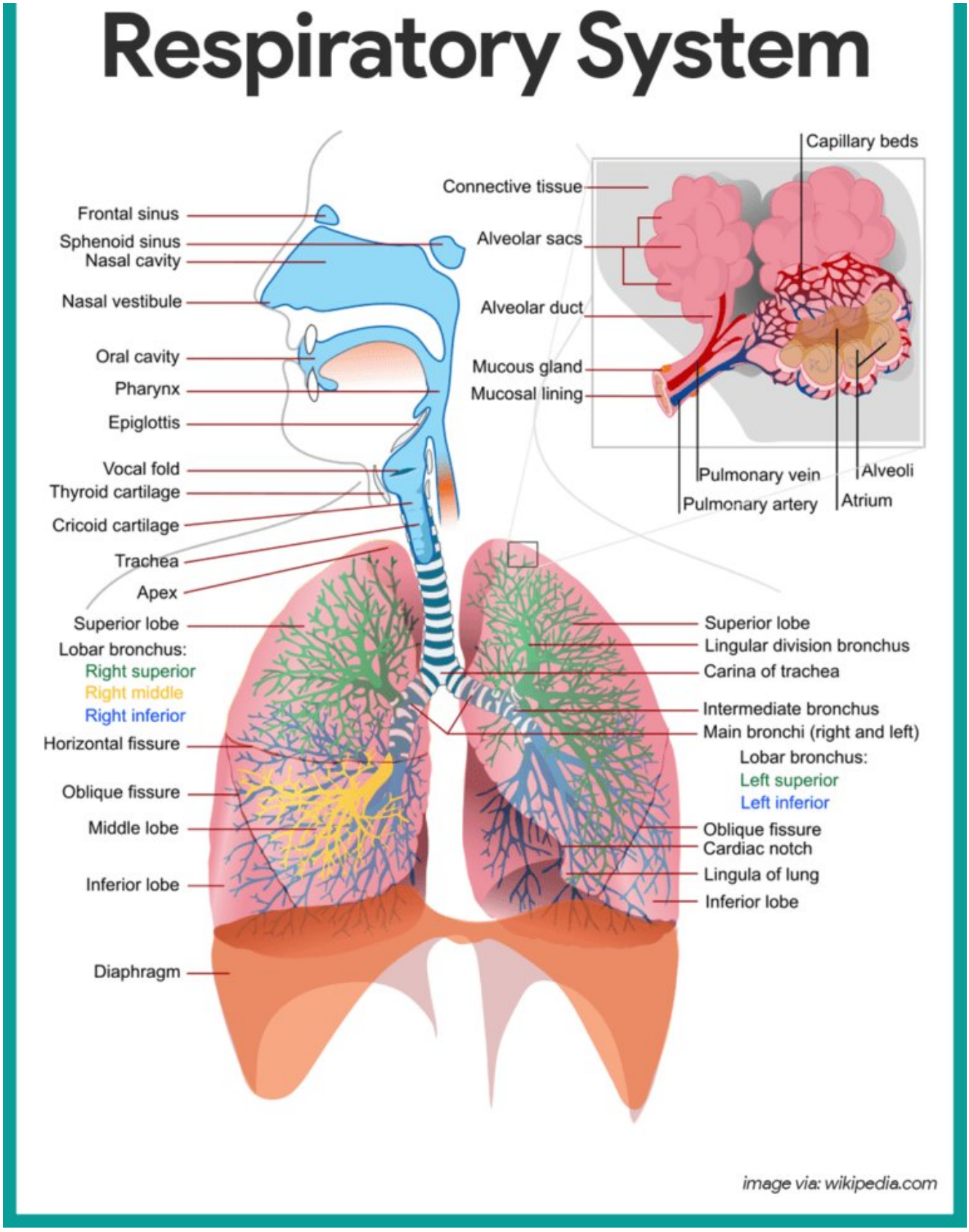
Functions of the Respiratory System

The functions of the respiratory system are:

1. **Oxygen supplier.** The job of the respiratory system is to keep the body constantly supplied with oxygen.
2. **Elimination.** Elimination of carbon dioxide.
3. **Gas exchange.** The respiratory system organs oversee the gas exchanges that occur between the blood and the external environment.
4. **Passageway.** Passageways that allow air to reach the lungs.
5. **Humidifier.** Purify, humidify, and warm incoming air.

