Review of
ENT PHYSIOLOGY
Textbook Guideline for MS, DLO, FCPS (ENT)

2nd Edition

Edited by
Dr. Md. Hedaiyat Islam

SYNAPSE

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ENT PHYSIOLOGY

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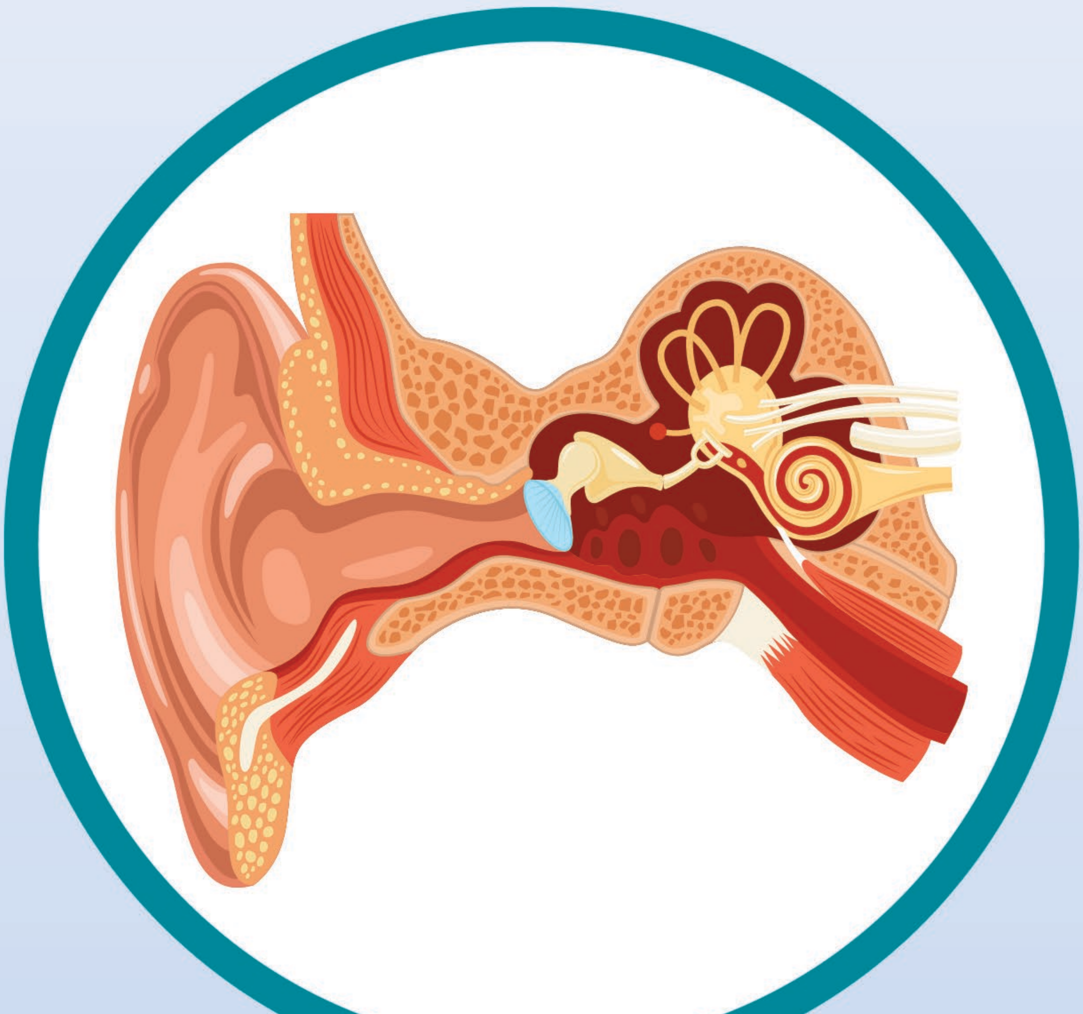
Chapter-01

Hearing and Equilibrium

Ref: Ganong 26E, Guyton 14E, Dhingra 8E, Synopsis 5E, Janquiera 16E



Hearing and Equilibrium

Ref: Ganong 26E, Janquiera Histology 16E

Introduction:

There are six groups of hair cells in each inner ear: one in each of the three semicircular canals, one in the utricle, one in the saccule, and one in the cochlea. Receptors in the semicircular canals detect rotational acceleration, those in the **utricle detect linear acceleration in the horizontal direction, and the ones in the saccule detect linear acceleration in the vertical direction.**

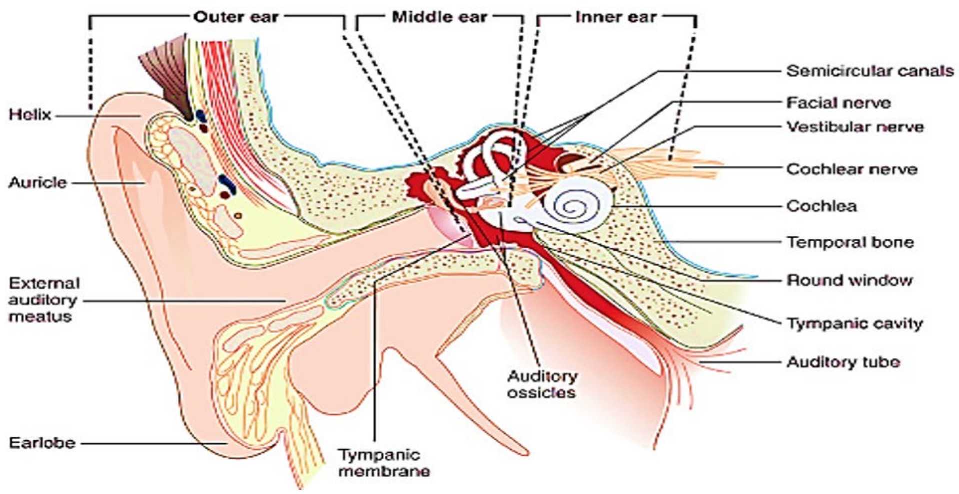
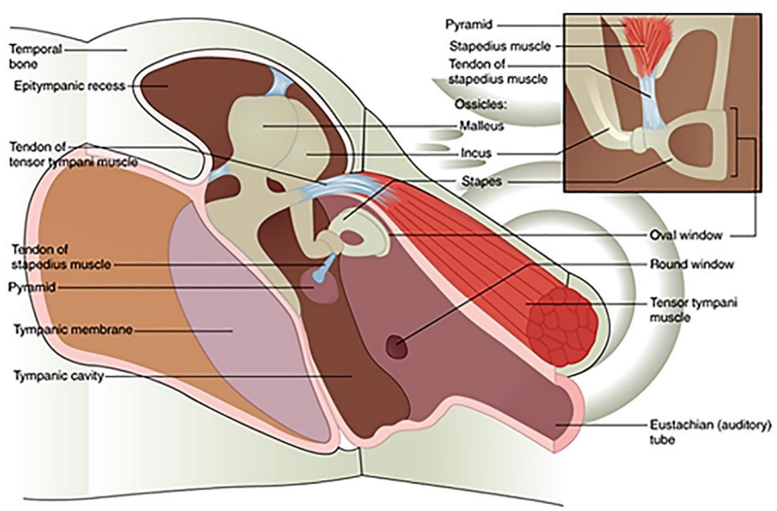


Figure: The medial view of the middle ear containing three auditory ossicles (malleus, incus, and stapes) and two small skeletal muscles (tensor tympani muscle and stapedius). The manubrium (handle of the malleus) is attached to the back of the tympanic membrane. Contraction of **the tensor tympani muscle pulls the manubrium medially and decreases the vibrations of the tympanic membrane; contraction of the stapedius muscle pulls the footplate of the stapes out of the oval window.**



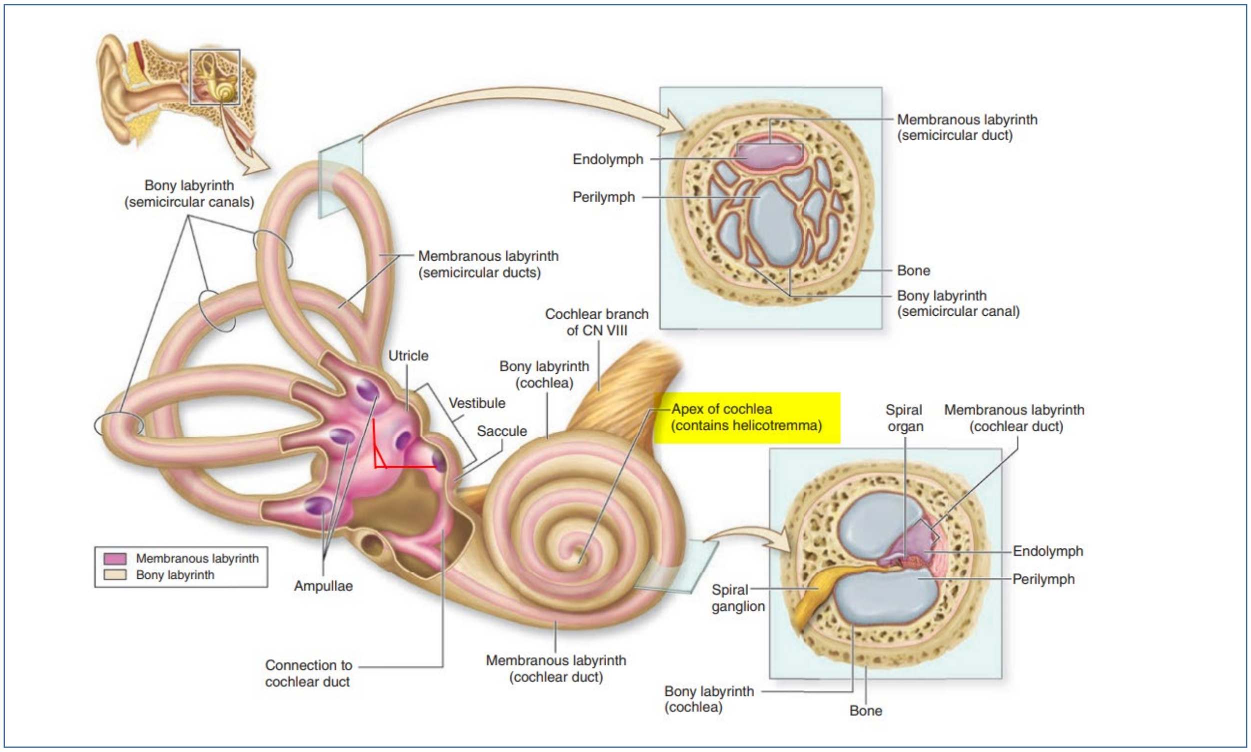


Figure: Cochlea, Vestibule, Semicircular Canal-Internal Ear (Janquiera Histology 16E)

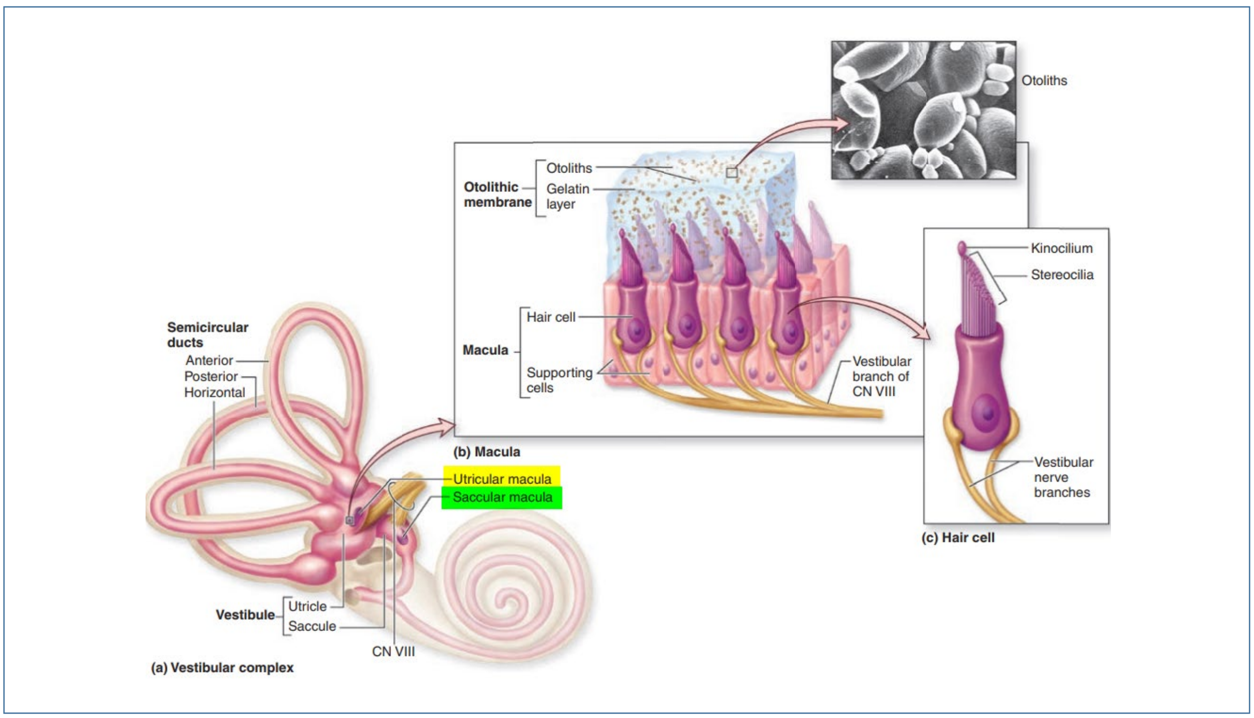


Figure: Vestibular Maculae- Internal Ear (Janquiera Histology 16E

Peripheral Receptors and Physiology of Auditory and Vestibular Systems

Ref: Dhingra 8E

Auditory system

Organ of corti

Organ of Corti is the sense organ of hearing and is situated on the basilar membrane. Important components of the organ of Corti:

1. Tunnel of Corti. It is formed by the inner and outer rods. It contains a fluid called cortilymph. the exact function of the rods and cortilymph is not known.

2. Hair cells they are important receptor cells of hearing and transduce sound energy into electrical energy. Inner hair cells form a single row while outer hair cells are arranged in three or four rows. Inner hair cells are richly supplied by afferent cochlear bres and are probably more important in the transmission of auditory impulses. Outer hair cells mainly receive efferent.

The **Organ of Corti**, also known as the **spiral organ**, is a remarkable structure located within the **cochlea** of the inner ear.

- **Location**:
  - The Organ of Corti resides within the **scala media** of the cochlea.
  - It is positioned on the **basilar membrane**, which separates it from the **scala tympani** below.

- **Structure**:
  - **The Organ of Corti consists of specialized cells:**
    1. **Tunnel of Corti:** It is formed by the inner and outer rods. It contains a fluid called cortilymph
    2. **Hair cells:** 2 types of hair cells are present here.

