Respiratory system

Anatomy

sheet | handout | slides

Number	1 + Lab 1
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This font means that it was also mentioned in the lab, and by the end of the sheet I've wrote exactly what was mentioned in the lab. ***You'll find in this sheet all the figures and what was mentioned in the lecture or in the lab are highlighted in the figure by squares. Good Luck ☺***

Respiratory system organs:

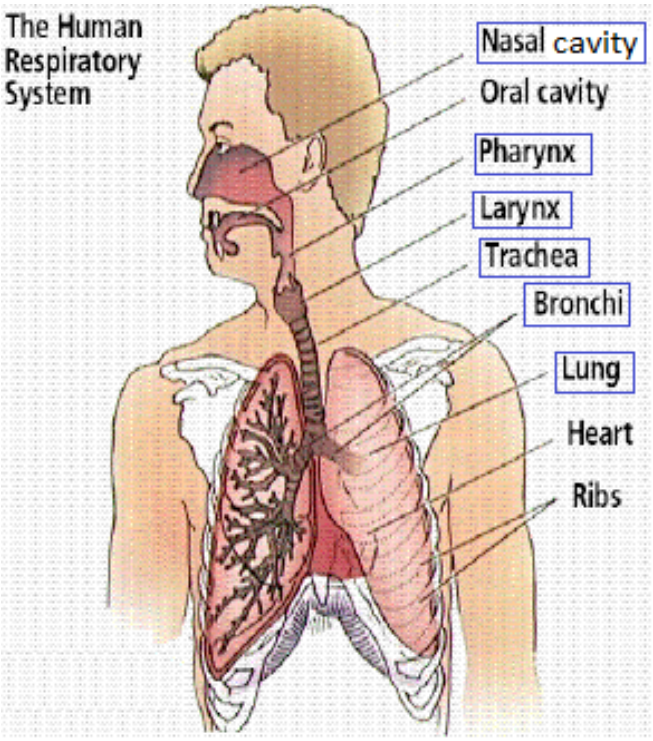
1. The Nose, Nasal Cavity, and nasal sinuses, we will discuss in detail in this sheet.

2. We have the pharynx, which we discussed in the digestive system

-The pharynx is divided into: Nasopharynx, Oropharynx, and Laryngopharynx.

3. The next part is the larynx which contains the true vocal cords and is responsible for phonation of the voice and air passage.

4. This is followed by the trachea which contains hyaline cartilage that helps the trachea to stay opened for the passage of air.



5. Right and left main bronchus that give rise to smaller bronchi (secondary, tertiary bronchi or bronchopulmonary segments).

-The bronchi are either extra- or intra- pulmonary

6. The bronchi are followed by bronchioles

-The **difference between bronchi and bronchioles** is that bronchi contain cartilage while bronchioles don't. This is why bronchioles are susceptible to asthma, which is contraction of the smooth muscles of the bronchioles (cartilage helps in opening the bronchi but in the case of bronchiole the smooth muscle contraction results in obstruction of the air passage).

* The bronchioles are divided into conducting and respiratory.

7. The lungs contain hundreds of millions of alveoli, each alveolus is surrounded by a network of capillaries.

-The alveoli and capillaries are involved in gas exchange (The respiratory system's most important function).

***Respiration (process of breathing);**

- Inspiration: filling of lungs with O2.
- Expiration: the exhalation of breath from the lung, and the production of voice (vocal cord movements) accompany expiration.

Respiration is a very important process, when you cut the oxygen from the brain for 2-5 minutes it will result in brain death.

In clinical practice:

You should check if the patient is breathing (no airway obstruction), if he's awake and can't breathe you should insert an endotracheal tube in order for him to start breathing again. Sometimes tracheostomy (an opening in the trachea to allow breathing) is done.

- **Respiratory tract lining epithelium: pseudostratified ciliated columnar**.

Functions of the Respiratory System

1) **Gas exchange,** which occurs in the alveolar-capillary membrane

2) **Regulation of blood pH** by controlling CO2 and O2 concentrations

3) **Filtrates the inspired air** from dust, foreign bodies, viruses, and bacteria

-The type of epithelium on structures responsible for filtration is **Pseudostratified ciliated columnar epithelium** because cilia moves unwanted particles from inside to the outside of the body (The cilia are unidirectional from inside to outside movement).

-The part of the nose responsible for filtration is the vestibule.

-The vestibule contains short, thick hair called vibrissae and is present on the anterior part of the nose

4) Olfaction/smell

-Bipolar cells in the roof of the nasal cavity are responsible for your smell sensation.

Phonation/Sound production

-This occurs due to the vibration of the true vocal cords of the larynx.

5) Mucous secretion

-This contributes to filtration and moisturizing and heating the air entering the respiratory tract.

The Nose, Nasal Cavity, and Paranasal Sinuses

The Nose is mainly divided into the:

1) External Nose

2) Internal Nose (Nasal Cavity)

The nose can be generally described as two cavities separated by a septum.

