

CHAPTER
18

CHEMICAL COORDINATION

Key Concepts

- 18.1 Hormones: The chemical messenger
- 18.2 Endocrine system of man
- 18.3 Feed back mechanism

EXERCISE

SECTION I: Multiple Choice Questions

Select the correct answer from the following choices.

1. Steroid hormones are secreted by:

(a) the adrenal cortex	(b) the gonads
(c) the thyroid	(d) both A and B
2. Examples of posterior pituitary hormones are:

(a) FSH and LH	(b) prolactin and parathormone
(c) melatonin and prostaglandin	(d) ADH and oxytocin
3. The primary targets for FSH are cells in the:

(a) hypothalamus	(b) ovary
(c) thyroid	(d) pituitary
4. Which of the following controls the activity of all others?

(a) thyroid	(b) pituitary	(c) adrenal cortex	(d) gonads
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5. Which of the following have antagonistic (opposing) effects?

(a) parathyroid hormone and calcitonin
(b) glucagons and thyroxine
(c) growth hormone and epinephrine
(d) cortisone and ACTH
6. Which of the following hormones has broadest range?

(a) ADH	(b) cortisol
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7. The pancreas increases its output of insulin in response to:

- (a) an increase in body temperature
- (b) changing cycle of dark and light
- (c) a decrease in blood glucose
- (d) an increase in blood glucose

Answer

1	(d)	2	(b)	3	(b)	4	(b)	5	(a)
6	(d)	7	(d)						

SECTION II: Short Questions

Give short answers of the following questions.

Q1. What are major endocrine glands of the body and where they are located?

Answer

Endocrine system is the type of glandular system, consists of some 20 ductless glands lying in different parts of the body.

Major Endocrine Glands

1. **Pituitary glands:** Located in brain
2. **Hypothalamus:** Located in brain
3. **Thyroid gland:** In neck region on either side of the trachea
4. **Parathyroid:** Embedded in thyroid in neck region.
5. **Adrenal gland:** Located on kidneys
6. **Pancreas:** Alongwith stomach
7. **Ovaries:** In female only internal to body.
8. **Testicles:** Only in male in between groin area.
9. **Thymus gland:** At chest
10. **Pineal gland:** In brain

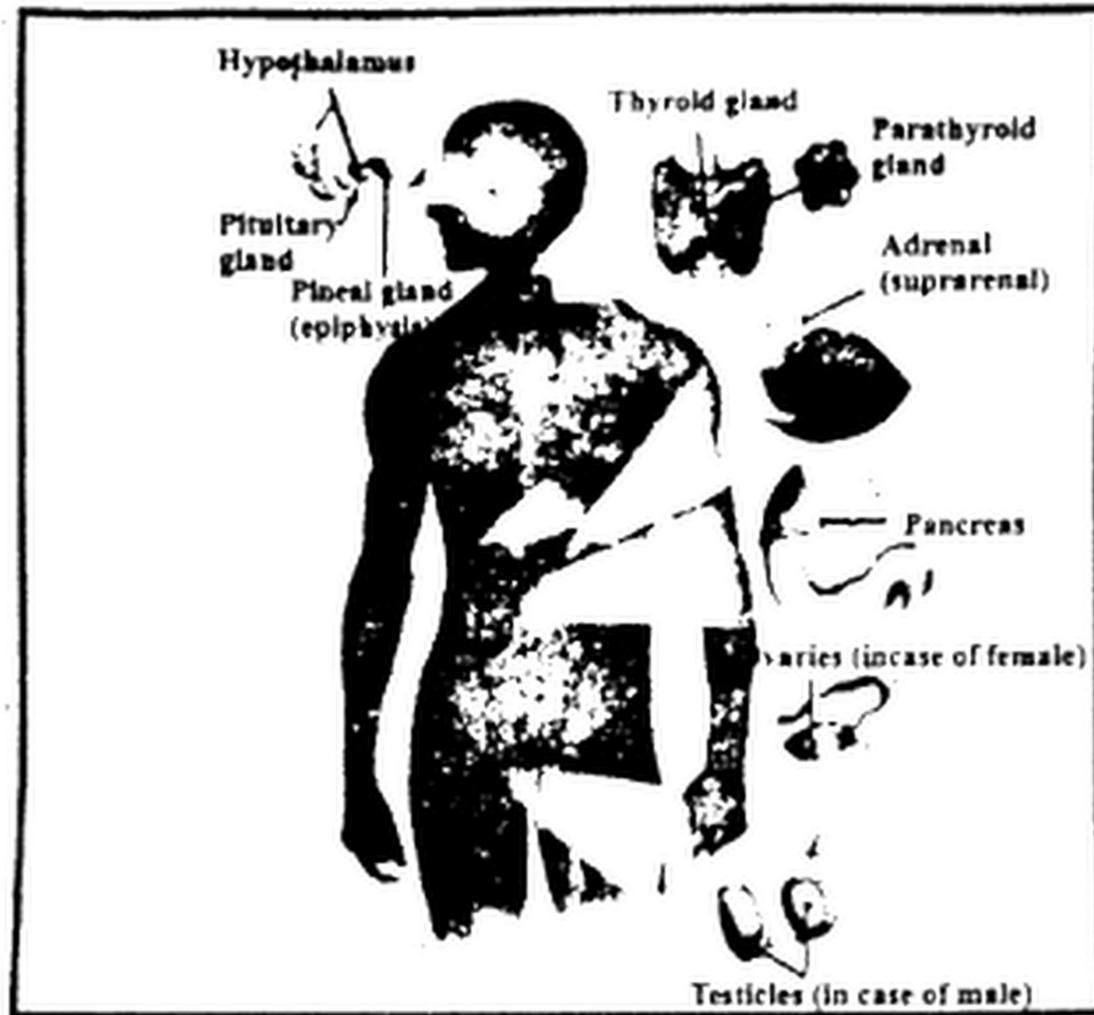


Fig. Location of various endocrine glands in human body

Q2. Define second messenger and give their names.

Answer

Protein and peptide hormones, like epinephrine and prostaglandins find their receptors decorating the plasma membrane of target cells. Binding of hormone to receptor initiates a series of events which leads to generation of so-called second messages within the cell (the hormone is the first messenger). The second messenger these trigger a series of molecular interactions that physiological state of the cell. For example:

- 1) When a non-steroid hormone (first messenger) is attached to the receptor protein.
- 2) A series of events are triggered which activates an enzyme that in turn
- 3) Converts ATP to camp (second messenger)
- 4) The effect on cellular function is observed.

Q3. What is function of prolactin, ACTH and oxytocin?

Answer

- i) **Prolactin:** is continuously produced from pituitary gland and is inhibited by prolactin inhibiting factor (PIH) from hypothalamus.

Function: It stimulates milk production.

- ii) **ACTH (adrenocorticotrophic hormone) or corticotrophic hormone**

ACTH is released by the secretion of corticotrophin releasing factor (CRF) from hypothalamus which is controlled by steroid level in blood and by direct nervous stimulation of hypothalamus as a result of stress e.g. cold, heat, pain fright and

Function: ACTH act on adrenal cortex and stimulates the secretions of corticosteroids (cortisone and aldosterone)

- iii) **Oxytocin:** is released after stimulation by distension of cervix decrease in progesterone level in blood and neural stimuli during parturition (child birth) and sucking.

Function: Its primary action is on smooth muscle, particularly in the uterus during childbirth and also causes milk ejection from mammary glands.

Q4. Differentiate between dwarfism and cretinism.

Answer

- i) Dwarfism: Deficiency of GH (growth hormone) result in dwarfism in which development is much slower and individual has short stature, however the body parts stay in proportion and brain development and IQ are unaffected.
- ii) Cretinism: In infants, the deficiency of thyroxine causes a dwarfed condition called cretinism. The individual are small, have coarse scanty hair, thick yellowish scaly skin and mentally retarded. They do not develop sexually.

