

CELLULAR MESSAGING

- Cell-to-cell communication is essential for both multicellular and unicellular organisms.
- Biologists have discovered some universal mechanisms of cellular regulations.
- Cells most often communicate with each other via chemical signals.
- A **signal transduction pathway** is a series of steps by which a signal on a cell's surface is converted into a specific cellular response.
- Signal transduction pathways convert signals on a cell's surface into cellular responses.
- Pathway similarities suggest that ancestral signaling molecules evolved in prokaryotes and were modified later in eukaryotes.

Local and Long-Distance Signaling

- Cells in a multicellular organisms communicate by chemical messengers.
- Animal and plant cells have cell junctions that directly connect the cytoplasm of adjacent cells.
- In local signaling, animal cells may communicate by direct contact, or cell-cell recognition.

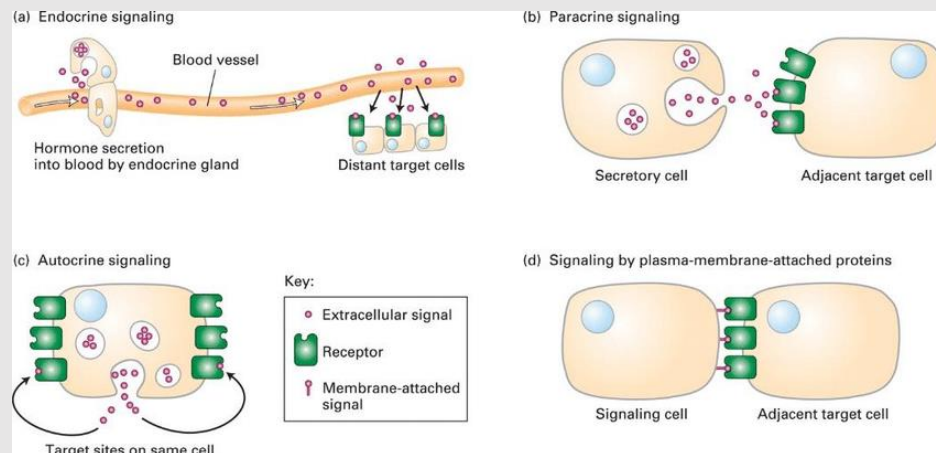
TYPES OF LOCAL CELL SIGNALING:

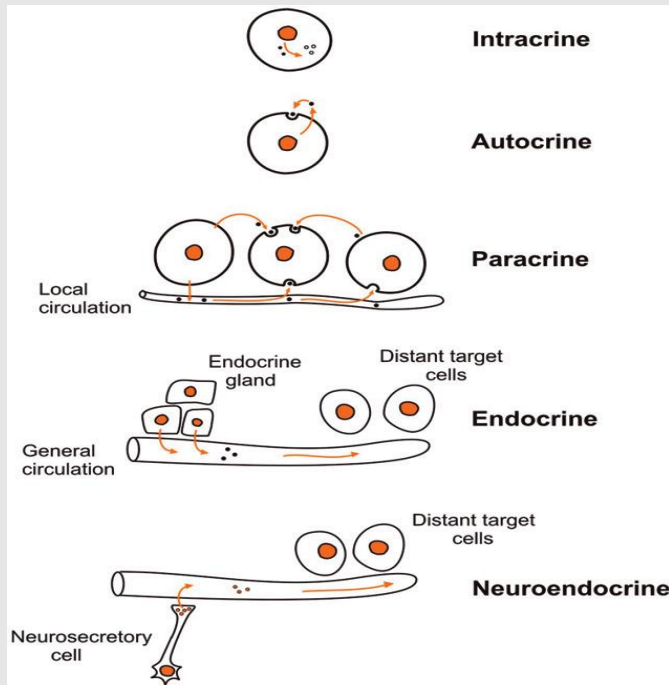
1. **Intracrine** signaling

2. **Autocrine** signaling

3. **Juxtacrine** signaling

4. **Paracrine** signaling





INTRACRINE SIGNALLING

Intracrine signaling is a mechanism of growth control involving the direct action of growth factors within the cell. Some growth factors produce factor/receptor complexes at the cell surface and are rapidly internalized by the cell in question and translocated to the nucleus without degradation.

AUTOCRINE SIGNALING

Autocrine signals are produced by the target cells are secreted and affect the target cells itself via receptors. Sometimes autocrine cells can target cells close by if they are the same type of cell as the emitting cell. An example is an immune cell.

