Testosterone and Male Aggression

- Testosterone and other male hormones seem to be related to aggressive behavior in some species
  - In the fish species *Oreochromis mossambicus*, elevated levels have been found in the males that engage in, or even just observe, territorial battles
Research has concluded that high levels of testosterone in human males does not lead directly to higher levels of violent aggression. But scientists have demonstrated a correlation between testosterone levels and competition.
• The overarching role of hormones is to coordinate activities in different parts of the body
  – Hormones regulate energy use, metabolism, and growth
  – Hormones and other chemicals also maintain homeostasis
26.1 Chemical signals coordinate body functions

- Endocrine glands and neurosecretory cells secrete hormones
  - Hormones are chemical signals that are carried by the blood and cause specific changes in target cells

- All hormone-secreting cells constitute the endocrine system
  - It works with the nervous system to regulate body activities
• Hormone from an endocrine cell

What is a hormone?

Hormones in cell

Secretory vesicles

Blood vessel

ENDOCRINE CELL

Target cell

Hormone molecules

Figure 26.1A
• Hormone from a neurosecretory cell

Figure 26.1B

Neurotransmitter passes signal from one cell to another has a protein receptor.
• Local regulators produce changes in cells
  – Neurotransmitters
  – Prostaglandins
26.2 Hormones affect target cells by two main signaling mechanisms

• Most hormones derived from amino acids bind to receptor proteins in the target-cell plasma membrane
  – They initiate signal-transduction pathways that cause changes inside the target cell
(1) A hormone binds to a receptor protein in the plasma membrane

(2) The receptor protein activates a signal-transduction pathway in the cell

(3) A series of relay molecules transmits the signal to a protein that carries out the cell’s response
• Steroid hormones bind to intracellular receptors
  – The steroid-receptor complex binds to DNA, turning specific genes on or off

• In this example, a new protein is synthesized
The vertebrate endocrine system consists of more than a dozen glands.

- The glands secrete more than 50 hormones.

Only the sex glands and the adrenal cortex secrete steroids.

- The remaining glands secrete nonsteroid hormones.
Hypothalamus
Pineal gland
Pituitary gland
Thyroid gland
Parathyroid glands
Thymus
Adrenal glands (atop kidneys)
Pancreas
Ovary (female)
Testis (male)

Figure 26.3
<table>
<thead>
<tr>
<th>Gland</th>
<th>Hormone</th>
<th>Chemical Class</th>
<th>Representative Actions</th>
<th>Regulated by</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypothalamus</td>
<td>Hormones released by the posterior pituitary and hormones that regulate the anterior pituitary (see below)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pituitary gland</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Posterior lobe</td>
<td>Oxytocin</td>
<td>Peptide</td>
<td>Stimulates contraction of uterus and mammary gland cells</td>
<td>Nervous system</td>
</tr>
<tr>
<td></td>
<td>Antidiuretic hormone (ADH)</td>
<td>Peptide</td>
<td>Promotes retention of water by kidneys</td>
<td>Water/salt balance</td>
</tr>
<tr>
<td>Anterior lobe</td>
<td>Growth hormone (GH)</td>
<td>Protein</td>
<td>Stimulates growth (especially bones) and metabolic functions</td>
<td>Hypothalamic hormones</td>
</tr>
<tr>
<td></td>
<td>Prolactin (PRL)</td>
<td>Protein</td>
<td>Stimulates milk production</td>
<td>Hypothalamic hormones</td>
</tr>
<tr>
<td></td>
<td>Follicle-stimulating hormone (FSH)</td>
<td>Protein</td>
<td>Stimulates production of ova and sperm</td>
<td>Hypothalamic hormones</td>
</tr>
<tr>
<td></td>
<td>Luteinizing hormone (LH)</td>
<td>Protein</td>
<td>Stimulates ovaries and testes</td>
<td>Hypothalamic hormones</td>
</tr>
<tr>
<td></td>
<td>Thyroid-stimulating hormone (TSH)</td>
<td>Protein</td>
<td>Stimulates thyroid gland</td>
<td>Thyroxine in blood; hypothalamic hormones</td>
</tr>
<tr>
<td></td>
<td>Adrenocorticotropic hormone (ACTH)</td>
<td>Protein</td>
<td>Stimulates adrenal cortex to secrete glucocorticoids</td>
<td>Glucocorticoids; hypothalamic hormones</td>
</tr>
<tr>
<td>Pineal gland</td>
<td>Melatonin</td>
<td>Amine</td>
<td>Involved in rhythmic activities (daily and seasonal)</td>
<td>Light/dark cycles</td>
</tr>
</tbody>
</table>

