

Chapter 9
Cell-Cell Interactions

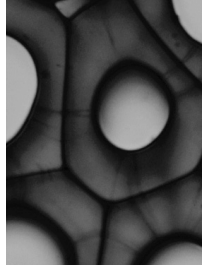
•Cell Signaling

- Receptor Proteins
 - Intracellular Receptors
 - Cell Surface Receptors

•Initiating the Intracellular Signal

•Amplifying the Signal

•Expression of Cell Identity (last chapter -reminder)



How do cells communicate?

- chemical signals (chemoelectric)
- electromagnetic signals
- mechanical signals

WHY DO CELLS COMMUNICATE?

- yeast *Saccharomyces cerevisiae* (bread, wine, and beer) identifies mate

- two sexes -**a** and *alpha*

signaling molecules

- **a** factor and *alpha* factor

- factors bind to receptor proteins on mate cells fuse



- **a/alpha** cell -genes of both

• microbes communicate

- Myxobacteria
- soil-dwelling
- chemical signals



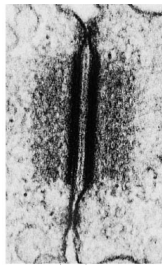
communicate nutrient availability

- food scarce- signal lead cells to aggregate and form thick-walled spores.

• Cell Communication
MULTICELLULAR

- Signaling molecule LIGAND
- Receiving molecule receptor

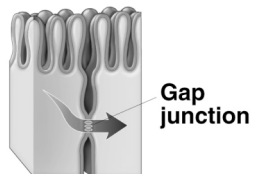
- Plant Cell Connections—
 - plasmodesmata
- Animal Cell Connections
 - gap junctions
 - transmitter/receptor



0.1 μm

- Cells sometimes communicate via direct contact

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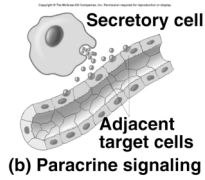
(a) Direct contact

• **local regulators**

influence all cells in vicinity

– *Paracrine signaling* –

– many cells respond to growth factors produced by single cell

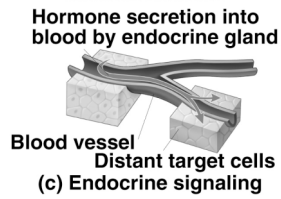


• Plants and animals - Endocrine signaling

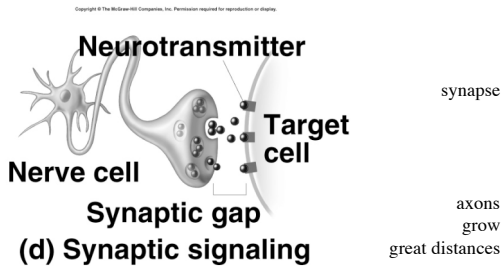
• **hormones**
• signal great distances

– animals- endocrine cells release hormones into circulatory system

– plants - hormones diffuse

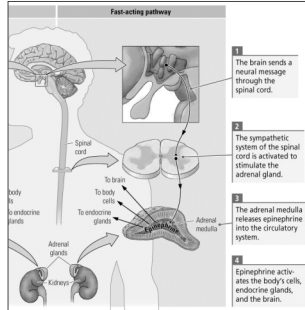


• Synaptic signaling
• nerve cells usually use neurotransmitter

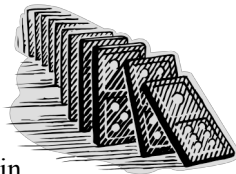


Conway to Little Rock!

1. **reception** - signal binds to receptor protein
2. **transduction** - change in receptor triggers a series of changes along a signal-transduction pathway.
3. **response** - triggers specific cellular activity.



- falling dominoes
 - original signal molecule is not passed along

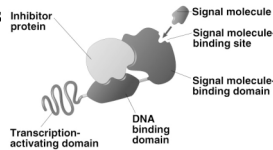


- “information” is transduced
- change in a protein

- yeast and animal cells – similar
- last common ancestor – a billion years ago
 - evolved first in ancient prokaryotes

