

DEVELOPMENT OF RESPIRATORY TRACT

- In mammals, the respiratory system consists of a gaseous conducting portion and a site where exchange of respiratory gases takes place.
- The conducting portion comprises the nostrils, nasal cavities, paranasal sinuses, pharynx, larynx, trachea, bronchi and bronchioles.
- The structures involved in gaseous exchange include the respiratory bronchioles, alveolar ducts, alveolar sacs and alveoli.
- Development of the nostrils, nasal cavities and paranasal sinuses are discussed in association with the development of the head.

- The respiratory primordium develops as a ventral groove in the floor of the foregut at the level of the fourth pharyngeal arch.
- The groove, referred to as the laryngo-tracheal groove, deepens and forms an elongated outgrowth, which extends in a caudal direction and becomes separated from the foregut proper by the formation of two tracheo-oesophageal grooves, one on the left side and one on the right side.

- When these grooves meet and fuse they form a septum, the tracheo-oesophageal septum.
- The septum separates the dorsal portion of the foregut, the primordium of the oesophagus, from the ventral portion, the primordium of the laryngo-tracheal tube.
- The part of the foregut cranial to the tracheo-oesophageal septum becomes the primordial pharynx.

FORMATION OF THE LARYNX

- The larynx, which develops from the cranial region of the laryngo- tracheal tube, communicates with the primordial pharynx.
- The epithelium of the larynx is derived from foregut endoderm, while the cartilages and muscles of the larynx develop from pharyngeal arch mesenchyme.
- The mesenchyme of the left and right fourth pharyngeal arches gives rise to two swellings which develop lateral to the laryngo-tracheal groove, the primordia of the arytenoid, thyroid and cricoid cartilages.

FORMATION OF THE LARYNX

- As these arytenoid swellings develop, they convert the cranial end of the slit-like laryngo-tracheal groove into a T-shaped aperture, the glottis.
- A single swelling which develops from the mesenchyme of the left and right third and fourth pharyngeal arches cranial to the developing glottis, referred to as the epiglottic swelling, gives rise to the epiglottic cartilage.
- The intrinsic laryngeal muscles, which develop from myoblasts in the fourth and sixth pharyngeal arches, are innervated by branches of cranial nerves X and XI.

FORMATION OF THE LARYNX

- The crico-thyroid muscles, which are derived from the fourth pharyngeal arches, are innervated by the cranial laryngeal branches of cranial nerve X.
- The other intrinsic laryngeal muscles, which develop from the sixth pharyngeal arches, are innervated by the recurrent laryngeal nerves, which contain fibres from cranial nerves X and XI.

- As the laryngeal cartilages develop, the epithelial lining of the larynx forms a left and a right diverticulum in the lateral walls of the larynx.
- Cranial vestibular and caudal vocal folds of the larynx, composed of mucosal, connective and muscular tissue, form the boundaries through which the diverticula project laterally.
- These diverticula, referred to as laryngeal ventricles, are present in humans, horses, dogs and pigs but are not present in ruminants and cats.

TRACHE, BRONCHI AND LUNGS

- The laryngo-tracheal tube, which consists of an inner endodermal lining and an outer layer of splanchnic mesoderm, elongates.
- Bifurcation of the blind end of this tube results in the formation of two bronchial buds, the primordia of the left and right lungs.
- The portion of the laryngo-tracheal tube from the larynx to the bifurcation gives rise to the trachea.

TRACHE, BRONCHI AND LUNGS

- The endodermal lining of the tube gives rise to respiratory epithelium and the mucosal and submucosal glands of the trachea.
- The connective tissue of the tracheal lamina propria, cartilaginous rings, smooth muscle, blood vessels and lymphatic vessels of the tracheal wall are all of mesenchymal origin.

- Each bronchial bud enlarges, forming a left and a right principal bronchus.
- These bronchi elongate caudally, between the developing oesophagus dorsally and the developing heart ventrally.
- Unlike the left bronchus, which deviates from the midline in a lateral direction, the right bronchus deviates to a lesser extent, and consequently the right lung is more prone to inhalation pneumonia than the left lung.
- In domestic animal species, with the exception of horses, the right principal bronchus gives off four secondary or lobar bronchi which later give rise to the cranial, middle, accessory and caudal lobes of the right lung.

- A middle lobe is not present in the equine right lung.
- The right human bronchus gives off three branches and so an accessory lobe is not present.
- The left principal bronchus in domestic animals gives off two lobar bronchi, which in turn give rise to the cranial and caudal lobes.

