



The respiratory system is an outgrowth of the ventral wall of the foregut, and the epithelium of the larynx, trachea, bronchi, and alveoli originales in the endoderm. The cartilaginous, muscular, and connective tissue components arise in the mesoderm. In the fourth week of development, the tracheoesophageal septum separates the trachea from the foregut, dividing the foregut into the lung bud anteriorly and the esophagus posteriorly. Contact between the two is maintained through the larynx, which is formed by tissue of the fourth and sixth pharyngeal arches. The lung bud develops into two main bronchi: The right forms three secondary bronchi and three lobes; the left forms two secondary bronchi and two lobes.

The respiratory tract is divided anatomically into 2 main parts:

1. **upper respiratory tract** - consisting of the nose, nasal cavity and the pharynx.

2. **lower respiratory tract** - consisting of the larynx, trachea, bronchi and the lungs.

FORMATION OF THE LUNG BUDS

When the embryo is approximately 4 weeks old, the respiratory diverticulum (lung bud) appears as an outgrowth from the ventral wall of the foregut (Fig. 1). The appearance and location of the lung bud are dependent upon an increase in retinoic acid (RA) produced by adjacent mesoderm. Hence, epithelium of the internal lining of the larynx, trachea, and bronchi, as well as that of the lungs is entirely of endodermal origin. The cartilage- nous, muscular, and connective tissue components of the trachea and lungs are derived from splanchnic mesoderm surrounding the foregut.



FIGURE 14.1 A. Embryo of approximately 25 days' gestation showing the relation of the respiratory diverticulum to the heart, stomach, and liver. **B.** Sagittal section through the cephalic end of a 5-week embryo showing the openings of the pharyngeal pouches and the laryngotracheal orifice.

Initially, the lung bud is in open communication with the foregut (Fig. 14.1B). When the diverticulum expands caudally, however, two longitudinal ridges, the tracheoesophageal ridges, separate it from the foregut (Fig. 14.2A). Subsequently, when these ridges fuse to form the tracheoesophageal septum, the foregut is divided into a dorsal portion, the esophagus, and a ventral portion, the trachea and lung buds (Fig. 14.2B,C). The respiratory primordium maintains its communication with the pharynx through the laryngeal orífice (Fig. 14.2D).



FIGURE 14.2 A-C. Successive stages in development of the respiratory diverticulum showing the tracheoesophageal ridges and formation of the septum, splitting the foregut into esophagus and trachea with lung buds. **D.** The ventral portion of the pharynx seen from above showing the laryngeal orifice and surrounding swelling.

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The internal lining of the larynx originates from endoderm, but the cartilages and muscles originate from mesenchyme of the fourth and sixth pharyngeal arches. As a result of rapid proliferation of this mesenchyme, the laryngeal orifice changes in appearance from a sagittal sit to a T-shaped opening (Fig. 14.4A). Subsequently, when mesenchyme of the two arches transforms into the thyroid, cricoid, and arytenoid cartilages, the characteristic adult shape of the laryngeal orifice can be recognized (Fig. 14.4B).At about the time that the cartilages are formed, the laryngeal epithelium also proliferates rapidly, resulting in a temporary occlusion of the lumen. Subsequently, vacuolization and recanalization produce a pair of lateral recesses, the laryngeal ventricles. These recesses are bounded by folds of tissue that differentiate into the false and true vocal cords.

Because musculature of the larynx is derived from mesenchyme of the fourth and sixth pharyngeal arches, all laryngeal muscles are innervated by branches of the tenth cranial nerve.



FIGURE 14.2 A-C. Successive stages in development of the respiratory diverticulum showing the tracheoesophageal ridges and formation of the septum, splitting the foregut into esophagus and trachea with lung buds. **D.** The ventral portion of the pharynx seen from above showing the laryngeal orifice and surrounding swelling.

TRACHEA, BRONCHI, AND LUNGS

During its separation from the foregut, the lung bud forms the trachea and two lateral outpocketings, the bronchial buds (Fig. 14.2B,C). At the beginning of the fifth week, each of these buds enlarges to form right and left main bronchi. The right then forms three secondary bronchi, and the left, two (Fig. 14.5A), thus foreshadowing the three lobes of the lung on the right side and two on the left (Fig. 14.5fí,C)



FIGURE 14.5 Stages in development of the trachea and lungs. A. 5 weeks. B. 6 weeks. C. 8 weeks.

Successful development and function of the lung requires the completion of both physical development, required for the structure of the lung, and biochemical development of the surfactant system, required for the stability of this very large surface area. The two processes clearly are related. Incomplete development of lung structure and premature birth prior to the development of the surfactant system will lead to respiratory compromise or insufficiency in the newborn. The stages of lung development are summarized in Table 14-1.

TABLE 14.1 Maturation of the Lungs		
Pseudoglandular period	5-16 wk	Branching has continued to form terminal bronchioles. No respiratory bronchioles or alveoli are present.
Canalicular period	16-26 wk	Each terminal bronchiole divides into two or more respiratory bronchioles, which in turn divide into three to six alveolar ducts.
Terminal sac period	26 wk to birth	Terminal sacs (primitive alveoli) form, and capillaries establish close contact.
Alveolar period	8 mo to childhood	Mature alveoli have well-developed epithelial endothe- lial (capillary) contacts.