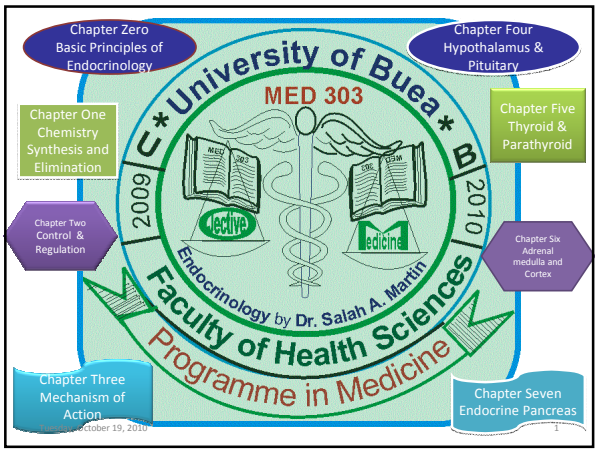
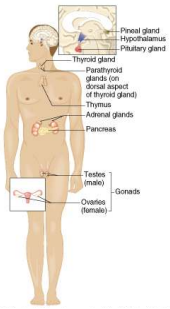


Location of the Major Endocrine Glands

- The major endocrine glands include:
  - Pineal gland, hypothalamus, and pituitary
  - Thyroid, parathyroid, and thymus
  - Adrenal glands and pancreas
  - Gonads – male testes and female ovaries



ENDOCRINE SYSTEM

- Endocrine system – the body's second great controlling system which influences metabolic activities of cells by means of hormones
- Endocrine glands – pituitary, thyroid, parathyroid, adrenal, pineal, and thymus glands
- The pancreas and gonads produce both hormones and exocrine products
- The hypothalamus has both neural functions and releases hormones

Hormones

- Hormones – chemical substances secreted by cells into the extracellular fluids
  - Regulate the metabolic function of other cells
  - Have lag times ranging from seconds to hours
  - Tend to have prolonged effects
  - Are classified as amino acid-based hormones, or steroids
- Eicosanoids – biologically active lipids

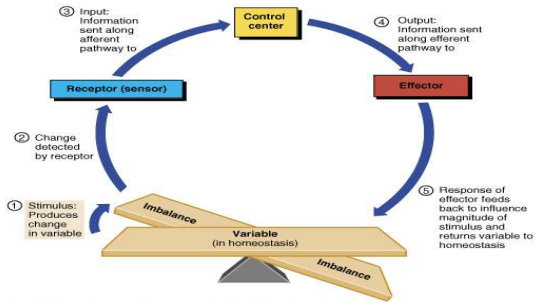
Types of Hormones

- Amino acid–based – most hormones belong to this class, including:
  - Amines, thyroxine, peptide, and protein hormones
- Steroids – gonadal and adrenocortical hormones
- Eicosanoids – leukotrienes and prostaglandins

Hormone Action

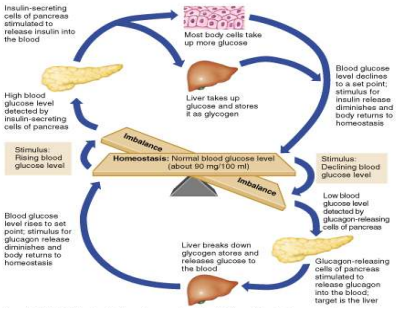
- Hormones alter cell activity by one of two mechanisms
  - Second messengers involving:
    - Regulatory G proteins
    - Amino acid–based hormones
  - Direct gene activation involving steroid hormones
- The precise response depends on the type of the target cell

Homeostatic Control Mechanisms



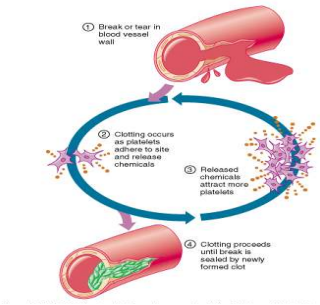
Negative Feedback

- In negative feedback systems, the output shuts off the original stimulus
- Example: Regulation of blood glucose levels



Positive Feedback

- In positive feedback systems, the output enhances or exaggerates the original stimulus
- Example: Regulation of blood clotting



Mechanism of Action of Hormones

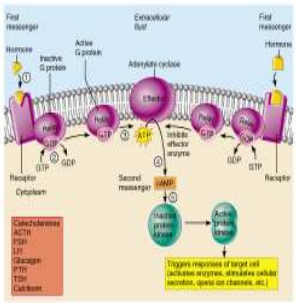
Location of Receptor	Classes of Hormones	Principle Mechanism of Action
Cell surface receptors (plasma membrane)	Proteins and peptides, catecholamines and eicosanoids	Generation of *second messengers* which alter the activity of other molecules - usually enzymes - within the cell
Intracellular receptors (cytoplasm and/or nucleus)	Steroids and thyroid hormones	Alter transcriptional activity of responsive genes

MECHANISM OF HORMONE ACTION

- Hormones produce one or more of the following cellular changes
  - Alter plasma membrane permeability
  - Stimulate protein synthesis
  - Activate or deactivate enzyme systems
  - Induce secretory activity
  - Stimulate mitosis

