68. Ans. is ‘b’ i.e., Vagus nerve & ‘c’ i.e., Trigeminal nerve [Ref: BDC Vol. III 6/e p. 223-224]
   o All muscles (except tensor veli palatini) → By cranial part of accessory nerve via vagus through pharyngeal plexus.
   o Tensor veli palatini → Mandibular division of trigeminal.

69. Ans. is ‘a’ i.e., Tonsilar branch of facial artery [Ref: Keith moore 4/e p. 938; BDC Vol. III 6/e p. 226]

Blood supply of soft palate
   o Arterial supply of soft palate is as follows:
     i) Greater palatine branch of descending palatine artery, which in turn is a branch of maxillary artery.
     ii) Ascending palatine branch of facial artery.
     iii) Palatine branch of ascending pharyngeal artery.
     iv) Lesser palatine artery a branch of descending palatine artery, which is a branch of maxillary artery.

***
There are 12 pairs of cranial nerves (olfactory), II (optic), III (oculomotor), IV (trochlear), V (trigeminal), VI (abducent), VII (facial), VIII (vestibulocochlear), IX (glossopharyngeal), X (vagus), XI (accessory) and XII (hypoglossal) Attachment of nerves are: I and II to forebrain; III and IV to midbrain; V, VI, VII and VIII to pons; and IX, XI and XII to medulla(10, 5, 4, 6, 17, 59).

CRANIAL NERVE NUCLEI

There are mainly two types of nuclei of cranial nerves: -

i) **Efferent nuclei (motor nuclei or nuclei of origin)**: These are groups of neurons in the brain from which the nerve fibers arise. And then the nerve supplies specific motor organ (gland, muscle etc).

ii) **Afferent nuclei (sensory nuclei or nuclei of termination)**: These are the nuclei to which cranial nerve carry sensation from peripheral organs.

Based on the type of effector organ supplied by the nerve and/or sensory organ from which the nerve carries sensation, these two types (effector and afferent) of nuclei are divided into following types:

Efferent nuclei (Motor nuclei)

A) **General somatic efferent nuclei**: These nuclei supply skeletal muscles of somatic origin. These are:

1) **Oculomotor nucleus**: It lies in upper midbrain (near superior colliculus) and supplies extraocular muscles (except for lateral rectus and superior oblique) through oculomotor nerve.

2) **Trochlear nucleus**: It lies in lower midbrain (near inferior colliculus) and supplies superior oblique through trochlear nerve.

3) **Abducent nucleus**: It lies in pons (lower part) and supplies lateral rectus through abducent nerve.

4) **Hypoglossal nucleus**: It lies in medulla and through hypoglossal nerve supplies muscles of tongue, except palatoglossus.

B) **Special visceral efferent (Branchial efferent) nuclei**: These nuclei supply skeletal (striated) muscles derived from the branchial arches. These are:

1) **Motor nucleus of trigeminal**: It lies in upper pons and supplies muscles of mastication and tensor tympani through mandibular nerve.

2) **Motor nucleus of facial nerve**: It lies in lower pons and supplies muscles of facial expression, buccinator and stapedius.

3) **Nucleus ambiguus**: Its fibers are distributed through three cranial nerves: glossopharyngeal (IX), vagus (X), and accessory (XI). The destination is:

   i) To stylopharyngeus through glossopharyngeal;
   ii) To muscles of soft palate (except tensor veli palatini), pharynx (except stylopharyngeus) and larynx through vagus and cranial part of accessory nerve.

C) **General visceral efferent nuclei (Parasympathetic)**: These nuclei give rise to preganglionic parasympathetic neurons that relay in peripheral autonomic ganglion. Postganglionic fibers arising in the ganglion supply smooth muscles and glands. These are:

1) **Edinger-westphal nucleus in the midbrain**: Fibers pass through the third nerve to the ciliary ganglion to supply the pupillary and ciliary muscle.

2) **Lacrimal nucleus in the pons**: Fibers pass through facial nerve and its greater petrosal nerve to relay in the pterygopatine ganglion to supply lacrimal, nasal and palatal glands.

3) **Superior salivatory nucleus in the pons**: Fibers pass through facial nerve and its chorda tympani branch to the submandibular ganglion to supply submandibular and sublingual glands.

4) **Inferior salivatory nucleus in the pons**: Fibers pass through glossopharyngeal nerve to relay in the otic ganglion to supply parotid gland.

5) **Dorsal nucleus of vagus in medulla**: Fibers pass through vagus nerve to be distributed to the thoracic and abdominal viscera through respective ganglia.

