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

3rd Edition

Edited by

Dr. Md. Hedaiyat Islam

MBBS, DLO, MRCS Final (England)
FCPS Final (ENT)
Senior Consultant, Department of Otolaryngology-Head and Neck Surgery
Reverend Abdul Wadud Memorial Hospital, Khulna, Bangladesh
Ex-Non Resident, Bangladesh Medical University

SYNAPSE PUBLICATIONS

CONTENTS

Review of ENT Physiology

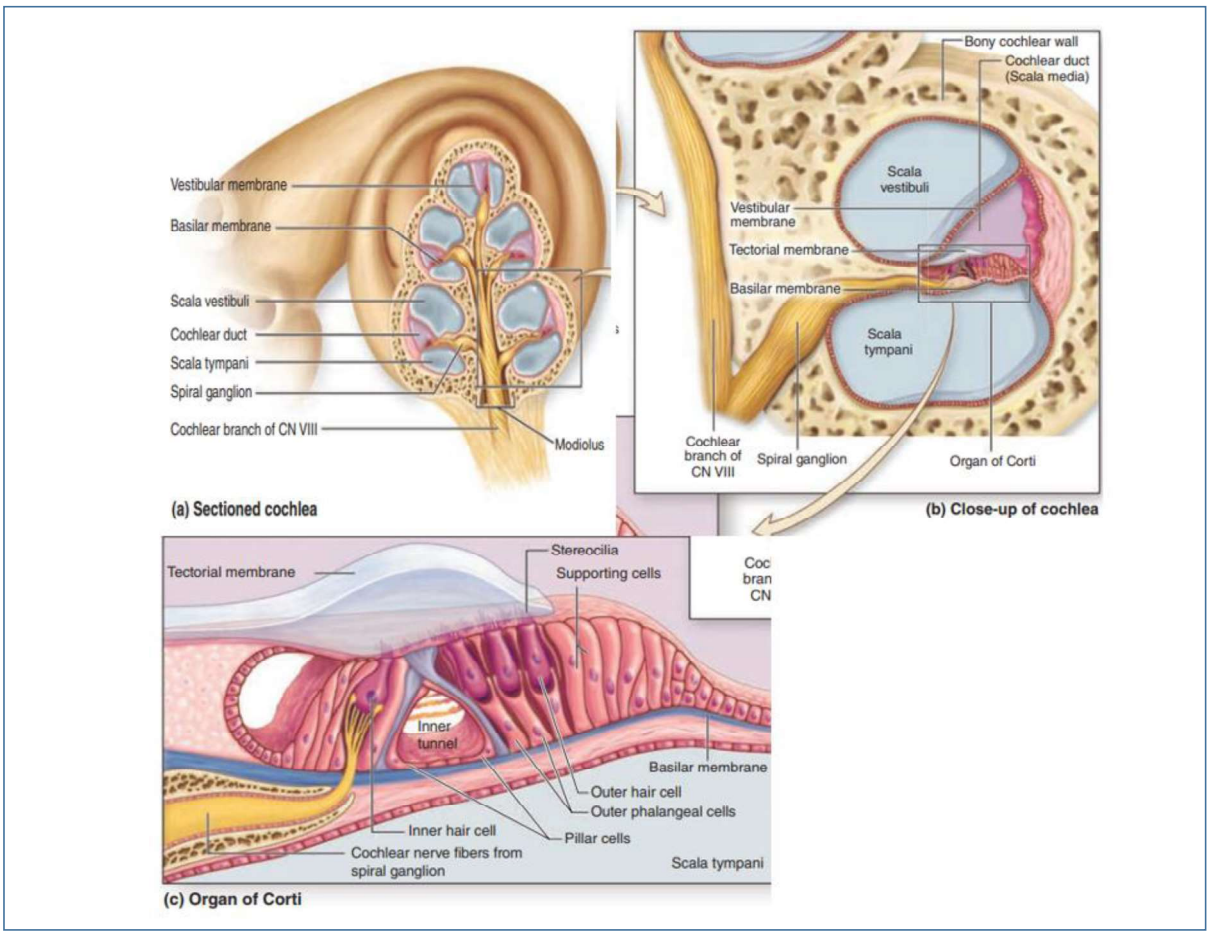
SL NO	Topic	Page
	Chapter-01 Hearing and Equilibrium	
01	Hearing and Equilibrium-Ganong 26E, Junqueira's Histology 16E	03
02	Peripheral Receptors and Physiology of Auditory and Vestibular Systems-Dhingra 9E	16
03	Audiology and Acoustics - Dhingra 9E + Synopsis ENT 5E	24
04	Audiology_Synopsis ENT 5E	32
05	The Sense of Hearing - Guyton 14E	38
06	Vestibular Sensations and Maintenance of Equilibrium - Guyton 14E	49
07	Equilibrium - Synopsis ENT 5E	53
08	Practice Questions from Roddie and Ganong 26E	55
	Chapter-02 Audiology Mnemonics	
01	Audiology Mnemonics	63
02	Tuning Fork Test	92
03	Hearing Aids	98
04	Presbycusis	108
05	Ototoxicity	110
	Chapter-03 Physiology of the Nose and Paranasal Sinuses	
01	Physiology of the Nose & PNS- Hazarika 5E	121
02	Physiology of Nose & PNS-Dhingra 9E	129
03	Physiology of Paranasal Sinuses- Dhingra 9E	131
04	Respiratory Protective Reflexes- Essential of Physiology by K. Semibulingum 8E	133
05	Applied Physiology of the Nose and Paranasal Sinuses - Synopsis ENT 5E	135
06	Practice Questions from Roddie and Ganong 26E	137
	Chapter-04 Smell & Taste	
01	Smell/ Olfaction – Ganong Physiology 26E	143
02	Sense of Smell – Guyton 14E	148
03	Taste/ Gustaception – Ganong 26E	152
04	Sense of taste – Guyton 14E	156
05	Smell and Taste- Synopsis ENT 5E	159
06	Practice Questions from Roddie and Ganong 26E	161

