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DEPARTMENT OF ANIMAL PHYSIOLOGY**

LECTURE NOTES ON ANP 201

THE ENDOCRINE SYSTEM

Introduction

The glands of the body are organs that produce or secrete a variety of substances, such as Saliva, pancreatic juice, bile, epinephrine etc. The first type is the digestive system which transports its secretion to where they are needed by means of a tube or duct. These are called exocrine glands. The other type has no duct, and its cells secrete directly into the vascular system, these are referred to as endocrine glands. Endocrine is derived from two Greek words endon – within, krino – to separate and their secretions are called hormones. The word hormone was coined by E.H. Starling in 1905 in describing secretin, which is a Greek word for “I arouse”

Properties of hormones (characteristics).

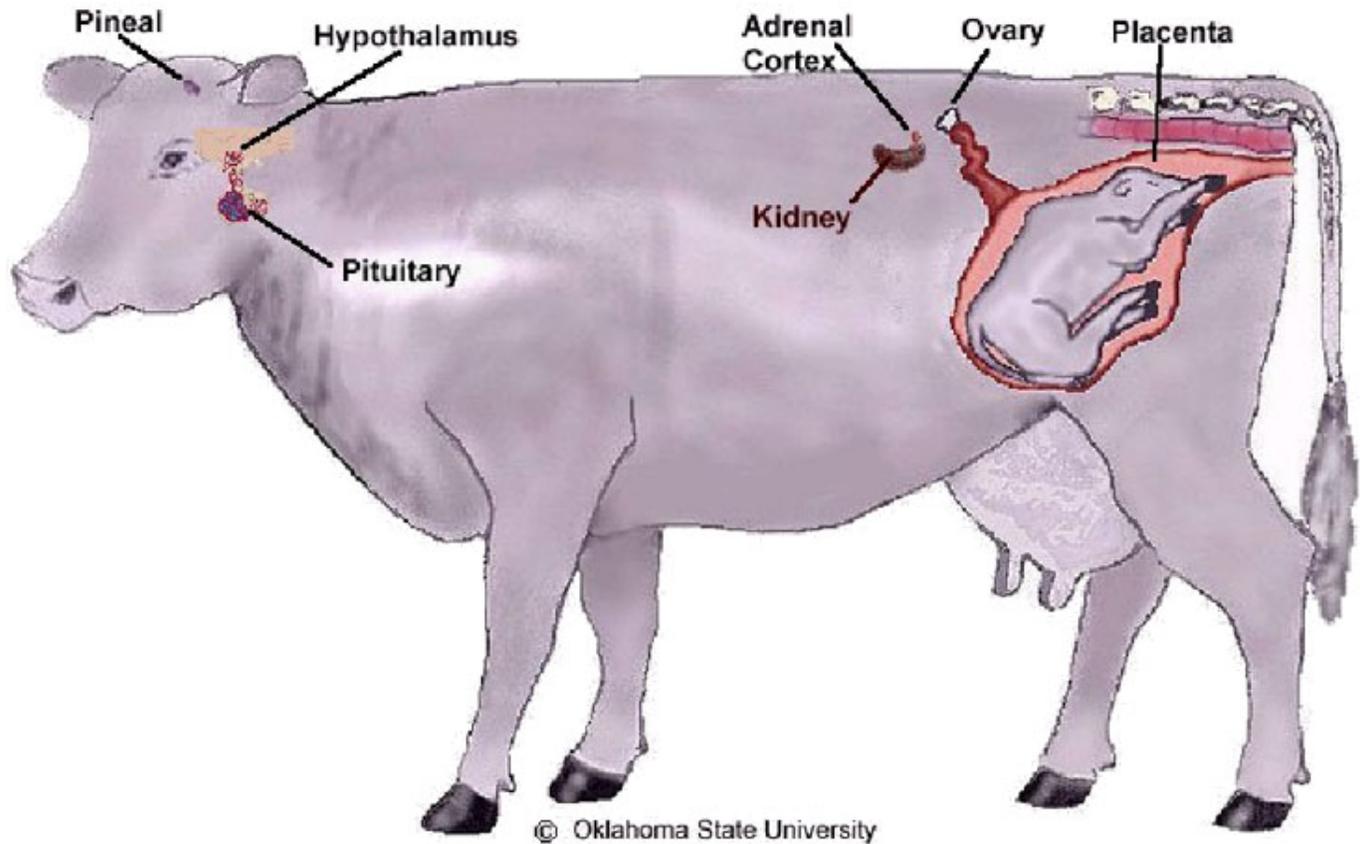
1. Hormones are produced and secreted by endocrine cells in very small amounts
2. They circulate in the blood and reach all tissues
3. They react with specific receptor molecules present in certain target cells
4. Hormones act in catalytic quantities, frequently by activating specific enzymes
5. A single hormone may have multiple effects on a single target tissue or on several different target tissues