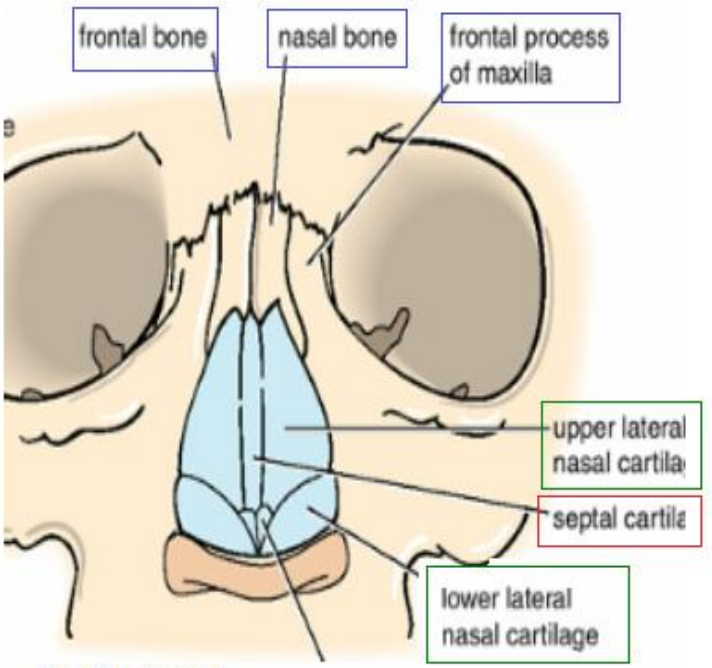
-The Septum is considered the medial wall of the nose.

1) External Nose

Anterior part: Movable cartilage

Cartilaginous framework:

- Septal cartilage (middle wall)
- Lateral nasal cartilage (lateral wall)
- Alar cartilage (lateral wall) it is made up of two muscles; compressor and dilator.



Bony framework
Medial wall cartilage
Lateral wall cartilage

All are plates of hyaline cartilage.

Posterior part: Bone

Bony framework:

- Nasal bones
- Frontal process of the maxillae
- Nasal part of the frontal bone

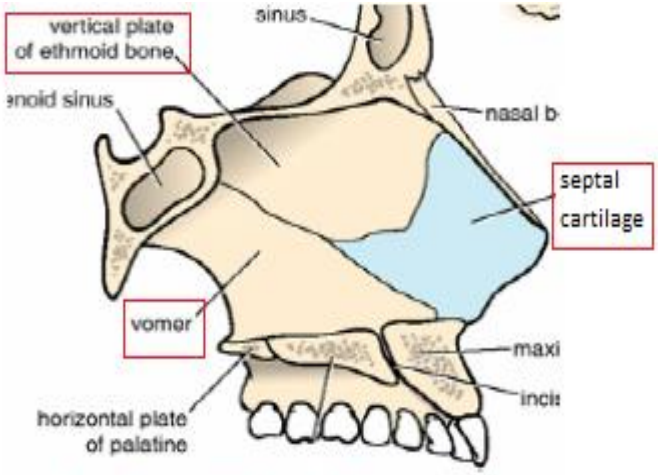
A) Nasal Septum/ Medial wall of the Nasal Cavity

If we look at this picture of the septum of the nose, we see that

1) The anterior part is cartilage (Septal cartilage).

2) The upper posterior part is the vertical/perpendicular plate of the ethmoid bone.

3) The lower posterior part is made up of the vomer.



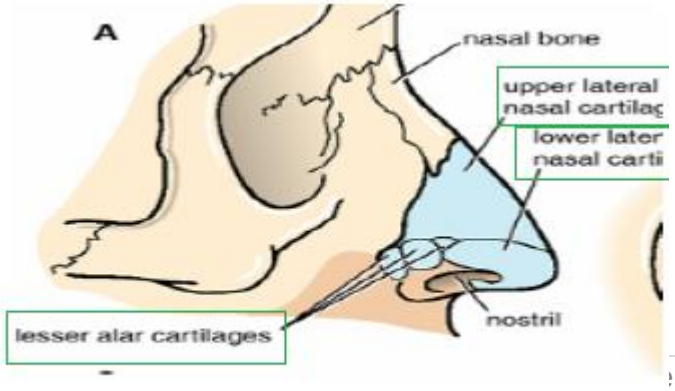
Nasal Septum/ Medial wall of the nasal cavity.

- 90% of people have deviation of septum but without complications, if there's complications like snoring during sleep or breathing through the mouth we interfere by surgery to correct the septum deviation.

B) Lateral Wall of the External Nose

The lateral wall is made up of cartilage, bones, and mucosa

Anteriorly, it's formed of the upper and lower lateral nasal cartilages, plus the alar cartilage.



lateral wall of the external nose

The ala contains two muscles important for the nose; The dilator and the compressor nasalis.

*Nasalis: a sphincter-like muscle of the nose whose function is to compress and dilate the nasal cartilages. It is the muscle responsible for "flaring" of the nostrils.

Blood Supply of the External Nose

Most blood supply to the external nose is from the **Ophthalmic** (branch of internal carotid artery) and **Maxillary** (branch of external carotid artery) arteries.

1. **The ophthalmic artery**

The ophthalmic artery enters the orbital cavity through the optic canal, while accompanying the optic nerve.

When the ophthalmic artery enters the nasal canal, it gives the **anterior and posterior ethmoidal arteries** which supply the lateral wall. The anterior ethmoidal artery is the one which goes to the external nose and becomes the external nasal artery.

2. **The maxillary artery**

One of the terminal branches of external carotid. Gives blood supply to the upper jaw and then enters the inferior orbital foramen to become the infraorbital artery.

3. **The facial artery** (branch from external carotid artery) also participates in the blood supply to the external nose.