Q5. How is the secretion of ADH controlled?

Answer

Antidiuretic hormone (ADH: also called vasopressin)

Secretion: Secretions caused by decrease in blood pressure, blood volume, and osmotic pressure of the blood detected by osmoreceptors in hypothalamus. External sensory stimuli also influence hypothalamic neurosecretory cells.

Function: Increased levels cause increased water reabsorption in distal parts of kidney. A lack of this hormone produces diabetes insipidus, characterized by production of large quantities of dilute urine and great thirst.

Q6. Which reproductive organs secrete hormones and what are their functions?

Answer

1. Ovary

Ovary is female reproductive organ.

There are three hormones all with very similar effects, oestrone, oestrole and oestradiole, of which the most important is oestradiol.

- i) Oestrogens are secreted by ripening follicles (and, in many species, by interstitial cells of the ovary) whose development has been initiated by FSH from the pituitary.

Functions: Oestrogens bring about:

- a) the development of the secondary sexual characters in the female,
- b) cause thickening of the uterine wall
- c) at a point during the oestrous or menstrual cycle, exert a positive feedback which results in a sharp rise in LH output by the pituitary.
- d) It also aids in healing and repair of uterine wall after menstruation.

- e) Some of cells of uterine wall become glandular and start secreting proteinaceous secretions which are taken up by the embryo during its early stages of development.
- f) Deficiency of the sex hormones leads, in the young to failure to mature sexually and sterility in the adult.

ii) **Progesterone:** It is produced by the ruptured follicle in response to LH from the pituitary.

Functions: It performs the following functions:

- a) Progesterone inhibits further FSH secretion from the pituitary, thus preventing any more follicles from ripening.
- b) It also affects the uterus, causing further thickening and vascularisation of its wall, and other areas of the female body, preparing it for maintaining state of pregnancy.
- c) It suppresses ovulation. That is why it is a major constituent of birth control pill.

2. Testes

Secretion: The testes consist of many coiled seminiferous tubules where the spermatozoa develop and, between the tubules, regions of interstitial cells which produce gonadal hormones called Testosterone and 17 β -hydroxytestosterone.

After the initiation of development, the sex organs in the foetus produce them, and their level rises fairly consistently until puberty. After puberty the supply of LH (ICSH), and therefore and level of testosterone, remains constant.

Actions: i) In the foetus it initiates the development of the sex organs.

- ii) At puberty it brings about development of the male secondary characteristics and promotes the sex drive.
- iii) The castrated male fails to develop secondary sexual characteristics and his body tends more towards the form of the immature female.

Q7. What are the types of molecules used as hormones in man?

Answer

Chemically, hormones are of three basic types i.e., steroids, amino acids or their derivatives, proteins or polypeptides and a few belong to the fatty acids e.g., prostaglandins.

Steroid hormones are derivatives of cholesterol. Different steroidal hormones are secreted by, the adrenal cortex (cortisol and aldosterone), the ovaries (estrogen and progesterone), the testes (testosterone) and the placenta (estrogen and progesterone).

Two groups of hormones are derivatives of amino acid tyrosine. The metabolic hormones thyroxin and tri-iodothyronin from thyroid glands and epinephrine and norepinephrine from adrenal medullae are all derived from amino acid tyrosine.

Many important endocrine hormones are proteins, peptides or immediate derivatives of these. Growth hormone and prolactin are protein while antidiuretic hormone and oxytocin are peptides of nine amino acids each. Insulin, glucagon and parathormone are large polypeptides.

Answer

Epinephrine is the more potent stimulator of metabolic activities, bronchial dilation and increased blood flow to skeletal muscles and the heart.

Q9. Why anterior lobe of pituitary is also called master gland?**Answer**

Classically, the anterior lobe of pituitary is considered the master gland of endocrine system because it secretes numerous hormones, many of which regulate the activity of other endocrine glands.

It secretes six hormones, all of which regulate the secretory action of other endocrine glands.

Q10. Differentiate between calcitonin and parathormone.**Answer****Parathormone**

The parathormone is the single most important hormone of parathyroids controlling the calcium balance of the blood. Its release is triggered by low blood Ca^{2+} levels and inhibited by high blood calcium levels. Parathormone stimulates osteoclasts to reabsorb bone mineral and liberating calcium in the small intestine and also its reabsorption in the kidney tubules.

Over secretion of parathormone is usually a result of a parathyroid gland tumor. Calcium is released from the bones, and bones get soften and tend to fracture spontaneously. Blood calcium level elevates (hypercalcemia) which depresses nervous system and causes weakness of muscles. Excess calcium salts precipitate in the kidneys leading to stone formation. Under secretion of parathormone causes hypocalcemia. This increases the excitability of neurons. Also it can lead to tetany in which muscles remain in contracted state. If untreated, it can be fatal.

Calcitonin

The thyroid gland also secretes calcitonin. This hormone plays a minor but direct role in controlling extracellular levels of calcium ions (Ca^{++}). When the levels rise, calcitonin promotes calcium deposition into bones. When the levels return to normal, thyroid cells decrease their secretion of calcitonin.

Calcitonin inhibits Ca^{2+} absorption by the intestines and decreases its reabsorption by the kidney tubules allowing its excretion in urine. It also inhibits potassium ions reabsorption in kidney tubules.

Calcitonin appears more important in childhood, when the skeleton grows quickly and the bones are changing dramatically in mass, size, and shape. If deficient, Ca^{2+} are not

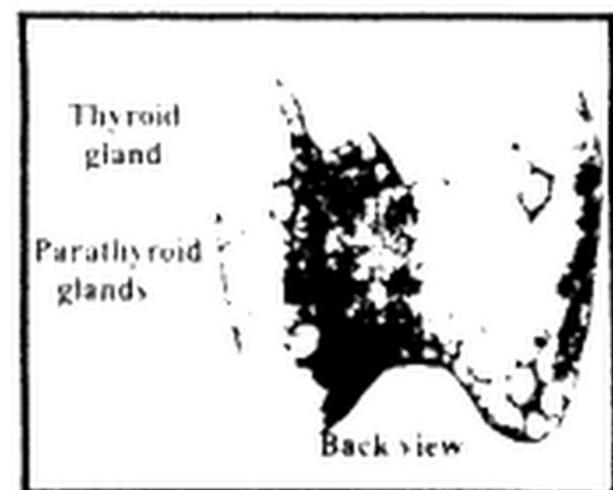


Fig. Parathyroid glands are present on the thyroid gland.

Q11.Explain on what grounds some companies claim that growth is possible in people having short heights?

Answer

If growth hormone is administered to young people before growth of their long bones is complete, it causes long bones to grow and they will grow taller. To accomplish this however, GH (growth hormone) have to be administered over a considerable length of time.

Q12.Why antidiuretic hormone is also called vasopressin?

Answer

Antidiuretic hormone (ADH) regulates water balance and is produced from posterior lobe of pituitary gland. Under certain conditions, such as severe blood loss exceptionally large amount of ADH is released causing a raise in blood pressure. The alternative name for this hormone, vasopressin, reflects this particular effects.

Q13.Write a very brief note on:

Answer

a) Gigantism

Gigantism is resulted by over secretion of GH during childhood. As the bones are still capable of growth, person becomes a giant. Over secretion of GH in adult life causes acromegaly. Bones are no longer capable of increasing in length but grow in thickness. Acromegaly is characterized by enlarging the hands, feet, skull, nose and jawbone.

b) Diabetes insipidus

ADH is produced during the state of dehydration, decreased blood volume and low blood pressure. Under secretion of ADH causes diabetes insipidus, which is characterized by excessive production of dilute urine and frequent thirst.

c) Graves disease

Graves' disease is believed to be an autoimmune disease. The serum of patients contains abnormal antibodies that mimic TSH and continuously stimulate thyroxin release. The symptoms include high metabolic rate, rapid and irregular heartbeat, increased breathing rate, increased body temperature, sweating and weight loss despite adequate food intake. Mostly exophthalmia (protrusion of the eye balls) results from Graves' disease and is a classic symptom of hyperthyroidism.

d) Cretinism

Under secretion of thyroxin in infants called cretinism.

