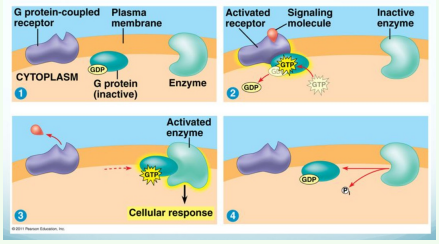
Cell Signals

1. Direct Contact	
↳ *plasmodesmata of plants~*	open channels through the cell wall connecting adjacent cells allowing substances to pass between
↳ *cell-cell recognition~*	interaction between molecules protruding from their surfaces (immune cells)
2. Local Signaling	
↳ *paracrine signaling~*	secreting cell acts on nearby target cells by discharging growth factor molecules
↳ *synaptic signaling~*	nerve cells release neurotransmitter molecules into synapse
3. Long Distance	
↳ *animal hormones~*	cells secrete hormones into body fluids to target cell
↳ *plant hormones~*	hormones move through the cells (by xylem) or diffuse through the air as a gas

Step 1: Reception

- ligand:	molecule that binds specifically to another molecule
- plasma membrane receptors:	transmit information from extracellular environment to inside of the cell by changing shape or aggregating when a ligand binds
↳ cell surface receptors~	*1. G protein-coupled receptors (GPCRs)*
	2. receptor tyrosine kinases (RTK)
	3. ligand gates ion channels
↳ intracellular receptor proteins	

G Protein-Coupled Receptor (GPCR)



- *function/activity:* 1. embryonic development 2. sensory reception (smell, vision, etc.)

GPCR Sequence

↳ receptor is activated & changes shape

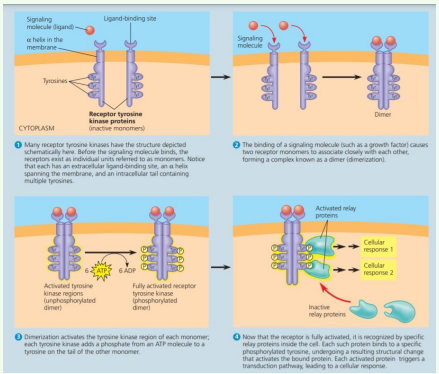
↳ binds to inactive G protein = GTP to replace GDP (activating G protein)

↳ G protein binds to an enzyme (change in shape/activity)

↳ enzyme triggers next step for response

↳ G protein inactivates by hydrolyzing bound GATP to GDP

Receptor Tyrosine Kinases (RTK)



- kinase: enzyme that catalyzes the transfer of phosphate groups

- differs from GPCR by triggering *many pathways*

RTK Sequence

↳ binding of signal causes 2 receptor monomers to come together = dimer

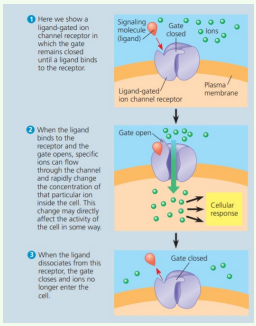
↳ tyrosine kinase region activated by ATP (adds a phosphate group)

↳ receptor recognized by relay proteins

↳ proteins bind (change shape) & activates protein

↳ transduction/response triggered

Ligand Gated Ion Channels



- for larger/hydrophilic molecules

- can be controlled by electrical conditions -- *voltage-gated ion channels*

Ligand Channel Sequence

↳ *signal molecule causes receptor gate to open/close*

↳ *ions flow through (NA^+ or Ca^+)*

Intracellular Receptor Proteins

2 areas present~	cytoplasm
	nucleus of target cells
3 signal molecule types~	1. steroid hormones
	2. thyroid hormones
	3. nitric oxide

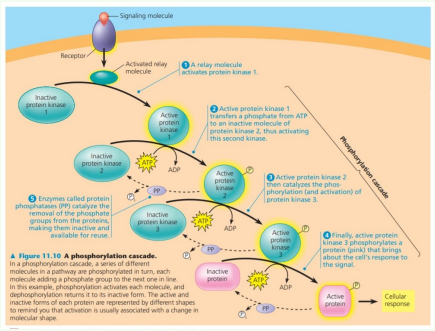
- once receptor protein is activated the signal molecules enter the nucleus and turn on specific genes

Step 2: Transduction

molecular interactions relay signals from receptors to target molecules in the cell

	ex) phosphorylation cascade; second messengers
- signal amplification:	molecules in a pathway transmit the signal to many molecules at the next step
- advantage of multistep pathway responses~	more coordination & regulation (fine--tuning of response)

Protein Phosphorylation



- protein phosphatases: enzymes that remove phosphate groups (dephosphorylation)

- acts as a molecular switch to turn activities on/off or up/down

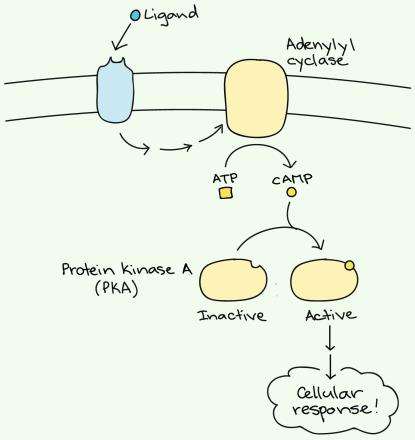
Phosphorylation Sequence

↳ *a molecules receive phosphate group from ATP (serine & threonine) = phosphorylation*