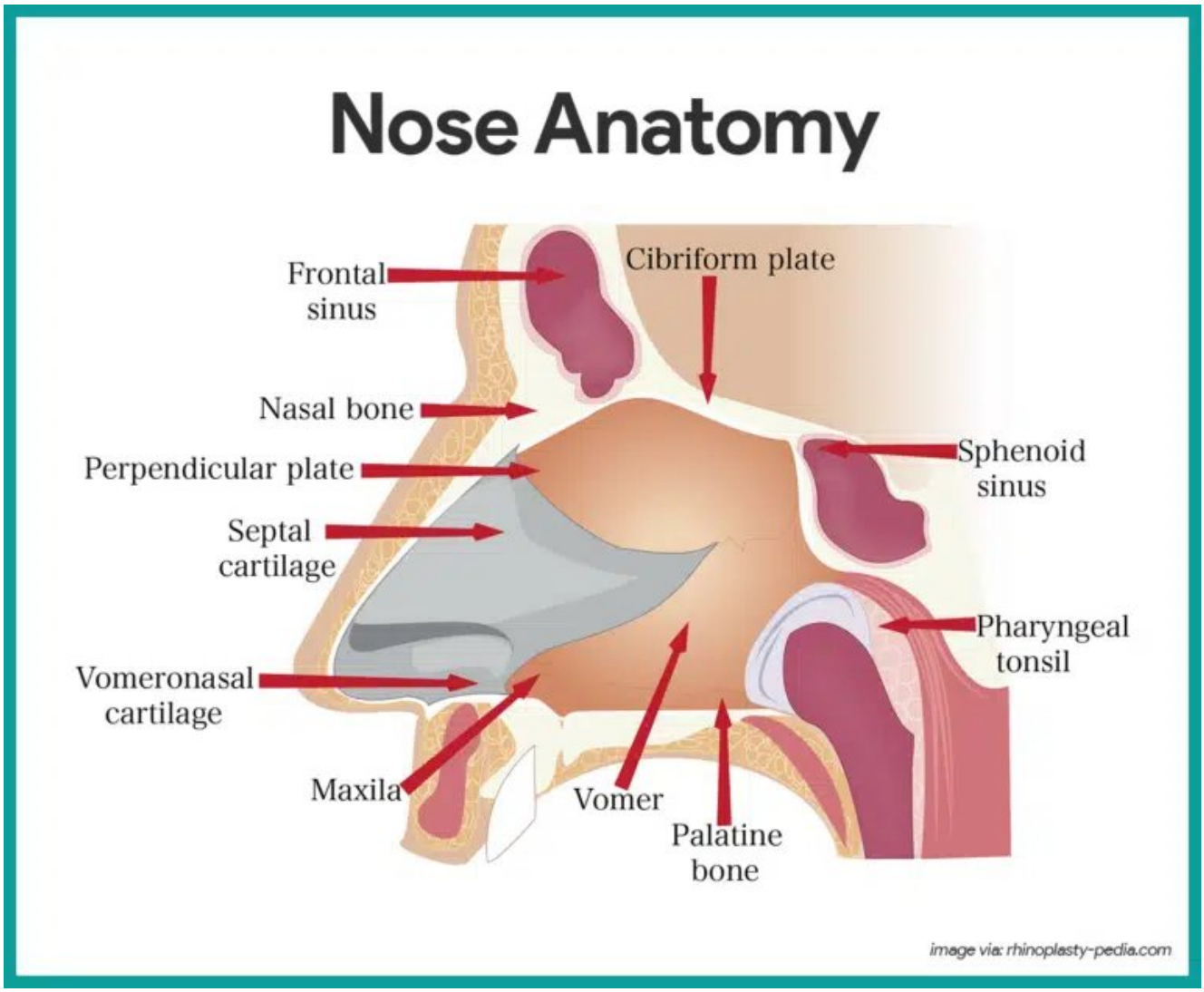
Anatomy of the Respiratory System

The organs of the respiratory system include the nose, pharynx, larynx, trachea, bronchi, and their smaller branches, and the lungs, which contain the alveoli.



The Nose

The nose is the only externally visible part of the respiratory system.

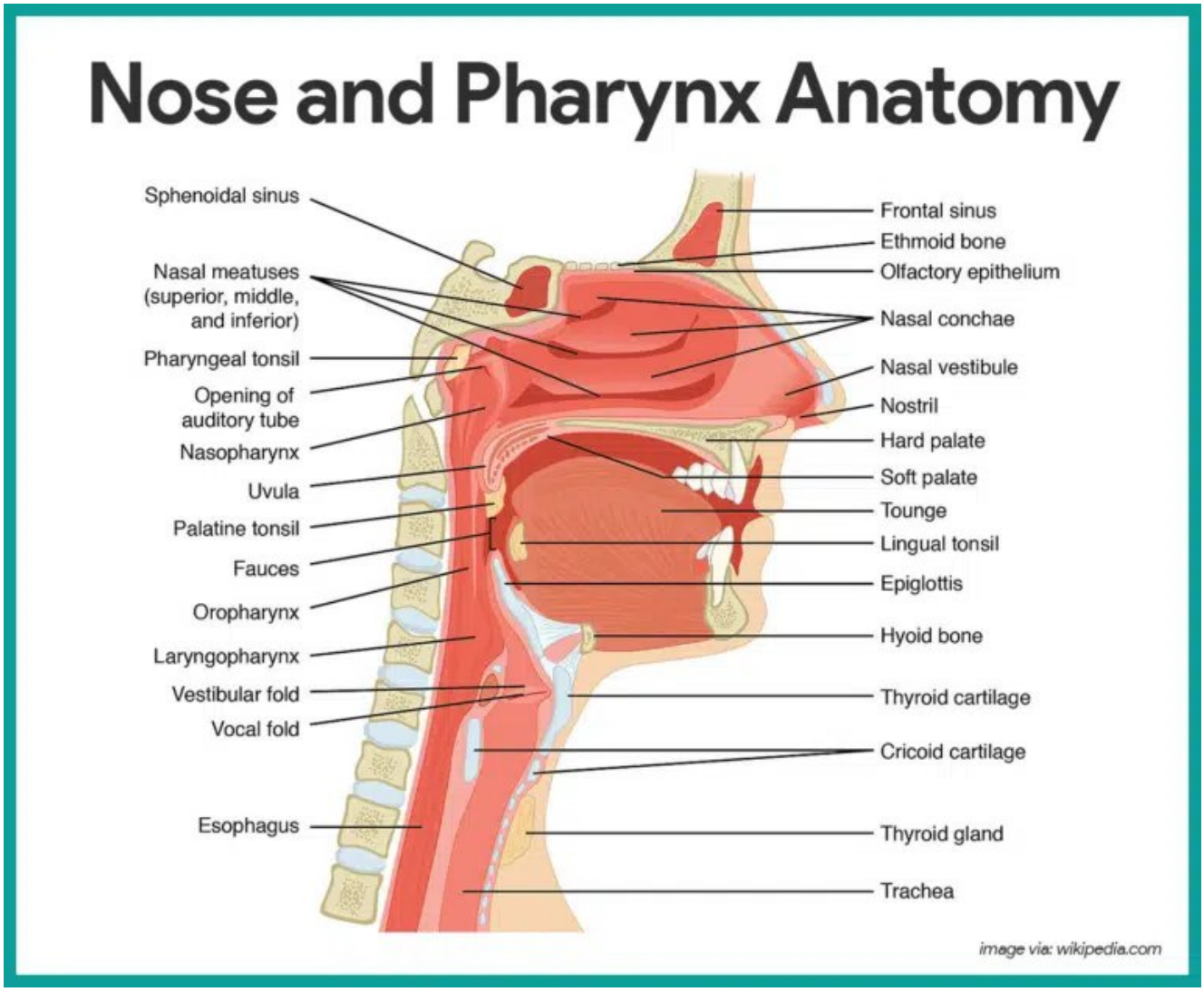


- **Nostrils.** During breathing, air enters the nose by passing through the nostrils, or nares.
- **Nasal cavity.** The interior of the nose consists of the nasal cavity, divided by a midline **nasal septum**.
- **Olfactory receptors.** The olfactory receptors for the sense of smell are located in the mucosa in the slitlike superior part of the nasal cavity, just beneath the ethmoid bone.
- **Respiratory mucosa.** The rest of the mucosal lining, the nasal cavity called the respiratory mucosa, rests on a rich network of thin-walled veins that warms the air as it flows past.
- **Mucus.** In addition, the sticky mucus produced by the mucosa's glands moistens the air and traps incoming bacteria and other foreign debris, and **lysozyme enzymes** in the mucus destroy bacteria chemically.
- **Ciliated cells.** The ciliated cells of the nasal mucosa create a gentle current that moves the sheet of contaminated mucus posteriorly toward the throat, where it is swallowed and digested by stomach juices.
- **Conchae.** The lateral walls of the nasal cavity are uneven owing to three mucosa-

