AP Biology Exam Unit 4 Review

Byron Strohm

UNIT AT A GLANCE

Enduring Understanding	Topic	Suggested Skill	Class Periods ~9–11 CLASS PERIODS
IST-3	4.1 Cell Communication	1.B Explain biological concepts and/or processes.	
	4.2 Introduction to Signal Transduction	1.A Describe biological concepts and/or processes.	
	4.3 Signal Transduction	6.C Provide reasoning to justify a claim by connecting evidence to biological theories.	
	4.4 Changes in Signal Transduction Pathways	6.E.b Predict the causes or effects of a change in, or disruption to, one or more components in a biological system based on a visual representation of a biological concept, process, or model.	
ENE-3	4.5 Feedback	6.E.b Predict the causes or effects of a change in, or disruption to, one or more components in a biological system based on a visual representation of a biological concept, process, or model.	
IST-1	4.6 Cell Cycle	4.B.b Describe data from a table or graph, including describing trends and/or patterns in the data. 5.A.e Perform mathematical calculations, including percentages.	
	4.7 Regulation of Cell Cycle	6.E.a Predict the causes or effects of a change in, or disruption to, one or more components in a biological system based on biological concepts or processes.	

AP Biology Exam Review

4.1

UNIT 4

Cell Communication and Cell Cycle

~9-11 Class Periods | 10-15% AP Exam Weighting

IST 1 — 4.1 Cell Communication

IST 1 — 4.2 Introduction to Signal Transduction

IST 6 — 4.3 Signal Transduction

IST 6 — 4.4 Changes in Signal Transduction Pathways

ENE 6 — 4.5 Feedback

IST 4 5 — 4.6 Cell Cycle

IST 6 — 4.7 Regulation of Cell Cycle

ENDURING UNDERSTANDING

IST-3

Cells communicate by generating, transmitting, receiving, and responding to chemical signals.

LEARNING OBJECTIVE

IST-3.A

Describe the ways that cells can communicate with one another.

IST-3.B

Explain how cells communicate with one another over short and long distances.

ESSENTIAL KNOWLEDGE

IST-3.A.1

Cells communicate with one another through direct contact with other cells or from a distance via chemical signaling—

a. Cells communicate by cell-to-cell contact.

IST-3.B.1

Cells communicate over short distances by using local regulators that target cells in the vicinity of the signal-emitting cell—

a. Signals released by one cell type can travel long distances to target cells of another cell type.

Cells Respond in Diverse Ways to External Stimuli

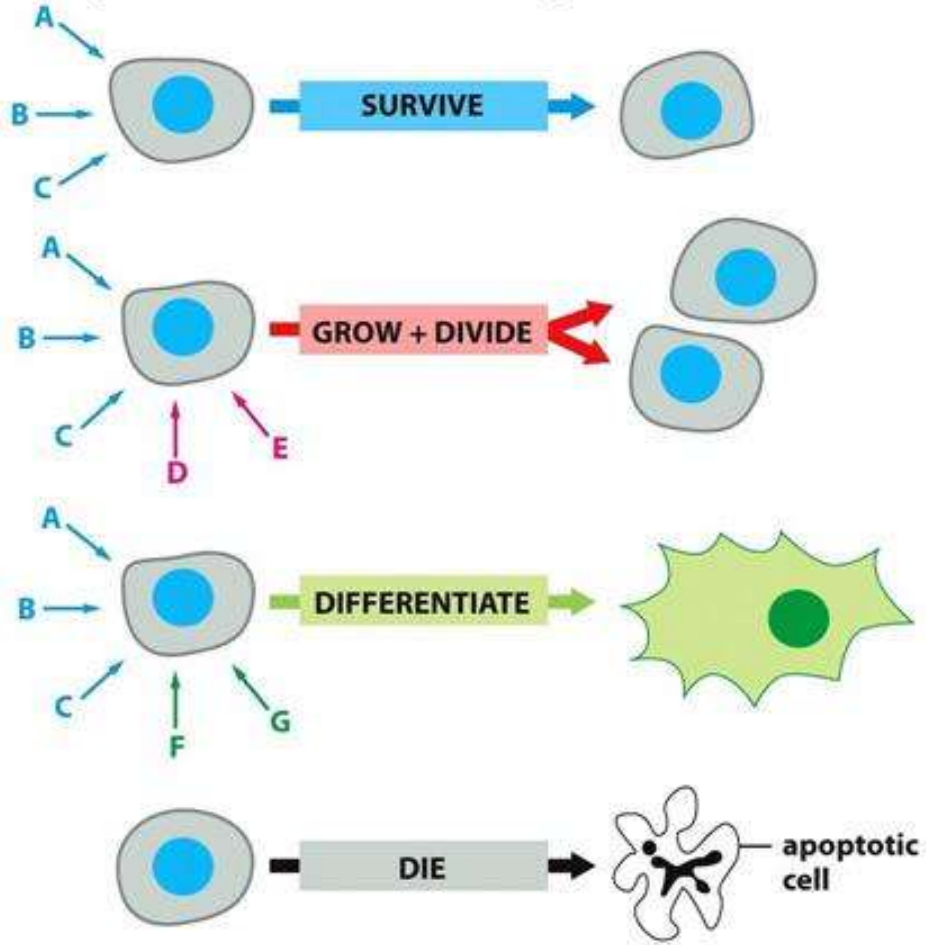
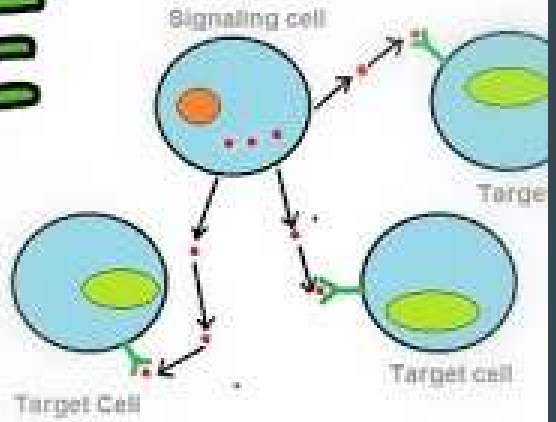


Figure 16-6 *Essential Cell Biology* (© Garland Science 2010)

CELL SIGNALING

JUXTACRINE
PARACRINE
SYNAPTIC
ENDOCRINE



communicate directly with the cells they innervate by releasing chem
neurotransmitters at specialized junctions called chemical synapses.

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4.2-4.3

UNIT 4

Cell Communication and Cell Cycle

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ENDURING UNDERSTANDING

IST-3

Cells communicate by generating, transmitting, receiving, and responding to chemical signals.

LEARNING OBJECTIVE

IST-3.C

Describe the components of a signal transduction pathway.

IST-3.D

Describe the role of components of a signal transduction pathway in producing a cellular response.

ESSENTIAL KNOWLEDGE

IST-3.C.1

Signal transduction pathways link signal reception with cellular responses.

IST-3.C.2

Many signal transduction pathways include protein modification and phosphorylation cascades.

IST-3.D.1

Signaling begins with the recognition of a chemical messenger—a ligand—by a receptor protein in a target cell—

a. The ligand-binding domain of a receptor recognizes a specific chemical messenger, which can be a peptide, a small chemical, or protein, in a specific one-to-one relationship.

b. G protein-coupled receptors are an example of a receptor protein in eukaryotes.

IST-3.D.2

Signaling cascades relay signals from receptors to cell targets, often amplifying the incoming signals, resulting in the appropriate responses by the cell, which could include cell growth, secretion of molecules, or gene expression—

a. After the ligand binds, the intracellular domain of a receptor protein changes shape, initiating transduction of the signal.

b. Second messengers (such as cyclic AMP) are molecules that relay and amplify the intracellular signal.

c. Binding of ligand-to-ligand-gated channels can cause the channel to open or close.

