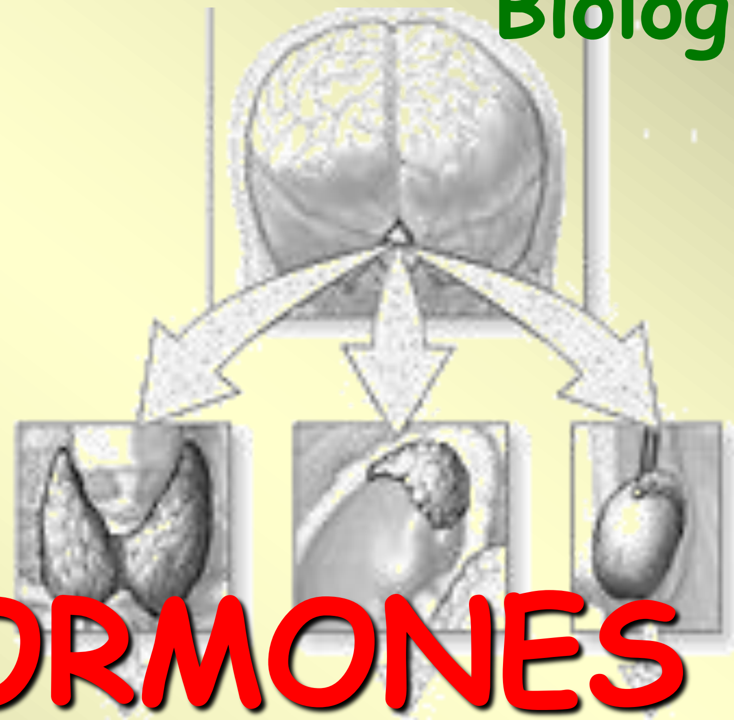
Biological Chemistry Department
Biological Chemistry



HORMONES AND NEUROMEDIATORS

Speciality: Pharmacy for foreign students (Language of instructions – English)

Lecturer: ass. prof. Kravchenko G.B.

Lecture Plan

1. General Characteristics of Endocrine System.
2. General Mechanisms of the Hormone Action.
3. Hypothalamic Hormones.
4. Pituitary Hormones.
5. Pineal Gland Hormones.
6. Adrenal Medullary Hormones.
7. Adrenal Cortical Hormones.
8. Pancreatic Hormones.
9. Hormones of Thyroid and Parathyroid glands.
10. Hormones of the Reproductive Systems.

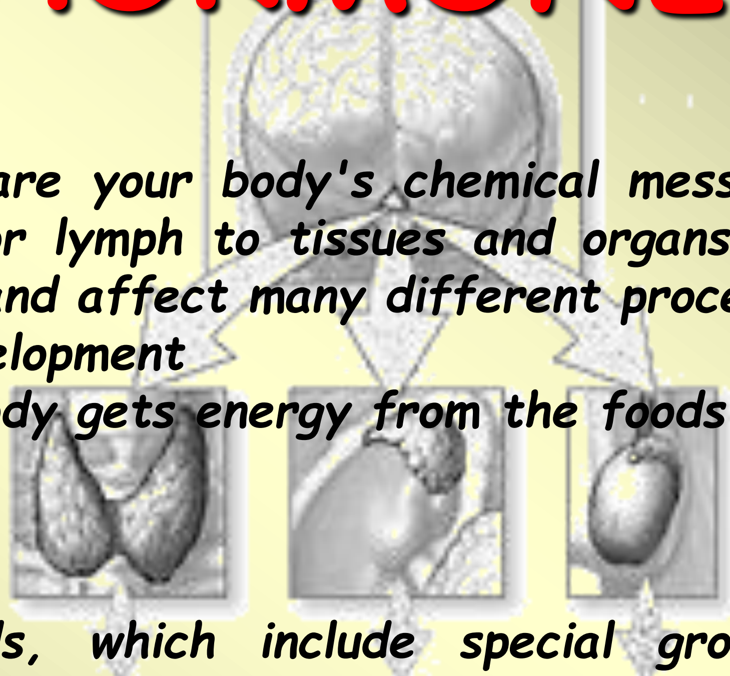
Individual work

1. Neuromediators: Structure and Functions.

Information Resources

1. Biological Chemistry: Textbook / A.L. Zagayko, L.M. Voronina, G.B. Kravchenko, K.V. Strel`chenko. – Kharkiv: NUPh; Original, 2011. – 212-238 p.
2. Training Journal for Licensed Exam "KROK-1": Study Material in Biological Chemistry. – Kharkiv: NUPh, 2017. – 143-172 p.
3. Laboratory Manual on Biochemistry. Kharkiv: NUPh, 2017. - 69-71 p.
4. Table of Major Human Hormones: Water and Fat Soluble: The Medical Biochemistry Page. Available on: https://themedicalbiochemistrypage.org/hormone-table.php.
5. Steroid Hormones and Receptors: The Medical Biochemistry Page. Available on: https://themedicalbiochemistrypage.org/steroid-hormones.php.
6. Peptide Hormones and Receptors: The Medical Biochemistry Page. Available on: https://themedicalbiochemistrypage.org/peptide-hormones.php.

HORMONES



Hormones are your body's chemical messengers. They travel in your bloodstream or lymph to tissues and organs. They work quickly or slowly, over time, and affect many different processes, including:

- ✓ *Growth and development*
- ✓ *Metabolism - body gets energy from the foods you eat*
- ✓ *Sexual function*
- ✓ *Reproduction*
- ✓ *Mood*

Endocrine glands, which include special groups of cells, produce hormones. The major endocrine glands are the hypothalamus, pineal, thymus, thyroid, adrenal glands and pancreas. In addition, men get sexual hormones primarily from their testes and women - from their ovaries.

Hormones are powerful. It takes only a tiny amount to cause great changes in a cell or even in the whole body. That is why too much or too little of a certain hormone can be a serious factor of influence.

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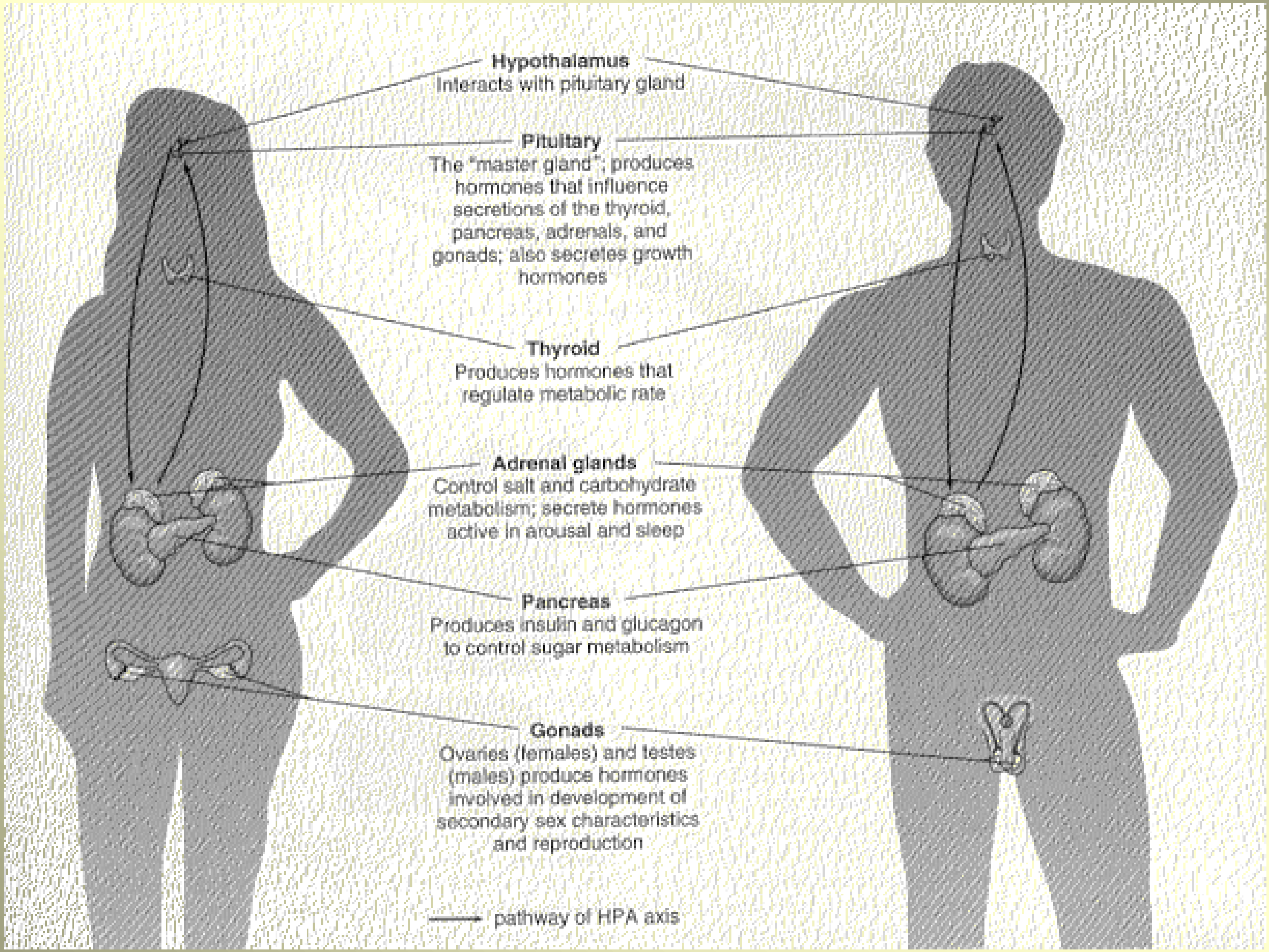
The endocrine system



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The main hormones produced in humans and the diseases and conditions associated with imbalance in their production

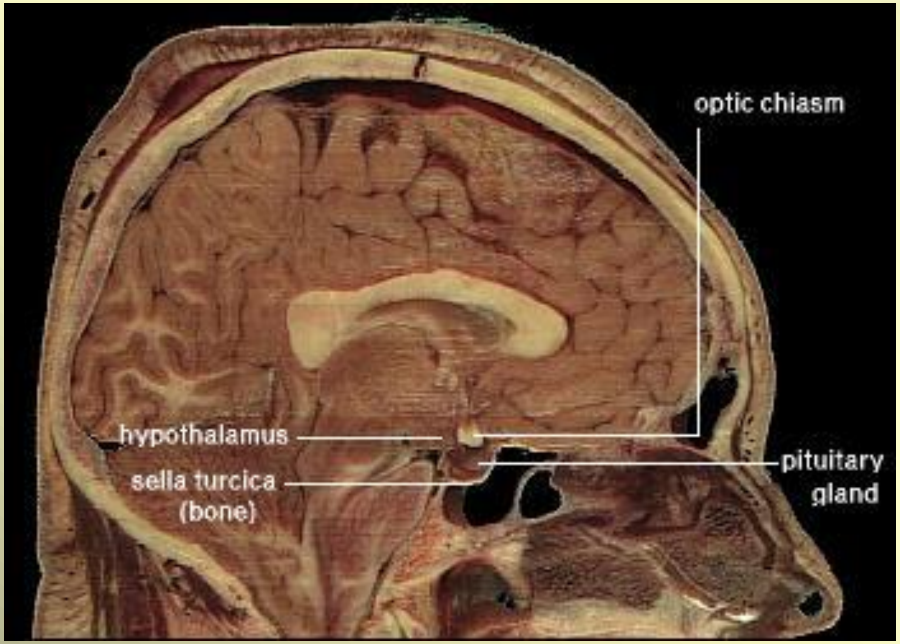
Endocrine Gland	Location/ Description	Hormones Gland Produces	Examples of Disorders Associated with Improper Function
Hypo thalamus	Lower middle of the brain	Growth hormone-releasing factor; Thyrotropin-releasing factor; Corticotropin-releasing factor; Gonadotropin-releasing factor; Prolactin Inhibitory Factor and some others	Precocious puberty (early GnRF production); Thyroid diseases
Pituitary	Below hypothalamus, behind sinus cavity	Prolactin, Growth Hormone, ACTH, TSH, LH, FSH and some others	Galactorrhea (milk production not during pregnancy due to high prolactin); Acromegaly or Gigantism; Cushing's disease (excess ACTH); Loss of menstrual period; Loss of sex drive