JUXTACRINE SIGNALING

Juxtacrine signals target adjacent cells. These signals are transmitted along cell membranes via protein or lipid components integral to the membrane and are capable of affecting either the emitting cell or cells immediately adjacent

PARACRINE SIGNALING

Paracrine signaling is a form of cell **signaling** or cell-to-cell communication in which a cell produces a **signal** to induce changes in nearby cells, altering the behaviour of those cells.

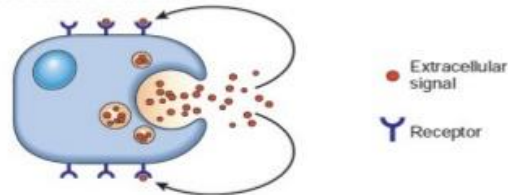
Paracrine signals target cells in the vicinity of emitting cells. An example is neurotransmitters.

How these cells respond to other factors

Autocrine:

Cells have receptors for their own secreted factors (liver regeneration)

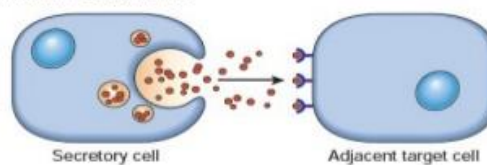
AUTOCRINE SIGNALING



Paracrine:

cells respond to secretion of nearby cells (healing wounds)

PARACRINE SIGNALING



Endocrine:

cells respond to factors (hormones) produced by distant cells

ENDOCRINE SIGNALING

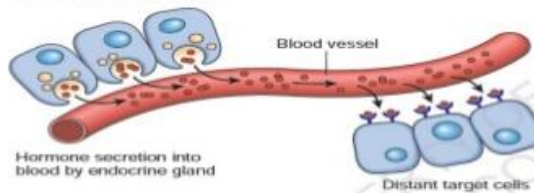


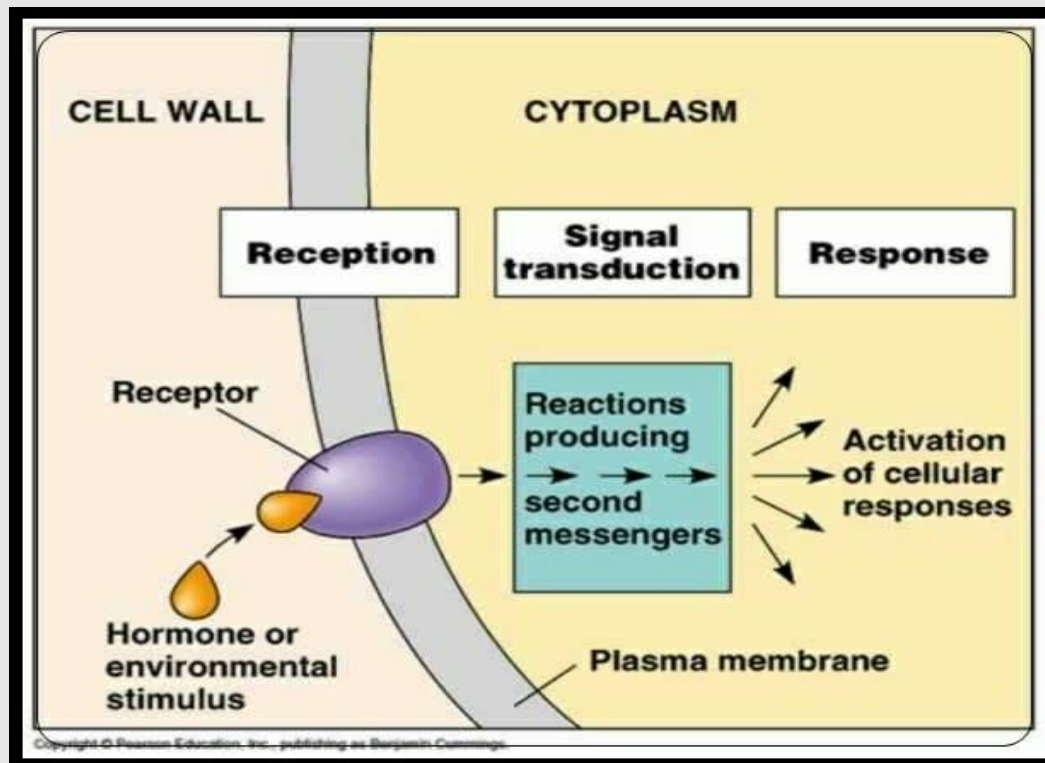
Fig: local signaling (autocrine & paracrine) long distance(endocrine)

- In many other cases, cells communicate using local regulators, messenger molecules that travel only short distances.
- In long-distance signaling, plants and animals use chemicals called **hormones**.
- The ability of a cell to respond to a signal depends on whether or not it has a receptor specific to that signal.

