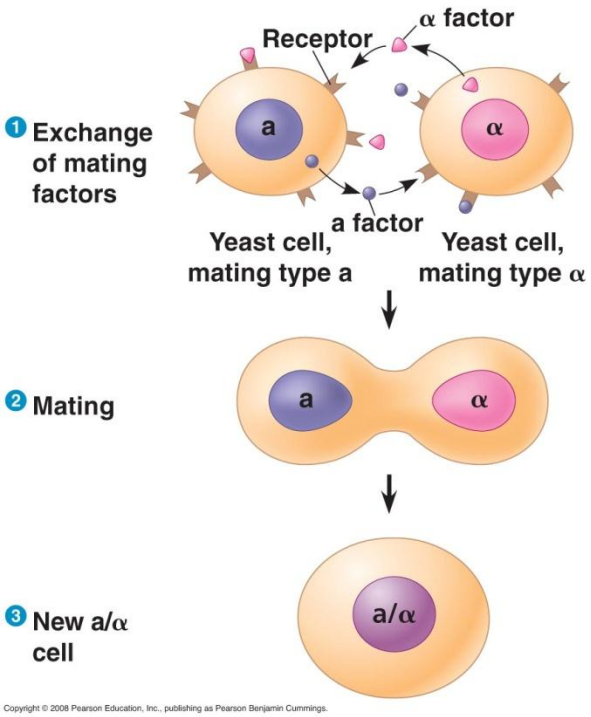
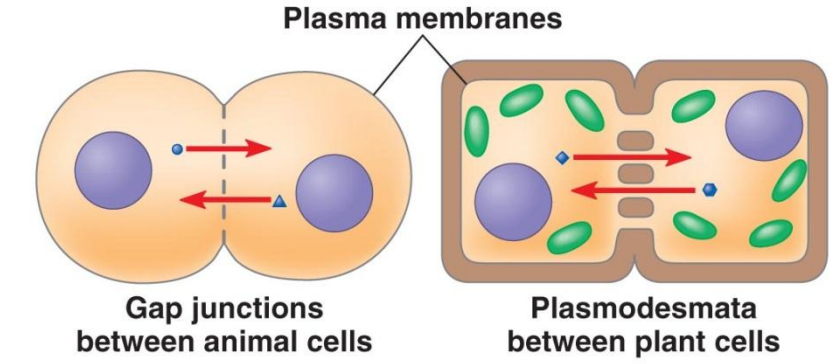
Cellular Communication

The first cell communication to be discovered was between two mating types of yeast cells.

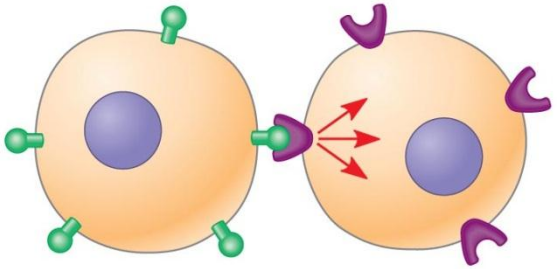


Communication can occur through junctions through which chemical signals that are dissolved in the cytosol can move.

Cells can recognize each other through cell surface molecules

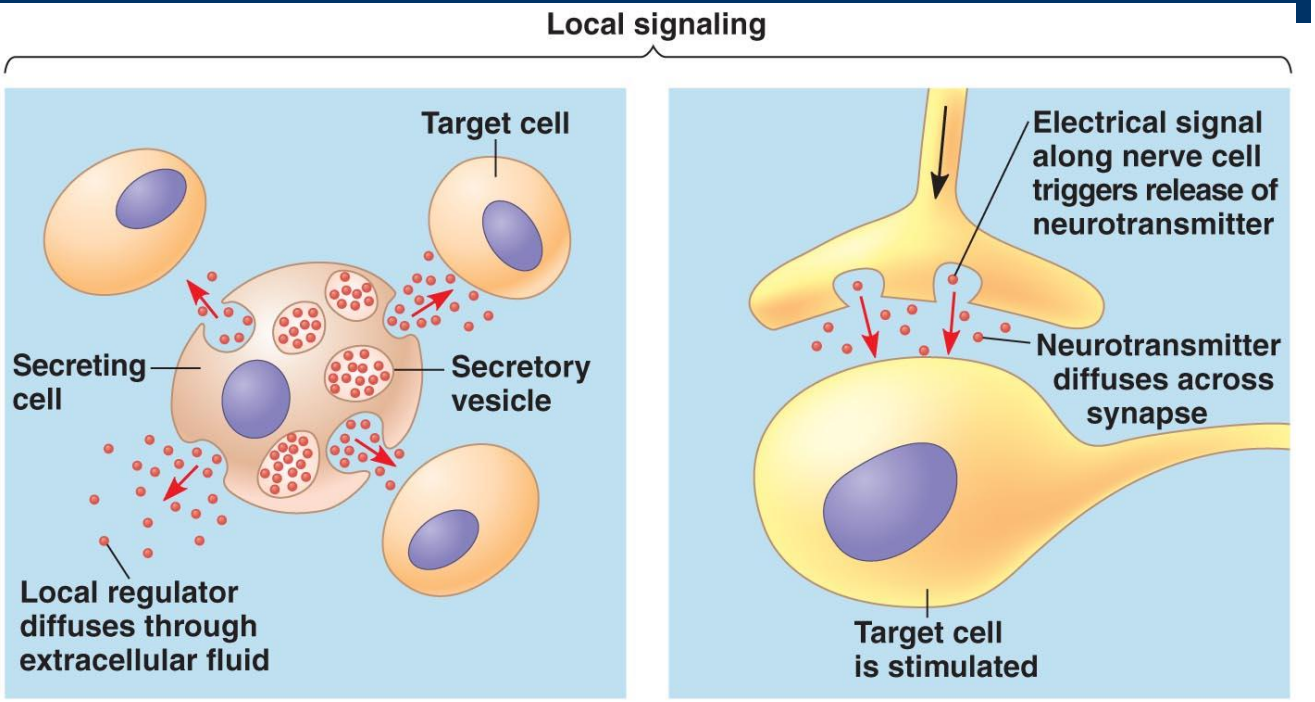


(a) Cell junctions



(b) Cell-cell recognition

Some chemicals signal nearby target cells. This is know as paracrine signaling or synaptic signaling.

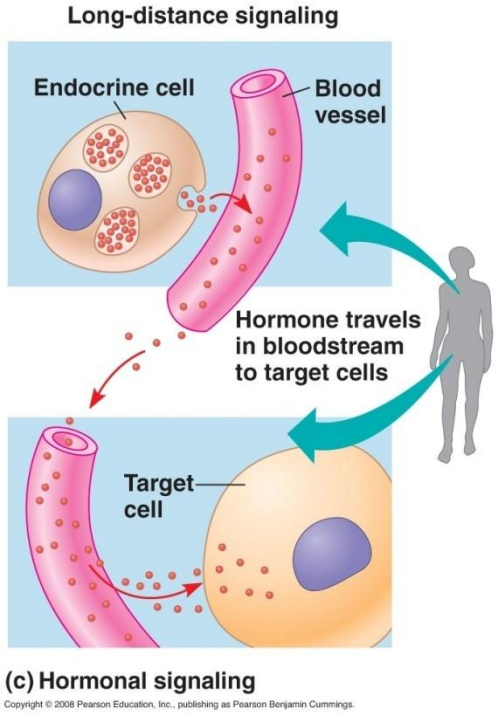


Local regulators affect neighboring target cells.

- Growth factors are peptides and proteins that stimulate cell proliferation
- Nitric oxide functions as a neurotransmitter
  - Secreted by white blood cells it kills bacteria and certain cancer cells
  - Released by endothelial cells it relaxes smooth muscles in blood vessel walls causing dilation
- Prostaglandins (PGs)
  - Help induce childbirth, fever and inflammation

Hormones are used in plants and animals for long distance signaling.

In animals, this is called endocine signaling.



The three stage of cellular signaling: Reception, Transduction, and Response.

