Special Senses

Different special senses with their organ

Special senses	*Organ*	*Receptor*
1. Vision	1. Eye	1. Rods and cones
2. Hearing	2. Ear (organ of corti)	2. Hair cells
3. Taste	3. Tongue	3. Taste bud
4. Smell	4. Olfactory mucous membrane	4. Olfactory neurones
5. Rotational acceleration	5. Ear (semicircular canals)	5. Hair cells
6. Linear acceleration.	6. Ear (utricle and saccule).	6. Hair cells.

(Ref. Ganong 22th Edition, page-122)

Q. 00. **What are the effects of vit-A deficiency in eye?**

Ans. Deficiency sings (consequences of vitamin A deficiency) :

1. ***Eye changes*** : Deficiency causes disintrigation of epithelium of cornea and lacrimal gland causes--
   a. Night blindness (nyctalopia) : This is the earliest change and is due to les formation of rhodopsin.
   b. Xeropthalmia : Cojunctival kertinization.
   c.Keratomalacia : Corneal softening and ulceration.
   d. Bitot's sports : Triangular, shiny, gray (white plaques) spots on the conjunctiva.
   e. Corneal scarring and blindness.

Q. 01. **How vitamin A deficiency can be prevented?**

Ans. Vitamin A deficiency can be prevented by :

1. Improvement of diet.
2. *Vitamin A* fortified food (sugar fortified with vit-A)
3. Prophylactic use of high potency oral vitamin-A capsule in the high risk children.
4. Health education of the people.

(Ref. Community medicine; J, E. Park)

Eye

Eye is the principal organ of vision. It is located in the eye ball with accessory visual apparatus.

Functional anatomy

Covering of eye ball : Eyeball has three coats or tunics from outwards to inwards :

a. ***Outer fibrous coat*** : It consists of two parts :
   i. Sclera : posterior 5/6 th, which is opaque.
   ii. Cornea : anterior 1/6 th, which is transparent.

   Limbus : The junction between the sclera and cornea.

   Functions of the outer coat :
   1. Sclera is responsible for maintaining the shape & form of eye ball.
   2. Sclera and cornea converts the eye ball into a closed chamber.
   3. Cornea is the main refracting surface of the eye.

b. *Middle vascular coat* : This coat lies just underneath the sclera. It consists of three parts from behind forward :
   i. *Choroid* : Choroid is a dark brown, highly vascular layer situated between the slera and retina.
   ii. *Cilliary body* : Cilliary body is triangular in shape with base forwards. The iris is attached to the middle of the base. It consists of non-striated muscle fibres (*cilliary muscles*), stroma and secretory epithelial cells. It consists of two main parts namely pars plicata and pars plana
   iii. *Iris* : Iris is a coloured, free, circular diaphram with an aperture in the centre- the *pupil*. It consists of endothelium,stroma, pigment cells and two group of plain muscle fibres, one circular (*spincter pupillae*) and the other radiating (*dilator pupillae*).

   Functions of the middle coat :
   a. It is concerned with nutrition of the eye ball.
   b. Aquous humour is formed by the epithelium covering of the cilliary body.
   c. Action of cilliary muscles regulate the anterior curvature of the lens and thus helps in focussing the object on the retina.
   d. The iris muscle regulate the size of pupil.

c. ***Inner nervous coat*** : This is the receptive and conducting part of the eye ball and forms its innermost layer consisting of several layers of cells of retina.

   Functions of the inner coat : It is concerned with vision and various other reflexes which are evoked by light stimulus.

Refractive media

Refractive media	*Refractive power*
i. Cornea	1.38
ii. Aqueous humor	1.33
iii. Lens	1.40
iv. Vetrious body	1.34

(Ref. Guyton & Hall 11th edition)

Cornea

Cornea is the anterior modified part of the sclera It is the round, transparent and convexity in the anterior part of the eye ball.

Function :

a. Allows free entry of light
b. Acts as refractive media.

Histology or structure : From outside inward there are the folowing 5 layers :

1. Corneal epithelium or external stratified epithelium: Several layers of cells contineues with conjuctiva :
   i. The superficial four or five layers are stratified squamous.
   ii. The deepest (basal) layer is columnar.
   iii. The intermediate two or three layers are polyhedral
2. Bowman's capsule or anterior elastic lamina.
3. Susbtantia propria or coneal stroma.
4. Descemet's membrane or posterior elastic lamina.
5. Corneal endothelium or inner layer of squamous epithelium.

Nutrition of cornea : Cornea is avascular. It's epithelium, corneal corpuscles and endothelium get nutrition and O_2 supply from :

a. Aqueous humour
b. The superficial marginal plexus of capillaries at the limbus.
c. The capillaries in the tarsal conjunctiva.
d. O_2 dissolved in the layer of tear film on the epithelial surface.

Aqeous Humour

Aqueous humour is a clear watery fluid occupying both the anterior and posterior chambers of the eye.

Composition :

1. Water : 98.69 %
2. Solids : 1.31 %
   a. Colloids : Much less than serum.
   b. Chlorides : Much higher than serum.

Formation : Formed by the *enzymatic activity* of the cilliary process and is secreted mainly by active transport.

Circulation of aqeous : Cilliary process → Posterior chamber of eye → Through pupil → Aterior chamber of eye → Iridiocorneal angle → Canal of Schlemm → Episcleral vein → Aqueous vein → Opthalmic vein.

Functions :

a. Maintains intra occular pressure and shape of the eye ball.
b. Acts as refractive media.
c. Supplies nutrition to and drains the metabolis from the surrounding structures.

Pupil

Pupil is the central round aperture within the iris. The normal size of the pupil is 3-4 mm.

i. *Miosis* : Contraction of the pupil is called miosis.
ii. *Mydriasis* : The dilation of the pupil is called mydriasis.

Functions :

1. Pupil modifies the amount of the light entering the eye.
2. Pupil controls the depth of focus of the optical system of eye. Smaller pupil increases the depth of the focus.
3. Acuity of vision is dependent upon pupillary size.

Iris

Iris is a circular disc of the anterior part of the coroid situated in between cornea and lens. It has a central rounded aperture called pupil.

Histology : Histologically iris consist of following layers.

1. Squamous endothelium.
2. Anterior border layer.
3. Vessel layer or stroma
4. Muscles-spincter pupillae and dilator pupillae
5. Pigment epithelium.

Nerve supply :

a. *Sphinter pupillae :* supplied by *parasympathic* which arises from the Edenger westphal nucleus of 3rd cranial nerve via occulomotor nerve, cilliary ganglion and short cilliary nerve.
b. *Dilator pupillae :* supplied by *sympathetic arising* from superior cervical ganglion.

Function :

1. Act as a adjustable diaphragm by maintaining the diameter of pupill and the quantity of entry of light.
2. Increase the depth of focus.

Lens of eye

It is the chief refracting media of the eye ball having the maximum refractive power. It is transparent, elastic and bi-convex, enclosed in a cpasule. Posteriorly, it is more convex. It is circular about 11 mm in diameter. The thickness in the centre is about 3.6-3.9 mm. Refractive index - 1.4 at the centre, less in the periphery. It is held in situ by suspensory ligament.

Structure : The lens consists of three elements :

a. *Capsule :* Forms a trasparent structureless membrane.
b. *Anterior epithelium :* It is formed by a single row of cuboidal or low columnar cell which cover the anterior surface only.

c. *Lens substance :* Composed of concentric layers of elongated modified cells. The peripheral parts are soft & nucleated; central part forms a dense non-nucleated mass.

Nutrition : It has no vascular supply. It gets its nutrition almost entirely from the aqueos humour and partly from the vitreous humour.

Function : It refract light from distant or near objects into a focus exactly on the retina and thus aids in vision. It absorbs all rays below 300 nm or above 2500 nm.

Vitreous Humour (Body)

It is a jelly like transparent substance, is enclosed by a thin homogeneous membrane; the hyaloid membrane, and occupying the posterior compartment of eye.

Structure : It is made up of a series of lamellae arranged concentrically round the hyaloid canal.

The Lamellae composed of flat cells. The space between the lamellae are filed up with fluid.

Refractive index : 1.34

Functions :

1. Acts as a refractive media.
2. It maintains the shape and intraocular pressure of eye ball.
3. It provides nutrition to the lens.
4. It prevents detachment of retina.
5. It supports the lens posteriorty.

Retina

***Layers of retina** : From outside to inside*

i. Pigmented layer
ii. Layer of rods and cones
iii. External limiting membrance
iv. Outer nuclear layer (cell bodies of rods and cones)
v. Outer plexiform (molecular) layer
vi. Inner nuclear (bipolar cells) layer
vii. Inner plexiform (molecular) layer
viii. Ganglionic cell layer
ix. Nerve fibers layer
x. Inner limiting layer.

(Ref. Ganong 22th Edition)

Q. 00. **Briefly describe the vascular supply of the retina.**

Ans. *Arteries, arterioles, and veins of retina* : The arteries, arterioles, and veins in the superficial layers of the retina near its vitreous surface can be seen through the ophthalmoscope. Since this is the only place in the body where arterioles are readily visible. Ophthalmoscopic examination is of great value in the diagnosis and evaluation of *diabetes mellitus, hypertension*, and other diseases that affect blood vessels.

i. The retinal vessels supply the bipolar and ganghion cells
ii. The receptors are nourished for the most part by the capillary plexus in the cboroid. This is why retinal detachment is so damaging to the receptor cells.

(Ref. Ganong 22th Edition)

Description of retina

a. ***Retinal neurons*** : The retina contains four types of neuron :
   i. Bipolar cells
   ii. Ganglion cells
   iii. Horizontal cells
   iv. Aamacrine cells.

b. ***Synapses in retina*** : The rods and cones synapse with bipolar cells, and the bipolar cells synapse with ganglion cells. The axons of the ganglion cells converge and leave the eye as the optic nerve.

c. ***Supporting cells*** :
   i. *Horizontal cells* connect receptor cells to the other receptor cells in the outer plexiform layer.
   ii. *Amacrine cells* connect ganglion cells to one another in the inner plexiform layer. They have no axons, and their processes make both pre and postsynaptic connections with neighboring neural elements.

d. ***Convergence of cells in retina*** : There is considerable overall convergence of receptors on bipolar cells and of bipolar cells on ganglion cells. Gap junctions also connect

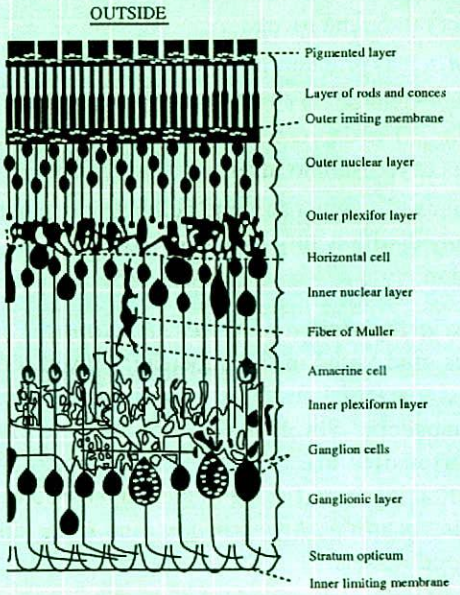


Fig. 17-11. *Layers of Retina*

retinal neuron to one another, and the permeability of these gap junctions is regulated.

e. ***Pigment epithelium*** : Since the receptor layer of the retina

rests on the *pigment epithelium* next to the choroid, light rays must pass through the ganglion cell and bipolar cell layers to reach the rods and cones. The pigment epithehum absorbs light rays, preventing the reflection of rays back through the retina. Such reflection would produce blurring of the visual images.

f. ***External and internal limiting membrane*** : The neural elements of the retina are bound together by glial cells called Muller cells. The processes of these cells form an internal limiting membrane on the inner surface of the retina and an external limiting membrane in the receptor layer.

g. ***Optic disk and blind spot*** : The optic nerve leaves the eye and the retinal blood vessels enter it at a point 3 mm medial to and slightly above the posterior pole of the globe. This region is visible through the ophthalmoscope as the optic disk. There are no visual receptors overlying the disk, and consequently this spot is blind (*the blind spot*).

h. ***Macula lutea and fovea centralis*** : Near the posterior pole of the eye, there is a yellowish pigmented spot, the *macula lutea.*

Fovea centralis : A thinned-out, rod-free portion of the macula lutea. In it, the cones are densely packed, and each synapses to a single bipolar cell which in turn synapses on a single ganglion cell, providing a direct pathway to the brain. There are very few overlying cells and no blood vessels.

Consequently, the *fovea* is the point where visual acuity is greatest. When attention is attracted to or fixed on an object, the eyes are normally moved so that light rays coming from the object fall on the fovea.

Situation : It is situated at a point on retina about 2.5 mm lateral to the margin of the optic papilla.

Formation : The depression is due to lateral displacement of the layers of retina upto layer 5.