The facial artery gives rise to the superior labial artery which gives rise to the nasal artery. The fascial artery supplies the ala and the lower part of the septum.

Nerve Supply of the External Nose

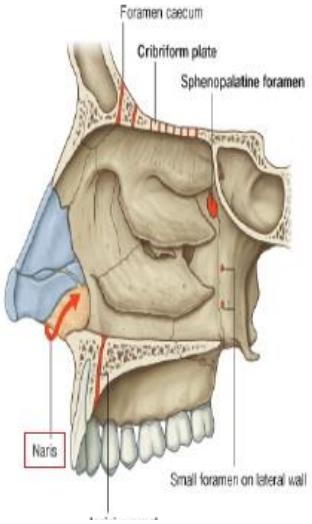
- The External nose is supplied by the **infratrochlear** and **external nasal** which are branches of the ophthalmic nerve.

The ophthalmic nerve, like the artery, gives rise to anterior and posterior ethmoidal branches
The external nasal branch is a direct branch of the anterior ethmoidal nerve

- The maxillary nerve, like the maxillary artery, gives an **infraorbital** branch when entering the inferior orbital foramen

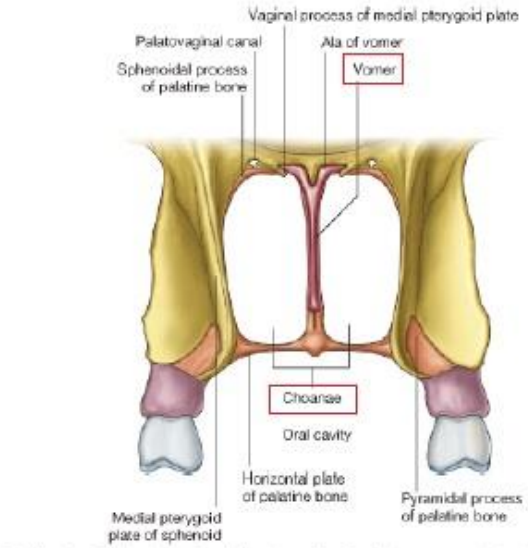
*The maxillary and the ophthalmic nerve are both branches of the trigeminal nerve (Cranial Nerve V)

2) The Nasal Cavity



- Two cavities divided by nasal septum.
- Extend from the anterior nasal aperture *(nostril/anterior nares)* to the posterior nasal apertures *(choana/posterior nares)*
- *Nostril* → Held open by the surrounding alar cartilage and septal cartilage. Can be widened further by the action of the related muscles of facial expression.
- *Vestibule* is located above the nostril. It is the area of the nasal cavity lying just inside the nostril. It is also covered by skin and contain vibrissae (thick hair).
- *Choana* → opens into the nasopharynx, divided by the vomer (nasal septum).

  Septum is made up of the septal cartilage, the vertical plate of the ethmoid, and the vomer.
- *Eustachian tube is in the lateral wall of the nasopharynx.*



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IMPORTANT question; what are the boundaries of the choana?

Medially → vomer

Roof → ala of vomer, sphenoid process of palatine bone, palatovaginal canal, vaginal process of medial pterygoid plate.

Laterally → medial pterygoid plate

Inferiorly → horizontal plate of palatine bone

The reason why choana is surrounded by bone is to stay open and allow the passage of air to the nasopharynx.

Functions of the Nasal Cavity:

1) Respiration

2) Olfaction

3) Resonance of the voice

The part of the nasal cavity responsible for this function is the paranasal sinuses.
The paranasal sinuses are the frontal, ethmoidal, maxillary, and sphenoid air sinuses (each air sinus has a duct that opens in the lateral wall of the nose).

*They are small cavities filled with air and covered by mucosa
*This is why sinusitis leads to change in voice

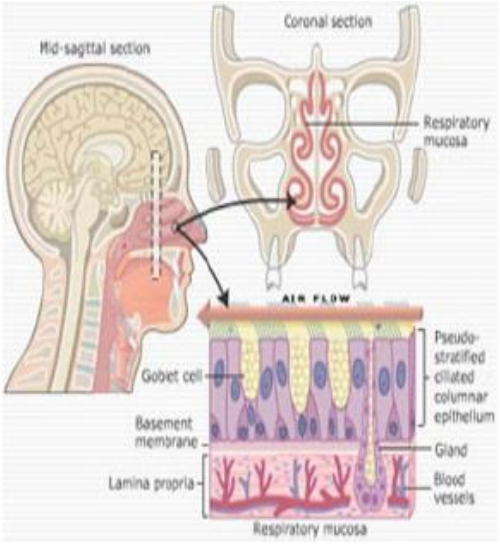
4) Draining of lacrimal fluid

The lacrimal sac in the medial angle of the eye is filled with tears and secretions and connects to the nasolacrimal duct.
The nasolacrimal duct is drained into the inferior meatus of the lateral wall of the nasal cavity. This is why excessive production of tears, like in crying, can lead to leakage from the nose.

5) Protective

These protective functions include sneezing to excrete unwanted substances, filtration to prevent foreign body entrance, proteolytic enzymes to kill bacteria, and warming and moistening of the air.

The mucous membrane in the nasal cavity is very thick. This is because it contains a large plexus of veins. This plexus of veins serves to warm blood.

