Endocrine Physiology: 100 Questions and Explanatory Answers for Students

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PREFACE

This book is intended to review, assess, evaluate and further improve the student’s knowledge in the endocrine physiology that presented in an easy to understand, graphical and tubulated structure format.

This book's multiple-choice questions have been extensively prepared to emphasize the relative significance of the various endocrine glands and to act as a foundational source for endocrine physiology.

The aim of this book is to provide the learner with an in-depth, rapid review of hormone functions and the effects of abnormal hormone levels. It also functions as an essential reading for the endocrine physiology course.

The reader is encouraged to send comments, critiques and recommendations to improve subsequent editions.

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CHAPTER 1: INTRODUCTION TO THE ENDOCRINE SYSTEM

1. Hormones are usually classified based on their chemical structure. Aldosterone would be categorized as _____.
   A. protein hormone
   B. steroid hormone
   C. amines and amino acid hormone
   D. peptides and polypeptides hormone

2. Regarding endocrine glands, which of the following is **FALSE**?
   A. They produce hormonal substances.
   B. They have ducts.
   C. Adrenal gland is an example of the endocrine gland.
   D. They have no ducts.

3. Thyroid stimulating hormone (TSH) induces thyroid hormone production. TSH is then inhibited by thyroid hormone. Which of the following scenarios describe this relationship?
   A. Membrane receptor transformation.
   B. Non-hormonal chemical messengers.
   C. Negative feedback regulation.
   D. Intercellular communication.

4. Which of the following unsaturated fatty acid is the source of eicosanoids' synthesis?
   A. Oleic acid
   B. Linoleic acid
   C. Linolenic acid
   D. Arachidonic acid

5. Select the **TRUE** statement regarding the half-life of a hormone:
   A. A hormone is half the time taken for it to disappear from the blood.
   B. Insulin is between five and ten hours.
   C. Thyroxine is longer than that of adrenaline.
   D. Aldosterone is longer than cortisol.

6. Which endocrine glands located anterior to the neck?
   A. Thyroid glands.
   B. Pancreas.
   C. Adrenal glands.
   D. Pineal gland.

7. In an examination room, a student has an elevated heart rate and increased breathing rate. What type of endocrine system stimulus did the student receive?
   A. Hormonal.
   B. Negative feedback.
   C. Neural.
   D. Positive feedback.

8. The endocrine system works together with the _____ system to maintain the body’s homeostasis?
   A. Digestive system.
   B. Nervous system.
   C. Respiratory system.
   D. Reproductive system.

9. The largest endocrine gland(s) that makes 3 hormones that affect the metabolism is the _____.
   A. pancreas
   B. adrenal glands
   C. thyroid gland
   D. pituitary gland

10. Which of the following hormones is stored in secretory vesicles prior to secretion?
   A. Estrogen.
   B. Progesterone.
   C. Aldosterone
   D. Insulin

Answers:

1. (B) Aldosterone is a steroid hormone. Hormones can be classified into three types. Proteins, steroid hormones and amine hormones.

Classification of hormones according to their chemical structures.

Classes of hormones	Characteristics	Examples
Protein/ Peptide hormones	1. Made of chains of amino acids. 2. These hormones are stored in secretory vesicles. 3. Cell membrane receptor. 4. Water soluble. 5. Do not require carrier protein.	**Protein hormones:** Growth hormone (GH), Prolactin (PRL), Parathyroid hormone (PTH). **Peptide hormones:** Antidiuretic hormone (ADH) Oxytocin and Somatostatin (SS).
Steroid hormones	1. Derived from Cholesterol. 2. Lipid soluble. 3. Immediately released from the cell following synthesis 4. Cytoplasmic or nuclear receptors. 5. Require carrier proteins.	**Adrenal cortex hormones:** Aldosterone and Cortisol. Reproductive hormones: Estrogen, Testosterone and Progesterone.
Amine hormones	1. Derived from a single amino acid for example tyrosine. 2. Receptors either on: Cell surface (Catecholamines) Intracellular (Thyroid hormone).	Adrenal medulla: Norepinephrine (NE) and Epinephrine (Epi). Thyroid hormones: Thyroxine (T4) and Triiodothyronine (T3).

2. (B) Endocrine glands are a ductless gland made up epithelial cells that release chemical signals called hormones. Hormones pass through the bloodstream to react on target cells receptors, influencing the cell's metabolic activities.

