

Endocrine System
ANS 215
Physiology and Anatomy of
Domesticated Animals

I. Introduction

- A. Considered to be part of animals communication system
 - 1. Nervous system uses physical structures for communication
 - 2. Endocrine system uses body fluids to transport messages (hormones)
 - a. referred to as humeral versus neural control

II. Hormones

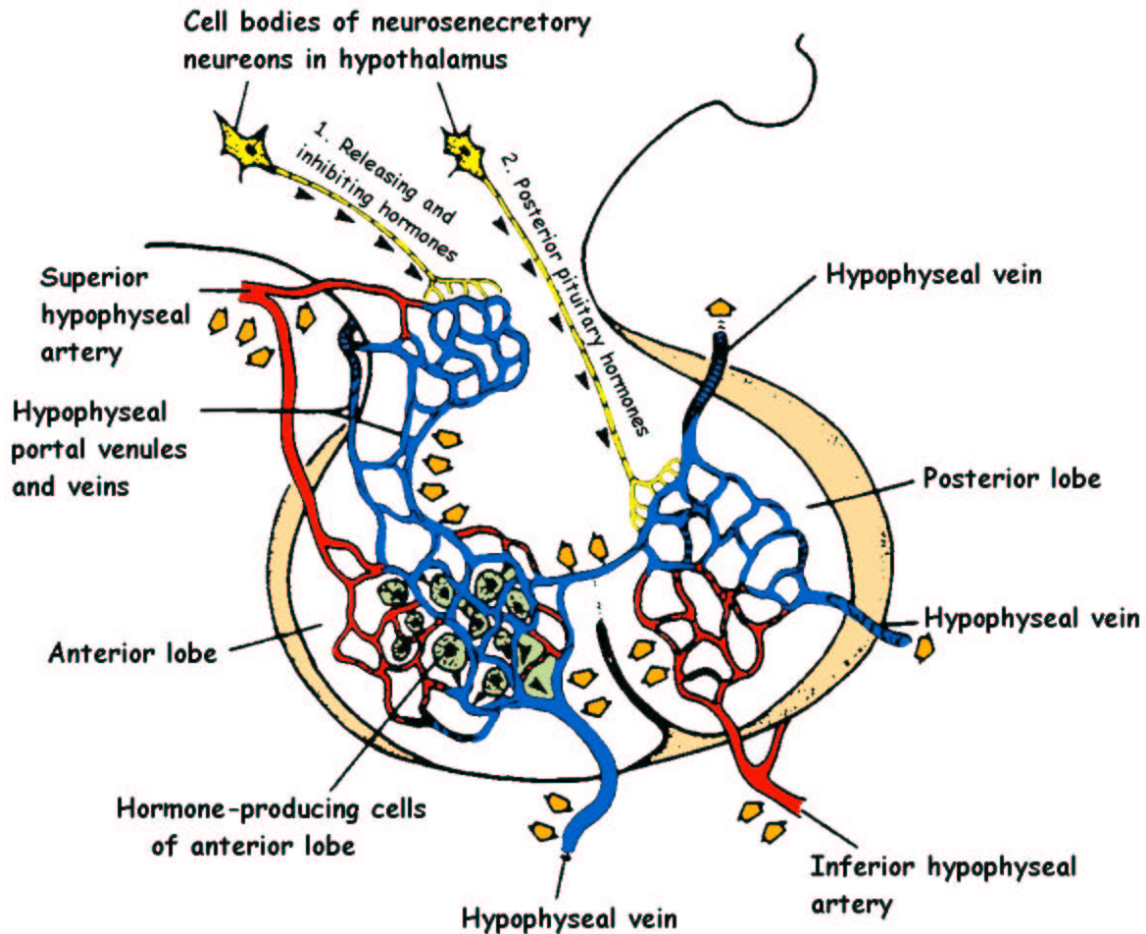
- A. Classically, hormones are defined as chemical substances produced by ductless glands and secreted into the blood supply to affect a tissue distant from the gland, but now it is understood that hormones can be produced by single cells as well.
 - 1. epicrine
 - a. hormones pass through gap junctions of adjacent cells without entering extracellular fluid
 - 2. neurocrine
 - a. hormones pass through synaptic clefts between neurons as do neurotransmitters; hormones can also be synthesized in a neuron (e.g. oxytocin) and secreted directly into the blood from the axon
 - 3. paracrine
 - a. hormones diffuse through interstitial fluid (e.g. prostaglandins)
 - 4. endocrine
 - a. hormones are delivered via the bloodstream (e.g. growth hormone)
 - 5. exocrine
 - a. chemical substance is secreted to exterior of the body (e.g. pheromones) or into the digestive tract (e.g. somatostatin)
- B. Biochemistry
 - 1. Hormones are biochemically categorized as amines, peptides, steroids, or prostaglandins.
 - a. amines – thyroid hormones, adrenal catecholamines
 - b. peptides – growth hormone, prolactin, luteinizing hormone
 - c. steroids – estradiol, testosterone, cortisol, progesterone
 - d. prostaglandins – PGF₂

