

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

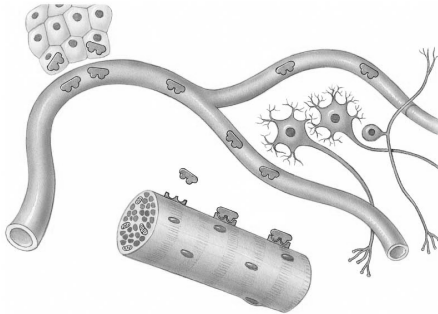


Table 37-1 How Cells Communicate

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

Table 37-1 Biology: Life on Earth, 6/e  
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Endocrine System: Hormones and the various cells that secrete and receive them

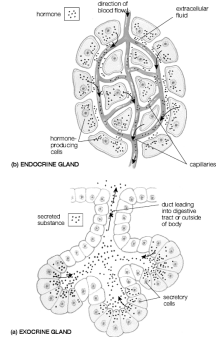
Types of Glands:

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

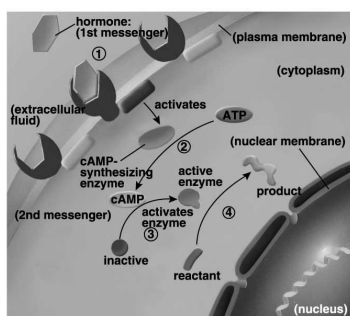
Hormones Bind to Receptors at Target Cells:

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



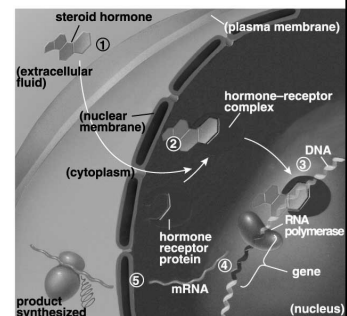
Hormones Bind to Receptors at Target Cells:

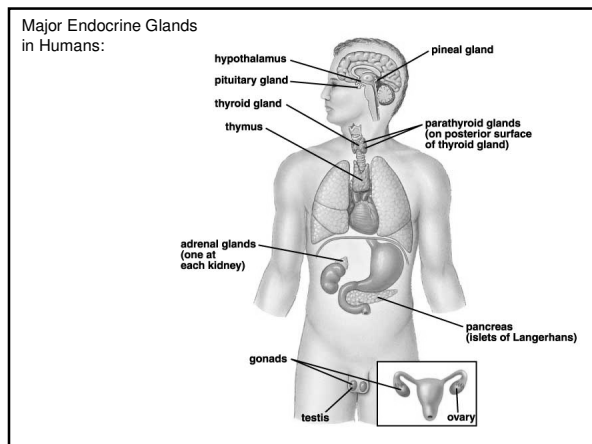
2) Internal Receptor System: Steroid / Prostaglandin Hormones (hydrophobic)

Hormone binds with receptor (cytoplasm - nucleus)

Receptor-hormone complex binds to DNA

Complex increases rate of gene transcription





**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
- Adrenocorticotrophic 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.

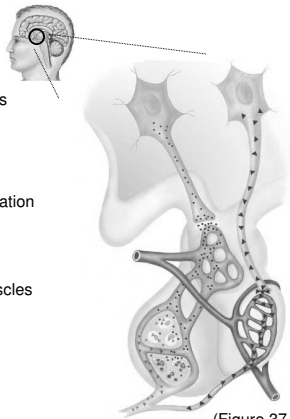
**Too much growth hormone**

- 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):

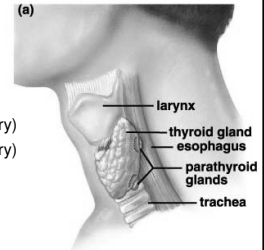
- Increases metabolic rate of cells ( $\uparrow$  glucose breakdown)
  - Important for: 1) Regulating growth
  - 2) Regulating body temperature

#### • Release stimulated by Thyroid-stimulating hormone

#### • Levels in blood controlled via negative feedback loop

- $\uparrow T_4$  in blood =  $\downarrow$  TSH (pituitary)
- $\downarrow T_4$  in blood =  $\uparrow$  TSH (pituitary)

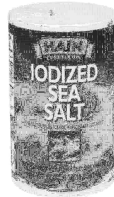
#### • Iodine required for $T_4$ production



Goiter: Enlarged thyroid gland due to iodine deficiency



Treatment = iodine



### Thyroid Gland:

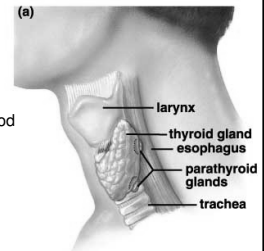
#### • Calcitonin (Peptide Hormone):

- ❖ 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:

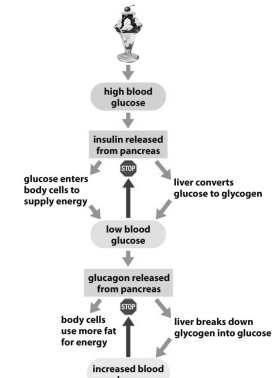


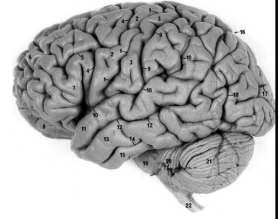
Figure 37-12 Biology: Life on Earth, 8/e  
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#### Pancreas:

- 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



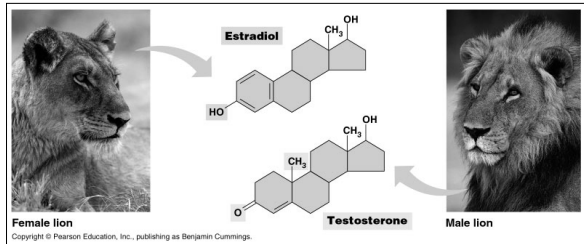
Glucose is the primary fuel for your brain

#### 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      Luteinizing 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

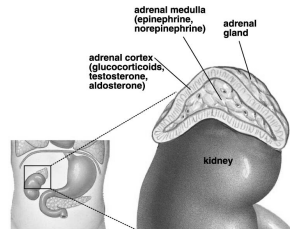
- When excess anabolic steroids are administered:
  - ❖ Greater muscle mass
  - ❖ More hair (especially in female athletes)
  - ❖ More aggression ('roid rage)
  - ❖ Testicular atrophy
  - ❖ Cardiac pathologies
  - ❖ Hypertension (high blood pressure)

### 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)
- 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

### Erythropoietin : 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

