Development of Respiratory System

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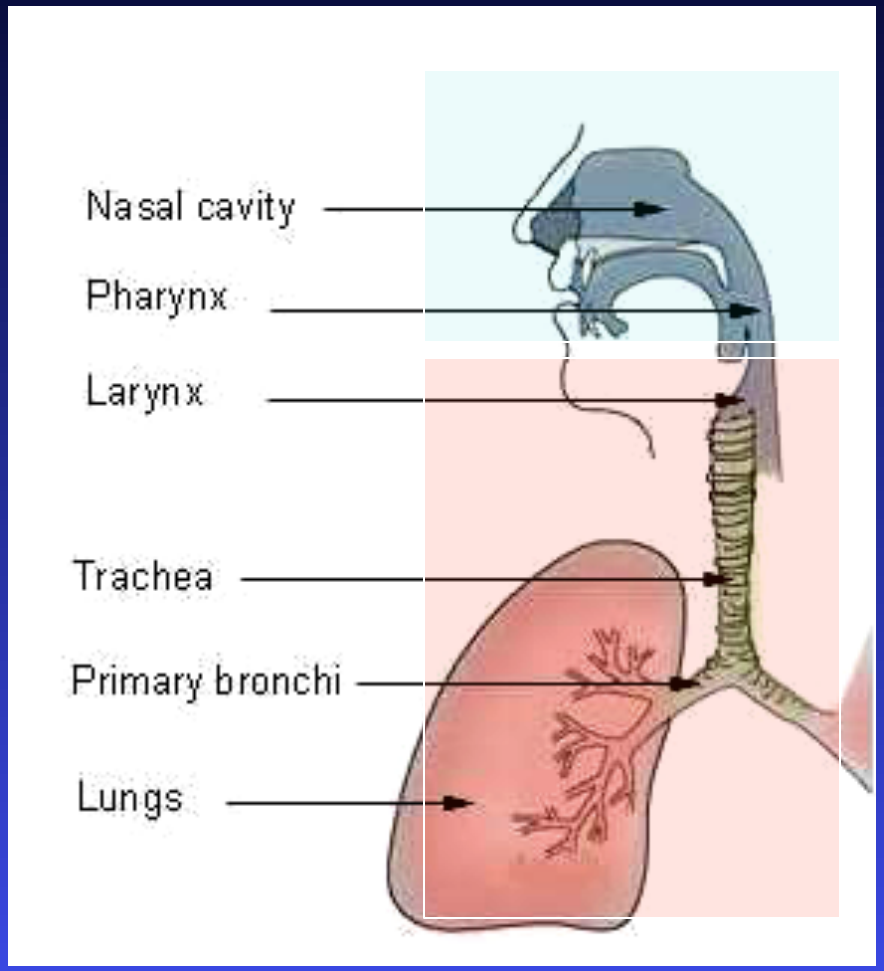
OBJECTIVES

At the end of the lecture the students should be able to:

- Identify the development of the laryngeotracheal (respiratory) diverticulum.
- Identify the development of the larynx.
- Identify the development of the trachea.
- Identify the development of the bronchi & Lungs.
- Describe the periods of the maturation of the lung.
- Identify the most congenital anomaly.

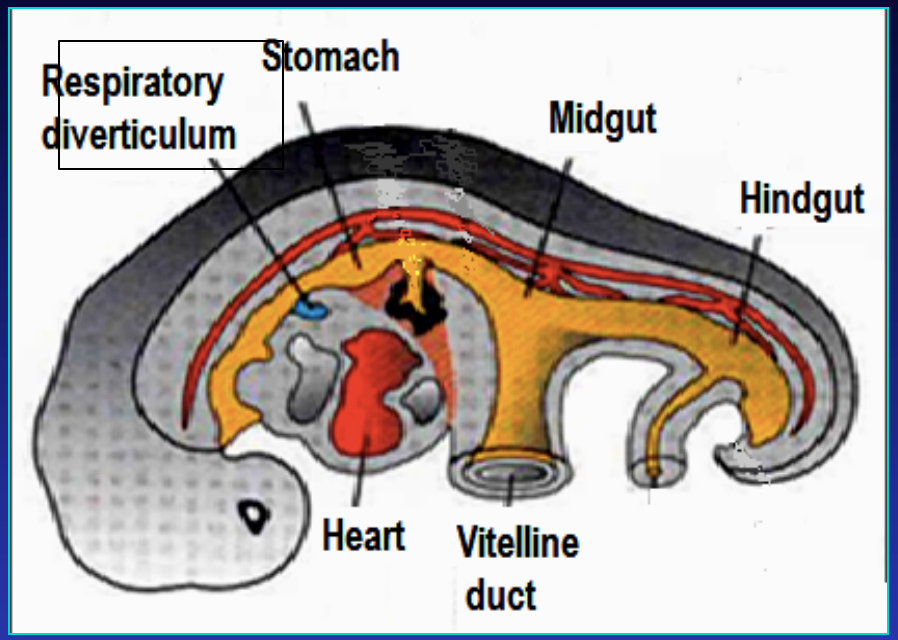
Respiratory System

- Upper respiratory tract:
  - Nose
  - Nasal cavity & paranasal sinuses
  - Pharynx
- Lower respiratory tract:
  - Larynx
  - Trachea
  - Bronchi
  - Lungs