III. Pituitary Gland (hypophysis cerebri)

- A. Has two distinct parts
 - 1. anterior lobe (adenohypophysis)
 - 2. posterior lobe (neurohypophysis)
- B. Located in a bony recess (sella turcica) at the base of the brain

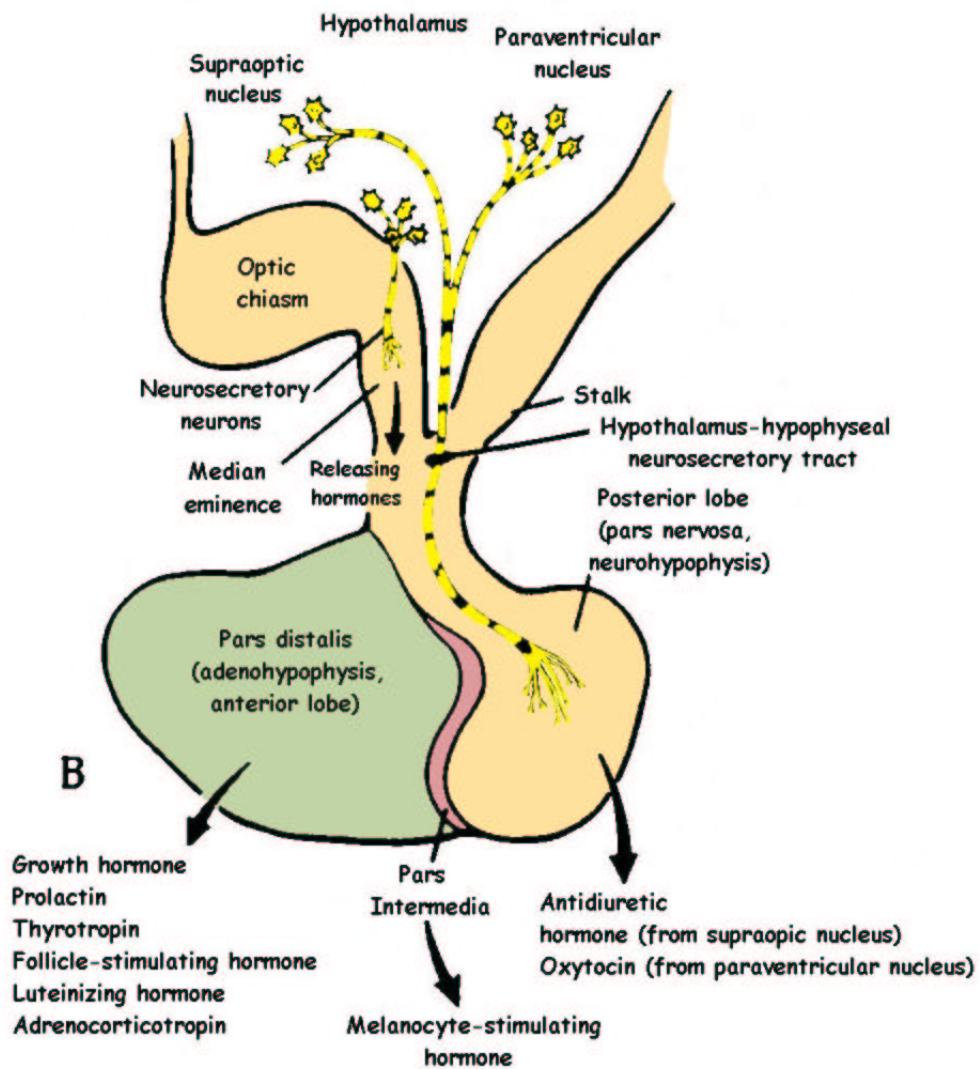
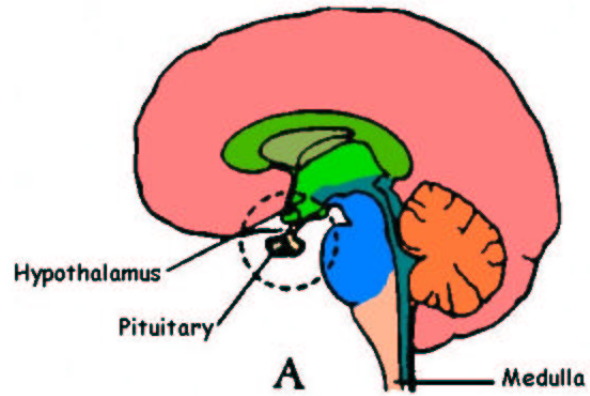
- C. Connected to the brain by the hypothalamus and a portal blood supply