Hormones of the hypothalamus

Hormones	Major actions
Thyrotropin releasing hormone: (TRH)	Stimulate release of TSH and prolactin secretion
Gonadotropin releasing hormone (GnRH)	Stimulate release of LH and FSH
Corticotropin releasing hormone (CRH)	Stimulate release of ACTH
Growth hormone-releasing hormone (GHRH)	Stimulate secretion of growth hormone (GH)
Growth hormone-inhibitory hormone (GHIH) also known as somatostatin	Inhibit the release of GH
Prolactin-inhibitory factor (PIF) also known as dopamine	Inhibit release of Prolactin

Hormones of the pituitary gland

Pituitary gland	Hormones	Major actions
Anterior pituitary	Adrenocorticotropic hormone (ACTH)	Stimulate steroid hormones formation from the adrenal cortex (aldosterone, cortisol and androgens).
	Growth hormone (GH)	Promote release of somatomedins from the liver. Stimulate bone growth. Increase blood glucose and fatty acids.
	luteinizing hormone (LH)	In males stimulate the release of testosterone from the testes Leydig cells. In females stimulate ovulation and the release of progesterone.
	follicle stimulating hormone (FSH)	In males stimulate sperm maturation. In females stimulate ovarian follicle development.
	Prolactin	Stimulate milk production and growth of breast.
	Thyroid stimulating hormone (TSH)	Stimulate the synthesis and secretion of thyroid hormones T3 and T4
Posterior pituitary	Antidiuretic hormone (ADH) also known as arginine vasopressin	Maintain plasma osmolality by promoting water reabsorption from the nephron. Arteriolar vasoconstriction. Stimulate the release of ACTH
	Oxytocin	Stimulate uterine contraction during labor Stimulate milk ejection

Hormones of the adrenal glands

Adrenal gland	Hormones	Major actions
Adrenal cortex	Aldosterone	Maintain blood volume by promoting Na^+ and water reabsorption from the kidney nephrons. Stimulate urinary excretion of K^+ and H^+
	Cortisol	Increase plasma glucose concentration. Anti-inflammatory actions.
	Androgens	In females stimulate growth of pubic and axillary hair and increase libido.
Adrenal medulla	Epinephrine and norepinephrine	Promote fight or flight responses as the sympathetic nervous system

Hormones of thyroid and parathyroid glands

	Hormones	Major actions
Thyroid	Triiodothyronine (T3) and Thyroxine (T4)	Increase basal metabolic rate and oxygen consumption. Enhance neural and bone growth and development.
	Calcitonin	Decreases serum Ca^{++}
Parathyroid	Parathyroid hormone (PTH)	Increases serum Ca^{++} levels by resorption of Ca^{++} from bone and reabsorption of Ca^{++} from the distal tubule.

Hormones of the pancreas

Pancreas	Hormones	Major actions
Pancreas	Insulin	Promote storage of glucose Promote storage of triglyceride
	Glucagon	Increases blood glucose

Hormones of the gonads

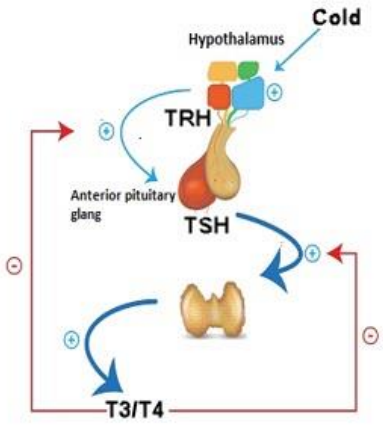
Gonads	Hormones	Major actions
Testes	Testosterone	Maintenance of spermatogenesis Maintenance of secondary sex characteristic including growth of facial, pubic and axillary hair. Maintenance of muscle mass
Ovary	Estrogens	Maintenance of secondary sex characteristic including breast development. Stimulate cervical mucus production. Stimulate endometrial cells proliferation. Increase libido
	Progesterone	Maintenance of pregnancy. Maintain the secretion of the endometrium during the secretory phase of menstrual cycle.

In addition, a number of organs including the gastrointestinal tract, kidney, liver heart, skin, adipose tissue can be regarded as an endocrine gland because they can all release hormones but they do not form a distinct endocrine gland.