covered projections, or lobes called conchae, which greatly increase the surface area of the mucosa exposed to the air, and also increase the air turbulence in the nasal cavity.

- **Palate.** The nasal cavity is separated from the oral cavity below by a partition, the palate; anteriorly, where the palate is supported by bone, is the **hard palate;** the unsupported posterior part is the **soft palate**.
- **Paranasal sinuses.** The nasal cavity is surrounded by a ring of paranasal sinuses located in the frontal, sphenoid, ethmoid, and maxillary bones; theses sinuses lighten the skull, and they act as a resonance chamber for speech.

Pharynx



- **Size.** The pharynx is a muscular passageway about **13 cm (5 inches)** long that vaguely resembles a short length of red garden hose.
- **Function.** Commonly called the **throat**, the pharynx serves as a common

passageway for food and air.

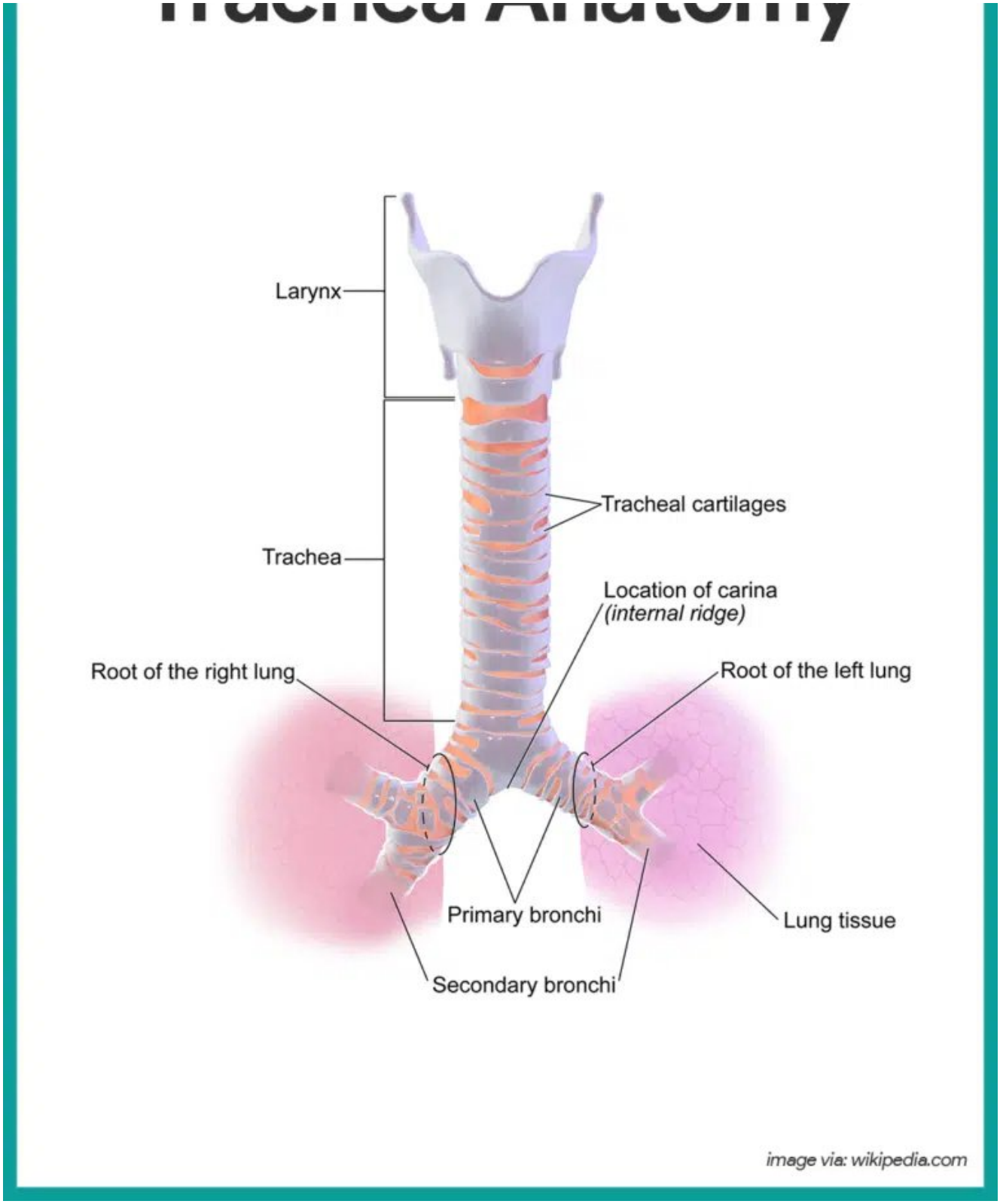
- **Portions of the pharynx.** Air enters the superior portion, the **nasopharynx**, from the nasal cavity and then descends through the **oropharynx** and **laryngopharynx** to enter the larynx below.
- **Pharyngotympanic tube.** The pharyngotympanic tubes, which drain the middle ear open into the nasopharynx.
- **Pharyngeal tonsil.** The pharyngeal tonsil, often called **adenoid** is located high in the nasopharynx.
- **Palatine tonsils.** The palatine tonsils are in the oropharynx at the end of the soft palate.
- **Lingual tonsils.** The lingual tonsils lie at the base of the tongue.