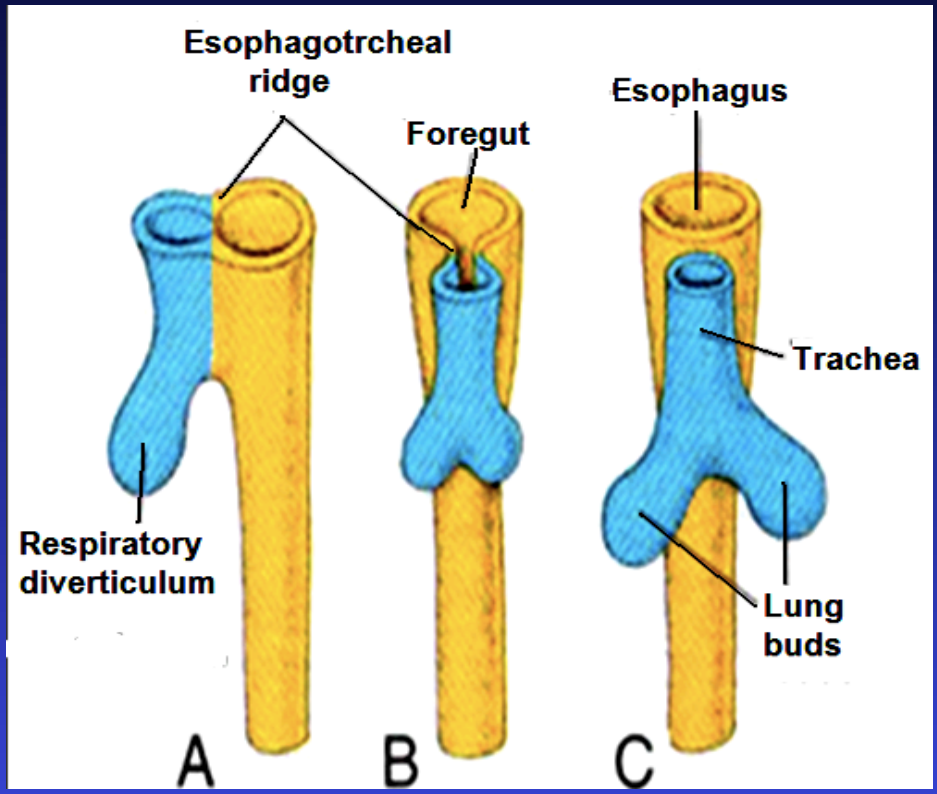


Development of the Lower Respiratory Tract

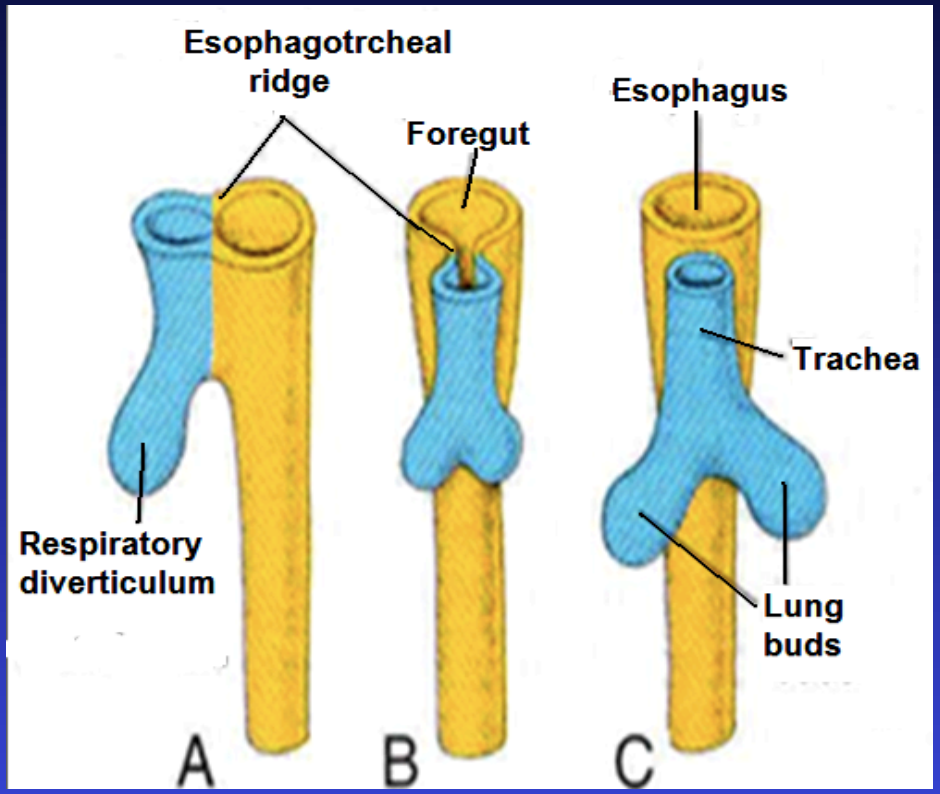
- Begins to form during the 4th week of development
- Begins as a median outgrowth (laryngotracheal groove) from the caudal part of the ventral wall of the primitive pharynx (foregut)
- The groove envaginates and forms the laryngotracheal (respiratory) diverticulum



- A longitudinal tracheo-esophageal septum develops and divides the diverticulum into a:
  - Dorsal portion: primordium of the oropharynx and esophagus
  - Ventral portion: primordium of larynx, trachea, bronchi and lungs



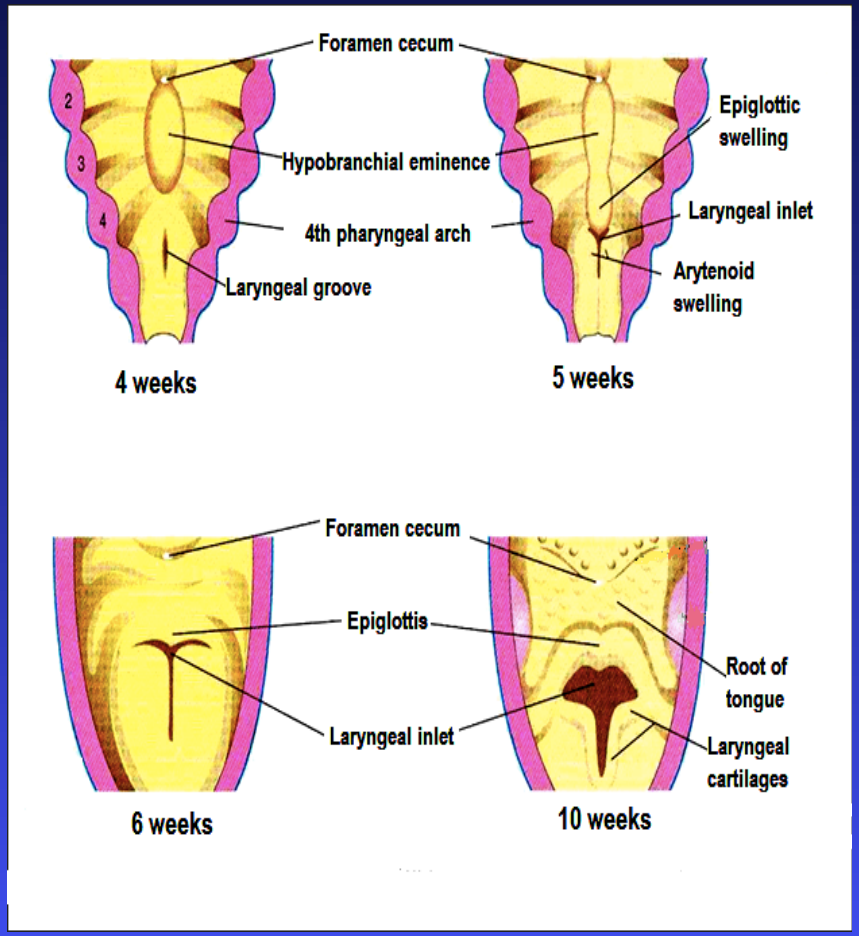
- **The proximal part** of the **respiratory diverticulum** remains tubular and forms **larynx** & **trachea.**
- **The distal end** of the diverticulum dilates to form **lung bud**, which divides to give rise to **2 lung buds (primary bronchial buds)**



- The **endoderm** lining the **laryngotracheal diverticulum** gives rise to the:
  - **Epithelium & Glands** of the respiratory tract
- The surrounding **splanchnic mesoderm** gives rise to the:
  - **Connective tissue, Cartilage** & **Smooth muscles** of the respiratory tract