1. vein draining the hypothalamus breaks up into a capillary bed within the anterior pituitary
2. route by which releasing factors from the hypothalamus travel to cause release of hormones from the anterior pituitary



Schematic representation of the pituitary. 1. Hypothalamic-hypophyseal portal circulation and the pathway followed by the hypothalamic-hypophysiotropic hormones (releasing and inhibiting) in reaching the anterior pituitary (left). 2. Pathway by which the posterior pituitary hormone oxytocin and ADH (antidiuretic hormone) reach the capillaries of the posterior lobe (right). Hormone-containing blood leaves each lobe of the pituitary through a number of hypophyseal veins. The orange arrows indicate the direction of blood flow; the black arrowheads indicate the path taken by the hormones involved.

3. Posterior pituitary
 - a. is an outgrowth of the hypothalamus and contains the terminal axons from two pairs of nuclei
 - i. supraoptic – secretes antidiuretic hormone
 - ii. paraventricular – secretes oxytocin
 - b. action potentials generated by the need for each of the stored hormones causes release of the substance into the blood supply



Location of the pituitary in the primate brain. A. The pituitary is situated at the base of the hypothalamus. B. Hypothalamic neurons from the supraoptic and paraventricular nuclei transmit their neurosecretions of antidiuretic hormone and oxytocin, respectively, to the posterior lobe.

4. Anterior pituitary
 - a. Anterior pituitary lies forward from the posterior pituitary and is composed of three parts
 - i. pars distalis
 - principal part – 5 cell types
 - somatotropes – growth hormone
 - corticotropes – corticotropin releasing hormone
 - mammatropes – prolactin
 - ii. pars intermedia
 - melanocyte stimulating hormone
 - iii. pars tuberalis
 - layer of cells surrounding the neural stalk with no known function

D. Functions of anterior pituitary hormones

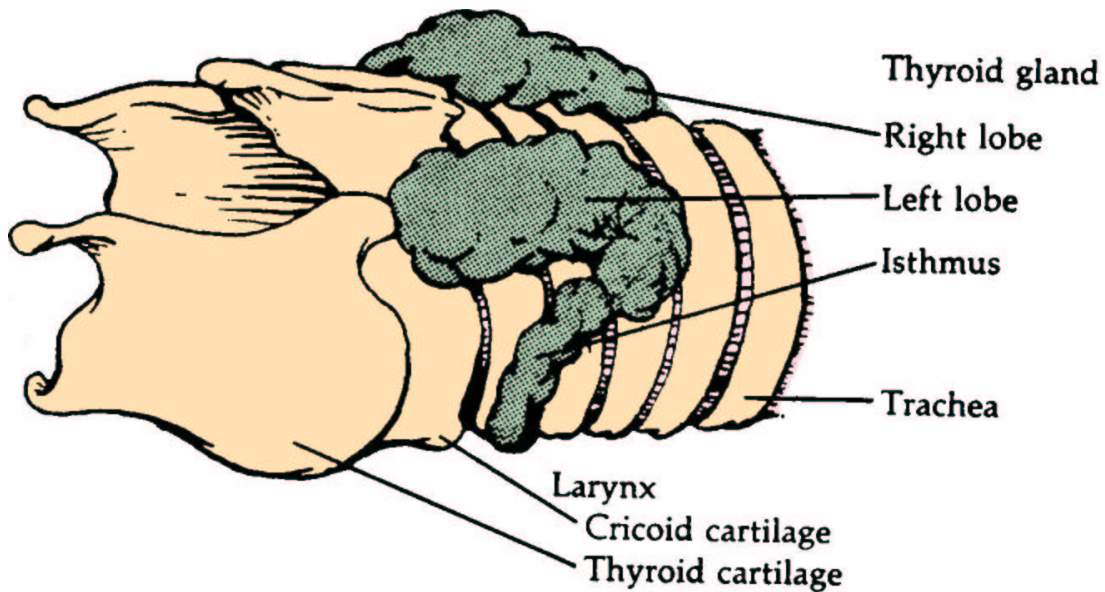
1. growth hormone – regulates growth, metabolism
 - a. acts on liver to cause production of somatomedins and somatomedin binding proteins
2. adrenocorticotrophic hormone
 - a. stimulates adrenal cortex to release cortisol and aldosterone, involved in metabolic regulation
3. gonadotrophic hormones
 - a. follicle stimulating hormone
 - i. stimulates follicular growth in the ovary
 - b. luteinizing hormone
 - i. stimulates ovulation and growth of corpora lutea
4. thyroid stimulating hormone
 - a. stimulates release of thyroxine from thyroid gland
5. prolactin
 - a. stimulates mammary development and lactation
6. beta-lipotrophin
 - a. secreted by corticotropes
 - b. involved in pain relief

