Histology of respiratory system:

During a 24-hour period, more than 9000 liters of air enter the interior of the body to participate in gas exchange. This air must be warmed, cleansed, humidified and conducted to the respiratory surface. In the lung, gas traverses a very thin epithelium and connective tissue space to reach capillaries carrying oxygen-poor, carbon dioxide-laden blood from the right ventricle.

The ventilatory mechanism consists of diaphragmatic, intercostal, and abdominal musculature as well as elastic tissue within the lung. This mechanism alternately pulls air into (inspiration) or drives air from (expiration) the lung. The lungs are capable of undergoing wide variations in size. In maximum inspiration, the lungs may hold up to 7 liters of air, and with forced expiration may hold as little as 1 liter.

The respiratory system contains a proximal conducting portion that connects the exterior of the body with the distal respiratory portion where exchange of gases between air and blood occurs. The conducting portion, which consists of the nasal cavities, pharynx, larynx, and paired main bronchi, delivers air to structures within the lung where gas exchange takes place. Cellular specializations are readily apparent as one follows the flow of air from the nose to the respiratory surface. Although the lung's primary function is gas exchange, studies over the past several decades have detailed a variety of important metabolic functions of the lung. The respiratory system represents a classic example of the relationship of structure to function. In the case of the lung's alveoli, if the only pertinent information one had prior to viewing a histological slide was that blood carried oxygen and that the alveolus was the site of gas exchange, one could easily deduce that diffusion is the

mechanism of gas exchange. In this lecture we will very briefly describe the microscopic anatomy of the nasal cavities, pharynx and larynx, and focus on the organization and histological detail of the trachea and structures within the lung, including bronchi, bronchioles, alveolar ducts, and alveoli.

MECHANICS OF BREATHING:

INSPIRATION:

Inspiration is the active part of the breathing process, which is initiated by the respiratory control centre in medulla oblongata (Brain stem). Activation of medulla causes a contraction of the diaphragm and intercostal muscles leading to an expansion of thoracic cavity and a decrease in the pleural space pressure. The diaphragm is a dome-shaped structure that separates the thoracic and abdominal cavities and is the most important muscle of inspiration. When it contracts, it moves downward and because it is attached to the lower ribs it also rotates the ribs toward the horizontal plane, and thereby further expands the chest cavity. In normal quite breathing the diaphragm moves downward about 1 cm but on forced inspiration/expiration total movement could be up to 10 cm. When it is paralysed it moves to the opposite direction (upwards) with inspiration, paradoxical movement. The external intercostal muscles connect adjacent ribs. When they contract the ribs are pulled upward and forward causing further increase in the volume of the thoracic cavity. As a result fresh air flows along the branching airways into the alveoli until the alveolar pressure equals to the pressure at the airway opening.

EXPIRATION:

Expiration is a passive event due to elastic recoil of the lungs. However, when a great deal of air has to be removed quickly, as in exercise, or when the airways narrow excessively during expiration, as in asthma, the internal intercostal muscles

and the anterior abdominal muscles contract and accelerate expiration by raising pleural pressure.

Respiratory System General:

The respiratory system composed of the following structures:

1-Nasal cavity, 2- Pharynx, 3-Larynax, 4- Trachea, 5- Lung

The shape of each lung is congruent with the pleural cavity it occupies. The visceral pleura (a simple squamous mesothelium covering layers of fibrous and elastic connective tissue) tightly coats each lung and is closely apposed to the parietal pleura that lines each pleural cavity. The visceral and parietal pleurae are continuous at the lung hilum (the entry site of the airways, vasculature, nerves, and lymphatics from the mediastinum into the lung).

