Endocrine System

• The word endocrine derives from the Greek words "endo," meaning within, and "crinis," meaning secrete.

• It is the collection of glands, each of which secretes different types of hormones that regulate metabolism, growth and development, tissue function, sexual function, reproduction, sleep and mood, among other things.
<table>
<thead>
<tr>
<th>Nervous System</th>
<th>Endocrine System</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Communication travels in one direction from one neuron to another</td>
<td>• Chemical messages are released into bloodstream or extracellular fluid</td>
</tr>
<tr>
<td>• Has a clear destination (targets a specific cell)</td>
<td>• Target is less specific</td>
</tr>
<tr>
<td>• Fast acting, short-lived neurotransmitters</td>
<td>• Hormones are slower-acting, longer lived</td>
</tr>
<tr>
<td></td>
<td>(can last days, weeks or years)</td>
</tr>
</tbody>
</table>
Endocrine vs. Exocrine Glands

- Endocrine Glands – Ductless organs that secrete hormones directly into the bloodstream or extracellular fluid

- Exocrine glands – Use ducts (tube-like structures) to transport substances to specific locations inside and outside the body (Ex: sweat glands, mucous glands, salivary glands)
Glands

• Organ that releases hormones for homeostasis
Hormones

• Chemical messengers that effect the functions of specifically receptive organs or tissues when transported to them by body fluids

• Functions:
  1. Regulate growth, development, behavior and reproduction
  2. Coordinate production, use, and storage of energy
  3. Maintain homeostasis (body temperature, metabolism, excretion, water and salt balance)
  4. Response to external stimuli
Control of Hormone Release

**Humoral stimuli** - Changing blood levels of ions and nutrients directly stimulates secretion of hormones

**Neural stimuli** - Nerve fibers stimulate hormone release

**Hormonal stimuli** - Hormones stimulate other endocrine organs to release their hormones
Chemistry of Hormones

• Two main classes
  1. Amino acid-based hormones
     • Amines, thyroxine, peptides, and proteins
  2. Steroids
     • Synthesized from cholesterol
     • Gonadal and adrenocortical hormones
Mechanisms of Hormone Action

1. Water-soluble hormones (all amino acid–based hormones except thyroid hormone)
   - Cannot enter the target cells
   - Act on plasma membrane receptors
   - Coupled by G proteins to intracellular second messengers that mediate the target cell’s response

2. Lipid-soluble hormones (steroid and thyroid hormones)
   - Act on intracellular receptors that directly activate genes
Hormone (1st messenger) binds receptor. G protein (G<sub>S</sub>) activates adenylate cyclase. Adenylate cyclase converts ATP to cAMP (2nd messenger). cAMP activates protein kinases.

Hormones that act via cAMP mechanisms:
- Epinephrine
- ACTH
- FSH
- LH
- Glucagon
- PTH
- TSH
- Calcitonin

Triggers responses of target cell (activates enzymes, stimulates cellular secretion, opens ion channel, etc.)
The steroid hormone diffuses through the plasma membrane and binds an intracellular receptor.

The receptor-hormone complex enters the nucleus.

The receptor-hormone complex binds a hormone response element (a specific DNA sequence).

Binding initiates transcription of the gene to mRNA.

The mRNA directs protein synthesis.
Responding to hormones

• Lock and key system
  • hormone fits receptor on “target” cell
Interaction of Hormones at Target Cells

- Multiple hormones may interact in several ways
  - **Permissiveness**: one hormone cannot exert its effects without another hormone being present
  - **Synergism**: more than one hormone produces the same effects on a target cell
  - **Antagonism**: one or more hormones opposes the action of another hormone
Prostaglandins

- Hormone-like substances (sometime called “localized hormones”)
- Modified fatty acids produced by a wide range of cells that affect cells and tissues nearby
- Named for the prostate where they were first discovered

Ex: Found in smooth muscle that cause vessel contraction, stimulating uterine contraction for labor, cause aggregation or disaggregation of platelets
Negative Feedback

• Response to changed body condition that inhibits the initial stimulus
  • Ex: if body is **high** or **low** from **normal level**
    • signal tells body to make changes that will bring body back to normal level
  • once body is back to normal level, signal is turned off (like the thermostat in a house)