E. Functions of posterior pituitary hormones

1. ADH – regulates reabsorption of water in the kidney
3. Oxytocin – milk ejection reflex

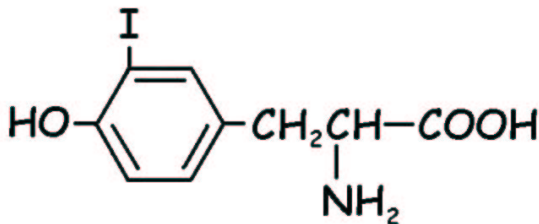
II. Thyroid Gland

- A. In most mammals the thyroid gland is located on the trachea, just caudal to the larynx.

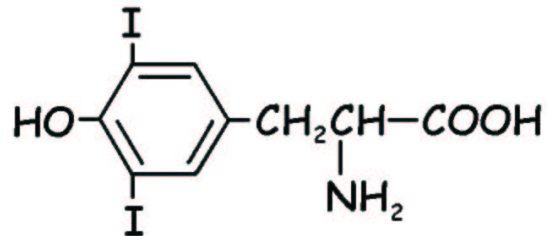


B. Thyroid hormones

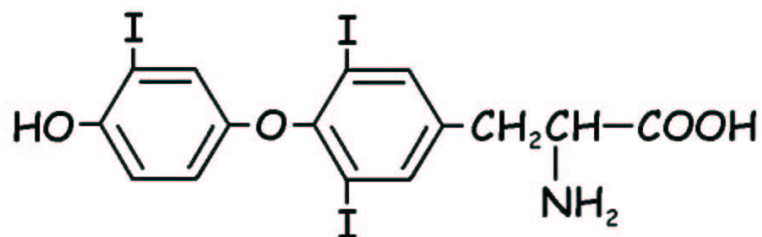
1. Thyroid hormones belong to the amine classification of hormones. They are derived from the amino acid tyrosine.
2. Thyroid hormones also contain iodine.



MONOIODOTYROSINE



DIIODOTYROSINE



3,5,3' TRIIODOTHYRONINE

Structural formulas of the iodinated amino acids monoiodotyrosine and diiodotyrosine and the compounds formed by their coupling. The coupling of monoiodotyrosine and diiodotyrosine with loss of H₂O and glycine produces 2,5,3'-triiodotyrosine, known as T₃. The coupling of two molecules of diiodotyrosine with loss of H₂O and glycine produces thyroxine, known as T₄.

