By ~Shahanshah Shahid

PGT- Biology

Chandra Public School, Mau (U.P)

Chemical Control and Coordination

- For maintenance of homeostasis and regulation of various body function Nervous and Endocrine system pay a important role
- By control and coordinate different part of body.
- Nervous system- act rapidly in a friction of second and response last for only few milliseconds.
- Endocrine system – release hormone from a few second to minutes but stimulate large number of cell in target tissue which last much larger in body.

Types of Gland in Body

Exocrine Gland	**Endocrine Gland**
1.Gland with duct.	Ductless gland
2. Discharge their secretion into ducts	Discharge secretion into blood
3. Present near the site of action.	Present faraway from site of action.
4. Secretion called enzyme.	Secretion called hormones.

Hormone:

- Non nutrient chemical that act as intercellular messengers which influence synthesis activation or inhibition of process in the body.

Properties of Hormone:

- Produce at a place other than site of action and travel through blood.
- Structure or position/ organ/ part of body that respond to hormones called target organs.
- Secrete in response to change in external or internal environment of body.
- It may stimulate or inhibit activity of target organs.
- Effective in minute quantities.
- It altered or destroyed immediately after their action over.

Human Endocrine system

1. Hypothalamus-pituitary	*Protein*
2. Thyroid	*Biogenic amine*
3. Parathyroid	*Polypeptide*
4.1. Adrenal Cortex	*Steroid*
4.2. Adrenal Medulla	*Biogenic amine*
5. Pancreases	*Polypeptide*
6. Ovaries	*Protein and Steroid.*
7. Testis	*Steroid*
8. Pineal	*Biogenic amine*
9. Thymus	*Polypeptide*

- **biogenic amine neurotransmitters**: the three catecholamines—dopamine, norepinephrinei6\7 (noradrenaline), and epinephrine (adrenaline)—and histamine and serotonin

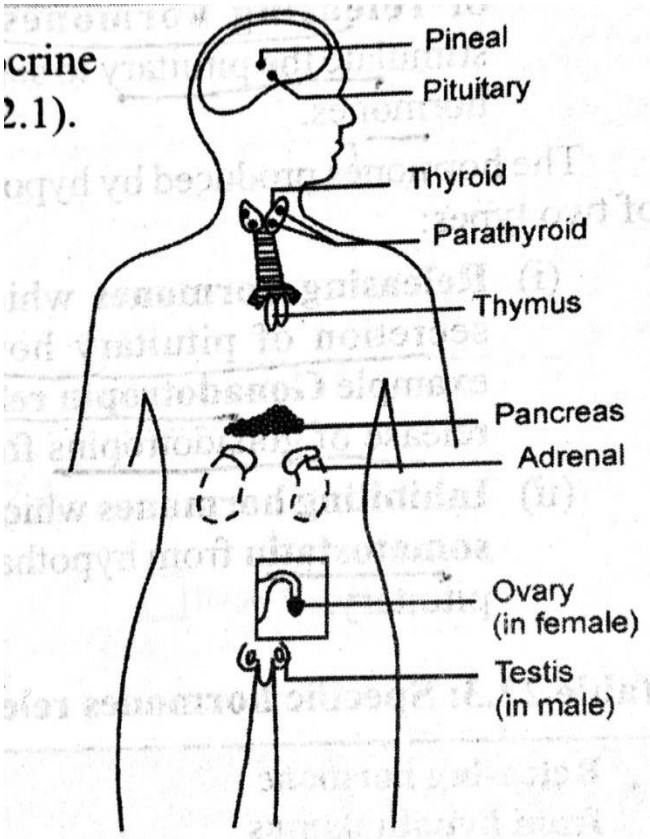


Fig. 22.1 Location of various endocrine glands

Hypothalamus – Pituitary Axis

- It is control center of the body that coordinates and integrates various system or physiological process.
- Hypothalamus send information (***through releasing hormones***) to the pituitary which secrete hormone (***control activity of other endocrine gland directly or indirectly***).