Afferent nuclei (Sensory nuclei)

A) **General visceral afferent nucleus**: It receives general sensations from viscera. This nucleus is:

   i) **Nucleus of tractus solitarius**: It lies in medulla and its lower part receives general visceral sensations as follows:

      i) From tonsil, pharynx, posterior part of tongue, carotid body and sinus → through glossopharyngeal nerve.
      ii) From pharynx, larynx, trachea, esophagus, and other thoracic and abdominal viscera → through vagus nerve.
Optic Nerve
Optic nerve is made up of axons of ganglion cells of the retina. In a strict sense, the optic nerve is not a peripheral nerve because its fibres have no neurilemmal sheaths. It is a tract. Its fibres have no power of regeneration. The nerve is described in Chapter 13.

Optic Chiasma
In the chiasma, the nasal fibres (i.e. fibres of the optic nerve arising in the nasal, or medial half of the retina) including those from the nasal half of the macula, cross the midline and enter the opposite optic tract. The temporal (lateral) fibres pass through the chiasma to enter the optic tract of the same side (Fig. 24.8).

Optic Tract
Each optic tract winds round the cerebral peduncle of the midbrain. Near the lateral geniculate body, it divides into lateral and medial roots. The lateral root is thick and terminates in the lateral geniculate body. A few of its fibres pass to the superior colliculus, the pretectal nucleus and the hypothalamus. The medial root is believed to contain the supraoptic commissural fibres.

Each optic tract contains temporal fibres of retina of the same side and nasal fibres of the opposite side.

Lateral Geniculate Body
Lateral geniculate body receives the lateral root of the optic tract. Medially, it is connected to the superior colliculus, and laterally, it gives rise to the optic radiation.
The area of the visual cortex that receives impulses from the macula is relatively much larger than the part related to the rest of the retina.

REFLEXES

These are: (1) pupillary light reflex (Fig. 24.9 and Flow chart 24.1), (2) accommodation reflex (Fig. 24.10 and Flow chart 24.2), (3) dilation of pupil (Flow chart 24.3), (4) corneal/conjunctival reflex (Fig. 24.11 and Flow chart 24.4), (5) visual body reflex (Fig. 24.12 and Flow chart 24.5).

**Flow chart 24.1: Pupillary light reflex**

- Shining of torch light in left eye
  - Optic nerve
  - Optic chiasma
  - Optic tract
  - Few fibres go to pretectal nucleus of same and even opposite side
    - Edinger-Westphal nuclei of both sides
      - III nerve nuclei of both sides
        - Branch to inferior oblique, relay in ciliary ganglion
          - Short ciliary nerves of both sides
            - Sphincter pupillae muscle of both eyes, constrict
              - Both pupils constrict

**Flow chart 24.2: Accommodation reflex**

- Read a film magazine
  - Optic nerve
  - Optic chiasma
  - Optic tract
  - Lateral geniculate body
    - Optic radiation
      - Occipital cortex
        - Superior longitudinal fasciculus
          - Medial frontal gyrus (frontal eye field)
            - III nerve nuclei
              - Nerve to inferior oblique
                - Branch to ciliary ganglia
                  - Relay
                    - Short ciliary nerves
                      - Constrictor pupillae and ciliaris

**Fig. 24.9: Pupillary light and consensual light reflex**
Some fibers from lateral geniculate body terminate via the interlaminar pathway which terminate onto layers 2 and 3 of visual cortex. Layer 2 and 3 of visual cortex contain clusters of cells about 0.2 mm diameter, that unlike neighbouring cells contain a high concentration of the mitochondrial enzyme ‘cytochrome oxidase’. These clusters have been named as blobs (44-46). They are arranged in a mosaic in the visual cortex and are concerned with colour vision (44-46).

**COLOUR VISION**

As perceived by the human eye; light consists of those wavelengths of electromagnetic radiation (approximately 400-700 nm) which are capable of eliciting retinal response and subsequent visual image. An individual with normal colour vision is known as trichromate. This is because normal human eye can appreciate three primary
colours (red, green and blue) due to presence of three different type of cones, i.e. red sensitive, green sensitive and blue sensitive. Therefore, all the colors of spectrum can be obtained by the fusion of these three colors in varying proportions.

- There are two major theories that explain color vision: the Trichromatic theory also known as the Young-Helmoltz theory, and the Opponent-process theory. These two theories are complementary and explain processes that operate at different levels of the visual system.

Trichromatic theory
- The Trichromatic theory states that color vision is possible due to 3 types of cones (L, M and S) - Long (L) or red cones, Medium (M) or green cones, Short (S) or blue cones. It assumes that the signals generated in the three cone types, which are independent and have different spectral sensitivities (L for long wavelength sensitivity, M for medium wavelength sensitivity, and S for short wavelength sensitivity), are transmitted directly to the brain where “color sensations” are experienced that correlate in a simple and direct way to the three cone signals. The underlying premise of the theory is that it is possible to create all colors of the spectrum by mixing two primary colors.