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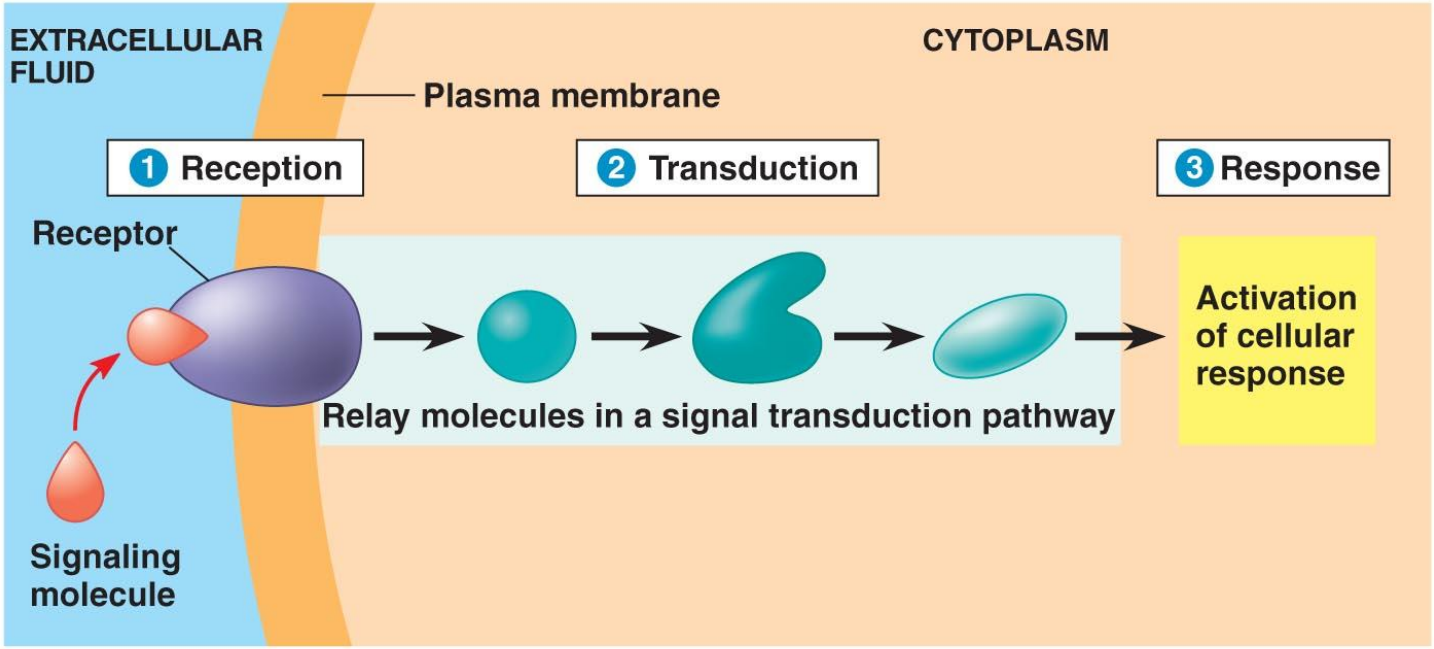


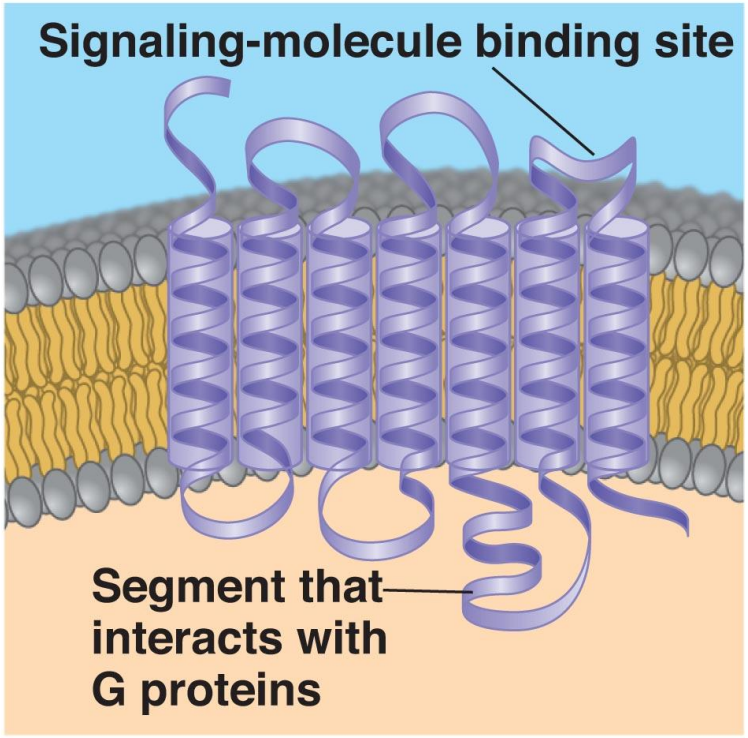
Signal Transduction Pathway

- The process by which a signal received on a cell's surface is converted into particular cellular response.

A signal molecule, a ligand, binds to a receptor protein in a lock and key fashion, causing the receptor to change shape.

Most receptor proteins are in the cell membrane but some are inside the cell.

The G-protein is a common membrane receptor.

