BIO 311C
Spring 2010

Your graded Exam 3 will be available for you to pick up at the end of Wednesday's lecture.

The key to Exam 3 will be posted on the course web site on Wednesday (April 21).

If you believe that a question on your Exam 3 was graded incorrectly or your score was calculated inaccurately, then see Rebecca before 4:00 p.m. on Monday (April 26) to explain your concern. We cannot consider changes after that time.

Lecture 32 – Monday 19 Apr.

Cell Communication

The lecture/PowerPoint presentation on Cell Communication is abbreviated, so Final Exam questions on that topic may rely more heavily on information contained in the textbook reading assignment than is the case for other topics covered in this course.

*

Cells sense and respond to their environment in various ways.

Example 1:

food, energy → **Living Cell** (*metabolism*) → wastes

The cell senses sources of food/energy in the environment and responds by utilizing specialized mechanisms to incorporate and metabolize these substances, then selectively discard wastes.

Example 2:

biological, physical or chemical assault on the cell → **Living Cell** (*altered metabolism (fight back, adjust, or die)*)

The cell senses an agent of potential damage in the environment and responds by (1) generating a counteractive assault, (2) by protecting itself in some way from the danger, and/or (3) by dying, often by a carefully regulated mechanism called apoptosis.

*

Single-celled (unicellular) organisms often communicate via chemical signals.

Example : a unicellular eukaryote species containing males and females

Organism of One Sex		Organism of Opposite Sex
Produces a chemical substance intended to alert another cell	→ sexual signal →	*Responds in a way that facilitates sexual reproduction*
signaling cell		responding cell

A unicellular organism senses a signal from an organism of the opposite sex, then responds by preparing to contact the signaling organism in order to transfer or combine combine genetic information.

Also see Textbook Fig. 11.2, p. 207.

*

The Cells within a complex multicellular organism communicate extensively via chemical signals.

Example: hormonal communication

Signaling cell
(produces and secretes a hormone)

Produces a chemical substance intended to solicit a response in another cell

→ **hormone** →
(a kind of signaling molecule)
Moves via body fluid throughout the body

Responding Cell
(responds to the hormone)

Response that may profoundly change characteristics of the cell

A hormone may be defined as:
a chemical substance that is produced in one kind of cell of a multicellular organism, and that is sensed by another kind of cell within the organism where it elicits a response.

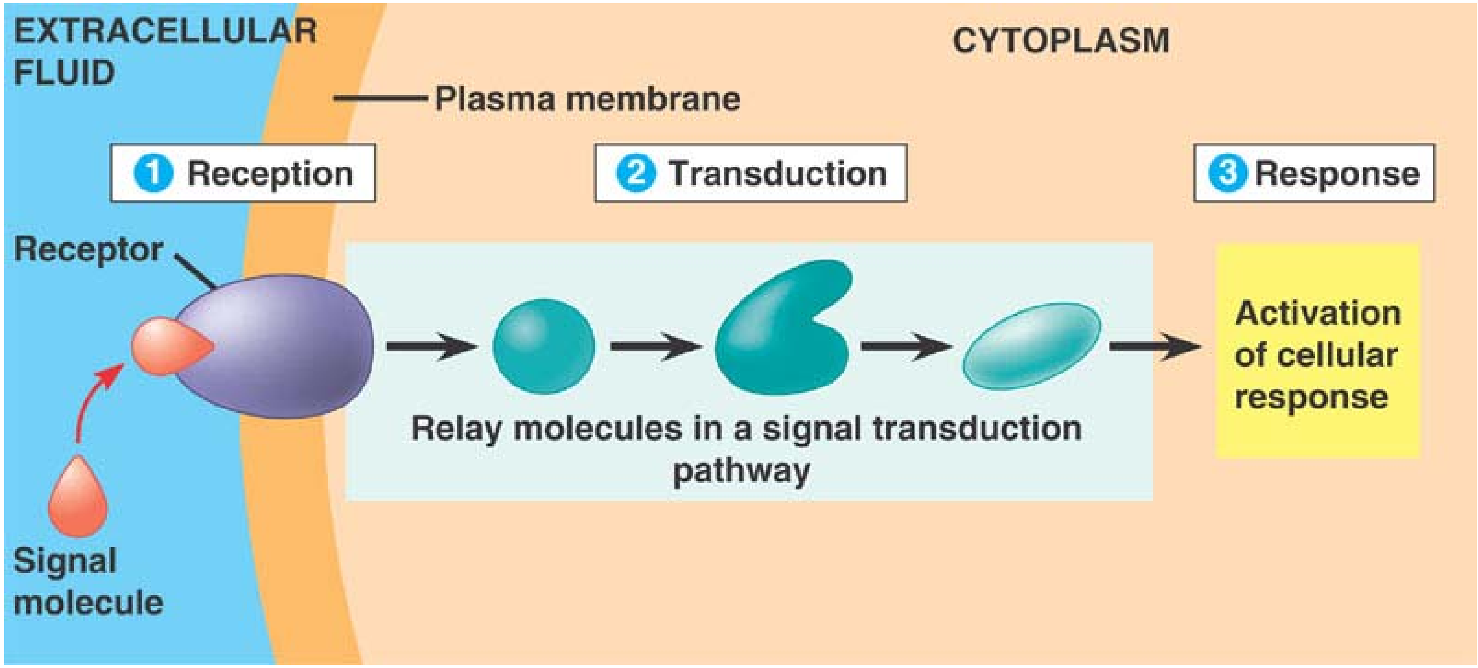
(Also see textbook glossary for a different wording of the definition.)

*

The results of a signal molecule reaching a responsive receptor cell can be divided into three stages

- signal reception
- signal transduction
- signal response

Textbook Fig. 11.6, p. 209.