Classification of hormones

1. Amines: these are the smallest group of hormones derived from two amino acids e.g. epinephrine
2. Steroids: these are large group of hormones originating from cholesterol e.g. testosterone and estrogen
3. Proteins and polypeptides: these are the largest group of hormones and they vary in length from 8 to more than 180 amino acids with CHO attached to it e.g. hypothalamic and pituitary hormones

Endocrine Glands and their Secretions

Body Diagram of Endocrine Glands



A. Hypothalamic control of the adenohipophysis

In recent years, evidence indicated that the secretory activity of the adenohipophysial endocrine cells is regulated by at least seven hypothalamic hormones. Four of these are releasing hormones (or factors) and three are release-inhibiting hormones

(i) Corticotropic releasing hormones

A polypeptide in structure and the target tissue is adenohypophysis. Stressful input increases secretion while ACTH inhibits secretion

Primary action

- Stimulates ACTH release

(ii) Thyroid stimulating hormone releasing hormone (TRH)

A polypeptide and the target tissue is the adenohypophysis. Large meal and low body temperature induce secretion

Primary action

- Stimulates TSH release

(iii) Growth hormone releasing hormone (GRH)

Also a polypeptide and the target tissue is adenohypophysis. It is stimulated by insulin

Primary action

- Stimulates growth hormone release

(iv) Gonadotropin releasing hormone or FSH-and LH – releasing hormone

Also a polypeptide and has target on the adenohypophysis. Its regulation is by

(a) Male: low blood testosterone levels stimulate secretion

Female: decreased estrogen levels stimulates secretion

(b) High blood FSH and LH inhibits secretion

Primary action

- Stimulates the release of FSH and LH

(v) Growth hormone inhibiting hormone (GIH or Somatostatin)

A polypeptide in structure and the target tissue is adenohypophysis.

Hypoglycemia and exercise induce secretion

Primary action

- It inhibits growth hormone release and also interferes with TSH release

(vi) Prolactin-release-inhibiting hormone (PIH)

Structure has not been determined yet but its target tissue is the adenohypophysis.

The regulation is by

(a) high levels of prolactin increase secretion

(b) estrogen, testosterone and suckling inhibit secretion

Primary action

- It inhibits prolactin release

(vii) Melanocyte-release-inhibiting hormone (MIH)