Pecularities : It contains no rod cell but only cone cell. So, it is concerned with acuity of vision, colour vision and bright light vision.

i. ***Arteries, arterioles, and veins of retina*** : The arteries, arterioles, and veins in the superficial layers of the retina near its vitreous surface can be seen through the ophthalmoscope. Since this is the one place in the body where arterioles are readily visible, ophthalmoscopic examination is of great value in the diagnosis and evaluation of *diabetes mellitus*, *hypertension*, and other diseases that affect blood vessels.

i. The retinal vessels supply the bipolar and ganghion cells
ii. The receptors are nourished for the most part by the capillary plexus in the cboroid. This is why retinal detachment is so damaging to the receptor cells.

(Ref. Ganong 22th Edition; page 148, 149)

j. **Retinal receptors** *:* Retinal receptors are -

a. ***Rod cell*** : The rod cells are long sylender, highly specialized photorecptor cells found in the retina. It is about 120 million. *(Ref. Ganong 22th Edition)*

Parts of rod cell : It is divided into two parts.

1. Outer segment : It consists of two parts-
   I. Outer part : Thin cylindrical composed of a myelin - like substance and contains rhodopsin.
   II. Inner part : Broad, longitudinaly striated and is protoplasmic.
2. Inner segment : Thinner, consists of a nucleus and a long fibre terminating in end bulb or a spherule.

Functions of rod cell :

i. It concerned with dim light vision and have no play in colour vision & visual acuity.
ii. The outer segment is most sensative which abosrbs light and the inner segment is concerned with metabolic activity of the rod cells.

b. ***Cone Cell*** *:* These are conical photosensative visual cells found in retina. About 6 millions (Ref. Ganong 21th Edition) in each human retina.

Parts of cone cell : It is divided into 2 segments :

1. Inner segment.
2. Outer segment : It consists of two parts -
   a. Outer part contain iodopsin.
   b. Inner part.

Functions of cone cell : Cone cells are concerned with bright light vision, visual acuity and colour vision.

(Ref. Ganong 22th Edition; page 148, 149)

Difference between rod and cone cell

Rods	*Cones*
1. Cylindrical in shape	1. Conical in shape
2. Numerous in pheriphery.	2. Numerous in foeva centrlis.
3. Absent in fobea centralis	3. Numerous in fovea centralis.
4. Visual pigment is rodopsin.	4. Visual pigment is iodopsin.
5 It concerned with dim light vision	5. It concerned with bright, light vision, colour vision, acquity of vision.

Neural pathways & primary visual cortex

Primary visual cortex : The primary visual receiving area (primary visual cortex, Brodmann's area 17; also known as V1), is located principally on the sides of the calcarine fissure.

i. The axons of the *ganglion cells* pass caudally in the *optic nerve* and *optic tract* to end in the lateral geniculate body, a part of the thalamus. The fibers from each nasal hemiretina decussate in the *optic chiasm*. In the *lateral geniculate body*, the fibers from the nasal half of one retina and the temporal half of the other synapse on the cells whose axons form the *geniculocalcarine tract*. This tract passes to the occipital lobe of the cerebral cortex.

ii. Some ganglion cell axons pass from the optic tract to the ***pretectal region*** of the midbrain and the superior colliculus, where they form connections that mediate *pupillary reflexes* and *eye movements*.

iii. The *frontal cortex* is also concerned with eye movement, and especially its refinement. The bilateral ***frontal eye fields*** in this part of the cortex are concerned with control of saccades, and an area just anterior to these fields is concerned with *vergence* and the *near response*.

The frontal areas concerned with vision probably project to the *nucleus reticularis tegmentalis pontinus*, and from there to the other brain stem nuclei mentioned above.

iv. Other axons pass directly from the optic chiasm to the *suprachiasmatic nuclei* in the ***hypothalamus***, where they form connections that synchronize a variety of endocrine and other circadian rhythms with the light-dark cycle.

v. Activation occurs not only in the occiptal lobe but also in parts of the *inferior temporal cortex*, the *posteroinferior parietal cortex*, portions of the *frontal lobe* and the *amygdala*.

vi. The ***subcortical structures*** activated in addition to the lateral geniculate body include the-

a. Superior colliculus
b. Pulvinar
c. Caudate nucleus
d. Putamen
e. Claustrum.

(Ref. Ganong 22th Edition; page 149)

Photoreceptor mechanism

i. ***Ionic basis of photoreceptor potentials in rods and cones*** : Na^+ channels in the outer segments of the *rods* and *cones* are open in the dark, so current flows from the inner to the outer segment. Current also flows to the synaptic ending of the photoreceptor. *Na^+-K^+ ATPase* in the inner segment maintains ionic equilibrium. Release of synaptic transmitter is steady in the dark. When light strikes the outer segment, the reactions that are initiated close some of the Na^+ channels, and the result is a hyperpolarizing receptor potential. The hyperpolarization reduces the release of synaptic transmitter, and this generates a signal that ultimately leads to action potentials in ganglion cells. The action potentials are transmitted to the brain.

(Ref. Ganong 22th Edition; page 157)

ii. ***Photosensitive compounds*** : The photosensitive compounds in the eyes of humans and most other mammals are made up of-

a. *Opsin* : a protein
b. *Retinene*$_1$, the aldehyde of vitamin A_1. Since the retinenes are aldehydes, they are also called retinals. The A vitamins themselves are alcohols and are therefore called retinols.

(Ref. Ganong 22th Edition; page 157)

iii. ***Rhodopsin*** : The photosensitive pigment in the *rods* is called rhodopsin or *visual purple*. Its opsin is called scotopsin. Rhodopsin has a peak sensitivity to light at a wave length of 505 nm.

a. Molecular weight : 4 1,000.

b. It is found in the membranes of the rod disks and makes up 90% of the total protein in these membranes.

It is one of the many serpentine receptors coupled to G proteins. Retinene$_1$ is parallel to the surface of the membrane and is attached to a lysine residue at position 296 in the seventh transmembrane domain.

(Ref. Ganong 22th Edition; page 158)

iv. ***Phototransduction mechanism*** : *In the dark*, the retinene$_1$ in rhodopsin is in the *11-cis configuration*. The only action of light is to change the shape of the retinene, converting it to the *all-trans isomer*. This in turn alters the configuration of the opsin, and the opsin change activates the associated heterotrimeric G protein, which in this case is called ***transducin*** or G_{t1}. The G protein exchanges GDP for GTP, and the α subunit separates. This subunit remains active until its intrinsic *GTPase* activity hydrolyzes the GTP. Termination of the activity of transducin is also accelerated by its binding of β-arrestin.

The α subunit activates cGMP phosphodiesterase, which converts cGMP to 5'-GMP. cGMP normally acts directly on Na^+ channels to maintain them in the open position, so the decline in the cytoplasmic cGMP concentration causes some Na^+ channels to close. This produces the hyperpolarizing potential. The hyperpolarization reduces the release of synaptic transmitter, and this generates a signal that ultimately leads to action potentials in ganglion cells. The action potentials are transmitted to the brain.

(Ref. Ganong 22th Edition; page 158)

Sequence of events involved in phototransduction in rods and cones :

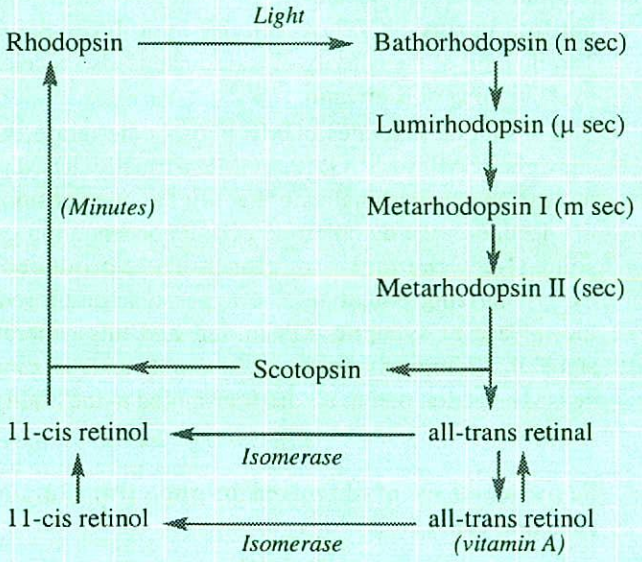
Incident light
↓

Structural change in the retinene$_1$ of photopigment
↓
Conformational change of photopigmen
↓
Activation of transducin
↓
Activation of phosphodi- esterase
↓
Decreased intracellular cGMP
↓
Closure of Na^+ channels
↓
Hyperpolarization
↓
Decreased release of synaptic transmitter
↓
Response in bipolar cells and other neural elements.

(Ref. Ganong 21th Edition; page 159)

v. ***Cyclic resynthesis of rhodopsin*** : After retinene$_1$ is converted to the *all-trans configuration*, it separates from the opsin (bleaching). Some of the rhodopsin is regenerated directly, while some of the retinene$_1$ is reduced by the enzyme alcohol dehydrogenase in the presence of NADH to *vitamin A$_1$*, and this in turn reacts with scotopsin to form ***rhodopsin***. All of these reactions except the formation of the all-trans isomer of *retinene$_1$* are independent of the light intensity, proceeding equally well in light or darkness. The amount of rhodopsin in the receptors therefore varies inversely with the incident light level.

(Ref. Ganong 22th Edition; page158)



(Ref. Guyton & Hall 11th edition; page 629)

Decomposition of rhodopsin

When light energy is absorbed by rodopsin it decomposed to form prelumirodopsin. The prelumirodopsin converts to form lumirodopsin. This then decay to metarodopsin-I, metarodopsin-II and finally split to form all-transretinal and scotopsin.

Reformation of rodopsin : All-transretinal first reconvert to form 11-cis retinal catalyzed by retinal isomerase. This 11-cisretinal then combine with scotopsin to form rodopsin.

Dark adaptation

If a person spends a considerable length of time in brightly lighted surroundings and then moves to a dimly lighted environment, the retinas slowly become more sensitive to light as the individual becomes accustomed to the dark.

This decline in *visual threshold* is known as *dark adaptation*. It is nearly maximal in about 20 minutes, although there is some further decline over longer periods.

There are actually two components to the dark adaptation response :

a. The first drop in visual threshold, rapid but small in magnitude, is known to be due to dark adaptation of the cones.
b. In the peripheral portions of the retina, a further drop occurs as a result of adaptation of the rods.

The total change in threshold between the light-adapted and the fully dark-adapted eyes is very great.

The *time required for dark adaptation* is determined in part by the time required to build up the rhodopsin stores. In bright light, much of the pigment is continuously being broken down, and some time is required in dim light for accumulation of the amounts necessary for optimal rod function.

(Ref. Ganong 22th Edition; page166)

Light adaptation

On the other hand, when one passes suddenly from a dim to a brightly lighted environment, the light seems intensely and even uncomfortably bright until the eyes adapt to the increased illumination and the visual threshold rises.

This adaptation occurs over a period of about 5 minutes and is called *light adaptation*, although, strictly speaking, *it is merely the disappearance of dark adaptation.*

(Ref. Ganong 22th Edition; page166)

Deficiency sings of vitamin A

(Consequences of vitamin A deficiency) : In a word vitamin A deficiency produce *infection.*

1. ***Eye changes :*** Deficiency causes disintrigation of epithelium of cornea and lacrimal gland causes--
   a. Night blindness (nyctalopia) : This is the earliest change and is due to les formation of rhodopsin.

b. Xeropthalmia : Cojunctival kertinization.
c. Keratomalacia : Corneal softening and ulceration.
d. Bitot's sports : Triangular, shiny, gray (white plaques) spots on the conjunctiva.
e. Corneal scarring and blindness.

2. *Squamous metaplasia* : Squamous metaplasia of columnar mucus-secreting surfaces and transitional epithelium.
   Common sites are : Cornea, conjunctiva, upper respiratory tract, urinary tract, salivary gland, pancrease, sebaceous gland and sweat gland.
3. *Impaired immunity and increased susceptivity* to infections in childhood.

Reflexes of eye

Reflexes of eye are :

i. Light reflex
ii. Accomodation reaction
iii. Visual reflex.
iv. Conjuctival reflex
v. Lid closure reflex.

Direct & consentual light reflexes

If a light is shone (fall) into one eye, the pupils of both eyes normally constrict. The constriction of the pupil upon which the light is shone is called the *direct light reflex*; the constriction of the opposite pupil even though no light fell upon that eye is called the *consensnal light reflex.*

The afferent impulses travel through the optic nerve, optic chiasma, and optic tract. Here a small number of fibers leave the optic tract and synapse on nerve cells in the ***pretectal nucleus***, which lies close to the *superior colliculus*. The impulses are passed by axons of the pretectal nerve cells to the parasympathetic nuclei *(Edinger-Westphal nuclei)* of the third cranial nerve on *both sides*.