Opponent Processing theory of Colour Vision
- Developed by Ewald Hering, the opponent-process theory states that the cone photoreceptors are linked together to form three opposing colour pairs - Blue/Yellow, Red/Green, and Black/White. Activation of one member of the pair inhibits activity in the other. Consistent with this theory, no two members of a pair can be seen at the same time. This, thus, explains why we don’t experience such colors as “bluish green” or “reddish green”. Where as bluish-green (turquoise) and yellowish-reds (orange) are very common mixture descriptions.

Colour blindness
- There are following types of colour blindness.

- When green cones are absent, the person is green blind. The condition is called Deuteranopia and the person is called deuteranope.

- When red cones are absent, the person is red blind. The condition is called Protanopia and the person is called protanope.

- These are the two most common types of colour blindness. 6 percent of all men are green colour blind (deuteranopes) and 2 percent of all men are red colour blind (protanopes) making a total of about 8 percent who are red-green blind. These two types are grouped together and called red green colour blindness because these are the most common type of colour blindness and as both are unable to differentiate between red and green colors.

- When blue cones are absent, the person is blue blind. The condition is called tritanopia and the person is called tritanope. This is a very rare condition.

As all these patients can appreciate only two primary colours, this defect is called Dichromatic colour blindness.

- Sometimes person does not have colour blindness but has colour weakness for a particular colour because colour cones are not missing but they are under-represented. The person can appreciate all three primary colour but is defective for one or two of them, therefore called trichromatic colour blindness. Three types of such anomalies are there:

  i) Red color defective → Protanomaly
  ii) Green color defective → Deuteranomaly

GUSTATION (TASTE)
- Taste is mainly a function of the taste buds. Taste buds contain the receptors for taste called taste cells. Taste buds are found in tongue, epiglottis, palate and pharynx.

- In tongue, taste buds are grouped in structures called papillae. Taste buds are located in the walls of papillae. There are three types of papillae:

  i) Fungiform papillae - Are especially numerous near the tip and the margins of the tongue.

  ii) Circumvallate (Vallate) papillae - These are the largest papillae and are distributed to a V-shaped region near the base of tongue.

  iii) Foliate papillae - Confined to the back edge of the tongue.

- Besides these three types of papillae, there is also a fourth type, the filiform papillae but these have no taste buds.

Sapid Substances (taste-producing substances)
- Sapid substances must dissolve in the saliva before they can stimulate in taste receptors. All taste sensations result from various combinations of four basic tastes (primary taste sensations):

  1) Sour taste - The sour taste is caused by acids, i.e., hydrogen ions. More acidic the food, more sour is the taste.

  2) Salty taste - The salty taste is elicited by ionized salts mainly by sodium ion concentration. The cation of the Salt (Na+) is mainly responsible, but anions can also contribute, to a lesser extent. Anterior half of the tongue is more sensitive to salty taste.

  3) Sweet taste - The sweet taste is not caused by any single class of chemicals. It is produced by various classes of organic molecules. The tip of the tongue is most sensitive to sweet.

  4) Bitter taste - Bitter taste is produced by long-chain organic substances containing nitrogen and by alkaloids such as quinine and caffeine. The back of the tongue is particularly sensitive to bitter.
Flow chart 24.3: Dilation of pupil

Hypothalamus
→ Brain stem

Spinal cord-with lateral horn (thoracic segments)

T1-T4 roots

Superior cervical ganglion

Relay

Fibres pass along internal carotid artery

Ophthalmic artery

→ Long ciliary artery

Branch to ciliary ganglion

No relay

Dilator pupillae

Flow chart 24.4: Corneal/conjunctival reflex

Touching of cornea or conjunctiva

→ Ophthalmic nerve

Superior sensory nucleus of V

→ Medial longitudinal bundle

Motor nucleus of VII

→ Orbitalis muscle of eyelid

→ Motor nuclei of cranial nerves for movements of head and neck

→ Anterior horn cells of spinal cord for movements of body
of one side results in loss of the opposite
field of vision.
• A lesion on the right optic tract leads
to homonymous hemianopia (left half of fi
vision).
• Papilloedema: Results due to increased intraocular
pressure. It leads to swelling of optic disc due
to blockage of tributaries of the retinal veins.
• Optic neuritis: Lesion of optic nerve that results
in decrease of visual acuity. Optic disc appears
flatter and smaller. Methyl alcohol is a usual
cause, leading to blindness.

Argyll-Robertson pupil: In this condition
accommodation reflex is present but
light reflex is absent. The pretectal area is aff
(see Fig. 25.14).

THIRD CRANIAL NERVE

OCULOMOTOR NERVE

This is the third cranial nerve. It is distributed
equally as well as the extraocular muscles. Si
as a somatic motor nerve, it is in series with the I
and XII cranial nerves, and also with the ventral
of spinal nerves.