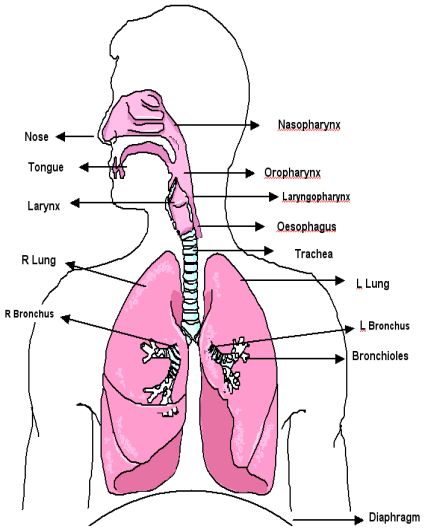
An extensive elastic network connects the visceral pleura to the hilum via elastin elements in the gas exchange tissue of the lung. Thus, when the diaphragm and intercostal muscles contract, the volume of the pleural cavities is quickly increased, pressure in the lungs drops relative to that at the nose or mouth, and air rushes into the lungs. At the completion of a large inspiration, the elastic network within the lung is maximally stretched. Expiration is largely passive but is occasionally aided by abdominal muscle contraction.

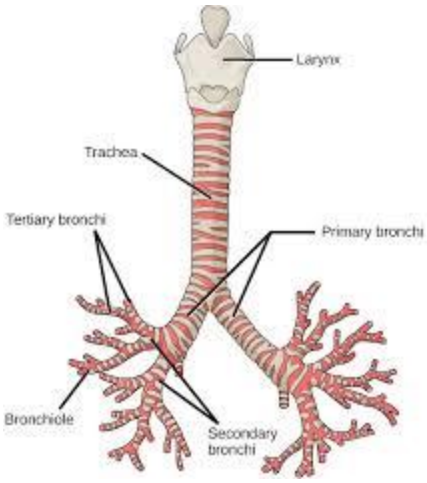
Conductive Portion of the Respiratory Tract (The Airways):

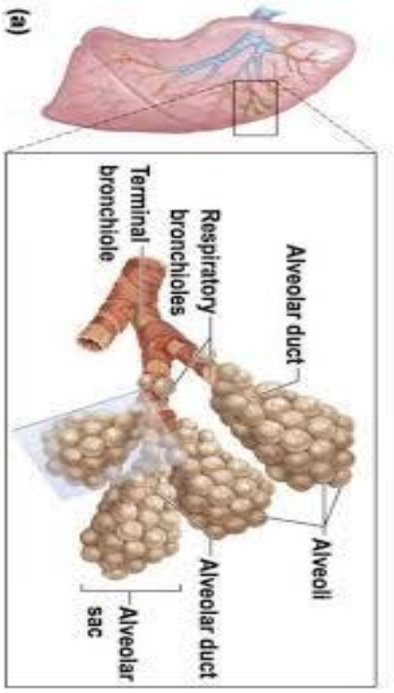
Design The upper respiratory tract is arbitrarily designated as beginning at the nasal and oral openings and extending to the trachea, the point of bifurcation of the trachea into the two main bronchi. The nasal cavities have three conchae which included (cranial, medium, and olfactory conchae).

The mucosa of the nasal cavities has olfactory nerves as well as tubuloalveolar olfactory glands that secrete on the epithelial surface of conchae that keeps the surface moist. The pharynx contains mucous glands and is lined distally by stratified squamous epithelium that is continuous with this type of epithelium at the proximal end of the larynx. The larynx is an elongated, irregularly shaped structure lined by stratified squamous epithelium at its proximal end and ciliated pseudostratified column at its distal end. Its walls contain hyaline and elastic cartilage, connective tissue, elastic tissue, striated muscle, and mucosal glands. The tension in large mucosal folds (vocal cords) and the size of the luminal opening between the folds are regulated by contraction of the skeletal muscle, determining the pitch of sounds caused by vocal cord vibration during movement of air through the larynx.

Air passes from the larynx through the trachea and into the right and left primary bronchi. The lower respiratory tract begins at the bronchi and terminates at the ends of the terminal bronchioles--the last purely conductive tubes (no gas exchange takes place in this portion of the respiratory tract). Each branch subsequently divides into two daughter branches, which usually differ in diameter and/or length—a pattern termed irregular dichotomous branching. This continues for about 16 generations of bronchioles to reach the terminal bronchiolar level and may continue an additional three to seven generations to reach the most distal air sac or alveolus.