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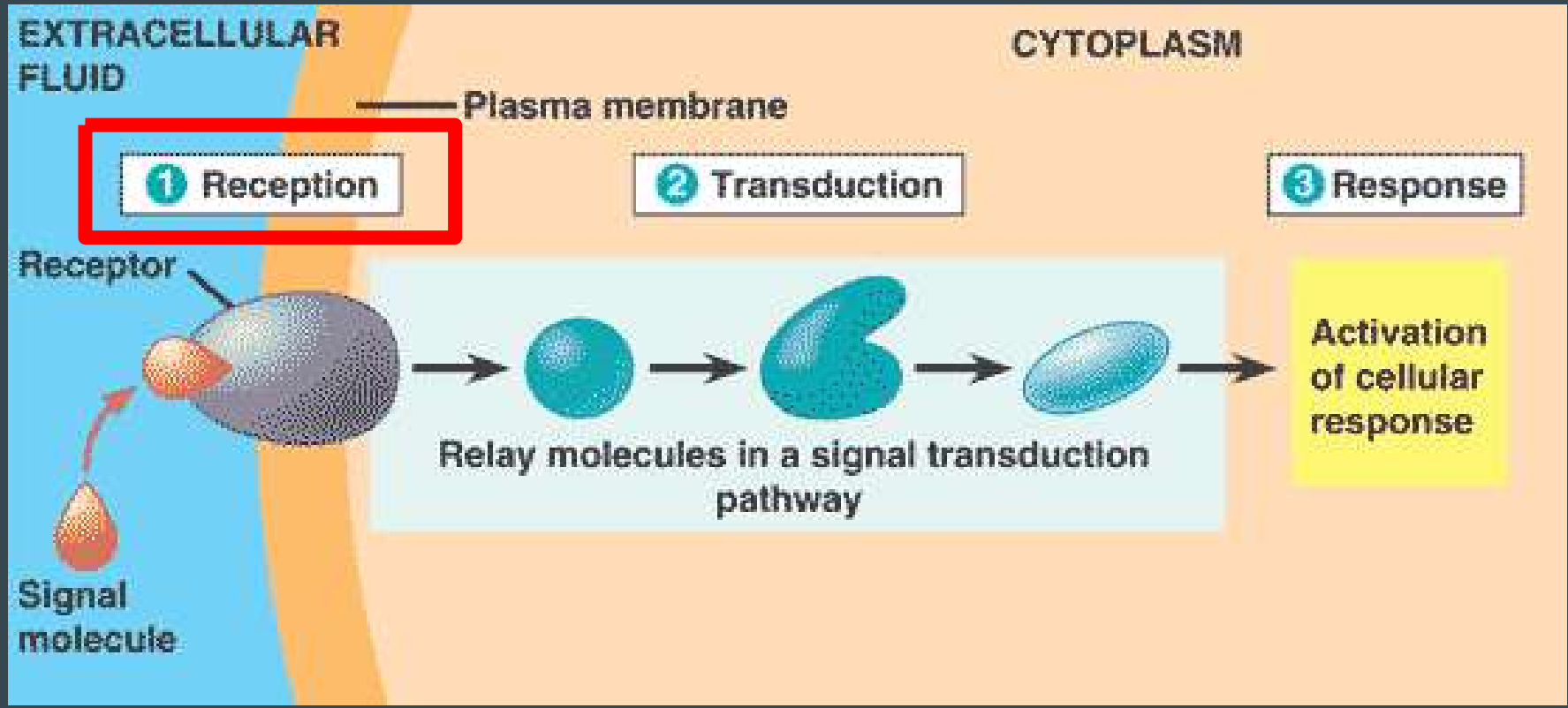
ENDURING UNDERSTANDING

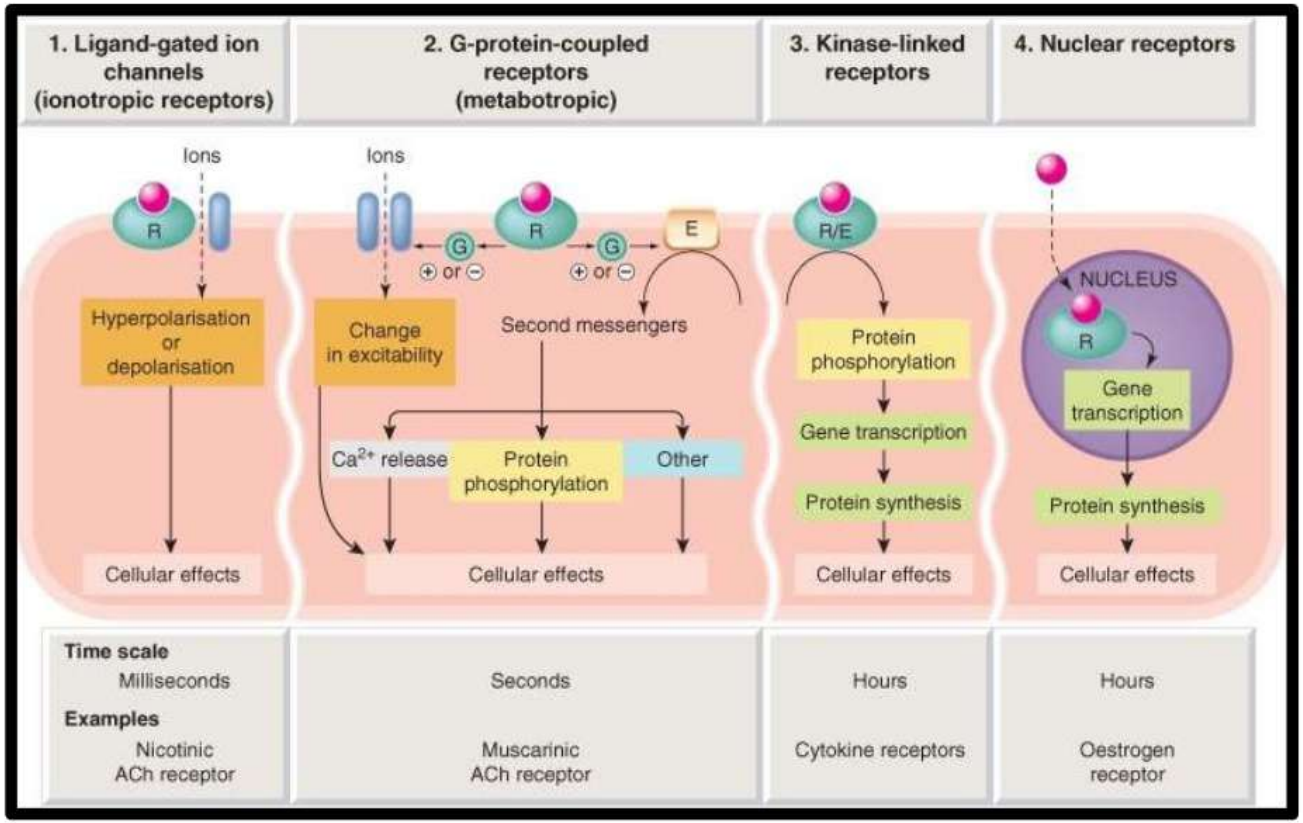
IST-3

Cells communicate by generating, transmitting, receiving, and responding to chemical signals.

LEARNING OBJECTIVE	ESSENTIAL KNOWLEDGE
IST-3.E Describe the role of the environment in eliciting a cellular response.	IST-3.E.1 Signal transduction pathways influence how the cell responds to its environment.
IST-3.F Describe the different types of cellular responses elicited by a signal transduction pathway.	IST-3.F.1 Signal transduction may result in changes in gene expression and cell function, which may alter phenotype or result in programmed cell death (apoptosis).

