HISTOLOGY AND HISTOLOGICAL TECHNIQUES

MLAB - 241

LEVEL: 4
Unit 8 - Respiratory tract

Upper respiratory tract
- Nasal cavity
- Pharynx
- Larynx

Lower respiratory tract
- Trachea
- Primary bronchi
- Lungs
In humans, the respiratory tract is the part of the anatomy involved with the process of respiration.

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Structure

The respiratory tract is divided into 3 segments:

**Upper respiratory tract:** nose and nasal passages, Para nasal sinuses, and throat or pharynx

Respiratory airways: voice box or larynx, trachea, bronchi, and bronchioles

Lungs: respiratory bronchioles, alveolar ducts, alveolar sacs, and alveoli

Moving down the respiratory tract starting at the trachea, the tubes get smaller and divide into more and more tubes. There are estimated to be about 20 to 23 divisions, ending up at an alveolus.
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Upper respiratory tract

The **upper respiratory tract** or **upper airway** primarily refers to the parts of the respiratory system lying outside of the thorax[1] or above the sternal angle. Another definition commonly used in medicine is the airway above the glottis or vocal cords. Some specify that the glottis (vocal cords) is the defining line between the upper and lower respiratory tracts;[2] yet even others make the line at the cricoid cartilage.[3] The tract consists of:

- nasal cavity and paranasal sinuses
- Pharynx
  - Nasopharynx
  - Oropharynx
  - Laryngopharynx[citation needed]

Larynx (The larynx can be considered part of the upper respiratory tract,[4] the lower respiratory tract, or both, depending on the source.). The larynx is also called the voice box and has the associated cartilage that produce sound.
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Lower respiratory tract
The lower respiratory tract consists of:
the **trachea** (windpipe)
the two **mainstem bronchi** (singular: bronchus, one to each lung)
lobar bronchi to the lobes of the lung
segmental bronchi to the segments of the lung
additional smaller divisions of bronchi
the **bronchioles**, which are similar to small bronchi except that they lack cartilage and the lungs.[5]
Some sources include the larynx as part of the lower respiratory tract, whereas others include it in the upper respiratory tract (which also comprises the nasal cavity (nose) and the pharynx).

The larynx is not just our voice box; it also serves as protection for our trachea. The larynx has a flap called the epiglottis which prevents food and water from entering our lungs when we breathe. If the epiglottis does not close when swallowing food or water, there is an involuntary reaction to cough. The larynx also has cilia.
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Trachea
The trachea consists of cartilage, and is the largest tube in the respiratory system. At the bottom of the tube, it branches off into two individual tubes, called the bronchial tubes, or bronchi. The bronchial tubes then branch off into smaller sections inside the lungs, called bronchioles. These bronchioles hold the air sacs in the lungs called the alveoli.[6] The lungs are the biggest organ in the lower respiratory tract.
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Lungs
The lungs are suspended within the pleural cavity. This cavity is contained within the thorax, or chest. The pleura is a thin membrane, one cell layer thick, that envelopes the lungs (visceral pleura) and lines the inner surface of the chest wall (parietal pleura). This membrane secretes a small amount of fluid, allowing the lungs to move freely within the pleural cavity while expanding and contracting during breathing. The pleura can become inflamed by a viral or bacterial infection to the lungs - a condition called pleuritis.
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The lungs are divided into different lobes. The right lung is larger in size than the left, because of the heart's being situated to the left of the midline. The right lung has three lobes - upper, middle, and lower (or superior, middle and inferior), and the left lung has two - upper and lower (or superior and inferior), plus a small tongue-shaped portion of the upper lobe known as the lingula. Each lobe is further divided up into segments. Each lung has a costal surface, which is adjacent to the ribcage; a diaphragmatic surface, which faces downward toward the diaphragm; and a mediastinal surface, which faces toward the center of the chest, and lies against the heart, great vessels, and the carina where the two mainstem bronchi branch off from the base of the trachea.
Respiratory tree