The Three Stages of Cell Signaling

Sutherland suggested that cells receiving signals went through three processes.

- ⚙ Reception
- ⚙ Transduction
- ⚙ Response



☀ **Reception**

A signaling molecule binds to a receptor protein, causing it to change shape.

- The binding between a signal molecule (**ligand**) and receptor is highly specific.
- A shape change in a receptor is often the initial transduction of the signal.

Most signal receptors are plasma membrane proteins.

Receptors in the Plasma Membrane

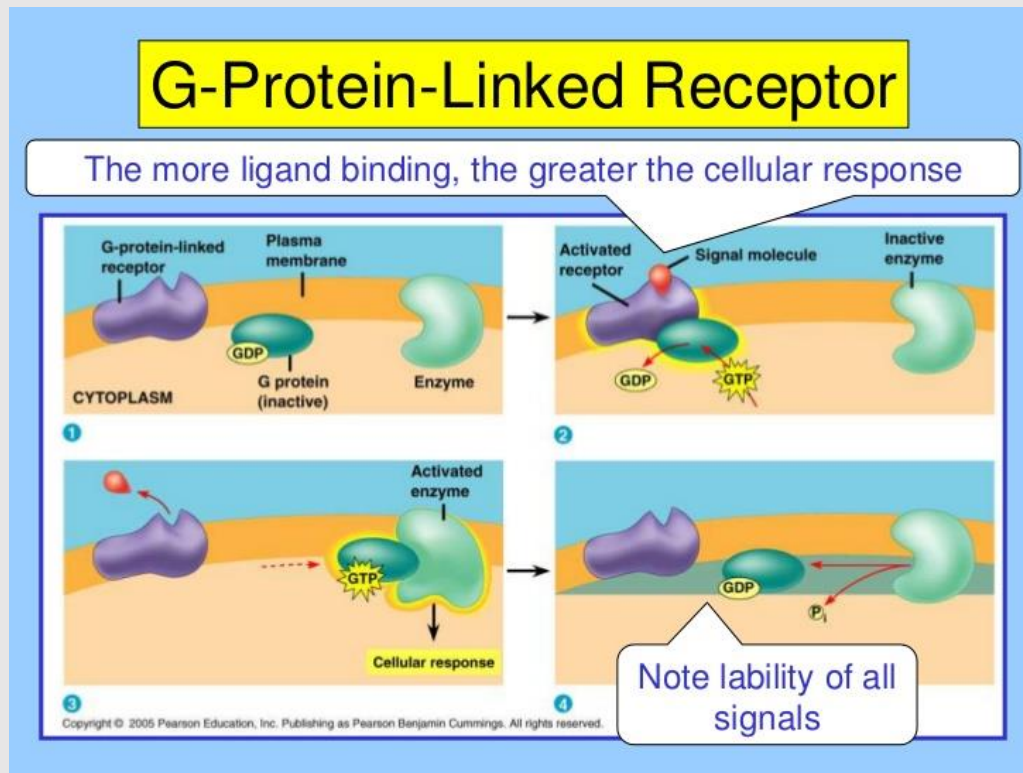
- Most water-soluble signal molecules bind to a specific site on receptor proteins that span the plasma membrane.

There are three main types of membrane receptors:

- ◆ G protein-coupled receptors
- ◆ Receptors tyrosine
- ◆ Ion channel receptors

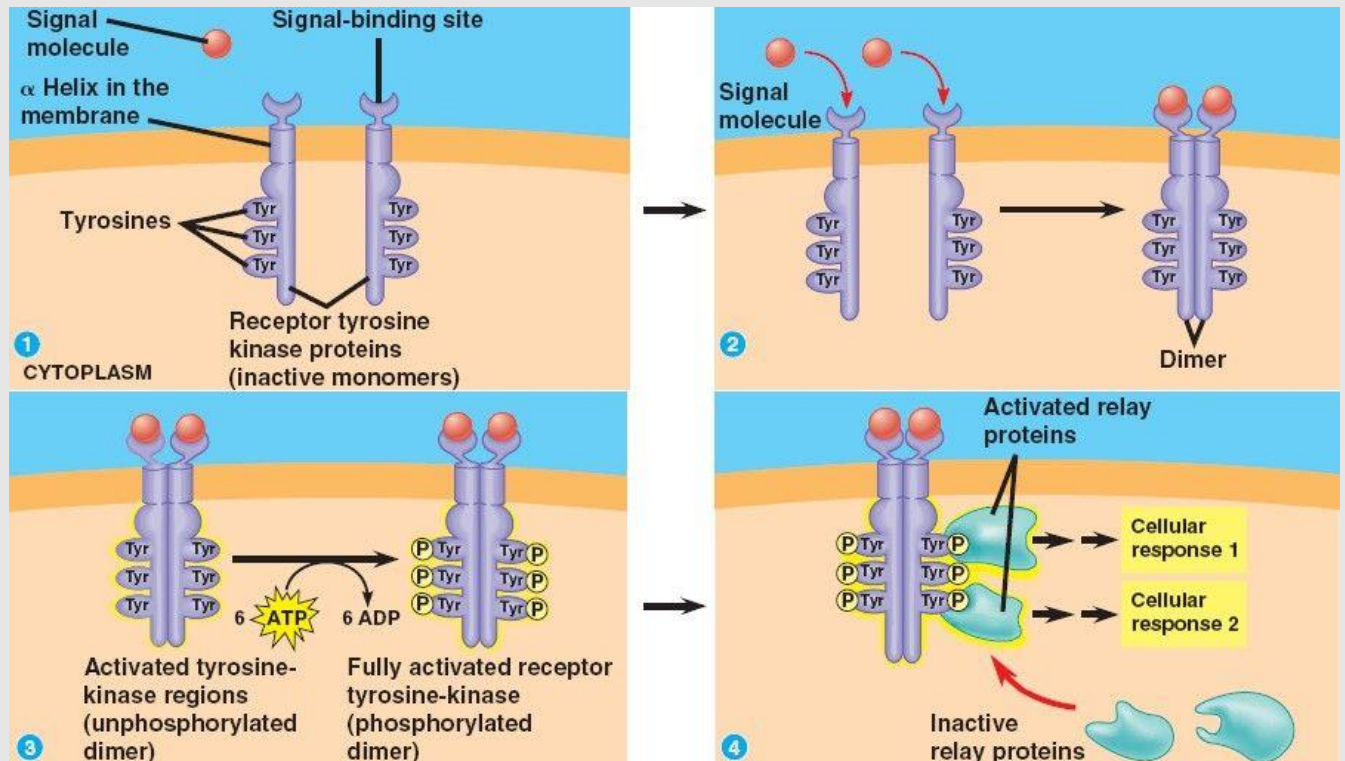
◆ **G protein-coupled receptors (GPCRs)** are the largest family of cell-surface receptors.

- A GPCR is a plasma membrane receptor that works with the help of a **G protein**.
- The G protein acts as an on/off switch: If GDP is bound to the G protein, the G protein is inactive.



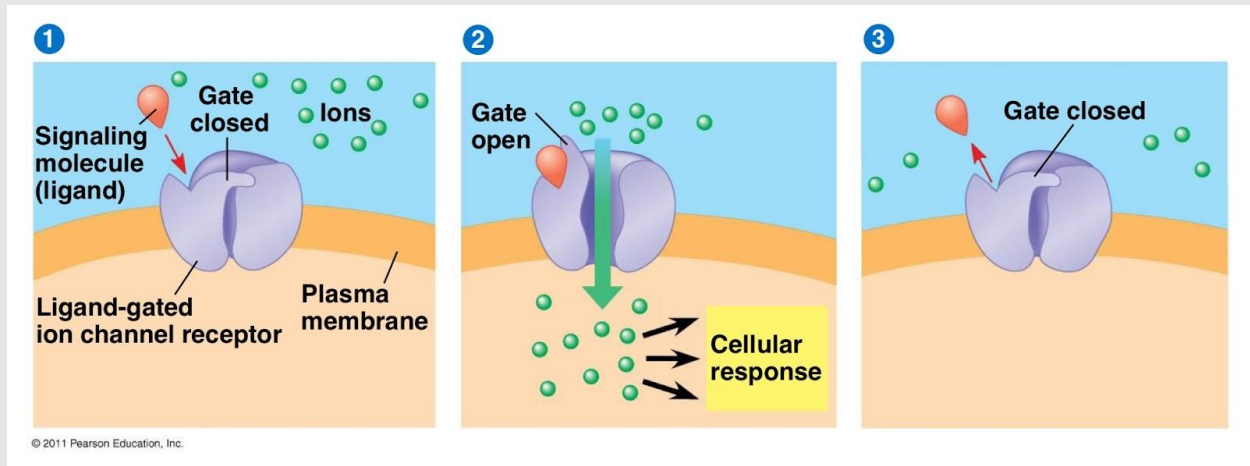
◆ **Receptor tyrosine kinase (RTKs)** are membrane receptors that attach phosphates to tyrosines.

