

## 4

# EXPERIENCING THE ENVIRONMENT

### 4.1 Introduction

Human beings and animals are able to see the world around them, hear sounds, taste various types of foods, smell different fragrances, feel the warm and cold climate outside, and, when hurt, feel the pain. The most remarkable characteristics of the organism, human or non-human, is its possession of different sense organs. These sense organs (e.g., eyes, ears, tongue, nose, skin) are our windows to collect information from the external world. Each of these sense organs are selectively sensitive to different stimuli. For example, visual sense organ (the eye) is sensitive to receive only light energy, audition to sound energy, tactile to pressure and touch and so on. We human beings depend primarily on vision, hearing, and cutaneous senses to gather information about the world around us.

### 4.2 Objectives

After reading this lesson you will be able to :

- understand the structure and function of different human sense organs;
- understand how the organism gathers information about the external and internal environment;
- understand the physical nature of stimuli and how these are received and processed at the sensory level;
- understand the relationship between physical stimuli and psychological responses to these stimuli.

### 4.3 Sense Modalities

We can identify 10 different senses in human beings (Eleven sense organs if we consider heat and cold as two separate senses). These 10 senses are identified as :

- (1) Vision
- (2) Audition
- (3) Tactile (Touch and Pressure)
- (4) Temperature (Heat and Cold)
- (5) Pain
- (6) Taste
- (7) Smell
- (8) Kinesthesia
- (9) Vestibular
- (10) Proprioception

External stimulus (e.g. light) is received by the specific sense organ (e.g. eye). Within the sense organs are the receptors that transform the physical energy into neural signals (process known as transduction) which are transmitted to the specialized area in the brain. The pattern of neural activity is recognized by the brain. In other words, the physical energy (information) is received by the specific sense organ. The sense organ preprocesses the information and the encoded information is transmitted to the specific area in the brain where encoded message is decoded and further processed which leads to perception.

Let us take up the various sense organs one by one and describe the structure and processes associated with different sense organs. First we will take-up the sense of vision which will be discussed in some detail and other modalities will be taken up later briefly.

#### **Sensory Adaptation**

An interesting characteristic of the sense organs is that on continued stimulation the awareness of sensation involved diminishes or fades out completely. For example, if we sit in a room in which some fragrance has been sprayed, initially, we are aware of the fragrance in the room but after sitting for some time the sensation diminishes or completely fades out. This process is known as sensory adaptation. All sensory systems display adaptation, but touch and smell adapt quickly whereas sense of pain adapts slowly.

---

---

**Intext Questions 4.1**

---

Choose the correct alternative

1. Which sense organ is not associated with the collection of information from within the body
    - A. Kinesthetic
    - B. Vestibular
    - C. Taste
    - D. Proprioception
  2. Human beings possess \_\_\_\_\_ sense organs
    - A. 10
    - B. 5
    - C. 7
    - D. 8
  3. The process by which physical stimulus is converted into neural signals is called :
    - A. Transmission
    - B. Transformation
    - C. Transduction
    - D. Signalling
- 

**4.4 Vision**

The most developed and most used sense organ in human being is vision. More of the brain is devoted to mechanisms for vision than to any other sense. Vision dominates over the information received from other senses. For example, what we see carries more importance than what we hear.

**Physical Nature of Visual Stimuli**

As discussed earlier, each of the different sense organs is sensitive to specific physical stimulus. For example, tactile sense (touch and pressure) is sensitive to some touch or pressure upon the skin surface. Similarly, the eyes are only sensitive to photopic (light) stimulation. That is, the adequate stimulus for the eyes are light waves (electromagnetic energy). The light waves activate the visual receptors, called rods and cones. The eyes receive light reflected from objects in the world and from this we perceive colour, shape, depth, texture etc.

