Development of the Respiratory System

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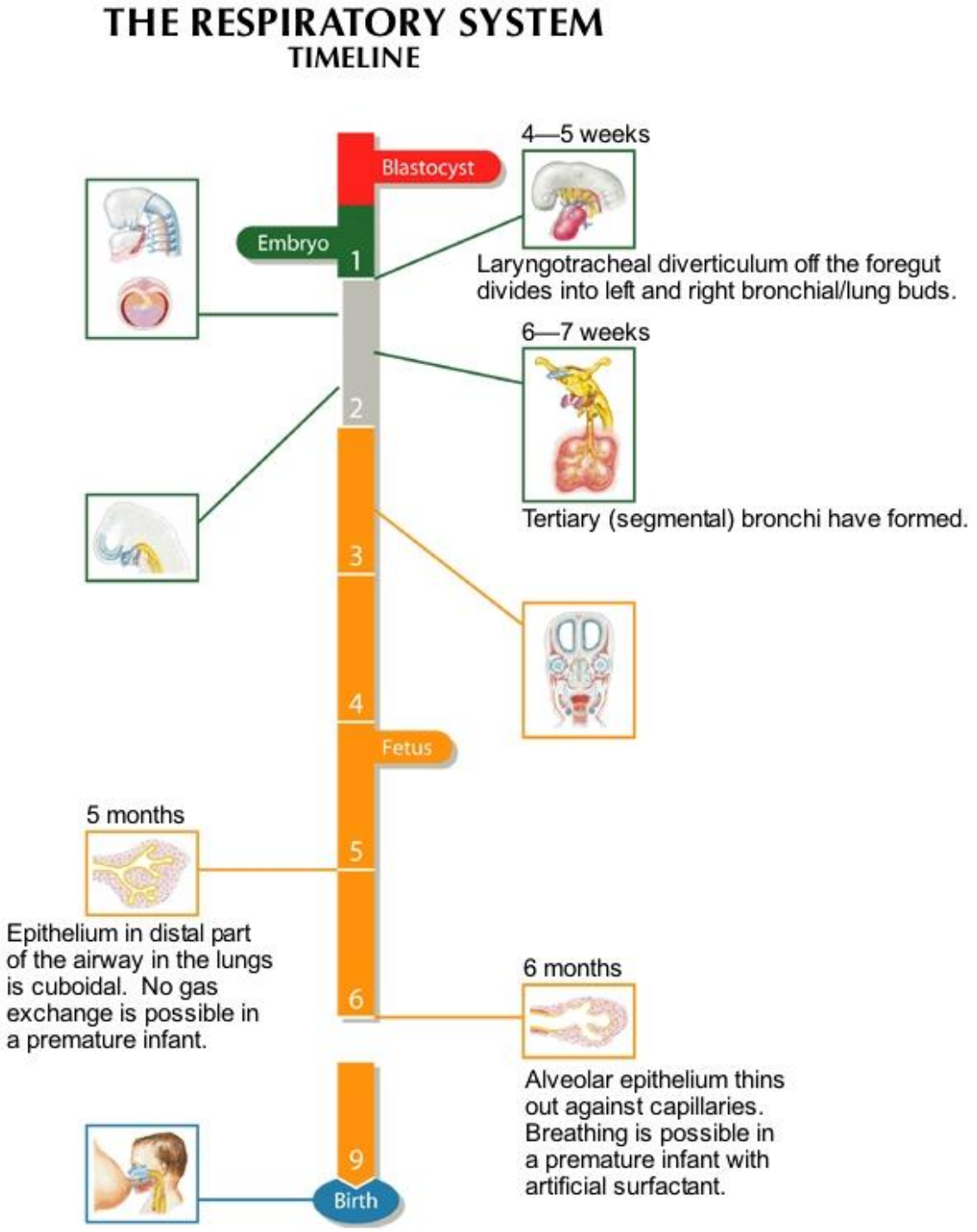
Prenatal time scale (in months)



(Cochard 2002)

Plan of development

- The primordia for the respiratory system consists of ***upper*** and ***lower*** *airway*:
- The main event in the ***upper airway*** is the division of stomodeum by the palate into separate respiratory (nasal) and gastrointestinal (oral) components .
- The development of the ***lower airway*** is characterized by the creation of the ***pleural cavity*** and ***extensive branching of the airway*** within it. The continuous intraembryonic coelom is partitioned into separate pleural, pericardial and peritoneal components, each lined by mesothelium. A bud from *the* ***laryngotracheal diverticulum*** pushes into the pleural sac and continues to branch for more than 22 generations to produce a surface area of 85 m^2 for gas exchange between alveoli and the blood stream.