Larynx

The larynx or **voice box** routes air and food into the proper channels and plays a role in speech.

- **Structure.** Located inferior to the pharynx, it is formed by eight rigid hyaline cartilages and a spoon-shaped flap of elastic cartilage, the **epiglottis**.
- **Thyroid cartilage.** The largest of the hyaline cartilages is the shield-shaped thyroid cartilage, which protrudes anteriorly and is commonly called **Adam's apple**.
- **Epiglottis.** Sometimes referred to as the **"guardian of the airways"**, the epiglottis protects the superior opening of the larynx.
- **Vocal folds.** Part of the mucous membrane of the larynx forms a pair of folds, called the vocal folds, or **true vocal cords**, which vibrate with expelled air and allows us to speak.
- **Glottis.** The slitlike passageway between the vocal folds is the glottis.

Trachea



- **Length.** Air entering the trachea or **windpipe** from the larynx travels down its length (10 to 12 cm or about 4 inches) to the level of the **fifth thoracic vertebra**, which is approximately midchest.
- **Structure.** The trachea is fairly rigid because its walls are reinforced with **C-shaped rings** of hyaline cartilage; the open parts of the rings abut the esophagus and allow it to expand anteriorly when we swallow a large piece of food, while the solid portions support the trachea walls and keep it patent, or

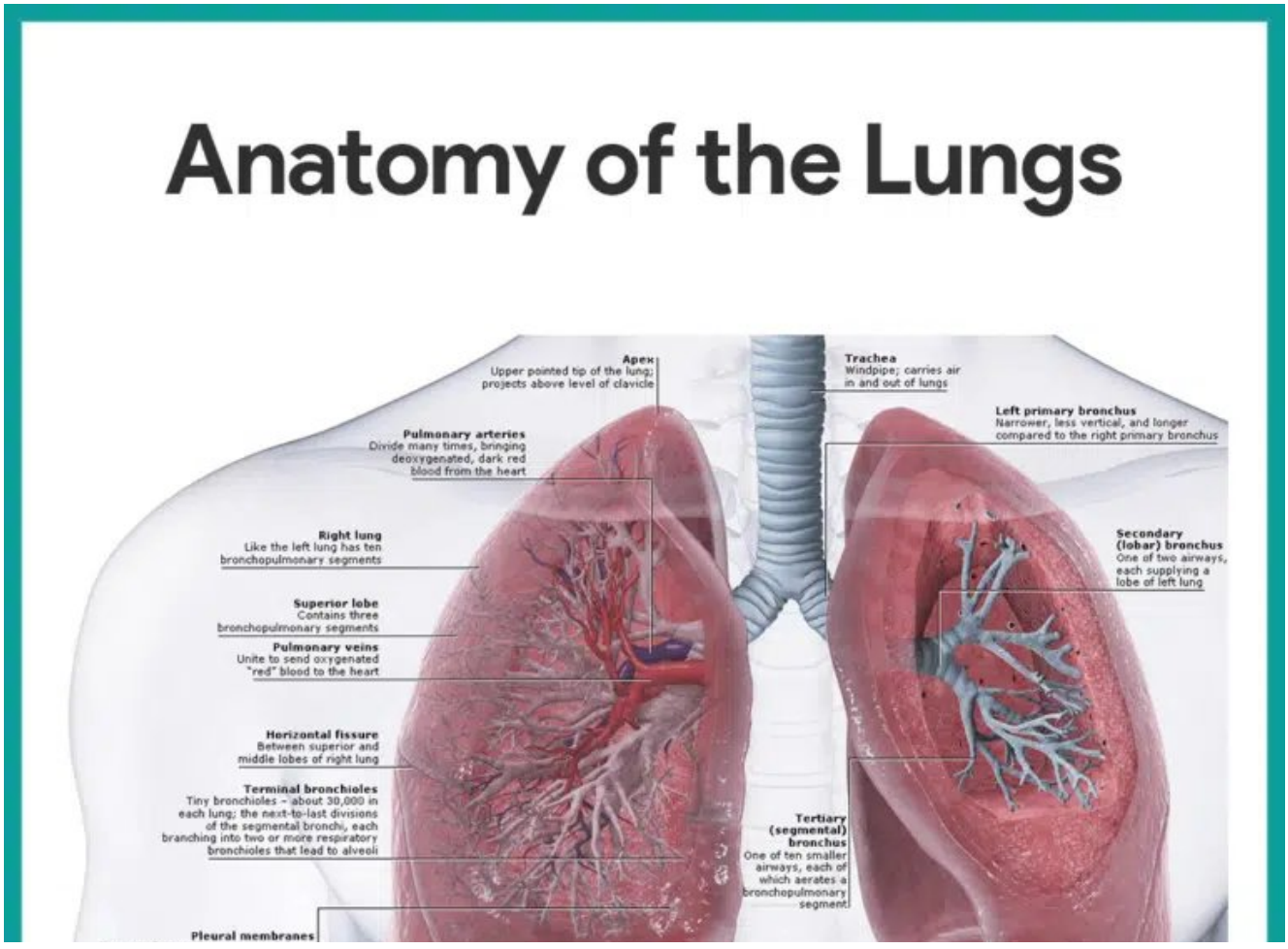
open, in spite of the pressure changes that occur during breathing.

- **Cilia.** The trachea is lined with ciliated mucosa that beat continuously and in a direction opposite to that of the incoming air as they propel mucus, loaded with dust particles and other debris away from the lungs to the throat, where it can be swallowed or spat out.

Main Bronchi

- **Structure.** The right and left main (primary) bronchi are formed by the division of the trachea.
- **Location.** Each main bronchus runs obliquely before it plunges into the medial depression of the lung on its own side.
- **Size.** The right main bronchus is wider, shorter, and straighter than the left.

