5.1.2

Respiratory Structure

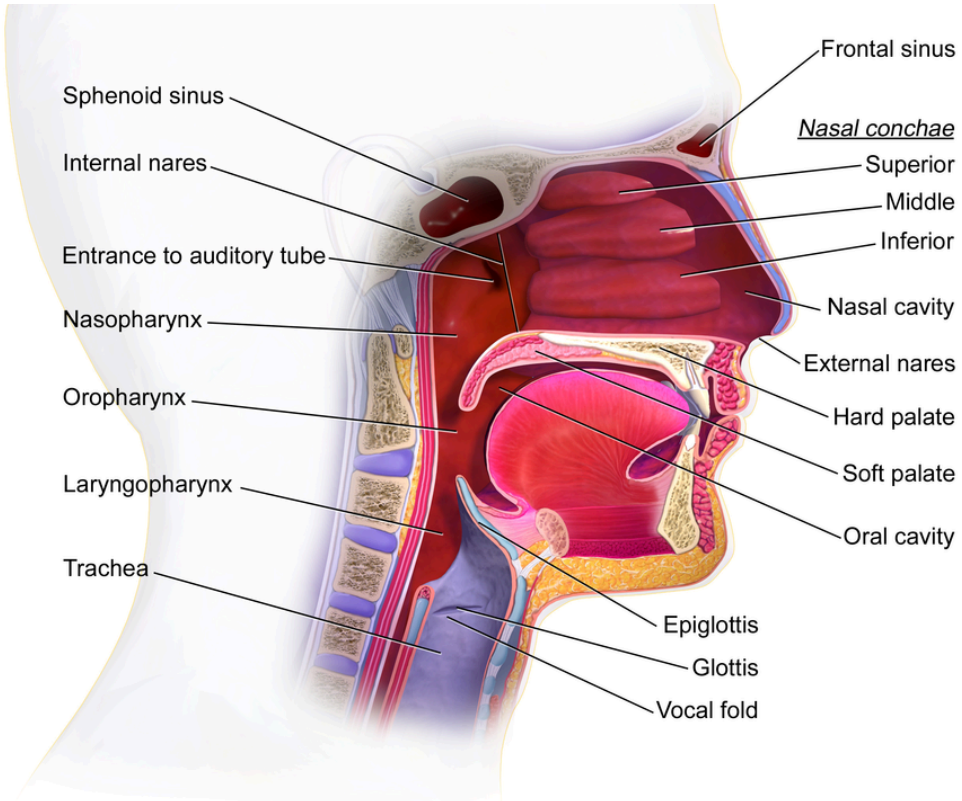
Major parts of the respiratory system include: the nose, nasal cavity, pharynx, larynx, trachea, bronchi, and the lungs. Respiratory structures may also be divided into the upper and lower respiratory tract - the division between the two is typically the larynx. It is also important to remember that the diaphragm, abdominal muscles, and muscles that elevate or depress the ribs, make inhalation and exhalation possible.

Nose

The nose is the very obvious external structure that juts out in the center of the face. It is supported by bone and hyaline cartilage and has an internal **nasal cavity** divided in its midline by a nasal septum. A deviated nasal septum means that the septum is not centered so normal airflow is altered, increasing the likelihood of the narrower side becoming congested or for sinusitis to develop. There are three ridges of bone in the nasal cavity called **turbinates** or **conchae** (kon'ke) and three **meatus** or tunnels beneath the conchae that together act to increase air turbulence, slowing down the air so that it has time to be warmed and humidified by the blood that flows through the mucus membranes. This warming and humidification prevents damage to more sensitive, deeper respiratory structures.

Pharynx

The **pharynx** (throat) is about 5 inches long. It acts as a passageway for both food and air and lies posterior to the nasal cavity, oral cavity, and larynx. The pharynx is divided into three parts in relation to the previously mentioned organs it is posterior to - namely, the nasopharynx, oropharynx, and laryngopharynx.