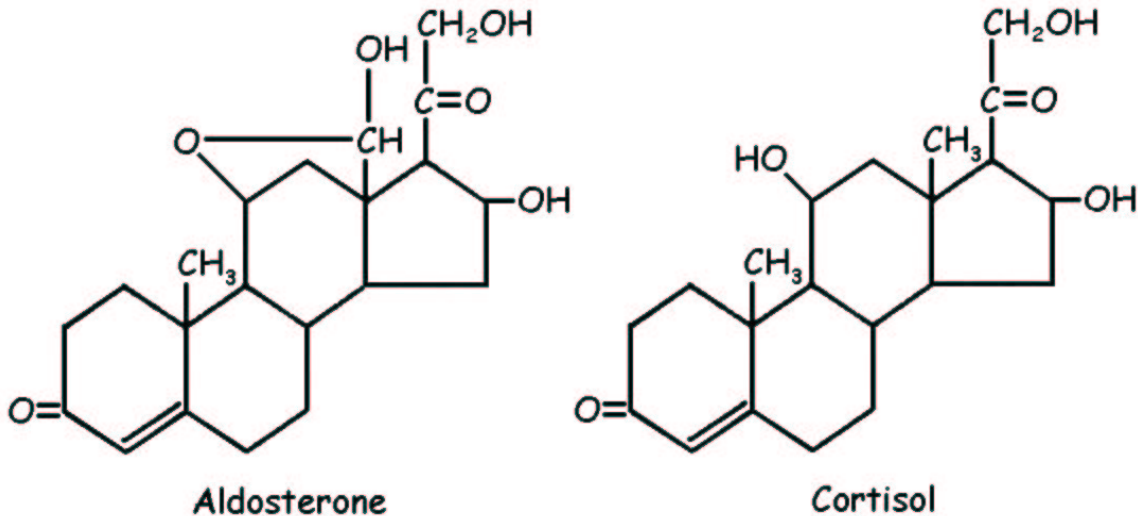
3. Thyroid hormones increase basal metabolism and heat production
4. secretion of thyroid hormones (thyroxine and triiodothyronine) is regulated by thyroid stimulating hormone (TSH) from the anterior pituitary
5. Thyroglobulin is a large glycoprotein molecule secreted into the thyroid follicles by the cells lining the follicles.
6. Thyroid deficiency typically results from iodine deficiency. The thyroid gland enlarges because of accumulation of thyroglobulin.
7. Hypo and hyper thyroidism are rare in domestic animals, but it does occur in dogs and cats.
8. calcitonin
 - a. hormone of the thyroid gland secreted by the parafollicular or C cells
 - b. inhibits calcium reabsorption at the kidney and stimulates calcium deposition in bone – lowers blood calcium

III. Parathyroid Gland

- A. One or two glands which are located near or embedded in the thyroid glands.
- B. Low calcium levels in plasma stimulate parathyroid hormone (PTH) release.
- C. PTH stimulates the release of calcium and phosphorus from the bones.
- D. PTH also stimulates osteoclasts to dissolve bone
- E. PTH enhances both calcium and phosphate absorption from the intestine by increasing the rate of formation of 1,25-dihydroxycholecalciferol, the active form of vitamin D.

