InterTech presents

Communication with environment

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- signal transduction
- signal
  - lipophilic hormones
  - gas
  - hydrophilic hormones
  - neurotransmitters
- receptor
  - cytosol receptors
  - membrane receptors
- transducer
  - phosphorylations
  - G proteins
- actuator
  - transcription factors
- examples
  - Ras-Raf-MAPk
  - quorum sensing
  - chemotaxis

signal transduction

- elements
  - signal
  - receptor
  - transducer
  - actuator
- function
  - communication
  - coordination
  - differentiation

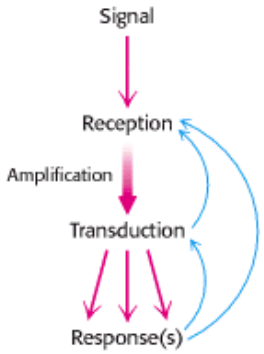


Figure 15.1. Principles of Signal Transduction. (Berg *et al*, 2002)

signal transduction

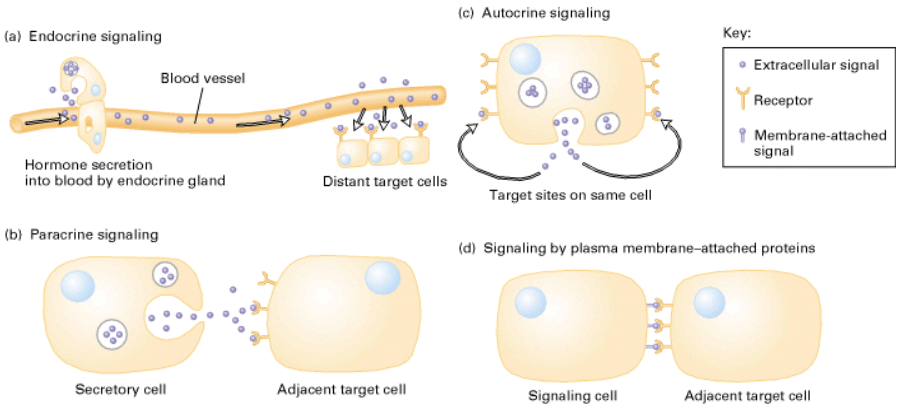


Figure 20-1. General schemes of intercellular signaling in animals. (Lodish *et al*, 2000)

signals

signals : lipophilic hormones

- steroid
  - estrogens
  - progesterone
  - testosterone
- thyroid
- cytosol receptors

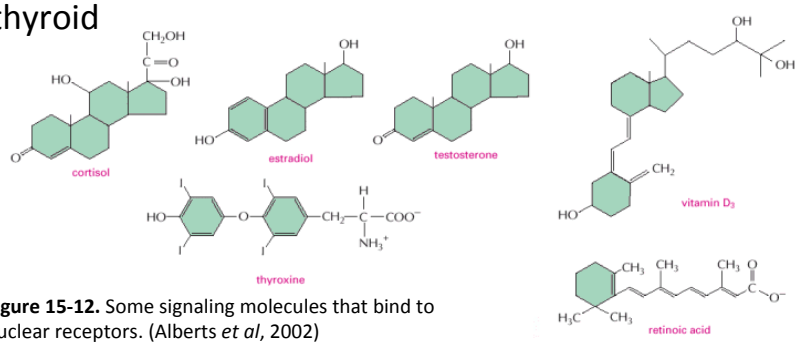


Figure 15-12. Some signaling molecules that bind to nuclear receptors. (Alberts *et al*, 2002)

signals : gas

- nitric oxide
- carbon monoxide
- cytosol receptors

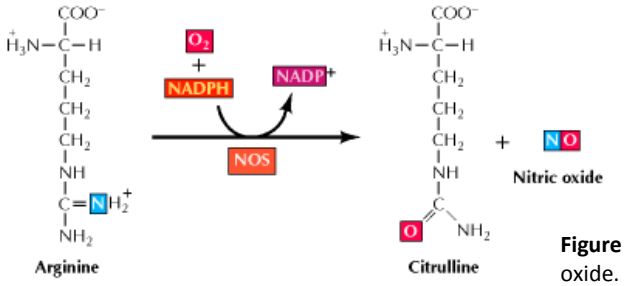


Figure 13.5. Synthesis of nitric oxide. (Cooper, 2000)

