

# ENDOCRINOLOGY (INTRODUCTION)

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# INTRODUCTION

- Endocrine vs exocrine gland
- Chemical messengers
- Hormone
  - Definition
  - Chemical structure
  - Paracrine, autocrine, endocrine, neuroendocrine
  - Transport and clearance
- Mechanism of action
  - Receptors, down-regulation and up-regulation
  - Intracellular signaling
  - Second messenger (cAMP, IP3)

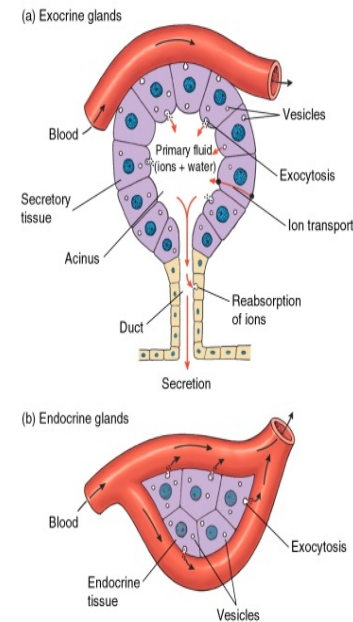
# INTRODUCTION

## A. Exocrine gland

- Ducts
- Secrets enzymes
- Lumen and surfaces

## B. Endocrine gland

- No ducts
- Secrets Chemical messengers
- Blood stream



# CHEMICAL MESSENGERS

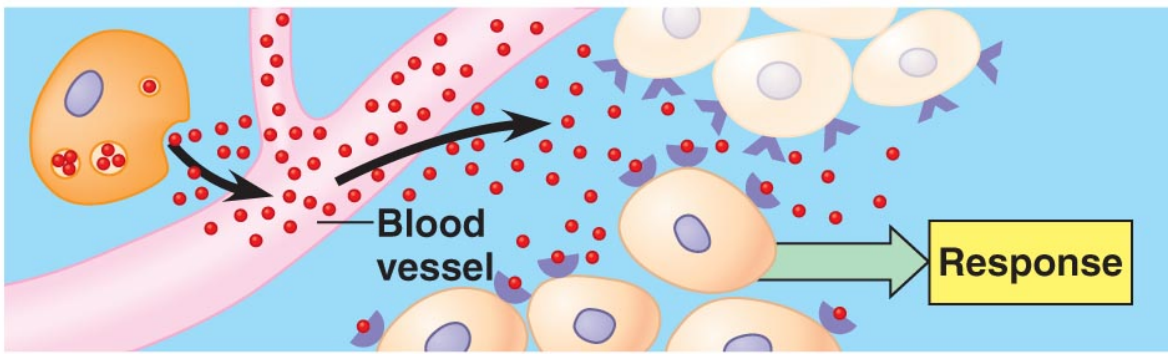
- The activities of cells, tissues and organs are coordinated by chemical messengers
  - Neurotransmitters
  - Endocrine hormones
  - Neuroendocrine hormones
  - Paracrines
  - Autocrines
  - Cytokines

# SMALL GROUP ACTIVITY

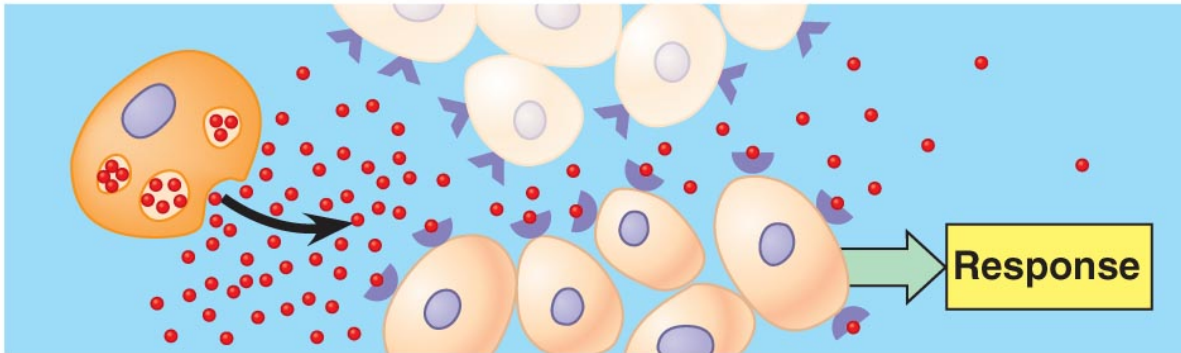
- Divide into 6 groups
- Explain
  - Neurotransmitter
  - Neuroendocrine
  - Endocrine
  - Paracrine
  - Autocrine
  - Cytokines