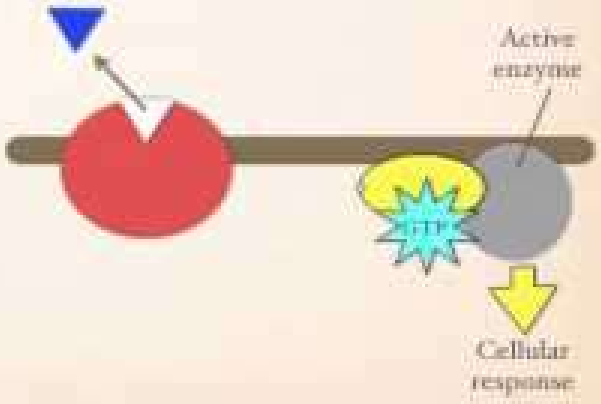

EXTRACELLULAR FLUID
CYTOPLASM
Plasma membrane
1 Reception
2 Transduction
3 Response
Receptor
Signal molecule
Relay molecules in a signal transduction pathway
Activation of cellular response

Types of receptors



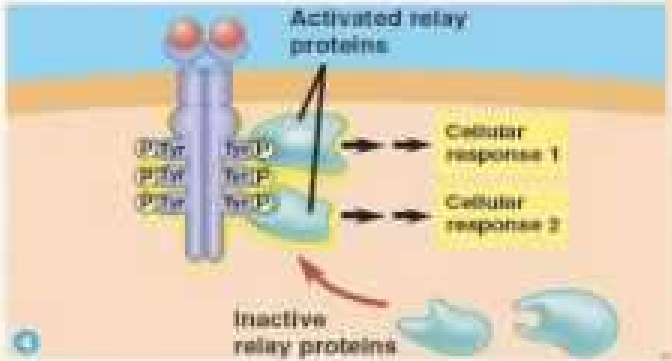
G PROTEIN COUPLED RECEPTORS

- **Step 3**: The now activated G protein disassociated from the receptor and moves to the enzyme, binds with it and <u>turns on a cellular response</u>



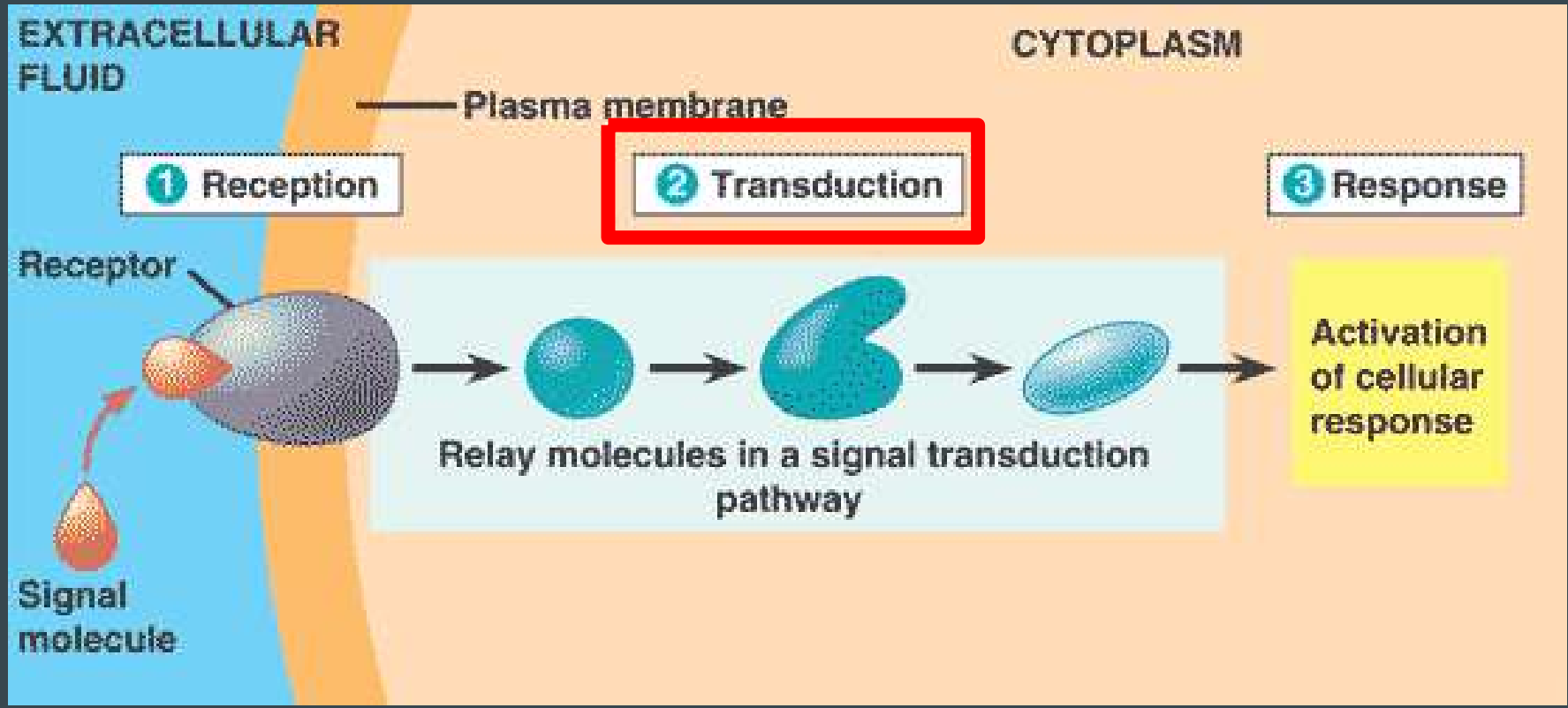
RECEPTOR TYROSINE KINASES

- Step 4: Fully phosphorylated, the active receptor is now recognized by multiple relay proteins.
- Each can trigger a separate cellular response.



IMPORTANCE

- Important in the nervous system
  - Neurotransmitters function as ligands, bonding to receptor proteins on the target cell across the synapse
  - These receptor proteins **are ion channel receptors**
  - Once open, ions flow into the target cell
  - Change in ion concentration triggers a nerve impulse


EXTRACELLULAR FLUID
CYTOPLASM
Plasma membrane
1 Reception
2 Transduction
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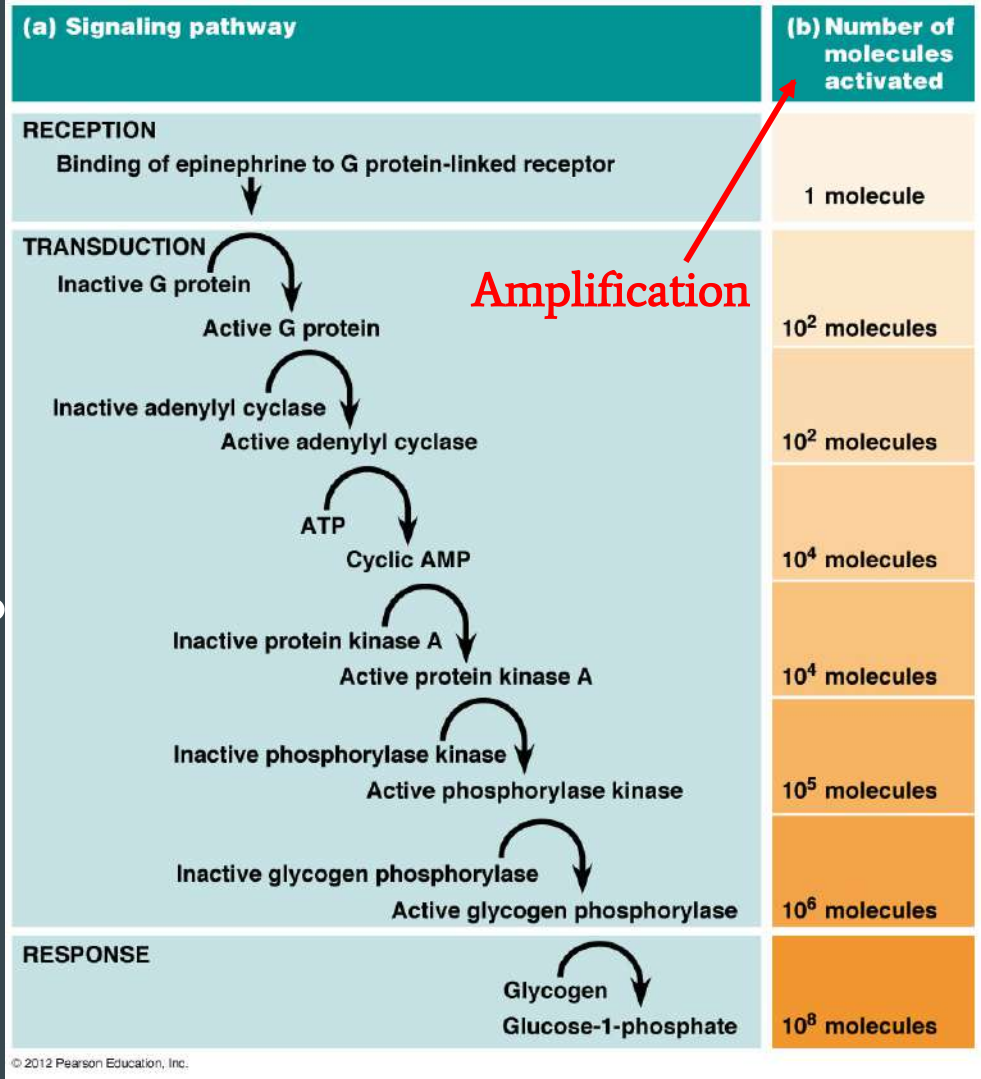
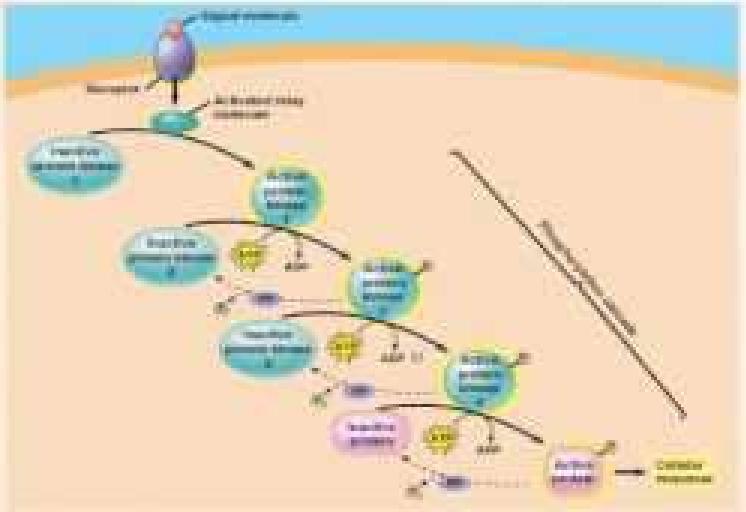
Receptor
Relay molecules in a signal transduction pathway
Activation of cellular response
Signal molecule

