ENDOCRINE SYSTEM

OBJECTIVES/RATIONALE

To pursue a career in health care, proficiency in anatomy and physiology is vital. The student will describe biological and chemical processes that maintain homeostasis; analyze forces and the effects of movement, torque, tension, and elasticity on the human body; associate the disease process with changes in homeostasis; identify changes in structure and function due to trauma and disease; and identify normal and abnormal anatomy and physiology.

TEKS:	121.3 (c)(1)(F)(H), 121.4 (c)(1)(G)(H)(I), 121.5 (c)(1)(E)(F)(G)	TAKS	ELA 1, 3, 4 Social Studies 5 Science 1, 2, 3, 4

KEY POINTS

I. Glands
   - A. Endocrine: Ductless glands that secrete hormones directly into the bloodstream that flows through the gland
   - B. Exocrine: Carried by a duct to a surface of a tissue
   - C. Gland: any organ/structure that produces a secretion
     1. Exocrine: carried by a duct or organ to the tissues
     2. Endocrine: carried by blood or lymph; NO ducts

II. Hormone: biologically active chemical (steroid, amino acid, polypeptide, glycoprotein) that combines with specific receptor proteins and regulates the function of other organs
   - A. Functions of Hormones
     1. Regulation of metabolism
     2. Regulation of growth and development
     3. Regulation of reproduction
     4. Regulation of stress response
     5. Regulation of cell permeability
   - B. Secretion and Storage of Hormones
     1. All are formed by the endoplasmic reticulum
     2. Transported by the Golgi apparatus that packages the hormones in secretory vesicles which are stored in the cytoplasm of the endocrine cell
     3. Waits for nerve signal or chemical signal to initiate the secretion
        - a. Hormonal stimuli
        - b. Humoral stimuli
        - c. Neural stimuli
   - C. Negative Feedback
     1. Endocrine glands tend to over secrete their hormones so the target organ has enough to function properly

2. When too much function occurs, some factor feeds back to the endocrine gland to cause a negative effect on the gland to decrease its secretory rate
3. Hormone is monitored and regulated internally

D. Transport
1. Hormones travel to target cells by carrier blood plasma proteins for specific hormones
2. Target cells have specific receptor proteins for specific hormones
3. Target cells become biologically active to regulate the function of other organs when binding occurs on the target cell

III. Endocrine Glands

A. Pituitary Gland: hypophysis, located in the sella turcica of the sphenoid bone; called the master gland
1. Anterior Lobe: adenohypophysis; connected to hypothalamus by a system of vessels
a. ACTH (adrenocorticotrophic hormone): stimulates the adrenal cortex to secrete steroids
b. GH, HGH (growth hormone): somatotropin that controls body size by increasing mitosis, increasing cell size, and increasing the rate of protein synthesis
(1) Dwarfism: hyposecretion in a child
(2) Simmonds' disease: hyposecretion in adult → lethargy, obesity, premature senility
(3) Gigantism: hypersecretion in child (tumors)
(4) Acromegaly: adult hypersecretion → enlarged bones of head/hands/feet/face
c. TSH (thyroid stimulating hormone): stimulates thyroid to secrete thyroxin (T4)
d. Gonadotropins = FSH and LH
(1) FSH (follicle stimulating hormone): stimulates maturation of ovarian follicle and sperm
(2) LH (luteinizing hormone): stimulates corpus luteum development (ovulation) and testosterone synthesis (ICSH)
e. LTH (Prolactin): promotes growth of breast tissue and milk secretion after delivery
f. MSH (Melanocyte stimulating hormone): stimulates melanin skin pigment formation
2. Posterior Lobe: neurohypophysis, connected to the hypothalamus by a stalk of nerve tissue
a. ADH (Antidiuretic hormone/vasopressin): promotes water reabsorption by kidney tubules and increases blood pressure
(1) Trauma increases ADH, so body retains fluid
(2) Alcohol decreases ADH, so diuresis occurs

(3) Diabetes insipidus: decreased ADH secretion; S & S → polyuria, polydipsia, dehydration

b. Oxytocin: sucking stimulates oxytocin release, so milk is let down, contracts uterus too

(1) Pitocin: synthetic oxytocin

B. Adrenal Glands: 2 small glands located above each kidney that secrete hormones made from cholesterol (LDL), ACTH secretion from the anterior pituitary regulates secretion