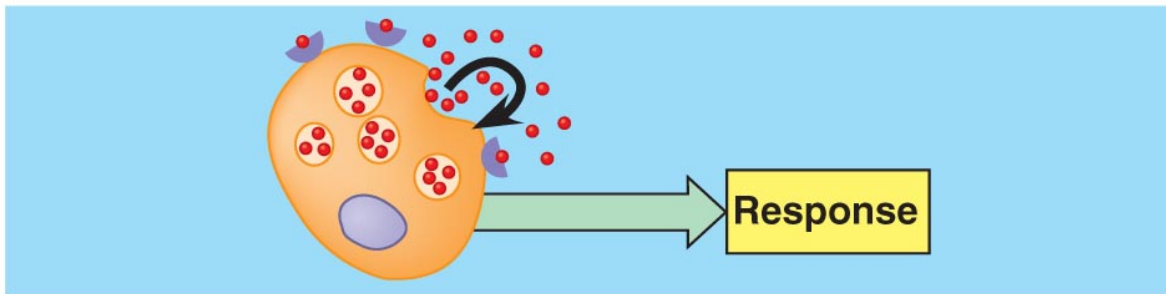




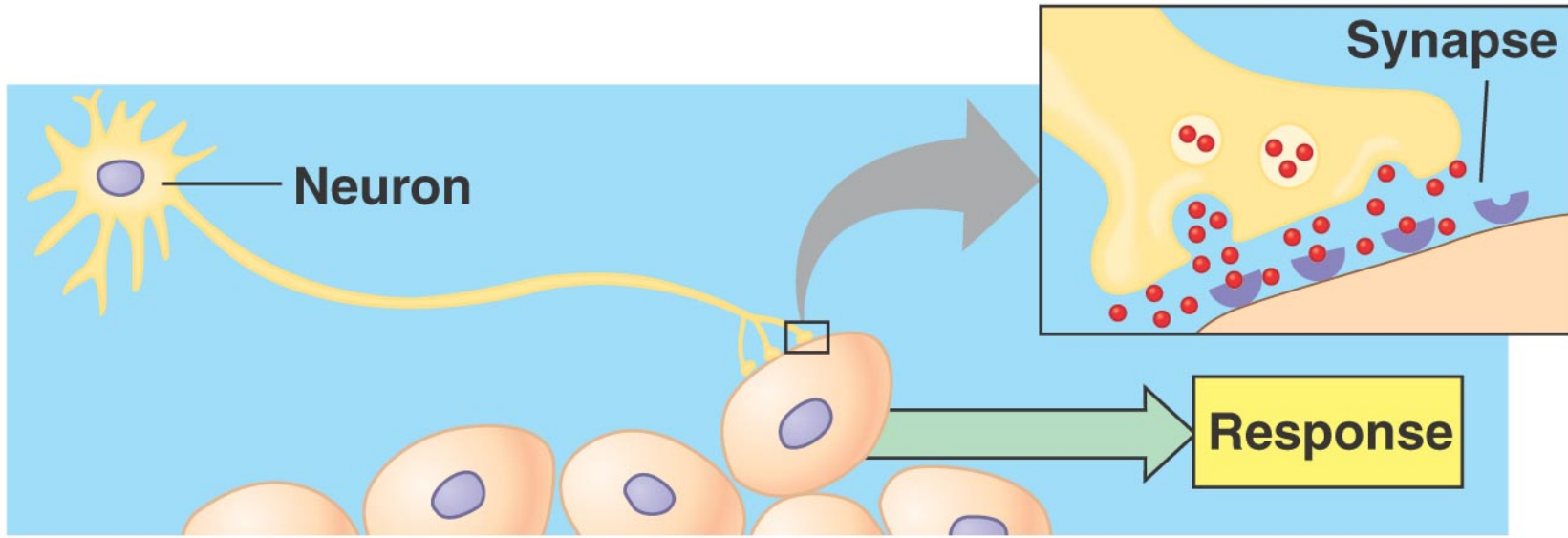
**(a) Endocrine signaling**



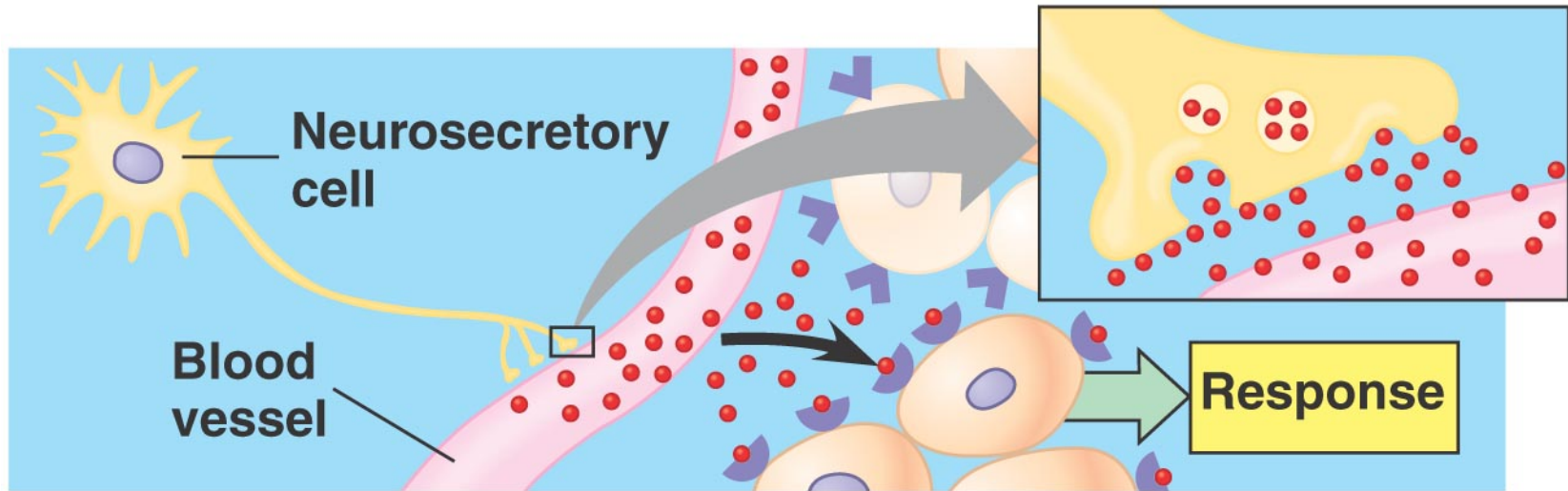
**(b) Paracrine signaling**



**(c) Autocrine signaling**



**(d) Synaptic signaling**

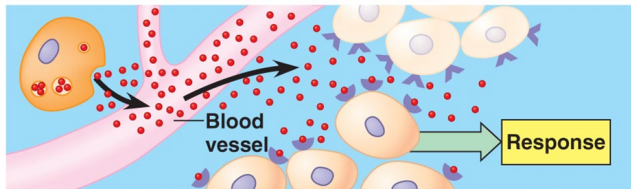


**(e) Neuroendocrine signaling**

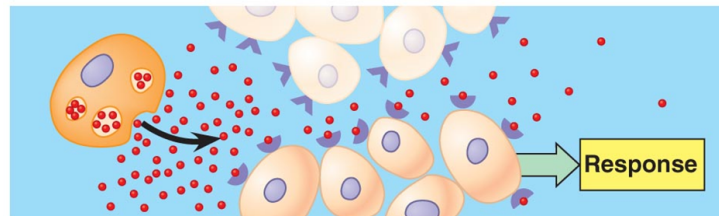


# CYTOKINES

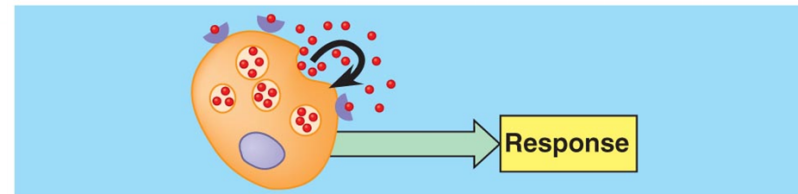
- Peptides (interleukins, lymphokines, adipokines)
- Secreted by cells into extracellular fluid.
- Can function as



(a) Endocrine signaling



(b) Paracrine signaling



(c) Autocrine signaling

# LARGE GROUP ACTIVITY

- List the endocrine glands.



# INTRODUCTION

## ○ Endocrine glands:

- Pituitary
- Thyroid
- Parathyroid
- Adrenal
- Pancreas
- Ovaries
- Testes

### Major endocrine glands:

Hypothalamus

Pineal gland

Pituitary gland

Thyroid gland

Parathyroid glands

Adrenal glands

Pancreas

Kidney

Ovaries

### Organs containing endocrine cells:

Thymus

Heart

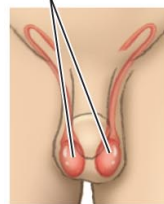
Liver

Stomach

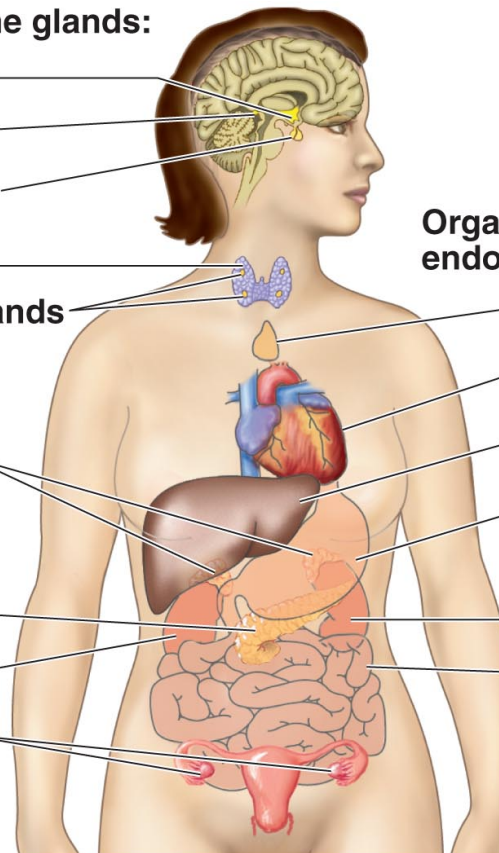
Kidney

Small intestine

Testes



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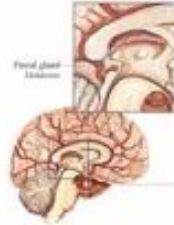