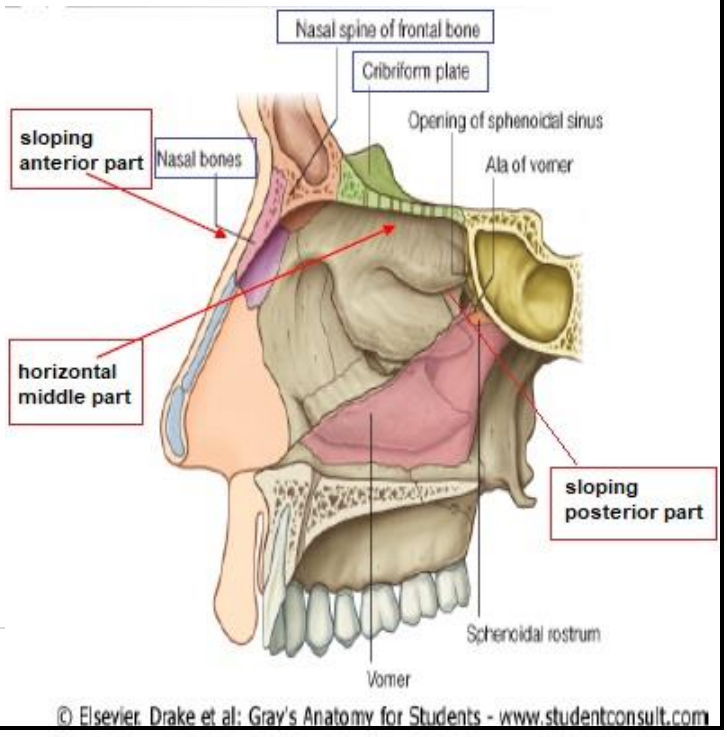


Borders of the Nasal Cavity Medial wall

The medial wall: septum; composed of the septal cartilage (anteriorly), vertical plate of ethmoid (superio-posterior), and the vomer (inferio-posterior).

Roof

Is divided into anterior sloping part, middle and posterior sloping part



The sloping, anterior part of the roof is made up of the nasal spine of the frontal bone and the nasal bones

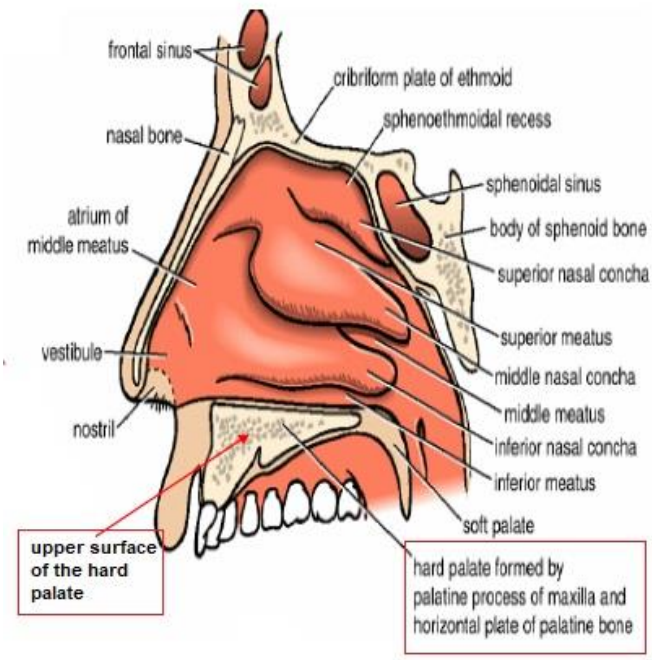
The horizontal, middle part of the roof is made up of the cribriform plate of the ethmoid bone

-It's called cribriform (مخرّمة) because it contains perforations to allow passage of the filaments of the *olfactory* nerve (Cranial nerve I). You can notice bipolar cells around the cribriform plate which reach to the olfactory nerve.

Bipolar cells → smell cells which transfer the odor into smell impulses until it reaches the smell center in the temporal lobe of the brain which stores all kinds of smells you know.

The olfactory nerve is responsible for smell sensations

The sloping posterior part is the anterior surface of the sphenoid bone, the ala of the vomer, and the vaginal process of the palatine bone.

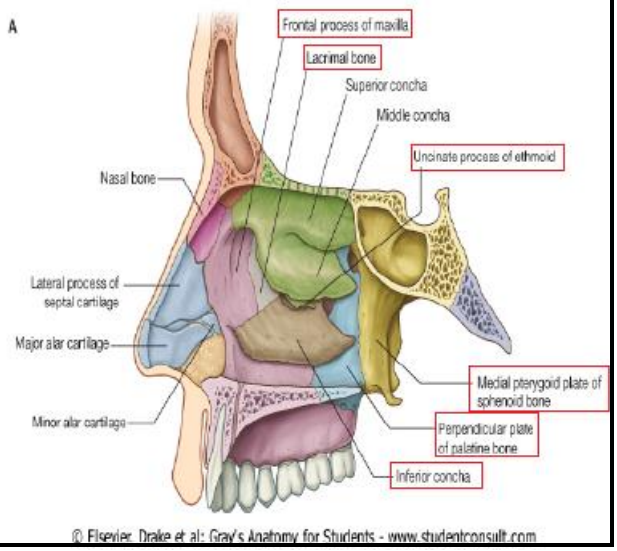


Floor

Is made up of the **Hard Palate**

-The hard plate is made up of the palatine process of maxilla anteriorly, and the horizontal plate of palatine bone posteriorly

- in the hard palate there's incisive foramen that opens in the nasal cavity.