Chapter-01

Hearing and Equilibrium

Ref: Ganong 26E, Guyton 14E,
Dhingra 9E, Synopsis 5E, Janquiera 16E

tips of the hairs of the outer but not the inner hair cells. Most (90–95%) of these sensory neurons innervate the inner hair cells; only 5–10% innervate the more numerous outer hair cells. the outer efferent fibers in the auditory nerve. The bases of the hair cells are bathed in perilymph. The processes of the hair cells are bathed in endolymph, whereas their bases are bathed in perilymph. The macula, the sensory epithelium of these organs, are vertically oriented in the saccule and horizontally located in the utricle When is upright. The otoliths or otoconia range from 3 to 19 μm in length. The processes of the hair cells are embedded in the membrane.



Figures- (Janquiera 16E)

(a) The auditory portion of the inner ear, the cochlea.

(b) This diagram shows a more detailed view of one such turn of the cochlear duct (scala media), the **organ of Corti** on the basilar membrane, and the adjacent perilymph-filled spaces, the scala vestibuli and scala tympani.

(c) This diagram shows the organ of Corti in more detail, including the **tectorial membrane.**

Sensory Receptors in The Ear: Hair Cells

The specialized sensory mechanoreceptors in the ear consist **of six patches of hair cells** in the membranous labyrinth (Figure 11–5). The hair cells in the organ of Corti signal hearing; the hair cells in the utricle signal horizontal acceleration; the hair cells in the saccule signal vertical acceleration; and a patch in each of the three semicircular canals signal rotational acceleration. Each hair cell is embedded in an epithelium made up of supporting cells, with the basal end in close contact with afferent neurons. A hair bundle projects from the apical end. It has one large kinocilium, a true but nonmotile cilium, with nine pairs of microtubules around a core and a central pair of microtubules**. The kinocilium is lost from the cochlear hair cells in**

Figure (b): Movements in the opposite direction, *away from* the kinocilium, produce slackness on the tip links, allowing the mechanically gated apical K+ channels to close completely, producing *hyperpolarization*, and inhibiting transmitter release. With different numbers of afferent and efferent fibers on the hair cells and with various hair cells responding differently to endolymph movements due to their positions within the maculae and cristae ampullares, the sensory information produced collectively by these cells can be processed by the vestibular regions of the brain and used to help maintain equilibrium. **(Reference_Janquiera 16E)**

