Hormones and Biological Rhythms

Hormones

A. Introduction.
   1. The endocrine system consists of a variety of loosely related cells, tissues, and organs that act together with parts of the nervous system to control physiological activities and maintain homeostasis.
   2. Whereas the parts of the nervous system communicate with various cells by means of nerve impulses on nerve fibers, the endocrine system uses hormones that act as chemical messengers to regulate the metabolism of their target cells.

B. Endocrine and exocrine glands.
   1. Endocrine glands secrete their products directly into body fluids (e.g., the thyroid and parathyroid glands).
   2. Exocrine glands secrete their products into ducts that lead to the outside of the body (e.g., sweat and salivary glands).

C. The hypothalamus—the master gland.
   1. The hypothalamus is connected to the pituitary gland by a stalk of nerve cells and blood vessels called the infundibular stalk.
   2. This stalk provides a direct link between the nervous system and the endocrine system.

D. The pituitary gland.
   1. Location.
      a. The pituitary is located at the base of the brain.
      b. It is attached to the hypothalamus by the infundibulum.
   2. The pituitary is structurally and functionally divided into 2 distinct portions.
      a. The anterior lobe—the adenohypophysis.
         1) Contains secretory cells.
         2) The hormones of the adenohypophysis.
            a) Growth hormone (GH)—regulates the rate of growth of all body cells and promotes mitotic activity.
            b) Prolactin (PRL)—assists other hormones in initiating and sustaining milk production by the mammary glands.
            c) Thyroid-stimulating hormone (TSH)—regulates the hormonal activity of the thyroid gland.
            d) Adrenocorticotropic hormone (ACTH)—promotes normal functioning of the adrenal cortex.
            e) Follicle-stimulating hormone (FSH)—in males, stimulates sperm production; in females, regulates the monthly development of a follicle and ovum.
f) Luteinizing hormone (LH)—in females, works with FSH to initiate ovulation; in males, stimulates interstitial cells to develop and secrete testosterone.
g) Melanocyte-stimulating hormone (MSH)—exact function unknown; can cause darkening of the skin.
3) The hypothalamus controls the adenohypophysis.
a) Since axons do not enter the adenohypophysis, hypothalamic control of the adenohypophysis is achieved through hormonal rather than neural regulation.
b) This vascular link between the hypothalamus and the adenohypophysis is called the hypothalamo-hypophysial portal system.
c) Neurons of the hypothalamus secrete polypeptide hormones into this portal system that regulate the secretion of the adenohypophysis.
b. The posterior lobe—the neurohypophysis.
  1) Is the neural part of the pituitary gland.
  2) Nerve fibers extend through the infundibulum along with small neuroglia-like cells, called pituicytes.
  3) Secretes 2 hormones, both of which are produced in the hypothalamus and merely stored in the posterior lobe of the pituitary.
   a) Antidiuretic hormone (ADH)—also called vasopressin; reduces amount of water excreted by kidneys.
   b) Oxytocin (OT)—causes uterine contractions during parturition.
E. The adrenal glands.
  1. Location and structure.
     a. Paired glands that cap the superior borders of the kidneys.
     b. Each adrenal gland consists of an outer cortex and an inner medulla, which function as separate glands that secrete different hormones.
  2. The adrenal cortex—consists of 3 zones that secrete different hormones.
     a. Zona glomerulosa—secretes mineralocorticoids that regulate Na+ reabsorption and K excretion.
     b. Zona fasciculata—secretes glucocorticoids that promote vasoconstriction and resistance to stress.
     c. Zona reticularis—secretes gonadocorticoids that supplement gonadal hormones.
  3. The adrenal medulla.
     a. The cells of the adrenal medulla secrete epinephrine and norepinephrine.
     b. Epinephrine and norepinephrine increase cardiac output and heart rate, dilate coronary blood vessels, increase mental alertness, increase the respiratory rate, and elevate metabolic rate.
     c. Activation of the adrenal medulla together with the sympathetic nervous system prepares the body for greater physical performance—the fight-or-flight response.
F. The thyroid and parathyroid glands.
1. The bilobed thyroid gland is located in the neck just below the larynx. Four small parathyroid glands are embedded in its posterior surface.
2. The thyroid is the largest of the endocrine glands, weighing between 20 and 25g in humans.
3. On a microscopic level, the thyroid gland consists of many spherical hollow sacs called thyroid follicles.
   a. These follicles are lined with cells that synthesize 2 hormones:
      1) Thyroxine (T₄)—increases rate of protein synthesis and rate of energy release from carbohydrates.
      2) Triiodothyronine (T₃)—functions same as T₄.
   b. Between the follicles are cells that produce a hormone called calcitonin, which lowers blood Ca⁺⁺ levels by inhibiting release of calcium from bone tissue.
4. The parathyroid glands are embedded in the posterior surface of the thyroid gland. They are composed of cells that synthesize parathyroid hormone.

G. The pancreas.
1. The pancreas is a soft, lobulated, glandular organ that has both exocrine and endocrine functions.
2. It is located in back of the stomach and is attached to the small intestine.
3. The endocrine portion of the pancreas consists of scattered clusters of cells called the islets of Langerhans.
4. On a microscopic level, the most conspicuous cells in the islets are the alpha and beta cells.
   a. Alpha cells secrete glucagon in response to a fall in the blood glucose concentration.
   b. Beta cells synthesize and secrete insulin, which promotes movement of glucose through cell membranes to lower blood glucose concentration.