The proximal respiratory tree from human lung, showing the trachea down to the conducting bronchioles. The respiratory tree describes the branching structure of the vertebrate lung. Beginning with the top of the respiratory system, the trachea, the order of branchings is as follows:
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• **trachea**
  • **main bronchus:**
    • **lobar bronchus**
      • **segmental bronchus**
      • **conducting bronchiole**
        • **terminal bronchiole**
          • **respiratory bronchiole**
            • **alveolar duct**
              • **alveolar sac**
              • **alveolus**
At each division point or generation, one airway branches into two or more smaller airways. The human respiratory tree may consist on average of 23 generations, while the respiratory tree of the mouse has up to 13 generations. Proximal divisions (those closest to the top of the tree, such as the bronchi) mainly function to transmit air to the lower airways. Latter divisions including the respiratory bronchiole, alveolar ducts and alveoli, are specialized for gas exchange.
Alveoli
The alveoli are tiny little air sacs in the lungs where gas exchange takes place. There are “about 150 million per lung”. (1) When the diaphragm contracts, a negative pressure is generated in the thorax and air rushes in to fill the cavity. When that happens these sacs fill with air making the lung expand. The alveoli are rich with capillaries, called alveolor capillaries. Here the red blood cells absorb oxygen from the air and then carry it back in the form of oxyhaemoglobin, to nourish the cells. The red blood cells also carry carbon dioxide (CO2) away from the cells in the form of carboxyhaemoglobin and releases it into the alveoli through the alveolor capillaries. When the diaphragm relaxes, a positive pressure is generated in the thorax and air rushes out of the alveoli expelling the carbon dioxide (CO2).
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Histology
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This image compares the histological differences along the respiratory tract.

Our lungs are made up of thirteen different kinds of cells, eleven are called epithelial and the other two are mesenchymal cells. (6)[7] The epithelial cells make the lining of our tracheal, and bronchial tubes, while the mesenchymal cells line the lungs.

The respiratory tract is covered in an epithelium, the type of which varies down the tract. There are glands and mucus produced by goblet cells in parts, as well as smooth muscle, elastin or cartilage.

Most of the epithelium (from the nose to the bronchi) is covered in pseudostratified columnar ciliated epithelial cells, commonly called respiratory epithelium. The cilia beat in one direction, moving mucus towards the throat where it is swallowed. Moving down the bronchioles, the cells get more cuboidal in shape but are still ciliated.
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Cartilage is present until the small bronchi. In the trachea they are C-shaped rings, whereas in the bronchi they are interspersed plates.

Glands are abundant in the upper respiratory tract, but there are fewer lower down and they are absent starting at the bronchioles. The same goes for goblet cells, although there are scattered ones in the first bronchioles.

Smooth muscle starts in the trachea, where it joins the C-shaped rings of cartilage. It continues down the bronchi and bronchioles, which it completely encircles.

Instead of hard cartilage, the bronchi and bronchioles are composed of elastic tissue.
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Illustration depicting Pseudostratified Ciliated Columnar Epithelium.
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Transverse section of tracheal tissue. Note that image is incorrectly labeled "ciliated stratified epithelium" at upper right.
Function
Most of the respiratory tract exists merely as a piping system for air to travel in the lungs, and **alveoli** are the only part of the lung that exchanges **oxygen** and **carbon dioxide** with the **blood**.

Even though the cross-sectional area of each bronchus or bronchiole is smaller, because there are so many, the total surface area is larger. This means there is less resistance at the terminal bronchioles. (Most resistance is around the 3-4 division from the trachea due to turbulence.)

When a human being inhales, air travels down the trachea, through the bronchial tubes, and into the lungs. The entire tract is protected by the rib cage, spinal cord, and sternum bone. In the lungs, oxygen from the inhaled air is transferred into the blood and circulated throughout the body. Carbon dioxide (CO$_2$) is transferred from returning blood back into gaseous form in the lungs and exhaled through the lower respiratory tract and then the upper, to complete the process of **breathing**.
Respiration

Unlike the trachea and bronchi, the upper airway is a collapsible, compliant tube. As such, it has to be able to withstand suction pressures generated by the rhythmic contraction of the diaphragm that sucks air into the lungs. This is accomplished by the rhythmic contraction of upper airway muscles, such as the genioglossus (tongue) and the hyoid muscles. In addition to rhythmic innervation from the respiratory center in the medulla oblongata, the motoneurons controlling the muscles also receive tonic innervation that sets a baseline level of stiffness and size.

The diaphragm is the main muscle involved for the lungs to breathe and is the largest muscle. There are smaller muscles in between our rib cage that help the lungs expand and contract.
Defences against infection
The human trachea has a membrane lining that produces a layer of mucus that helps filter waste that an organism breathes in through the air. There is also a small lining of tiny hairs in our lungs called cilia. These tiny hairs act as a filter in our lungs and control the amount of mucus that enters our lungs. The reason why we cough is because the cilia push up the mucus, so not too much enters our lungs. If these hairs are not functioning properly, an organism is at risk of a lower respiratory tract infection.
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The cilia of the respiratory epithelium beat in concert cranially, effectively moving secreted mucus containing trapped foreign particles toward the laryngopharynx, for either expectoration or swallowing to the stomach where the acidic pH helps to neutralize foreign material and micro-organisms. This system is collectively known as the mucociliary escalator and serves two functions: to keep the lower respiratory tract sterile, and to prevent mucus accumulation in the lungs.