Differences between inner and outer hair cells

Inner hair cells		Outer hair cells
Total No.	3500 **Type 1 Sensory cell**	12,000 **Type 2 Sensory cell**
Rows	One row **Sterocilia = 40-60, U-shape**	Three or four rows **Sterocilia = 80-100, U or W Shaped**
Shape	Flask shaped /Pyriform/Cup like	Cylindrical
Nerve supply	Primarily afferent fibres and very few efferent	Mainly efferent fibers and very afferent
Development	Develop earlier	Develop late
Function	Transmit auditory stimuli **by inhibition**	Modulate function of inner hair cells **by excitation**
Vulnerability	More resistant	Easily damaged by ototoxic drugs and high-intensity noise
	Vestibulotoxic	**Cochleotoxic + Cytotoxic**

3. **Supporting cell**
   Deiters' cells are situated between the outer hair cells and provide support to the latter. Cells of Hensen lie outside the Deiters' cells. [**Mnemonics CBD HP= Claudia, Botcher, Deiter, Hensen, Pillar Cells]**

4. **Tectorial membrane**
   It consists of gelatinous matrix with delicate fibres. It overlies the organ of Corti. The shearing force between the hair cells and tectorial membrane produces the stimulus to hair cells.

- **Function**:
  - The Organ of Corti converts **sound vibrations** into **electrical signals** that travel to the brain via the **auditory nerve**.
  - It is essential for our ability to perceive different frequencies of sound.

Italian anatomist **Alfonso Giacomo Gaspare Corti** discovered the Organ of Corti in 1851. Its intricate structure allows us to experience the richness of auditory sensations.

Nerve Supply of Hair Cells

Ninety-five per cent of afferent fibres of spiral ganglion supply the inner hair cells while only 5% supply the outer hair cells.

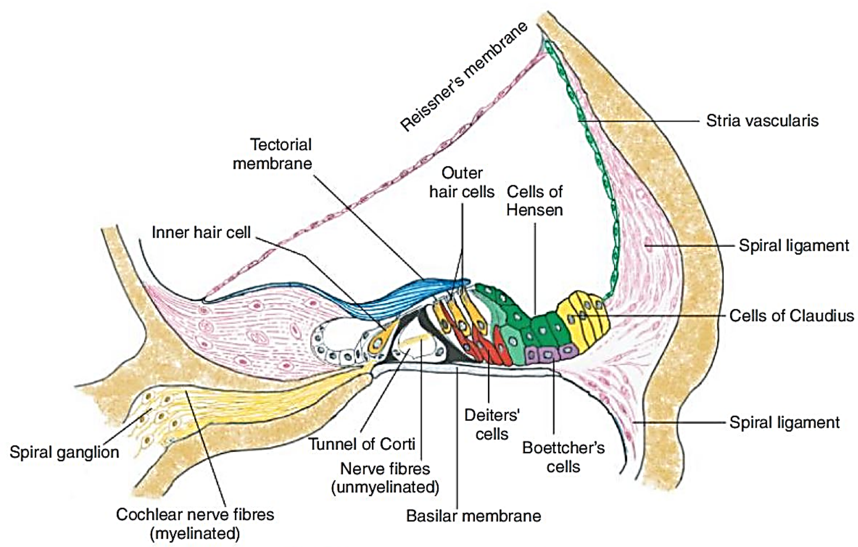


Fig. 2.1 Structure of organ of Corti.

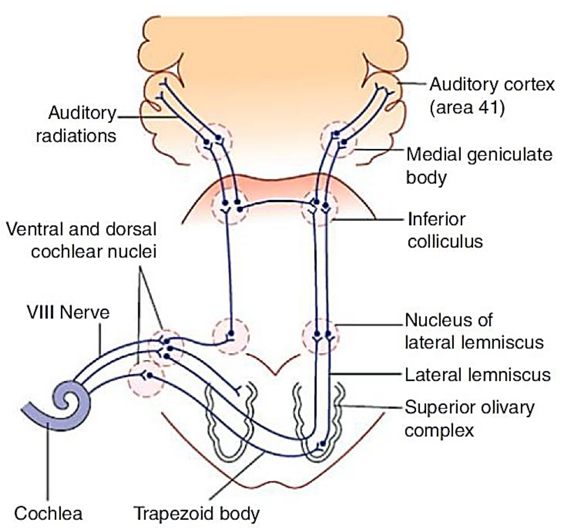


Fig. 2.2 Auditory pathways from the right cochlea. Note the bilateral route through brainstem and bilateral cortical representation.

Audiology and Acoustics

Ref: Dhingra 8E

Frequency
It is the number of cycles per second. The unit of frequency is Hertz (Hz) named after the German scientist Heinrich Rudolf Hertz. A sound of 1000 Hz means 1000 cycles per second.

Pitch
It is a subjective sensation produced by frequency of sound. Higher the frequency, greater is the pitch.

Intensity
It is the strength of sound which determines its loudness. It is usually measured in decibels. Some examples of intensity at a distance of 1 m are as follows:

Whisper	= 30 dB
Normal conversation	= 60 dB
Shout	= 90 dB
Discomfort of the ear	= 120 dB
Pain in the ear	= 130 dB

Loudness
It is the subjective sensation produced by intensity. More the intensity of sound, greater the loudness.

Masking
Masking of nontest ear is essential in all bone conduction tests, but for air conduction tests, it is required only when difference of hearing between two ears exceeds 40 dB.

Speech Frequencies
Frequencies of 500, 1000 and 2000 Hz are called speech frequencies, because most of human voice falls within this range. PTA (pure tone average) is the average threshold of hearing in these three speech frequencies. It roughly corresponds to the speech reception threshold.

Audiometric Zero
Threshold of hearing, i.e. the faintest intensity which a normal healthy person can hear will vary from person to person.

Assessment of Hearing

A. Clinical tests of hearing
1. Finger friction test
2. Watch test
3. Speech tests
4. Tuning fork tests

4. Tuning Fork Tests
These tests are performed with tuning forks of different frequencies such as 128, 256, 512, 1024, 2048 and 4096 Hz, but for routine clinical practice, tuning fork of 512 Hz is ideal. Forks of lower frequencies produce sense of bone vibration while those of higher frequencies have a shorter decay time and are thus not routinely preferred.

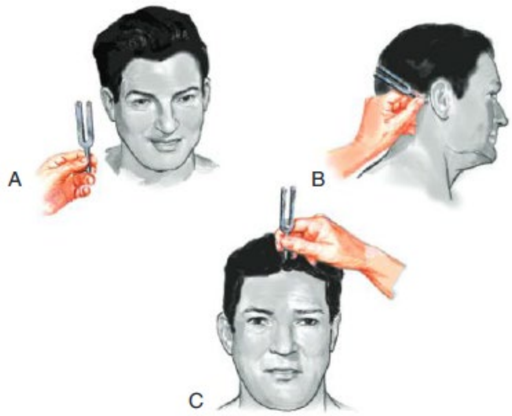


Figure: Tuning fork tests. (A) Testing for air conduction. (B) Testing for bone conduction. (C) Weber test. Animation 1: Hearing tests and tuning fork test.

- A Rinne test equal or negative for 256 Hz but positive for 512 Hz indicates air–bone gap of 20–30 dB.
- A Rinne test negative for 256 and 512 Hz but positive for 1024 Hz indicates air–bone gap of 30–45 dB.
- A Rinne negative for all the three tuning forks of 256, 512 and 1024 Hz indicates air–bone gap of 45–60 dB.

Figure: Two-room audiometry set-up. Audiometrician watches responses of the patient sitting across a glass partition.

Uses of Pure Tone Audiogram:

a) It is a measure of threshold of a hearing by air and BC and thus the degree and type of hearing loss.
b) A record can be kept for future reference.
c) Audiogram is essential for prescription of hearing aid.
d) Helps to find degree of handicap for medicolegal purposes.
e) Helps to predict speech reception threshold (SRT).

Hz	250	500	1k	2k	4k
dB (HL)	80	90	100	105	100
+Factor	25	11	7	9	9
dB (SPL)	105	101	107	114	109

Figure: Conversion table

Physiology of Hearing

For physiological purposes, the ear is divided into two parts–conducting apparatus, consisting of external ear, tympanic membrane, chain of ossicles, eustachian tube and labyrinthine fluids; and perceiving (sensorineural) appa-ratus, consisting of end-organ (organ of Corti), auditory division of VIIIth cranial nerve, and central connections.

Conduction of sound

Sound can be transmitted to the inner ear in one of three ways:

1. By way of the ossicular chain, from the vibrating tympanic membrane to the oval window. The is the most important route.

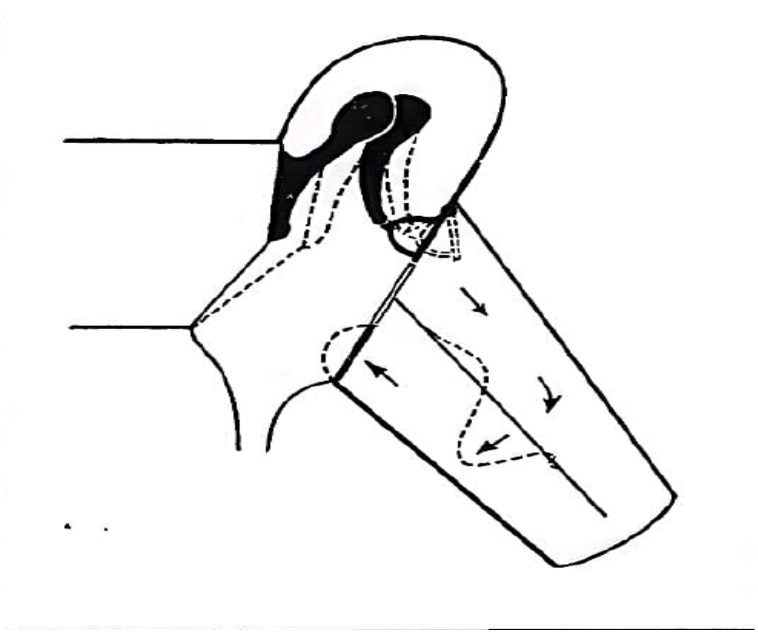


Figure: Function of ossicles

Pathological states causing conductive deafness

1. Non-marginal perforation of the tympanic membrane with intact ossicular chain. (Hearing loss approximately 10 – 30 dB.) (Figure 2.3a)
2. Posterosuperior mariginal perforation of the tympanic membrane with disruption of the ossicular chain. (Hearing loss 40 – 60 dB.)
3. Total or subtotal perforation of the tympanic membrane with loss of malleus and incus, the stapes remaining mobile (Figure 2.3b). (Hearing loss 60 – 80 dB.)

This state is approximated by a radical mastoidectomy. Such hearing as remains is probably due to a difference in acoustical loading upon the fluids of the scala vestibule and scala tympani respectively. A possible explanation is that the expression of blood through veins leaving th labyrinth allows a

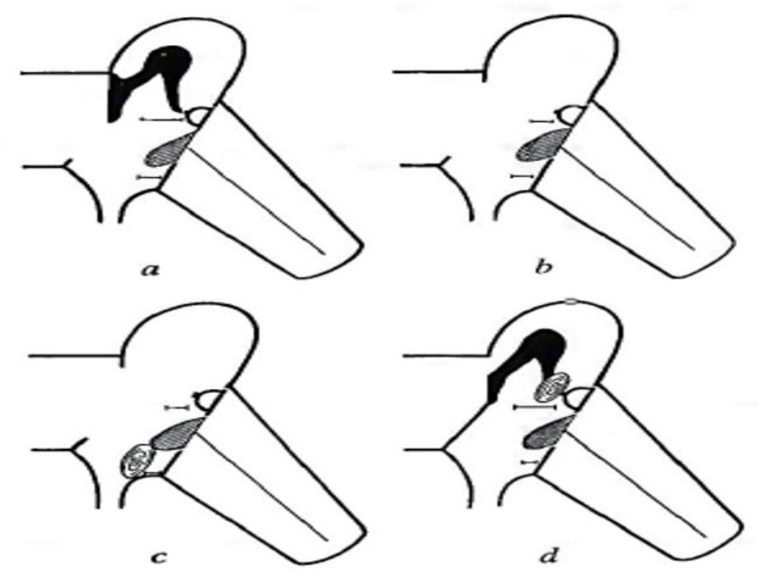


Figure: Pathological conditions causing conductive deafness. a, Non-marginal perforation of the tympanic membrane with intact ossicular chain. The sound energy transmitted to the oval window is reduced but remains greater than that at the round window; b, total or subtotal perforation of the tympanic membrane with loss of malleus and incus, the stapes remaining mobile. The sound energy transmitted to the oval window is so reduced as to be equalled by that at the round window; c, shielding of the round window by granulation. The sound energy transmitted to each window is reduced, but that at the oval window is greater than that at the round window. A 'differential' therefore exists, again in favour of the oval window; d, epitym-painc disease with 'attic' perforation and disruption of the ossicular chain between incus and stapes. The resuting gap is bridged by a cholesteatoma.

Greater yielding to sound pressures on the vestibular side than on the tympanic side of the cochlear partition. Hearing can be partially restored if the round window is shielded by gran-ulations or the introduction of a disc of silicone rubber moistened with paraffin.

Tympanic muscle reflexes

Contraction of the intratympanic muscles increases the stiffness of the middle ear conducting apparatus. Their action is a reflex one, the stimulus being sound at levels of 90 dB and above. By attenuating loud sounds, especially in the lower frequency range, the reflex probably protects the inner ear against acoustic trauma. Impact or explosive noise reaches the cochlea before the reflex is activated hence it is more damaging than steady state noise.

The Sense of Hearing

Ref: Guyton 14E

Tympanic membrane and the ossicular system

Conduction of sound from the tympanic membrane to the cochlea

The malleus is bound to the incus by minute ligaments, so whenever the malleus moves, the incus moves with it. The opposite end of the incus articulates with the stem of the stapes, and the faceplate of the stapes lies against the membranous labyrinth of the cochlea in the opening of the oval window.

"Impedance Matching" by the Ossicular System. The amplitude of movement of the stapes faceplate with each sound vibration is only three fourths as much as the amplitude of the handle of the malleus. The impedance matching is about 50 to 75 percent of perfect for sound frequencies between 300 and 3000 cycles/sec, which allows utilization of most of the energy in the incoming sound waves.

In the absence of the ossicular system and tympanic membrane, sound waves can still travel directly through the air of the middle ear and enter the cochlea at the oval window. However, the sensitivity for hearing is then 15 to 20 decibels less than for ossicular transmission— equivalent to a decrease from a medium to a barely perceptible voice level.