Biological Rhythms

A. Biological rhythms are patterns of activity that occur at regular intervals during the life of the animal.
B. There are 3 kinds of biological rhythms.
   2. Diurnal activity patterns.
      a. Probably our most common perceptions about activity patterns in mammals relate to their cycle of daily activity.
      b. DAPs have a period of about 24 hours.
      c. Some mammals are diurnal, meaning they are active primarily during daylight hours and inactive at night.
      d. Nocturnal mammals exhibit peak activity during hours of darkness and rest during the day.
e. Crepuscular activity patterns, moving about more and feed near sunrise and sunset, include diurnal and nocturnal mammals.

3. The primary cue for establishing and maintaining circadian rhythms is photoperiod.
   a. The timing mechanism appears to have 3 major components located in the retina, a portion of the thalamus in the brain called the intergeniculate nucleus, and the suprachiasmatic nucleus (SCN) of the hypothalamus.
   b. Light striking the retina follows several pathways, 2 of which lead to the SCN and intergeniculate nucleus. One pathway from the intergeniculate nucleus then leads to the SCN.

   a. CAPs have a period of about a year.
   b. CAPs regulate a number of processes in mammals, including seasonal changes in coat color, hibernation, and reproduction.
   c. The primary cue for annual patterns of activity is photoperiod.

5. Ultradian activity patterns.
   a. Some mammals have regular cycles of activity with periods that are shorter than a day in length.
   b. Some rodents, for example, exhibit 6 to 12 approximately evenly spaced, short bouts of activity and rest during a 24-hour day.
   c. Photoperiod probably plays a role in timing these activities patterns.

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<thead>
<tr>
<th>GLAND</th>
<th>HORMONE</th>
<th>TARGET(S)</th>
<th>ACTION(S)</th>
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<tr>
<td>Hypothalamus</td>
<td>Releasing and release-inhibiting hormones</td>
<td>Anterior pituitary</td>
<td>Control secretion of hormones of anterior pituitary</td>
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<tr>
<td>Anterior pituitary</td>
<td>Growth hormone (GH)</td>
<td>Bones, liver, muscles</td>
<td>Promotes mitotic activity</td>
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<td></td>
<td>Prolactin (PRL)</td>
<td>Mammary glands</td>
<td>Initiates and sustains milk production</td>
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<td>Thyroid-stimulating hormone (TSH)</td>
<td>Thyroid gland</td>
<td>Regulates thyroid gland</td>
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<td>Adrenocorticotrophic hormone (ACTH)</td>
<td>Adrenal cortex</td>
<td>Promotes normal functioning of adrenal cortex</td>
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<td></td>
<td>Follicle-stimulating hormone (FSH)</td>
<td>Gonads</td>
<td>Stimulates sperm production in males; stimulates growth and maturation of eggs in females</td>
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<td></td>
<td>Luteinizing hormone (LH)</td>
<td>Gonads</td>
<td>Stimulates secretion of sex hormones</td>
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<tr>
<td>Endocrine System</td>
<td>Hormone/Peptide</td>
<td>Target Tissues</td>
<td>Function</td>
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<td><strong>Posterior pituitary</strong></td>
<td>Melanocyte-stimulating hormone (MSH)</td>
<td>Melanocytes</td>
<td>Controls skin pigmentation</td>
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<td>Oxytocin (OT)</td>
<td>Uterus, mammary glands</td>
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<td>Induces birth by stimulating uterine contractions; causes milk flow</td>
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<td><strong>Adrenal cortex</strong></td>
<td>Antidiuretic hormone (ADH)</td>
<td>Kidneys</td>
<td>Stimulates water reabsorption</td>
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<tr>
<td>Mineralocorticoids (Aldosterone)</td>
<td>Kidneys</td>
<td></td>
<td>Stimulates secretion of K ions and reabsorption of Na ions</td>
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<td>Glucocorticoids (Cortisol)</td>
<td>Muscles, immune system</td>
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<td>Mediate response to stress</td>
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<td>Gonadocorticoids</td>
<td>Gonads</td>
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<td>Stimulates the production of steroid hormones</td>
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<td><strong>Adrenal medulla</strong></td>
<td>Epinephrine</td>
<td>Heart, blood vessels, liver, fat cells</td>
<td>Stimulate fight-or-flight reactions</td>
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<td>Norepinephrine</td>
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<td><strong>Thyroid</strong></td>
<td>Thyroxine (T4)</td>
<td>Many tissues</td>
<td>Stimulates and maintains metabolism</td>
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<td>Triodothyronine (T3)</td>
<td>Many tissues</td>
<td></td>
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<td>Calcitonin</td>
<td>Bones</td>
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<td>Stimulates bone formation; lowers blood Ca</td>
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<tr>
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<td>Bones</td>
<td>Absorbs bone; raises blood Ca</td>
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<td><strong>Pancreas</strong></td>
<td>Glucagon</td>
<td>Liver</td>
<td>Stimulates breakdown of glycogen and raises blood sugar</td>
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<td>Insulin</td>
<td>Muscles, liver, fat</td>
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<td>Stimulates uptake</td>
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