signals : hydrophilic hormones

- peptides
  - insulin
  - glucagon
  - growth hormone
- membrane receptors

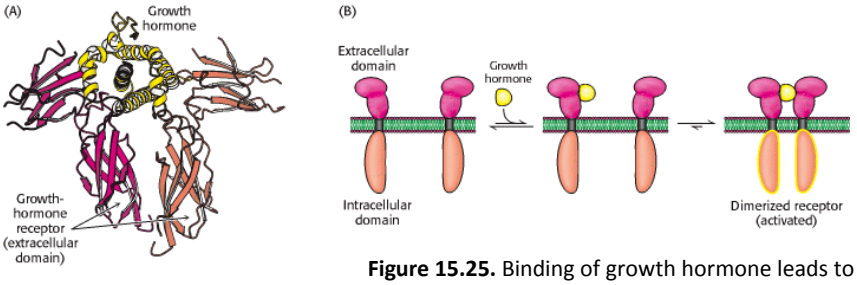


Figure 15.25. Binding of growth hormone leads to receptor dimerization. (Berg *et al*, 2002)

signals : neurotransmitters

- neuron's synapsis

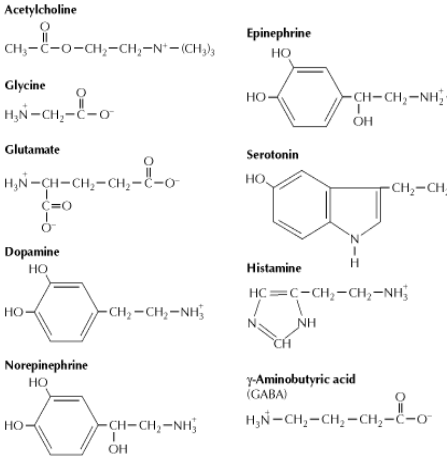


Figure 13.6. Structure of representative neurotransmitters. (Cooper, 2000)

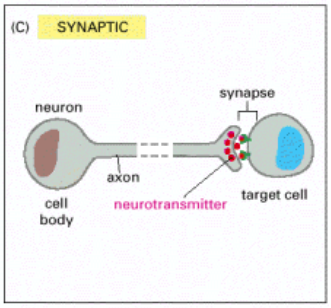
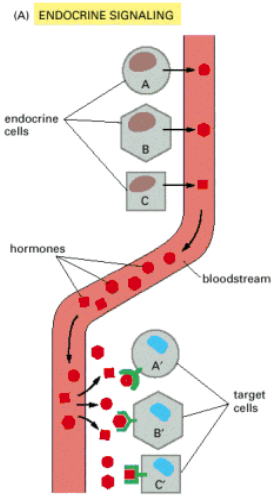


Figure 15-4. Forms of intercellular signaling . (Alberts *et al*, 2002)

signals : neurotransmitters

- neuron's synapsis



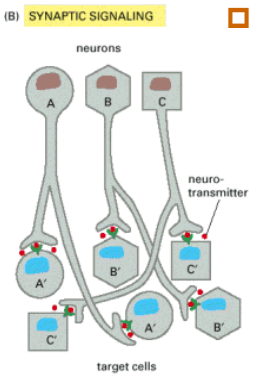


Figure 15-5. The contrast between endocrine and synaptic signaling. (Alberts *et al*, 2002)

receptors

receptors : cytosol receptors

- usually transducer & activator

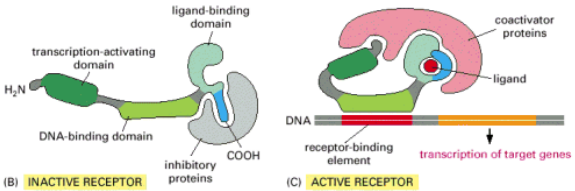


Figure 15-13. The nuclear receptor superfamily.(Alberts *et al*, 2002)