# THE ENDOCRINE SYSTEM

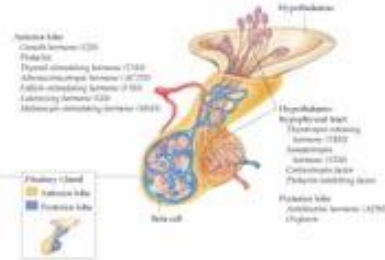
## Thyroid and Parathyroid Glands



## Pineal Gland



## Pituitary Gland and Hypothalamus



## Thymus Gland



## Heart

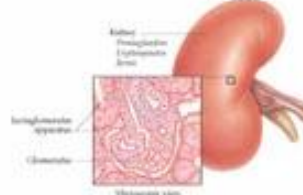


Coronary vessels allow blood to flow to the heart muscle.

## Adrenal Glands



## Kidney



## Ovary



## Placental Hormones

(Secreted during pregnancy)

- Human chorionic gonadotropin (HCG)
- Human placental lactogen (HPL)
- Human chorionic somatomedin (HCSM)

## Stomach, Duodenum, and Jejunum



## Pancreas



## Testes



# INTRODUCTION

- The multiple hormone systems play a key role in regulating almost all body functions:
  - Metabolism
  - Growth and development
  - Water and electrolyte balance
  - Reproduction
  - Behavior

# INTRODUCTION

## ○ Definition :

- Hormone is a chemical substance released by group of cells to control the function of other type of cells.

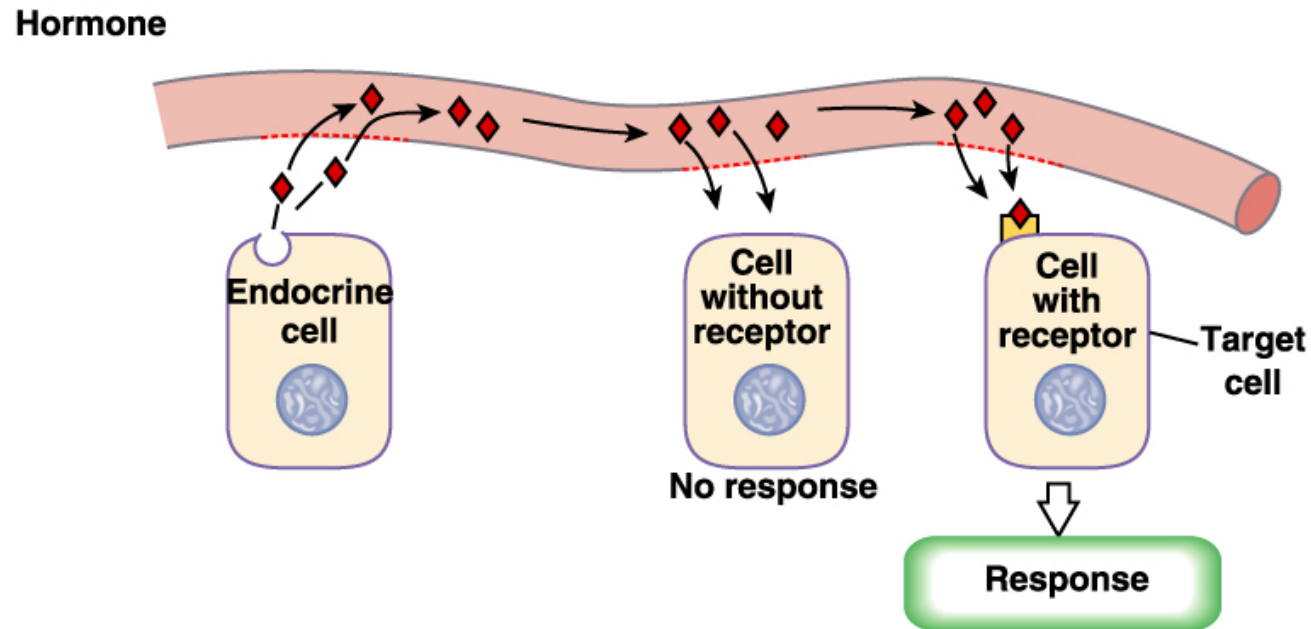
## ○ Types of hormones

- Affect many different types of cells (eg. GH and Thyroxin)
- Affect only specific target cells (eg. ACTH and estrogen)

# INTRODUCTION

- What are **target cells**?

Target cells refer to cells that contain specific receptors (binding sites) for a particular hormone.