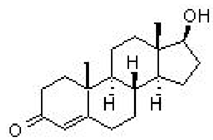


Receptor cell

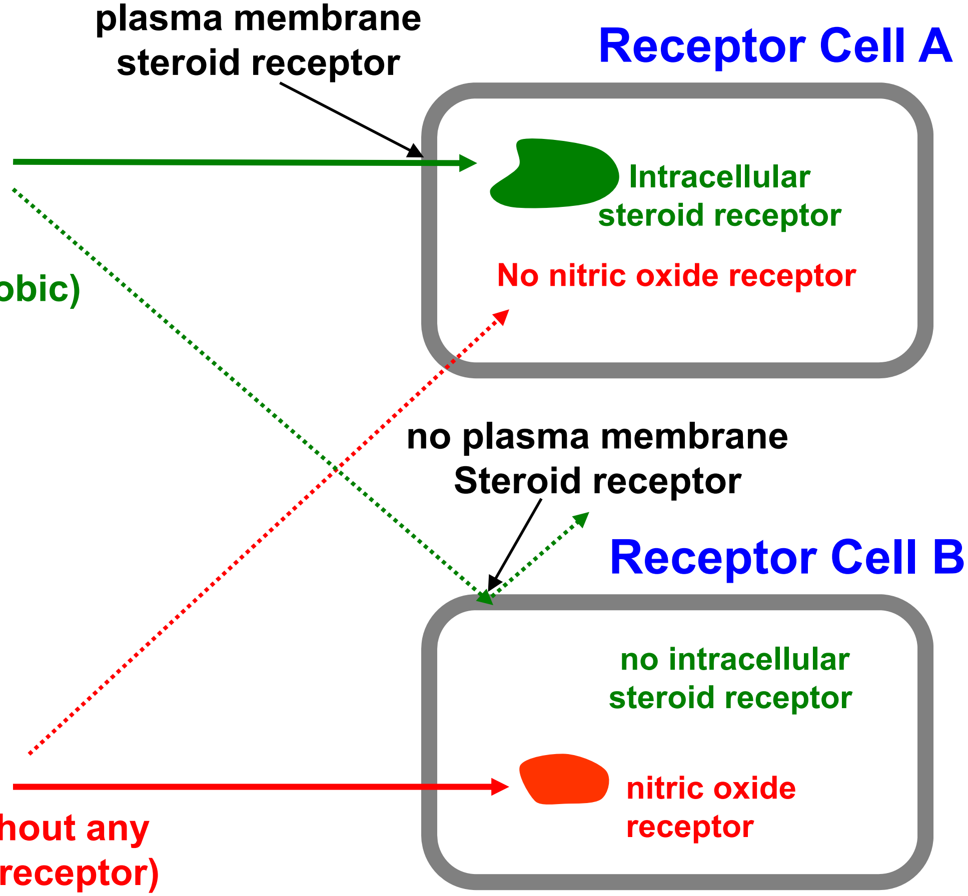
*

Some signal molecules pass through the plasma membrane and bind to a receptor in the cytoplasm

Examples:



a steroid
(very hydrophobic)



Steroid hormones and nitrous oxide are produced within specific cells in the body and circulate throughout the body.

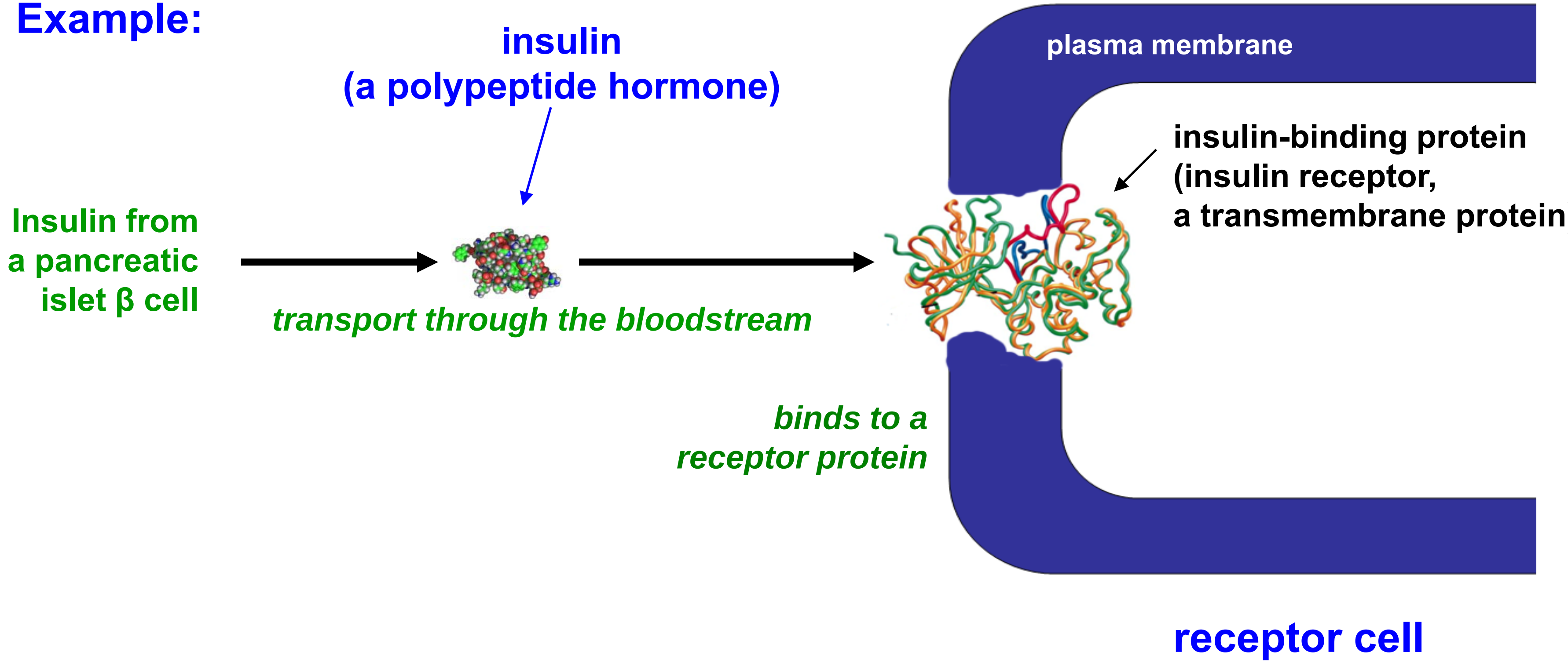
nitric oxide
(NO, a gas)
(enters the cell without any plasma membrane receptor)

A signal molecule is only perceived by a cell that contains a receptor molecule which recognizes that specific signal molecule.

*

Insulin-binding protein, and example of a transmembrane signal receptor protein.

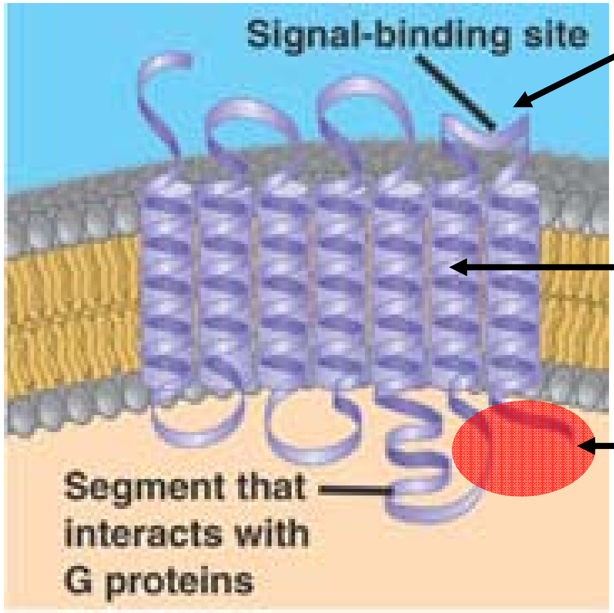
Example:



*

<u>G-protein-linked receptors</u> are transmembrane proteins that relay a signal from a signaling molecule on the external face of the plasma membrane to a G protein on the cytoplasmic face of the plasma membrane.

