

ENDOCRINE SYSTEM

Endocrine - General

- Ductless Glands; Produce Hormones
- Diffuse into Blood
- **Slow** Initial Effects, but Effects **Persist** much longer
- Hormones act on specific Targets

Endocrine Organs

- Pineal Gland
- Hypothalamus
- Pituitary
 - Anterior
 - Posterior
- Thyroid Gland
- Parathyroid Glands
- Thymus
- Adrenal Glands
 - Cortex
 - Medulla
- Pancreas
- Gonads
- Kidney/adipocytes/
small intestine

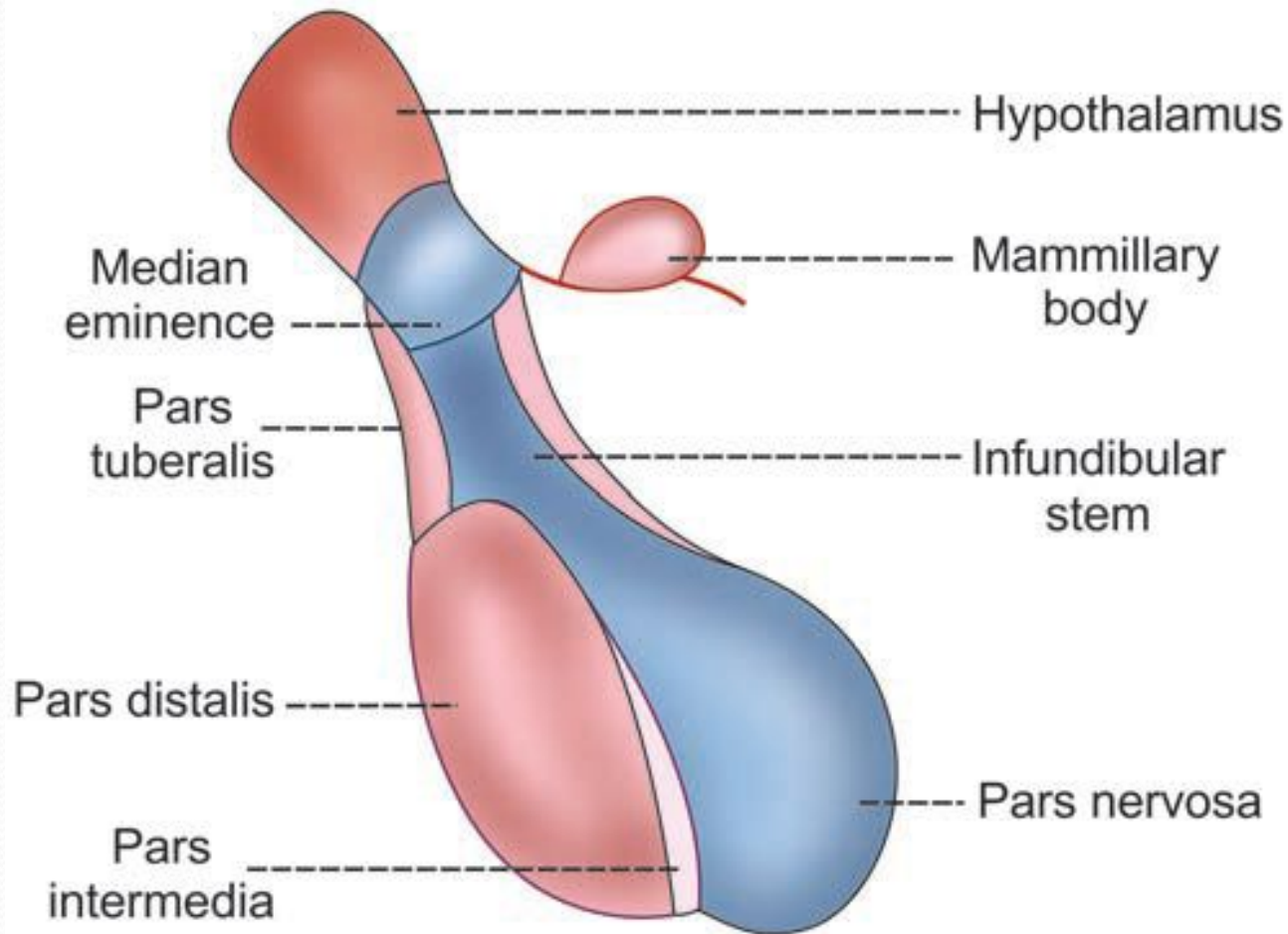
Pituitary gland

- Pituitary gland or **hypophysis** is a **small endocrine** gland with a diameter of 1 cm and weight of 0.5 to 1 g.
- It is situated in a depression called '**sella turcica**', Present base of skull. It is connected with the hypothalamus by the **pituitary stalk** or **hypophyseal stalk**.

