Categories of cellular secretions:

**Autocrine** - affect the secreting cell directly

**Paracrine** - affect neighboring cells
  e.g., histamine and inflammation

**Endocrine** - release into bloodstream
  e.g., sweat onto skin, bile into digestive system

**Exocrine** - release onto epithelial surface
  e.g., sweat onto skin, bile into digestive system

**Pheromone** - exocrine secretion to signal other individuals

**Neuroendocrine** - secretion from axon terminal into blood stream

Chap 14. Endocrine System – Glands and Hormones

**Secretions with consequences**

All cells secrete, but
Specialized secretory cells grouped into glands
  Secrete same specialized substance (e.g., hormone)

Nervous System neurotransmitter acts near and fast

Other secretions, such as hormones, may act more distantly and over a longer time period

**Neuroendocrine Systems**

Neurosecretory cells secrete neurohormones

Axon terminates into neurohemal organ

Neurohormones often [effect] other glands/hormones
Hormone Types

1. **Amines** – small (e.g., epi, norepi, thyroid)
   - Eicosanoids from arachidonic acid (prostaglandins etc.)

2. **Steroid** Hormones from cholesterol (e.g., testosterone, estrogen)

3. **Peptide** Hormones – common, large, complex (e.g., insulin, ADH, GH)
   - (autocoids = others like histamine and serotonin)

Modified Amino Acids

1. catecholamines (epi, norepi, dopamine; tyrosine)
2. thyroid (lipid soluble; tyrosine)
3. melatonin (tryptophan)

Glandular Secretion

- **Response to stimulus**
  - Hormone
  - Neurotransmitter
  - Action Potential etc. (e.g., osmolarity and ADH)

Storage before Secretion

- Large molecules easily stored because can’t leave readily
- Small molecules often stored bound to accessory proteins
- Some molecules actively/continuously taken into vesicles
- Steroid hormones (lipid soluble) tend to leak out soon
  - Hydrophobic steroid and thyroid hormones move in blood, bound to carrier proteins

Hormone ACTION! (receptors etc.)

1. **Lipid Soluble**
   - Steroid and Thyroid Hormones (~long-lived)
   - Through Membrane
   - Bind Cytoplasmic Receptors, then to Nucleus
   - Directly affect transcription (therefore long-term)

2. **Lipid Insoluble**
   - Bind cell-surface receptors
   - Often one or more 2nd messengers
   - Amplification
   - Rapid, short-duration responses
Hormone ACTION! (receptors etc.)

1. Lipid Soluble

2. Lipid Insoluble

Hormone ACTION! (receptors etc.)

2. Lipid Insoluble Hormones and Intracellular Signaling

A few receptors with direct catalytic activity, but most via 2nd messengers:

Possible 2nd messengers:
1. cAMP, cGMP (cyclic nucleotide monophosphates)
2. IP₃, DAG (diacylglycerol; inositol phospholipids)
3. Ca²⁺ ions

General Model of Hormone Binding and Intracellular Signaling:

Glandular Secretion

Secretory Granules/Vesicles - similar to synaptic vesicles but usually larger

Exocytosis - common release mechanism

Regulation via Calcium - remember that free cytosolic calcium concentration is correlated with exocytosis (including of NT, hormones, etc.)
Endocrine System

Tropic hormones = act on other endocrine tissues (e.g., adrenal cortex, thyroid, gonads)

Major Players:

**Hypothalamus**
- (~7 neurohormones)
- mostly peptides

**Pituitary** (9 hormones)
1. Anterior (~nonneuronal)
2. Posterior (~neuronal control)

**Neuroendocrine System**

**Posterior Pituitary**
- Oxytocin — uterine contractions, milk ejection
- Antidiuretic Hormone (ADH) — water retention in kidney

Both are peptide hormones
Both are similar and highly conserved

**Endocrine System**

Example:
In response to cold, fright, pain etc...

**Hypothalamus**
- corticotropin-releasing hormone

**Anterior Pituitary**
- Adrenocorticotropic hormone (ACTH)

**Adrenal Cortex**
(corticosterone; stress hormones)

Response (lizard example)
Hormone Effects

**Adrenal Gland**

**Catecholamines** (from medulla)

**Glucocorticoids** (from cortex)

---

**Glucocorticoids**

(From adrenal cortex)

Released in response to ACTH (Adrenocorticotropic) from Anterior Pituitary

**Steroid hormones** (lipid soluble) derived from cholesterol

1. Reproductive
2. Kidney Function (mineralocorticoids)
3. Glucocorticoids (mobilize a.a.s and glucose, etc.)

Includes ‘Stress Hormones’

Cortisol, cortisone, corticosterone

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**Catecholamines**

(adrenal medulla)

- Epi, Nor ep, etc.

Secretion regulated by sympathetic preganglionic cholinergic neurons

Catecholamine receptors are Alpha and Beta adrenoreceptors

<table>
<thead>
<tr>
<th>Alpha</th>
<th>Beta1</th>
<th>Beta2</th>
</tr>
</thead>
<tbody>
<tr>
<td>smooth muscle contraction</td>
<td>cardiac muscle stimulant</td>
<td>broncho/vaso dilation</td>
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**Vertebrate Reproduction**
Reproductive Hormones
Steroid Hormones from Adrenal cortex and Gonads

Hypothalamus
  GnRH
Anterior Pituitary
  FSH, LH
  Gonads, Adrenal Cortex

See Fig 14.1, Hill et al. 2004

Male Sex Hormones
Testosterone and other androgens

Released from Leydig Cells in response to LH, FSH

FSH binding to Sertoli cells stimulates spermatogenesis

Female Sex Hormones
Estrogens

Ova created and stored before birth (mammals and birds)

Repro cycle in 2 phases:
  Follicular and Luteal

FSH stimulates beginning of follicular phase -> development of ovarian follicles

See Fig 14.1, Hill et al. 2004

Follicular Phase
1- FSH ⬆
   Causing follicular maturation
2- LH ⬆
   FSH and LH help generate Estrogen (3)
   This Estrogen causes hypothal and ant. pit. to release spike of LH and FSH leading to ovulation (4)
   (endometrium 5)
   = release of ovum (6)

Luteal Phase
7- FSH, LH ↓
   Estrogen ↓
8- LH changes ruptured follicle into corpus luteum
9- corpus luteum secretes estrogen and progesterone which inhibit FSH, LH release from anterior pituitary by slowing GnRH
10- progesterone leads to richer endometrium
11- without fert. CL degenerates and cycle begins again

See Fig 14.1, Hill et al. 2004

Luteal Phase
12- with fert.
   Chorionic gonadotropin maintains CL, maintaining high levels of estrogen and progesterone; maintaining endometrium; follicular development inhibited
13- Placenta takes over hormone production

9-48 Randall et al. 2002

9-46 Randall et al. 2002

9-45 Randall et al. 2002

9-47 Randall et al. 2002
Birth Control Pills?

Progesterone and Estradiol - mimic early pregnancy and inhibit ovulation