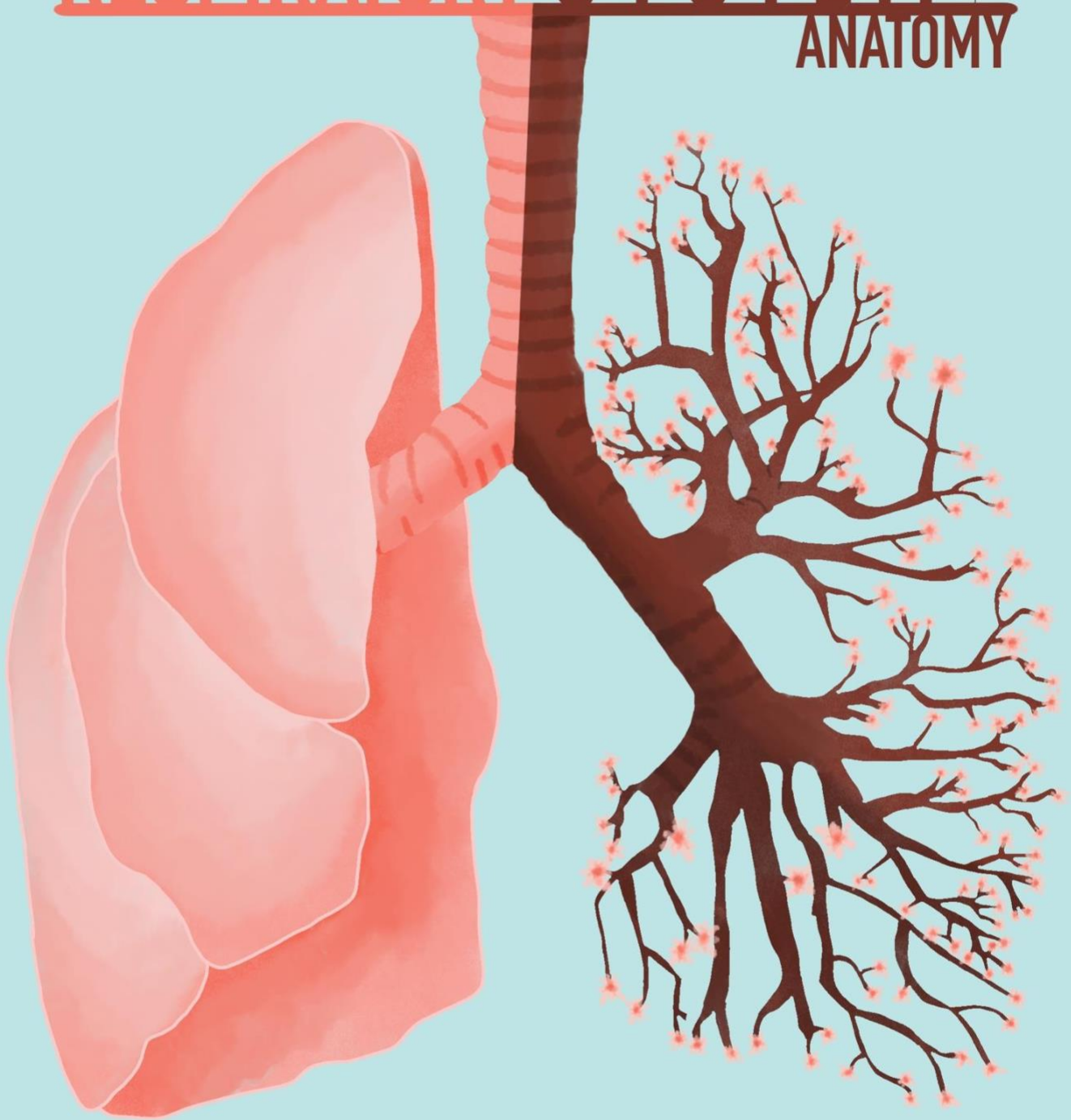


RESPIRATORY SYSTEM

ANATOMY



Title: Sheet 1 – Nasal Cavity 1

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Science: -

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Doctor: Dr.Mohammed Hisham Al-Muhtaseb

Color code: (green → from the slides *not mentioned by the dr, Red → newly mentioned in 2022 lecture)

Respiratory System Organs

The Respiratory tract starts from:

1) Nose (nasal cavity)

→ 2) Pharynx

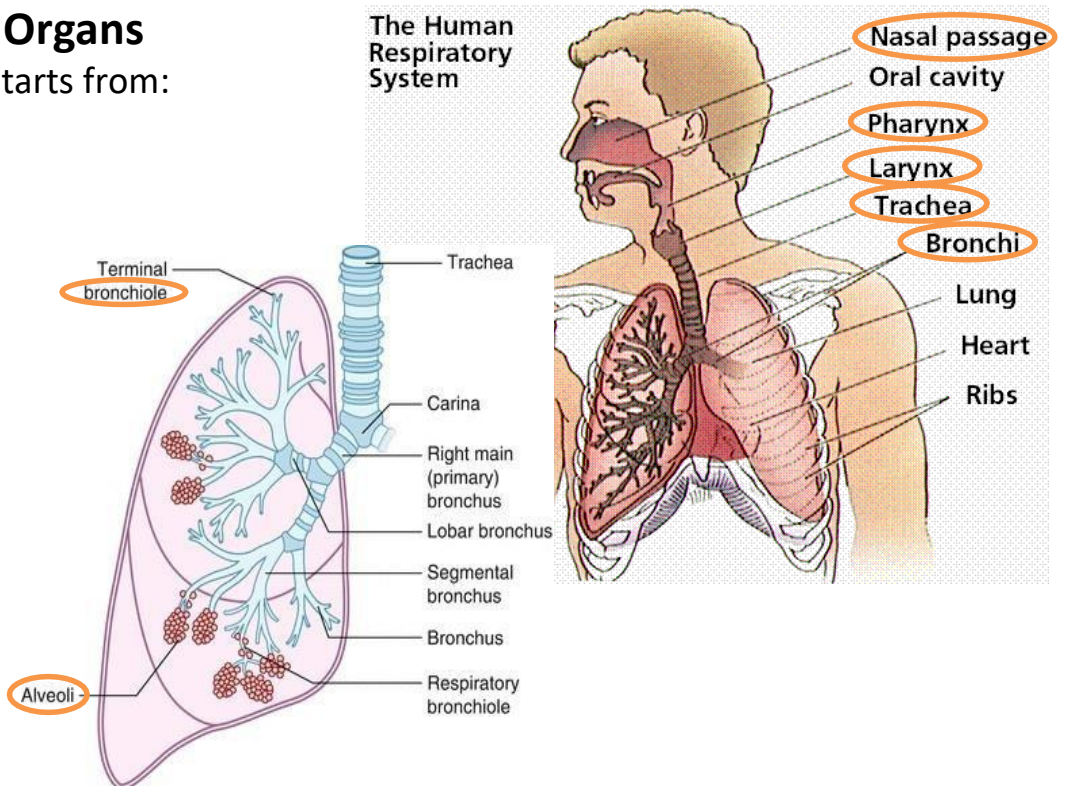
→ 3) Larynx

→ 4) Trachea

→ 5) Bronchi

→ 6) Bronchioles

→ 7) Alveoli



Side Notes

- Pharynx is divided into 3 regions according to location: Nasopharynx, Oropharynx and Laryngopharynx.
- Larynx is the site of phonation or where the articulation occurs, since it contains vocal cords that are responsible for speech.
- Trachea bifurcates to form 2 bronchi; main **right** bronchus and main **left** bronchus, each main bronchus further branches inside the lungs to form bronchioles.
- Bronchioles end in **alveoli** (a cluster of air sacs) **which are the main building unit that performs the lung function**
→ we have billions of them in the lungs, they're responsible for gas exchange, they are surrounded by a very large network of blood capillaries (the **largest** capillaries in the body) to give a large surface area for gas exchange.
- The **lungs** are surrounded by pleura (the same as the pericardium), two major types:
A) Parietal pleura: lines the thoracic cage -to be specific walls of the pleural cavity-
B) Visceral pleura that adheres to the lungs.
- Each **lung** has a hilum; the place where the bronchi and blood vessels enter the lung and the veins exit, it also contains nerves and lymphatics.

Functions of the respiratory system

1. Gas exchange, which occurs during respiration.

Normally the respiratory rate is 18-22 per minute, but we have some variations:

- A. During rest: Normal inspiration & expiration.
- B. During exercise: Deep inspiration & expiration = increase of respiration rate.
- C. Children have: Rapid respiration, it can reach >40/minute.