---

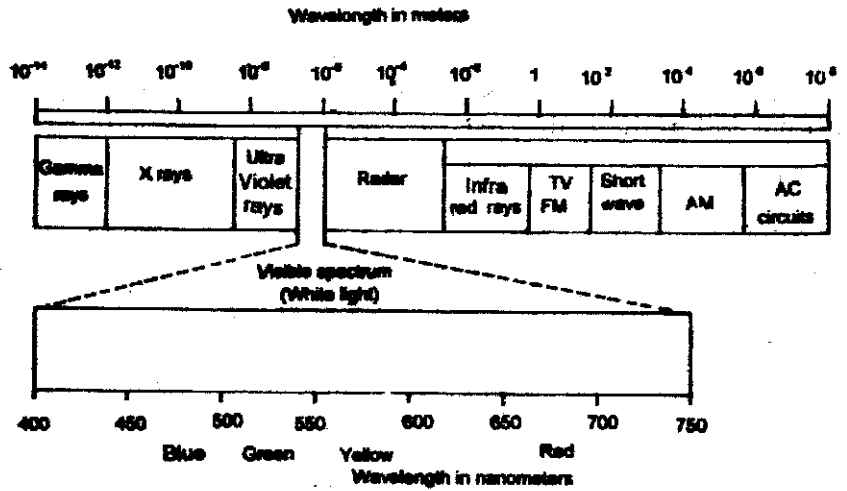


Fig. 4.1 of Visible Spectrum

The visible spectrum for human eye ranges just below 400nm (nanometers or milli-microns) to about 750 nm. Even within this visible spectrum human eye is not uniformly sensitive to all wavelengths. As can be observed from Fig. 1, the lower end of the visible spectrum has ultraviolet rays and on the upper are infrared. These rays are not visible to the human eye and if the eye is exposed to these rays in sufficient quantity they can harm the eyes.

**STRUCTURE OF THE EYE**

Each eye is about 25 mm in diameter and weighs about 7 gms. The human eye consists of four major parts :

- (i) the cornea,

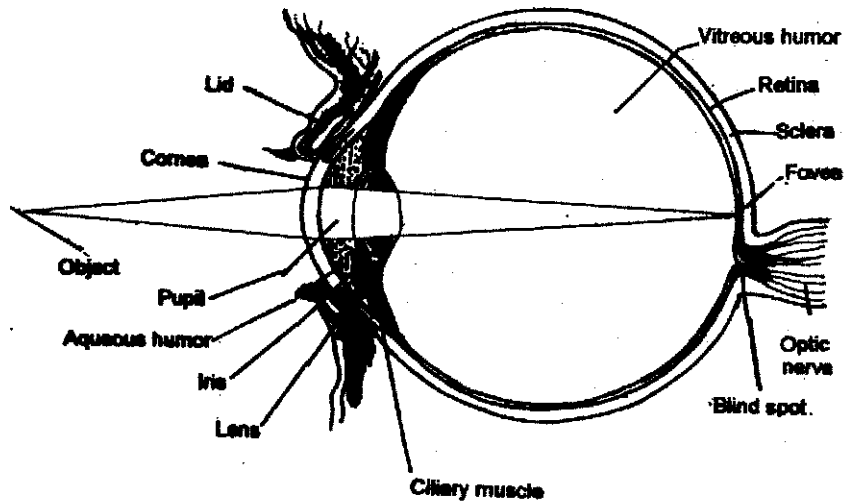


Fig. 4.2 Structure of eye

- (ii) the iris,
- (iii) the lens and
- (iv) the retina.

Light rays enter the eye through cornea, the transparent covering in front of the eye. The cornea is sharply curved and focus the light rays on the retina. Behind the cornea is the pupil that appears black. The amount of light that enters the pupil is regulated by the iris, a ring of muscle whose pigmentation gives the eye its colour (brown, blue etc.). The iris contracts and dilates reflexively and regulates the amount of light that reaches the retina. Iris also allows the eye to adapt as light levels change. For example, when we enter a dark room the iris dilates the pupil so that more light can enter the eye, and when we step out from the dark room into bright sunlight, the iris constricts the pupil to reduce the amount of light entering the eye. After passing through a small aperture (pupil), the light rays pass through a transparent structure called lens. The ciliary muscle attached to the lens modify its curvature to focus light on the retina.