DIVISIONS OF PITUITARY GLAND

- Pituitary gland is divided into two divisions:
- 1. Anterior pituitary or adenohypophysis.
- 2. Posterior pituitary or neurohypophysis.

Parts of pituitary gland



Adenohypophysis (red region) Neurohypophysis (blue region)

ANTERIOR PITUITARY OR ADENOHYPHYSIS

Anterior pituitary is also known as the **master gland** because it regulates many other endocrine glands through its hormones.

„ PARTS

Anterior pituitary consists of three parts :

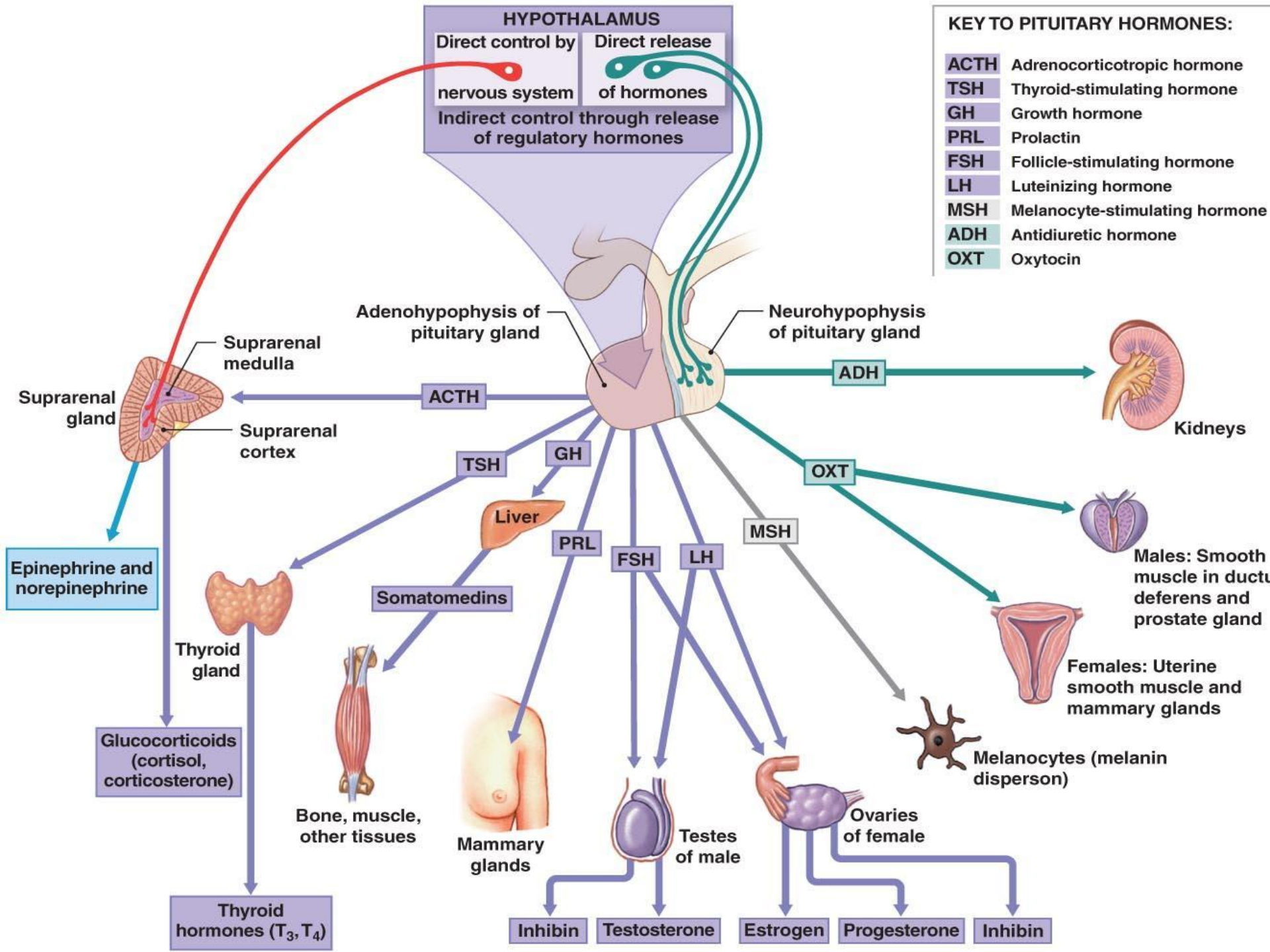
1. Pars distalis
2. Pars tuberalis
3. Pars intermedia.