Lungs



- **Location.** The lungs occupy the entire thoracic cavity except for the most central area, the **mediastinum**, which houses the heart, the great blood vessels, bronchi, esophagus, and other organs.
- **Apex.** The narrow, superior portion of each lung, the apex, is just deep to the clavicle.
- **Base.** The broad lung area resting on the diaphragm is the base.
- **Division.** Each lung is divided into lobes by fissures; the left lung has **two lobes**, and the right lung has **three**.
- **Pleura.** The surface of each lung is covered with a visceral serosa called the **pulmonary**, or **visceral pleura** and the walls of the thoracic cavity are lined by the **parietal pleura**.
- **Pleural fluid.** The pleural membranes produce pleural fluid, a slippery serous secretion which allows the lungs to glide easily over the thorax wall during breathing movements and causes the two pleural layers to cling together.
- **Pleural space.** The lungs are held tightly to the thorax wall, and the pleural space is more of a potential space than an actual one.
- **Bronchioles.** The smallest of the conducting passageways are the bronchioles.
- **Alveoli.** The terminal bronchioles lead to the respiratory zone structures, even smaller conduits that eventually terminate in alveoli, or air sacs.
- **Respiratory zone.** The respiratory zone, which includes the respiratory bronchioles, alveolar ducts, alveolar sacs, and alveoli, is the only site of gas exchange.
- **Conducting zone structures.** All other respiratory passages are conducting zone structures that serve as conduits to and from the respiratory zone.
- **Stroma.** The balance of the lung tissue, its stroma, is mainly elastic connective tissue that allows the lungs to recoil passively as we exhale.

The Respiratory Membrane

- **Wall structure.** The walls of the alveoli are composed largely of a single, thin layer of squamous epithelial cells.
- **Alveolar pores.** Alveolar pores connecting neighboring air sacs and provide alternative routes for air to reach alveoli whose feeder bronchioles have been clogged by mucus or otherwise blocked.
- **Respiratory membrane.** Together, the alveolar and capillary walls, their fused basement membranes, and occasional elastic fibers construct the respiratory membrane (air-blood barrier), which has gas (air) flowing past on one side and blood flowing past on the other.
- **Alveolar macrophages.** Remarkably efficient alveolar macrophages sometimes called **"dust cells"**, wander in and out of the alveoli picking up bacteria, carbon particles, and other debris.
- **Cuboidal cells.** Also scattered amid the epithelial cells that form most of the alveolar walls are chunky cuboidal cells, which produce a lipid (fat) molecule called **surfactant**, which coats the gas-exposed alveolar surfaces and is very important in lung function.

Physiology of the Respiratory System

The major function of the respiratory system is to supply the body with oxygen and to dispose of carbon dioxide. To do this, at least four distinct events, collectively called respiration, must occur.