In this disease there is menial retardation with poor physical growth and disproportionate body size. Bone maturation and puberty are severely delayed and infertility is common.

e) Calcitonin

Excessive Ca^{2+} level of blood stimulate release of calcitonin whereas declining blood Ca^{2+} levels inhibits its secretion. Calcitonin increases the deposition of calcium in bone

reabsorption by the kidney tubules allowing excretion in urine. Calcitonin appears more important in childhood, when skeleton grows quickly and the bones are changing dramatically in mass, size and shape. If deficient Ca^{2+} are not deposited in bones and high blood Ca^{2+} level causes disturbance in functioning of muscles and nervous system may lead to kidney stones.

f) Pancreas (Islets of Langerhans)

The pancreas is a double gland as it serves both as exocrine and endocrine gland. The bulk of the gland is exocrine and is formed of acinar cells which synthesize pancreatic juice rich in digestive enzymes. Pancreatic juice is delivered to the duodenum by pancreatic duct during food digestion.

Endocrine pancreas consists of islets of Langerhans. In human pancreas has about one million islets scattered among the acinar cells. Each islet is a small mass of cells with two major types of cells; glucagon producing α cells and insulin producing β cells.

Insulin

It is released by β cells in response to a rise in blood glucose level. Its overall effect is to:

- Reduce blood glucose level to the normal level.
- Increase the rate of glucose uptake by most body cells especially skeletal muscles and fat cells.
- Promotes glycogenesis in liver and muscle cells.
- Increases the use of the glucose in cellular respiration.
- Promotes the conversion of excess glucose to fats.
- Inhibits gluconeogenesis (glucose synthesis)
- Increases the rate of uptake of amino acids into the cells and the rate of protein synthesis.

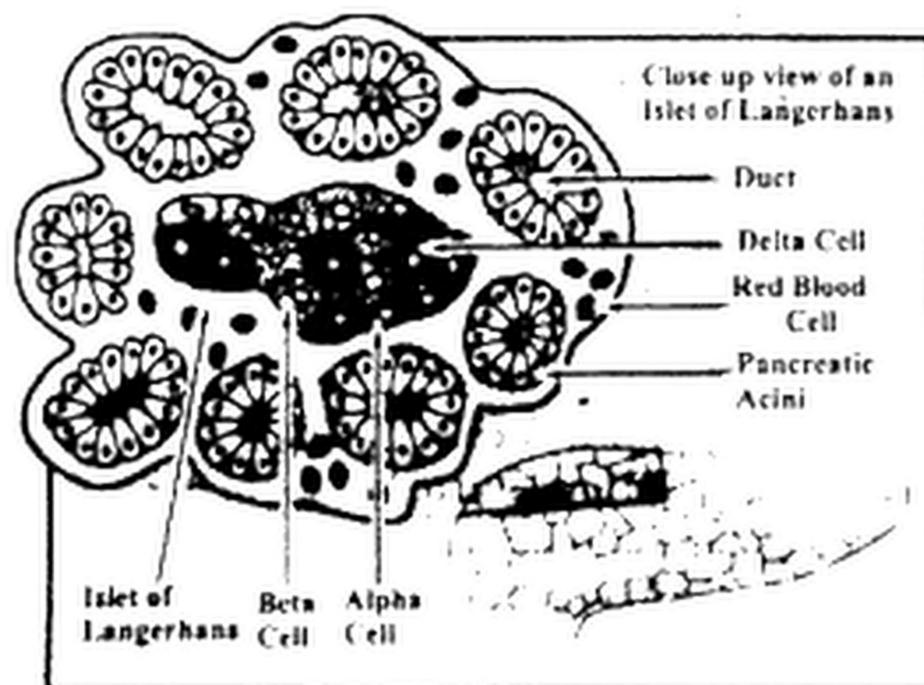


Fig: 18.8 Pancreas showing Islets of Langerhans

If insulin is deficient or is hypoactive, blood glucose level after meal remains high

This metabolic disease is known as diabetes mellitus. The three cardinal signs of diabetes mellitus are:

- Polyuria; a condition in which abnormally large volume of urine is produced.
- Polydipsia; a condition of excessive thirst.
- Polyphagia; a condition of excessive hunger ingestion of food.

Low blood glucose level causes breakdown of the muscle tissue, loss of weight and tiredness. If untreated diabetes finally leads to the disruption of the heart activity and oxygen transport, and severe depression of the nervous system leads to coma and death. Hypersecretion (a rare disorder) of insulin results in hypoglycaemia. Other effects include hunger, sweating, irritability, double vision, unconsciousness, and even death.

Glucagon

Glucagon is a hyperglycemia agent. It is released by α cells when blood glucose level is low. Sympathetic nervous system also stimulates its secretion. High blood glucose levels, insulin, and somatostatin suppress its secretion.

Its role is to increase the blood glucose level:

- i) It promotes glycogenolysis
- ii) It promotes gluconeogenesis
Synthesis of glucose from lactic acid and other non-carbohydrate compounds like protein and fats.
- iii) Promotes release of glucose to the blood by liver cells, which causes blood glucose levels to rise.

Addison's disease: Under secretion of cortical hormone causes this disease, which is characterized by general metabolic disturbance, weakness of muscle action and loss of salts. Stress situation, such as cold, which would normally be overcome, lead to collapse and death.

h) Cushing disease

Over secretion of cortical hormone cause cushing disease, which is characterized by excessive protein breakdown resulting in muscular and bone weakness.

- i) **Endorphins:** are produced in brain. Endorphins bind to pain receptors and so block sensation of pain.
- i) **Myxedema:** Hypothyroidism is the under secretion of thyroxin in adults. The full blown hypothyroid syndrome is called myxedema, which is characterized by low metabolic rate, feeling chilled, puffy eyes, thick and dry condition with hair lost from scalp and eye-brows; oedema, tongue swelling, constipation and enlarged thyroid gland. i.e. goiter. Myxedema may result due to deficiency of iodine in diet.

Q14. Write the functions of:

Answer

- a) **Growth hormone**

somatostatin. GH has a direct effect on growth and development. GH stimulates cell growth and cell division. It also stimulates uptake of amino acids into cells and increase rate of protein synthesis.

Deficiency of GH results in dwarfism in which development is much slower and individual has short stature, however, the body parts stay in proportion and brain development and IQ are unaffected.

Gigantism is result of over secretion of GH during childhood in which the bones are still capable of growth, person increase in height abnormally. Over secretion of GH in adult life cause acromegaly in which bones are no longer capable of increasing in length but grow in thickness. Acromegaly is characterised by enlarging the hands, feet, skull, nose and jawbone.

b) Thyroid Stimulating Hormone

Thyrotrophin releasing factor (TRF) from hypothalamus stimulates the synthesis and release of thyroid stimulating hormone (TSH) from the anterior pituitary. TSH regulates the endocrine function of the thyroid gland. It increases the number of cells and secretory activity of the thyroid gland. Over secretion of TSH causes hyperthyroidism i.e., excess of thyroxin and its under secretion causes hypothyroidism i.e., lack of thyroxin.

c) Antidiuretic hormone

Diuresis means urine formation/production. Antidiuretic is any substance which inhibits urine formation. Osmoreceptors in hypothalamus monitor the solute concentrations of blood. ADH is released when solute concentration increases as a result of water loss. It acts on kidney tubules to enhance water reabsorption. More water is reabsorbed, concentrated urine is produced.

Blood volume increases and solute concentration become normal.

d) Oxytocin: (ocytocia = childbirth)

oxytocin is released during child birth and in nursing women. Stretching of the uterus and cervix during parturition is a strong stimulus for the release of oxytocin. Low level of progesterone in blood to the end of pregnancy and neural stimuli of mother during child birth also stimulate release of oxytocin. During birth it is released in waves and results in labour contractions.

