

Embryology of the respiratory system

Respiratory Block - Lecture 1

Color index:

Important

In male's slides only

In female's slides only

Extra information, explanation

Doctors notes

Objectives:

- Identify the development of the laryngotracheal (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 anatomy

Respiratory system

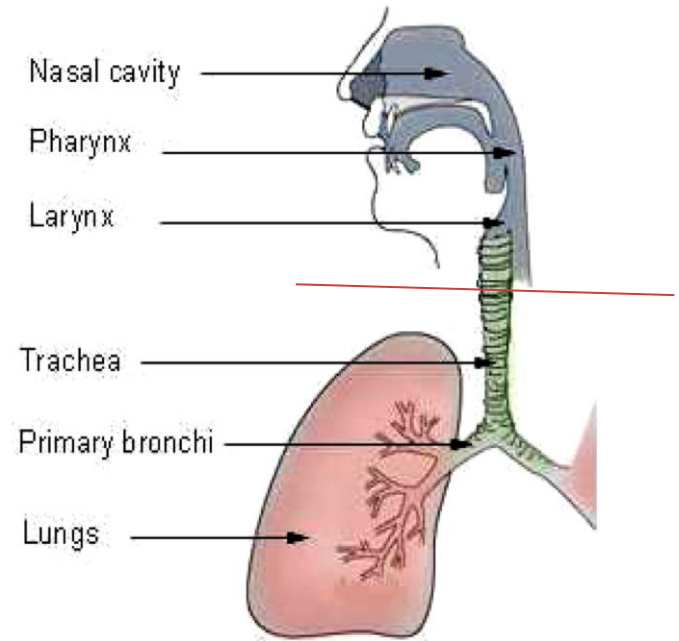
Upper respiratory tract:

- Nose
- Nasal cavity & paranasal sinuses
- Laryngo-pharynx
- Larynx

Lower respiratory tract:

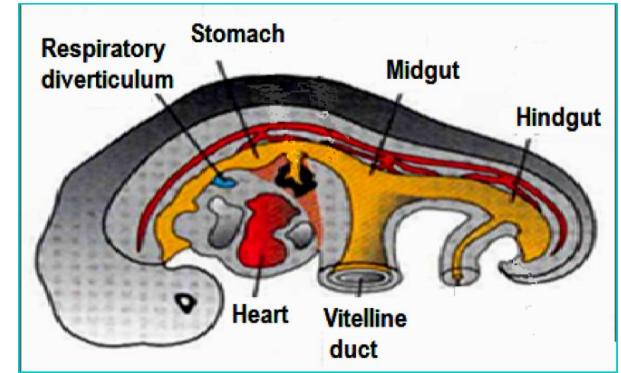
- Trachea
- Bronchi
- Lungs

In embryology, the lower respiratory tract includes the larynx



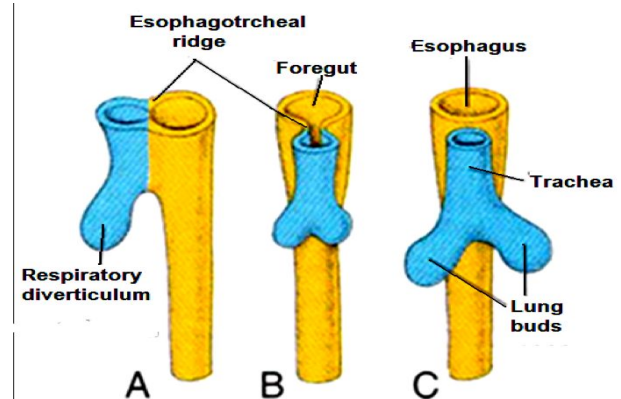
Development of the respiratory tract

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



A longitudinal tracheo- esophageal septum develops and divides the diverticulum into a:

- Dorsal portion:
Primordium of the oropharynx and esophagus (digestive)
- Ventral portion:
Primordium of larynx, trachea, bronchi and lungs (respiratory)



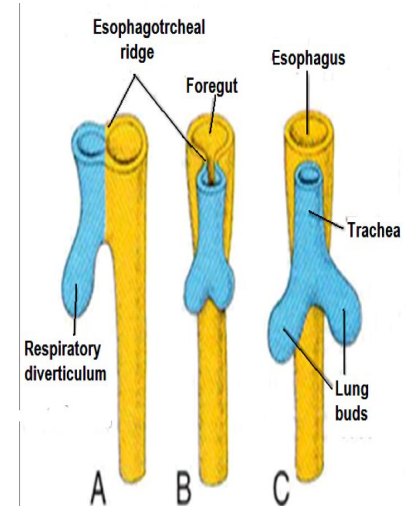
- The proximal part of the respiratory diverticulum remains tubular and forms larynx & trachea.
- The distal end of the diverticulum dilates to form lung bud, which divides to give rise to 2 lung buds (primary bronchial buds)