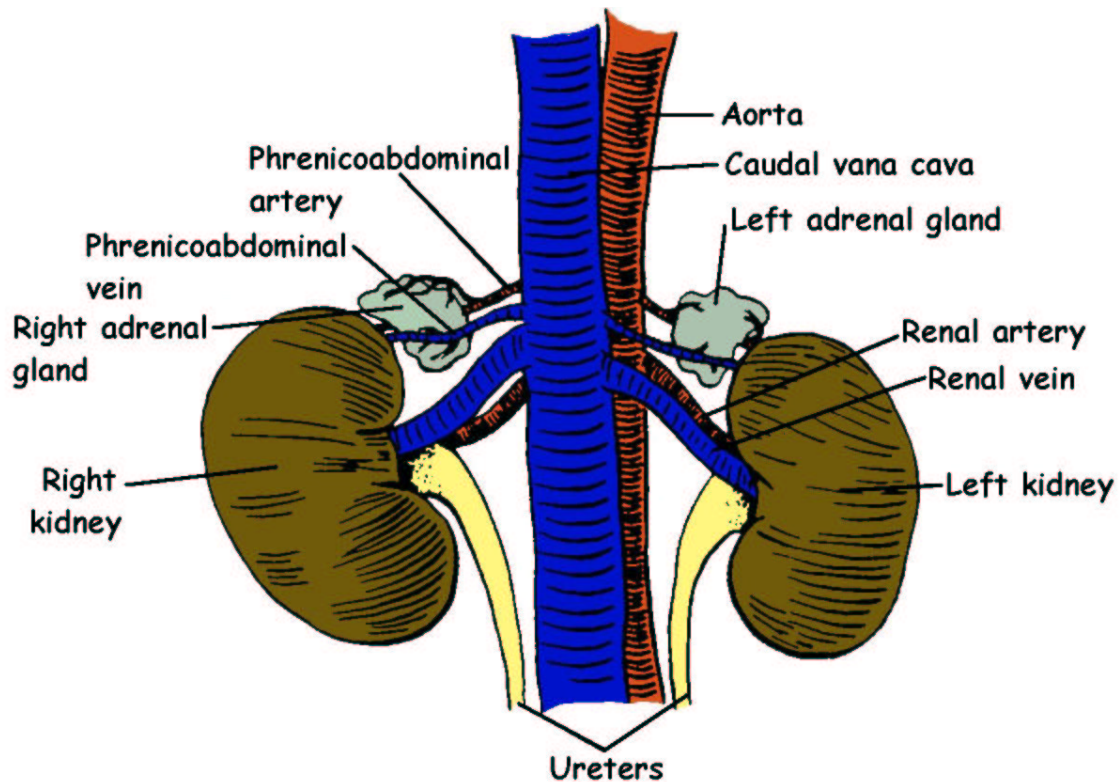
IV. Adrenal Glands

- A. Hormones from the adrenal gland are steroids formed mostly from cholesterol.



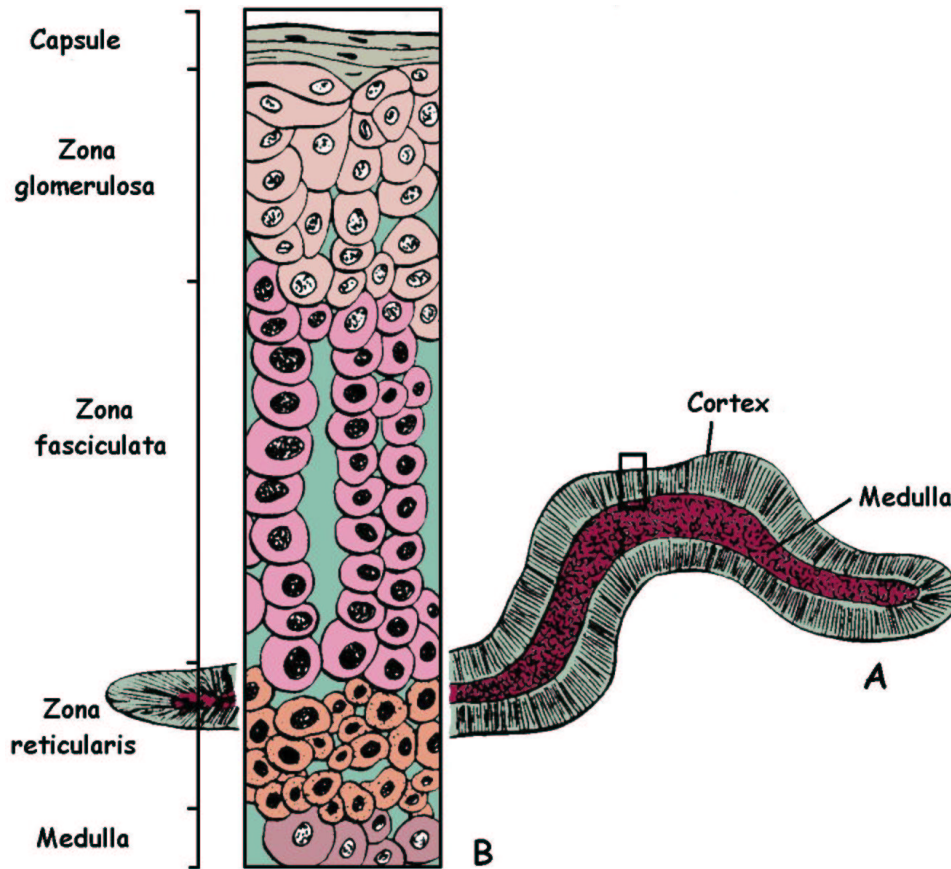
Structural formulas of the principal adrenocortical hormones.

- B. Adrenal glands are small, paired structures that lie immediately cranial to the kidneys and are close to the junction of the renal vein with the posterior vena cava.



The canine adrenal glands (ventral view). Their blood supply and venous drainage is by way of branches from the phreniocabdominal arteries and veins.