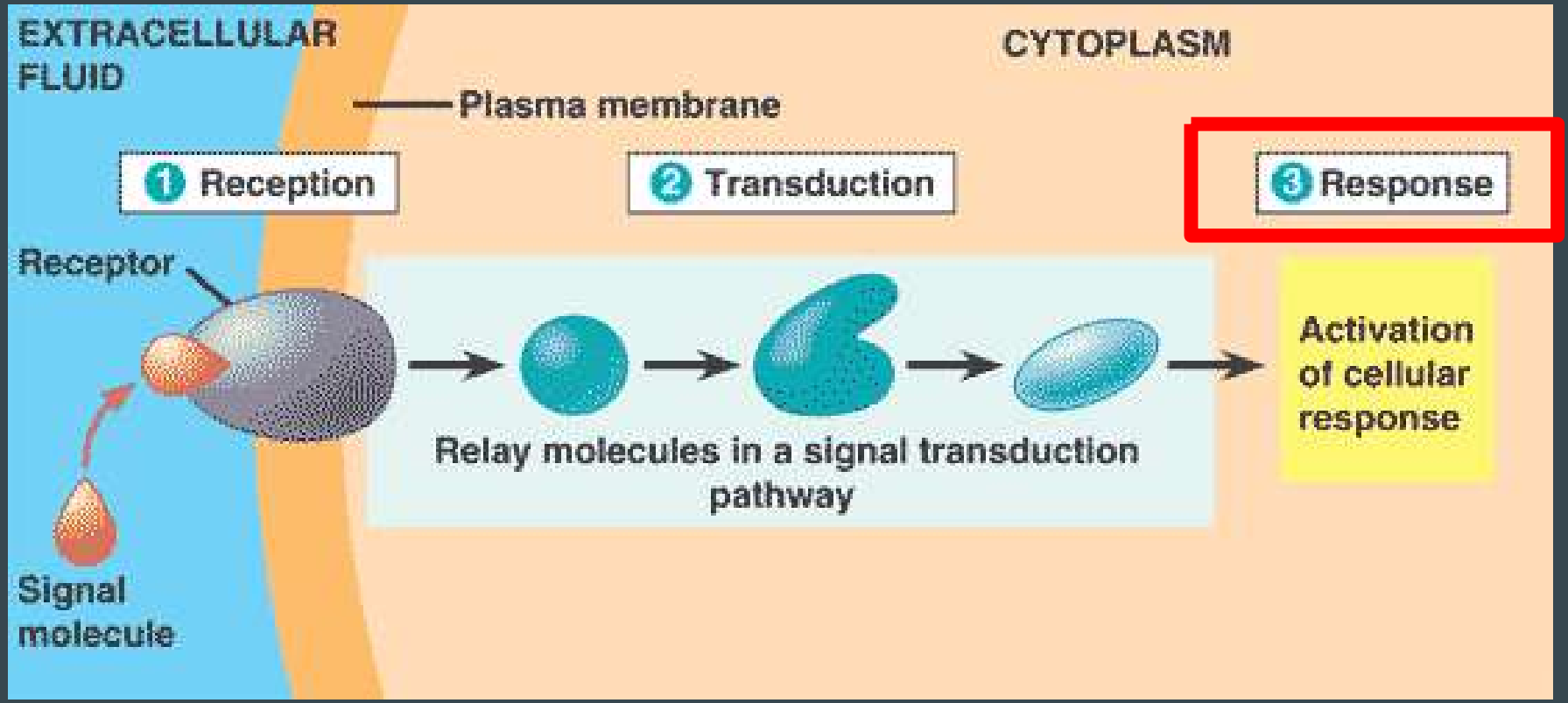
Signal Transduction Pathways obtain their "power" in being able to amplify the binding of a single ligand into a litany of coordinated Cellular Responses.



ROLE OF PROTEIN KINASES



Finally, a protein is phosphorylated that causes a cellular response


EXTRACELLULAR FLUID
CYTOPLASM
Plasma membrane
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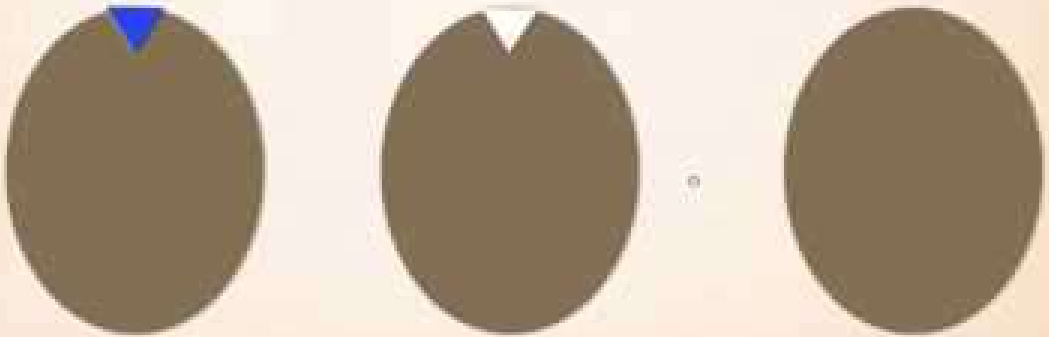
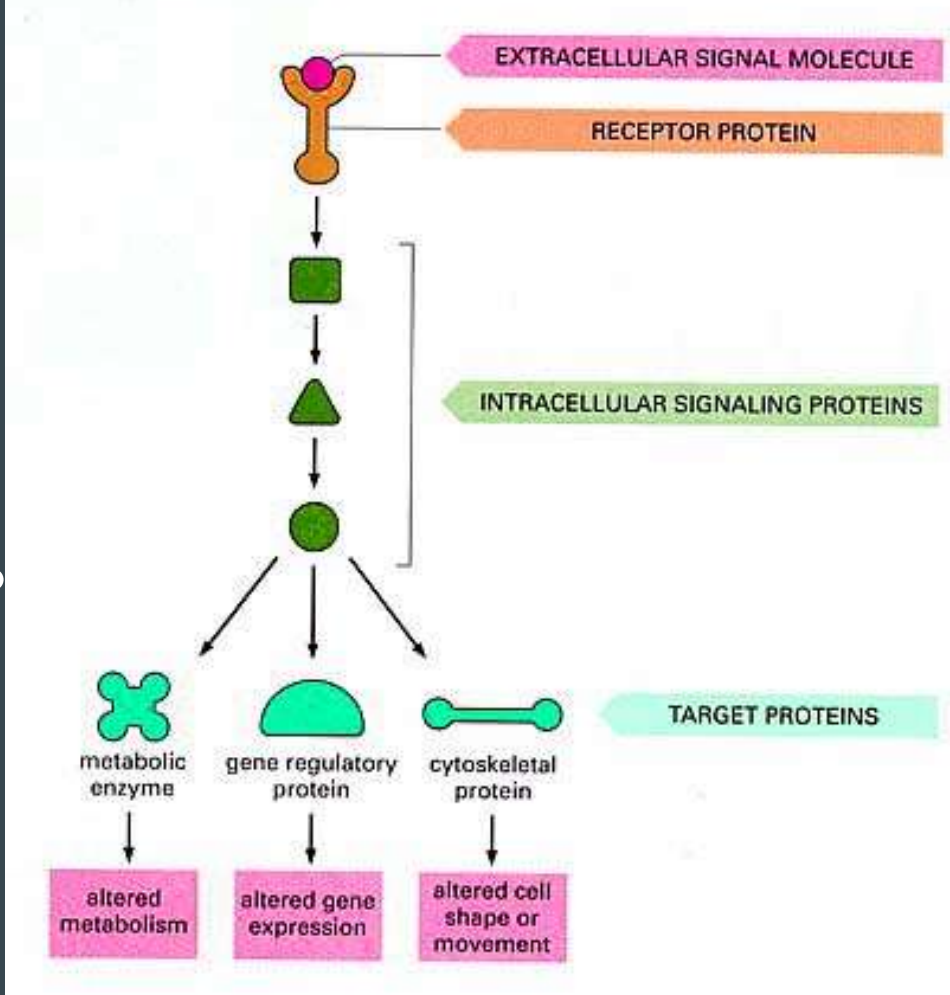
Receptor
Signal molecule
Relay molecules in a signal transduction pathway
Activation of cellular response