1. Cortex: outer portion, secretes 30+ steroids

a. Mineralocorticoids: aldosterone; main function is to promote the transport of Na+ and K+ through the renal tubules so Na+ is saved and K+ is excreted and so secretion increases extracellular fluid volume

(1) Hypoadrenalism: Addison's disease

i. Decreased blood glucose level = low energy
ii. Decreased immune function = infections
iii. Increased melanin pigmentation = lips and nipples darken , lots of black freckles
iv. Decreased Na+ and water = diuresis, dehydration
v. Decreased fluid volume = shock, death, adrenal crisis

(2) Hyperadrenalism: Cushing's syndrome

i. Tissue swelling and fat redistribution → "buffalo torso" and "moon face"
ii. Hirsutism: excessive facial hair
iii. Increased blood glucose → increased insulin production until cells burn out and causes Type II diabetes mellitus
iv. Rx/Tx: adrenalectomy

b. Glucocorticoids: cortisol (Cortisone, Prednisone); regulate the amounts of sugars, fats, CHO in cells, stimulates gluconeogenesis in liver; Hyperfunction: fat deposits, "moon face"

c. Androgens, estrogens, progesterone: help supplement other hormones to maintain secondary sexual characteristics

d. Stressful situations

(1) ACTH from anterior pituitary secreted which then stimulates cortisol secretion from Adrenal Cortex, which has an anti-inflammatory effect

(2) Cortisol increases rate of healing by decreasing the immune reactions (important in inflammatory diseases such as allergic reactions, rheumatoid arthritis, and rheumatic fever

2. Medulla: central portion, has same effect as a direct sympathetic nerve response, called the stress hormones, ‘fight or flight” response
    a. Epinephrine: adrenaline, adrenalin
        (1) Accelerates heart rate, increases blood pressure, increases heart output
        (2) Weak vasoconstriction in skin
        (3) Vasodilation of skeletal and cardiac muscles
        (4) Relaxes bronchioles, treats severe respiratory distress
        (5) Increases respirations
        (6) Increases metabolic rate of every cell
        (7) Increases blood glucose levels by increasing glycogen breakdown in liver
        (8) Increases muscle strength and mental activity
        (9) Decreases GI function
    b. Norepinephrine: noradrenaline
        (1) Neurotransmitter, strong vasoconstrictor
        (2) Increases BP, but slows heart, dilates pupils
    c. Dopamine: dilates systemic arteries, increases cardiac output, increases flow of blood to the kidneys, therefore, increases urinary output (used to treat shock)
        (1) Pheochromocytoma: tumor of adrenal medulla; S & S = hypertension, headaches, sweating, N & V, flushed face, tingling of extremities
        (2) Raynaud’s disease: extreme skin vasoconstriction with exposure to cold or stress; causes ischemic pain, pallor followed by cyanosis then redness of hands and feet

C. Ovaries: hormones stimulated by FSH and LH of anterior pituitary then secreted by the ovarian follicles
    1. Estrogens develops and maintains secondary sexual characteristics
        a. Hypofunction (congenital): eunuch; no 2 sex characteristics, high voice, no facila hair, taller, no body fat
        b. Hypofunction (adult): menopause
        c. Hyperfunction: rare tumors of pituitary gland
    2. Progesterone: secreted by corpus luteum during the last half of the menstrual cycle, prepares uterus for pregnancy and the breasts for lactation, also secreted by the placenta during pregnancy

D. Testes: hormone secretion stimulated by LH of the anterior pituitary and secreted by the Leydig cells of the testes
    1. Testosterone: causes the growth and maintenance of secondary sexual characteristics and spermatogenesis under FSH control
        a. Hypofunction

(1) In children: eunuch, infantile 2 sex characteristics
(2) In adults: Frohlich's syndrome (obesity, muscle and hair loss, decreased sex drive)
(3) Cryptorchidism: undescended testes
(4) Castration: removal of testes

b. Hyperfunction: usually tumors (teratoma)
(1) In children: increased muscle and bone growth, early closure of epiphysis, increased secondary sex characteristics
(2) In adults: gynecomastia, overgrowth of breasts

E. Pineal Gland (Body): above the roof of the 3rd ventricle of the brain
Melatonin: suppresses/regulates gonadotropic hormones, controls sexual drive, delays puberty, some research relates it to SAD (seasonal affective disorder)