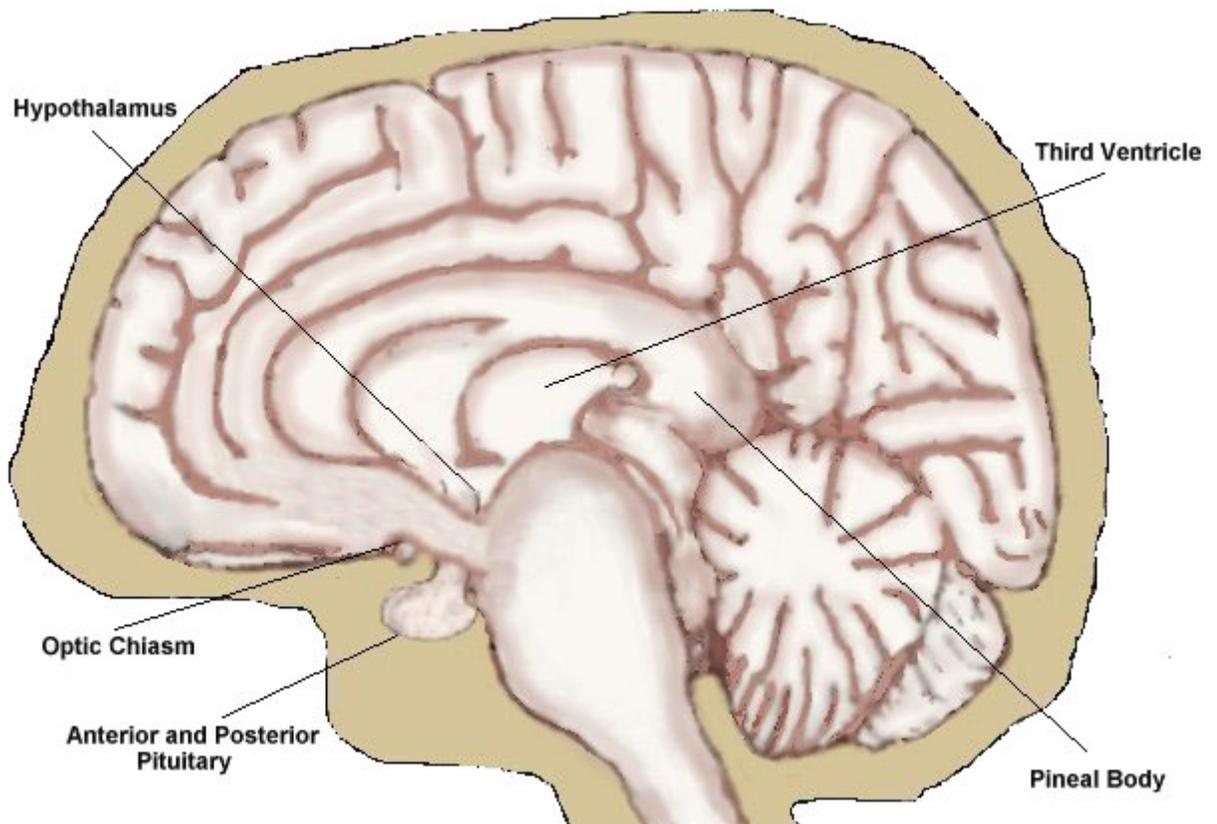
It is a polypeptide and has adenohypophysis as the target tissue. Melatonin stimulates secretion

Primary action

- It inhibits MSH release

B. Hormones of the pituitary gland

Brain Diagram of Endocrine Glands



The pituitary gland consists of two portions, the adenohypophysis (anterior lobe) and neurohypophysis (posterior lobe).

(i) Anterior lobe of the pituitary gland (adenohypophysis)

The anterior lobe of the pituitary also termed the adenohypophysis secretes at least seven hormones. They are: Growth hormone (somatotropin), prolactin, thyrotropin (thyroid stimulating hormone), Adrenocorticotrophic hormone, Leutinizing hormone, Follicle stimulating hormone (gonadotropins) and lipotropins (melanocyte stimulating hormone)

1. Growth hormone (Somatotropin) (GH)

It is a peptide hormone and the target tissue are all organs of the body. It is regulated by GH-releasing hormone

Primary action

- (a) Promotes growth of tissues
- (b) It increases protein synthesis
- (c) It increases amino acid and glucose transport
- (d) It causes mobilization of fatty acids from deposits thus playing a role in providing cellular fuel (lipolysis)
- (e) It increases RNA synthesis

2. Prolactin

It is a peptide hormone and the target organ is the mammary gland and its regulation is by prolactin-release-inhibiting hormone (PIH)

Primary action

- (a) Growth of mammary glands
- (b) Increases synthesis of milk proteins

3. Thyrotropin (Thyroid stimulating hormone, TSH)

It is a peptide hormone and the target tissue is the thyroid gland. It is regulated by thyroid releasing hormone (TRH) which induces TSH release