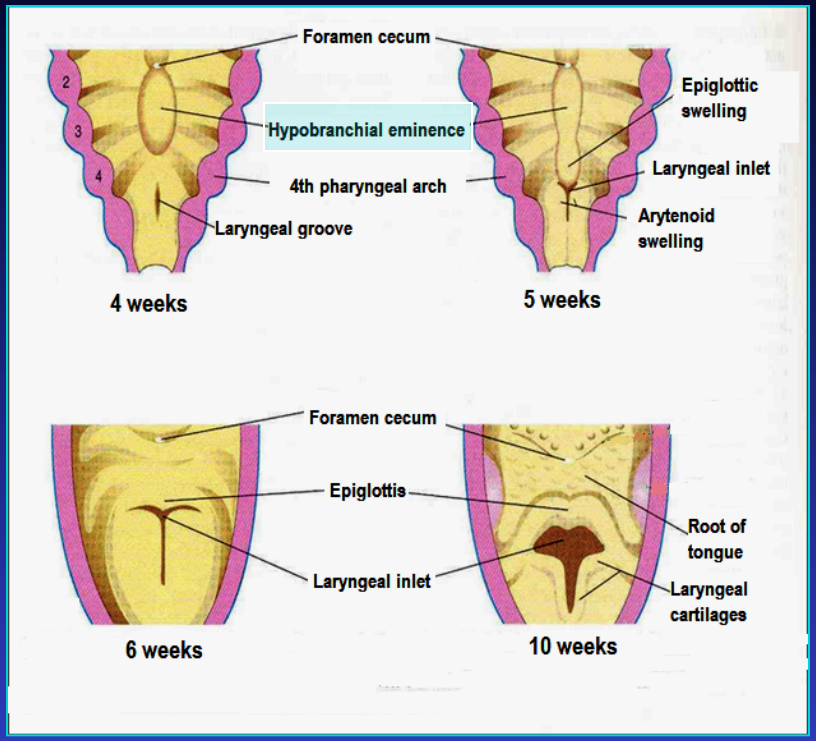
Development of the Larynx

- The opening of the laryngotracheal diverticulum into the primitive foregut becomes the laryngeal orifice.
- The epithelium & glands are derived from **endoderm.**
- Laryngeal muscles & the cartilages of the larynx **except Epiglottis** that develop from the **mesoderm of 4th & 6th pairs of pharyngeal arches.**



Epiglottis

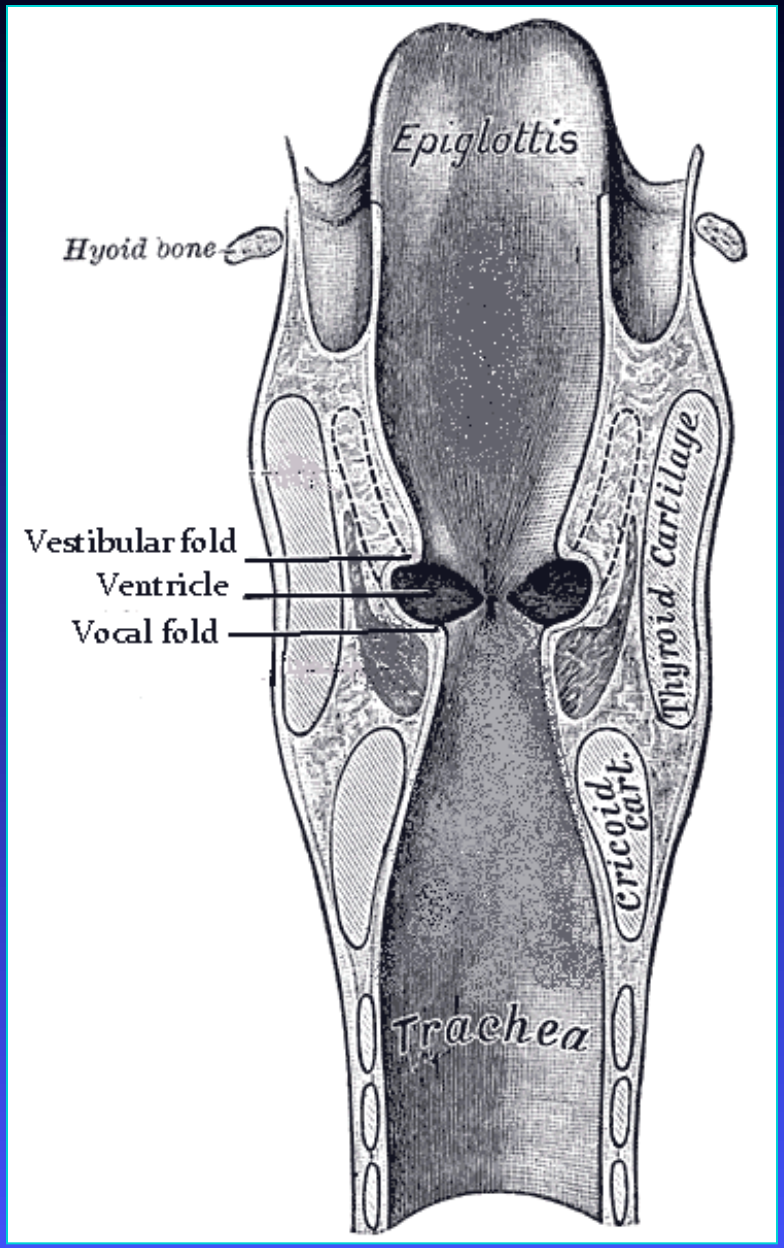
- It develops from the caudal part of the hypopharyngeal eminence, a swelling formed by the proliferation of mesoderm in the floor of the pharynx.



Growth of the larynx and epiglottis is rapid during the first three years after birth. By this time the epiglottis has reached its adult form.

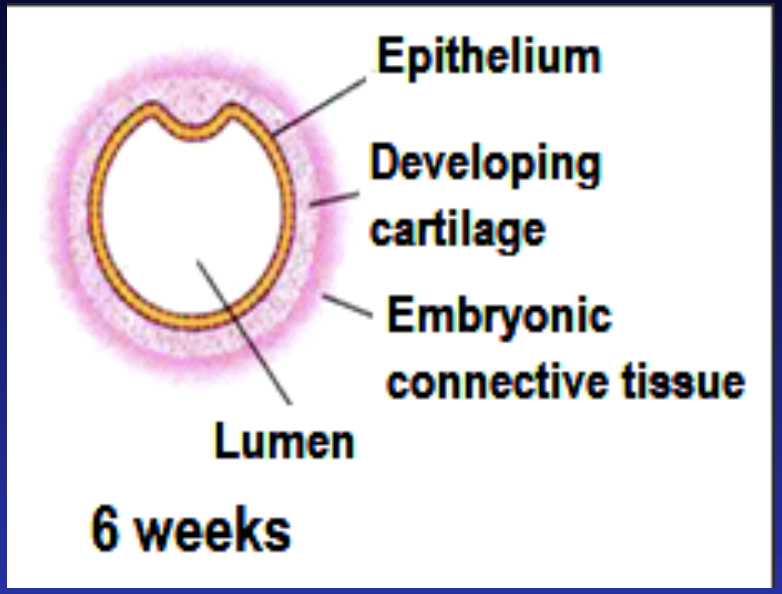
Recanalization of larynx

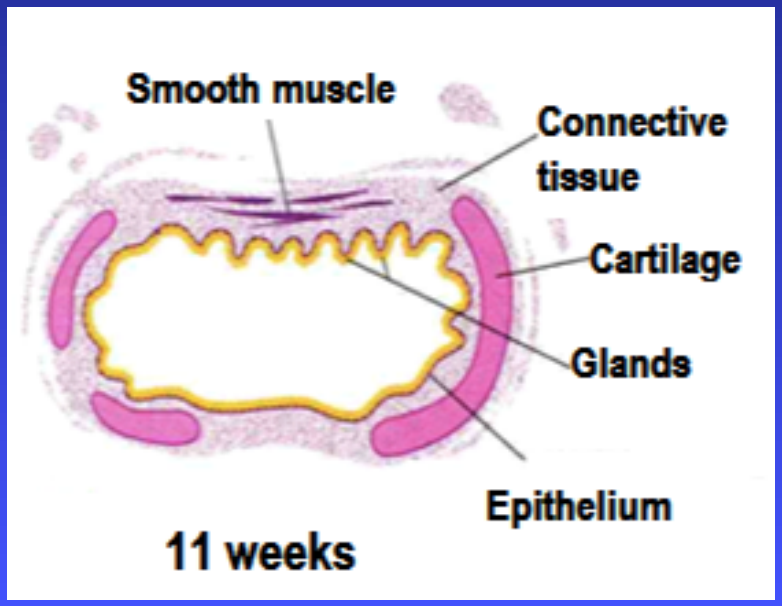
- The **laryngeal epithelium** proliferates rapidly resulting in **temporary occlusion** of the laryngeal lumen
- **Recanalization** of larynx normally occurs by the **10th week.**
- Laryngeal **ventricles**, **vocal folds** and **vestibular folds** are formed during **recanalization.**