Hypothalamus

- It is part of diencephalon (***Forebrain***), present just below the thalamus region and above pituitary gland.
- Contain ***hypothalamic nuclei*** (*nuclear mass of gray matter*) in the white matter.
- Contain two ***nervous centers*** (N1 and N2) which collect the information from the brain and pass it to pituitary gland controlling its activity.
- *N1 - connected to anterior lobe of pituitary* by the **portal blood vessel** and *N2 – connected to posterior lobe of pituitary* by **specialized neurons**.

*Non-mylinated nerve fibres of N2 form **Hypothalamo – hypophysial tract** with in pituitary stalk.*

- Two types of hormone release from hypothalamus:

1. **Releasing hormones:** viz *stimulate secretion of pituitary hormone*. Example – **Gonadotropin releasing hormones (GnRH)**.
2. **Inhibiting Hormone:** viz *inhibit secretion of pituitary hormones*. Example – **somatostatin**.

Hormone released by Hypothalamus and their effects on pituitary:

Table 22.3: Specific hormones released by hypothalamus and their effect on pituitary

Releasing hormone from hypothalamus	Hormones released from anterior pituitary in response to releasing hormones
1. Thyrotropin releasing hormone or TSH releasing hormone	Stimulates the release of thyrotropin or thyroid stimulating hormone (TSH)
2. Corticotropin releasing hormone or ACTH releasing hormone	Stimulates the release of corticotropin or adrenocorticotropic hormone (ACTH)
3. Gonadotropin releasing hormone (GnRH) or FSH + LH releasing factor and prolactin release and inhibitor factor	Stimulates the release of three gonadotropins. (i) Follicle stimulating hormone (FSH) (ii) Luteinising hormone (LH) (iii) Prolactin or Luteotrophin hormone (LTH)
4. GH release factor and GH inhibitor factor called somatostatin	Release or inhibition of growth hormone or somatotropin, i.e., GH or STH

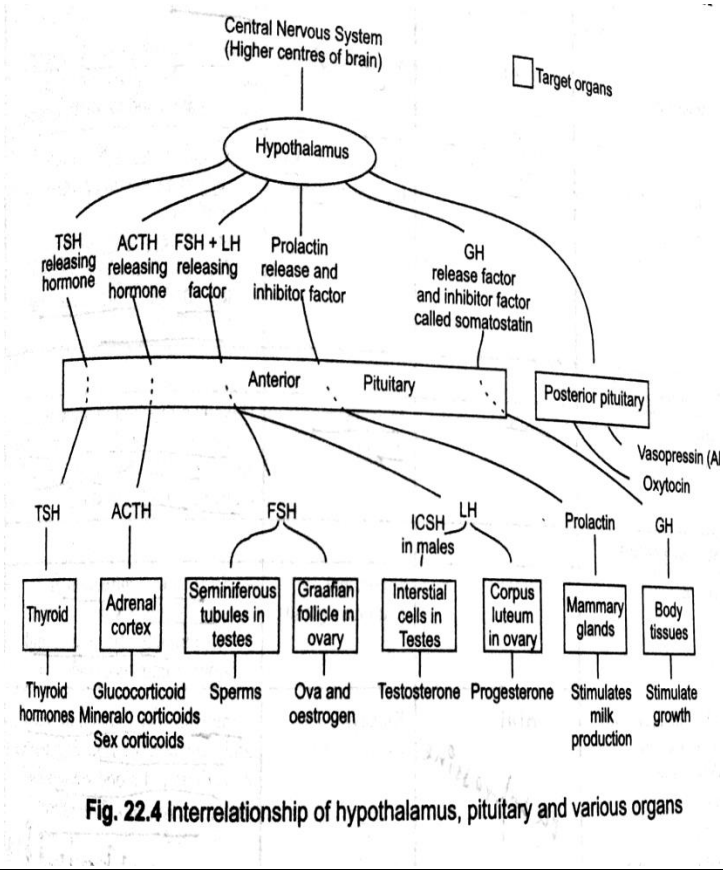


Fig. 22.4 Interrelationship of hypothalamus, pituitary and various organs

Pituitary or Hypophysis

- It is pinkish pea sized (*1.3 cm diameter*) gland present just below the hypothalamus.
- It works under the influence of hypothalamus.
- It consists of three lobes in which two have main role (*i.e anterior and posterior*).