- A receptor tyrosine kinase can trigger multiple signal transduction pathways at once.
- Abnormal functioning of RTKs is associated with many types of cancer.



💧 A **ligand-gated ion channel** receptors acts as a gate when the receptor changes the shape.

- When a signal molecules binds as a ligand to the receptor, the gate allows specific ions, such as Na^+ and Ca^{2+} , through a channel, in the receptor.



Intercellular Receptors

- Intracellular receptor proteins are found in the **cytosol** or **nucleus** of target cell.
- Small or hydrophobic chemical messengers can readily cross the membrane and activate receptors.
- **Examples** of hydrophobic messenger are the **steroid** and **thyroid** hormones of animals (prokaryotes or eukaryotes)
- An activated hormone-receptor complex can act as a transcription factor, turning on specific genes.

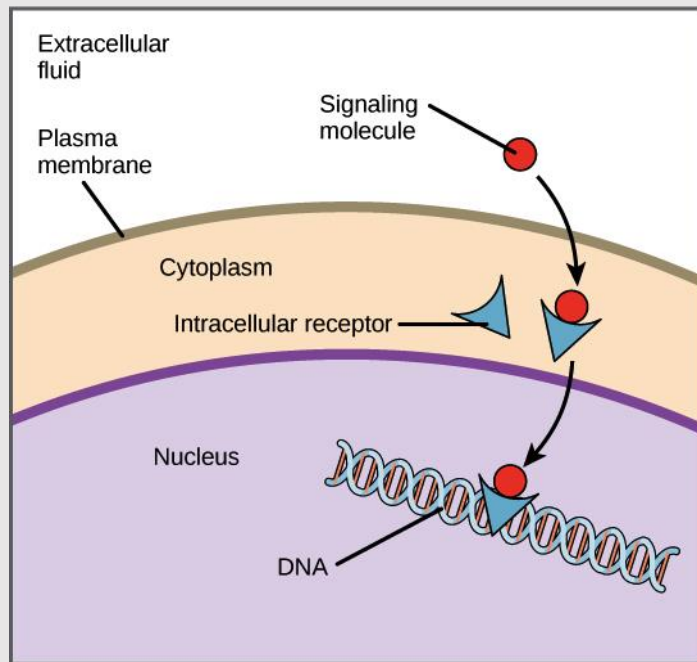


Fig:Intracellular receptor

☀ **Transduction**

Cascades of molecular interactions relay signals from receptors to target molecules in the cell.

- Signal transduction usually involves multiple steps.
- Multistep pathways can amplify a signal: A few molecules can produce a large cellular response.
- Multistep pathways provide more opportunities for coordination and regulation of the cellular response.

💧 **Signal Transduction Pathways**

- The molecules that relay a signal from receptor to response are mostly proteins.
- Like falling dominoes, the receptor activates another protein, which activates another, and so on, until the protein producing the response is activated.
- At each step, the signal is transduced into a different form, usually a shape change in a protein.

💧 **Protein Phosphorylation and Dephosphorylation**

- In many pathways, the signal is transmitted by a cascade of protein phosphorylation
- **Protein kinase** transfer phosphates from ATP to protein, a process called **phosphorylation**.
- **Protein phosphatases** remove the phosphates from proteins, a process called **dephosphorylation**.

This phosphorylation and dephosphorylation system acts as a molecular switch, turning activities on and off or up or down, as required.

