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-->suprachiasmic 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 (cholecystokinin)

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 somatotropic 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)
Hyposcretion: 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
Hypossecretion-
- cretinism (child)
- Myxedema (adults)
- if iodine deficient --> Goiter

Hypersecretion -
- Graves Disease (Mrs. Bush!)
- Sign- Exopthalmos

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. Ca2+
- 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'
nearal 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 - Cushings syndrome
- Hyposecretion - Addisons disease

Gonadocorticoids (sex hormones)

Androgens (male sex hormone)

- similar to testosterone produced in tests
- 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