Anterior pituitary or Adenohypophysis or Pars Distalis

Hormone release from Anterior Pituitary	Target organ	Principal Actions
1. Thyroid stimulating hormone (TSH)	Thyroid gland	Secretion of thyroid hormones.
2. Adrenocorticotroic hormone (ACTH)	Adrenal cortex	Secretion of adrenal cortex hormone such as cortisol.
3. Follicle stimulating hormone (FSH)	Gonads (i) Seminiferous tubules in males. (ii) Graafian follicle in ovary	In males- stimulate spermatogenesis. In females – growth of ovarian follicles and estrogen.
4. Luteinising hormone (LH)	Gonads (i) Interstitial cells in testis (ii) Corpus luteum in ovary	In male- secretion of testosterone. In female with FSH – trigger ovulation, development of corpus luteum and progesterone.
5. Prolactin (PRL)	(i) Mammary glands	Stimulate milk production, carbohydrate and fat metabolism.
6. Human growth hormone	(i) General body, soft tissues and bones	Stimulate growth of body cells, bones, promote breakdown of fat and blood glucose.

Various disorders related to growth hormone (GH)

1. **Dwarfism:**

- Due to deficiency or lower than normal GH level in childhood Cause less or stoppage of growth of long bones and prematuration of body.

2. <u>Gigantism:</u>

- Due to too much of GH during early year of development which results giants (i.e. 7feet 8 inches).
- Cause abnormal elongation of all the long bones.

3. <u>Acromegaly:</u>

- Due to hypersecreation of GH after adolescence.
- Cause enlargement of parts like hands feet and jaws (***gorilla like appearance***)

Intermediate pituatary or pars intermedia

- Secrete Melanocyte stimulating hormone (MSH) which darkens the skin of fish and amphibians by stimulating the synthesis of melanin.

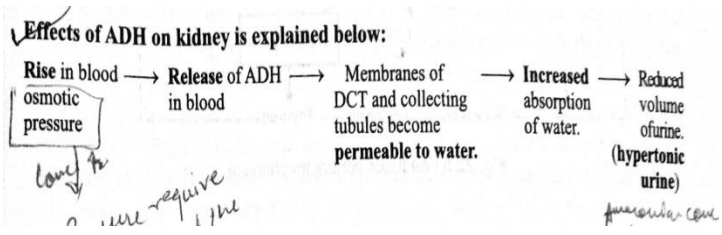
- *MSH has no role in the pigmentation of skin in man.*

Posterior pituitary or Neurohypophysis

- Connected to hypothalamus by nerve fibres.
- Does not produce any hormone only store two hormones i.e ***Vasopressin and oxytocin.***
- Hormone synthesis in nerve cell bodies in the hypothalamus and transported to posterior pituitary so that it is only storage-release center for the hormone *(i.e. synthesis entirely by the hypothalamus*).

1. <u>Vasopressin or ADH or Antidiuretic hormone:</u>

- Act on kidney to reduce the volume of urine.
- Also increase the arterial blood pressure by acting as a vasoconstrictor (*i.e narrowing of arteries*).
- Failure of secretion of ADH causes Diabetes Insipidus.



2. <u>Oxytocin:</u>

- It has two important functions in adult females.

a) Contraction of uterine sooth muscles during parturition.

b) Contraction of mammary gland muscles and help in milk ejection.

 # Sound of baby can cause secretion of this hormone.

- Integrated Role of Hormones and Feedback Mechanism
- There are number of feedback mechanism that controls the release of hormones by the glands.

Integrated Role of Hormones and Feedback Mechanism:

- There are number of feedback mechanisms that control the release of hormones by the glands.

1) <u>Feedback control by another hormone:</u>

- As we know that production of pituitary hormone governed by hypothalamus while production of hormone from the respective endocrine glands govern by pituitary hormone.
- Release of less or more hormones affects the hypothalamus and pituitary to produce less or more of the endocrine regulating hormone so it could be a positive feedback or a negative feedback.