Action: cAMP Second Messenger

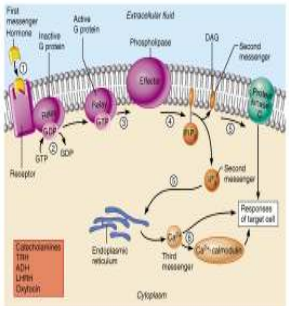
- Hormone (first messenger) binds to its receptor, which then binds to a G protein
- The G protein is then activated as it binds GTP, displacing GDP
- Activated G protein activates the effector enzyme *adenylate cyclase*
- Adenylate cyclase generates cyclic AMP (cAMP) (second messenger) from ATP
- cAMP activates protein



Action: PIP–Calcium

13

- Hormone binds to the receptor and activates G protein
- G protein binds and activates a phospholipase enzyme
- Phospholipase splits the phospholipid PIP_2 into diacylglycerol (DAG) and IP_3 (both act as second messengers)
- DAG activates protein kinases; IP_3 triggers release of Ca^{2+} stores



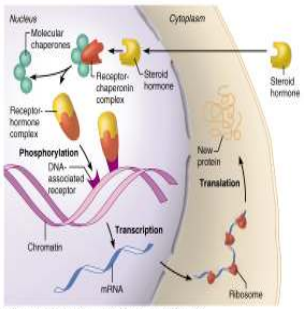
Hormones with Cell Surface Receptors

Second	Examples of Hormones Which Utilize This System
Protein kinase activity	Epinephrine and norepinephrine, glucagon, luteinizing hormone, follicle stimulating hormone, thyroid-stimulating hormone, calcitonin, parathyroid hormone, antidiuretic hormone
Protein kinase activity	Insulin, growth hormone, prolactin, oxytocin, erythropoietin, several growth factors
Calcium and/or phosphoinositides	Epinephrine and norepinephrine, angiotensin II, antidiuretic hormone, gonadotropin-releasing hormone, thyroid-releasing hormone.
Cyclic GMP	Atrial naturetic hormone, nitric oxide

Steroid Hormones

15

- Steroid hormones and thyroid hormone diffuse easily into their target cells
- Once inside, they bind and activate a specific intracellular receptor
- The hormone-receptor complex travels to the nucleus and binds a DNA-associated receptor protein
- This interaction prompts DNA transcription to produce mRNA



Hormone–Target Cell Specificity

- Hormones circulate to all tissues but only activate cells referred to as *target cells*
- Target cells must have specific receptors to which the hormone binds
- These receptors may be intracellular or located on the plasma membrane
- Examples of hormone activity
  - ACTH receptors are only found on certain cells of the adrenal cortex
  - Thyroxin receptors are found on nearly all cells of the body

TARGET CELL ACTIVATION

Tuesday, October 19, 2010

- Target cell activation depends upon three factors
  - Blood levels of the hormone
  - Relative number of receptors on the target cell
  - The affinity of those receptors for the hormone
- Up-regulation – target cells form more receptors in response to the hormone
- Down-regulation – target cells lose receptors in response to the hormone

Hormone Concentrations in the Blood

Tuesday, October 19, 2010

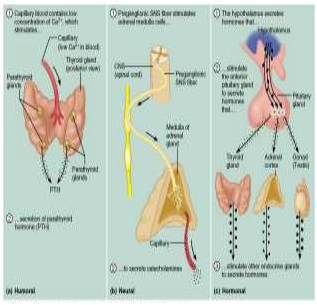
- Concentrations of circulating hormone reflect:
  - Rate of release
  - Speed of inactivation and removal from the body
- Hormones are removed from the blood by:
  - Degrading enzymes
  - The kidneys
  - Liver enzyme systems

CONTROL OF HORMONE SYNTHESIS AND RELEASE

- Blood levels of hormones:
  - Are controlled by negative feedback systems
  - Vary only within a narrow desirable range
- Hormones are synthesized and released in response to:
  - Humoral stimuli
  - Neural stimuli
  - Hormonal stimuli

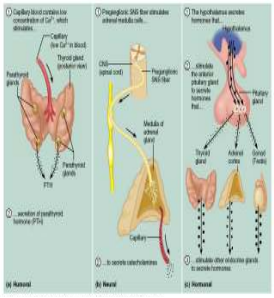
Humoral Stimuli

- Humoral stimuli – secretion of hormones in direct response to changing blood levels of ions and nutrients
- Example: concentration of calcium ions in the blood
  - Declining blood Ca^{2+} concentration stimulates the parathyroid glands to



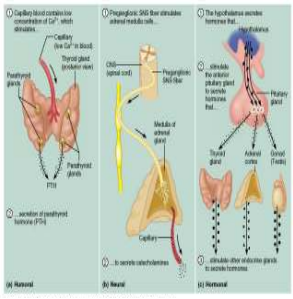
Neural Stimuli

- Humoral stimuli – secretion of hormones in direct response to changing blood levels of ions and nutrients
- Example: concentration of calcium ions in the blood
  - Declining blood Ca^{2+} concentration stimulates the parathyroid glands to secrete PTH (parathyroid hormone)
  - PTH causes Ca^{2+}



Hormonal Stimuli

- Hormonal stimuli – release of hormones in response to hormones produced by other endocrine organs
  - The hypothalamic hormones stimulate the anterior pituitary
  - In turn, pituitary hormones stimulate targets to secrete still



Nervous System Modulation

- The nervous system modifies the stimulation of endocrine glands and their negative feedback mechanisms
- The nervous system can override normal endocrine controls
  - For example, control of blood glucose levels
    - Normally the endocrine system maintains blood glucose
    - Under stress, the body needs more glucose
    - The hypothalamus and the sympathetic nervous system are activated to supply ample glucose