In lactating women, suckling causes the release of oxytocin. The letdown reflex also known as the milk ejection reflex, is set off by this hormone.

e) Insulin is secreted by the Beta (β) cells which are larger in number and glucagon is secreted by alpha (α) cells which are lesser in number. These cells respond directly to the level of blood glucose. Insulin is secreted when the level of blood sugar rises, such as right after a meal. Its overall effect is to reduce blood glucose level to the normal level by increasing the rate of glucose uptake by most body cells especially skeletal muscles and fat cells. It promotes glycogenesis (conversion of glucose to glycogen), increases the use of glucose in cellular respiration, promotes the conversion of excess glucose to fats and inhibits gluconeogenesis (glucose synthesis).

The under secretion of insulin leads to the metabolic disease known as diabetes mellitus which is characterized by high blood glucose level in blood (hyperglycaemia), high blood glucose level in urine (glycosuria). If excess of insulin is produced the utilization of glucose is too great and its level falls in the blood (hypoglycaemia) which upsets nerve and muscles functioning.

f) **Glucagon** is released by α cells when blood glucose level is low. Sympathetic nervous system also stimulates its secretion. High blood glucose levels, insulin and somatostatin suppress its secretion. Its role is to increase the blood glucose level. It acts antagonistically to the insulin and thus reverses the activities performed by insulin.

g) **Cortisone**: Helps to regulate the blood glucose level.

h) **Aldosterone**: Help to regulate the level of minerals in the blood

i) **Estrogens**: These are three hormones all with very similar effects, oestrone, oestrole and oestradiol, of which the most important is oestradiol.

Secretion: estrogens are secreted by ripening follicles (and, in many species, by interstitial cells of the ovary) whose development has been initiated by FSH from the pituitary.

Functions: estrogens bring about:

- The development of the secondary sexual characters in the female.
- Cause thickening of the uterine wall.
- At a point during the oestrous or menstrual cycle, exert a positive feedback which results in a sharp rise in LH output by the pituitary.
- It also aids in healing and repair of uterine wall after menstruation.
- Some of cells of uterine wall become glandular and start secreting proteinacious secretions which are taken up by the embryo during in its early stages of development.
- Deficiency of the sex hormones leads, in the young to failure to mature sexually and sterility in the adult.

j) **Progesterone**

Secretion: It is produced by the ruptured follicle in response to LH from the pituitary.

Functions

It performs the following functions:

- Progsterone inhibits further FSH secretion from the pituitary, thus preventing any more follicles from ripening.
- It also affects the uterus, causing further thickening and vascularisation of its wall, and other areas of the female body, preparing it for maintaining state of pregnancy.
- It suppresses ovulation. That is why it is a major constituent of birth control pill.

k) **Testosterone**

The testes consist of many coiled seminiferous tubules where the spermatozoa develop and between the tubules region of interstitial cells and hormones testosterone and 17β -

The castrated male fails to develop secondary sexual characteristics and his body tends more towards the form of immature female.

j) Gastrin

Hormone secreted by stomach wall travels in blood stream but exerts its effects locally, stimulating the production of pepsinogen and hydrochloric acid (HCl).

M) Secretin

The duodenum produce secretion especially when the food contains acid. It affects pancreas to produce and release pancreatic juice and also affects the rate of bile production in liver.

N) Prostaglandin

A group of hormone like compounds. They provide protection against / during infections.

O) Endorphins: are produced in brain. Endorphins bind to pain receptors and so block sensation of pain.

SECTION III: Extensive Questions

Q1. State the role of hormones as chemical messengers and discuss their chemical nature.

Answer

Hormone as a Chemical Messenger

A hormone is a small soluble organic molecule which is effective in low concentration. It is essentially a chemical messenger that transports a signal from one cell to another. It has its effect at a site where specific receptors are present, called the target; hence it is termed as messenger.

Chemical Nature of Hormone

Chemically, hormones are of three basic types i.e., steroids, amino acids or their derivatives, proteins or polypeptides and a few belong to the fatty acids e.g., prostanglandins.

Steroid hormones are derivatives of cholesterol. Different steroidal hormones are secreted by, the adrenal cortex (cortisol and aldosterone), the ovaries (estrogen and progesterone), the testes (testosterone) and the placenta (estrogen and progesterone).

Two groups of hormones are derivatives of amino acid tyrosine. The metabolic hormones thyroxin and tri-iodothyronin from thyroid glands and epinephrine and norepinephrine from adrenal medullae are all derived from amino acid tyrosine.

Many important endocrine hormones are proteins, peptides or immediate derivatives of these. Growth hormone and prolactin are protein while antidiuretic hormone and oxytocin are peptides of nine amino acids each. Insulin, glucagon and parathormone

Q2. Describe the hormonal regulation of calcium level in the body.

Answer

I) Role of Thyroid Gland In Regulation of Calcium Level

Excessive Ca^{2+} level of blood stimulate release of calcitonin whereas declining blood Ca^{2+} levels inhibit its secretion. Calcitonin increases the deposition of calcium in bone matrix. Calcitonin inhibits Ca^{2+} absorption by the intestines and decreases its reabsorption by the kidney tubules allowing its excretion in urine.

Calcitonin appears more important in childhood, when the skeleton grows quickly and the bones are changing dramatically in mass, size, and shape. If deficient, Ca^{2+} are not deposited in bones and high blood Ca^{2+} level causes disturbance in the functioning of muscles and nervous system and may lead to kidney stones.

II) Role of Parathyroid Gland

Parathyroid gland secretes parathormone, which controls the calcium balance of blood. Its release is triggered by low blood Ca^{2+} levels and inhibited by high blood calcium levels. Parathormone works antagonistically to the calcitonin.

Q3. Explain the mechanism of hormone action at the target cell.

Answer

Mode of Hormone Action

Protein and peptide hormones, like epinephrine, and prostaglandins find their receptors decorating the plasma membrane of target cells. Binding of hormone to receptor initiates a series of events which leads to generation of so-called second messengers within the cell (the hormone is the first messenger). The second messengers then trigger a series of molecular interactions that alter the physiologic state of the cell. Another term used to describe this entire process is signal transduction.

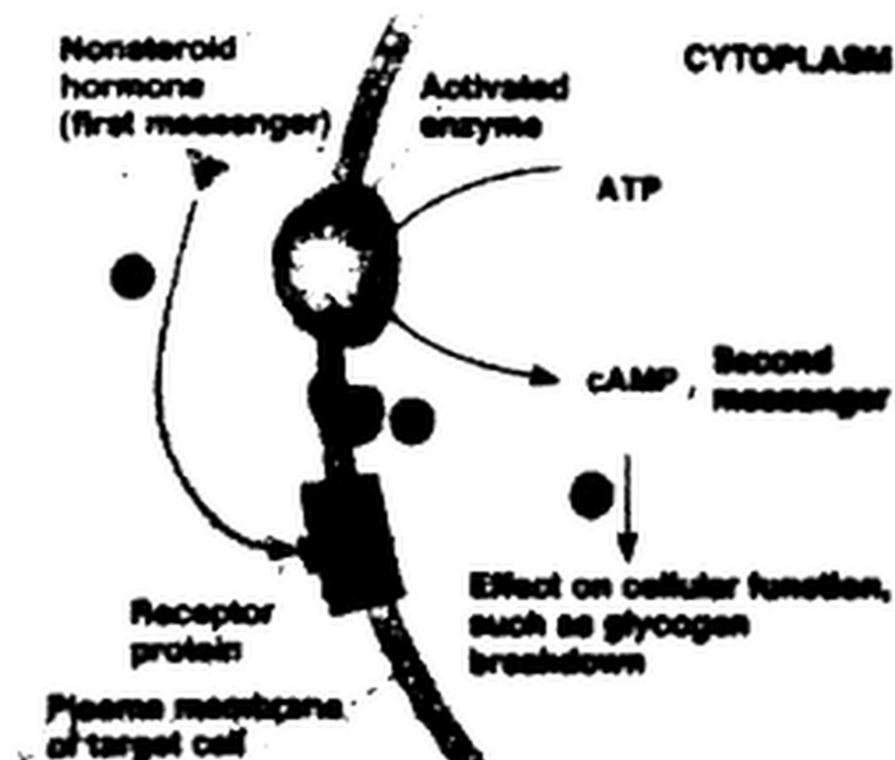


Fig. Mode of action of non-steroid hormone. (1) When nonsteroid hormone first messenger) is attached to the receptor protein, (2) a series of events are triggered which activates an enzyme that in turn (3) converts ATP to cAMP

