

The Endocrine System

ENDO - 'within'

CRINE - to secrete

Hormon - ' to excite'

Endocrine System Characteristics:

No continuity

Targets are distant

Ductless Glands (unlike exocrine)

Produce/release hormones into blood or lymph

Diverse effects

Duration of effect variable

Half life brief (secs--> 30 min)

Time for onset of effects variable

[conc] in blood depends on: rate of appearance/ disappearance

May exhibit Diurnal variation

response to light (eyes->suprachiasmatic nuclei)

Hormonal activity

Hormonal release stimulated by :

Other hormones or releasing factors

Humoral factors: blood- borne chemicals, ions

Neural input

Hormones effect only specific receptors of target cells:

Receptors can # (up-regulate)

Down-regulation (decreased number of receptors)

Anatomical Structures

Classical Endocrine organs:

Pituitary

Thyroid

Parathyroid

Adrenal

Pineal

Thymus

Other organs with endocrine function:

Gastrointestinal tract:

Stomach --> Gastrin

Duodenum ---> CCK (cholecystekinin)

Kidney: Renin Erythropoietin

Endocrine & Exocrine function Organs:

Pancreas (insulin, glucagon -hormones digestive secretions via duct)

Gonads (ovaries, testes) - sex hormones, male sex cells via ducts

Neuroendocrine organ: Hypothalamus (ADH, Oxytocin)

Chemistry of Hormones

Amino acid-based (most hormones) e.g. catecholamines, ADH, prolactin

Steroid (cholesterol- precursor) e.g. adrenal cortical, gonadal hormones

Prostaglandins -biologically active lipids (arachidonic acid) in most cells; varied effects, (prostacyclin)

Mechanism of Action

Second messenger (protein, peptides can't penetrate plasma membrane)

cyclic AMP- activates an inactive protein kinase

enzyme activation

secretion

alters membrane permeability.

Other Second messenger

PIP complex (phosphatidyl inositol) phospholipase enzyme splits into:

diacylglycerol activates protein kinase Inositol 3 P stimulates Ca²⁺ release

both second messengers cause "Cascade effect" generating large output

Direct Gene Activation: (lipid soluble, steroid hormones,thyroxine)

receptor binds to DNA-receptor, turns on transcription mRNA, ...protein synthesis

Selected Components Of Endocrine System

Pituitary Gland (Hypophysis)

linked to hypothalamus via Infundibulum

Different Lobes:

Posterior pituitary (Neurohypophysis or Pars nervosa)

arise from neurons/glial cells

release & store hypothalamic hormones

- ADH, Oxytocin

not a 'true' endocrine gland

Anterior Pituitary (adenohypophysis)

true endocrine function (epithelium)

'master gland'?

produce, releases 7 hormones:

- ACTH
- GH

- FSH
- LH
- TSH
- Prolactin
- MSH

connected to hypothal. via hypophyseal portal system (unique: capillary-vein-capillary)

Neurohypophyseal hormones

made in hypothalamus (supraoptic & para ventricular nuclei)

Oxytocin

- stimulates uterine contraction when cervix / uterus stretch (neural)
- milk letdown to suckling
- utilizes Positive Feedback control

ADH (vasopressin)

- inhibits urine production by kidney
- stimulus is osmoreceptors
- high [solute] in blood + --> ADH release
- hypersecretion rare
- inhibition (-) of ADH (alcohol, diuretics)
- Diabetes insipidus (polyuria, polydipsia)

Anterior Pituitary hormones

Precursor -Pro-opiomelanocortin (POMC) prohormone forming:

ACTH

opiates (endorphin, enkephalins)

MSH (increases melanin)

Tropic hormones (tropi= change)- regulate other glands (FSH, LH, ACTH, TSH)

Growth Hormone (GH)

Growth hormone (somatotropin)

produced by somatotrophic cells

mediated by somatomedins (proteins made by liver, kidneys)

Effects (anabolic)

increased AA uptake (muscle)

increased sulfur into cartilage matrix

Fat released into blood (inhibits adipose synthesis)

Decreased glucose use by cells (anti-insulin action)

Targets (non-endocrine)

Bone

Skeletal muscle

Stimulated by:

exercise, stress

amino acids (arginine)

hypoglycemia

Inhibited by:

Somatostatin (via hypothalamus)

high GH

hyperglycemia, hyperlipidemia

Abnormalities:

Hypersecretion: Gigantism (child) Acromegaly (adult)

Hyposecretion: Dwarfism

Other features:

synergist w/ Thyroid hormones

circadian rhythm (low a.m., high sleep)

ACTH- corticotropin

Target - Adrenal cortex

(stimulates release of > 20 different corticosteroids)

Stimulus: CRH (corticotropin releasing hormone) from hypothalamus due to:

Fever

Hypoglycemia

Stress (all types)

Main effects:

increase blood glucose

water retention

anti-inflammatory (via Cortisol & derivatives)

Inhibition

inhibited by feedback inhibition of glucocorticoids

Prolactin (PRL)

Main Effects

stimulates milk production mammary glands (only known effect in humans)

Stimulated by:

PRH (hypothalamus)

high estrogen

Inhibited by:

PIH or dopamine

low estrogen (cyclic)

Abnormalities

Hypersecretion: galactorrhea, impotence, lack of menses

TSH (thyrotropin)

Main Effects:

develop, secretion of thyroid hormone

Stimulated by:

TRH (hypothalamus)

cold temperature

pregnancy

Inhibited by:

rising thyroxine

somatostatin

Abnormalities

Hyposecretion-

- cretinism (child)
- Myxedema (adults)
- if iodine deficient --> Goiter

Hypersecretion -

- Graves Disease (Mrs. Bush!)
- Sign- Exophthalmos

Gonadotropins (LH, FSH)