- Clinical note: First thing to check while being in the emergency is the respiration, if it stops for 2-5 minutes, brain death may occur.

Extra!! So, if respiration stops, we may do a tracheostomy (an opening in the trachea), or to put a nasal oryngal tube or named endotracheal tube (a tube in the trachea between true vocal cords), if you put it above the vocal cords, it may cause → adduction & suffocation.

2. Regulation of blood Ph.

In patients with respiratory disorders, we do gas analysis in the blood, which is the amount of O₂ and CO₂ in the arterial blood (not venous blood).

→ blood pH is determined by PCO₂ in the blood which is controlled by the respiratory system

3. Filters the inspired air

Filtration begins at the nose, the vestibule of the nose (nose bulge) contains thick hair called vibrissae, where the inspired air is firstly filtered from dust, bacteria, and viruses. glands in the lining epithelium of respiratory tract whose secretions also aid in filtering.

4. Contains receptors for smell, and produce vocal sounds (phonation)

The roof of the nose contains bipolar cells for smell sensation, and filaments of olfactory nerve “1st cranial nerve” (starting from the roof of the nose and ending in the smell center in the brain which translates this smell).

Also, the larynx contains true vocal cords, which are responsible for phonation or speech.

- there are 2 types of vocal cords: 1) True (produces voice or sound)
2) False (do not produce sound)

5. Excretes small amounts of water and heat. Warming the inspired air is important to protect internal organs from damage especially the brain

Histological layers of *respiratory tract*

Mucosa → **Submucosa** → **Supportive layer** → **adventitia**.

Mucosa: Common lining epithelium in the respiratory tract is pseudostratified ciliated columnar epithelium.

→ Exception: in bronchioles simple cuboidal/columnar ciliated (some could be non-ciliated)

In the **submucosa**: there is a gland responsible for mucous secretion, important for filtration of dust and foreign bodies and moisturizing the air, especially in the nose.

Supportive layer: cartilage (hyaline cartilage in the trachea) **OR** (smooth muscle in the bronchioles)

→ bronchi have cartilage as well to maintains them open, whereas bronchioles lack cartilage, this explains why asthma happens in bronchioles not in bronchi.

Structure-function correlation

The epithelium of the respiratory tract allows it to perform the filtration function
Pseudostratified + ciliated + mucus glands

Let's go deeply in the organs, starting from **THE NOSE**:

The Nose is divided into:

- 1) **External Nose** 2) **Nasal Cavity (Internal Nose)**

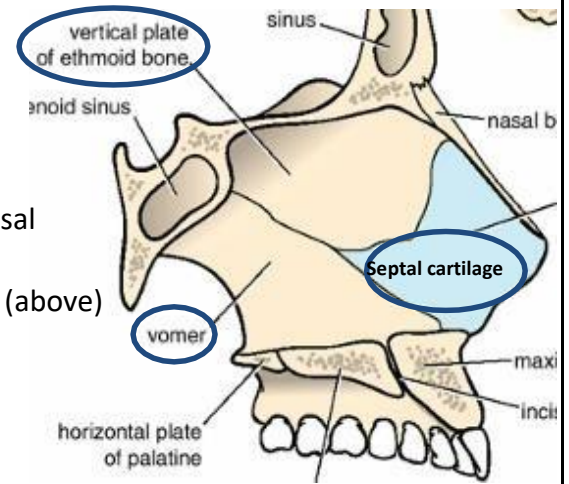
There are 2 nasal cavities, separated by a **septum** (aka medial wall of nasal cavity) the septum is divided into:

- A. septal cartilage (anteriorly) B. perpendicular plate of ethmoid bone (above)
 C. the vomer (posteriorly & downward)

Each nasal cavity has two openings (Anterior & Posterior)

Anterior opening → Nares, where air enters

Posterior opening → Choana which opens into the nasopharynx

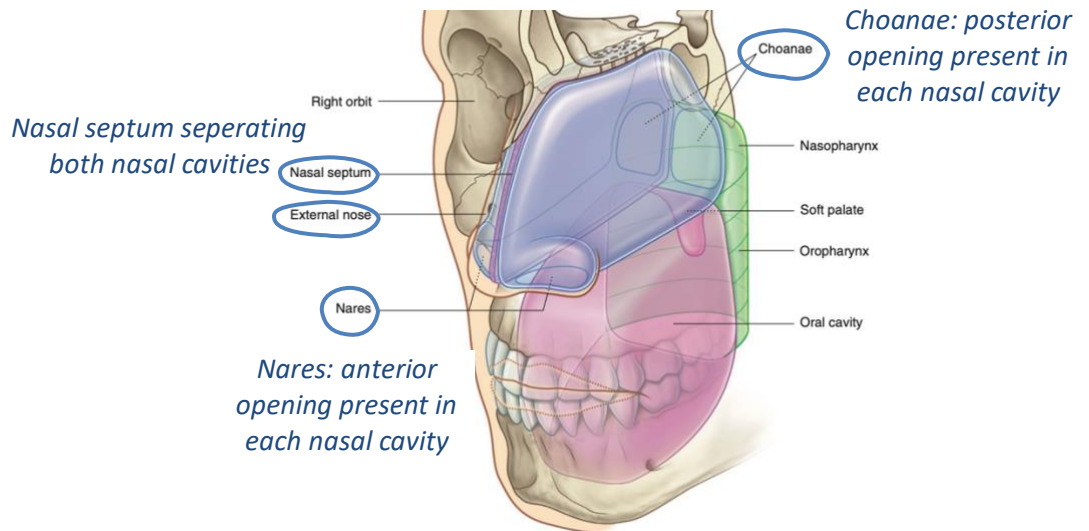


(Three parts of the septum are shown in this picture)



External nose covers the anterior region of the nasal cavity

As seen in this picture there are two nasal cavities on each side of the face



Nasal septum separating both nasal cavities

Choanae: posterior opening present in each nasal cavity

Nares: anterior opening present in each nasal cavity

1) External Nose

Has 2 main parts, **cartilaginous** and **bony**.

A. **Cartilaginous framework**: Plates of hyaline cartilage in the anterior 2/3 of the nose, and it's movable.

It has three parts:

- **Septal cartilage** (which forms the anterior part of the nasal septum and the medial wall of nasal cavity)
- **Lateral nasal cartilage** (lateral wall) divided into:

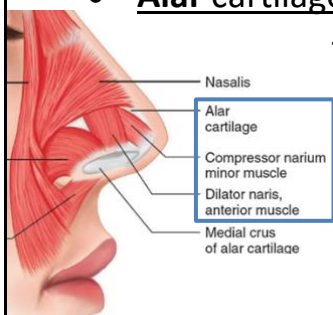
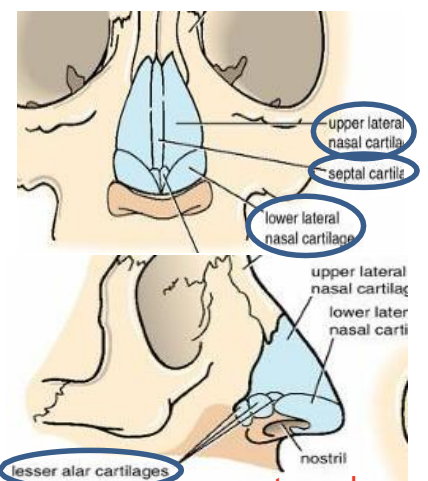
Upper & Lower lateral cartilages

- **Alar cartilage**, in the ala of the nose.

→ it's covered by muscles:

nasalis **compressor** and nasalis **dilatator**

(These muscles move the ala, their movement can be clearly observed in rabbits).