Hypothalamus

- Communicates with anterior pituitary via hypothalamic-hypophyseal portal vein
- Dumps protein hormones into portal vein to anterior pituitary
- Releasing hormones stimulate hormone production in anterior pituitary
- Inhibiting hormones prevent hormone production in anterior pituitary.

Releasing and Inhibitory Hormones Secreted by Hypothalamus

- 1. Growth hormone-releasing hormone (GHRH):**
Stimulates the release of growth hormone
- 2. Growth hormone-releasing polypeptide (GHRP):**
Stimulates the release of growth hormone
- 3. Growth hormone-inhibitory hormone (GHIH)** Inhibits the growth hormone release
- 4. Thyrotropic-releasing hormone (TRH):** Stimulates the release of thyroid stimulating hormone
- 5. Corticotropin-releasing hormone (CRH):** Stimulates the release of adrenocorticotropin (ACTH)
- 6. Gonadotropin-releasing hormone (GnRH):** Stimulates the release of gonadotropins, FSH and LH
- 7. Prolactin-inhibitory hormone (PIH):** Inhibits prolactin.



REGULATION OF ANTERIOR PITUITARY SECRETION

Hypothalamus controls anterior pituitary by secreting the releasing and inhibitory hormones (factors), which are called **neurohormones**.

These hormones from hypothalamus are transported to anterior pituitary **through hypothalamo-hypophyseal portal vessels**.

HORMONES SECRETED BY ANTERIOR PITUITARY

Six hormones are secreted by the anterior pituitary:

1. Growth hormone (GH) or somatotropic hormone (STH)

2. Thyroid-stimulating hormone (TSH) or thyrotropic hormone

3. Adrenocorticotropic hormone (ACTH)

4. Follicle-stimulating hormone

Luteinizing hormone (LH) in females or interstitialcell-stimulating hormone (ICSH) in males

6. Prolactin.

GROWTH HORMONE

Growth hormone is transported in blood by GH-binding proteins (GHBPs).

GH is protein in nature, having 191 aminoacids.

GH is responsible for the growth of almost all tissues of the body.

Action of Growth hormone

On metabolism

GH increases the synthesis of proteins, mobilization of lipids and conservation of carbohydrates.

a. On protein metabolism

GH accelerates the synthesis of proteins by: i. Increasing amino acid transport through cell Membrane and thus, the synthesis of proteins is accelerated.

ii. Increasing ribonucleic acid (RNA) translation:

GH increases the translation of RNA in the Cells. Because of this, ribosomes are activated and more proteins are synthesized.

iii. Increasing transcription of DNA to RNA: *It also* stimulates the transcription of DNA to RNA. RNA, in turn accelerates the synthesis of proteins in the cells

iv. Decreasing catabolism of protein: *GH inhibits* the breakdown of cellular protein. It helps in the building up of tissues.

On fat metabolism:

GH mobilizes fats from adipose tissue. So, the concentration of fatty acids increases in the body fluids. These fatty acids are used for the production of energy. by the cells. Thus, the **proteins are spared**.

On carbohydrate metabolism:

Major action of GH on carbohydrates is the **conservation of glucose**. Decrease in the peripheral utilization of glucose for the production of energy. **Increase in the deposition of glycogen** in the cells.