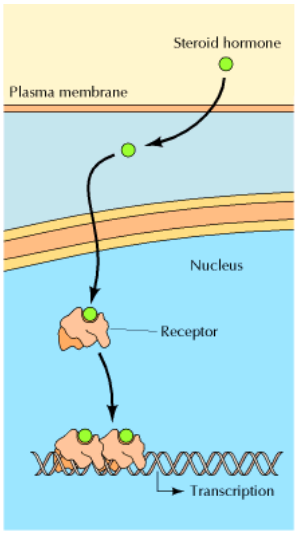


Figure 13.3. Action of steroid hormones (Cooper, 2000)

receptors : cytosol receptors

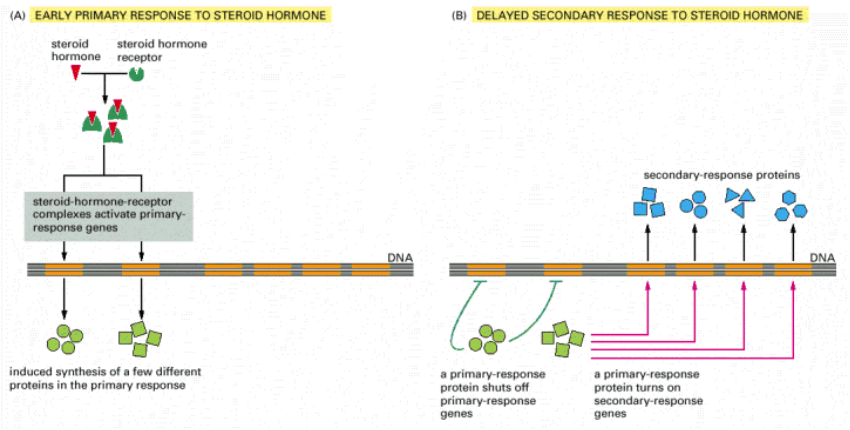
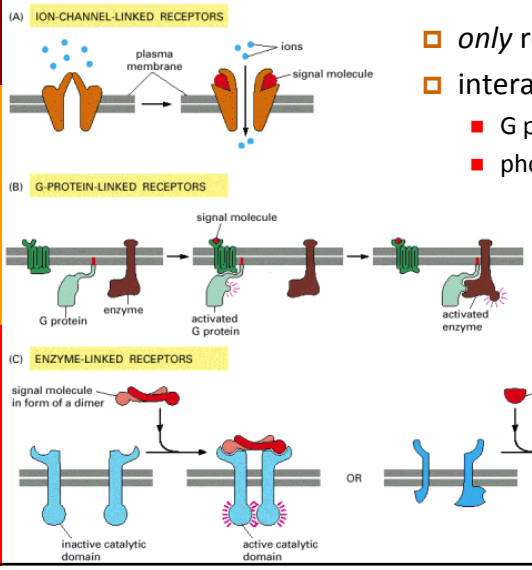


Figure 15-14. Responses induced by the activation of a nuclear hormone receptor. (Alberts *et al*, 2002)

receptors : membrane receptors



- *only* receptors
- interact with transducers
  - G protein
  - phosphorylation

Figure 15-15. Three classes of cell-surface receptors. Alberts *et al*, 2002)

receptors : membrane receptors

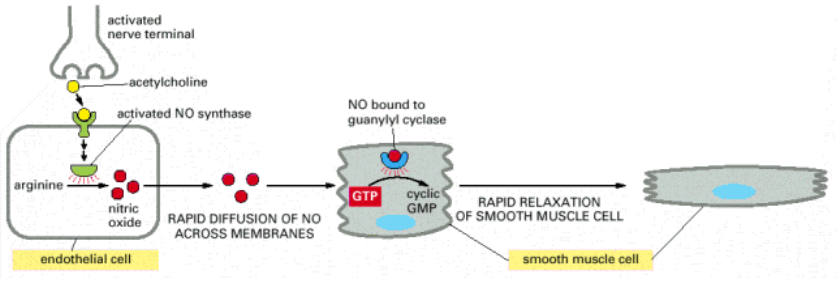


Figure 15-11. The role of nitric oxide (NO) in smooth muscle relaxation in a blood vessel wall. (Alberts *et al*, 2002)

transducers

signal transducers

- phosphorylations
  - phosphorylation cascades

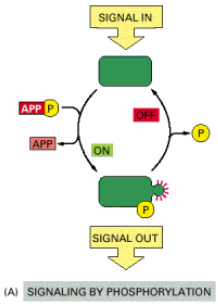


Figure 15-17. (Alberts *et al*, 2002)