Formation of the pleural cavity

- 3-week embryo has three **germ layers**

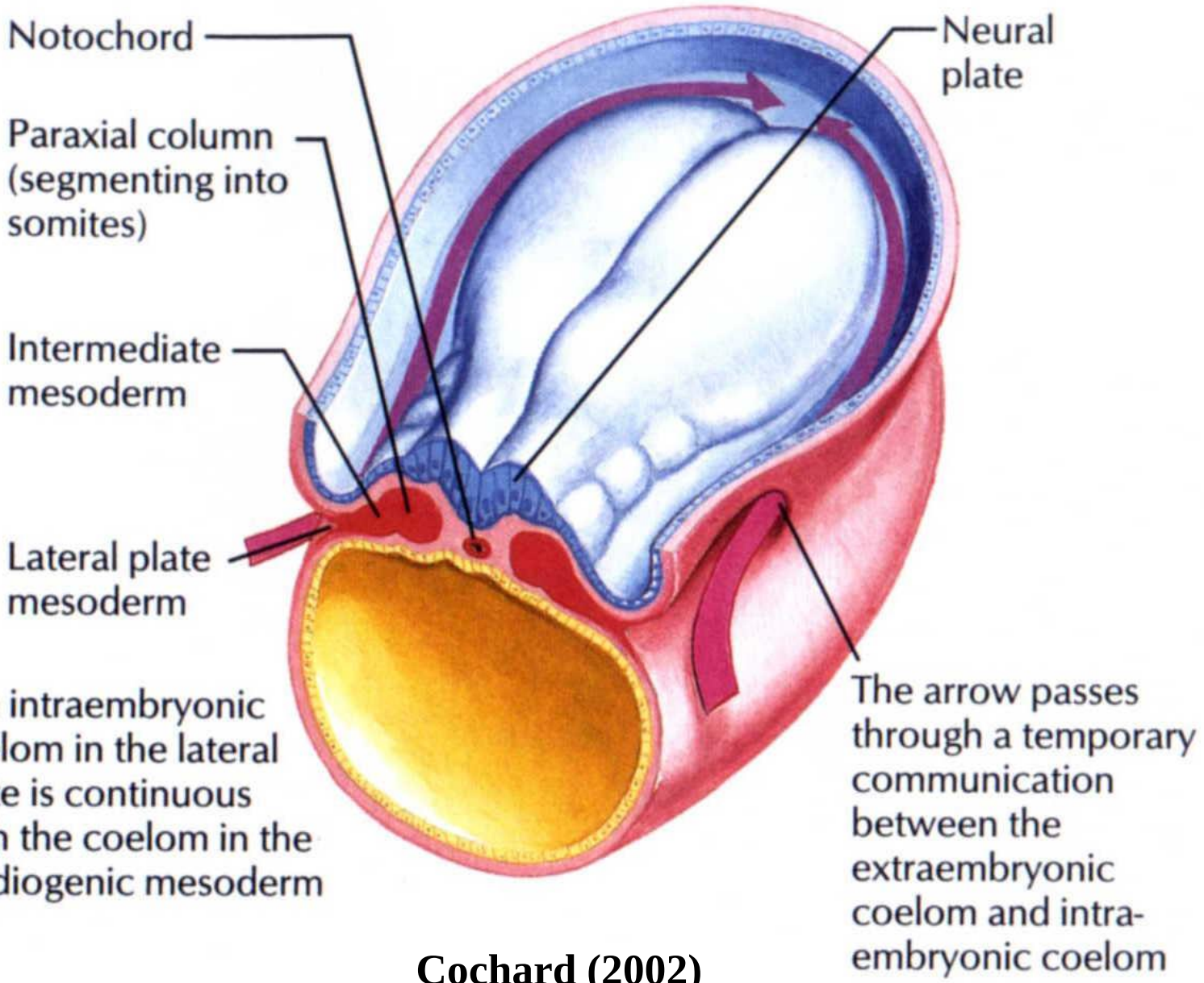
  Ectoderm

  Mesoderm

  Endoderm

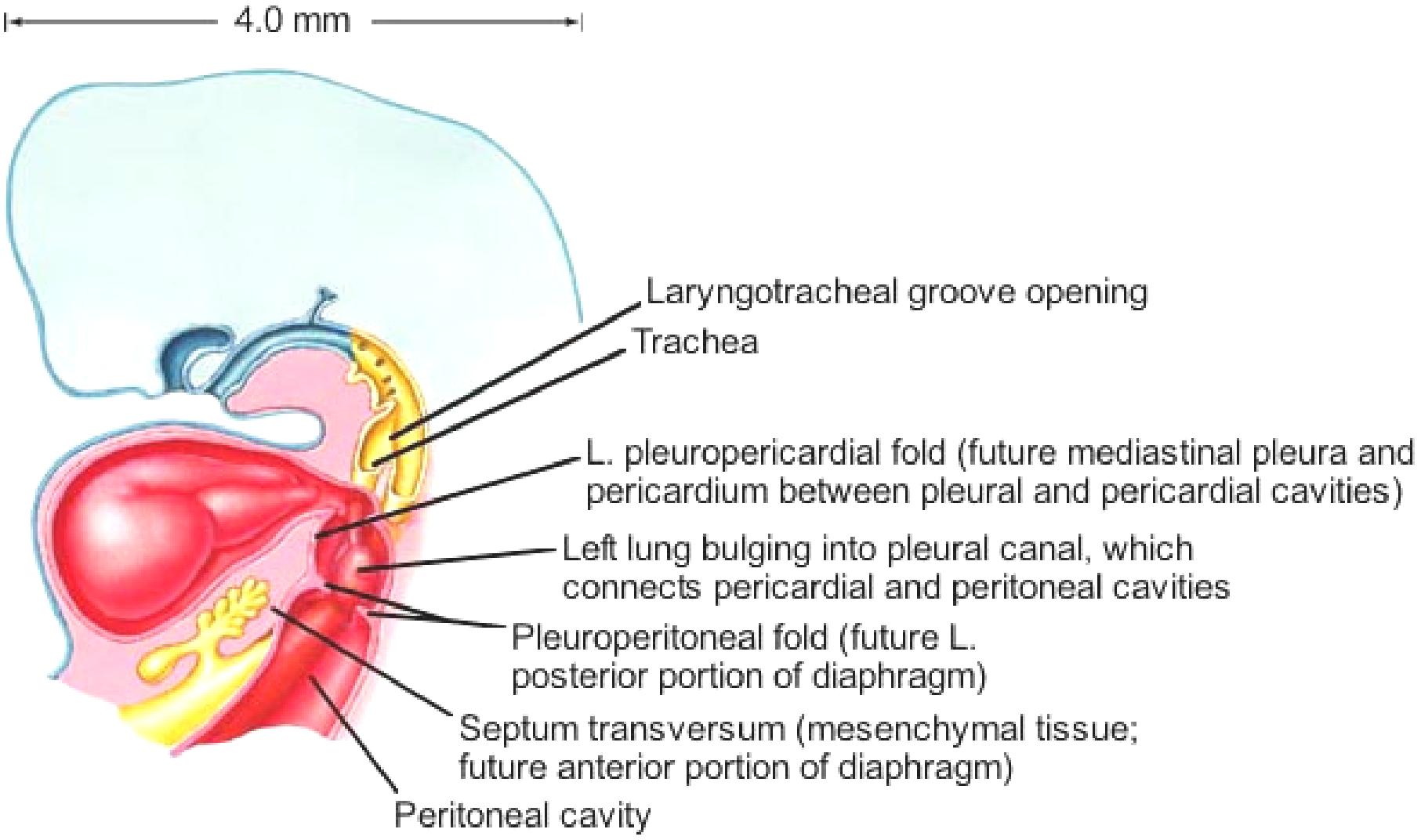
- **Intraembryonic coelom** is formed from lateral mesoderm

3rd week embryo



Cochard (2002)