See textbook fig. 11.7, p. 211

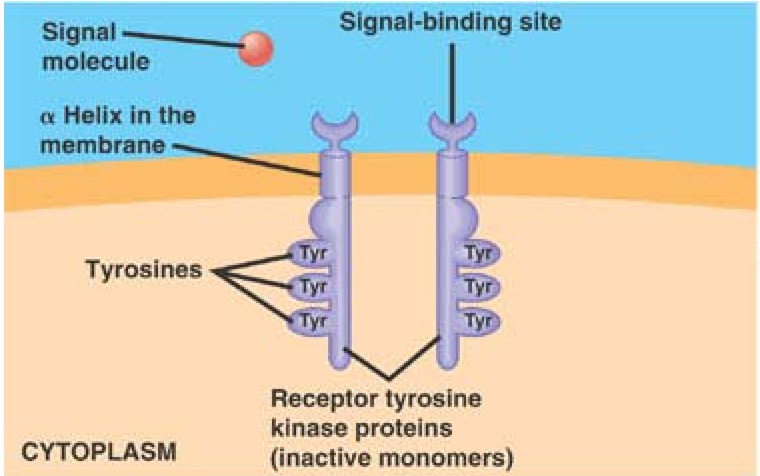


G-protein-linked receptors do not allow the signal molecule to enter the cell. Instead, the signal is <u>transduced</u> across the membrane.

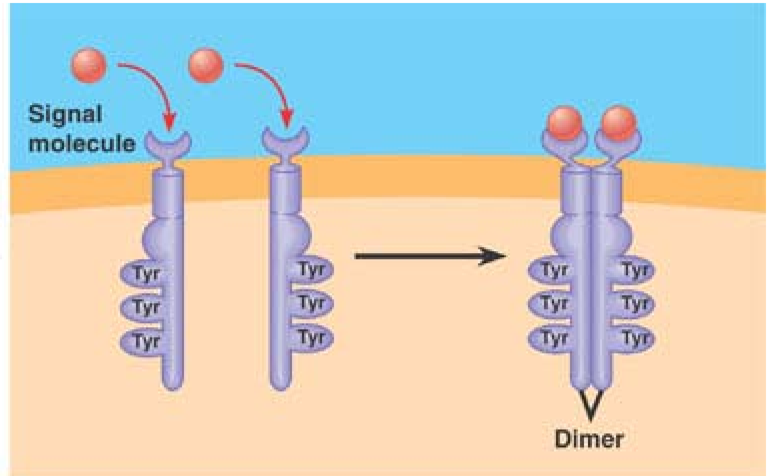
G proteins are a class of peripheral membrane proteins of eukaryotic cells. They initiate a signal transduction pathway when a signal molecule binds to a G-protein-linked receptor.

G-proteins are sometimes called <u>molecular</u> <u>switches</u> because, when activated, they in turn activate a signal transduction pathway which results in switching certain metabolic pathways on and others off. *

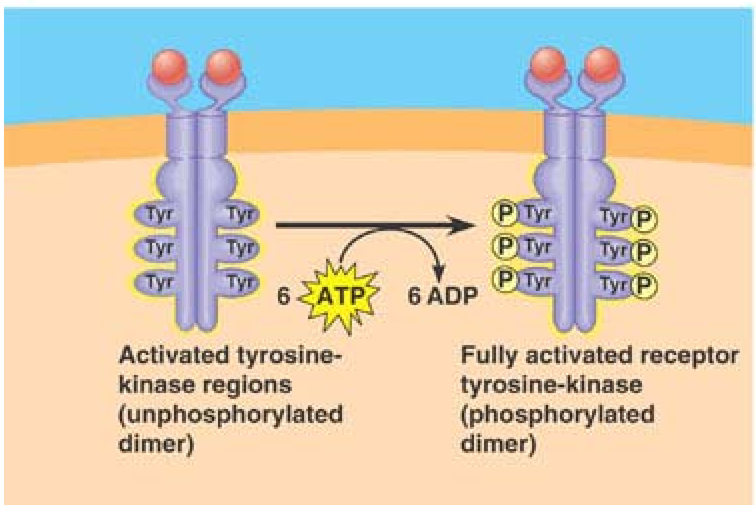
Activation of a Tyrosine Kinase Receptor



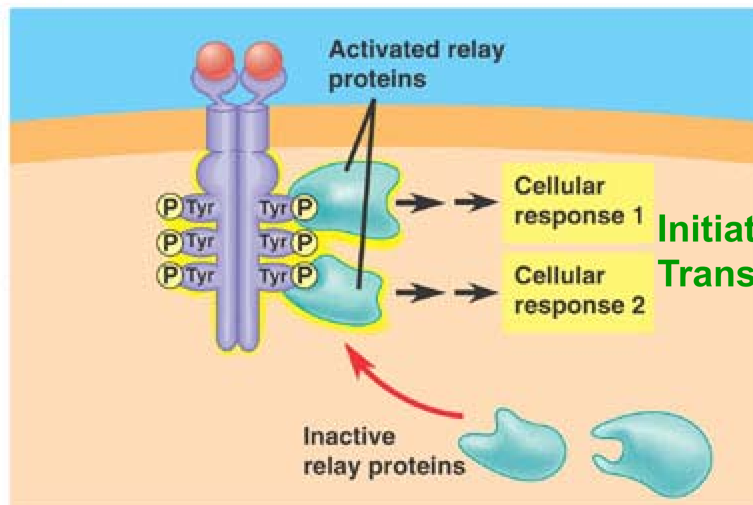
1 Two protein subunits separated



2 Bound signal molecules causes dimer formation



3 Each protein monomer catalyzes phosphorylation of the other monomer



Initiation of signal Transduction pathways

4 Phosphorylated receptor tyrosine kinase elicits one or more responses

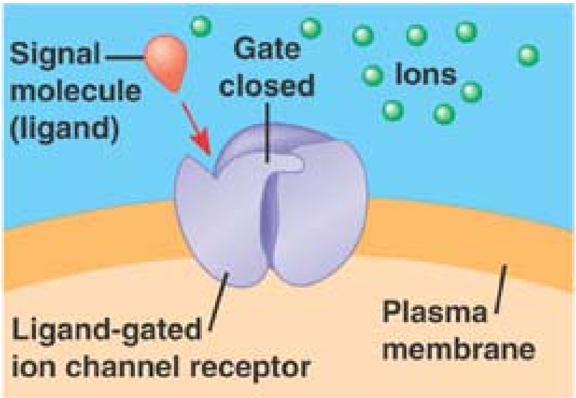
Enzymes that transfer a phosphate functional group from ATP to another molecule are often called kinases. Tyrosine is the name of one of the 20 different kinds of amino acids that occur in all proteins.

*

Activation and De-activation of a Ion Channel Receptor

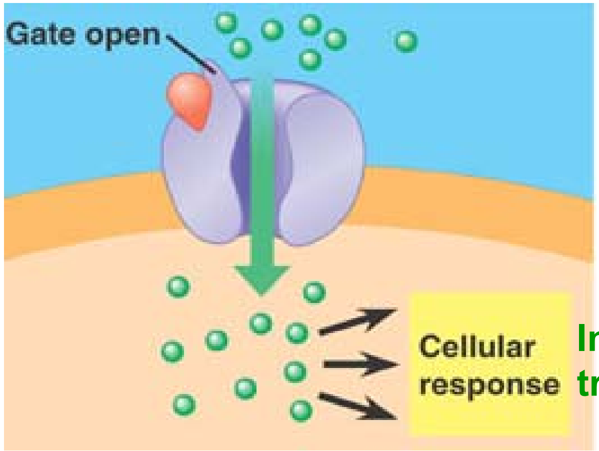
From textbook Fig. 11.7, p. 213

1



Gate is closed before the signal binds to the receptor.