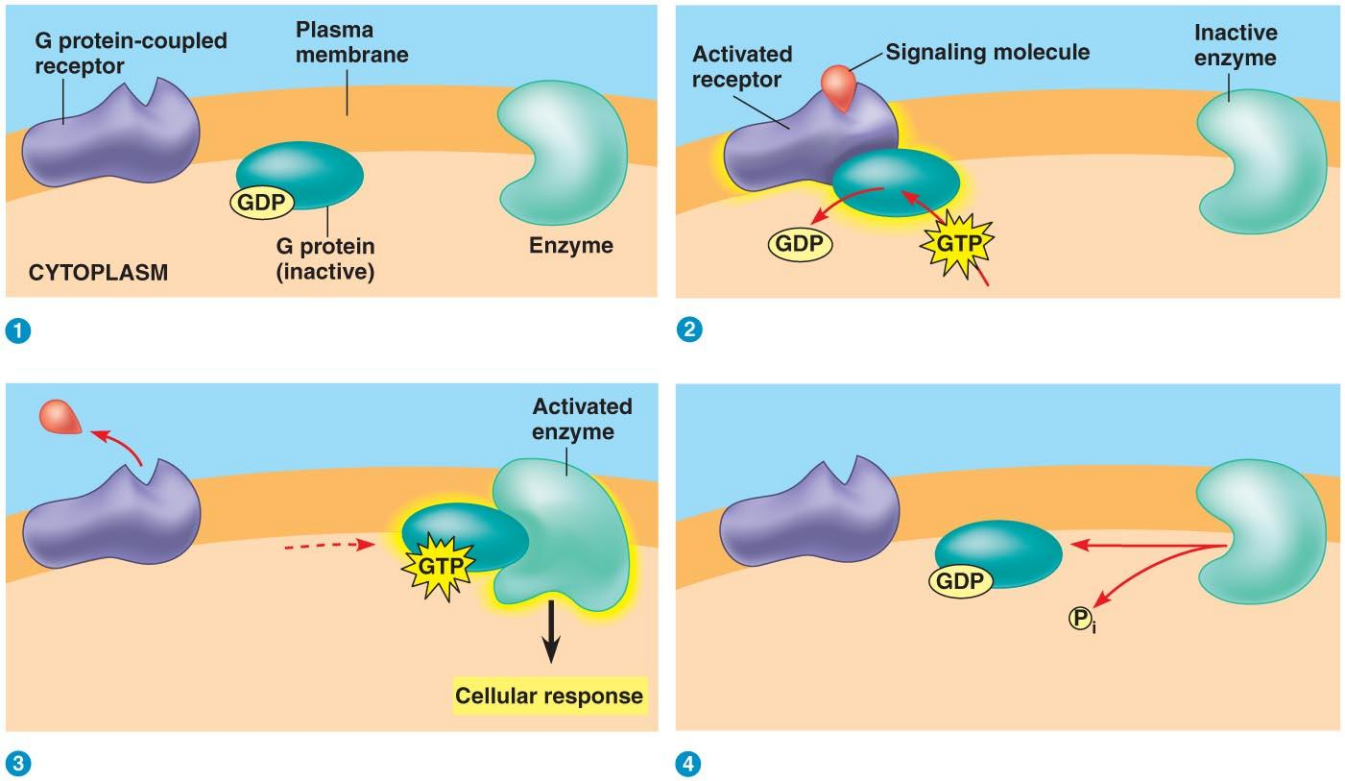


G protein-coupled receptor

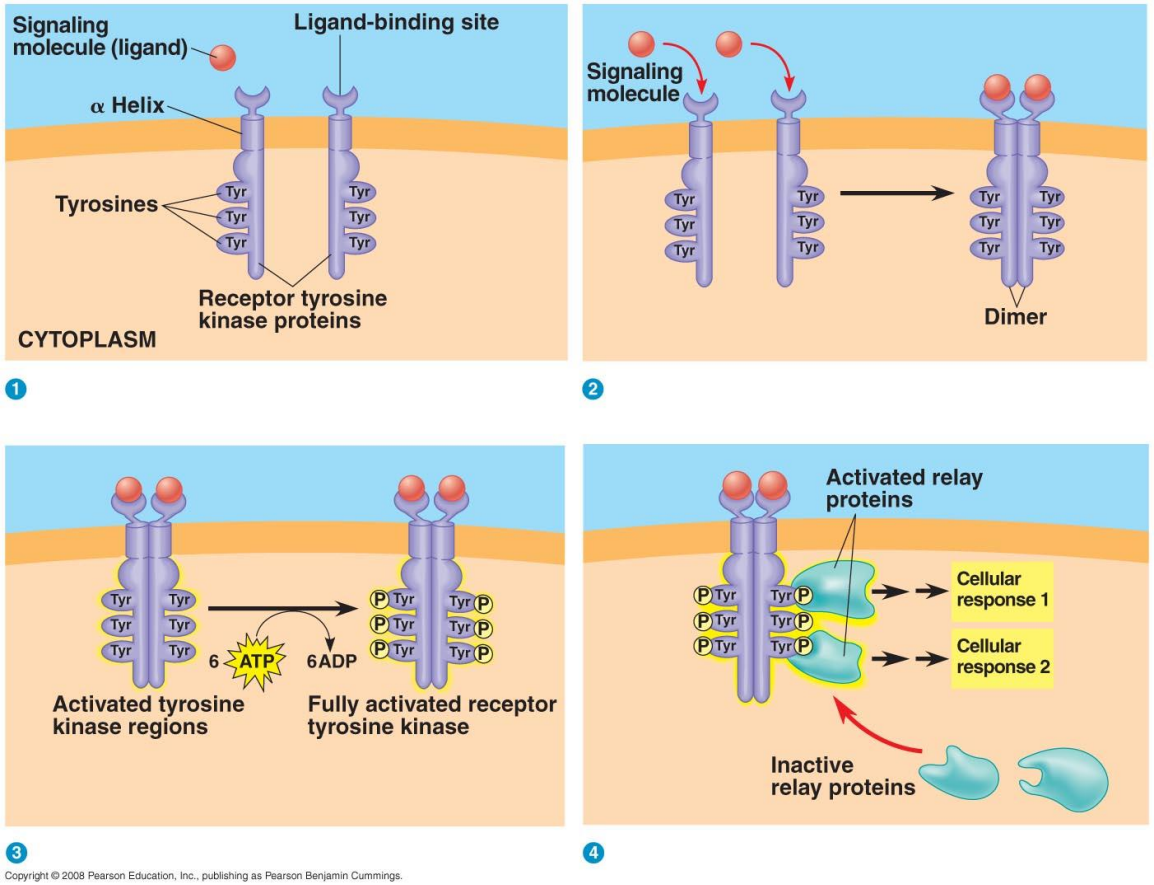
There are three most common types of membrane receptor proteins.

- G-protein coupled receptors
- Receptor tyrosine-kinases
- Ion channel receptors

G-Protein Coupled Receptors are often involved in diseases such as bacterial infections.



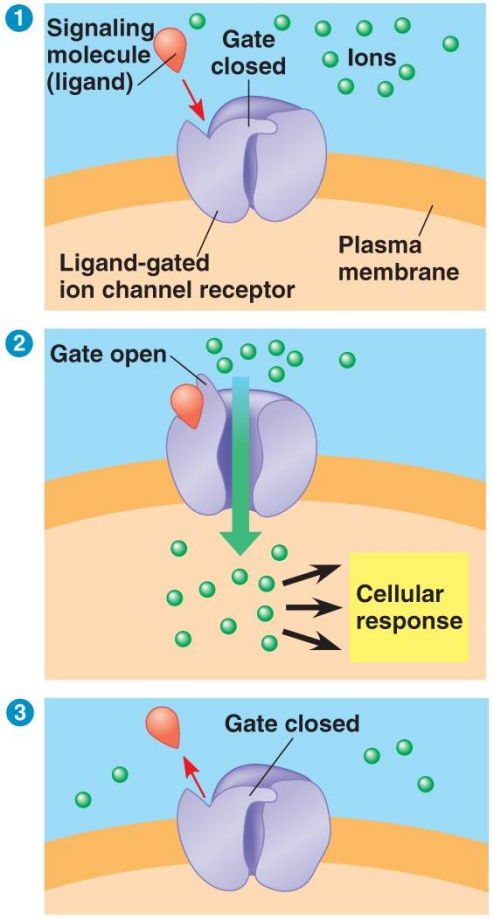
Receptor Tyrosine kinases catalyze the transfer of phosphate groups to initiate cell response.



Ligand-Gated Ion Channel Receptors contain a region that can act as a "gate" when the receptor changes shape.

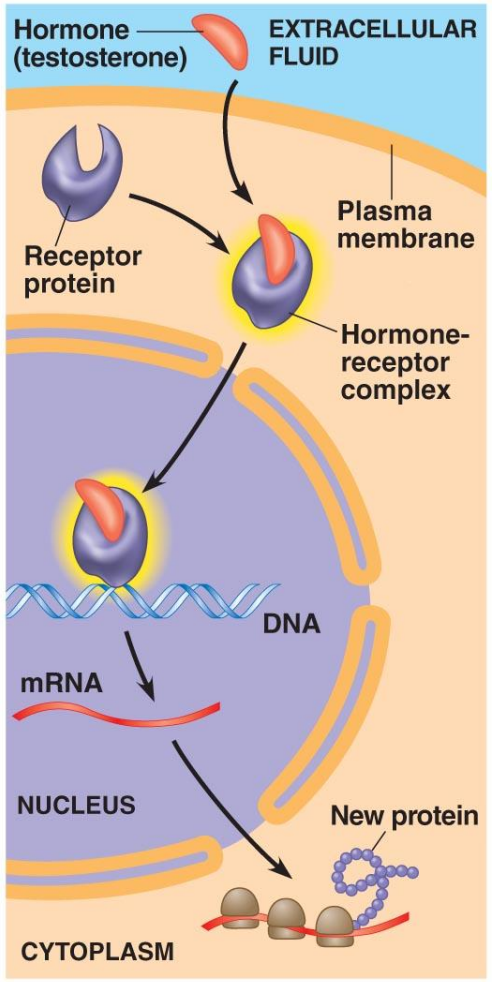
Ligand gated channels are very important in the nervous system- neurotransmitters.

Voltage-gated ion channels are crucial to functioning of nervous system.



Intracellular signaling includes hormones that are hydrophobic and can cross the cell membrane.

- Once inside the cell, the hormone attaches to a protein that takes it into the nucleus where transcription can be stimulated.
- Testosterone acts as a transcription factor.



The transduction stage of signaling is often a multistep process that amplifies the signal.

About 2% of our genes are thought to code for kinases.