The Upper Respiratory System

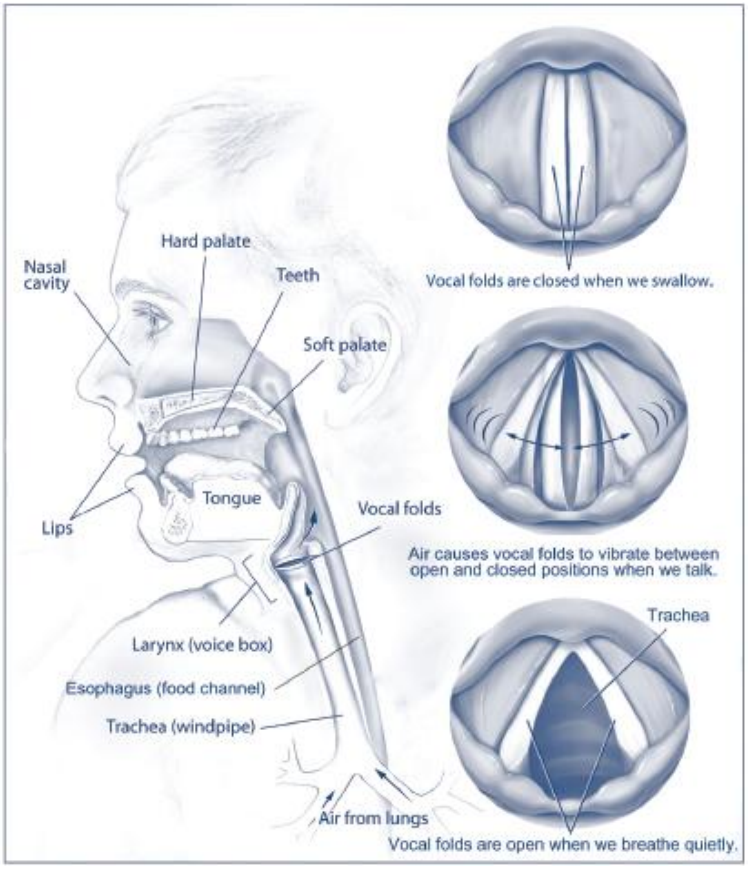
Author: Blausen.com staff (2014). "Medical gallery of Blausen Medical 2014". WikiJournal of Medicine 1 (2). DOI:10.15347/wjm/2014.010. ISSN 2002-4436. (Own work) [CC BY 3.0 (http://creativecommons.org/licenses/by/3.0)], via Wikimedia Commons https://commons.wikimedia.org/wiki/File%3ABlausen_0872_UpperRespiratorySystem.png

The nasopharynx (Click here to see another image of the Nasal Cavity) is normally only a passageway for air and is superior to the oral cavity and posterior to the **soft palate.** The soft palate with its extension called the **uvula** (that dangly thing on the top back of your mouth leading into the throat) form the posterior region of the oral cavity and elevates during swallowing to prevent food from passing into the nasopharynx. If you laugh, speak, or try to breathe during swallowing, the soft palate does not stay fully elevated and food or drink may enter the nasal cavity and pass out the nostrils. So be moderately careful while eating - especially on a first date trying to make a good lasting impression.

Larynx

The **larynx** is roughly a 2-inch cylinder-like airway commonly known as the voice box. It is located anteriorly in the throat and is continuous with the laryngopharynx superiorly and the trachea inferiorly. The larynx mainly functions as a passageway for air and in sound production. To maintain its shape, the larynx is supported by 9 cartilages connected and supported by ligaments and muscle. The spoon-shaped **epiglottis** is an unpaired elastic cartilage that acts a flexible flap to prevent food from passing to the lower respiratory tract. Its inferior end is attached to the posterior side of the thyroid cartilage. During swallowing, the epiglottis covers the larynx and food then slides against it toward the esophagus. If the epiglottis is open and a substance other than air enters the lower respiratory tract, the cough reflex is initiated to expel the substance. This reflex is not active when one is unconscious so please don't try to give an unconscious person oral fluid. Elastic ligaments associated with the larynx serve a vocal cords and produce sound due to air passing between causing vibrations (Click here to see another image of the Vocal Cords). The **glottis** is the vocal fold together with the space between the folds. Vestibular ligaments are the **vestibular folds** or **false vocal cords** and are located superiorly to the vocal folds and don't function to produce sound but to protect the vocal folds. During

swallowing, the vocal and vestibular folds pinch together closing the glottis to seal off the opening into the trachea. This same action occurs when one holds his/her breath.