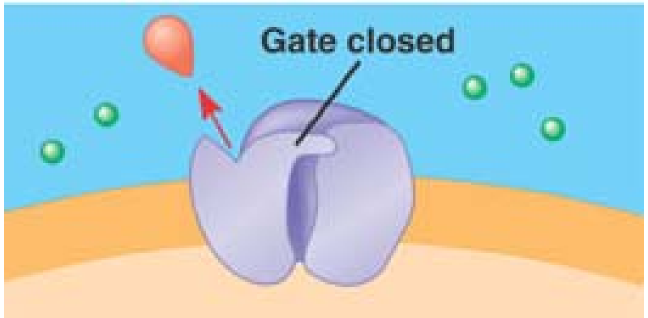
2



Initiation of signal transduction pathways

Gate opens in response to signal binding, allowing a specific kind of ion to pass freely through the channel in the receptor.

3

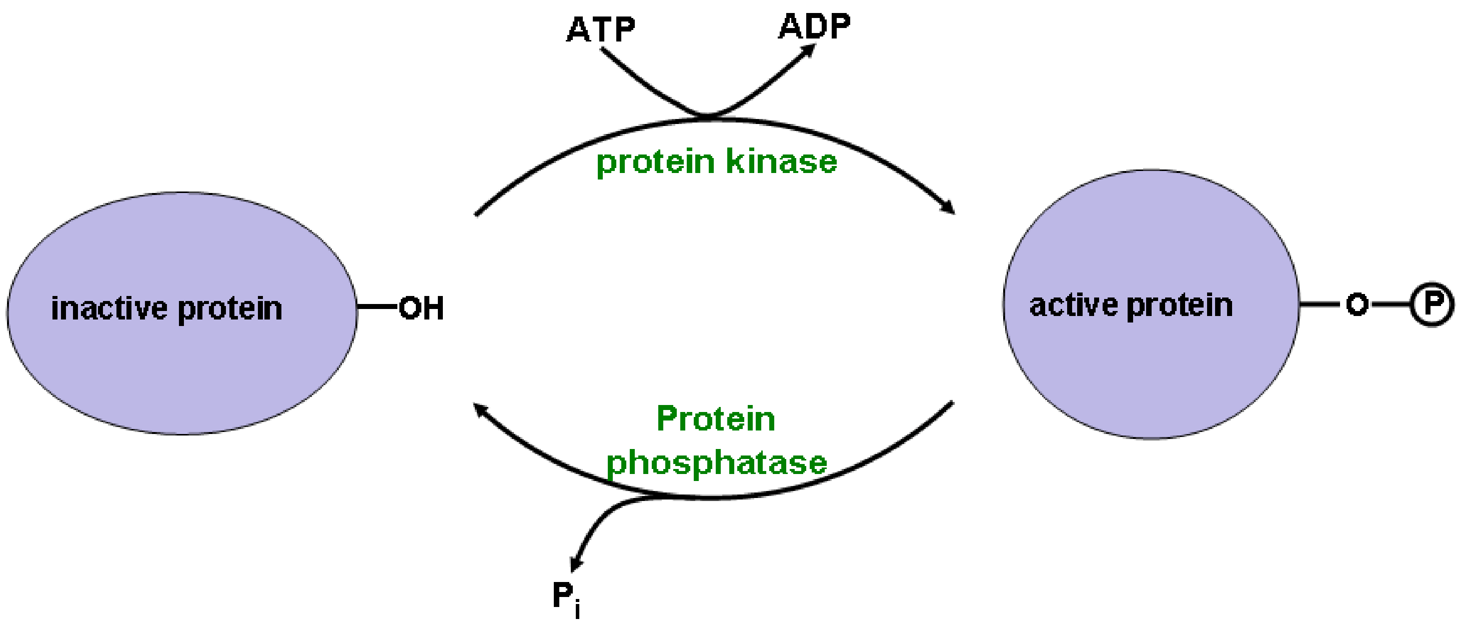


Gate closes when the signal molecule is released from the receptor.

A ligand is a molecular species that bonds to (sometimes described as "clasping") another molecular species without using covalent bonds.

*

Many signals are transduced in cells in the form of proteins that are inactive in a non-phosphorylated state, but are active when phosphorylated.



A protein kinase (abbreviated PK) is an enzyme that transfers a phosphate functional group from ATP to an alcohol functional group of an R-group on an amino acid in a protein.

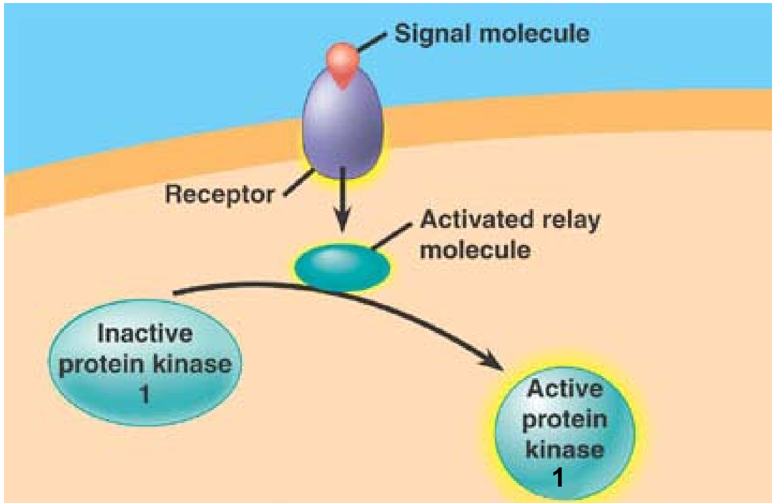
A protein phosphatase (abbreviated PP) is an enzyme that removes a phosphate functional group from a protein and releases it as inorganic phosphate (P_i).

Recall that the symbol Ⓟ refers to a phosphate functional group.

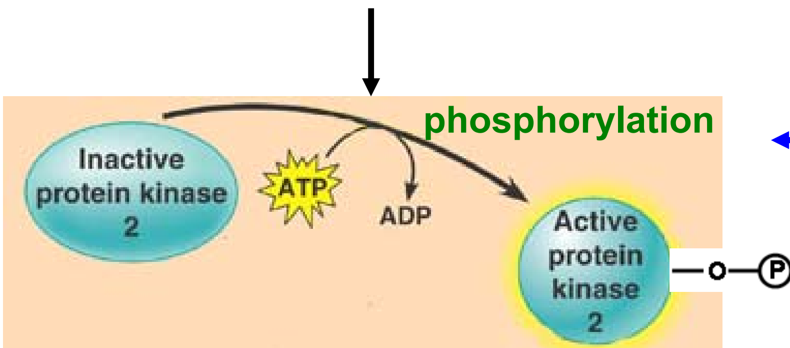
*

The initial steps of a signal reception and signal transduction sequence that uses protein kinases

From textbook Fig. 11.9, p. 215.