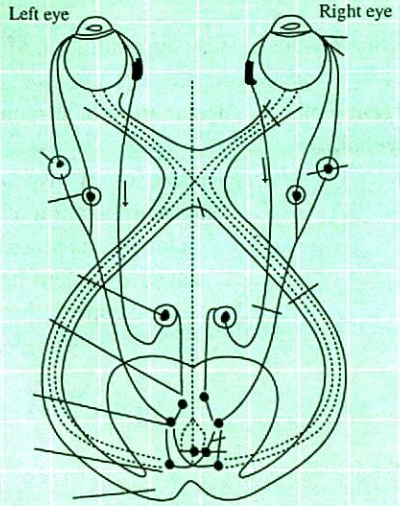


Fig. 17-7. Pathway of light reflex.

Here the fibers synapse and the parasympathetic nerves travel through the third cranial nerve to the cilliary ganglion in the orbit. Finally, postganglionic parasympathetic fibers pass through the short clliary nerves to the eyeball and the constrictor pupillae muscle of the iris.

Both pupils constrict in the consensual light reflex because the pretectal nucleus sends fibers to the parasympathetic nuclei on both sides of the midbrain. The fibers that cross the median plane do so close to the cerebral aqueduct in the posterior commissure.

(Clinical neuroanatomy 5th edition- R S. Snell; page 336)

Schematic representation of light reflex :

Fall of light on cornea
↓
Received by Rods and cones
↓
Optic nerve
↓
Optic tract
↓
Pretectal nucleus
↓
Edinger-westphal nucleus of both sides
↓
Occulomotor nerve
↓
Cilliary ganglion
↓
Short cilliary nerve
↓
Sphincter pupillae
↓
Constriction of the pupil.

Accomodation reaction

When the eyes are directed from a distant to a near object, contraction of the medial recti brings about convergence of the ocular axes; the lens thicken to increase its refractive power by contraction of the ciliary muscle; and the pupils constrict to restrict the light waves to the thickest central part of the lens.

The afferent impulses travel through the optic nerve, the optic chiasma, the optic tract, the lateral geniculate body, and the optic radiation to the *visual cortex*. The visual cortex is connected to the eye field of the ***frontal cortex***. From here-

i. Cortical fibers descend through the *internal capsule* to the *oculomotor nuclei* in the midbrain. The oculomotor nerve travels, to the medial recti muscles.

ii. Some of the descending cortical fibers synapse with the parasympathetic nuclei *(Edinger-Westphal nuclei)* of the third cranial nerve on *both sides*. Here the fibers synapse

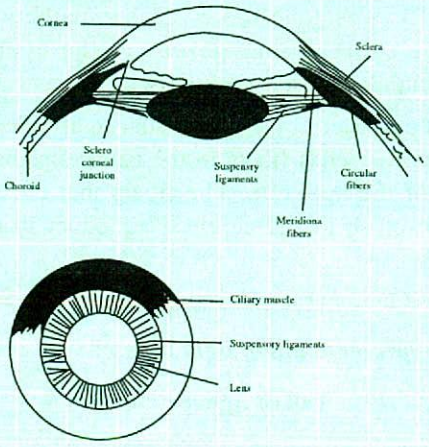


Fig. 17 - 8. *Mechenism of accomodation reaction.*

and the parasympathetic nerves travel through the occulomotor nerve to the ciliary ganglion in the orbit. Finally, postganglionic parasympathetic fibers pass through the short ciliary nerves to the *ciliary muscle* of the ciliary body and the *constrictor pupillae muscle* of the iris.

(Lens of eye lies within lens capsule. The capsule is suspended by suspensory ligament of which the other end is attached to the cilliary body. So, When cilliary muscle contract, the suspensory ligament relaxes. The relaxation of suspensory ligament causes relaxation of lens capsule. Due to this relaxtion of lens capsule the lens become more convex specially the anterior surface.)

(Clinical neuroanatomy 5th editison- R S. Snell; page 336)

In this reaction following changes occur :

1. Convergence of eye ball..
2. Modification of the shape of the lens i.e increase anterior-posterior diameter of the len; specially anterior surface (due to contraction of cilliary muscle → relaxation of suspensory ligament)

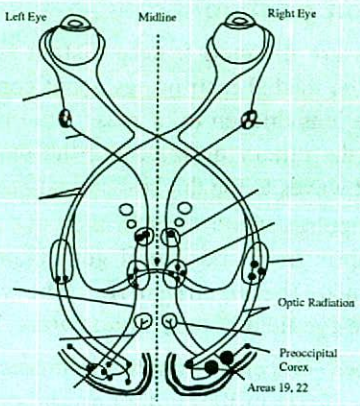


Fig. 17-9. *Pathway for the accomodation reaction.*

3. Constriction of pupil.

Structures involved in accomodation :

i. Cilliary muscle
ii. Suspensory ligament.
iii. Lens capsule
iv. Lens.
v. Iris.

Schematic representation of accomodation reaction

Light falling on cornea
↓
Rods and cones
↓
Optic nerve
↓
Optic tract
↓
Lateral geniculate body
↓
Optic radiation
↓
Visul cortex
↓
Superior longitudinal fasciculus
↓
Frontal eye field (frontal cortex)
↓
Through the internal capsule to the

↓	↓
Occulomotor nucleus	*Endinger westphal nucleus*
↓	↓
Occulomotor nerve	Ciliary ganglion
↓	↓
Contraction of the	Short ciliary nerve
↓	↓
medial rectus muscle	Causes contration of ciliary muscle
↓	↓
Convergence of the eyeball.	Relaxation of suspensory ligament
	↓
	Relaxation of suspensory ligament causes relaxation of lens capsule. Due to this relaxtion of lens capsule the lens become more convex specially the anterior surface.
	↓
	Helps to see the near objects.

Visual reflex

Sudden turning of the head, neck and upper part of the trunk towards a sudden flash of light is called visual reflex.

Pathway of visual reflex : Light falling on the cornea after traversing the refractive media of the eye ball stimulates the rods and cones of the retina → Optic nerve → Optic tract → Brachium of the superior colliculus →

i. Tectobulber tract → accessory nerve, supplying the muscles of the neek and head.
ii. Tectospinal tract → Anterior horn cells of the spinal cord, which supplies the muscles of the back concerned.

Visual pathway

Light falling on the cornea after traversing the refractive media

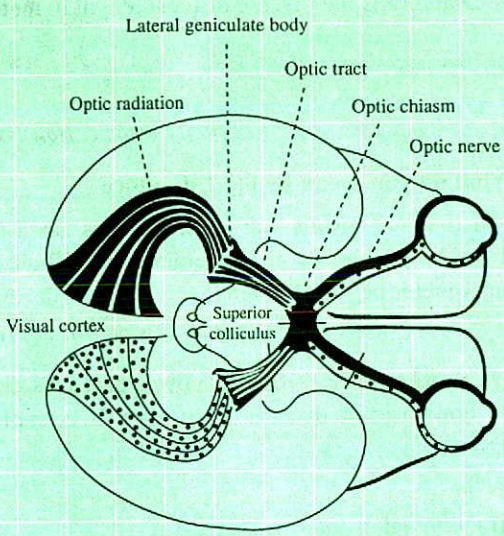


Fig. 17 - 10. *The visual Pathway.*

of the eye ball, stimulates the Rods and cones → Optic nerve → Optic tract → Lateral geniculate body → Optic radiation → visual cortex.

Effect of injury/lesion at different levels of visual pathway :

Site of injury	*Effect*
i. Optic nerve	Blindness of the affected eye.
ii. Crossed fibre	Bitemporal hemianopia.
iii. Uncrossed fibre	Binasal hemianopia.
iv. Optic tract	Homonymous hemianopia.

Corneal reflex

Light touching of the cornea or conjunctiva results in blinking of the eyelids. Afferent impulses from the cornea or conjunctiva travel through the ophthalmic division of the *trigeminal nerve* to the sensory nucleus of the trigeminal nerve. *Internuncial neurons* connect with the motor nucleus of the facial nerve on both sides through the *medial longitudinal fasciculus*. The *facial nerve* and its branches supply the *orbicularis oculi muscle*, which causes ***closure of the eyelids***.

(Clinical neuroanatomy 5th edition- R S. Snell; page 337)

Visual body reflexes

The automatic *scanning movements* of the eyes and head made when reading. The automatic movement of the eyes, head, and neck toward the source of the visual stimulus and the protective closing of the eyes and even the raising of the arm for protection are reflex actions that involve the following reflex arcs. The visual impulses follow the optic nerves, optic chiasma. and optic tracts to the *superior colliculi*. Here the impulses are relayed to the *tectospinal* and *tectobulbar* (tectonuclear) tracts and to the neurons of the *anterior gray* columns of the *spinal cord* and *cranial motor nuclei.*

(Clinical neuroanatomy 5th edition- R S. Snell; page 337)

Pupillary skin reflex

The pupil will dilate if the skin is painfully stimulated by pinching. The afferent sensory fibers are believed to have connections with the efferent preganglionic sympathetic neurons in the lateral gray columns of the first and second thoracic segments of the spinal cord. The *white rami communicantes* of these segments pass to the sympathetic trunk and the preganglionic fibers ascend to the superior *cervical sympathetic ganglion*. The postganglionic fibers pass through the *internal carotid plexus* and the long clilary nerves to the dilator pupillae muscle of the iris.

(Clinical neuroanatomy 5th edition- R S. Snell; page 338)

Argyll Robertson pupil

Definition : It is a condition in which light reflex is lost but accomodation is retained.

Cause :

1. Syphilitic degeneration of CNS.
2. Lesion close to the occulomotor nucleus so that pretectal fibre are affected.
3. Lesion of fibres from pretectal nucleus to Edinger westphal nucleus.

Binocular vision

Definition : The process of seeing one object by two eye is called binocular vision.

Visual sensation that is produced when the images fall on the symetrical points or corresponding points of each retina is called binocular vision. The central parts of the visual fields of the Iwo eyes coincide; therefore, anything in this portion of the field is viewed with binocular vision.

Coresponding points : The points on the retina on which the image of an object must fall if it is to be seen binocularly as a single object.

Condition for binocular vision :

1. Two visual field must overlape.
2. Similar image must form on two retina at similar points.

3. The coordinated movement of extra ocular muscles.

Advantage of binocular vision :

1. It provides accurate perception of depth, size and distance.
2. Optical defects of one eye is corrected by another.
3. The combined field of vision is wider than that of single eye.

Diplopia or Double vision

i. *Definition* : Seeing of an object as two is called double vision.

ii. *Cause* :

a. Derangements of extraocular muscles
b. Neurological disorders
c. Refractive error i.e. astigmatism
d. Incorrect spectacles
e. Media opacity i.e. cataract
f. Macular disease.

Focal point : Parallel light rays passing through the lens will bent and pass through a single point is called focal point.

Nodal point : Center of lens is called nodal point. The optical centre lies in the posterior part of the lens.

Optic axis : The line passing through the centre of curvature of cornea and the two surfaces of the lens, meets the retina at fovea centralis.

Anterior focal distance : It is about 15 mm in front of the cornea.

Posterior focal distance : It is about 24 mm in front of the cornea.

Principal axis : The light which pass through the nodal point without deviation is called principal axis.

Refraction : The bending of light rays at an angulated interface while passing from one media to another madia of different density, is called refraction.

(Ref. Guyton & Hall 11th edition)

Refractive index : The refractive index is a relative measure of transmission of light through a refracting surface in relation to the speed of light in the air.

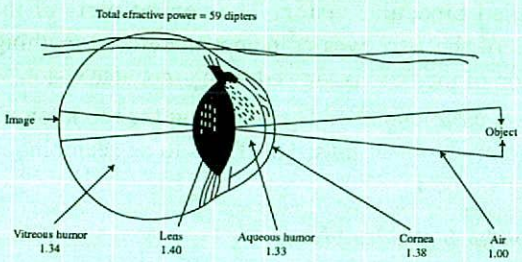


Fig. 17-3. *Refractive media with refractive index.*

Calculation : It is calculated as the velocity of light in air/ velocity of light in the medium concerned.

Example : Light passes through the lens of eye 214285 km/second

Light passes through the air 3,00000 km/second.

$$\text{So, Refractive index of lens} = \frac{300000}{214285}$$

$$= 1.4$$

(Refractive index of air is : 1.00*).*

Diaptores : Refracvtive power of lens is measured in terms of diaptores. Diaptore is the inverse of focal length in meter.

$$D \propto \frac{1}{f} \text{ m}$$

(Ref. Guyton & Hall 11th edition)

Q. 00. **What do you mean by (+) 1 diaptore***?*

Ans. (+) 1 diaptore means that a convex lens has a refractive power of (+) 1 diaptore and it converges parallel light rays to a focal point 1 meter beyond the lens.

(Ref. Guyton & Hall 11th edition)

Refractive power : The refractive power of a lens denotes its power to converge or diverge light rays. It is expressed as diapter (D).

It depends on -

a. Its refractive index and
b. Its radius of curvature.

Deffraction : Light rays passing along the edges of lens are bent. This bending of light are called deffraction. When light rays are allowed to pass through a small aperture, deffrafction takes place. As a result of deffraction, a point object will form dark and light rings which can be seen if is focussed on a screen.

