

RESPIRATORY SYSTEM

ANATOMY



Title: Sheet 1 – Nasal Cavity 1

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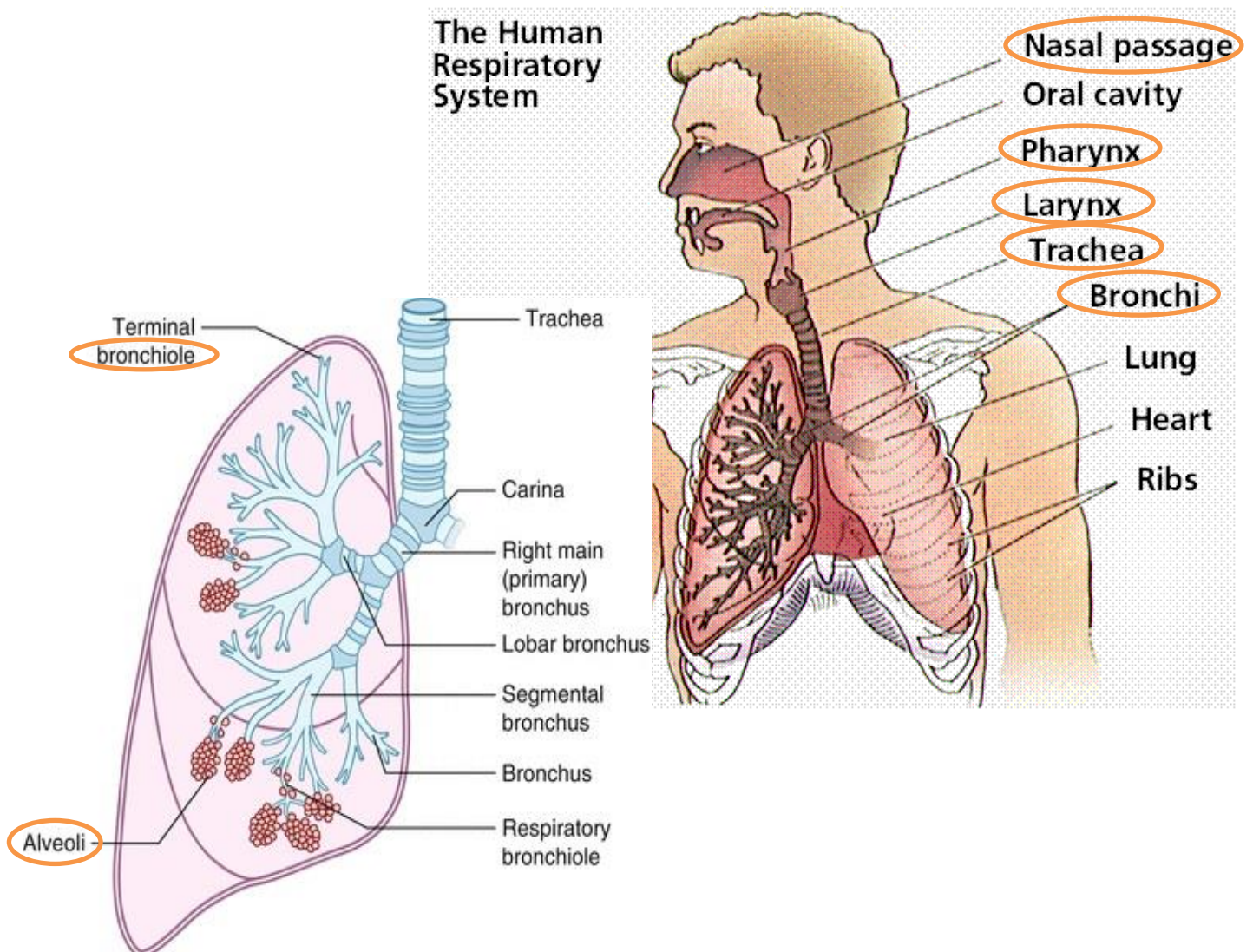
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(note: anything in blue is not mentioned by the doctor)

We'll start with the respiratory system **organs**:

From the **Nose** or the **nasal cavity** → to the **Pharynx** (it's divided into 3 regions according to location: Nasopharynx, Oropharynx and Laryngopharynx) → **Larynx** where the phonation or the articulation occurs, since it contains vocal cords that are responsible of speech → **Trachea** which branches to form → 2 main **Bronchi**, main right bronchus and main left bronchus, bronchi also branch to form → **Bronchioles** inside the lungs, which end in → *a cluster of air sacs called Alveoli*, we have billions of them in the lungs and these alveoli are 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) so there is parietal and visceral pleura.
- 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.
So, if respiration stops, we may do a tracheostomy (an opening in the trachea), or to put a nasalaryngeal 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).

3. Filters the inspired air

The vestibule of the nose (nose bulge) contains thick hair called vibrissae, where the inspired air is firstly filtered.

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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 which translates this smell).

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

5. Excretes small amounts of water and heat.

Histological layers of respiratory tract:

Mucosa → **Submucosa** → **Supportive layer** (cartilage ‘hyaline cartilage in the trachea’ **OR** smooth muscle ‘in the bronchioles’) → **adventitia**.

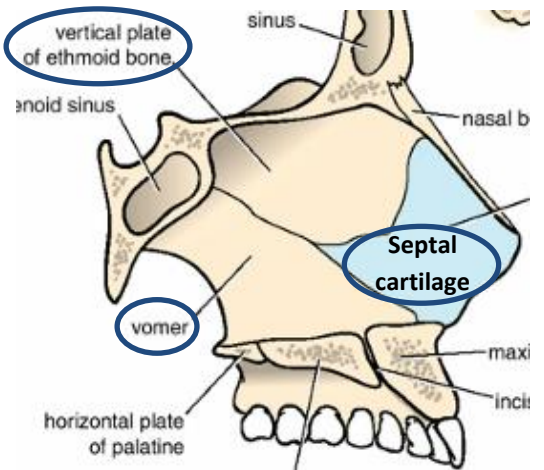
In the **submucosa**: there is a gland responsible for mucous secretion, filtration of dust and foreign bodies and moisturizing the air, especially in the nose.

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

The Nose is divided into to **two cavities**:

External Nose & Nasal Cavity (Internal Nose), separated by a **septum** (medial wall of the nose), the septum is divided into: cartilage (anteriorly) & vertical plate of ethmoid bone (above) & the vomer (posteriorly & downward).