Endocrine Gland	Location/ Description	Gland Produces Hormones	Examples of Disorders Associated with Improper Function
Thyroid	Butterfly-shaped	T4 (thyroxine); T3 (triiodothyronine); Calcitonin	Thyroid diseases
Para thyroid	Behind, next to, or below the thyroid	Calcitonin; Parathyroid hormone	Hyperparathyroidism; Hypoparathyroidism
Adrenal	On top of each kidney	Epinephrine; Norepinephrine; Aldosterone; Cortisole	Pheochromocytoma; Addison's Disease
Ovaries	In the pelvis	Estrogen; Progesterone	Polycystic ovary syndrome
Testes	In the groin	Testosterone	Hypogonadism
Pancreas	Behind the stomach	Insulin; Glucagon; Somatostatin	Diabetes mellitus

HORMONES OF THE CENTRAL ENDOCRINE GLANDS

Hypothalamus and Pituitary Gland

The hypothalamus is a region of the brain that controls an immense number of body functions. It is located in the middle of the base of the brain, and encapsulates the ventral portion of the third ventricle. The pituitary gland, also known as hypophysis, is a roundish organ that lies immediately beneath the hypothalamus, resting in a depression of the base of the skull called the sella turcica ("Turkish saddle").



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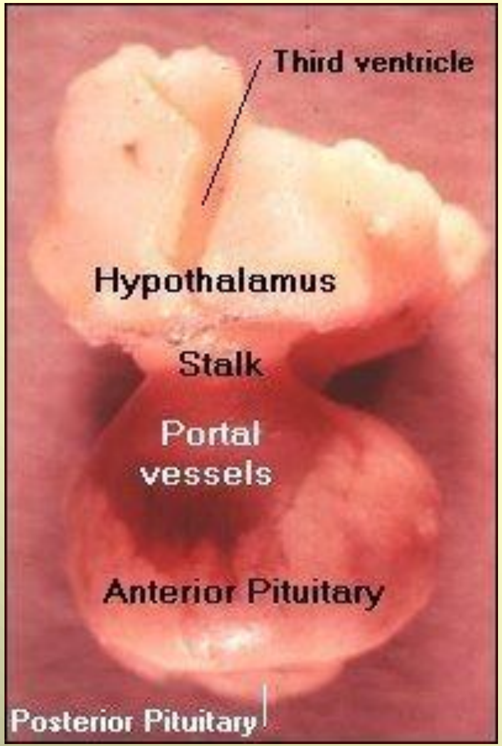
Careful examination of the pituitary gland reveals that it is composed of two distinctive parts:

✓***the anterior pituitary** or* adenohypophysis ***is a classical gland composed predominantly of cells that secrete protein hormones;***

✓***the posterior pituitary** or* neurohypophysis ***is not really an organ, but an extension of the hypothalamus. It is composed largely of the axons of hypothalamic neurons which extend downward as a large bundle behind the anterior pituitary. It also forms the so-called pituitary stalk, which appears to suspend the anterior gland from the hypothalamus.***



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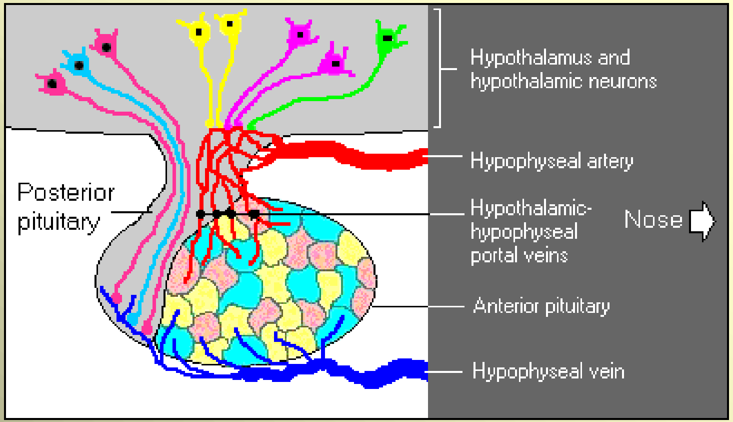
A key to understanding the endocrine relationships between hypothalamus and anterior pituitary is to appreciate the vascular connections between these organs. Secretion of hormones from the anterior pituitary is under the strict control of the hypothalamic hormones. These hypothalamic hormones reach the anterior pituitary through the following routes:

- ***a branch of the hypophyseal artery ramifies into a capillary bed in the lower hypothalamus, and hypothalmic hormones destined for the anterior pituitary are secreted into that capillary blood;***
- ***blood from those capillaries drains into the hypothalamic-hypophyseal portal veins. Portal veins are defined as veins between two capillary beds; the hypothalamic-hypophyseal portal veins branch again into another series of capillaries within the anterior pituitary.***
- ***capillaries within the anterior pituitary, which carry hormones secreted by that gland, coalesce into veins that drain into the systemic venous blood. Those veins also collect capillary blood from the posterior pituitary gland.***



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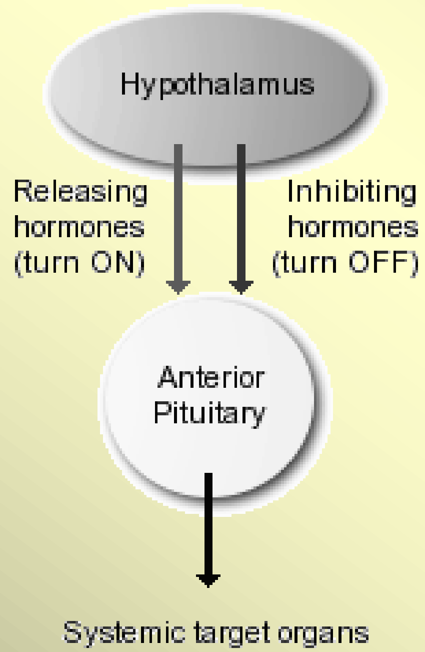
The pituitary gland is often portrayed as the "master gland" of the body. Such praise is justified in the sense that the anterior and posterior pituitary secrete a group of hormones that collectively influence all cells and affect virtually all physiologic processes.

The pituitary gland may be a king, but the power behind the throne clearly belongs to the hypothalamus. As alluded to in the last section, some of the neurons within the hypothalamus - neurosecretory neurons - secrete hormones that strictly control secretion of hormones from the anterior pituitary. The hypothalamic hormones are referred to as releasing hormones and inhibiting hormones, reflecting their influence on anterior pituitary hormones.

Hypothalamic releasing and inhibiting hormones are carried directly to the anterior pituitary gland via the hypothalamic-hypophyseal portal veins. Specific hypothalamic hormones bind to the receptors on specific anterior pituitary cells, modulating release of the hormone they produce.

As an example, thyroid-releasing hormone from the hypothalamus binds to the receptors on anterior pituitary cells called thyrotrophs, stimulating them to secrete thyroid-stimulating hormone or TSH. The anterior pituitary hormones enter the systemic circulation and bind to their receptors on other target organs. In the case of TSH, a target organ is the thyroid gland.

Clearly, robust control systems must be in place to prevent over or under-secretion of hypothalamic and anterior pituitary hormones. A prominent mechanism for control of the releasing and inhibiting hormones is a negative feedback.



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Hormone	Major target organ(s)	Major Physiologic Effects
Growth hormone	Liver, adipose tissue	Promotes growth (indirectly), control of protein, lipid and carbohydrate metabolism
Thyroid-stimulating hormone	Thyroid gland	Stimulates secretion of thyroid hormones
Adrenocorticotropic hormone	Adrenal gland (cortex)	Stimulates secretion of glucocorticoids
Prolactin	Mammary gland	Milk production
Luteinizing hormone	Ovary and testis	Control of reproductive function
Follicle-stimulating hormone	Ovary and testis	Control of reproductive function
Antidiuretic hormone	Kidney	Conservation of body water
Oxytocin	Ovary and testis	Stimulates milk ejection and uterine contractions

Growth Hormone (GH)

Human GH has about 200 amino acids, 2 disulfide bonds, and no glycosylation.

In humans, growth hormone promotes gluconeogenesis and is consequently hyperglycemic. It promotes amino acid uptake by cells, with the result that GH therapy puts an organism into positive nitrogen balance, similar to that seen in growing children. Finally, growth hormone is lipolytic, inducing the breakdown of tissue lipids and thus providing energy supplies that are used to support the stimulated protein synthesis induced by increased amino acid uptake.

There are a number of genetic deficiencies associated with GH. GH-deficient dwarfs lack the ability to synthesize or secrete GH. The production of excessive amounts of GH before epiphyseal closure of the long bones leads to gigantism, and when GH becomes excessive after epiphyseal closure, acral bone growth leads to the characteristic features of acromegaly.

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Prolactin (PRL)

PRL initiates and maintains lactation in mammals, but normally only in mammary tissue that has been primed with estrogenic.

The Gonadotrophins

The molecular weight of the gonadotrophins (follicle stimulating hormone, FSH; luteinizing hormone, LH) is about 25,000 Daltons. All of them are highly glycosylated.

The gonadotrophins bind to cells in the ovaries and testes, stimulating the production of the steroid sex hormones estrogens, testosterone and dihydrotestosterone. In males, luteinizing hormone binds to Leydig cells of the testes to induce the secretion of T, while follicle stimulating hormone binds to Sertoli cells and induces the secretion of T and DHT. In females, LH induces thecal cells to secrete estradiol, and FSH stimulates estrogen synthesis by granulosa cells.

Adrenocorticotrophic hormone (ACTH)

The biological role of ACTH is to stimulate the production of adrenal cortex steroids, principally cortisol and costicosterone.