The process of adjusting the lens in accordance with distance, so that the image of the external object is focussed on the retina, is called accommodation, similar to focussing in the camera.

The transparent cornea in front and the tough *sclera* surrounding the retina of the eye serve to protect it from injury and to maintain its shape. The *choroid* is the middle layer of dark material richly supplied with blood vessels. The retina is a thin and delicate inner layer containing the photo-receptors and an elaborate network of interconnecting nerve tissues. Retina is the most important part of the eye.

### **The Retina**

The light reaches the retina by passing through the anterior (front) chamber and posterior chamber containing watery fluid (called aqueous and vitreous humor) and the various retinal layers. Finally it reaches the visual receptors, the rods and the cones. Each retina contains approximately 120 million rods and 6 million cones, located near the back of the retina. These specialized cells (receptors) convert light energy into electrical potential.

#### ***Try it yourself (Sensitivity of visual receptors)***

*It has been stated that rods function most efficiently in the scotopic range or dim light and cones are relatively ineffective in dim light. It is interesting to see for yourself the functioning of rods and cones in darkness.*

*Throw a coin in a dark room and try to search the coin by directly looking at it. You will be surprised to find that the coin is not visible if you look straight at it. Now try looking at it off center by  $10^\circ$ . That is, fixate your eye little away from the coin so that the image of the coin falls away from fovea, on the rods. You can now find the coin. This shows that the fovea, containing only cones, is blind in dark, rods function efficiently at this level.*

Rods mediate scotopic vision (vision in dim light), achromatic vision and signal information about brightness. Cones, on the other hand, mediate photopic vision i.e. daylight vision and responsible for colour vision and detailed vision (like reading).

The rods function most efficiently at low levels of illumination. So they are responsible for scotopic or night time vision. Nocturnal animals, like bats, have been found to have only rods and no cones in their retina. The cones, on the other hand, are most responsive to the daylight vision.

The receptors are not uniformly spread in the human eye. *Fovea*, the very center of retina, contains only cones and no rods. This small region (about 20° of visual angle), the size of a pea, is the only region of the retina with which we can see clearly. Whenever, we read a printed page the image falls on this region. While reading we move our eyes so that the image falls on the fovea. Moving out of this region, rods start appearing and in the periphery there are only rods and no cones.

### **Light and Dark Adaptation**

We have all experienced the momentary blindness when we walk into a movie theatre on a sunny afternoon. This happens because going from a bright light to very dark setting requires a rapid shift from cones to rods. The rods take long to adapt to dim light, the process known as dark adaptation. The chemical in the rods (rhodopsin or visual purple) is bleached in the bright light and restoration process in the dim light takes about half an hour.

The problem starts again when we leave the theatre and go into the bright light. In this case there is a shift from rods to cones. However, the cones are adapted in about 5 minutes; light adaptation is a quick process.

Dark adaptation is a slow process and a chemical in the rods (rhodopsin) undergoes a slow process of regeneration. Light adaptation is a faster process and cones adapt quickly to the differences in brightness. Cones are said to have a chemical known as iodopsin.