Receptors for steroid and thyroid hormones are located inside target cells, in the cytoplasm or nucleus, and function as ligand-dependent transcription factors. That is to say, the hormone receptor complex binds to promoter regions of responsive genes and stimulates or sometimes inhibits transcription from those genes. Thus, the mechanism of action of steroid hormones is to modulate gene expression in target cells. By selectively affecting transcription from a battery of genes, the concentration of those respective proteins are altered, which clearly can change the phenotype of the cell.



Fig. Mode of action of steroid hormone

Q4. List the hormones secreted by posterior lobe of pituitary gland and write their functions.

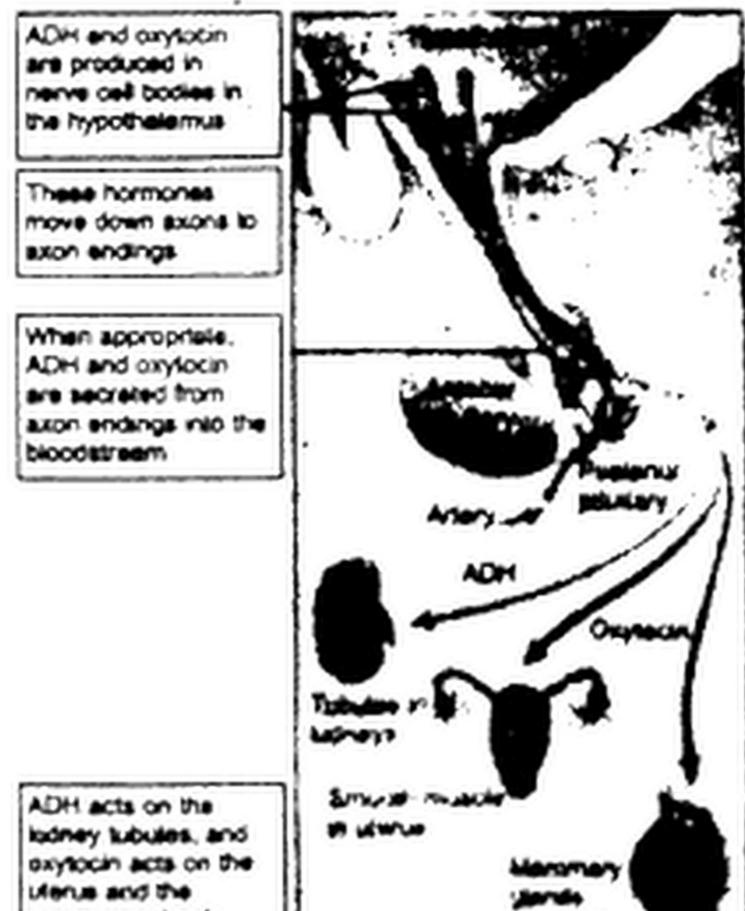
Answer

Posterior Lobe of Pituitary

Posterior is not glandular by itself. It does not synthesize any hormone. It is largely made up of axons of neurosecretory cells of hypothalamus. Posterior pituitary stores antidiuretic hormone (ADH or vasopressin) and oxytocin. These hormones are released in response to nerve impulses from hypothalamus.

ADH is produced during the state of dehydration, decreased blood volume and low blood pressure. Under secretion of ADH causes diabetes insipidus which is characterized by excessive production of diluted urine and frequent thirst. Over secretions may lead to the kidney problems.

Oxytocin is released during child birth and in nursing women. During birth it is



Somatostatin	Inhibition of GH
Thyrotrophin releasing factor (TRF)	Secretion of thyroid stimulating hormone (TSH)
Adrenocorticotrophin releasing factor (CRF)	Secretion of adrenocorticotrophic hormone
Prolactin inhibiting factor (PIF)	Inhibits secretion of prolactin
Gonadotrophin releasing hormone (GnRH)	Secretion of FSH and LH

In addition, the neurosecretory cells that arise from the hypothalamus also produce two primary hormones i.e., antidiuretic hormone (ADH) and oxytocin which are stored in posterior lobe of pituitary gland and are released from here when needed.

Q6. Name the hormones secreted by the thyroid gland and list the general functions of each hormone.

Answer

Thyroid Gland

Thyroid gland is composed of two lobes which are located on either side of trachea inferior to the larynx. Thyroid gland produces three active hormones, tri iodothyronine (T₃), tetra iodothyronine (T₄) or thyroxin, and calcitonin.

T₃ and T₄ are iodine containing hormones. Tri iodothyronine contains three iodine atoms in structure and thyroxin contains four, hence the names T₃ and T₄. TSH from anterior pituitary stimulates production and release of these hormones. These hormones show a variety of physiological effects. They promote basal metabolic rate of the body. Enhance glucose catabolism and synthesis of cholesterol in the liver.

Promote development of nervous system in foetus and infants. They act on muscles for their development and functioning. Promote growth and maturation of skeleton. These hormones also promote normal motility of the gastrointestinal tract.

Hyperthyroidism term is applied to excess of these hormones. Over secretion of T₃ and T₄ causes Grave's disease.

Graves' disease is believed to be an autoimmune disease. The serum of patients contains abnormal antibodies that mimic TSH and continuously stimulate thyroxin release. The symptoms include high metabolic rate, rapid and irregular heartbeat, increased breathing rate, increased body temperature, sweating and weight loss despite adequate food intake. Mostly exophthalmia (protrusion of the eyeballs) results from

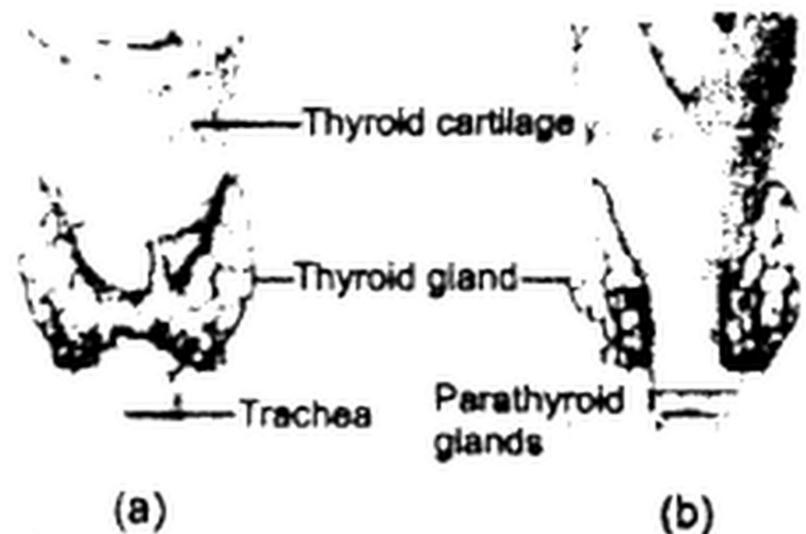


Fig. Thyroid and parathyroid gland

hypothyroid syndrome is called myxedema which is characterized by low metabolic rate, feeling chilled, puffy eyes, thick and dry skin with hair loss from the scalp and eyebrows, oedema, tongue swelling, constipation; and enlarged thyroid gland i.e., goiter. Myxedema may result due to deficiency of iodine in diet. Congenital under secretion results in a severe hypothyroidism in infants called cretinism which is characterized by mental retardation with poor physical growth and disproportionate body size. Bone maturation and puberty are severely delayed and infertility is common.