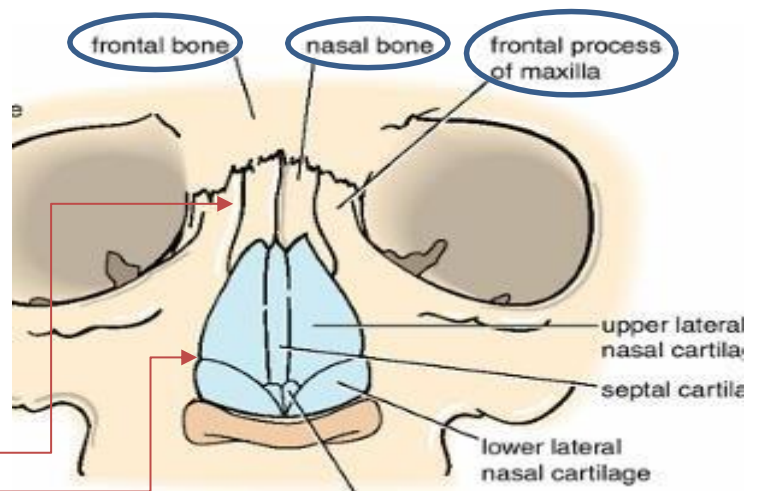


B. Bony framework

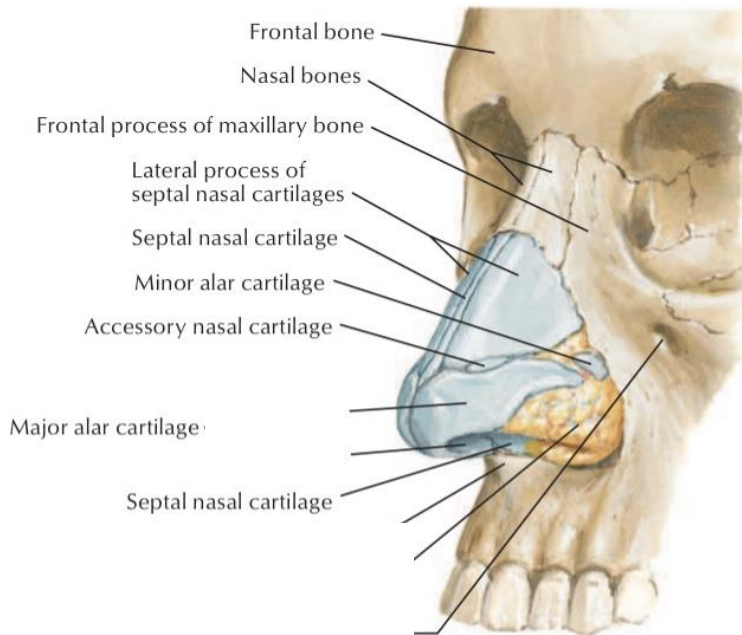
It also has three parts:

- The nasal bone.
- Frontal process of maxilla
- Nasal part of frontal bone

The lateral wall of the nose from outside is formed by the 3 bones superiorly + cartilage anteriorly and inferiorly
*previously mentioned 3 parts

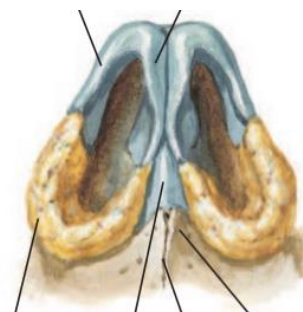


Anterolateral view



Inferior view

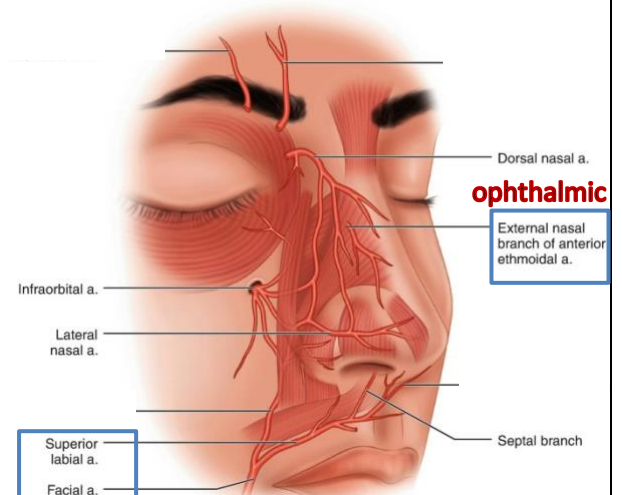
Major alar cartilage



The blood supply of skin of External nose:

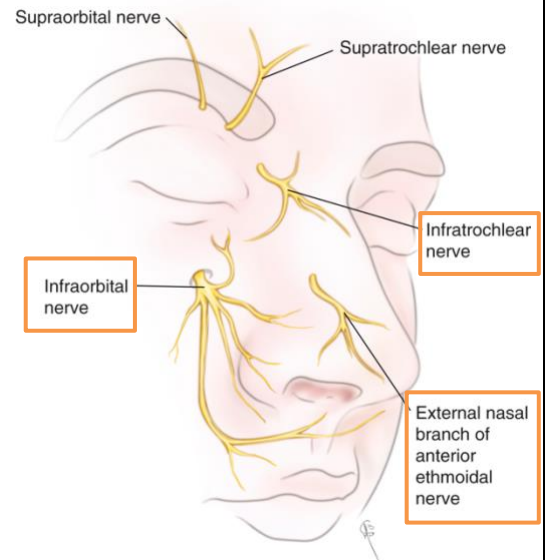
- The **ophthalmic** artery: A Branch of the internal carotid artery from the skull. The ophthalmic artery travels with the optic nerve via optic canal to the eye then to the nose.
- The **maxillary** artery: One of the terminal branches of external carotid artery. The external carotid artery branches in the parotid gland to give us the maxillary and superficial temporal arteries
→ exists the orbital cavity via the infraorbital foramen to supply external nose.
- The **facial** artery: Also branches from external carotid artery, it gives rise to the superior labial artery, it supplies the ala and the lower part of the septum.

Remember that the facial artery can be pulsated over the ramus of mandible, gives rise to two branches superior & inferior labial arteries, superior mainly supplies the external nose



Nerve supply of external nose (sensory innervation)

- Branches of the ophthalmic nerve of trigeminal:
 - A. **Infratrochlear** nerve.
 - B. **External nasal** (a direct continuation of the anterior ethmoidal nerve which comes from the ophthalmic nerve).
 - Both are branches of **Nasociliary nerve**
- The maxillary nerve gives the infraorbital branch (when traveling through the infraorbital foramen).

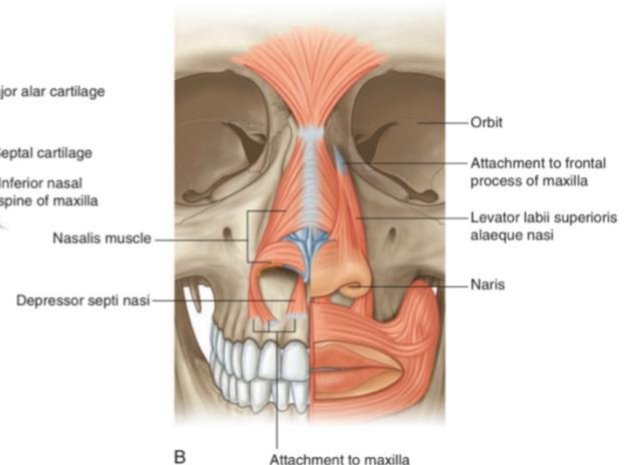
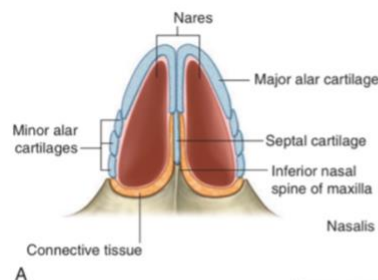


2) Nasal Cavity (Internal Nose)

The nasal cavity extends from the **anterior nasal opening** (**nostril**/anterior nares) to the **posterior nasal apertures** (**choana**/ posterior nares) where it opens into the nasopharynx.

Nasal cavity parts:

- **Nostril:** The anterior nares of the nasal cavity from which air comes in.
Held open continuously by the surrounding alar cartilage and septal cartilage.
Can be widened further by the action of the related muscles of facial expression when you take a deep breath for example



- **Vestibule:**

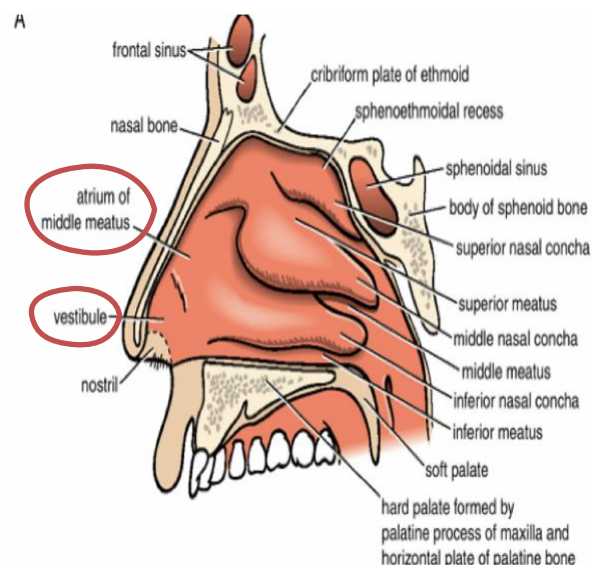
- is the area of the nasal cavity that lies above the nostril in the ala of the nose.
- It's a dilated part that's surrounded laterally by the ala of the nose.