Table 26.3

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<table>
<thead>
<tr>
<th>Gland</th>
<th>Hormone</th>
<th>Chemical Class</th>
<th>Representative Actions</th>
<th>Regulated by</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thyroid gland</td>
<td>Thyroxine (T₄) and triiodothyronine (T₃)</td>
<td>Amine</td>
<td>Stimulate and maintain metabolic processes</td>
<td>TSH</td>
</tr>
<tr>
<td>Parathyroid glands</td>
<td>Calcitonin</td>
<td>Peptide</td>
<td>Lowers blood calcium level</td>
<td>Calcium in blood</td>
</tr>
<tr>
<td></td>
<td>Parathyroid hormone (PTH)</td>
<td>Peptide</td>
<td>Raises blood calcium level</td>
<td>Calcium in blood</td>
</tr>
<tr>
<td>Thymus</td>
<td>Thymosin</td>
<td>Peptide</td>
<td>Stimulates T-cell development</td>
<td>Not known</td>
</tr>
<tr>
<td>Adrenal glands</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adrenal medulla</td>
<td>Epinephrine and norepinephrine</td>
<td>Amines</td>
<td>Increase blood glucose; increase metabolic activities; constrict certain blood vessels</td>
<td>Nervous system</td>
</tr>
<tr>
<td>Adrenal cortex</td>
<td>Glucocorticoids</td>
<td>Steroids</td>
<td>Increase blood glucose</td>
<td>ACTH</td>
</tr>
<tr>
<td></td>
<td>Mineralocorticoids</td>
<td>Steroids</td>
<td>Promote reabsorption of Na⁺ and excretion of K⁺ in kidneys</td>
<td>K⁺ (potassium) in blood</td>
</tr>
<tr>
<td>Pancreas</td>
<td>Insulin</td>
<td>Protein</td>
<td>Lowers blood glucose</td>
<td>Glucose in blood</td>
</tr>
<tr>
<td></td>
<td>Glucagon</td>
<td>Protein</td>
<td>Raises blood glucose</td>
<td>Glucose in blood</td>
</tr>
<tr>
<td>Testes</td>
<td>Androgens</td>
<td>Steroids</td>
<td>Support sperm formation; development and maintenance of male secondary sex characteristics</td>
<td>FSH and LH</td>
</tr>
<tr>
<td>Ovaries</td>
<td>Estrogens</td>
<td>Steroids</td>
<td>Stimulate uterine lining growth; development and maintenance of female secondary sex characteristics</td>
<td>FSH and LH</td>
</tr>
<tr>
<td></td>
<td>Progesterone</td>
<td>Steroid</td>
<td>Promotes uterine lining growth</td>
<td>FSH and LH</td>
</tr>
</tbody>
</table>

Table 26.3, part 2

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26.4 The hypothalamus, closely tied to the pituitary, connects the nervous and endocrine systems

- The hypothalamus is the master control center of the endocrine system
  - It regulates the posterior and anterior pituitary gland
• Posterior pituitary
  – Composed of nervous tissue
  – Stores and secretes hormones made in the hypothalamus

• Anterior pituitary
  – Composed of glandular tissue
  – Exerts control over the anterior pituitary by secreting releasing hormones or inhibiting hormones
• Homeostasis is maintained by **negative-feedback** mechanisms coupled with environmental cues.
• Neurosecretory cells extending from the hypothalamus into the posterior pituitary
  – synthesize oxytocin and antidiuretic hormone (ADH)
  – transmit nerve signals that trigger oxytocin and ADH release from the posterior pituitary
Figure 26.5A

Hypothalamus

Neurosecretory cell

Hormone

Posterior pituitary

Blood vessel

Anterior pituitary

Oxytocin

ADH

Uterine muscles

Mammary glands

Kidney tubules

Copyright © 2003 Pearson Education, Inc. publishing as Benjamin Cummings
• Releasing and inhibiting hormones secreted by the hypothalamus control the anterior pituitary

• The brain and anterior pituitary also produce endorphins
Neurosecretory cell

Blood vessel

Releasing hormones from hypothalamus

Endocrine cells of the anterior pituitary

Pituitary hormones

TSH

ACTH

FSH and LH

Growth hormone (GH)

Prolactin (PRL)

Endorphins

Thyroid

Adrenal cortex

Testes or ovaries

Entire body

Mammary Glands (in mammals)

Pain receptors in the brain

Figure 26.5B
The thyroid regulates development and metabolism

- The thyroid gland produces two amine hormones
  - $T_4$ and $T_3$
  - These regulate development and metabolism
- Negative feedback maintains homeostatic levels of $T_4$ and $T_3$ in the blood
Thyroid imbalance can cause cretinism, metabolic disorders, and goiter.