Decrease in the uptake of glucose by the cells: As glycogen deposition increases, the cells become saturated with glycogen. Because of this, no more glucose can enter the cells from blood. So, the **blood glucose level increases**.

On bones

It increases both the length as well as the thickness of the bones.

In bones, GH increases:

- i. Synthesis and deposition of proteins by osteogenic cells.
- ii. Multiplication of **chondrocytes and osteogenic cells** by enhancing the intestinal calcium absorption.
- iii. Formation of new bones by converting chondrocytes into osteogenic cells
- iv. Availability of calcium for mineralization of bone matrix.

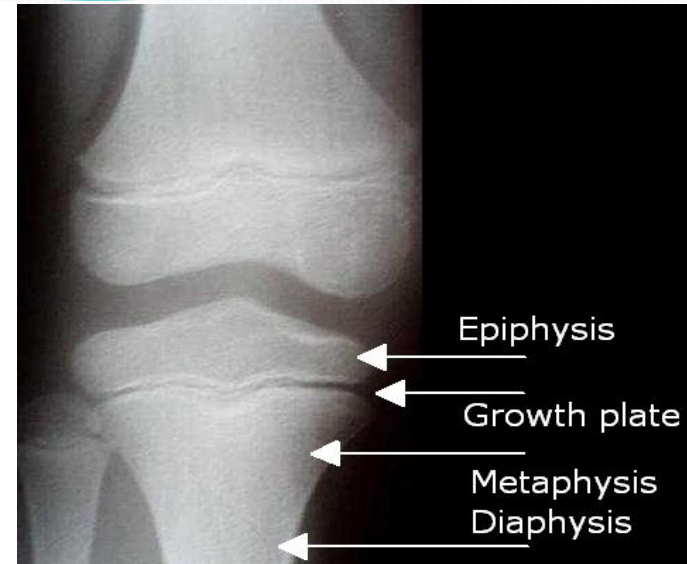
GH increases the length of the bones, until epiphysis fuses with shaft, which occurs at the time of puberty.

After the **epiphyseal fusion, length of the bones cannot** be increased. However, the bone continues to grow in thickness.

EPIPHYSEAL FUSION OF BONE

Long bones have three distinct sections — the **diaphysis**, or shaft; the **metaphysis**, and the **epiphysis**, or end cap of the bone.

Long bone growth takes place at the epiphyseal plate or growth plate, located between the metaphysis and epiphysis. In the picture above, all three sections of bone are clearly visible in a knee x-ray of a young person. Which, show the gap where the growth plate still exists. Second picture is a X ray adult knee.



POSTERIOR PITUITARY OR NEUROHYPOPHYSIS

PARTS

Posterior pituitary consists of three parts:

1. Pars nervosa or infundibular process
2. Neural stalk or infundibular stem
3. Median eminence.

Posterior pituitary hormones are:

1. **Antidiuretic hormone (ADH) or vasopressin**
2. **Oxytocin.**

Posterior pituitary does not secrete any hormone.

ADH and oxytocin are synthesized in the hypothalamus.

From hypothalamus, these two hormones are transported to the posterior pituitary through the nerve fibers of **hypothalamo-hypophyseal tract** by means of axonic flow.

Proteins involved in transport of these hormones are called neurophysins.

In the posterior pituitary, these hormones are stored at the nerve endings. Whenever, the impulses from hypothalamus reach the posterior pituitary, these hormones are released from the nerve endings into the circulation. Hence, these two hormones are called **neurohormones**.

Neurophysins

Neurophysins are the binding proteins which transport ADH and oxytocin from hypothalamus to posterior pituitary via hypothalamo-hypophyseal tract and storage of these hormones in posterior pituitary. Neurophysin I or oxytocin-neurophysin is the binding protein for oxytocin and neurophysin II or ADH-neurophysin is the binding protein for ADH.