Intracellular Receptors

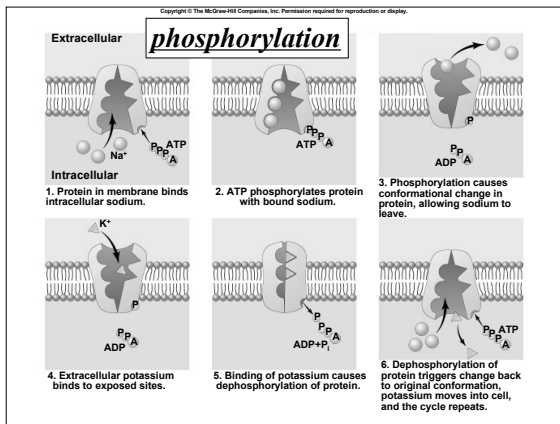
- within the cell
- trigger a variety of responses, depending on the receptor.
 - acting as gene regulators
 - acting as enzymes



nitric oxide (NO), gas – slides between membrane

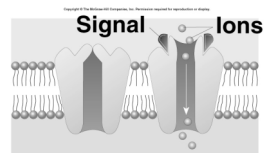
Cell Surface Receptors

- Extracellular signals converted to intracellular
 - chemically-gated ion channels
 - open or close when signal molecules bind to the channel
 - enzyme receptors
 - usually activate intracellular proteins by **phosphorylation**
 - G-protein receptors
 - activate intermediary protein



Cell Surface Receptors

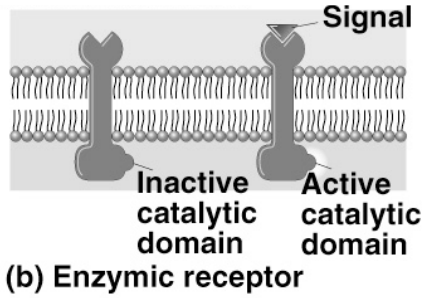
- signal binds - shape
- **ligands** (small molecules bind specifically to a larger molecule) induce change in shape



(a) Chemically gated ion channel

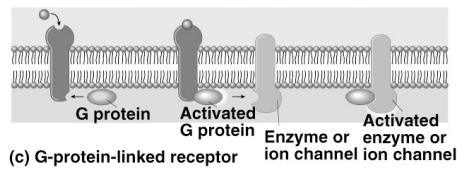
- interact
- aggregate

Cell Surface Receptors



Cell Surface Receptors

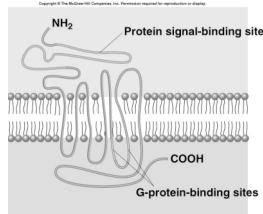
- **G protein** - on-off switch
 - If GDP bound- inactive
 - If ATP bound - active



- **G-protein-linked receptor** - associated G-protein on cytoplasmic side.

- seven alpha helices spanning the membrane

- yeast mating factors
- hormones (epinephrine)
- neurotransmitters



- Most prevalent in CNS - Cannabis
- Many human diseases - G-protein function

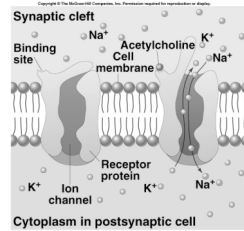
- Some microbes cause disease by disrupting G-protein signaling pathways

- cholera bacterium (*Vibrio cholerae*) colonizes small intestine
-
- produces toxin -modifies G protein that regulates salt and water secretion
- - stuck in active form
- intestinal cells secrete large amounts of water and salts into the intestines
- profuse diarrhea ,often death

- **Some Ligand-gated ion channels**

alter flow of Na⁺ K⁺ or Ca²⁺

- change in protein's shape opens channel
- changes ion concentration
- channel closes when ligand leaves