Figure 26.6A, B

Add I to treat from lack of iodine.
26.7 Hormones from the thyroid and parathyroids maintain calcium homeostasis

- Blood calcium level is regulated by a tightly balanced antagonism between
  - calcitonin from the thyroid
  - parathyroid hormone from the parathyroid glands
Thyroid gland releases calcitonin

**Calcium homeostasis**

- **Calcium** deposition
  - Stimulated by Estrogen Menopause
  - Little Bones

- **Bone = Ca^2+ reservoir**
- **Calc** from blood to bone
- **Ca** not saved

- **STIMULUS:** Rising blood Ca^2+ level (imbalance)
- Thyroid gland releases calcitonin
- Calcitonin

- **Calcitonin**
  - Stimulates Ca^2+ deposition in bones
  - Reduces Ca^2+ uptake in kidneys

- **Stimulates Ca^2+ deposition in bones**
- **Reduces Ca^2+ uptake in kidneys**

- **Active vitamin D**
  - Stimulates Ca^2+ release from bones
  - Increases Ca^2+ uptake in kidneys
  - Increases Ca^2+ uptake in intestines

- **Parathyroid glands release parathyroid hormone (PTH)**
  - Increases function of Ca^2+

- **Parathyroid gland**

**Homeostasis:** Normal blood calcium level (about 10 mg/100 mL)**

- STIMULUS: Falling blood Ca^2+ level (imbalance)

**Figure 26.7**
26.8 Pancreatic hormones manage cellular fuel

- Blood glucose levels are controlled by two antagonistic hormones secreted by the pancreas
  - Insulin signals cells to use and store glucose as glycogen
  - Glucagon signals cells to release stored glucose into the blood
Glucose homeostasis

Insulin

Beta cells of pancreas stimulated to release insulin into the blood

Body cells take up more glucose

Liver takes up glucose and stores it as glycogen

Blood glucose level declines to a set point; stimulus for insulin release diminishes

STIMULUS: Rising blood glucose level (e.g., after eating a carbohydrate-rich meal)

Homeostasis: Normal blood glucose level (about 90 mg/100 mL)

80-100 mg/dL

High blood glucose level

STIMULUS: Declining blood glucose level (e.g., after skipping a meal)

Alpha cells of pancreas stimulated to release glucagon into the blood

Glucagon

Liver breaks down glycogen and releases glucose to the blood

Liver takes up glucose and stores it as glycogen

Blood glucose level rises to set point; stimulus for glucagon release diminishes

STIMULUS: Declining blood glucose level (e.g., after skipping a meal)

Alpha cells of pancreas stimulated to release glucagon into the blood

Glucagon
Diabetes mellitus is a serious hormonal disease

- Body cells are unable to absorb glucose from the blood

There are two types of diabetes
• Type I (insulin-dependent) diabetes
  – Autoimmune disease in which pancreatic beta cells are destroyed and thus not enough insulin is produced
    – Often develops before age 15
    – Patient requires insulin supplement, often by injection
• Type II (non-insulin-dependent) diabetes
  – Pancreatic cells function properly and there are sufficient amounts of insulin produced
  – Body cells fail to respond to insulin
  – Accounts for 90% of diabetes cases in the United States
  – Associated with obesity
  – Often develops after age 40
  – Manageable
• The diagnostic test for diabetes is a glucose-tolerance test

![Blood glucose levels over time for normal and diabetic individuals](image)

**Figure 26.9**

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26.10 The adrenal glands mobilize responses to stress

- Hormones from the adrenal glands help maintain homeostasis when the body is stressed

- Adrenal medulla
  - Nervous signals from the hypothalamus stimulate secretion of epinephrine and norepinephrine
  - These quickly trigger the fight or flight response
• Adrenal cortex

  – Chemical signals (ACTH) stimulate secretion of corticosteroids, including glucocorticoids and mineralocorticoids

  – Corticosteroids boost blood pressure and energy in response to long-term stress
• How the adrenal glands control our responses to stress

**SHORT-TERM STRESS RESPONSE**
1. Glycogen broken down to glucose; increased blood glucose
2. Increased blood pressure
3. Increased breathing rate
4. Increased metabolic rate
5. Change in blood-flow patterns, leading to increased alertness and decreased digestive and kidney activity

**LONG-TERM STRESS RESPONSE**
1. Retention of sodium ions and water by kidneys
2. Increased blood volume and blood pressure

1. Proteins and fats broken down and converted to glucose, leading to increased blood glucose
2. Immune system may be suppressed

*Figure 26.10*
Athletes often take glucocorticoids

- They relieve pain and inflammation
- But they also mask the injury and suppress immunity
- Example: cortisone
The gonads secrete sex hormones

- Secretion is controlled by the hypothalamus and the pituitary

The steroid hormones are found in both sexes but in different proportions

- estrogens
- progestins
- androgens
• Estrogen and progestins
  – maintain the female reproductive system
  – stimulate the development of female characteristics
• Androgens, such as testosterone, trigger the development of male characteristics

– In male elephant seals, androgens account for bodies weighing 2 tons or more, a thick hide, and aggressive behavior