



Notes



4

**BECOMING AWARE OF THE
WORLD AROUND US**

Human beings and animals are able to know the world around them, hear sounds, taste various types of foods, smell different fragrances, feel the warm and cold climate outside, and feel the pain when hurt. The most remarkable characteristic of the organism, human or non-human, is its possession of different sense organs. These sense organs (e.g., eyes, ears, tongue, nose, skin, etc.) are our windows to collect information from the external world. Each of these sense organs is selectively sensitive to different kinds of stimuli. For example, visual sense organ (the eye) is sensitive to receive only light energy, the ear is sensitive to the sound, and so on. Human beings depend primarily on visual, auditory, and cutaneous senses to gather most of the information from the world around them. About 90 percent of the time we use the visual sense, followed by the auditory. In this lesson we will learn about the various sense organs.

**OBJECTIVES**

After studying this lesson, you will be able to:

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



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4.1 VISION, AUDITION, AND OTHER SENSES

The **sense organs**, 10 in all, constitute the information gathering system. Eight of these sense organs are those that collect information from the external world: **vision, audition, smell, taste, touch, warmth, cold, and pain**. The other two are termed as deep senses: **vestibular** and **kinesthetic**. They help us in maintaining body equilibrium and provide important information about body position and movement of body parts relative to each other. In this section, you will study about the structure and function of different human sense organs and how they help us in gathering information from the external and internal world.

External stimulus (e.g. light) is received by a specific sense organ (e.g. eye). Within a sense organ are the specialized receptors that transform the physical energy into **neural signals** (process known as *transduction*) which are then transmitted to the specific 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 pre-processes (encode) 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. The sequence of events is described in Fig. 4.1.

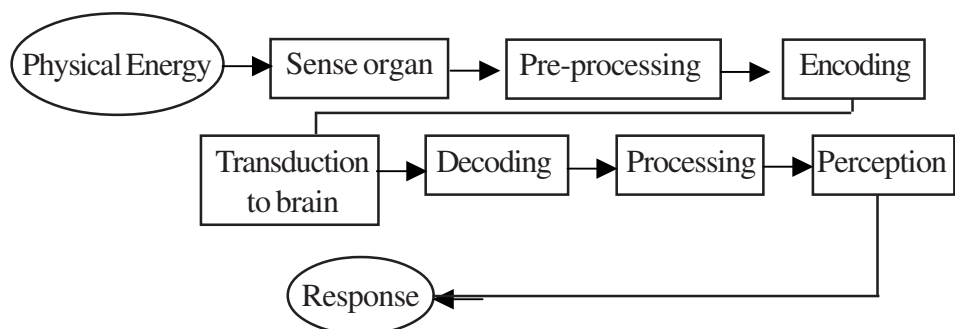


Fig. 4.1: The sequence of processing of stimulus information

Do You Know

Sensory Adaptation

Do you know 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 become aware of that fragrance 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. The sense of touch and smell adapt

quickly whereas sense of pain adapts slowly. On the other hand, the process is very different in visual modality. That is, if you keep looking at one object, the object does not fade or vanish, as is the case with other senses. This is possible because the eye ball, due to very fast tremors, keeps shifting image from one set of receptors to others. Different type of adaptation takes place in the visual modality, called light and dark adaptation.



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

4.2 VISION

The most developed and most frequently used sense organ in human beings is vision. More of the brain is devoted to mechanisms for vision than to any other



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sense. Vision dominates over the information received from other senses. For example, what we see has more importance than what we hear. In our day to day transactions, within the external world, we make the use of vision much more than all the senses combined, about 90 percent of the time.

4.2.1 Physical Nature of Visual Stimuli

As discussed earlier, each of the different sense organs is sensitive to specific physical stimulus called **adequate stimulus**. For example, tactile sense (touch and pressure) is sensitive to touch or pressure upon body's skin surface. Similarly, the eyes are only sensitive to **photopic stimulation** (light). 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.