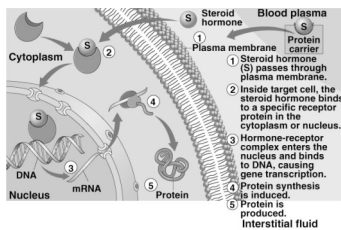


hormones- travel through the blood

- activate near and distant receptor proteins

enter nucleus

- turn on genes
- Protein synthesis



signal-transduction pathways

- transduction multistep pathway

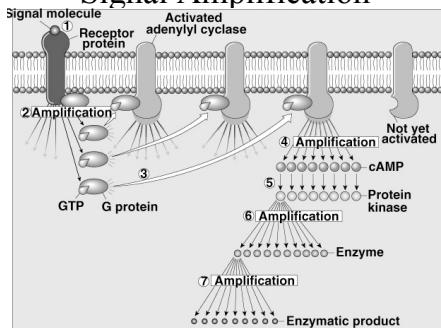


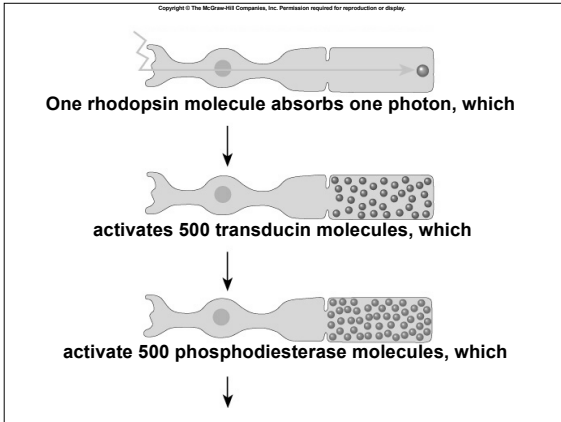
- WHY?
 - amplify signal -small number - large response
 - more opportunities for coordination and regulation

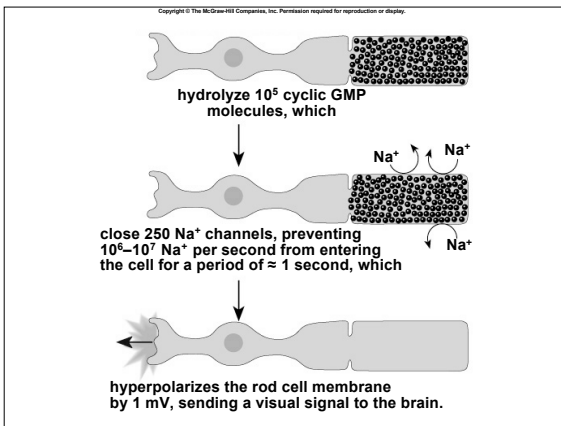
Amplifying the Signal

- signaling molecules low concentration
 - single receptor stimulates cascade of protein kinases
 - weak signal outside
 - strong response inside

Signal Amplification





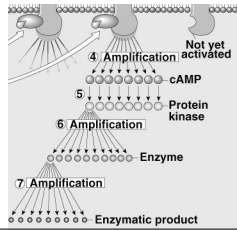


“phosphorylation cascade”

- Each leads to shape change
-interaction between phosphate group and amino acid

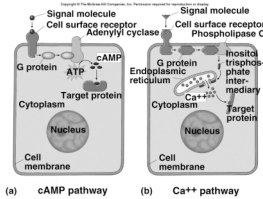
The text “phosphorylation cascade” is written in a serif font. To its right is a black and white photograph of a waterfall cascading over rocks. Below the text and image is a bulleted list item.

- Phosphorylation - converts from inactive form to active form.
- hundreds of protein kinases, each specific
 - 1% of genes code for protein kinases
- Abnormal activity development of cancer



signaling pathways + second messengers

- molecules or ions
- small
 - water-soluble
 - rapidly diffuse
- initiated by
 - G-protein-linked receptors
 - kinase receptors



– ***Two of the most important are cyclic AMP and Ca²⁺.***

- response depends on proteins

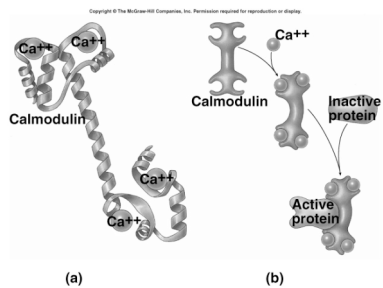
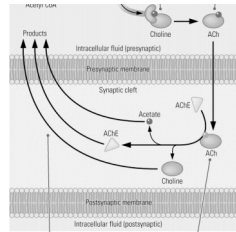


Fig 7.9

- inactivating mechanisms also important

- Binding must be quick and reversible
- inactivated by appropriate enzymes

– nerve gases



- Many signal molecules increase cytosolic concentration of Ca^{2+}

- contraction of muscle cells, secretion of substances, and cell division
- In plant cells, trigger responses for coping with environmental stress, including drought

- Cells use Ca^{2+} as second messenger
 - G-protein pathways



- When proteins are defective or missing

- Wiskott-Aldrich syndrome (WAS)
 - absence of single relay protein
 - abnormal bleeding
 - eczema
 - predisposition to infections and leukemia
- WAS protein interacts with microfilaments that regulate immune cell proliferation

Expression of Cell Identity

- array of proteins on the cell surface
 - glycolipids - tissue-specific cell surface markers
 - MHC proteins - identify self versus non-self cells
 - immune histocompatibility complex