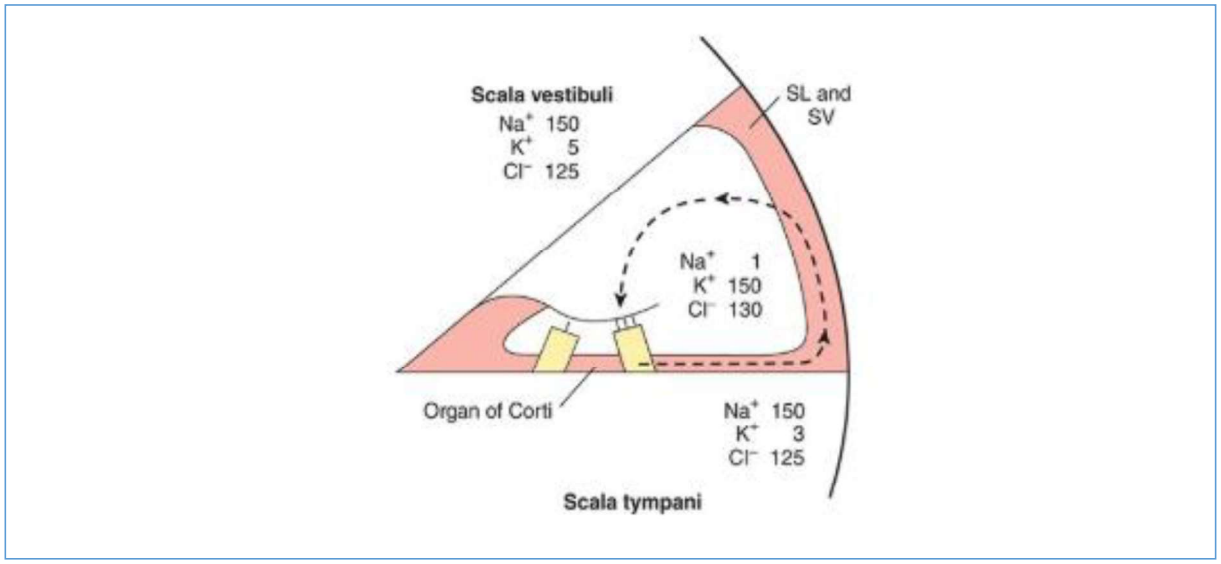
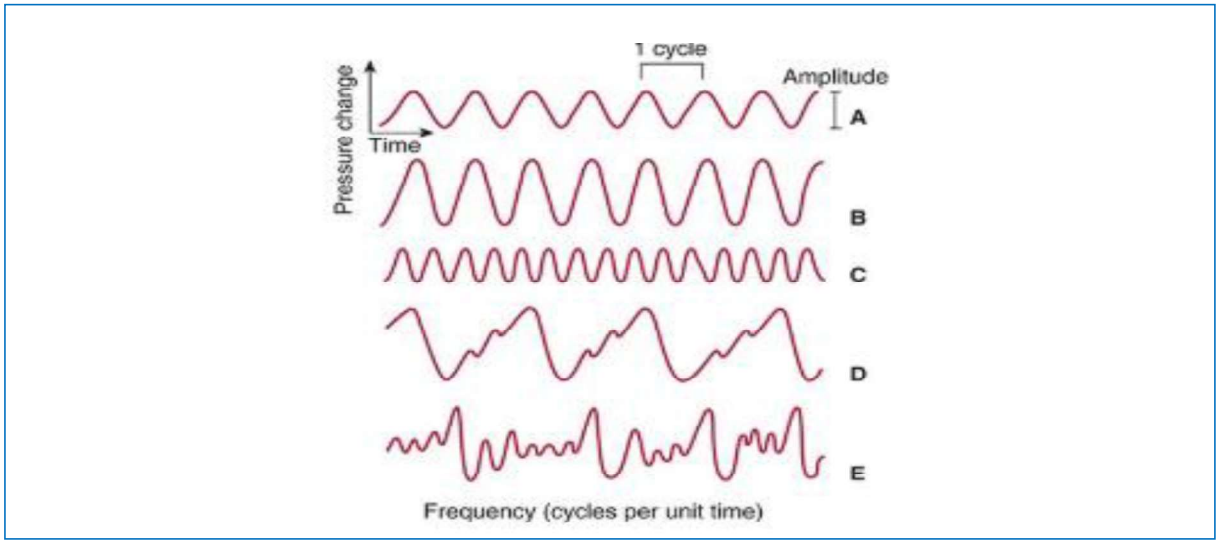


Figure: Ionic composition of perilymph in the scala vestibuli, endolymph in the scala media, and perilymph in the scala tympani. As described above, the processes of hair cells project into the endolymph and the bases are bathed in perilymph. Cells in the stria vascularis have a high concentration of Na+, K+ ATPase. A unique electrogenic K+ pump in the stria vascularis may account for the fact that the scala media is electrically positive by 85 mV relative to the scala vestibuli and scala tympani. The resting membrane potential of hair cells is about −60 mV.