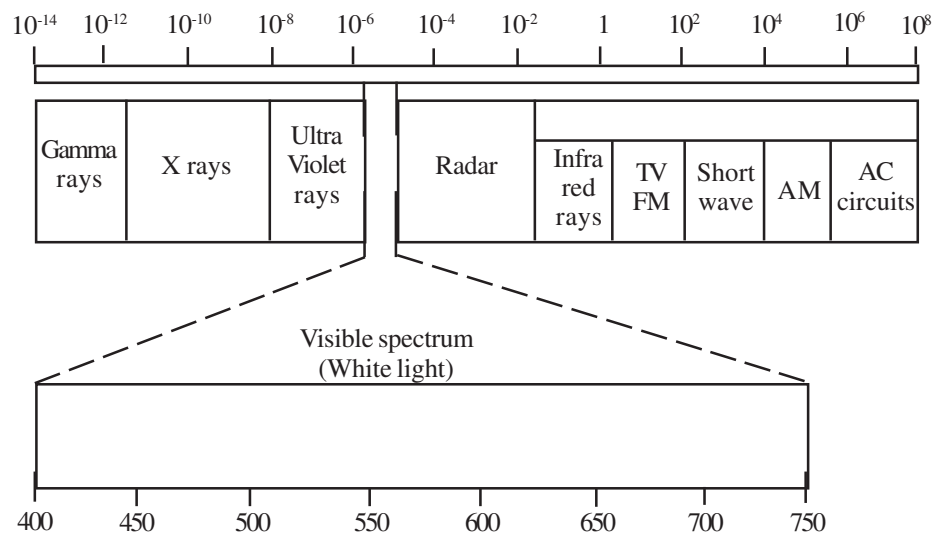


Fig. 4.2: Visible spectrum

The **visible spectrum** for human eye ranges just below 400 nm (**nanometers** or mili-microns) to about 750 nm. Even within this visible spectrum human eye is not uniformly sensitive to all the wavelengths. It can be observed from Fig. 4.2 that the lower end of the **visible spectrum** has Ultraviolet rays and on the upper end are Infrared. These rays are not visible to the human eye and if the eye is exposed to these rays (ultraviolet and infra-red) in large quantity it can harm the eyes.

4.2.2 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:



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- (i) the cornea
- (ii) the iris
- (iii) the lens
- (iv) the retina.

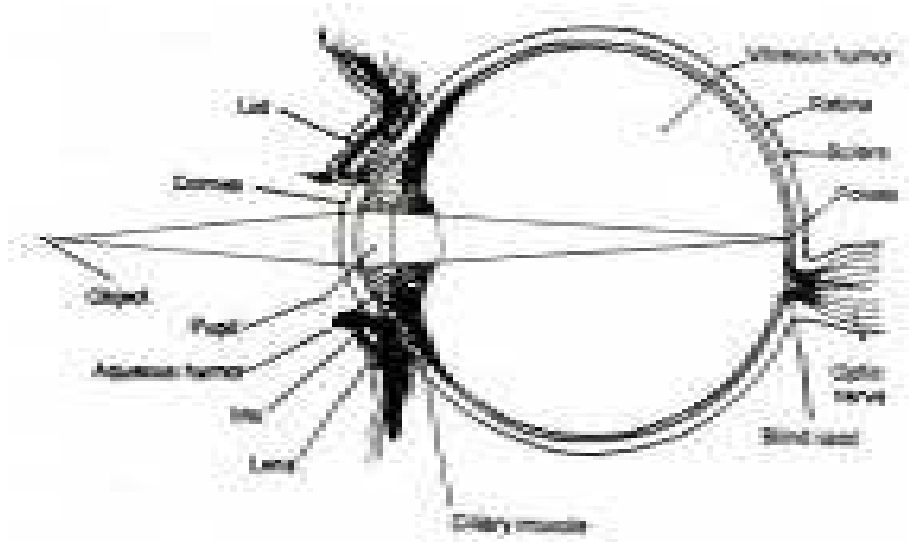


Fig. 4.3 : Structure of eye

Light rays enter the eye through **cornea**, the transparent covering in front of the eye. The cornea is sharply curved. It focuses 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 in accordance with brightness conditions outside. 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 muscles** attached to the **lens** modify its curvature to focus light (accommodation) 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 the focusing 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



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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.

