Chapter 37:
Chemical Control of the Animal Body -
The Endocrine System

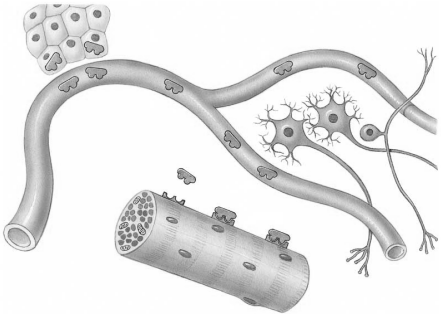

Table 37-1 How Cells Communicate

Communication	Chemical Messengers	Mechanism of Transmission	Examples
Direct	Ions, small molecules	Direct movement through gap junctions linking cytosol of adjacent cells	Ions flowing between cardiac muscle cells
Paracrine	Local hormones	Diffusion through interstitial fluid to nearby cells bearing receptors	Prostaglandins
Endocrine	Hormones	Carried in the bloodstream to near or distant cells bearing receptors	Insulin
Synaptic	Neurotransmitters	Diffusion from a neuron across a narrow space (synaptic cleft) to a cell bearing receptors	Acetylcholine

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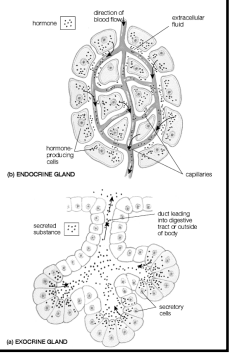
Endocrine System: Hormones and the various cells that secrete and receive them

Types of Glands:

1) Endocrine Glands:
   - Release substances within the body via bloodstream

2) Exocrine Glands:
   - Release substances outside the body via ducts
     - Sweat glands
     - Salivary glands
     - Mammary glands



Target Cells: Cells specialized to respond to hormones

- Changes may be: 1) prolonged and irreversible (puberty)
  2) transient and reversible (adrenaline)
- Hormone release regulated via feedback mechanisms

General Classes of Hormones:

1) Peptide Hormones: Amino acid chains
2) Amino Acid-based Hormones: Single amino acids
3) Steroid Hormones: Resemble cholesterol
4) Prostaglandins: Synthesized from fatty acids

Hormones Bind to Receptors at Target Cells:

1) Second Messenger System: Peptide / Amino acid Hormones (hydrophilic)

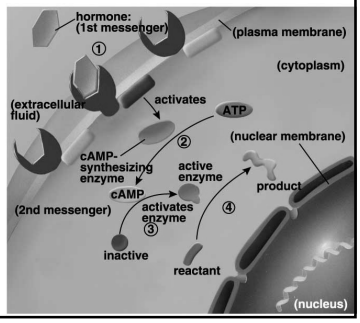
Hormone binds with receptor (plasma membrane)

↓

Receptor activates 2nd Messenger (e.g. cAMP)

↓

2nd messenger activates biochemical reactions



Hormones Bind to Receptors at Target Cells:

2) Internal Receptor System: Steroid / Prostaglandin Hormones (hydrophobic)

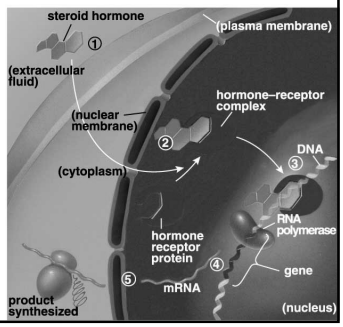
Hormone binds with receptor (cytoplasm - nucleus)

↓

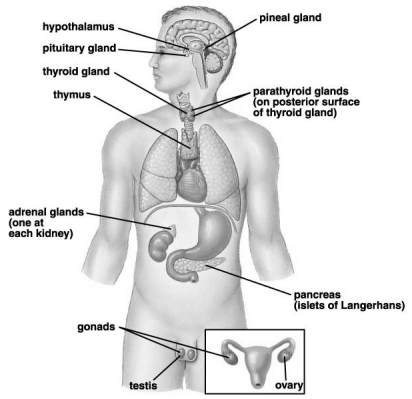
Receptor-hormone complex binds to DNA

↓

Complex increases rate of gene transcription

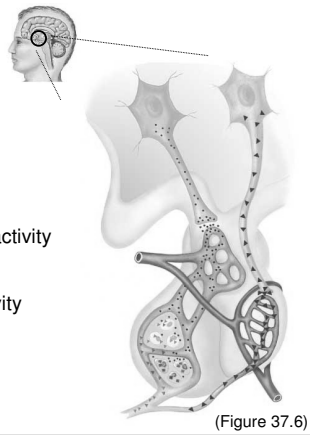


Major Endocrine Glands in Humans:



Pituitary Gland:

- Pea-sized gland; hanging from hypothalamus
- Receives instructions from hypothalamus:
  - Releasing hormones:
    - Stimulate pituitary activity
  - Inhibiting hormones:
    - Inhibit pituitary activity