↳ *next molecule is activated in the pathway*

↳ *process continues to trigger response*

Second Messengers



- second messenger: small, nonprotein, water-soluble molecule/ion in transduction pathways

ex) cAMP, Ca^{2+}

- *cAMP* level rise when epinephrine binds to liver membrane receptors

↳ causing a break down of glucose

↳ levels go back down from phosphodiesterase (cAMP to AMP)

- 3 possible responses to *calcium* =

↳ 1. muscle cell contration 2. secretion of substances 3. cell division

↳ calcium released from ER when signal molecule (IP3) binds to cell

Step 3: Response

- cell signaling leads to *regulation of transcription*/cytoplasmic activities

- many pathways *regulate protein synthesis* by turning specific genes on/off

4 FINE TUNING RESPONSE

1. signal amplification~	# of activated products gets increasingly bigger
	proteins process many molecules
2. specificity of signaling & coordination of response~	different kinds of cells have different collections of proteins (diff. responses from same signal)
3. efficiency~	*scaffolding proteins:* large relay proteins w/ several relay proteins attached
	creates more than one pathway
4. termination of signal~	reverse change from prior signal to receive new one
	by dephosphorization of relay proteins

Apoptosis

" programmed cell death"

- general process~

↳ DNA chopped up & organelles fragmented

↳ cell shrinks & becomes lobe shaped

↳ cell's parts are packaged into vesicles

↳ cell parts engulfed & digested by scavenger cells

- processes this is needed for~

1. development of nervous system

2. operation of immune system

3. morphogenesis of hands/feet/paws

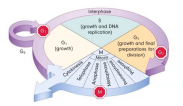
Cell Cycle Background

- what two organism have cell division the same as reproduction?	1. prokaryotes 2. unicellular eukaryotes
- what are the roles of cell division?	↳ growth, repair, reproduction, & replacement
- how do the genomes of prokaryotes & eukaryotes differ?	↳ eukaryotes~ # of DNA molecules; larger; linear DNA; lots of non-coding DNA
	↳ prokaryotes~ single DNA molecule; smaller; looped DNA; more coding DNA
- somatic cell:	any cell in an organism except reproductive cells (body cells)
- sister chromosome:	2 copies of a duplicated chromosome attached at the centromere
- mitosis:	process of nuclear division (P, PM, M, A, T)
- cytokinesis:	division of the cytoplasm to form 2 separate daughter cells
- centromeres	produce microtubules (in plants & animals)
- centrioles	microtubules that spindle fibers attach to (in animals only)
- binary fission:	asexual reproduction by "division in half" (prokaryotes & unicellular eukaryotes)
- origin of replication:	site where replication of DNA molecule begins

Cell Cycle Background (cont)

- density-dependent inhibition:	cell stop dividing when in contact with one another
- anchorage dependence:	cell must attach to a substance in order to divide

Cell Cycle Diagram



Interphase

- 3 sub phases of interphase~

↳ *G1 phase (first gap)=*	cell growth
↳ *S phase (synthesis)=*	DNA replication
↳ *G2 phase (second gap)=*	cell components double (prep to divide)

- different rates of division~

↳ *skin cells =*	divide frequently
↳*liver cells =*	divide when needed
↳ *nerve/muscle cells =*	don't divide at all

- 3 major checkpoints~

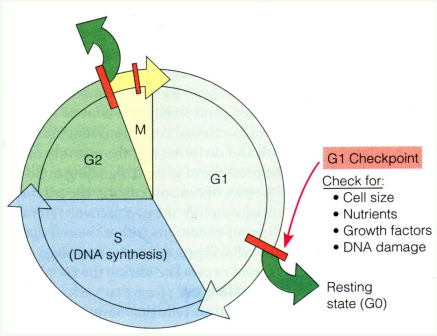
1. G1

2. G2

3. Metaphase

- platelet--derived growth factor (PDGF):	made by platelets to help heal wounds
	PDGF bind to membrane receptor ➞ transduction pathway triggered ➞ cell passes G1 checkpoint ➞ cell division

G1 Checkpoint

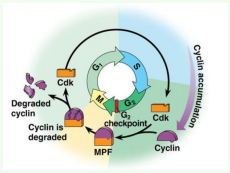


- a.k.a. 'restriction point'

↳ **if gets go-ahead signal... continues on to divide**

↳ **if doesn't get go-ahead signal... exits cycle/goes into G0 phase (nondividing)**

G2 Checkpoint



- protein kinases: give go-ahead signal at G1 & G2 checkpoints

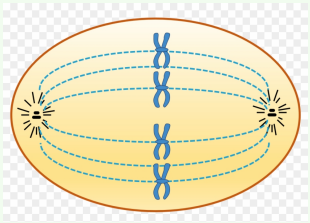
- cyclins: attach to kinases to make them active

↳ **cyclin-dependent kinases (cdk) & cyclin combine to form...MPF (maturation-promoting factors)**

↳ **MPF formation occurs when cyclin accumulates = mitosis initiated**

↳ **MPF breaks down during anaphase** (cyclin destroyed; cdk stays to be reused)

Metaphase Checkpoint



- anaphase won't begin until *chromosomes are properly attached to spindles*

Cancer	
- cancer cells are a change in 1+ genes that result in...	faulty cell cycle control
- normal cell cycle amount =	*20-50 times*
- cancer cell cycle amount =	*continuous*
- benign tumor:	cells that are NOT capable of surviving at a new site (slow growing; small; localized)
- malignant tumor:	cancerous tumor capable of surviving in a new site (fast growing; large; invasive)
- metastasis:	the spread of cancer cells to a different location from the original site