SPECIFICITY



There is a massive range of Cellular Responses which can be induced through a Signal Transduction Pathway.

*Gene Regulation is a primary response in which specific genes will either be turned “on or off” (Expressed or Repressed) due to the upstream signaling of a specific pathway.



The same ligand can activate different pathways in different cell types due to the different intracellular proteins found within these different cells. This allows for the release of a single ligand type to trigger responses in tissues all over your body at the same time.

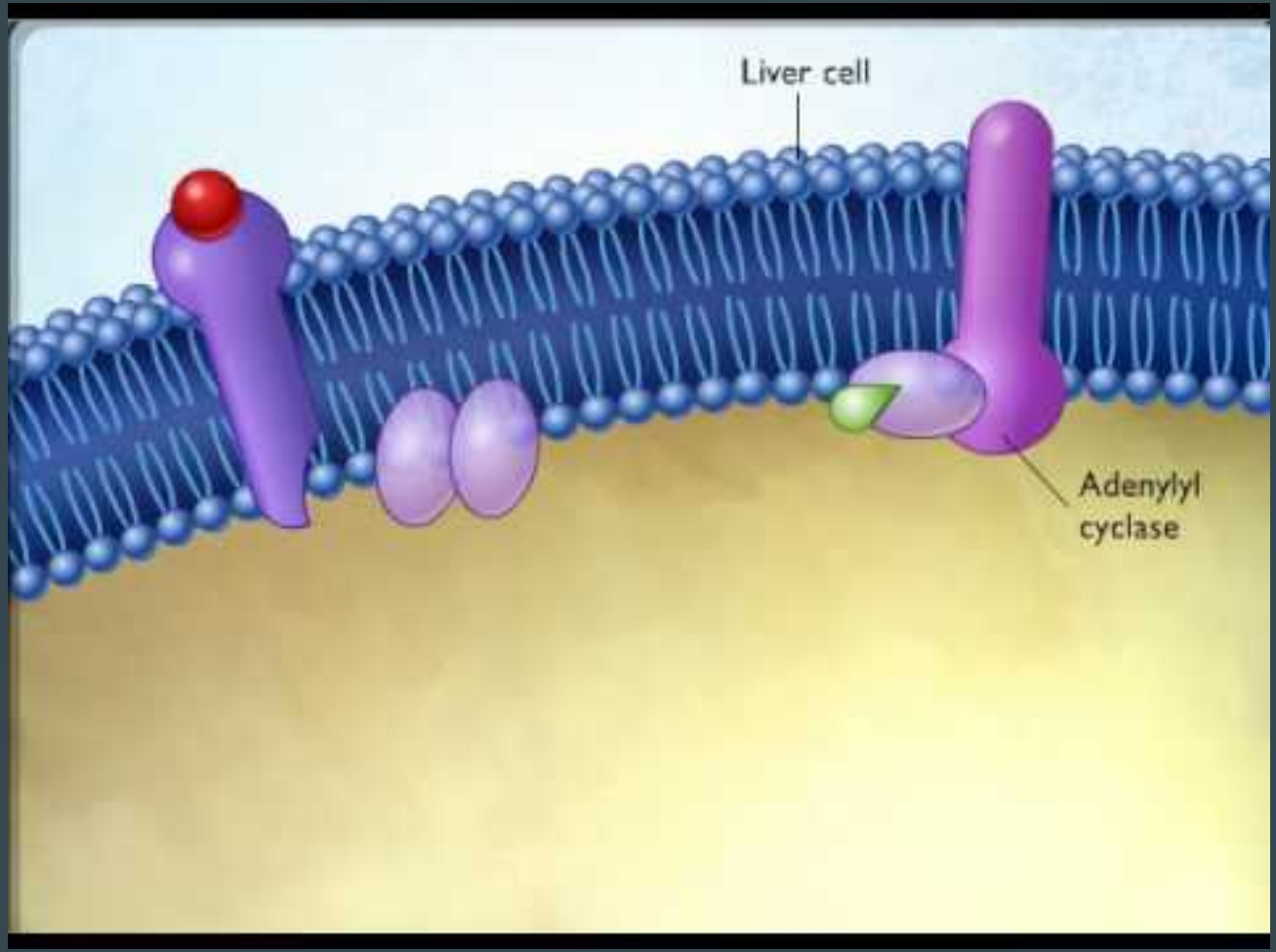
In order for this to work, each cell that is capable of responding to the ligand must produce the same receptor protein. The downstream impacts of the binding ligand is what causes the responses to be different within each cell type.

Table 2. **Physiological effects of adrenaline and noradrenaline**

Organ	Effect	How this translates clinically
Brain	● Activation of cells in the amygdala, locus coeruleus and periaqueductal grey ● Altered balance between limbic and frontal cortex control of micturition	● Heightened awareness ● Fear ● Analgesia ● Urge to pass urine or incontinence
Heart	● Increased heart rate ● Increased contractility ● Increased speed of conduction	● Increased heart rate ● Increased blood pressure
Blood vessels	● Constriction of blood flow to skin ● Dilation of blood vessels to muscles	● Cold, paler skin ● Increased exercise capacity
Kidneys	● Constriction of blood vessels to kidneys ● Increased production of antidiuretic hormone ● Increased production of renin ● Retention of sodium	● Activation of renin-angiotensin-aldosterone pathway ● Increased glomerular filtration rate ● Water retention
Gut	● Decreased motility to stomach and intestine	● Inability to digest ● Nausea, vomiting, constipation
Liver/pancreas	● Breakdown of glycogen into glucose ● Increased metabolic rate ● Inhibition of insulin production ● Increased blood glucose	● Monitor fluid balance ● Monitor urine output and colour
Skin	● Constriction of blood flow to the skin	● Pilo-erection (goose bumps) ● Hair standing on end
Skeletal muscle	● Rhythmic contraction	● Shaking or shivering ● Teeth chattering

Adrenaline (Epinephrine) is a hormone which acts as a ligand in a large variety of Transduction Pathways. Each responding cell must present a receptor on its surface which is able to bind with the Adrenaline molecule.

Can you identify the Reception, Transduction, and Response phases of this pathway?



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UNIT 4

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ENDURING UNDERSTANDING

IST-3

Cells communicate by generating, transmitting, receiving, and responding to chemical signals.

LEARNING OBJECTIVE

IST-3.G

Explain how a change in the structure of any signaling molecule affects the activity of the signaling pathway.