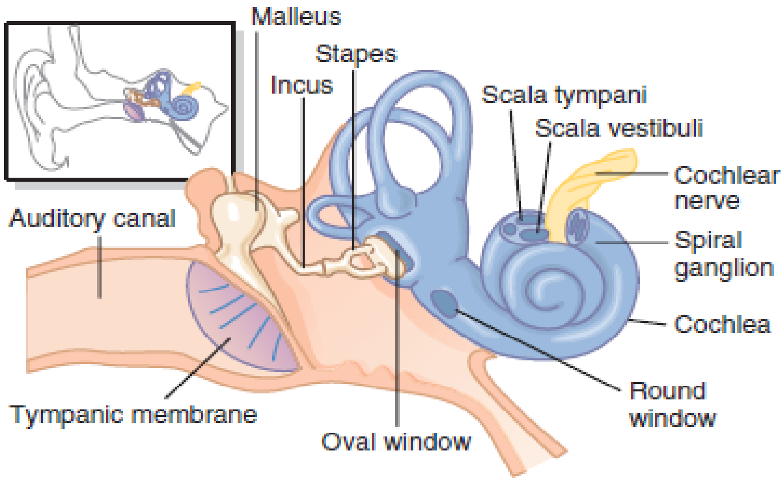


Figure: The tympanic membrane, ossicular system of the middle ear, and inner ear.

Attenuation of Sound by Contraction of the Tensor Tympani and Stapedius Muscles.
When loud sounds are transmitted through the ossicular system and from there into the central nervous system, a reflex occurs after a latent period of only 40 to 80 milliseconds to cause contraction of the stapedius muscle and, to a lesser extent, the tensor tympani muscle. The tensor tympani muscle pulls the handle of the malleus inward while the stapedius muscle pulls the stapes outward. These two forces oppose each other and thereby cause the entire ossicular system to develop increased rigidity, thus greatly reducing the ossicular conduction of low-frequency sound, mainly frequencies below 1000 cycles/sec.

Vestibular Sensations and Maintenance of Equilibrium

Ref: Guyton 14E

Vestibular Apparatus
The vestibular apparatus, shown in Figure 56-9, is the sensory organ for detecting sensations of equilibrium. It is encased in a system of bony tubes and chambers located in the petrous portion of the temporal bone, called the bony labyrinth. Within this system are membranous tubes and chambers called the membranous labyrinth. The membranous labyrinth is the functional part of the vestibular apparatus.

The top of Figure 56-9 shows the membranous labyrinth. It is composed mainly of the cochlea.

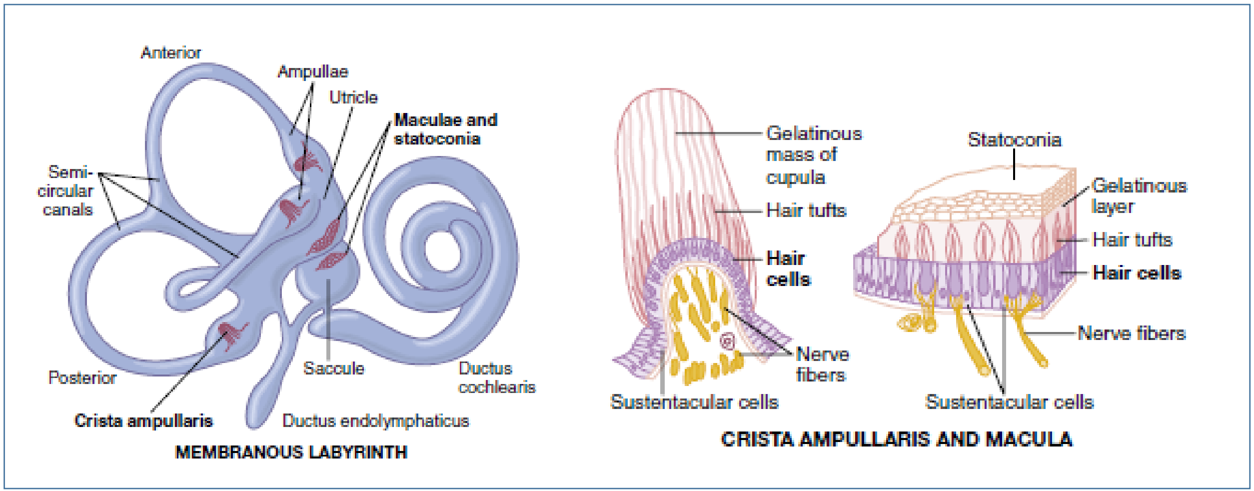


Figure: Membranous labyrinth and organization of the crista ampullaris and the macula.

"Maculae"—Sensory Organs of the Utricle and Saccule for Detecting Orientation of the Head with Respect to Gravity. Located on the inside surface of each utricle and saccule, shown in the top diagram of Figure 56-9, is a small sensory area slightly greater than 2 millimeters in diameter called a macula. The macula of the utricle lies mainly in the horizontal plane on the inferior surface of the utricle and plays an important role in determining orientation of the head when the head is upright.
Conversely, the macula of the saccule is located mainly in a vertical plane and signals head orientation when the person is lying down.

The calcified statoconia have a specific gravity **two to three times** the specific gravity of the surrounding fluid and tissues. The weight of the statoconia bends the cilia in the direction of gravitational pull.

Directional Sensitivity of the Hair Cells—Kinocilium. Each hair cell has about 100 small cilia called stereocilia, plus one large cilium, the kinocilium, as shown in Figure 56-10.
When the stereocilia bend in the direction of the kinocilium, the filamentous attachments tug in sequence on the stereocilia, pulling them outward from the cell body.

Therefore, positive ions pour into the cell from the surrounding endolymphatic fluid, causing receptor membrane depolarization. Conversely, bending the pile of stereocilia in the opposite direction (backward, away from the kinocilium) reduces the tension on the attachments; this movement closes the ion channels, thus causing **receptor hyperpolarization.**

Equilibrium

Ref: Synopsis ENT 5E

Physiology of The Vestibular System

The vestibular system has two major functions:

1. Maintenance of our equilibrium and hence prevention of injury.
2. Maintenance of the position of the eyes in order to obtain maximum reso¬ lution of any object that is being observed.

The detailed anatomy and physiology of the vestibular system is complex but can simply be divided into interconnecting component parts. The sensory side of the system consists of the vestibular labyrinth, eyes and the somatosensors in muscle, joints and skin. These sensory organs connect directly with the brainstem. They also connect with the cerebellum and cerebrum.

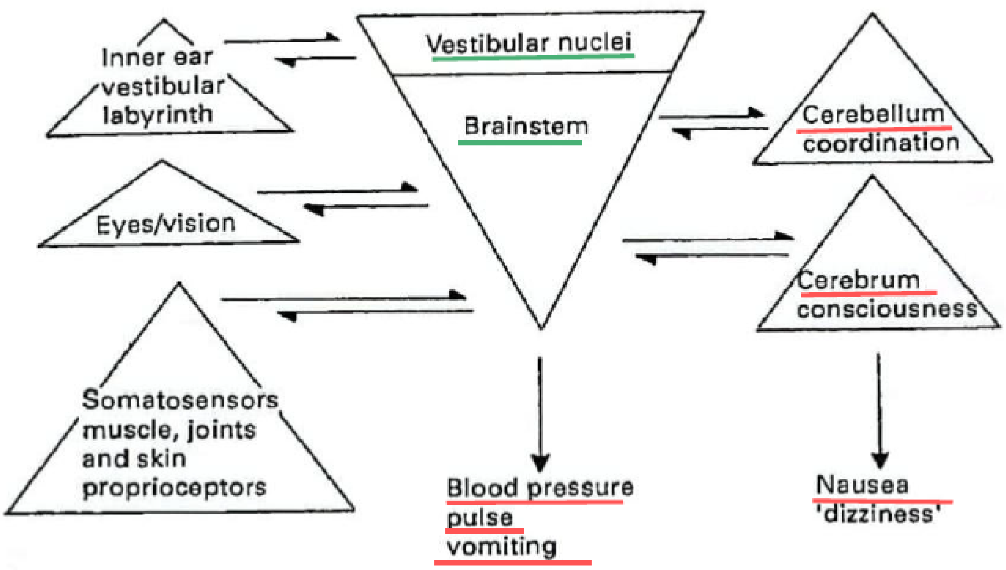


Figure: The interacting components of the vestibular system

Cerebral interpretation of visual clues such as the horizon, floors, walls, and the effect of gravity gives valuable information about the body's orientation. The brainstem and cerebellum coordinate the sensory information and send out a reflex response to the muscles that maintain posture and eye position.

Labyrinthine function

The receptor organs in the membranous vestibular labyrinth are concerned with the reflex adjustments of posture as well as with subjective sensations.

Utricle

Utricular maculae, situated in the horizontal plane, are quiescent as long as the head is horizontal and stationary. They respond (by gravity) to the slightest tilt and to linear acceleration. Such a movement also results in compensatory ocular reflexes whereby the visual axis is fixed when the head is deviated slightly from its previous position.

Practice Questions

Ref: Roddie and Ganong 26E

01. Endolymph

a) Is found within the membranous labyrinth.
b) Has a potassium concentration close to that of extracellular fluid.
c) Bathes the hair cells of the inner ear.
d) Is electrically negative with respect to perilymph.
e) Inertia is a factor in the stimulation of receptors in the semicircular canals during rotatory acceleration.

Answer: T F T F T

Explanation:

a. True Perilymph surrounds the membranous labyrinth.
b. False It is similar to that of intracellular fluid.
c. True It bathes cochlear and vestibular hair cells.
d. False It is positive, of the order of 80 mV.
e. True The inertia causes endolymph movements to lag those of the membranous labyrinth and displace the hairs of the hair cells

02.The basilar membrane of the cochlea vibrates

a) At the same frequency as the applied sound.
b) With an amplitude which is proportional to the frequency of the applied sound.
c) With an amplitude which is proportional to the loudness of the applied sound.
d) Along more of its length when the applied sound has a high rather than a low frequency.
e) Mainly at the base of the cochlea for the sound frequencies commonly used in speech.

Answer: T F T F T

Explanation:

a. True Harmonics are also faithfully reproduced.
b. False Frequency and amplitude need not be related.
c. True Hence very loud sounds can damage the basilar membrane.
d. False Low frequency vibrations travel further up the cochlea.
e. True Speech frequencies (about 1000–3000 Hz) cause maximum vibration in this region.

03. The tympanic membrane

a) Modifies the frequencies of sound waves impinging on the ear.
b) Stops vibrating almost immediately after the sound stops.
c) Bulges outwards when the pharyngotympanic tube is blocked.
d) Transmits sound more effectively when the small muscles of the middle ear are contracted.
e) Cannot transmit sound waves if it is perforated.

Answer: F T F F F

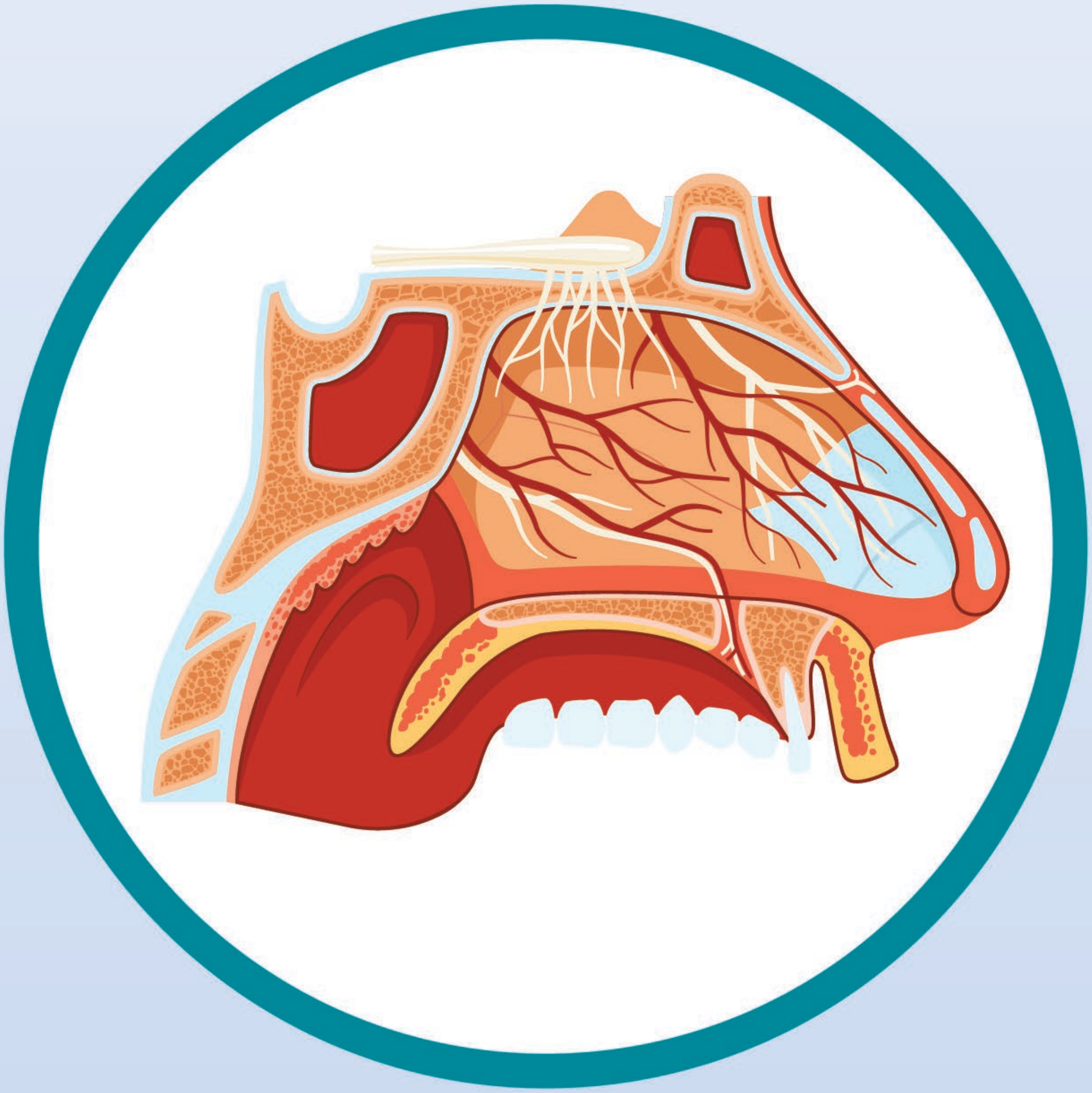
Explanation:

a. False It faithfully reproduces the frequencies.
b. True It is very nearly 'critically damped'.
c. False It bulges inwards as middle ear air is absorbed.
d. False Reflex contraction of these muscles protects by damping vibration transmission.
e. False Small perforations cause about 5 decibels loss; complete destruction about 50.