F. Thyroid: butterfly shaped gland on each side of the trachea covering the 2nd-4th tracheal rings, has a narrow connecting band called the isthmus
1. Thyroxine (T4) and Triiodothyronine (T3)
a. Requires iodine for hormone synthesis
b. Regulates metabolism
(1) Increased metabolic rate
(2) Increases the glucose, fat, carbohydrates, and vitamin metabolism
c. Hypofunction
(1) Fetal/congenital (cretinism): decreased mental growth, obese, dwarfism
(2) Acquired/adult (myxedema): fatigue, increases desire to sleep, edema, bags under eyes, rough voice, decreased heart rate
d. Hyperfunction
(1) Graves' disease: autoimmune disease that stimulates TSH, intolerance to heat, increased sweating, weight loss, diarrhea, fatigue, insomnia, exophthalmia (bulging eyes)
(2) Thyrotoxicosis: tachycardia, hypertension, hyperthermia, NVD, confusion
(3) Goiter: without dietary iodine, there is a decreased amount of T4 and T3, so there is a high level of TSH secretion which stimulates abnormal growth of thyroid tissue
2. Calcitonin: regulates calcium metabolism (vitamin D is essential for calcium absorption)

G. Parathyroid Glands: 4 tiny pea-like structures embedded posterior to the thyroid gland
1. Parathormone: PTH; regulates the amount of calcium and phosphorus in circulating blood and storage of calcium in bones and teeth

a. Hypo PTH: hypocalcemia causes tetany with laryngeal spasms
b. Hyper PTH: hypercalcemia
(1) Osteitis: weak, cystic bones, excessive stone production (nephrolithiasis)
(2) Rickets: calcium deficiency in children, usually a decrease in vitamin D in diet
(3) Osteomalacia: adult rickets/renal rickets
(4) Osteoporosis: aging bones/decreased calcium

H. Thymus: secretes thymosin which stimulates the production of antibodies in early life by maturing the T-cells, atrophies after puberty

I. Pancreas: located behind the stomach, secretions are produced by the Islets of Langerhans
1. Glucagon: secreted by alpha cells; converts glycogen to glucose in the liver, therefore increasing blood sugar
2. Insulin: secreted by the beta cells; regulates the transport and storage of glucose into body cells, decreases blood glucose levels
3. Effects of pancreatic hormones
a. After a meal, blood sugar increases. Insulin secretion increases and glucagon secretion decreases to lower the high plasma glucose concentration.
b. With fasting, blood sugar decreases. Insulin secretion decreases and glucagon secretion increases to keep plasma glucose concentrations up to a safe minimum level.
4. Diagnostic Tests for Pancreatic Function
a. FBS: fasting blood sugar
b. GTT: glucose tolerance test
c. 2 Hour postprandial test
5. Diabetes Mellitus: insulin deficiency, inherited, 5 million in USA
a. Type I: insulin dependent diabetes (IDDM)
(1) Juvenile, rapid onset
(2) Hereditary predisposition
(3) Viral destruction of beta cells
(4) Body lacks ability to produce insulin
(5) Rx/Tx: insulin injections
b. Type II: non-insulin dependent diabetes (NIDDM)
(1) Adult/maturity, slow onset
(2) Obesity causes beta cells to overreact, but they become less responsive, therefore a decrease in insulin secretion
(3) Rx/Tx: diet, oral replacements
c. Symptoms
(1) Polydipsia: excessive thirst
(2) Polyphagia: excessive eating with weight loss
(3) Polyuria: excessive urination with dehydration

(4) Glycosuria: sugar in urine due to increase in blood glucose

d. Complications
   (1) Atherosclerosis and heart disease
   (2) Retinopathy: increased blood glucose destroys the retina, 2nd leading cause of blindness
   (3) Renal disease: glucose destroys nephrons
   (4) Circulatory deficiency: gangrene and amputations

e. Side effects
   (1) Diabetic coma: hyperglycemia caused by eating too much or too little insulin causes increased blood glucose (normal = 70-100 mg/100 ml)
      i. Ketoacidosis: by product of fat metabolism
      ii. Acetone breath: fruity odor, N/V
      iii. Kussmaul's breathing: rapid, deep, labored
      iv. Restlessness, confusion, coma
      v. Rapid, weak pulse, low BP
      vi. Skin warm, dry, flushed
      vii. Tx: insulin
   (2) Insulin shock: hypoglycemia caused by not eating or too much exercise so body has too much insulin
      i. Dizzy, headache, nervousness
      ii. Full, rapid pulse
      iii. Diaphoresis
      iv. Pale, cold skin
      v. Tremors, seizures
      vi. Loss of consciousness, coma
      vii. Normal breathing, normal BP
      viii. Tx: sugar ASAP

ACTIVITIES

I. Complete Hormone Chart as notes are given.
II. Label diagram of endocrine organs.
III. Identify and report on nutrients that affect the endocrine system.