Other endocrine organs

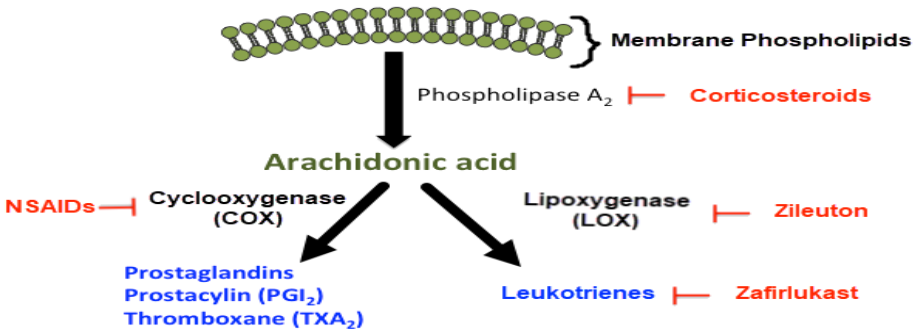
Organs	Hormones	Major actions
Heart	Atrial natriuretic peptide (ANP)	Maintain blood volume by promoting excretion of Na^+ and water.
Kidney	Renin	Maintain arterial blood pressure by activating the renin angiotensin aldosterone system.
	1-25-Dihydroxycholecalciferol	Stimulate absorption of calcium and phosphate from the gastrointestinal tract.
	Erythropoietin	Stimulate red blood cell production.
GIT	Gastrin	Stimulate HCl production by the parietal cells of gastric mucosa.
	Cholecystokinin (CCK)	Stimulate the release of pancreatic enzymes. Inhibits stomach motility.
	Secretin	Increases HCO_3^- secretion by the pancreatic duct.
Placenta	Human chorionic gonadotropin (hCG)	Prevent the regression of corpus luteum and maintain pregnancy.
	Human Chorionic Somatomammotropin (hCS)	Stimulate breast development during pregnancy

3. (C) Negative feedback prevents over secretion of the hormone or over activity at the target tissue such as regulation of thyroid hormone by thyroid stimulating hormone (TSH).



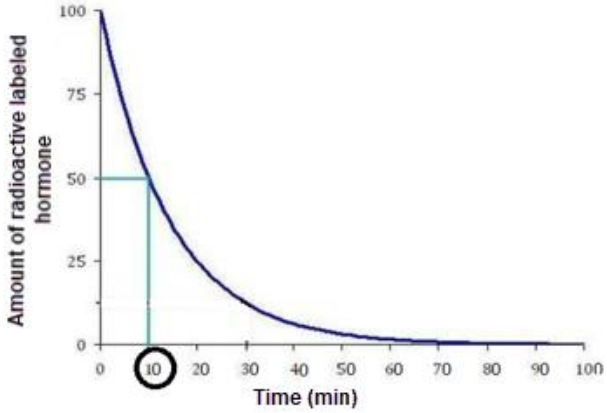
Negative Feedback Mechanism: A stimulus such as cold causes an increase in thyrotropin-releasing hormone (TRH) from the hypothalamus, which in turn acts to increase the secretion of thyroid-stimulating hormone (TSH) from the anterior pituitary. The high levels of TSH stimulate the thyroid gland to produce thyroid hormones (T3 and T4). One of the effects of thyroid hormones is to act on both the hypothalamus and anterior pituitary to inhibit the production of TRH and TSH, respectively. Thus, the blood levels of TRH and TSH are maintained by a negative feedback system to prevent over secretion of these hormones caused by the stimulus in this case cold.
Positive feedback is two or more variables, if one increases the second one, the second one, in turn, increases the first one such as estrogen during ovulation. Cyclical variations occur in hormone release such as growth hormone.

4. (D) Arachidonic acid is the precursor of eicosanoids synthesis. Arachidonic acid is derived from the membrane phospholipids when the enzyme phospholipase A_2 is activated via G protein (Gq). Eicosanoids which include prostaglandins, thromboxanes, prostacyclins and leukotrienes are locally produced regulatory hormones. The synthesis of eicosanoids is differed according to the enzymes that expressed in the target cell (cyclooxygenase or lipoxygenase).



Arachidonic acid, which is produced from the phospholipid in the cell membrane, is the precursor of eicosanoids. Phospholipids in cell membranes are converted into arachidonic acid by the enzyme phospholipase A_2. Two distinct processes the cyclooxygenase and lipoxygenase convert arachidonic acid into prostaglandins, thromboxanes, prostacyclins and leukotrienes.

