A slice of cell and molecular biology:
A cell signaling and cell communication primer

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Lecture Outline:

I. Overview of the Cell

II. Overview of the Cell Signaling Challenge

III. Common themes among many different cell types

IV. Different types of signals: electrical, chemical, mechanical

V. External stimulus → membrane interactions → intracellular cytoplasmic events → gene expression changes

VI. Membrane composition and membrane function

VII. Gene expression events: Transcription (RNA synthesis)
Translation (protein synthesis)

VIII. Summary
What’s going on inside this cell? How does it respond to its environment?
Cells Respond in Diverse Ways to External Stimuli
Cells Respond in Diverse Ways to External Stimuli

- **SURVIVE**: Cells respond by surviving external stimuli.
- **GROW + DIVIDE**: Cells grow and divide in response to external stimuli.
- **DIFFERENTIATE**: Cells differentiate into specialized forms in response to external stimuli.
- **DIE**: Cells undergo programmed cell death (apoptosis) in response to external stimuli.
**extracellular signal molecule**

**intracellular signaling pathway**

**cell-surface receptor protein**

**nucleus**

**FAST (< sec to mins)**

**ALTERED PROTEIN FUNCTION**

**ALTERED PROTEIN SYNTHESIS**

**ALTERED CYTOPLASMIC MACHINERY**

**ALTERED CELL BEHAVIOR**

**SLOW (mins to hrs)**

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Figure 16-7  *Essential Cell Biology* (© Garland Science 2010)
Figure 16-12  *Essential Cell Biology* (© Garland Science 2010)
CELL MEMBRANES

- Semi-permeable to ions and organic molecules (allows selective influx and efflux)
- Protects cell from surroundings; responds to surroundings
- Comprised of phospholipids and embedded proteins
- Protein composition is most variable part between different types of cells
Phospholipids

(A) Phospholipid structure with polar (hydrophilic) head and nonpolar (hydrophobic) tails.

(B) Chemical structure of a phospholipid, showing the polar head group and the two hydrocarbon tails.

(C) Three-dimensional model of a phospholipid molecule, illustrating the head and tails.

Figure 11-6 Essential Cell Biology (© Garland Science 2010)
Cell Membrane showing orientation of phospholipids in the bilayer
Protein Components of Membranes

Binding of a single ligand type to a receptor can cause different cellular responses depending on the cell type.

(A) heart muscle cell
(B) salivary gland cell
(C) skeletal muscle cell

(D) Acetylcholine (a type of neurotransmitter)

\[
\begin{align*}
H_3C & \quad C \quad O \quad CH_2 \quad CH_2 \quad N^+ \quad CH_3 \\
& \quad CH_3
\end{align*}
\]
Neuronal Communication and Signaling

a) Chemical synapse

- Action potential
- Ca²⁺
- Presynaptic terminal
- Synaptic vesicle
- Neurotransmitter
- Ionotropic receptor
- Metabotropic receptor
- Membrane potential
- Gene expression
- Biochemical cascades
- Postsynaptic terminal

b) Electrical synapse

- Action potential
- Gap junction channel
- Coupling potential

Nature Reviews | Neuroscience
Optional video to reinforce signaling themes
Gene Expression Events

Transcription (RNA Synthesis)
Translation (Protein Synthesis)
Central Dogma of Molecular Biology

- DNA
  - Transcription
  - Reverse transcription
- RNA
  - Translation
- Proteins

www.2classnotes.com

- DNA
  - Transcription
  - RNA Transport to cytoplasm
- mRNA
  - 5' to 3'
  - Growing Amino Acid chain

www.tokresource.org
Take Home Summary

Cells communicate with their environment through interactions at the cellular membrane.

Membrane proteins are essential features that enable cellular communication by interacting with signals (e.g., chemical, electrical, mechanical).

Signaling at the membrane causes intracellular changes that affect different pathways depending on the type of cell.

Cell signaling can stimulate changes in gene expression at the nuclear level, resulting in the production of new proteins.