MATERIALS NEEDED

Diagram of endocrine organs.
Hormone Chart
Endocrine System Terminoogy

ASSESSMENT

Completed chart and diagram

ACCOMMODATIONS

For reinforcement, students will create flashcards for the terminology associated with the endocrine system.

For enrichment, the students will identify and report on pharmaceutical agents used to treat diseases of the endocrine system. Present using multimedia technology.

REFLECTIONS

Hypothalamus and Anterior Pituitary Gland

Hypothalamus			Ant. Pituitary		
Type of Stimulus	**Hormone**	**Result**	**Hormone (All Hormonal Stimuli)**	**Organ Stimulated**	**Action**

Posterior Pituitary, Thyroid, Adrenal Glands

Gland	Hormone	Stimulus	Result	Action
Posterior Pituitary				
Thyroid Gland				
Parathyroid Gland				
Adrenal Cortex				
Adrenal Medulla				

Pancreas

Gland	Hormone	Stimulus	Result	Action
Pancreas				

Gonads, Pineal, and Thymus Gland

Gland	Hormone	Stimulus	Result	Action
Ovaries				
Testes				
Pineal				
Thymus				

Hypothalamus and Anterior Pituitary Gland

Hypothalamus			Ant. Pituitary		
Type of Stimulus	**Hormone**	**Result**	**Hormone (All Hormonal Stimuli)**	**Organ Stimulated**	**Action**
Humoral	GHRH (GHIH or decreasedGH)	AP	GH	Bone, Muscle	Growth
Humoral (decreased TH)	TRH	AP	TSH	Thyroid	T3, T4
Neural (stress), Humoral (decreased glucose)	CRH	AP	ACTH	Adrenal cortex	Corticosteroids
Humoral (levels of sex hormones)	GnRH	AP	FSH	Gonads (testes, ovaries)	Gamete Production (sperm, egg)
Humoral (sex hormones)	GnRH	AP	LH	Gonads	Sex hormones
Humoral (sex hormones, Neural (breast feeding)	PRH	AP	PRL	Breasts	Milk Production

Posterior Pituitary, Thyroid, Adrenal Glands

Gland	Hormone	Stimulus	Result	Action
Posterior Pituitary	Oxytocin	Neural (Uterine stretch, baby suckling)	Mammary Glands	Milk Release
	ADH	Neural (decreased BP)	Kidneys	Conserve Fluid
Thyroid Gland	TH	Hormonal, TSH	All Cells of Body, Needed for Normal Tissue Growth	Increases BMR
	Calcitonin	Humoral (increased Ca++)	Bones	Decreases Ca++ Levels
Parathyroid Gland	PTH	Humoral (decreased Ca++)	Bones	Increases Ca++ Levels
Adrenal Cortex	Aldosterone	Humoral (decreased fluid, decreased Na+)	Kidneys	Conserves Na+
Adrenal Medulla	Epinephrine	Neural (Sympathetic Nervous System)	Heart, Lungs, Etc.	Increase VS

Pancreas

Gland	Hormone	Stimulus	Result	Action
Pancreas	Insulin	Humoral (increased glucose)	All cells of body	Decreases blood glucose
	Glucagon	Humoral (decreased glucose)	Liver	Increases blood glucose

Gonads, Pineal, and Thymus Gland

Gland	Hormone	Stimulus	Result	Action
Ovaries	**Estrogen**	**Hormonal**	**Reproductive Development**	**Puberty Changes**
	Progesterone	**Hormonal**	**Breast Development**	**Menstruation**
Testes	**Testosterone**	**Hormonal**	**Reproductive Development**	**Sperm/Puberty Changes**
Pineal	**Melatonin**	**Neural, Light**	**Hypothalamus**	**Sleep/Wake Cycle**
Thymus	**Thymosin**	**Humoral**	**Immune**	**Lymphocytes**