💧 **Second Messenger**

- The extracellular signal molecule (ligand) that binds to the receptor is a pathway's "first messenger".
- **Second messenger** are small, nonprotein, water-soluble, molecules or ions that spread throughout a cell by diffusion.
- Second messenger participate in pathways initiated by GPRs and RKTs.
- **Cyclic AMP and Calcium ions** are common second messenger.
- **Cyclic AMP (cAMP)** is one of the most widely used second messenger.
- **Adenylyl cyclase**, enzyme in plasma membrane, converts ATP to cAMP in response to an extracellular signal.
- **Calcium ions** act as a second messenger in many pathways.
- **Calcium** is an important second messenger because cells can regulate its concentration.

A phosphorylation cascade

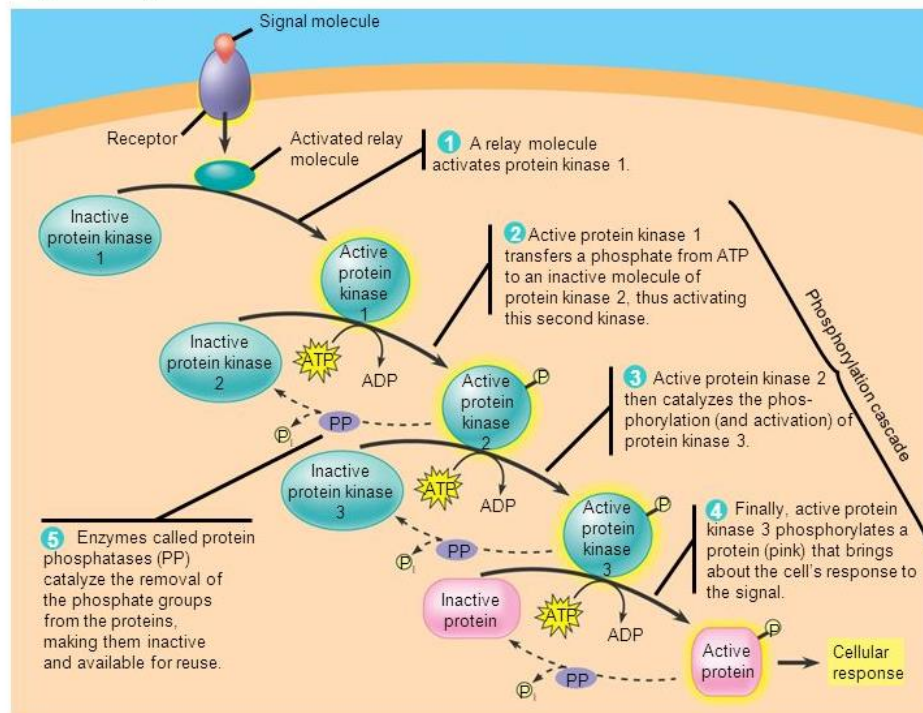


Figure 11.8

⚙️ Response

The cell's response to an extracellular signal is sometimes called the "output response".

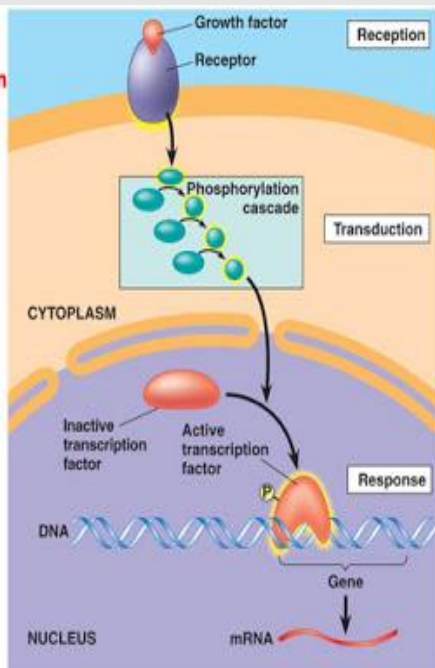
💧 Nuclear and Cytoplasmic Responses

- Ultimately, a signal transduction pathway leads to regulation of one or more cellular activities.
- The response may occur in the cytoplasm or in the nucleus.
- Many signaling pathways regulate the synthesis of enzymes or other proteins, usually by turning genes on or off in the nucleus.
- The final activated molecule in the signaling pathway may function as a **transcription factor**.

Other pathways regulate the activity of enzymes rather than their synthesis.

- Signaling pathways can also affect the overall behaviour of a cell, **for example**, changes in cell shape

11.14 gene activation



11.8 steroids