Lateral Wall

Complex and formed by bones (posteriorly), cartilage (anteriorly), and soft tissues.

The bony support:

-Ethmoidal labyrinth and uncinated process,

- Ethmoidal bone (green colour in the figure)→ superior and middle conchae (Conchae are projections of bone covered by mucosa)

-Perpendicular plate of palatine bone

-Medial plate of pterygoid process

-Medial surfaces of the lacrimal bones and the maxilla.

-Inferior concha (it is part of the maxilla but it is considered as a separate bone)

Lateral wall parts:

1. *Vestibule*

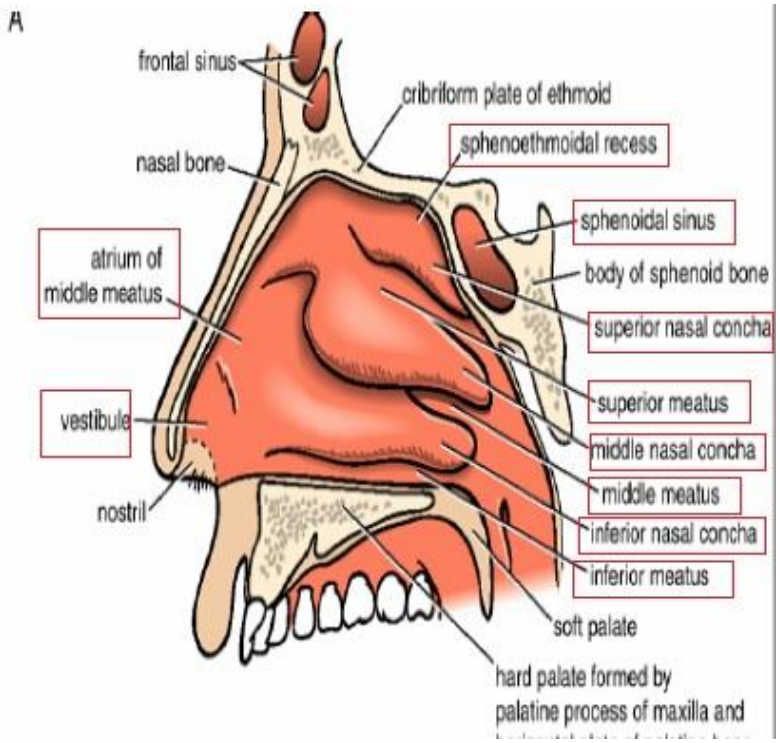
Is the area of the nasal cavity lying just inside the nostril.

Covered with skin and contains thick hair (vibrissae) which is responsible for filtration of air that enter the nose.

Mucosa: is lined with modified skin and has coarse hair.

2. *After the vestibule, we have the atrium or antrum*

3. Finally the lateral wall of the nasal cavity is made up of 3 conchae, 3 meatuses, and 1 recess.



(All air sinuses have a duct that opens in the lateral wall of the nasal cavity).

A. Conchae are projections (processes) of bone covered by mucosa.

- *Superior, middle, and inferior nasal conchae.*
  - Mucosa above the superior concha is lined with olfactory mucous membrane and contains nerve endings.
  - *inferior conchae is the largest among them.*
  - All choncae extend medially across the nasal cavity, separating it into 4 air channels:

Inferior, middle, and superior meatus, and a spheno-ethmoidal recess.

- Anterior end of each choncha curves inferiorly to form a lip that overlies the end of the related meatus.

B. Meatuses are grooves directly below the conchae. Their function is drainage of the paranasal sinuses.

The middle meatus contains 2 structures: The bulla ethmoidalis (lateral wall of the middle meatus) and the hiatus semilunaris (inferior to the ethmoidal bulla), they are clearer when you remove the conchae.

Hiatus semilunaris: anteriorly; anterior ethmoidal air sinus and posteriorly;maxillary air sinus.

Ethmoidal infundibulum: small area infront (anterior) of the hiatus semilunaris.

There are 3 ethmoidal paranasal sinuses (Anterior, middle, and posterior), 1 maxillary, 1 frontal, and 1 sphenoid air sinus on each side of the skull.

1. *Maxillary sinus drain into the middle meatus through **middle or posterior hiatus semilunaris.***
2. *Frontal sinuses drain into middle meatus via **infundibulum and frontonasal duct.***
3. *Sphenoidal air sinus drain into **sphenoethmoidal recess.***
4. *Anterior group of the ethmoidal sinuses drain into the **anterior part of hiatus semilunaris.***
5. *Middle group of ethmoidal sinuses drain into the middle meatus on or above **bulla ethmoidalis.***
6. *Posterior group of ethmoidal sinuses drain into the **superior meatus.***
7. *Nasolacrimal duct opens onto the lateral wall of the **inferior nasal meatus.***

The ethmoidal air sinuses are perforated, and they are in the ethmoidal bone.