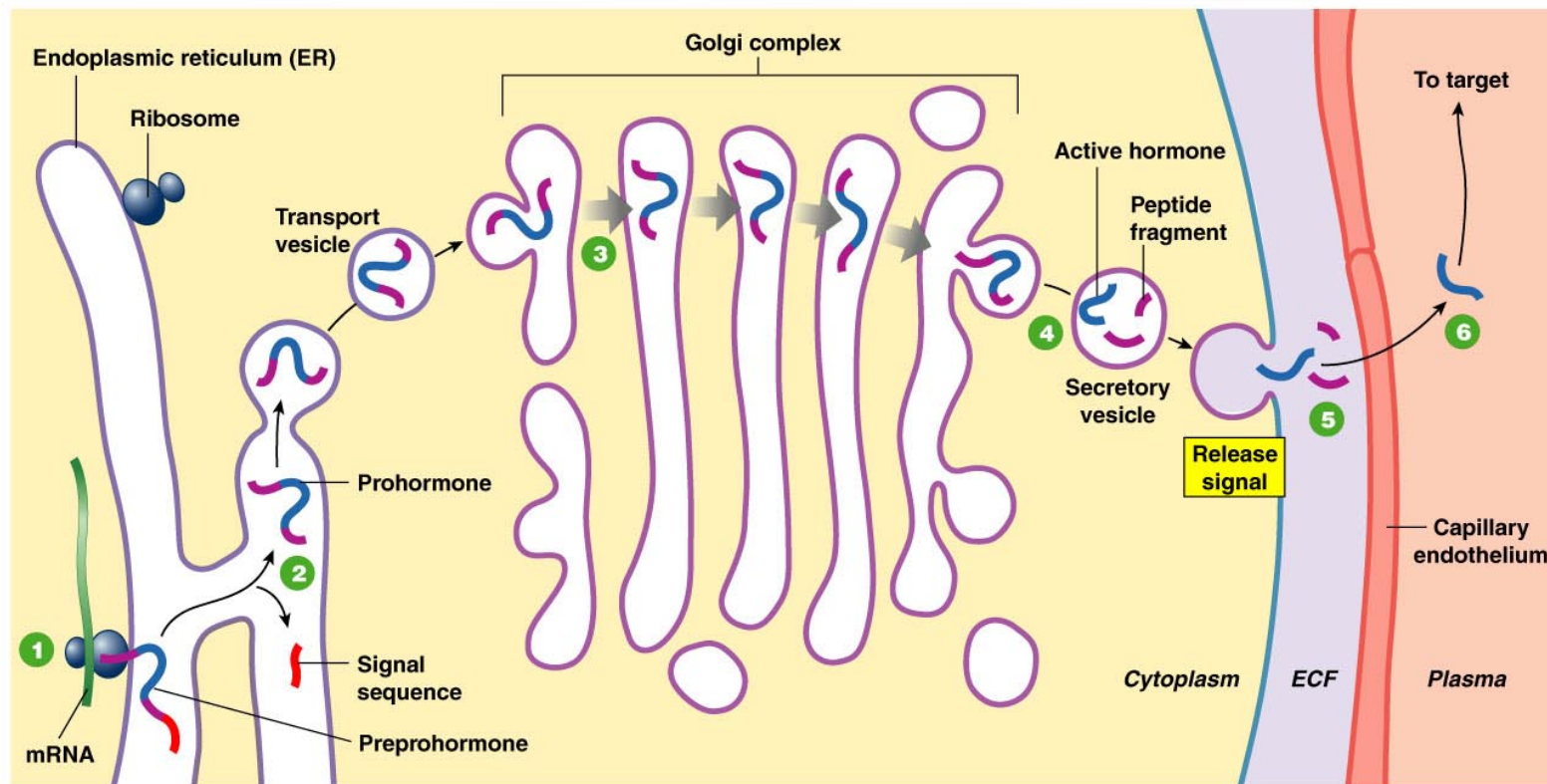
# INTRODUCTION

- Chemical structure of hormones
  - Three general classes of hormones:
    - **Proteins** and polypeptides (anterior and posterior pituitary, pancreas and parathyroid hormones) stored in vesicles until needed
    - **Steroids** (adrenal cortex, ovarian and testicular hormones) diffuse across the cell membrane
    - **Derivatives of amino acid tyrosine** (thyroid hormones and catecholamines)



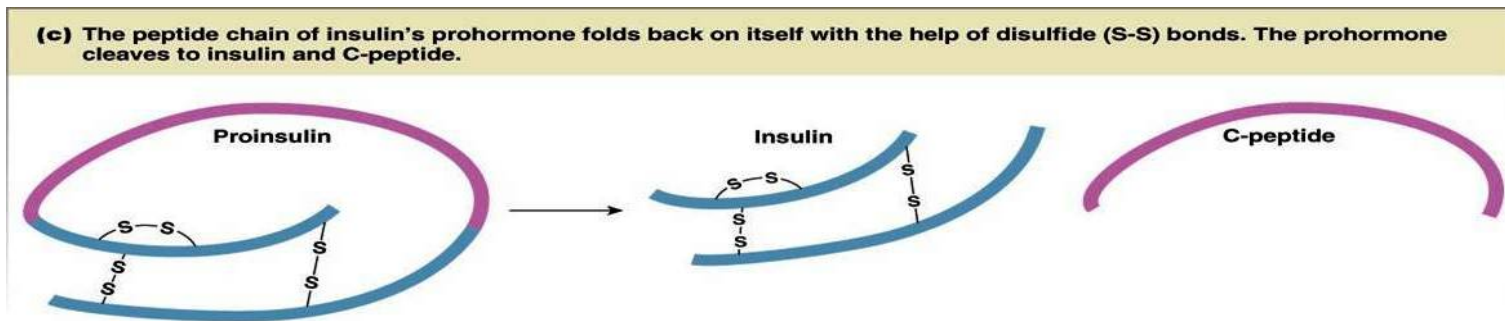
# PEPTIDE (PROTEIN) HORMONES

- Synthesized as **preprohormone** → **post-translational modification to prohormone** → then **hormone**



# PEPTIDE (PROTEIN) HORMONES

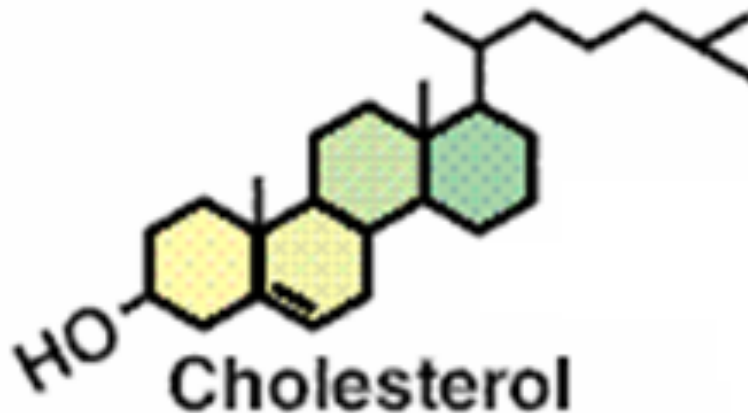
- Example of protein hormone
  - Insulin



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# STEROID HORMONES

- Secreted by gonads, adrenals, placenta
- Derived from cholesterol (lipophilic)
  - Cross membranes (no storage)
- On-demand synthesis (SER)
- Usually Bound to **Carrier** proteins



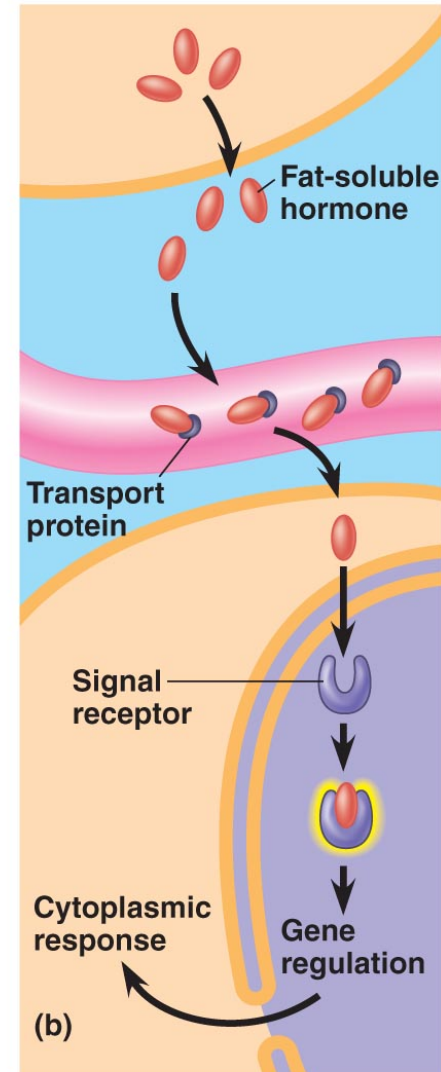
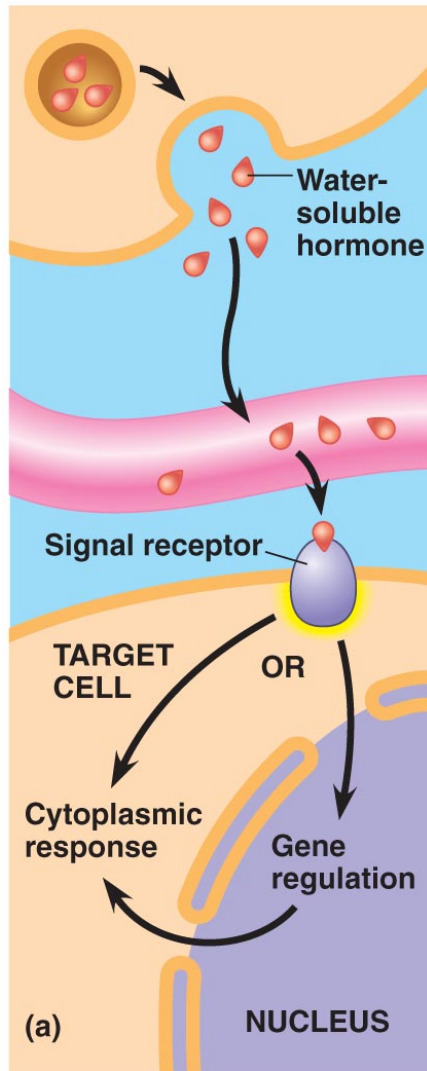
# AMINE HORMONES