ESSENTIAL KNOWLEDGE

IST-3.G.1

Changes in signal transduction pathways can alter cellular response—

a. Mutations in any domain of the receptor protein or in any component of the signaling pathway may affect the downstream components by altering the subsequent transduction of the signal.

IST-3.G.2

Chemicals that interfere with any component of the signaling pathway may activate or inhibit the pathway.

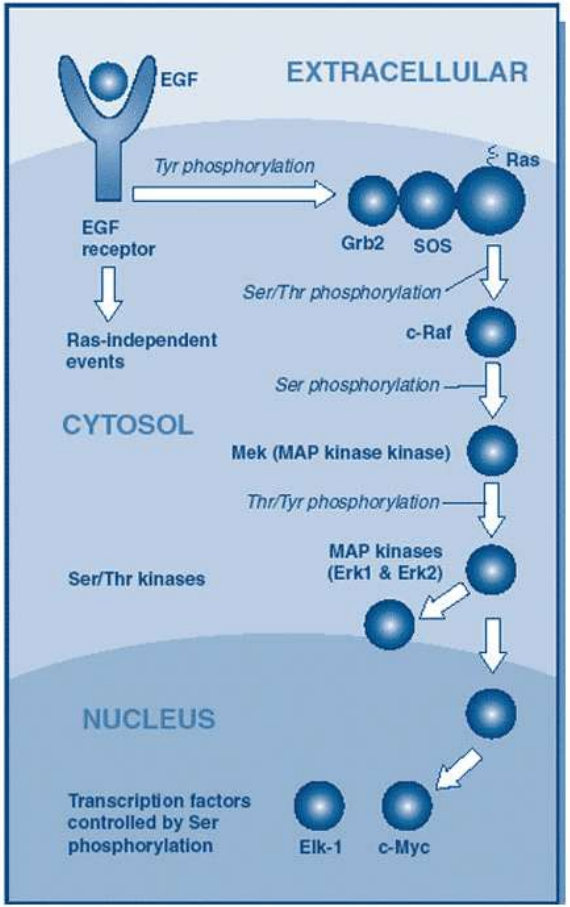
Signal Transduction Pathways can be shut down by disrupting the activity of any of the proteins involved in the transduction pathway upstream from the generated cellular response.

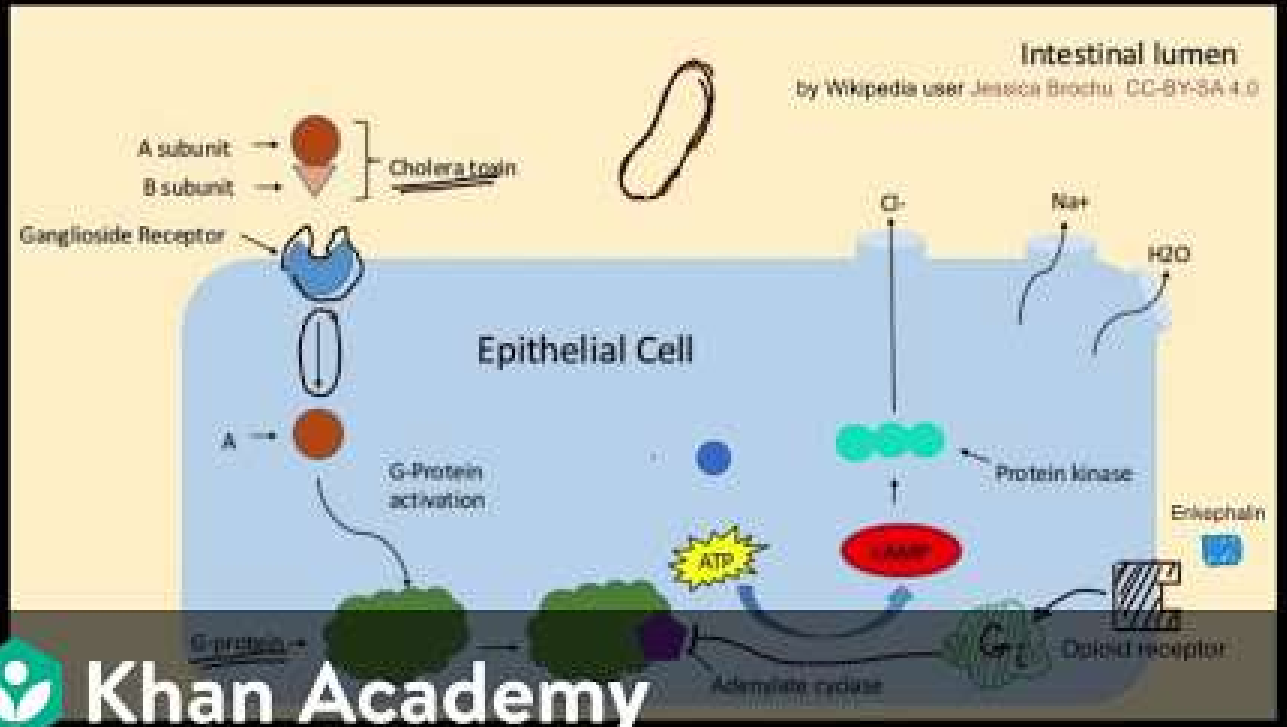
This can occur through a variety of means:

- Competitive/Non-competitive inhibition of the proteins involved in the pathway
- Mutations in the genes which code for the proteins involved in the pathway
- Mutations in the genes which code for the proteins which produce/release the pathway's ligand

**The bottom line: If you disrupt any part of the signal transduction pathway, you can change or prevent the cellular response from occurring. (This is how most medications work)*

Figure 1. Simplified signal transduction cascade through binding of a ligand to the membrane receptor to final effects on gene expression in the nucleus.[5]





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AP Biology Exam Review

4.5

UNIT 4

Cell Communication and Cell Cycle

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ENDURING UNDERSTANDING

ENE-3

Timing and coordination of biological mechanisms involved in growth, reproduction, and homeostasis depend on organisms responding to environmental cues.

LEARNING OBJECTIVE	ESSENTIAL KNOWLEDGE
ENE-3.A Describe positive and/or negative feedback mechanisms.	**ENE-3.A.1** Organisms use feedback mechanisms to maintain their internal environments and respond to internal and external environmental changes.
ENE-3.B Explain how negative feedback helps to maintain homeostasis.	**ENE-3.B.1** Negative feedback mechanisms maintain homeostasis for a particular condition by regulating physiological processes. If a system is perturbed, negative feedback mechanisms return the system back to its target set point. These processes operate at the molecular and cellular levels.
ENE-3.C Explain how positive feedback affects homeostasis.	**ENE-3.C.1** Positive feedback mechanisms amplify responses and processes in biological organisms. The variable initiating the response is moved farther away from the initial set point. Amplification occurs when the stimulus is further activated, which, in turn, initiates an additional response that produces system change.