The endoderm lining the **laryngotracheal diverticulum** (respiratory 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

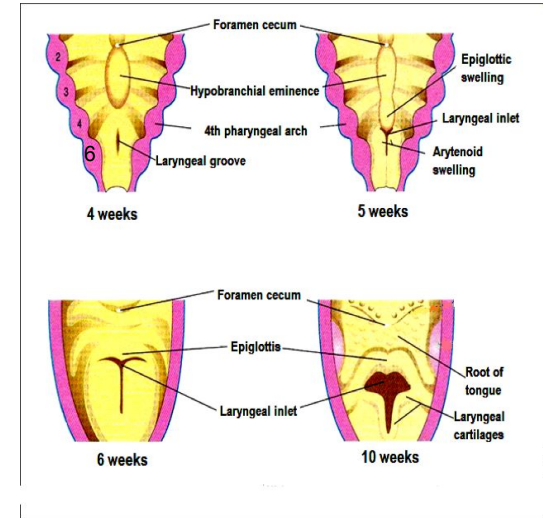


Development of the larynx

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

Epiglottis

It develops from the caudal part of the hypopharyngeal eminence, a swelling formed by 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.

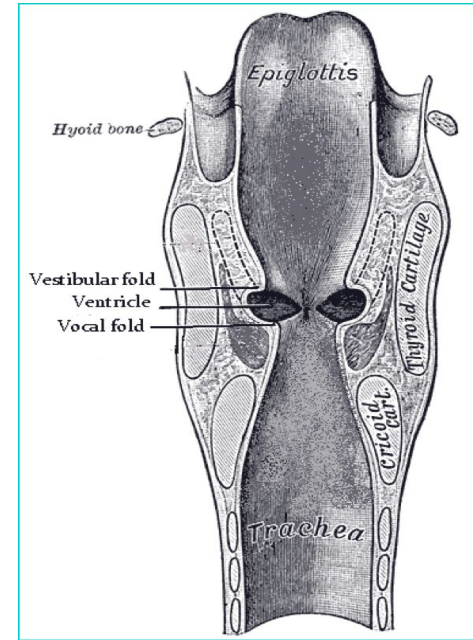
The mucosal folds that bound these recesses became:

- Vestibular folds (false)
- Vocal folds (true)

All laryngeal muscles are innervated by 10th cranial nerve (vagus nerve)

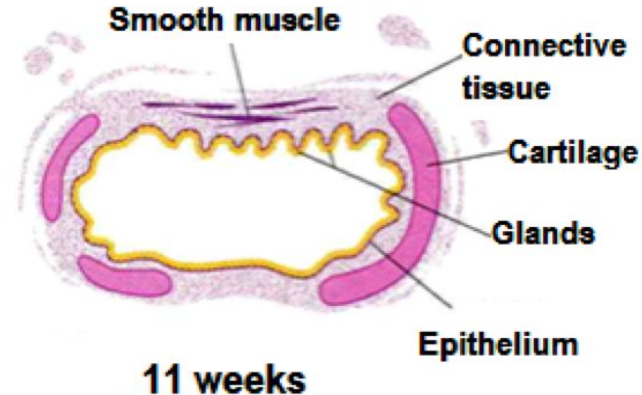
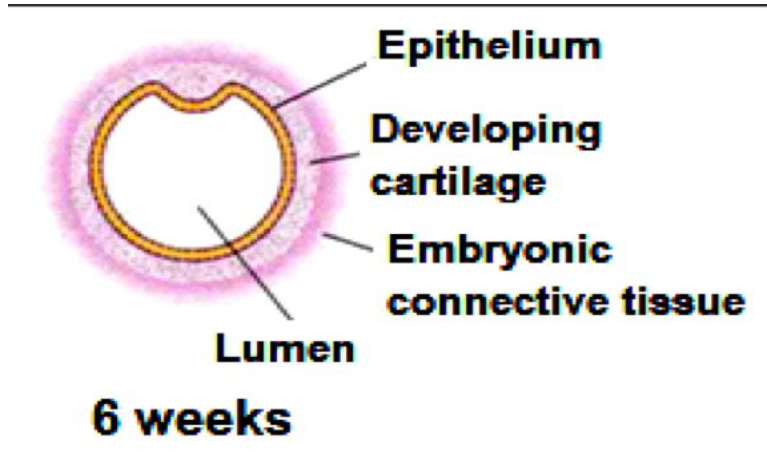
The superior laryngeal innervates the 4th pharyngeal arch derivatives.