C. *This recess is called the sphenoethmoidal recess (above the superior conchae) and sphenoid air sinus opens in it.*

Function of mucous membrane:

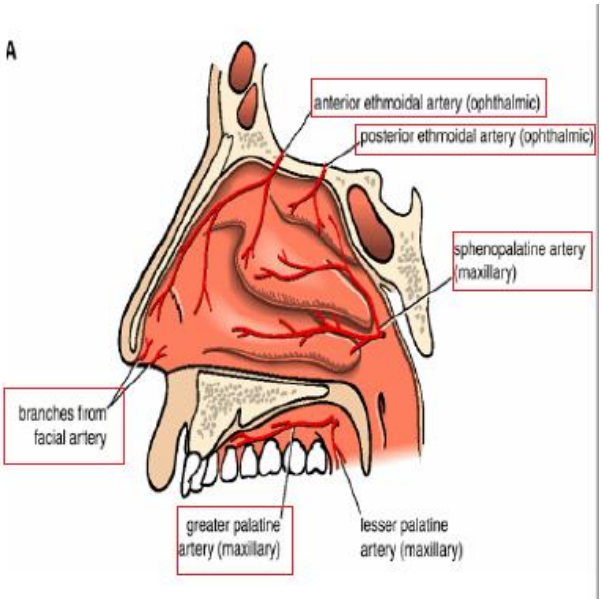
(remember the respiratory mucous membrane is lined with pseudostratified ciliated columnar epithelium with goblet cells, except : 1. The vestibule is lined with modified skin and has coarse hairs 2. Above the superior concha is lined with olfactory mucous membrane and contains nerve endings.

We also notice a seromucous gland that opens to the surface .In the lamina propria, especially in the middle and inferior chonchae we have thick mucosa because of the presence of plexus of veins with the ability to warm air; and this is protective for brain cells.

- Large plexus of veins in the submucous connective tissue is present in the respiratory region.

1. Warm blood in the venous plexuses serves to heat up the inspired air as it enters the respiratory system. (you can notice that the area related to the middle and inferior chochae contain thick mucosa due to the presence of venous plexus)
2. Mucous trap foreign particles and organisms in the inspired air.

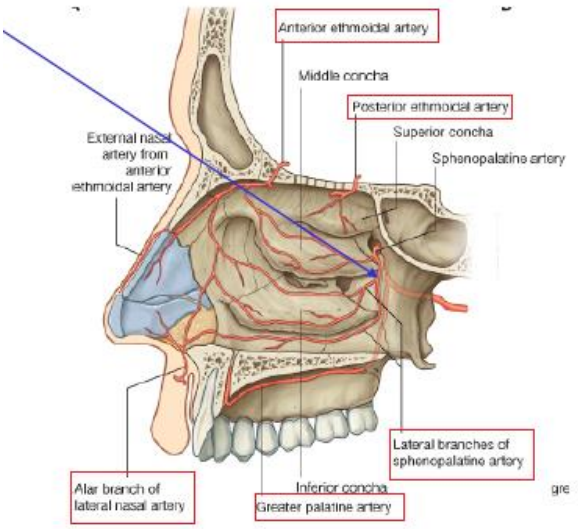
Blood Supply of the Nasal Cavity



When discussing the blood or nerve supply of the nose, we divide it into two major categories: Vessels which supply the septum and vessels which supply the lateral wall.
The lateral wall can be divided into 4 quadrants: Superior anterior, superior posterior, inferior anterior, and inferior posterior

Generally, almost all of the blood supply comes from the **ophthalmic artery**, a branch of the internal carotid, or the **maxillary artery**, a branch of the external carotid.

- **Ophthalmic artery** give branches to anterior and posterior ethmoidal arteries.
    - Anterior ethmoidal artery accompany the anterior ethmoidal nerve and supply the medial wall, and anterior superior quadrant of lateral wall.
    - Posterior ethmoidal artery descend into the nasal cavity through the cribriform plate and has branches to upper parts of medial and lateral walls.



- **Maxillary artery** give branches to sphenopalatine artery and greater palatine artery.

- About sphenopalatine artery: it is the largest vessel supplying the nasal cavity, it is a terminal branch of the maxillary artery in the pterygopalatine fossa, and it enters the nasal cavity by passing medially through the sphenopalatine foramen.

Branches of sphenopalatine artery→

1. Posterior lateral nasal branch (short sphenopalatine artery) supply the posterior superior quadrant of the lateral wall.
2. Posterior septal branch (long sphenopalatine artery/nasopalatine) supply the medial wall.

- About greater palatine artery: arise in the pterygopalatine fossa as a branch of the maxillary artery, enters the nasal cavity by the incisive canal, supply the anterior region of the medial wall, posterior and anterior inferior quadrant of lateral wall.

- **Facial artery** give branches to Superior labial and lateral nasal artery

Superior labial → alar → region around nares

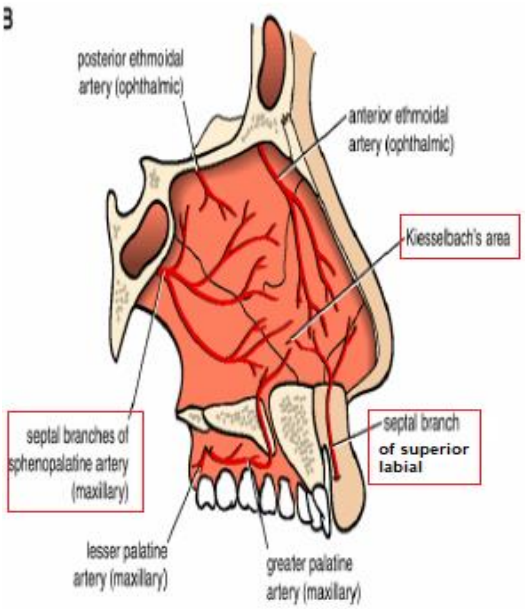
Superior labial → septal → anterior of nasal septum

