General Physiology
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Lecture 23
Autonomic Nervous System II

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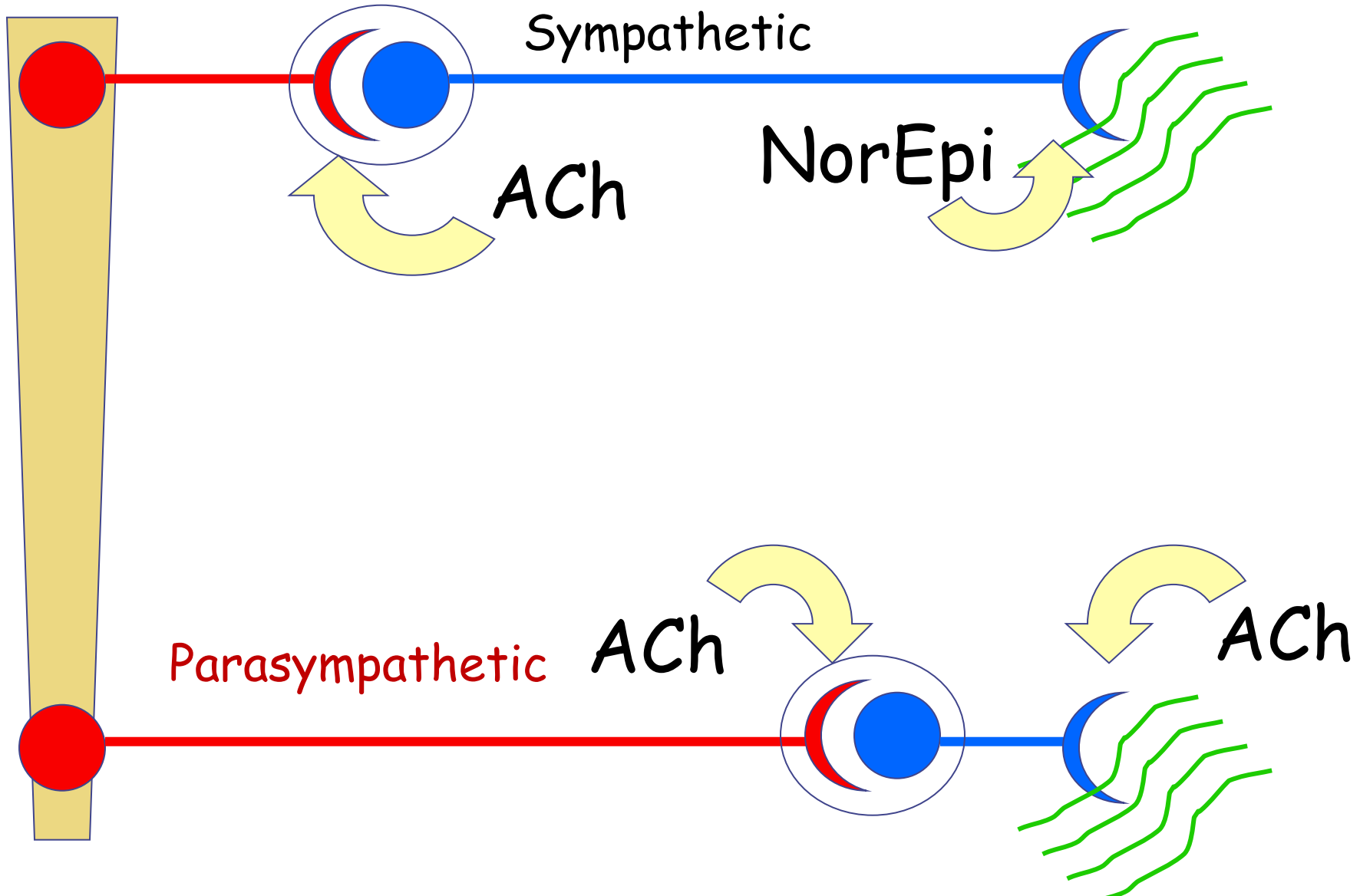