The parts of the septum are shown in this picture →

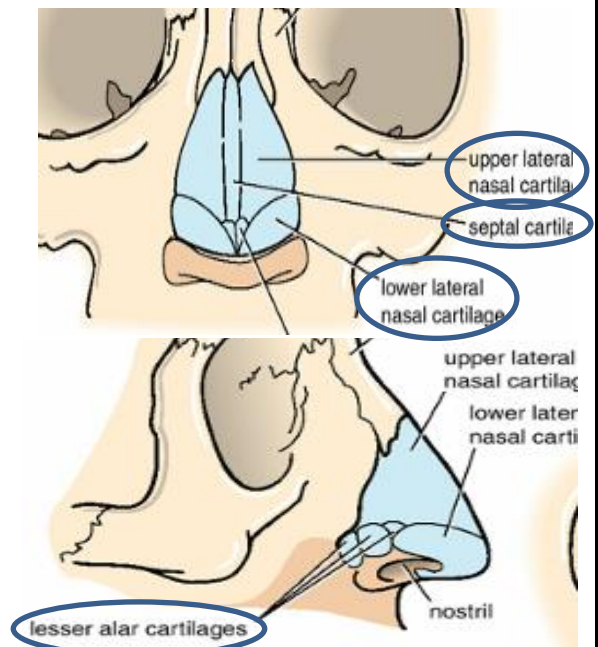


1) External Nose: Has 2 main parts, **cartilaginous** and **bony**:

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

It has three parts:

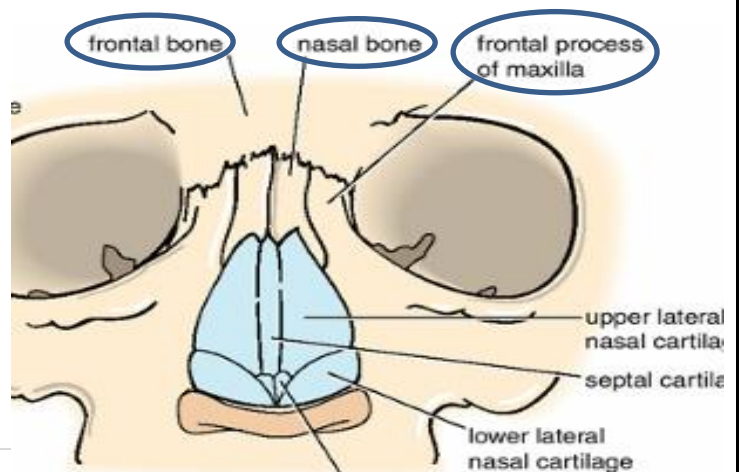
- Septal cartilage (medial wall).
- Lateral nasal cartilage (lateral wall) divides into: Upper & Lower lateral cartilages
- Alar cartilage, in the ala of the nose, it's covered by muscles: naris compressor and naris dilator muscles (these muscles are the reason why rabbits and some humans can move their alas).



B. **Bony framework**:

It also has three parts:

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



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 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.
- 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.

Nerve supply of external nose (sensory innervation) :

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

2) Nasal Cavity (Internal Nose):

Starting with Nasal cavity **functions**:

A. Respiratory.

B. Olfactory.

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

- This function is done by the nasal 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.

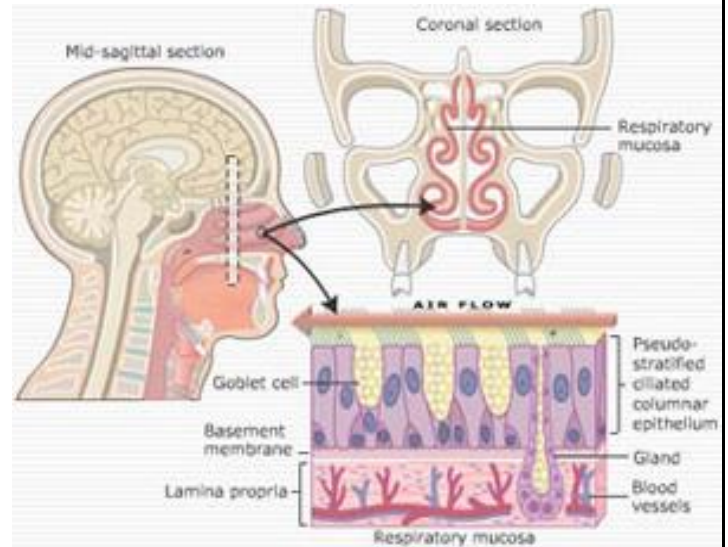
To remember them: My Extremely Sweet Friend.

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 and filled with tears.

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.



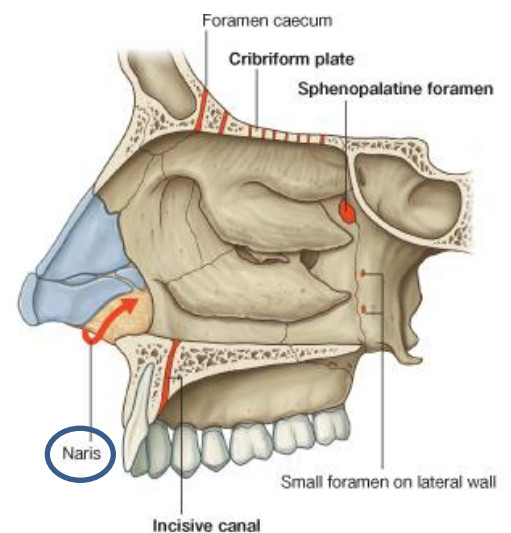
- Clinical note: Some children are born with blocked nasolacrimal duct, either at the beginning, middle or end of it. As a result, all of their tears are flushed on the cheeks, and this may induce an inflammation → the surgeon should open the blocked duct (drainage).

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

The nasal cavity extends from the **anterior nasal opening (nostril/anterior nares)** to the **posterior nasal apertures (choana/ posterior nares)**. 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.



- **Vestibule:** which is the area of the nasal cavity lying above the nostril in the ala of the nose, the vestibule's mucosa is the same as skin stratified squamous keratinized with hair follicles (vibrissae).

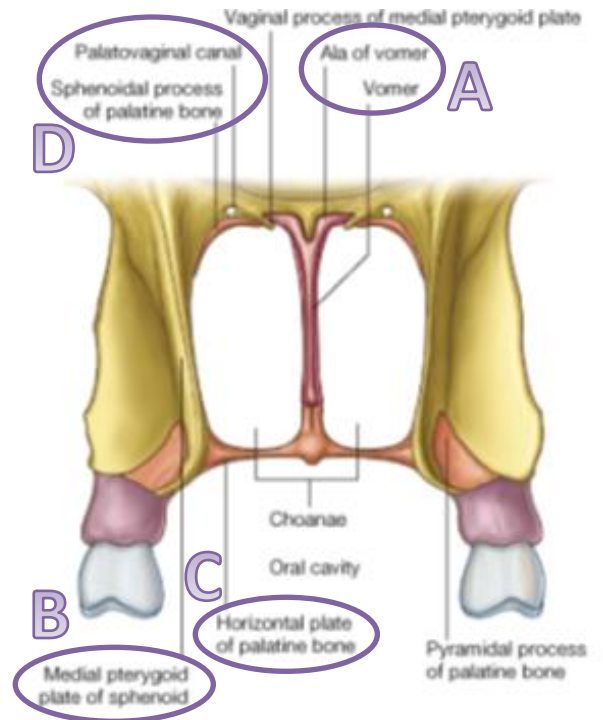
It's divided into right and left halves by the nasal septum.