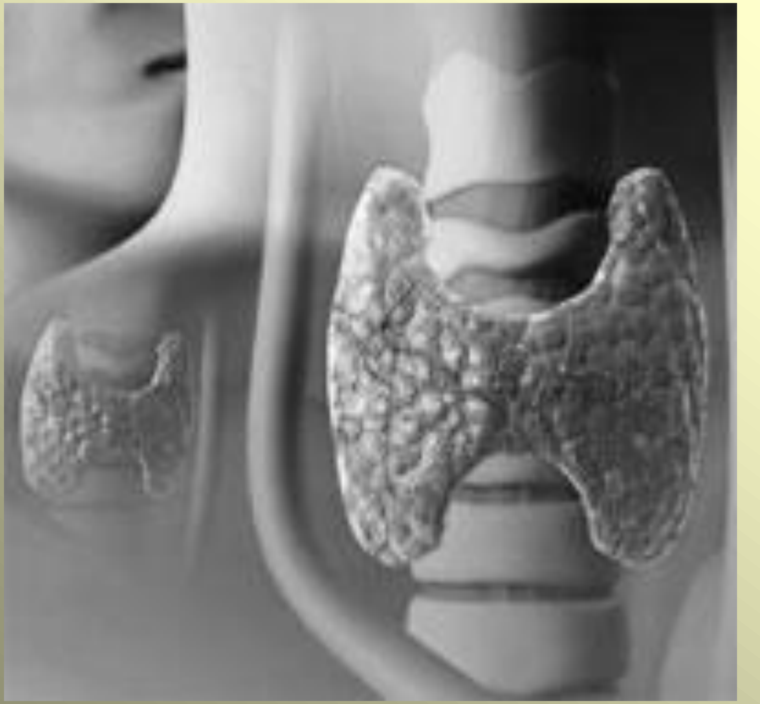
Vasopressin and Oxytocin

Vasopressin is also known as antidiuretic hormone (ADH), because it is the main regulator of body fluid osmolarity. The secretion of vasopressin is regulated in the hypothalamus by osmoreceptors, which sense water concentration and stimulate increased vasopressin secretion when plasma osmolarity increases. The secreted vasopressin increases the reabsorption rate of water in kidney tubule cells, causing the excretion of urine that is concentrated in Na+ and thus yielding a net drop in osmolarity of body fluids. Vasopressin deficiency leads to watery urine and polydipsia, a condition known as diabetes insipidus.

Oxytocin secretion in nursing women is stimulated by direct neural feedback obtained by stimulation of the nipple during suckling. Its physiological effects include the contraction of mammary gland myoepithelial cells, which induces the ejection of milk from mammary glands, and the stimulation of uterine smooth muscle contraction leading to childbirth.

Thyroid hormones

The thyroid is a small, butterfly-shaped gland located just below the Adam's apple. This gland plays a very important role in the controlling of body metabolism,i.e. the rate at which your body uses energy fuels. It does this by producing thyroid hormones (primarily thyroxine, or T4 (A), and triiodothyronine, or T3 (B). These thyroid hormones tell the cells in your body how fast to use energy and create proteins. The thyroid gland also produces calcitonin, a hormone that helps to regulate calcium levels in the blood by inhibiting the breakdown (resorption) of bones and increasing calcium excretion through the kidneys.



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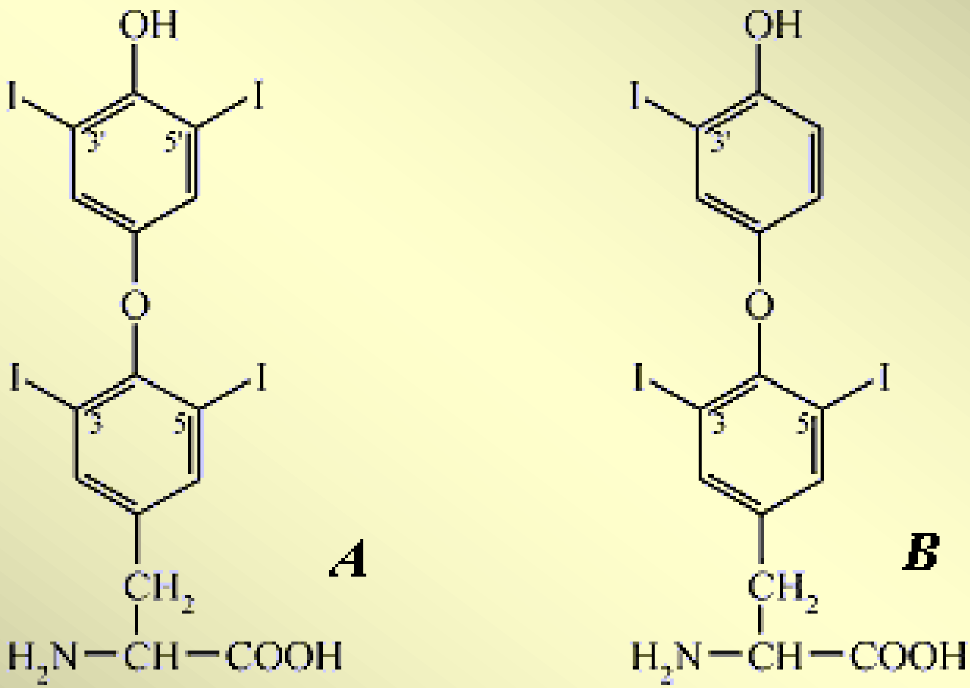

Thyroid hormones' effects

Thyroid hormones have profound effects on many "big time" physiologic processes, such as development, growth and metabolism. They are clearly necessary for normal growth of children, as evidenced by the growth-retardation observed in thyroid deficiency. Of critical importance in mammals is the fact that normal levels of thyroid hormone are essential to the development of the fetal and neonatal brain. Thyroid hormones stimulate diverse metabolic activities in most tissues, leading to an increase in basal metabolic rate. One consequence of this activity is to increase body heat production, which seems to result from increased oxygen consumption, rates of ATP hydrolysis and influence of uncoupling proteins.

Increased thyroid hormone levels stimulate fat mobilization, leading to a build-up of free fatty acids in plasma. They also enhance oxidation of fatty acids in many tissues. Finally, plasma concentrations of cholesterol and triacylglycerols are inversely correlated with thyroid hormone levels – one diagnostic criterion of hypothyroidism is increased blood cholesterol concentration. Thyroid hormones stimulate almost all aspects of carbohydrate metabolism, including enhancement of insulin-dependent entry of glucose into the cells and increased gluconeogenesis and glycogenolysis to generate free glucose.

Thyroid diseases

Thyroid diseases are primarily conditions that affect the amount of thyroid hormones being produced. Some create too few, leading to hypothyroidism and a slowing of body functions that causes symptoms such as weight gain, dry skin, constipation, cold intolerance, puffy skin, hair loss, fatigue, and menstrual irregularity in women. Severe untreated hypothyroidism, called myxedema, can lead to heart failure, seizures, and coma. In children, hypothyroidism can stunt growth and delay sexual development. In infants it can cause a mental retardation.

Myxedema

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Mental retardation

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If a thyroid disorder creates excessive amounts of thyroid hormones, the result is hyperthyroidism and the acceleration of body functions (Graves disease). This can lead to symptoms such as increased heart rate, anxiety, weight loss, difficulty of sleeping, tremors in the hands, weakness, and sometimes diarrhea. There may be puffiness around the eyes, dryness, irritation, and, in some cases, bulging of the eyes. The affected person may experience light sensitivity and visual disturbances. Because the eyes may not move normally, the person may appear to be staring.

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Hyperthyroidism

PARATHYROID HORMONES

Parathyroid hormone is the most important endocrine regulator of calcium and phosphorus concentration in extracellular fluid. This hormone is secreted from cells of the parathyroid glands and finds its major target cells in bones and kidneys.

Parathyroid Hormone (PTH)

Parathyroid hormone (molecular weight 9,500) is synthesized and secreted by chief cells of the parathyroid in response to systemic Ca^{2+} levels. The body response to PTH is complex but is aimed in all tissues at increasing Ca^{2+} levels in extracellular fluids. PTH induces the dissolution of bones by stimulating osteoclast activity, which leads to elevated plasma Ca^{2+} and phosphate concentrations. In the kidneys, PTH reduces renal Ca^{2+} clearance by stimulating its reabsorption; at the same time, PTH reduces the reabsorption of phosphate and thereby increases its clearance. Finally, PTH acts on the liver, kidneys, and intestine to stimulate the production of calcitriol, which is responsible for Ca^{2+} absorption in the intestine.

Calcitonin (CT)

Calcitonin has the ability to decrease blood calcium levels by effects on two well-studied target organs. Calcitonin suppresses resorption of bones by inhibiting the activity of osteoclasts, a cell type that "digests" bone matrix, releasing calcium and phosphorus into the blood.

Disease States

Excessive PTH secretion is known as hyperparathyroidism, and is often the result of a benign parathyroid tumor (primary hyperparathyroidism) that loses its sensitivity to circulating calcium levels. In chronic renal failure a secondary hyperparathyroidism can be a result. Common manifestations of this disorder are chronic elevations of blood calcium concentration (hypercalcemia), kidney stones and decalcification of bones.

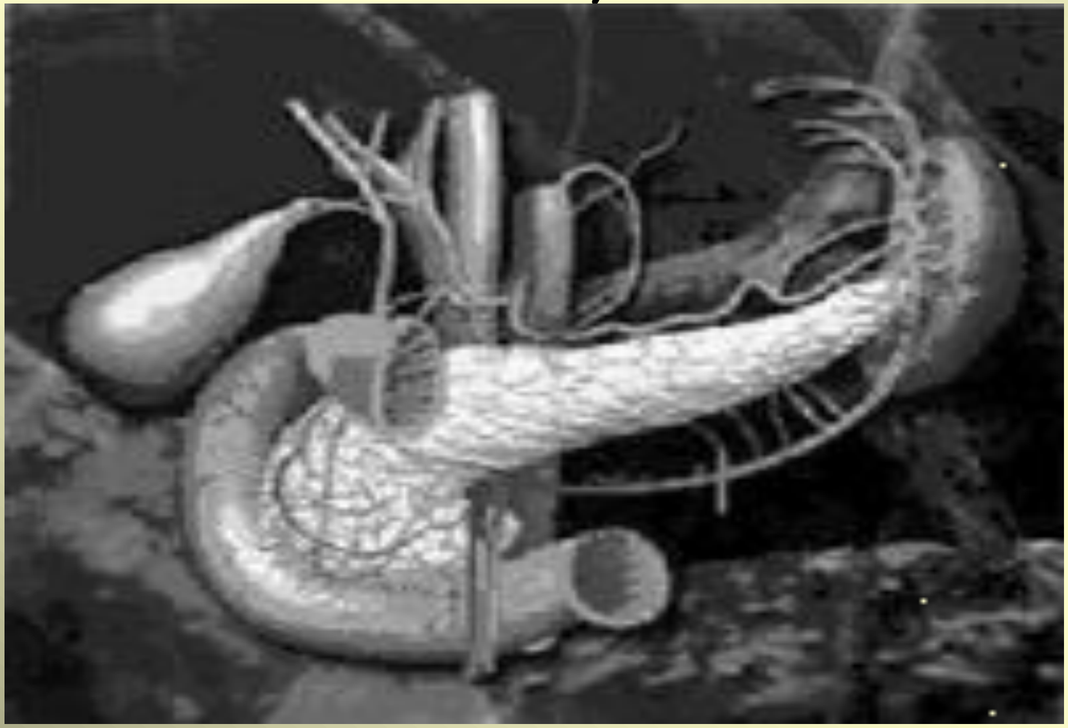
Insufficient PTH secretion is known as hypoparathyroidism, and is commonly caused by surgical misadventure (e.g. inadvertent removal during routine thyroid surgery), autoimmune disorder, or inborn errors of metabolism. The resulting hypocalcemia often leads to tetany and convulsions, and can be acutely life-threatening. Treatment focuses on restoring normal blood calcium concentrations by calcium infusions, oral calcium supplements and vitamin D therapy.