Sagittal section at 5-6 weeks

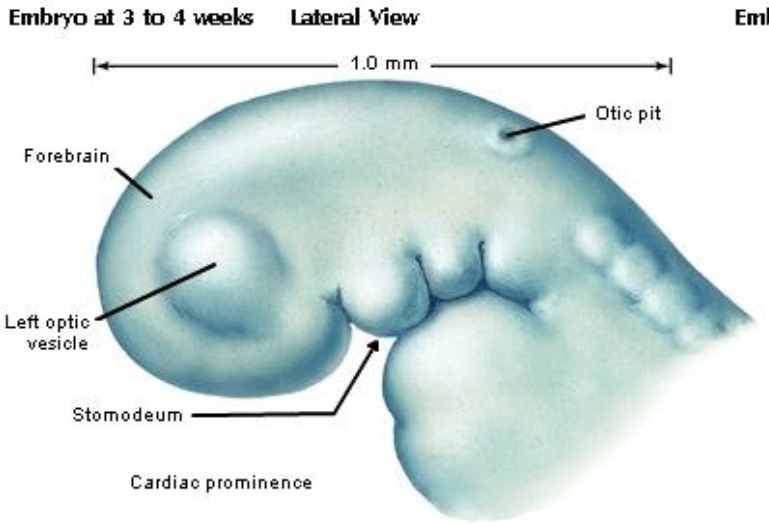


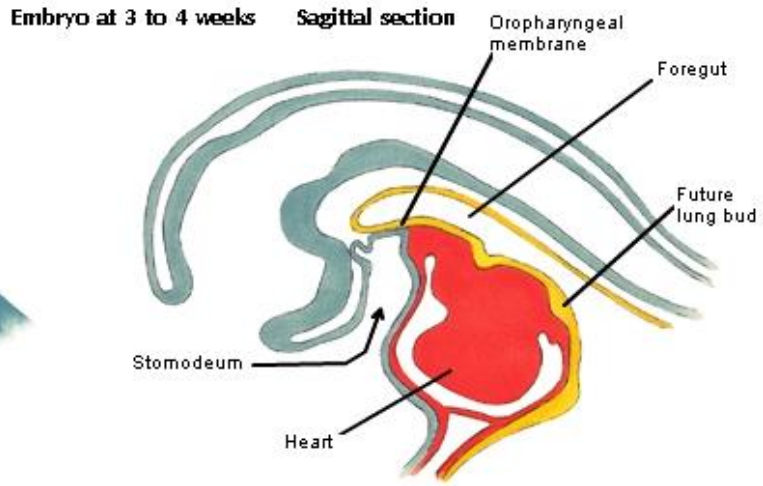
Cochard, 2002

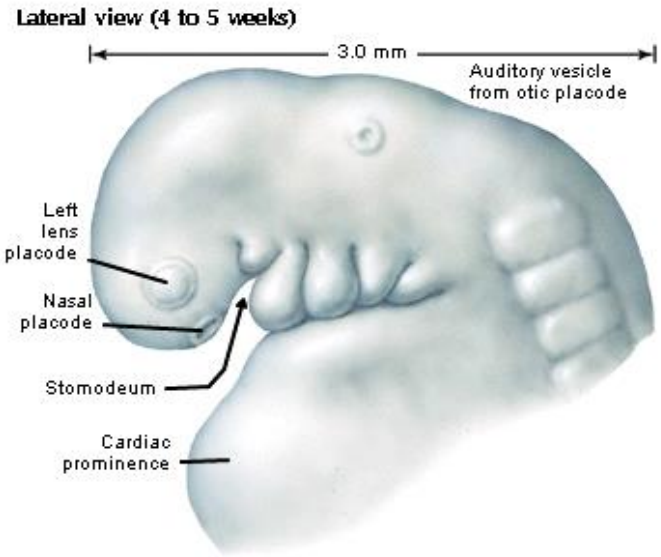
The Respiratory System

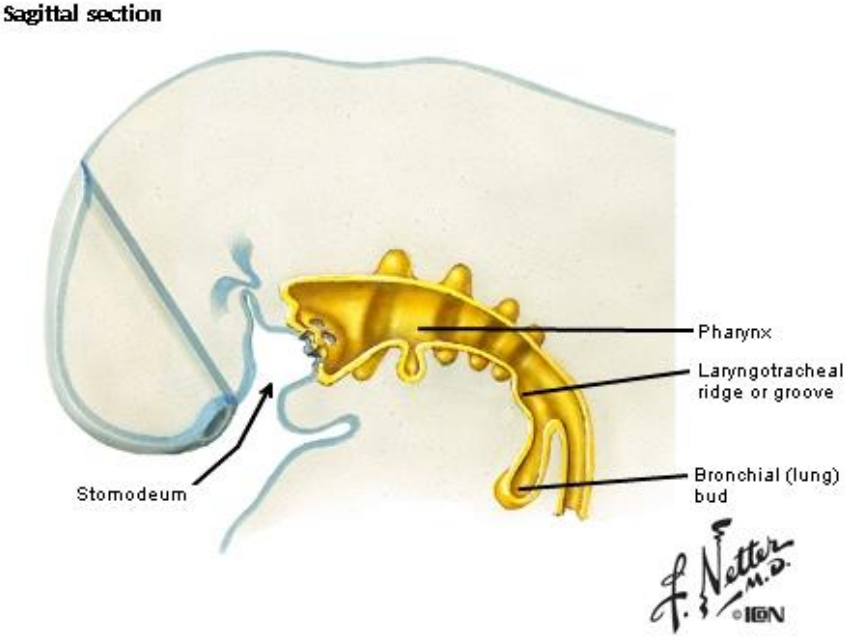
- The ***upper airway*** – division of the **stomodeum** by the ***palate*** into the **nasal** (respiratory) and **oral** (gastrointestinal) components.
- The ***lower airway*** – creation of the pleural cavity and extensive branching of the airway within it.