5. (C) The half-life is the time taken to reduce hormone concentration (due to metabolism and excretion) by one half. The half-life of protein bounds hormones such as cortisol, thyroid hormones, testosterone is longer than those which does not bound to plasma proteins such as most peptide hormones and aldosterone.



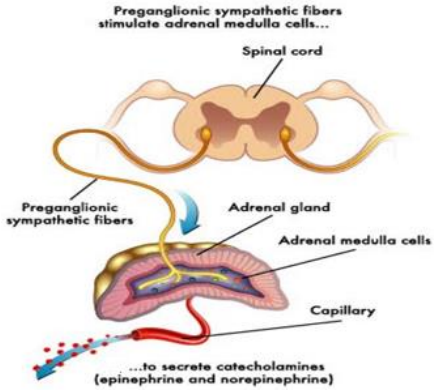
Half-life is the time interval between 0 and half the concentration of the hormone. In this example, the plasma half-life of a hormone is 10min. Normally peptide hormones have a short half-life as compared to steroid hormones.

6. (A) The thyroid gland is the largest endocrine gland, located in the anterior neck, consists of two lateral lobes connected by a median tissue mass called the isthmus. Composed of follicles that produce the glycoprotein thyroglobulin.

The major endocrine glands and their location

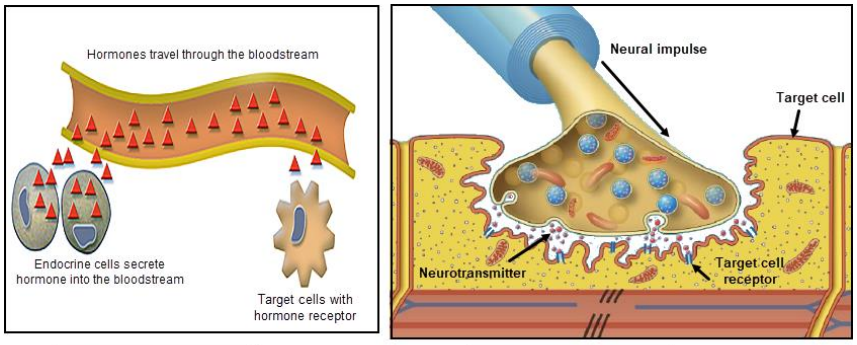
Glands	Location
Hypothalamus	Central nervous system (brain)
Pituitary gland	Central nervous system
Pineal gland	Central nervous system (brain)
Thyroid gland	Neck (Anterior to trachea)
Parathyroid gland	Neck (Posterior to thyroid gland)
Adrenal glands	Abdominal cavity (above the kidney)
Pancreas	Abdominal cavity
Testes	Within the scrotum
Ovaries	Pelvic cavity

7. (C) Activation of preganglionic sympathetic nervous system (SNS) fibers directly stimulate the adrenal medulla gland to release epinephrine and norepinephrine. Negative feedback is to maintain a ‘set point’ of hormone levels by a correction mechanism that opposes (negative) the changes from this point. Hormonal stimuli refer to the release of hormones in response to hormones produced by other endocrine organs. For example, the release of thyroid hormones is controlled by the anterior pituitary, thyroid-stimulating hormone (TSH) hormone which is in turn controlled by hypothalamic releasing factors (TRH).



Release of adrenal medulla hormones in response to neural stimuli by sympathetic nervous system

8. (B) Both the endocrine and the nervous system act to maintain homeostasis through the production of hormones and neurotransmitters respectively.