→ the vestibule's mucosa is modified skin: stratified squamous keratinized with thick hair follicles (vibrissae → functions in air filtration)

*Not the common respiratory lining epithelium

Above the vestibule lies atrium or also known as antrum

If it helps you to get a better picture, when you put your finger inside your nose, the 1st part you'd be touching is the vestibule, medially the septum is located & laterally is the lateral wall of the nose

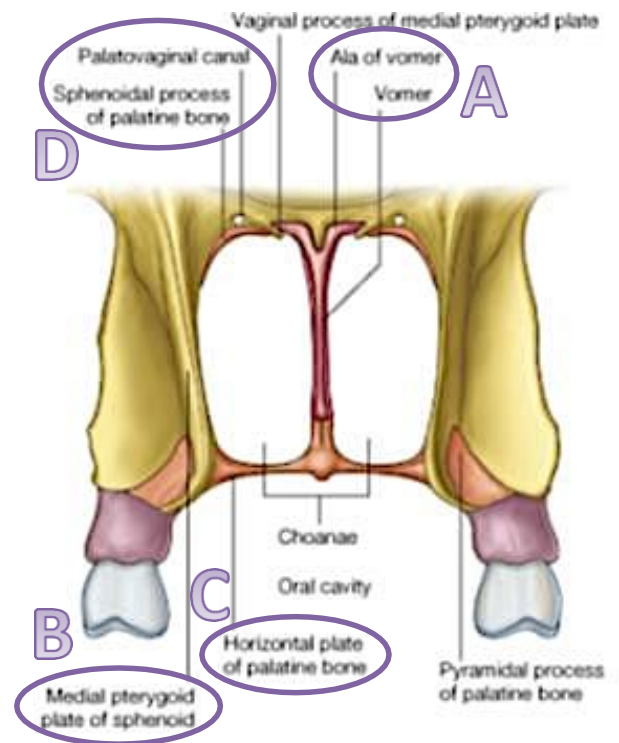


- **Choana: (posterior nares of the nasal cavity)**
They're *rigid openings* between the nasal cavities and the nasopharynx

! Very important, exam question

(*Boundaries of choanae*) completely surrounded by bone:

- Medially**, the vomer (posterior part of nasal septum) and it has a superior process called ala of vomer.
- Laterally**, Medial pterygoid plate.
- Anteriorly and inferiorly (floor)** horizontal plate of palatine bone.
- At the **roof**, there is:
 - A foramen called palatovaginal canal which leads to the nasopharynx.
 - Vaginal process of medial pterygoid plate.
 - Sphenoidal process of palatine bone.



Other structures that also form the nasal cavity:

3 conchae, 3 meatuses and sphenoidal recess. (All will be discussed later in sheet)

Functions of Nasal cavity

A. Respiratory.

B. Olfactory (smell sensation)

C. Resonance of the voice (نغمة الصوت), it differs from one person to another.

- This function is done by the air sinuses and paranasal sinuses (cavities covered by mucosa and contains air).
- That's why when a person has sinusitis (inflammation of air sinuses) you notice that their voice will change.
- Nasal sinuses are found inside some of the skull bones, not all skull bones.
- They are: The Maxillary, Ethmoidal, and Sphenoid, Frontal air sinuses. They have ducts that open in the lateral wall of the nose. When you find a green-yellow secretion in your nasal cavity this indicates sinusitis because normally the secretions should be watery.

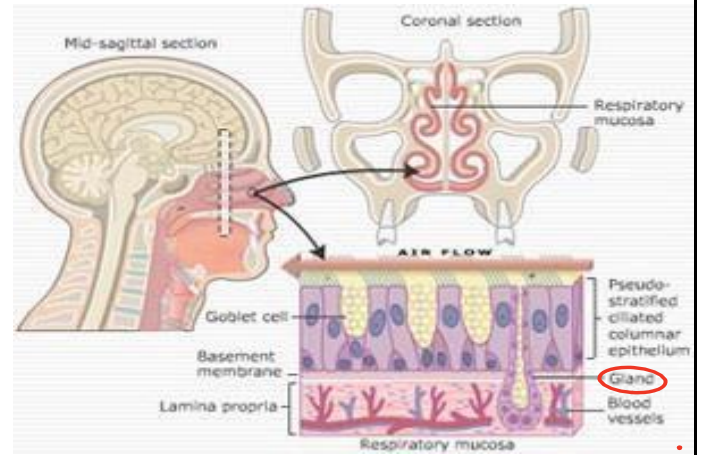
To remember them: My Extremely Sweet Friend.

D. Drains lacrimal fluid

The inferior meatus has an opening for the nasolacrimal duct.

This duct starts from the lacrimal sac which is located at the medial side of the eye, when filled with tears it drains in the lateral wall of the nasal cavity

So, when someone cries a lot some of his tears go down on his cheek and most of the tears move into the lacrimal sac to the inferior meatus, so it's normal that tears go down from his nose.



E. Protective functions: Sneezing, Filtration, Proteolytic enzymes that kill bacteria, Warming and moistening the air

→ remember that this function is carried out by the structural features of respiratory epithelium

Extra

- Clinical note: Some children are born with blocked nasolacrimal duct, either at the beginning, middle or end of it. As a result, all of their tears are flushed on the cheeks, and this may induce an inflammation → the surgeon should open the blocked duct (drainage).

The nasal cavity is bounded by medial wall, lateral wall, roof and floor:

boundaries of the nasal cavity (1-4)

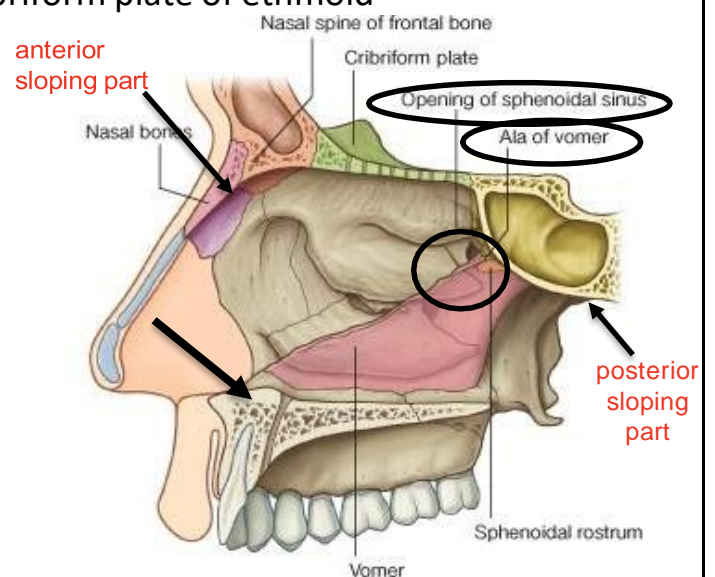
1- Roof (mainly formed by ethmoidal bone)

A. **Anterior** Sloping part: made of Nasal spine of the frontal bone and the nasal bones.

B. **Middle** part: Contains the horizontal cribriform plate of ethmoid

C. **Posterior** Sloping part:

- Anterior surface of the sphenoid bone(body) and sphenoidal sinus.
- Ala of the vomer.
- Vaginal process of the palatine bone.



Extra from 019

cribriform means(غرباليه) because of the fact that filaments of the olfactory nerve pass through it}

→ **Bipolar cells** give rise to filaments of **olfactory nerve** (which pass through the cribriform)

→ the filaments gather **synapse in the olfactory bulb** (above cribriform) →give rise to the

olfactory tract→ This tract travels till it reaches the **center of smell in temporal lobe** →

you get the smell **sensation**.

2- Floor: The upper surface of the hard palate

2 bones

It's composed of 2 parts:

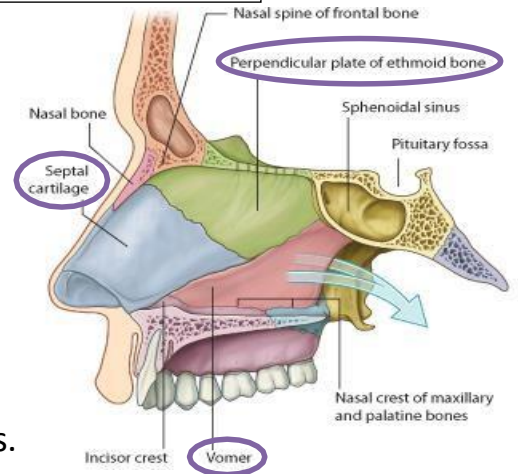
- A. Palatine process of maxilla. anteriorly
- B. Horizontal plate of palatine bone. posteriorly



The floor of the nasal cavity →

hard palate formed by palatine process of maxilla and horizontal plate of palatine bone

3- The medial wall: The nasal septum
 the septum is divided into: cartilage (anteriorly), perpendicular plate of ethmoid bone (posteriorly & superiorly), and the vomer (posteriorly & downward).