Development of the Trachea

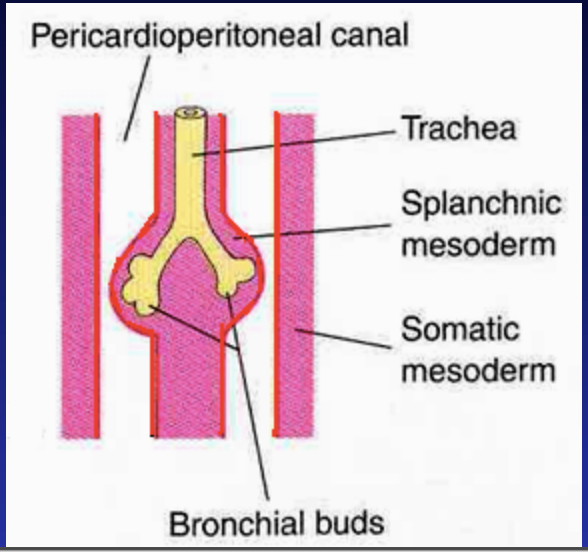
- The endodermal lining of the laryngotracheal tube distal to the larynx differentiates into the epithelium and glands of the trachea and pulmonary epithelium
- The cartilages, connective tissue, and muscles of the trachea are derived from the mesoderm.

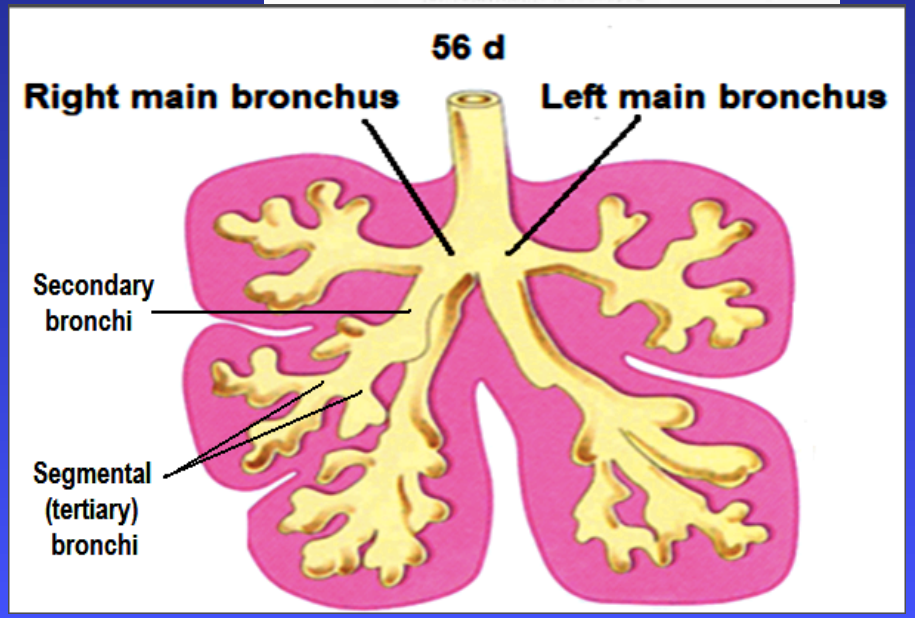




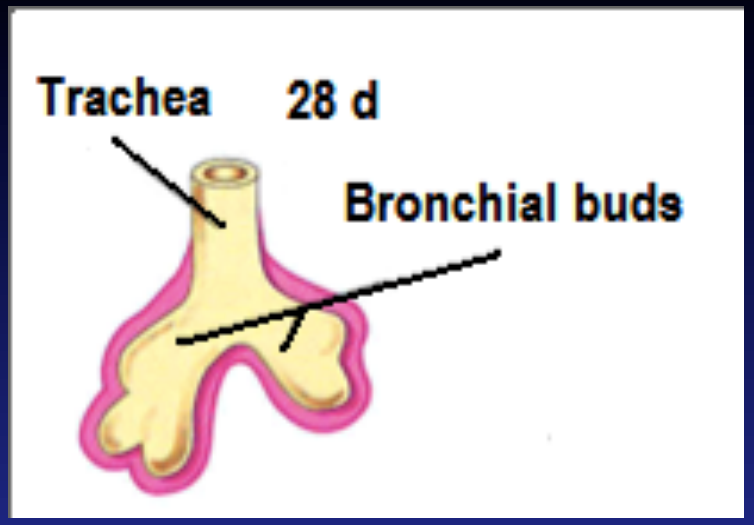
Development of the Bronchi & Lungs

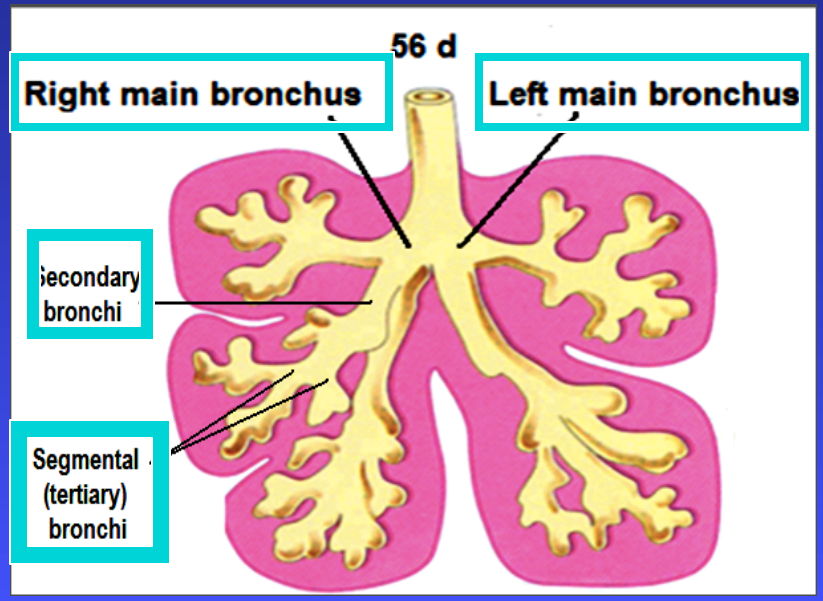
- **The 2 primary bronchial buds grow laterally into the pericardio-peritoneal canals (part of the intraembryonic celome), the primordia of pleural cavities**
- **Bronchial buds divide and re-divide to give the bronchial tree.**