Increased levels of calcitonin are associated with two rare conditions, medullary thyroid cancer and benign C-cell hyperplasia. When excessive calcitonin is produced, the patient may experience chronic diarrhea.

PANCREATIC HORMONES

Scattered throughout the exocrine tissue are several hundred thousand clusters of endocrine cells (islets of Langerhans), which house three major cell types, each of which produces a different endocrine product:

- ✓α (A cells) secrete the hormone glucagon.
- ✓β (B cells) produce insulin and are the most abundant of the islet cells.
- ✓δ (D cells) secrete the hormone somatostatin, which is also produced by a number of other endocrine cells in the body.



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Insulin action

Insulin is a quite simple protein consisting of two polypeptide chains with 51 amino acid residues.The major function of insulin is to counter the concerted action of a number of hyperglycemia-generating hormones and to maintain low blood glucose levels. In addition to its role in regulating glucose metabolism, insulin stimulates Lipogenesis, diminishes Lipolysis, and increases amino acid transport into cells. Insulin also modulates transcription, altering the cell content of numerous mRNAs. It stimulates growth, DNA synthesis, and cell replication.

In liver glucose uptake is dramatically increased by insulin because of increased activity of the enzymes glucokinase, phosphofructokinase-1, and pyruvate kinase, the key regulatory enzymes of Glycolysis. In most nonhepatic tissues, insulin increases glucose uptake by increasing the number of plasma membrane glucose transporters: GLUTs.

Insulin promotes synthesis of fatty acids in the liver and inhibits breakdown of fat in adipose tissue by inhibiting the intracellular lipase that hydrolyzes triglycerides to release fatty acids. Insulin facilitates entry of glucose into adipocytes, and within those cells, glucose can be used to synthesize glycerol. This glycerol and the fatty acids delivered from the liver, are used to synthesize triglyceride within the adipocyte. By these mechanisms, insulin is involved in further accumulation of triglyceride in fat cells. In addition to insulin's effect on entry of glucose into cells, it also stimulates the uptake of amino acids, again contributing to its overall anabolic effect.

Glucagon action

Glucagon is a polypeptide which consists of 29 amino acid residues. The major effect of glucagon is to stimulate an increase in blood concentration of glucose. Glucagon exerts control over two pivotal metabolic pathways within the liver, leading that organ to dispense glucose to the rest of the body. Glucagon stimulates breakdown of glycogen stored in the liver. When blood glucose levels begin to fall, glucagon is secreted and acts on hepatocytes to activate the enzymes that depolymerize glycogen and release glucose. At the same time glucagon activates hepatic Gluconeogenesis. As such, it provides another source of glucose for blood.

Glucagon also appears to have a minor effect of enhancing Lipolysis of triglyceride in adipose tissue, which could be viewed as an addition means of conserving blood glucose by providing fatty acid fuel to most cells.

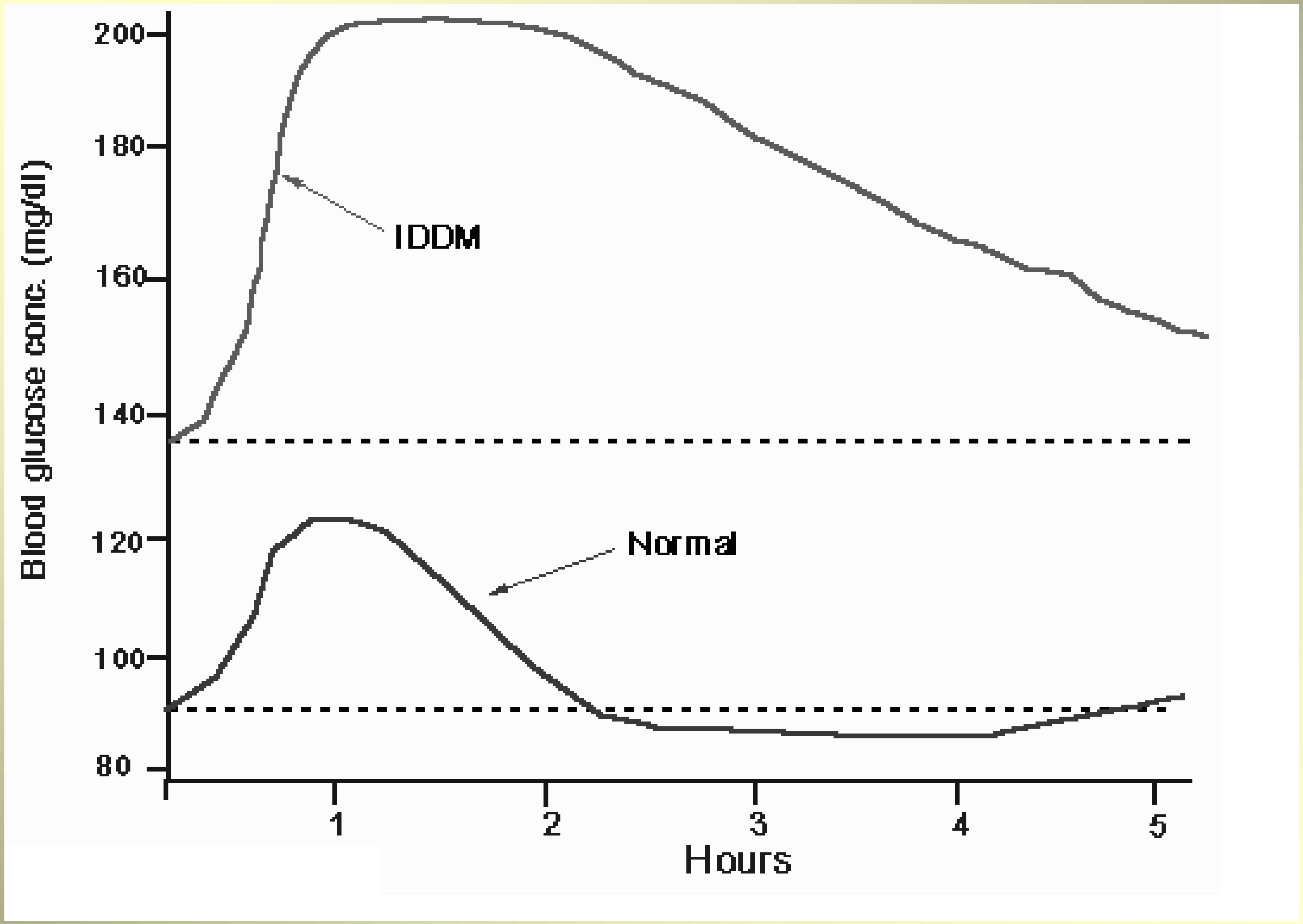
Definition of Diabetes

Diabetes is any disorder characterized by excessive urine excretion. The most common form of diabetes is Diabetes mellitus, a metabolic disorder in which there is an inability to oxidize carbohydrate due to disturbances in insulin function. Diabetes mellitus is characterized by elevated glucose in the plasma and episodic ketoacidosis. Additional symptoms of Diabetes mellitus include excessive thirst, glucosuria, polyuria, lipemia and hunger. Another form is Diabetes insipidus. It is the result of a deficiency of antidiuretic hormone. The major symptom of Diabetes insipidus (excessive urine output) results from an inability of the kidneys to resorb water.

Criteria, which clinically establish an individual as suffering from Diabetes mellitus, include:

- ✓having a fasting plasma glucose level in excess of 126 mg/dL (7 mmol/L). Normal levels should be less than 100 mg/dL (5.6 mmol/L) or
- ✓having plasma glucose levels in excess of 200 mg/dL (11 mmol/L) at two times points during an oral glucose tolerance test, OGTT, one of which must be within 2 hrs of ingestion of glucose.

Oral glucose tolerance test



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Insulin-Dependent Diabetes Mellitus (IDDM)

Type I Diabetes has been shown to be the result of an autoimmune reaction to antigens of the islet cells of the pancreas.

Metabolism abnormalities

Uncontrolled IDDM leads to increased hepatic glucose output. First, liver glycogen stores are mobilized, then hepatic Gluconeogenesis is activated to produce glucose. Insulin deficiency also impairs non-hepatic tissue utilization of glucose. Reduced glucose uptake by peripheral tissues in turn leads to a reduced rate of glucose metabolism. The combination of increased hepatic glucose production and reduced peripheral tissue metabolism leads to elevated plasma glucose levels. When the capacity of the kidneys to reabsorb glucose is surpassed, glucosuria ensues. Glucose is an osmotic diuretic and an increase in renal loss of glucose is accompanied by loss of water and electrolytes, termed polyuria.

In uncontrolled IDDM there is a rapid mobilization of triglycerides leading to increased levels of plasma free fatty acids. The free fatty acids are taken up by numerous tissues and metabolized to provide energy. In hepatocytes the majority of acetyl-CoA is metabolized into the ketone bodies: acetoacetate, β-hydroxybutyrate and acetone. Production of the ketone bodies, in excess of the organism ability to utilize them leads to ketoacidosis. Insulin deficiency leads to increased catabolism of proteins. The increased rate of proteolysis leads to elevated concentrations of amino acids in plasma.

Non-Insulin-Dependent Diabetes Mellitus (NIDDM)

NIDDM is characterized by a lack of the needed sensitivity to insulin of corresponding tissue receptors to prevent ketoacidosis. Type II of Diabetes refers to as the common form of idiopathic NIDDM. NIDDM is not an autoimmune disorder, however, there is a strong genetic correlation with the susceptibility to NIDDM. Obesity is a major risk factor that predisposes a man to NIDDM.

Oral hypoglycemic drugs

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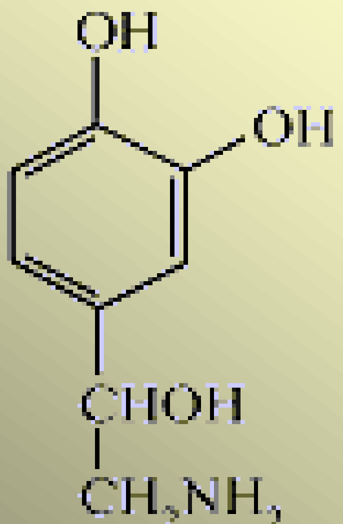
ADRENAL MEDULLARY HORMONES

Cells in the adrenal medulla synthesize and secrete Norepinephrine (noradrenaline,A) and Epinephrine (adrenaline, B). In humans roughly 80% of the catecholamine output is epinephrine.



