Chapter 44—Chemical Signals in Animals

I. Hormones are secreted chemical signals that travel to target cells.
   A. They are effective at extremely low concentrations.
   B. Their action is amplified through . . .
      1. Changes in gene expression
      2. Activation of enzymes.
   C. Partial list of vertebrate endocrine (= hormone secreting) glands Figure 44.4
      1. Hypothalamus & pituitary: Regulate other glands
      2. Thyroid: Metabolic rate & calcium level in blood
      3. Adrenals: Short & long term stress responses
      4. Testes & ovaries: Development & maintenance of sexual characteristics
      5. Parathyroid: calcium level in blood
      6. Pancreas: Blood sugar levels

II. Pituitary gland Figure 44.7
   A. “Mastergland”
      1. Releases hormones that control other glands
      2. Located at end of a stalk under the hypothalamus in middle of skull.
   B. Posterior Pituitary Figure 44.9a
      1. Releases neurohormones
         a Produced in hypothalamus
         b Carried in axons to posterior pituitary where released
      2 Examples
         a Oxytocin - release of milk
         b Antidiuretic Hormone (= ADH) or vasopressin: Decrease urine volume
            [See Lecture Notes Chapter 39, III, A]
   C. Anterior Pituitary Figure 44.9b
      1 Releases tropic hormones which control activities of other glands
         a Thyrotropin determines thyroid gland activity
         b ACTH stimulates adrenal gland
         c Follicle stimulating hormone (FSH)
         d Luteinizing hormone
      2 Endorphins & Enkephalins
         a Control pain
         b Produce "Runners high"
      3 Growth Hormone (GH)
         a Causes growth
         b Too much causes acromegaly Figures not in text

SIDETRACK: Gigantism of Parasitized Mice
Mice with larval stage of some tapeworms grow abnormally large
1. Easier prey for cat (next host)
2. Tapeworm produces a chemical mimic of vertebrate GH
3. GH mimic is also a proteinase that is used by tapeworm to . . .
   a. Burrow through host tissues
   b. Destroy host antibodies

Example of how cooptation leads to new traits over evolutionary time
1. A side effect (i.e., an amino sequence on a proteinase by chance activates host’s GH receptors) provides an additional selective advantage to parasite
2. Molecule now has two active sites: Proteinase & GH mimic
3. Natural selection works on both traits independently [See Sidetract, Chap. 37 notes]

III. The Effects of Hormones Are Diverse
A. One hormone may trigger multiple responses
B. One physical process may be controlled by many different hormones.
C. Hormones coordinate a cell’s response to . . .
   1. Environmental Challenges
      a. Short-term stress response (fight-or-flight) is activated by epinephrine and prepares the body for heightened alertness and rapid energy utilization.
         Figure 44.5; 44.13
      b. Long-term stress response is activated by glucocorticoids (such as cortisol) and prepares the body to save glucose by metabolizing fats and proteins.
         Figure 44.2a, b
   2. Development
      a. Development of vertebrate reproductive tracts requires hormones from the developing testes or ovaries
      b. Insects metamorphose if juvenile hormone is low, and ecdysone is high.
         [See text Chap 30, pp 589-590; Figure 30.14b]
   3. Homeostasis
      a. Hormones often act between the integrator and the effector cells. Figure 44.6
      b. Salt and water concentrations in blood [See Lecture Notes, Chap 39, III, A]
         (1) Measured in hypothalamus
         (2) When salt is high, ADH is released from posterior pituitary
         (3) ADH increases water reabsorption in the kidney.
      c. Control of adrenal gland activity Figure 44.8a,b
         (1) CRF (cortisol releasing factor) from hypothalamus causes release of ACTH from anterior pituitary
         (2) ACTH causes release of cortisol from adrenals
         (3) High level of cortisol in blood inhibits release of CRF and, thus ACTH

D. Regulating Hormone Production
1. Controlled by other hormones & the nervous system.
2. Product inhibition or negative feedback loops
   a. Most common
   b. A high concentration of a hormone inhibits production of that hormone
   c. A low concentration of a hormone stimulates production of that hormone
   d. Example: Control of adrenal gland activity (See III, C, 3, c above)
   e. Example: Control of calcium levels in blood Figure 44.6
      (1) Thyroid releases calcitonin when calcium levels high
         (a) Calcium deposited in bones
         (b) Inhibits calcium uptake in intestine and kidney
         (c) Blood calcium concentration drops
(2) Parathyroid releases PTH when calcium levels low
   a. Calcium released from bones
   b. Calcium taken up in intestine and kidney
   c. Blood calcium concentration rises

3. Up-regulation or positive feedback loops
   a. Presence of a hormone or stimulus induces more of the stimulus
   b. Eventually a climatic event breaks cycle
   c. FSH in females
      1. Initial effect is to increase the number of FSH receptors on target cells
      2. Target cells become more sensitive to FSH
   d. Child-birth labor contractions
   e. Sexual arousal

IV. How Do Hormones Act on Target Cells? Figure 44.3
A. Steroid Hormones and Intracellular Receptors
   1. Steroid hormones are small lipids that slip easily through cell membranes.
   2. Receptors for steroid hormones are inside the cell.
   3. The receptor has a DNA-binding domain.
   4. The hormone binds to the receptor, altering its conformation.
   5. The activated receptor binds to the hormone response element of certain genes,
      which causes them to be transcribed. Figure 44.11

B. Non-steroidal hormones (proteins & polypeptides) bind to cell-surface receptors.
   1. Not lipid soluble and do not enter the cell.
   2. The hormone binds to a cell-surface receptor, which activates a G protein.
   3. The G protein activates a membrane protein that catalyzes the formation of a
      second messenger.
   4. The second messenger leaves the membrane to activate enzymes inside the
      cell by phosphorylation or release of ion cofactors.
   5. A cascade of enzyme activation occurs, producing the cell's response to the
      hormone. Figure 44.14