4.2.3 The Retina

The light reaches the retina by passing through the **anterior** (front) and **posterior chambers** 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** (electrical signals).

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 cone 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 about 10 degrees that is, fixate your eye little away from the coin so that the image of the coins falls away from fovea, on the rods. You can now find the coin. This shows that the fovea, containing only cones, is blind in the dark, rods function efficiently at this level.



INTEXT QUESTIONS 4.2

Choose the correct alternative

1. Among the different sense organs _____ occupies the most important and dominant position:
 - a. Ear
 - b. Eye
 - c. Semi circular canals
 - d. Tongue



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2. The adequate stimulus for each of the four sense modalities is given below. Identify the stimulus that is not the adequate stimulus 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 called:
 - a. Convergence
 - b. Accommodation
 - c. Focusing
 - 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.



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4.3 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 and vestibular.

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**. It vibrates in a pattern that corresponds to the 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 (e.g. women's voice has more pitch than that of a male). 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 concept of dB.

Whisper – 30dB

Normal conversation – 60dB

Loud thunder – 120dB

Jet plane take off – 140dB

Sounds above 120 dB are likely to be painful to the human ear. If the sound is produced by the great number of unrelated sound waves, it is perceived as **noise**,



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which we cannot analyze. The sound you hear from a jet aircraft engine or your pressure cooker is called **white noise**.

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 called **ossicles** namely the **malleus** (hammer), **incus** (anvil), and the **stappes** (stirrup).

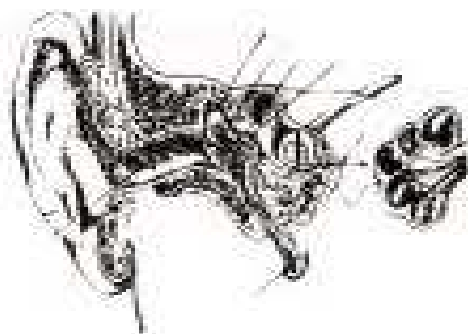


Fig. 4.4: The Structure of Ear

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 (dB) |
| b. Intensity | q. Frequency (Hz) |
| c. Audible range | r. Expansion |
| d. Compression | s. 20-20,000 Hz. |



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(B) Choose the correct alternative

1. What is not a part of the auditory system?
 - a. Tympanic membrane
 - b. Decibels
 - c. Stapes
 - d. Cochlea
2. Auditory receptors for hearing 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 as a “**giant sense organ**” that covers the entire human body. Skin senses, also called **somesthetic system**, consist of :

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

It has been found that the skin is not uniformly sensitive throughout the body, but has differential sensitivity. That is, points of greatest sensitivity to touch, cold, warmth, and pain are differently located in the human body, some areas are more sensitive to touch, others to pain, and so on.

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 or touch 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 **nerve endings** do the



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same for the roots of the hairs. It is believed that **free nerve** endings convey touch impulses.

Sensing the Temperature: Cold and Warmth

Experiences of cold and warmth are felt by the changes in normal **gradient** of skin temperature. That is, difference (gradient) between skin surface temperature and blood temperature. It is believed that free nerve endings appear to be responsible for signaling information about temperature.

Pain

Let us talk about another side of pain, which one has never thought of. 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. If pain sensations were not there, we could bleed to death without being aware of the wound. So pain is friend, not enemy.

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. That is, free nerve ending are specialized to pick up and convey different body conditions.



INTEXT QUESTIONS 4.4

Choose the correct alternative

1. What is not a part of the cutaneous sense?
 - a. Pressure and touch
 - b. Temperature
 - c. Pain
 - d. Kinesthesia
2. Which is 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



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3. Sensation of temperature is believed to be signaled 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 perceptual system. 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 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 several 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 some music on the tape-recorder.

The Sense of Taste

The sense of taste, or the **gustatory system**, has four basic tastes: **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. People, on an average, possess 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*.