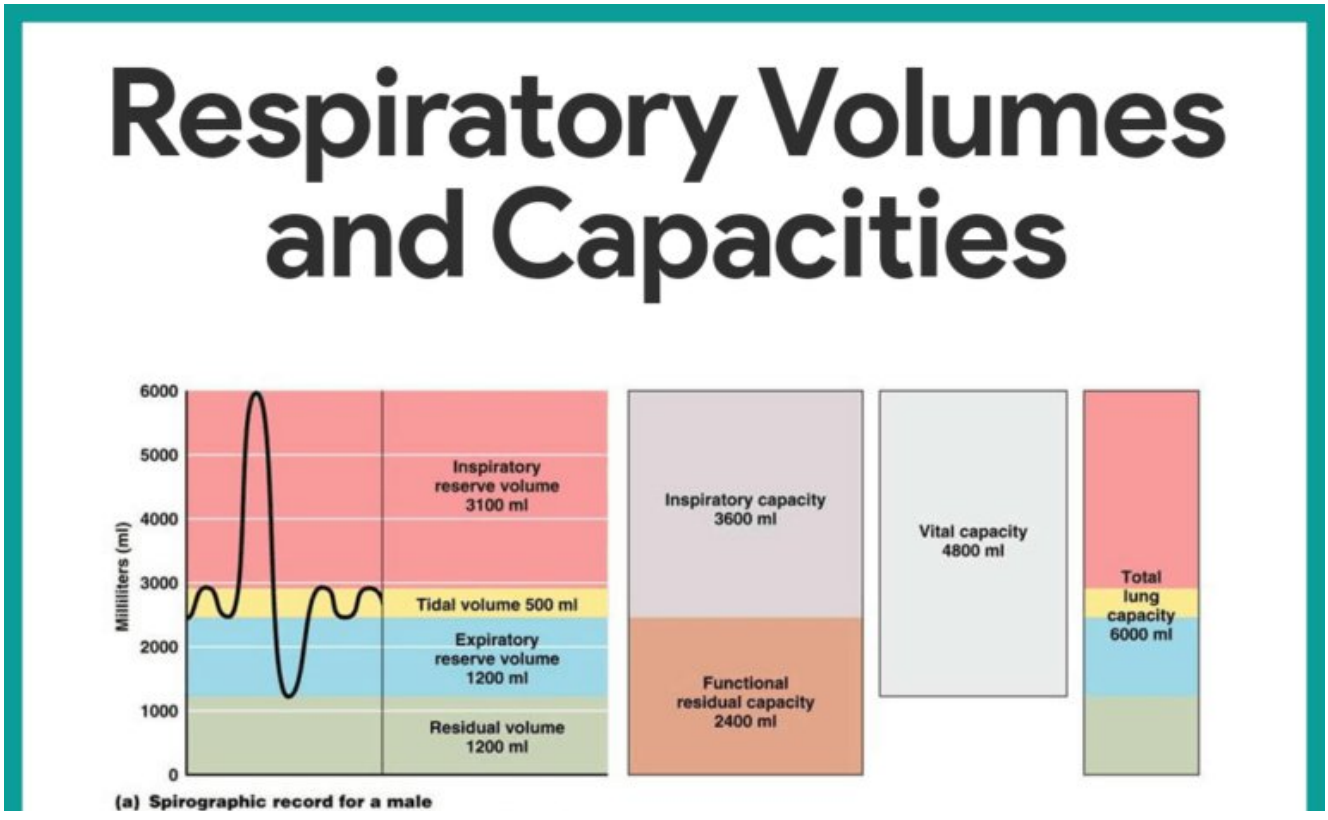
Respiration

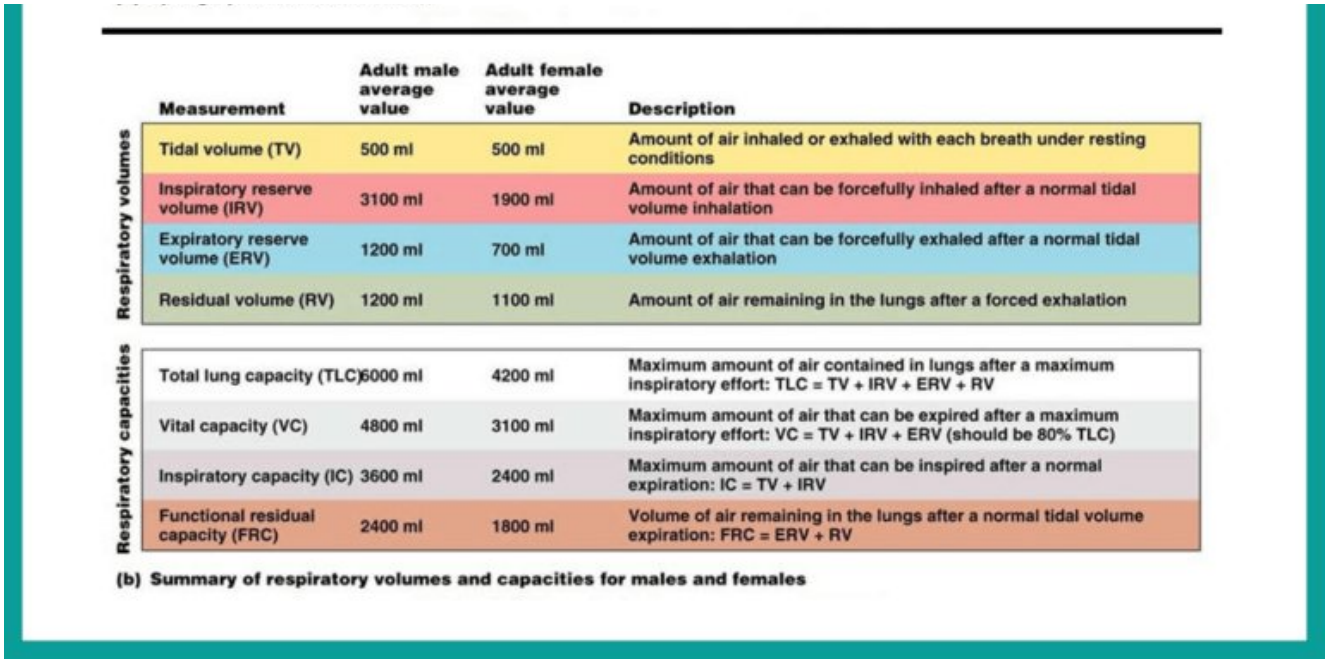
- **Pulmonary ventilation.** Air must move into and out of the lungs so that gasses in the air sacs are continuously refreshed, and this process is commonly called breathing.
- **External respiration.** Gas exchange between the pulmonary blood and alveoli must take place.
- **Respiratory gas transport.** Oxygen and carbon dioxide must be transported to and from the lungs and tissue cells of the body via the bloodstream.
- **Internal respiration.** At systemic capillaries, gas exchanges must be made between the blood and tissue cells.

Mechanics of Breathing

- **Rule.** Volume changes lead to pressure changes, which lead to the flow of gasses to equalize pressure.
- **Inspiration.** Air is flowing into the lungs; chest is expanded laterally, the rib cage is elevated, and the diaphragm is depressed and flattened; lungs are stretched to the larger thoracic volume, causing the intrapulmonary pressure to fall and air to flow into the lungs.
- **Expiration.** Air is leaving the lungs; the chest is depressed and the lateral dimension is reduced, the rib cage is descended, and the diaphragm is elevated and dome-shaped; lungs recoil to a smaller volume, intrapulmonary pressure rises, and air flows out of the lung.
- **Intrapulmonary volume.** Intrapulmonary volume is the volume within the lungs.
- **Intrapleural pressure.** The normal pressure within the pleural space, the intrapleural pressure, is always negative, and this is the major factor preventing the collapse of the lungs.
- **Nonrespiratory air movements.** Nonrespiratory movements are a result of reflex activity, but some may be produced voluntarily such as cough, sneeze, crying, laughing, hiccups, and yawn.

Respiratory Volumes and Capacities





	Measurement	Adult male average value	Adult female average value	Description
Respiratory volumes	Tidal volume (TV)	500 ml	500 ml	Amount of air inhaled or exhaled with each breath under resting conditions
	Inspiratory reserve volume (IRV)	3100 ml	1900 ml	Amount of air that can be forcefully inhaled after a normal tidal volume inhalation
	Expiratory reserve volume (ERV)	1200 ml	700 ml	Amount of air that can be forcefully exhaled after a normal tidal volume exhalation
	Residual volume (RV)	1200 ml	1100 ml	Amount of air remaining in the lungs after a forced exhalation
Respiratory capacities	Total lung capacity (TLC)	6000 ml	4200 ml	Maximum amount of air contained in lungs after a maximum inspiratory effort: TLC = TV + IRV + ERV + RV
	Vital capacity (VC)	4800 ml	3100 ml	Maximum amount of air that can be expired after a maximum inspiratory effort: VC = TV + IRV + ERV (should be 80% TLC)
	Inspiratory capacity (IC)	3600 ml	2400 ml	Maximum amount of air that can be inspired after a normal expiration: IC = TV + IRV
	Functional residual capacity (FRC)	2400 ml	1800 ml	Volume of air remaining in the lungs after a normal tidal volume expiration: FRC = ERV + RV

(b) Summary of respiratory volumes and capacities for males and females

- **Tidal volume.** Normal quiet breathing moves approximately 500 ml of air into and out of the lungs with each breath.
- **Inspiratory reserve volume.** The amount of air that can be taken in forcibly over the tidal volume is the inspiratory reserve volume, which is normally between 2100 ml to 3200 ml.
- **Expiratory reserve volume.** The amount of air that can be forcibly exhaled after a tidal expiration, the expiratory reserve volume, is approximately 1200 ml.
- **Residual volume.** Even after the most strenuous expiration, about 1200 ml of air still remains in the lungs and it cannot be voluntarily expelled; this is called residual volume, and it is important because it allows gas exchange to go on continuously even between breaths and helps to keep the alveoli inflated.
- **Vital capacity.** The total amount of exchangeable air is typically around 4800 ml in healthy young men, and this respiratory capacity is the vital capacity, which is the sum of the tidal volume, inspiratory reserve volume, and the expiratory reserve volume.
- **Dead space volume.** Much of the air that enters the respiratory tract remains in the conducting zone passageways and never reaches the alveoli; this is called the dead space volume and during a normal tidal breath, it amounts to about 150 ml.
- **Functional volume.** The functional volume, which is the air that actually reaches the respiratory zone and contributes to gas exchange, is about 350 ml.
- **Spirometer.** Respiratory capacities are measured with a spirometer, wherein as a person breathes, the volumes of air exhaled can be read on an indicator, which shows the changes in air volume inside the apparatus.

