Endocrine System

A. 2 types of glands in the body

1. Exocrine – secrete their products into ducts

A) Ex. sweat & salivary

2. Endocrine – secrete their products into blood or surrounding fluid

A) Usually carried to target cells in other parts of the body

B. Hormones

1. Classification of Hormones

A) Localized hormones – act locally without entering the bloodstream

1) Paracrine

a) Carry out actions on other cells in the immediate area

b) Ex: prostaglandins

2) Autocrine

a) Carry out actions on the cells releasing them

b) Ex: nitric oxide

B) Circulating hormones (endocrines) – enter the bloodstream and act on distant cells

2. Chemical Nature of Hormones

A) Amino-acid based hormones – the majority of hormones; water-soluble

1) Amines

a) Simple hormones derived from the amino acid tyrosine (ex: epinephrine)

2) Peptides and proteins

a) Long chains of amino acids (ex: oxytocin)

B) Steroid based hormones

1) Lipid-soluble hormones derived from cholesterol (ex: testosterone & estrogen)

C) Eicosanoids

1) Hormone-like substances derived from arachidonic acid which act only on cells

in their immediate vicinity (ex: prostaglandins & leukotrienes)

3. Mechanism

A) Release stimulated by the nervous system, other hormones, or other physiological

factors

B) May act in immediate area but usually transported in blood to target cells

C) Alter the cellular activity of target cell to achieve physiological response

1) Typical physiological responses

a) Open/close membrane ion channels to alter membrane permeability or

potential

b) Stimulate/inhibit synthesis of proteins

c) Activate/deactivate enzymes

d) Induce/block secretion of cellular products

e) Stimulate/inhibit mitosis or meiosis

4. Transport

A) Water-soluble hormones

1) Flow freely in blood

B) Lipid-soluble hormones

1) Attach to a transport protein

2) Must detach to carry out action

5. Method of Action

A) Water-soluble hormones

1) Usually work via a second messenger system

2) 2 main second messenger systems

a) Cyclic AMP (cAMP) Signaling Mechanism

i) The hormone binds to a receptor on the target cell’s membrane

ii) The bound receptor changes shape activating a nearby G protein

iii) The activated G protein activates adenylate cyclase (a membrane enzyme)

(a) This inactivates the G protein

iv) Adenylate cyclase will stimulate the production of cAMP within the

target cell

v) cAMP activates protein kinase A within the cell

vi) Protein kinase A phosphorylates other enzymes within the target cell

causing the physiological response

(a) Activates some enzymes & inhibits others

vii) Phosphodiesterase degrades cAMP thereby stopping its action

b) PIP-Calcium Signal Mechanism

i) The hormone binds to a receptor on the target cell’s membrane

ii) The bound receptor changes shape activating a nearby G protein

iii) The activated G protein activates phospholipase C (a membrane enzyme)

(a) This again inactivates the G protein

iv) Phospholipase C splits PIP2 (phosphatidylinositol 4,5-bisphosphate) into

DAG (diacylgycerol) & IP3 (triphosphoinositol)

v) DAG activates protein kinase C causing a physiological response

vi) IP3 causes the release of Ca++ from the endoplasmic reticulum

(a) This amplifies the physiological response

B) Lipid-soluble hormones

1) Diffuse directly through the target cell’s membrane

2) Bind to receptors in cytoplasm or nucleus

a) Translocation

3) Turns on/off gene transcription of the cell’s DNA

4) Causes the production of a new protein by the cell or stops the production of an

already present protein

5) Causes physiological response

6. Feedback Systems

A) Negative feedback system

1) Physiological response causes decreased release of the hormone

B) Positive feedback system

1) Physiological response causes increased release of the hormone

7. Responsiveness of Target Cell

A) Dependent on 4 factors

1) Blood levels of the hormone

2) Abundance of receptors on the target cell

a) Some cells have the ability to produce more receptors when blood hormone

levels are high = up-regulation

b) Others cells lose receptors in response to prolonged exposure to a hormone =

down-regulation

3) Affinity of the bond between hormone and receptor

a) Affinity can also be influenced by blood levels of a particular hormone

4) Interaction with other hormones

a) Permissive interaction

i) Hormone requires current or recent exposure to another hormone

(a) Reproductive hormones require the presence of thyroid hormones to

work properly

b) Synergistic interaction

i) 2 hormones together cause a stronger response than their individual

responses combined

(a) Glucagon and epinephrine both increase blood glucose individually;

when working together blood glucose levels increase 150% more than if

each hormone worked alone

c) Antagonistic interaction

i) One hormone inhibits the response of another

(a) Glucagon inhibits the action of insulin

C. Glands

1. Pituitary (Hypophysis)

A) Attached directly to the hypothalamus via the infundibulum

B) Subdivided into 2 lobes

1) Anterior (adenohypophysis)

a) Human growth hormone (HGH)

i) Stimulates cell growth & protein synthesis

b) Thyroid stimulating hormone (TSH)

i) Stimulates production of T3 & T4

c) Follicle stimulating hormone (FSH)

i) Females

(a) Stimulates follicle development & release of estrogen

ii) Males

(a) Stimulates sperm production

d) Luteinizing hormone (LH)

i) Females

(a) Stimulates follicle development & ovulation

ii) Males

(a) Stimulates testicular development & release of testosterone

e) Prolactin (PRL)

i) Initiates & maintains milk production

2) Posterior (neurohypophysis)

a) Oxytocin (OT)

i) Enhances labor & stimulates milk production

b) Antidiuretic hormone (ADH)

i) Increases water reabsorption in the kidneys (DCT & CD)