Primary action

- (a) It increases thyroid hormone synthesis and secretion

4. Adrenocorticotrophic hormone (ACTH)

It is also a peptide hormone and the target organ is the adrenal cortex. It is regulated by corticotrophic releasing hormone (CRH) in stimulating the release but ACTH inhibits release

Primary action

- (a) Increases steroidogenesis and secretion in adrenal gland

5. Leutenizing hormone (LH)

It is a peptide hormone with the target organs as the ovarian interstitial cells (female) and the testicular interstitial cells (male). It is regulated by LH/FSH-releasing hormone or gonadotropin releasing hormone which stimulates release

Primary action

In females

- (a) induces final maturation of follicle
- (b) it allows ovulation to take place
- (c) it allows secretion of estrogen from the ovary
- (d) it induces corpus luteum formation
- (e) it allows progesterone secretion

In males

- (a) increases the synthesis and secretion of androgens

6. Follicle stimulating hormone (FSH)

A peptide hormone affecting organs such as the seminiferous tubules in male and ovaries in female. It is regulated by gonadotropin releasing hormone (GnRH)

Primary action

In male

- (a) increases sperm production

In female

- (a) stimulates follicle maturation

7. Melanocyte stimulating hormone (MSH)

A peptide hormone whose target tissues are melanophores (ectotherm pigment cells) and melanocytes (endotherm pigment cells). It is regulated by melanin inhibiting hormone which inhibits release

Primary action

- (a) It increases melanin synthesis in melanophores and melanocytes
- (b) Increases dispersal in melanophores (skin darkening)

(ii) Hormones of the posterior pituitary gland (neurohypophysis)

The neurohypophysis releases two octapeptides: vasopressin (antidiuretic hormone, ADH) and oxytocin.

1. Vasopressin or Antidiuretic hormone (ADH)

It is a peptide hormone and the target tissue is the kidney. Its regulation is by decrease in plasma osmotic pressure, blood volume and blood pressure cause increased release of the hormone.

Primary action

- Increased water resorption

2. Oxytocin

It is a peptide hormone and the target tissues are uterus and mammary glands. Its regulation is by

- Decreases in progesterone level, suckling stimulus cause release of hormone
- Increased progesterone inhibits release

Primary action

- It causes the contraction of smooth muscle of uterus
- It allows milk ejection from mammary glands

(C) Sex Hormones

The sex hormones are under the class of steroid hormones. They are derived from cholesterol in the gonads (testes and ovaries) and adrenal cortex of both sexes. They include estrogens, androgens and progesterone.

1. Testosterone (androgen)

The androgens of which testosterone is the most prominent are produced mainly by the interstitial cells of the testes. They affect most tissues

Primary action

- Maintenance of the testes and reproductive tract

- Promotes development and maintenance of masculine characteristics and behavior in male
- Necessary for spermatogenesis

Its regulation is that increased LH level stimulates secretion

2. Estrogen (Estradiol-17 β)

Estradiol is the most active naturally occurring estrogen. It is produced during follicular growth of the developing ovarian follicle and the corpus luteum

Primary action

- It acts on the hypothalamus and pituitary to inhibit LH secretion
- They are important in the development of the gonadal duct system of the female
- Also important in the development of the mammary gland duct
- Promotes development and maintenance of female characteristics and behavior

3. Progesterone

It is formed by the corpus luteum of pregnancy. The target tissues are the uterus and mammary glands.

Primary action

- It speeds the movement of the ovum through the oviducts
- It prepares the uterine mucosa for implantation of the fertilized egg
- During pregnancy, it inhibits uterine muscle contractility making pregnancy to persist.
- In its absence pregnancy terminates quickly

Regulation: increased LH and prolactin levels stimulate secretion.

(D) Prostaglandin

The prostaglandins are a family of substances showing a wide diversity of biologic effects. They are basically fatty acids and the body produces them in very small quantities. The two important prostaglandins are prostaglandin E series (particularly E₂) and prostaglandin F series (particularly F₂ α). Prostaglandins are 20-carbon carboxylic acids and are synthesized in the body from certain polyunsaturated fatty acids. Tissue of origin includes

seminal vesicles, kidney, neural tissue and most cells. The target tissues are uterus, ovaries, fallopian tubes, blood vessels, adrenergic terminals and most cells.

