What is Cell Communication?

-- Cell communication is **how cells sense and react to their environment and/or signals from other cells**

-- It can be through direct cell-to-cell contact

-- It consists of **ligands and receptors**; ligands are molecules that bind to receptors (signals); receptors are proteins that detect external signals (antenna)

-- The signal **always** come from the exterior of the cell (extracellular)

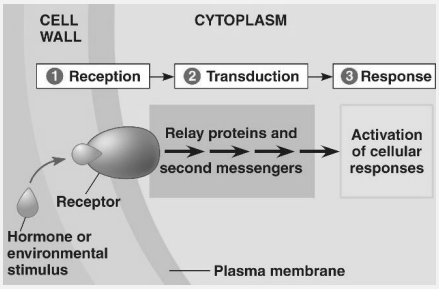
Steps of Cell Signaling:

1. **Reception** -- ligand binds to receptor causing receptor to change shape

2. **Transduction** -- information transfer from receptor throughout cell

3. **Response** -- how the cell changes

Signal Transduction



Understanding Pathway Diagrams

-- *Pointed arrows* means **activates**

-- *Blunt arrow* means **inhibit**

-- For multi-step pathways you should simplify into the overall result

-- Similar to math, if there is two inhibitions it would result in an activation

Summary of Cell Signaling

-- Different cell types can have different response to the same ligand because they have different receptors

RECEPTION

-- Types of receptors:

-- Cell surface receptors

Ligand-gated ion channels:	Receptors are ion channels that open and let ions cross the membrane
G protein-coupled receptors (GPCR):	Receptors are associated with G protein. When the receptor is activated it causes the G protein to activate. The G protein activates enzymes. ligand --> GPCR --> G protein --> enzyme --> second messengers
Receptor tyrosine kinases (RTK):	Kinases are enzymes that add phosphate groups to other molecules. When a ligand binds it turns on kinase activity of RTKs.

-- Intracellular receptors

-- This is when the receptor is in side the cell. Unlike cell surface receptors, the ligands are nonpolar. These regulate gene expression.

Types of Ligand

-- Ligands can be: **gases ions, lipids, proteins, amino acids, nucleotides, etc**

Structure Determines Function

-- Ligand binding to a receptor changes the receptors shape

-- ***Change in receptor shape = change in receptor function***

TRANSDUCTION

Amplification

-- When one ligand binding to one receptor it results in many molecules inside the cell	-- Each molecule in the signaling pathway can be recycled

Second Messengers

-- These activate many enzymes within the cell	-- **For example: Cyclic AMP.** The activation of some GPCRs increase cAMP while others decrease cAMP.
-- Activation of GPCRS regulate the production of second messengers	-- cAMP can activate other proteins like protein kinase A which is an important regulator of metabolic pathways

the "first messenger" is the ligand binding to the receptor

Phosphorylation cascades

-- Phosphorylation changes the shape of protein, in result changes the function

RESPONSE

Common cellular response

Gene expression:	activation of transcription of specific genes
Enzyme activation:	turning on kinases
Apoptosis:	programmed cell death in which the cell breaks down while protecting neighboring cells. It is important for development and a normal process in healthy organisms

CELL CYCLE

-- There are **four phases** to the cell cycle

G1 (gap 1) = cell growth

S (synthesis) = DNA replication

G2 (gap 2) = cell growth, prepare for mitosis

M (mitosis) = cell division

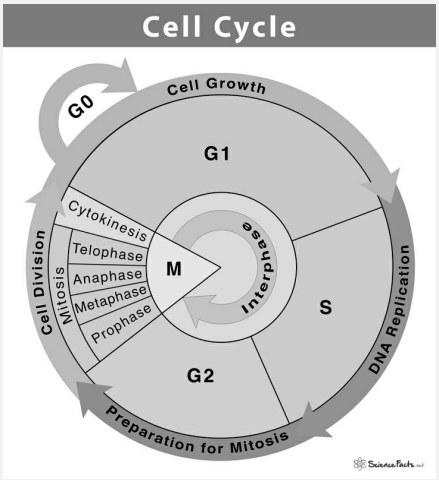
Regulation of Cell Cycle

-- Cyclins are proteins that regulate cyclin-dependent kinases (CDKs)

-- Cyclins/CDKs **control which phase of the cell cycle a cell is in**

-- If the cell is not regulated, it can result in **cancer** which is abnormal growth due to the continuous progression through the cell cycle

Diagram of The Cell Cycle



Cell Cycle Checkpoints

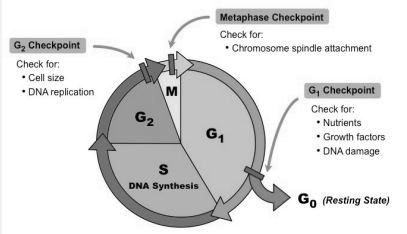
Checkpoints determine if the cell is ready to progress to the next phase of the cell cycle

-- **G1 check point:**	It checks whether the cell is big enough and has made the proper proteins for the synthesis phase. If not, the cell goes through a resting period (G0) until it is ready to divide.
-- **G2 check point:**	It checks whether DNA has been replicated correctly. If so, the cell continues on to mitosis.

Cell Cycle Checkpoints (cont)

-- **M check point:**	It checks whether mitosis is complete. If so, the cell divides, and the cycle repeats.

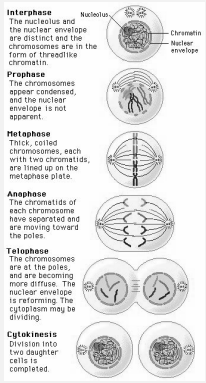
Cell Checkpoints



MITOSIS

-- **Interphase**	DNA is replicated, cell prepare for mitosis. The nuclear envelop are distant and the chromosomes are in the form of threadlike chromatin.
-- **Prophase**	Chromatin condenses making the chromosomes visible and nuclear envelop breaks down
-- **Metaphase**	The thick, coiled chromosomes, each with two chromatids, become aligned at the equatorial/metaphase plane
-- **Anaphase**	Sister chromatids separate and the daughter chromosomes move toward the poles
-- **Telophase & Cytokinesis**	The chromosomes are at the poles, and are becoming more diffuse. The nuclear envelop is reforming. They cytoplasm may be dividing. Then the division into two daughter cells.

Stages of Mitosis



Mitosis vs. Meiosis

	Mitosis	Meiosis
Divisions	One	Two
Independent Assortment	No	Yes (metaphase I)
Synapsis	No	Yes – form bivalents
Crossing Over	No	Yes (prophase I)
Outcome	Two cells	Four cells
Ploidy	Diploid	Haploid
Use	Body cells	Sex cells (gametes)
Genetics	Identical cells	Variation

Mitosis vs. Meiosis (continued)