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

They're completely surrounded by bone:

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



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

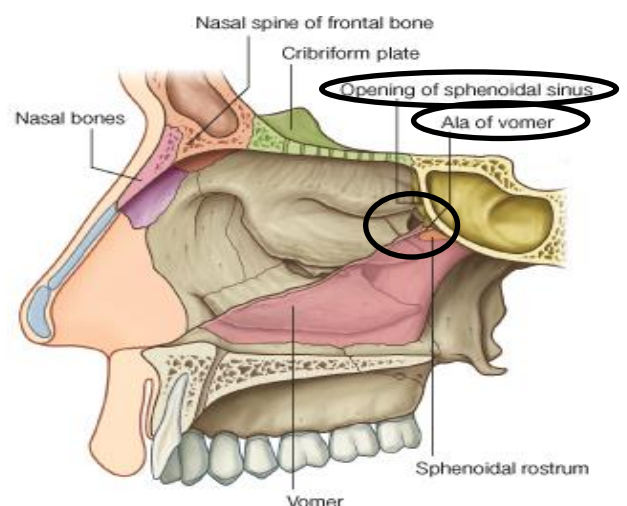
1- Roof:

- A. *Sloping Anterior* part: Made of Nasal spine of the frontal bone and the nasal bones.
- B. **Middle** part: Contains the horizontal cribriform plate of ethmoid {cribriform means (غرابية) 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**.

C. *Sloping Posterior* part: (The picture →)

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

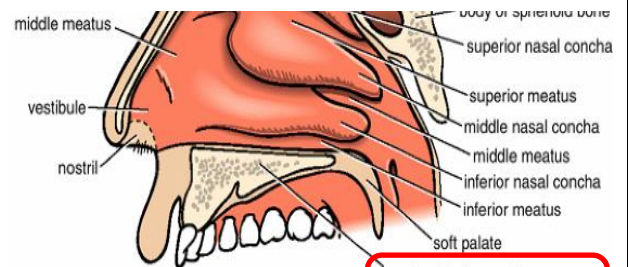


2- Floor: The upper surface of the hard palate

It's composed of 2 parts:

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

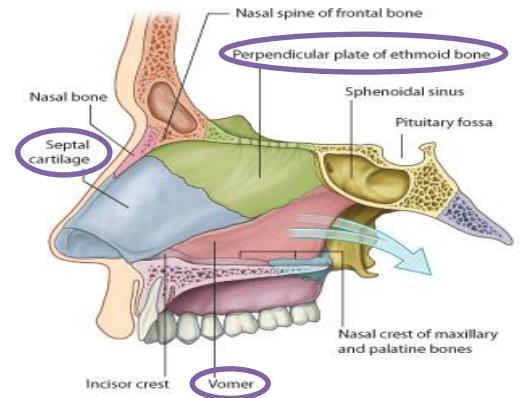
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The floor of the nasal cavity →

3- The medial wall: The nasal septum

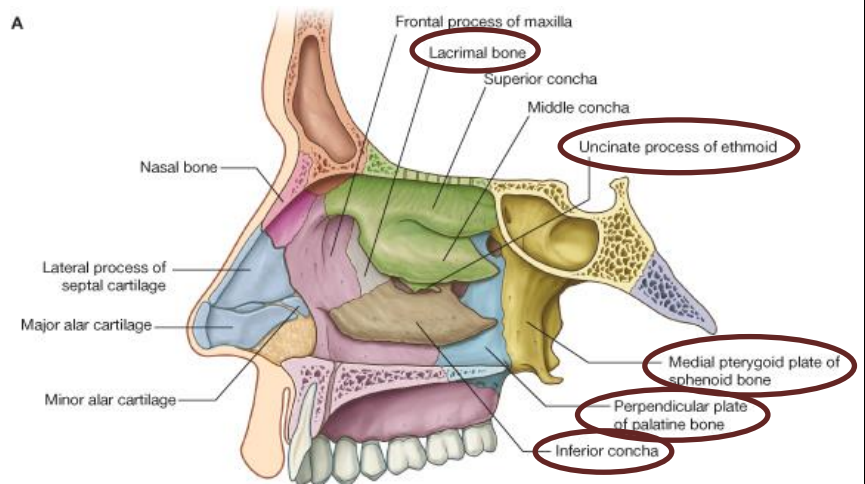
(as we mentioned in p3) the septum is divided into: cartilage (anteriorly), perpendicular plate of ethmoid bone (posteriorly & superiorly), and the vomer (posteriorly & downward).



4- The lateral wall: It's formed by bone, cartilage, and soft tissues. For warming and moisturizing since it contains large number venous blood plexus.

Bony support of the lateral wall:

- A. Ethmoidal 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 of maxilla.



Parts of the lateral wall:

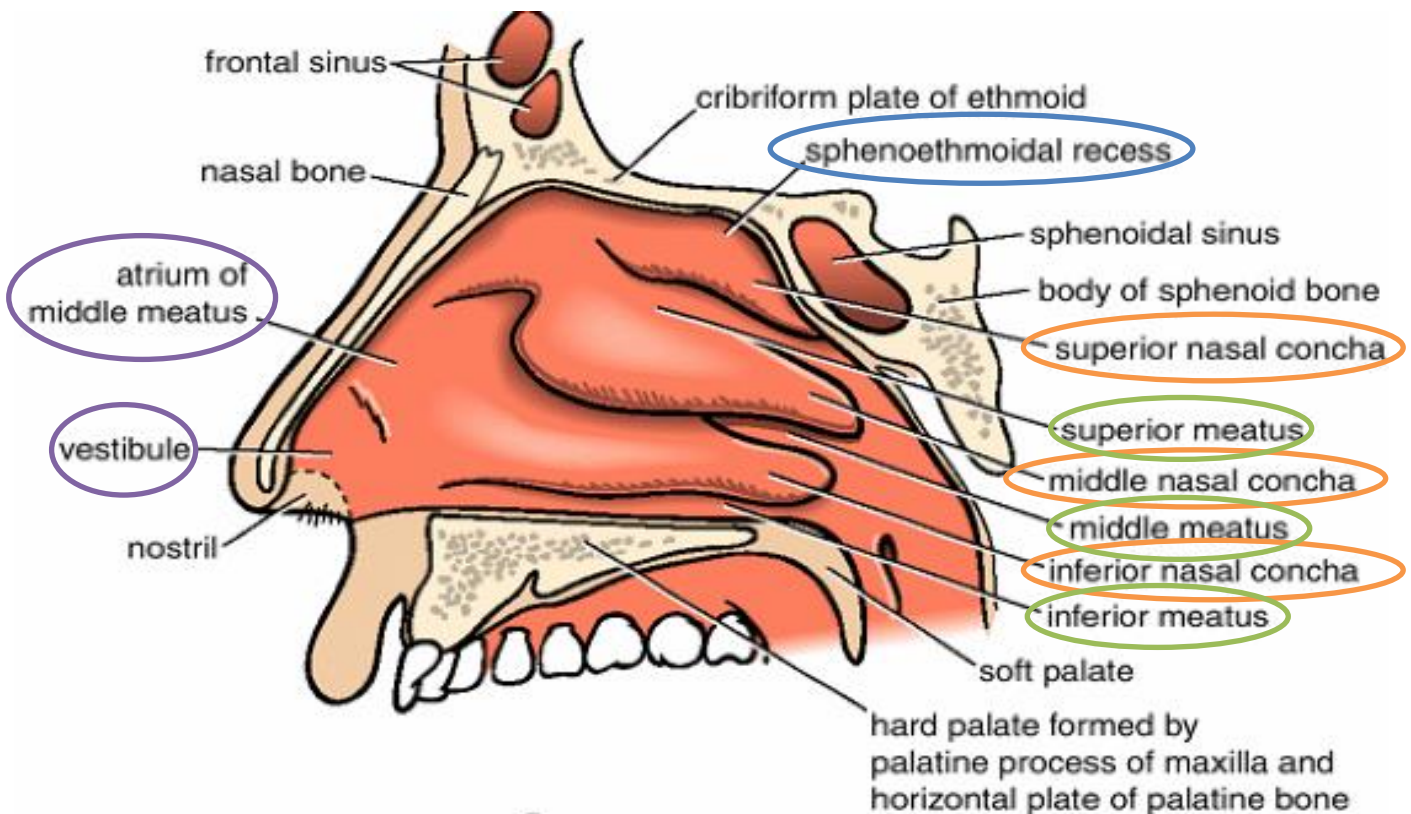
- A. **Vestibule** (mentioned before).
- B. **Antrum** (atrium): Located at the same level of **middle meatus**. ↓
- C. **3 Conchaes** and **3 meatuses** and **1 recess**:

- **The conchae:** It is a bulge of bone which is covered by mucosa. The conchae functions to increase the surface area of the nasal cavity. There are three conchae:
 - **Superior**, it originates from ethmoidal bone.
 - **Middle**, originates from ethmoidal bone.
 - **Inferior**, originates from is the maxilla.

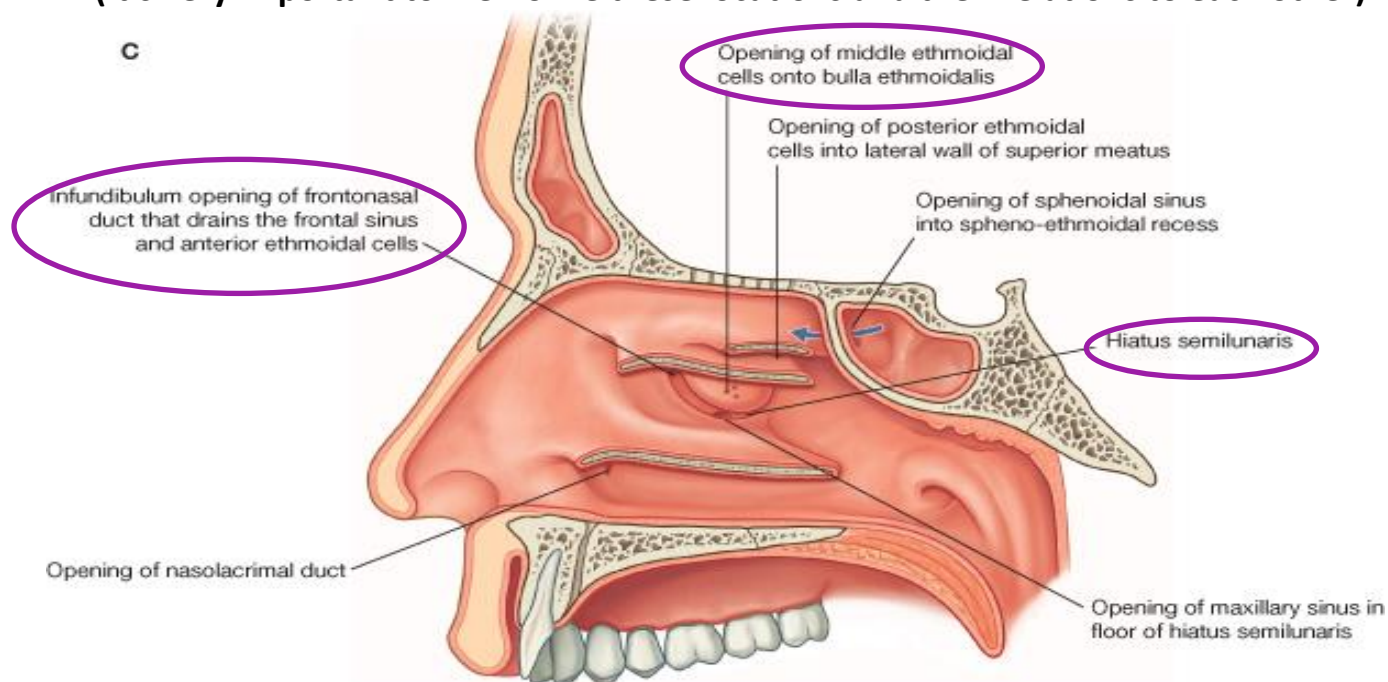
All Conchae extend medially across the nasal cavity → separating it into four air channels: 3 meatuses & 1 Spheno-ethmoidal recess.

- **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 below a conchae** (*Anterior end of each concha curves inferiorly to form a lip that overlies the end of the related meatus*).
- **The recess:** It is called sphenoethmoidal recess. It's the recess into which **sphenoid sinus opens**. *It lies in the lateral wall of nasal cavity*. And it 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:



- Lateral wall of the **middle meatus** elevates to form → the *dome-shaped Ethmoidal bulla (or bulla ethmoidalis)*. *Formed by the underlying middle ethmoidal cells, which expand the medial wall of the ethmoidal labyrinth.*
- **Inferior** to the ethmoidal bulla is *a curved gutter*: The **Hiatus semilunaris**. *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 and nasolacrimal duct and their site of drainage into the lateral wall of nasal cavity:

- The **sphenoidal** air sinus opens into → sphenoethmoidal recess.
- The **maxillary** air sinus opens in → the middle and posterior meatus into the inferoposterior part of hiatus semilunaris.
- The **frontal** air sinus opens into → *the middle meatus anterior to the infundibulum and frontonasal duct.*
- The **ethmoidal** sinuses: There are 3 ethmoidal sinuses on each side, meaning they are 6 in total, their drainage openings are:
 - The **anterior** ethmoidal sinus opens in → the anterior part of **hiatus semilunaris** in the middle meatus.
 - The **middle** ethmoidal sinus opens in → the middle meatus in the bulge called **ethmoidal bulla** which contains the sinus & the opening of the sinus.
 - The **posterior** ethmoidal sinus opens in → the superior meatus.
- **Nasolacrimal duct** opens into → the lateral wall of the inferior nasal meatus.

All of the air sinuses have good drainage except the maxillary, because **all sinuses** (except maxillary) **drain in the infundibulum anterior to hiatus semilunaris**, and even if there is an infection, the secretion will flow down easily to the nose through drainage openings.

Why except for the maxillary sinus? since the maxillary drainage opening is **high up** in the inferoposterior part of hiatus semilunaris → so the drainage is very bad.

When can we drain it? If the person bends over and his head is below (like in prostration/ السجود) → so when an inflamed maxillary air sinus patient prostrates this will cause a throbbing pain.