1. Signal molecule attaches to receptor
2. Signal receptor activates a relay molecule.
3. Relay molecule activates PK1.



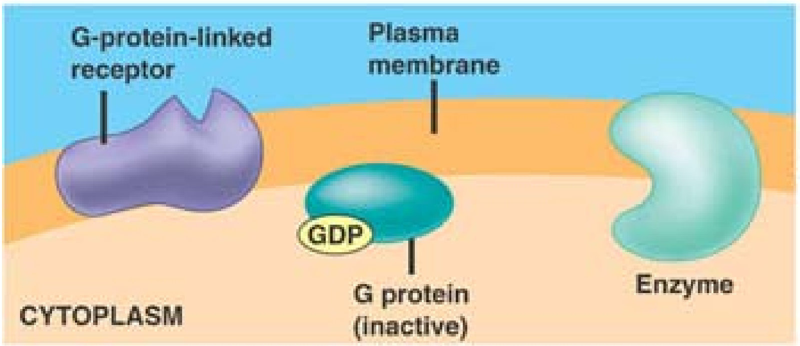
4. PK1 catalyzes the phosphorylation of PK2, thereby activating it.
5. (not shown) PK2 phosphorylates another protein.

In many signal transduction sequences, after a protein becomes phosphorylated by a kinase, then it, itself, becomes an active kinase and phosphorylates another protein.

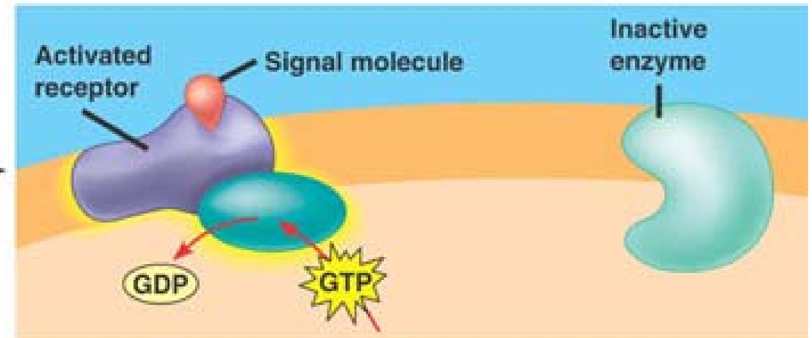
*

G-proteins are activated as the first step in many different signal transduction pathways.

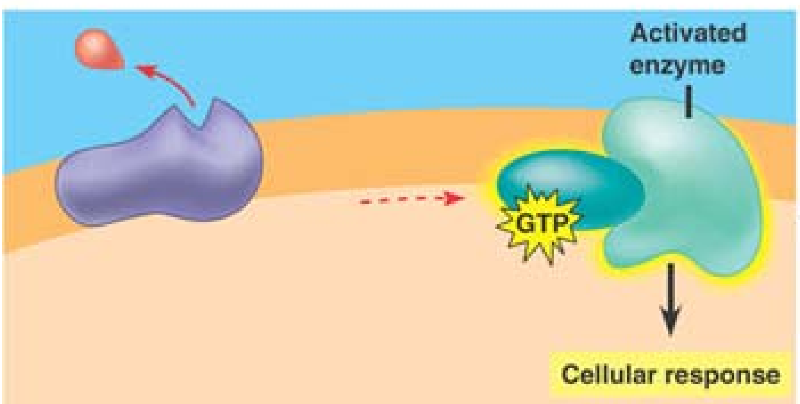
From textbook Fig. 11.7, p. 211



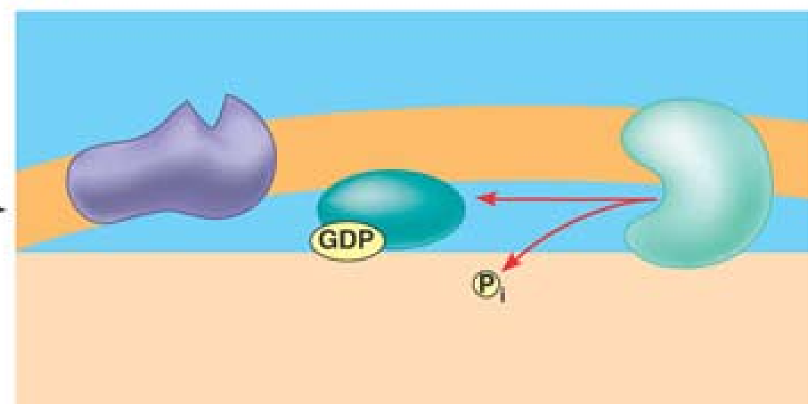
❶ Inactive G protein (no signal molecule)



❷ signal molecule bound, activates G protein



❸ Activated G protein initiates a signal transduction sequence by activating an enzyme. Eventually the signal molecule is released from its receptor.