2. Thyroid

A) Follicular cells

1) T3 (triiodothyronine) & T4 (thyroxine)

a) Regulate cellular metabolism, growth & development

B) Parafollicular cells

1) Calcitonin (CT)

a) Decreases blood Ca++ levels by increasing osteoblast activity

3. Parathyroid

A) Parathyroid hormone (PTH)

1) Increases blood Ca++  by increasing osteoclast activity

4. Adrenal Glands

A) Adrenal cortex

1) Aldosterone

a) Promotes Na+ reabsorption in the kidneys (DCT & CD)

2) Androgens

a) Considered a male sex hormone although its produced by both sexes

b) Effects are generally not seen in males due to the presence of testosterone

c) In females, it is responsible for skeletal changes seen with puberty, body hair

growth, and libido

3) Cortisol (hydrocortisone)

a) Regulates one’s resistance to stress

b) Depression of immune responses

c) Anti-inflammatory agent

B) Adrenal medulla

1) Epinephrine & norepinephrine

a) Same functions as norepinephrine in sympathetic NS

5. Pancreas

A) Primarily composed of aciner cells

1) Produce pancreatic juice (enzymes)

B) Scattered among the aciner cells are about one million islets of Langerhans

(pancreatic islets)

1) Composed of 4 hormone-producing cell types

a) Alpha cells

i) Glucagon

(a) Increases blood glucose (sugar)

b) Beta cells

i) Insulin

(a) Decreases blood glucose (sugar)

c) Delta cells

i) Somatostatin

(a) Inhibits release of insulin & glucagon

d) F cells (PP cells)

i) Pancreatic polypeptide

(a) Inhibits secretion of somatostatin

(b) May play a role in regulating appetite

6. Gonads

A) Ovaries

1) Progesterone & estrogen

a) Regulate reproductive cycle

b) Prepares body for pregnancy

c) Stimulates development of secondary sex characteristics

2) Inhibin

a) Inhibits FSH

3) Relaxin

a) Relaxes cervix during labor and delivery

B) Testes – interstitial cells

1) Testosterone

a) Promotes spermatogenesis

b) Stimulates development of secondary sex characteristics

2) Inhibin

a) Inhibit FSH

7. Pineal Gland

A) Melatonin

1) Promotes sleepiness

a) Its release is inhibited by light

8. Placenta

A) Human chorionic gonadotropin (HCG)

1) Stimulates ovary to produce estrogen & progesterone to maintain pregnancy

2) Detected by home pregnancy tests

B) Estrogen & progesterone

1) Maintain pregnancy until mother’s hormones take over

C) Human chorionic somatostatin

1) Stimulates development of mammary glands for lactation

D) Relaxin

1) Relaxes cervix during labor & delivery

9. Other endocrine organs

A) Heart

1) Atrial natriuretic peptide (ANP)

a) Decreases total blood volume by decreasing Na+ reabsorption in the

kidneys (DCT & CD)

B) Kidney

1) Renin – from the JGA

a) Increases total blood volume by stimulating the angiotensin-aldosterone

mechanism

2) Erythropoietin (EPO)

a) Increases RBC production

D. Disorders of the Endocrine System

1. Goiter – an enlarged thyroid gland; many causes but can be linked to a lack of iodine

2. Grave’s disease – autoimmune disorder resulting in hyperthyroidism and an enlarged

thyroid gland

3. Addison’s disease – hyposecretion of cortisol due to progressive destruction of the

adrenal cortex

4. Cushing’s syndrome – hypersecretion of cortisol; causes a breakdown of muscle and a

redistribution of body fat

A) Characterized by a rounded “moon face” and a “buffalo hump” on the back

5. Diabetes insipidus – caused by an inability to secrete or respond to ADH; causes excess

urine production, dehydration, and thirst

6. Diabetes mellitus – the most common endocrine disorder

A) A group of disorders caused by an inability of the body to produce or use insulin

resulting in increased blood glucose; characterized by polyuria (excessive urine

production), polydipsia (excessive thirst), and polyphagia (excessive hunger)

B) 2 main types

1) Type I diabetes (insulin-dependent diabetes mellitus)

a) Caused by a deficiency of insulin

b) Autoimmune disease characterized by the destruction of beta cells

c) Patients are dependent on insulin injections throughout their life

2) Type II diabetes (non-insulin-dependent diabetes mellitus)

a) Patients have normal insulin levels but target cells are desensitized due to down-

regulation

b) Most common type; linked to obesity

c) Often controlled by diet, exercise, and weight loss