Primary action

- PGE₂ lowers blood pressure
- PGF₂ alpha raises blood pressure
- PGE₂ and PGF₂ alpha stimulates uterine contraction
- PGE₂ and PGF₂ alpha play a role in parturition. Infusion of prostaglandin E2 can induce delivery in a few hours, so also oral administration
- PGF₂ alpha is used in the regression of the corpus luteum

(E) Adrenal Medulla Hormones

The principal hormone of the adrenal medulla is epinephrine. Norepinephrine is also present in smaller amounts but functions mainly as neurotransmitters in the sympathetic nervous system. These two hormones (norepinephrine and epinephrine) along with their precursor, dopamine, make up a group of substances called catecholamines. The two catecholamines are emergency or stress hormones. They contribute to the sympathetic fight or flight response to emergencies which enable an animal to mobilize and meet emotional and physical changes. There are two kinds of tissue targets based on the differences in their actions. Epinephrine binds to beta receptors of adrenal medulla while norepinephrine binds to the alpha receptors.

Physiological responses to epinephrine and norepinephrine

	Epinephrine	Norepinephrine
Heart rate	Increase	Decrease
Cardiac output	Increase	Variable
Total peripheral resistance	Decrease	Increase
Blood pressure	Rise	Greater rise
Respiration	Stimulation	Stimulation
Skin vessels	Constriction	Constriction
Muscle vessels	Dilatation	Constriction
Bronchus	Dilatation	Less dilatation

Metabolism	Increase	Slight increase
Oxygen consumption	Increase	No effect
Blood sugar	Increase	Slight increase
Uterus in vivo in late pregnancy	Inhibition	Stimulation
Kidney	Vasoconstriction	Vasoconstriction

(F) Pancreatic Hormones

The pancreas has two functions (i) endocrine secretion (ii) synthesis of digestive enzymes. The endocrine portion of the pancreas called Islets of Langerhans secretes two important hormones (a) Insulin and (b) Glucagon. There are four types of cells found in the Islets of Langerhans. These are the A or alpha cells, B or beta cells, C cells and D cells. The B cells are the most common and produce the hormone insulin which is necessary to prevent diabetes mellitus. The A or alpha cells produce the hormone, glucagons, that is antagonistic to insulin. The C cells and D cells look much alike, and their significance is unknown.

Primary action

- Insulin increase glucose and amino acid uptake by cells, increases GRH secretion
- Glucagon stimulates glycogenolysis and releases glucose from liver. It regulates blood glucose

(F) Thyroid Hormones

The thyroid gland produces two different kinds of hormones. The first group are thyroxine and triiodothyronine, the second is called calcitonin. Thyroid stimulating hormone (TSH) released from the adenohypophysis maintains the volume, weight and secretory activity of the thyroid gland. As the name implies, it stimulates the release of thyroid hormones. The target tissue includes most cells but especially those of muscle, heart, liver and kidney.

Primary action

- It regulates the metabolism of most of the adult tissues such as kidney, liver, heart and skeletal muscles
- Thyroid hormones play an essential role in normal growth and development. Its

shortage during infancy leads to a condition called cretinism. The cretin is a mental and physical dwarf with inhibited growth. Gonadal development is juvenile, mental retardation prevails. Condition can be reversed if treated early in the growth period with T_3 or T_4 (T_3 = triiodothyronine, T_4 = thyroxine)

- Calcitonin regulates the blood calcium levels

G. Gastrointestinal Hormones

1. Gastrin

It is produced in the stomach and duodenum. The primary action is the stimulation of HCl production and secretion. It also stimulates the secretion of pepsin

2. Cholecystokinin (pancreozymin)

It is produced in the stomach and duodenum. It causes the contraction of gall bladder (i) stimulates digestive enzymes secretion (bile) (ii) it neutralizes the acid from the stomach from moving into duodenum.

3. Secretin

It is produced in the duodenum. It secretes water and salt (i) neutralizes acid in the small intestine.