Lateral nasal→ external nose

Epistaxis: Bleeding through the nose

- The **Long Sphenopalatine artery and the Superior Labial artery** form anastomoses on the lower anterior wall of the septum of the nasal cavity

IMPORTANT question; what is the main cause of epistaxis?
- anastomoses of long sphenopalatine artery and the superior labial of facial artery.
-The area of anastomosis between these 2 arteries is called Keisselbach's area
-Any trauma in Keisselbach's area could lead to bleeding
- The usual treatment should just be to avoid swallowing any blood (avoid lying position) and placing pressure on the cartilage of the anterior nares for a few minutes



If this treatment doesn't work, cauterization should be performed or silver nitrate should be administered

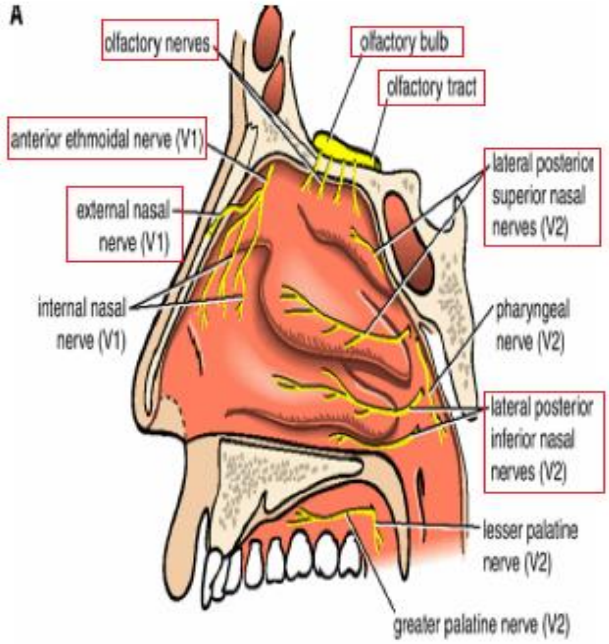
Venous Drainage

Superiorly → Ophthalmic veins →Cavernous sinus

Anteriorly → through the facial vein → internal jugular vein

Posteriorly → pterygoid plexus of veins-> continues as maxillary vein→parotid gland→unites with superficial temporal→make up the retromandibular vein

Is there a connection between the pterygoid plexus of veins and the cavernous sinus? Ofcourse, through the ophthalmic veins and emissary veins and this is a very dangerous issue, if puss cells reach the cavernous sinus it could lead to thrombosis and it is fatal.



Lymphatics

Mainly anterior part drain into the submandibular nodes
Upper and posterior → internal jugular → deep cervical

Innervation

The nerves are organized the same way as the blood supply (into lateral wall and septum) and take the same names as their arteries we have three types of sensation:

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

Nerves and arteries are the same, in name and in distribution. We have greater and lesser palatine nerves with the arteries. Long and short sphenopalatine nerves.

The main nerve supply to the septum of the nose is the Long Sphenopalatine(Nasopalatine nerve)
The **ophthalmic nerve** gives rise to the anterior and posterior ethmoidal nerves, which give of branches to the lateral and septal walls of the nose (originate from the nasocilliary nerve in the orbit).

Anterior ethmoidal nerve travels with the anterior ethmoidal artery, It has branches to the medial and lateral wall of the nasal cavity and continues forward on the undersurface of the nasal bone, onto the external surface of the nose by traveling between the nasal bone and lateral nasal cartilage, terminates as the **external nasal nerve**

Posterior ethmoidal nerve leaves the orbit through a similar canal in the medial wall of the orbit.
Terminates by supplying the mucosa of the ethmoidal cells and sphenoidal sinus.
Normally does not extend into the nasal cavity itself.

2. the parasympathetic stimulation and secretomotor innervation is supplied by the greater petrosal nerve (which is a branch of the facial nerve) to the gland of the nose.

3. The olfactory nerve is responsible for special smell sensation/olfaction; composed of axons from receptors in the olfactory epithelium at the top of each nasal cavity, pass superiorly through the cribriform plate to synapse with the olfactory bulb of the brain.

What are the nerves that supply the septum?

1) Greater palatine
2) Nasopalatine (long sphenopalatine)

Branches of the Maxillary Nerve (from slides):

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** supply the lateral wall near the anterior end of the inferior concha.

4. Largest of these nerves is the **nasopalatine nerve**, pass through the incisive canal onto the roof of the oral cavity, and terminates by supplying the oral mucosa posterior to the incisors.

5. **Posterior superior medial nasal nerves** cross the roof to the nasal septum and supply both these regions

Summary for blood supply and innervations (from the slides):

1. **Postero-superior quadrant**: Posterior-superior lateral nerve and vessels (short spheno palatine)

2. **Postero-inferior quadrant:** Greater palatine nerve and vessels

3. **Antero-superior quadrant**: Anterior Ethmoidal nerve (internal and external nerve) and artery

4. **Antero-inferior quadrant:** Ant. Superior alveolar nerve and branches from the facial and greater palatine artery

5. **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.