- ◉ Derived from tyrosine or tryptophan
- ◉ 3 groups
  - Tryptophan ⇒ Melatonin
  - Tyrosine ⇒ Catecholamines  
behave like peptide hormones
  - Tyrosine ⇒ Thyroid hormones  
behave like steroid hormones

# TRANSPORT OF HORMONES

- ◉ Water soluble hormones- hydrophilic (peptides & catecholamines) dissolved in plasma
- ◉ Fat soluble hormones - hydrophobic Steroids and thyroid hormones transported bound to plasma proteins (90%),  
binding to proteins helps to
  - Provide reservoirs
  - Slow hormones clearance

# DIFFERENCES BETWEEN WATER AND FAT SOLUBLE HORMONES









# HORMONES & RECEPTORS

## ○ Receptors:

- Hormonal receptors are large proteins
- 2000-100,000 receptors/cell
- Receptors are highly specific for a single hormone

## ○ Receptor's Location:

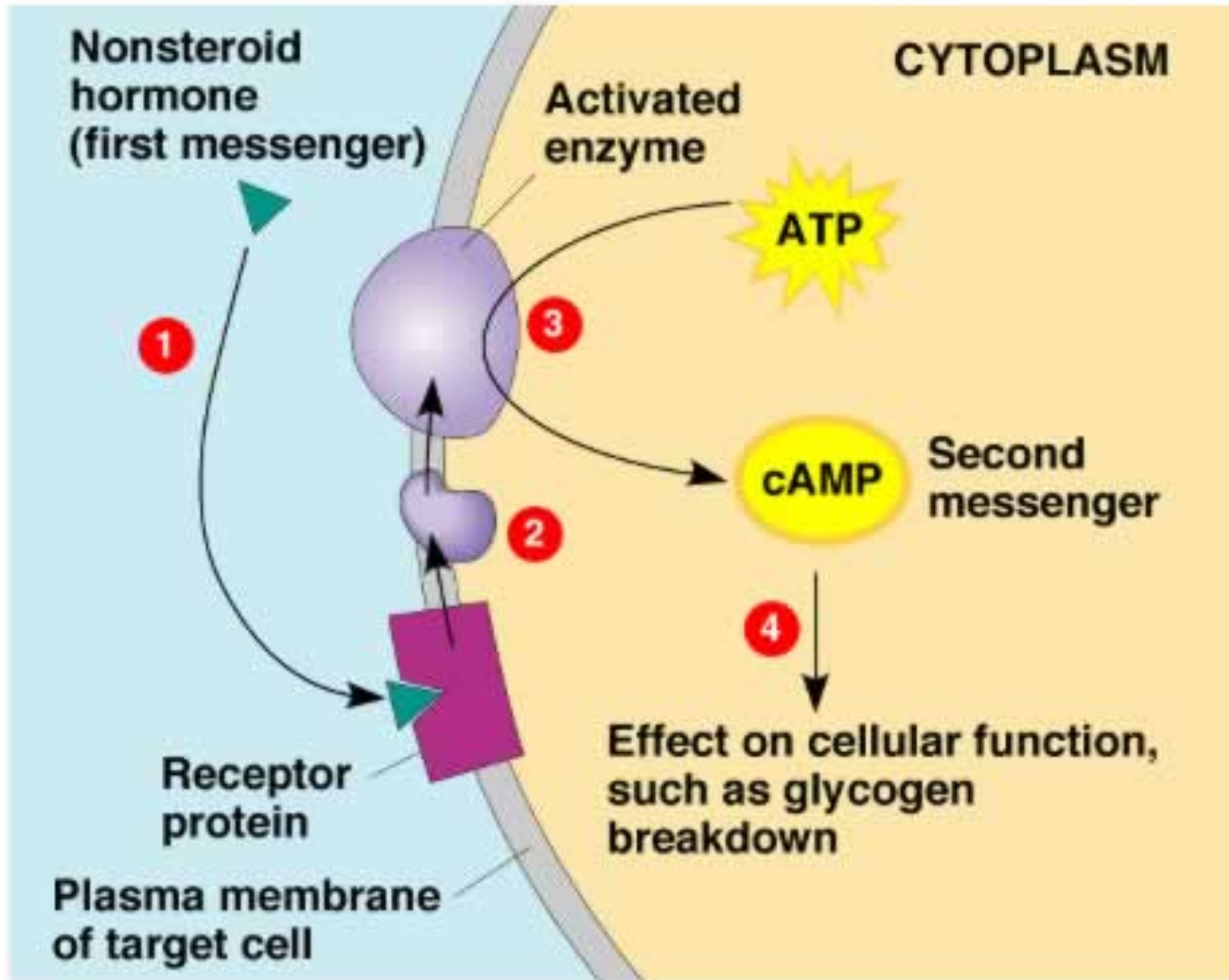
- On the surface of cell membrane (proteins, peptides and catecholamines)
- In the cell cytoplasm (Steroids)
- In the cell nucleus (thyroid hormones)

