1. Cerebrum

The cerebrum makes up the bulk of the human brain. It constitutes 80% of the brain. It develops from the ***fore brain.*** It consists of two large ***cerebral hemispheres.*** The two hemispheres are connected by three bundles of fibres, namely the ***corpus callosum,*** the ***anterior commissure*** and the ***posterior commissure.***

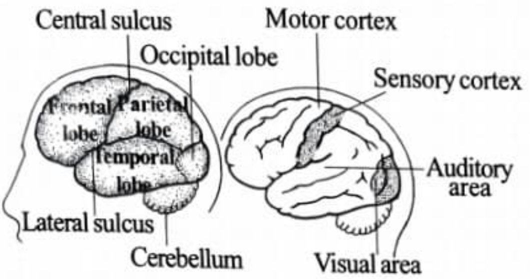

Fig.7.92: Brain of man showing the different areas.

The cerebrum is formed of ***grey matter*** and ***white matter***. The surface of the cerebrum is formed of a thick layer of grey matter. This surface layer of cerebrum is called ***cerebral cortex.***

The surface of the cortex is wrinkled and folded. This increases the surface area of the cortex. The cortex has many ***fissures*** (grooves) and ***convulsions.*** The fissures are called ***sulci*** (sing.sulcus) and the convulsions are called ***gyri.***

The sulci or fissures divide the brain into four lobes, namely ***frontal lobe, temporal lobe, parietal lobe*** and ***occipital lobe.*** These lobes correspond in position to the bones beneath which they lie.

The ***longitudinal fissure*** is a deep cleft in the median plane separating the cerebrum into right and left cerebral hemispheres; it dips a thin plate of duramater called the ***falx cerebri.***

The ***lateral sulcus*** or the fissure of Sylvius separates the temporal lobe from the frontal lobe anteriorly and from the parietal lobe more posteriorly.

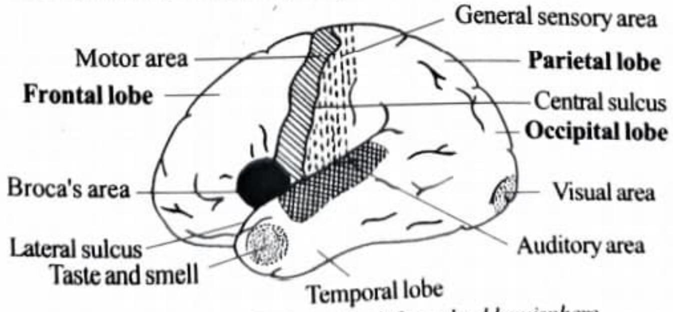

Fig.7.93: Lateral view of the left cerebral hemisphere.

The ***central sulcus*** or ***fissure of holando*** separates the frontal lobes from the parietal lobes. The occipital lobes of the cerebrum are situated behind the parietal lobes and rest upon the ***tentorium cerebelli*** - a fold of duramater which separates the middle cranial fossa from the posterior cranial fossa below.

The cerebral cortex is composed of many layers of nerve cells; it is the ***grey matter*** of the cerebrum. It is arranged in irregular folds of convolutions. This arrangement increases the surface area.

The white matter lies more deeply and consists of nerve fibres belonging to the cells of the cortex.

The cerebral cortex is divided into various ***areas***; some motor and some sensory in function.

The motor area lies just infront of the ***central sulcus.*** This area of the cortex contains large cells which form the beginning of the ***motor*** pathway which controls movement of the opposite side of the body. In the motor area, the body is represented upside down - the lower limb, trunk, upper limb, neck and finally head controlling areas lie from upside down.

The lowest part of the motor cortex is called ***Broca's area*** and is concerned with speech. ***Broca's area*** lies in the left cerebral hemisphere in right-handed people and on the opposite side in those who are left handed.

The ***sensory cortex*** lies immediately behind the central sulcus. Here the various modalities of sensation are appreciated and interpreted.