The recurrent laryngeal innervates the 6th pharyngeal arch derivatives.



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 splanchnic 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.

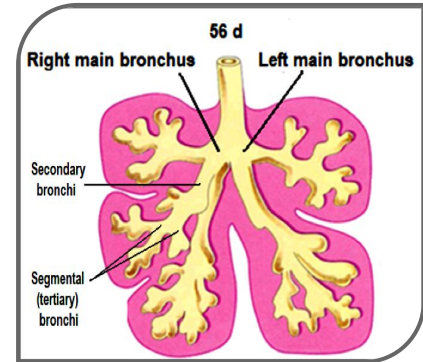
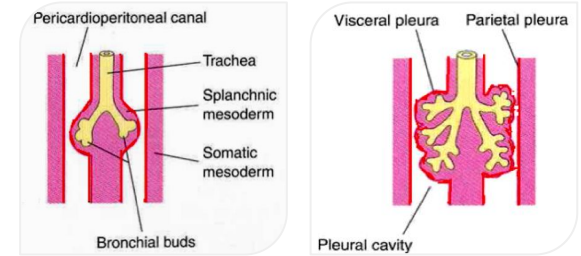
Bronchial buds divide and re-divide to give the bronchial tree.

The embryonic right main bronchus is slightly **larger (wider) than the left one & 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.

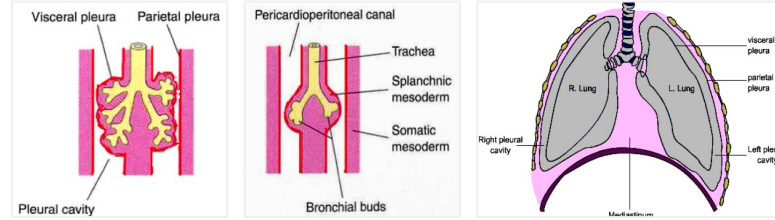
The segmental bronchi, 10 in right lung and 8 or 9 in the left lung, begin to form by the **7th week**. The surrounding mesenchyme also divides.

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

Pseudoglandular period

Canalicular period

Terminal sac period

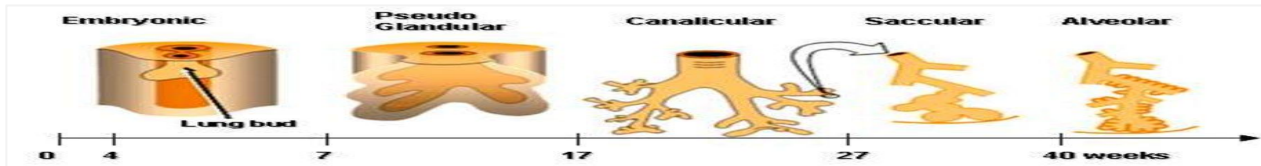
Alveolar period

- 5- 16/17 weeks

- 16 - 25/26 weeks

- 24/26 weeks - birth

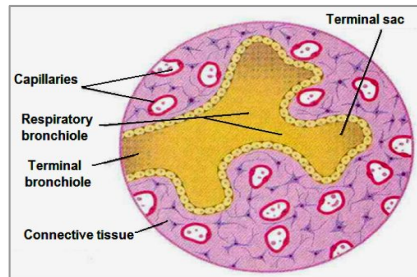
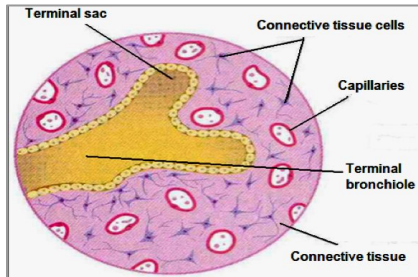
- 8 months (late fetal period) - childhood
- 32 weeks - 8 years



These periods overlap each other because the cranial segments of the lungs mature faster than the caudal ones.

Pseudoglandular period (5-16/17 weeks)

- Developing lungs somewhat resembles an exocrine gland during this period.
- By 16/17 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**.

