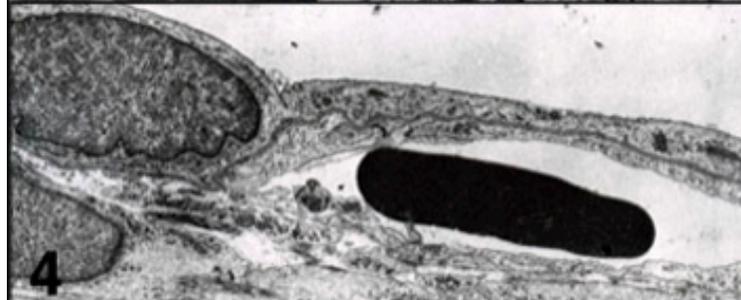
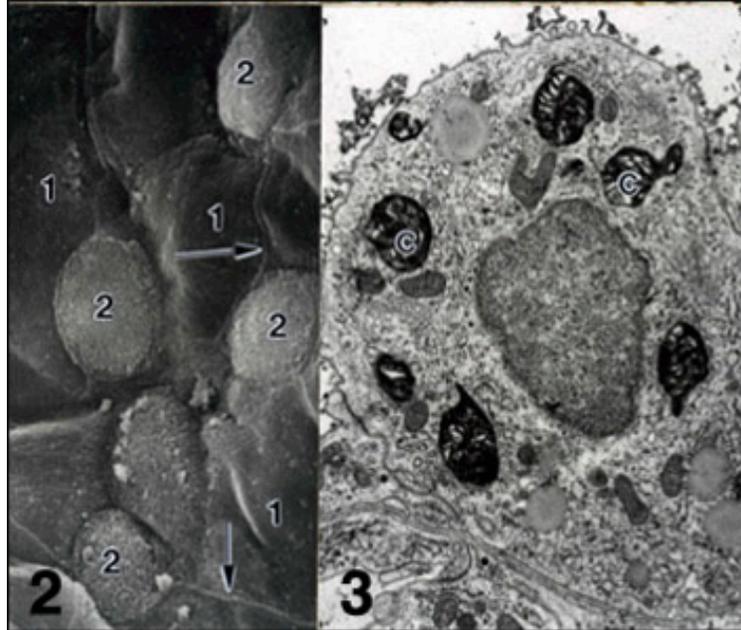
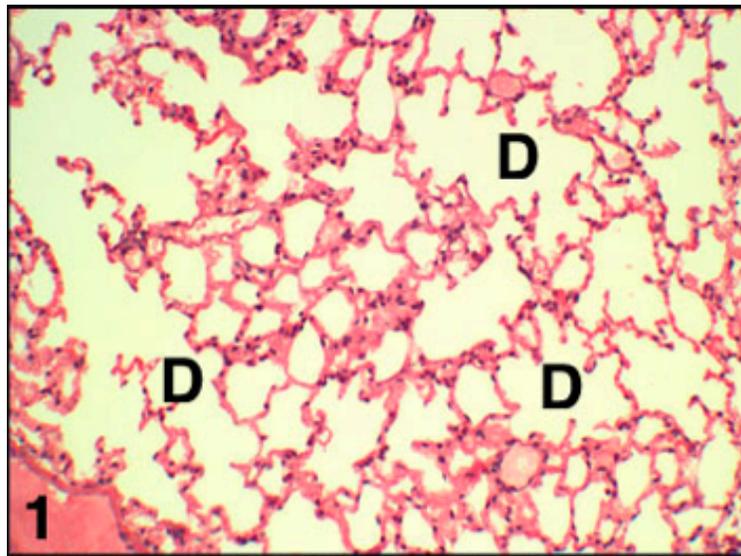


Lung//Respiratory Tissue



1. Alveoli of the lung. Note the alveolar ducts (D).
2. An SEM of an alveolus interior showing type (1) and type (2) pneumocytes. The arrows identify cell junctions.
3. A TEM of a type 2 pneumocytes filled with multilamellar bodies (C).
4. The blood air barrier consisting of a type 1 cell, fused basal laminae and an endothelial cell.

Exchange of gases between air and blood occurs only when air and blood are in close relation. Such a condition occurs first in the respiratory bronchioles, which form a transition between the purely conducting and purely respiratory regions of the lung. The walls of *respiratory bronchioles* consist of collagenous connective tissue with interlacing bundles of smooth muscle and elastic fibers. The larger respiratory bronchioles are lined by simple cuboidal epithelium with only a few ciliated cells; goblet cells are lacking. Many of the cuboidal cells are Clara cells. In the smaller respiratory bronchioles, the epithelium becomes low cuboidal without cilia. Alveoli bud from the walls of the respiratory bronchioles and represent the respiratory portions of these airways. The alveoli become more numerous distally. Respiratory bronchioles end by branching into alveolar ducts. *Alveolar ducts* are thin walled tubes from which numerous alveoli or clusters of alveoli open around its circumference so that the wall becomes little more than a succession of alveolar openings. Appearances of a tube persist only in a few places, where small groups of cuboidal cells intervene between successive alveoli and cover underlying bundles of fibroelastic tissue and smooth muscle. The alveolar ducts end in irregular spaces surrounded by clusters of alveoli called alveolar sacs.

Alveoli are thin-walled, polyhedral structures of varying size that are open at one side to allow air into their cavities. They number between 300 and 800 million (both lungs) and provide a surface area of 70 to 95 square meters for gaseous exchange.