The ***auditory area*** lies in the temporal lobe just below the longitudinal fissure. Here sound impressions are received and interpreted.

The ***visual area*** lies at the tip of the occipital lobe and receives images and impressions for interpretations.

The centres of ***taste*** and ***smell*** lie well forward in the temporal lobe.

The white matter of the cerebral hemispheres consists of nerve fibres running to and from the cortex linking up the various centres of the brain with the spinal cord.

Lobe				Functions
Frontal lobe	Precentral cortex	Primary motor area	Area 4	Initiates of movements
			Area 4S	Inhibits exaggeration of movements initiated by area 4
		Premotor area	Area 6	Coordinates movements initiated by area 4 Acts as higher center for extrapyramidal system
			Area 8	Frontal eye field Concerned with conjugate movements of eyeballs Concerned with voluntary movements of eyeballs
			Broca area: Areas 44 and 45	Initiates movements involved in speech; motor speech area
		Supplementary motor area	–	Concerned with coordinated skilled movements
	Prefrontal cortex	Areas 9, 10, 11, 12, 13, 14, 23, 24, 29 and 32		Concerned with emotion, learning, memory and social behavior Act as the center for planned actions Form seat of intelligence Initiate autonomic changes during emotional conditions
Parietal lobe	Somesthetic area I	Area 1		Perceives cutaneous and kinesthetic sensations
		Areas 3 and 2		Integrate cutaneous and kinesthetic sensations
		Areas 3, 2 and 1		Send feedback to premotor area Concerned with movements of head and eyeballs Concerned with recognition of discriminative features of sensations
	Somesthetic area II	–		Perceives cutaneous and kinesthetic sensations
	Somesthetic association area	Areas 5 and 7		Synthesize sensations perceived by somesthetic area I (forms the center for combined sensations)
Temporal lobe	Primary auditory area	Areas 41 and 42		Perceive auditory sensation
		Wernicke area		Interprets auditory sensation (along with area 22)
	Secondary auditory area	Area 22		Interprets auditory sensation (along with Wernicke area)
	Area for equilibrium	–		Concerned with maintenance of equilibrium of body
Occipital lobe	Primary visual area	Area 17		Perceives visual sensation
	Secondary visual area	Area 18		Interprets visual sensation
	Occipital eye field	Area 19		Concerned with reflex movement of eyeballs Concerned with associated movements of eyeballs while following a moving object

3. Cerebellum

Cerebellum is the derivative of hind brain. It is the largest part of hind brain. It occupies the posterior cranial fossa and is roofed over by the ***tentorium cerebelli***, a fold of duramater which separates it from the occipital lobes of the cerebrum.

The cerebellum is separated from the pons and medulla by the cavity of IV ventricle. It is divided into two hemispheres by a deep cleft into which dips another fold of duramater, the ***falx cerebelli.***

The arrangement of grey and white matter is similar to that found in the cerebrum with the grey matter arranged at the surface.

The surface is ***ridged*** rather than folded into convolutions, the fissures between the ridges being very much closer together than the sulci of the cerebral cortex.

The cerebellum has connections with many other parts of the nervous system. Its principal connections are with the cerebral hemisphere of the opposite side and with brain stem. It also receives fibres from the spinal cord and is connected with the reflex centres of sight in the roof of the midbrain, with thalamus and with the auditory or acoustic nerve of hearing.

Functions of Cerebellum

Cerebellum regulates ***posture*** and postural activities. It plays an important part in ***muscular coordination*** and the ***maintenance of balance.*** Because of the coordination capacities of the cerebellum we are able to carry out complex functions such as ***walking***, ***riding a bicycle***, ***driving a car***, ***swallowing*** and ***playing a piano.***

Hypothalamus: Hypothalamus is a derivative of forebrain. It is located in the floor of the third ventricle. It produces two hormones, namely ***oxytocin*** and ***antidiuretic hormone*** (and are released through the posterior lobe of pituitary). It also regulates the secretion of ***tropic hormones*** from the pituitary gland. Hypothalamus is the control centre for sexual drive, anger, hunger, thirst, pleasure, body temperature, blood pressure, heart beat rate, etc.