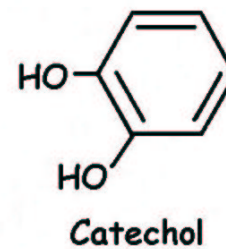
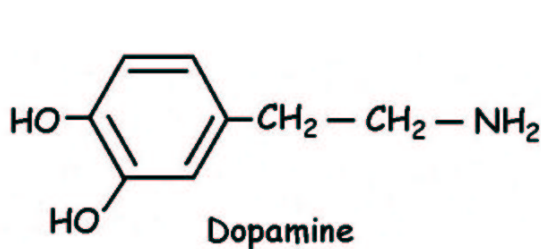
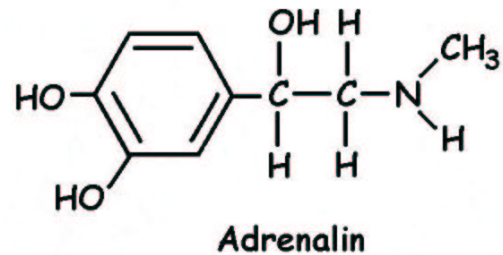
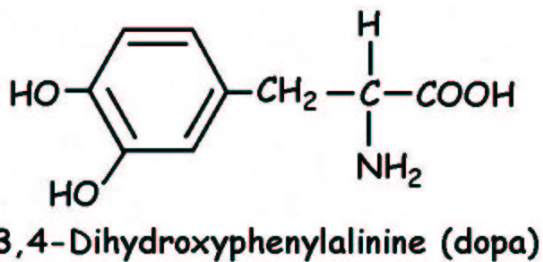
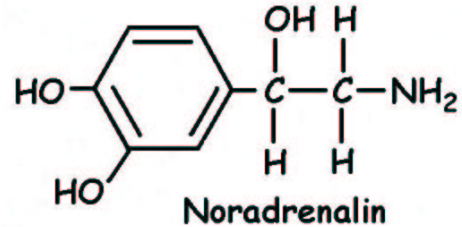
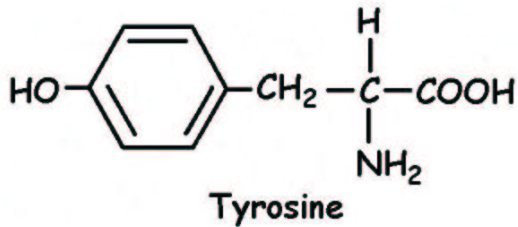
- C. Seven adrenocortical hormones are recognized as secretions of the adrenal cortex.
1. Corticosterone, cortisone, 11-dehydrocorticosterone, are called glucocorticoids.
 - a. principal role in carbohydrate metabolism
 - b. enhance gluconeogenesis – production of glucose from non-carbohydrate precursors
 - c. enhance water and sodium loss
 - d. also are potent anti-inflammatory compounds
 - e. glucocorticoids secreted by the zona fasciculata of the adrenal cortex
 - f. secretion of glucocorticoids regulated by ACTH from pituitary gland
 2. 11-deoxycorticosterone, 17-hydroxy-11deoxycorticosterone, and aldosterone are all called mineralcorticoids.
 - a. enhances sodium retention and potassium excretion
 - b. mineralcorticoids are secreted from zona glomerulosa of adrenal cortex
 - c. regulation of aldosterone secretion is under the rennin-angiotensin system
 - d. rennin is secreted by juxtaglomerular cells in kidney and acts on angiotensinogen in blood to form angiotensin I
 - e. angiotensin I is converted in the lungs to angiotensin II which causes aldosterone release



Diagrammatic representation of the adrenal gland. A. Cross-section of the adrenal gland showing the contrasting appearance of the cortex and medulla. B. Magnification of boxed-in area in A that shows the different cell types associated with the three zones of the cortex.

V. Hormones of the Adrenal Medulla

- A. Hormones of the adrenal medulla belong to the amine class and are known as epinephrine and nor-epinephrine
- B. These hormones are referred to as catecholamines and are derived from the amino acid tyrosine.
- C. Epinephrine is secreted only by the adrenal medulla, but norepinephrine is also secreted by the post-ganglionic sympathetic neurons.
- D. Catecholamines have pronounced metabolic effects.
- E. Catecholamines are also associated with the fight or flight response
- F. Two types of receptors are associated with binding catecholamines
 1. alpha receptors
 - a. stimulatory, except in intestinal smooth muscle where they are inhibitory
 2. beta receptors
 - a. inhibitory, except in cardiac muscle where they are stimulatory