oxytocin

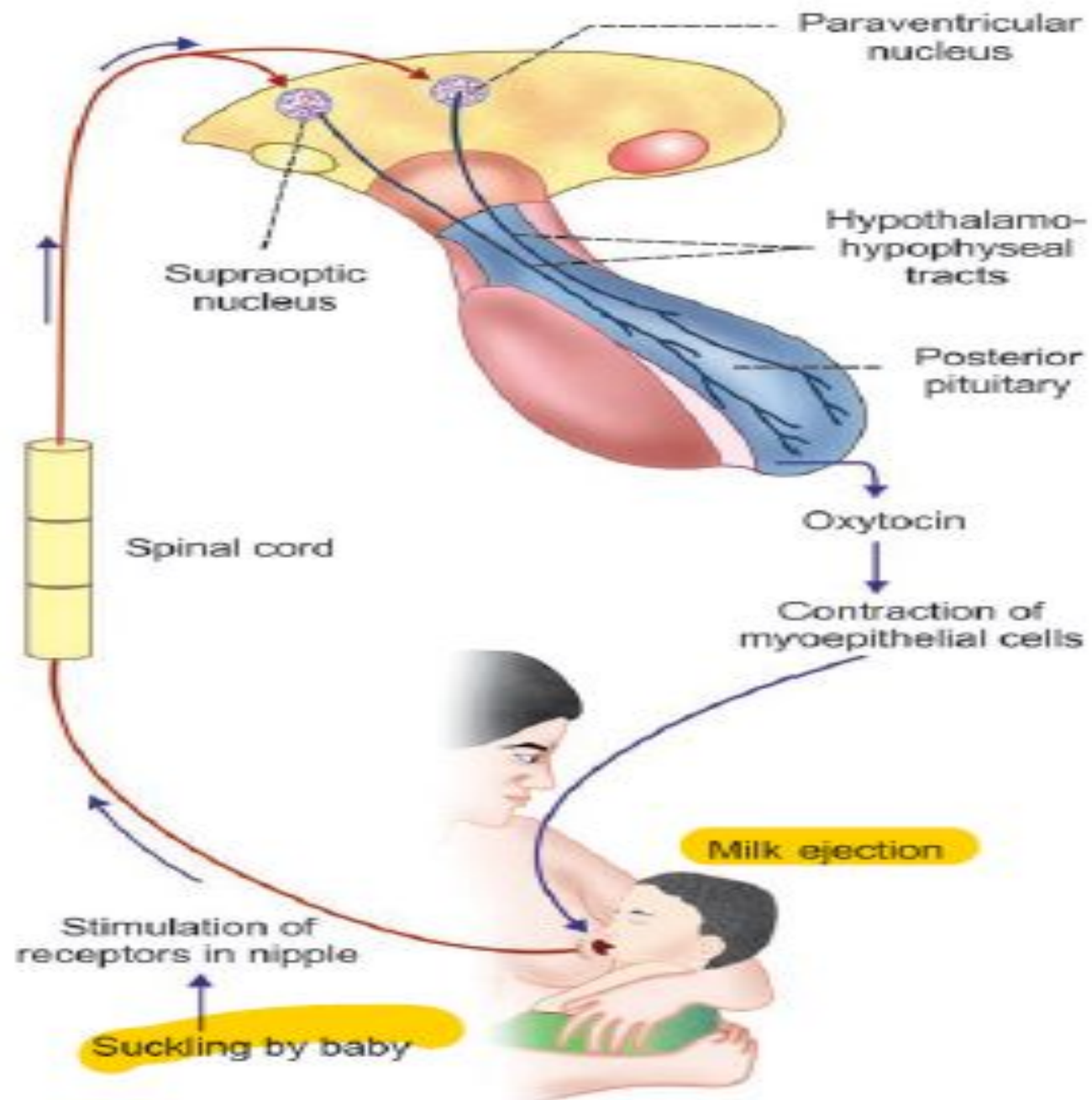
Oxytocin is secreted mainly by **paraventricular nucleus** of hypothalamus. It is also secreted by **supraoptic nucleus** in small quantity and it is transported from hypothalamus to posterior pituitary through the nerve fibers of **hypothalamo-hypophyseal tract**.

Actions in Females

In females, oxytocin acts on **mammary glands** and uterus. *Action of oxytocin on mammary glands*

Oxytocin causes **ejection of milk** from the mammary glands. Ducts of the mammary glands are lined by myoepithelial cells. **Oxytocin causes contraction of the myoepithelial cells and flow of milk from alveoli of mammary glands to the exterior through duct system and nipple.**

The process by which the milk is ejected from alveoli of mammary glands is called milk ejection reflex .