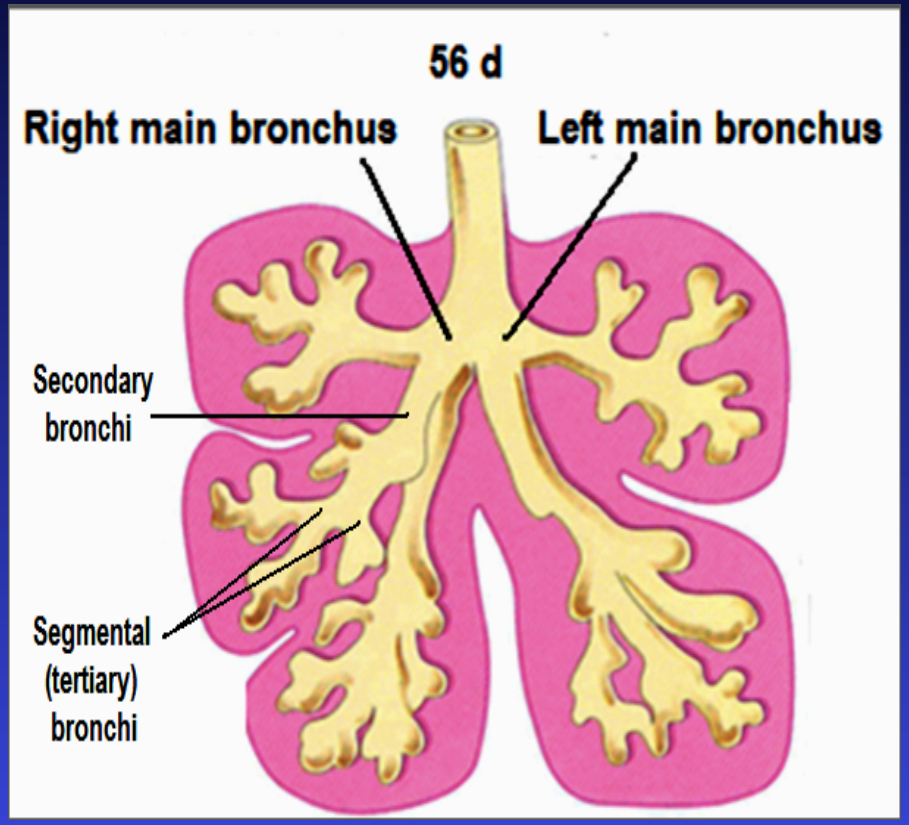


- **The right main bronchus** is slightly **larger (wider)** than the left one and is **oriented more vertically**
- The embryonic relationship persists in the adult.
- **The main bronchi** subdivide into **secondary** and **tertiary (segmental) bronchi** which give rise to further branches.



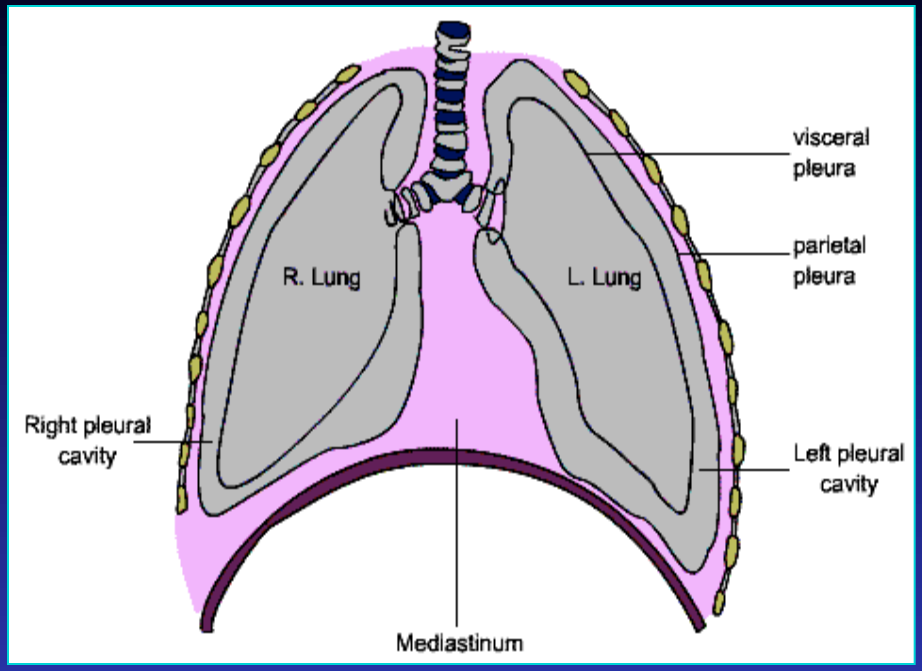


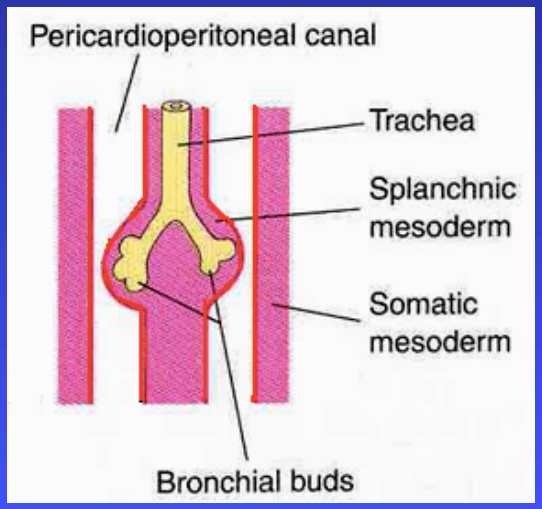
- **The segmental bronchi 10 in right lung and 8 or 9 in the left lung begin to form by the 7th week**
- **The surrounding mesenchyme also divides.**
- **Each segmental bronchus with its surrounding mass of mesenchyme is the primordium of a bronchopulmonary segment.**

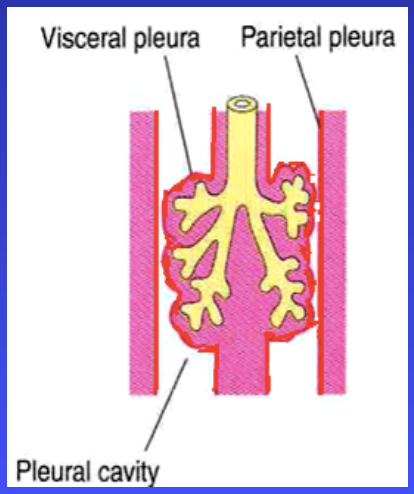


Development of the pleura

- As the lungs develop they acquire a layer of visceral pleura from splanchnic mesenchyme.
- The thoracic body wall becomes lined by a layer of parietal pleura derived from the somatic mesoderm.