# MECHANISM OF ACTION OF HORMONES

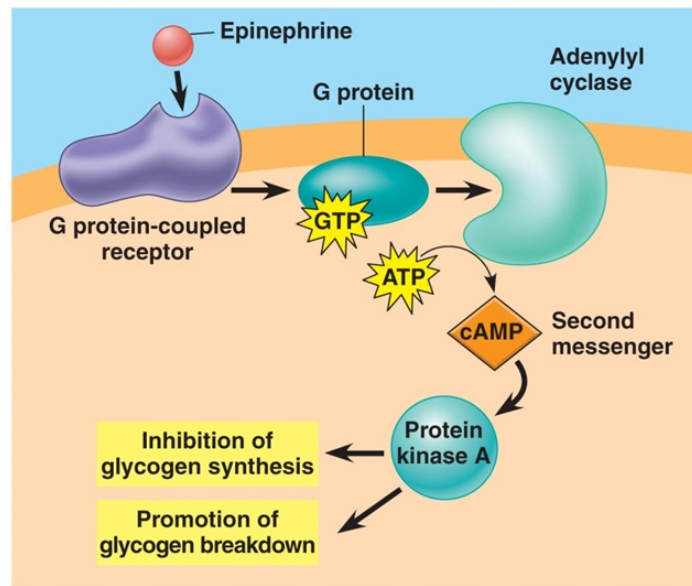
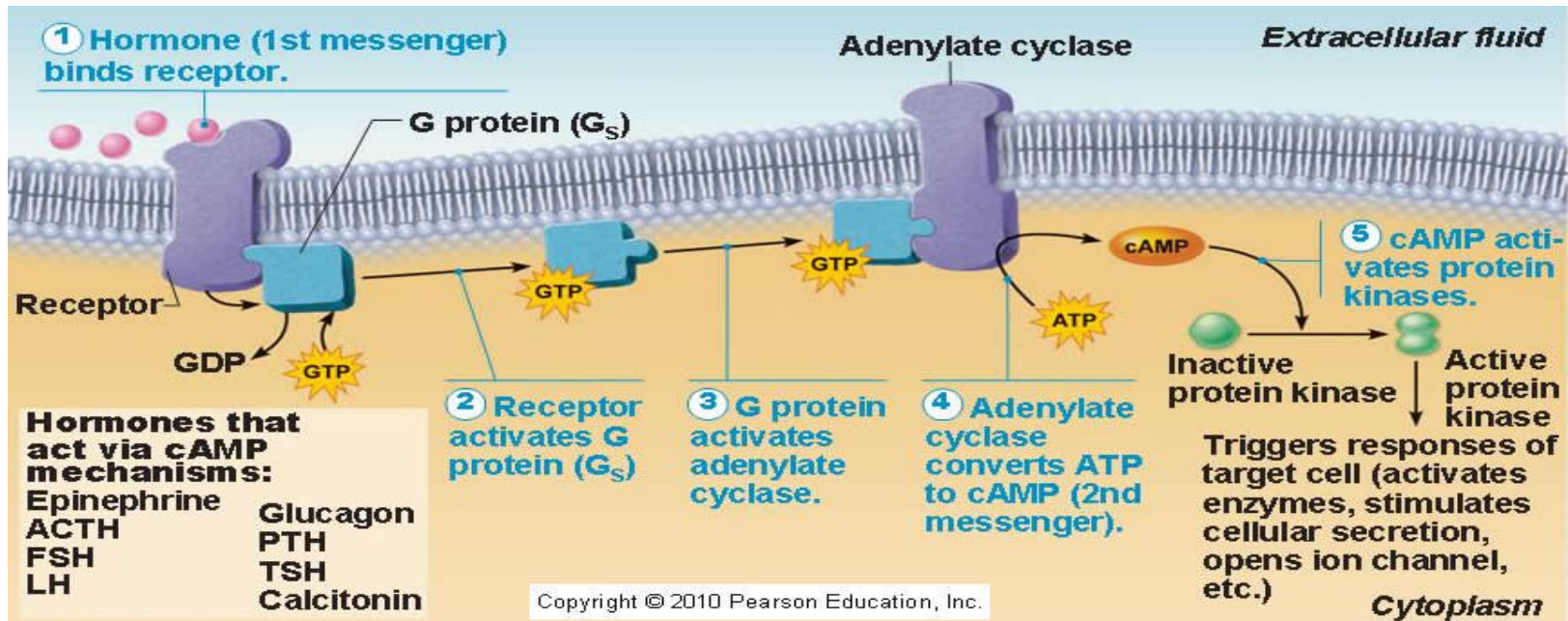
## ○ Mechanism of action :

1. Hormone-receptor interaction (1<sup>st</sup> messenger)
2. Enzyme activation
3. Release of the second messenger
4. Effects on cellular function

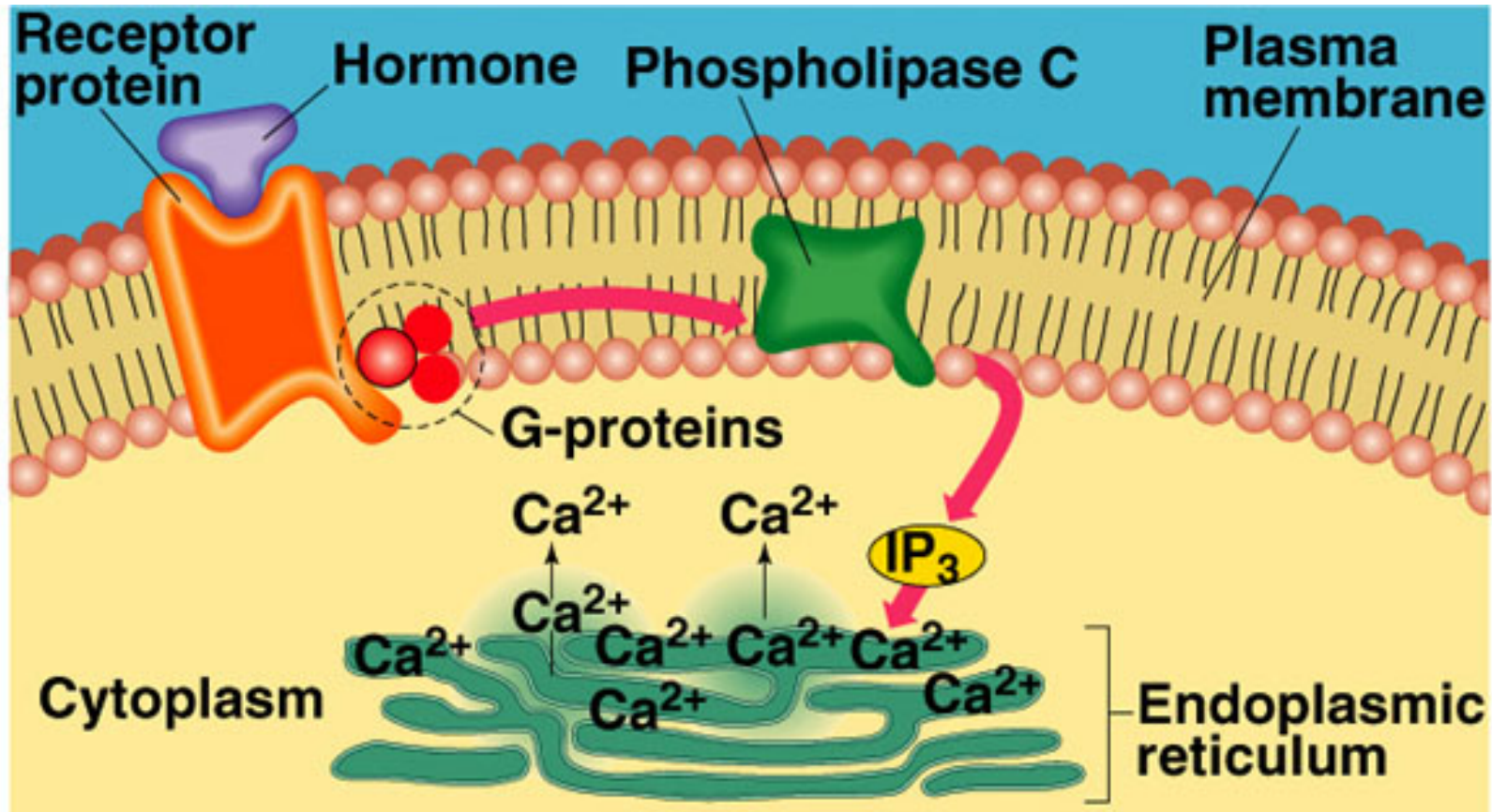
# MECHANISM OF ACTION (PEPTIDES AND PROTEIN HORMONES)