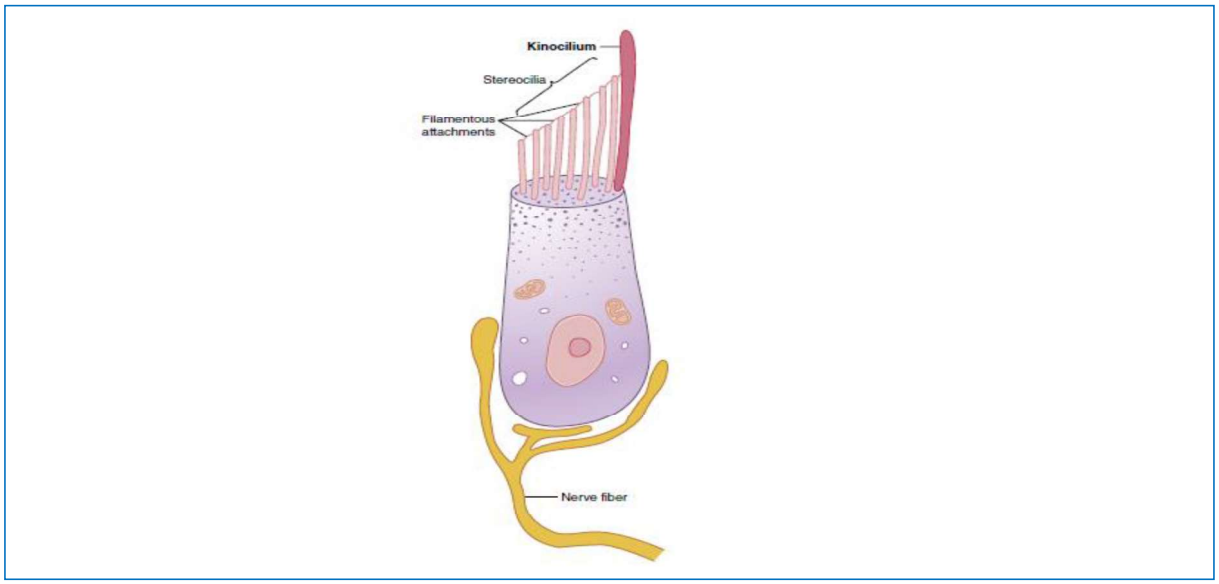


Figure: A hair cell of the equilibrium apparatus and its synapses with the vestibular nerve.

As the orientation of the head in space changes and the weight of the statoconia bends the cilia, appropriate signals are transmitted to the brain to control equilibrium.

Therefore, a different pattern of excitation occurs in the macular nerve fibers for each orientation of the head in the gravitational field. **It is this "pattern" that apprises the brain of the head's orientation in space.**

Semicircular Ducts. When the head is bent forward about 30 degrees, the lateral semicircular ducts are approximately horizontal with respect to the surface of the Earth; Rotation of the head in the opposite direction causes the cupula to bend to the opposite side.

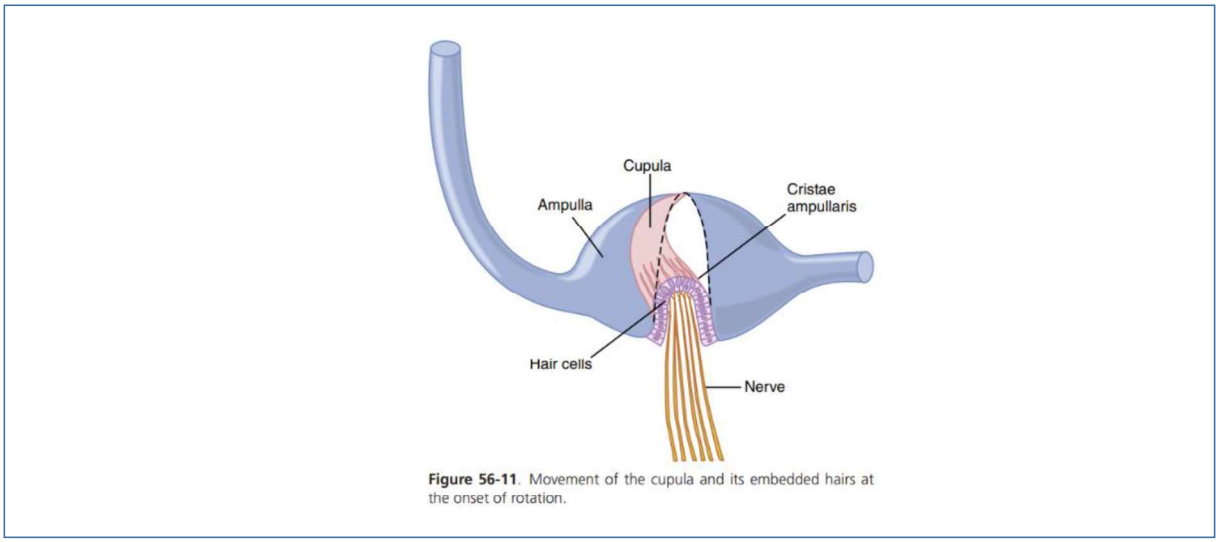


Figure 56-11. Movement of the cupula and its embedded hairs at the onset of rotation.

Then, from the hair cells, appropriate signals are sent via the vestibular nerve to apprise the central nervous system of a change in rotation of the head and the rate of change in each of the three planes of space.

Hearing Aids

Principles:

- **Gain** → Amplify
- **Compression** → Comfortable
- **Telecoil & Loop System** → Magnetic sound
- **Acclimatization**
- **Directionality** → Sound localization

Acoustic feedback: It occurs when amplified sound leaks from the receiver back into the microphone. It leads to an unpleasant high-pitched squeal.

Acoustic feedback, which is more common in in-the-ear (ITE) and in-the-canal (ITC), results from short microphone-to-receiver distance, wax, vents and poor fitting.

Poor earmold-fitting results in annoying acoustic feedback, amplification of background noise and distortion of sound.