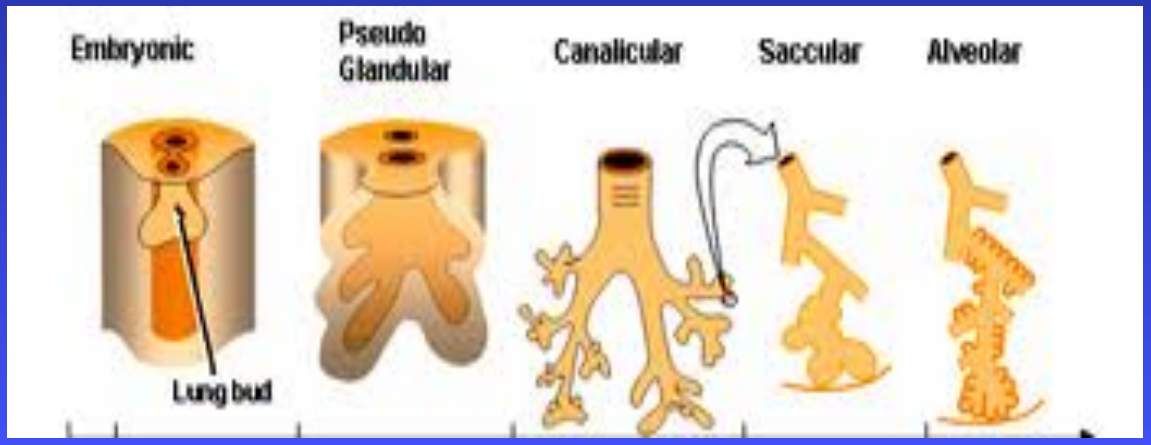


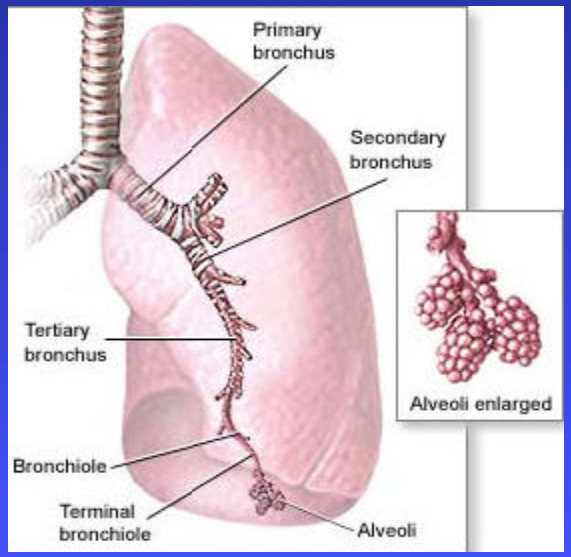




Maturation of the Lungs

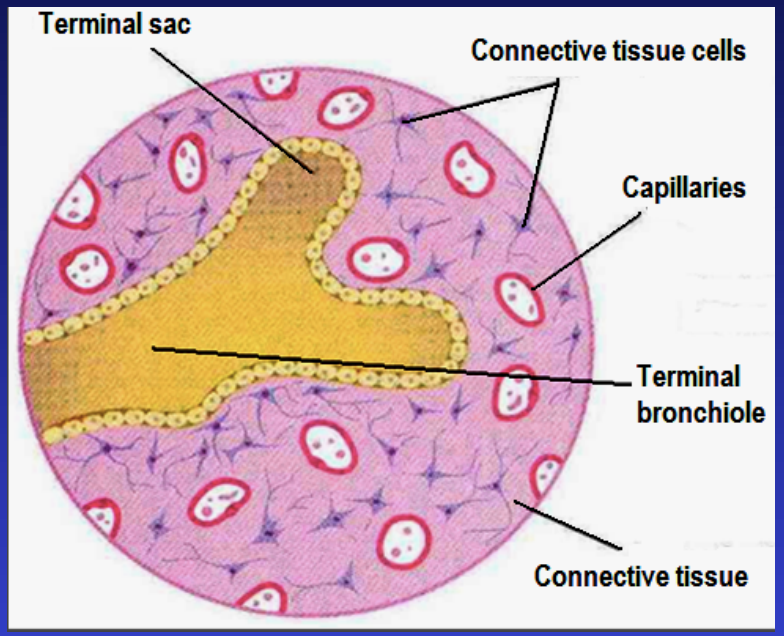
- Maturation of lung is divided into 4 periods:
  - Pseudoglandular (5 - 17 weeks)
  - Canalicular (16 - 25 weeks)
  - Terminal sac (24 weeks - birth)
  - Alveolar (late fetal period - childhood)
- These periods overlap each other because the cranial segments of the lungs mature faster than the caudal ones





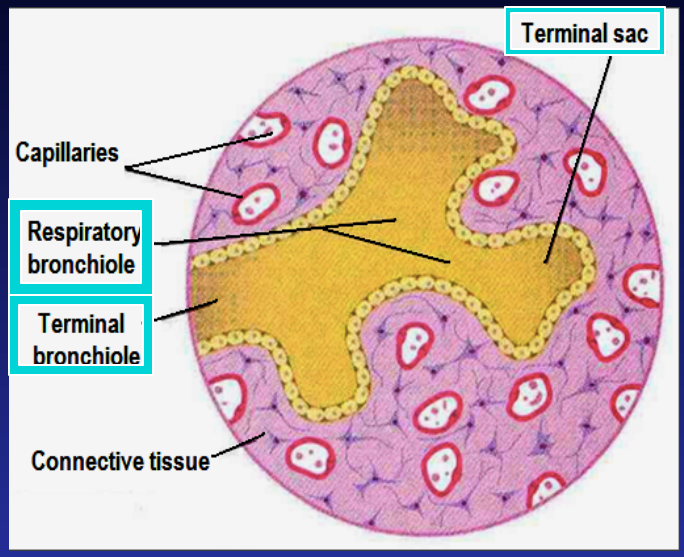
Pseudoglandular Period (5-17 weeks)

- Developing lungs somewhat resembles an exocrine gland during this period.
- By **17 weeks** all major elements of the lung have formed except those involved with gas exchange (alveoli).
- Respiration is **NOT** possible.
- Fetuses born during this period are unable to survive.



Canalicular Period (16-25 weeks)

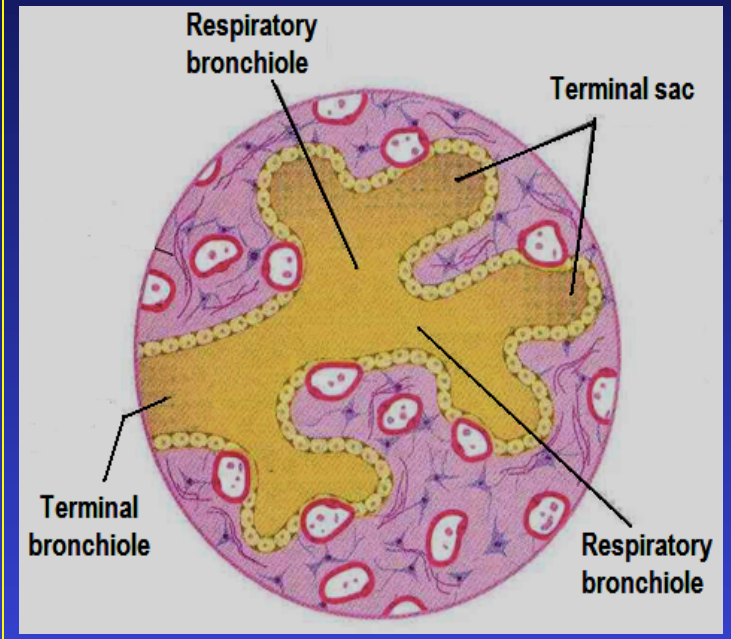
- Lung tissue becomes highly vascular.
- Lumina of bronchi and terminal bronchioles become larger.
- **By 24 weeks** each terminal bronchiole has given rise to two or more **respiratory bronchioles.**
- The respiratory bronchioles divide into 3 to 6 tubular passages called **alveolar ducts.**
- **Some** thin-walled **terminal sacs (primordial alveoli)** develop at the end of respiratory bronchioles.

