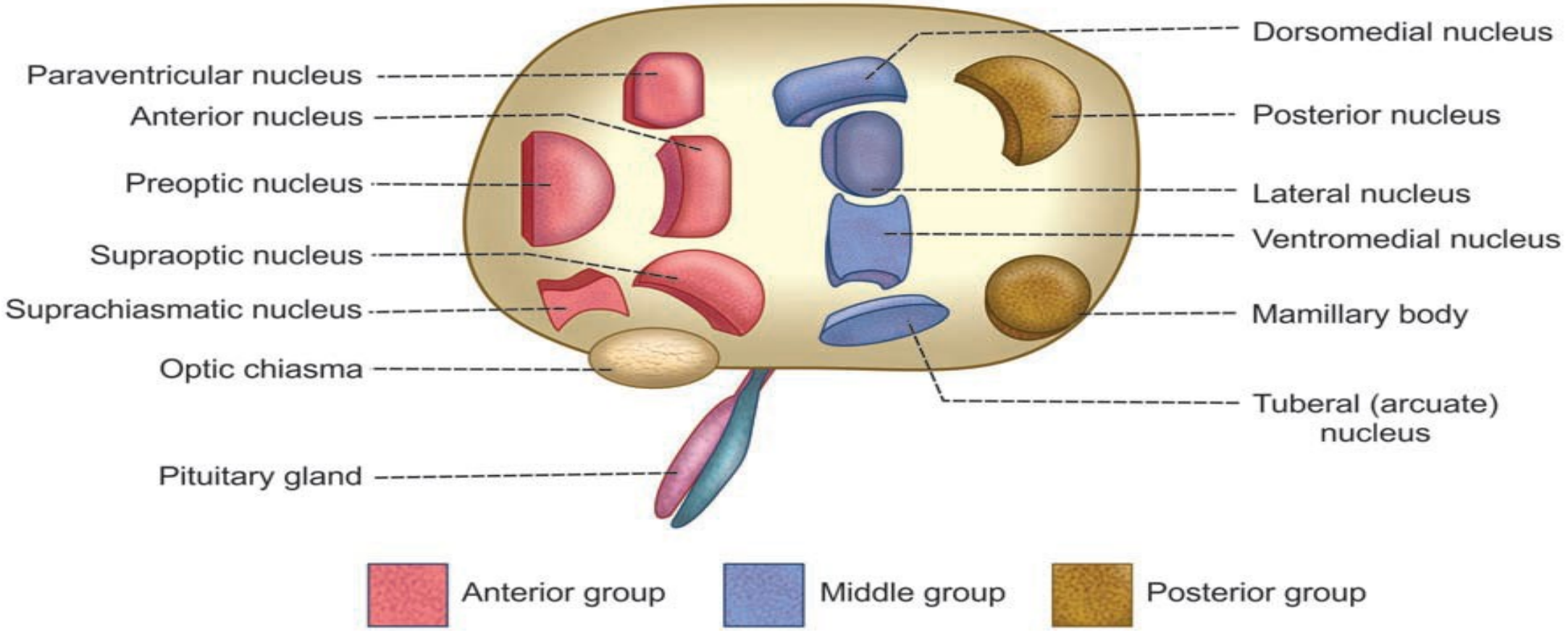
HYPOTHALAMUS

BY Dr. DINESH CHOUHAN

INTRODUCTION

- Hypothalamus is a diencephalic structure.
- It is situated just below thalamus in the ventral part of **diencephalon.**
- It is formed by groups of nuclei, scattered in the walls and floor of third ventricle.
- It extends from optic chiasma to mamillary body.



NUCLEI OF HYPOTHALAMUS

- Nuclei of hypothalamus are divided into three groups:

1. Anterior or preoptic group
2. Middle or tuberal group
3. Posterior or mamillary group.

- Nuclei of each group are listed in Table.

Anterior or Preoptic group	Middle or Tuberal group	Posterior or Mamillary group
1. Preoptic nucleus	1. Dorsomedial nucleus	1. Posterior nucleus
2. Paraventricular nucleus	2. Ventromedial nucleus	2. Mamillary body
3. Anterior nucleus	3. Lateral nucleus	
4. Supraoptic nucleus	4. Arcuate (tuberal) nucleus	
5. Suprachiasmatic nucleus		

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.

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.

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.**

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.

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.

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.

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.

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.

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.

9. REGULATION OF HUNGER AND FOOD INTAKE

- Food intake is regulated by two centers present in hypothalamus:

i. 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.

ii. 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.

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.

13. REGULATION OF SEXUAL FUNCTION

- In animals, hypothalamus plays an important role in maintaining the sexual functions, especially in females.
- In human beings 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.

APPLIED PHYSIOLOGY – DISORDERS OF HYPOTHALAMUS

- The lesion of hypothalamus occurs due to tumors, encephalitis and ischemia.
- Following features develop in hypothalamic lesion:

1. Disturbances in carbohydrate and fat metabolisms, when lateral, arcuate and ventromedial nuclei are involved in lesion.

2. Disturbance in sleep due to lesion in mamillary body and anterior hypothalamus.
3. Disturbance in sympathetic or parasympathetic function occurs due to lesion in posterior, lateral and anterior nuclei.
4. Emotional manifestations, leading to sham rage due to lesion in ventromedial and posterolateral parts.
5. Disturbance in sexual functions due to the lesion in midhypothalamus.

- One or more of the above features can become prominent, resulting in some clinical manifestations such as:

i. **Diabetes insipidus** is characterized by excretion of large quantity of water through urine.
ii. **Dystrophia adiposogenitalis** is characterized by obesity and sexual infantilism.
iii. **Kallmann syndrome** genetic disorder characterized by hypogonadism, associated with **anosmia.**

iv. **Laurence-Moon-Biedl syndrome** characterized by moon face (facial contours become round by hiding the bony structures), obesity, **polydactylism**, mental retardation and hypogenitalism.
v. **Narcolepsy** abnormal sleep pattern. There is a sudden attack of uncontrollable desire for sleep and the person suddenly falls asleep. It occurs in the daytime.
vi. **Cataplexy** sudden uncontrolled outbursts of emotion associated with narcolepsy. Due to emotional outburst like anger, fear or excitement, the person becomes completely exhausted with muscular weakness.