![Diagram showing negative feedback loop]

- hormone 1
- lowers body condition
- specific body condition
- high
- gland
The hypothalamus releases TRH (TSH Releasing Hormone) which stimulates the anterior pituitary to release TSH (Thyroid-Stimulating Hormone). TSH stimulates the thyroid gland to produce thyroxine. The feedback mechanism involves inhibition from thyroxine to inhibit the release of TRH, TSH, and stimulation of the thyroid.
Gland Campaign

For your chosen gland you must:

• Include the name of the gland (1 point)
• Include a picture (2 points)
• Include a slogan that summarizes why your gland should be selected as the most important gland in the body (3 points)
• Explain why your gland should be selected as most important (3 points)
## Gland Campaign – 1st

<table>
<thead>
<tr>
<th>Gland</th>
<th>Student 1</th>
<th>Student 2</th>
<th>Student 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pituitary Gland</td>
<td>Randi</td>
<td>Danielle</td>
<td></td>
</tr>
<tr>
<td>Hypothalamus</td>
<td>Kiersten</td>
<td>Summer</td>
<td>Chasey</td>
</tr>
<tr>
<td>Pineal Gland</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thyroid</td>
<td>Katelyn</td>
<td>Dalton</td>
<td>Nicole</td>
</tr>
<tr>
<td>Parathyroid</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thymus</td>
<td>Jeff</td>
<td>Ryan</td>
<td>Daniel</td>
</tr>
<tr>
<td>Adrenal Glands</td>
<td>Hannah</td>
<td>Stephanie</td>
<td>Kristin</td>
</tr>
<tr>
<td>Pancreas</td>
<td>Bethany</td>
<td>Lauren</td>
<td></td>
</tr>
<tr>
<td>Gonads</td>
<td>Sarah</td>
<td>Brenda</td>
<td>Sierra</td>
</tr>
</tbody>
</table>
## Gland Campaign – Period 2

<table>
<thead>
<tr>
<th>Gland</th>
<th>Student 1</th>
<th>Student 2</th>
<th>Student 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pituitary Gland</td>
<td>Lauren</td>
<td>Brittany</td>
<td>Travis</td>
</tr>
<tr>
<td>Hypothalamus</td>
<td>Courtney</td>
<td>Kaleigh</td>
<td></td>
</tr>
<tr>
<td>Pineal Gland</td>
<td>Alec</td>
<td>Dani</td>
<td></td>
</tr>
<tr>
<td>Thyroid</td>
<td>Jordan</td>
<td>Taylor</td>
<td>Shannon</td>
</tr>
<tr>
<td>Parathyroid</td>
<td>Ashley</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thymus</td>
<td>Casey</td>
<td>Savannah</td>
<td></td>
</tr>
<tr>
<td>Adrenal Glands</td>
<td>Elizabeth</td>
<td></td>
<td>Efa</td>
</tr>
<tr>
<td>Pancreas</td>
<td>Maddie</td>
<td>Sarah</td>
<td></td>
</tr>
<tr>
<td>Gonads</td>
<td>Melody</td>
<td></td>
<td>Christina</td>
</tr>
<tr>
<td>Gland</td>
<td>Student 1</td>
<td>Student 2</td>
<td>Student 3</td>
</tr>
<tr>
<td>------------------</td>
<td>-----------</td>
<td>-----------</td>
<td>-----------</td>
</tr>
<tr>
<td>Pituitary Gland</td>
<td>Chandler</td>
<td>Destry</td>
<td></td>
</tr>
<tr>
<td>Hypothalamus</td>
<td>Laurel</td>
<td>Renee</td>
<td>Jesenia</td>
</tr>
<tr>
<td>Pineal Gland</td>
<td>Russ</td>
<td>Nick</td>
<td></td>
</tr>
<tr>
<td>Thyroid</td>
<td>Austin</td>
<td>Leah</td>
<td>Amanda</td>
</tr>
<tr>
<td>Parathyroid</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thymus</td>
<td>Jocelyn</td>
<td>Bethany</td>
<td>Alexa</td>
</tr>
<tr>
<td>Adrenal Glands</td>
<td>Esha</td>
<td>Corey</td>
<td></td>
</tr>
<tr>
<td>Pancreas</td>
<td>Katie</td>
<td>Taylor</td>
<td></td>
</tr>
<tr>
<td>Gonads</td>
<td>Kevin</td>
<td>Lucy</td>
<td>Jamie</td>
</tr>
</tbody>
</table>
Place the following glands in the appropriate rectangles on your concept map:

- Hypothalamus
- Pituitary
- Pineal
- Thyroid
- Parathyroid
- Thymus
- Adrenal
- Pancreas
- Teste
- Ovary

(The heart, kidney and stomach can go into the boxes with the faded outline as reference points)
Body Regulation

• Nervous system & Endocrine system work together
  • hypothalamus
    • “master nerve control center”
    • receives information from nerves around body about internal conditions
  • communicates with pituitary gland
    • “master gland”
    • releases many hormones
      • sexual development, growth, milk production, pain-relief
HYPOTHALAMUS

- ‘Master Gland’
- Function: Control center
- Continuously receive information on status of body systems via nerve impulses
- Monitors composition & temperature of blood
- Messages interpreted, evaluated: outgoing messages dispatched via nerves / hormones
- Plays role in feedback systems that govern secretions of endocrine system
Pituitary

- Pea Sized Mass of Glandular Tissue
- Location: Sella Tursica (depression in sphenoid)

Indirectly controls:
- Growth
- Metabolism
- Sexual reproduction
- Lactation
Pituitary Gland

22 = Thalamus
24 = Hypothalamus
## PITUITARY GLAND: HORMONES

<table>
<thead>
<tr>
<th>HORMONES</th>
<th>EFFECTS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Posterior Pituitary</strong></td>
<td></td>
</tr>
<tr>
<td>Oxytocin (OC)</td>
<td>Stimulates contraction of uterus &amp; contractile cells of breast</td>
</tr>
<tr>
<td>ADH</td>
<td>Prevents excess urine production</td>
</tr>
<tr>
<td><strong>Anterior Pituitary</strong></td>
<td></td>
</tr>
<tr>
<td>GH</td>
<td>General body growth</td>
</tr>
<tr>
<td>ACTH</td>
<td>Stimulate adrenal cortex to release hormone</td>
</tr>
<tr>
<td>TSH</td>
<td>Controls thyroid gland</td>
</tr>
<tr>
<td>LH</td>
<td>Stimulates sexual &amp; reproductive function</td>
</tr>
<tr>
<td>FSH</td>
<td>Stimulate production of sperm &amp; egg in ovaries &amp; testis</td>
</tr>
<tr>
<td>PRL</td>
<td>Initiates milk production</td>
</tr>
</tbody>
</table>
Oxytocin - Oxytocin causes milk letdown in nursing mothers and contractions during childbirth.

Pitocin, the synthetic form of oxytocin, can be used to induce labor, or to augment (speed up) labor.
Antidiuretic hormone or ADH

• ADH, also called vasopressin, is stored in the back part of the pituitary gland and regulates water balance. If this hormone is not secreted properly, this can lead to problems of sodium (salt) and water balance, and could also affect the kidneys so that they do not work as well.
Problems with the pituitary gland can result in Dwarfism

Primordial Dwarfism
or Gigantism. These are pictures of the tallest man known as “The Alton Giant”

Robert Wadlow was 8’11”
Andre the Giant

7'4" and 500 pounds
Acromegaly

- Over production of growth hormone after the epiphyseal plates have fused
- Bone shape changes
- Cartilaginous areas of skeleton enlarge
- Broad facial features
- Enlarged lower jaw
That’s a bull of the Belgian Blue breed, which has a genetic anomaly that suppresses the production of a hormone called myostatin that inhibits muscle growth – hence the ‘double muscling’ seen above.

Myostatin inhibitor drugs are being developed with the intent of treating muscle-wasting diseases like muscular dystrophy in humans.
Prolactin (PRL)

Stimulates milk production from a woman's breasts after childbirth and can affect sex hormone levels from the ovaries in women and the testes in men.