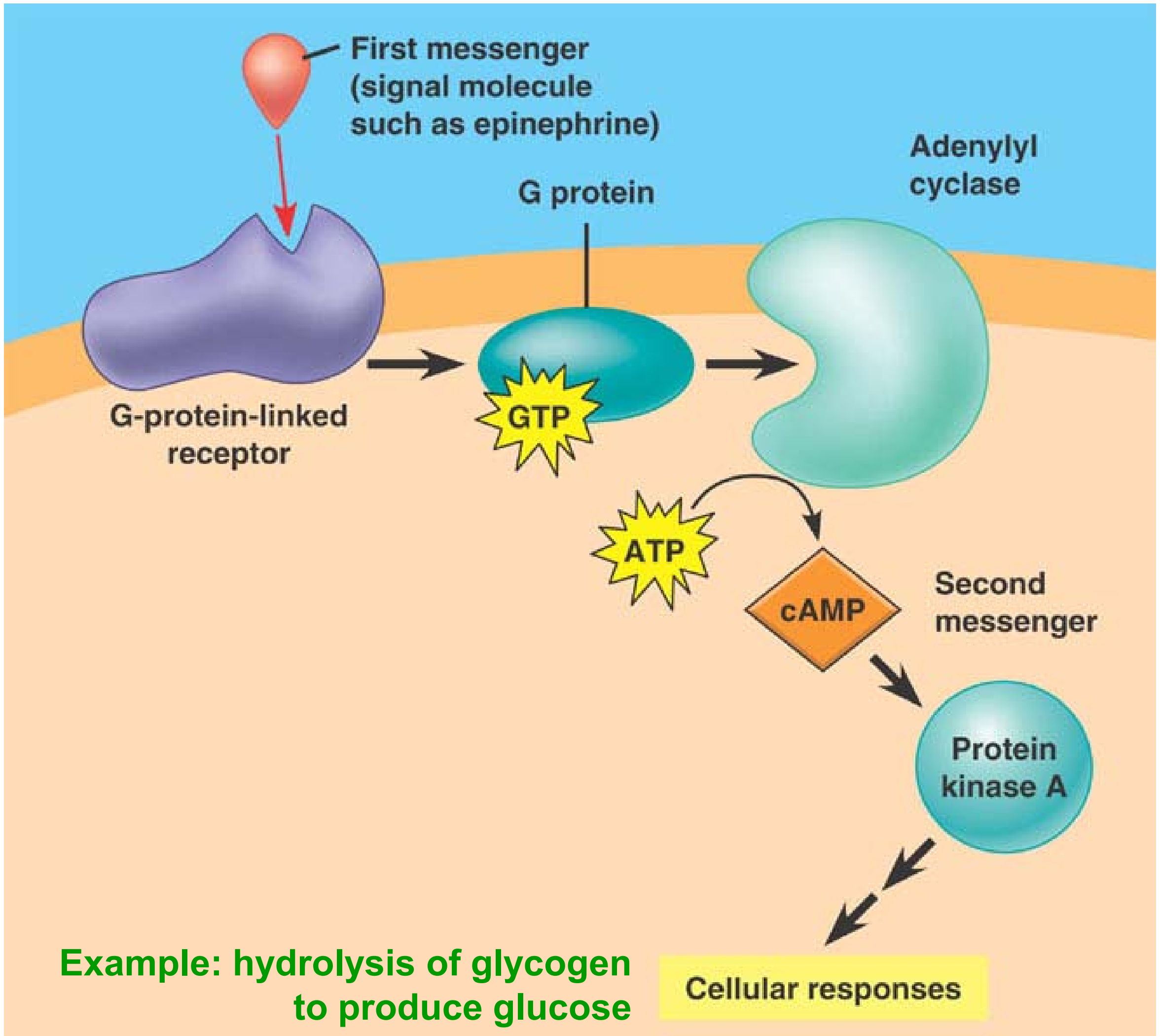


❹ After a time the GTP is hydrolyzed to GDP, inactivating the G protein by facilitating its release from the enzyme and inactivating the signal transduction pathway.

*

Cyclic AMP and protein kinases often participate in G-protein mediated signal transduction pathways.

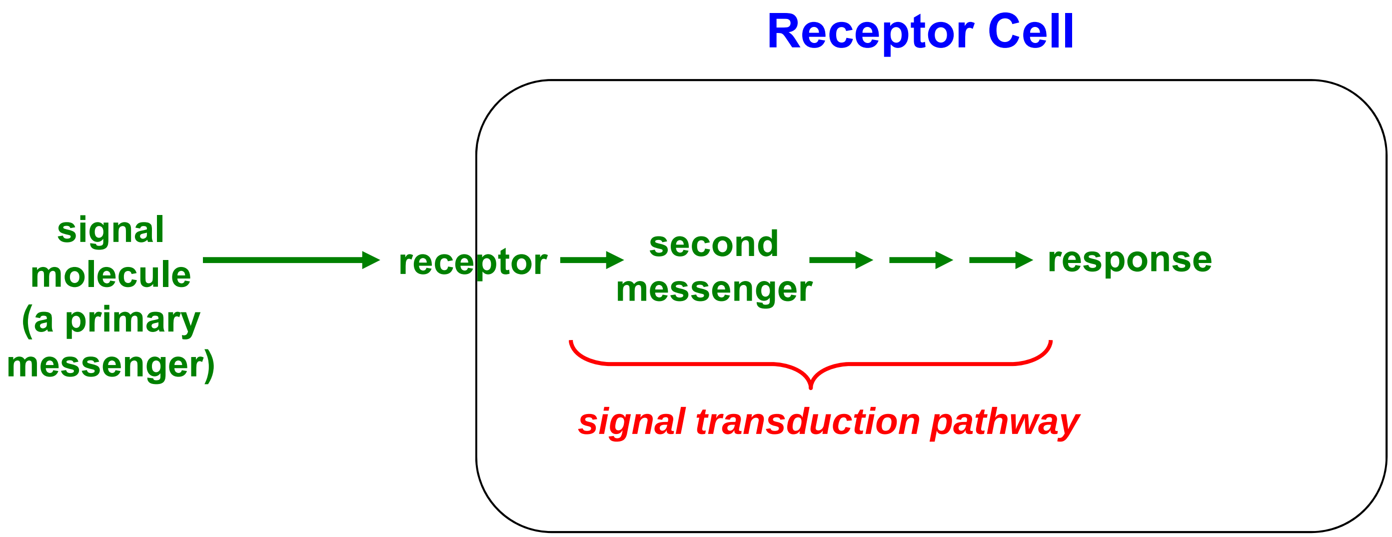
Textbook Fig. 11.11, p. 216 (also see Fig. 11.13, p. 218)



*

Most components of signal transduction pathways are proteins, and many of these proteins have enzymatic activity.

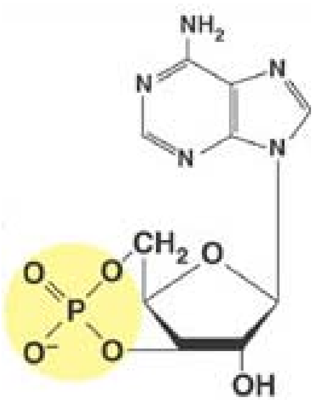
A few signal transduction components are not proteins, but are small molecules or ions. These small chemical species that participate in an early step in a signal transduction pathway are called "second messengers".



*

Two of the most important second mesenger molecules in cells are cyclic AMP and calcium ions (Ca^{2+}).

From textbook Fig. 11.10, p. 216



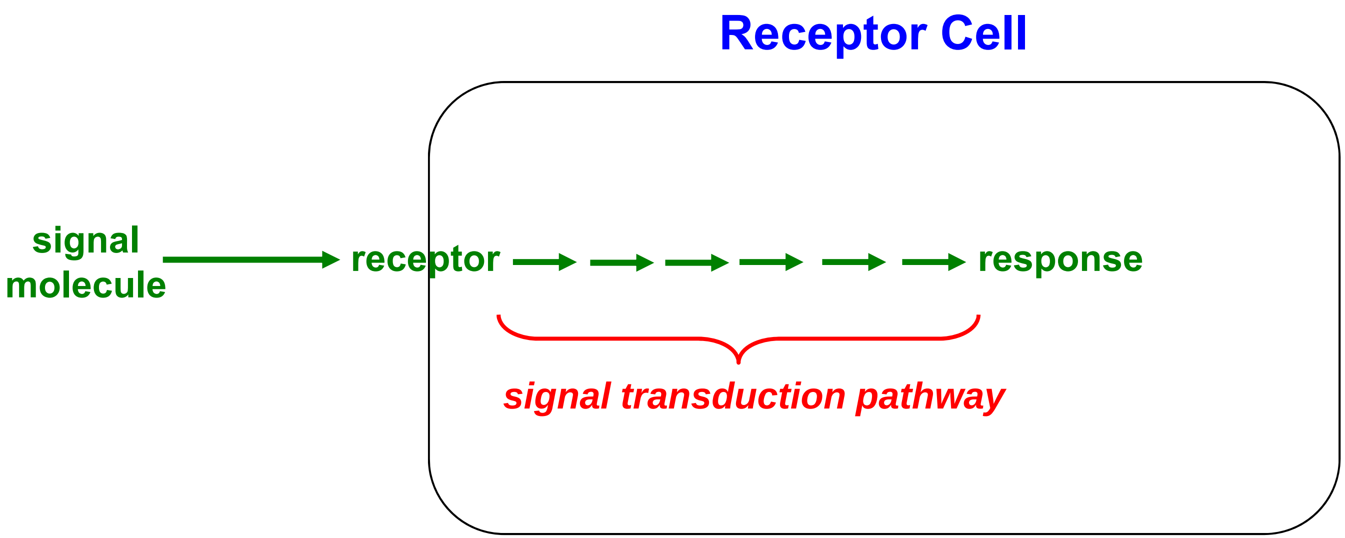
Cyclic AMP

Also see Lecture 17, Slide 31.