Colour vision

Cones are responsible for color vision. Human are *trichromats* i.e. they have three cone pigments.

a. *Cone pigments are* :
   i. Short wave pigment : senses blue
   ii. Medium wave pigment : senses green
   iii. Long wave pigment : senses yellow and red.

b. *Cone systems in human retina* : Three cone systems in human retina give rise to three pigments :
   i. Blue sensitive or short wave pigment i.e *cyanolabe*
   ii. Green sensitive or medium wave pigment i.e *chlorolabe*
   iii. Red sensitive or long wave pigment i.e *erythrolabe.*

The sensation of any given color being determined by

relative frequencies of the impulses from each of these systems.

c. *Characteristics of color*
   i. Colors have three attributes : hue, intensity, and saturation i.e. degree of freedom from dilution with white.
   ii. For any colour there is a complementary colour that, when properly mixed with it, produces a sensation of white.
   iii. Black is the sensation produced by the absence of light, but it is probably a positive sensation, because the blind eye does *see black*, it sees nothing.

d. *Primary colors* : Primary colors are-
   i. Red
   ii. Green
   iii. Blue.
      * The sensation of white, any spectral color, and even the extraspectral color, purple, can be produced by mixing various proportions of red light, green light and blue light.
      * Red and blue are called the primary colors.

Young-Helmholtz theory

The sensation of color will depend on the extent to which each type of cones is excited to different color. This is called Young-Helmholtz theory.

e. *Mechanism of color vision* : Color is mediated by ganglionic cells that subtract or add input from one type of cone to input from another type. Processing in the ganglionic cells and lateral geniculate nucleus produces impulses that pass to the visual cortex. However, it is not known how visual cortex converts color input into the sensation at color.

   The sensation of any given color being determined by the relative frequencies of the impulses from each of three cone systems :
   a. *S pigment* i.e blue sensitive or short-wave pigment : Absorbs light maximally in the blue-violet portion of the spectrum.
   b. *M pigment* i.e green sensitive or medium-wave pigment : Absorbs light maximally in the green portion of the spectrum
   c. *L pigment* i.e red sensitive or long-wave pigment : absorbs light maximally in the yellow portion of the spectrum and also sensitive enough in the red portion.

Colour blindness

The suffix- *anomaly* denotes colour weakness and the suffix *anopia*- color blindness.

The prefix *prot*-, *deuter*-, and *tri*- refer to defects of the red, green, and blue cone systems respectively.

i. *Colour weakness are* :
   a. *Trichromats* : Individuals with normal color vision and all three cone system, but one may be weak.
   b. *Dichromats* : Individuals with two cone systems. They may have protanopia, deuteranopia, or tritanopia.
   c. *Monochromats* : Individuals with only one cone system.

ii. Types of colour blindness :
   a. *Protanopia* : Lack of red color sensation
   b. *Deuteranopia* : Lack of green color sensation
   c. *Tritanopia* : Lack of blue color sensation

iii. Causes of color blindness include:
   a. Inherited
   b. Lesion in visual cortex i.e area V8
   c. Drugs : Sildenafil (Viagra) causes transient blue-green color weakness because this drug inhibits the phosphodiesterase of retina.

iv. *Inheritance of colour blindness* : Color blindness is a sex linked (i.e. X-linked recessive) disorder resulting from the absence of the appropriate color genes on the X chromosome or X chromosomes contain abnormal gene.
   a. Male have only one X chromosome, but female have two X chromosomes. Therefore colour blindness mostly occurs in male.
   b. Female only shows when both X chromosomes are defective.
   c. Female child of a man with X-linked color blindness are carriers of colour blindness and pass to defects on to half of their sons.
   d. X-linked color blindness skips generations and appears in males of every second generation.

Types of eye

i. ***Emmetropia*** : It is the normal optical condition. The eye is considered to be emmetropic when incident parallel rays of light from infinity come to a focus on the retina *(fovea centralis)* with accommodation at rest.
   a. There is no error of refraction. An emmetropic eye will have a clear image of a distant object without any internal adjustment of its optics.
   b. The average power of a normal emmetropic eye is +58 to +60 D (diaptor).
   c. Most emmetropic eyes are approximately 24 mm in length.

Defect of vision

It is usually of two types :
i. Refractive errors
ii. Normal aberrations.

Refractive errors : There are 4 refractive errors

1. Myopia or short sightness
2. Hypermeteropia
3. Astigmatism
4. Presbiopia.

Normal aberration :

a. *Spherical aberration* : The peripheral rays in a convex lens are focussed at a nearer point than the central rays. So, that the margins of immage become blurred. This is called spherical aberration.

Correction : In normal eye it is corrected in two ways-

i. The iris shuts off the peripheral rays.

ii. The refractive power of the central part of lens is higher than peripheral.

b. *Chronic aberration* : Due to different wave lengths, light of different colour undergo different degree of refraction. (Red light refracted least; violet light refracted most). Hence the margin of the image may show rain bow colour. This is called chronic aberration.

Correction : It is normally rectified in two ways -

i. The difference of refractive power of the various refractive media of eye ball partly correct it.

ii. The colour fringes are ignored by the brain.

Errors of refraction *(ametropia)*

The optical condition of the eye in which the incident parallel rays of light do not come to a focus upon the light sensitive layer of the retina, with accommodation at rest is known as *ametropia*.

Etiology :

i. Axial ametropia : There is abnormal length of the eyeball.
   a. Too long : In myopia
   b. Too short : In hypermetropia

ii. Curvature ametropia There is abnormal curvature of the refracting surfaces of the cornea or lens.
   a. Too strong : In Myopia
   b. Too weak : In hypermetropia

iii. Index ametropia : There is abnormal refractive index of the media.
   a. Too high : In myopia
   b. Too low : In hypermetropia.

iv. Abnormal position of the lens :
   a. Forward displacement : In myopia
   b. Backwanl displacement : In hypermetropia.

Myopia (short sight)

It is that dioptric condition of the eye in which with the accommodation at rest, incident parallel rays of light come to a focus anterior to the light sensitive layer of retina.

Etiology :

a. It is basically a disturbance of growth on which degenerative changes are superimposed.

b. The part anterior to the equator is normal.

c. The increase in axial length affects the posterior pole and the surrounding area.
   i. *Axial* : Increased anteroposterior diameter of the globe is the most common cause.
   ii. *Curvature* : Increased curvature is seen in following conditions :
      Corneal : Conical cornea. ectasia
      Lens : Lenticonus.
   iii. *Index* : Increased refractive index of the nucleus as in senile nuclear cataract.
   iv. *Forward displacement of the lens*, e.g as in anterior dislocation of the lens.

Tpes of myopia :

i. Congenital (developmental myopia)
ii. Simple myopia
iii. Pathological

Signs of myopia :

i. Prominent eyes, large pupil and deep anterior chamber are commonly seen.
ii. Apparant divergent squint may be present

Complications of myopia :

i. Vitreous degeneration (liquefaction), opacities and detachment are commonly seen.
ii. Tear and haemorrhages occur in the retina due to chorioretinal degeneration.
iii. Retinal detachment (simple) is always due to break in the retina through which fluid seeps in, raising the retina from its bed.
iv. Complicated cataract (posterior cortical) is due to the disturbance to the nutrition of the lens.
v. High myopia is sometimes associated with chronic simple glaucoma.

Treatment :

i. Spectacles : By spherical concave lens.
ii. Hygiene of eyes : Proper position, good illumination and

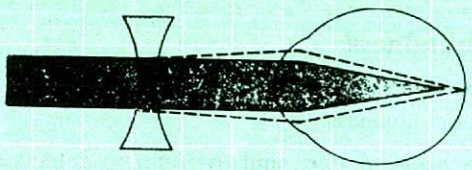


Fig. 17-4. *Corrction of Myopia.*

correct distance from the book (about 25 cm) while reading is essential.

iii. Operative :
   a. Radial keratotomy
   b. Excimer laser
   c. Epikeratophakia
   d. Keratomileusis
   e. LASIK (Laser-assisted in situ keratomileusis) : It corrects myopia of -8 to -16.

Hypermetropia (Far sight)

It is that dioptric condition of the eye in which with the accommodation at rest the incident parallel rays of light come to a focus posterior to the light sensitive layer of the retina.

Incidence : Newborns are invariably hypermetropic (average 2.5 D). The incidence decreases rapidly with age remaining at about 50% after 20 years.

Etiology :

i. Axial : There is short length of the eyehall.
ii. Curvature : There is flat carvature of the cornea.
iii. Index : There is increase in refractive index of the cortex, e.g. as in diabetic and senile cortical cataracts.
iv. Backward displacement of the lens as in posterior dislocation of the lens.
v. Absence of lens or aphakia

Types of hypermetropia :

i. *Latent hypermetropia* : It is overcome by the normal tone of the ciliary muscle. It is detected only when the ciliary muscle is paralysed by atropine.
ii. *Manifest hypermetropia* : It is detected without paralysing the ciliary muscle.
   a. *Facultative* : It can be overcome by an effort of accommodation.
   b. *Absolute* : It cannot be overcome by an effort of accommodation.

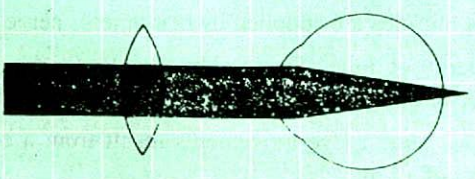


Fig. 17-5. *Correction of hypermetropia.*

Treatment : It is treated by prescribing suitable correcting spherical convex lenses.

Astigmatism

It is that condition of refraction in which a point of light cannot be made to produce a punctatc image upon the retina by any spherical correcting lens (astigmatism = a point).

Etiology :

i. There is unequal curvature of the cornea in difierent meridian.
ii. There is decentring of the lens, e.g. as in subluxation of lens.

Types :

i. Regular
   a. Simple
   b. Compound
   c. Mixed
ii. Irregular.

Treatment :

i. If there are no symptoms, no treatment is required in low degree of astigmatism
ii. When there are symptoms, suitable cylindrical lenses are prescribed for constant use.

Presbiopia

Fall of immage behind the retina due to defect or failure in accmodation. In this condition the person fell difficulty for viewing near vision due to failure in accommodation.

Correction : By using convex lens.

Visual acuity

Visual acuity is the degree to which the details and contours of objects are perceived. Although there is evidence that other measures are more accurate, visual acuity is usually defined in terms of the minimum separable- ie, *the shortest distance by which two lines can be separated and still be perceived as two lines.*

Clinically, visual acuity is often determined by the use of the familiar Snellen letter charts viewed at a distance of 20 ft (6 m). The individual being tested reads aloud the smallest line distinguishable.

The results are expressed as a fraction :

i. Numerator : The numerator of the fraction is 20, the distance at which the subject reads the chart.
ii. Denominator : The denominator is the greatest distance from the chart at which a normal individual can read the smallest line the subject can read.

Normal visual acuity is 20/20; a subject with 20/15 visual acuity has better than normal vision (not farsightedness); and one with 20/100 visual acuity has subnormal vision.

The *Snellen charts* are designed so that the height of the letters in the smallest line a normal individual can read at 20 ft subtends a visual angle of 5 minutes. Each of the lines in the letters are separated by 1 minute of arc. Thus, the minimum separable in a normal individual corresponds to a visual angle of about 1 minute.

Factors affecting visual acuity :

i. Image-forming mechanisms of the eye
ii. Retinal factors such as the state of the cones
iii. Stimulus factors including-
   a. Illumination
   b. Brightness of the stimulus
   c. Contrast between the stimulus and the background
   d. Length of time the subject is exposed to the stimulus.

(Ref. Ganong 22th Edition; page167)

N. B.

a. Normal VA : 6/6
b. Subnormal VA : 6/9
c. Visual acuity 6/12 means, that a person sees at 6 m what the normal eye could see at 12 m.
d. Visual acuity needed for driving: 6/9 - 6/12
e. Visual acuity < 1/60 is legal blindness.
f. Visual acuity 3/60 indicates that the individual can not see the line at 3 meters which a normally sighted person could read at 60 meters.

Importance of visual acuity : It helps in determining shape, form outline and minute details of sunoundings.

Visual fields

The visual field of each eye is the portion of the external world visible out of that eye. The normal field extends 160° horizontally and 130° vertically with a blind spot 15° from fixation in the temporal field.

Lens causes the image on the retina to be inverted. Thus an object in the lower part of the visual field is projected to the upper retina and an object in the temporal half of the visual field is projected to the nasal half of the retina.

a. *Visual field in each eye is named as* :
   i. Nasal field of vision i.e superior and inferior quadrant of nasal side.
   ii. Temporal field of vision i.e superior and inferior quadrant of temporal side.
b. *Decussation fibers* :
   i. The fibers from the nasal half of each retina decussate in the optic chiasma.
   ii. The optic tract conntains fibres from the temporal half of one retina and nasal half of the other i.e optic tract subserves half of the field of vision.