Features

released at puberty

stimulated by gonadotropin releasing hormone (hypothalamus)

exhibits feedback inhibition

found both in males & females

Main effects

FSH - gamete production, maturation

LH - Stimulate sex hormone release

- female: LH & FSH egg maturation triggers ovulation
estrogens, progesterone synthesis
- male: stimulates testosterone

Parathyroid glands

Location

May be 4-8 embedded in thyroid

little change with aging

Parathyroid hormone (PTH)

Main effect

important in control of blood calcium

Stimulus:

hypocalcemia

Targets:

Bone

- increased osteoclast activity
- bone releases Calcium, Phosphorus

Intestine

- increases calcium absorption from food

Kidney

- activation of Vitamin D 1,25 dihydroxycholecalciferol (dietary inactive form)
- Increased calcium Reabsorption

Abnormalities (Calcium control -vital!)

Hyperparathyroidism:

- rare (tumor)
- hypercalcemia (bones soften)
- nervous system depressed
- kidney stones

Hypoparathyroidism:

- Trauma/removal
- decreased bld. Ca^{2+}
- increased nervous system excitability (tetany, spasm)

Thyroid Gland

General info

Largest pure endocrine gland

Located inferior to larynx

very vascular

2 hormones produced

Calcitonin (opposes PTH)

Synthesized: parafollicular (c cells)

Stimulus:

Hypercalcemia

Target:

Bone

- Decreased bone resorption
- Increased calcium uptake/deposit

Thyroid Hormone

Structure

contains iodine

Two forms:

- Thyroxine (T4)
- Triiodothyronine(T3)

Produced in follicles

- epithelial cells produce thyroglobulin in cavity
- iodine, colloid activate thyroglobulin--> thyroid hormone

Main Effects: (major metabolic hormone)

calorigenic (increased BMR)

tissue growth in most body cells

can be stored/ later released

Stimulus:

TRH (hypothalamus)

TSH (Anterior Pituitary)

Abnormalities

Hyposecretion- cretinism (child) Myxedema (adults)

Hypersecretion - Graves Disease (*Same as mentioned previously for TSH*)

Adrenal gland (2 glands)

Adrenal Medulla-'inner gland'

neural tissue (Sympathetic N.S.)

hormones (tyrosine derivatives): catecholamines

epinephrine - increased HR, bronchodilate

norepinephrine - vasoconstriction, BP

Abnormalities

Deficiency - no problem

hypersecretion - Elevated Stress Response

Adrenal Cortex - 'outer gland': *secretes steroids (-corticoids)*

Mineralocorticoids - electrolytes in blood (salt)

Aldosterone - most important

- sodium balance (kidney retains)
- H₂O follows Na⁺ (H₂O retained)
- K⁺ elimination increased

Stimulus:

- renin-angiotension (BP)

Inhibitor:

- Natriuretic factors

Glucocorticoids- life essential

Cortisol (cortisone, corticosterone) Effects:

- increased bld glucose
- increase bld volume
- prolonged effect (stress response)
- anti- immune & anti inflammatory

Abnormalities

- Hypersecretion - Cushing's syndrome
- Hyposecretion - Addison's disease

Gonadocorticoids (sex hormones)

Androgens (male sex hormone)

- similar to testosterone produced in testes
- small amount in males and females
 - plays a role in sex drive in females?
 - converts to estrogen (significant after menopause)
- Hypersecretion - virilization in females

Estrogens (female)

- sex hormones produced are identical to those from gonads

Pancreas

Function

mixed function (endocrine & exocrine)

Cells

Acinar cells --> digestive juices

Islet of Langerhans --> hormones

- alpha cells --> glucagon
- Beta cells ---> insulin
 - Both control blood glucose & CHO metabolism

Glucagon

Effects:

hyperglycemic hormone (raises blood sugar)
forms "new glucose" (gluconeogenesis)

Target:

liver (glycogen--> glucose)

Stimulus:

low bld. sugar
epinephrine

Inhibited by:

somatostatin (produced by D cells)

high blood glucose

Insulin- (51 AA)

Effects:

Hypoglycemic hormone (acts to lower blood glucose)

store energy (synthesis of glycogen, protein, triglyceride)

Decreases glycogenolysis, gluconeogenesis

Targets:

muscle cells

connective tissue

(liver, brain, kidney don't use facilitated diffusion for use of glucose)

Stimulus:

High bld. glucose

hGH

gastrointestinal hormones

ACTH

Inhibited by:

Somatostatin (GHIH)

Abnormalities- Relative insulin deficiency

Diabetes mellitus:

- hi bld sugar (cells can't use)
- increased fat breakdown --> ketosis
- leads to polyuria, polydipsia, polyphagia
- juvenile (Type I)- insulin hyposecretion
- mature onset (Type II)- insulin level normal but cells unresponsive to insulin (resistance) - NIDDM (non insulin dependent diabetes mellitus)

Hyperinsulinism (diabetic injects too much insulin)

Pineal gland

Location

found in diencephalon of brain

Major hormone- Melatonin

diurnal (peaks at night) dark-light cycle

Stimulated by darkness

Inhibited by input from eye (light)

maybe anti-gonadotropic in children (inhibits GnRH from hypothalamus)

May explain diurnal rhythm of other physiologic functions?

Thymus gland

General features

location- deep to the sternum

atrophies with age

Hormones:

Thymopoietin

Thymosin -> maturation of T lymphocytes involved in
immune response

REVIEW POINTS