Early Primordia

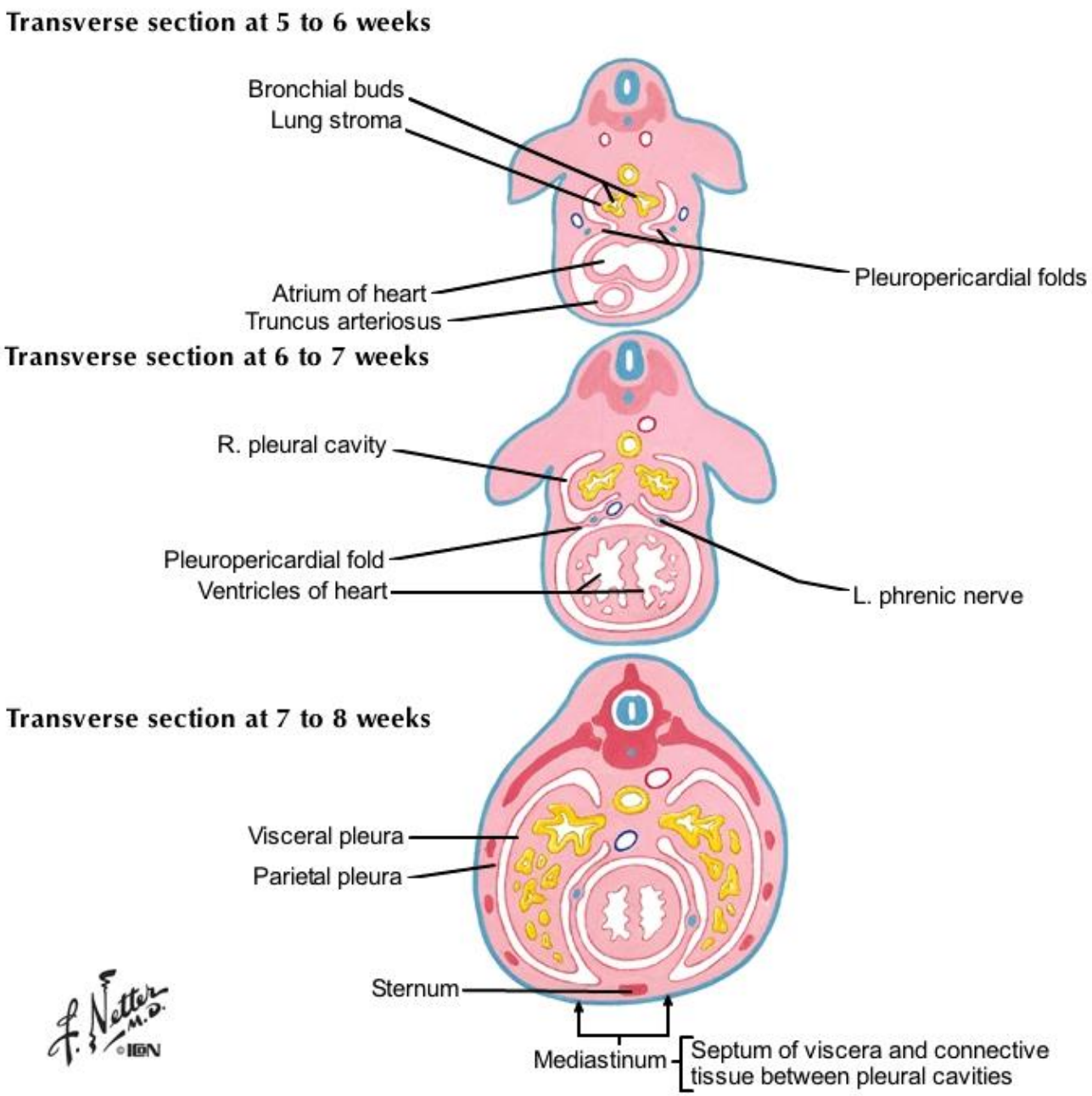








Visceral and Parietal Pleura

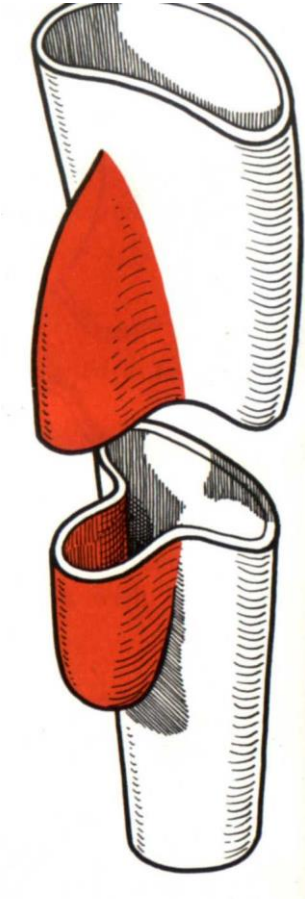


Formation of the pleural cavity

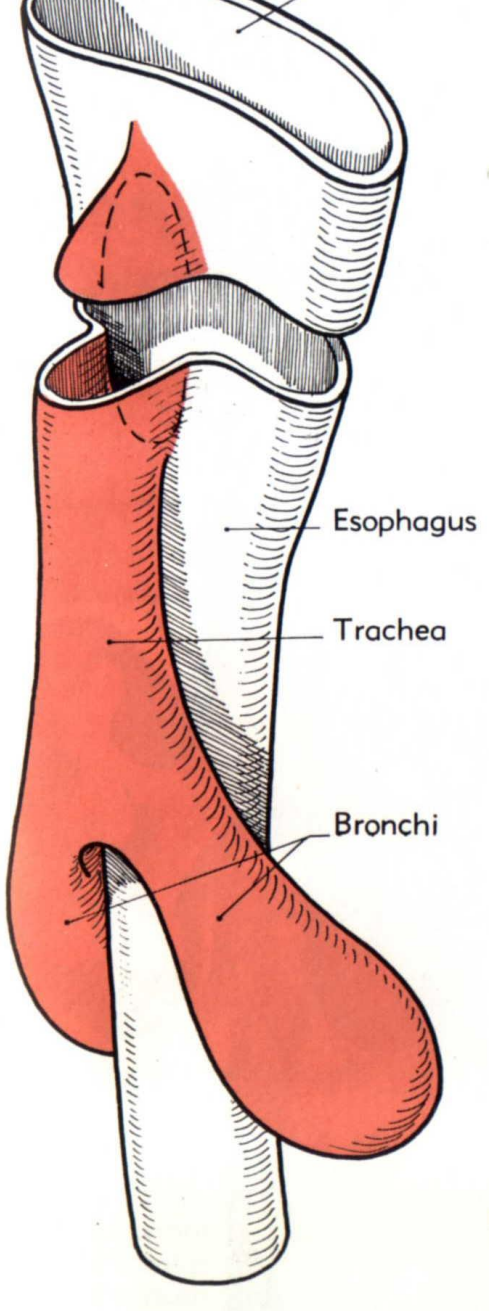
- The U-shaped ***coelomic cavity*** is partitioned into separate ***pleural*** (2), ***pericardial*** (1) and ***peritoneal*** (1) cavities.
- Division of the pleural and pericardial cavities is by fusion of ***pleuropericardial folds***.
- The ***septum transversum*** and ***pleuro-peritoneal*** membranes forms the **diaphragm** separating the peritoneal cavity from the pleural cavities.

Development of the airway

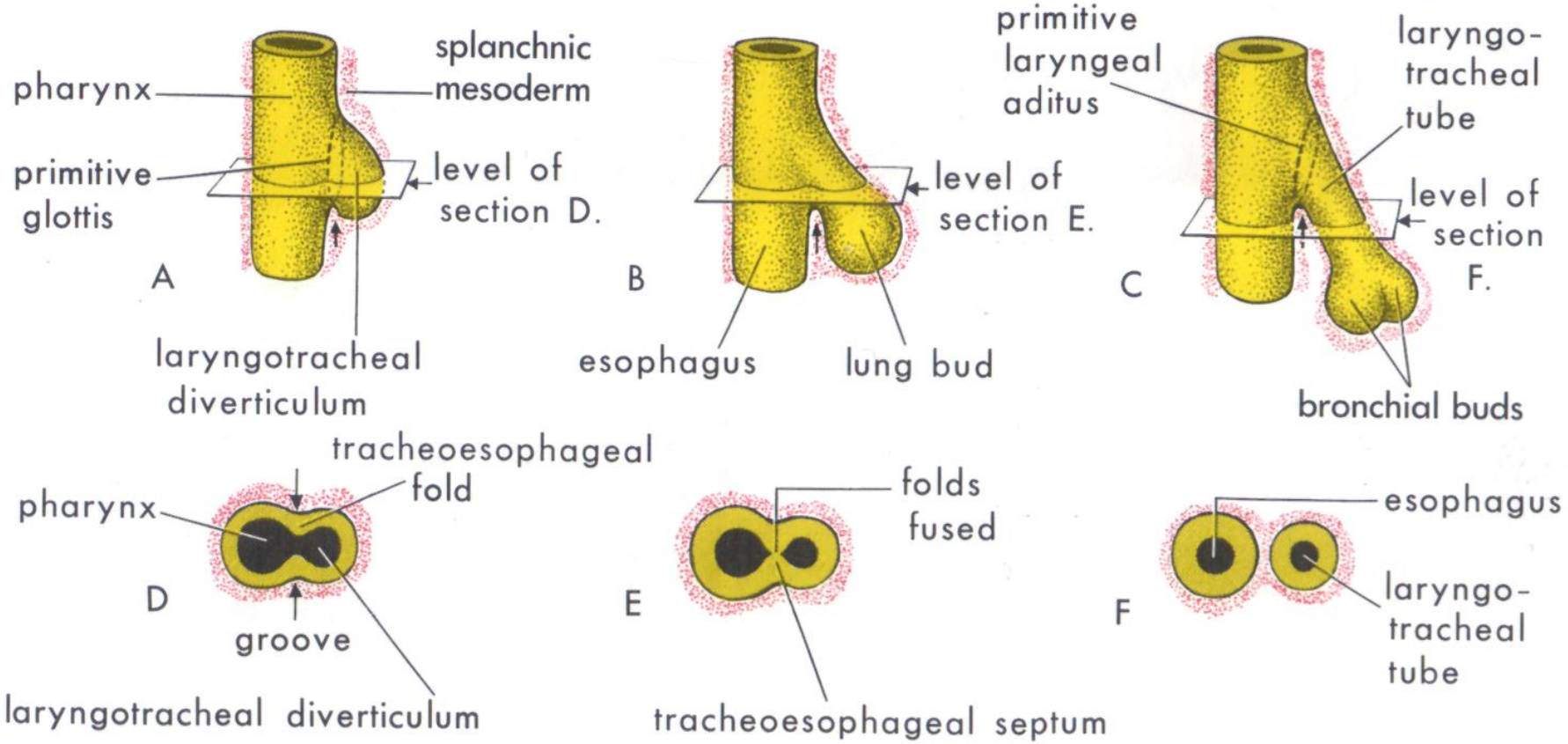
- **Respiratory primordium** is a median outgrowth from ventral part of pharynx, the **laryngotracheal groove**.
- At the end of the 4th week, the groove forms a pouch-like diverticulum, **laryngotracheal diverticulum**.
- The growth of a longitudinal **oesophago-tracheal folds** separate the *ventral* **laryngo-tracheal tube** from the *dorsal* **oropharynx** and **oesophagus.**