Adjacent alveoli are separated by a common interalveolar septum, whose most conspicuous feature is a rich network of capillaries that bulge from within the septal wall. Reticular and elastic fibers form a tenuous framework for the septa. Small openings in the septal wall 1 to 10 μm in diameter, alveolar pores of Kohn, permit communication and equalization of air pressure between alveoli. The pores can play a significant role in obstructive lung disease by serving as a bypass mechanism to aerate alveoli distal to the blockage. On each side, the alveolar wall is covered by an attenuated epithelium beneath which is a basal lamina. In many areas the epithelial basal lamina is separated from the basal lamina of the capillary by a space of only 15 to 20 nm; in other regions the two laminae are fused. Thus, at its thinnest, the blood-air barrier consists of a thin film of fluid, the attenuated epithelium of the alveolar lining cell, the fused basal laminae, and the endothelium of the capillaries within the septal wall. The blood-air barrier measures between 0.2 to 0.5 μm in thickness.

Several types of cells are present in the septa. The attenuated squamous cells that form a continuous lining for the alveolar wall are called pulmonary epithelial cells or *type I pneumocytes*. In addition to these are septal cells, alveolar macrophages and endothelial cells that line blood capillaries. *Septal cells (type II pneumocytes)* are rounded or cuboidal cells that may lie deep in the surface epithelium or bulge into the alveolar lumen between pulmonary (type I) epithelial cells. Their free surfaces have short microvilli, and laterally, the cells are united to pulmonary epithelial cells by junctional complexes. The most distinctive feature of the septal cells is the presence of multilamellar bodies in their cytoplasm. These bodies consist of thin, concentric lamellae and are the storage sites of surfactant. It is synthesized by septal cells and released by exocytosis. The released surfactant forms a monolayer over the thin film of fluid that coats alveoli and acts as a detergent thereby lowering surface tension at the liquid-air interphase. The lowering of surface tension aids in preventing the collapse of alveoli at the end of expiration. Thus, pulmonary surfactant forms the surface-active film that is crucial for normal lung function.

It consists of a complex mixture of various phospholipids (primarily dipalmitoyl phosphatidyl choline) and four proteinaceous components known as surfactant-associated proteins: SP-A, SP-B, SP-C, and SP-D. SP-A is the most abundant and is a water-soluble oligomeric

glycoprotein that facilitates the formation of the surface-active film. It also has a role in anti-microbial defense.

The type I pneumocytes make up about 40% of the alveolar lining cell population but account for over 90% of the alveolar surface area. In contrast, type II pneumocytes make up about 60% of the alveolar cell population but account for only 8 to 10% of the alveolar surface area. Type I pneumocytes have little capacity to divide, however, type II pneumocytes have retained their mitotic capacity and serve as a pool of replacement cells for type I and type II pneumocytes

Alveolar macrophages are present within the interalveolar septa and alveolar lumina. Many contain particles of inhaled material and have been called "dust" cells. As with all macrophages, the alveolar macrophages originate from blood monocytes. Most of these cells ultimately are eliminated via the air passages and appear in the sputum; a few may migrate into lymphatics and escape the lungs by this route.

It is important to realize that the lungs are provided with a dual vascular supply. A bronchial vascular system provides oxygenated blood to the major components of the bronchial tree. The bronchial artery arises directly from the thoracic aorta and the bronchial veins of the major subcomponents of bronchial region drain into the azygos and hemiazygos veins. The distal branches of the bronchial veins drain into the pulmonary veins. In contrast, it is the capillaries of the pulmonary vascular system that are the site of gaseous exchange. The pulmonary arteries supply the lung with relatively deoxygenated blood rich in carbon dioxide coming from the body tissues via the right side of the heart. Pulmonary vessels are generally short and wide and because less smooth muscle occurs in their walls they are more distensible. Pulmonary vessels are further characterized by low pressure, low resistance and because all cardiac output from the right side of the heart goes through the lungs have a high rate of flow. Pulmonary capillaries are arranged in a sheet-like fashion (in contrast to systemic vessels arranged more like roots of a plant) positioned between and around alveoli. The capillaries that envelop alveoli are referred to as septal or alveolar capillaries; those positioned at the corners between alveoli are often referred to as extra-alveolar or corner capillaries. Capillaries of the lung form one of the largest surface areas for exchange in the body (about 90 M²). Following gaseous exchange in the pulmonary capillaries the reoxygenated blood is collected by pulmonary venules and veins to be distributed back to the body tissues via the left side of the heart. The arterioles of the pulmonary vascular circuit are unusual in comparison to the systemic arterioles in that in ischemic regions of the lung these arterioles tend to shunt blood away from such regions rather than towards an area of low oxygen tension as would be true of systemic vessels. Lymphatic capillaries begin at about the level of the respiratory bronchioles and gradually merge to form larger vessels that follow the bronchial tree to the hilum and exit from the lung. If pressure within the pulmonary capillaries increases the fluid component of the blood readily passes through the extremely thin alveolar wall and into the alveolar lumen. Such an event occurs during pulmonary edema resulting from left heart failure. In this situation the left ventricle of the heart fails to empty completely and pressure builds in the left atrium as well as the pulmonary veins. The increased pulmonary venous pressure extends into the extensive pulmonary capillary network forcing fluid from the capillaries into the alveolar spaces. The fluid flow overburdens the lymphatics, which begin within the distal bronchial tree, and the respiratory portion of the lung fills with fluid preventing gaseous exchange.