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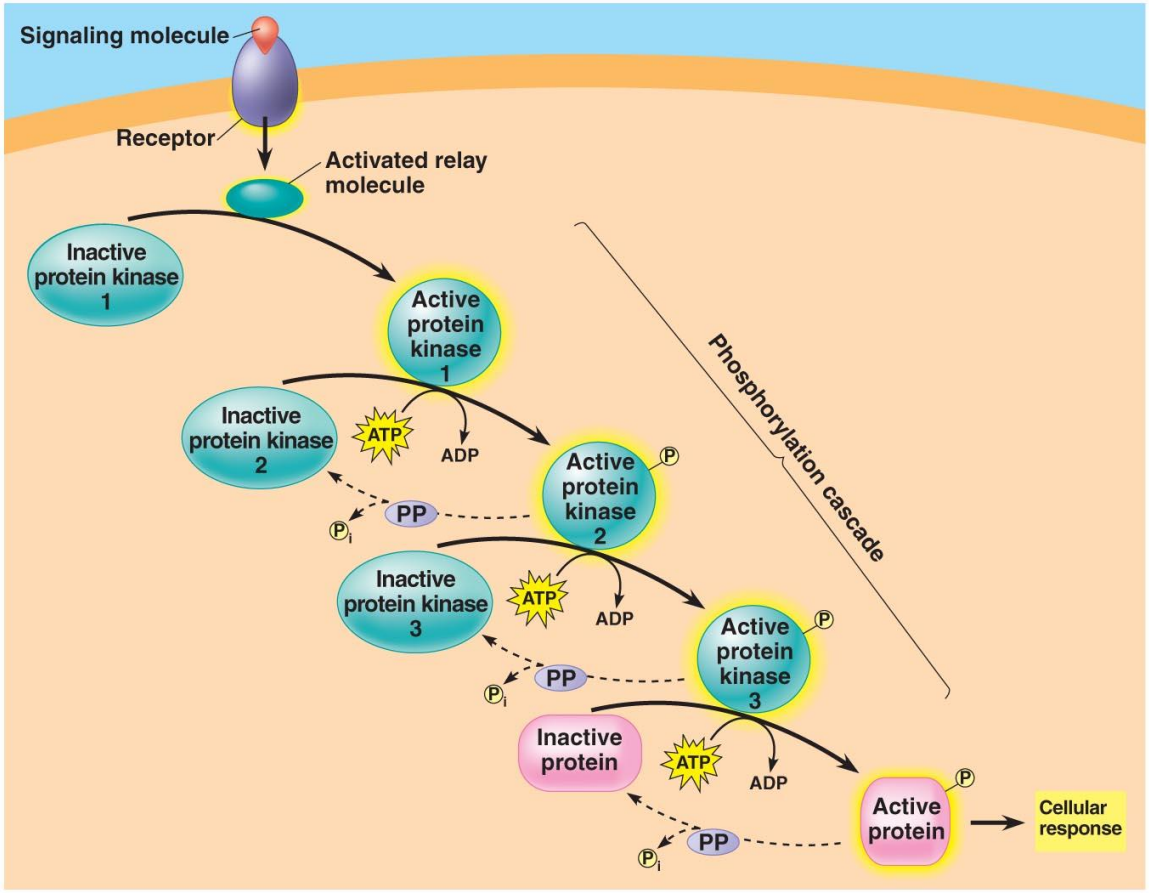
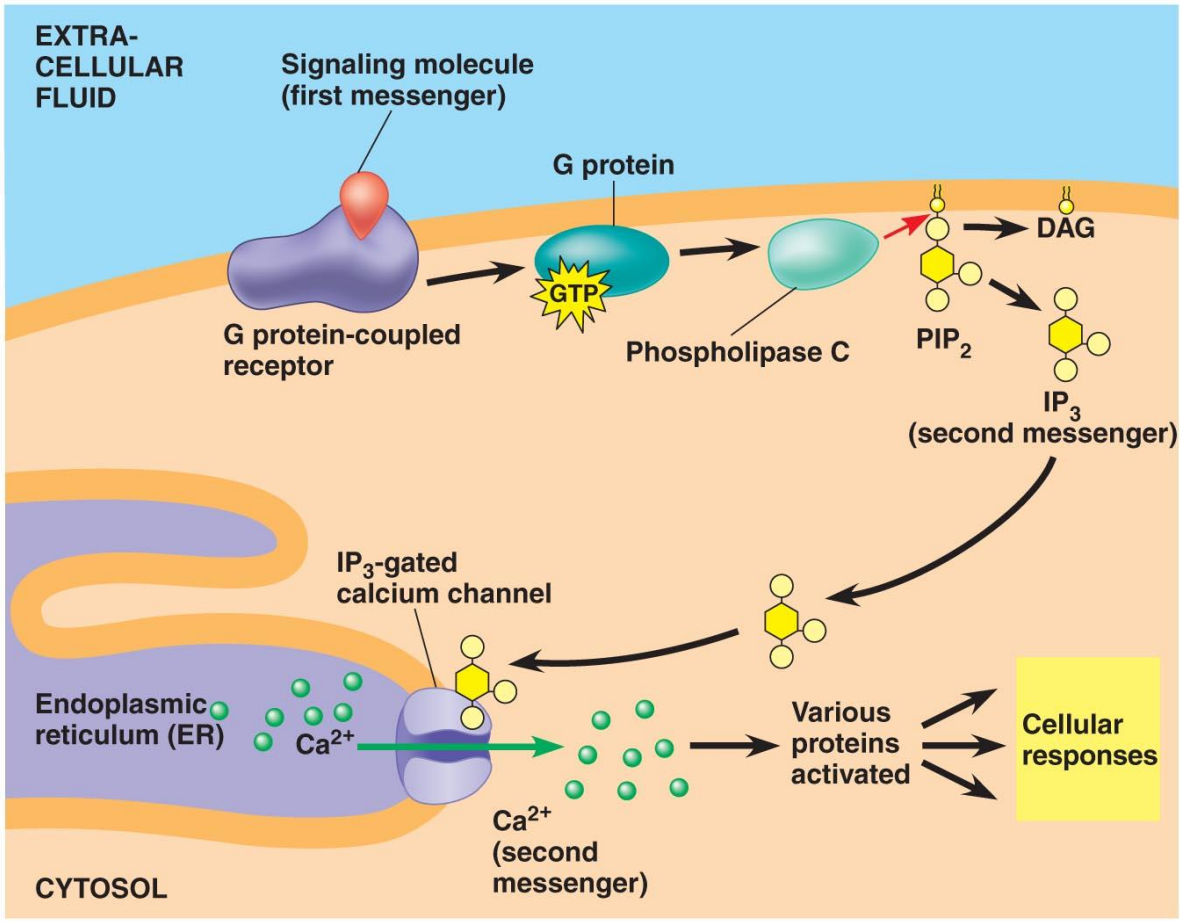
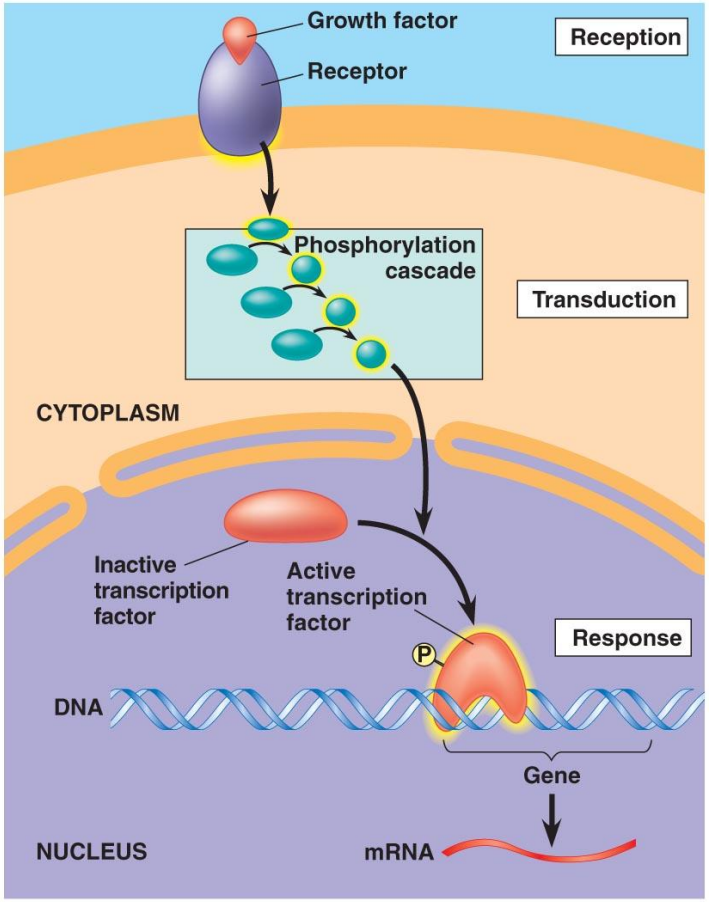
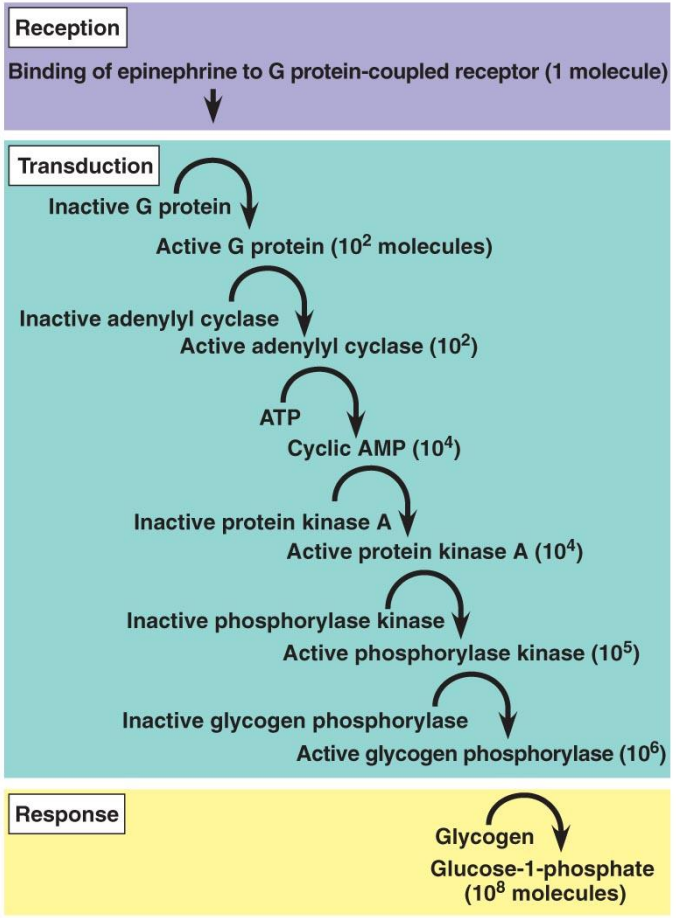


Small molecules and ions act as secondary messengers.