Laryngotracheal groove
4th week



Laryngotreal diverticulum



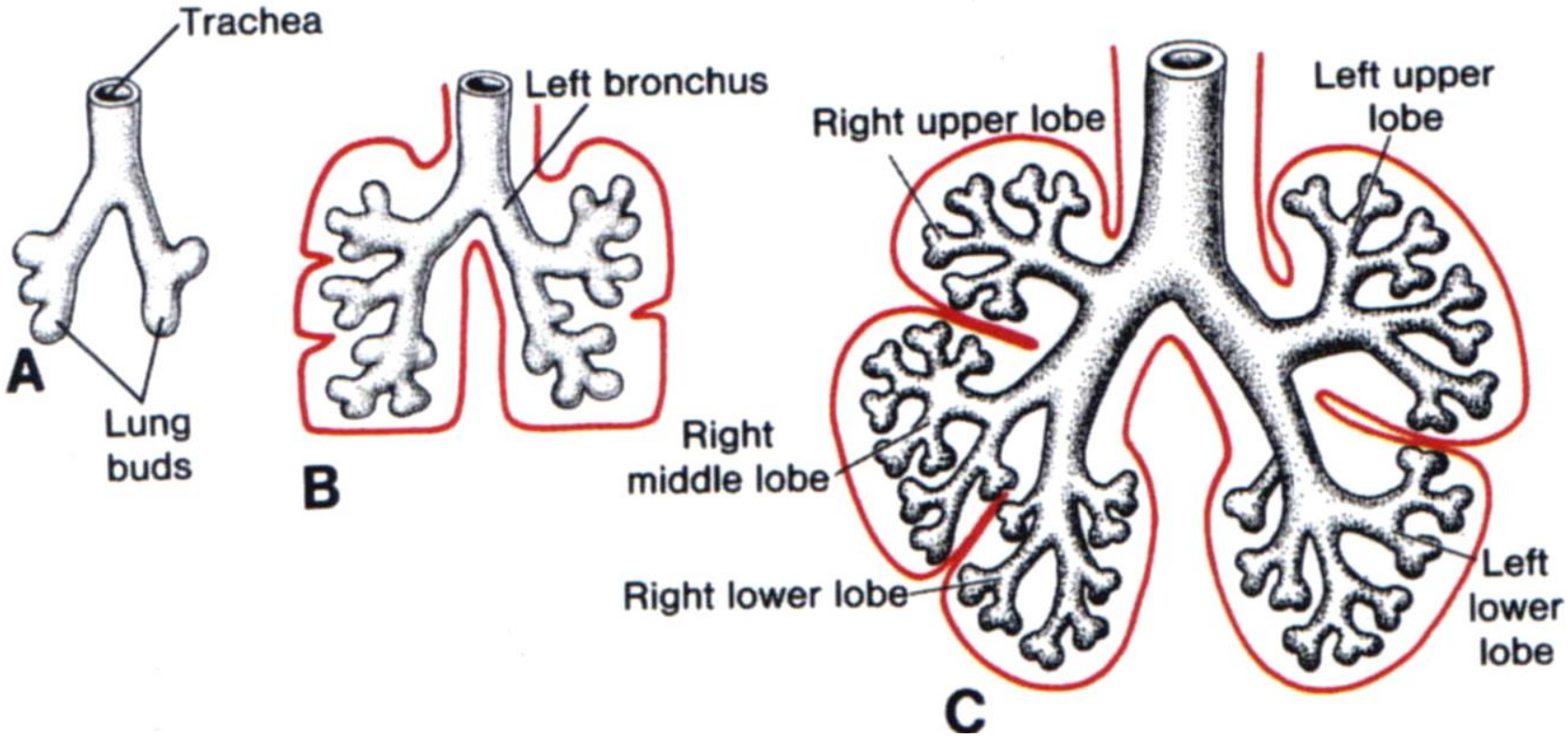
Successive stages in the development of the tracheoesophageal septum during the 4th and 5th weeks

Sadler 2004

Development of the trachea and bronchi

- The endoderm lining the laryngotracheal tube differentiates into the typical respiratory epithelium and glands.
- The laryngotracheal diverticulum branch into the **main (primary) bronchi**.
- The next divisions give **secondary** and **tertiary bronchi**.
- Up to the 18th division, unequal divisions may give rise to accessory lobes.

Development of the trachea and main bronchi



5-wk Primary bronchi

6-wk Secondary bronchi

8-wk Tertiary bronchi

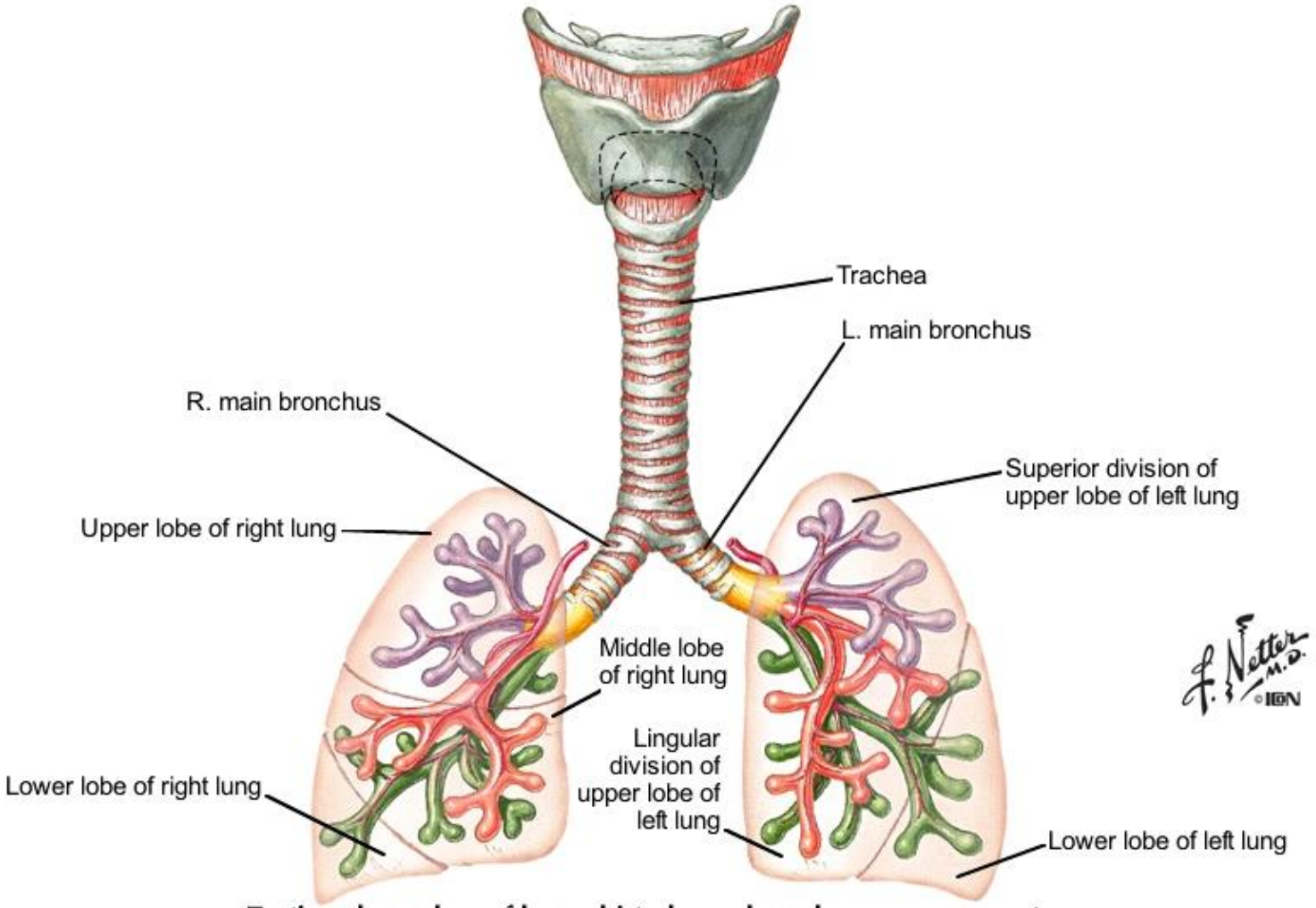
Sadler 2004

Development of bronchioles and alveoli

- Tertiary bronchi continue to divide for many generations: total ranges from 23 to 30+.
- The bronchial tree terminates in **alveoli**, the sac-like structure.
- About one-sixth of the adult number of alveoli are present at birth. The remaining develop in postnatal life.