Chapter-02

Physiology of the Nose and Paranasal Sinuses

Ref: Hazarika 5E, Ganong 26E, Guyton 14E, Dhingra 8E, Synopsis 5E, Semibulingum 8E



Physiology of the Nose & PNS

Ref: Hazarika 5E

Functions of The Nasal Cavity:

1. Nasal respiration
2. Protection of the lower respiratory tract
    - Filtration
    - Air conditioning of inspired air (Temperature and humidity regulation)
    - Mucociliary function
    - Sneeze reflex
3. Vocal resonance
4. Olfaction
5. Outlet to lacrimal secretions

50 percent of the total resistance is contributed by the nasal cavities. Man is an obligatory nasal breather for the first six months of life. It has been estimated that an adult inspires up to 10,000 liters of air daily (Kerr, 1997)

Nasal airway resistance: The nasal vestibule is the first component of nasal resistance.

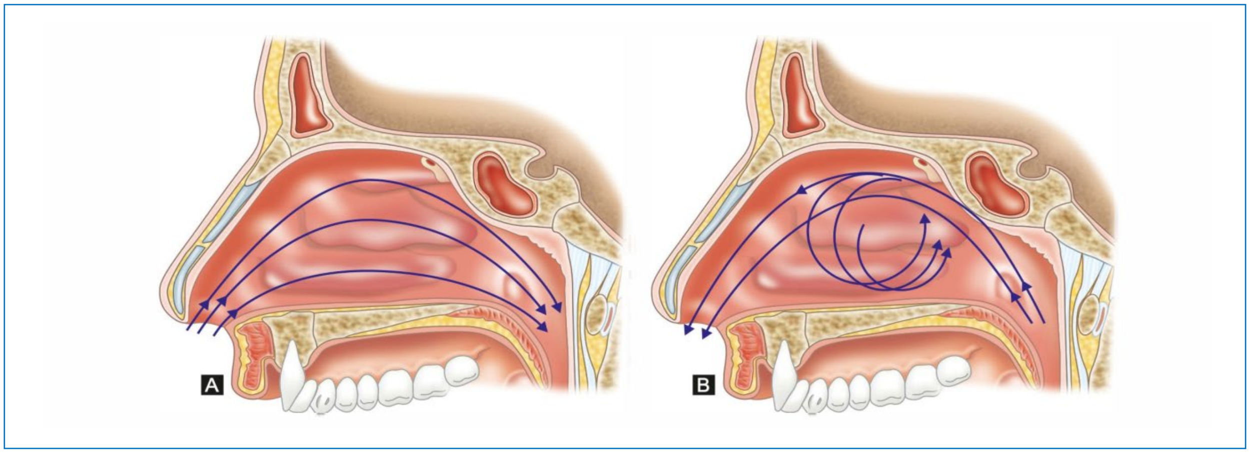


Figure: 1a and b: Inspiratory and expiratory phases of nasal airflow.

The vestibule has been termed the external nasal valve. It contributes to one third of the nasal airway resistance. The valve region is formed slightly posterior to the posterior edge of the lower lateral cartilage and the nasal septum contributes most of the remaining two third of the resistance.

Inferior and middle turbinates contain erectile tissue, the anterior end of which has a major effect on nasal resistance and functions as an internal nasal valve.

Physiology of Nose & PNS

Ref: Dhingra 8E

Functions of the nose are classified as:

1. Respiration.
2. Air-conditioning of inspired air.
3. Protection of lower airway.
4. Vocal resonance.
5. Nasal reflex functions.
6. Olfaction.
7. Protection of eyes from trauma
8. Sound protection from own's speech to the ears.
9. Thermal insulation of skull base and orbit
10. Outlet to Lacrimal Secretion

Nasal Cycle:
Nasal mucosa undergoes rhythmic cyclical congestion and decongestion, thus controlling the airflow through nasal chambers. When one nasal chamber is working, total nasal respiration, equal to that of both nasal chambers, is carried out by it. Nasal cycle varies every 2.5–4 h and may be characteristic of an individual.

The principal physiological function of the nose is to –

- Humidify and warm inspired air
- Remove noxious particles from the air
- Also serves as a sense organ

1. Filtration and purification: Nasal vibrissae at the entrance of nose act as filters to sift larger particles like fluffs of cotton. Finer particles like dust, pollen and bacteria adhere to the mucus which is spread like a sheet all over the surface of the mucous membrane. The front of the nose can filter particles up to 3 mm, while nasal mucus traps particles as fine as 0.5–3.0 mm. Particles smaller than 0.5 mm seem to pass through the nose into lower airways without difficulty.

2. Humidification: This function goes on simultaneously with the temperature control of inspired air. Relative humidity of atmospheric air varies depending on climatic conditions. Air is dry in winter and saturated with moisture in summer months. Nasal mucous membrane adjusts the relative humidity of the inspired air to 75% or more. Water, to saturate the inspired air, is provided by the nasal mucous membrane which is rich in mucous and serous secreting glands. About 1000 mL of water is evaporated from the surface of nasal mucosa in 24 h. Moisture is essential for integrity and function of the ciliary epithelium. At 50% relative humidity, ciliary function stops in 8–10 min.

Physiology of Paranasal Sinuses

Ref: Dhingra 8E

Ventilation of Sinuses

Ventilation of paranasal sinuses takes place through their ostia. During inspiration, air current causes negative pressure in the nose. This varies from 26 mm to 2200 mm H2O, depending on the force of inspiration. During expiration, positive pressure is created in the nose and this sets up eddies which ventilate the sinuses. Thus, ventilation of sinuses is paradoxical; they are emptied of air during inspiration and filled with air during expiration. This is just the reverse of what takes place in lungs which fill during inspiration and empty during expiration.

Mucociliary Clearance of Sinuses

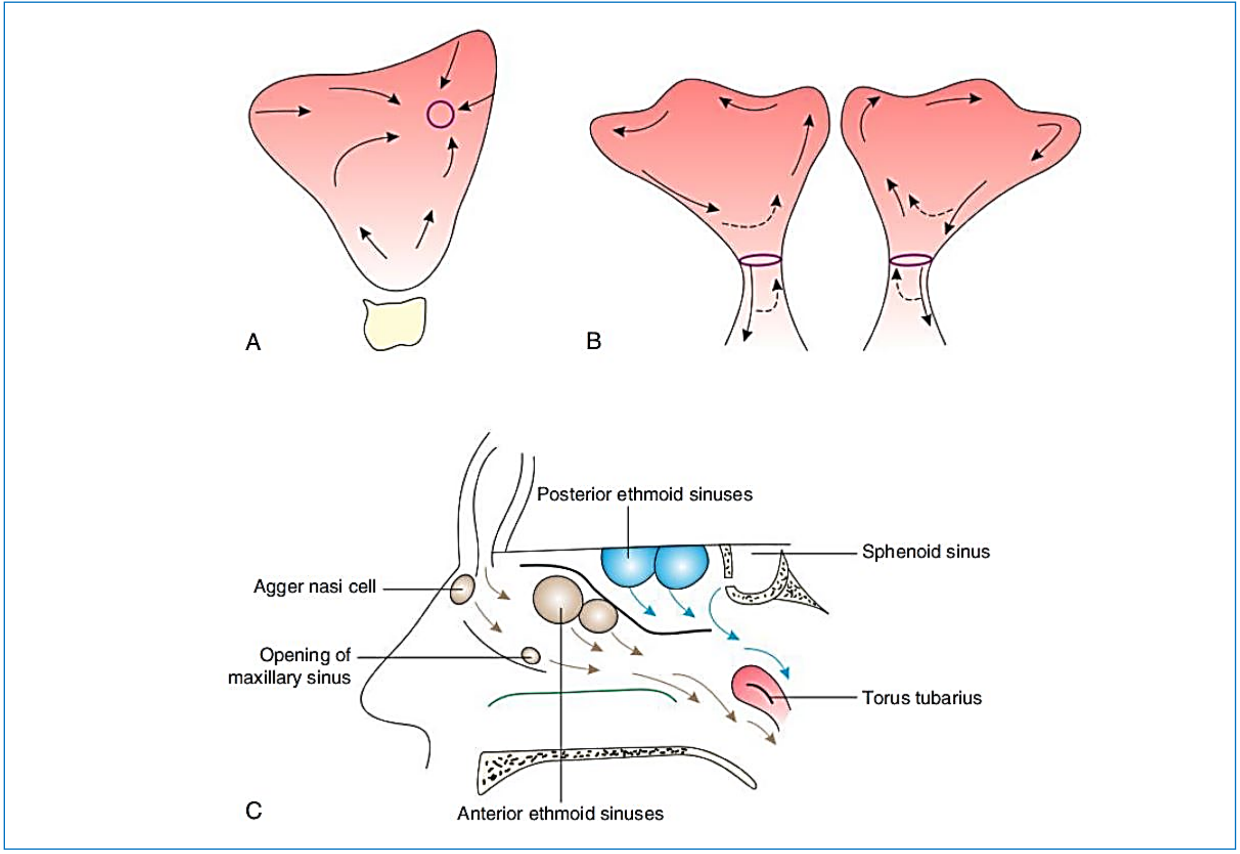


Figure: Mucociliary clearance of paranasal sinuses. (A) Maxillary sinus. (B) Frontal sinus. (C) Anterior and posterior group of sinuses. See text for details.

Maxillary Sinus Mucus from all the walls of the maxillary sinus—anterior, medial, posterior, lateral and roof— is transported by the cilia to the natural ostium and then through it into the middle meatus. Mucus always drains from the natural ostium, even though accessory ostia be present in the fontanelle. It is also observed that inferior meatal antrostomy made in Caldwell– Luc operation provides ventilation to the sinuses, but it does not help in mucociliary clearance which still takes place through the natural ostium.

Respiratory Protective Reflexes

Ref: Essential of Physiology by K. Semibulingum 8E

Respiratory protective reflexes are the reflexes that protect lungs and air passage from foreign particles. Respiratory process is modified by these reflexes in order to eliminate the foreign particles or to prevent the entry of these particles into the respiratory tract. Following are the respiratory protective reflexes:

Cough Reflex

Cough is a modified respiratory process characterized by forced expiration. It is a protective reflex and it is caused by irritation of respiratory tract and some other areas such as external auditory canal (see below).

Causes

Cough is produced mainly by irritant agents. It is also produced by several disorders such as cardiac disorders (congestive heart failure), pulmonary disorders (chronic obstructive pulmonary disease – COPD) and tumor in thorax, which may exert pressure on larynx, trachea, bronchi or lungs.

Mechanism

Cough begins with deep inspiration followed by forced expiration with closed glottis. This increases the intrapleural pressure above 100 mm Hg. Then, glottis opens suddenly with explosive outflow of air at a high velocity. Velocity of the airflow may reach 960 km/hour. It causes expulsion of irritant substances out of the respiratory tract.

Reflex Pathway

Receptors that initiate the cough are situated in several locations such as nose, paranasal sinuses, larynx, pharynx, trachea, bronchi, pleura, diaphragm, pericardium, stomach, external auditory canal and tympanic membrane.

Afferent nerve fibers pass via vagus, trigeminal, glossopharyngeal, and phrenic nerves. The center for cough reflex is in the medulla oblongata.

Efferent nerve fibers arising from the medullary center pass through the vagus, phrenic and spinal motor nerves. These nerve fibers activate the primary and accessory respiratory muscles.

Sneezing Reflex

Sneezing is also a modified respiratory process characterized by forced expiration. It is a protective reflex caused by **irritation of nasal mucous** membrane.

Causes

Irritation of the nasal mucous membrane occurs because of dust particles, debris, mechanical obstruction of the airway and excess fluid accumulation in the nasal passages.

Mechanism

Sneezing starts with deep inspiration, followed by forceful expiratory effort with opened glottis resulting in expulsion of irritant agents out of respiratory tract.

Applied Physiology of the Nose and Paranasal Sinuses

Ref: Synopsis ENT 5E

Nasal Respiration
The nose forms the uppermost part of the respiratory tract. So firmly established is the normal pattern of nasal respiration that infants unable to breathe through the nose have been known to breathe through the nose have been known to asphyxiate. Mouth-breathing has to be learned. Nasal respiration also allows normal breathing to continue during mastication of food, although it is reflexly arrested during the act of swallowing. Further importance lies in the preparation of inspired air for the lower respiratory passages.

Nasal air currents

Inspiratory air currents are determined by:
1. Direction of the anterior nares.
2. Narrowness of the limen nasi compared with the size of the posterior choanae. During quiet breathing, inspired air passes upwards, upwards, to curve below.

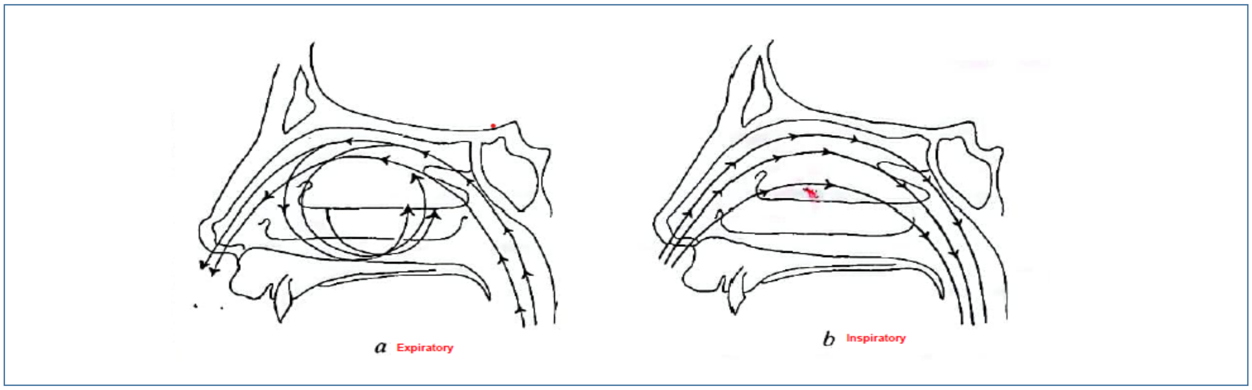


Figure: Respiratory air currents. a) Expiratory b) inspiratory (After Proetz)

The roof of the nose (through the 'olfactory cleft') and continues downwards through the posterior choanae. The anterior end of the inferior turbinate is important in regulating the airflow in a parabolic manner.

Expiratory air currents pass in roughly the same parabolic curve as the inspiratory currents. Frictional resistance at the narrowed limen nasi allows only part of the expired air to reach the outside directly.

Eddies are formed by the remainder, partly under cover of the middle turbinate. In this way the sinus ostia are subjected only to air that has been conditioned by the methods to be described below.

Protective Functions of the Nose
The lower respiratory passages receive some protection by the nose through its treatment of the inspired air. The air is purified, warmed and moistened.

Purification:
1. **Vibrissae:** These sift the coarser particles.
2. **Cilia:** The respiratory portion of the nose is lined in its entirety by a ciliated epithelium. The cilia are bathed in a viscous sheet of mucus. Fine particles (including bacteria) stick to the mucus, which is impelled as a continuous 'conveyor belt' into the nasopharynx, whence they are swallowed.