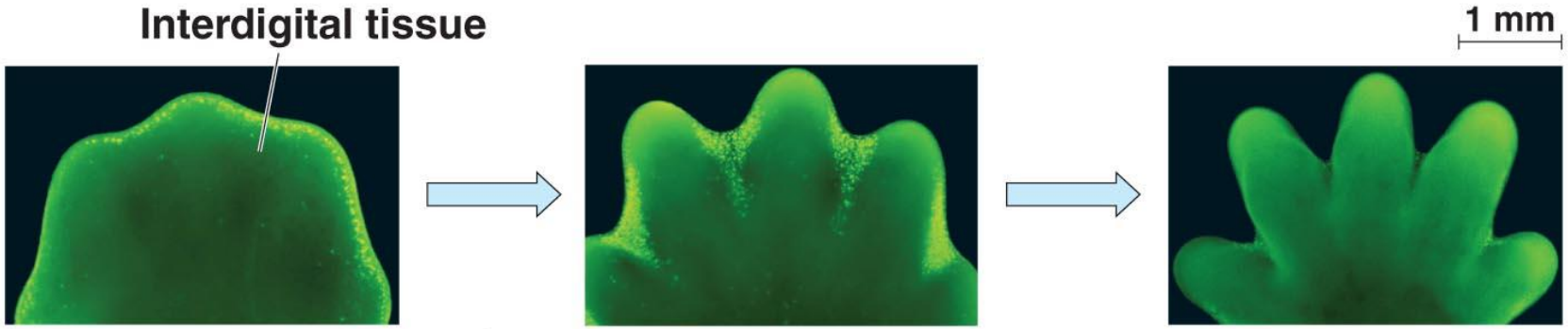
Response- cell signaling leads to regulation of transcription or cytoplasmic activities.





Apoptosis, programmed cell death, integrates multiple cell-signaling pathways.

- Paw development and digit development requires apoptosis.

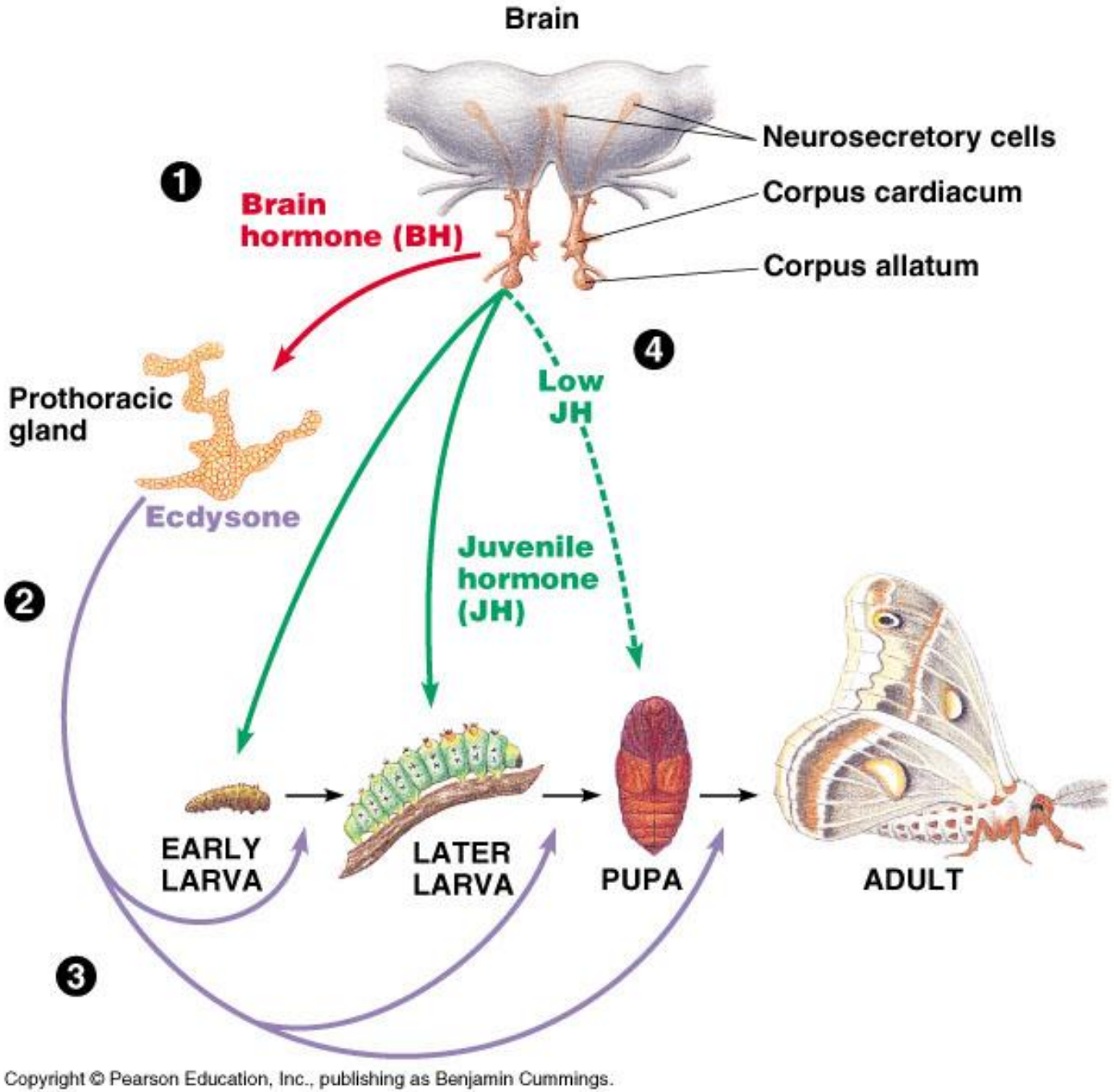


Invertebrates have a variety of hormones for signaling

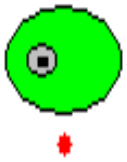
- Regulation of water balance

- In hydra- regulation of growth and budding
- Specialized neurons control egg laying in mollusks and reduce feeding and locomotion
- Arthropod molting is hormonally controlled by an enzyme called ecdysone
- In insects, control is by brain hormone (BH): Juvenile hormone (JH) controls BH and ecdysone

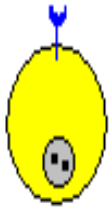
Hormonal regulation of insect development



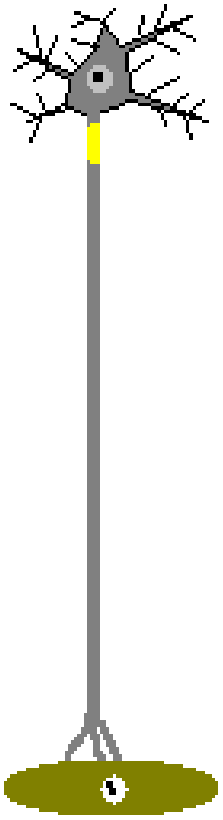
Two systems control all physiological processes



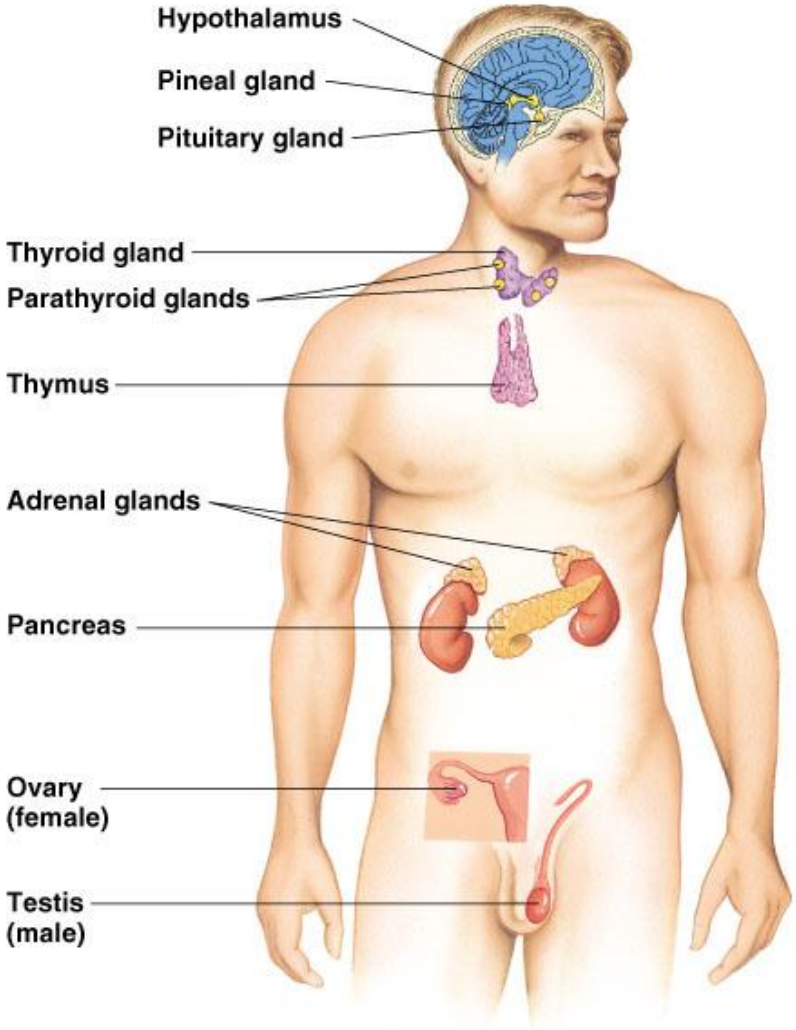
1. Nervous System –
   neurosecretory glands in
   endocrine tissues secrete hormones.