FUNCTIONS OF HYPOTHALAMUS

Hypothalamus is the important part of brain, concerned with **homeostasis** of the body. It regulates many vital functions of the body like endocrine functions, visceral functions, metabolic activities, hunger, thirst, sleep, wakefulness, emotion, sexual functions, etc. (Table 149.2).

1. SECRETION OF POSTERIOR PITUITARY HORMONES

Hypothalamus is the site of secretion for the posterior pituitary hormones. **Antidiuretic hormone** (ADH) and **oxytocin** are secreted by supraoptic and paraventricular nuclei. These two hormones are transported by means of axonic or axoplasmic flow through the fibers of hypothalamohypophyseal tracts to posterior pituitary. Refer Chapter 66 for details.

2. CONTROL OF ANTERIOR PITUITARY

Hypothalamus controls the secretions of anterior pituitary gland by secreting **releasing hormones** and **inhibitory hormones.** It secretes seven hormones.

i. Growth hormone-releasing hormone (GHRH)
ii. Growth hormone-releasing polypeptide (GHRP)
iii. Growth hormone-inhibiting hormone (GHIH) or somatostatin
iv. Thyrotropin-releasing hormone (TRH)
v. Corticotropin-releasing hormone (CRH)
vi. Gonadotropin-releasing hormone (GnRH)
vii. Prolactin-inhibiting hormone (PIH).

These hormones are secreted by discrete areas of hypothalamus and transported to anterior pituitary by the **hypothalamohypophyseal portal blood vessels.** Refer Chapter 66 for details.

3. CONTROL OF ADRENAL CORTEX

Anterior pituitary regulates adrenal cortex by secreting **adrenocorticotropic hormone** (ACTH). ACTH secretion is in turn regulated by corticotropin-releasing hormone (CRH), which is secreted by the paraventricular nucleus of hypothalamus (Refer Chapter 70 for details).

4. CONTROL OF ADRENAL MEDULLA

Dorsomedial and posterior hypothamic nuclei are excited by emotional stimuli. These hypothalamic nuclei, in turn, send impulses to adrenal medulla through sympathetic fibers and cause release of **catecholamines,** which are essential to cope up with emotional stress (Chapter 71).

5. REGULATION OF AUTONOMIC NERVOUS SYSTEM

Hypothalamus controls autonomic nervous system (ANS). Sympathetic division of ANS is regulated by posterior and lateral nuclei of hypothalamus. Parasympathetic division of ANS is controlled by anterior group of nuclei. The effects of cerebral cortex on ANS are executed through hypothalamus (Chapter 164).

TABLE 149.2: Functions of hypothalamus

Functions	Action/Center	Nuclei/Parts involved
1. Control of anterior pituitary	Releasing hormones Inhibiting hormones	Discrete areas
2. Secretion of posterior pituitary hormones	Oxytocin Antidiuretic hormone (ADH)	Paraventricular nucleus Supraoptic nucleus
3. Control of adrenal cortex	Corticotropin-releasing hormone (CRH)	Paraventricular nucleus
4. Control of adrenal medulla	Catecholamines during emotion	Posterior and dorsomedial nuclei
5. Regulation of autonomic nervous system (ANS)	Sympathetic Parasympathetic	Posterior and lateral nuclei Anterior nuclei
6. Regulation of heart rate	Acceleration Inhibition	Posterior and lateral nuclei Preoptic and anterior nuclei
7. Regulation of blood pressure	Pressor effect Depressor effect	Posterior and lateral nuclei Preoptic area
8. Regulation of body temperature	Heat gain center Heat loss center	Posterior hypothalamus Anterior hypothalamus
9. Regulation of hunger and food intake	Feeding center Satiety center	Lateral nucleus Ventromedial nucleus
10. Regulation of water intake	Thirst center Water retention by ADH	Lateral nucleus Supraoptic nucleus
11. Regulation of sleep and wakefulness	Sleep Wakefulness	Anterior hypothalamus Mamillary body
12. Regulation of behavior and emotion	Reward center Punishment center	Ventromedial nucleus Posterior and lateral nuclei
13. Regulation of sexual function	Sexual cycle	Arcuate and posterior nuclei
14. Regulation of response to smell	Autonomic responses	Posterior hypothalamus
15. Role in circadian rhythm	Rhythmic changes	Suprachiasmatic nucleus