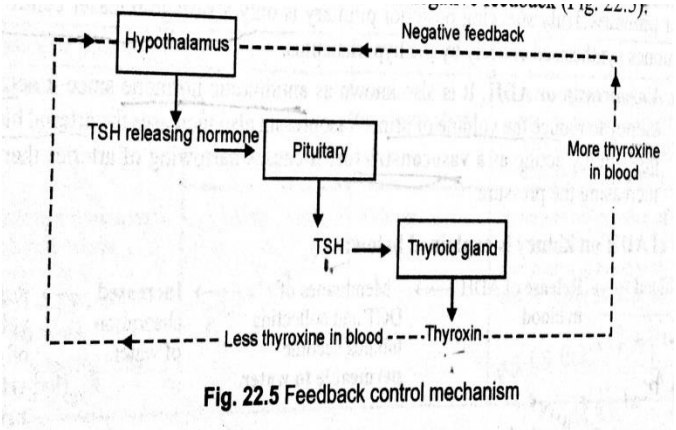


Fig. 22.5 Feedback control mechanism

2. <u>Feedback control by metabolite:</u>

Level of metabolite affects the secretion of specific hormone for example:

3. <u>Feedback control by nerves:</u>

Secretions of adrenal medulla are controlled by nerve of sympathetic nervous system.

- The coordination of various endocrine gland helps to maintain constancy of blood sugar level, body temperature, and heart ate. Blood pressure, osmotic concentration of body fluids ect.

Pineal Gland

- Small cone shaped gland located in the midbrain area.
- It has no direct connection with the central nervous system.
- It functions as a biological clock of our body because it involve in our circadian rhythm (***i.e at night melatonin levels increases, we become sleepy and awaken when day light return and melatonin level is low***).
- When light enter the eyes and stimulate the retinal neuron which transmit impulses to the hypothalamus and finally to pineal gland which results inhibition of melatonin secretion.
- It also have been seen that children with a brain tumor that destroys pineal gland have early puberty.

Thyroid Gland

- Butterfly shaped gland present just below the larynx with its lobes on either side of the trachea.
- Lobes are connected by **isthmus** (*thin strip of tissue*) and each lobe consist of numerous **follicles** (*i.e made up of single layer of secretory cuboidal cells*).
- It has **lumen** (*i.e cavity*) filed with **colloid** (*i.e gel like material, composed of glycoprotein thyroglobulin*).
- It produce three hormones:

1. **Thyroxine -** also called tetraiodothyronine or T4 because it contain 4 atom of iodine.
2. **Triiodothyronine or T3** because it contain 3 atom of iodine.
3. **Calcitonine** (*i.e sceated by parafolicular cells*) – regulate calcium level in blood plasma and inhibit the calcium loss in bones.

- Thyroid gland produce hormone when it get activated by TSH from neurohypophysis.
- Thyroid hormone control Basal Metabolic Rate (BMR), stimulate protein synthesis, maintain normal body temperature, stimulate tissue differentiaation.

*# **Thyroxine is an essential hormone during metamorphosis of frog.***

Disorders due to malfunctioning of thyroid gland :

1. **<u>Hypothyroidism (i.e deficiency of thyroid hormone):</u>**

- It occurs due to malfunctioning of thyroid gland or deficiency of iodine in the diet.
- It lead slow respiration rate, decrease heart beat, BMR get lowered by 20-30% etc.

a) <u>Cretinism:</u>

- It is disorder in children when thyroid secretion is less from infancy or childhood.
- Lead dwarfism with serious mental deficiencies and individual called **cretins**.
- Affected child show pot-bellied, pigeon – chested, and protruding tongue and BP body temperature and BMR are below normal.

*# **It can be cured if detected early and hormone is administered does in child.***

b) <u>Myxedema: (</u>disorder in adults**)**

- It is characterized by puffiness of the skin due to **edema** (*i.e. accumulation of interstitial fluid at face and hand*).
- Person looks dull, lacks alertness and intelligence as well as lead reproductive failure.
- BP, heart rate, body temperature and BMR are below normal.

c) <u>Simple goitre:</u>

- In this thyroid gland become enlarge which get visible as a lump in the neck region.