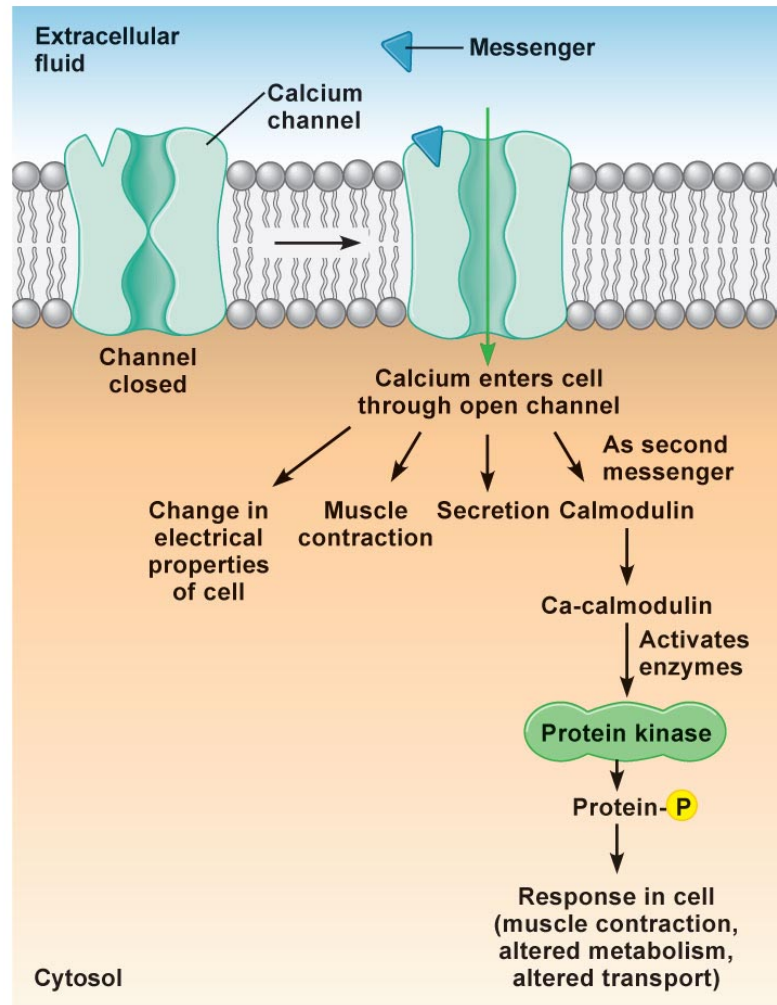
# SECOND MESSENGER (ADENYLYLATE CYCLASE-CAMP)



# SECOND MESSENGER (PHOSPHOLIPASE C-IP<sub>3</sub>)

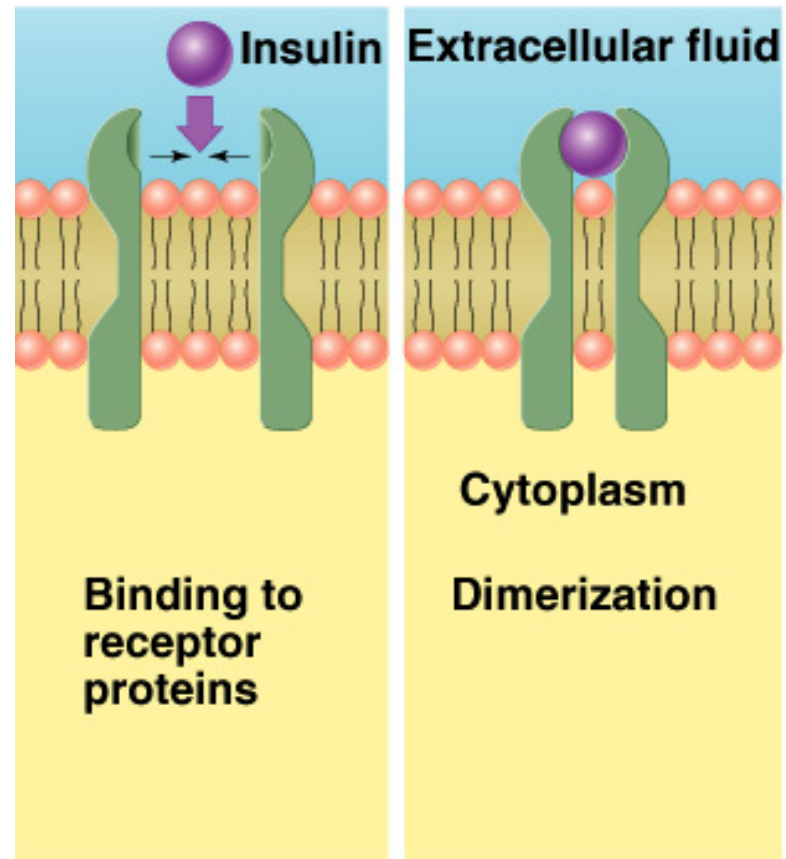


# SECOND MESSENGER (CALCIUM-CALMODULIN COMPLEX)



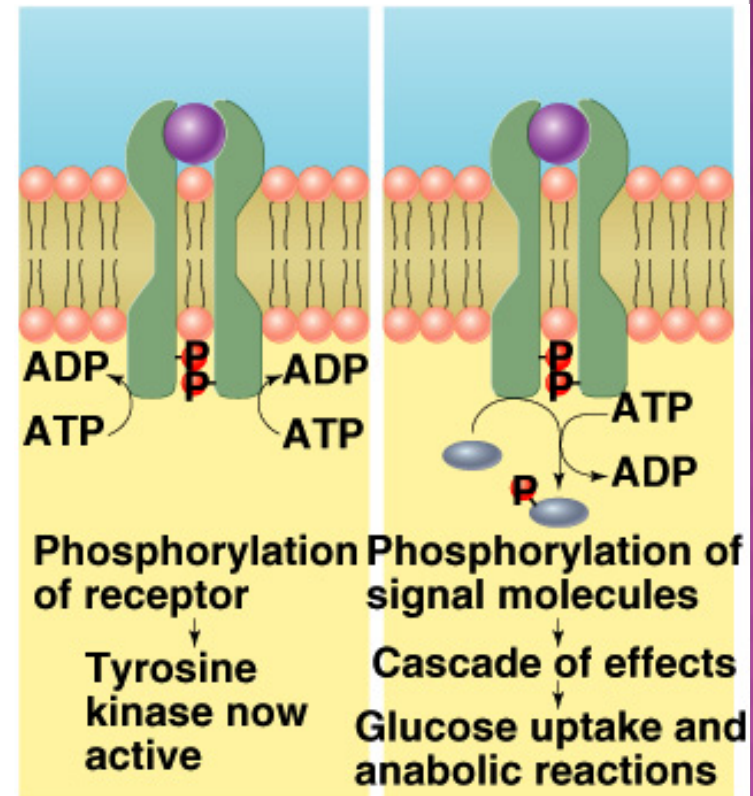
# SECOND MESSENGER (TYROSINE KINASE SYSTEM)

- Is used by insulin & many growth factors to cause cellular effects
- Surface receptor is tyrosine kinase
  - Consists of 2 units that form active dimer when insulin binds