Mucous membrane:

The nasal cavity and respiratory tract are lined with pseudostratified ciliated columnar epithelium. **Excluding 2 structures:**

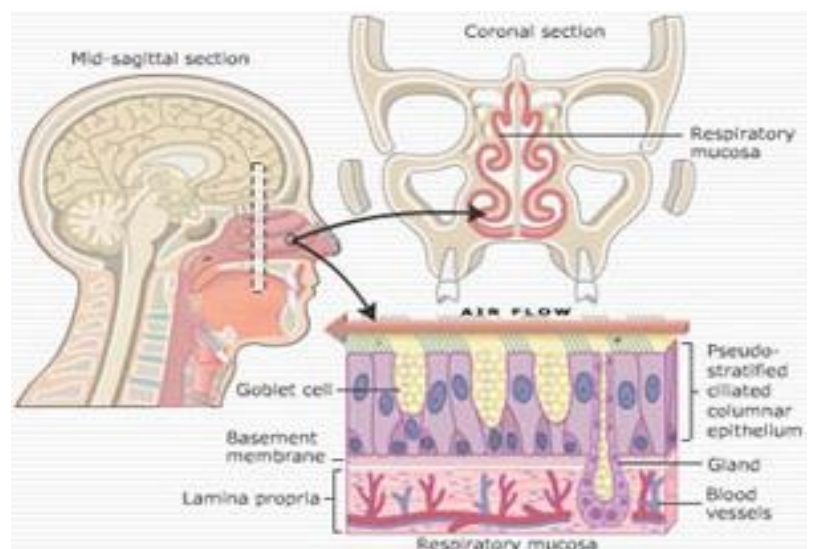
- 1- The **vestibule's** epithelium: stratified squamous keratinized with hair follicles (modified skin with vibrissae).
- 2- The **roof of the nasal cavity** just above the superior conchae is covered with olfactory mucosa (pseudo stratified ciliated columnar + bipolar cell), since it contains bipolar cells (olfactory nerve endings) for smell sensation.

- The mucous membrane is very thick around the conchae, that is the reason behind the feeling of nose obstruction in the case of rhinitis (inflammation in the mucosa of the nose), as the mucosa gets extremely thick which makes breathing from nose harder.

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- Trapping foreign particles and organisms in the inspired air.



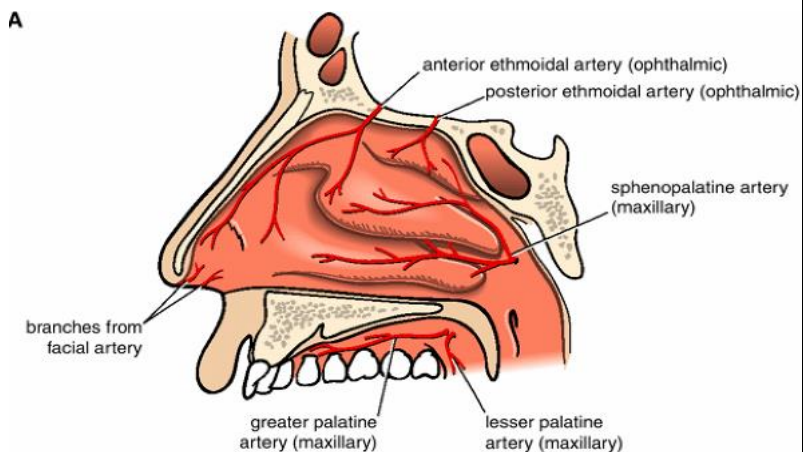
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Blood supply and nerve supply of the nasal cavity

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**. (The doctor said don't focus on quadrants but he read them)



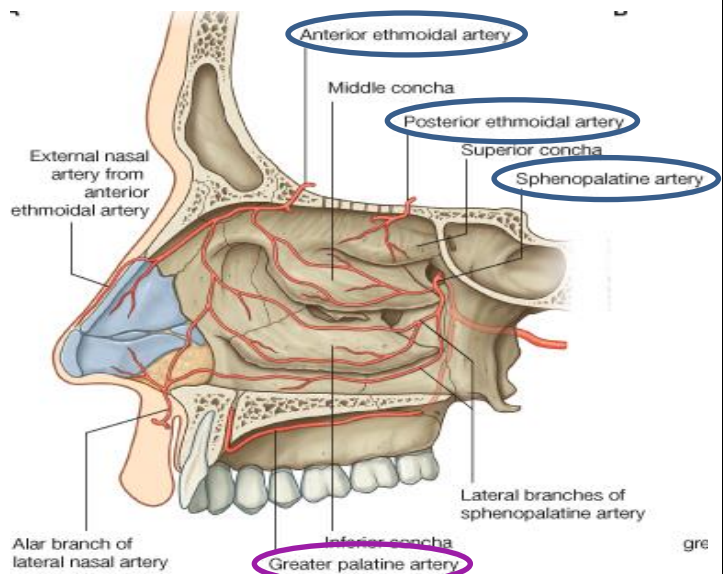
1- Sphenopalatine artery (or nasopalatine A.): (The largest vessel supplying the nasal cavity) it's one of **maxillary artery branches** artery in the **pterygopalatine fossa**, it enters the nasal cavity by passing medially through the sphenopalatine foramen.

which then gives **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 (Posterior septal nasal branch) → *passes over the roof of the cavity and onto the nasal septum* to contribute to **medial wall "septum"** blood supply (It's the most important branch going to the septum).

It can also supply part of the lateral wall.



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 supply the anterior regions of the medial wall and* adjacent floor of the nasal cavity (postero and antero-inferior quadrant of **lateral wall**).

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

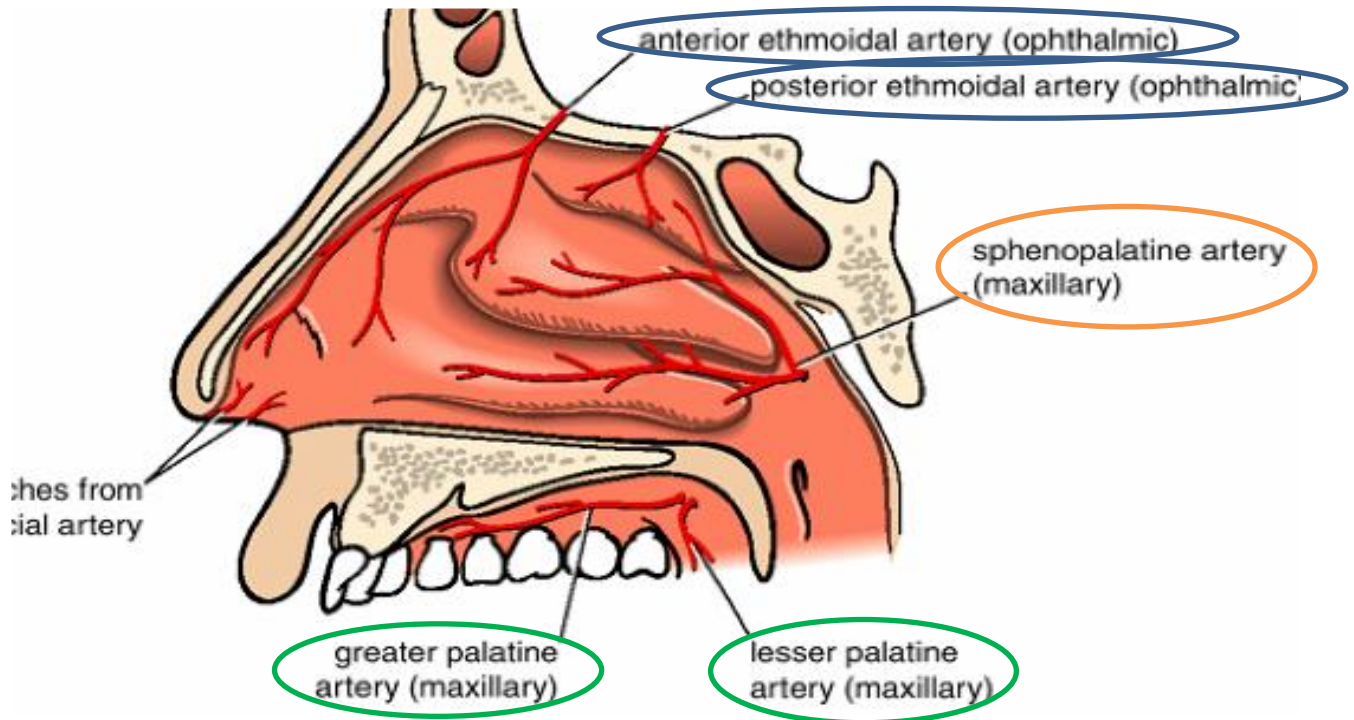
3. The ethmoidal arteries: originate in the orbit from the ophthalmic artery:

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).