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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.

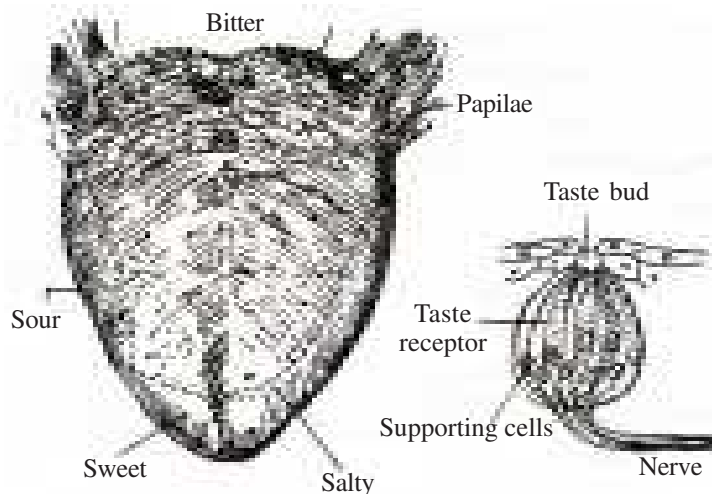


Fig. 4.5: *The Structure of the Tongue*

The Sense of Smell

Smell, or the **olfactory system**, provides information about chemical compounds suspended in the air. We have three main senses that respond to stimuli at a distance: **Smell, hearing, and vision**. Smell is the most primitive of these three. Though, smell is a minor sense in human beings, it greatly adds to our enjoyment of food and appreciation of perfumes and deodorants. In contrast, smell is of vital importance to many animals, like dogs. Dogs and other animals use this sense to locate food, prey, etc.

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 other 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**. Human beings can distinguish among about 10,000 different odours. Interestingly females are somewhat more sensitive and accurate than males in odour recognition.



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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 two different senses, **Kinesthetic** and **Vestibular** systems is called deep senses.

- (i) **The Kinesthetic System :** 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**. Of course, vision helps us a lot in this respect.
- (ii) **The Vestibular System:** 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. The system responds to gravity and keeps us informed about our body's location in space.



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



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- 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
4. The deep senses include:
- a. Kinesthetic system
 - b. Vestibular apparatus
 - c. Semicircular canals
 - d. All of the above
5. In kinesthetic system we get information from receptors in the :
- a. Muscles
 - b. Tendons
 - c. Joints
 - d. All of the above
6. The vestibular system is a feedback system that provides information to the brain about:
- a. pain
 - b. touch
 - c. the movement of our body
 - d. all of the above



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4.4 MIND, BRAIN AND CONSCIOUSNESS

In part I, you studied the role of the senses in providing information about the external and internal world. However, receiving information from the external world and transmitting the same to the brain is just half the story. The chain of events start from stimulus reception through our senses and ends up in reports such as “beautiful flower”, “a bitter taste, or “bright green”. The sensory experience that we get from stimulus through our receptors is a process and a product the end outcome is what we call **perception**, which is discussed in detail in a subsequent lesson (Lesson 5). However in this section we will study how our brain processes the information received from our senses into a **conscious sensory experience**.

Usually, our **conscious experience** (perception) is a result of processing of information that we receive from different sense modalities (e.g. vision, audition, touch, etc.). So, what we experience is a product of the contributions made by different sense organs (modalities) that results in a conscious sensory experience or sensation.

Consciousness

We become aware of the world around us through our consciousness. **Consciousness** is a state of awareness of external and internal events experienced by an individual. In ordinary waking state (consciousness) we are aware of what is going on around us, we are aware of our thoughts, feelings, desires, perceptions etc. On the other hand, if one falls down unconscious due to low blood pressure, one is not aware of all that is happening around the person. When this person gains consciousness, he/she does not know all that was being done to revive him/her.