2. Endocrine System



Human Endocrine System

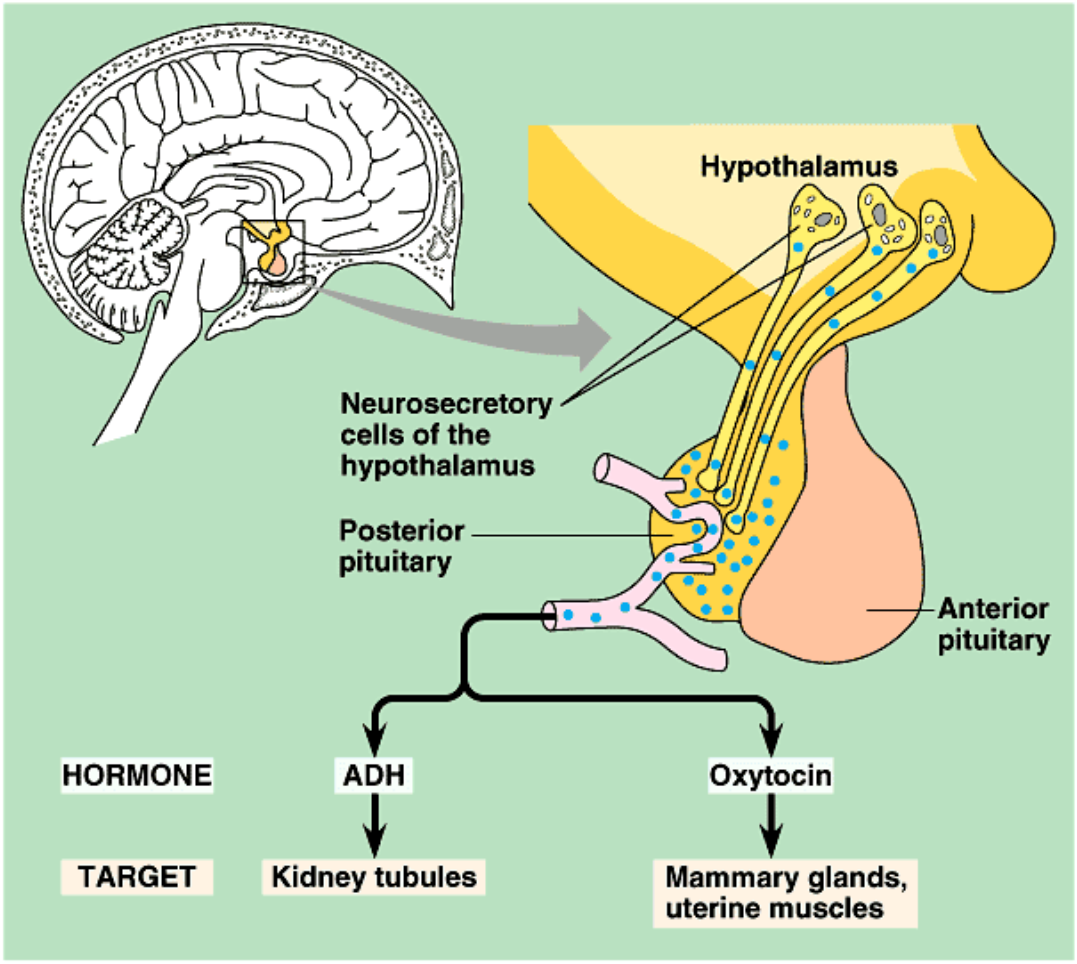


Major Vertebrate Endocrine Glands Their Hormones (Hypothalamus–Parathyroid glands)

Gland		Hormone	Chemical Class	Representative Actions	Regulated By
Hypothalamus		Hormones released by the posterior pituitary and hormones that regulate the anterior pituitary (see below)			
Pituitary gland Posterior pituitary (releases hormones made by hypothalamus)		Oxytocin	Peptide	Stimulates contraction of uterus and mammary gland cells	Nervous system
		Antidiuretic hormone (ADH)	Peptide	Promotes retention of water by kidneys	Water/salt balance
Anterior pituitary		Growth hormone (GH)	Protein	Stimulates growth (especially bones) and metabolic functions	Hypothalamic hormones
		Prolactin (PRL)	Protein	Stimulates milk production and secretion	Hypothalamic hormones
		Follicle-stimulating hormone (FSH)	Glycoprotein	Stimulates production of ova and sperm	Hypothalamic hormones
		Luteinizing hormone (LH)	Glycoprotein	Stimulates ovaries and testes	Hypothalamic hormones
		Thyroid-stimulating hormone (TSH)	Glycoprotein	Stimulates thyroid gland	Thyroxine in blood; hypothalamic hormones
		Adrenocorticotropic hormone (ACTH)	Peptide	Stimulates adrenal cortex to secrete glucocorticoids	Glucocorticoids; hypothalamic hormones
Thyroid gland		Triiodothyronine (T_3) and thyroxine (T_4)	Amine	Stimulate and maintain metabolic processes	TSH
		Calcitonin	Peptide	Lowers blood calcium level	Calcium in blood
Parathyroid glands		Parathyroid hormone (PTH)	Peptide	Raises blood calcium level	Calcium in blood

Gland		Hormone	Chemical Class	Representative Actions	Regulated By
Pancreas		Insulin	Protein	Lowers blood glucose level	Glucose in blood
		Glucagon	Protein	Raises blood glucose level	Glucose in blood
Adrenal glands					
Adrenal medulla		Epinephrine and norepinephrine	Amine	Raise blood glucose level; increase metabolic activities; constrict certain blood vessels	Nervous system
Adrenal cortex		Glucocorticoids	Steroid	Raise blood glucose level	ACTH
		Mineralocorticoids	Steroid	Promote reabsorption of Na^+ and excretion of K^+ in kidneys	K^+ in blood
Gonads					
Testes		Androgens	Steroid	Support sperm formation; promote development and maintenance of male secondary sex characteristics	FSH and LH
Ovaries		Estrogens	Steroid	Stimulate uterine lining growth; promote development and maintenance of female secondary sex characteristics	FSH and LH
		Progesterone	Steroid	Promotes uterine lining growth	FSH and LH
Pineal gland		Melatonin	Amine	Involved in biological rhythms	Light/dark cycles
Thymus		Thymosin	Peptide	Stimulates T lymphocytes	Not known