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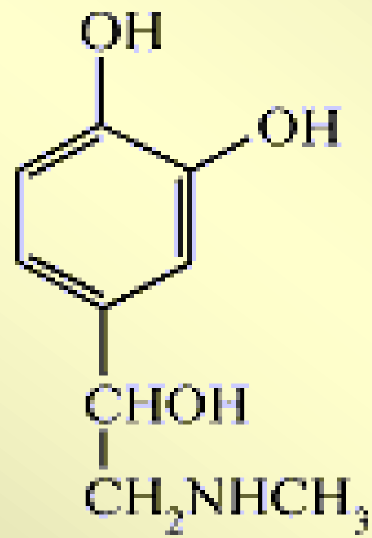

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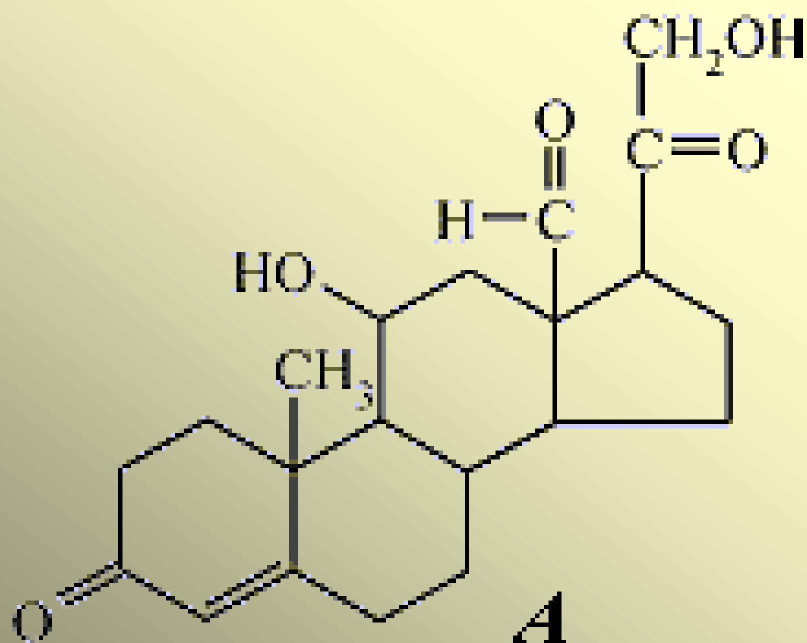
Major effects mediated by epinephrine and norepinephrine :

- Increased rate and force of contraction of the heart muscle: this is predominantly an effect of epinephrine acting through β–receptors.
- Constriction of blood vessels: norepinephrine, in particular, causes widespread vasoconstriction, resulting in increased resistance and hence high arterial blood pressure.
- Dilation of bronchioles: assists in pulmonary ventilation.
- Stimulation of Lipolysis in fat cells: this provides fatty acids for energy production in many tissues and aids in conservation of dwindling reserves of blood glucose.
- Increased metabolic rate: oxygen consumption and heat production increase throughout the body in response to epinephrine. Medullary hormones also promote breakdown of glycogen in skeletal muscle to provide glucose for energy production.
- Dilation of the pupils.
- Inhibition of certain "non-essential" processes: an example is inhibition of gastrointestinal secretion and motor activity.
- It elevates blood sugar level by increasing hydrolysis of glycogen to glucose in the liver.
- Suppressive effect on the adaptive immune system.

ADRENAL CORTICAL HORMONES

The adrenal cortex produces steroid hormones. In total, at least two to three dozen different steroids are synthesized and secreted from this tissue, include some sex steroids. But two classes are of particular importance: mineralocorticoids (aldosterone, A), and glucocorticoids (cortisole, B).



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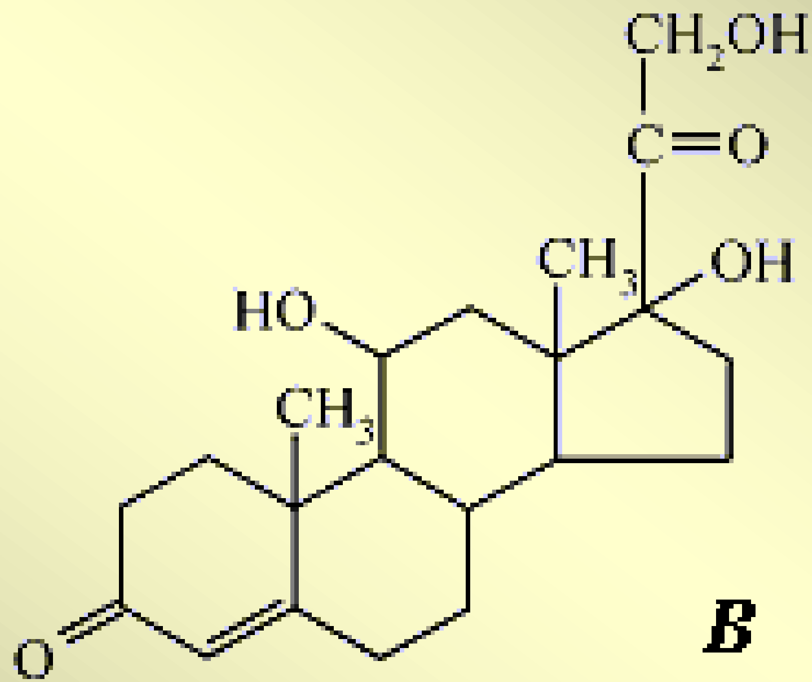
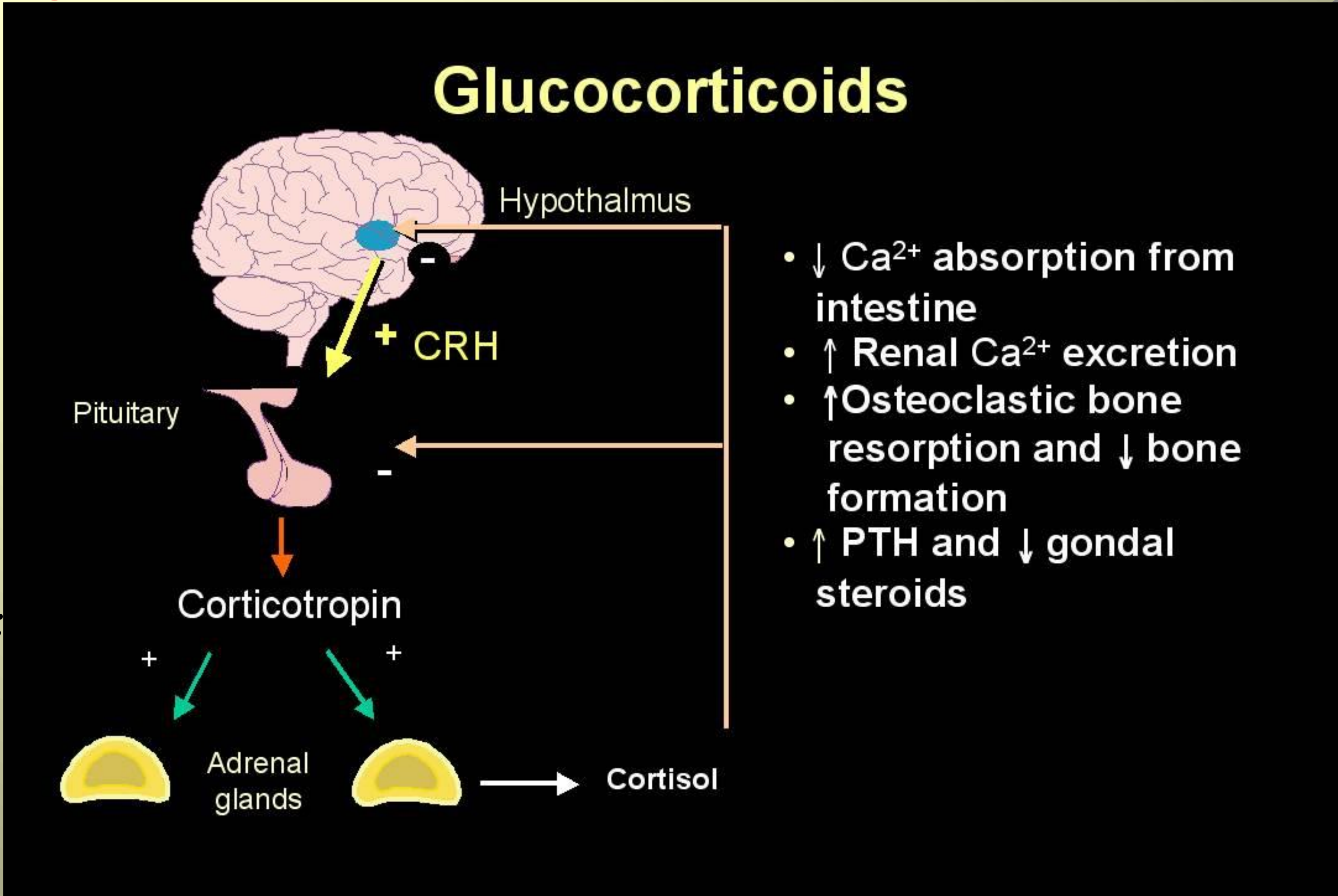


B

GLUCOCORTICOIDS

Glucocorticoids stimulate Gluconeogenesis, particularly in the liver. Enhancing the expression of the enzymes involved in Gluconeogenesis is probably the best-known metabolic function of glucocorticoids. It inhibits the glucose uptake in muscle and adipose tissue and stimulates the fat breakdown in adipose tissue – the fatty acids released by Lipolysis are used for production of energy in tissues like muscle, and the released glycerol provides another substrate for Gluconeogenesis.

Glucocorticoids have potent anti-inflammatory and immunosuppressive properties. This is particularly evident when they administered at pharmacologic doses, but also is important in normal immune responses.



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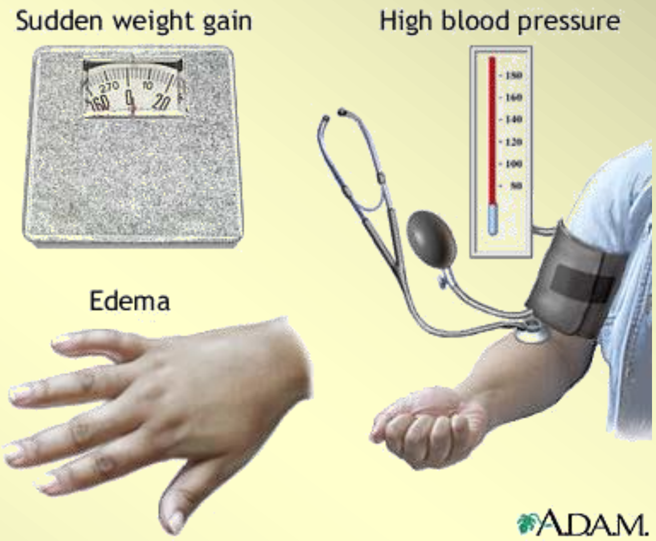
MINERALOCORTICOIDS

Mineralocorticoids play a critical role in regulating concentrations of minerals – particularly sodium and potassium in extracellular fluids. The major targets of aldosterone are the distal tubules of the kidney, where it stimulates exchange of sodium and potassium. This results in increased reabsorption of sodium and water, with consequent expansion of extracellular fluid volume. This is an osmotic effect directly related to increased reabsorption of sodium. But aldosterone increases renal excretion of potassium.

Conn's syndrome



Conn's syndrome is another name for primary hyperaldosteronism, which is the most common cause of secondary hypertension and may also be referred to as aldosteronism. It is a condition characterized by the excess secretion of aldosterone from the cortex – the outer layer – of the adrenal glands. Increased aldosterone leads to polyuria (frequent urination), increased thirst, weakness, temporary paralysis, headaches, muscle cramps, and tingling.