Functional Components

1. General somatic efferent, for movements of
   eyelids (Fig. 24.14).
2. General visceral efferent or parasympathetic,
   contraction of pupil and accommodation.
3. General somatic afferent column carries prop.
   ceptive fibres from the extracranial muscles
   mesencephalic nucleus of V.

Nucleus

The oculomotor nucleus is situated in the ventromedial
part of central grey matter of midbrain at the level of su
oprior colliculus. The fibres for the constrictor
pupillae and for the ciliary muscles from the Edinger-
Westphal nucleus which forms part of the oculomotor
nuclear complex.

Wrongly, it is closely related to the medial
longitudinal bundle.

The nucleus is connected:

a. To the pyramidal tracts of both sides which forn
   the supranuclear pathway of the nerve.

b. To the pretectal nuclei of both sides for the light
   reflex.

C. To the fourth, sixth and eighth nerve nuclei by
   medial longitudinal bundle for coordination of the
   eye movements.

d. To the tectobulbar tract for visuoprotective reflexes.
Fig. 24.13: Field defects associated with lesion of visual pathway. 1. Blindness of left eye, 2. bitemporal hemianopia, 3. left nasal hemianopia, 4. right homonymous hemianopia with macular involvement, 5. right homonymous hemianopia, and 6. right homonymous hemianopia with macular sparing.

Course and Distribution

1. In their intraneural course, the fibres arise from the nucleus and pass ventrally through the tegmentum, red nucleus and substantia nigra.

2. At the base of the brain, the nerve is attached to the oculomotor sulcus on the medial side of the crus cerebri (Fig. 24.1).

3. The nerve passes between the superior cerebellar and posterior cerebral arteries, and runs forwards in the interpeduncular cistern, on the lateral side of posterior communicating artery to reach the cavernous sinus (Fig. 24.15).

Fig. 24.14: Third cranial nerve and its nucleus.

Fig. 24.15: Scheme to show the precavernous courses of the third, fourth and sixth cranial nerves.
4 The nerve enters the cavernous sinus (Fig. 24.16) by piercing the posterior part of its roof on the lateral side of the posterior clinoid process. It descends to the lateral wall of the sinus where it lies above the trochlear nerve. In the anterior part of the sinus, the nerve divides into upper and lower divisions.

5 The two divisions of the nerve enter the orbit through the middle part of the superior orbital fissure. In the fissure, the nasociliary nerve lies in between the two divisions while the abducens nerve lies interlateral to them.

6 In the orbit, the smaller upper division ascends on the lateral side of optic nerve, and supplies the superior rectus and part of the levator palpebrae superioris. The larger, lower, division divides into three branches for the medial rectus, the inferior rectus and the inferior oblique. The nerve to the inferior oblique is the longest of these. It gives off the parasympathetic root to the ciliary ganglion and then supplies the inferior oblique muscle (Fig. 24.17).

All branches enter the muscles on their ocular surfaces except that for the inferior oblique which enters its posterior border.

Figures 24.18 and 24.19 show the actions of extracocular muscles.

**CLINICAL ANATOMY**

- Complete and total paralysis of the third nerve results in:
  a. Ptosis, i.e. drooping of the upper eyelid.
  b. Lateral squint.
  c. Dilatation of the pupil (Fig. 24.20)
  d. Loss of accommodation
  e. Slight proptosis, i.e. forward projection of the eye.
  f. Diplopia or double vision.
  g. Ptosis of drooping of upper eyelid due to paralysis of voluntary part of levator palpebrae superioris muscle.
  h. Pupillary light reflex in affected eye is absent.
  i. Dilatation of pupil due to paralysis of parasympathetic fibres to sphincter pupillae muscle
  j. Eyeball gets turned downwards and laterally due to unopposed action of lateral rectus and superior oblique muscles.
  k. Loss of accommodation due to paralysis of ciliary muscles.
  l. Pupil dilates and becomes fixed to light.

**Features are:**

- Light shown in affected right eye (Fig. 24.21):
  - No light reflex in affected eye.
  - Consensual light reflex in normal eye/ left eye.

- Light shown in normal eye:
  - Light reflex in normal eye.
  - No consensual light reflex in affected eye (Fig. 24.22).

- A midbrain lesion causing contralateral hemiplegia and ipsilateral weakness of the third nerve is know as Wallenberg syndrome (Fig. 25.14).

- Supranuclear paralysis of the third nerve causes loss of conjugate movements of eyes.

- Compression of all nerve from above of III nerve due to extramedullary mass which compresses the pupil. Paralysis of all muscles of attack first. Pupil dilates on affected side and there is little response to light.

- Aneurysm of posterior cerebral or superior cerebellar artery: Aneurysm of any of these two arteries may compress III nerve as it passes between them.

**FOURTH CRANIAL NERVE**

This is the fourth cranial nerve. It supplies only the superior oblique muscle of the eyeball (Fig. 24.23).