Development of the nasal cavity:

several processes contribute to the development of the nose, the nose consists of 2 cavities separated by a septum, and the nasal cavity is separated from the oral cavity by the palate (hard + soft palate).

So we have:

1- frontonasal process: from It's name, It comes from the frontal bone and descends downward and contributes to the formation of the septum.

2- Maxillary process

3- mandibular process and below it is the 2\textsuperscript{nd} and 3\textsuperscript{rd} pharyngeal arches

4- olfactory pit: it's a small opining in the end of frontonasal process; it will increase in size and forms the nostril. Lateral to the nostril is the lateral nasal process, medial to it is the medial nasal process, and those are the nasal processes. Inferior to the nostril is the maxillary process. These processes will grow and fuse with each other.

The medial nasal process will form the tip of the nose, maxillary process will form the roof and the lateral wall, and the lateral nasal process will contribute to the formation of the lateral wall.

These processes after growth will fuse with each other, specially the maxillary process, which will form the hard palate and separates the nasal cavity from the oral cavity.
Buccopharyngeal membrane (stumodium): ruptures and separates nasal cavity form the oral cavity.

so the maxillary process with lateral nasal process will form the roof and lateral wall of the nose, and the Olfactory pit forms the nostril and then becomes deeper to form the vestibule(which contain thick hairs - vibrissae).

The floor of the nose, first it's very short and contains; medial nasal process, and the anterior part of the maxillary process on each side.
The olfactory pit ruptures, so communication occurs between the nasal cavity and the developing mouth, then separation.

- The doctor did points the previous structures that we
talked about on the slide and he mentions:
the palatal process of maxilla, it contributes to the
formation of the palate, which separates the nasal cavity
and the oral cavity.
The nasal septum which's formed as downward growth
from the frontonasal process and medial nasal process
when they meet.

the palatal processes of maxilla grow medially and fuse
with each other and with the nasal septum, completing
the floor of the nose.

Posteriorly, the choanae is formed which makes the
communication between the nasal cavity and the
nasopharynx.

on the lateral wall, we see the choncea which is bone
processes, invaginates in the lateral wall forming 3
choncea. Also on the lateral wall, we see the openings of
the paranasal sinuses which's a diverticula of the lateral
nasal wall extends into the maxilla, ethmoid, frontal and
sphenoid bones.

Note: at the end of the diverticula → cavity(sinus), so the
sinus is a cavity lined by mucosa and has a duct which
opines on the lateral wall of the nose.

Note: these sinuses reach their maximum size at puberty

► At birth, the nasal sinuses are small in size, and they
grow with the growing face.
The development of the palate:

The primary palate: formed from the end of nasal septum which in turn is formed by the fusion of medial nasal processes.

The secondary palate: the palatal process of maxilla grows medially and forms the secondary palate.

The fusion of the primary and secondary palate forms the hard palate.

Incisive foramen forms at the junction between the primary and the secondary palate and it is a passage for nerves and arteries.

The backward growth of the hard palate will form uvula, which's the end of the soft palate.

The lateral palatine processes will extend past the nasal septum and fuse to form the soft palate.

Clinical Note: cleft lip or cleft palate, it can be unilateral or bilateral; partial or complete, and sometimes it extends to the nasal cavity, it occurs usually in the upper lip because of failure of the maxillary process to fuse.

The union of the 2 folds of soft palate occurs during the 8th week and they fuse in the midline during the 11th week to form the uvula.

Development Respiratory system:

At the 4th week of pregnancy, the respiratory diverticulum (lung bud) forms from the anterior wall of the foregut (i.e. outgrowth from the ventral wall of the foregut)
The lining epithelium of the larynx, trachea, bronchi and lung are endodermal in origin.

The cartilage, muscles and connective tissue of the lung and trachea originate from the splanchnic mesoderm.

The splanchnic mesoderm surrounds the foregut and gives the mesenchyme of the muscles, cartilage and connective tissue of the trachea and lung.

The lung bud (diverticulum) initially opens and communicates with the foregut, but later it expands caudally and forms 2 esophageotracheal ridges.

These ridges fuse and form septum which separates anteriorly the trachea and lung buds from the esophagus posteriorly.

The respiratory premordium maintains its communication with the pharynx through laryngeal orifice.

The laryngeal orifice (initially slit-like then becomes T shaped) connect the larynx with the nasopharynx.

The sides of the nasopharynx forms the pharyngeal arches (from 1-6) which are important in the development of pharynx.
There are certain abnormalities that may arise during the development of trachea and esophagus:

- **esophageal atresia or tracheo-esophageal fistula (TEF):**

  90% of TEF variations are: blind proximal end of esophagus and distal fistula between esophagus and trachea.

There are many Complications that may occur with TEF like:

Polyhydramnios: results from inability of the amniotic fluid to pass through the proximal blind end of esophagus to the stomach and later to be excreted, so it will be back to the amniotic sac and cause increase in the amount of amniotic fluid in the amniotic sac which is called polyhydramnios.

Pneumonia: results from the passage of the stomach secretions through the fistula to the lung which leads to lung infection.

- the passage of air from the lung to stomach through the fistula will lead to stomach distention and bulging (air filled)

The TEF may be associated with other complications like:

- cardiac anomalies: like opening between 2 atriums (ASD), or opening between 2 ventricles (VSD).
- renal agenesis: absence of kidneys.

And too many other anomalies.

Other variants of TEF or esophageal atresia:

- proximal and distal blind ends without fistula.
- H-shaped TEF which is fistula between both proximal and distal ends of esophagus with the trachea. (around 1%)

- proximal fistula and distal atresia.

Babies born with TEF will need early surgical correction.