Q7. What are the functions of parathormone. Relate the problems associated with inbalance of its secretion.

Answer

Parathyroid Glands

In humans, there are four parathyroid glands. All four glands are located on the thyroid gland. They are small, light coloured lumps that stick out from the posterior surface of the thyroid gland. The parathormone is the single most important hormone of parathyroid controlling the calcium balance of the blood. Its release is triggered by low blood Ca^{2+} levels and inhibited by high blood calcium levels. Parathormone works antagonistically to the calcitonin.

Over secretion of parathormone is usually a result of a parathyroid gland tumour. Calcium is released from the bones, and bones deform soften and tend to fracture spontaneously. Blood calcium level elevates (hypercalcemia) which depresses nervous system and causes weakness of muscles. Excess calcium salts precipitate in the kidneys leading to stone formation.

Under secretion of parathormone is usually a result of a parathyroid gland tumour. Calcium is released from the bones, and bones deform soften and tend to fracture spontaneously. Blood calcium level elevates (hypercalcemia) which depresses nervous system and causes weakness of muscles. Excess calcium slats precipitate in the kidneys leading to stone formation.

Under secretion of parathormone causes hypocalcemia. This increases the excitability of neurons. Also it can lead to tetany in which muscles remain in contracted state. If untreated, it can be fatal.

Q8. What are the functions of hormones secreted by adrenal glands? What are the problems associated with the imbalance of these hormones?

Answer

Adrenal Glands

Each of the two adrenal glands rests on a kidney. Each adrenal gland is composed of an inner portion called the medulla and outer portion the cortex.

Epinephrine (adrenaline) and norepinephrine are produced by the adrenal medulla. Both are released during the state of emergency under the influence of sympathetic nervous system. Both are involved in the body's immediate response to stress. The two

blood flow to skeletal muscles and the heart but norepinephrine has the greater influence on peripheral vasoconstriction. The net effect is the rise in blood pressure.

Over secretion of these hormones may cause hypertension and aggressive behaviour during routine life. Under secretion causes failure to combat with stress situation.

The two major types of hormones produced by the adrenal cortex are glucocorticoids, e.g., cortisone, which help to regulate the blood glucose level and mineralocorticoids, e.g., aldosterone, which help to regulate the level of minerals in the blood. Both are produced under the influence of ACTH. Under secretion of cortical hormones will lead to Addison's disease which is characterized by general metabolic disturbance, in particular, weakness of muscle action and loss of salts. Stress situation, such as cold, which would normally be overcome, lead to collapse and death. Over secretion of cortical hormone cause Cushing's disease which is characterized by excessive protein breakdown resulting muscular and bone weakness. Another hormone androgen (testosterone) is also produced from adrenal cortex in small amount in both male and female bodies. Its major site of secretion is testis, which are male gonads.

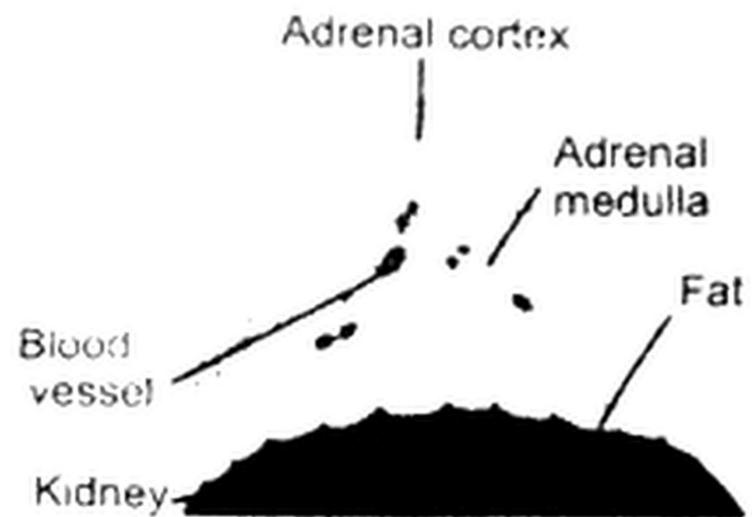


Fig. Adrenal gland

Q9. Write a note on: a) Estrogen b) Progesterone c) Testosterone

Answer

Gonads are special type of endocrine glands which beside hormone secretions also produce gametes. Female gonads are ovaries while male gonads are testes.

The ovaries secrete female sex hormones estrogen and progesterone.

- i) **Estrogen** is secreted by Graffian follicle under the stimulation of FSH but estrogen has negative feedback upon FSH. Estrogen is secreted at the time of puberty and is responsible for secondary sex characteristics in females. It aids in healing and repair of uterine wall after menstruation. Due to its deficiency in the young females, they fail to mature sexually. Deficiency of this hormone in adults leads to sterility. Its over secretion may lead to the development of fibroids (abnormal growth) in uterus and polycystic ovaries.
- ii) **Progesterone** is produced by corpus luteum in response to LH during normal menstrual cycle but it is produced and released from placenta during pregnancy. It inhibits further FSH secretion from pituitary, thus preventing any more follicles from ripening it causes further thickening and vascularisation of the uterus wall for maintaining state of pregnancy.

iii) Testosterone

The male gonads are testes. Testes produce sperm and male sex hormones called testosterone which is secreted from interstitial cells among seminiferous tubules under

reproductive organs and the appearance of secondary sex characteristics and sex drive. In addition, testosterone is necessary for normal sperm production and maintains the reproductive organs in their mature functional state in adult males. Under secretion of this hormone causes the development of feminine characteristics and male sterility.

Q10. Describe the functions of hormones secreted by the endocrine tissues other than the endocrine glands.

Answer

Other Endocrine Tissues/Cells

Hormones are also produced by organs or tissues whose function is not primarily an endocrine one. Even nerve cells produce hormones. The hormone gastrin, produced by the stomach wall, travels in the blood stream but exerts its effect locally, stimulating the production of pepsinogen and hydrochloric acid. Secretin and cholecystikiniñ control pancreatic and liver secretions. Both are formed in the cells of duodenal wall. The placenta secretes progesterone, which maintains pregnancy. Prostaglandins are a group of hormone-like compounds. They provide protection during infections. Endorphins are produced in the brain. Endorphins bind to pain receptors and so block sensation of pain. The pineal gland is attached to the hypothalamus. Its primary hormone is melatonin. It influences daily rhythms called circadian rhythm. The thymus reaches its largest size and is most active during childhood. Thymus produces various hormones called thymosin. Certain lymphocytes that originate in the bone marrow and then pass through the thymus are transformed into T lymphocytes with the help of this hormone.

Q11. What is feedback mechanism? Describe positive feedback mechanism with reference to oxytocin and negative feedback.

Answer

Feedback Mechanism

It is a type of interaction in which a controlling mechanism is itself controlled by the product of reactions it is controlling. After receiving the signal, a change occurs to correct the deviation by depressing it with negative feedback or enhancing it with positive feedback.