Practice Questions

Ref: Roddie and Ganong 26E

01.Olfactory cells

a) Are epithelial cells which synapse with olfactory nerves.
b) Generate impulses when stimulated which are relayed in the thalamus.
c) Are chemoreceptors.
d) Show little adaptation.
e) Are more important than taste in appreciating the flavour of food.

Answer: F F T F T

Explanation:

a. False They are modified nerve cells in the nasal epithelium.
b. False Unlike other sensory inputs, olfactory impulses are not relayed in the thalamus.
c. True They recognize certain molecular structures.
d. False It is the newcomer who recognizes the smell in the room.
e. True in their absence, food loses much of its flavour.]

02.The olfactory system can detect

a) 20–40 distinct odours.
b) Differences in odour between isomers of the same substance.
c) The direction from which an odour comes.
d) Small differences in the concentration of the substance responsible for the odour.
e) Odours better in old than in young people.

Answer: T F T F F

Explanation:

a. False It is thought that humans can differentiate between 2000 and 4000 different odours.
b. True The receptors can detect small differences in molecular configuration.
c. True Probably due to the different time of arrival of the odour at the two nostrils.
d. False Though very low concentrations of odorous substances can be detected, differ-ences in concentration of more than 30 per cent are needed to detect a difference in intensity.
e. False Olfaction ability falls with age.

03. The receptor cells serving taste

a) Are confined to the tongue.
b) Are stimulated when chemicals diffuse through the overlying epithelium to reach them.
c) Are primary sensory neurones.
d) Are histologically different for the four primary taste modalities.
e) For sweetness are more common at the tip than at the back of the tongue.

Answer: F F F F T

Explanation:

a. False They are found also in the soft palate, pharynx and larynx.
b. False The microvilli on top of receptors protrude through taste pores into the buccal cavity.
c. False They are receptor cells which synapse with primary sensory neurones.
d. False They look alike.
e. True Sweet sensation is experienced at the front of the tongue; bitterness at the back.

Chapter-03

Smell & Taste

Ref: Ganong 26E, Guyton 14E, Synopsis ENT 5E

Smell/Olfaction

Ref: Ganong Physiology 26E

Introduction
Smell and taste receptors are chemoreceptors that are stimulated by chemical molecules in solution in mucus in the nose (odorants) and saliva in the mouth (tastants). The sensations of smell and taste likely evolved as protective mechanisms to avoid the intake of potentially harmful substances.

Smell

Olfactory Epithelium

The yellowish pigmented olfactory epithelium is a specialized portion of the nasal mucosa that covers an area of 10 cm^2 in the roof of the nasal cavity near the septum in humans (Figure 9–1). The olfactory epithelium is the place in the body where the nervous system is closest to the external world. It contains three types of neurons that are important for olfaction: olfactory sensory neurons, supporting cells, and basal stem cells.

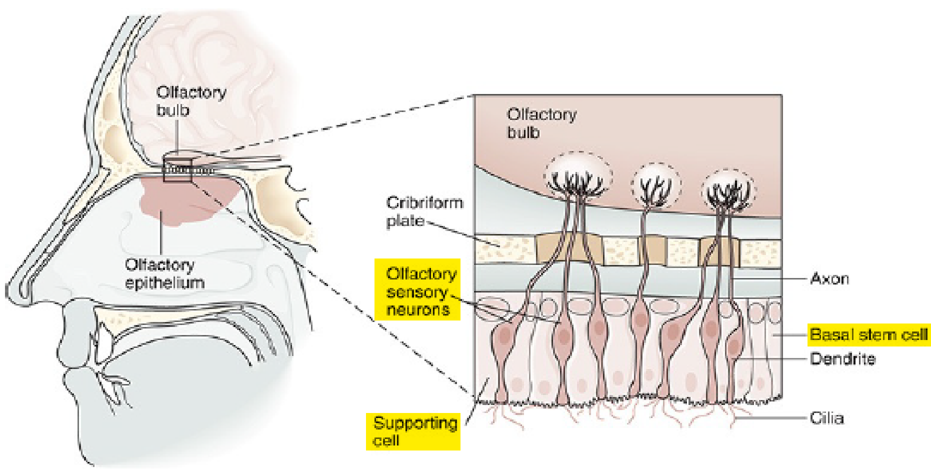


Figure: Structure of the olfactory epithelium. There are three cell types: olfactory sensory neurons, supporting (sustentacular) cells, and basal stem cells at the base of the epithelium. Each olfactory sensory neuron has a dendrite that projects to the epithelial surface. Numerous cilia protrude into the mucus layer lining the nasal lumen. Odorants bind to specific odorant receptors on the cilia and initiate a cascade of events leading to generation of action potentials in the sensory axon. Each olfactory sensory neuron has a single axon that projects to the olfactory bulb, a small ovoid structure that rests on the cribriform plate of the ethmoid bone. (Reproduced with permission from Kandel ER, Schwartz JH, Jessell TM [editors]: Principles of Neural Science, 4th ed. New York, NY: McGraw-Hill; 2000.)

The bipolar olfactory sensory neurons (also called olfactory receptor cells) are responsible for olfactory transduction**. They have a short, thick dendrite** that projects into the nasal cavity where it terminates in a knob containing **6–12 cilia** that protrude into the thin layer of mucus overlying the epithelium. The axons of the olfactory sensory neurons (ie, **olfactory nerve**) pass through the **cribriform plate of the ethmoid bone to enter the olfactory bulbs.**
The supporting cells secrete the mucus that provides the appropriate molecular and ionic environment for odor detection in the olfactory epithelium. Odor-producing molecules (odorants) dissolve in the mucus and

Sense of Smell

Ref: Guyton Physiology 14E

Stimulation of The Olfactory Cells

Mechanism of Excitation of the Olfactory Cells.
The portion of each olfactory cell that responds to the olfactory chemical stimuli is the *olfactory cilia*. The odorant substance, on coming in contact with the olfactory membrane surface, first diffuses into the mucus that covers the cilia and then it binds with *receptor proteins* in the membrane of each cilium. Each receptor protein is actually a long molecule that threads its way through the membrane about seven times, folding inward and outward.

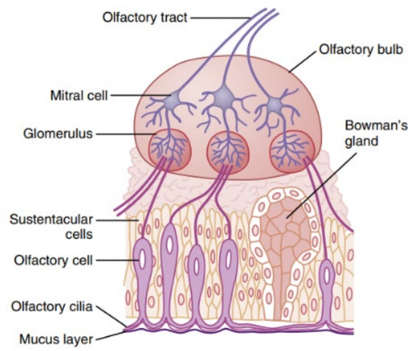


Figure: Organization of the olfactory membrane and olfactory bulb and connections to the olfactory tract.

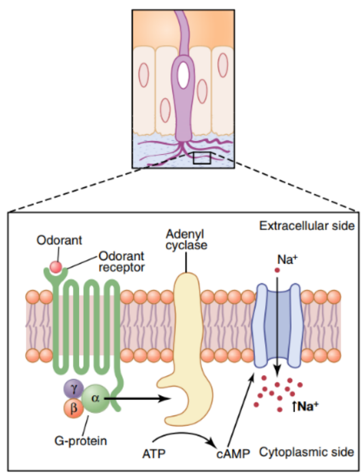


Figure: Summary of olfactory signal transduction. Binding of the odorant to a G-protein–coupled receptor causes the activation of adenylate cyclase, which converts adenosine triphosphate (ATP) to cyclic adenosine monophosphate (cAMP). The cAMP activates a gated sodium channel that increases sodium influx and depolarizes the cell, exciting the olfactory neuron and transmitting action potentials to the central nervous system.

The importance of this mechanism for activating olfactory nerves is that it greatly multiplies the excitatory effect of even the weakest odorant. To summarize: (1) activation of the receptor protein by the odorant substance activates the G-protein complex, which, in turn (2) activates multiple molecules of

Taste/ Gustation

Ref: Ganong 26E

Taste Buds

The specialized sense organ for taste (gustation) consists of approximately 10,000 taste buds, which are ovoid bodies measuring 50–70 μm.

The specialized sense organ for taste (gustation) consists of about 5000 taste buds located primarily on the papillae of the dorsal surface of the tongue in humans. The fungiform papillae are rounded structures most numerous near the tip of the tongue; the circumvallate papillae are prominent structures arranged in a V on the back of the tongue; the foliate papillae are on the posterior edge of the tongue. Each fungiform papilla has up to five taste buds, mostly located at the top of the papilla, while each circumvallate and foliate papilla contain up to 100 taste buds, mostly located along the sides of the papillae. Taste buds are also located in the soft palate, epiglottis, and pharynx.

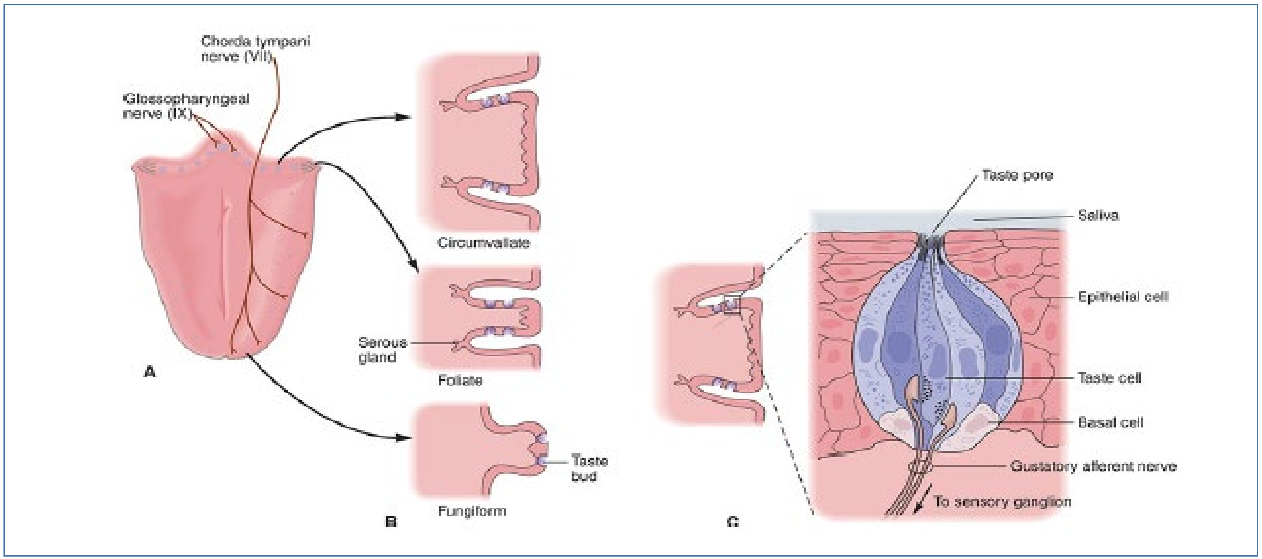


Figure: Taste buds located in papillae of the human tongue. A) Taste buds on the anterior two-thirds of the tongue are innervated by the chorda tympani branch of the facial nerve; those on the posterior one-third of the tongue are innervated by the lingual branch of the glossopharyngeal nerve. B) The three major types of papillae (circumvallate, foliate, and fungiform) are located on specific parts of the tongue. C) Taste buds are composed of basal stem cells and three types of taste cells (dark, light, and intermediate). Taste cells extend from the base of the taste bud to the taste pore, where microvilli contact tastants dissolved in saliva and mucus. (Modified with permission from Kandel ER, Schwartz JH, Jessell TM [editors]: Principles of Neural Science, 4th ed. New York, NY: McGraw-Hill; 2000.)

Each taste bud contains 50–100 taste receptor cells and numerous basal cells and support cells. The taste receptor cells are modified epithelial cells that respond to chemical stimuli or tastants. The apical ends of taste cells have microvilli that project into the taste pore, a small opening on the dorsal surface of the tongue where tastes cells are exposed to the oral contents. Saliva in the oral cavity acts as a solvent for tastants; after dissolving, the chemical diffuses to the taste receptor sites. Saliva may also function to cleanse the mouth to prepare the taste receptors for a new stimulant.

Sense of Taste

Ref: Guyton 14E

Threshold for Taste

The molar threshold for stimulation of the sour taste by hydrochloric acid averages 0.0009 M, for stimulation of the salty taste by sodium chloride, 0.01 M, for the sweet taste by sucrose, 0.01 M, and for the bitter taste by quinine, 0.000008 M. Note especially that the bitter taste sense is much more sensitive than all the others, which provides an important protective function against many dangerous toxins in food.

Table lists the relative taste indices (the reciprocals of the taste thresholds) of different substances. In this table, the intensities of four of the primary sensations of taste are referred, respectively, to the intensities of the taste of hydrochloric acid, quinine, sucrose, and sodium chloride, each of which is arbitrarily chosen to have a taste index of 1.

Sour Substances	Index	Bitter Substances	Index	Sweet Substances	Index	Salty Substances	Index
Hydrochloric acid	1	Quinine	1	Sucrose	1	NaCl	1
Formic acid	1.1	Brucine	11	1-Propoxy-2-amino-4-nitrobenzene	5000	NaF	2
Chloroacetic acid	0.9	Strychnine	3.1	Saccharin	675	$CaCl_2$	1
Acetoacetic acid	0.85	Nicotine	1.3	Chloroform	40	NaBr	0.4
Lactic acid	0.85	Phenylthiourea	0.9	Fructose	1.7	NaI	0.35
Tartaric acid	0.7	Caffeine	0.4	Alanine	1.3	LiCl	0.4
Malic acid	0.6	Veratrine	0.2	Glucose	0.8	NH_4Cl	2.5
Potassium H tartrate	0.58	Pilocarpine	0.16	Maltose	0.45	KCl	0.6
Acetic acid	0.55	Atropine	0.13	Galactose	0.32		
Citric acid	0.46	Cocaine	0.02	Lactose	0.3		
Carbonic acid	0.06	Morphine	0.02				

$CaCl_2$, Calcium chloride; KCl, potassium chloride; LiCl, lithium chloride; NaBr, sodium bromide; NaCl, sodium chloride; NaF, sodium fluoride; NaI, sodium iodide; NH_4Cl, ammonium chloride.

Data from Pfaffman C: Handbook of Physiology, vol 1. Baltimore: Williams & Wilkins, 1959, p 507.

Relative Taste Indices of Different Substances

Taste Blindness. Some people are taste blind for certain substances, especially for different types of thiourea compounds. A substance used frequently by psychologists for demonstrating taste blindness is *phenylthiocarbamide*, for which about 15% to 30% of all people exhibit taste blindness; the exact percentage depends on the method of testing and the concentration of the substance.

Specificity of Taste Buds for a Primary Taste Stimulus.

Microelectrode studies from single taste buds show that each taste bud usually *responds mostly to one of the five primary taste stimuli when the taste substance is in low concentration*. However, at high concentration, most buds can be excited by two or more of the primary taste stimuli, as well as by a few other taste stimuli that do not fit into the “primary” categories.