Vocal Chords.

By JohannaO14 (Own work) [CC BY-SA 4.0 (https://creativecommons.org/licenses/by-sa/4.0)], via Wikimedia Commons https://commons.wikimedia.org/wiki/File%3AHoarseness_image.jpg

During the **Valsalva's maneuver,** the epiglottis and glottis close so that air cannot escape and the abdominal muscles simultaneously contract. These actions increase intra abdominopelvic cavity pressure. This maneuver is also used to assist elimination of urine from the bladder and feces from the rectum, as well as for passage of a baby through the birth canal. This maneuver also helps stabilize the body trunk during heavy lifting; the weightlifters you see in the Olympics are holding their breath during a power lift for this reason.

Sound Production

The range of one's voice refers to whether it's soprano, bass, or somewhere in between. This is determined by the thickness and length of the vocal folds: longer and thicker results in the lower range voice while shorter and thinner result in a higher range voice. Pitch or the frequency of sound waves produced can be altered by changing the tension on the vocal folds. The force of the air streaming past the vocal cords determines the loudness of a sound produced by the larynx. Yelling comes from the violent vibrations of your vocal cords caused by abdominal and thoracic cavity muscles forcing air rapidly up your windpipe. Remember not to "vigorously vibrate your vocals" in the McKay Library.

The quality of the sound that is our voice is influenced by all of the structures that the sound wave will encounter before it leaves the mouth. These include oral and nasal cavities and sinuses that act as resonating chambers and the tongue and lips which change shape to alter the sound. Young children have a more nasal voice because their resonating sinus

chambers are not fully developed. Get a sinus infection, plug your nose, or take out your false teeth and see how it affects your voice.

Trachea

The **trachea,** commonly called the windpipe, extends inferiorly from the larynx. The trachea is composed of dense fibrous connective tissue, and 15-20 C-shaped hyaline cartilage rings that provide rigidity to prevent collapse caused by pressure changes during breathing. Since the cartilage rings do not extend all the way around the trachea, the esophagus is allowed to expand anteriorly when food passes down it. Next time you're voraciously "inhaling" Little Caesar's Pizza or Big Macs, be thankful your trachea has C-rings and not O-rings.

If the airway becomes obstructed or ventilation decreases or stops because of injury or disease, a **cricothyrotomy** or **tracheotomy** may be performed by trained medical professionals. These procedures involve making an incision in the larynx or trachea to reestablish airflow and breathing.

The trachea, as with most of the respiratory tract, is lined with ciliated pseudostratified columnar epithelial cells and numerous mucus secreting goblet cells. The cilia sweep the debris-trapped mucus superiorly to the pharynx where it is swallowed. For this reason, this transport system is often referred to as the **mucociliary escalator system.** Smoking interferes with and eventually destroys the cilia of the epithelial lining, allowing mucus, smoke, and dust to accumulate in the respiratory tract. Long-time smokers often have a chronic cough since they must continuously attempt to remove built up material that normally would have been swept out by cilia.

We are constantly inhaling bacteria and particulates. **Alveolar macrophages** or **dust cells** normally keep the internal alveolar membrane quite clean and sterile. They have a much bigger job in smokers or in those who live in an air-polluted city. Dust cells ingest particles and bacteria and are able to leave the lungs via the lymph system or by being coughed up to more superior areas to be swept away by the mucociliary escalator system. It is estimated that we swallow more than 1 million dust cells every hour to clear them from our lungs!

