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THE HISTOLOGICAL BASIS OF THE CONDUCTING PORTIIN OF THE RESPIRATORY SYSTEM

The conducting portion of the respiratory system functions to; provide a route for incoming and outgoing air, remove debris and pathogens from the incoming air, and warm and humidify the incoming air. Several structures within the conducting zone perform other functions as well. The epithelium of the nasal passages, for example, is essential to sensing odors.

 The conducting portion includes the nose, nasopharynx, larynx, trachea, and ends at the terminal bronchiole.

THE NOSE

The major entrance and exit for the respiratory system is through the nose. The nares and anterior portion of the nasal cavities are lined with mucous membranes, containing sebaceous glands and hair follicles that serve to prevent the passage of large debris, such as dirt, through the nasal cavity. An olfactory epithelium used to detect odors is found deeper in the nasal cavity.

The nose has the following parts conchae, meatuses, and paranasal sinuses which are lined by respiratory epithelium composed of pseudostratified ciliated columnar epithelium. The epithelium contains goblet cells, one of the specialized, columnar epithelial cells that produce mucus to trap debris. The cilia of the respiratory epithelium help remove the mucus and debris from the nasal cavity with a constant beating motion, sweeping materials towards the throat to be swallowed. Interestingly, cold air slows the movement of the cilia, resulting in accumulation of mucus that may in turn lead to a runny nose during cold weather.

This moist epithelium functions to warm and humidify incoming air. Capillaries located just beneath the nasal epithelium warm the air by convection. Serous and mucus-producing cells also secrete the lysozyme enzyme and proteins called defensins, which have antibacterial properties. Immune cells that patrol the connective tissue deep to the respiratory epithelium provide additional protection.

THE PHARNYX

The pharynx is a tube formed by skeletal muscle and lined by mucous membrane that is continuous with that of the nasal cavities. The pharynx is divided into three major regions: the nasopharynx, the oropharynx, and the laryngopharynx. At the top of the nasopharynx are the pharyngeal tonsils. A pharyngeal tonsil, also called an adenoid, is an aggregate of lymphoid reticular tissue similar to a lymph node that lies at the superior portion of the nasopharynx. The pharyngeal tonsil contains a rich supply of lymphocytes and is covered with ciliated epithelium that traps and destroys invading pathogens that enter during inhalation. The pharyngeal tonsils are large in children, but interestingly, tend to regress with age and may even disappear. The uvula is a small bulbous, teardrop-shaped structure located at the apex of the soft palate. Both the uvula and soft palate move like a pendulum during swallowing, swinging upward to close off the nasopharynx to prevent ingested materials from entering the nasal cavity.

The oropharynx is a passageway for both air and food. As the nasopharynx becomes the oropharynx, the epithelium changes from pseudostratified ciliated columnar epithelium to stratified squamous epithelium. The oropharynx contains two distinct sets of tonsils, the palatine and lingual tonsils. A palatine tonsil is one of a pair of structures located laterally in the oropharynx in the area of the fauces. The lingual tonsil is located at the base of the tongue. Similar to the pharyngeal tonsil, the palatine and lingual tonsils are composed of lymphoid tissue, and trap and destroy pathogens entering the body through the oral or nasal cavities.

The laryngopharynx is inferior to the oropharynx and posterior to the larynx. It continues the route for ingested material and air until its inferior end, where the digestive and respiratory systems diverge. The stratified squamous epithelium of the oropharynx is continuous with the laryngopharynx.

THE LARYNX

The larynx is a cartilaginous structure inferior to the laryngopharynx that connects the pharynx to the trachea and helps regulate the volume of air that enters and leaves the lungs. The structure of the larynx is formed by several pieces of cartilage. Three large cartilage pieces—the thyroid cartilage (anterior), epiglottis (superior), and cricoid cartilage (inferior)—form the major structure of the larynx.

The thyroid cartilage is the largest piece of cartilage that makes up the larynx. The thyroid cartilage consists of the laryngeal prominence, or “Adam’s apple,” which tends to be more prominent in males. The thick cricoid cartilage forms a ring, with a wide posterior region and a thinner anterior region. Three smaller, paired cartilages—the arytenoids, corniculates, and cuneiforms—attach to the epiglottis. The epiglottis, attached to the thyroid cartilage, is a very flexible piece of elastic cartilage that covers the opening of the trachea.

Continuous with the laryngopharynx, the superior portion of the larynx is lined with stratified squamous epithelium, transitioning into pseudostratified ciliated columnar epithelium that contains goblet cells. Similar to the nasal cavity and nasopharynx, this specialized epithelium produces mucus to trap debris and pathogens as they enter the trachea. The cilia beat the mucus upward towards the laryngopharynx, where it can be swallowed down the esophagus.

