Chapter 16 - Endocrine system

I. Overview

Nervous control is fast but short-lived
Hormonal control is slow and lasts a long time

A. Organs: hypothalamus, pituitary (hypophysis), thyroid, parathyroid, adrenal, pineal, thymus
   1. Other organs have more than one role: pancreas, testis, ovary

B. Chemistry of hormones: 2 main classes
   1. Amino acid-based: most hormones fall into this category
   2. Steroids: all synthesized from cholesterol

C. Target cell specificity: hormones circulate throughout body, but only affect cells that have receptors for that hormone
   1. Up-regulation: cell may produce more receptors to become more sensitive
   2. Down-regulation: cell may decrease number of receptors

D. Mechanism of hormone action
   1. Cell effects: not all cells do everything listed below
      a. Membrane permeability changes: example: ions
      b. Protein synthesis: example: enzymes, collagen
      c. Enzyme activity: activate or deactivate
      d. Secretory activity: change the activity level of glands
      e. Cell division: increase the rate of mitosis
   2. 2nd messenger system: cyclic AMP (cAMP) is the 2nd messenger
a. Sequence of steps:
1) 1st messenger: *is the hormone*
2) G protein
3) Active G protein
4) Adenylate cyclase
5) Cyclic AMP (cAMP) activates protein kinase
   *which in turn activates or deactivates some enzyme*

3. Direct gene activation
   a. Steroids: *easily diffuse through membrane*
   b. Steroids: *bind to intracellular receptor*
   c. Hormone/receptor complex

4. Control of hormone release

5. Endocrine gland stimuli: *glands are controlled by three different stimuli types*

<table>
<thead>
<tr>
<th>(a) Humoral Stimulus</th>
<th>(b) Neural Stimulus</th>
<th>(c) Hormonal Stimulus</th>
</tr>
</thead>
<tbody>
<tr>
<td>① Capillary blood contains low concentration of Ca²⁺, which stimulates...</td>
<td>① Preganglionic sympathetic fibers stimulate adrenal medulla cells...</td>
<td>① The hypothalamus secretes hormones that...</td>
</tr>
<tr>
<td>Parathyroid glands</td>
<td>CNS (spinal cord)</td>
<td>Hypothalamus</td>
</tr>
<tr>
<td>Capillary (low Ca²⁺ in blood)</td>
<td>Preganglionic sympathetic fibers</td>
<td>Pituitary gland</td>
</tr>
<tr>
<td>Parathyroid glands</td>
<td>Medulla of adrenal gland</td>
<td>Thyroid gland</td>
</tr>
<tr>
<td>Parathyroid glands</td>
<td>PTH</td>
<td>Adrenal cortex</td>
</tr>
<tr>
<td>② secretion of parathyroid hormone (PTH) by parathyroid glands*</td>
<td>② to secrete catecholamines (epinephrine and norepinephrine)</td>
<td>Gonad (Testis)</td>
</tr>
<tr>
<td>③ stimulate other endocrine glands to secrete hormones</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
a. Hormonal: a releasing or inhibiting hormone controls the gland

b. Humoral: the level of something in the body fluids controls the gland

c. Neural: the nervous system can cause hormone release

E. Specific organs

Defined: **RH**=releasing hormone, **IH**=inhibiting hormone

Defined: **tropic** hormones are those that control other endocrine organs

1. Pituitary (hypophysis): attached by stalk (infundibulum) to the inferior side of the brain

   a. 2 main lobes: each releases several hormones

   1) Anterior lobe (adenohypophysis)

      a) Growth hormone (GH)
      b) Thyroid stimulating hormone (TSH)
      c) Adrenocorticotropic hormone (ACTH)
      d) Gonadotropins
      e) Prolactin:

   2) Posterior lobe (neurohypophysis)

      a) ADH (antidiuretic hormone)
      b) Oxytocin: stimulates contraction of smooth muscle in uterus and breast
2. Flowchart of pituitary control:

3. Thyroid: *overlies the trachea, and is inferior to the larynx*

4. Parathyroid glands: *usually 4, hidden in the posterior thyroid gland*
5. Adrenal (suprarenal) glands: located in the fat above each kidney
   a. Adrenal cortex: three layers
      1) Zona glomerulosa: mineralocorticoids - ion balance
      2) Zona fasciculate: glucocorticoids - metabolic hormones
      3) Zona reticularis: glucocorticoids and gonadocorticoids
   b. Adrenal medulla: catecholamines
6. Pancreas: pancreatic islets (Langerhan's) are the endocrine part
a. **alpha cells:** release glucagon which increases blood glucose

b. **beta cells:** produce insulin which decreases blood glucose

c. **Diabetes**
   
   1) **Type I:** insulin dependent, formerly juvenile onset

   2) **Type II:** non-insulin dependent, formerly adult onset

7. **Pineal gland:** tiny gland hanging from the roof of the 3rd ventricle
   
   a. **Melatonin:** is the main hormone
   
   b. **Peak levels:** at night – makes us sleepy
   
   c. **Receives impulses:** from visual pathways
   
   d. **Bright light:** inhibits melatonin release
   
   e. **Antagonadotropic**

8. **Thymus:** deep to the sternum

**II. General adaptation syndrome (GAS):** the opposite of homeostasis; gear the body up to counteract stress

A. **Terminology**

   1. **Eustress:** true stress, where a small amount is good

   2. **Distress:** destructive stress, which is harmful; lowers the immune response

B. **Stressor:** any stress that initiates GAS (bacteria, bleeding, emotions)

   1. **Stress stimulates hypothalamus:** initiates GAS through 2 pathways
a. Alarm reaction: sympathetic stimulation of the body and adrenal medulla

  1) Initial reaction to stressor
  2) Fight/flight: activated by the nervous system

  3) Alarm reaction effects on organ systems

    a) Heart:
    b) Brain:
    c) Skeletal muscle:
    d) Lungs:
    e) Skin:
    f) Urinary:
    g) Digestive:
    h) Spleen contracts: forces extra blood into general circulation
    i) Liver: breaks down glycogen into glucose for quick energy
    j) Adrenal medulla: sympathetic stimulation to the adrenal medulla prolongs the alarm response

b. Resistance reaction: due to anterior pituitary and adrenal cortex hormones

  1) CRH \(\rightarrow\) ACTH \(\rightarrow\) aldosterone: uptake Na+ to maintain fluid/ion balance (at the expense of K+)
  2) TRH \(\rightarrow\) TSH \(\rightarrow\) TH: increases carbohydrate catabolism
  3) GHRH \(\rightarrow\) GH: increases fat catabolism
C. **Exhaustion**: occurs if alarm and resistance fail to counteract stressor

1. **Main cause**: *loss of extracellular K+ (due to excess aldosterone)*

2. **Cells then lose intracellular K+**