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.



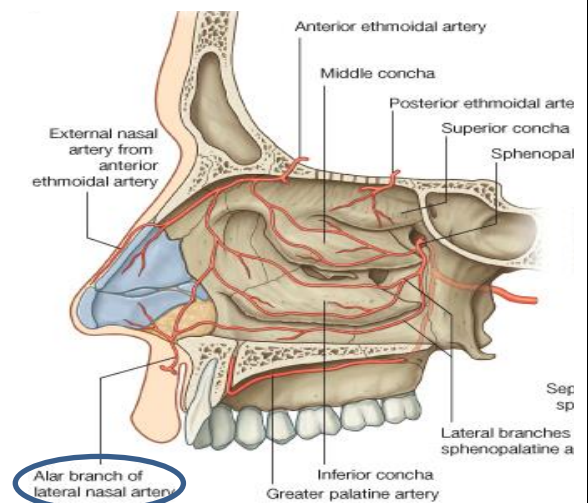
4. Superior labial and lateral nasal arteries: Facial artery branches anteriorly and supply lateral wall and medial wall.

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.

B. **Lateral nasal arteries** *supply blood of the external nose and give alar branches that pass around the lateral margin of the naris and supply the nasal vestibule.*

5. Alveolar arteries are: branches from the infraorbital, which is a branch from the maxillary artery.

Superior alveolar supplies the lateral wall.

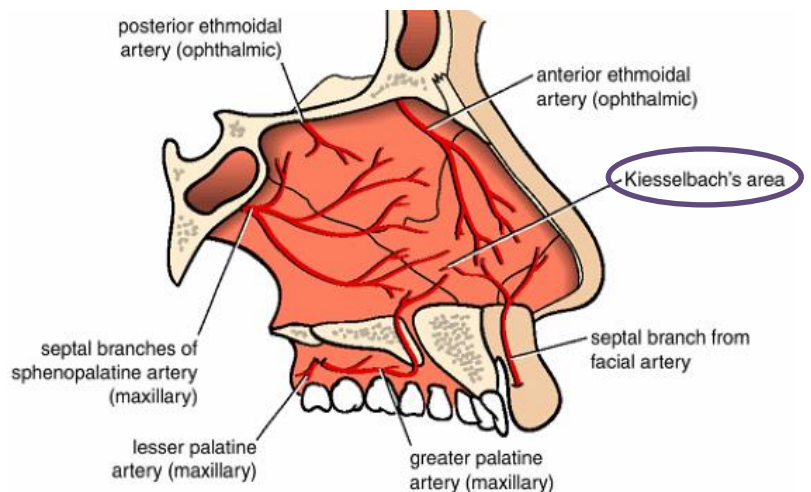


Epistaxis: It is **bleeding from the nose**.

- 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.



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

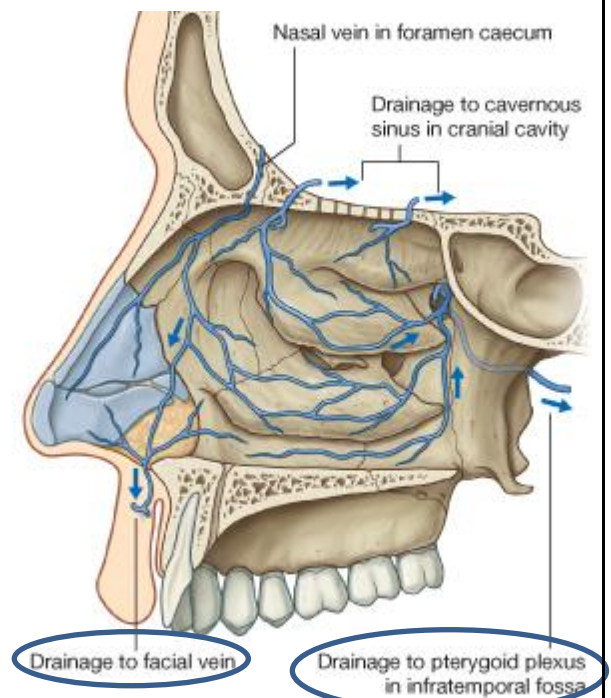
- **Control of bleeding:**

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.

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



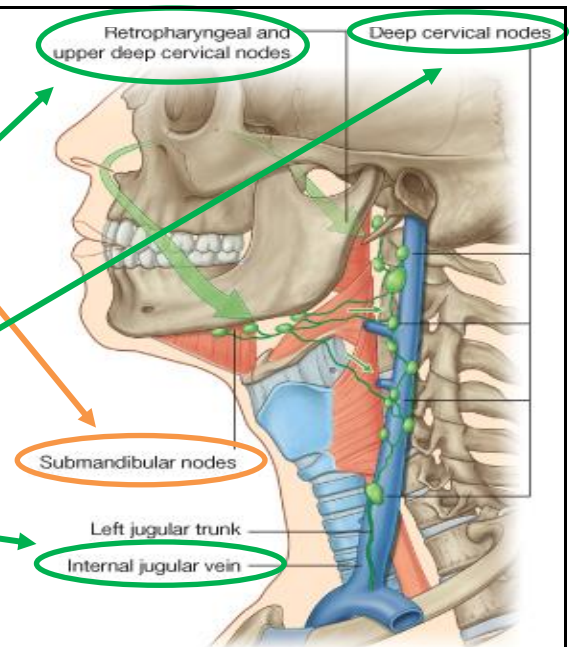
Usually the veins follow the arteries:

*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**).



Innervation of the nasal cavity:

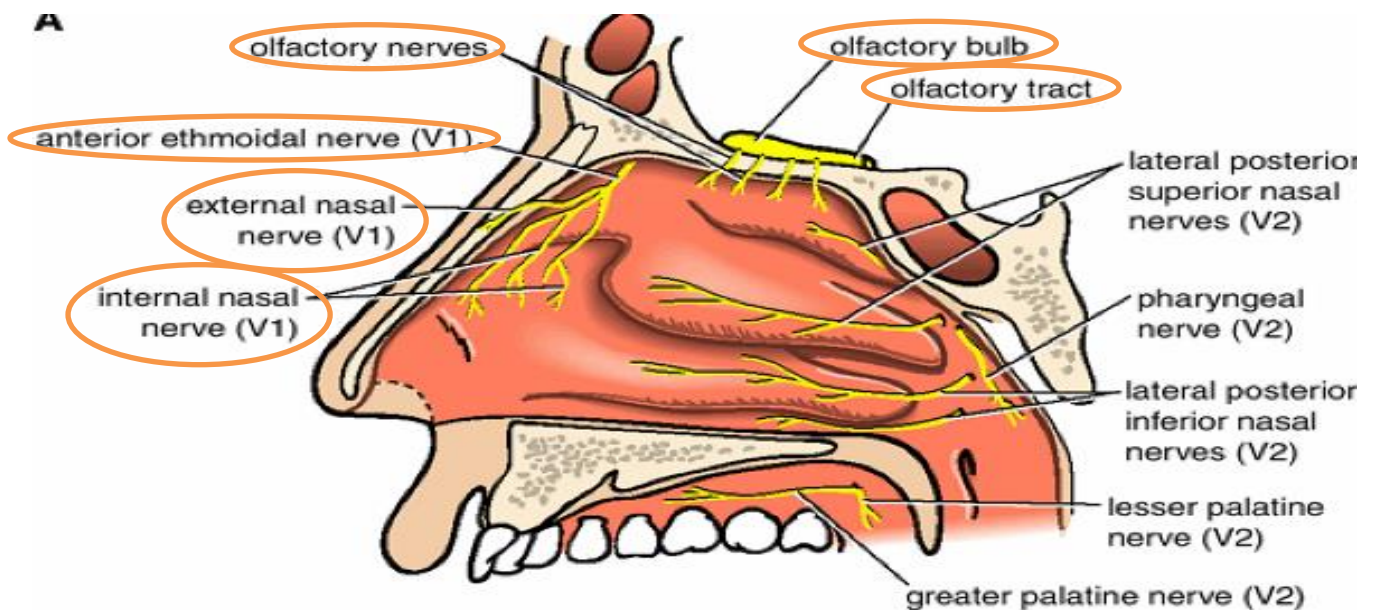
A. The olfactory nerve: starts as bipolar cells in the roof, responsible for special **smell sensation/olfaction**, *composed of axons from receptors in the olfactory epithelium at the top of each nasal cavity, olfactory filaments pass superiorly through the cribriform plate to synapse within the olfactory bulb of the brain.*

Bipolar cells → olfactory filaments → olfactory bulb → olfactory tract → smell center in the temporal lobe.

B. Branches of ophthalmic nerve through nasociliary nerve in the orbit:

Anterior ethmoidal N → sensory to lateral & medial walls → *continues on the undersurface of the nasal bone to → the external surface of the nose by traveling between the nasal bone and lateral nasal cartilage, terminates as the external nasal N.*

Posterior ethmoidal N → through a canal (post. Ethmoidal foramen) in the medial wall of the orbit → supplies the mucosa of the ethmoidal & sphenoid **air sinuses**. (Normally does not extend into the nasal cavity itself).



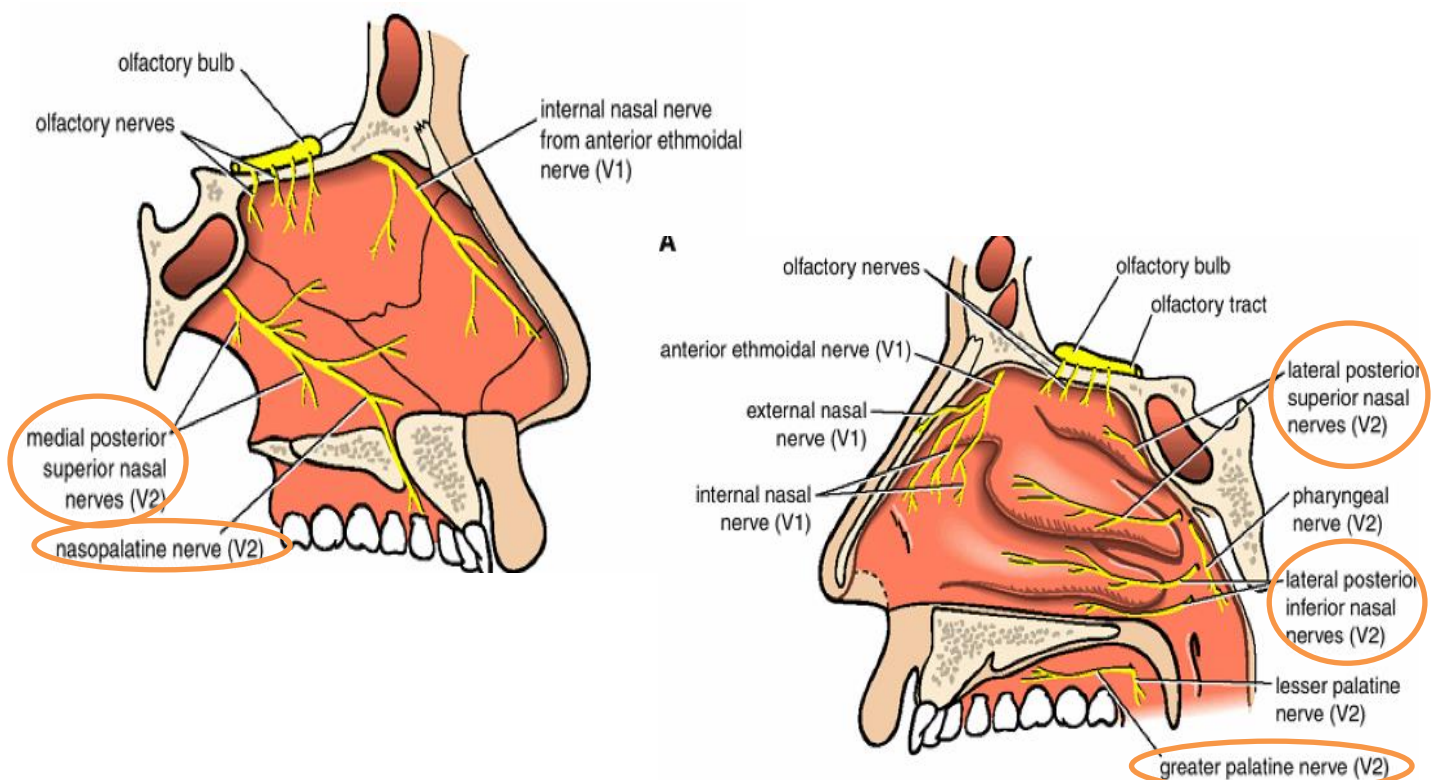
Branches of the **ophthalmic** and **maxillary** nerves: supply **general sensation** to the nose (sensory).