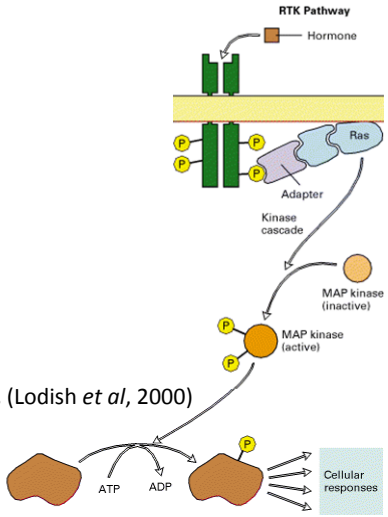


Figure 20-6. (Lodish *et al*, 2000)

signal transducers

- phosphorylations
  - examples
    - JAK/STAT pathway
    - Ras-Raf-Mapk pathway

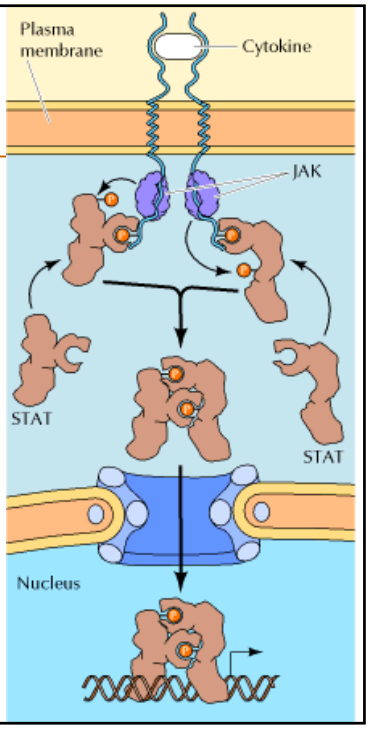


Figure 13.37. The JAK/STAT pathway (Cooper, 2000)

signal transducers

- G proteins
  - second messenger
    - cAMP
    - cGMP
    - Ca^{2+}

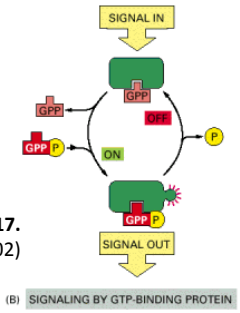


Figure 15-17. (Alberts *et al*, 2002)

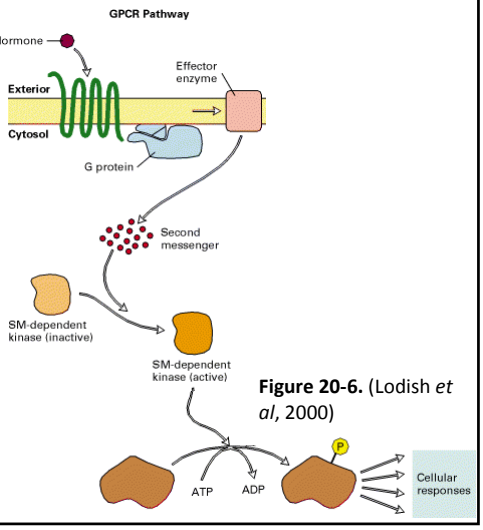
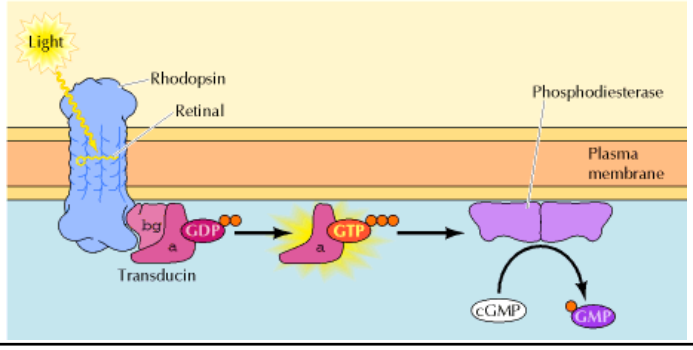


Figure 20-6. (Lodish *et al*, 2000)

signal transducers

- G proteins
  - examples
    - human photoreception
    - phospholipase C_β

Figure 13.23. Role of cGMP in photoreception (Cooper, 2000)



actuators

actuators

- transcription factors
- alter gene expression
  - activate or up regulate
  - inhibit or down regulate
  - change division
  - change metabolism
  - change cell shape