Visual field defects

Visual field defects are termed as :

i. *Homonymous hemianopia* : Same side of the both visual field defects (half blindness).
   Example : In right half of visual field defect nasal field of left eye is affected, and temporal feld of right eye is affected.
ii. *Heteronymous hemianopia* : Opposite side of the both visual field defects (half blindness).

Perimetry

Visual fields are mapped with an instrument called perimeter and the process is referred to as peirmetry.

Eye movement

Since much of the visual field is binocular, it is clear that a very order of coordination of the movements of the two eyes is necessary if visual images are to fall at all times on corresponding points in the retinas and diplopia is to be avoided.

i. Types : There are four types of eye movements :
   a. *Saccades* : Sudden jerky movements, occurs as the gaze shifts from one object to another.
   b. *Smooth pursuit movements* : Tracking movements of the eyes as they follow moving objects.
   c. *Vestibular movements* : Adjustments that occur in response to stimuli initiated in the semicircular canals, maintains visual fixation as the head moves.
   d. *Convergence movements* : Movements that bring the visual axes towards each other as attention is focused on objects near the observer.

   Saccadic movements seek out visual targets; pursuit movements follow them as they move about; and vestibular movements stabilize the tracking device i.e the head.

ii. *Muscles involved* : Six muscles (extraocular muscles) control eye movements :
   a. Superior rectus
   b. Inferior rectus
   c. Medial rectus
   d. Lateral rectus

   These 4 muscles are supplied by oculomotor nerve (3rd)

   e. Superior oblique : Supplied by trochlear nerve (SO4)
   f. Inferior oblique : Supplied by abducens nerve (LR6).

ii. *Eye movements* : Eye movements result from a continuous interplay of all muscles.
   a. Superior rectus : Rotates the eyeball upwards
   b. Inferior rectus : Rotates the eyeball downward
   c. Medial rectus : Rotates the eyeball inward
   d. Lateral rectus : Rotates the eyeball outward

   These 4 muscles are supplied by oculomotor nerve (3rd)

e. Superior oblique : Rotates the eyeball so that cornea turns in a downward and outward directions.
f. Inferior oblique : Rotates the eyeball so that the cornea turns upwards and outward.

Q. 00. **What is the effect of sympathetic and parasympathetic stimulation on pupil?**

i. Sympathetic : Dilatation of pupil *(mydriasis)* due to contraction of radial muscle of iris.
ii. Parasympathetic : Constriction of pupil *(miosis)* due to contraction of circular muscte of iris.

Q. 00. **What is the function of conjunctiva?**

Ans. Protection and lubrication of eye.

Q. 00. **How aqueous humour is formed?**

Ans. The cilliary body produces aqueous humour by diffusion and active transport process.

Q. 00. **What is intraocular pressure?**

Ans. Intraocular pressure :

i. *Definition* : Intraocular pressure is the pressure inside the eyeball.
ii. *Normal values* : It is about 16 mmHg in normal eye (range : 12 - 20 mmHG).
iii. Importance : lOP is increased in glaucoma.

Strabismus /Squint

When the axes of the eyes are not equal the visual images no longer fall on corresponiing points, and strabismus (squint) is said to be present.

Applied

Q. 00. **Write short notes on- Miosis.**

Ans. Miosis :

I. *Definition* : The pupil is small and constricted due to the action of sphincter pupillae muscle.
II. *Etiology* :
   a. Physiological : Babies, old age, blue eyes.
   b. Pharmacological :
      i. Local : Miotic i.e. pilocarpine
      ii. Systemic : Morphin.
   c. Pathological :
      i. Unilateral : Acute iritis i.e. Healed iritis, Horner's syndrome.
      ii. Bilateral : Pontine haemorrhage, Argyll-Robertson pupil.

Q. 00. **Write short notes on- Mydriasis.**

I. *Definition* : The pupil is dilated due to the action of dilator pupillae muscle.
II. *Etiology* :
   a. *Physiological* : Myopia, nervous excitement.
   b. *Pharmacological* : Mydriatics i.e. atropine, phenylephrine, cyclopentolate, tropicamide,.
   c. *Pathological* :
      i. *Retina and optic nerve diseases* : Optic nerve atrophy, absolute glucoma, acute congestive glucoma,
      ii. *Central lesion* (above lateral geniculate body) : Meningitis, haemorrhage, uraemia.
      iii. *Oculomotor nerve paralysis* : Trauma, syphilis, diphtheria, meningitis.
      iv. *Irritation of cervical sympathetics* : Apical pneumonia, pleurisy, cervical rib.

Q. 00. **Write short notes on- Aphakic eye.**

Ans. Aphakic eye :

i. *Definition* : Aphakia is a condition of the eye where lens has been been removed i.e. absence of lens. It is a classical example of acquired high hypermetropia.
ii. *Optical condition* :
   a. The eye is hypermetropic
   b. There is loss of accommodation
   c. The retinal image is about 25% larger.
   d. Astigmatism (against the rule) : The surgical scar at the corneoscleral junction in the upper part ot the cornea flattens the vertical meridian of the cornea.
iii. *Symptom* : There is gross dimness of vision because of acquired high hypermetropia.
iv. *Signs* :
   a. A linear semicircular corneo-scleral scar mark is seen in the upper half of cornea.
   b. The iris shows peripheral buttonhole iridectomy at or near 12 O'clock position.
   c. The anterior chamber is deep due to lack of support of the iris by the lens.
   d. There is often iridodonesis or tremulousness of the iris due to lack of support.
   e. The pupil is jet black.
v. *Correction* :
   a. By spectacles : Spherical convex lens (+ 10 D approximately).
   b. Contact lens.
   c. Introcular lens implantation (IOL).

Taste

Taste is mainly a function of the taste buds in the mouth, but it is common experience that one's sense of smell also contributes strongly to taste perception.

Importance of taste : Taste allows a person to select food in accord with desire and perhaps also in accord with the needs of the tissues for specific nutritive subatances.

(Ref. Guyton & Hall 11th edition)

Primary taste sensation or basic taste modalities

On the basis of physiological studies, there are generally steaded to be four primary sensations of taste.

1. Sour taste : is caused by acid
2. Salty taste : is elicited by ionized salts.
3. Sweet taste : is caused by sugars, gly-cols, alcohols, aldehydes, Ketones, ami-des, esters, amino-acids, sulfuric acids, halogina-ted acids and inorganic salts of lead and beryllium.

   Saccrine - can be used as sweeting agent. It is more than 600 times as sweet as common table sugar, and since it is not toxic (except that it might be mildly carcinogenic).
4. *Bitter* taste : Two particular classes of substance are specially likely to cause bitter test sensation-
   a. Long chain organic susbstances containing nitrogen.
   b. Alkaloids : include many of the drugs used in medicines such as quinine, caf-feine, strychnine and nicotin.

(Ref. Guyton & Hall 11th edition)

Taste blindness

Many persons are taste blind for certain substances, especially for different types of thiourea compounds. A substance used frequently by psychologists for demonstrating taste blindness is phenyl thiocarbamide, for which approximately 15 to 30 percent of all people. exhibit taste blindness, the exact percentage depanding on the method of tasting and the concentration of the substance. *(Ref. Guyton & Hall 11th edition)*

Location of the taste bud

Taste buds for :

1. The *sweet* and *salty* taste : are located principally on the tip of the tongue.
2. The *sour* taste : on the two lateral sides of the tongue.
3. The *bitter* taste : on the circumvallate papillae on the posterior tongue.

(Ref. Guyton & Hall 11th edition)

Taste bud

i. *Definition* : Taste buds are the sense organ for taste.
ii. *Shape* : Ovoid
iii. *Diameter* : 50-70 μm
iv. *Length* : 1/16 millimeter
v. *Diameter* : 1/30 millimeter
v. *Total number* : About 10,000.
vi. *Situation* :
   a. In the wall of the fungiform and vallate papillae of the tongue.
   b. Mucosa of the epiglotis, palate, and pharynx.
vii. *Location* : Taste buds for the-
   a. *Sweet and salty* : on the tip of the tongue.
   b. *Sour* : on the two lateral sides of the tongue.
   c. *Bitter taste* : on the circumvallate papillae on the posterior tongue.
vii. *Innervation* : Each taste bud is innervated by about 50 nerve fibres and consequently each nerve fibre receives input from an average of five taste buds.
vi. *Composition* :
   i. About 40 modified epithelial cell, some of which are supporting cells called sustenti-cular cells and others are taste cells.
   ii. Inter woven among the taste cells is a branching terminal net work of several taste nerve fibres that are stimulated by the taste cells.
vii. *Replacement* : The taste cells are continualy being replaced by mitotic division from the surrounding epithelial cells so that some are young cells and others are mature cells that lie toward the centre of the bud and soon dissolute.
viii. *Pores* : The outer tips of the taste cells are arranged around a minute pore. From the tip of each cell, several micro villi or taste hairs, about 2 to 3 mic rons in length and 0·1 to 0·2 micron in width prorude outward into the taste pore to approach the cavity of the mouth.

   These microul are beleived to provide the receptor surface for taste.
ix. *Degereration* : An interesting features of the taste buds is that they completly degenerate when the taste nerve fibres are destroyed.

(Ref. Guyton & Hall 11th edition)

N. B. *Other information* : The taste cells are continualy being replaced by mitotic division from the surrounding epithelial cells so that some are young cells and others are mature cells that lie toward the centre of the bud and soon dissolute.

The outer tips of the taste cells are arranged around a minute pore. From the tip of each cell, several micro villi or taste hairs, about 2 to 3 microns in length and 0·1 to 0·2 micron in width prorude outward into the taste pore to approach the cavity of the mouth.

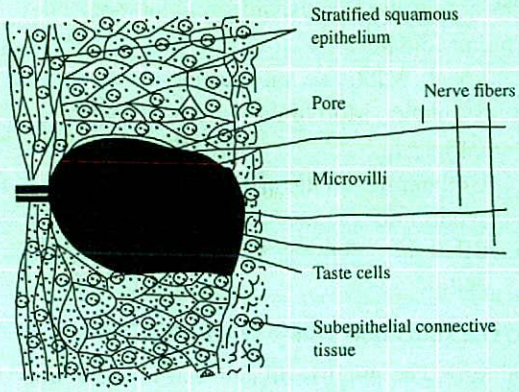


Fig. 17-12. *The taste bud*

These microul are beleived to provide the receptor surface for taste.
An interesting features of the ta ste buds is that they completly degenerate when the taste nerve fibres are destroyed.

(Ref. Guyton & Hall 11th edition and others)

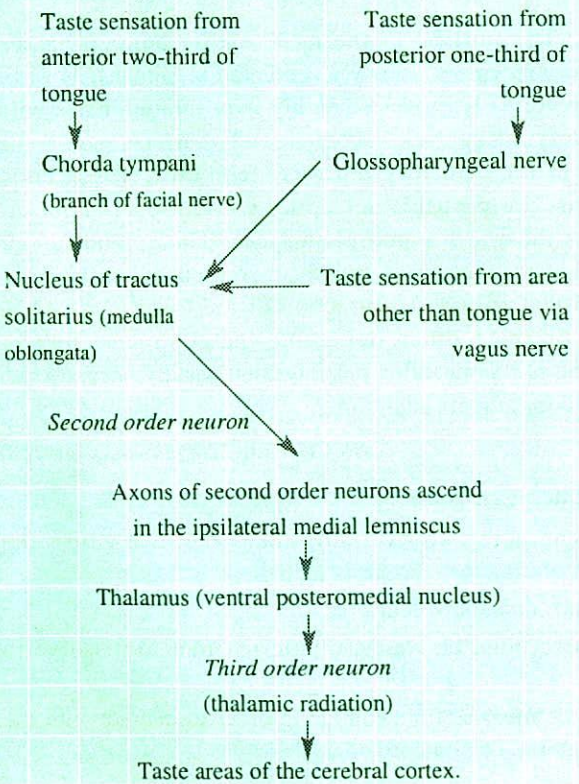
Transmission of taste signals *(in the central nervous system)* :

Taste impulses from the anterior two thirds of the tongue pass first into the fifth nerve and then through the chorda tympani into the facial nerve, thence into the tractus solitarius in the brain steam. Taste sensation from the circumvallate papillae on the back of the tongue and from the other posterior regions of the mouth are trans-mitted through the glossopharyn-geal nerve also into the tractus solitarius but at a slightly lower level. A few taste singnals are transmitted into the tractus solitarius from the base of the tongue and other parts of the pharyngeal region by way of the vagus nerve.

All taste fibres synapse in the nuclei of the tractus solitarius and send second order neurone to the thalamus. From the thalamus third order neurons are transmitted to the lower tip of the post central gyrus in the parietal cortex. Where it curls deep into the sylvian fissure. Third order neurons also project to the near by opercular- insular area.

Q. 00. Trace the pathway of taste sensation.

Ans. Pathway of taste sensation :



Q. 00. **Describe the pathway of taste sensation.**

Ans. Transmission of taste signals *(in the central nervous system)* :

i. *Taste impulses from the anterior two thirds of the tongue* : pass first into the fifth cranial nerve and then through the chorda tympani into the facial nerve, thence into the tractus solitarius in the brain steam.