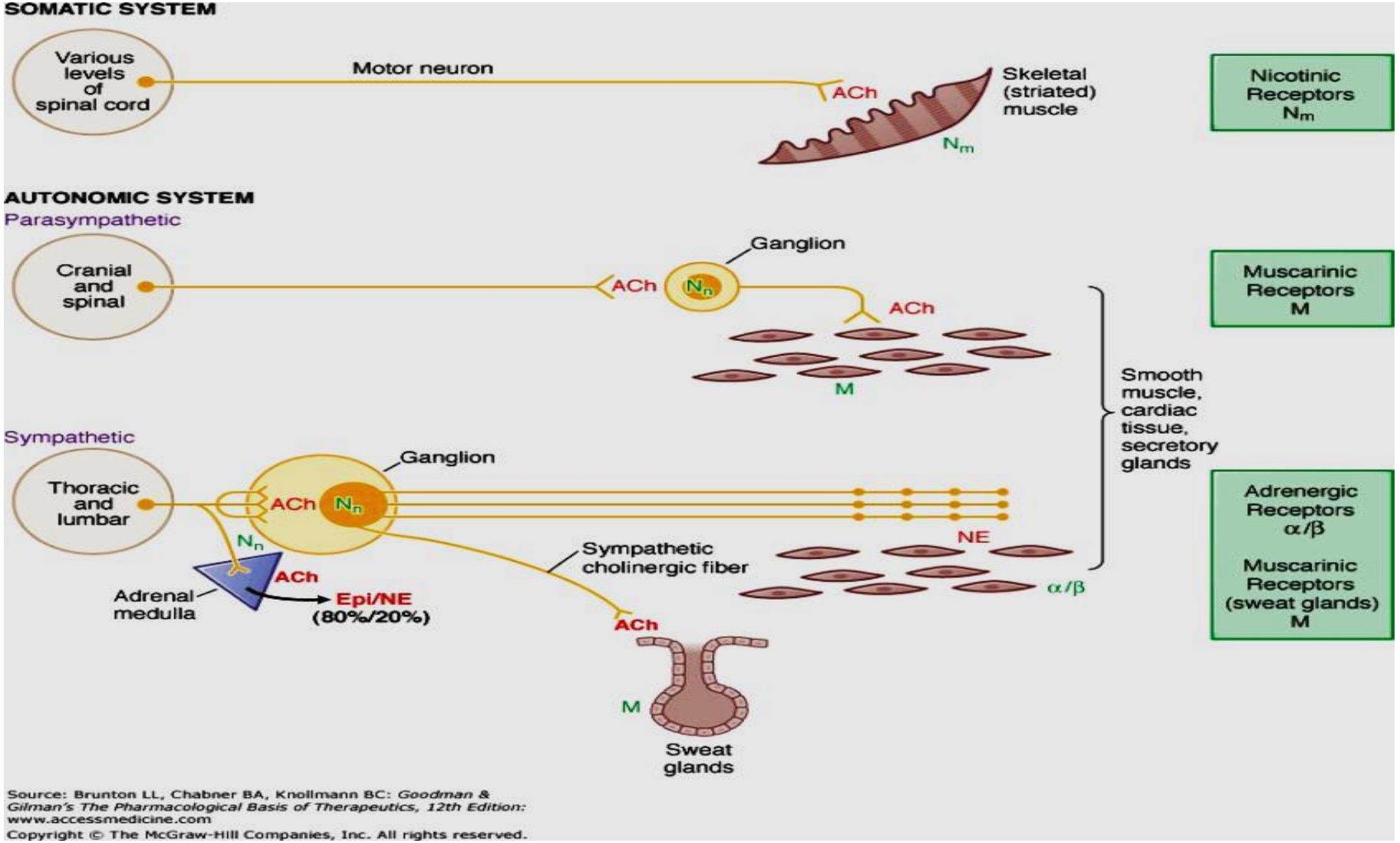
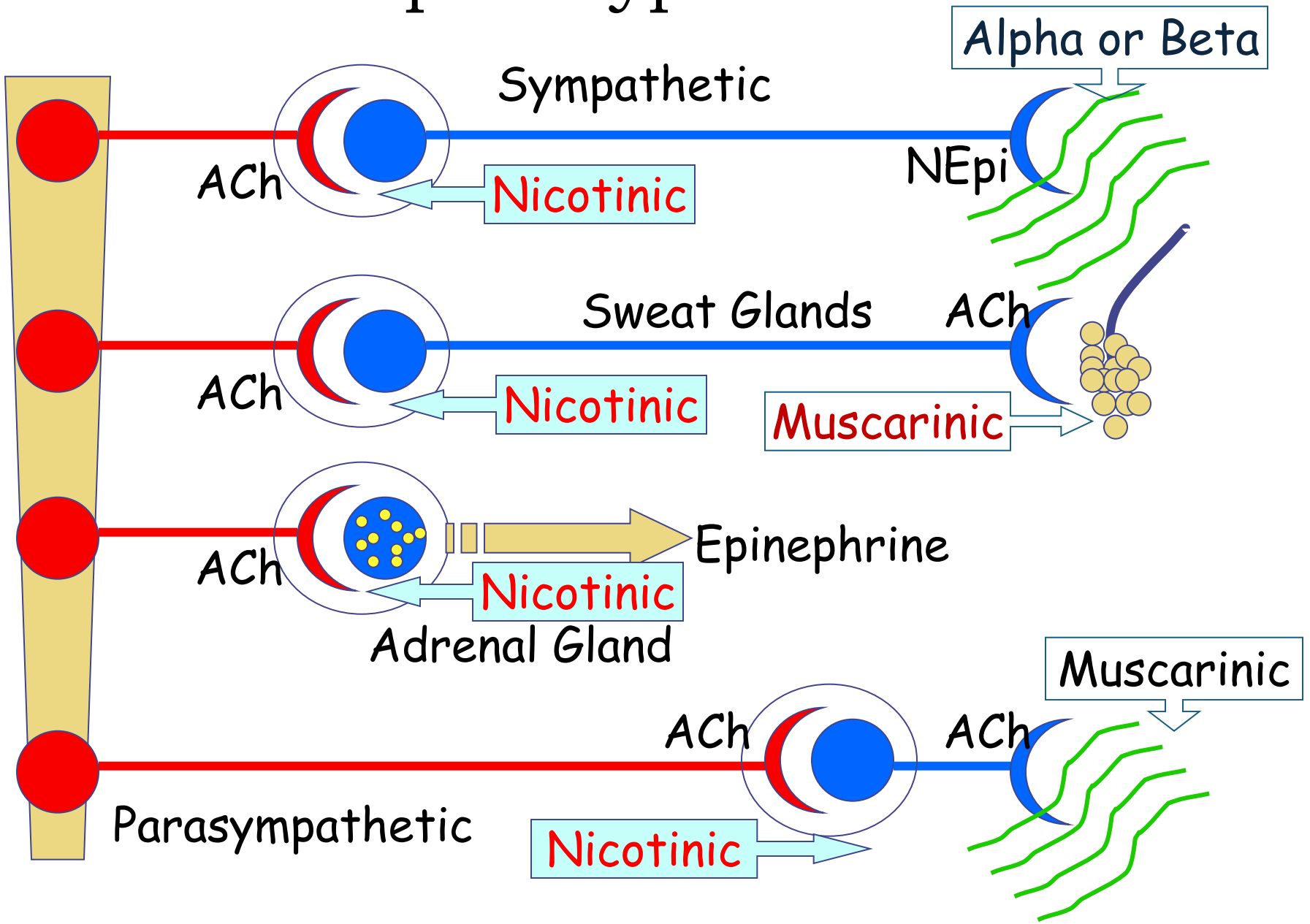
Transmitters and Receptors of ANS



