Chapter 15
Mechanisms of Cell Communication

TABLE 16-1 SOME EXAMPLES OF SIGNAL MOLECULES

<table>
<thead>
<tr>
<th>SIGNAL MOLECULE</th>
<th>SITE OF ORIGIN</th>
<th>CHEMICAL NATURE</th>
<th>SOME ACTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adrenaline (epinephrine)</td>
<td>adrenal gland</td>
<td>derivative of the amino acid tyrosine</td>
<td>increases blood pressure, heart rate, and metabolism</td>
</tr>
<tr>
<td>Cortisol</td>
<td>adrenal gland</td>
<td>steroid (derivative of cholesterol)</td>
<td>affects metabolism of proteins, carbohydrates, and lipids in most tissues</td>
</tr>
<tr>
<td>Estriol</td>
<td>ovary</td>
<td>steroid (derivative of cholesterol)</td>
<td>induces estradiol in secondary female sexual characteristics</td>
</tr>
<tr>
<td>Glucagon</td>
<td>α cells of pancreas</td>
<td>peptide</td>
<td>stimulates glucose synthesis, glycogen breakdown, and lipid breakdown, e.g., in liver and fat cells</td>
</tr>
<tr>
<td>Insulin</td>
<td>β cells of pancreas</td>
<td>protein</td>
<td>stimulates glucose uptake, protein synthesis, and lipid synthesis, e.g., in liver cells</td>
</tr>
<tr>
<td>Testosterone</td>
<td>testis</td>
<td>steroid (derivative of cholesterol)</td>
<td>induces and maintains secondary male sexual characteristics</td>
</tr>
<tr>
<td>Thyroid hormone (thyroxine)</td>
<td>thyroid gland</td>
<td>derivative of the amino acid tyrosine</td>
<td>stimulates metabolism of many cell types</td>
</tr>
</tbody>
</table>

Table 16-1 part 1 of 2 Essential Cell Biology 3/e (© Garland Science 2010)
Figure 1: The Leptin feedback loop. The ob gene in fat cells encodes the leptin protein, which triggers the hypothalamus to suppress appetite.

Mice without the leptin gene are morbidly obese (right) compared to normal mice (left). Image courtesy Sebastien Bouret/University of Oregon.
2. Each cell responds to a limited set of signals, depending on its history and its current state.

- A signal molecule vs. a receptor protein (or receptor).

- Each receptor is activated by only one type of signal (without the receptor, a cell will be deaf to the signal).

- By producing only a limited set of receptors out of the thousands that are possible, the cell restricts the types of signals that can affect it.

Intracellular relay system (effector proteins) vary from one type of specialized cell to another.

![Figure 15-9](Molecular Biology of the Cell © Garland Science 2008)

**Figure 15-9** Molecular Biology of the Cell (© Garland Science 2008)
1. Same signal molecule — different response

One signal, binding to one type of receptor protein, can cause a multitude of effects in the target cell.

*One example is acetylcholine (Ach); it binds to similar receptor on heart muscle cells, and salivary gland cells produce different responses in each cell.*

*The extracellular signal molecule alone is not the message:*

the information conveyed by the signal depends on ‘how the target cell receives and interprets the signal’.
Multiple Extracellular Signals

2. Multiple extracellular signal

A typical cell possesses *many sorts of receptors* - each present in tens to hundreds of thousands of copies. *Simultaneously sensitive* to many different signals. *Small number* of signal molecules to exert subtle and complex control over cell behavior.

**Combinations** of signals

*Different responses* due to interaction between intracellular relay systems. One signal can *modify* the responses to another. Enable a cell to survive, proliferate, differentiate, or die (apoptosis).

3. A cell’s response to a signal can be fast or slow

*The length of time* to response to a signal vary greatly depending on the *needs*.

Fast response

Ach - skeletal muscle contraction (milliseconds). Ach - salivary gland secretion (a minute).

Affects the activity of proteins that are already present.

Slow response

Cell growth and cell division (hours) Requires *changes in gene expression*. 
4. Some hormones cross the plasma membrane and bind to intracellular receptors

**Extracellular signal molecules**

- **Large Hydrophilic** signal molecules, largest class, too large or too hydrophilic to cross the plasma membrane, bind **cell-surface receptors**

- **Small hydrophobic** signal molecules, small enough or hydrophobic, activate intracellular enzymes, bind **intracellular receptors** and regulate gene expression, e.g., steroid hormones

Some small hydrophobic steroid hormones (cortisol, estradiol, testosterone) and thyroid hormone (thyroxine) bind to **intracellular receptors** that act as transcription regulators.

---

Figure 15-3b: Molecular Biology of the Cell (© Garland Science 2008)

Extracellular signal molecules bind either to cell-surface receptors or to intracellular enzymes or receptors

**The nuclear receptor superfamily**

- DNA-binding domain
- cortisol receptor
- estrogen receptor
- progesterone receptor
- vitamin D receptor
- thyroid hormone receptor
- retinoic acid receptor
3-D structure of a ligand-binding domain with and without ligand bound.
Nuclear receptors

Both cytosolic and nuclear receptors bound by hydrophobic molecules.

Proteins capable of regulating gene transcription.

- **Transcription regulator**

  When hormone binds, the inactive receptor undergoes a large conformational change that activates the protein, allowing it to promote or inhibit the transcription of a selected set of genes.

---

**Nuclear receptors and hormones in human physiology** (p.538)

Testosterone receptor in sexual development.

Testosterone receptor is required not only in one cell type but also in many cell type to produce the whole range of features that distinguish men from women.