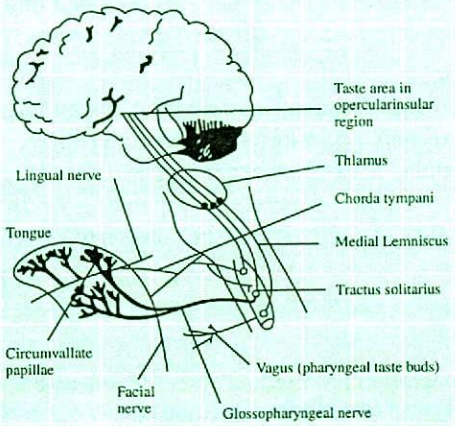


Fig. 17-13. *Transmission of taste signals in the the central nervous system.*

ii. *Taste sensation from the circumvallate papillae on the back of the tongue and from the other posterior regions of the mouth* : are transmitted through the glossopharyngeal nerve also into the tractus solitarius but at a slightly lower level.

iii. A few taste singnals are transmitted into the tractus solitarius from the *base of the tongue and other parts of the pharyngeal region* by way of the vagus nerve.

All taste fibres synapse in the nuclei of the tractus solitarius and send *second order neurone* to the thalamus. From the thalamus *third order neurons* are transmitted to the lower tip of the post central gyrus in the parietal cortex. Where it curls deep into the sylvian fissure. Third order neurons also project to the near by opercular-insular area.

(Ref. Guyton & Hall 11th edition)

Taste reflexes

From the tractus solitarius a large number of impulses are transmitted directly into the superior and inferior salvatory nuclei and these inturn transmit impulses to the submandibular, sublingual and parotid glands to help control the secretion of saliva during the ingestion of food.

(Ref. Guyton & Hall 11th edition)

Abnormalities of taste

i. *Ageusia* : Absence of the sense of taste

ii. *Hypogeusia* : Diminished taste sensitivity. Many different diseases can produce hypogeusia. In addition, drugs such as captopril and penicillamine, which contain sulfhydryl groups, cause temporary loss of taste sensation.

iii. Dysgeusia : Disturbed sense of taste.

(Ref. Ganong 22th Edition; page 188)

Applied

Q. 00. **What is taste blindness?**

Ans. *Taste blindness* : Many persons are taste blind for certain substances, especially for different types of thiourea compounds.

A substance used frequently by psychologists for demonstrating taste blindness is phenyl thiocarbamide, for which approximately 15 to 30 percent of all people exhibit taste blindness, the exact percentage depanding on the method of tasting and the concentration of the substance.

(Ref. Guyton & Hall 11th edition)

Smell

Smell is generally classified as visceral senses because of their close association with gastrointestinal function.

i. *Smell receptors* : are chemoreceptors that are stimulated by molecules in solution in mucus in the nose. The smell receptors are distance receptors (*teleceptors*), and the smell pathways have no relay in the thalamus.

Location : In a specialized portion of the nasal mucosa, the yellowish-pigmented olfactory mucous membrane it covers an area of 5 cm^2 in the roof of the nasal cavity near the septum.

ii. *Olfactory mucous membrane* : It contains supporting cells and *progenitor cells* for the olfactory receptors. Interspersed between these cells are 10-20 million receptor cells. Each olfactory receptor is a neuron, and the olfactory mucous membrane is said to be the place in the body where the nervous system is closest to the external world.

The olfactory mucous membrane is constantly covered by mucus. This mucus is produced by Bowman's glands, which are just under the basal lamina of the membrane.

iii. *Olfactory neurons* : Each neuron has a short, thick dendrite with an expanded end called an *olfactory rod*. From these rods, cilia project to the surface of the mucus. The cilia are unmyelinated processes about 2 μg long and 0.1 μm in diameter. There are 10-20 cilia per receptor neuron.

Axons : The axons of the olfactory receptor neurons pierce the cribriform plate of the ethmoid bone and enter the olfactory bulbs.

The olfactory neurons, like the taste receptor cells but unlike most other neurons, are *constantly being replaced* with a half-time of a few weeks. The olfactory renewal process is carefully regulated, and there is evidence that in this situation, a bone morphogenic protein (BMP) exerts an inhibitory effect.

iv. *Olfactory bulbs* : In the olfactory bulbs, the axons of the receptors contact the primary dendrites of the *mitral cells* and *tufted cells* to form the complex globular synapses called *olfactory glomeruli.*

Olfactory bulbs contain *periglomerular cells*, which are inhibitory neurons connecting one glomerulus to another, and *granule cells*, which have no axons and make reciprocal synapses with the lateral dendrites of the mitral and tufted cells. At these synapses, the mitral or tufted cell excites the granule cell by releasing glutamate, and the granule cell side of the synapse in turn inhibits the mitral or tufted cell by releasing GABA.

v. *Olfactory cortex* : The axons of the *mitral* and *tufted* cells pass posteriorly through the intermediate olfactory stria and the lateral olfactory stria to the olfactory cortex.

The axons terminate on the apical dendrites of pyramidal cells in the olfactory cortex. In humans, sniffing activates the piriform cortex, but smells with or without sniffng activate the lateral and anterior orbitofrontal gyri of the frontal lobe. The orbitofrontal activation is generally greater on the right side than the left. Thus, the cortical representation of olfaction is asymmetric. Other fibers project to the amygdala, which is probably involved with the emotional responses to olfactory stimuli, and to the entorhinal cortex, which is concerned with olfactory memories.

(Ref. Ganong 22th Edition; page 185, 186)

Sniffing : The portion of the nasal cavity containing the olfactory receptors is poorly ventilated in humans. Most of the air normally moves smoothly over the turbinates with each respiratory cycle, although eddy currents pass some air over the olfactory mucous membrane. These eddy currents are probably set up by convection as cool air strikes the warm mucosal surfaces. The amount of air reaching this region is greatly increased by sniffing, an action that includes contraction of the lower part of the nares on the septum, deflecting the airstream upward. Sniffing is a semi-reflex response that usually occurs when a new odor attracts attention.

(Ref. Ganong 22th Edition; page-188)

Odor producing substances

Physical characteristics of substances that can cause the stimulation of olfactory receptors include :

i. Substance must be volatile
ii. Substance must be water-soluble in order to dissolve in mucus
iii. Substance must be lipid soluble in order to interact with the lipid material of olfactory cilia.

Primary olfactory stimulant

i. Camporaceous
ii. Musky
iii. Floral
iv. Pepperminty

v. Etherea
vi. Putrid.

Pathway of olfaction :

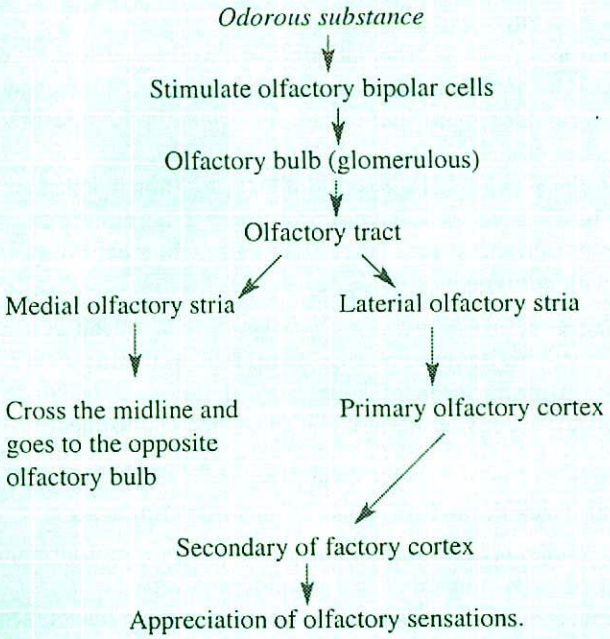
In contrast to all other sensory pathways, the olfactory afferent pathway has only two neurons and reaches the cerebral cortex without synapsing in one of the thalamic nuclei.

Olfactory receptors cells with one type of odorant receptor project to one olfactory glomerulous and olfactory receptors cells with another type of odorant receptor project to a different olfactory glomerulous.

i. First order neuron : bipolar cells of olfactory mucosa
ii. Second order neuron : mitral and tufted cells in the olfactory bulb.

The synapse occurs between these two neurons in the glomerulus of the olfactory bulb. The axons of the mitral and tufted cells form olfactory tracts which go to the opposite olfactory bulb and primary olfactory cortex.

Q. 00. **Trace the pathway of olfaction.**



Abnormalities of olfaction : Abnormalities of olfaction include-

a. *Anosmia* : Absence of the sense of smell. Several dozen different anosmias have been detected in humans. They are presumably due in each case to absence or disrupted function of one of the many members of the odorant receptor family.
b. *Hyposmia* : Diminished olfactory sensitivity
c. Dysosmia : Distorted sense of smell.

Olfactory thresholds increase with advancing age, and more than 75% of humans over the age of 80 have an impaired ability to identify smells.

(Ref. Ganong 22th Edition; page-191)

Hearing and Equilibrium

Introduction : Receptors for two sensory modalities, hearing and equilibrium, are housed in the ear.

a. *Hearing apparatus* :
   i. External ear
   ii. Middle ear
   iii. Cochlea of the inner ear.
b. *Equilibrium apparatus* :
   i. Semicircular canals
   ii. Utricle
   iii. Saccule of the inner ear.
c. *Receptors of hearing and equilibrium* : The receptors for hearing and equilibrium are hair cells, and there are six groups of hair cells in each inner ear :
   i One in each of the three semicircular canals
   ii. One in the utricle
   iii. One in the saccule
   iv. One in the cochlea.

   Function :
   i. Receptors in the semicircular canals detect rotational acceleration.
   ii. Receptors in the utricle detect linear acceleration in the horizontal direction.
   iii. Receptors in the saccule detect linear acceleration in the vertical direction.

(Ref. Ganong 22th Edition; page-171)

Anatomical considerations

a. ***External ear*** : The external ear funnels sound waves to the external auditory meatus. From the meatus, the external auditory canal passes inward to the tympanic membrane (eardrum).

(Ref. Ganong 22th Edition; page-171)

b. ***Middle ear*** : The middle ear is an air-filled cavity in the temporal bone that opens via the auditory (*eustachian*) tube into the nasopharynx and through the nasopharynx to the exterior. The tube is usually closed, but during swallowing, chewing, and yawning it opens, keeping the air pressure on the two sides of the eardrum equalized.

Auditory ossicles : The three auditory ossicles are in the middle ear :
i. Malleus
ii. Incus
iii. Stapes.

The *manubrium* (handle of the malleus) is attached to the back of the tympanic membrane. Its head is attached to the wall of the middle ear, and its short process is attached to the incus, which in turn articulates with the head of the

stapes. The stapes is named for its resemblance to a stirrup. Its foot plate is attached by an annular ligament to the walls of the oval window.

Skeletal muscles : Two small skeletal muscles, the *tensor tympani* and the *stapedius*, are also located in the middle ear. Contraction of the former pulls the manubrium of the malleus medially and decreases the vibrations of the tympanic membrane; contraction of the latter pulls the footplate of the stapes out of the oval window.

(Ref. Ganong 22th Edition; page-171)

c. ***Inner ear*** : The inner ear (*labyrinth*) is made of two parts, one within the other.

i. *Bony labyrinth* : The bony labyrinth is a series of channels in the petrous portion of the temporal bone. Inside these channels, surrounded by a fluid called *perilymph*, is the membranous labyrinth.

ii. *Membranous labyrinth* : This membranous structure more or less duplicates the shape of the bony channels. It is filled with a fluid called *endolymph*, and there is no communication between the spaces filled with endolymph and those filled with perilymph.

(Ref. Ganong 22th Edition; page-171)

d. ***Cochlea*** :

i. Coiled tube

ii. Length : 35 mm long and makes 23/4 turns.

iii. Throughout its length, the basilar membrane and Reissner's membrane divide it into three chambers (scalae).

The upper *scala vestibuli* and the lower *scala tympani* contain perilymph and communicate with each other at the apex of the cochlea through a small opening called the *helicotrema*. At the base of the cochlea, the scala vestibuli ends at the oval window, which is closed by the footplate of the stapes. The scala tympani ends at the round window, a foramen on the medial wall of the middle ear that is closed by the flexible secondary tympanic membrane. The scala media, the middle cochlear chamber, is continuous with the membranous labyrinth and does not communicate with the other two scalae. It contains endolymph.

(Ref. Ganong 22th Edition; page-171)

e. ***Organ of Corti*** :

i. *Location* : Located on the basilar membrane

ii. *Content* : *Hair cells* which are the auditory receptors.

The hair cells are arranged in four rows : *three rows of outer hair cells* (20,000) lateral to the tunnel formed by the rods of Corti, and *one row of inner hair cells* (3500) medial to the tunnel.

iii. *Afferent neurons* : The cell bodies of the afferent neurons that arborize around the bases of the hair cells are located in the spiral ganglion within the modiolus, the bony core around which the cochlea is wound.