- Occurs due to deficiency of iodine in diet which leads less productivity of **thyroxine** (*because iodine is the major constituent of the thyroxine*).
- Increase amount of TSH , induced cells to grow larger in the thyroid.

2. Hyperthyroidism:

It occurs due to increased activity of thyroid gland which leads to excess of hormone in body.

a) Exophthalmic goitre or Grave's disease:

- Affected individual show ***goitre*** *(i.e.* swelling in the neck region) and ***exophthalmos*** (*i.e bulging of eye balls*).
- It is autoimmune disorder in which affected individual produce antibodies which mimics the action of TSH but not regulated by normal feedback control.
- It show increased BMR, rapid respiration, palpitation, sweating and increased heartbeat rate and also lead mental restlessness, insomnia and nervousness.

 # Person tends to lose weight due to rapid oxidation of food.

- It controlled by doses of radioactive iodine which taken up by thyroid cells killing those where it accumulated above a certain level.

Parathyroid gland

- It embedded on the dorsal side of the thyroid gland.
- They are four small sized glands (i.e two on each side of thyroid gland).
- It is totally independent of thyroid gland for development and function.
- It produces parathormone or parathyroid hormone (PTH) (i.e hypercalcemic hormone which increases Ca ions in blood plasma).

Role of Hormone:

- It is opposite to calcitonin (i.e regulate Ca ions level in blood plasma) .

 # Parathromone and Calcitonin together regulate the calcium and phosphate level in the blood.

- Parathromone increase the Ca^+ level in the blood and decreases the phosphate level in blood plasma by mobilizing it from bone to blood plasma and reduce its elimination in urine.

 # Ca^+ control the PTH by feedback mechanism.

- It affects the growth of bones, membrane permeability, and nerve functioning and muscle activity of the body.

Disorder due to malfunctioning of parathyroid glands

Table 22.6: Disorders resulting from malfunctioning of parathyroid glands

Hypoparathyroidism	Hyperparathyroidism
Cause: Accidental damage to the parathyroid glands or to their blood supply during thyroidectomy surgery. It leads to **hyposecretion** of parathyroid hormone (PTH).	**Cause:** Usually due to a tumour in the parathyroid glands. This leads to **hypersecretion** of PTH.
Hypocalcemic tetany or **parathyroid tetany** – Due to deficiency of Ca^{2+}, neurons become depolarised, without usual stimulus. – Nerve and muscle action potentials arise spontaneously, leading to muscle twitches, spasms and convulsions. – Sustained contractions or tetany in the muscles of larynx, face, hands and feet.	**Osteoporosis** Due to demineralisation, the bones become porous, get deformed, and soft and get easily fractured. **Osteitis fibrosa cystica** If osteoporosis is not treated on time, the areas of destroyed bone tissue are replaced by cavities that are filled with fibrous tissues. For this reason, this disease is called osteitis fibrosa cystica.

Thymus gland:

- In involve in production of antibody and development of immune response.
- It located on the dorsal side of heart and aorta.
- It release hormone Thymosin (*i.e polypeptide hormone*) which promote the growth of lymphoid tissue and help in immune response.
- Release of thymosin in blood stream promotes proliferation and maturation of **T-lymphocytes** (*provide cell mediate immunity*) and production of **antibody** (*provide humoral immunity*).
- It is active in young children and reaches at maximum size at 10-12 years of age.

 # It gradually reduces in size with age and thymosin production entirely ceases by about 50 years.

Adrenal gland

- Location: It is two small yellowish glands present just above the kidney.
- Structure: It consist of two distinct region:

1. Outer – cortex - release hormone which help to recover from stress.
2. Inner – medulla - allow us to respond to emergency situation.

1. Adrenal cortex:

- It produces 30 different kinds of steroid hormones which boardly classified into three groups (***mineralocorticoids, glucocorticoids and gonadocorticids***) according to their function.