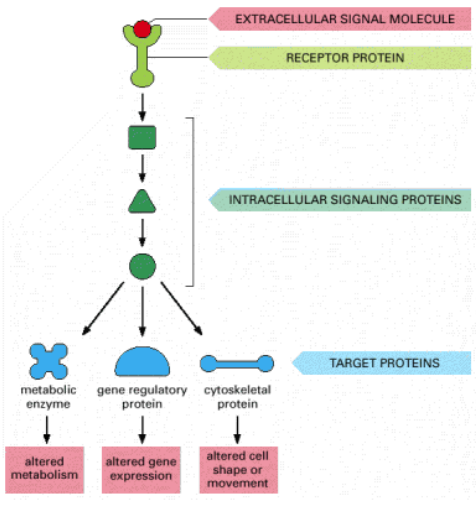


Figure 15-1. A simple intracellular signaling pathway activated by an extracellular signal molecule. (Alberts *et al*, 2002)

examples

Ras-Raf-MAPk

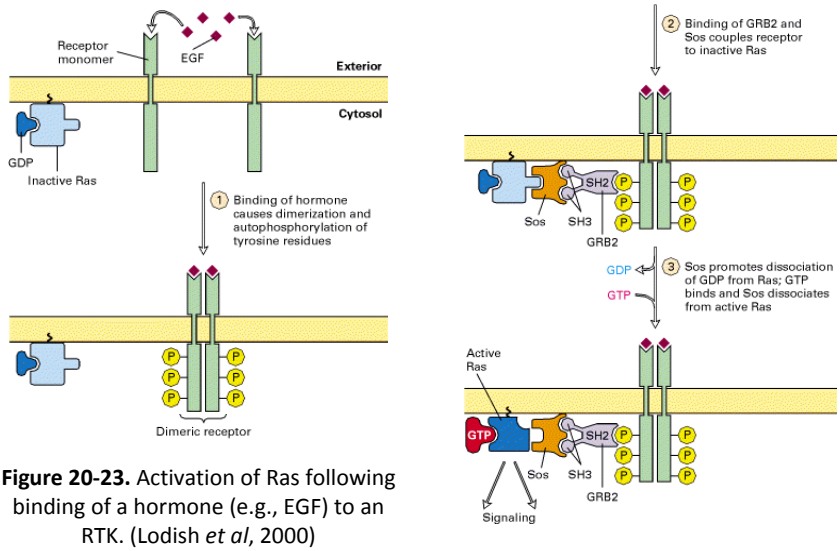


Figure 20-23. Activation of Ras following binding of a hormone (e.g., EGF) to an RTK. (Lodish *et al*, 2000)

Ras protein : a molecular switch

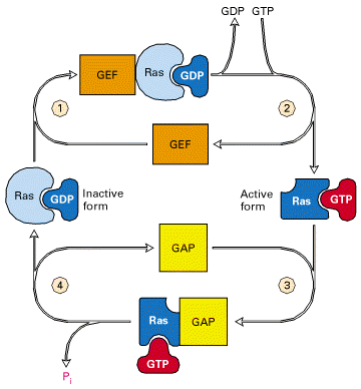


Figure 20-22. Cycling of the Ras protein between the inactive form with bound GDP and the active form with bound GTP occurs in four steps. (Lodish *et al*, 2000)