**The development of the larynx:**

As mentioned earlier, the larynx communicates with the nasopharynx through the slit-like laryngeal orifice which later become T-shaped, later become the adult shape larynx.

The lining epithelium of the larynx forms from endoderm.

The thyroid, cricoid, and arytenoid cartilage are formed from the mesenchyme of the 4th and 6th pharyngeal arches. Their lining epithelium proliferates rapidly to form temporary occlusion of the laryngeal lumen.

The recanalization of the lumen produces a pair of laryngeal ventricles with the saccule which is diverticulum that is bounded by folds of tissues that differentiate into false and true vocal cords.

Innervation of the laryngeal muscles (origin from 4th and 6th arches):

- superior laryngeal nerve: arise from the 4th pharyngeal arch and give the external laryngeal nerve that supply the cricothyroid muscle which is responsible for the pitch of the voice.

- recurrent laryngeal nerve: arise from the 6th arch,

So we can see that the development of nerves follows the development of muscles.
The laryngeo-tracheal tube forms the tracheal tube which divides distally to right and left lung buds.

In the fifth week, the right and left lung buds form the right and left primary bronchi.

In the 6th week, the rt and lt primary bronchi form the secondary bronchial buds (which are intrapulmonary).

There are 3 secondary bronchi on the right lung and 2 on the left lung.

The secondary bronchi will divide repeatedly in dichotomous fashion (2 -4 -8 ...) forming 10 tertiary bronchi on the right and 8 on the left which are called Broncho pulmonary segments.

During adulthood, on the left lung the apicoposterior tertiary bronchus in lt upper lobe divides to apical and posterior segments and the anteromedial tertiary bronchus in the rt lower lobe divides to anterior and medial segments.

At 6 months (after fertilization), the number of subdivisions is 17.

Postnatally, there are additional 6 subdivisions, so the total number become 23 subdivisions of bronchopulmonary segments.

Bronchioles form at the end.

After birth, the lung is still under development and as we said, the no. of bronchopulmonary subdivisions at birt is 17, and postnatally, there are additional 6, so the total is 23.

The lung alveoli continue to increase in size and so the lung till it reaches the complete inflation size.
The formation of lung pleura:

There are:

Parietal pleura and visceral pleura.

The lung buds grow through the coelomic cavity and the growth which is adherent to lung surface is called the visceral pleura and the growth which is adherent to the wall is called the parietal pleura and the space in between is the pleural space.

The growth of both visceral and parietal pleura is associated with a decrease in size of coelomic cavity (since the growth occur through the coelomic cavity).

The celomic cavity initially is in the form of pericardioperitoneal canal which separates to peritoneal cavity and pericardial cavity.

There is also pleuro-pericardial fold which separates into pleural cavity dorsally and pericardial cavity ventrally.

Note that both parietal and visceral pleura formed from the splanchnic layer of mesoderm.

The parietal and visceral pleura fuse to form 3 blind spaces around the hilum which forms the pulmonary ligament in mediastinum.

The phrinc nerve arise from C3 C4 AND C5 cervical spinal nerves and it descends between 2 coelomic cavities and while it descends, it innervates the medistinal surface of the parietal pleura. When it reaches the diaphragmatic surface, it supplies the diaphragm.
The visceral pleura receives autonomic innervation.

**Alveoli:**

The terminal bronchioles are lined by simple cuboidal epithelium.

The terminal bronchioles form respiratory bronchioles.

The blood capillaries are away from the terminal bronchioles and become closer as the terminal bronchioles form the respiratory bronchioles, so it is closer to respiratory bronchioles.

The lining epithelium changes from simple cuboidal in terminal bronchioles to simple squamous in respiratory bronchioles.

The respiratory bronchioles will form alveolar ducts that has close contact with the capillary endothelium.

The respiratory membrane consists of alveolar squamous cells, capillary endothelium and the fused basement membrane in between (fusion of basal laminas of both)

The respiratory membrane is different from interstitium in that interstitium consists of connective tissue and endothelial cells while the membrane consists of alveolar squamous cells and capillary endothelium with the basement membrane in between.

**The stages of alveolar development:**

**First stage:**

**Pseudoglandular**: from 5-16 weeks, during this period the bronchi continue to form terminal bronchioles. No respiratory bronchioles or alveoli formed during this stage.
The lining epithelium is simple cuboidal during this stage and the capillaries are at a distance.

**Second stage:**

**Canalicular period** between 16-26 weeks, each terminal bronchiole divides into 2 or more respiratory bronchioles which in turn divides into 3-6 alveolar ducts.

**Third stage:**

**Terminal sac period:** from 26 weeks – birth, during this stage, the primitive alveoli are formed and respiration is possible at age of 26 weeks (26 wks equals almost 6 months). During this stage, Specialized cells of the respiratory epithelium appear at this time, including type I alveolar cells across which gas exchange occurs, and type II alveolar cells which secrete pulmonary surfactant.

The surfactant can be given during this period to the mother to help in reducing the surface tension at the air-alveolar surface, allowing expansion of the terminal saccules.

**Fourth stage:**

**Alveolar:** from 8 months to childhood, during which the maturation of alveoli occurs and increase in size, but not in number. The contact with capillary endothelium is established and lymphatic capillaries are adherent.

Note: at the 7 month the premature infant is able to survive, has sufficient no. of capillaries and adequate gas exchange.

Note: at the beginning of respiration, the lung fluid is protein, mucous and surfactant. Absent or insufficient surfactant cause
respiratory distress syndrome also called hyaline membrane disease.

Growth of the lung after birth is mainly due to increase in number of alveoli and not in size.

The growth of the lung continues to age of 10 years but it is maximum at age of 6-8 weeks after birth.

Sorry for mistakes

your colleague: Sohaib Khalil