Smell and Taste

Ref: Synopsis ENT 5E

The process by which an odorous substance stimulates the olfactory end-organ is not entirely known. Recent evidence indicates that the odour of a substance is related to the shape of its molecules, and to some extent to its molecular vibrations.

Disturbances of smell

Anosmia
The complete loss of the sense of smell. It must be bilateral before it is noticeable. Loss of olfaction is olfaction is often described as a loss of 'taste' as flavours are largely perceived through the olfactory apparatus. Medicolegally, tests of semll are important. Being subjective, they may be difficult to interpret. Test solutions, such as lemon, peppermint and cloves, must not be stale. Quanti-tative tests (Elsberg, Douek) have been described. Ammonia, which stimu-lates the Vth cranial nerve, may be used when a psychogenic cause is suspected.

Hyposmia
This is a partial loss. It may be qualitative or quantitative, or both. There are several causes:
1. Nasal obstruction from polypi, enlarged turbinates, or gross deflections and swelling of the septum. There must be sufficient obstruction to prevent the passage of odours the 'olfactory cleft'. The oedema and rhinorrhea of the common cold and in some cases of allergic or vasomotor rhinitis cause temporary anosmia.
2. 'Vasomotor rhinitis' causes permanent anosmia quite commonly, even in the absence of mechanical obstruction.
3. Peripheral neuritis particularly from influenza, in which the symptom is usually permanent.
4. Atrophic rhinitis is a degenerative lesion of the nasal mucosa which may involve the olfactory area.
5. Trauma especially in basal skull fractures involving the anterior cranial fossa, with tering of the olfactory filaments. This is likely to be permanent unless recovery has begun within three months of the injury.
6. Intracranial lesions may cause compression of the olfactory tracts. They include abscess, tumour and meningitis.
7. Exposure to noxious gases e.g. bromine.

Cacosmia
The perception of bad smell due to some intrinsic cause. Common causes are:
1. Maxillary sinusitis usually due to dental origin.
2. Foreign bodies in the nose.
3. The presence if foetid pus in chronic infections of the middle ear cleft.

Parosmia
A perversion of the sensation of smell or a subjective sensation of non-exis-tent smells. It may be:
1. Functional
2. Organic

-Of central origin, due to:
- (a) Influenzal neuritis.
- (b) Epileptic aure.
- (c) 'Uncinate fits'. In lesions of the temporal lobe of the brain.
- (d) Drugs, e.g. streptomycin, arsphenamine.

-Of peripheral origin, due to:
- (a) Nasal disease, as in the causes of anosmia, above.
- (b) Drugs, e.g. topical applications of tyrothricin.

Practice Questions

Ref: Roddie and Ganong 26E

01. Increasing the salt concentration applied to a 'salt' taste bud increases

a) Its sensitivity to salt.
b) The amplitude of its generator potentials.
c) The amplitude of the action potentials generated.
d) Impulse traffic to the thalamus.
e) Impulse traffic up the ascending reticular formation.

Answer: F T F T T

Explanation:

a. False It decreases; taste receptors adapt to stimuli applied to them.
b. True Stronger stimuli lead to generator potentials of greater amplitude.
c. False There is an increase in impulse frequency, not amplitude.
d. True All but olfactory impulses are relayed in the thalamus.
e. True All sensory inputs send impulses via collaterals to this system.

02.The receptor cells serving taste

a) Are confined to the tongue.
b) Are stimulated when chemicals diffuse through the overlying epithelium to reach them.
c) Are primary sensory neurones.
d) Are histologically different for the four primary taste modalities.
e) For sweetness are more common at the tip than at the back of the tongue.

Answer: F F F F T

Explanation:

a. False They are found also in the soft palate, pharynx and larynx.
b. False The microvilli on top of receptors protrude through taste pores into the buccal cavity.
c. False They are receptor cells which synapse with primary sensory neurones.
d. False They look alike.
e. True Sweet sensation is experienced at the front of the tongue; bitterness at the back.

03.Taste receptors

a) For sour taste predominate at the sides of the tongue.
b) May respond to more than one modality of stimulus.
c) Give rise to a sour taste when stimulated by hydrogen ions.
d) Cannot detect small (10 per cent) differences in the concentration of taste-evoking chemicals.
e) Respond more to substances in warm solutions than in cold ones even though the substance concentration is the same in both.

Answer: T T T T T

Explanation:

a. True Receptors for bitter taste predominate on the posterior dorsum of the tongue.
b. True Recording from single taste receptors demonstrates that a single receptor can respond to more than one modality.
c. True All acids taste sour.
d. True Taste receptors are poor at discriminating between intensities; a concentration difference of more than 30 per cent is needed for discrimination.
e. True Food flavour is accentuated when hot; unpleasant medicine less offensive when cold.

Chapter-04

Applied physiology of Larynx Phonation and Speech

Ref: Dhingra 8E, Synopsis 5E, AK Dutta Head Neck 6E

Anatomy and physiology of the larynx

Ref: Dhingra ENT 8E

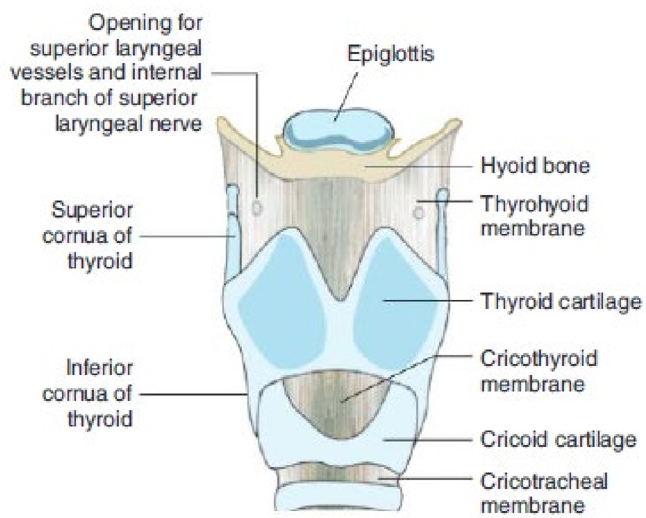


Figure: Laryngeal framework.

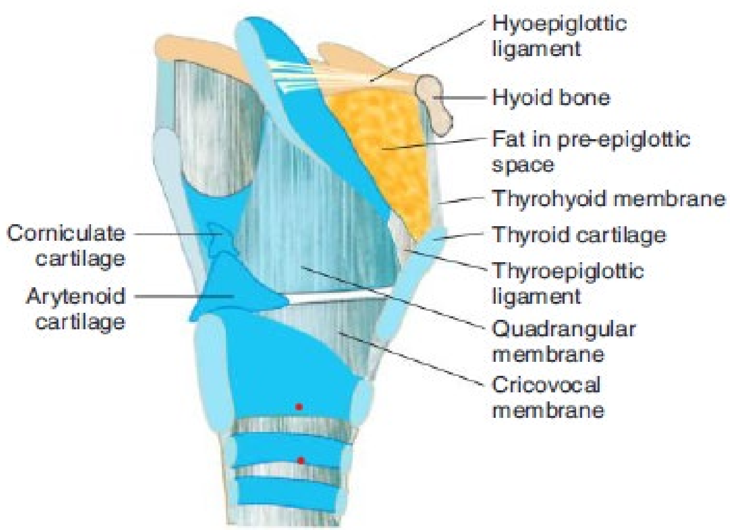


Figure: Sagittal section of larynx showing cricovocal and quadrangular membranes and boundaries of the pre-epiglottic space.

Applied physiology of the larynx

Ref: Synopsis ENT 5E

Functions of the Larynx

Protection of the lower air passages
The most important function of the larynx and is the earliest one to develop phylogenetically. Several mechanisms are involved:

- **Closure of the laryngeal inlet**
- **Closure of the glottis**
- **Cessation of respiration**

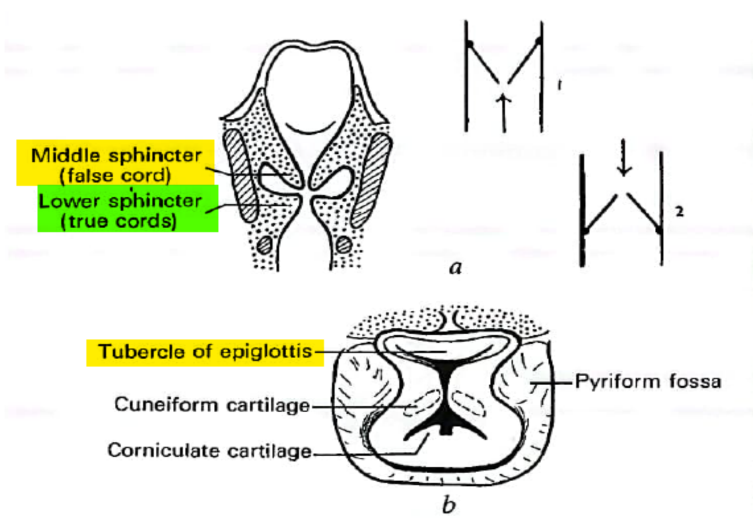
  Automatic. The IXth cranial nerve forms the afferent pathway of the reflex which is initiated by the contact of food with the posterior pharyngeal wall and base of tongue, which are supplied by this nerve.
- **Cough reflex**

Should any particles enter the trachea and bronchi the act of coughing will usually dislodge them. Forced expiration is made against a closed larynx. Chevalier Jackson called the larynx the 'watchdog of the lungs'. The rarity with which foreign bodies gain entrance to the lower air passages, even in early infancy, is perhaps the highest testimony to the efficiency of the larynx in performing this function.

Laryngeal sphincters
The larynx has been described as **a three-tiered sphincter**

1. True Vocal cords
2. False vocal cords
3. Aryepiglottic sphincter

Perhaps the most important of all, for it protects the lower air passages by preventing the invasion of foreign material. The tubercle of the epiglottis fills an anterior dehiscence between the aryepiglottic folds when the sphincter is closed. The cartilages of Wrisberg are sited in the aryepiglottic folds as sesamoid carti-lages and serve a stiffeners for these folds. The sphincter is active in retching, gagging, swallowing and vomiting, or when threatened by a foreign body.



Tensor Vs Relax of Vocal Cord

(Tension নিয়ে CV) দিয়ে (Relax এ TV) দেখি ।
Tightening the cord or Tensor = Cricothyroid(External)+ Vocalis (Internal) = CV
Shortening the cord or Relax = Th.A + Vocalis = TV

Openers of VC:
Thy-Epi Muscle = Ary-Epi Fold Outward

Closers of VC:
Oblique Interarytenoid (OA) = AE fold together with a scissor action
AryEpiglottis (AE) Muscle = Closers to Epiglottis

Abduction= Inspiration
Posterior cricoarytenoid (PCA)

Adduction = Voice Production

- Lateral cricoarytenoid (LCA)
- Oblique arytenoid (OA)
- Thyroarytenoid (Tr. A)
- Transverse Areytenoid (Thy. Ar)

(কথা বলে LOTT Muscle)

Adduction Vs Abduction of the Cord

Abduction = Inspiration	Adduction/Voice Production	
PCA (Post to MP)	**LCA, OA, Tr. A, Thy. Ar (কথা বলে LOTT Muscle)**	
Muscular Process (MP) – Medially (Backward) Vocal Process (VP)-Laterally (Outward)	MP = Forward ➡ LCA VP = Medially	
Vertical Axis Backward bracing of Arytenoid	Longitudinal Axis (Inter Membranous Part – LCA) (Inter Cartilaginous Part- OA + Tr.A)	
Inspiration – Diamond/Enlarged Triangular Shaped (Diamond-In)	Whisper (Low Pitch) Inverted Funnel IM = High Adducted IC = Separated By Triangular (Gap)	High Pitch Linear Chink IM+IC=Adducted

Phonation (Vocalization)

Ref: AK Dutta Head Neck 5E

Phonation (Vocalization)

Phonation involves four successive processes

- Expired air from the lungs
- Vibrators
- Resonators
- Articulators.

- **Expired air:**

  A blast of air is blown from the lungs in expiration, by the contraction of the abdominal, intercostal and other expiratory muscles. With the rise of intra-abdominal pressure, the diaphragm moves passively upward and forces the air out from the lungs.
  Loudness or intensity of voice depends on the expiratory force.

- **Vibrators:**
  The vocal folds act as vibrators and are blown apart intermittently by the pressure of expired air and thereby produce the sounds. Pitch of the sound depends on the length, tension and mass of the vocal folds.
  Pitch varies directly with the rate of vibration of vocal folds.

  The larynx is a tone-producing organ, and tones have characteristic fundamental pitch of sounds. The average rate of vibration of vocal folds in human larynx is about 100 cycles per second for males, 200 cycles for females and 250 cycles for children. Vowels are voiced in the larynx due to vibration of vocal folds, whereas consonants remain unvoiced.

  All laryngeal sounds are called the voice.
  Changes in rima glottidis during phonation:
  (a) At first the glottis is adducted to a linear chink.
  (b) This is followed by tension and elongation of the vocal folds by the contraction of cricothyroid and posterior crico-arytenoid muscles. Changes in the mass of the vocal folds are produced by the thyro-arytenoid and vocalis muscles.

- **Resonators:**
  These are formed by the column of air extending from the vocal folds to the lips and nostrils. The resonators change their configuration by altering the position of the tongue and the soft palate. They greatly modify the fundamental tones and their accompanying harmonics; some harmonics are dampened and other enhanced.

  Quality of the sounds depends on the resonators.
  There is different configuration of the resonating chamber for each vowel, and the extrinsic muscle
  s of the tongue help in the process.

Speech

Ref: Synopsis ENT 5E

Speech

Vocal resonance
The pharynx, mouth and nose act as resonating cavities which modify the basic laryngeal sounds. Certain overtones (harmonics) are picked out or exaggerated by modifications in the size and shape of these cavities. The vowel sounds of speech are produced in this way.

Articulation

The pharynx, soft palate, tongue, and lips, i.e. the whole vocal tract above the larynx, all play a part in the articulation of the various sounds which make up speech.

The two basic classes of speech sounds are: vowels, in which the vocal tract is relatively open above the larynx; and consonants, in which it is constricted or completely obstructed for some time. Within these classes, much of the differentiation is based on the movements of the tongue.

Consonants are determined in large measure by the point within the supraglottic vocal tract at which constriction or closure is made.

In bilabial sounds, the lips are brought together; labiodental sounds are produced by approximating the upper teeth and lower lip; in alveolar sounds, the edge of the tongue is brought into contact with the upper alveolar ridge; in palatal sounds, the front of the tongue is carried up under the hard palate; and in velar sound, the back of the tongue is brought up under the soft palate.