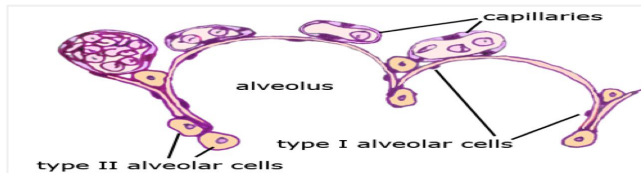
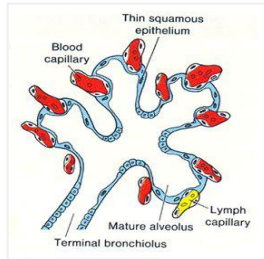
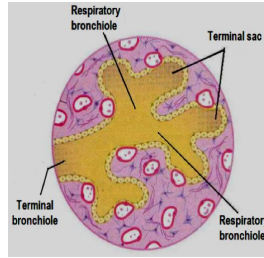


Canalicular period (16-25/26 weeks)

- 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 (24/26 weeks - birth)

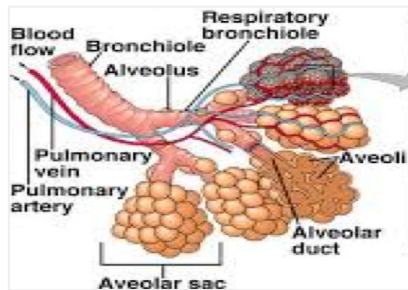
- Many more terminal sacs develop.
 - Their epithelium becomes very thin forming the developing alveoli.
 - Capillaries begin to bulge into developing alveoli.
 - The epithelial cells of the alveoli and the endothelial cells of the capillaries come in intimate contact and establish the **blood-air barrier**.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



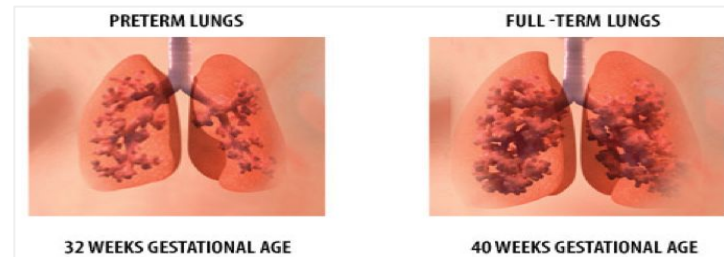
- By 24 weeks, the terminal sacs are lined by:
 - squamous type I pneumocytes
 - rounded secretory type II pneumocytes, that secrete a mixture of phospholipids called surfactant.
 - Surfactant production begins by 24 weeks and increases during the terminal stages of pregnancy particularly in the last 2 weeks.
- ★ The Sufficient terminal sacs, pulmonary vasculature & surfactant are present to permit survival of a prematurely born infant.
- ★ 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 (alveoli) separated from one another by loose connective tissue.
- These terminal saccules or alveoli represent future alveolar sac.



- Characteristic mature alveoli do not form until after birth, so; **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.



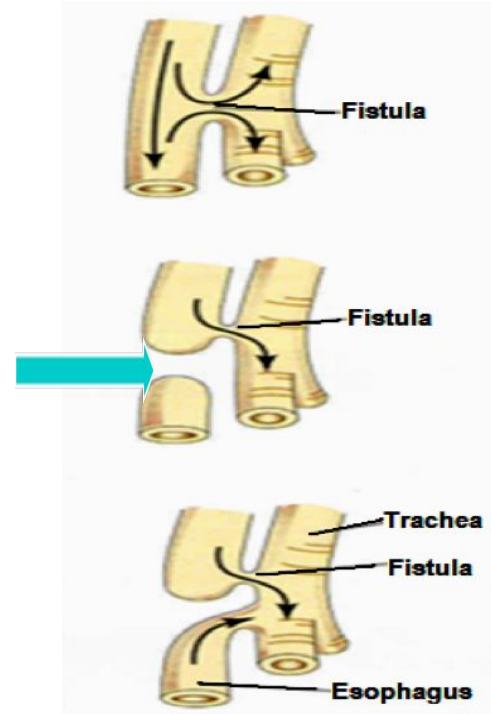
Development anomalies (tracheo-esophageal fistula)