Action on uterus

Oxytocin acts on pregnant uterus and also non-pregnant uterus.

On pregnant uterus

Throughout the period of pregnancy, oxytocin secretion is inhibited by estrogen and progesterone.

At the end of pregnancy, the secretion of these two hormones decreases suddenly and the secretion of oxytocin increases.

Oxytocin causes contraction of uterus and helps in the expulsion of fetus.

During the later stages of pregnancy, the number of receptors for oxytocin increases in the wall of the uterus.

Oxytocin secretion increases during **labor**. i.e. oxytocin induces contraction of uterus.

On non-pregnant uterus

The action of oxytocin on non-pregnant uterus is to facilitate the transport of sperms through female genital tract up to the fallopian tube,

Action in Males

In males, the release of oxytocin increases during ejaculation. It facilitates release of sperm into urethra by causing contraction of smooth muscle fibers in reproductive tract.

„ HYPERACTIVITY OF POSTERIOR PITUITARY

Syndrome of Inappropriate Hypersecretion of Antidiuretic Hormone (SIADH)

SIADH is the disease characterized by loss of sodium through urine due to hypersecretion of ADH.

In **normal conditions**, ADH decreases the urine output by reabsorption of water in distal convoluted tubule and the collecting duct. Urine that is formed is concentrated with sodium and other ions. Loss of sodium decreases the osmolarity of plasma, making it hypotonic. **Hypotonic plasma** inhibits ADH secretion resulting in restoration of plasma osmolarity.

In SIADH, secretion of ADH from tumor or cancer cells - Hypersecretion of ADH.

So there **is continuous loss of sodium in urine.**

Urine that is formed is concentrated with sodium and other ions.

Loss of sodium decreases the osmolarity of plasma, making it hypotonic.

Signs and symptoms

1. Loss of appetite
2. Weight loss
3. Nausea and vomiting
4. Headache
5. Muscle weakness, spasm and cramps
6. Fatigue
7. Restlessness and irritability.

In severe conditions, the patients die because of convulsions and coma.

„ HYPOACTIVITY OF POSTERIOR PITUITARY

Diabetes Insipidus

Diabetes insipidus is characterized by excess excretion of water through urine due to the deficiency of ADH

Causes

which occurs in the following conditions:

- i. Lesion (injury) or degeneration of supraoptic and paraventricular nuclei of hypothalamus
- ii. Lesion in hypothalamo-hypophyseal tract
- iii. Atrophy of posterior pituitary
- iv. Inability of renal tubules to give response to ADH hormone.

Signs and symptoms

Polyuria: Excretion of large quantity of dilute urine
Daily output of urine varies between 4 to 12 liter.

Polydipsia: Intake of excess water is called polydipsia.
Because of polyuria, lot of water is lost from the body. It stimulates the thirst center in hypothalamus, resulting in intake of large quantity of water.

Dehydration: In some cases, the thirst center in the hypothalamus is also affected by the lesion. Water intake decreases in these patients and loss of water through urine is not compensated.

So, dehydration develops which may lead to death.

ENDORPHINS

NEUROMODULATORS

Neuromodulator is the chemical messenger, which modifies and regulates activities that take place during the synaptic transmission.

Types of Neuromodulators

1. Non-opioid peptides
2. Opioid peptides.

„ **NONOPIOID PEPTIDES**- Non-opioid neuropeptides act by binding with G protein coupled receptors.

OPIOID PEPTIDES - Peptides, which bind to opioid receptors are called **opioid peptides**.

Name	Site of secretion	Action
Enkephalins	Many parts of brain, substantia gelatinosa and retina	
Dynorphins	Hypothalamus, posterior pituitary and duodenum	Inhibit pain sensation
β -endorphin	Thalamus, hypothalamus, brainstem and retina	

Endogenous opioid peptides have opiate like activity and inhibit the neurons in the brain involved in pain sensation. (Pain killer)

Opioid peptides are of three types:

- i. Enkephalins
- ii. Dynorphins
- iii. Endorphins.

Endorphins are the large peptides derived from the precursor pro-opiomelanocortin. Endorphins are pre - dominant in diencephalic region particularly hypothalamus and anterior and intermediate lobes of pituitary gland.