Anatomy of the Respiratory System

Anatomically the lung is situated within the chest cage. However all gases passing in and out of the lung pass through the mouth or nose and upper airway. This upper airway - that is the airway above the trachea - has an important role in the transport of gas, and therefore we shal spend some time considering its anatomy and physiology.

The Upper Respiratory Tract

The upper airway comprises the complex airway in the head and neck down to the trachea. The purpose of the upper airway is not simply to act as a passage for air to and from the lung, but also to humidify the air and raise its temperature to body heat. It is also responsible for the removal of most of the particulate material inspired.

The geometry of the nasal passages in incredibly complicated and defies a precise description here. The purpose of the design appears to be to provide a very high surface area of tissue (approx. 160 cm^2) to the gas flowing over it. In parallel with the nasal passages we have the oral passage of perhaps less complicated geometry. These conduits then join in the region of the pharynx, and pass on to the larynx, chords and trachea.

The surfaces of all these airways are lined with a mucous membrane and this in turn is supplied with a very adequate blood supply necessary for the high water and heat transfer rates to the incoming air.

In common with the majority of the airways of the lower respiratory tract, the upper airway is lined with cilia. The purpose of these cilia appears to be to transport the mucous blanket towards the nose and mouth and thus remove surface deposits from the lung.

References: a good source of information on the anatomy and physiology of the upper airway is contained in Section 3 vol I, Chapter 8. Handbook of Physiology, American Physiology Society.

The Lower Respiratory Tract

The tracheo-bronchial tree comprises the airways within the lung itself. We may think of the system rather like an inverted tree. The trachea or main trunk divides into 2 daughter bronchi and these again rapidly divide. This process continues for a number of generations, the daughter tubes at each bifurdation being smaller than the parent. Finally the respiratory zone of the lung is reached, here the conducting airways give into outpouchings or alveolar sacs. It is the gas within these sacs which exchange with the capillary blood in the lung tissue.

The diameter of the trachea is approx. 1.8 cm and its length about 12 cms. The bronchi successively decrease in size to approx. 0.04 cm and the typical diameter of an alveolus is 300 μ.

The bronchial tree divides by dichotomy - that is each parent produces 2 daughter bronchi. However the branching pattern tends to be somewhat irregular. It is important to note that bronchi are short in length compared with their diameter (L/d 3.5) and branching angles in the region of 70^{o}. In the human lung there are approx 300×10^{6} alveoli.

The surfaces of the bronchi are lined with cilia and a mucous blanket. Election micrographs show up the surface in rather a dramatic way. The trachea in lined with a very copious cilial blanket and as we proceed down the bronchi we see a pattern of cilia and clara cells on the surface. As we proceed even further, we begin to see alveoli, When looking close up at an alveolus we can further see that the alveoli themselves are porous - the pores of Kohn. These pores provide a network of communications directly between alveoli and thus it is possible for gas to pass directly between alveoli which are individually connected to different bronchi.

The properties of the tracheo-bronchial tree described above apply in general to all the large mammals. There are however differences in detail between species. For example the pattern of branching in humans may be likened to an oak tree, whereas the pattern in dogs tends to look more like a pine tree. Not all species, for example the pig, have interalveolar pores.

References: The best morphological data on lungs can be obtained from:
E.R. Weibel. Morphometry of the Human Lung. Berlin Springer 1963.
K. Horsfield & G. Cumming, Angles of Branching and Diameter of Bronchus in the Human Bronchial Tree. Bull, Mathematical Biophysics 29, 245, 1967.