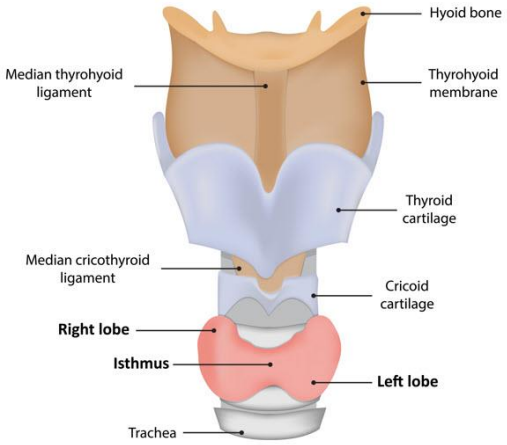


Endocrine system vs Nervous system

Comparison between nervous and the endocrine system

Feature	Endocrine system	Nervous system
Overall function	Maintain homeostasis	Maintain homeostasis
Control by feedback mechanism	By negative and positive feedback	By nervous reflexes
Effector cells	Target cells throughout that have receptors for the specific hormone	Postsynaptic cells the body in muscle, neurons and glandular tissue
Chemical messenger	Hormone	Neurotransmitter
Cells that secrete the chemical messenger	Glandular epithelial cells or neurosecretory cells	Neurons
Distance travel of chemical messenger	Long (through bloodstream)	Short (though synapse)
Location of receptors	On the plasma or within cell membrane	On the plasma membrane
Speed of communication	Slow	Fast

9. (C) Thyroid gland is the largest endocrine gland, located in the anterior neck, consists of two lateral lobes connected by a median tissue mass called the *isthmus*.



Location of thyroid hormone

10. (D) Endocrine cells that secrete peptides store hormones in secretory vesicles and release them via exocytosis when a stimulus initiates hormone secretion. This is true for insulin, which is produced in the β cells of pancreas. In contrast, steroid hormones are not stored in secretory vesicles and released rapidly once synthesized.

Comparison between peptides and steroids hormones

Characteristic	Peptides	Steroids
Source of hormone	Amino acids	Cholesterol
Storage of hormones	Secretory vesicles	Stored as precursor
Location of receptors	Cell surface membrane	Intracellular (cytoplasm or nucleus)
Transport with carrier protein	No	Yes

Hormone receptors

1. Action of hormone, on the target cells, depending on binding of hormone with
   A. hormone
   B. receptor
   C. steroids
   D. proteins

2. Receptors for peptide hormones are located _____.
   A. on the cell membrane
   B. in the cytoplasm
   C. in the ribosome
   D. in the nucleus

3. Which of the following signaling molecules **DO NOT** couple to G proteins?
   A. Cyclic adenosine monophosphate (cAMP).
   B. Diacylglycerol (DAG).
   C. Inositol triphosphate (IP_3).
   D. Tyrosine kinase.

4. A newly developed drug has been observed to bind to an intracellular hormone receptor. If ingested, residue from this drug could disrupt levels of_____.
   A. melatonin
   B. thyroid hormone
   C. growth hormone
   D. insulin

5. Which one of the following is **NOT** typical of the cellular responses that occurs after a hormone binds to its target cells:
   A. plasma membrane permeability changes
   B. cellular mutations occur
   C. enzymes are activated or inactivated
   D. mitosis is stimulated

6. Being lipid soluble, steroids hormone can cause all the following cellular activities **EXCEPT:**
   A. catalyze cyclic AMP
   B. diffuse through the plasma membranes of target cells
   C. enter the nucleus
   D. activate genes to transcribe mRNA for protein synthesis

7. Which of the following hormones activate enzyme-linked receptors?
   A. Antidiuretic hormone
   B. Growth hormone
   C. Cortisol
   D. Aldosterone

8. Atrial natriuretic peptide increases the formation of
   A. cyclic GMP
   B. tyrosine kinase
   C. cyclic AMP
   D. diacylglycerol

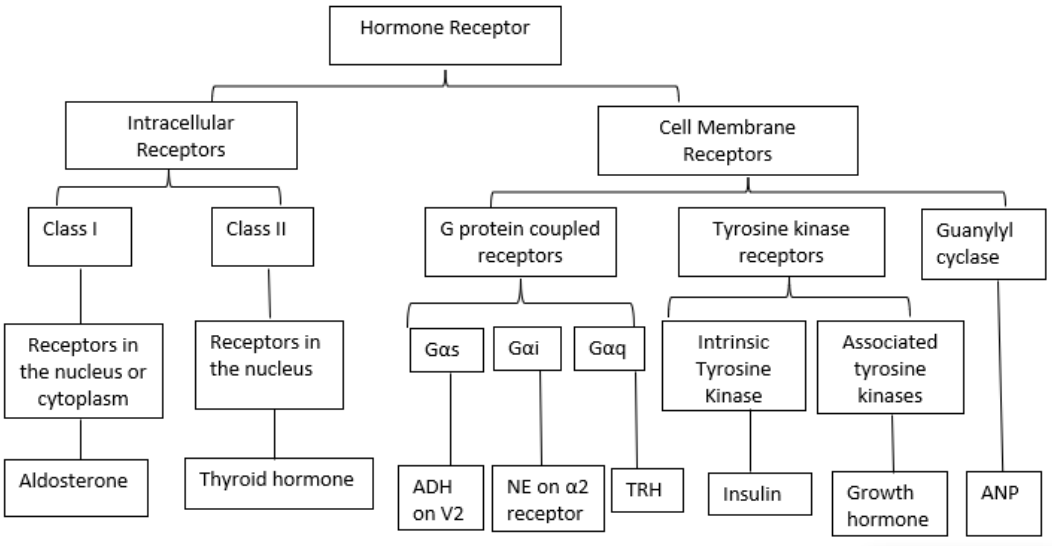
9. All of the following bind to intracellular receptors **EXCEPT**:
   A. thyroxine
   B. aldosterone
   C. 1, 25-dihydroxycholecalciferol
   D. parathyroid hormone