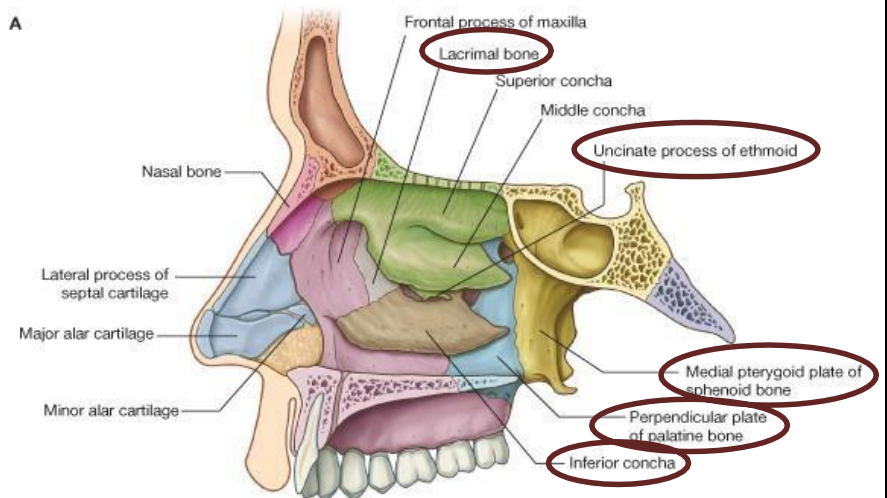


(Medial wall of nasal cavity)

4- The lateral wall: is complex, formed by bone, cartilage, and soft tissues for warming and moisturizing since it contains large number venous plexus.

Bony support of the lateral wall:

- A. Ethmoidal bone (**labyrinth**) and its uncinated process.
- B. Perpendicular plate of the palatine bone.
- C. Medial plate of the pterygoid process.
- D. Medial surfaces of the lacrimal bones and maxillae.
- E. Inferior concha.



Parts of the lateral wall:

- A. **Vestibule** (mentioned before).
- B. **Antrum** (atrium): Located above the vestibule at the same level of **middle meatus**.
- C. **3 Conchae** and **3 meatuses** and **1 recess**

- **The concha:** It is a bulge of bone which is covered by thick mucosa.
 - mucosa type: respiratory pseudostratified ciliated columnar epithelium
 - submucosa of conchae & meatuses are thick because they contain large venous plexus which have a protective function of warming air

- Functions to increase the surface area of the nasal cavity (specifically the lateral wall)
- There are three conchae:
 - **Superior**, it originates from ethmoidal bone.
 - **Middle**, originates from ethmoidal bone.
 - **Inferior**, originates from is the maxilla.

All Conchae extend medially across the nasal cavity → separating it into four air channels: 3 meatuses & 1 Spheno-ethmoidal recess.

➤ **The meatus:**

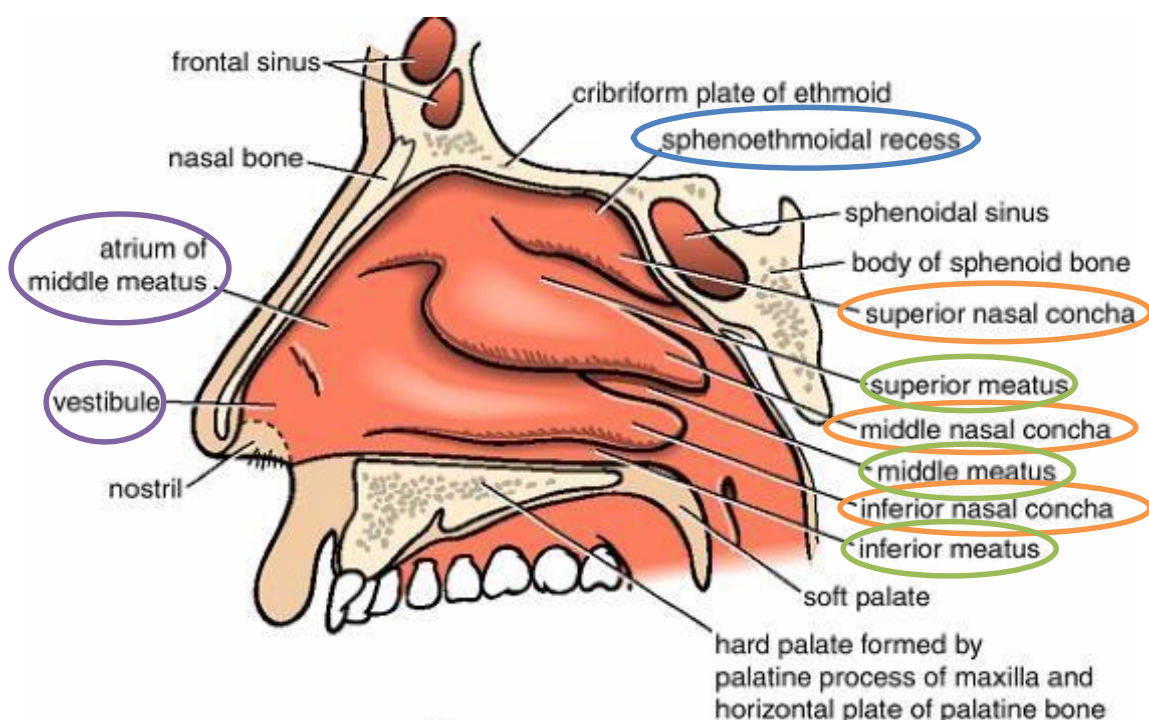
Which is a **groove** below the conchae “groove below the bulge”.
(the **conchae** = **shelf** & below them **grooves** = **meatus**).

- There are three meatuses on the lateral wall of the nasal cavity: **Superior, Middle, and Inferior** meatuses, **each meatus lies below a conchae**
(*Anterior end of each concha curves inferiorly to form a lip that overlies the end of the related meatus*)

➤ **The recess:** called sphenoethmoidal recess

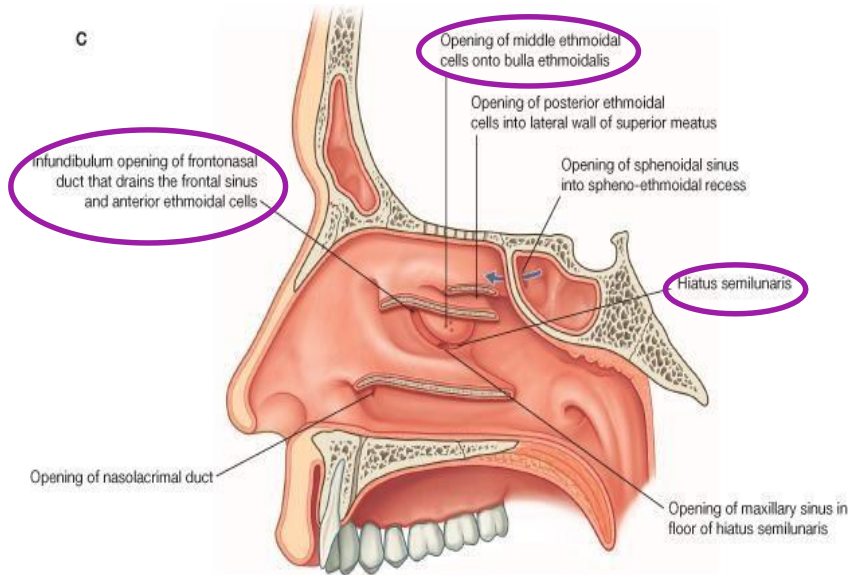
Where **sphenoid sinus** drains the sphenoidal air sinus (Drainage: allowing a passage for the secretions of the sphenoidal air sinus if it gets inflamed).

Here's all the parts of the lateral wall (function of these parts of the lateral wall -> association with the air sinuses)



Very important, exam question

- **Middle meatus** lies under the middle conchae, has two anatomical structures:



1) **Ethmoidal bulla (or bulla ethmoidalis)** → dome shaped *bulge* resulted from elevation of the lateral wall of middle meatus
Formed by the underlying middle ethmoidal cells, which expand the medial wall of the ethmoidal labyrinth.