Adrenal cortex can be dividing into three layers:

1. **Zona reticularis** (*inner layer*)
2. **Zona fasciculata** (*middle layer*)
3. **Zona gloemerulosa** (*outer layer*)

Disorder due to malfunctioning of Adrenal Cortex

a) Addison's disease:

- It occurs due to under activity of the adrenal cortex which may be cause by disease like tuberculosis.
- Affected individual show following symptoms like :

1. Deficiency of both *glucocorticoids* and *mineralocorticoids*.
2. Dark bronxe colour pigmentation of skin, weakness, anemia, vomiting and diarrhea etc.
3. Low Na^+ and K^+ level in blood plasma and low BP.

- It is discovered by DR. Thomas Addison in 1855.

b) Cushing's syndrome:

- It occurs due to over activity of the adrenal cortex which may be cause by the formation of tumour (*due to over secretion of cortisol*) in cortex region.
- Affected individual show following symptoms like :

1. Abdominal obesity and wasting of limb muscles.
2. High Na^+ and K^+ level in blood plasma.
3. High blood sugar in urine.
4. Increase hair growth.
5. Increase blood volume.

c) Aldosteronism:

- It is due to increased secretion of aldosterone from an adrenal cortex tumor.
- Affected individual show following symptoms like :

1. High Na^+ and K^+ level in blood plasma.
2. High BP an increased blood volume.

d) Adrenal virilism:

- It occurs due to increased secretion of ***Sex corticoids***.
- It produces male type external sex characters like beard, moustache, and male voice in women.

2. Adrenal medulla:

- It form central core of adrenal gland and is not essential for life.
- It produce two catecholamine hormones:

1. **Adrenaline** or epinephrine
2. **Nor-adrenaline** or nor-epinephrine.

- They called emergency hormones or hormones of Fight or Flight.
- Effect of hormones are same as those produced by sympathetic nervous system like: reduced blood flow to capillaries near the body surface, increase in blood pressure and stimulate breakdown of ***Glycogen*** (*results in increase in blood sugar level*) and ***Gluconeogenesis*** from lipids and proteins, dialation of eye pupils, increased alertness, piloerection (raising of hairs), sweting ect.

Tabel 22.8

Pancreas:

- It acts as *both endocrine gland (islets of Langerhans) and exocrine gland (produce pancreatic juice).*
- *Islets of Langerhans consist of three types of cells:*

1. α- cells (***produce hormone glucagon***).

2. β- Cells (***produce hormone insulin***).

3. δ- Cells (***produce hormone somatostatin***).

1) **Role of Insulin:**

- It controls the amount of sugar available in the body by conversion of glucose to glycogen in muscles and liver.
- It act as anabolic hormone in condition of high blood glucose level which stimulate to release of insulin *(increases the rate of protein and fat synthesis)*
- It act on the liver, muscles and adipose tissue.

Diabetes Mellitus or insulin-dependent diabetes:

- It caused by under activity of β- cells which result in deficiency of insulin.
- It cause ***hyperglycaemia condition*** *(increase in blood sugar level*) and ***glycosuria*** (*sugar appear in urine*).
- Affected person show following symptom:
- Breakdown of muscles fat and protein, increase amount of ketone bodies in *body (due to increase oxidation of fat*), increased volume of urine due to osmotic effect of glucose which increased thirst to compensate the loss of water.

2) Role of glucagon:

- It has opposite effect of insulin.
- Lower blood glucose level stimulate the release of glucagon from islet of Langarhans (*which increase the breakdown of glycogen, fat and proteins in liver*).
- It acts upon liver and adipose tissue.

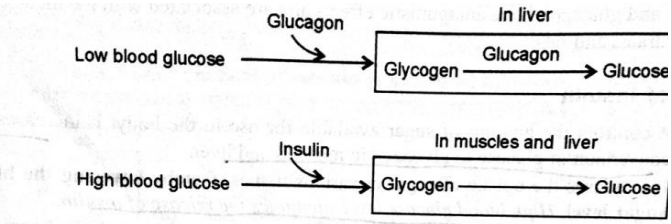


Fig. 22.11 Role of insulin and glucagon

Gonads or sex organs

- Gonads produce sex hormones (i.e responsible for secondary sexual characteristics and secreted at onset of puberty).
- Sex hormones are under the control of pituitary.