10. All the following second messenger is increased when antidiuretic hormone (ADH) acts on its receptors **EXCEPT:**
   A. cyclic AMP (cAMP)
   B. tyrosine kinase (TK)
   C. diacylglycerol (DAG)
   D. inositol triphosphate (IP3)

Answers:

1. (B) Hormones act by binding to a specific protein called receptors that is located either on the cell membrane or inside the cell (cytoplasm or nucleus) of the target cells.

Classification of hormone receptors

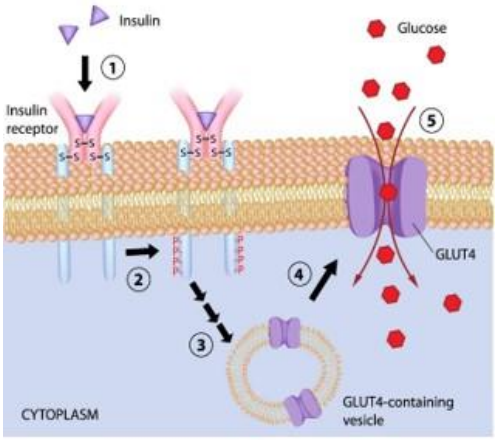


2. (A) The location of the receptors depends on the chemical structure of the hormone. Receptors for peptide hormones and catecholamine's are located in the cell membranes of target cells. Thyroid and steroid hormones cross the membrane and bind to receptors in the nucleus and cytoplasm. When hormones bind to their receptors, modifications in the receptor occur, resulting in an intracellular signaling system that triggers cellular responses such as increased protein synthesis, channel protein synthesis, cellular permeability alterations, and cell proliferation.

Hormones and their receptor's location

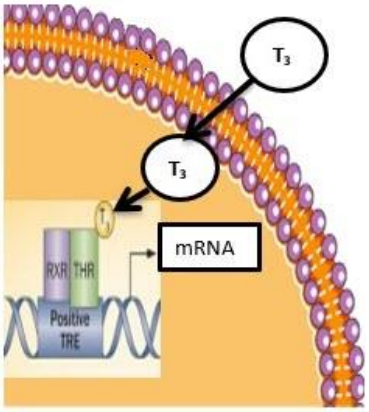
Hormone	**Class of Hormone**	**Receptor Location**
Amine (epinephrine)	Water-soluble	Cell surface
Amine (thyroid hormone)	Lipid soluble	Intracellular
Peptide/protein	Water-soluble	Cell surface
Steroids and Vitamin D	Lipid soluble	Intracellular

3. (D) Tyrosine Kinases is integral proteins within the plasma membrane. Example of tyrosine kinase receptors is insulin. The remaining second messengers are G protein coupled receptors (GPCRs).
When insulin for instance, binds to the receptor, it triggers
1. Dimerization of the receptor and signaling mechanism is triggered and the intrinsic tyrosine kinase is activated.
2. Tyrosine kinase activation enables phosphorylation of tyrosine residue within the receptor itself and intracellular tyrosine of target proteins.
3. Increase transportation of GLUT4 receptors through the cell to the cell membrane.
4. Increase the ability of the cells to uptake of glucose.