- 2) **Hiatus semilunaris** → *curved gutter* or groove **inferior** to the ethmoidal bulla
- *Formed by the mucosa covering the lateral wall*
Defect in the bony wall between the ethmoidal bulla above and the uncinete process below.
 - **Anterior end** of the hiatus semilunaris forms a channel (the **Ethmoidal infundibulum**) → Curves upwards and continues as the **Frontonasal duct** through the anterior part of the ethmoidal labyrinth to open into the **frontal sinus**.

!! It's very important to memorize these locations and their relations to each other !!

➤ **Paranasal sinuses**

Air sinuses are air bags with ducts that open into the lateral wall of the nose, they also play part in determining resonance

Lateral Wall Structure	Associated Air Sinus
sphenoethmoidal recess	sphenoidal air sinus
Superior meatus	posterior ethmoidal sinus
inferior meatus	Nasolacrimal duct (specifically lateral wall)
Ethmoidal bulla of middle meatus	middle ethmoidal sinus (above the bulla)
Hiatus semilunaris of middle meatus	Anteriorly: anterior ethmoidal air sinus Middle: maxillary air sinus
Ethmoidal infundibulum of middle meatus	Frontal air sinus by <i>frontonasal duct</i> .

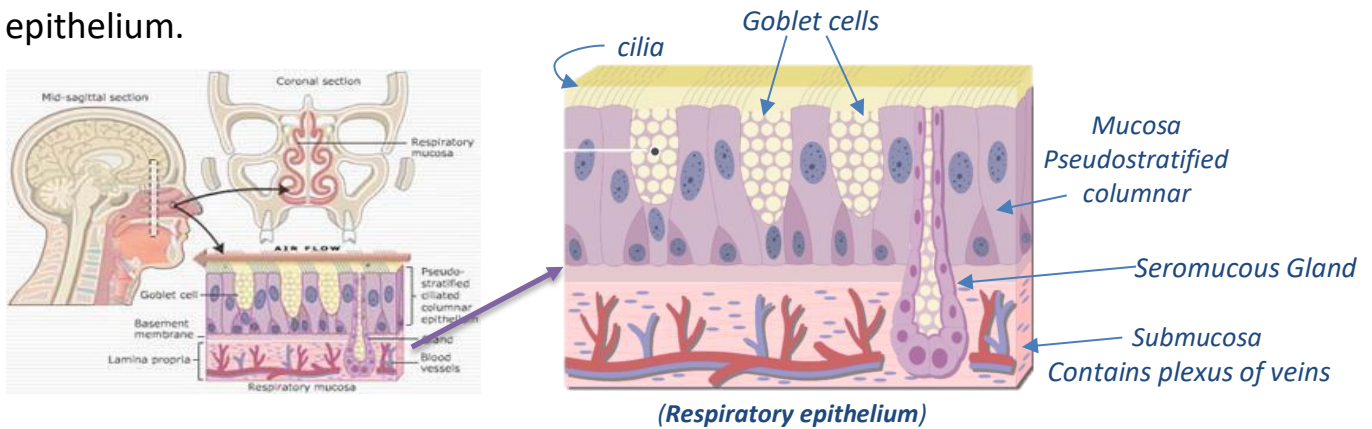
There are 3 ethmoidal sinuses on each side (6 in total):

1. **Anterior** ethmoidal sinus
2. **Middle** ethmoidal sinus
3. **Posterior** ethmoidal sinus

NOTE: anterior ethmoidal air sinus opens posterior to infundibulum and into hiatus semilunaris

Mucous membrane

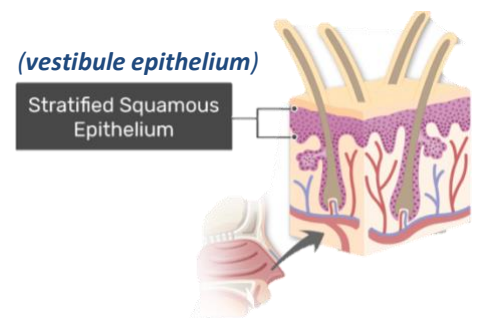
The nasal cavity and respiratory tract are lined with pseudostratified ciliated columnar epithelium.



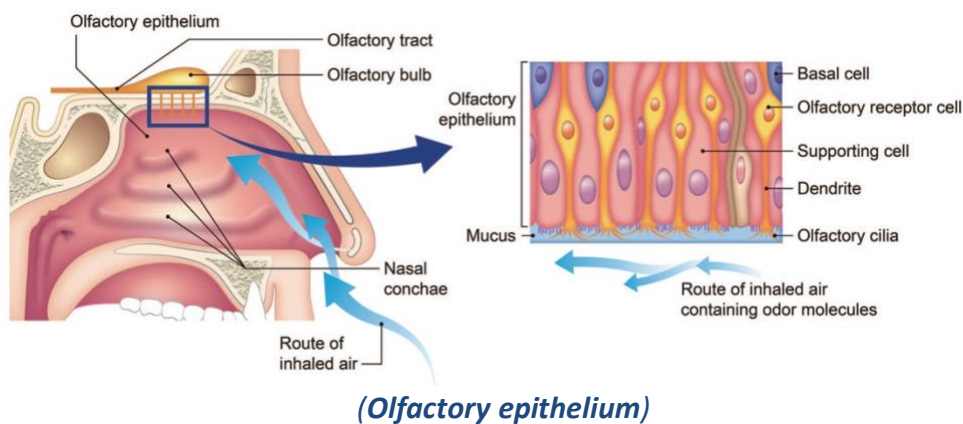
Excluding 2 structures:

- 1- The **vestibule's** epithelium: stratified squamous keratinized with hair follicles (modified skin with vibrissae).

The dr said its non-keratinized in the lecture but the internet says its keratinized, so yea idk



- 2- The **roof of the nasal cavity** (above the superior conchae) is covered with olfactory mucosa:
 1. pseudostratified ciliated columnar
 2. bipolar cell
 3. olfactory nerve endings for smell sensation.



Functions of the mucous membrane:

- 1- **Heating and moisturizing** of air, this occurs due to the large number of **veins plexuses** in the **submucosa**.
- 2- **Mucous traps foreign particles and organisms in the inspired air.**

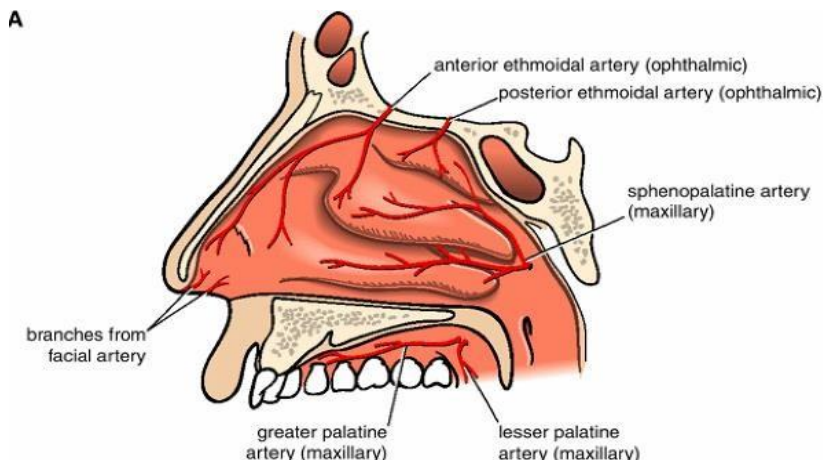
- The mucous membrane is very thick around the conchae, that is the reason behind the feeling of nose congestion in the case of rhinitis (inflammation in the mucosa of the nose), as the mucosa gets extremely thick which makes breathing from nose harder due to blood congestion in the veins and blockage of the nasal cavity, treated by decongestants.

Blood supply and nerve supply of the nasal cavity

When discussing the blood or nerve supply of the nose, we divide it into two major categories:

Vessels and nerves that supply the **septum** & the ones that supply the **lateral wall**.

The **lateral wall** is divided into 4 quadrants: **Superior anterior**, **superior posterior**, **inferior anterior**, and **inferior posterior**.



1- Sphenopalatine artery (or nasopalatine A.): (The **largest vessel** supplying the

nasal cavity) it's one of **maxillary artery branches** artery in the **pterygopalatine fossa**, it enters the nasal cavity by passing medially through the sphenopalatine foramen.