90% to 95% of these afferent neurons innervate the inner hair cells; only 5-10% innervate the more numerous outer hair cells, and each neuron innervates several of these outer cells.

iv. *Efferent fibers* : By contrast, most of the efferent fibers in the auditory nerve terminate on the outer hair cells rather than on the inner hair cells. The axons of the afferent neurons that innervate the hair cells form the auditory (cochlear) division of the *vestibulocochlear acoustic nerve* and *terminate* in the dorsal and ventral cochlear nuclei of the *medulla oblongata*.

The total number of afferent and efferent fibers in each auditory nerve is approximately 28,000.

(Ref. Ganong 22th Edition; page-171, 173)

Q. 00. **What do you mean by perilymph and endolymph? Discuss their functions.**

Ans. Perilymph and endolymph :

i. *Perilymph* : The bony labyrinth is a series of channels in the petrous portion of the temporal bone. Inside these channels, surrounded by a fluid called *perilymph*, is the membranous labyrinth.

ii. *Endolymph* : The membranous labyrinth is filled with a fluid called *endolymph*, and there is no communication between the spaces filled with endolymph and those filled with perilymph.

Function of perilymph and endolymph : With the vestibular nuclei perilymph and endolymph are primarily concerned with maintaining the position of the head in space i.e. mediate head-on-neck and head-on-body adjustment.

(Ref. Ganong 22th Edition)

Q. 00. **Discuss the functions of vestibular apparatus?**

Ans. *Functions of vestibular apparatus* : The vestibular nuclei are primarily concerned with maintaining the position of the head in space. The tracts that descend from these nuclei mediate head-on-neck and head-on-body adjustment.

i. Receptors in the semicircular canals detect rotational acceleration.

ii. Receptors in the utricle detect linear acceleration in the horizontal direction.

iii. Receptors in the saccule detect linear acceleration in the vertical direction.

(Ref. Ganong 22th Edition)

Central auditory pathways :

i. From the cochlear nuclei, auditory impulses pass via a variety of pathways to the *inferior colliculi*, the centers for auditory reflexes, and via the *medial geniculate body* in the *thalamus* to the *auditory cortex*.

ii. Others enter the *reticular formation*. Information from both ears converges on each superior olive, and at all higher levels most of the neurons respond to inputs from both sides.

The ***primary auditory cortex***, Brodmann's area 41, is in the superior portion of the temporal lobe. In humans, it is located in the sylvian fissure and is not normally visible on the surface of the brain. In the primary auditory cortex, most neurons respond to inputs from both ears, but there are also strips of cells that are *stimulated by* input from the *contralateral ear* and *inhibited by* input from the *ipsilateral ear*. There are several additional auditory receiving areas, just as there are several receiving areas for cutaneous sensation.

The *auditory association areas* adjacent to the primary auditory receiving area are widespread. The *olivocochlear bundle* is a prominent bundle of efferent fibers in each auditory nerve that arises from both the ipsilateral and the contralateral superior olivary complex and ends primarily around the bases of the outer hair cells of the organ of Corti.

(Ref. Ganong 22th Edition; page-174)

Neural pathways of equilibrium :

The cell bodies of the *19,000 neurons* supplying the cristae and maculas on each side are located in the *vestibular ganglion*. Each vestibular nerve terminates in the ipsilateral four-part vestibular nucleus and in the *flocculonodular lobe* of the cerebellum. Fibers from the semicircular canals end primarily in the superior and medial divisions of the vestibular nucleus and project mainly to nuclei controlling eye movement. Fibers from the utricle and saccule end predominantly in the lateral division (Deiters' nucleus), which projects to the spinal cord. They also end in the descending nucleus, which projects to the cerebellum and the reticular formation. The vestibular nuclei also project to the thalamus and from there to two parts of the primary somatosensory cortex.

(Ref. Ganong 22th Edition; page-174)

Q. 01. **Briefly discuss the modern concept regarding mechenisms of hearing.**

Ans. *Mechenisms of hearing /auditory pathway/ neural pathway of sound transmission* :

The ear converts sound waves in the external environment into action potentials in the auditory nerves. The sound waves are transformed by the eardrum and auditory ossicles into movements of the footplate of the stapes. These movement set up waves in the fluid of the inner ear. The action of the waves on the organ of Corti generates action potentials in the fibers.

The complete auditory pathway involved four neuronal arrangements :

i. *First-order neuron* : sensory neuron of the spiral ganglion
ii. *Second-order neuron* : neurons of the cochlear nuclei
iii. *Third-order neuron* : neurons in the inferior colliculi
iv. *Fourth order neuron* : neurons in the medial geniculate body to the thalamus.

Mechenism : The cell bodies of the first-order neurons that innervate the hair cells are located in the *spiral ganglion*. The axons of the first-order neurons form the *auditory (cochlcar)* division of the vestibulocochlear nerve and terminate in the *ventral* and *dorsal cochlear nuclei* in the medulla oblongata. *From the cochlear nuclei-*

i. *Auditory impulses* pass via a variety of pathways to the *inferior colliculi*, the centers for auditory reflexes, and via the *medial geniculate body* in the *thalamus* to the *auditory cortex (Broabman's area 41)*.
ii. *Others enter* the *reticular formation*. Information from both ears converges on each superior olive, and at all higher levels most of the neurons respond to inputs from both sides.

(Ref. Ganong 22th Editio; Guyton & Hall 11th edition)

Equilibrium

Q. 00. **Briefly describe the neural pathways of equilibrium.**

Ans. Neural pathways of equilibrium :

i. The cell bodies of the *19,000 neurons* supplying the cristae and maculas on each side are located in the *vestibular ganglion*.
ii. Each vestibular nerve terminates in the ipsilateral four-part vestibular nucleus and in the *flocculonodular lobe* of the cerebellum.
iii. *Fibers from the semicircular canals* : end primarily in the superior and medial divisions of the *vestibular nucleus* and project mainly to *nuclei controlling eye movement*.
iv. *Fibers from the utricle and saccule* : end predominantly in the lateral division (Deiters' nucleus), which projects to the spinal cord.

They also end in the descending nucleus, which projects to the cerebellum and the reticular formation.

v. The vestibular nuclei also project to the thalamus and from there to two parts of the primary somatosensory cortex.

(Ref. Ganong 22th Edition)

Deafnes

i. *Types* :
   a. *Conduction deafness* : Due to impaired sound transmission in the external or middle ear
   b. *Nerve deafness* : Due to damage to the hair cells or neural pathways.
ii. *Causes of conduction deafness* :
   a. Plugging of the external auditory canals with wax or foreign bodies
   b. Destruction of the auditory ossicles,
   c. Thickening of the eardrum following repeated middle ear infections
   d. Abnormal rigidity of the attachments of the stapes to the oval window.

ii. *Causes of nerve deafness* :
   a. *Aminoglycoside antibiotics* such as streptomycin and gentamicin obstruct the meehanosensitive channels in the stereocilia of hair cells and can cause the cells to degenerate, producing nerve deafness and abnormal vestibular function.
   b. *Damage to the outer hair cells* by prolonged exposure to noise is associated with hearing loss.
   c. Tumors of the vestibulocochlear nerve and cerebellopontine angle
   d. Vascular damage in medulla.

iii. ***Presbycusis***, the gradual hearing loss associated with aging, affects more than one-third of those over 75 and is probably due to gradual cumulative loss of hair cells and neurons.

iv. ***Deafness due to genetic mutations*** occurs in about 0.1% of newborns.
   a. *Syndromic deafness* : It is associated with abnormalities in other systems. In 30% of the cases.
   b. *Non-syndromic deafness* : It is the only apparent abnormality. In the remaining 70% of the cases.

v. *Deafness due to proteins mutation* :
   a. Connexon 26
   b. Mutations in three nonmuscle myosins cause deafness. These are-
      1. *Myosin-VIIa*, associated with the actin in the hair cell processes
      2. *Myosin-Ib*, which is probably part of the *adaptation motor* that adjusts tension on the tip links
      3. *Myosin-VI*, which is essential in some way for the formation of normal cilia.
   c. Mutant forms of *α–tectin*, one of the major proteins in the tectorial membrane.

(Ref. Ganong 22th Edition; page 182, 183)

Tympanic reflex : Loud sounds initiate a reflex contraction of the- tensor tympani and stapedius- to decrease sound transmission. This is called tympanic reflex. Its function is protective, preventing strong sound waves from causing excessive stimulation of the auditory receptors.

Ossicular conduction : Conduction of sound waves to the fluid of the inner ear via the tympanic membrane and auditory ossicles is called ossicular conduction. It is the main pathway for normal hearing.

Air conduction : Sound waves also initiates vibrations of the secondary tympanic membrane that closes the round window. This process is called air conduction.

Bone conduction : Transmission of vibrations of the bones of the skull to the fluid of the inner ear is called bone conduction.

Masking

The presence of one sound decreases an individual's ability to hear other sounds. This phenomenon is known masking. probably due to the relative or absolute refractoriness of previously stimulated auditory receptors and nerve fibres to other stimuli.

Table : **Common tests with a tuning fork to distinguish between nerve and conduction deafness.**

	Weber	*Rinne*	*Schwabach*
Method	Base of vibrating tuning fork placed on vertex of skull,	Base of vibrating tuning fork placed on mastoid process until subject no longer hears it, then held in air next to ear.	Bone conduction of patient compared with that of normal subject.
Normal	Hears equally on both sides.	Hears vibration in air after bone conduction is over.	
Conduction deafness (one ear)	*Sound louder* in diseased ear because masking effect of environmental noise is absent on diseased side.	*Vibrations in air not heard* after bone conduction is over,	*Bone conduction better than normal* (conduction defect excludes masking noise).
Nerve deafness (one ear)	Sound *louder* in normal ear.	*Vibration heard* in air after bone conduction is over, as long as nerve deafness is partial.	Bone conduction *worse* than normal.

(Ref. Ganong 22th Edition; page-182)

17.23

Special Sense

Introduction

Q. 01. **Special senses are**
- T a. vision
- T b. hearing
- T d. smell
- T c. taste
- F e. temperature.

Vision

Q. 02. **Which structure in the eye is pain sensitive**
- T a. Iris
- T b. Choroid
- T c. Ciliary body
- T a. Cornea
- T d. All of the above

Q. 03. **The visible range in electromagnetic spectrum by human eye is**
- T a. 370-740 nm
- F b. 200-300 nm
- F c. 310 -340 nm
- F d. 740-870 nm
- F e. 350-550 nm

Q. 04. **Power of a lens is**
- T a. the greater the power of a lens, the greater its ability to bend
- T b. it is expressed in terms of diopter
- T c. it increases as the curvature of the lens increases
- F d. it is diverging in nature.
- F e. if increased, the image is formed far away from the lens

Q. 05. **The optical power of the eye is**
- T a. 58 Dioptres
- F b. 25 Dioptres
- F c. 50 Dioptres
- F d. 75 Dioptres
- F e. 44 Diopters

Q. 06. **The medium with highest refractive index in the eye is**
- T a. Nucleus of the lens
- F b. Cornea
- F c. Cortex of the lens
- F d. Aqueous humor
- F e. Vitreous

Q. 07. **Intraocular fluid**
- T a. Is produced by the ciliary process
- T b. Helps to maintain the curve of cornea
- F c. Is produced at the canal of schlemm
- F d. Is reabsorbed by ciliary process
- F e. None of the above

Q. 08. **Most of the refraction that occurs in the eye occurs at the**
- T a. Anterior surface of cornea
- F b. Posterior surface of cornea
- F c. Anterior surface of lens
- F d. Posterior surface of lens
- F e. Aqueous humor.

Q. 09. **In the rod**
- T a. photopigment is rhodopsin
- T b. all colour pigments are absent.
- T c. the receptor potential is hyperpolarized
- F d. all three colour pigments are present
- F e. the permeability change is secondary to a decomposition of rhodopsin

Q. 10. **The fovea centralis of the eye**
- T a. is located in the posterior pole of the eye
- T b. is the region of highest visual acuity
- F c. contains only cones
- F d. has the lowest light threshold
- F e. contains maximum number of cones.

Q. 11. **Neural components of the retina are**
- T a. inner nuclear layer.
- T b. garglion cell layer
- T c. optic nerve layer

F d. pigment layer
F e. external limiting layer

Q. 12. **Accomodation reaction involves**
T a. contraction of the ciliary muscle
T b. relaxation of suspensory ligaments.
T c. convergence of the eye ball
T d. contraction of the constrictor pupillae
F e. increased intraocular pressure

Q. 13. **Under resting conditions the ganglion cells of the retina discharge at approximately what rate?**
T a. 25 per second
F b. One per second
F c. Five per second
F d. 125 per second
F e. 1250 per second

Q. 14. **The receptors in retina for those of blue, green and red wave lengths are called**
T a. Modulators
F b. Trichomators
F c. Dominators
F d. Homonymous hemianopia
F d. None of these

Q. 15. **Rhodopsin is most sensitive and least sensitive to**
T a. Green light, red light
F b. Violet light, red light
F c. Red light, violet light
F d. Blue light, green light
F e. red light, violet light.