The mucociliary escalator is vital for the movement of mucus up the respiratory tract to the pharynx. The mucus layer is biphasic with a serous, sol layer in which the cilia beat and, above this, a viscoelastic or gel layer. Due to the viscous properties of this upper mucous layer, the tips of the cilia catch in the layer, which may contain particulate matter, and drag it cranially toward the laryngopharynx.
Clinical significance
The respiratory tract is a common site for infections. 

**Upper respiratory tract infection**

Upper respiratory tract infections are probably the most common infections in the world.

**Lower respiratory tract infections**

Our respiratory system is very prone to developing infections in the lungs. Infants and older adults are more likely to develop infections in their lungs, because their lungs are not as strong in fighting off these infections. Most of these infections used to be fatal, but with new research and medicine, they are now treatable. With bacterial infections, antibiotics are prescribed, while viral infections are harder to treat, but still curable.
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**Lung cancer**
Some of these infections have environmental factors such as smoking. When you inhale a tobacco product, the smoke paralyzes the cilia, causing mucus to enter the lungs. If you smoke frequently, over time these cilia hairs die, and can no longer filter mucus. Tar from the smoke inhaled enters your lungs, turning the pink-coloured lungs black. The accumulation of this tar could eventually lead to lung cancer, emphysema or chronic obstructive pulmonary disease (C.O.P.D.).(5)
Emphysema
This is a common lower respiratory disease that can be caused by exposure to harmful chemicals, or prolonged use of tobacco. This disease is chronic and progressive, the damage to your lungs is irreversible and eventually fatal. This disease destroys the alveoli, and lung tissue. Damage to these air sacs, and tissue makes breathing very difficult, causing shortness in breath, hyperventilation, and raised chest. The decreased amount of alveoli causes loss of oxygen (O2) to the lungs, and more accumulation of carbon monoxide (CO). There are two types of emphysema: primary and secondary. Primary emphysema can be found in younger adults. This type of emphysema deteriorates the air sacs, and lung mass. Secondary emphysema can be found in older adults who smoke/have smoked and have a history of chronic bronchitis.
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Pneumonia

The common cold/flu is the most common cause for the upper respiratory tract infection, which can cause more serious illness that can develop in the lower respiratory tract. Pneumonia is the most common, and frequent lower respiratory tract infection. This can be either viral, bacterial, or fungal. This infection is very common, because pneumonia can be airborne, and when you inhale this infection in the air, the particles enter the lungs and move into the air sacs. This infection quickly develops in the lower part of the lung, and fills the lung with fluid, and excess mucus. This causes difficulty in breathing, and coughing as the lower respiratory tract tries to get rid of the fluid in the lungs. You can be more prone to developing this infection if you have asthma, flu, heart disease, or cancer(7)
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**Bronchitis**

*Bronchitis* is another common infection that takes place in the lower respiratory tract. It is an inflammation of the bronchial tubes. There are two forms of this infection: acute bronchitis, which is treatable and can go away without treatment, or chronic bronchitis, which comes and goes, but will always affect ones lungs. Bronchitis increases the amount of mucus that is natural in your respiratory tract. Chronic bronchitis is common in smokers, because the tar from smoking accumulates over time, causing the lungs to work harder to repair themselves. (7)
Tuberculosis

*Tuberculosis* is one of many other infections that occurs in the lower respiratory tract. You can contract this infection from airborne droplets, and if inhaled you are at risk of this disease. This is a bacterial infection which deteriorates the lung tissue resulting in coughing up blood. (7) This infection is deadly if not treated.
Asthma

Our bronchial tubes are the main passages to our right and left lungs. These tubes carry the oxygen (O2) to the bronchioles inside the lungs. If these tubes swell up, this is the result of asthma which could lead to an asthma attack. This results in wheezing, tightness of the chest and severe difficulty in breathing. There are different types of asthma that affects the functions of the bronchial tubes. Allergies can also set off an allergic reaction causing swelling to the bronchial tubes, and as a result the air passage will swell up, or close up completely. (7)
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Additional images
DR. Ebtsam Mohammad