Positive feedback responses are not homeostatic and are rare in healthy individuals. In positive feedback an end product speeds up its production. An example of positive feedback is childbirth. The early contractions of labour begin to force the

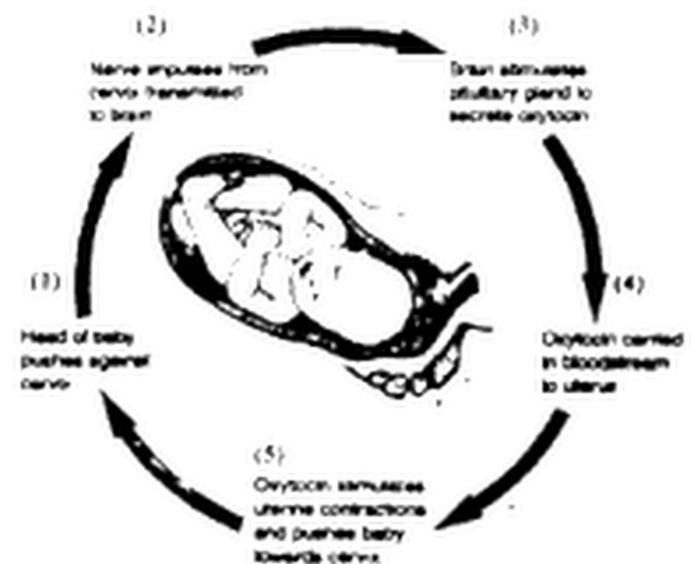
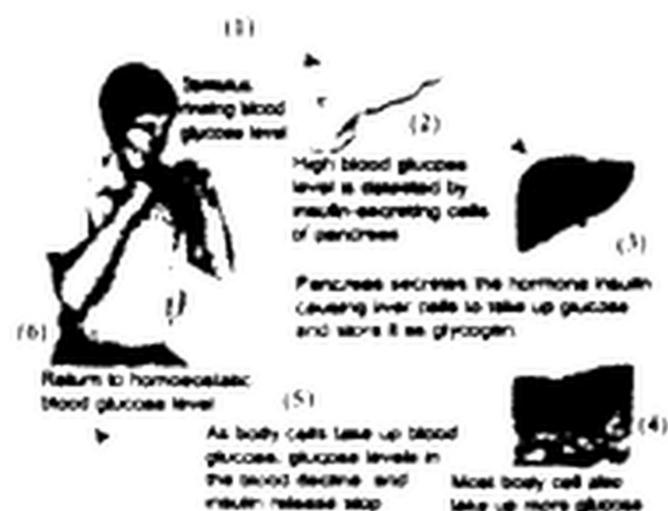


Fig. Positive feedback mechanism



respond to this extension by signalling the hypothalamus, which response by triggering the release of the hormone oxytocin that stimulates more and stronger uterine contractions. Stronger contractions create further pressure on the cervix, which in turn prompts the release of more hormones. The feedback cycle is finally terminated by the expulsion of the baby and its placenta.

In a negative feedback system an endocrine gland is sensitive either to the concentration of a substance it regulates or to the concentration of a product from a process it controls. For example if blood glucose becomes too high, beta (β) cells in the islets of Langerhans respond by releasing insulin. Insulin lowers blood glucose by making cell surface membranes more permeable to glucose. It activates transport proteins in the membranes, allowing glucose to pass into the cells. Insulin also activates enzymes inside the cells. Some of these enzymes convert glucose to glycogen (Fig: 18.10). If the levels of blood glucose get too low, alpha (α) cells in the islets of Langerhans secrete glucagon. This hormone fits into the receptor sites on the cell surface membranes, and activates the enzymes inside the cells that convert glycogen to glucose. The glucose then passes out of the cells and into the blood, raising blood glucose levels. In this way, negative feedback mechanism controls blood glucose.

Q12. Describe how hormones of pancreas act together to regulate the concentration of glucose in the blood.

Answer

Pancreas (Islets of Langerhans)

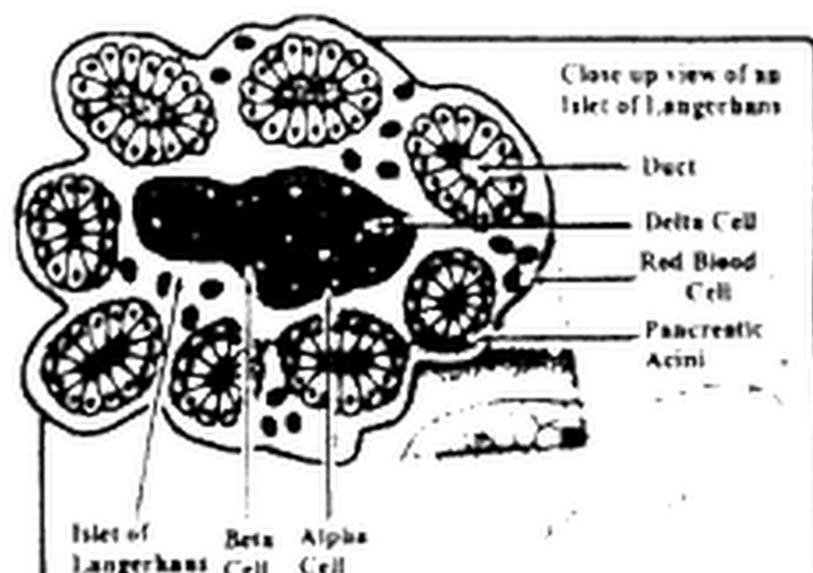
The pancreas is a double gland as it serves both as exocrine and endocrine gland. The bulk of the gland is exocrine and is formed of acinar cells which synthesize pancreatic juice rich in digestive enzymes. Pancreatic juice is delivered to the duodenum by pancreatic duct during food digestion.

Endocrine pancreas consists of islets of Langerhans. In humans pancreas has about one million islets scattered among the acinar cells. Each islet is a small mass of cells with two major types of cells; glucagon producing α cells and insulin producing β cells.

Insulin

It is released by β cells in response to a rise in blood glucose level. Its overall effect is to:

- Reduce blood glucose level to the normal level.
- Increases the rate of glucose uptake by most body cells especially skeletal muscles and fat cells.
- Promotes glycogenesis in liver and muscle cells.
- Increases the use of glucose in cellular respiration



glucose to fats.

- Inhibits gluconeogenesis (glucose synthesis).
- Increases the rate of uptake of amino acids into the cells and the rate of protein synthesis.

If insulin is deficient or is hypoactive, blood glucose level after meal remains high (hyperglycemia). Kidneys cannot reabsorb such high volume of glucose from the filtrate and excess of glucose begins to be lost from the body in the urine (glycosuria). This metabolic disease is known as diabetes mellitus. The three cardinal signs of diabetes mellitus are:

- Polyuria; a condition in which abnormally large volume of urine is produced.
- Polydipsia; a condition of excessive thirst.
- Polyphagia; a condition of excessive hunger ingestion of food.

Low blood glucose level causes breakdown of the muscle tissue, loss of weight and tiredness. If untreated diabetes finally leads to the disruption of the heart activity and oxygen transport, and severe depression of the nervous system leads to coma and death. Hypersecretion (a rare disorder) of insulin results in hypoglycemia. Other effects include hunger, sweating, irritability, double vision, unconsciousness, and even death.

Glucagon

Glucagon is a hyperglycaemic agent. It is released by α cells when blood glucose level is low. Sympathetic nervous system also stimulates its secretion. High blood glucose levels, insulin, and somatostatin suppress its secretion.

Its role is to increase the blood glucose level.

- It promotes glycogenolysis
- It promotes gluconeogenesis; synthesis of glucose from lactic acid and other non-carbohydrate compounds like proteins and fats.
- Promotes release of glucose to the blood by liver cells, which causes blood glucose levels to rise.

ADDITIONAL QUESTIONS

Q13. What is a pituitary gland? Why anterior lobe of pituitary gland is called master gland. Explain the role of different hormones secreted by median & posterior lobe of pituitary gland.

Answer

Pituitary Gland

Pituitary gland is located just below the hypothalamus. It is attached to hypothalamus by a stalk called infundibulum which is composed of blood vessels and the fibres of neurosecretory cells. Pituitary gland is divided into three lobes, the anterior, posterior and the median.

Anterior Lobe of Pituitary

Classically, the anterior pituitary is considered the master gland of the endocrine system because it secretes numerous hormones, many of which regulate the activity of other endocrine glands. It secretes six hormones, all of which regulate the secretory action of other endocrine glands.