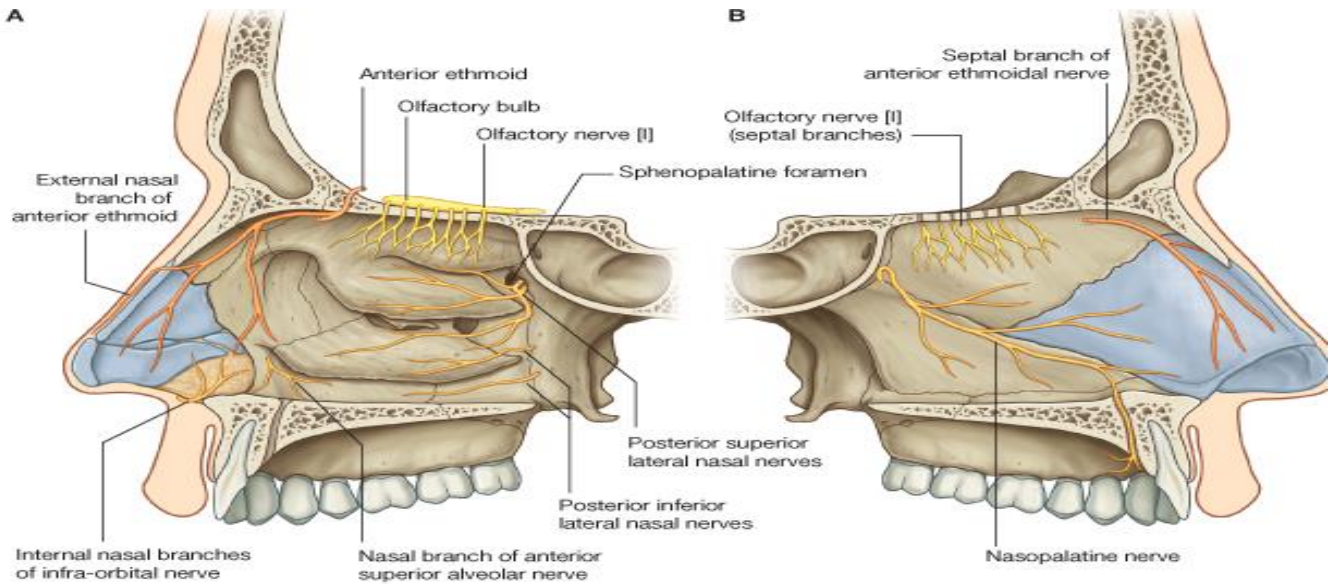
Maxillary nerve: has branches that supply the **lateral wall and the septum** and their names **correspond to the names of the arteries**. (The doctor didn't read the following, but he explained them in the second lecture).

- *Originates in the pterygopalatine fossa just lateral to the lateral wall of the nasal cavity*
- *Leaves the fossa to enter the nasal cavity by passing medially through the sphenopalatine foramen*

1. *Posterior superior lateral nasal nerves: pass forward on and supply the lateral wall of the nasal cavity.*
2. *Posterior inferior nasal nerves: originate from the greater palatine nerve, innervate the lateral wall of the nasal cavity.*
3. *Anterior superior alveolar branch of the infra-orbital nerve: supplies the lateral wall near the anterior end of the inferior concha.*
4. *Largest of these nerves is the nasopalatine nerve : passes through the incisive canal onto the roof of the oral cavity and terminates by supplying the oral mucosa posterior to the incisor teeth.*
5. *Posterior superior medial nasal nerves: cross the roof to the nasal septum and supply both these regions.*

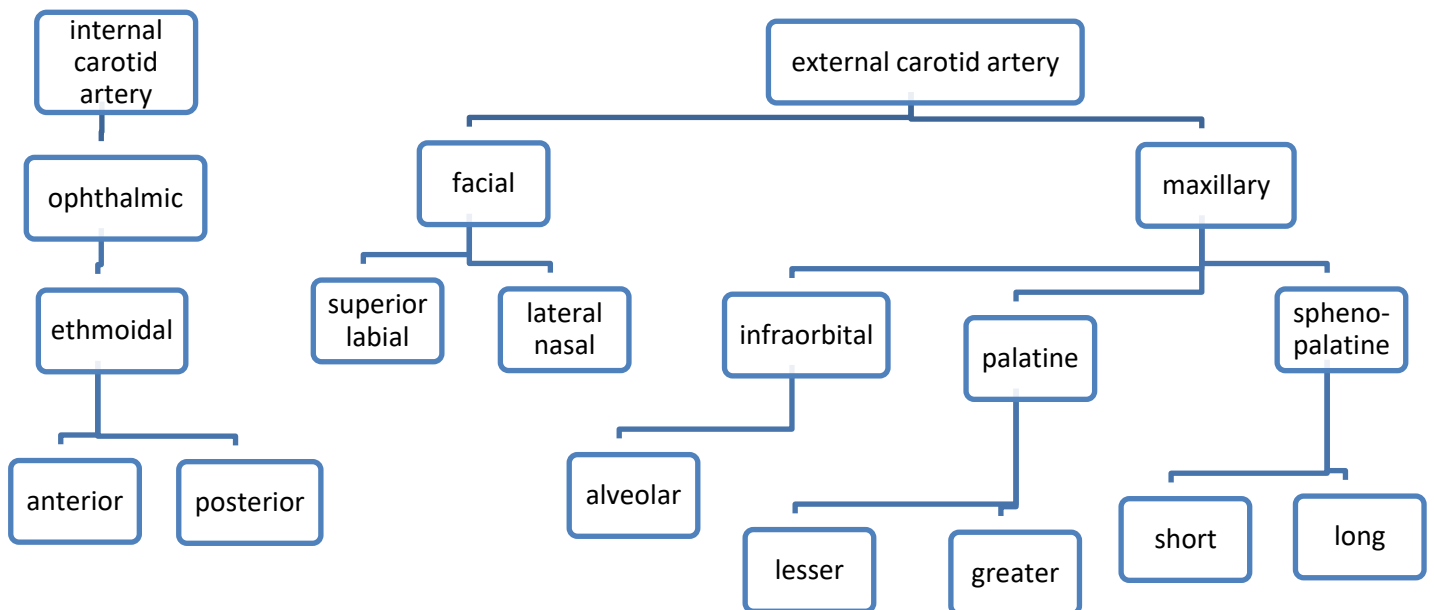
C. **Parasympathetic (secretomotor)** comes through the **facial nerve** so the facial gives the secretomotor innervation for the **mucous glands** of the nose.





Summary for blood supply and innervations:

- Postero-superior quadrant:** Posterior-superior lateral nerve and vessels (**short sphenopalatine**)
- Postero-inferior quadrant:** **Greater palatine** nerve and vessels
- Antero-superior quadrant:** **Ant. Ethmoidal** nerve (internal and external nerve) and artery
- Antero-inferior quadrant:** **Ant. Superior alveolar** nerve and branches from the **facial** and **greater palatine** artery
- Nasal septum:** Lower posterior part by the **long sphenopalatine** nerve
Upper anterior part by the septal branch of the **anterior ethmoidal** nerve.
Blood supply by the **long sphenopalatine** artery.



Superior meatus	Middle meatus	Inferior meatus	Sphenoethmoidal recess
Posterior ethmoidal sinus	Anterior ethmoidal sinus Middle ethmoidal sinus Maxillary air sinus Frontal air sinus	Nasolacrimal duct	Sphenoidal air sinus

Questions from sheet 2017:

1) pseudostratified ciliated columnar epithelium lining all of the following except:

A-infraepiglottis

B- Lateral wall of nasal cavity

C- Conducting bronchiole

D- Superior part of nasal cavity (or olfactory part/roof)

E- Nasopharynx

2) All of the following nerves supply the lateral wall of the nasal cavity except:

A- anterior ethmoidal nerve

B- Posterior ethmoidal nerve

C- Anterior palatine nerve (greater)

D- Posterior superior lateral nasal nerve

E- Anterior superior alveolar

3) Epistaxis in the kiesselbach's area most common artery?

A- short sphenopalatine artery

B- anterior ethmoidal artery

C- posterior ethmoidal artery

D- lateral nasal artery

E- superior labial artery

Good luck 

Answers: 1) D , 2) B , 3) E