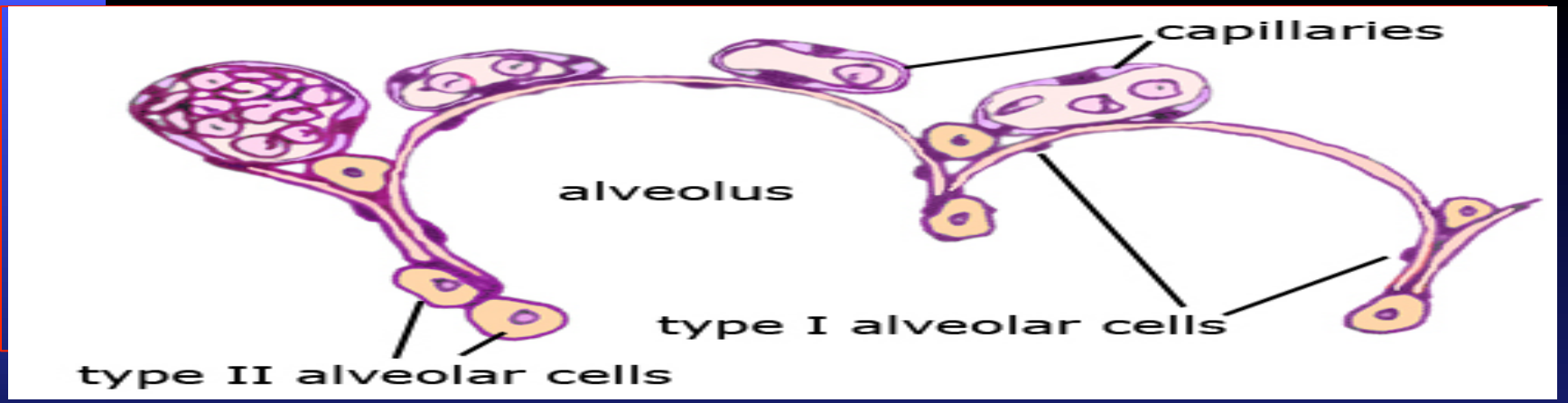


- **Respiration is possible at the end of this period.**
- Fetus born at the end of this period may survive if given intensive care (but usually die because of the immaturity of respiratory as well as other systems)

Terminal Sac Period (24 weeks - birth)

- Many more terminal sacs develop.
- Their epithelium becomes very thin.
- Capillaries begin to bulge into developing alveoli.
- The epithelial cells of the alveoli and the endothelial cells of the capillaries come in intimate contact and establish the blood-air barrier.
- Adequate gas exchange can occur which allows the prematurely born fetus to survive

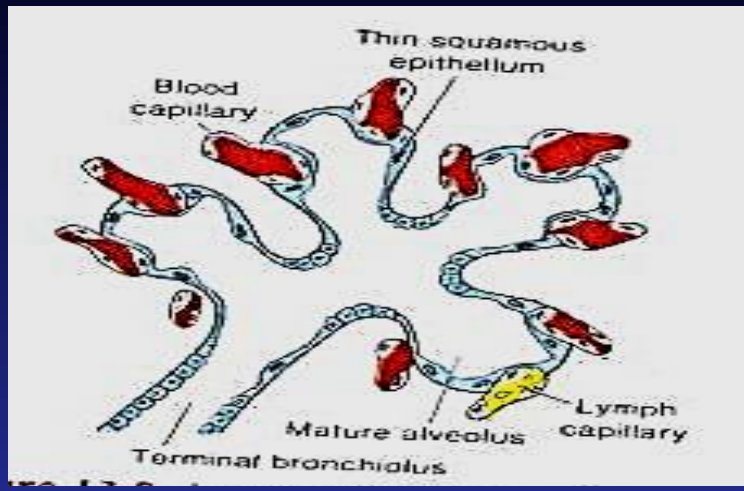


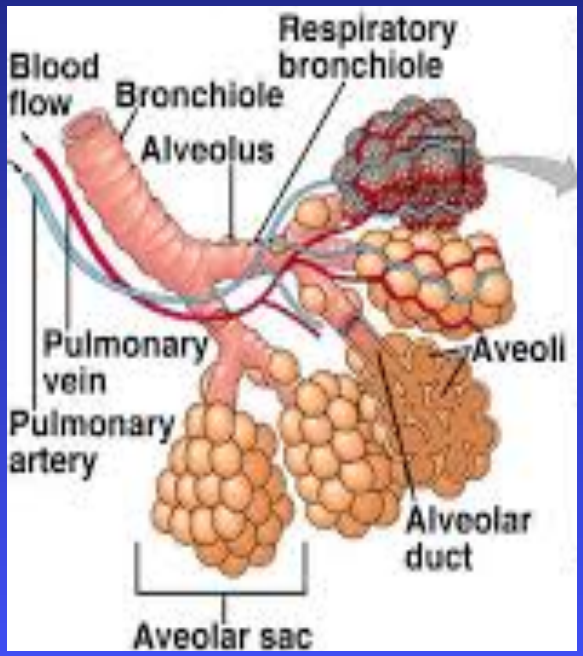


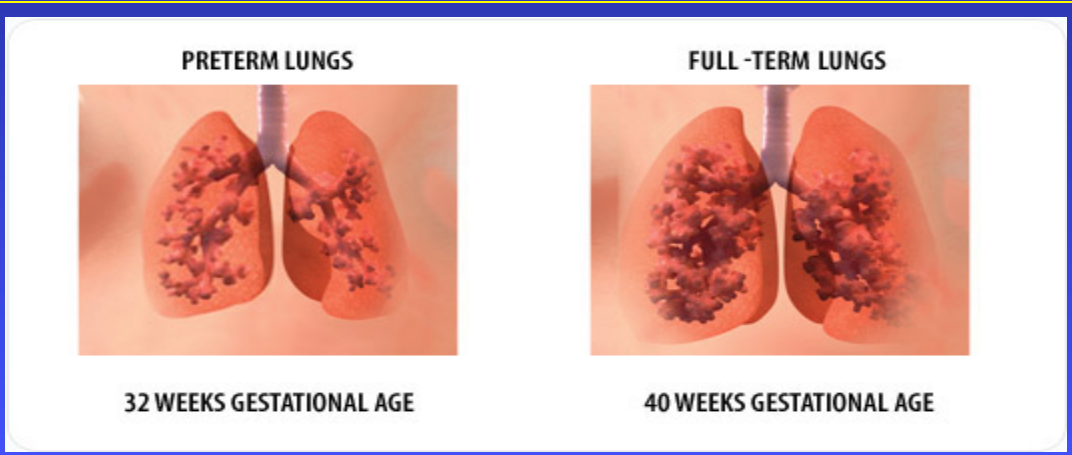
- **Surfactant** production begins by 20 weeks and increases during the terminal stages of pregnancy.
- **Sufficient terminal sacs**, **pulmonary vasculature** & **surfactant** are present to permit survival of a prematurely born infants
- Fetuses born prematurely at 24-26 weeks may suffer from **respiratory distress** due to **surfactant deficiency** but **may survive** if given **intensive care.**