Molds

- **Occlusion effect** → Tight occlusion leads to hearing own chewing sound
- **Feedback** → Sound returns back to earmold → rehearing

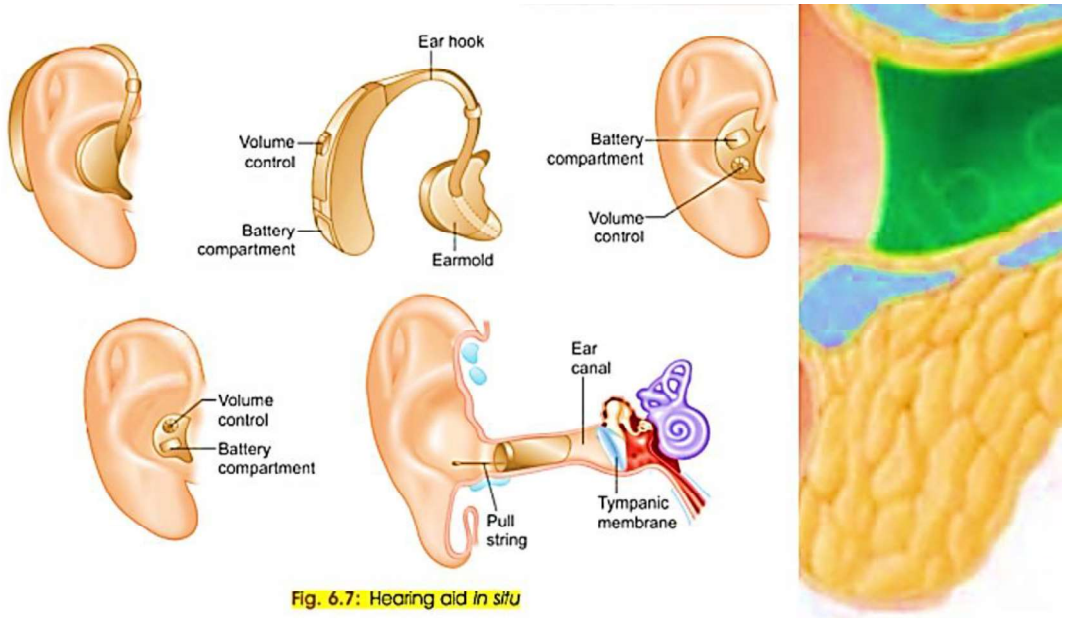
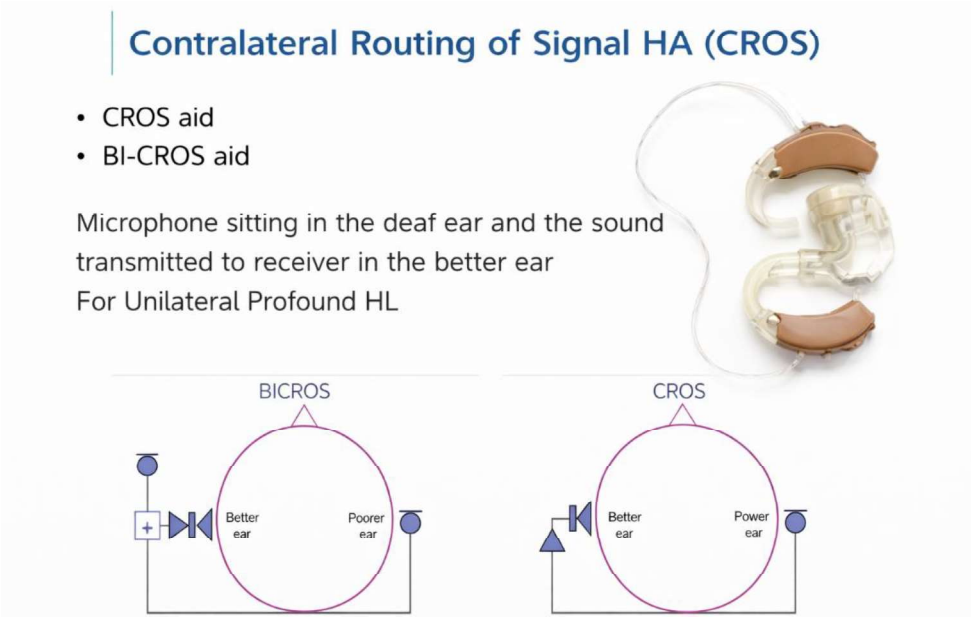


Fig. 6.7: Hearing aid *in situ*

Table 10.1 Relative advantages of different hearing aid styles. Greater advantages relative to the other styles are indicated by a greater number of check marks.