- In ruminants and pigs, the right cranial lobar bronchus, which branches off the trachea, is referred to as the tracheal bronchus.
- During further development, the lobar bronchi give off tertiary or segmental bronchi which supply large areas within the lobes known as bronchopulmonary segments.
- The number of bronchopulmonary segments within a particular pulmonary lobe in a given species is usually constant but the number of bronchopulmonary segments within a given pulmonary lobe is subject to significant variation among species.

- The segmental bronchi undergo 14 to 18 bifurcations with the diameter of each succeeding branch becoming progressively smaller until a diameter approaching 0.5 mm is reached; structures of this size are referred to as bronchioles.
- The final bronchiolar branches, which represent the termination of the exclusively conducting portion of the respiratory system, are referred to as terminal bronchioles.

- Each terminal bronchiole subdivides into two or more respiratory bronchioles which are structurally similar to terminal bronchioles except that their walls give off numerous saccular alveoli where gaseous exchange takes place.
- The respiratory bronchioles are transitional zones between the conducting and respiratory regions of the respiratory system.
- These respiratory bronchioles give off a number of alveolar ducts from which alveolar sacs and alveoli arise.

- Based on histological features, the development of the lungs may be divided into five arbitrary stages, namely the embryonic, pseudoglandular, canalicular, terminal sac and alveolar stages.
- The embryonic stage extends from the formation of the laryngo-tracheal groove to the formation of segmental bronchi.
- During this period, the developing lungs, which grow into the common pleuro-pericardial canal, become surrounded by visceral pleura.
- In the pseudoglandular stage, the developing lungs extend into the surrounding mesenchyme in a manner similar to the formation of an exocrine gland.
- By the end of this period, when up to 14 sequential bifurcations have occurred, all the major conducting branches of the bronchial tree are formed.

- Subsequently, the histological structure of the bronchial tree undergoes change, a consequence of extensive cellular differentiation.
- Epithelial cells, cartilage, submucosal glands and smooth muscle are formed and vascularisation of pulmonary tissue commences.
- During the canalicular stage, the lumina of the bronchi and bronchioles enlarge and the terminal bronchioles give off a number of respiratory bronchioles.
- Increased vascularisation is evident with capillaries in direct contact with the epithelium forming a peri-canalicular vascular network.

- During the penultimate stage of pulmonary development, referred to as the terminal sac stage, large numbers of terminal sacs bud off from the respiratory bronchioles.
- Initially, the terminal sacs, which correspond to primitive alveoli, are lined by cuboidal epithelial cells.
- The epithelium lining these primitive alveoli differentiates into two cell types, type I alveolar cells and type II alveolar cells.

- During the final stage of pulmonary development, referred to as the alveolar stage, capillaries surrounding the terminal sacs become intimately associated with the alveolar epithelial cells.
- At the site where gaseous exchange will occur in the neonatal animal, the alveolar epithelial cells are separated from the endothelium of the capillaries solely by the fused basal laminae of the alveoli and the capillaries.
- Thus, the blood–air barrier is composed of the capillary endothelial cell, the fused basal laminae of both the endothelial cell and the contiguous alveolar epithelial cell, and the alveolar epithelial cell itself.

- As the lungs are not fully developed at birth, postnatal alveolar development continues for some time.
- Postnatal growth of the lungs is due to the formation of additional respiratory bronchioles and alveoli, either by the formation of additional alveoli or by subdivision of existing alveoli through the formation of septa which increase the surface area for gaseous exchange.

- Although lungs are not functional in a respiratory sense during foetal life, they must, however, be sufficiently developed to render them capable of assuming a respiratory role immediately an animal is born.
- During foetal development, the lungs are filled with fluid.
- The source of this fluid is primarily secretions of the pulmonary epithelial cells and mucosal glands.
- As movements of muscles associated with respiration begin prior to birth, it is possible that a small amount of aspirated amniotic fluid may also be present in the lungs.

SUBDIVISION OF THE LUNG

- Lungs of domestic animals are normally subdivided into relatively large areas called pulmonary lobes.
- All domestic animal species, with the exception of horses, have four lobes in the right lung, namely cranial, middle, accessory and caudal lobes.
- Because the right principal bronchus in horses does not have a middle lobar branch, the equine right lung does not have a middle lobe.
- Accordingly, the equine right lung is composed of cranial, accessory and caudal lobes.

- Based on the area supplied by a bronchus or bronchiole, the following pulmonary functional units are described.
- A bronchopulmonary segment is the area supplied by a single segmental bronchus with its accompanying vascular and nerve supply.
- Adjacent bronchopulmonary segments are separated by connective tissue septa which are continuous with the pulmonary pleura.
- Because of this segmental anatomical arrangement, it is feasible to surgically resect a complete bronchopulmonary segment.