Respiratory Sounds

- **Bronchial sounds.** Bronchial sounds are produced by air rushing through the large respiratory passageways (trachea and bronchi).
- **Vesicular breathing sounds.** Vesicular breathing sounds occur as air fills the alveoli, and they are soft and resemble a muffled breeze.

External Respiration, Gas Transport, and Internal Respiration

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- **External respiration.** External respiration or pulmonary gas exchange involves the oxygen being loaded and carbon dioxide being unloaded from the blood.
- **Internal respiration.** In internal respiration or systemic capillary gas exchange, oxygen is unloaded and carbon dioxide is loaded into the blood.
- **Gas transport.** Oxygen is transported in the blood in two ways: most attaches to hemoglobin molecules inside the RBCs to form oxyhemoglobin, or a very small amount of oxygen is carried dissolved in the plasma; while carbon dioxide is transported in plasma as bicarbonate ion, or a smaller amount (between 20 to 30 percent of the transported carbon dioxide) is carried inside the RBCs bound to hemoglobin.

Control of Respiration

Neural Regulation

- **Phrenic and intercostal nerves.** These two nerves regulate the activity of the respiratory muscles, the diaphragm, and external intercostals.
- **Medulla and pons.** Neural centers that control respiratory rhythm and depth are located mainly in the medulla and pons; the medulla, which sets the basic rhythm of breathing, contains a pacemaker, or self-exciting inspiratory center, and an expiratory center that inhibits the pacemaker in a rhythmic way; pons centers appear to smooth out the basic rhythm of inspiration and expiration set by the medulla.

- **Eupnea.** The normal respiratory rate is referred to as eupnea, and it is maintained at a rate of **12 to 15 respirations/minute**.
- **Hyperpnea.** During exercise, we breathe more vigorously and deeply because the brain centers send more impulses to the respiratory muscles, and this respiratory pattern is called hyperpnea.

Non-neural Factors Influencing Respiratory Rate and Depth

- **Physical factors.** Although the medulla's respiratory centers set the basic rhythm of breathing, there is no question that physical factors such as talking, coughing, and exercising can modify both the rate and depth of breathing, as well as an increased body temperature, which increases the rate of breathing.
- **Volition (conscious control).** Voluntary control of breathing is limited, and the respiratory centers will simply ignore messages from the cortex (our wishes) when the oxygen supply in the blood is getting low or blood pH is falling.
- **Emotional factors.** Emotional factors also modify the rate and depth of breathing through reflexes initiated by emotional stimuli acting through centers in the hypothalamus.
- **Chemical factors.** The most important factors that modify respiratory rate and depth are chemical- the levels of carbon dioxide and oxygen in the blood; increased levels of carbon dioxide and decreased blood pH are the most important stimuli leading to an increase in the rate and depth of breathing, while a decrease in oxygen levels become important stimuli when the levels are dangerously low.
- **Hyperventilation.** Hyperventilation blows off more carbon dioxide and decreases the amount of carbonic acid, which returns blood pH to normal range when carbon dioxide or other sources of acids begin to accumulate in the blood.
- **Hypoventilation.** Hypoventilation or extremely slow or shallow breathing allows carbon dioxide to accumulate in the blood and brings blood pH back into normal range when blood starts to become slightly alkaline.

Practice Quiz: Respiratory System Anatomy and Physiology

Here's a 10-item quiz about the study guide. Please visit our **nursing test bank page** for more **NCLEX practice questions**.

1. Which of the following descriptions regarding the larynx is CORRECT?

A. The most inferior cartilage in the larynx is the epiglottis.
B. Unlike the other cartilages of the larynx, the epiglottis consists of hyaline cartilage.
C. The larynx contains four unpaired cartilages.
D. When the vestibular folds come together, they prevent air from leaving the lungs.

1. Answer: D. When the vestibular folds come together, they prevent air from leaving the lungs.

D: When the vestibular folds come together, they prevent air from leaving the lungs, such as when a person holds his breath. Along with the epiglottis, the vestibular folds also prevent food and liquids from entering the larynx.
A: The most inferior cartilage of the larynx is the unpaired cricoid cartilage, which forms the base of the larynx on which the other cartilages rest.
B: The epiglottis differs from the other cartilages in that it consists of elastic cartilage rather than hyaline cartilage.
C: The larynx consists of an outer casing of nine cartilages that are connected to one another by muscles and ligaments. Three of the nine cartilages are unpaired, and six of them form three pairs.

2. Given these respiratory passageways:

1. **alveoli**
2. **bronchi**
3. **bronchioles**
4. **respiratory bronchioles**
5. **terminal bronchioles**

From largest to smallest, the accurate order for these passageways is:

A. 2, 4, 5, 3, 1
B. 2, 4, 3, 5, 1
C. 2, 3, 5, 4, 1
D. 2, 3, 4, 5, 1

2. Answer: C. 2, 3, 5, 4, 1

The main bronchi branch many times to form the tracheobronchial tree. Within the lungs, the main airways (bronchi) branch off into smaller and smaller passageways. The

conducting portion is made up of nasal cavities, nasopharynx, larynx, trachea, bronchi and bronchioles. The trachea branches to give rise to two primary (main) bronchi. These then branch successively to give rise in turn to secondary and tertiary bronchi. These then branch to give rise to several orders of progressively smaller airways called bronchioles, the smallest of which are called terminal bronchioles. These are the last components of the conducting portion of the respiratory system. Terminal bronchioles give rise to respiratory bronchioles, which ultimately lead to the alveoli.