### ***Try it yourself (Light and dark adaptation)***

*We have learned about light and dark adaptation in the context of level of stimulation. If we enter a dark room after being in bright light, we are not able to see anything in the room. However, after some time, say 20 minutes or more, we are able to see objects in the room. Let us experience this phenomenon ourselves.*

*Sit in bright sun light for about 10 minutes. Now, move to a dark room (a room in which doors are closed and dark curtains on the windows). You will be surprised to find that you are not able to see various objects in the room. Sit*

*down in the room and you will find that after half an hour or so all the objects are visible clearly. This is possible because rods have been adapted to the dark conditions.*

*Now, again move out in the bright light and you will find it difficult to open your eyes, the level of illumination is intolerable. However, after 5 minutes or so, the eyes are able to tolerate the bright light without any problem.*

## INTEXT QUESTIONS 4.2

Choose the correct alternative

1. Among the different sense organs \_\_\_\_\_ occupies the most dominant position :
  - a. Ear
  - b. Eye
  - c. Semi circular canals
  - d. Tongue
2. The adequate stimulus for the sense modality is given for each of the four senses. Identify the stimulus that is inappropriate for the sense modality :
  - a. Vision - light
  - b. Audition - sound
  - c. Tactile - chemical
  - d. Temperature - heat and cold.
3. Light rays pass through \_\_\_\_\_ to finally reach the retina.
  - a. Cornea
  - b. Pupil
  - c. Lens
  - d. All of the above.
4. The changes in lens which enable the light rays to focus on the retina is :
  - a. Convergence
  - b. Accommodation
  - c. Focussing
  - d. Centering
5. The cones mediate :
  - a. Daylight vision
  - b. Chromatic vision

- c. Detailed vision
  - d. All the above.
6. The rods mediate :
- a. Scotopic vision
  - b. Achromatic vision
  - c. Signal information about brightness
  - d. All the above.

#### 4.5 Sensory Processes other than Vision

We have so far discussed vision and visual processes in some detail. Now we take up briefly the other senses. After vision, audition is used more often than any other sense. The senses, other than vision and audition can be grouped in the following manner :

1. Cutaneous senses that include pressure, touch, temperature (cold and warmth) and pain.
2. Taste
3. Smell
4. Deep senses that include kinesthesia, vestibular, and proprioceptive.

Let us consider these senses briefly.

#### Audition

The auditory receptors in the ears respond to sound waves to produce neural signals. Sound waves are produced by pressure changes in the atmosphere. The eardrum is pushed and pulled by the compressions and expansions and this vibrates in a pattern that corresponds to sound.

Sound waves have two important physical aspects : frequency and amplitude. The pitch of a sound depends on its frequency, higher the frequency, higher the pitch. Frequency is expressed in units called Hertz (Hz.). Young people can hear sounds with frequencies ranging from 20 Hz to 20,000 Hz, with maximum sensitivity in the middle region. With age the audible range is reduced especially on the high frequency side.

The intensity depends upon the amplitude. Intensity is usually expressed in units called the decibels (dB).

*Some dB values are given below for you to grasp the term.*

|                            |   |               |
|----------------------------|---|---------------|
| <i>Whisper</i>             | - | <i>30 dB</i>  |
| <i>Normal conversation</i> | - | <i>60 dB</i>  |
| <i>Loud thunder</i>        | - | <i>120 dB</i> |
| <i>Jet plane take off</i>  | - | <i>140 dB</i> |

Sounds above 120 dB are likely to be painful to the human ear. If the sound is made up of great number of unrelated waves, it is perceived as noise, which we cannot analyze.

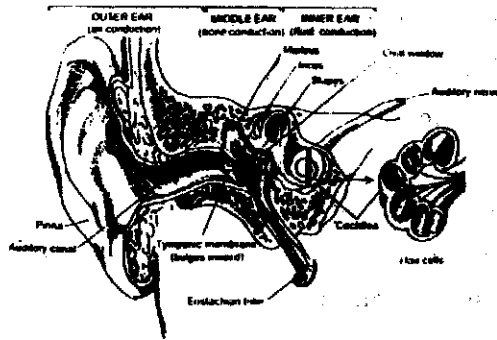


Fig. 4.3. The Structure of Ear

### The Structure of the Ear

The ear has three major divisions :

- (i) *the outer ear*, consisting of pinna and auditory canal;
- (ii) *the middle ear*, consisting of ear drum (tympanic membrane) and
- (iii) *the inner ear* formed by three small bones, also called ossicles the malleus (hammer), incus (anvil) and the stapes (stirrup).