6. REGULATION OF HEART RATE

Hypothalamus regulates heart rate through **vasomotor center** in the medulla oblongata. Stimulation of posterior and lateral nuclei of hypothalamus increases the heart rate. Stimulation of preoptic and anterior nuclei decreases the heart rate (Chapter 101).

7. REGULATION OF BLOOD PRESSURE

Hypothalamus regulates the blood pressure by acting on the **vasomotor center.** Stimulation of posterior and lateral hypothalamic nuclei increases arterial blood pressure and stimulation of preoptic area decreases the blood pressure (Chapter 103).

8. REGULATION OF BODY TEMPERATURE

Body temperature is regulated by hypothalamus, which sets the normal range of body temperature. The set point, under normal physiological conditions is 37°C. Hypothalamus has two centers which regulate the body temperature:

i. **Heat loss center** that is present in preoptic nucleus of anterior hypothalamus
ii. **Heat gain center** that is situated in posterior hypothalamic nucleus.

Regulation of body temperature is explained in Chapter 63.

9. REGULATION OF HUNGER AND FOOD INTAKE

Food intake is regulated by two centers present in hypothalamus:

i. Feeding center
ii. Satiety center.

Feeding Center

Feeding center is in the lateral hypothalamic nucleus. In experimental conditions, stimulation of this center in animals leads to uncontrolled hunger and increased food intake **(hyperphagia)**, resulting in obesity. Destruction of feeding center leads to loss of appetite **(anorexia)** and the animal refuses to take food.

Normally, feeding center is always active. That means, it has the tendency to induce food intake always.

Satiety Center

Satiety center is in the ventromedial nucleus of the hypothalamus. Stimulation of this nucleus in animals causes total loss of appetite and cessation of food intake. Destruction of satiety center leads to **hyperphagia** and the animal becomes obese. This type of obesity is called **hypothalamic obesity.**

Satiety center plays an important role in the regulation of food intake by temporary inhibition of feeding center after food intake.

10. REGULATION OF WATER BALANCE

Hypothalamus regulates water content of the body by two mechanisms:

i. Thirst mechanism
ii. Antidiuretic hormone (ADH) mechanism.

i. *Thirst Mechanism*

Thirst center is in the lateral nucleus of hypothalamus. There are some **osmoreceptors** in the areas adjacent to thirst center. When the ECF volume decreases, the osmolality of ECF is increased. If the osmolarity increases by 1% to 2%, the osmoreceptors are stimulated. Osmoreceptors in turn, activate the **thirst center** and thirst sensation is initiated. Now, the person feels thirsty and drinks water. Water intake increases the ECF volume and decreases the osmolality (Fig. 149.4).

ii. *ADH Mechanism*

Simultaneously, when the volume of ECF decreases with increased osmolality, the supraoptic nucleus is stimulated and ADH is released. ADH causes **retention of water** by facultative reabsorption in the renal tubules. It increases the ECF volume and brings the osmolality back to the normal level. On the contrary, when ECF volume is increased, the supraoptic nucleus is not stimulated and ADH is not secreted. In the absence of ADH, more amount of water is excreted through urine and the volume of ECF is brought back to normal.

11. REGULATION OF SLEEP AND WAKEFULNESS

Mamillary body in the posterior hypothalamus is considered as the **wakefulness center.** Stimulation of mamillary body causes wakefulness and its lesion leads to sleep. Stimulation of anterior hypothalamus also leads to sleep.