Consonants are also determined in part by the mode of articulation. Plosive consonants are those in which the vocal tract is completely obstructed for a short time; if instead of complete closure the articulatory movement merely narrows the vocal tract at some point, a fricative result; affricatives require a combination of plosive and fricative movements.
Finally, consonants may be voiceless or voiced.

Production of normal speech requires the stringing together of all these types of movement, in a great variety of sequences, each movement running smoothly into the next.

Examination of speech:
1. Content. The vocabulary range should be noted. The ability to form sentences of increasing grammatical complexity. The ability to name objects.
2. Diction. Fluency of the voice should be noted. The presence of mispronounciation of specific vowels or consonants intermittently or continuously in the flow of speech is looked for.
3. Quality. The volume, pitch and frequency range should be noted. The presence of hypo- or hypernasality should be observed as should hoarseness of the voice. The entire upper respiratory tract should be examined by endoscopy if necessary.

Special investigations include stroboscopy, phonetogram and voice recording

Chapter-05

Physiology of Throat Deglutition, Saliva

Ref: Dhingra 8E, Synopsis 5E, Hazarika 5E

Applied Anatomy of Pharynx

Ref: Dhingra 8E

It is a fibromuscular tube, about 25 cm long in an adult. It extends from the lower end of pharynx (C6) to the cardiac end of stomach (T11). It runs vertically but inclines to the left from its origin to thoracic inlet and again from T7 to oesophageal opening in the diaphragm. It shows three normal constrictions and it is important to know their location at oesophagoscopy. They are:

1. At pharyngo-oesophageal junction (C6)—15 cm from the upper incisors.
2. At crossing of arch of aorta and left main bronchus (T4)—25 cm from upper incisors.
3. Where it pierces the diaphragm (T10)—40 cm from upper incisors

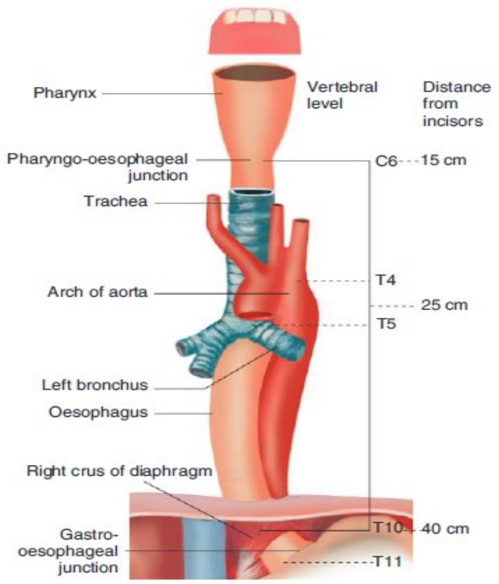


Figure: Anatomy of oesophagus and levels of normal constrictions from the upper incisors.

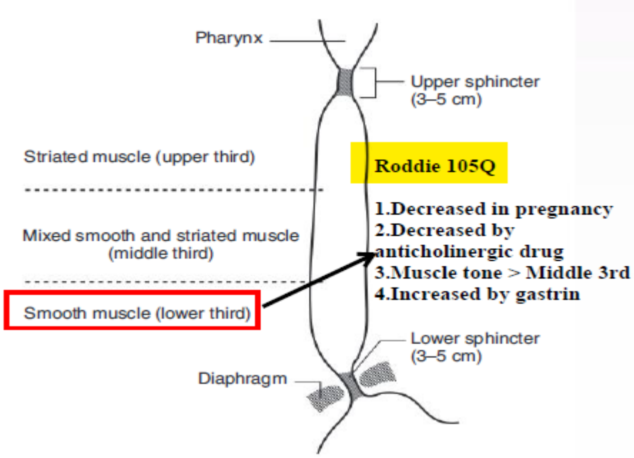


Figure: Oesophagus and its sphincters.

Physiology of Pharynx

Ref: Hazarika ENT 5E

Physiology of Deglutition

Deglutition refers to the process of propulsion of bolus of food from oral cavity to the stomach. It is controlled by neuromuscular activity which could be voluntary or involuntary.

3 Phases of deglutition are:
1. Oral phase: Voluntary
2. Pharyngeal phase: Both (mostly involuntary)
3. Esophageal phase: Involuntary.

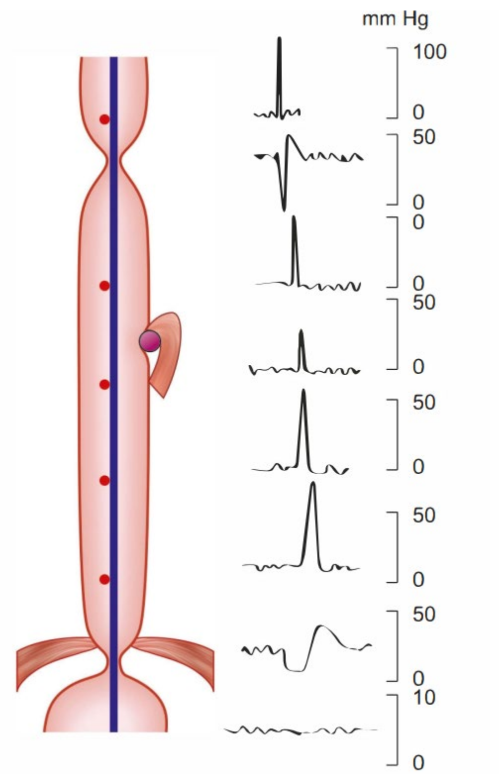


Figure: Showing pressure changes in the esophagus during swallow

Cranial Nerves and their Role in Deglutition:

CN V and XII: chewing and tongue movements
CN VII: Sensation of oral cavity through nervus intermedius and taste to anterior two-third of tongue and motor supply to orbicularis oris.
CN IX: Taste to posterior tongue, sensory and motor function to larynx and laryngopharynx and airway protection.
CN X: Taste to oropharynx and sensation and motor function to larynx and laryngopharynx and airway protection. Taste **from Vallecula+Epiglottis=ILN (Cr-X)**

Secretory Functions of the Alimentary Tract

Ref: Guyton 14E

General Principles of Alimentary Tract Secretion

Types of Alimentary Tract Glands

Several types of glands provide different types of alimentary tract secretions.

First, on the surface of the epithelium in most parts of the gastrointestinal tract are billions of single-cell mucous glands called simply mucous cells or sometimes goblet cells because they look like goblets. They function mainly in response to local irritation of the epithelium: They extrude *mucus* directly onto the epithelial surface to act as a lubricant that also protects the surfaces from excoriation and digestion

Second, many surface areas of the gastrointestinal tract are lined by pits that represent invaginations of the epithelium into the submucosa. In the small intestine, these pits, called crypts of Lieberkühn, are deep and contain specialized secretory cells. One of these cells is shown in Figure Typical function of a glandular cell for formation and secretion of enzymes and other secretory substances.

Third, in the stomach and upper duodenum are large numbers of deep tubular glands. A typical tubular gland can be seen in Figure 65-4, which shows an acid and pepsinogen-secreting gland of the stomach (oxyntic gland).

Fourth, also associated with the alimentary tract are several complex glands—the *salivary glands, pancreas,* and *liver*—that provide secretions for digestion or emulsification of food. The liver has a highly specialized structure. The salivary glands and the pancreas are compound acinous glands of the type shown in **Figure** Formation and secretion of saliva by a submandibular salivary gland**.** These glands lie outside the walls of the alimentary tract, and, in this aspect, they differ from all other alimentary glands. They contain millions of *acini* lined with secreting glandular cells; these acini feed into a system of ducts that finally empty into the alimentary tract itself.

The salivary glands and the pancreas are compound acinous glands of the type shown in Figure Formation and secretion of saliva by a submandibular salivary gland.

Basic Mechanisms of Stimulation of the Alimentary Tract Glands

Contact of Food with the Epithelium Stimulates Secretion—Function of Enteric Nervous Stimuli
In addition, local epithelial stimulation also activates the enteric nervous system of the gut wall. The types of stimuli that activate this system are (1) tactile stimulation, (2) chemical irritation, and (3) distention of the gut wall. The resulting nervous reflexes stimulate both the mucous cells on the gut epithelial surface and the deep glands in the gut wall to increase their secretion.

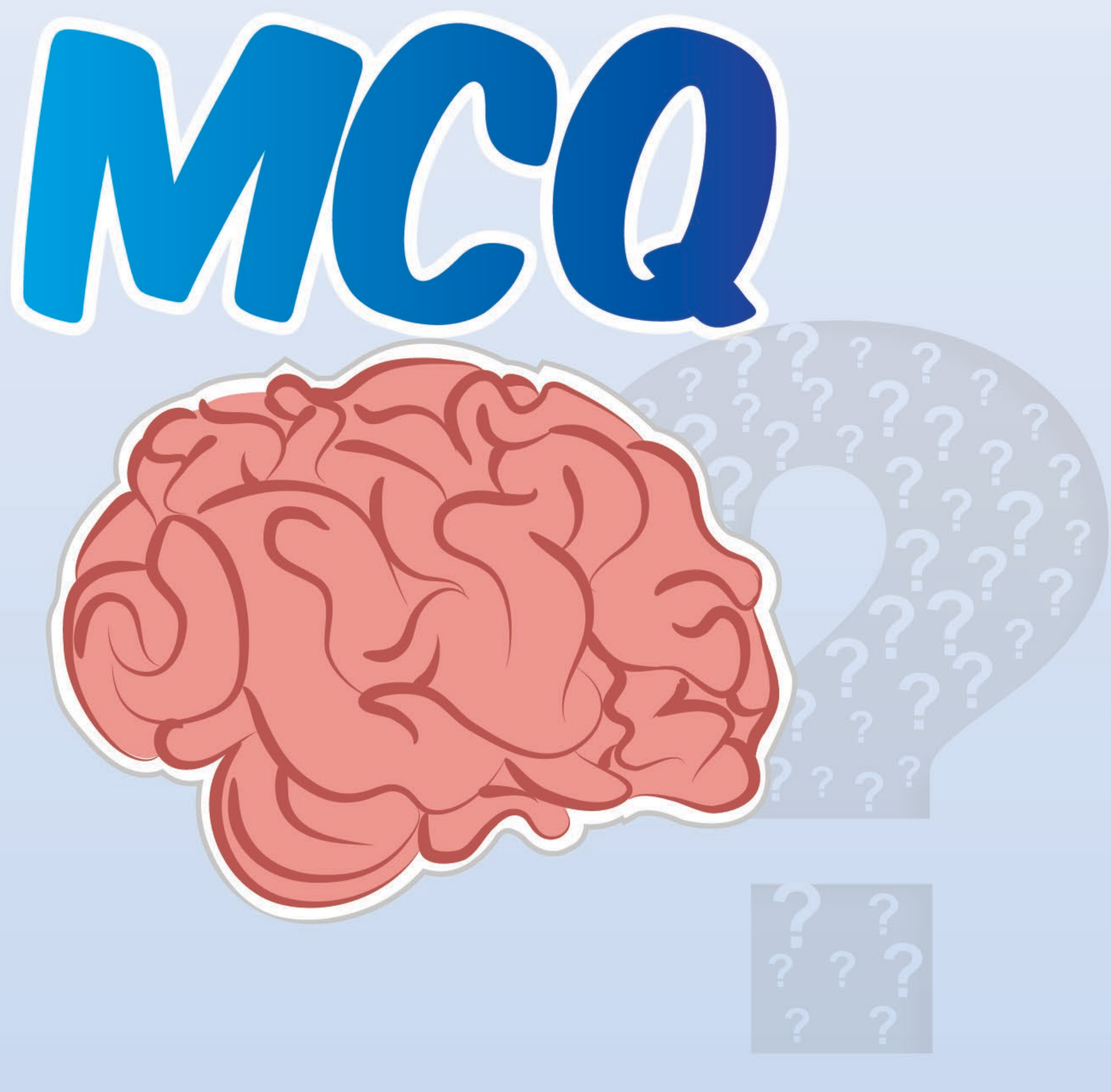
Autonomic Stimulation of Secretion

Parasympathetic Stimulation Increases the Alimentary Tract Glandular Secretion Rate. Stimulation of the parasympathetic nerves to the alimentary tract almost invariably increases the rates of alimentary glandular secretion. **This increased secretion rate is especially true** of the glands in the upper portion of

Chapter-06

Roddie MCQ for ENT

Roddie MCQ



Special Senses

01. The fovea centralis

a) Lies where the visual axis impinges on the retina.
b) Is not crossed by any major blood vessels.
c) Is the thickest part of the retina.
d) Has higher visual acuity than other parts of the retina.
e) Lies on the temporal side of the optic disc.

Answer: T T F T T

Explanation:

a. True It detects objects in the centre of the field of vision.
b. True There are no superficial structures to affect impinging light rays.
c. False It is relatively thin due to absence of superficial layers.
d. True The above factors contribute to this.
e. True It is marked by yellow pigment.

02. Endolymph

a) Is found within the membranous labyrinth.
b) Has a potassium concentration close to that of extracellular fluid.
c) Bathes the hair cells of the inner ear.
d) Is electrically negative with respect to perilymph.
e) Inertia is a factor in the stimulation of receptors in the semicircular canals during rotatory acceleration.

Answer: T F T F T

Explanation:

a. True Perilymph surrounds the membranous labyrinth.
b. False It is similar to that of intracellular fluid.
c. True It bathes cochlear and vestibular hair cells.
d. False It is positive, of the order of 80 mV.
e. True The inertia causes endolymph movements to lag those of the membranous laby-rinth and displace the hairs of the hair cells

03. Olfactory cells

a) Are epithelial cells which synapse with olfactory nerves.
b) Generate impulses when stimulated which are relayed in the thalamus.
c) Are chemoreceptors.
d) Show little adaptation.
e) Are more important than taste in appreciating the flavour of food.

Answer: F F T F T

Explanation:

a. False They are modified nerve cells in the nasal epithelium.
b. False Unlike other sensory inputs, olfactory impulses are not relayed in the thalamus.
c. True They recognize certain molecular structures.
d. False It is the newcomer who recognizes the smell in the room.
e. True In their absence, food loses much of its flavour.]

Roddie MCQ

Endocrine System

01. In plasma, the half-life of

a) A hormone is half the time taken for it to disappear from the blood.
b) Insulin is between five and ten hours.
c) Thyroxine is longer than that of adrenaline.
d) Thyroxine is longer than that of triiodothyronine.
e) Noradrenaline is longer than that of acetylcholine.

Answer: F F T T T

Explanation:

a. False It is the time it takes for the initial concentration to fall by half.
b. False It is much shorter (about five minutes); this allows more precise and continuous regulation of the blood glucose level.
c. True It is much longer since moment to moment regulation of its level is less critical.
d. True It is more highly protein-bound which appears to prolong its life.
e. True Acetylcholine is broken down almost immediately by cholinesterase

02. During sleep there is a fall in the circulating level of

a) Cortisol.
b) Insulin.
c) Adrenaline.
d) Antidiuretic hormone.
e) Growth hormone.