1. Testis:

- In male – a pair of testis produce **Testosterone** (*i.e male sex hormone*).
- In testis – seminiferous tubules are present which surrounded by **interstitial cells of Leydig** (*connective tissue*) – that act as endocrine and produce male hormones.

Role of testosterone:

- Stimulate the growth and development of male secondary sex organs (*i.e prostrate and seminal vesicles*) and development of male sex characters.
- It also stimulates the formation of sperm and lengthening of long bones.

Eunuchoidism:

- It occurs due to failure of testosterone in male.
- Due to this disorder secondary male sex organs are under development, failure of testis to produce sperms.
- It can be cured by administration of testosterone.

 # Production of testosterone is stimulated by the luteinising hormone (LH) or interstitial cell stimulating hormones (ICSH) (i.e release from anterior pituitary).

2. ovaries:

- In female – a pair of ovaries produce ova and female sex hormone.
- In ovary **Ovulation** take place *[i.e number of ovarian follicles present that having a developing ovum that develop in month known as **graafian follicle** (i.e. produce estrogen) and under the influence of **LH** - graafian follicle ruptured and release ovum]***.**
- After the ovulation, ruptured follicle change to form another structure called corpus luteum which secretes **progesterone** (*i.e. female hormone*).

***# Gonadotropin hormone** (i.e FSH and LH) stimulate the secretion of **estrogen** and **progesterone**.*

***# High concentration of Progeterone** and **Estrogen** inhibit the production of **FSH** and **LH** from pituitary known as negative feedback mechanism.*

Role of estrogen:

- Stimulate growth and development of female secondary sex organ and female sex character.
- It is responsible for repeated cyclic changes in the uterus *(like thickening of uterine lining*).

Role of progesterone:

- It stimulates secretion of mucus and further thickening of uterine lining during ovarian cycle.
- It is basically associated with changes necessary for implantation of embryo, pregnancy and changes in body thereafter in the body.
- It brings about the formation of placenta that attaches the foetus to the mother and stimulates growth of secondary alveolar cells in mammary glands.

Corpus luteum produces another hormone **Relaxin** (*i.e relaxes the pubic symphysis in pelvic girdle and also helps to dilate uterine cervix at the end of gestation period*).

Hormones of Heart, Kidney and Gastrointestinal tract

Table 22.10: Hormones of heart, kidney and gastrointestinal tract and their location and functions

Name of organ	Location	Functions
(i) Heart	The atrial wall of our heart secretes a very important peptide hormone called **atrial natriuretic factor (ANF).**	ANF decreases blood pressure. – When blood pressure increases, ANF is secreted which causes dilation of the blood vessels. It reduces the blood pressure.
(ii) Kidney	The juxtaglomerular cells of kidney produce a peptide hormone called **erythropoietin.**	– Erythropoietin stimulates erythropoiesis (formation of RBCs).
(iii) Gastrointestinal tract	Different parts of gastrointestinal tract secrete four major hormones.	
	(i) **Gastrin**	– **Gastrin** act on gastric glands and stimulates the secretion of HCl and pepsinogen.
	(ii) **Secretin**	– **Secretin** acts on exocrine part of pancreas and stimulates secretion of water and bicarbonate ions.
	(iii) **Cholecystokinin** (CCK)	– **CCK** acts on both pancreas and gall bladder and stimulates the secretion of pancreatic enzymes and bile juice respectively.
	(iv) **Gastric inhibitor peptide** (GIP)	– **GIP** inhibits gastric secretion.

Mechanism of hormone action

Hormone receptors:

- Specific protein that present that target tissue at which hormone can bind.
- Hormone receptors are two type:

1. Membrane-bound receptors (i.e present at the cell membrane of target tissue).

2. Intercellular receptors (i.e present inside the target cell) , mostly they are nuclear receptors (i.e present in the nucleus).