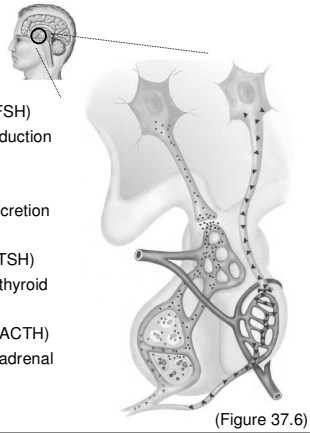


(Figure 37.6)

Pituitary Hormones:

1) Anterior Pituitary:

- Follicle-stimulating Hormone (FSH)
  - Regulates egg / sperm production
- Lutenizing Hormone (LH)
  - Regulates sex hormone secretion
- Thyroid-stimulating Hormone (TSH)
  - Regulates hormones from thyroid
- Adrenocorticotropic Hormone (ACTH)
  - Regulates hormones from adrenal cortex

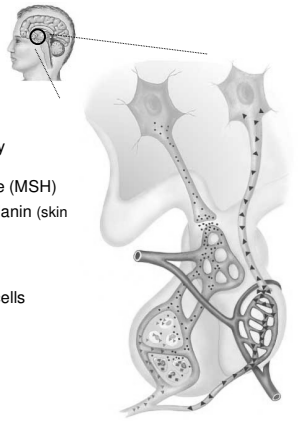


(Figure 37.6)

Pituitary Hormones:

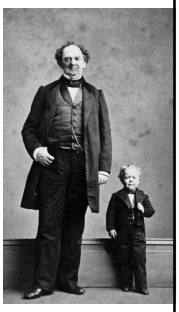
1) Anterior Pituitary:

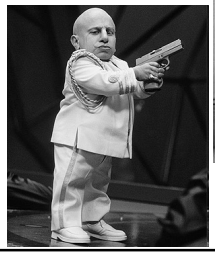
- Prolactin
  - Stimulates mammary gland development during pregnancy
- Melanocyte-stimulating Hormone (MSH)
  - Stimulates synthesis of melanin (skin pigment)
- Growth Hormone
  - Regulates growth of body cells



Too little growth hormone

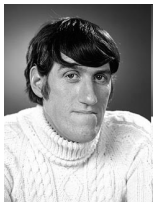
- Dwarfism
  - ❖Pituitary dwarfs are always proportional in size.





Too much growth hormone

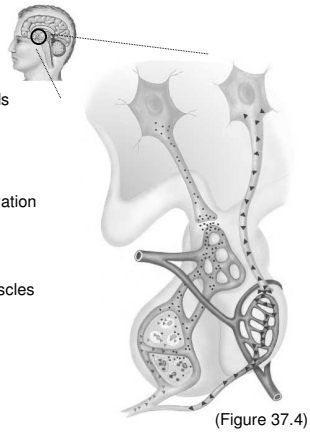
- Acromegaly
  - ❖Associated with gigantism.
  - ❖Patients rarely live beyond 40 if the disorder is not treated.
- Abuse of HGH is seeing a rise in acromegaly cases.



Pituitary Hormones:

2) Posterior Pituitary:

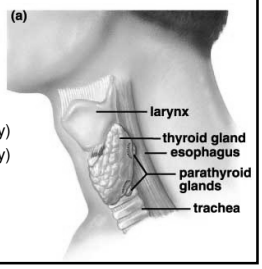
- ❖ Contains neurosecretory cells with bodies in hypothalamus
- ❖ Antidiuretic Hormone (ADH)
  - ➢ Stimulates water conservation (kidneys)
- • Oxytocin
  - ➢ Contraction of uterus muscles
  - ➢ "Milk letdown" reflex
  - ➢ Maternal behaviours



(Figure 37.4)

Thyroid Gland:

- • Thyroxine (T_4 - Amino Acid Hormone):
  - • Increases metabolic rate of cells (↑ glucose breakdown)
    - • Important for: 1) Regulating growth
      2) Regulating body temperature
  - • Release stimulated by Thyroid-stimulating hormone
  - • Levels in blood controlled via negative feedback loop
    - • ↑ T4 in blood = ↓ TSH (pituitary)
    - • ↓ T4 in blood = ↑ TSH (pituitary)
  - • Iodine required for T_4 production



Goiter: Enlarged thyroid gland due to iodine deficiency

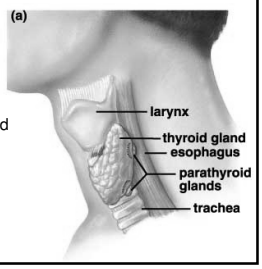
Treatment = iodine

Thyroid Gland:

- Calcitonin (Peptide Hormone):
  - ❖ Regulates concentration of calcium in blood
    - Decreases Ca^{++} level in blood (bones absorb Ca^{++})

Parathyroid Glands:

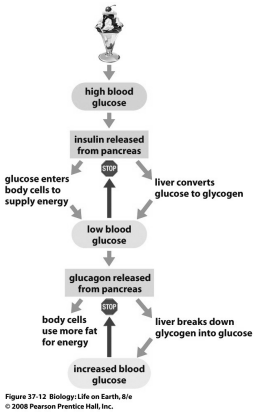
- Parathormone (Peptide Hormone):
  - ❖ Regulates concentration of calcium in blood
    - ➢ Increases Ca^{++} level in blood (bones release Ca^{++})
  - ❖ tumors can lead to kidney stones or death