The vibration of the oval window creates waves in the fluid that fills the cochlea. As the waves travel through the cochlear fluid the hair cells bend to and fro. At this point the mechanical energy of the waves is transduced into electro-chemical impulses that are carried by the auditory nerve to the brain. The hair cells in the cochlea are the receptors for hearing, corresponding to rods and cones for vision. The auditory nerve fibers convey the auditory information through series of relay stations to the auditory cortex, located in the temporal lobe of the brain.

### Intext Questions 4.3

(A) Match the following :

- |                  |                  |
|------------------|------------------|
| a. Pitch         | p. Decibels      |
| b. Intensity     | q. Frequency     |
| c. Audible range | r. Expansion     |
| d. Compression   | s. 20-20,000 Hz. |

(B) Choose the correct alternative

1. What is not a part of the auditory system ?
  - a. Tympanic membrane

- b. decibels
  - c. Semicircular canals
  - d. Cochlea
2. Auditory receptors in the ear are :
- a. Hair cells
  - b. Cochlea
  - c. tympanic membrane
  - d. Malleus

---

### **The Cutaneous Senses**

The skin or cutaneous senses give us information about the surface of our body. Skin could be considered a "giant sense organ" that covers the entire human body. Skin senses are :

- (i) Pressure and touch
- (ii) Temperature sensation : cold and warmth
- (iii) Pain

It has been found that the skin is not uniformly sensitive but has differential sensitivity. That is, points of greatest sensitivity to touch, cold, warmth, and pain are differently located.

#### **Pressure and Touch**

The amount of pressure required to produce the experience of pressure varies greatly for different parts of the body. The tip of the tongue, the tips of the fingers, and the hands are the most sensitive areas of the body. The experience of touch is felt if we apply gentle pressure on the skin or if we slightly move the hair on the body.

It is believed that a fairly complex structure called Meissner corpuscles serves the pressure sense in the hairless regions of the body. The basket nerve endings do the same for the roots of the hairs. It is believed that free nerve endings convey touch impulses.

#### **Temperature Sensations : Cold and Warmth**

Experience of cold and warmth are felt by changes in the normal gradient of skin temperature. That is, difference between skin surface temperature and blood temperature.

It is believed that *free nerve endings* appear to be responsible for signaling information about temperature.

#### **Pain**

Pain has great significance in human life, though, we would prefer not to experience it. It has immense biological importance because it signals

---

that something is wrong within the body or skin. If pain sensation were not there we could bleed to death without being aware of the wound.

There is evidence that *free nerve endings* are the receptors stimulated by tissue damage. It is believed that the free nerve endings of pain spots must be specialized in some way to respond to painful stimuli.

---

### Intext Questions 4.4

---

Choose the correct alternative

1. What is not a part of the cutaneous senses ?
  - a. Pressure and touch
  - b. Temperature
  - c. Pain
  - d. Kinesthesia
  
2. Which of the following receptors is not the part of pressure and touch sensation ?
  - a. Meissner corpuscles
  - b. Basket nerve endings
  - c. Free nerve endings
  - d. Hair cell
  
3. Sensation of temperature is believed to be signalled through :
  - a. Free nerve endings
  - b. Hair cells
  - c. neurons
  - d. None of the above

#### ***Try it yourself***

*Though we try to study the sense organs as entities or units but there is interaction of various sense organs in our perception. For example, when we taste an apple, its taste has the combined effect of specific smell, its visual quality (redness), its tactual quality (roundedness, smoothness, firmness etc.) and even its temperature (cold or warm).*

*It will be interesting to taste an apple when you have had cold, when the smell sensation is at its low functioning or no smell sensation at all. If you do not handle the apple yourself and you close your eyes, you will*