Story about the pharmaceutical side effect that caused lactation in young boys:

Adrenocorticotropicin or ACTH - ACTH stimulates production of cortisol by the adrenal glands.

Cortisol, a so-called "stress hormone," is vital to survival. It helps maintain blood pressure and blood glucose levels.

Many diet aids claim that they block cortisol levels. Cortisol from stress may lead to fat deposits in the belly.
Thyroid-stimulating hormone or TSH - TSH stimulates the thyroid gland to make thyroid hormones, which, in turn, control (regulate) the body's metabolism, energy, growth and development, and nervous system activity.
Luteinizing hormone or LH - LH regulates testosterone in men and estrogen in women. (gonadotropin)

1. Beginning at approximately age 8, the hypothalamus increases its production of gonadotropin-releasing hormone (GnRH).
2. GnRH triggers the anterior pituitary to release luteinizing hormone (LH) and follicle-stimulating hormone (FSH).
3. LH and FSH trigger testosterone production in the testes and estrogen production in the ovaries.
4. Effects of sex hormone release:
   - Testosterone release:
     - Spermatogenesis
     - Male Secondary Sex Characteristics:
       - Penis and scrotum grow
       - Facial hair grows
       - Larynx elongates, lowering voice
       - Shoulders broaden
       - Body, armpit, and pubic hair grow
       - Musculature increases body-wide
   - Estrogen release:
     - Folliculogenesis
     - Female Secondary Sex Characteristics:
       - Breasts develop and mature
       - Hips broaden
       - Pubic hair grows
5. Before puberty, the hypothalamus and pituitary are very sensitive to negative feedback signals from testosterone and estrogen. During puberty, the sensitivity of the hypothalamus and pituitary to this negative feedback decreases to levels typically seen in adults. This change allows an increase in the production of testosterone and estrogen that stimulates the development of secondary sex characteristics.
Follicle-stimulating hormone or FSH

FSH promotes sperm production in men and stimulates the ovaries to release eggs (ovulate) in women. LH and FSH work together to allow normal function of the ovaries or testes. (gonadotropin)
Pineal Body

• located between the cerebral hemispheres
• secretes melatonin, important for sleep and maintaining Circadian rhythms (light and dark activity)
THYROID GLAND

• Located in middle anterior part of neck: below larynx, in front of trachea
• “Butterfly” shape
• Regulates metabolism
• ↑ in size: puberty & pregnancy
• Rich blood supply: able to deliver high levels of hormones in short period of time
THYROID HORMONES

• Thyroxin (T4) & Tri-iodothyronine (T3) - both increase the rate at which cells release energy from carbohydrates

• Calcitonin – regulates the blood concentration of calcium
Goiter

- Thyroid hormone is partly made of iodine. Iodine is essential for the formation of thyroxin. If a person doesn’t eat enough iodine, they can’t make thyroid hormone so it the size of the follicle grows.

- Iodine is only found in seafood. If salt wasn’t iodized, a lot of people wouldn’t get enough iodine, and there would be a higher incidence of goiters.
Hypothyroidism
Before and After Treatment
Cretinism (hypothyroidism in infants)
Hyperthyroidism (Grave’s Disease)

Graves’ disease is a common cause of hyperthyroidism, an over-production of thyroid hormone, which causes enlargement of the thyroid and other symptoms such as exophthalmos, heat intolerance and anxiety.
Parathyroid Glands

• Four tiny glands located behind the thyroid
• Produces Parathyroid hormone (PTH)
• Controls metabolism of calcium, taking calcium from the bones to make it available in the blood
Thymus

• Responsible for maturation of T-lymphocytes

• Plays a role in the immune system

• Produces thymosin, thymic humaral factor & thymic factor

• Large in young children, gradually shrinks with age
Adrenal Glands

Located superior to the kidneys

Adrenal Cortex - outer area
Adrenal Medulla - inner area
Adrenal Medulla

• Epinephrine (Adrenaline) & Norepinephrine – increased heart rate, breathing rate, elevated blood pressure (fight or flight, response to stress)

People with severe life threatening allergies often carry injectors
Adrenal Cortex