Answer: T T T F F

Explanation:

a. True The waking catabolic state changes to an anabolic state.
b. True Insulin secretion occurs mainly in association with meals.
c. True Adrenaline secretion is associated with stress.
d. False This rises as plasma osmolality rises; water is lost but not replaced during sleep.
e. False This increases, allowing growth and anabolic repair of tissue wear and tear

03. Adrenocorticotrophic hormone (ACTH) secretion increases

a) When the median eminence of the hypothalamic is stimulated.
b) When aldosterone blood level falls.
c) When cortisol blood levels fall.
d) In bursts during the night as the normal hour of wakening approaches.
e) Following severe trauma.

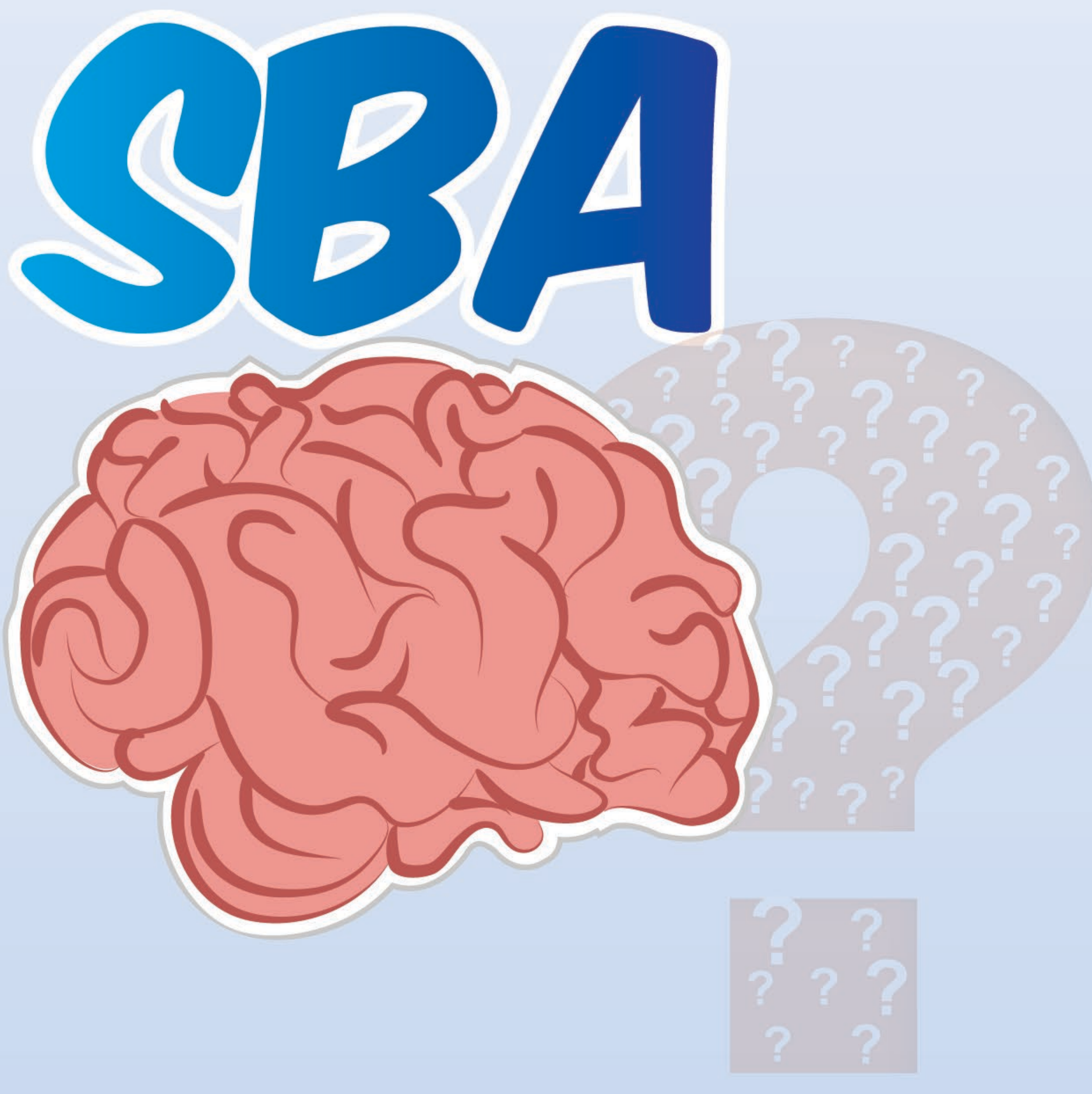
Answer: T F T T T

Explanation:

a. True The median eminence secretes corticotropin-releasing hormone (CRH), the releasing hormone for ACTH.
b. False Aldosterone secretion is regulated mainly by the renin/angiotensin system.
c. True This negative feedback helps to maintain the blood cortisol level.
d. True This is part of the circadian rhythm which produces high morning cortisol levels.
e. True Most forms of stress increase ACTH output by their neural input to the median eminence of the hypothalamus where CRH is formed.

Chapter-07

ALL SBA OF GANONG 26E



Section-I

Cellular & Molecular Basis for Medical Physiology

Chapter 1: General Principles & Energy Production in Medical Physiology

01. The membrane potential of a particular cell is at the K+ equilibrium. The intracellular concentration for K+ is at 150 mmol/L and the extracellular concentration for K+ is at 5.5 mmol/L. What is the resting potential?

a) −70 mV
b) −90 mV
c) +70 mV
d) +90 mV

Answer: B

02. The difference in concentration of H+ in a solution of pH 2.0 compared with one of pH 7.0 is

a) 5-fold
b) 1/5 as much
c) 105-fold
d) 10−5 as much

Answer: C

03. Transcription refers to

a) The process where an mRNA is used as a template for protein production.
b) The process where a DNA sequence is copied into RNA for the purpose of gene expression.
c) The process where DNA wraps around histones to form a nucleosome.
d) The process of replication of DNA prior to cell division.

Answer: B

04. The primary structure of a protein refers to

a) The twist, folds, or twist and folds of the amino acid sequence into stabilized structures within the protein (ie, α-helices and β-sheets).
b) The arrangement of subunits to form a functional structure.
c) The amino acid sequence of the protein
d) The arrangement of twisted chains and folds within a protein into a stable structure. Neuron Medical Academy 2

Answer: C

05. Fill in the blanks: Glycogen is a storage form of glucose. _______ refers to the process of making glycogen and _______ refers to the process of breakdown of glycogen.

a) Glycogenolysis, glycogenesis
b) Glycolysis, glycogenolysis
c) Glycogenesis, glycogenolysis
d) Glycogenolysis, glycolysis

Answer: C

Section-II

Central & Peripheral Neurophysiology

Chapter 8: Somatosensory Neurotransmission: Touch, Pain, & Temperature

01. A 28-year-old man was seen by a neurologist because he had experienced prolonged episodes of tingling and numbness in his right arm. He underwent a neurologic exam to evaluate his sensory nervous system. Which of the following cutaneous mechanoreceptors is correctly paired with the type of stimulus to which it is most apt to respond?

a) Pacinian corpuscle and rapid vibration
b) Meissner corpuscle and skin stretch
c) Merkel cells and slow vibration
d) Ruffini corpuscles and sustained pressure

Answer: A

02. An MD/PhD student was recording responses in different cutaneous receptors and noted the following. One receptor was inactive until the skin temperature was increased to 33°C and then its firing rate continued to increase as the skin temperature was gradually raised to 45°C. A second receptor was inactive until the skin temperature reached 46°C. A third receptor was inactive at skin temperatures of 40°C, but then steadily increases its firing rate as skin temperature was lowered to 24°C. For each of these cases, classify the type of receptor and the nonselective cation channel that was possibly activated.

a) Receptor one is a thermal nociceptor and the channel activated was TRPV1; receptor two is a thermal nociceptor and the channel activated was TRPA1; receptor three was an innocuous cold receptor and the channel activated was TRPV4.
b) Receptor one is an innocuous warm receptor and the channel activated was TRPV1; receptor two is a thermal nociceptor and the channel activated was TRPM8; receptor three was an innocuous cold receptor and the channel activated was TRPV3.
c) Receptor one is an innocuous warm receptor and the channel activated was TRPV3; receptor two is a thermal nociceptor and the channel activated wasTRPV1; receptor three was an innocuous cold receptor and the channel activated was TRPM8.
d) Receptor one is a thermal nociceptor and the channel activated was TRPA1; receptor two is a thermal nociceptor and the channel activated was TRPV1; receptor three was an innocuous cold receptor and the channel activated was TRPM8.

Answer: C

03. List the steps involved in the generation of an action potential in a sensory nerve fiber beginning with the stimulation of a Pacinian corpuscle.

a) Light touch is applied to the Pacinian corpuscle, and a receptor potential is generated; as the pressure is increased, the size of the receptor potential is increased; when it reaches 30 mV, an action potential is produced at a point of the sensory nerve within the corpuscle.
b) Light touch is applied to the Pacinian corpuscle, and a receptor potential is generated; as more receptors are brought into the receptive field, the size of the receptor potential increases; when it reaches 30 mV, an action potential is produced at the first node of Ranvier.
c) Sustained pressure is applied to the Pacinian corpuscle, and a receptor potential is generated; as more receptors are activated, the size of the receptor potential increases; when it reaches 10 mV, an action potential is produced at the first node of Ranvier.

Section-III

Endocrine & Reproductive Physiology

Chapter 16: Hypothalamic Regulation of Hormonal Functions

01. Thirst is stimulated by

a) Increases in plasma osmolality and volume.
b) An increase in plasma osmolality and a decrease in plasma volume.
c) A decrease in plasma osmolality and an increase in plasma volume.
d) Decreases in plasma osmolality and volume.
e) Injection of vasopressin into the hypothalamus.

Answer: B

02. When an individual is naked in a room in which the air temperature is 21°C (69.8°F) and the humidity 80%, the greatest amount of heat is lost from the body by

a) Elevated metabolism.
b) Respiration.
c) Urination.
d) Vaporization of sweat.
e) Radiation and conduction. In questions

Answer: E

3–8, select A if the item is associated with (a), B if the item is associated with (b), C if the item is associated with both (a) and (b), and D if the item is associated with neither (a) nor (b). (a) V1A vasopressin receptors (b) V2 vasopressin receptors

3. Activation of Gs
4. Vasoconstriction
5. Increase in intracellular inositol triphosphate
6. Movement of aquaporin
7. Proteinuria
8. Milk ejection

Answer: 3B 4A 5A 6B 7D 8D

Chapter 17: The Pituitary Gland

01. A neuroscientist is studying communication between the hypothalamus and pituitary in a rat model. She interrupts blood flow through the median eminence and then measures circulating levels of pituitary hormones following appropriate physiologic stimulation. Secretion of which of the following hormones will be unaffected by the experimental manipulation?

a) Growth hormone
b) Prolactin
c) TSH
d) FSH
e) Vasopressin

Answer: E

02. Loss of which of the following pituitary hormones might be expected to increase responses to painful stimuli?

a) α-Melanocyte–stimulating hormone (α-MSH)
b) β-MSH
c) ACTH
d) Growth hormone
e) β-Endorphin

Answer: E

03. A 20-year-old African American woman is evaluated for evaluation of patches of skin on her face and hands that have lost pigmentation over a period of weeks. She is otherwise healthy. Blood tests reveal the presence of autoantibodies to melanocytes. The most likely diagnosis is

a) Albinism.
b) Piebaldism.
c) Primary adrenal insufficiency.
d) Vitiligo.
e) Hypopituitarism.

Answer: D

04. A scientist finds that infusion of growth hormone into the median eminence of the hypothalamus in experimental animals inhibits the secretion of growth hormone and concludes that this proves that growth hormone feeds back to inhibit GHRH secretion. Do you accept this conclusion?

a) No, because growth hormone does not cross the blood-brain barrier.
b) No, because the infused growth hormone could be stimulating dopaminesecretion.
c) No, because substances placed in the median eminence could be transported to the anterior pituitary.
d) Yes, because systemically administered growth hormone inhibits growth hormone secretion.
e) Yes, because growth hormone binds GHRH, inactivating it.

Answer: C

Section-V
Cardiovascular Physiology

Chapter 28: Origin of the Heartbeat & the Electrical Activity of the Heart

01. Which part of the ECG (eg, Figure 29–5) corresponds to ventricular repolarization?
a) The P wave
b) The QRS duration
c) The T wave
d) The U wave
e) The PR interval
Answer: C

02. Which of the following normally has a slowly depolarizing "prepotential"?
a) Sinoatrial node
b) Atrial muscle cells
c) Bundle of His
d) Purkinje fibers
e) Ventricular muscle cells
Answer: A

03. In second-degree heart block
a) The ventricular rate is lower than the atrial rate.
b) The ventricular ECG complexes are distorted.
c) There is a high incidence of ventricular tachycardia.
d) Stroke volume is decreased.
e) Cardiac output is increased.
Answer: A

04. Currents caused by opening of which of the following channels contribute to the repolarization phase of the action potential of ventricular muscle fibers?
a) Na+ channels
b) Cl− channels
c) Ca2+ channels
d) K+ channels
e) HCO3− channels
Answer: D

05. In complete heart block
a) Fainting may occur because the atria are unable to pump blood into the ventricles.
b) Ventricular fibrillation is common.
c) The atrial rate is lower than the ventricular rate.
d) Fainting may occur because of prolonged periods during which the ventricles fail to contract.
Answer: D

Section-VII
Renal Physiology

Chapter 36: Renal Function & Micturition

01. In the presence of vasopressin, the greatest fraction of filtered water is absorbed in the

a) Proximal tubule.
b) Loop of Henle.
c) Distal tubule.
d) Cortical collecting duct.
e) Medullary collecting duct.

Answer: A

02. In the absence of vasopressin, the greatest fraction of filtered water is absorbed in the

a) Proximal tubule.
b) Loop of Henle.
c) Distal tubule.
d) Cortical collecting duct.
e) Medullary collecting duct.

Answer: A

03. If the clearance of a substance which is freely filtered is less than that of inulin,

a) There is net reabsorption of the substance in the tubules.
b) There is net secretion of the substance in the tubules.
c) The substance is neither secreted nor reabsorbed in the tubules.
d) The substance becomes bound to protein in the tubules.
e) The substance is secreted in the proximal tubule to a greater degree than in the distal tubule.

Answer: A

04. Glucose reabsorption occurs in the

a) Proximal tubule.
b) Loop of Henle.
c) Distal tubule.
d) Cortical collecting duct.
e) Medullary collecting duct.

Answer: A

05. On which of the following does aldosterone exert its greatest effect?

a) Glomerulus
b) Proximal tubule
c) Thin portion of the loop of Henle
d) Thick portion of the loop of Henle
e) Cortical collecting duct

Answer: E