Airway Branching

Larynx, Tracheobronchial Tree, and Lungs at 7 to 10 Weeks



Tertiary branches of bronchi to bronchopulmonary segments

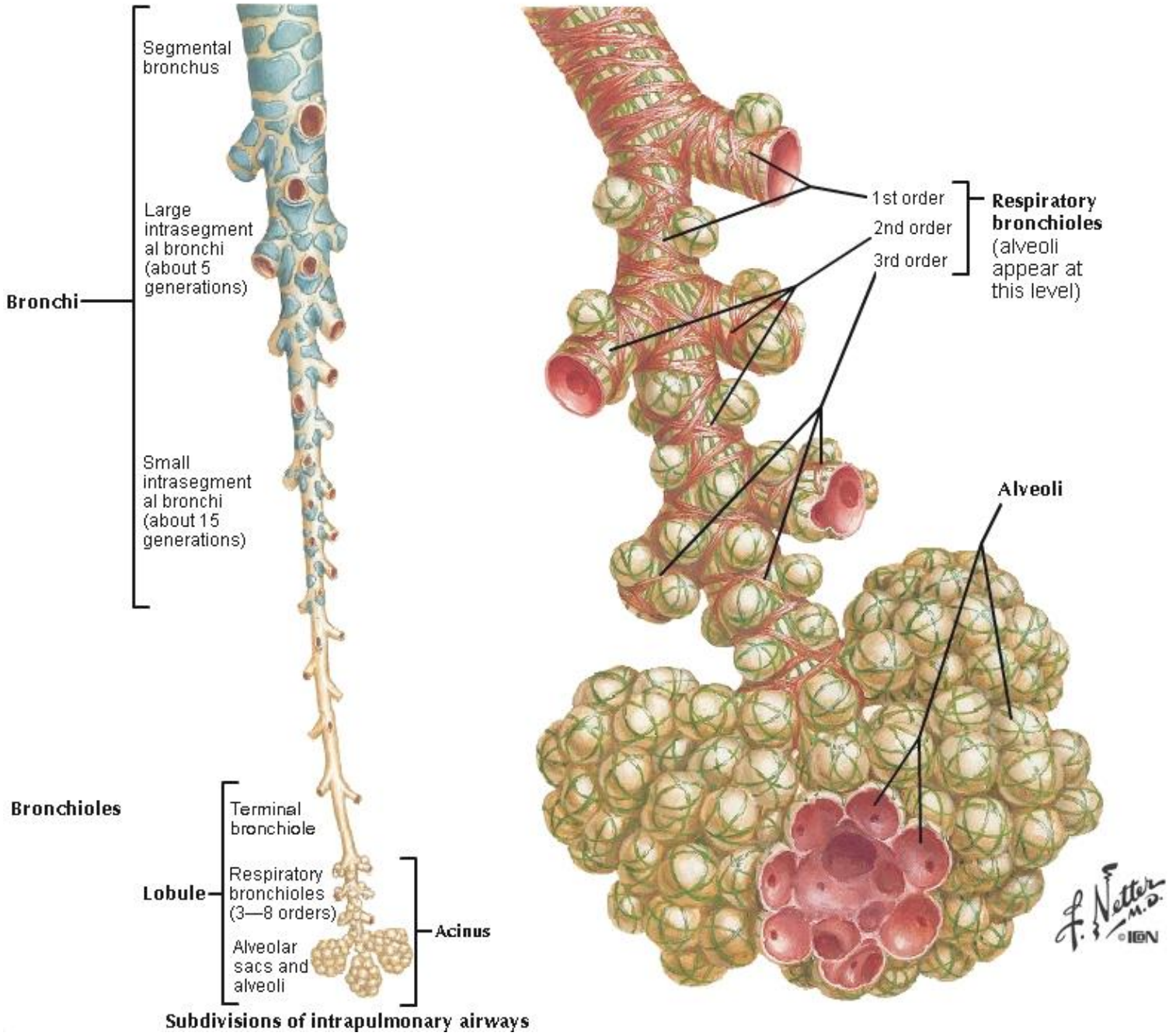
Right lung

- Upper lobe
- Middle lobe
- Lower lobe

Left lung

- Upper lobe
  - Superior division
  - Lingular division
- Lower lobe

Airway Branching



Subdivisions of intrapulmonary airways

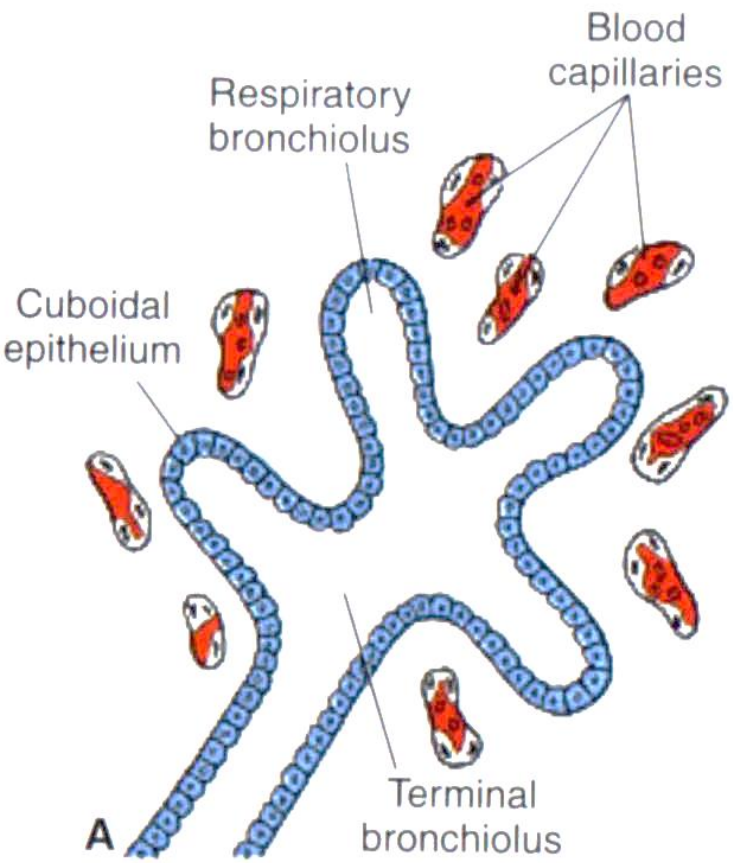
Bronchial epithelium maturation

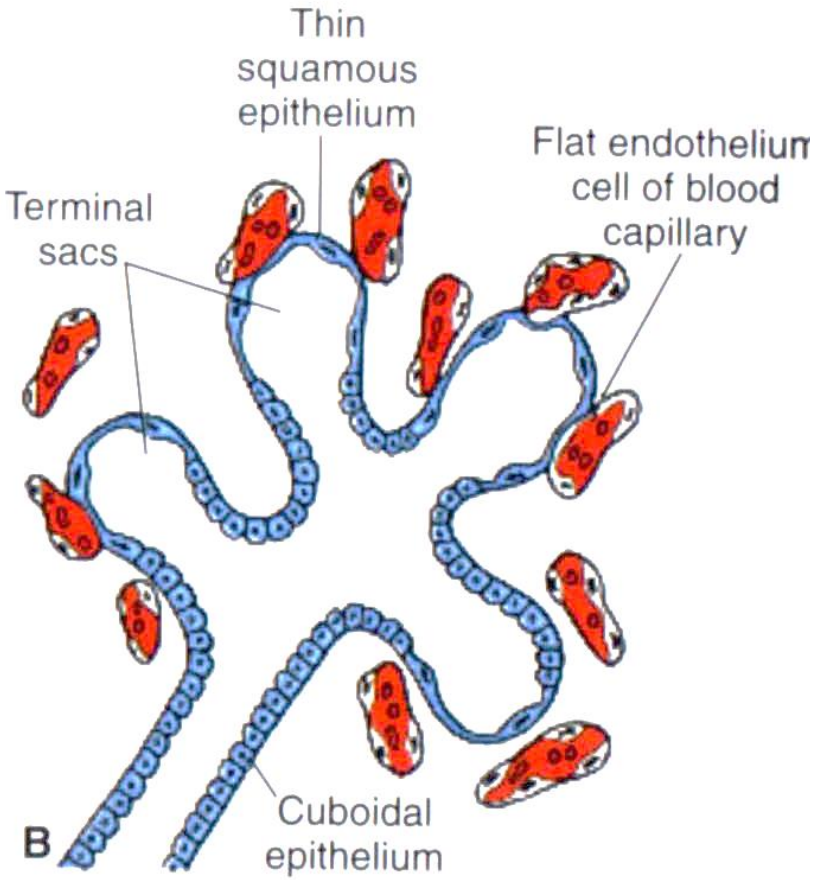
(1) The **pseudoglandular period** (5 -17th wk) - lined by tall columnar epithelium.

(2) The **canalicular period** (16-24th wk) – the respiratory portion separate from alveolar ducts lined by cuboidal cells.