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Addison's disease

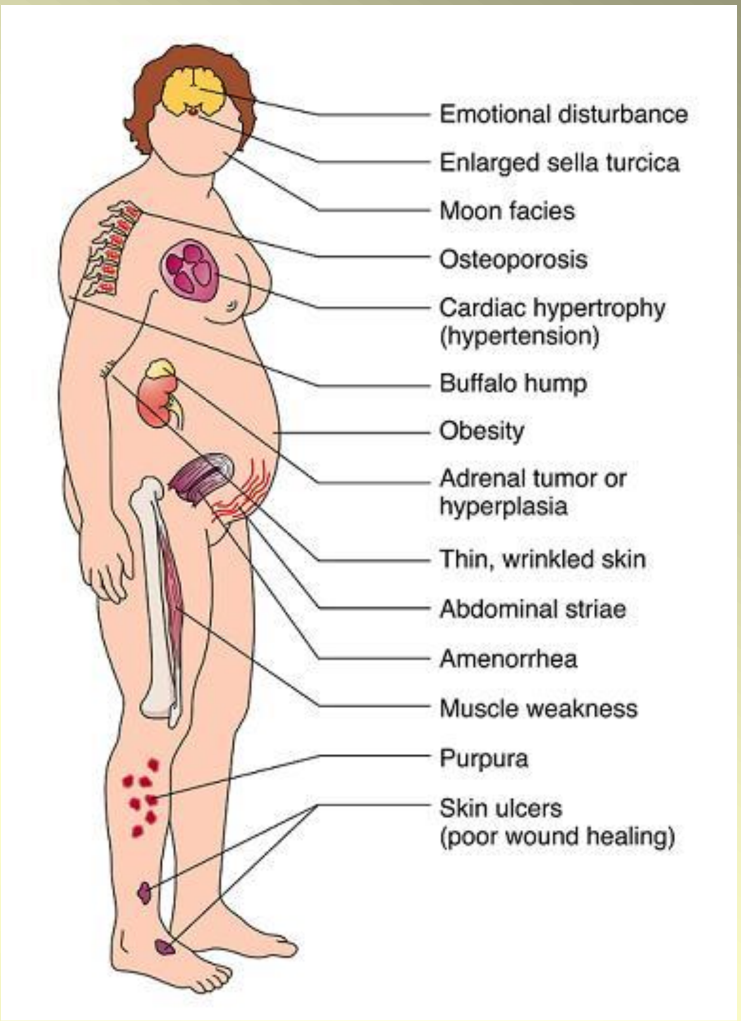
Adrenal insufficiency is a disorder characterized by underactive adrenal glands and an insufficient production of the hormones cortisol and, sometimes, aldosterone. Addison's disease is accompanied by numerous clinical abnormalities, including cardiovascular disease, lethargy, diarrhea, and weakness.

Addison's disease:

- Note the generalised skin pigmentation (in a Caucasion patient) but especially the deposition in the palmer skin creases, nails and gums.

- She was treated many years ago for pulmonary TB. What are the other causes of this condition?

Itsenko-Cushing's Desease manifestations



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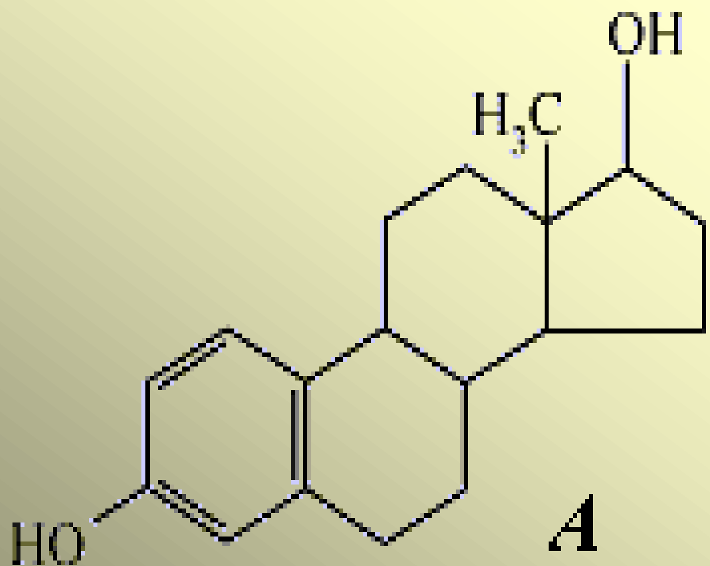
HORMONES OF THE REPRODUCTIVE SYSTEM
FEMALE SEX HORMONES

The ovaries of sexually-mature females secrete a mixture of three estrogens (estradiol, estriol and estrone) of which 17β-estradiol (A) is the most abundant (and most potent) and progesterone (B). Smaller amounts of estrogenes are also produced by the adrenal cortex. In men, the testes produce some estradiol.



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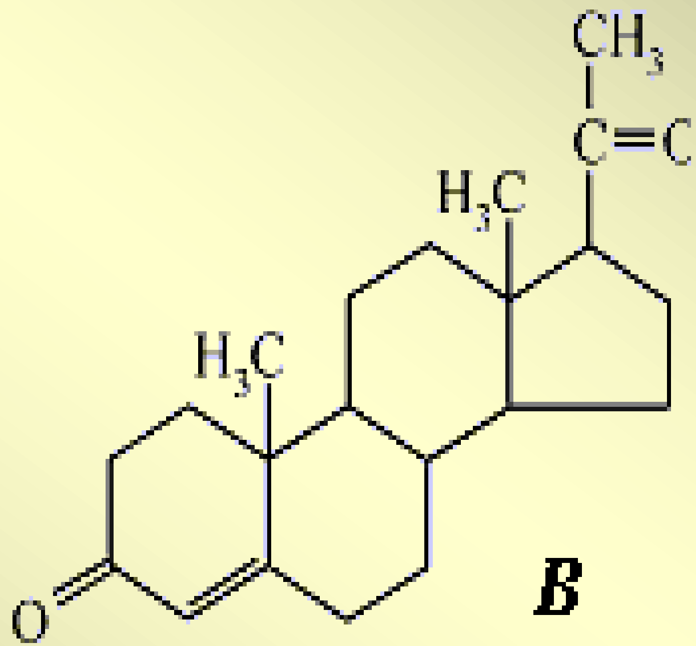
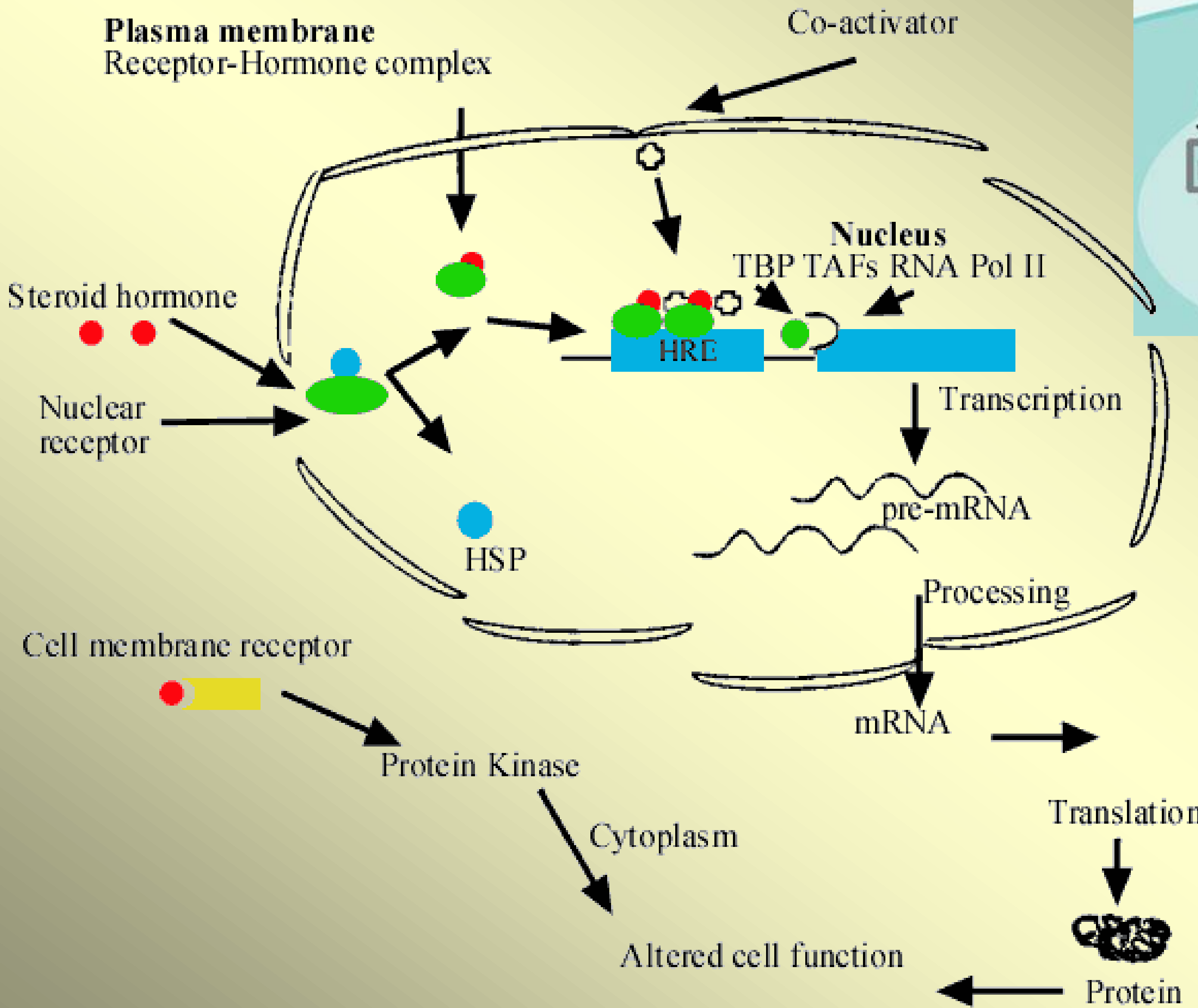
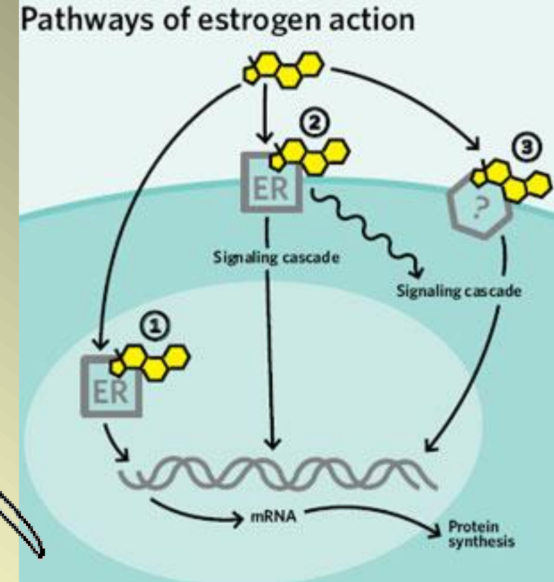