Q. 16. **In photopic vision**
T a. colour balance is perceived mainly by the cones
F b. the eye is most sensitive to blue ligh
F c. the rods are not stimulated
F d. the eye is accomodated to dim light
F e. visual acuity is lower than in scotopic vision.

Q. 17. **During photopic vision the**
T a. cones are responsible for most colour distinction
F b. eye is most effective in low light condition
F c. rods are not stimulated
F d. eye is maximally stimulated
F e. visual acuity is lower than in scotopic vision.

Q. 18. **Physiological changes in dark adaption are**
T a. shifting from cone to rod vision
T b. regeneration of rhodopsin
T c. dilatation of pupi
F d. bleaching off rhodopsin
F e. increased sensivity of rhodopsin.

Q. 19. **Colour vision**
T a. is maximum in fovea centralis.
T b. is primarily a function of cones
T c. depends on ganglionic cells that are reciprocally excited and inhibited by opponent colours
F d. depends upon the quantity of rhodopsin in the cones
F e. depends on a series of pigment sensitive to light

Q. 20. **The Helmholtz theory of colour vision states that**
T a. There are three kinds of cones in the retina respond ing to the three primary colours
F b. There are two kinds of cones called dominators and modulators
F c. There is only one kinds of cone and the colour is recognised only in area 17
F d. There are seven types of cones responding to the seven colours of the spectrum
F e. There are two kinds of cones.

Q. 21. **While seeing a colour chart a colour blind male has decreased vision for red light colour which appear very light than that of other colours. Which of the following is the likely anomaly in him?**
T a. Protanomaly
F b. Dutanomaly
F c. Tritanomaly
F d. Butanomaly
F e. Hemianopia

Q. 22. **Which of the following spectrum of colour is highest visualized due to central cones?**
T a. Blue Green
F b. Red Blue
F c. Blue Red
F d. Red Green
F e. Red yellow.

Q. 23. **If the red cones and the green cones are stimulated approximately equally. What colour will the person**
T a. Yellow
F b. Red
F c. Green
F d. Purple
F e. Blue.

Q. 24. **Regarding colour blindness**
T a. it is a sex linked disease
T b. it is due to the absence of colour genes in the x chromosomes
T c. it mostly occurs in male
F d. the male is carrier
F e. the female is sufferer.

Q. 25. **Red colour blindness is called**
T a. Protanopia
F b. Deuteranopia
F c. Protanomaly

F d. Deuteranomaly
F e. Hemianopia

Q. 26. **In normal illumination the area of most visual distinction is**
T a. in the fovea centralis
F b. an area that contains mostly rods
F c. where low light vision is best
F d. the lateral edges of the retina
F e. an area that contains few cones.

Q. 27. **Visual acuity depends on**
T a. sensibility of retina to light
T b. illumination of the surface
T c. the time of exposure
F d. contraction of the ciliary muscle
F e. increased tension of the lens ligaments.

Q. 28. **Parts of the brain concerned with the processing visual information are**
T a. lateral geniculate body
T b. primary visual cortex (area 17).
F c. post central gyrus
F d. medial geniculate body
F e. lateral portion of the temporal lobe

Q. 29. **The visual cortex has**
T b. complex cells (pyrimidal cells)
F a. simple cells
F c. hypocomplex cells
F d. distance cells
F e. bipolar cells.

Q. 30. **The first cell in the visual pathway to respond to a light stimulus is**
T a. amacrine cell
F b. rod
F c. bipolar neuron
F d. cone
F e. horizontal cell.

Q. 31. **Which one of the following procedures is most likely to increase intraocular pressure of glaucoma patient?**
T a. Dark environment
T b. Use of atropine
F c. Decreased pressure in jugular vein
F d. High does of vitamin C
F e. High fatty diet.

Q. 32. **When light falls behind the retina, the errors of refraction are**
T a. hypermetropia
T b. presbyopia
F c. astigmatism
F d. myopia
F e. emmetropia

Q. 33. **Myopia**
T a. results when the image falls in front of the retina
T b. is corrected by a concave lens
F c. is corrected by a convex lens
F d. results when the image falls behind the retina
F e. results when the image is formed on the retina.

Q. 34. **In hypermetropia**
T a. eye ball is shorter then normal
T b. parellel light rays are brought to a focus behind the retina
F c. anterior posterior diameter of the eye ball is increased
F d. a cylindrical lens is prescribed
F e. patient can see the near object.

Q. 35. **In astigmatism**
T a. curvature of the cornea is not uniform
T b. there are different degree of refraction in different planes
T c. image from all the portions of the object can not be simultaneously focused on the retina.
F d. lens are uniform
F e. it is corrected by using a convex lens.

Q. 36. **In argyll Robertson pupil**
T a. the light reflex is absent
T b. the accomodation reaction remains present
T c. the cause is destruction of the pretectal region and superior colliculi
F d. the cause is damage of medial geniculate body
F e. colour vision is intact.

Q. 37. **In spherical aberrations**
T a. the power of the lens is at the extrems of its periphery
T b. pupil is widely dilated
T c. blurring of vision may occur
F d. rays of the different wave length are refracted ifferently
F e. red light is refracted least whereas the violet light is the most.

Ear

Q. 38. **The ear**
T a. is the organ of hearing
T b. is the organ of equilibrium
T c. contains receptors that respond to the movement of head

T d. contains receptors that convert sound waves into nerve impulses.
F e. contains no receptors that respond to the movement of the head

Q. 39. **One of the following is seen in auditory pathway**
T a. Trapezoid body
F b. Lateral geniculate body
F c. Genu of internal capsule
F d. Lateral lemniscus
F e. Optic chiasma.

Q. 40. **Stapes rests in**
T a. Basilar membrane
F b. Round window
F c. Oval window
F d. Tympanic membrane
F e. Facial nerve.

Q. 41. **The attenuation reflex is due to**
T a. Contraction of tensor tympani and stapedius
F b. Contraction of tensor tympani
F c. Contraction of stapedius
F d. Inward movement of the oval window
F e. Outward movement of the oval window

Q. 42. **Reissner's membrane**
T a. separates scala vestibuli and scala media
T b. is thin and can easily move
T c. does not obstruct the passage of sound vibrations.
F d. seprates scala vestibuli and scala tympani
F e. is thick and not move

Q. 43. **Basilar membrane**
T a. separates scala tympani and scala media
T b. contains organ of corti.
T c. contains hair cells.
F d. seprates scala tymphani and scala vestibuli.
F e. contains no hair cells.

Q. 44. **The basilar membrane of the cochlea**
T a. vibrates due to transmission of sound wave to eochlear fluid
F b. covers the oval window and the round window
F c. is under tension
F d. is unaffected by movement of fluid in the scala vestibuli
F e. vibrates when the body is subjected to linear accelerati

Q. 45. **Inward movement of oval window causes fluid to move**
T a. into scala vestibuli
T b. into scala media
F c. into scala tympani
F d. into scala tympani and scala media
F e. not at all.

Q. 46. **Sound wave with**
T a. high frequency travels only a short distance
T b. medium frequency travels half way
T c. low frequency travels entire distance
F d. high frequency travels half way of basilar membrane
F e. low frequency travels short distance.

Q. 47. **Organ of corti**
T a. is the receptor organ of hearing
T b. generates nerve impulse
F c. is the receptor organ of smell
F d. is the receptor organ of taste
F e. lies on the reissner's membrane.

Q. 48. **Bending of the hairs of hair cells**
T a. excites the auditory nerve fibers.
T b. in one direction depolarizes hair cells
T c. in the opposite direction hyperpolarizes them
F d. in one direction repolarizes hair cells
F e. in the opposite direction depolarizes them

Q. 49. **Endolymph**
T a. is secreted by stria vascularis
T b. contains high concentration of potassium
T c. is present in scala media
F d. is present in scala vestibuli
F e. contains high concenration of sodium.

Q. 50. **Sounds with**
T a. high frequency sound activates basilar membrane near the base
T b. intermediate frequency activates the membrane at intermediate distance.
T c. low frequency activates basilar membrane near the apex
F d. low frequency activates basilar membrane near the base
F e. high frequency sound activates basilar membrane at the apex

Q. 51. **In humans the primary auditory cortex is located in the**
T a. superior part of the temporal lobe.
F b. limbic system
F c. posterior part of the occipital lobe
F d. posterior part of the parital lobe
F e. postcentral gyrus

Q. 52. **In conductive deafness**
T a. the person fails to hear satisfactorily
T b. bone conduction is better than air conduction
T c. in Weber test the patient hears better by the diseased ear

F d. the Rinne lest is positive
F e. air conduction is better than bone conduction

Q. 53. **In nerve deafness**
T a. there is fault in the organ of corti
T b. air conduction is longer than bone conduction.
T c. in Weber's test, the subject hears better by the normal ear as compared to diseased ear
F d. Rinne test is negative
F e. bone conduction is longer than air conduction.

Q. 54. **Sound intensity is measured in**
T a. Decibele
F b. diopter
F c. daltons
F d. torrs
F e. pounds.

Q. 55. **Abnormalities of hearing are**
T a. otitis media
T b. Labyrinthitis
F c. ageusia
F d. anosmia
F e. otosclerosis.

Q. 56. **For diagnosing middle ear deafness the flowing test is done**
T a. Weber's test
F b. Testing Babinski's reflex
F c. Eliciting Chvostek's reflex
F d. Finger-nose test
F e. Rinne test.

Q. 57. **Medial geniculate body is concerned with**
T a. Hearing
F b. Vision
F c. Smell
F d. Taste
F e. Smell and hearing.

Q. 58. **An aged violin player can get a correct pitch only by touching his teeth to the vibrating instrument. He is most likely to damage**
T a. Middle ear
F b. Inner ear
F c. Cochlear nuclei
F d. Medial geniculate body
F e. Lateral geniculate body

Taste

Q. 59. **Taste cells contain**
T a. two sodium receptors
T b. one chloride receptor
T c. two bitter receptors.
F d. one potassium receptor
F e. two chloride receptors

Q. 60. **Location of different tastes are**
T a. sweet at the tip of tongue
T b. sour along the edges of tongue
T c. bitter on the back of tongue
F d. sweet along the edges of tongue
F e. saltish on the back of tongue.

Q. 61. **The taste bud**
T a. is composed of 50 modified epithelial cells
T b. contains sustentacular cells
T c. contains taste cells
F d. is composed of 10 modified epithelial cells
F e. are mostly degenerate beyond the age of 30 years.

Q. 62. **The nerves that carry taste impules are**
T a. facial nerve
T b. glossopharyngeal nerve
T c. vagus nerve
F d. trigiminal nerve
F e. hypoglossal nerve.

Q. 63. **Taste buds are found on**
T a. tongue
T b. palate
T c. epiglottis
T d. tonsilar pillar.
F e. glottis

Q. 64. **Bitter taste is mediated by action of**
T a. G protein
F b. Guanyl cyclase
F c. Tyrosine kinase
F d. Epithelial Na^+ chain
F e. Adrenaline.

Q. 65. **Bitter taste is perceived mainly by which part of the tongue**
T a. Posterior 1/3
F b. Anterior 1/3
F c. Anterior 2/3
F d. Lateral aspect
F e. Tip.

Q. 66. **Abnormalities of taste are**
T a. ageusia
T b. dysgeusia.
T c. hypogeusi
F d. hyposmia
F e. anosmia

Q. 67. **Regarding sense of taste**
T a. taste area are located in the post central gyrus

T b. the threshold for stimilation of sour taste by hidrochloric acid averages 0.0009
T c. taste receptors are collected togather in the taste buds.
F d. the action protentials are transmitted via vii, ix and xii cranial nerves.
F e. the impulpse generated in the taste buds reaches the cerebral cortex via the internal capsule.

Smell

Q. 68. **Smell receptors are seen in**
T a. Upper 1/3 of nasal mucosa
F b. Lower 1/3 of nasal mucosa
F c. Amygdaloid body
F d. Cribriform plate
F e. Anterior 1/3 of the tongue

Q. 69. **Olfactory cells are**
T a. receptor cells for smell sensation.
T b. bipolar nerve cells
T c. derived from central nervous system
F d. unipolar nerve cells
F e. derived from peripheral nervous system.

Q. 70. **Olfactory epithelium contains**
T a. 100 million olfactory cells
T b. sustentacular cells
T c. 4 to 25 cili
F d. 50 million olfactory cells
F e. 30 to 40 cilia.

Q. 71. **The olfactory bulb**
T a. lies over the cribriform plate
T b. is an anterior outgrowth of the brain
T c. contains granule cells, mitral and tufted cell
F d. is an posterior outgrowth of the brai
F e. contains no glomeruli.

Q. 72. **Abnormalities of smell are**
T a. anosmia
T b. hyposmia
T c. dysosmia
F d. hypogeusia
F e. ageusxa.