Textbook Fig. 11.7 (p. 213) and Fig. 11.12 (p. 217) illustrate ways in which Ca^{2+} serves as a second messenger.

*

Signal transduction pathways generally involve several or many sequential steps rather than a single step from signal reception to a final response.



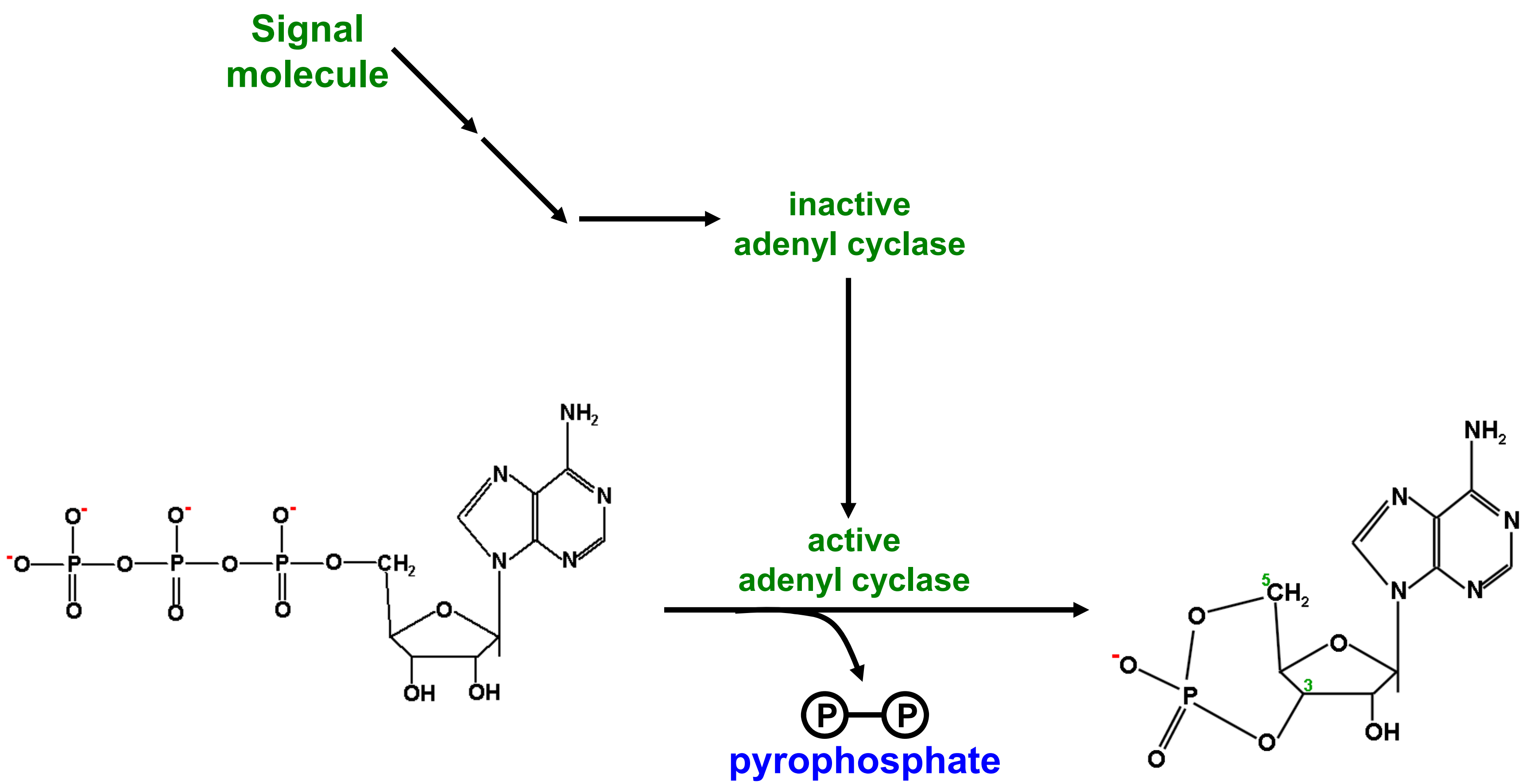
Questions:

How do signal transduction pathways differ from metabolic pathways?

Why do signal transduction pathways use multiple sequential steps rather than a single step?

*

Synthesis of Cyclic ATP in Signal Transduction Pathways



ATP

Cyclic AMP

Also textbook Fig. 11.10, p. 216.

*

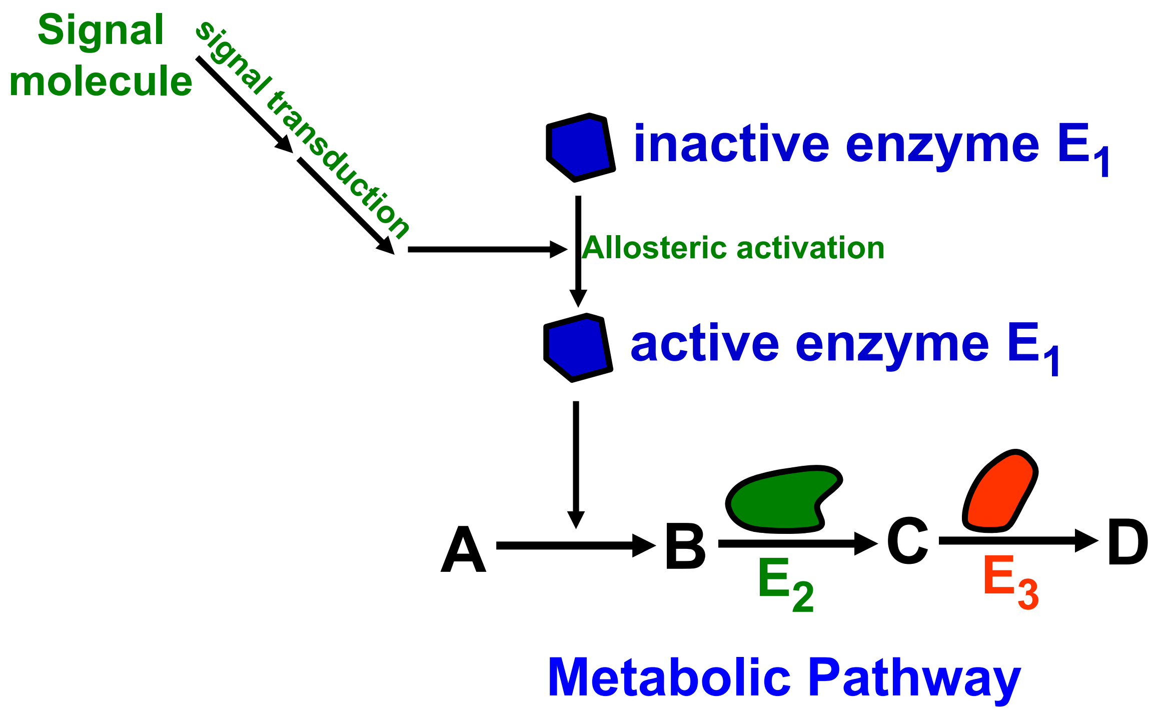
Typical responses of signal transduction pathways are:

- **the synthesis or modification of an allosteric affector that alters the rate or function of one or more metabolic pathways,**
- **an alteration in the rate of synthesis or destruction of one or more proteins.**