12. ROLE IN BEHAVIOR AND EMOTIONAL CHANGES

The behavior of animals and human beings is mostly affected by two responding systems in hypothalamus and other structures of limbic system. These two systems act opposite to one another.

The responding systems are concerned with the affective nature of sensations, i.e. whether the sensations are pleasant or painful. These two qualities are called the reward (satisfaction) and punishment (aversion or avoidance). Hypothalamus has two centers for behaviorial and emotional changes. They are:

i. Reward center
ii. Punishment center.

Reward Center

Reward center is situated in medial forebrain bundle and ventromedial nucleus of hypothalamus. Electrical stimulation of these areas in animals pleases or satisfies the animals.

Punishment Center

Punishment center is situated in posterior and lateral nuclei of hypothalamus. Electrical stimulation of these nuclei in animals leads to pain, fear, defense, escape reactions and other elements of punishment.

Role of Reward and Punishment Centers

The importance of the reward and punishment centers lies in the behavioral pattern of the individuals. Almost all the activities of day-to-day life depend upon reward and punishment. While doing something, if the person is rewarded or feels satisfied, he or she continues to do so. If the person feels punished or unpleasant, he or she stops doing so. Thus, these two centers play an important role in the development of the behavioral pattern of a person.

Rage

Rage refers to violent and aggressive emotional expression with extreme anger. It can be developed in animals by stimulating the punishment centers in posterior and lateral hypothalamus. The reactions of rage are expressed by developing a defense posture, which includes:

i. Extension of limbs
ii. Lifting of tail
iii. Hissing and spitting
iv. Piloerection
v. Wide opening of eyeballs
vi. Dilatation of pupil
vii. Severe savage attack even by mild provocation.

Sham Rage

Sham rage means false rage. It is an extreme emotional condition that resembles rage and occurs in some pathological conditions in humans.

In physiological conditions, the animals and human beings maintain a balance between the rage and its opposite state. This balanced condition is called the **calm emotional state.** A major irritation may make a person to loose the temper. However, the minor irritations are usually ignored or overcome. It is because of inhibitory influence of cerebral cortex on hypothalamus. But the calm emotional state is altered during brain lesions. In some cases, even a mild stimulus evokes sham rage. It can occur in decorticated animal also.

Sham rage is due to release of hypothalamus from the inhibitory influence of cortical control.

■ 13. REGULATION OF SEXUAL FUNCTION

In animals, hypothalamus plays an important role in maintaining the sexual functions, especially in females. A decorticate female animal will have regular estrous cycle, provided the hypothalamus is intact. In human beings also, hypothalamus regulates the sexual functions by secreting gonadotropin-releasing hormones. Arcuate and posterior hypothalamic nuclei are involved in the regulation of sexual functions.

■ 14. ROLE IN RESPONSE TO SMELL

Posterior hypothalamus along with other structures like hippocampus and brainstem nuclei are responsible for the autonomic responses of body to olfactory stimuli. The responses include feeding activities and emotional responses like fear, excitement and pleasure.

■ 15. ROLE IN CIRCADIAN RHYTHM

Circadian rhythm is the regular recurrence of physiological processes or activities, which occur in cycles of 24 hours. It is also called diurnal rhythm. The term circadian is a Latin word, meaning 'around the day'.

Circadian rhythm develops in response to recurring daylight and darkness. The cyclic changes taking place in various physiological processes are set by means of a hypothetical internal clock that is often called **biological clock.**

Suprachiasmatic nucleus of hypothalamus plays an important role in setting the biological clock by its connection with retina via retinohypothalamic fibers. Through the efferent fibers, it sends circadian signals to different parts and maintains the circadian rhythm of sleep, hormonal secretion, thirst, hunger, appetite, etc.

Whenever body is exposed to a new pattern of daylight or darkness rhythm, the biological clock is reset, provided the new pattern is regular. Accordingly, the circadian rhythm also changes.