Group of Hormones:

Group of hormone	Examples
Peptide , polypeptide and protein hormones	*ADH and oxytocin (short peptide), insulin and glucagon (long peptide), FSH and LH (proteins).*
Steroid hormones	*Estrogen, progesterone and testosterone (sex steroids), corticosteroids (secreted from adrenal cortex i.e cortisol).*
Idothyronines	*Thyroid hormone like thyroxine.*
Amino acid deivatives	*Epinephrine melatonin.*

Mechanism of hormonal action

Hormone work on the basis of two principal ways:

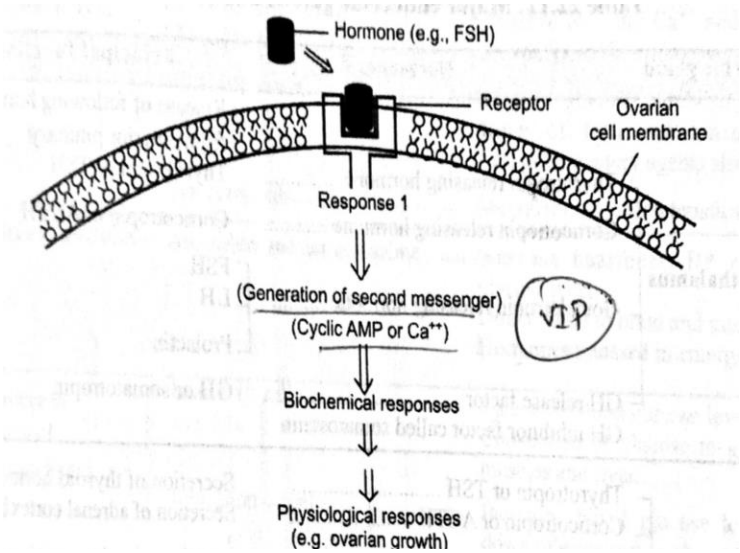
1. Hormone that binds to the extracellular receptor or bind with membrane bound receptor or hormone that does not enter the cells.

2. Hormone that bind to intracellular receptor or hormone that enter the cells.

Hormone that bind to the extracellular receptor or bind with membrane bound receptor

- These hormones are hydrophilic in nature due to that they do not cross the plasma membrane so they bind to a receptor protein present at the surface of plasma membrane at the target cells.
- These hormones called first messengers which activate certain molecule which act as ***secondary messengers*** (cyclic APM, IP3, Ca ions ect).
- Secondary messenger produce the effect of hormone.

 # Different hormones may use different molecules as secondary messengers.



<u>Hormone that bind to intracellular receptor or hormone that enter the cells</u>

- These hormones are lipophilic (lipid soluble) , they can enter the cell and nucleus freely.
- They dissolve in plasma and travel in the blood by attaching with protein carrier and arrive at target cell.
- They dissociate from their carrier and enter into cell, by binding with DNA they activate one or more genes and initiate transcription to produce mRNA.
- Resultant mRNA leaves the nucleus and translates to synthesize proteins (i.e enzyme).
- These enzymes change the metabolism of target cell causing physiological changes.

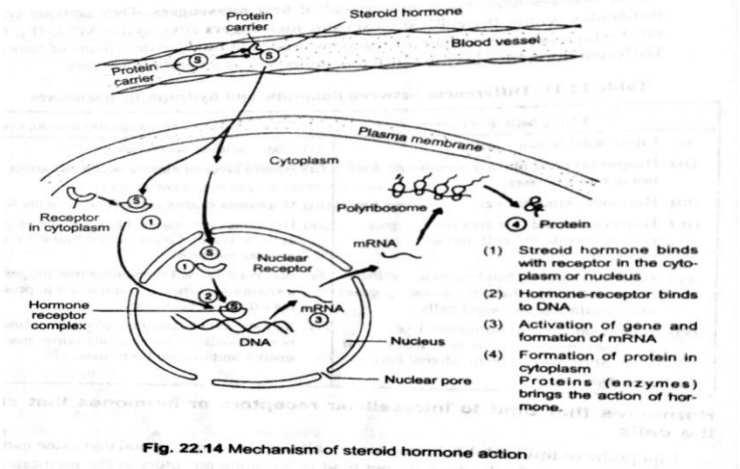


Fig. 22.14 Mechanism of steroid hormone action