Figure 45.6a Hormones of the hypothalamus and pituitary glands

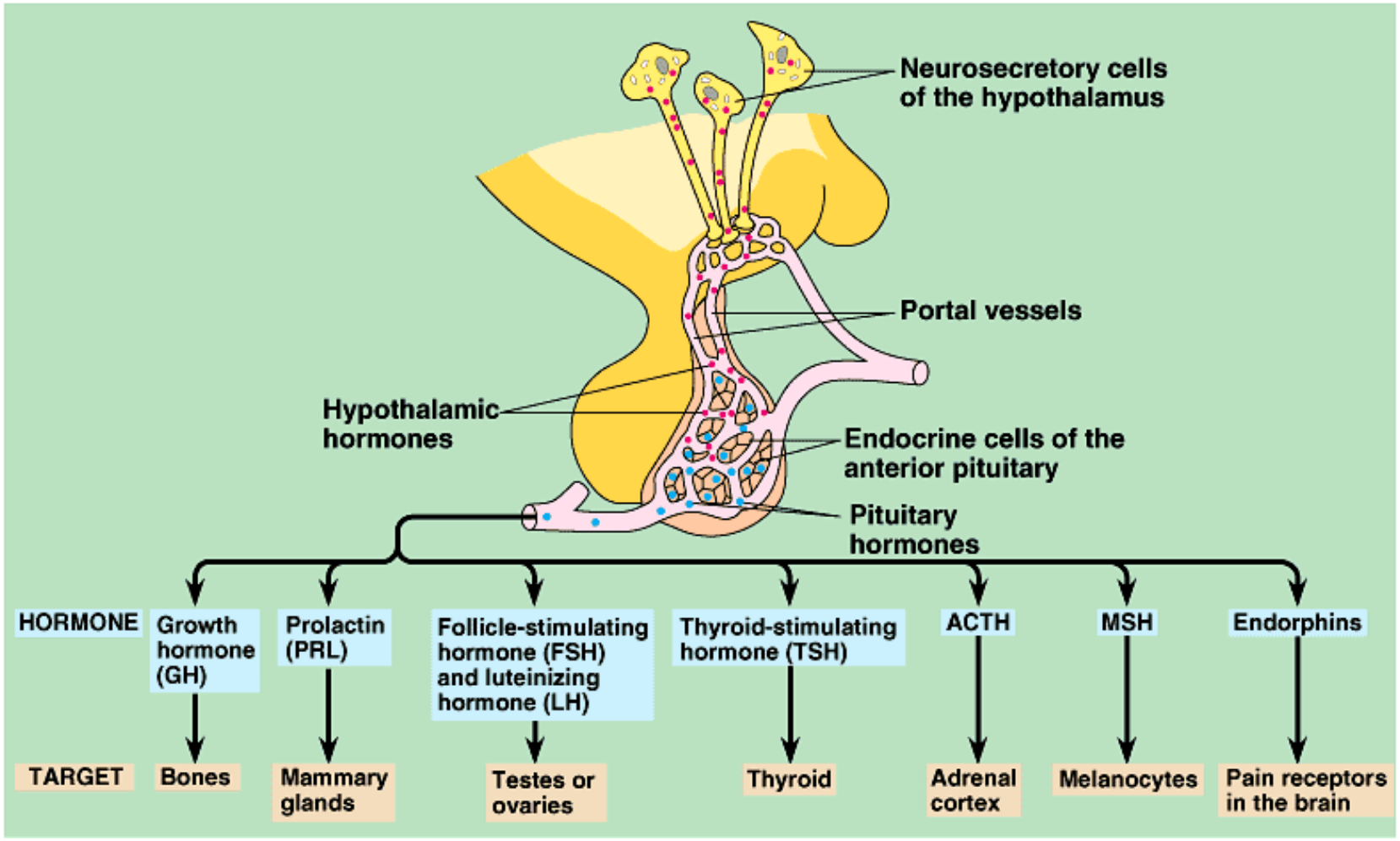


(a) The posterior pituitary

Two regulatory systems of humans work together

- Nervous system
- Endocrine system

Figure 45.6b Hormones of the hypothalamus and pituitary glands



(b) The anterior pituitary

Neurosecretory cells in endocrine organs and tissues secrete hormones. These hormones are excreted into the circulatory system.