Alveolar Period (32 weeks – 8 years)

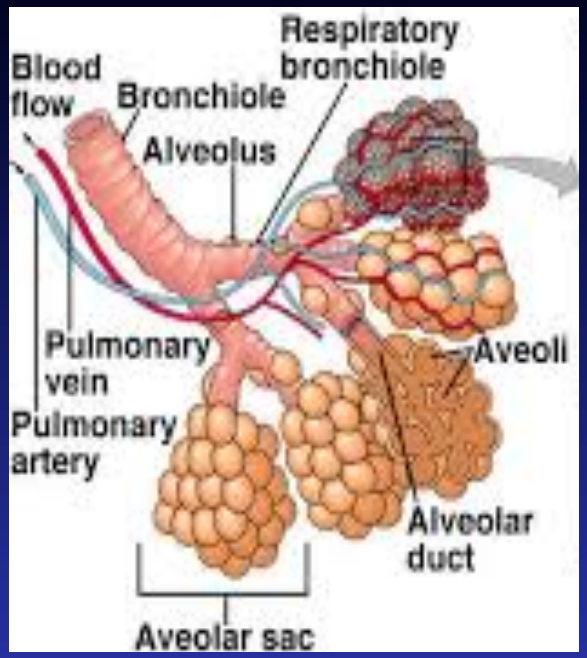
- At the beginning of the alveolar period, each respiratory bronchiole terminates in a cluster of thin-walled terminal saccules separated from one another by loose connective tissue.
- These terminal saccules represent future alveolar sacs.







- Characteristic mature alveoli do not form until after birth. 95% of alveoli develop postnatally.
- About 50 million alveoli, one sixth of the adult number are present in the lungs of a full-term newborn infant.



- **From 3-8 year or so, the number of alveoli continues to increase, forming additional primordial alveoli.**
- **By about the eighth year, the adult complement of 300 million alveoli is present.**

Breathing Movements

- Occur before birth, are not continuous and increase as the time of delivery approaches.
- Help in conditioning the respiratory muscles.
- Stimulate lung development and are essential for normal lung development.

Lungs at birth

- The lungs are half filled with fluid derived from the amniotic fluid and from the lungs & tracheal glands.
- This fluid in the lungs is cleared at birth: by:
  - Pressure on the fetal thorax during delivery.
  - Absorption into the pulmonary capillaries and lymphatics.

Lungs of a Newborn

- **Fresh healthy lung always contains some air (lungs float in water).**
  Diseased lung may contain some fluid and may not float (may sink).
  Lungs of a stillborn infant are firm, contain fluid and may sink in water.

Factors important for normal lung development

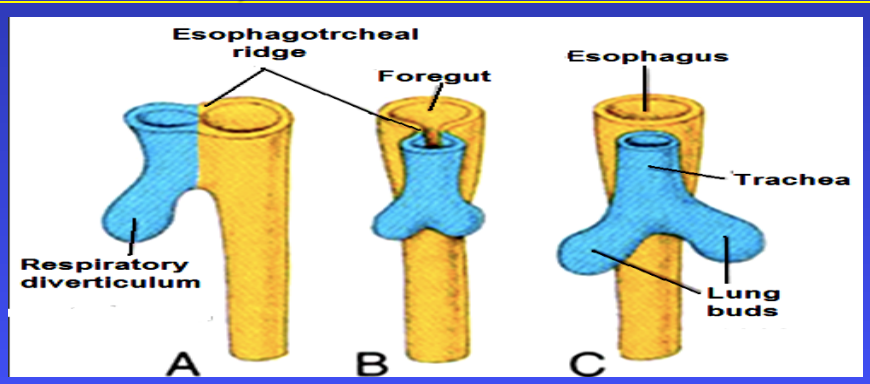
- Adequate thoracic space for lung growth.
- Fetal breathing movements.
- Adequate amniotic fluid volume.

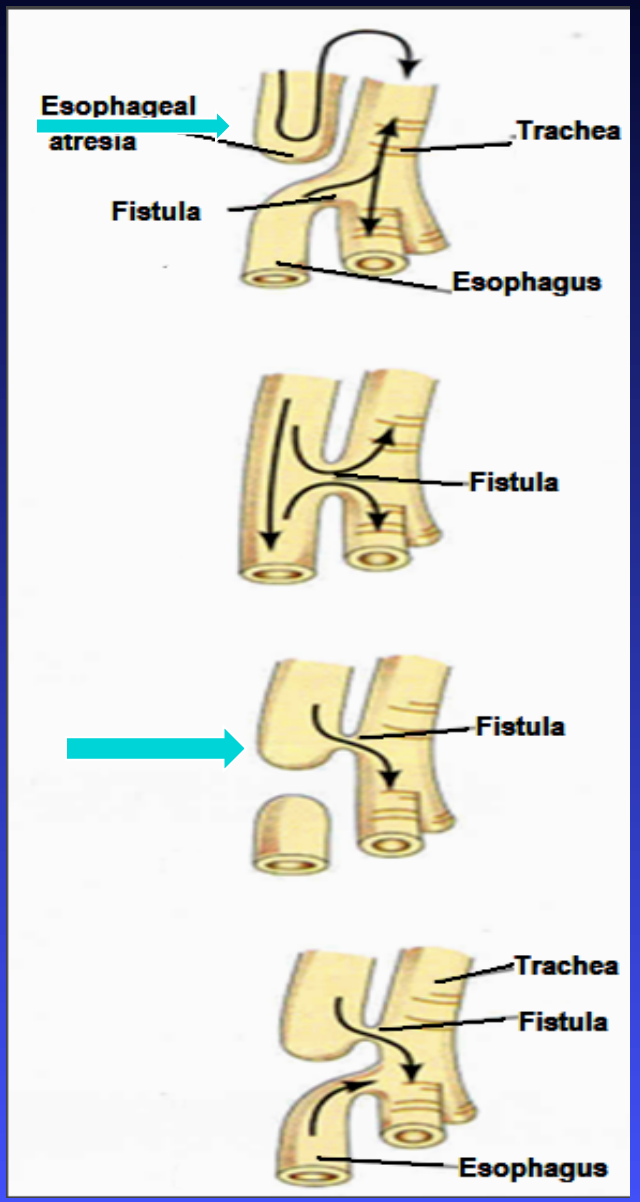
Developmental anomalies

- Laryngeal atresia.
- Tracheoesophageal fistula.
- Tracheal stenosis & atresia.
- Congenital lung cysts.
- Agenesis of lungs.
- Lung hypoplasia.
- Accessory lungs.

Tracheoesophageal Fistula

- An **abnormal passage** between the trachea and esophagus.
- **Results from incomplete division** of the cranial part of the foregut into respiratory and esophageal parts by the **tracheo-esophageal septum.**
- Occurs once in 3000 to 4500 live births.
- Most affected infants are **males.**
- In more than **85% of cases,** the fistula is associated with **esophageal atresia** (**esophagus** ends in a blind-ended pouch rather than connecting normally to the stomach).





Thank You