Factor	CIC	ITC	ITE	BTE	Spectacle	Body
Ease of insertion and removal	✓✓✓	✓✓✓	✓✓✓		✓✓	✓
Ease of manipulating user controls		✓	✓✓	✓✓✓	✓✓✓	✓✓✓
Invisibility	✓✓✓	✓✓	✓	✓		
High gain and maximum output			✓	✓✓	✓✓	✓✓✓
Insensitivity to wind noise	✓✓✓	✓✓	✓✓			
Directivity (omni-directional mics)	✓✓✓	✓✓	✓	✓	✓	
Directivity (directional mics)			✓✓✓	✓✓✓		
Reliability				✓✓✓	✓✓✓	✓✓✓
Compatibility with telephones	✓✓✓	✓	✓	✓✓✓	✓✓✓	✓
Flexibility (non-programmables)			✓	✓✓	✓	✓✓
Flexibility (programmables)	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓
Ease of cleaning				✓✓✓	✓✓✓	✓
Avoidance of occlusion and feedback		✓	✓✓	✓✓✓	✓✓✓	✓✓✓
Cost	✓	✓	✓	✓	✓	✓

Contralateral Routing of Signal HA (CROS)



Presbycusis

Ref: Scott Brown Otolaryngology 8E

Age-related hearing loss may be defined as a progressive bilateral sensorineural hearing loss of mid to late adult onset, where underlying causes have been excluded.

TABLE 56.1 Causes of sensorineural hearing loss, shown in order of prevalence and with approximate values where available	
Cause	**Prevalence (%)**
Age	Ultimately 100?
Noise	<5
Idiopathic	5–30
Ear infections	
Ménière's disease	
Head injury	> 0.004
Ototoxicity	
Non-syndromic genetic	0.7 (probably greater)
Syndromic genetic	0.3
Systemic illness (e.g. meningitis, renal failure, diabetes)	
Others (e.g. autoimmune, otosclerosis, acoustic neuroma)	

Pathophysiology:
The neural type of histopathology was believed to be the most common. Though a longitudinal study has indicated that metabolic, and mixed sensory-metabolic phenotypes increase with increasing age.
Sensory and neural histopathological types are associated with the common high-frequency loss pattern.

The various histological types have been correlated with audiogram patterns in post-mortem studies. Sensory and neural histopathological types are associated with the common high-frequency loss pattern, with associated poor auditory discrimination abilities. In contrast, the strial type has been associated with a 'flat' audiogram and good discrimination abilities also seen in age-related hearing loss

Central auditory processing abilities decline with age, and decrements in tests of temporal fine structure and word recognition and discrimination have been reported.

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 muscles of the tongue help in the process.

Propulsion and Mixing of Food in the Alimentary Tract

Ref: Guyton 14E

Mastication (Chewing)
All the jaw muscles working together can close the teeth with a force as great as 55 pounds on the incisors and 200 pounds on the molars.

Most of the muscles of chewing are innervated by the motor branch of the fifth cranial nerve, and the chewing process is controlled by nuclei in the brain stem. Stimulation of specific reticular areas in the brain stem taste centers will cause rhythmical chewing movements. In addition, stimulation of areas in the hypothalamus, amygdala, and even the cerebral cortex near the sensory areas for taste and smell can cause chewing.

Chewing is important for digestion of all foods, but it is especially important for most fruits and raw vegetables because they have indigestible cellulose membranes around their nutrient portions that must be broken before the food can be digested. Furthermore, chewing aids the digestion of food for another simple reason: Digestive enzymes act only on the surfaces of food particles; therefore, the rate of digestion is dependent on the total surface area exposed to the digestive secretions.

Swallowing (Deglutition)
In general, swallowing can be divided into
(1) a voluntary stage, which initiates the swallowing process.
(2) a pharyngeal stage, which is involuntary and constitutes passage of food through the pharynx into the esophagus; and
(3) an esophageal stage, another involuntary phase that transports food from the pharynx to the stomach.