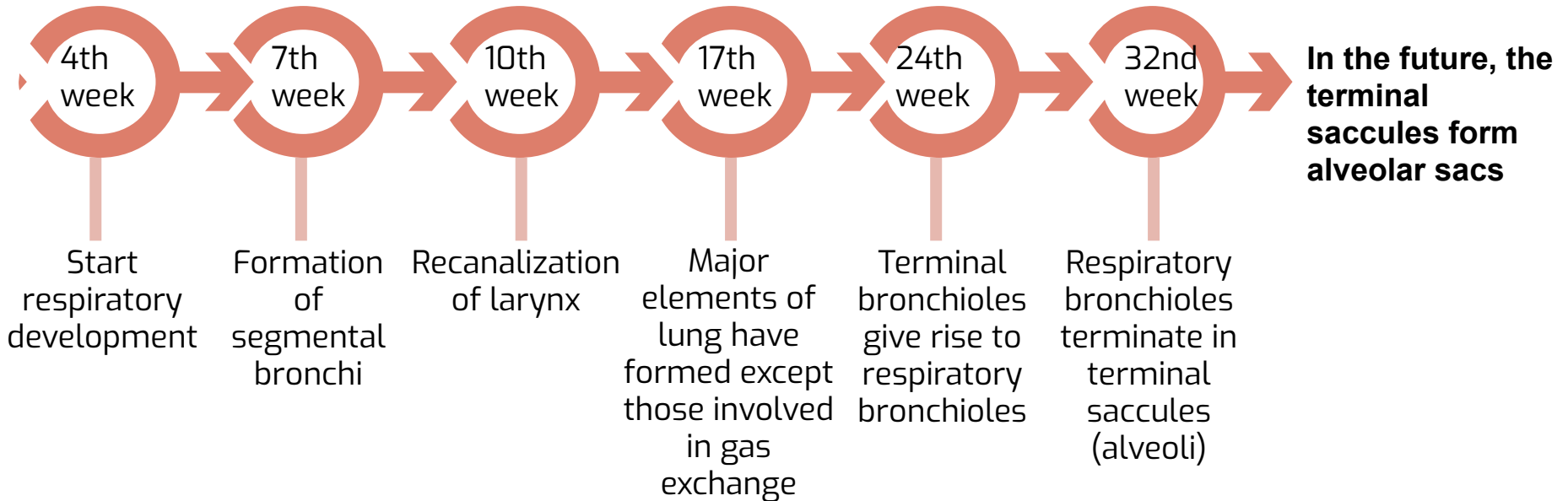
An abnormal passage between the trachea and esophagus.

- 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 birth , most affect male.

In more than 85% (90%) of cases, the fistula is associated with esophageal atresia (esophagus winds in blind ended pouch rather than connecting normally to the stomach.).

في هذه الحالات يكون فيه مشكله في الفاصل بين الحنجرة والبلعوم ويمكن يكون المريء مغلق بالنهاية ف الأكل ما يوصل للمعدة مما يسبب مشاكل ويكون علاجها جراحيا





MCQ

Q1: when does the respiratory tract start development?

- A.**10th week
- B.**4th week
- C.**24 week
- D.**17 week

Q4: the muscles of larynx derived from?

- A.**2&3 arches
- B.**endoderm
- C.**4&6 pharyngeal arches
- D.**mesenchyma

Q2: the dorsal portion gives rise to?

- A.**lung buds
- B.**larynx
- C.**esophagus
- D.**mesoderm

Q5: recanalization of the larynx at which week?

- A.**26
- B.**4th
- C.**10th
- D.**40

Q3: the endoderm gives rise to?

- A.**epithelium
- B.**cartilage
- C.**glands
- D.**A&C

Q6: abnormal passage between the trachea and esophagus?

- A.**tracheo-esophageal fistula
- B.**epiglottis abnormalities
- C.**tonsillitis
- D.**peptic ulcer

6:A
5:C
4:C
3:D
2:C
1:B
answer key:

MCQ

Q7: In which week does the segmental bronchi begin to form?

- A.** 10th week
- B.** 9th week
- C.** 8th week
- D.** 7th week

Q10: fetuses born during this period may survive but may suffer from respiratory distress

- A.** Alveolar period
- B.** Terminal sac period
- C.** Canalicular period
- D.** Pseudoglandular period

Q8: the pleura which covers the lungs is derived from which mesodermal tissue?

- A.** Somatic mesoderm
- B.** Splanchnic mesenchyme
- C.** Pericardioperitoneal canal
- D.** Pleural cavity

Q11: which statement describes the left main bronchus in relation to the right main bronchus?

- A.** Shorter and wider
- B.** Longer and narrower
- C.** Oriented more vertically
- D.** Both A & C

Q9: which event does NOT take place by the 24th week?

- A.** Establishment of the blood-air barrier
- B.** Development of terminal sacs
- C.** Surfactant production
- D.** Developing lungs somewhat resembles an exocrine gland

Q12: the majority of this structure develops postnatally

- A.** terminal sacs
- B.** Endothelial cells of capillaries
- C.** Bronchioles
- D.** alveoli

12: D
11: B
10: B
9: D
8: B
7: D
answer key:

SAQ :

1 : describe the periods of maturation of the lungs with their duration.

2 :what is the name of the septum which divides dorsal and ventral tubes?

3 :endoderm and mesoderm gives rise to ?

SAQ Answers

1 : slide 10

2 : slide 4

3 : slide 5

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