THE TRACHEA

The trachea (windpipe) extends from the larynx toward the lungs. The trachea is formed by 16 to 20 stacked, C-shaped pieces of hyaline cartilage that are connected by dense connective tissue. The trachealis muscle and elastic connective tissue together form the fibroelastic membrane, a flexible membrane that closes the posterior surface of the trachea, connecting the C-shaped cartilages. The fibroelastic membrane allows the trachea to stretch and expand slightly during inhalation and exhalation, whereas the rings of cartilage provide structural support and prevent the trachea from collapsing. In addition, the trachealis muscle can be contracted to force air through the trachea during exhalation. The trachea is lined with pseudostratified ciliated columnar epithelium, which is continuous with the larynx. The esophagus borders the trachea posteriorly.

### BRONCHIAL TREE

The trachea branches into the right and left primary bronchi at the carina. These bronchi are also lined by pseudostratified ciliated columnar epithelium containing mucus-producing goblet cells. The carina is a raised structure that contains specialized nervous tissue that induces violent coughing if a foreign body, such as food, is present. Rings of cartilage, similar to those of the trachea, support the structure of the bronchi and prevent their collapse. The primary bronchi enter the lungs at the hilum, a concave region where blood vessels, lymphatic vessels, and nerves also enter the lungs. The bronchi continue to branch into bronchial a tree. A bronchial tree (or respiratory tree) is the collective term used for these multiple-branched bronchi. The main function of the bronchi, like other conducting zone structures, is to provide a passageway for air to move into and out of each lung. In addition, the mucous membrane traps debris and pathogens.

A bronchiole branches from the tertiary bronchi. Bronchioles, which are about 1 mm in diameter, further branch until they become the tiny terminal bronchioles, which lead to the structures of gas exchange. There are more than 1000 terminal bronchioles in each lung. The muscular walls of the bronchioles do not contain cartilage like those of the bronchi. This muscular wall can change the size of the tubing to increase or decrease airflow through the tube.

CELLS FOUND IN THE RESPIRATORY EPITHELIUM

The conducting portion provides the pathway for the movement and conditioning of the air entering the lung. Specialized cells collaborate to warm, moisturize, and remove particles that enter. These cells are the respiratory epithelium and comprise the entire respiratory tree. Most of the respiratory epithelium is ciliated pseudostratified columnar epithelium. The following five types of cells are in this region:

1. Ciliated cells
2. Goblet cells
3. Basal cells
4. Brush cells
5. Neuroendocrine cells

The ciliated cells are the most abundant. They control the actions of the mucociliary escalator, a primary defense mechanism of the lungs that removes debris. While the mucus provided by the goblet cells traps inhaled particles, the cilia beat to move the material towards the pharynx to swallow or cough out.

Goblet cells, so named for their goblet-shaped appearance, are filled with mucin granules at their apical surface with the nucleus remaining towards the basilar layer. Goblet cells decrease in number as the respiratory tree gets progressively smaller and are eventually replaced by club cells (previously Clara cells) when they reach the respiratory bronchioles.

The basal cells connect to the basement membrane and provide the attachment layer of the ciliated cells and goblet cells. They may be thought of as the stem cells of the respiratory epithelium as they maintain the ability to potentiate ciliated cells and goblet cells.

Brush cells, occasionally referred to as type III pneumocyte cells are sparsely distributed in all areas of respiratory mucosa. Brush cells may be columnar, or flask-like and are identified by their short microvilli covered apical layer–resembling a push broom or appropriately, a brush. No function has been officially assigned to the brush cells though there are many proposed mechanisms. One popular proposal suggests they have a chemoreceptor function, monitoring air quality, due to their association with unmyelinated nerve endings.

The bronchial mucosa also contains a small cluster of neuroendocrine cells, also known as Kulchitsky cells. They have neurosecretory type granules and can secrete several factors. This includes catecholamine and polypeptide hormones, such as serotonin, calcitonin, and gastrin-releasing factors (bombesin). Like brush cells, these neuroendocrine cells make up only a small portion of mucosal epithelium, around 3%.

Within the bronchial submucosa are submucosal glands. These glands are composed of a mixture of serous and mucinous cells, similar to salivary gland tissue.  The secretions are emptied into ducts and then on the bronchial mucosa. Older individuals may show oncocytic metaplasia of these glands.  Smooth muscle bundles are present at all levels of the airway to allow for regulation of airflow. There are progressively fewer smooth muscle fibers progressing from bronchi to alveoli.