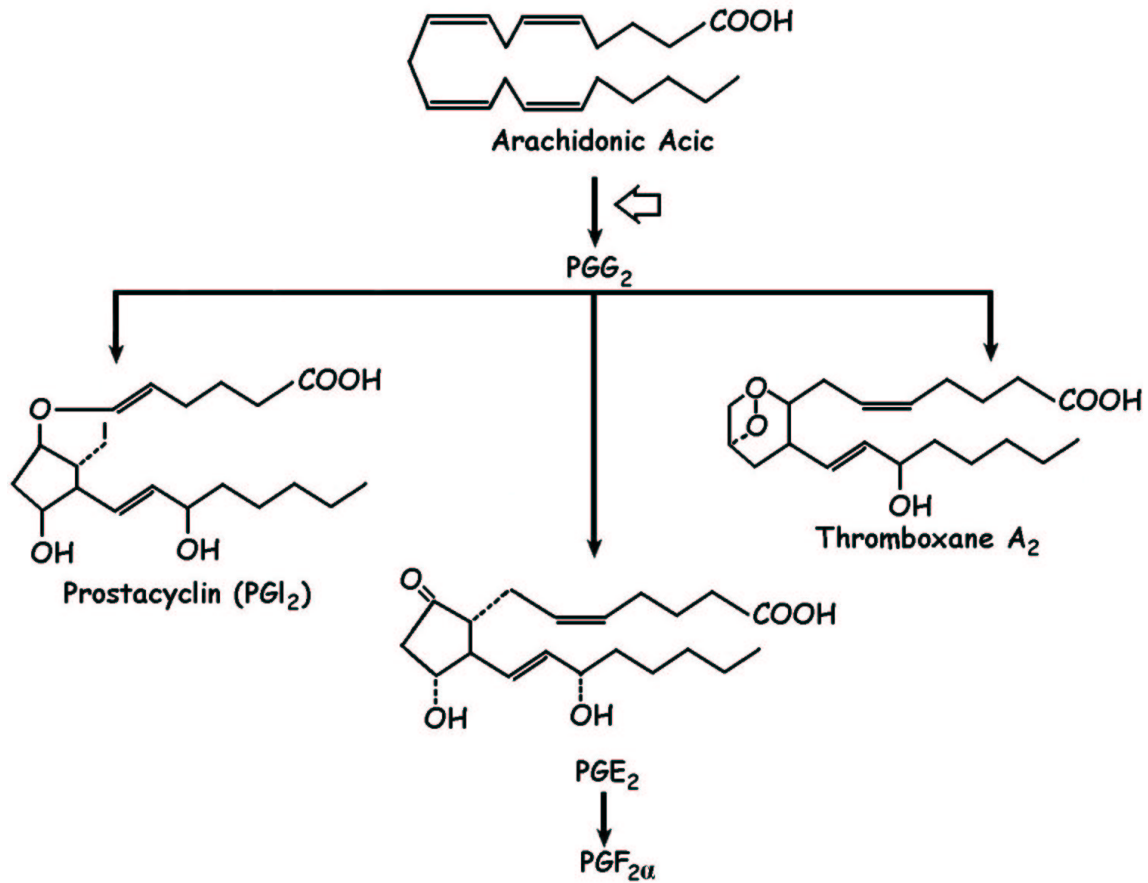
Structural formulas of catecholamine hormones. They are formed from the amino acid tyrosine and are derivatives of catechol. The abbreviation “dop” is derived from the German name of this compound, dioxyphenylalanine.

VI. Pancreas

- A. Hormones of the pancreas are insulin, glucagon, somatostatin, and pancreatic polypeptide.
- B. Each hormone is secreted by a specific cell type in the pancreatic islets.
 1. alpha cells – glucagon
 - a. stimulates production of glucose from liver
 2. beta cells – insulin
 - a. stimulate uptake of glucose
 3. delta cells – somatostatin
 - a. inhibits secretion of insulin and glucagon
 - b. inhibits secretion of gastrin, secretin, and gastric acid
 4. F cells – pancreatic polypeptide
 - a. secretion is stimulated by protein intake, exercise, and fasting – function unknown

VII. Prostaglandins and Their Functions

- A. First isolated from prostate gland and hence named prostaglandins
- B. Derived from arachidonic acid



Three major pathways of prostaglandin synthesis. The open arrow indicates the site of aspirin inhibition. Thromboxane A_2 is biochemically related to the prostaglandins and is formed from them as shown. Thromboxane A_2 promotes the platelet release reaction associated with blood coagulation. Therefore, aspirin retards blood coagulation.

- C. Prostaglandins promote inflammation and are involved in blood clotting.
- D. Prostaglandins are also involved in the regulation of ovarian function.