Homeostasis and Feedback
with the Amoeba Sisters

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UNIT 4

Cell Communication and Cell Cycle

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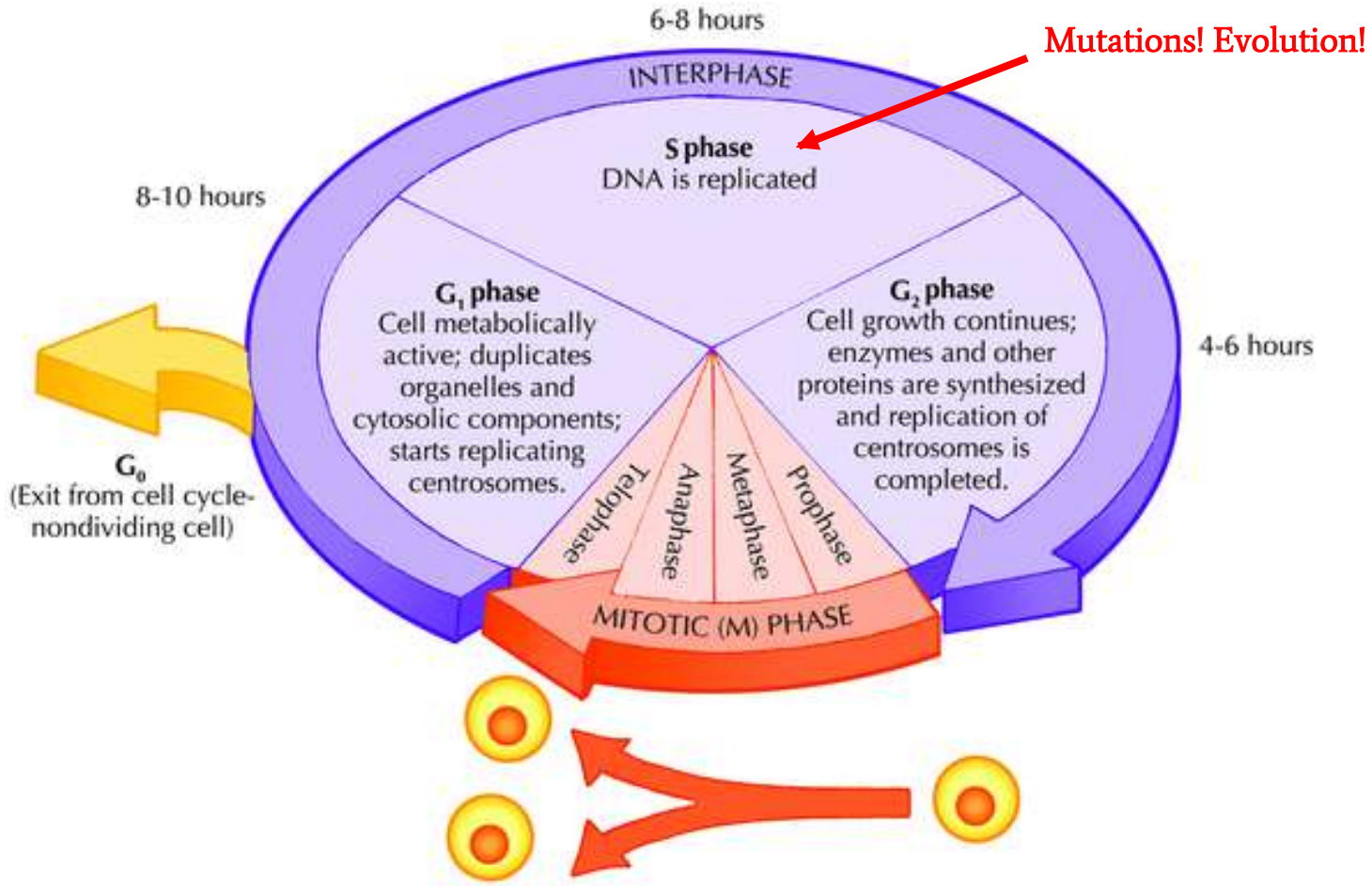
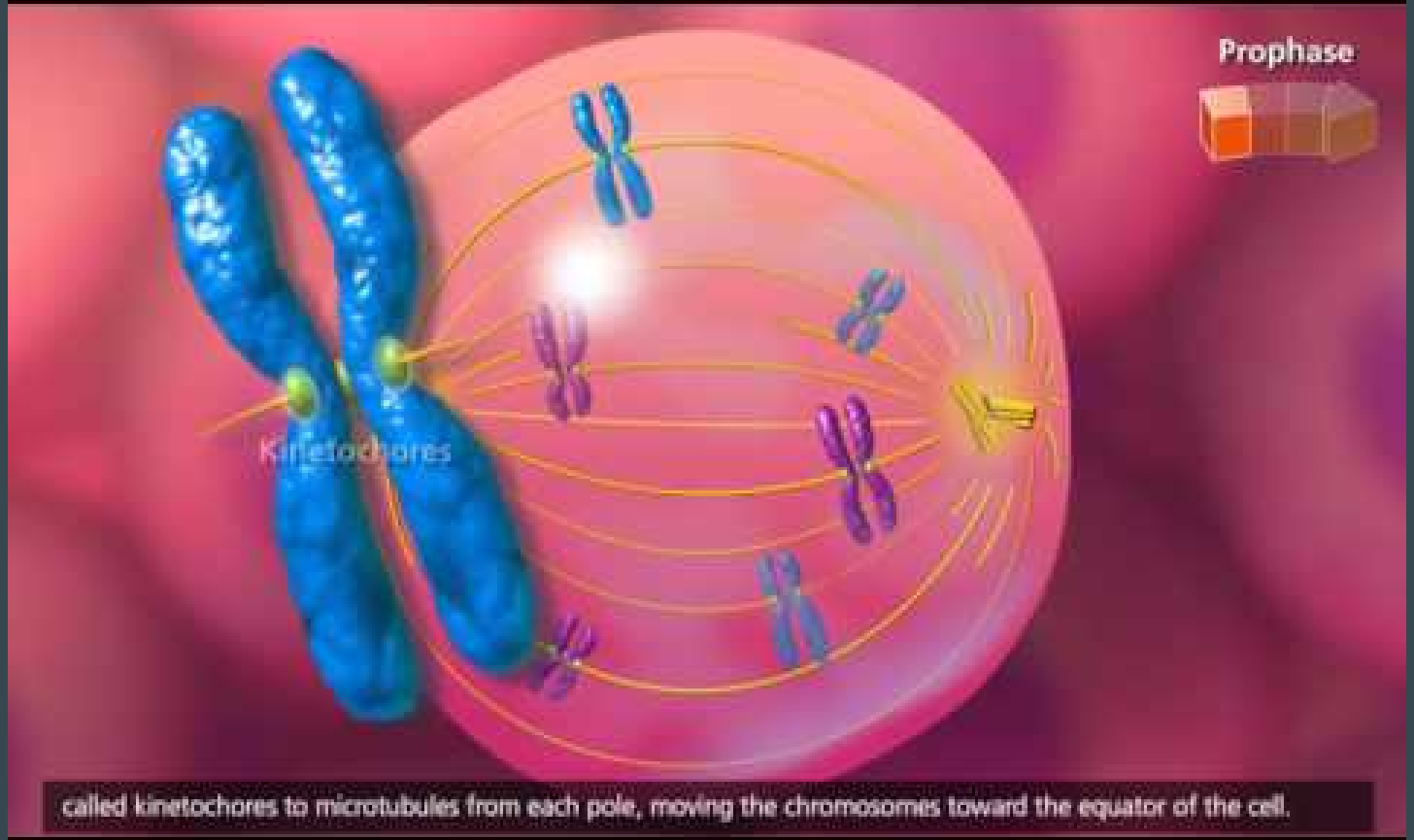
ENDURING UNDERSTANDING

IST-1

Heritable information provides for continuity of life.

LEARNING OBJECTIVE	ESSENTIAL KNOWLEDGE
IST-1.B Describe the events that occur in the cell cycle.	**IST-1.B.1** In eukaryotes, cells divide and transmit genetic information via two highly regulated processes. **IST-1.B.2** The cell cycle is a highly regulated series of events for the growth and reproduction of cells— a. The cell cycle consists of sequential stages of interphase (G1, S, G2), mitosis, and cytokinesis. b. A cell can enter a stage (G0) where it no longer divides, but it can reenter the cell cycle in response to appropriate cues. Nondividing cells may exit the cell cycle or be held at a particular stage in the cell cycle.
IST-1.C Explain how mitosis results in the transmission of chromosomes from one generation to the next.	**IST-1.C.1** Mitosis is a process that ensures the transfer of a complete genome from a parent cell to two genetically identical daughter cells— a. Mitosis plays a role in growth, tissue repair, and asexual reproduction. b. Mitosis alternates with interphase in the cell cycle. c. Mitosis occurs in a sequential series of steps (prophase, metaphase, anaphase, telophase).


6-8 hours
Mutations! Evolution!
INTERPHASE
S phase
DNA is replicated
8-10 hours
G1 phase
Cell metabolically active; duplicates organelles and cytosolic components; starts replicating centrosomes.
G2 phase
Cell growth continues; enzymes and other proteins are synthesized and replication of centrosomes is completed.
4-6 hours
G0
(Exit from cell cycle-nondividing cell)
Telophase
Anaphase
Metaphase
Prophase
MITOTIC (M) PHASE


Prophase
Kinetochores
called kinetochores to microtubules from each pole, moving the chromosomes toward the equator of the cell.