B

ESTROGEN ACTION





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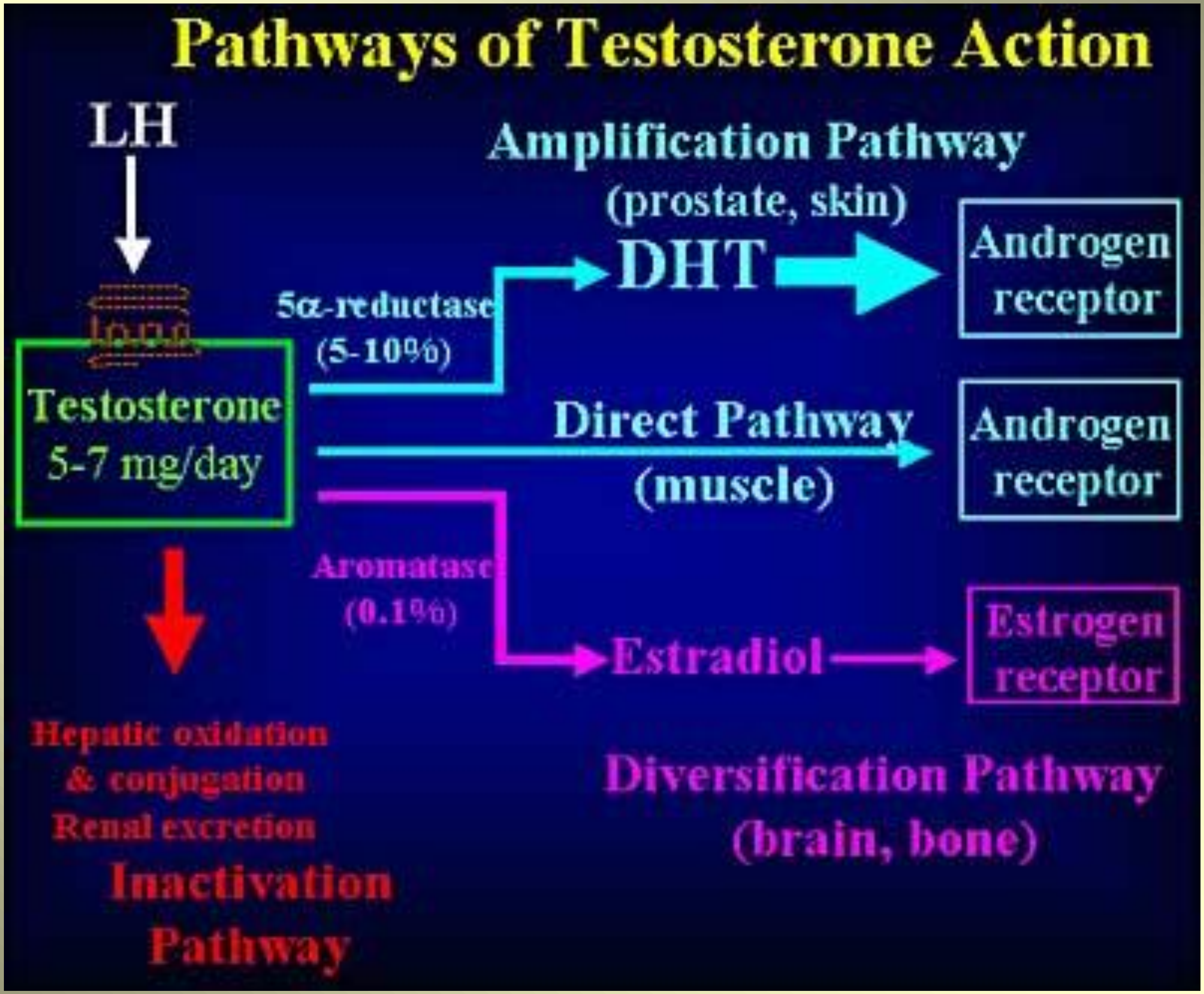
Estrogen effects

- ✓Sexual differentiation
- ✓Breast development and maintenance
- ✓Adding fat to breasts, hips, thighs during puberty
- ✓Improving bone strength and density
- ✓Accelerating bone maturation and bringing epiphyses to closure, completing growth
- ✓Growth of the uterus
- ✓Development of the endometrial lining to a thickness necessary to support pregnancy and menstruation
- ✓Thinning of cervical mucus at ovulation
- ✓Promoting and maintaining vaginal mucosal thickness and secretions
- ✓Serving as the primary feedback to the brain of sex hormone levels in both males and females.
- ✓Participating in triggering ovulation.
- ✓Preservation of egg cells.
- ✓Enabling spermatogenesis.
- ✓Effect on lipids.
- ✓Vascular effects.
- ✓Cerebral effects.

MALE SEX HORMONES

The principal androgen (male sex hormone) is testosterone. This steroid is manufactured by the interstitial (Leydig) cells of the testes. Secretion of testosterone increases sharply at puberty and is responsible for the development of the so-called secondary sexual characteristics (e.g., beard) of men.

Testosterone effects can be classified as virilizing and anabolic effects, although the distinction is somewhat artificial, as many of the effects can be considered both. Anabolic effects include growth of muscle mass and strength, increased bone density and strength, and stimulation of height growth and bone maturation. Virilizing effects include maturation of the sex organs, particularly the penis and the formation of the scrotum in fetuses, and after birth (usually at puberty) a deepening of the voice, growth of the beard and torso hair. Many of these fall into the category of male secondary sex characteristics.



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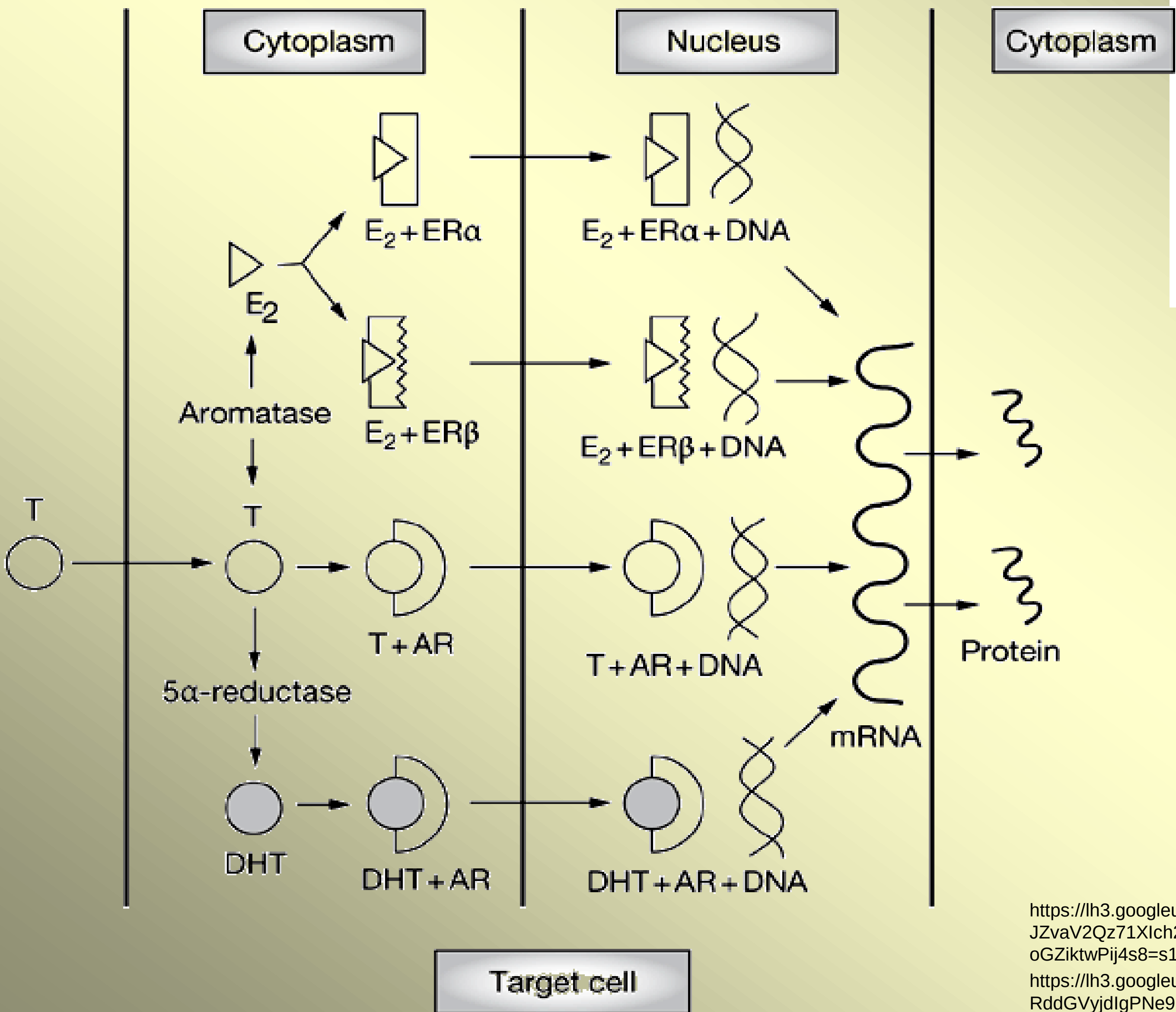
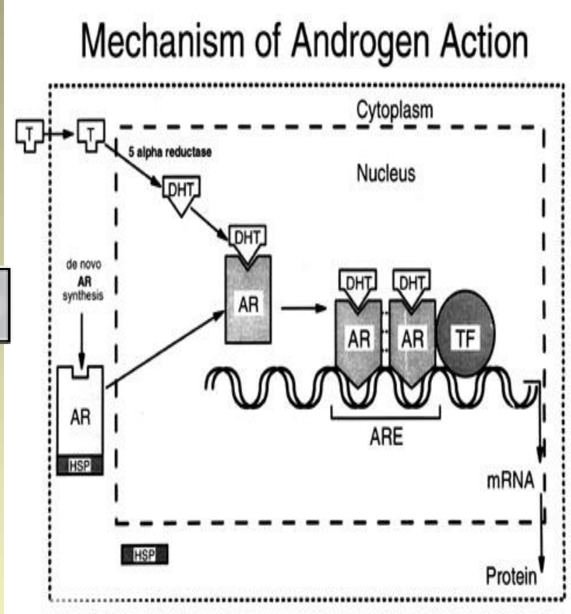
ANDROGEN ACTION