Check out this video link to see the mucociliary escalator system in action: Fisher & Paykel Healthcare: Introduction to Mucociliary Transport Video Microscopy: https://youtu.be/FQwqhblxz3I

Lungs

The paired lungs are housed inside the thoracic cage with one lung on each side of the mediastinum. Costal lung surfaces are in close proximity with the ribs and are the anterior, posterior, and lateral surfaces of each lung. The pleural membranes line the outer surface of the lungs (visceral pleura) and the walls of the thoracic cavity (parietal pleura). The space between these membranes is the pleural cavity. This cavity is filled with a thin layer of **serous fluid** produced by the epithelial cells of the serous membranes. A negative pressure is created in the pleural cavity that causes the lungs to firmly attach to the thoracic cavity wall. This enables the lungs to inflate or deflate with changes in thoracic cavity volume. Think of two wet microscope slides abutted up against one another. The water in between them creates a negative pressure, making it very difficult to pull them apart. Nevertheless, they are easily able to slide past one another. It is the same with the parietal pleura of the thoracic cavity and the visceral pleura of the lungs - they strongly adhere to one another and are almost impossible to pull apart. Nevertheless, they will easily slide past one another because of the friction-reducing serous fluid that is in between them.

An inflamed pleura is known as a **pleurisy** and can develop with an infection like pneumonia or trauma to the chest that may break blood vessels in the lungs. With a pleurisy, the surfaces of the visceral and parietal pleura become rough and it hurts to breathe as the pleura now experience more friction when they slide past one another. With left-sided congestive heart failure, the heart doesn't pump enough blood out of the aorta so it tends to back up in the lungs (pulmonary edema) and in the pleural cavity. **Pleural effusion** refers to fluid buildup in the pleural cavity.

The Tracheobronchial Tree

Zone	Name	Number	Cilia	Smooth Muscle	Cartilage
Conducting Zone	Trachea	1	Yes	Yes	Yes
	Bronchi	2 4 8	Yes	Yes	Yes
	Bronchioles	-	Yes	Yes	Patchy
Respiratory Zone	Respiratory Bronchioles	-	Some	Some	No
	Alveolar Ducts	-	No	Some	No
	Alveolar Sacs	$6x10^8$	No	No	No

Table created by BYU-Idaho student Nathan S: Fall 2015

The **tracheobronchial tree** consists of the trachea, the **main (primary) bronchi, lobar (secondary) bronchi,** the **segmental (tertiary) bronchi, bronchioles, terminal bronchioles, respiratory bronchioles, alveolar ducts,** and tiny air-filled sacs called **alveoli.** It's called a tree because it resembles an upside-down tree. The trachea is the tree trunk, the main bronchi are two large branches coming off the trunk, and the bronchi and bronchioles are progressively smaller branches. Think of the alveoli as being little pieces of fruit on the end of the very small branches. From the first branch at the carina to the terminal bronchioles near the alveoli, the air passageways branch approximately 23 times. When foreign objects accidently enter the trachea, they usually enter the right lung because the right main bronchus is shorter, wider, and more vertical than the left.

With each subsequent branching of the airways, the tubes become smaller and the cartilage surrounding them becomes thinner. Terminal bronchioles do not have any cartilage at all. While the cartilage thins out, the relative amount of smooth muscle in the tube walls does the opposite and increases with each additional branching. Relaxation and contraction of this smooth muscle changes the diameter of the bronchi and especially the bronchioles, affecting the volume of air that moves down the passages. During intense physical activity, smooth muscle lining respiratory tubes relax, resulting in decreased airflow resistance and increased airflow volume. An acute asthma attack is characterized by increased contraction of smooth muscle in the bronchi and bronchioles, decreasing air flow to the lungs. In extreme cases, airflow may become so restricted that an attack may be life threatening. A more detailed explanation of asthma is included in the "Pathological Conditions of the Respiratory System" at the end of this module.