Stress and the Adrenal Gland

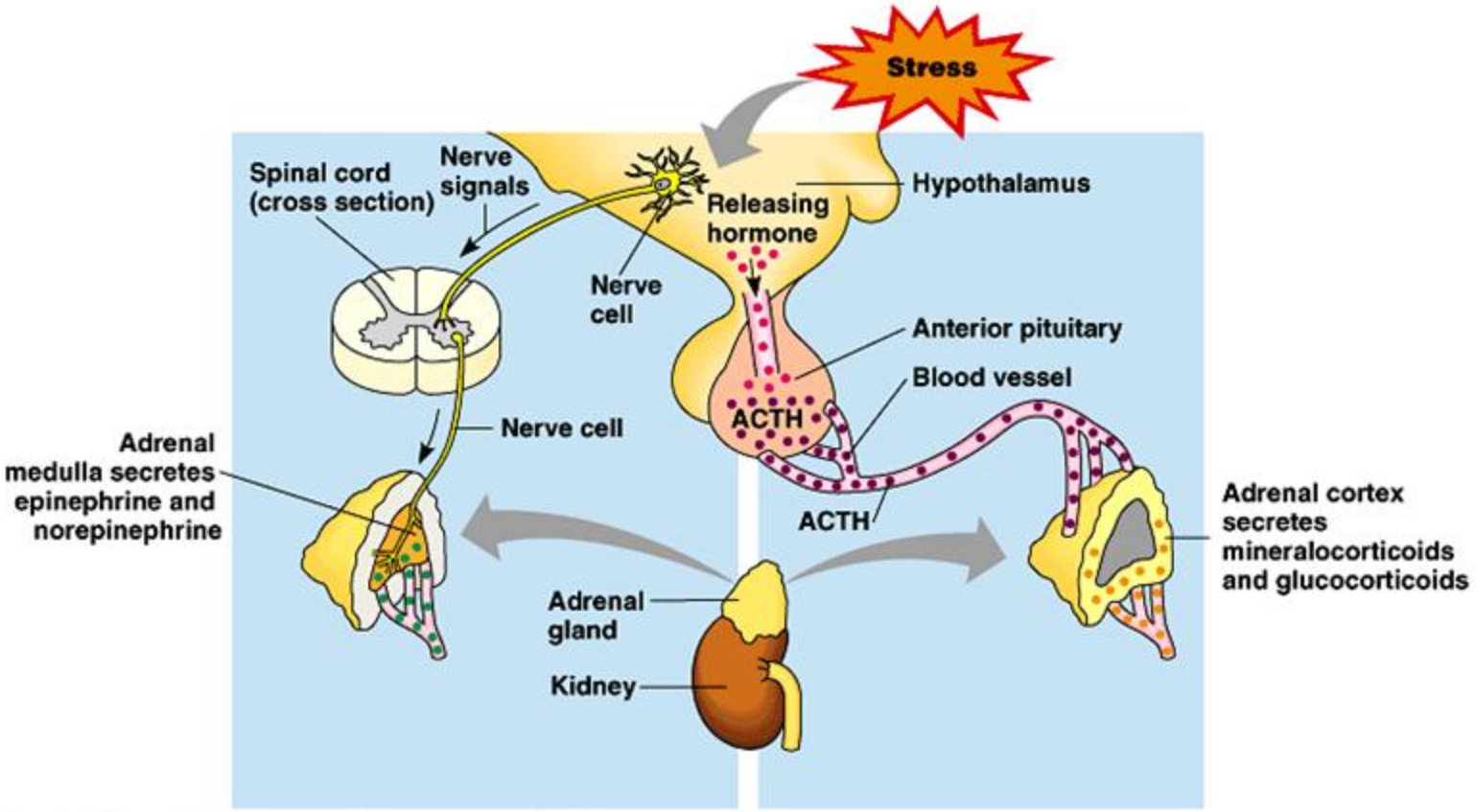


Figure 45.4 One chemical signal, different effects

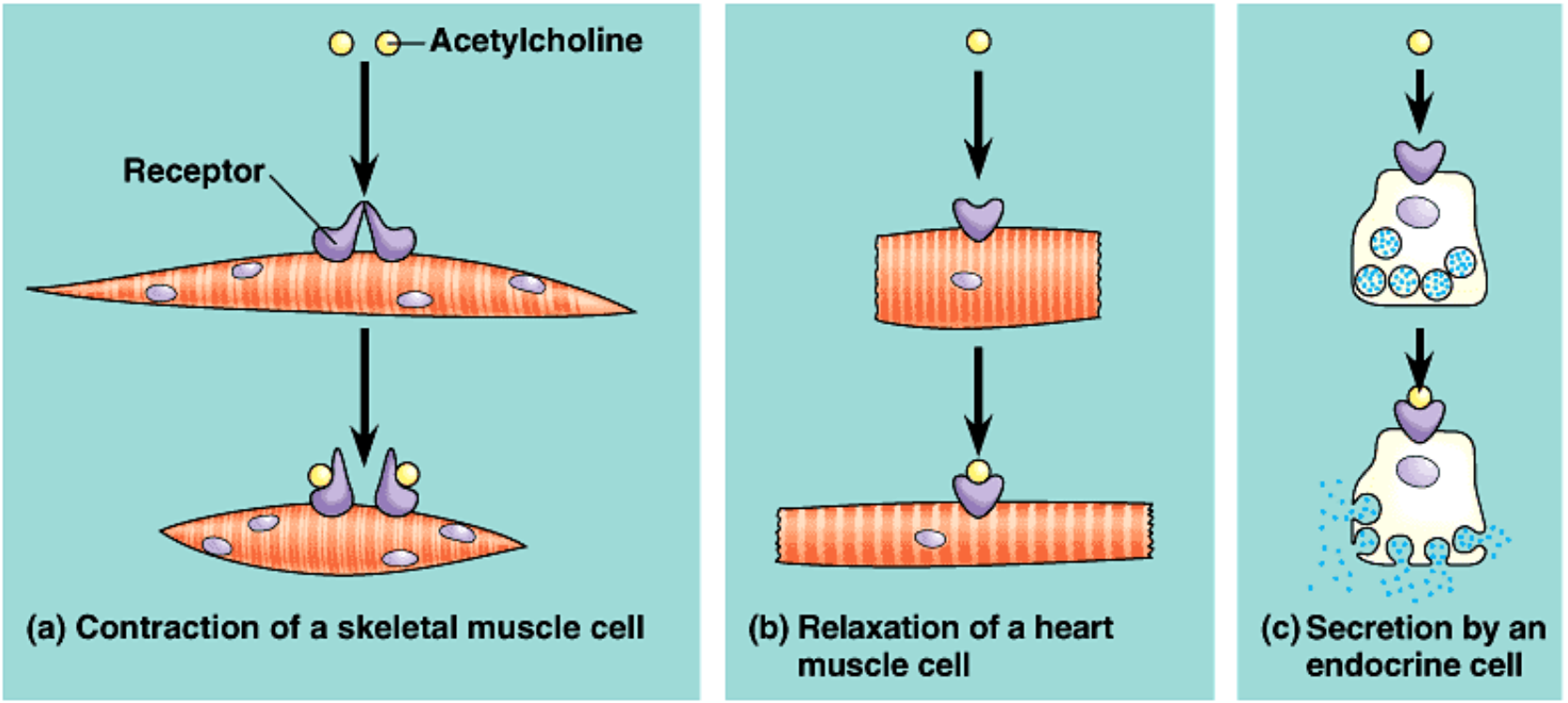


Figure 45.9 Hormonal control of calcium homeostasis in mammals

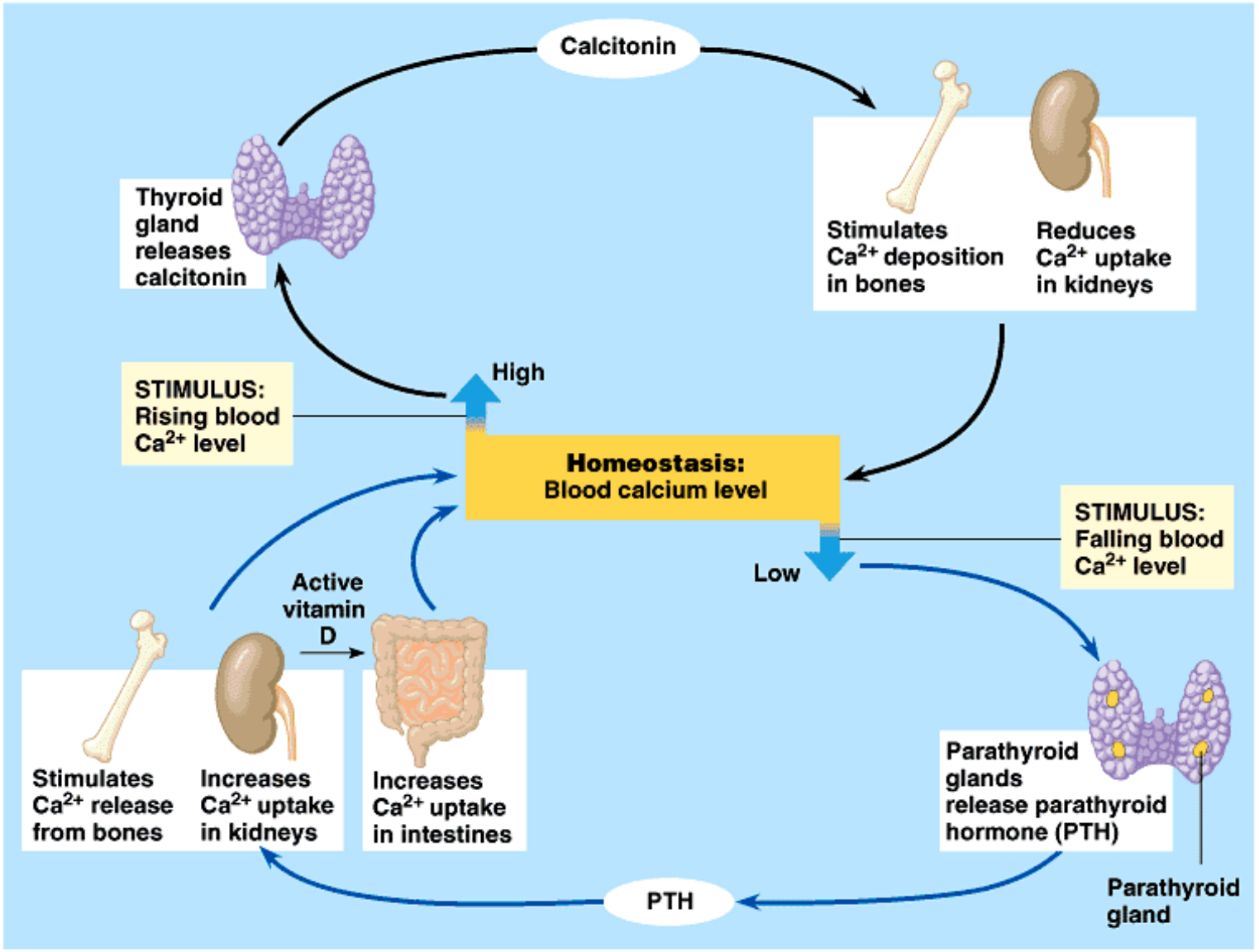
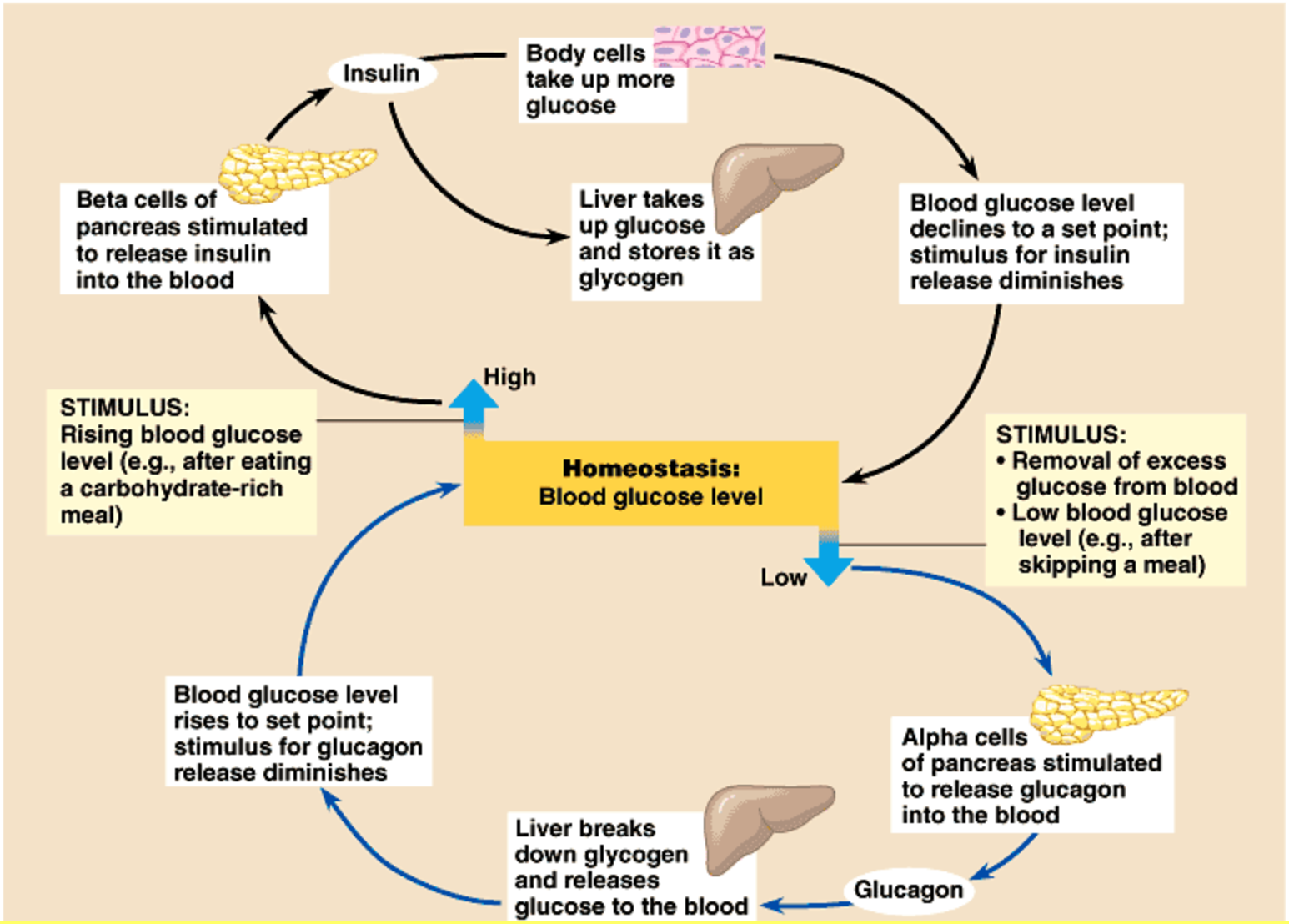


Figure 45.10 Glucose homeostasis maintained by insulin and glucagon



http://vcell.ndsu.nodak.edu/animations/regulatedsecretion/movie.htm