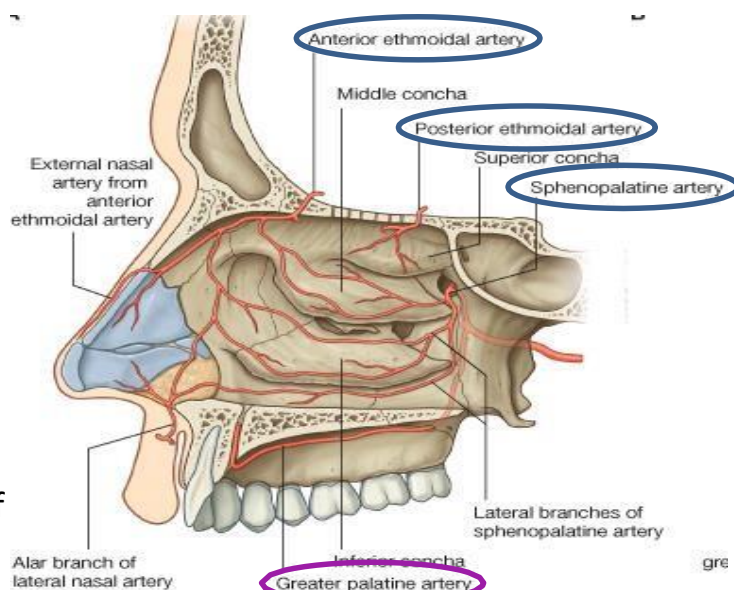
Gives two branches **Short** and **Long sphenopalatine arteries**.

A. Short sphenopalatine artery (Posterior lateral nasal branches) → supply a large part of the lateral side of the nose (Posterior Superior quadrant).

B. Long sphenopalatine artery (Posteriorseptal nasal branch) → *passes over the roof of the cavity and onto the nasal septum* to supply the **medial wall "septum"** (It's the most important branch going to the septum).

It can also supply part of the lateral wall.

→ this artery is one of the causes of epistaxis



2- The Palatine artery: Also a branch of the **maxillary artery** → it further divides into the **Greater & lesser palatine** arteries:

A. Greater palatine artery: Arises in the pterygopalatine fossa → then it passes through the greater palatine foramen of the hard palate → then to the incisive canal to enter nasal cavity and supply the anterior regions of the medial wall and adjacent floor of the nasal cavity (posterior and anterior inferior quadrants of lateral wall)

incisive foramen is located on the roof of the oral cavity

B. Lesser palatine artery: It supplies the soft palate.

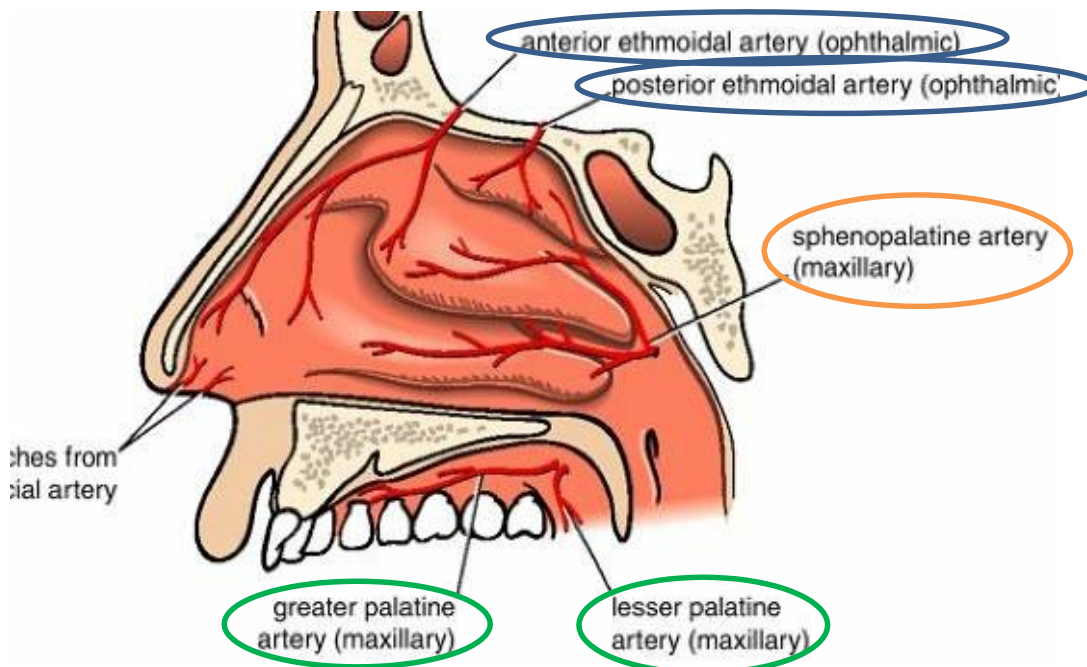
3. The ethmoidal arteries: originate in the orbit from the ophthalmic artery:

A. **Anterior ethmoidal artery** (it accompanies the anterior ethmoidal **nerve**) *descending through a slit-like foramen lateral to the crista galli.*

- It supplies the **medial (septal)** and **lateral wall** (anterior- superior quadrant) **continues its course to supply the external nose.**

B. **Posterior ethmoidal artery** *descends into the nasal cavity through the cribriform plate.*

- It gives branches to upper parts of the **medial** and **lateral** walls, **supplies some of the air sinuses.**



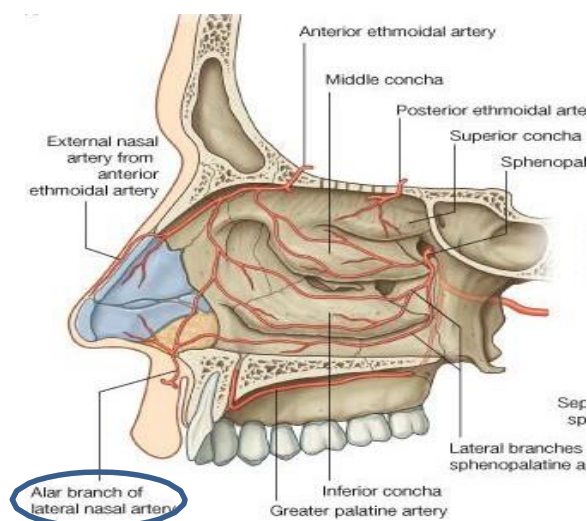
4. Superior labial and lateral nasal arteries: Facial artery branches anteriorly and supply lateral wall and medial wall.

A. **Superior labial** *gives an alar branch supplies the region around the naris, and a **septal branch** that supplies anterior regions of the nasal septum.*

- Also, supplies the lateral wall.
- **Anastomoses with long sphenopalatine artery**
- **2nd important artery in epistaxis**

B. **Lateral nasal arteries** supply blood of the external nose

C. **Alar branches** *that pass around the lateral margin of the naris and supply the nasal vestibule.*

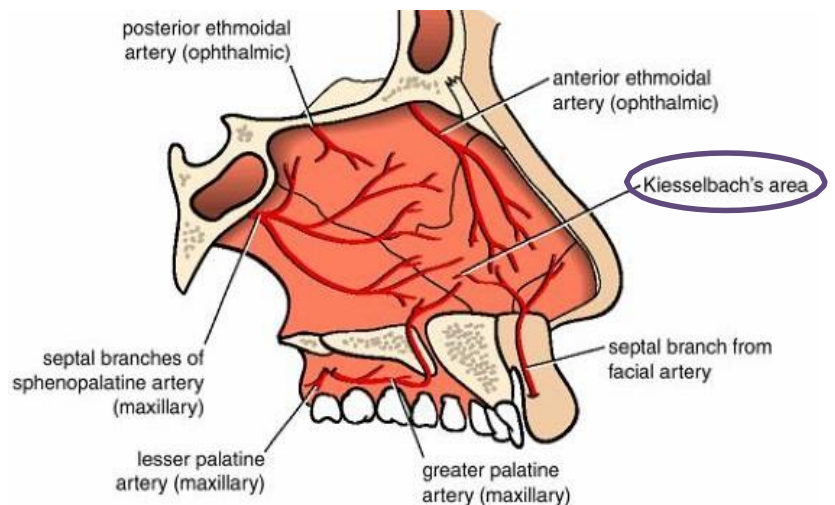


Epistaxis: It is **bleeding from the nose**.

- Occurs after a hit on the nose, especially in children.

- **Cause:**

Vessels that supply the nasal cavities form extensive **anastomoses** with each other in the **anterior region of the medial wall (septum)** close to the surface (**Kiesselbach's area**), this area is the major site of 'nose bleeds' or epistaxis.



→ Located between the upper 2/3rds & lower 1/3 of the septum.

→ main arteries that anastomose are long sphenopalatine (nasopalatine) & superior labial artery of facial

So, rupture of some of these blood vessels (esp. in **Kiesselbach's area**) → epistaxis.