AP Biology Exam Review

4.7

UNIT 4

Cell Communication and Cell Cycle

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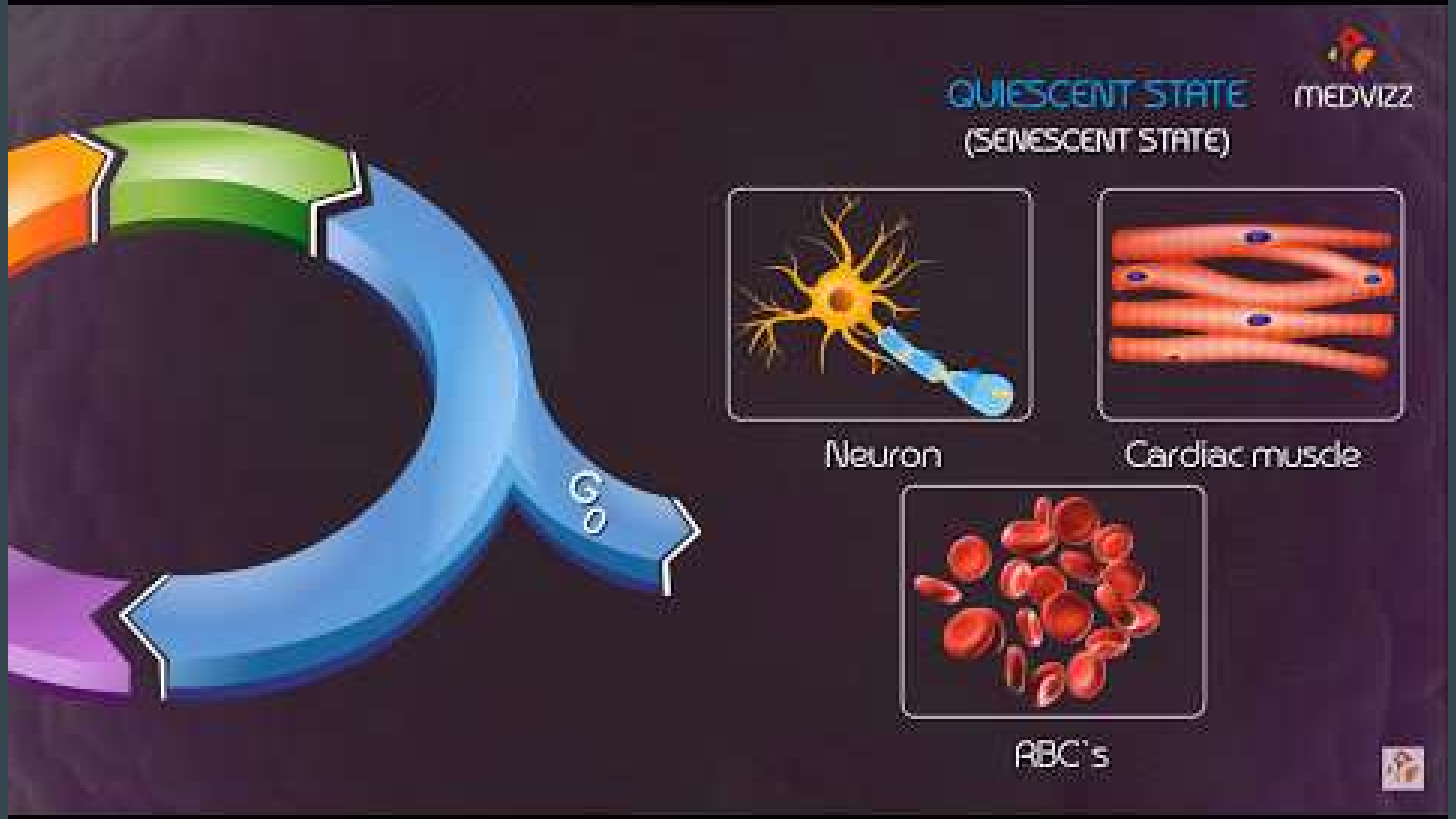
ENDURING UNDERSTANDING

IST-1

Heritable information provides for continuity of life.

LEARNING OBJECTIVE	ESSENTIAL KNOWLEDGE
IST-1.D Describe the role of checkpoints in regulating the cell cycle.	**IST-1.D.1** A number of internal controls or checkpoints regulate progression through the cycle.
	IST-1.D.2 Interactions between cyclins and cyclin-dependent kinases control the cell cycle.
	EXCLUSION STATEMENT—*Knowledge of specific cyclin-CdK pairs or growth factors is beyond the scope of the course and the AP Exam.*
IST-1.E Describe the effects of disruptions to the cell cycle on the cell or organism.	**IST-1.E.1** Disruptions to the cell cycle may result in cancer and/or programmed cell death (apoptosis).

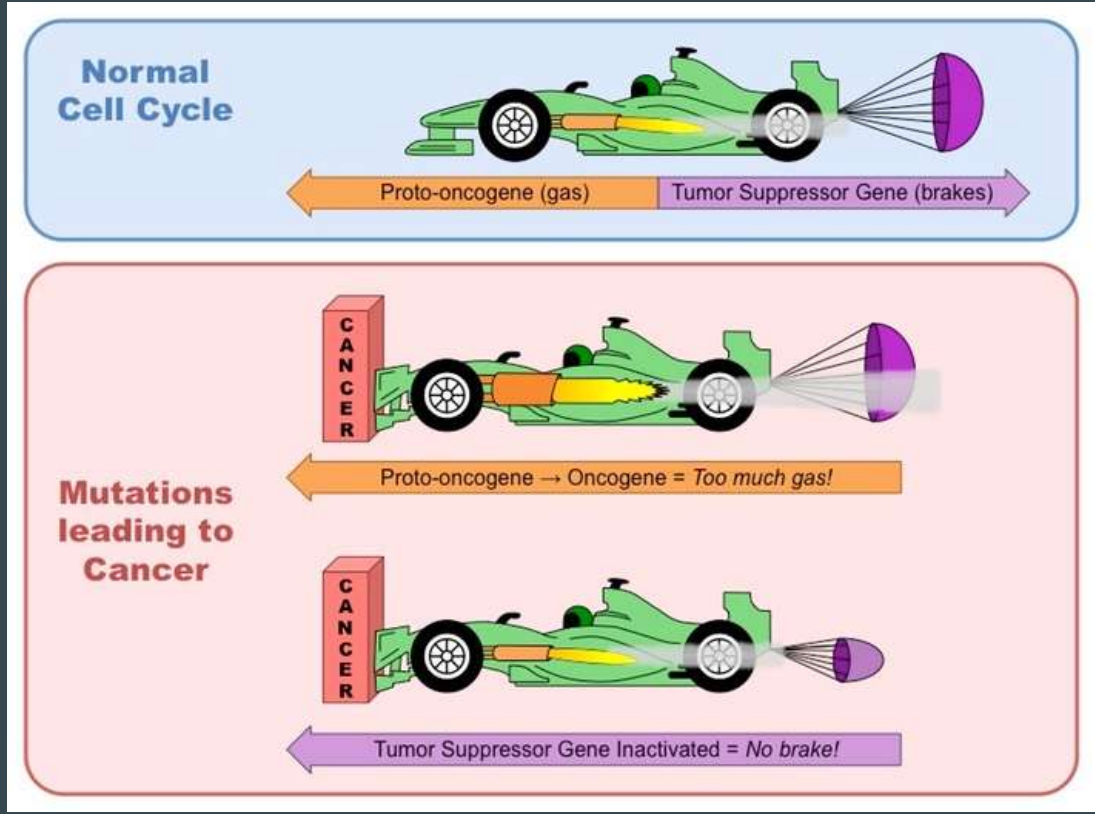

QUIESCENT STATE
(SENESCENT STATE)
MEDVIZZ
G0
Neuron
Cardiac musde
ABC`s

The cell cycle is regulated by two major classes of genes (and in turn by the proteins which they code for):

- Tumor Suppressor Genes: Code for proteins which inhibit the cell cycle. When deactivated the cell cycle is able to progress

- Proto-oncogenes: Code for proteins which stimulate the cell cycle.

**Mutations in these genes can lead to a cell progressing through the cell cycle in an abnormal and uncontrolled manner. This is what can cause a cell to become cancerous.*



Mutations build up over time leading to age being a primary risk factor in developing cancer.