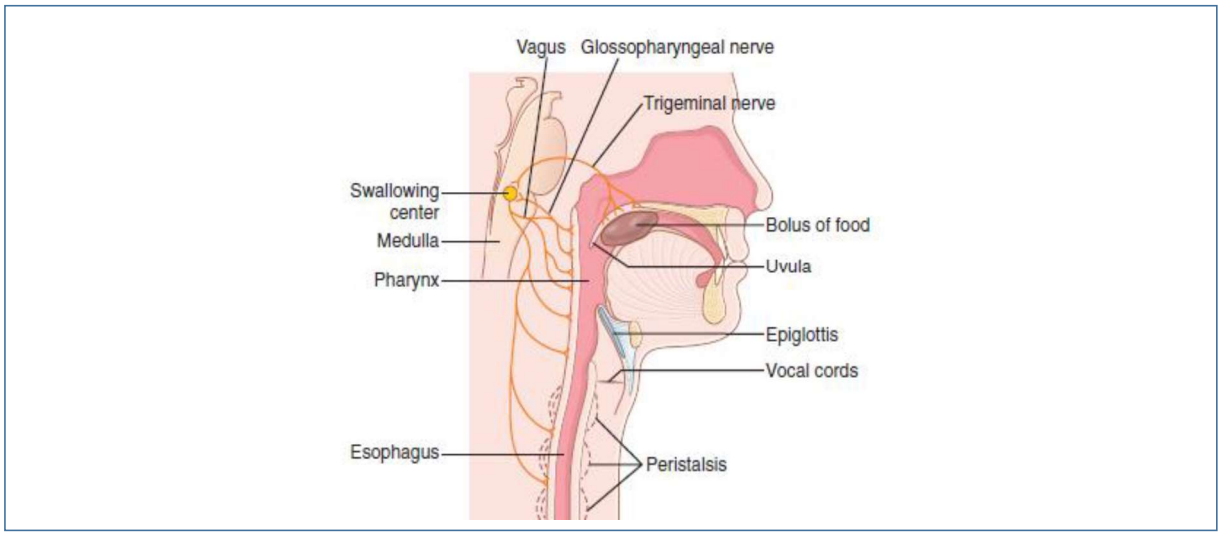


Figure: Swallowing mechanism.

Voluntary Stage of Swallowing. When the food is ready for swallowing, it is "voluntarily" squeezed or rolled posteriorly into the pharynx by pressure of the tongue upward and backward against the palate, as

43. Impairment of visual acuity in bright light can be explained by

a) Random light scattering when there is deficient pigmentation of the eye due to albinism.
b) Random light scattering when there is asymmetrical corneal curvature due to astigmatism.
c) Random light scattering in the cornea when there is vitamin A deficiency.
d) Impairment of rod function when there is vitamin A deficiency.
e) Inability to alter the focal length of the lens when a cataract is present.

Answer: T F T F F

Explanation:

a. True Normally absorption of light by dark pigment in the choroid prevents back-scattering of light into the retina.
b. False There is a refractive error but not random light scattering.
c. True Lack of vitamin A leads to keratin deposition in corneal epithelium (xerophthalmia).
d. False Rod function does not determine acuity in bright light.
e. False Impairment of acuity with cataract is due to random scattering by lens opacities.

44. In long-sightedness (hypermetropia)

a) Objects at infinity cannot be focused sharply on the retina.
b) Objects at the usual near-point are focused behind the retina.
c) Ciliary muscle contracts more strongly to bring objects in mid-visual range into clear focus.
d) The range of unblurred vision (near-point to far-point) is greater than normal.
e) The near-point can be brought closer to the eye by the use of a biconcave lens.

Answer: F T T F F

Explanation:

a. False This is true of shortsightedness (myopia).
b. True The eye is usually shorter than normal.
c. True This distance is closer than usual to the hypermetrope's near point.
d. False It is less than normal; the far point stays at infinity but the near point is further away.
e. False A convex lens is required to augment the power of the eye's refracting system.

Explanation:

a. False Insulin is required mainly in response to meals.
b. False The disease is not usually due to rapid insulin breakdown.
c. True Abnormal binding may occur in diabetes mellitus.
d. True Obese patients usually show increased insulin resistance.
e. False Exercise reduces insulin requirements.

44. The risk of tetany is increased by

a) Sudden rises in plasma bicarbonate.
b) Sudden rises in plasma magnesium.
c) Removal of the anterior pituitary gland.
d) The onset of respiratory failure.
e) The onset of renal failure.

Answer: T F F F F

Explanation:

a. True in alkalosis, the calcium-binding power of the plasma proteins increases.
b. False Like calcium, magnesium ions tend to prevent tetany.
c. False The pituitary is not involved in calcium homeostasis.
d. False The acidosis in respiratory failure reduces calcium binding by protein.
e. False The acidosis in renal failure also reduces calcium binding by protein.

45. Destruction of the anterior pituitary gland causes

a) Amenorrhoea.
b) Diabetes insipidus.
c) Skin pallor.
d) Impaired ability to survive severe stress.
e) A fall in basal metabolic rate (BMR).

Answer: T F T T T

Explanation:

a. True Due to absence of FSH and LH.
b. False ADH is released from the posterior pituitary.
c. True Due to loss of ACTH and melanocyte-stimulating hormone (MSH) actions.
d. True Due to loss of ACTH and failure of the cortisol surge in response to stress; loss of TSH and consequent hypothyroidism also contribute.
e. True BMR falls due to loss of TSH drive to the thyroid

46. Removal of the thyroid gland (without replacement therapy) leads to an increased

a) Blood TSH level.
b) Blood cholesterol level.
c) Blood glucose level during an oral glucose tolerance test.
d) Response time for tendon reflexes.
e) Tremor of the fingers.

Answer: T T F T F

02. When dynamic γ-motor neurons are activated at the same time as α-motor neurons to muscle

a) Prompt inhibition of discharge in spindle Ia afferents takes place.
b) Clonus is likely to occur.
c) The muscle will not contract.
d) The number of impulses in spindle Ia afferents is smaller than when α discharge alone is increased.
e) The number of impulses in spindle Ia afferents is greater than when α discharge alone is increased.