Pancreas

- Produces both exocrine and endocrine secretions:
  - ➢ Exocrine = Digestive enzymes (enter small intestine)
  - ➢ Endocrine = Hormones regulating glucose levels in blood
- Insulin
  - ❖ Reduced blood sugar levels (cells uptake glucose)
- Glucagon
  - ❖ Increased blood sugar levels (cells release glucose)

Control of Blood Glucose Levels:



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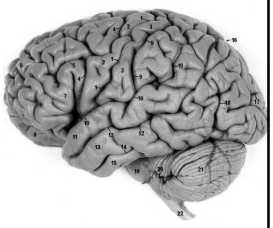
Pancreas:

- Produces both exocrine and endocrine secretions:
  - Exocrine = Digestive enzymes (enter small intestine)
  - Endocrine = Hormones regulating glucose levels in blood
- Insulin
  - Reduced blood sugar levels (cells uptake glucose)
- Glucagon
  - Increased blood sugar levels (cells release glucose)
- Diabetes Mellitus: Defect in insulin production/detection
  - High levels of sugar in blood (cleared via urine)
  - Insulin Shock = Too much glucose removed from blood

Hypoglycemia = low blood sugar

- Too much insulin can result in hypoglycemia
- Symptoms include:
  - ❖Shakiness
  - ❖Anxiety
  - ❖Mood changes
  - ❖Dizziness
  - ❖Fatigue



Glucose is the primary fuel for your brain

Sex Organs: gonads

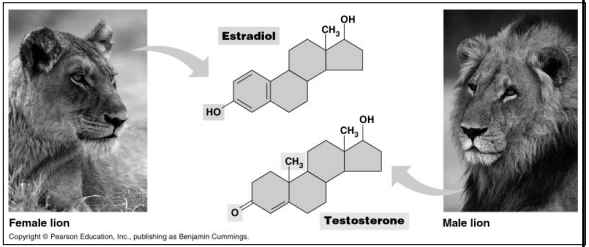
1) Ovaries (Female):
   - Estrogen / Progesterone (steroid hormone)
2) Testes (Male):
   - Testosterone (steroid hormone)

- Functions:
  - Early development
  - Puberty
    - ➢ Secondary sexual characteristics
  - Menstrual cycle; pregnancy
- Release regulated by FSH and LH

Follicle-stimulating Hormone

Lutenizing Hormone

Different steroids have different functional groups



Estradiol and testosterone differ only by the function group at the left.

What are anabolic steroids?

- Anabolic steroids are analogs of natural hormones
  - **Almost all of them are androgenic (testosterone)**
- Used in normal dosages, can help with certain diseases
  - **Bone marrow stimulation**
  - Wasting diseases (AIDS, Cancer)
  - Male puberty delay

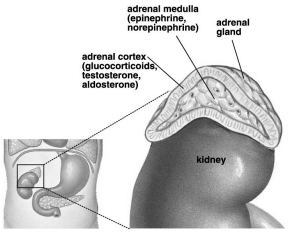
Anabolic steroid abuse

- When excess anabolic steroids are administered:
  - Greater muscle mass
  - More hair (especially in female athletes)
  - More aggression ('roid rage)
  - Testicular atrophy
  - Cardiac pathologies
  - Hypertension (high blood pressure)

Adrenal Gland:

1) Adrenal Medulla (center of gland)
   - Epinephrine/Norepinephrine (Amino acid hormones):
     - Released in stressful situations (sympathetic NS)
     - Release regulated by NS

   Fight or Flight response



Will you experience the adrenaline rush???

- Linky

Adrenal Gland:

- Adrenal Cortex (outside of gland)
  - ❖ Glucocorticoids (Steroid hormones)
    - ➢ Released in stressful situations
      - – Long-term stress
    - ➢ Released regulated by ACTH
  - ❖ Aldosterone (Steroid hormone)
- Regulates sodium concentration in blood
  - ❖ Target = Kidneys
- Testosterone

Other Sources of Hormones:

1) Most Cells in Body
   - Prostaglandins (Fatty Acid Hormones):
     - Target = Nearby cells
     - Function is varied (e.g. Inflammatory agents; Uterine contractors)

Ibuprofen

2) Pineal Gland
   - Melatonin (Amino Acid Hormone):
     - Regulate sleep/wake cycle; reproductive cycle (non-humans)
3) Thymus
   - Thymosin: Stimulates development of immune cells
4) Kidneys
   - Erythropoietin: Regulates red blood cell production
5) Adipose Cells:
   - Leptin: Regulates body fat

Erthropoietin : blood doping in athletic events

- Epo
  - ❖A natural hormone (a glycoprotein) that boost red blood cell production.
- Increase in red blood cells results in greater oxygen content (due to increase in hemoglobin)
- Used to treat patients with anemia, but use has fallen off due to sometimes deadly side effects.
  - ❖Blood clots, strokes, pulmonary embolism