Growth hormone (GH) or Somatotrophic hormone (STH) is released under influence of hypothalamic growth hormone releasing factor (GHRF) are inhibited by hypothalamic Somatostatin. GH has a direct effect on growth and development. GH stimulates cell growth and cell division. It also stimulates uptake of amino acids into cells and increase rate of protein synthesis.

Deficiency of GH results in dwarfism in which development is much slower and individual has short stature, however, the body parts stay in proportion and brain development and IQ are unaffected. Gigantism is result of over secretion of GH during childhood in which the bones are still capable of growth, person increase in height abnormally. Over secretion of GH in adult life causes acromegaly in which bones are no longer capable of increasing in length but grow in thickness. Acromegaly is characterised by enlarging the hands, feet, skull, nose and jawbone.

Thyrotrophin releasing factor (TRF) from hypothalamus stimulates the synthesis and release of thyroid stimulating hormone (TSH) from the anterior pituitary. TSH



Fig. Hypothalamus and anterior pituitary gland

hyperthyroidism i.e., excess of thyroxin and its under secretion causes hypothyroidism i.e., lack of thyroxin.

Adrenocorticotrophic Hormone (ACTH) is secreted by the release of corticotrophin releasing factor (CRF) from hypothalamus which is controlled by steroid level in the blood and by direct nervous stimulation of the hypothalamus as a result of stress e.g., cold, heat, pain, fright and infections. ACTH acts on adrenal cortex and stimulates the secretion of the corticosteroids (cortisone and aldosterone).

Follicle stimulating hormone (FSH), luteinising hormone (LH, also called interstitial cell Stimulating hormone, ICSH in the male) and prolactin or leuteotrophic hormone (LTH), are all collectively known as gonadotropic hormones. These hormones act upon reproductive system and regulate its function.



Fig. a. Gigantism makes a person look like a giant.



Fig. b. Acromegaly results in abnormal thickness of bones

Intermediate (median) Lobe

In humans, intermediate pituitary is a thin layer of cells between the anterior and posterior pituitary. It produces melanocyte stimulating hormone (MSH). Melanocyte stimulating hormone increases in humans during pregnancy also. It stimulates the production and release of melanin by melanocytes in skin and hair which darken the colour of the skin especially during pregnancy.

Posterior Lobe

Posterior pituitary stores antidiuretic hormone (ADH or vasopressin) and oxytocin. These hormones are released in response to nerve impulses from hypothalamus.

- **Antidiuretic Hormone:** Diuresis means urine production. Antidiuretic is any substance which inhibits urine formation. Osmoreceptors in hypothalamus monitor the solute concentration of blood.

ADH is Released When solute concentration increases as a result of water loss. It acts on kidney tubules to enhance water reabsorption. More water is reabsorbed, concentrated urine is produced. Blood volume increases and solute concentration

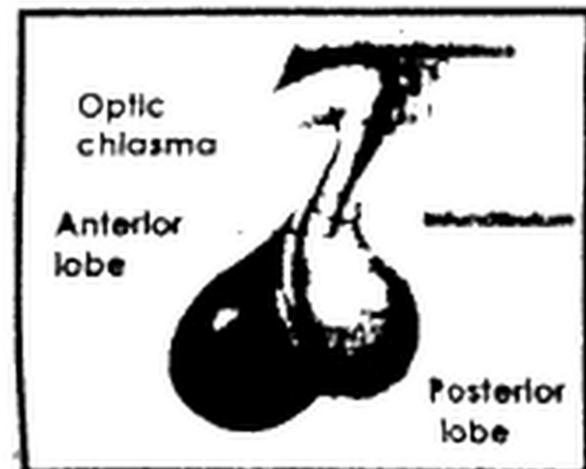


Fig. Lobes of pituitary gland.

- Oxytocin: (ocytocia = childbirth)

Oxytocin is released during child birth and in nursing women. Stretching of the uterus and cervix during parturition is a strong stimulus for the release of oxytocin. Low level of progesterone in blood to the end of pregnancy and neural stimuli of mother during child birth also stimulate release of oxytocin. During birth it is released in waves and results in labour contractions.

In lactating women, suckling causes the release of oxytocin. The letdown reflex also known as the milk ejection reflex, is set off by this hormone.

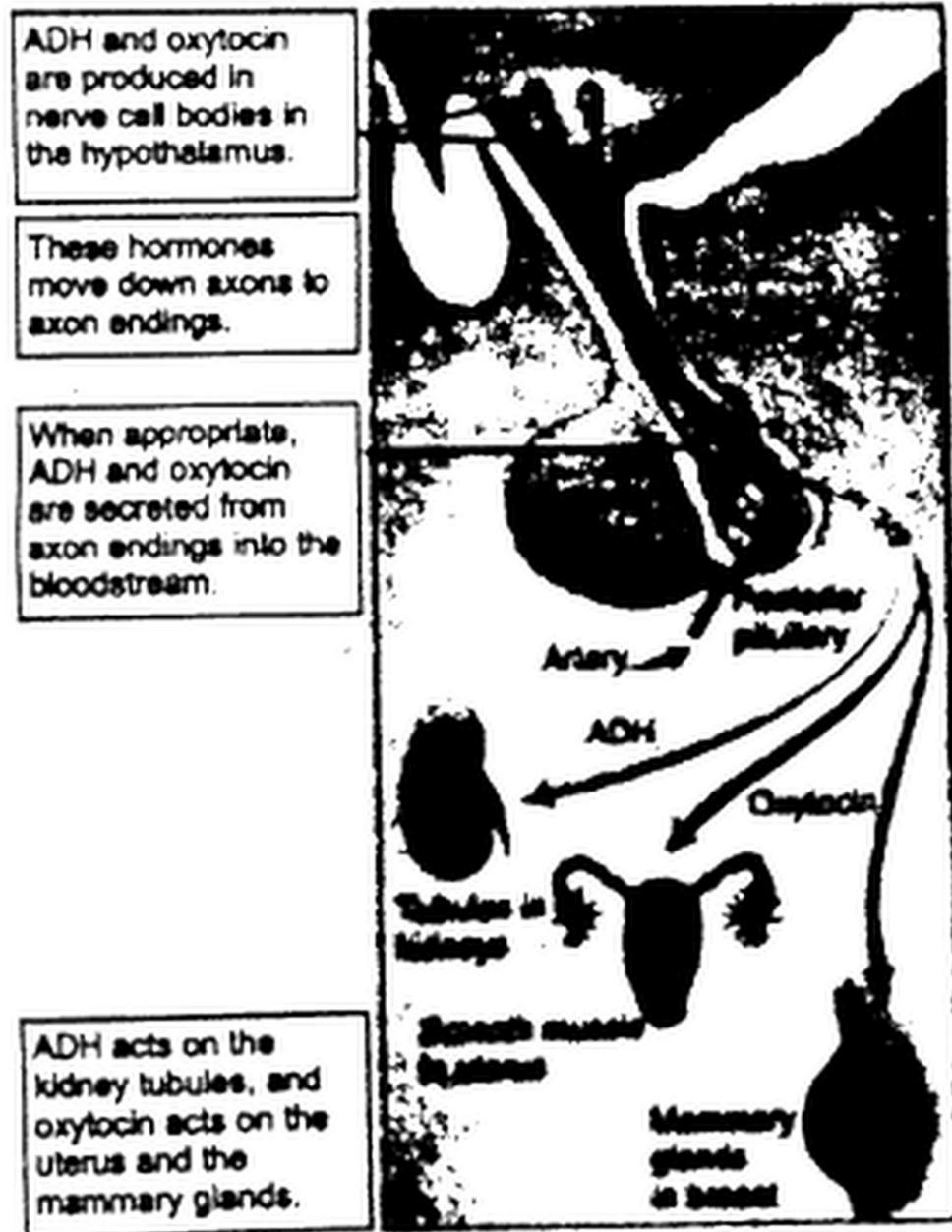


Fig. Hypothalamus and posterior pituitary gland