*find the taste very different. Again try to taste the same quality of apple when you are all right and eat under normal conditions. You will find the apple very tasty, different from the first condition. This indicates that the different sense organs contribute towards our sense of taste. This is true for other sense organs also. You enjoy the music more when the singer is singing before your eyes as compared to the same music on the tape-recorder.*

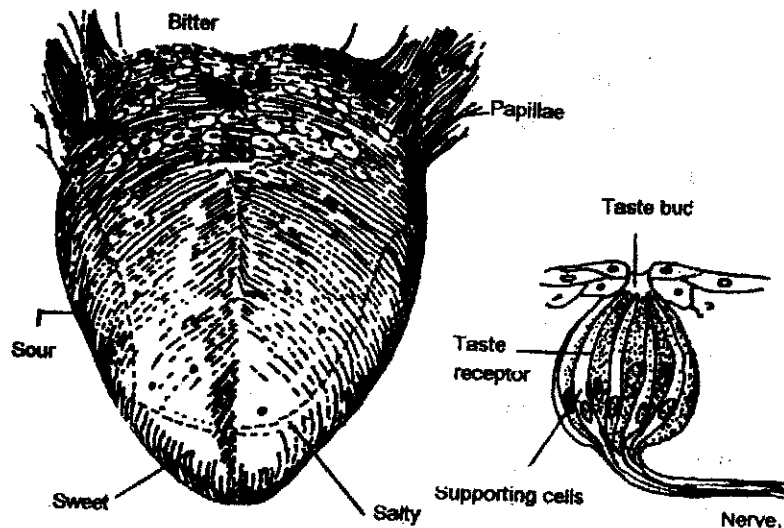


Fig. 4.4 The Structure of the tongue

### The Sense of Taste

The sense of taste, or more technical term gustation, has four basic qualities : Salty, Sour, Sweet, and Bitter. The tongue is not uniformly sensitive to all stimuli. For example, back of the tongue is sensitive to bitter stimuli and the tip of the tongue to sweet. The sides of the tongue respond mainly to sour stimuli and the tip and part of the sides respond to salty solutions.

Taste buds contain hair cells that are the taste receptors. The average person possesses about 10,000 such taste buds, the taste buds are spread all across the surface and sides of the tongue and some are located in other regions of the mouth. However, they are mostly found clumped together on the tongue and are called papillae.

Most of the papillae have grooves (moats) around their sides and when we eat or drink something, the liquid in the mouth fill up these grooves around the papillae and stimulate the hair cells chemically. The cells on their part send sensory message to the brain and results in the sensation of taste.

### The Sense of Smell

Smell, or to use more technical term olfaction, provides information about chemicals suspended in air. We have three main senses that respond to stimuli at distance: Smell, hearing, and vision smell being the most primitive of the three distance senses. Though, smell is a minor sense in human beings, but it greatly adds to our enjoyment of food and our appreciation of perfumes and deodorants. In contrast, smell is of vital importance to many animals like dogs.

Olfactory receptors are located high up in the nasal passage leading from the nostrils to the throat. These receptors lie in two small patches, one on the left and one on the right in the roofs of this passage. These receptors are embedded in a mucus-coated membrane called the olfactory epithelium. These receptors lie a little off the main route of air. Chemicals suspended in the air pass through the nasal passages and stimulate the olfactory receptors which connect with the olfactory nerve.

### Intext Questions 4.5

Choose the correct alternative

1. The back of the tongue is sensitive to \_\_\_\_\_ stimuli.
  - a. sour
  - b. bitter
  - c. salty
  - d. sweet
2. Taste receptors are :
  - a. Taste buds
  - b. Hair cells
  - c. Papillae
  - d. Free nerve endings
3. Olfactory receptors are located :
  - a. In the nose
  - b. High up in the nasal passage
  - c. In the throat
  - d. In the early part of the nose

### Deep Senses

One group of senses perform the function of informing the organism about its own movement and its orientation in space. The collection of three different senses, *Kinesthesia*, *Vestibular*, and *Proprioception*, are called deep senses.