3. The right lung has ___ lobes and ___ bronchopulmonary segments.

A. 2, 9
B. 2, 10
C. 3, 9
D. 3, 10

3. Answer: D. 3, 10

The right lung has three lobes called the superior, middle, and inferior lobes. The left lung has two lobes called the superior and inferior lobes. Each lobe is divided into bronchopulmonary segments. There are 9 bronchopulmonary segments in the left lung and 10 in the right lung.

4. The pleura that covers the surface of the lungs is the:

A. Pleural Cavity
B. Pleural Fluid
C. Visceral Pleura
D. Parietal Pleura

4. Answer: C. Visceral Pleura

C: The visceral pleura covers the surface of the lung.
A,B: The pleural cavity, between the parietal and visceral pleurae, is filled with a small volume of pleural fluid produced by the pleural membranes.
D: The parietal pleura lines the walls of the thorax, diaphragm, and mediastinum.

5. The muscles of inspiration include the diaphragm and internal intercostal muscles. The statement is:

A. True
B. False
C. Partially true
D. Partially false

5. Answer: B. False

Muscles associated with the ribs are responsible for ventilation. The muscles of inspiration include the diaphragm and muscles that elevate the ribs and sternum, such as the external intercostals.

6. During expiration, decreased thoracic volume results in increased pressure inside the alveoli, therefore, air moves out of the lungs. The statement is:

A. True
B. False
C. Partially true
D. Partially false

6. Answer: A. True

During expiration, the thoracic volume decreases, producing a decrease in alveolar volume. Consequently, alveolar pressure increases above the air pressure outside the body, and air flows from the alveoli through the respiratory passage to the outside.

7. It is the volume of air inspired or expired with each breath. At rest, quiet breathing results in a volume of about 500 milliliters (mL).

A. Tidal volume
B. Inspiratory reserve volume
C. Expiratory reserve volume
D. Residual volume

7. Answer: A. Tidal volume

A: *Tidal volume* is the volume of air inspired or expired with each breath. At rest, quiet breathing results in a tidal volume of about 500 milliliters (mL).
B: *Inspiratory reserve volume* is the amount of air that can be inspired forcefully after inspiration of the resting tidal volume (about 3000 mL).
C: *Expiratory reserve volume* is the amount of air that can be expired forcefully after

expiration of the resting tidal volume (about 1100 mL).
D: *Residual volume* is the volume of air still remaining in the respiratory passages and lungs after a maximum expiration (about 1200 mL).

8. Given these divisions of the pharynx:

1. **laryngopharynx**
2. **nasopharynx**
3. **oropharynx**

From superior to inferior, the correct sequence for the divisions of the pharynx is:

A. 1, 2, 3
B. 1, 3, 2
C. 2, 3, 1
D. 2, 1, 3

8. Answer: C. 2, 3, 1

The nasopharynx is the superior part of the pharynx. It is located posterior to the choanae and superior to the soft palate, which is an incomplete muscle and connective tissue partition separating the nasopharynx from the oropharynx. The oropharynx extends from the uvula to the epiglottis, and the oral cavity opens into the oropharynx. Thus, food, drink, and air all pass through the oropharynx. The laryngopharynx passes posterior to the larynx and extends from the tip of the epiglottis to the esophagus. Food and drink pass through the laryngopharynx to the esophagus.

9. Which of the following is NOT TRUE about the paranasal sinuses?

A. They increase the weight of the skull.
B. They act as resonating chamber for voice production.
C. They contribute to voice production.
D. They protect the nasal cavity by producing mucus.

9. Answer: A. They increase the weight of the skull.

Paranasal sinuses are air-filled spaces within bone. The maxillary, frontal, ethmoidal, and sphenoidal sinuses are named after the bones in which they are located. The paranasal sinuses open into the nasal cavity and are lined with a mucous membrane. They reduce the weight of the skull, produce mucus, and influence the quality of voice by acting as

resonating chambers.

10. Prominent bony ridges on the lateral walls of the nasal cavity which increases the surface area of the nasal cavity are called:

A. the choane
B. the nasal septa
C. the hard palate
D. the conchae

10. Answer: D. the conchae

D: Three prominent bony ridges called conchae are present on the lateral walls on each side of the nasal cavity.
A: The choane are the openings into the pharynx
B: The nasal septum is a partition dividing the nasal cavity into right and left parts.
C: The hard palate forms the floor of the nasal cavity, separating the nasal cavity from the oral cavity.

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Anatomy & Physiology

Adam's apple, alveolar pressure, alveolar sacs, asthma, atmospheric pressure, breathing, bronchi, bronchioles, bronchopulmonary segments, bronchus, carbon dioxide, choane, conchae, corniculate arytenoid cartilage, cough reflex, cricoid cartilage, cuneiform cartilage, Diaphragm, emphysema, epiglottis, exhalation, expiration, expiratory reserve volume, false vocal cords, forced expiratory vital capacity, functional residual capacity, hard palate, inhalation, inspiration, inspiratory capacity, inspiratory reserve volume, laryngitis, laryngopharynx, larynx, lingual tonsil, lobar bronchi, lobes, lung recoil, lungs, nares, nasal cavity, nasal septum, nasolacrimal ducts, nasopharynx,

Nose, nostril, oropharynx, Oxygen, palatine tonsils, paranasal sinuses, parietal pleura, pharyngeal tonsil, pharynx, pleura, pleural cavity, pleural pressure, Pneumonia, pneumothorax, pulmonary capacity, pulmonary volumes, residual volume, respiratory bronchioles, respiratory membrane, Respiratory Rate (RR), respiratory system, segmental bronchi, Sinus, sinusitis, sneeze reflex, soft palate, spirometer, spirometry, surface tension, surfactant, terminal bronchioles, thyroid cartilage, tidal volume, total lung capacity, trachea, tracheobronchial tree, tracheostomy, tracheotomy, true vocal cords, tuberculosis, uvula, Ventilation, vestibular folds, visceral pleura, vital capacity

‹ 9 Bad Career Shift Choices for Nurses

› 45 Labor Stages, Induced and Augmented, Dystocia, Precipitous Labor Nursing Care Plans

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