Epithelial transitions:

The respiratory system provides beautiful examples of epithelial transitions. The pseudostratified ciliated columnar epithelium of the trachea and bronchi gives way to a simple columnar epithelium then to simple cuboidal epithelia in the bronchioles and then to the simple squamous epithelium of the alveolar ducts and alveoli. The ciliated cells undergo a gradual reduction in height from trachea to terminal and respiratory bronchiole. Thus, in any given slide of lung, you are likely to see examples of epithelia varying from pseudostratified ciliated columnar of the bronchi to the simple squamous epithelium of the alveoli. Submucosal glands containing mucous and serous cells decrease in numbers in distal bronchi, and are usually not found in bronchioles. However, surface mucous epithelial cells (goblet cells) actually increase in number as the submucosal glands decrease, and are present throughout the bronchi.

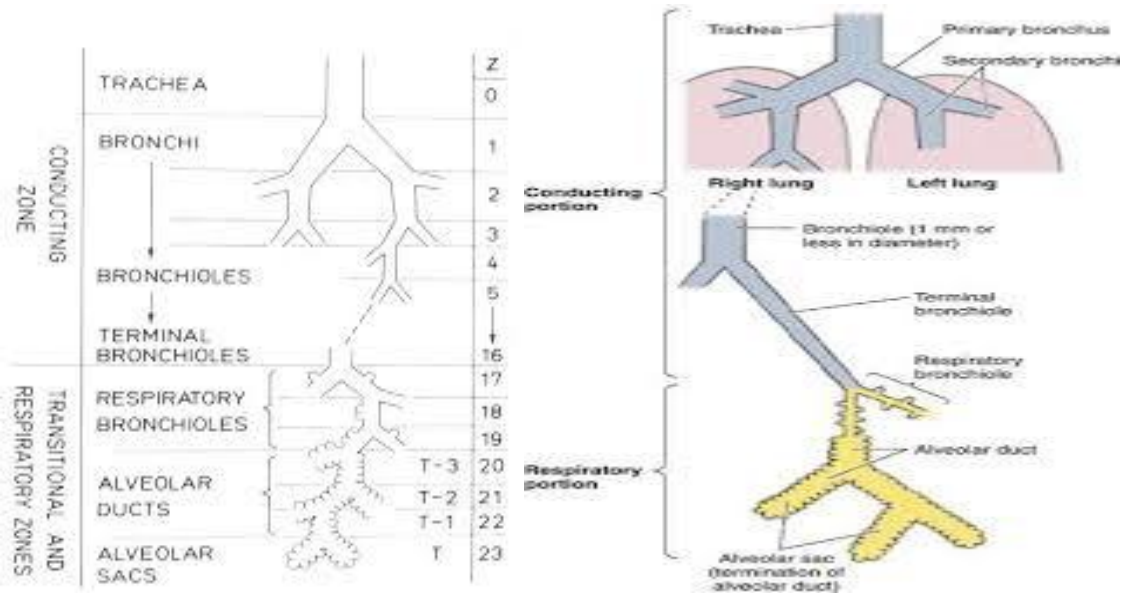
The tracheal wall consists of mucosa, submucosa, muscularis, and adventitia. In the mucosa, the epithelial cells rest on an unusually thick basal lamina, which in turns rests on a cellular connective tissue region called the lamina propria. The lamina propria has high elastin content and contains lymphocytes and lymphatic nodules. The underlying submucosa contains glands composed of mucous and serous cells. The ducts of these glands pierce the elastic lamina propria and terminate on the epithelial surface. Horseshoe-shaped hyaline cartilage tracheal rings, approximately 20 in number, are deep to the glands and encircle the trachea (except posteriorly). This gap is bridged by smooth muscle (trachealis m.) and connective tissue. The right and left main bronchi (extrapulmonary) are similar in structure to the trachea.