(i) **Kinesthesia** : Skeletal movement of the body is sensed through kinesthesia, a collective term for all the information that we get from receptors in the muscles, tendons and joints. It provides us information about the movement of the body as well as information about bodily posture and orientation.

(ii) **Vestibular Sense** : Another group of receptors, located in the inner ear, signal the rotation of the head. These are receptors in the semicircular canals which are located within the vestibular apparatus of the inner ear.

The three canals in the ear contain viscous liquid that moves when the head is rotated. The motion of this liquid bends hair cells that are located at one end of each canal. When bent these hair cells give rise to nerve impulses that provide information about the nature and extent of head movement or rotation. At the end of the semicircular canals are the vestibular sacs, which contain hair cells that are sensitive to the specific angle of the head. It provides information about the position of the head—straight up and down or tilted.

(iii) **Proprioception** :

The sense of proprioception provides information about the movement of our body parts and their position in space. This system provides us information about each part of our body with respect to its position and action. This is a feedback system that provides information about movement of our body parts.

---

### **Intext Questions 4.6**

---

Choose the correct alternative

1. The deep senses include :
    - a. Kinesthesia
    - b. Vestibular
    - c. Proprioception
    - d. All of the above
  2. In kinesthesia, we get information from receptors in the :
    - a. Muscles
    - b. Tendons
    - c. Joints
    - d. All of the above
  3. Proprioception is a feedback system that provides information to the brain about :
    - a. pain stimulation
    - b. touch sensation
    - c. the movement of our body
    - d. all of the above
-

## What you have learnt

- The sense organs are our windows to collect information from the external world.
- Ten different senses can be identified in human beings. They are Vision, Audition, Tactile, temperature, Pain, Taste, Smell, Kinesthesia, Vestibular and Proprioception. The specific sense organ transforms the physical energy (information) into neural signals and transmits those to the brain. This message is decoded and processed which leads to perception.
- The most developed and used sense organ in human being is vision. Light waves are the stimulus for eyes. The visual receptors, called rods and cones, are activated by these light waves.
- The auditory receptors in the ears respond to sound waves. The sound waves are produced by pressure changes in the atmosphere. The ear has three major divisions - outer ear, middle ear, inner ear.
- The skin (cutaneous senses) gives information about the surface of our body. Some main senses identified are pressure and touch, temperature sensation (cold and warmth) and pain.
- We can sense taste with the help of our tongue. The tongue contains taste buds which are spread all across the surface and sides of the tongue. The taste buds dumped together are called papillae.
- The sense of smell is sensed by the nose. The olfactory receptors are located in the nasal passage. These receptors are embedded in a mucus-coated membrane which is called olfactory epitheli.
- The kinesthesia, vestibular and proprioception are the group of senses which inform the organism about its own movement and orientation.

## Terminal Exercises

- (1) What are the different sense organs? How is the stimulus perceived by the brain.
  - (2) Discuss briefly the function of
    - (a) Retina
    - (b) Rods
    - (c) Cones
  - (3) What are the three major divisions of the ear ?
  - (4) What are the senses other than vision ? Name them and describe their function.
-

### Key to Intext Questions

#### 4.1

- (1) c
- (2) 10
- (3) c

#### 4.2

- (1) b
- (2) c
- (3) d
- (4) b
- (5) d
- (6) d

#### (A) 4.3

- a-q
- b-p
- c-s
- d-r

- #### (B)
- (1) b
  - (2) a

#### 4.4

- (1) d
- (2) d
- (3) a

#### 4.5

- (1) b
- (2) b
- (3) b

#### 4.6

- (1) d
- (2) d
- (3) c

#### Hint to terminal exercises

- (1) consult section 4.3
  - (2) consult section 4.4
  - (3) consult section 4.5
  - (4) consult section 4.5
-