- **Control of bleeding:**

→ During epistaxis the child **MUST NOT** lie on his back because he might swallow the blood down to his stomach, rather sit him down enter a piece of gauze through the vestibule and firmly press on the area of anastomoses to stop the bleeding

After very uncontrolled severe bleeding, we do cauterization (stop bleeding) of **long sphenopalatine** artery (from **nasopalatine A.** which is a branch of the **maxillary A.**) and **superior labial** artery (which is a branch of the **facial**) since the **most ruptured** anastomosis in epistaxis is the anastomose of these 2 arteries.

→ Bleeding can be also controlled by chemical substances like silver nitrate

Summary of blood supply

1. Septum (medial wall)

- a. Long sphenopalantine (main supplying artery)
- b. Greater palatine artery (supplies anterior region)
- c. Anterior ethmoidal artery
- d. Posterior ethmoidal (supplies upper part)
- e. Superior labial (supplies anterior region via septal branch)

2. Lateral Wall

blood supply according to its quadrants

- a. short sphenopalantine (supplies posterior superior quadrant)
- b. Greater palatine artery (supplies anterior & posterior inferior quadrant)
- c. Anterior ethmoidal artery (supplies anterior superior quadrant)
- d. Posterior ethmoidal (supplies upper part)
- e. Superior labial

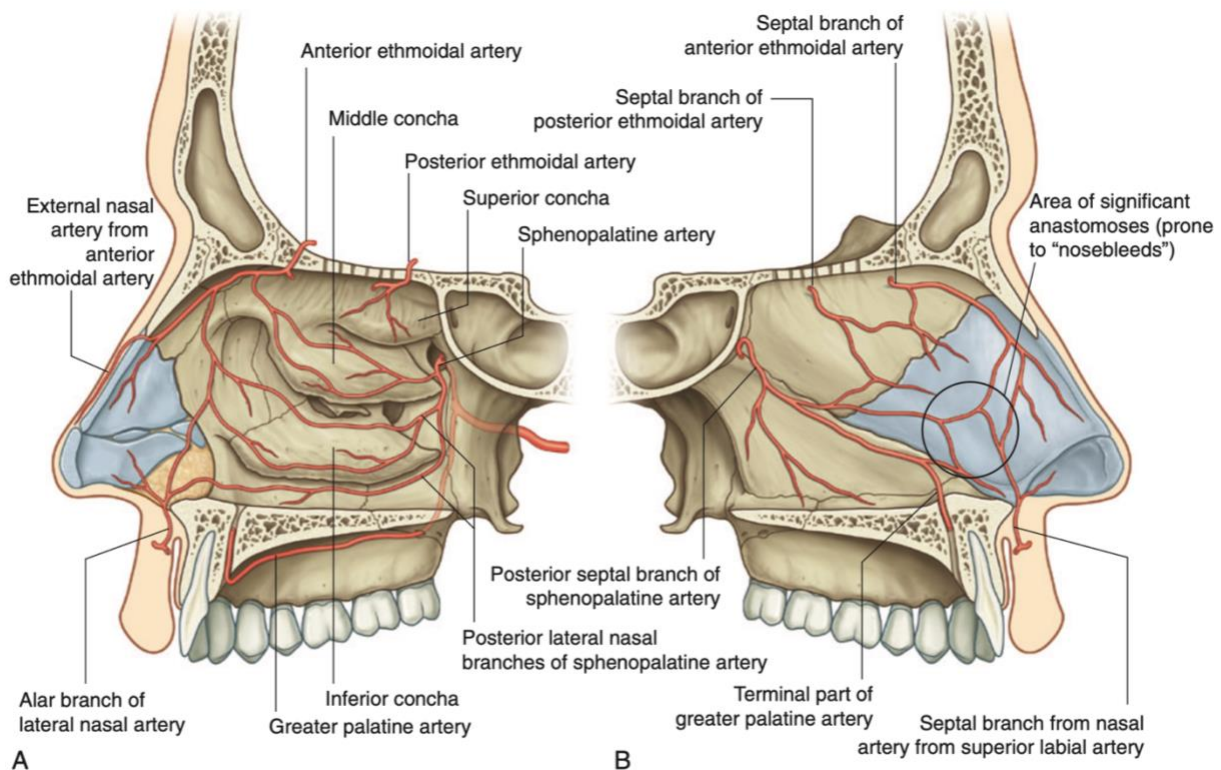
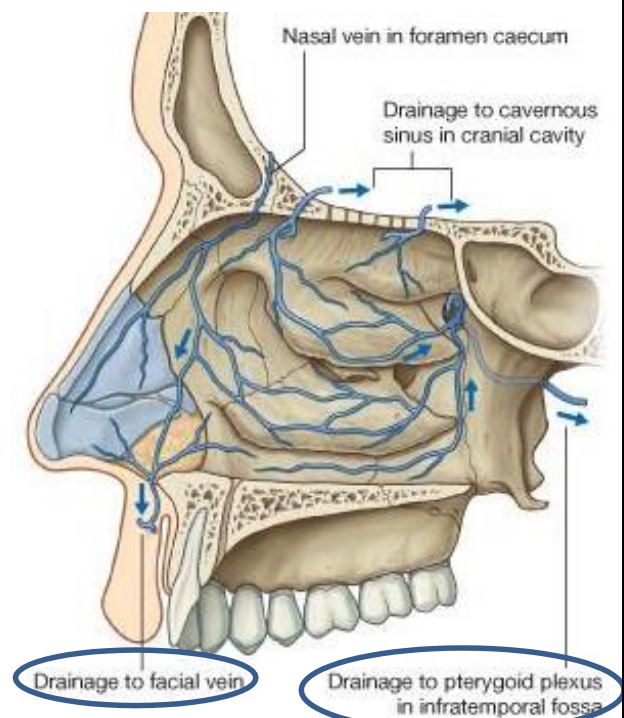


Fig. 8.243 Arterial supply of the nasal cavities. **A.** Lateral wall of the right nasal cavity. **B.** Septum (medial wall of right nasal cavity).

Venous drainage of the nasal cavity

The nasal cavity is divided into anterior 1/3 and posterior 2/3:

- The **anterior 1/3** drain into the **facial vein**.
that drains in the **internal jugular vein**
- The **posterior 2/3** drain into **lateral pterygoid venous plexus** (around the lateral pterygoid muscle) > the lateral pterygoid plexus drains into the **maxillary vein** > the maxillary joins the **superficial temporal** in the **parotid gland** to form **retromandibular vein**.



Usually the veins follow the arteries:

*Veins from **anterior** regions of the nasal cavities join → the **facial vein**.*

*Veins that pass with branches originating from the **maxillary artery** drain into → the **pterygoid plexus**.*

Lymphatic drainage of the nasal cavity:

- **Anterior** part passes around the margins of the nares and then drains into the **submandibular** lymph nodes.
- **Upper & posterior** parts drain into **retropharyngeal** (upper deep cervical) lymph nodes which then drain into **deep cervical** lymph nodes (which are located around the **internal jugular vein**)

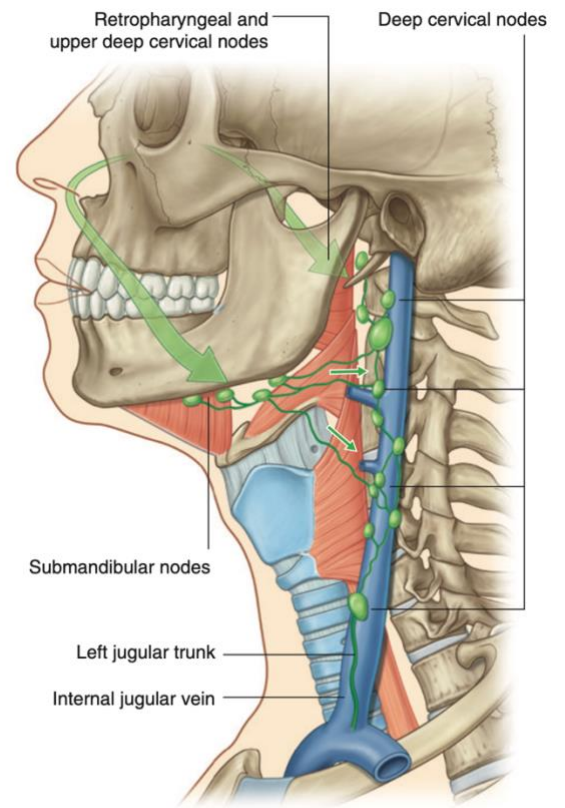


Fig. 8.246 Lymphatic drainage of the nasal cavities.

Good Luck <3