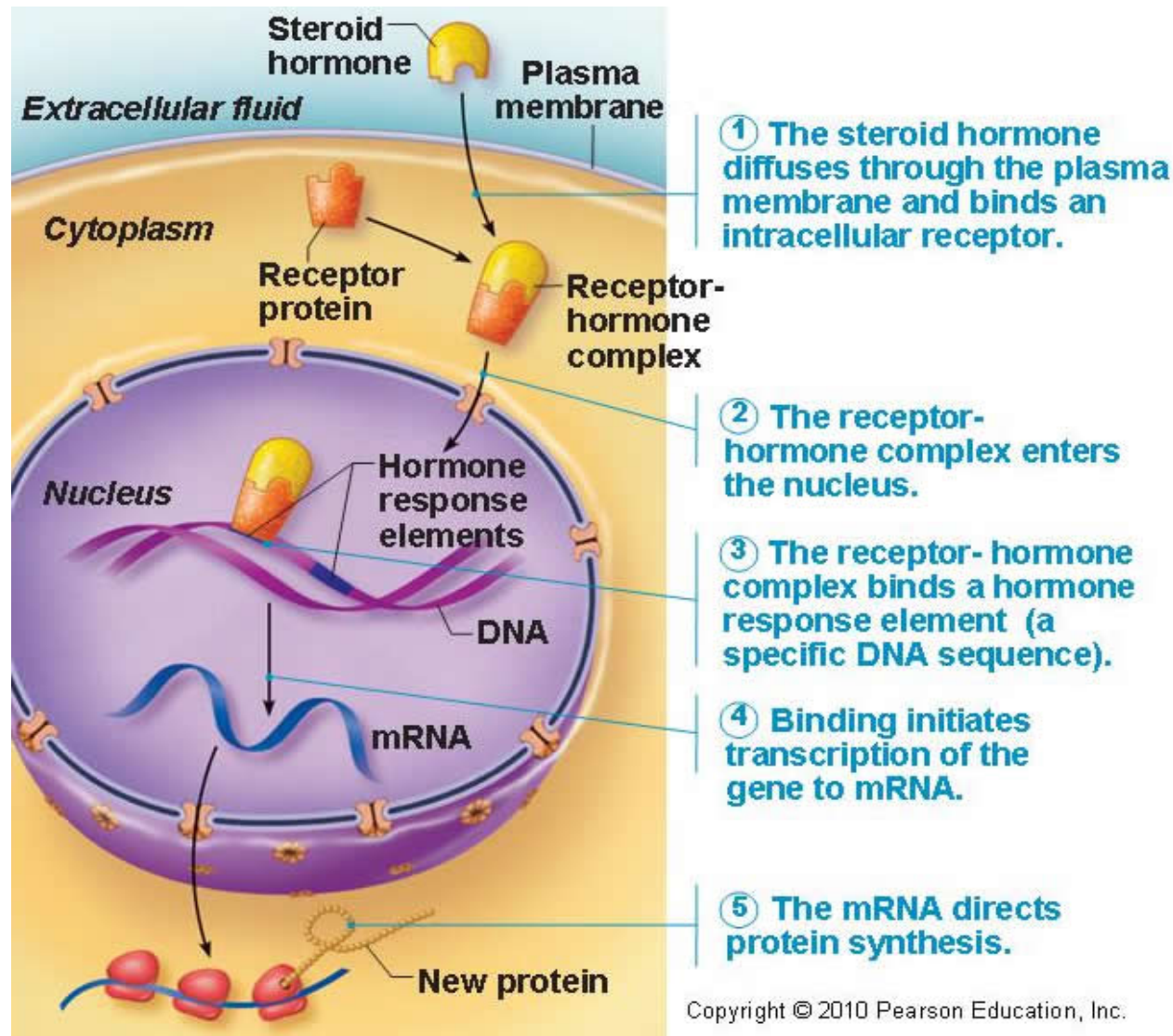
# SECOND MESSENGER (TYROSINE KINASE SYSTEM)

- Activated tyrosine kinase phosphorylates signaling molecules
- Induction of hormone/growth factor effects





# MECHANISM OF ACTION (STEROID HORMONES)



# REGULATION OF HORMONAL RECEPTORS

- Receptors does not remain constant
  - Inactivated or destroyed
  - Reactivated or manufactured
- Downregulation
  - Increase hormone concentration leads to decrease in the number of active receptors
  - Most peptide hormones have pulsatile secretion which prevents downregulation
- Upregulation
  - The hormone induces greater than normal formation of a receptor or intracellular signaling proteins

# CLEARANCE OF HORMONES

- Two factors control the concentration of a hormone in the blood:
  - The rate of its secretion
  - The rate of its removal (metabolic clearance)
- Hormones are cleared by:
  - Metabolic destruction by tissues
  - Binding with tissues
  - Excretion by the liver into bile
  - Excretion by the kidney into urine
- Clearance of protein bound hormones is slower than clearance of peptide hormones

# HORMONE INTERACTIONS

- Multiple hormones can affect a single target simultaneously
- Three types of hormone interactions:
  1. Synergism
  2. Permissiveness
  3. Antagonism

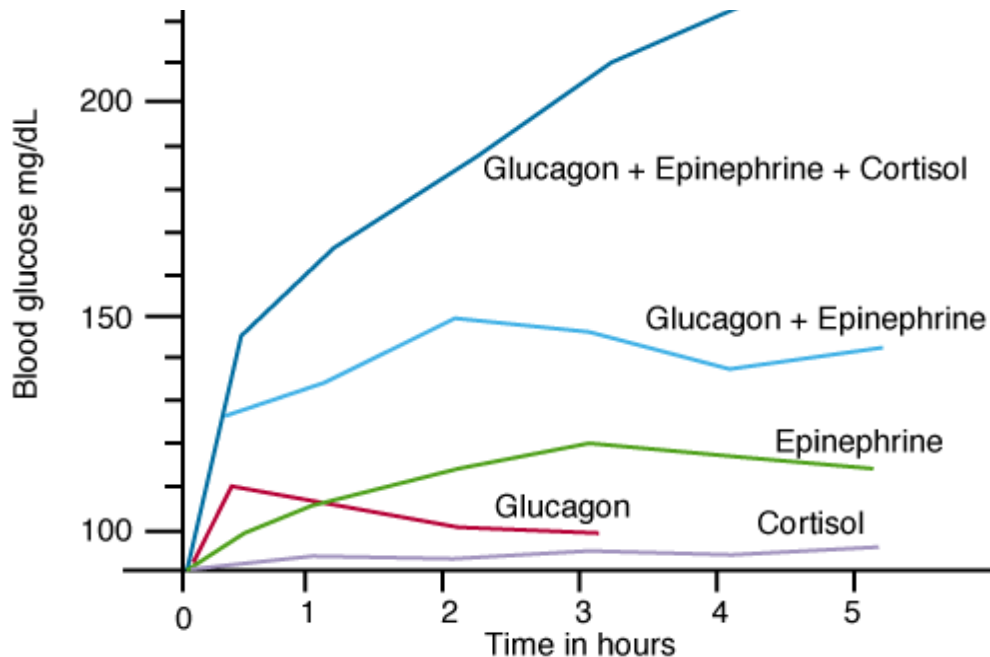
What is Synergism?

What is permissiveness?

What is antagonism?

# SYNERGISM

- ◉ Combined action of hormones is more than just additive!
- ◉ Example: Blood glucose levels & synergistic effects of glucagon, cortisol and epinephrine



# PERMISSIVENESS

- **One hormone allows another hormone to have its full effect**
  - Especially during growth
- **Example**
  - Thyroid hormone have permissive effect on growth hormone action
  - Deficiency of thyroid hormone in infants leads to dwarfism.

# ANTAGONISM

- Antagonistic hormones have opposing physiological actions -
  - Hormone B diminishes the effect of hormone A
- Example
  - Glucagon antagonizes the action of insulin
  - **Can you mention another example?**

HELP! WE'RE  
INCRISIS



INCRISIS