The state of consciousness, however, keeps on changing even during the waking state. We keep performing many actions at a particular time, some consciously some automatically. For example, while driving a car we keep talking to the person sitting by our side and during this period when we are busy talking we are not conscious (aware) when we lifted our foot from the acceleration pedal, pressed upon the clutch, changed the gear and again started accelerating. In this example the driver was paying attention to the conversation with the other person (conscious act) while the driving part was automatic (without our being conscious). Though, we can perform one action at a time where allocation of attention is required, we can simultaneously carry on the other task if it is highly learnt (it becomes automatic and no conscious control is required). But, think of a driver who is learning to drive, he will not be able to talk and drive because both the tasks require allocation of attention or conscious effort.



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Computers and Human Beings

It is interesting to compare computer and human being. Modern computers are impressive, but none can match the amazing abilities packed within the human brain. In some ways computer may be considered to be superior to human beings. For example, the memory of a computer could be more than that of human being. Further, computer can process large number of variables simultaneously (parallel processing). On the other hand, human being is basically capable of serial processing (one task at a time). For example, if you read a book which needs attention to grasp the material you cannot listen to the music simultaneously, unless the music does not require any attention. However, tasks which are highly practiced, like driving a car can be executed with other tasks that require attentional resources. That means, one task is being performed automatically (without conscious control) and the other under conscious control.

It is important to note that no computer can perform the function of thinking (atleast presently). Computer has no emotions, imagery, insight, desires, motives, and creativity of human brain. Computer can perform to the extent the hard-ware and programmes allow. On the other hand, human brain is capable of performing various cognitive and affective functions without any limit. The most important difference between the two is that human being has consciousness whereas the computer does not.

Mind is often considered a functional correlate of **brain**. Our thoughts, memory, mental images, reasoning, decision making, and so on are all aspects of the human mind. Brain has a physical structure. (e.g. neurons) and some physiological action is generated whenever the brain works. Its psychological correlate is what we call mind. The cognitive functions of the brain are what we call the functioning of mind. The process of socialization and learning experience a human being undergoes amount to programming the hard-ware (brain) the human being inherits.

Levels of Consciousness

Sigmund Freud, the founder of psychoanalysis, believed that human mind has three distinct levels: **the conscious**, **the preconscious**, and **the unconscious**. The conscious mind includes our current thoughts, whatever we are thinking or experiencing at a given movement. Beneath this conscious realm is the much larger preconscious. The preconscious contains memories that are not part of current thought but can be readily brought to mind (conscious) if need arises. Finally, there is the unconscious. This part of the human mind has been compared to iceberg, of



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which the major portion is concealed. The unconscious contains thoughts, desires, and impulses of which we remain largely unaware. Human behaviour reflects all the three levels of consciousness. However, many psychologists do not accept these three levels of consciousness. The first level, that is, consciousness is well accepted by all. The preconscious is what we call stored material (memory) and the material can be **retrieved** when required. However, the third level (unconscious) is very controversial and most of the psychologists, especially, the experimental or the cognitive psychologists do not accept this level at all.



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. These are : Vision, Audition, Tactile, Warmth, Cold, Pain, Smell, Taste, Kinesthetic, and Vestibular. The specific sense organ transforms the physical energy (information) into neural signals and transmits those to the brain. This message is decoded and processed in the brain which leads to perception.
- The most developed and often used sense organ in human being is vision. Light waves are the stimuli for eyes. The visual receptors, called rods and cones, are activated by the 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, and inner ear.
- The skin (cutaneous senses) provides 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 (gustation) 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 together are called papillae.
- The sense of smell (olfaction) 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 epithelium.
- The kinesthetic and vestibular are the group of senses which inform the organism about its own movement and orientation. These are called deep senses.



TERMINAL EXERCISE

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 human ear?
4. What are the cutaneous senses ? Name them and describe their functions.

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ANSWER 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

4.3 (A)

a-q

b-p

c-s

d-r

- (B) 1. b 2.a

4.4

1. d
2. b
3. a

**Notes****4.5**

1. b
2. b
3. b
4. d
5. d
6. c

HINTS TO TERMINAL EXERCISE

1. Refer to section 4.3
2. Refer to section 4.4
3. Refer to section 4.5
4. Refer to section 4.5