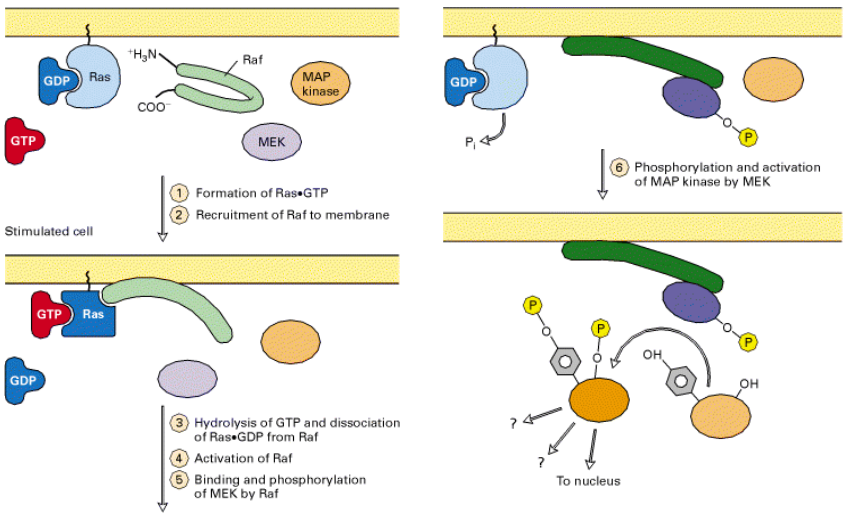


Figure 20-28. Kinase cascade that transmits signals downstream from activated Ras protein (Lodish *et al*, 2000)

- EGF is a growth factor → promotes cell division
- Ras-Raf-MAPk is a conserved pathway

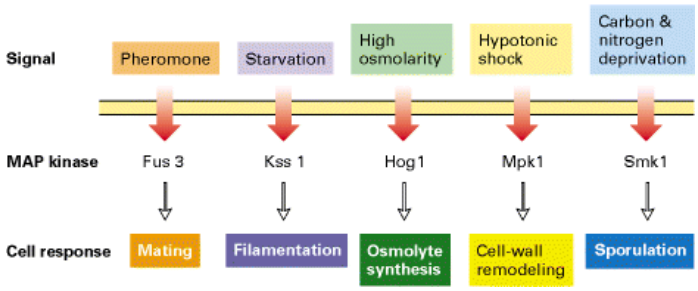
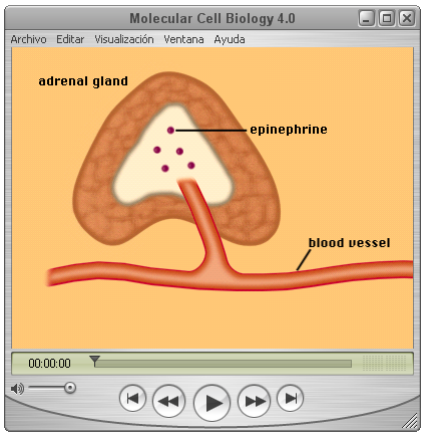


Figure 20-32. Overview of five MAP kinase pathways in *S. cerevisiae*. (Lodish *et al*, 2000)

movie : epinephrine



Ch20anim4. Lodish *et al*, 2000

quorum sensing

- bacterial gene activation by cell density
- virulence factors, bio-films, bio-luminescence

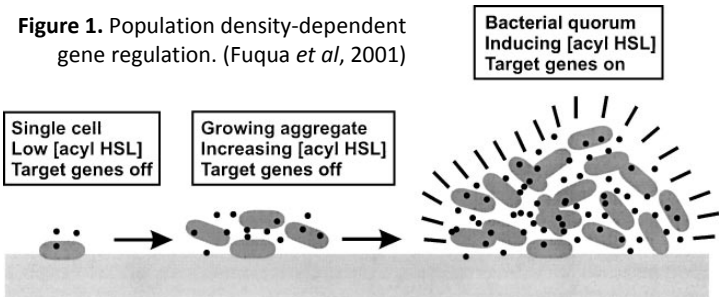
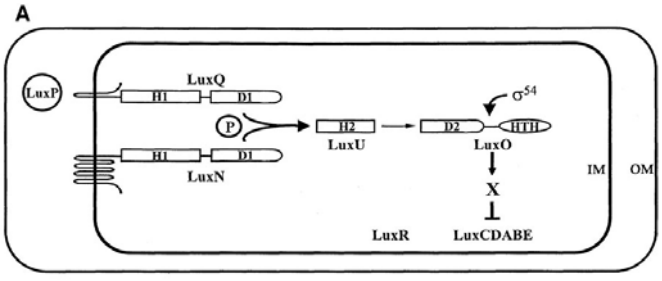


Figure 1. Population density-dependent gene regulation. (Fuqua *et al*, 2001)