Activation of intrinsic tyrosine kinase

4. (B) thyroid hormones pass across the cell membrane and binds to its intracellular receptor found in the nucleus. Peptide hormone receptors (growth hormone, antidiuretic hormone and insulin) located in the cell membrane.
The activation steps of thyroid hormone receptors:
1. Thyroid hormones readily diffuse through the cell membrane.
2. Thyroid hormone interacts with the thyroid hormone receptor (THR), bound as a heterodimer with a retinoid acid X receptor (RXR) of the thyroid hormone response element (TRE) of the gene.
3. This result to either activation or inhibition of transcriptional proteins of that gene through changes in mRNA and therefore new protein formation in the cell.



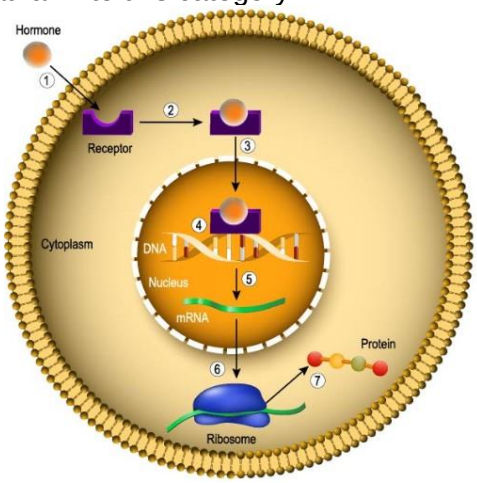
Receptors of thyroid hormone are found inside the nucleus.

5. (B) Hormones act by binding to a specific protein called receptors. This interaction will bring about changes in the receptor which result in intracellular signaling mechanism to initiate cellular responses that may include increase protein synthesis, formation of channel proteins, alteration in the cellular permeability, and cell growth (mitosis). A cellular response to hormone receptor binding does not result in cellular mutations.

6. (A) Steroid's hormones easily passing across the cell membrane and binds to intracellular receptor found in the cytoplasm or the nucleus.
The activation steps of steroid hormone receptors:
1. Steroid hormones diffuse easily into their target cells.
2. Steroid hormones bind and activate a specific intracellular receptor.
3. The hormone-receptor complex travels to the nucleus and dimerizes (not shown).

4. The hormone-receptor dimers binds to hormone response elements within the DNA.
5. This interaction prompts DNA transcription, to producing mRNA.
6. The new mRNA is translated into proteins.
7. Cellular effect by increasing cellular proteins and alteration of cellular functions. For example, aldosterone induces the synthesis of sodium channels in the distal tubules and collecting ducts of the nephron.

Aldosterone, cortisol, progesterone, estrogen, and androgens are examples of steroid hormones that fall into this category.

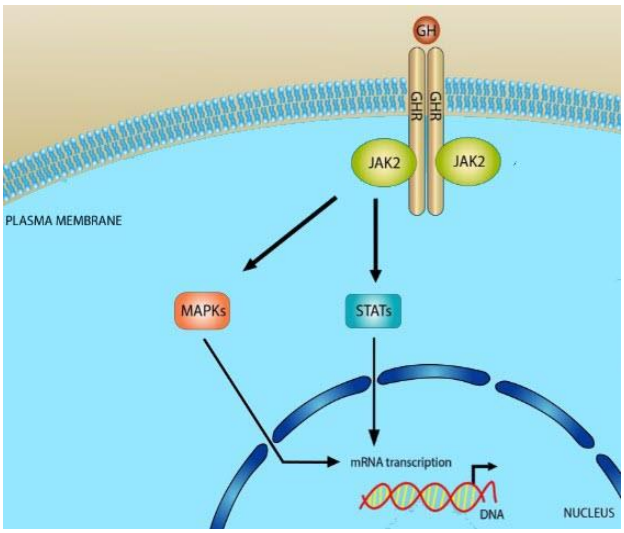


Receptors of steroid hormones are found inside the cell.

7. (B) Growth hormone receptors have single transmembrane spanning receptors that associated with tyrosine kinase such as Janus associated tyrosine kinase 2 (JAK2)

The activation steps of growth hormone receptors:

1. Growth hormone binds to the receptor causes dimerization of the receptor
2. Migration of tyrosine kinase in associated proteins such as JAK2 towards the receptor.
3. A number of target proteins are activated including signal transducers and activators transcription (STAT), which causes formation of new mRNAs and synthesis of new proteins. JAK2 also phosphorylate other associated protein kinase family of mitogen-activated protein kinases (MAPK) which involves in cell growth and mitotic division.



Activation of tyrosine kinase-associated receptor