(3) The **terminal sac period** (24th wk to birth) – cuboidal cells become very thin and intimately associated with blood and lymph vessels.

(4) The **alveolar period** (from birth to childhood) – a period of rapid growth and maturation.





Canalicular period -
16 - 24 weeks

Terminal sac Period
24 weeks - birth

Maturation of the bronchial epithelium

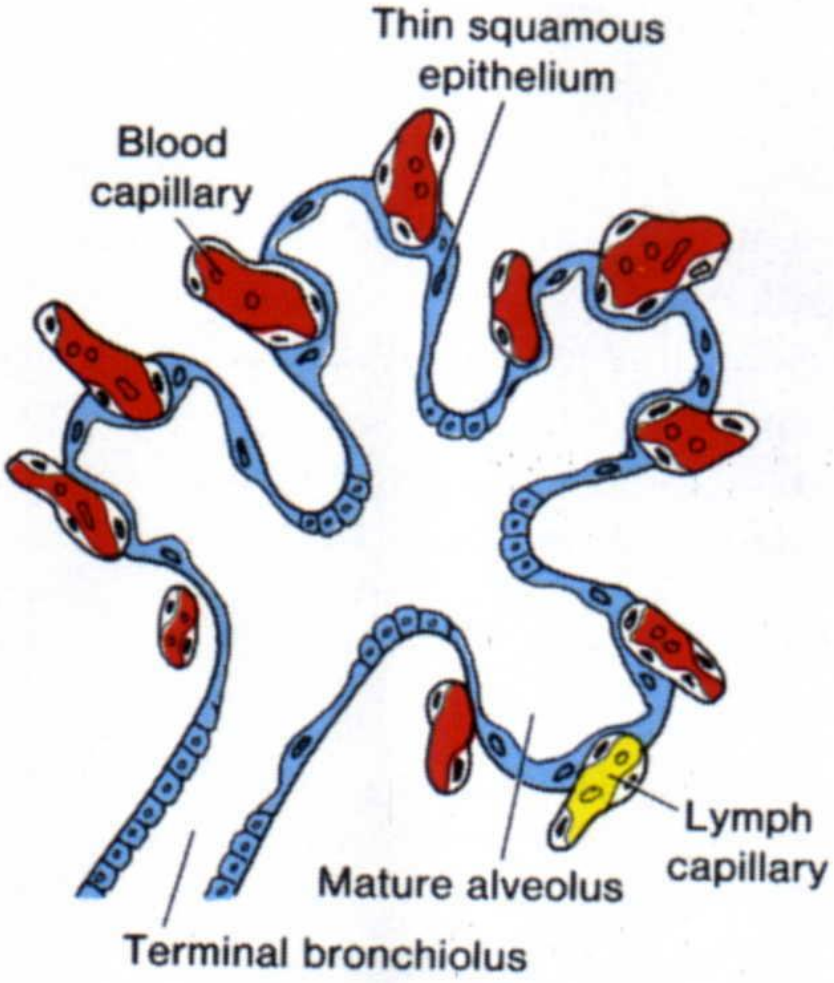


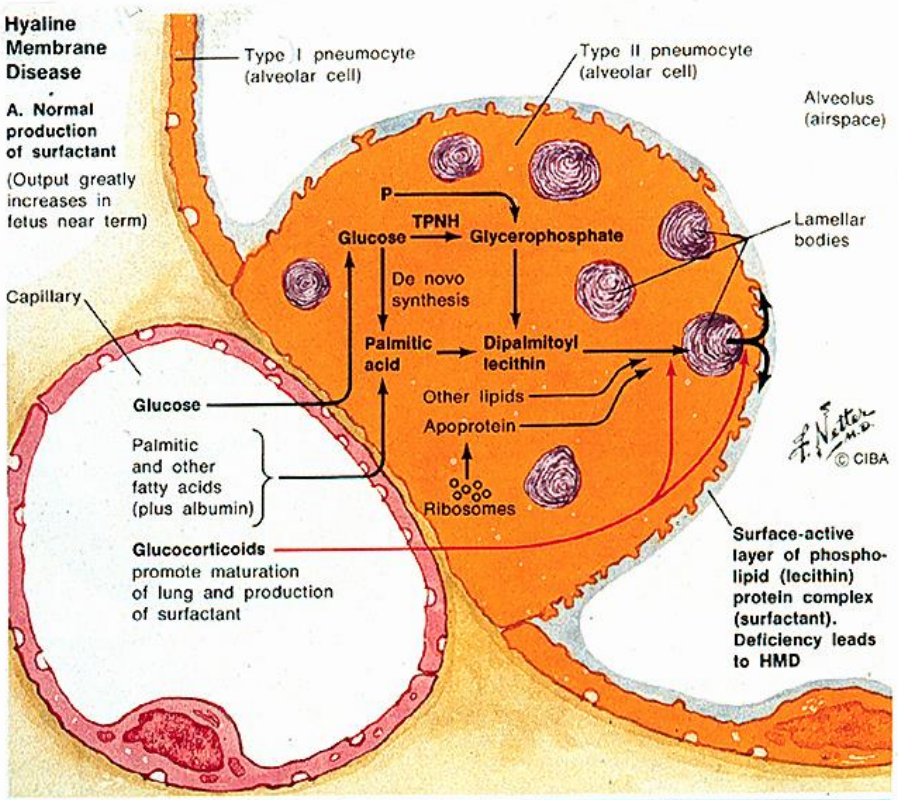
Figure 12.9. Lung tissue in a newborn. Note the thin squamous epithelial cells (also known as alveolar epithelial cells, type I) and surrounding capillaries protruding into mature alveoli.