Answer: E

03. The inverse stretch reflex

a) Occurs when Ia spindle afferents are inhibited.
b) Is a monosynaptic reflex initiated by activation of the Golgi tendon organ.
c) Is a disynaptic reflex with a single interneuron inserted between the afferent and efferent limbs.
d) Is a polysynaptic reflex with many interneurons inserted between the afferent and efferent limbs.
e) Uses type II afferent fibers from the Golgi tendon organ.

Answer: C

04. Withdrawal reflexes are

a) Initiated by innocuous stimulation of the skin.
b) Can lead to the appearance of clonus.
c) Prolonged if the stimulus is strong.
d) An example of a stretch reflex.
e) Accompanied by the same response on both sides of the body.

Answer: C

05. While exercising, a 42-year-old woman developed sudden onset of tingling in her right leg and an inability to control movement in that limb. A neurologic exam showed a hyperactive knee jerk reflex and a positive Babinski sign. What is a possible basis for these findings and does it reflect damage to an upper or lower motor neuron?

a) She had a lower thoracic disk rupture that damaged the right side of her spinal cord (upper motor neuron damage).
b) She had a mid-cervical disk rupture that damaged the left side of her spinal cord (upper motor neuron damage).
c) She had a lower lumbar disk rupture that compressed the spinal nerve at that segmental level (lower motor neuron damage).
d) She had a sacral disk rupture that put pressure on the ventral root at that segmental level (lower motor neuron damage).
e) She was experiencing dysfunction of both a lower motor neuron and an upper motor neuron.

Answer: A

06. Increased neural activity before a skilled voluntary movement is first seen in the

a) Spinal motor neurons.
b) Precentral motor cortex.
c) Midbrain.
d) Cerebellum.
e) Cortical association areas.

Answer: E

Chapter 18: The Adrenal Medulla & Adrenal Cortex

01. Which of the following is produced only by large amounts of glucocorticoids?

a) Normal responsiveness of fat depots to norepinephrine
b) Maintenance of normal vascular reactivity
c) Increased excretion of a water load
d) Inhibition of the inflammatory response E. Inhibition of ACTH secretion

Answer: D

02. Which of the following are incorrectly paired?

a) Gluconeogenesis: Cortisol
b) Free fatty acid mobilization: Dehydroepiandrosterone
c) Muscle glycogenolysis: Epinephrine
d) Kaliuresis : Aldosterone
e) Hepatic glycogenesis: Insulin

Answer: B

03. Which of the following hormones has the shortest plasma half-life?

a) Corticosterone
b) Renin
c) Dehydroepiandrosterone
d) Aldosterone
e) Norepinephrine

Answer: E

04. Mole for mole, which of the following has the greatest effect on Na+ excretion?

a) Progesterone
b) Cortisol
c) Vasopressin
d) Aldosterone
e) Dehydroepiandrosterone

Answer: D

05. Mole for mole, which of the following has the greatest effect on plasma osmolality?

a) Progesterone
b) Cortisol
c) Vasopressin
d) Aldosterone
e) Dehydroepiandrosterone

Answer: C

06. The secretion of which of the following would be least affected by a decrease in extracellular fluid volume?

a) CRH
b) Arginine vasopressin
c) Dehydroepiandrosterone
d) Estrogens
e) Aldosterone

Answer: D

Section-IV
Gastrointestinal Physiology

Chapter 24: Overview of Gastrointestinal Function & Regulation

01. A researcher conducts a study of the regulation of salivary secretion in a group of volunteer medical students under various conditions. Which of the following conditions would be expected to be associated with the lowest rates of secretion?

a) Chewing gum
b) Undergoing a mock dental exam
c) Sleep
d) Exposure to a nauseating odor
e) Resting control conditions

Answer: C

02. A patient suffering from anemia comes to his physician complaining of frequent bouts of gastroenteritis. A blood test reveals antibodies directed against gastric parietal cells. The anemia in this patient is attributable to hyposecretion of which gastric product?

a) Histamine
b) Gastrin
c) Pepsinogen
d) Intrinsic factor
e) Hydrochloric acid

Answer: D

03. A 50-year-old man comes to see his clinician complaining of severe epigastric pain, frequent heartburn, and unexplained weight loss of 20 pounds over a 6-month period. He claims to have obtained no relief from over-the-counter H2 antihistamine drugs. He is referred to a gastroenterologist, and upper endoscopy reveals erosions and ulcerations in the proximal duodenum and an increased output of gastric acid in the fasting state. The patient is most likely to have a tumor secreting which of the following hormones?

a) Secretin
b) Somatostatin
c) Motilin
d) Gastrin
e) Cholecystokinin

Answer: D

04. Which of the following has the highest pH?

a) Gastric juice
b) Colonic luminal contents
c) Pancreatic juice
d) Saliva
e) Contents of the intestinal crypts

Answer: C