• **Aldosterone** – a mineralcorticoid, helps kidneys conserve sodium and excrete potassium, maintaining blood pressure

• **Cortisol** – glucocorticoid, keeps blood glucose levels stable

• **Adrenal Sex Hormones** - androgens (male) and estrogens (female)
Cushing’s syndrome

- Hypersecretion of cortisol
- Adipose tissue accumulates in cheeks and base of neck resulting in round “moon” face and “buffalo hump”
Addison’s disease

- Hyposecretion of cortisol
- Low blood pressure results
- Increased pigmentation
Pancreas

• The pancreas is a large gland behind your stomach that helps the body to maintain healthy blood sugar (glucose) levels.
• Contains islands of cells called the Islets of Langerhans which secrete glucagon and insulin
• **Glucagon** – stimulates the liver to break down glycogen, raises blood sugar concentration

• **Insulin** – decreases blood sugar concentrations, affects the uptake of glucose by cells

*Both hormones work together to maintain a balance in the blood sugar*
Diabetic neuropathies are a family of nerve disorders caused by diabetes. People with diabetes can develop nerve damage throughout the body. Symptoms include pain, tingling, or numbness—loss of feeling—in the hands, arms, feet, and legs. This can result in wounds that are slow to heal.
Diabetes

• Diabetes Mellitus – results from an insulin deficiency, blood sugar rises (hyperglycemia) and excess is excreted in the urine.

• Type I - insulin dependent diabetes mellitus or juvenile onset diabetes, often caused by inherited immune disorder that destroys pancreatic cells
• Type II – mature onset diabetes (usually after the age of 40), often individuals are overweight, can be controlled with diet and exercise

Blood sugar test, device pricks the finger and measures the amount of sugar in the blood
Injection of insulin will lower the blood sugar levels

**Hypoglycemia** can occur if levels become too low, can be cured with direct injection of glucose or with eating something high in sugar.
Gestational Diabetes

Pregnancy hormones can block insulin from doing its job. When this happens, glucose levels may increase in a pregnant woman's blood.

Gestational diabetes usually starts halfway through the pregnancy. All pregnant women should receive an oral glucose tolerance test between the 24th and 28th week of pregnancy to screen for the condition.
Gonads

TESTES:
- Located within scrotum
- Produce testosterone (an androgen)
- Stimulates development of male sexual characteristics

OVARIES:
- Located in pelvic cavity
- Produce estrogen & progesterone
- Responsible for development & maintenance of female characteristics & menstrual cycle

Gonadotropins - include any hormone (or group of hormones) that affect the gonads
Anabolic steroids are artificially produced hormones that are the same as, or similar to, androgens, the male-type sex hormones in the body. There are more than 100 variations of anabolic steroids. The most powerful androgen is testosterone.
Testes
Ovary
Thyroid
Parathyroid
Pineal Body
Pituitary
Hypothalamus
Adrenal
Pancreas
Thymus
Heart
Kidney
Stomach
Melatonin
PTH
Thymosin
Insulin
Glucagon
Estrogen
Testosterone
Prolactin
GH
oxytocin
ADH
FSH
LH
ACTH
TSH
PTH
T3 & T4
Calcitonin
Epinephrine
Aldosterone
Cortisol
Calcitoni

Cortisol production
Makes thyroid hormones
Regulates sex hormones
growth
Water balance
Calcium regulation
Increase heart rate
Maintain blood pressure
Stabilize blood glucose
Male, female function
Male development
male
Female Characteristics
Menstrual Cycle
Stabilize blood glucose
Male, female function
Male development
Regulates sex hormones
contractions
Prolactin
milk production
Water balance
Calcium regulation
increase heart rate
Cortisol production
Male, female function
Male development
Regulates sex hormones
contractions
Prolactin
milk production
male development
male, female function
males, females
Calcium regulation
Growth
Growth
Calcium regulation
Calcium regulation
Calcium regulation
Calcium regulation
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Calcium regulation
Study tools

• Endocrine glands (6 foot 7 foot) rap - http://www.youtube.com/watch?v=uUr3j82qLQc

• Endocrine Glands Song - http://www.youtube.com/watch?v=fIJ7XN9upzs