Sadler 2004

Changes before and after birth

- Fetal breathing movement before birth aspirates amniotic fluid into the lungs.
- At birth the lungs inflated by fluid have to be replaced by air. Clearance is by:
  - Expulsion by pressure on the thorax during delivery
  - The fluid enters into lung capillaries
  - Passing into the lymph vessels
- The **surfactant coat** prevents alveoli from collapse.

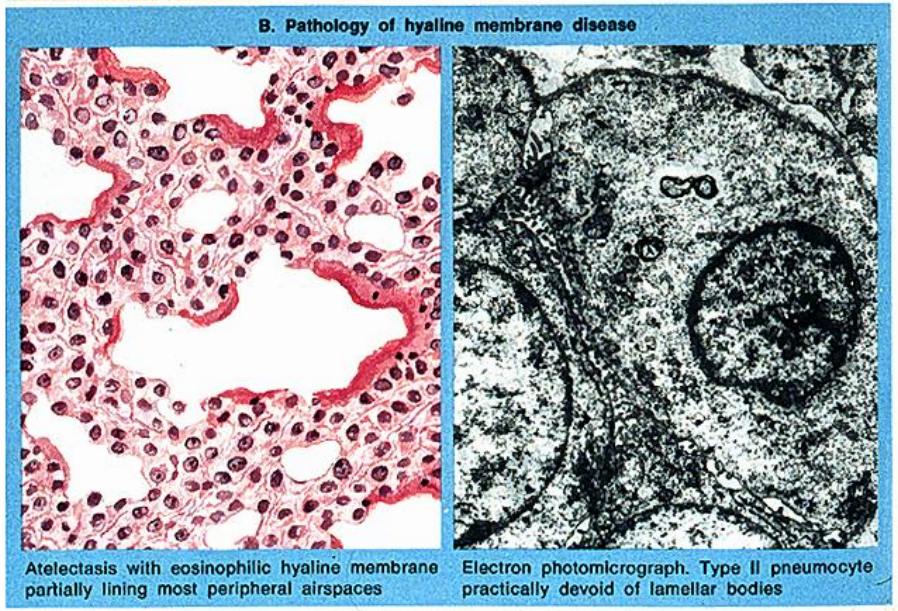
Pneumocyte type II secretes surfactant (DPPC –dipalmitoyl phosphatidylcholine)



Hyaline membrane disease (or respiratory distress syndrome):

Causing **atelectasis**

(*ateles*; *ektasis*)



Netter, 2004

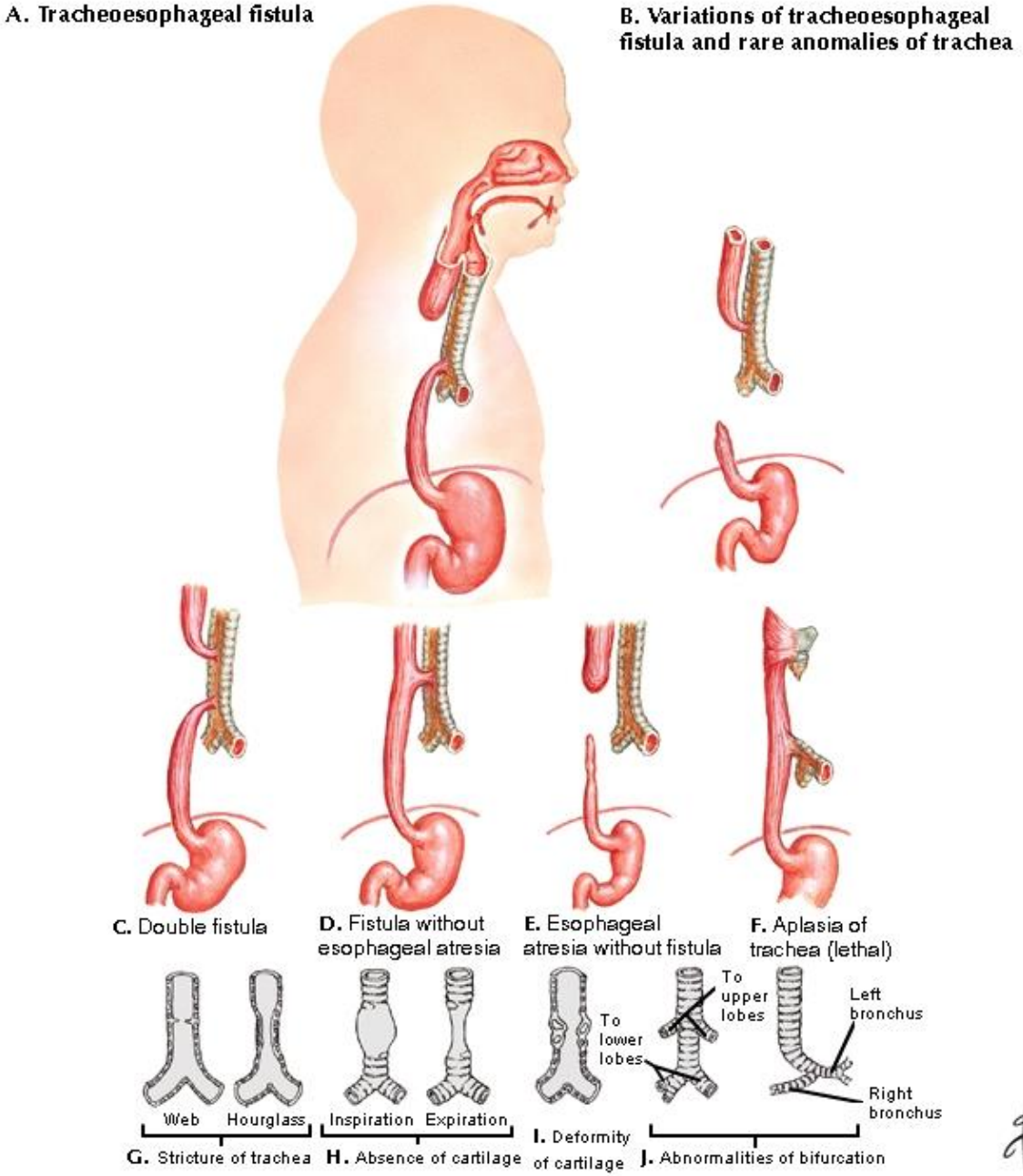
Congenital malformation

(1) ***Tracheoesophageal fistula*** is the most common anomaly of the lower respiratory tract.

(2) ***Respiratory distress syndrome*** (RDS). A deficiency or prolonged asphyxia makes the lung under inflated causing damage to alveoli.

(3) ***Congenital diaphragmatic hernia***. This is the most common diaphragmatic hernia.

Congenital Anomalies of the Lower Airway



Development of the diaphragm

- The diaphragm develops from 4 primordia

  Septum transversum,

  Pleuroperitoneal membranes

  Mesentery of the esophagus

  Cervical somite myotomes
- The septum transversum develops adjacent to the cervical region and then it “descends” relative to the growth of the embryonic trunk. It carries with it the phrenic nerve, the ventral ramus of spinal nerves C3, C4 and C5.
- The most common diaphragmic hernia results from a failure of the pleuroperitoneal membrane to grow across the intraembryonic coelom, resulting in distended thorax and flat stomach region.

Congenital Diaphragmatic Hernia