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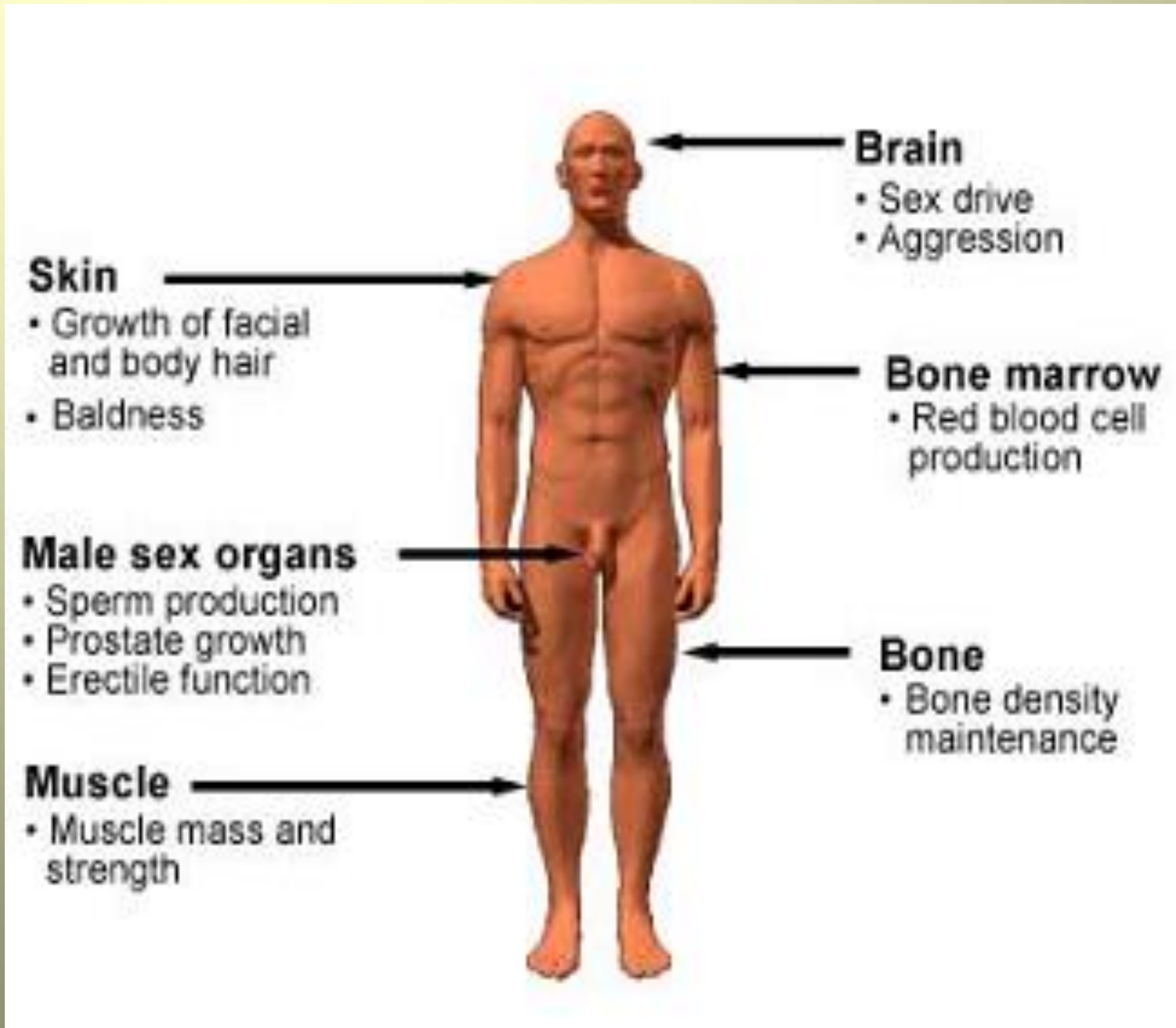
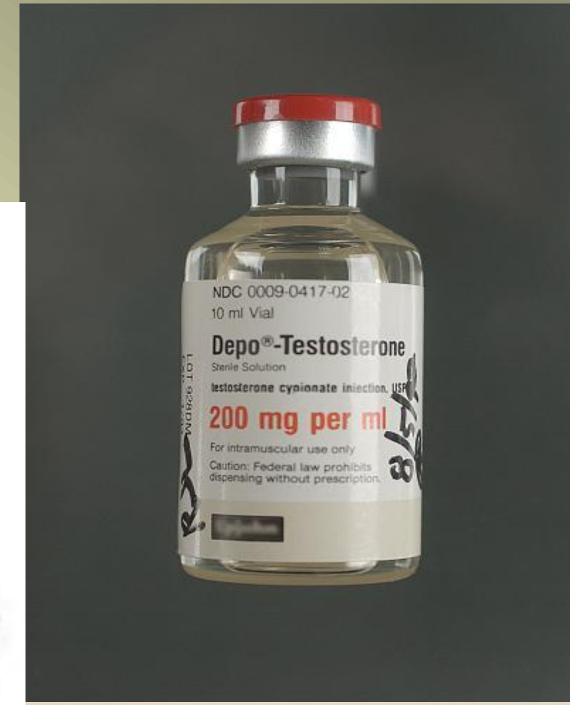
Testosterone preparation influence





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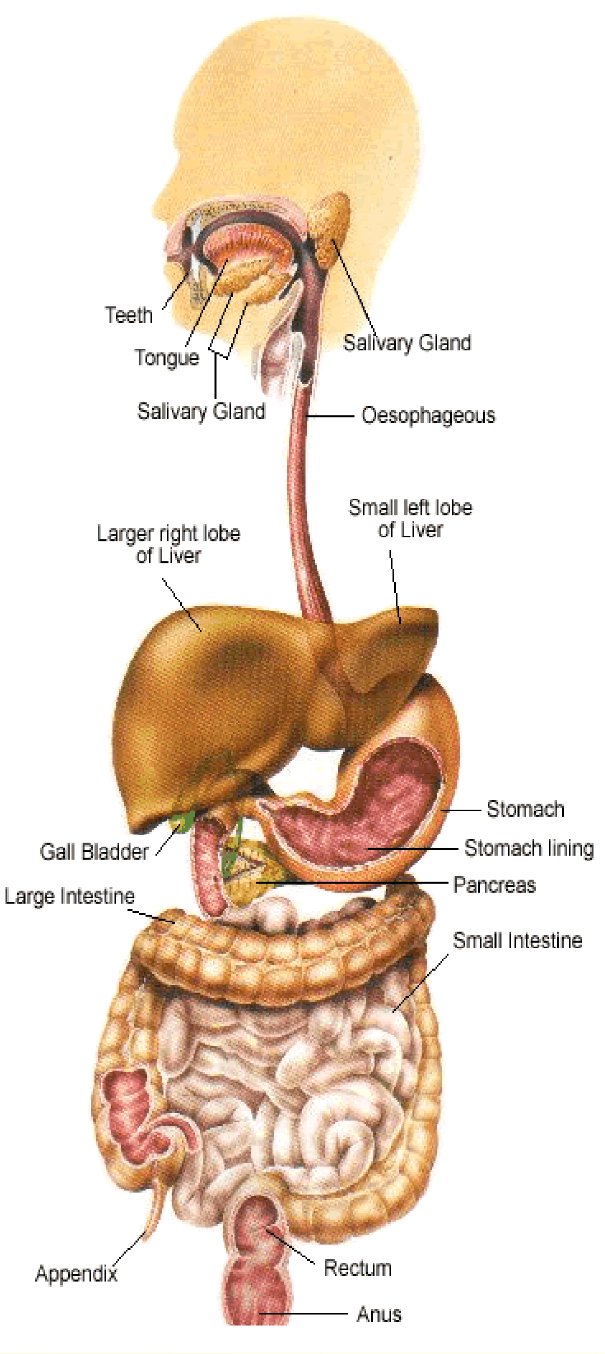
Digestive Hormones

Several hormones regulate the functions of the digestive process.

***Gastrin-**stimulates gastric juice secretions. Gastrin is necessary for the normal growth of the lining of the stomach, small intestine, and colon.*

***Secretin-**triggers pancreas to release bicarbonate which neutralizes stomach acids. Also stimulates stomach to produce pepsin and the liver to produce bile.*

***Cholecystokinin (CCK)-** signals the stomach to shut down, therefore reducing gastric secretions. Also causes pancreas to release digestive enzymes into the small intestine and the gall bladder to excrete bile.*



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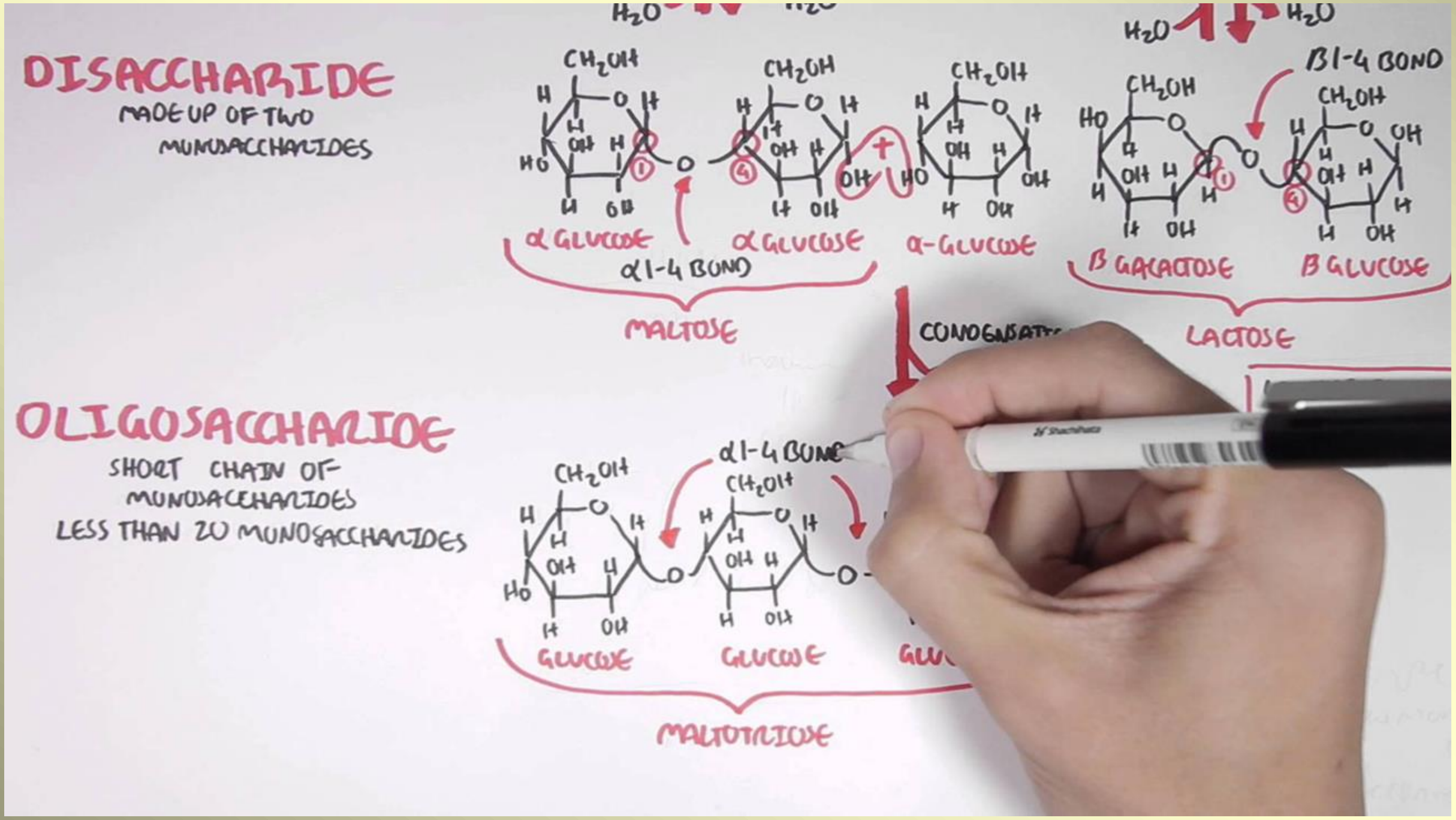
Conclusions

1. Hormones are molecules that organisms use to convey information to the cells.
2. Hormones can be categorized into three chemical groups: polypeptides, amino acid derivatives and steroid.
3. Hormones interact with receptors that are located either inside the cell or within the cell membrane.
4. Endocrine system resembles a sat of relays, carrying messengers through several steps from the central nervous system to a specific effector molecule in the target cells.

Do you have any questions?

Thank you for your attention!



https://www.youtube.com/watch?v=JxK5rZxbyQY