*

Example:

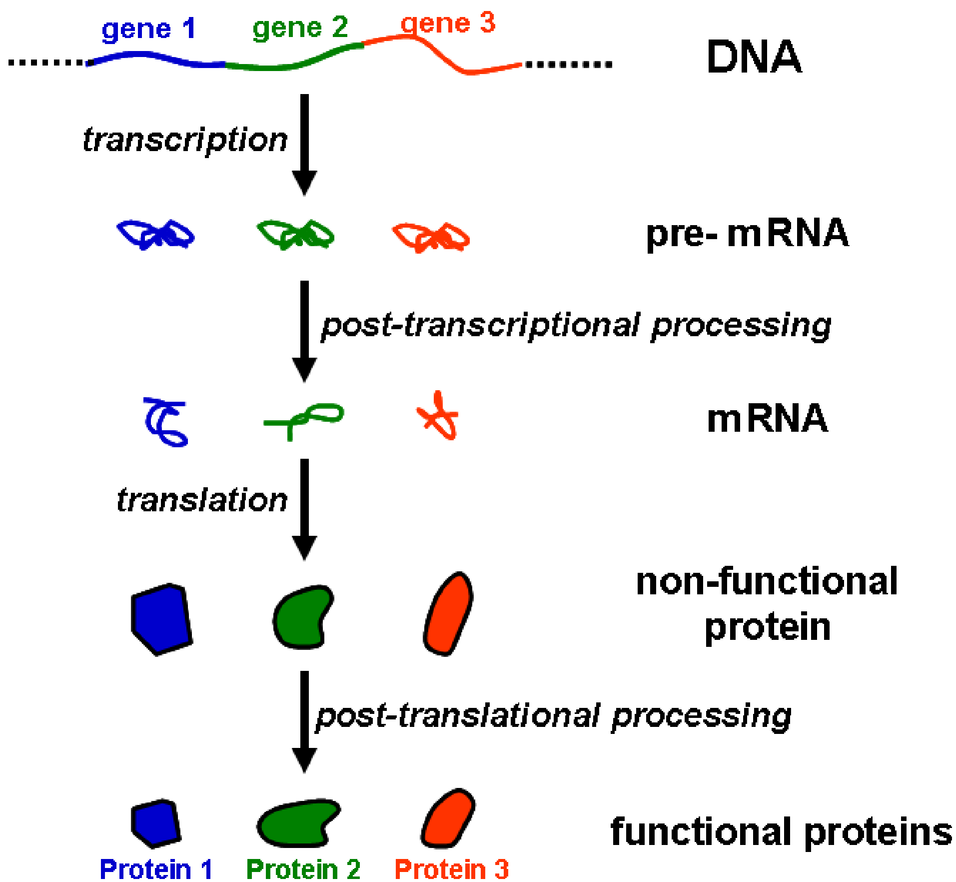
Allosteric Activation of a Metabolic Pathway Via a Signal Transduction Pathway



Product D can only be produced when enzyme E1 is active (functional).

*

Steps in the Synthesis of a Set of Functional Proteins

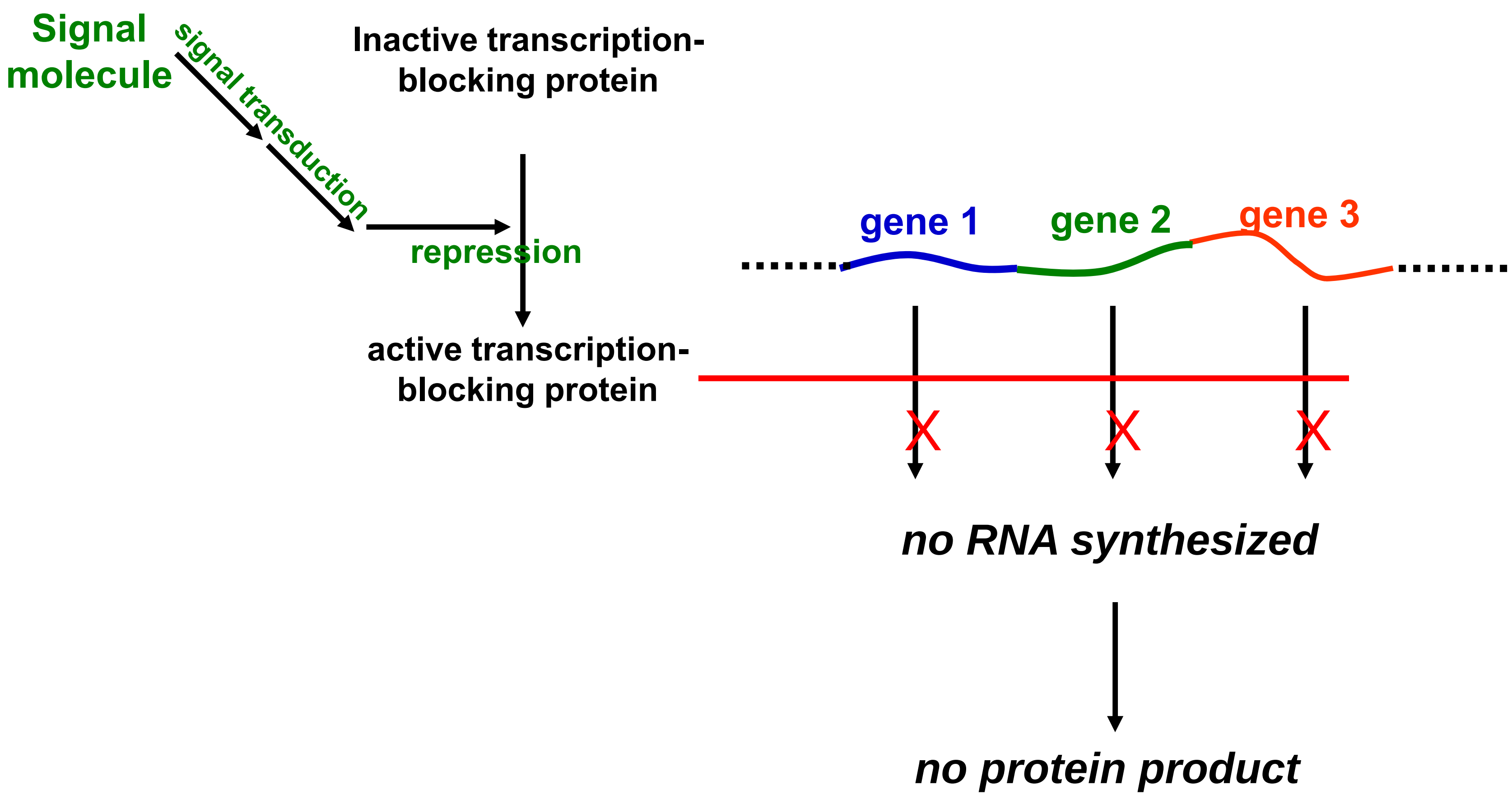


A final product of a signal transduction pathway might alter the rate of any of the steps (transcription, post-transcriptional processing, translation or post-translational processing) leading to the formation of one or more functional proteins.

*

Example:

Repression of Protein Synthesis by Repressing Transcription via a Signal Transduction Pathway



*