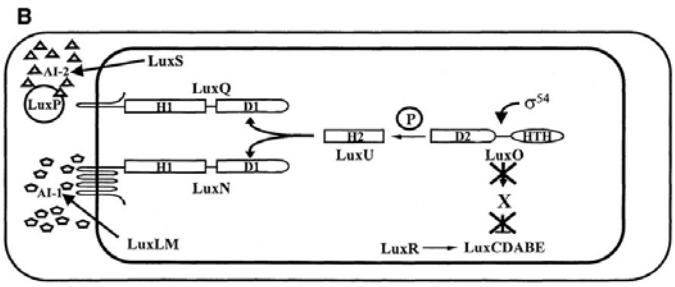
quorum sensing

- low cell density
  - LuxN & LuxQ ⟶ LuxU-P
  - LuxO represses *lux* operon
  - target genes ***OFF***



quorum sensing

- cell density over a threshold
  - AI-1 & AI-2 interact with LuxN & LuxQ ⟶ LuxU
  - *lux* operon derepressed & activated by LuxR
  - target genes ***ON***



chemotaxis

- clockwise :

  repellent ☑

  attractant ☒

- counterclockwise :

  repellent ☒

  attractant ☑

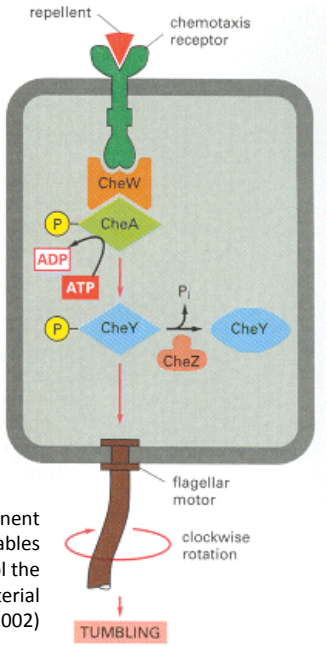


Figure 15-69. The two-component signaling pathway that enables chemotaxis receptors to control the flagellar motor during bacterial chemotaxis. (Alberts *et al*, 2002)

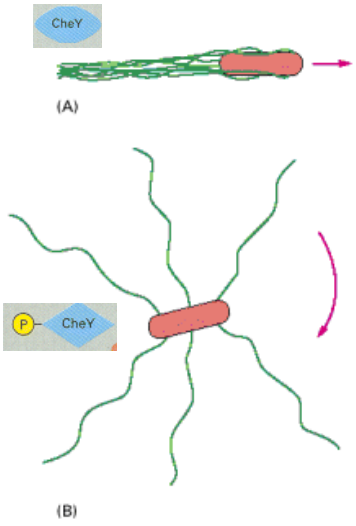


Figure 15-68. Positions of the flagella on *E. coli* during swimming. (Alberts *et al*, 2002)

(A) When the flagella rotate counterclockwise, they are drawn together into a single bundle, which acts as a propeller to produce smooth swimming.

(B) When the flagella rotate clockwise, they fly apart and produce tumbling.

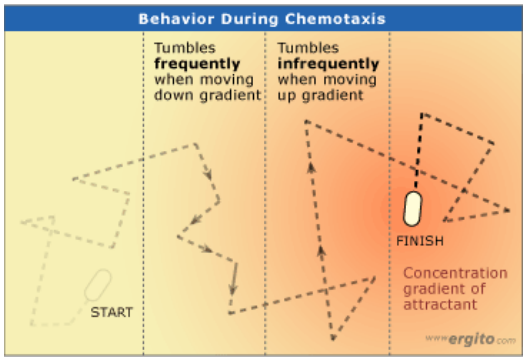
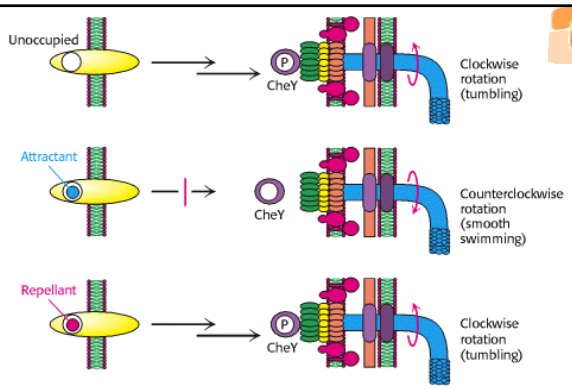
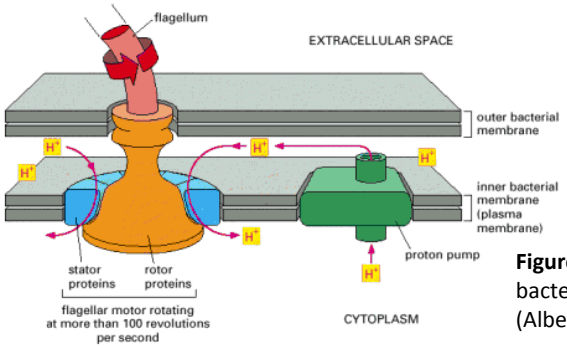