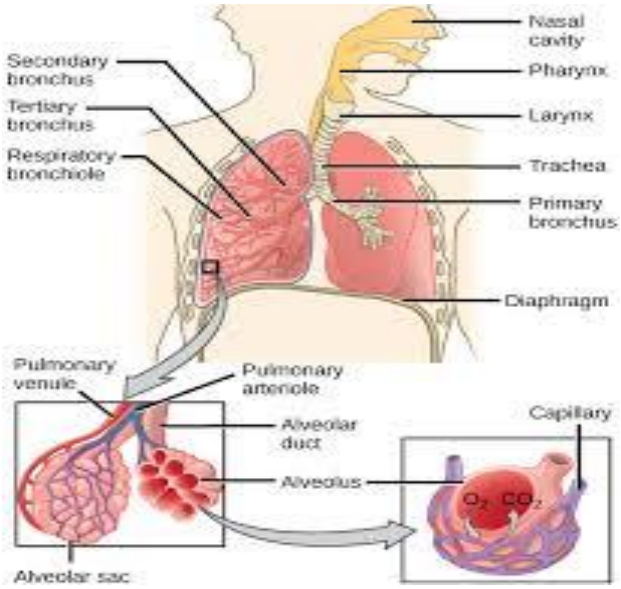
Epithelial cell secretions and ciliated cell action are the major components of the mucociliary apparatus or elevator. A watery hypophase covers the epithelial cell apices and is overlaid by an incomplete viscous mucus blanket that serves to trap foreign material and to prevent cellular drying. The cilia rhythmically beat in the hypophase. The resulting movement of the hypophase propels the inner mucus layer upwards towards the trachea removing the foreign material.

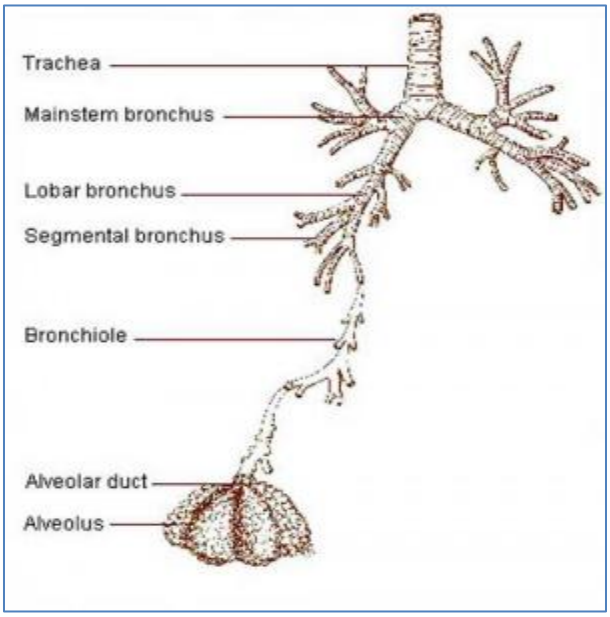
Respiratory Portion of the Respiratory Tract Design:

The major structural feature of the respiratory portion of the lung is the marked reduction in tissue mass per unit volume and the resultant increase in surface area available for gas exchange between air and blood (remember that this is the only site of gas exchange). The alveoli of the lung is designed to achieve this goal through an efficient connective tissue supporting system and highly functional cell specialization.

There are from 200-500 million alveoli (mean diameter = 200 micrometers) in adult human lungs. The epithelial cells of the alveolar septum are markedly thinned and the capillary network immediately beneath the epithelium is the richest in the body. The delicate alveolar septa are supported by a lattice of elastic connective tissue fibers that are anchored to both the axial (airway) and visceral pleural connective tissue.







Alveolar macrophages:

These large cells wander freely in the alveoli. Located in the aqueous hypophase of the surfactant layer, they move over the alveolar surface ingesting microorganisms and inhaled particulate matter. Contractive filaments within numerous pseudopodia permit these cells to advance over the surface. The types and concentrations of cytoplasmic organelles seen in macrophages vary widely, depending upon the functional state of the cell. An active cell may be stimulated to produce lysosomal enzymes for intracellular digestion and to secrete such products as lysozyme and interferon. Such cells display prominent vesicles, phagosomes, multivesicular bodies, lysosomes, and mitochondria. Macrophages apparently rarely divide and may be replenished from hematopoietic cells (probably monocytes) from the vasculature.