Paranasal Sinuses

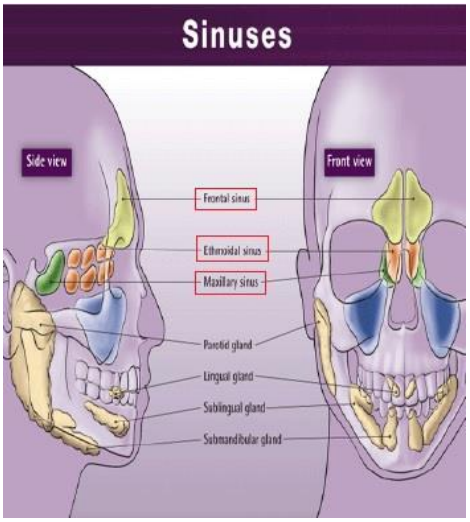
As we mentioned before, there are 4 paranasal sinuses on each side of the nasal cavity

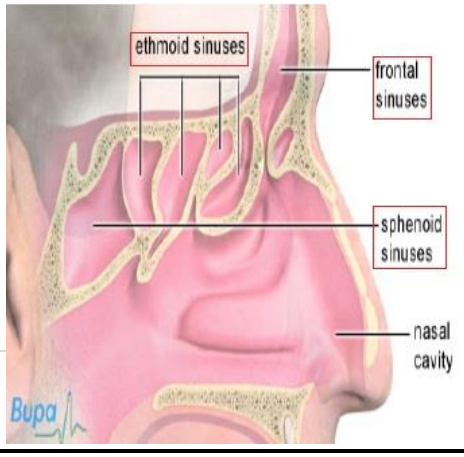
-There are 6 ethmoidal sinuses, 2 sphenoid, 2 maxillary, and 2 frontal air sinuses.

- These sinuses function in resonance of the voice, decreased weight of the skull, and protection (by reducing the intracranial pressure and preventing damage or compression to the brain).

- These sinuses start off rudimentary and enlarge with growth of the bones of the face.

-These air sinuses are innervated by branches of the trigeminal (maxillary and ophthalmic nerve)





1-The **Frontal air sinus** is innervated by the supra-orbital nerve of the ophthalmic nerve. When infected, it has easier drainage since it's located upward and the duct is directed below it.

2-The **Ethmoidal air sinuses** are innervated by the anterior and posterior ethmoidal branches of the nasocilliary nerve from the ophthalmic nerve.

2-The **sphenoid sinus** is innervated by the posterior ethmoidal nerve of the ophthalmic nerve AND the orbital branches of the maxillary nerve

Relations: Above to the pituitary gland and to the optic chiasm (the pituitary gland can be surgically approached), laterally to the cavernous sinuses, below and in front, to the nasal cavities

*A pituitary gland tumor can lead to block of the sphenoid air sinuses

4-The **Maxillary sinus** is innervated by the infraorbital and alveolar branches of the maxillary nerve.

The largest of the paranasal sinuses and completely fill the bodies of the maxillae.

- The maxillary sinus is pyramidal in shape and the apex is directed laterally. It has very bad drainage, this is because the opening of the maxillary sinus is the posterior of hiatus semilunaris and this opening is higher than the maxillary air sinus. You can drain the maxillary sinus surgically by extracting one of the upper molar teeth.

Extraction of upper teeth might lead to **fistula** formation and sinusitis

*Infection of the maxillary sinus can complicate to fistula formation (extract a molar teeth to drain it)

<u>Relations of the Maxillary Sinus</u>

1. Related above to the orbit
2. Related below to the roots of the upper molar and premolar teeth
3. Related behind to the infratemporal fossa
4. Related medially to the lower part of the nasal cavity

Anatomy Lab 1

- *Anterior nares, ala of the nose (two muscles → compressor and dilator), internally the vestibule (contains the vibrissae → filtration, and differs in epithelium) and above it is the antrum.*
- *Septum, cartilage, perpendicular plate of ethmoid and the vomer*
- *Olfactory region, above the cribriform plate of ethmoid, differs in epithelium, it contains olfactory epithelium and bipolar cells and sustentacular cells and filaments of olfactory nerve that pass through the cribriform plate of ethmoid, and the nerve filaments starts from this region (olfactory nerve)*
- *Three conchae (superior, middle, inferior), three meatuses (superior, middle, inferior), and one sphenoethmoidal recess (sphenoid air sinus drains into it). Inferior conchae is the largest among conchae.*
- *Paranasal sinuses; frontal, sphenoidal, maxillary, ethmoidal (anterior, middle, posterior)*
- *The ethmoidal air sinuses are located between the frontal and sphenoid air sinuses*
- *Each sinus has a duct that opens in the lateral wall of the nose*
- *Middle meatus ; bulla ethmoidalis, hiatus semilunaris (groove) ← you can clearly see them after removing the conchae. Middle ethmoidal, anterior ethmoidal, and maxillary opening are found here.*
- *Frontal air sinus opens in the middle meatus in the infundibulum*
- *Sphenoid air sinus opens in the recess*
- *Posterior ethmoidal air sinus opens in the superior meatus*
- *Nasolacrimal duct opens in the inferior meatus*
- *Posterior nares → choane, you can find the vomer between the two openings of the choane and in the posterior part of the septum*
- *Eustachian tube → connect the nasal cavity to the middle ear, and function to balance the tympanic membrane.*

IT NEVER GETS EASIER, YOU GET STRONGER!