Figure 34.35. Chemotaxis Signaling Pathway. (Berg *et al*, 2002)





movie : chemotaxis at *Dictyostelium* (Lodish *et al*, 2000)

Figure 14-17. The rotation of the bacterial flagellum driven by H^+ flow. (Alberts *et al*, 2002)

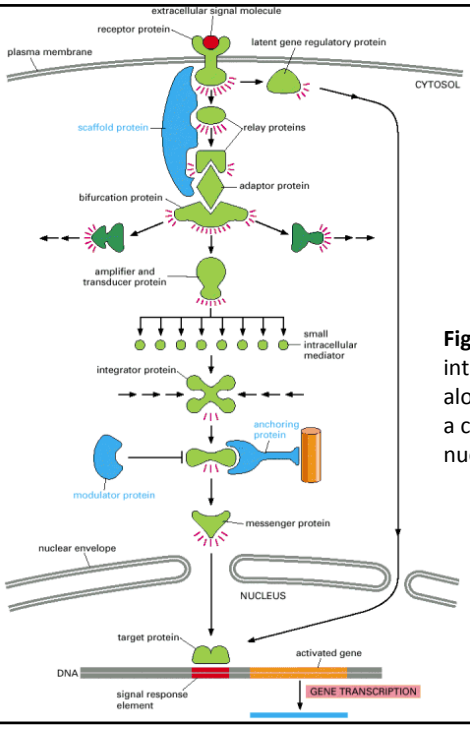


Figure 15-16. Different kinds of intracellular signaling proteins along a signaling pathway from a cell-surface receptor to the nucleus. (Alberts *et al*, 2002)

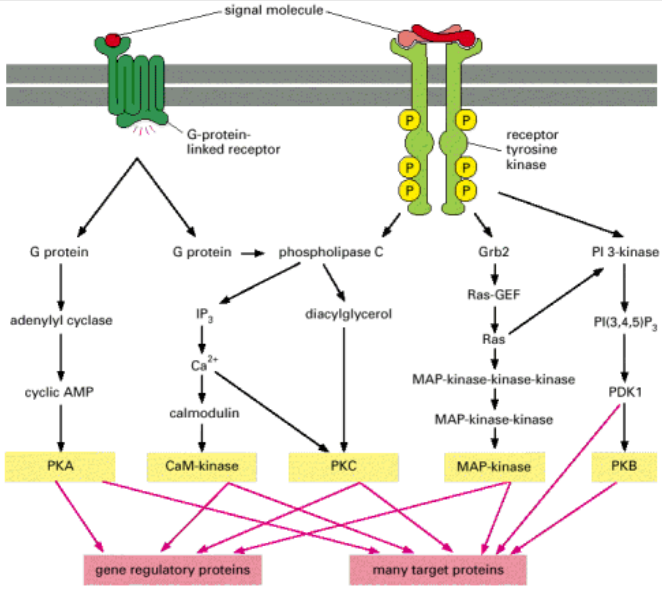


Figure 15-61. Five parallel intracellular signaling pathways activated by G-protein-linked receptors, receptor tyrosine kinases, or both. (Alberts *et al*, 2002)

sources

- Alberts *et al*, *Molecular Biology of the Cell*, **Garland Science**, 4th ed, 2002
- *Lodish et al, Molecular Cell Biology,* ***Freeman & Co.****, 4th ed., 2000*
- *Berg et al, Biochemistry,* ***Freeman & Co.****, 5th ed., 2002*
- *Cooper, The Cell - A Molecular Approach,* ***Sinauer Publishers****, 2nd ed., 2000*
- *Fuqua, et al, Regulation of gene expression by cell-to-cell communication AHL quorum sensing.* ***Annual Review Genetics****. 2001*
- *www.ergito.org*