Somatic and autonomic systems
Transmitters and Receptors of ANS



ANS Receptor Types



Neurotransmitters and receptors

- Neurotransmitter-receptor binding causes changes in post synaptic cell membrane depending on weather it is inotropic or metabotropic
- Autonomic transmitter substance can cause inhibition in some organs or excitation in others. This effect is determined by the nature of the receptor protein in the cell membrane.
- **Inotropic receptors :**
  - A change in cell membrane permeability to one or more ions. A change in cell membrane permeability results in either opening or closing of an ion channel
  - Opening of Na^+ and/or Ca^{2+} ion channels → rapid influx of the respective ions into the cell → depolarizing the cell membrane and exciting the effector cell.
  - Opening of potassium channels → K^+ efflux → inhibition of the effector cell because of the hyper-negativity inside the effector cell.

Metabotropic receptors

- Metabotropic receptors
- Neurotransmitter usually binds with a receptor protein linked to G protein located inside the cell Activation or inactivation of an enzyme attached to the intracellular side of the receptor protein.
  - For example: Binding of NE with its receptor on the outside of many cells acts through the **second messenger mechanism** by increasing the activity of the enzyme adenylyl cyclase on the inside of the cell, which causes formation of **cAMP**.
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Acetylcholine Receptors

- Two types
- **Muscarinic receptors** : The terminology comes from **muscarine**, a poison from toadstools
  - Muscarinic receptors are metatoropic , which use G proteins couple recptors as their signaling mechanism, are found on all **target** effector cells that are stimulated by the postganglionic cholinergic neurons of either the parasympathetic nervous system or cholinergic fibers of the sympathetic system
- **Nicotinic receptor : stimulated by Nicotine**
  - Nicotinic receptors are ligand-gated ion channels
  - Located in **autonomic ganglia** at the synapses between the preganglionic and postganglionic
  - These receptors are also found in myoneural junction (Synapse between somatic motor neurons and skeletal muscle fibers)

Adrenergic Receptors

- Alpha and Beta Receptors

- There are two major types of alpha receptors, alpha1 and alpha2, which are linked to different G proteins.
- The beta receptors are divided into beta1, beta2, and beta3 receptors. The beta receptors also use G proteins for signaling
- The beta receptors are divided into beta1, beta2, and beta3 receptors. The beta receptors also use G proteins for signaling.
- Norepinephrine and epinephrine, both of which are secreted into the blood by the adrenal medulla, have slightly different effects in exciting the alpha and beta receptors.
- Norepinephrine excites mainly **alpha receptors** but excites the beta receptors to a lesser extent as well
- Epinephrine is a **universal stimulator** and can excite both types of receptors approximately equally.
- Therefore, if an organ has just beta receptors (such as the heart), epinephrine will be the more effective excitant.

Adrenergic Receptors and Function

Alpha Receptor	Beta Receptor
Vasoconstriction	Vasodilation (β_2)
Iris dilation	Cardioacceleration (β_1)
Intestinal relaxation	Increased myocardial strength (β_1)
Intestinal sphincter contraction	Intestinal relaxation (β_2) Uterus relaxation (β_2)
Pilomotor contraction	Bronchodilation (β_2)
Bladder sphincter contraction	Calorigenesis (β_2)
Inhibits neuro-transmitter release (α_2)	Glycogenolysis (β_2) Lipolysis (β_1) Bladder wall relaxation (β_2) Thermogenesis (β_3)

Autonomic Effects on Various Organs of the Body

Organ	Effect of Sympathetic Stimulation	Effect of Parasympathetic Stimulation
Eye		
Pupil	Dilated	Constricted
Ciliary muscle	Slight relaxation (far vision)	Constricted (near vision)
Glands Nasal Lacrimal Parotid Submandibular Gastric Pancreatic	Vasoconstriction and slight secretion	Stimulation of copious secretion (containing many enzymes for enzyme-secreting glands)
Sweat glands	Copious sweating (cholinergic)	Sweating on palms of hands
Apocrine glands	Thick, odoriferous secretion	None
Blood vessels	Most often constricted	Most often little or no effect
Heart		
Muscle	Increased rate Increased force of contraction	Slowed rate Decreased force of contraction (especially of atria)
Coronaries	Dilated (β_2); constricted (α)	Dilated
Lungs		
Bronchi	Dilated	Constricted
Blood vessels	Mildly constricted	? Dilated
Gut		
Lumen	Decreased peristalsis and tone	Increased peristalsis and tone
Sphincter	Increased tone (most times)	Relaxed (most times)

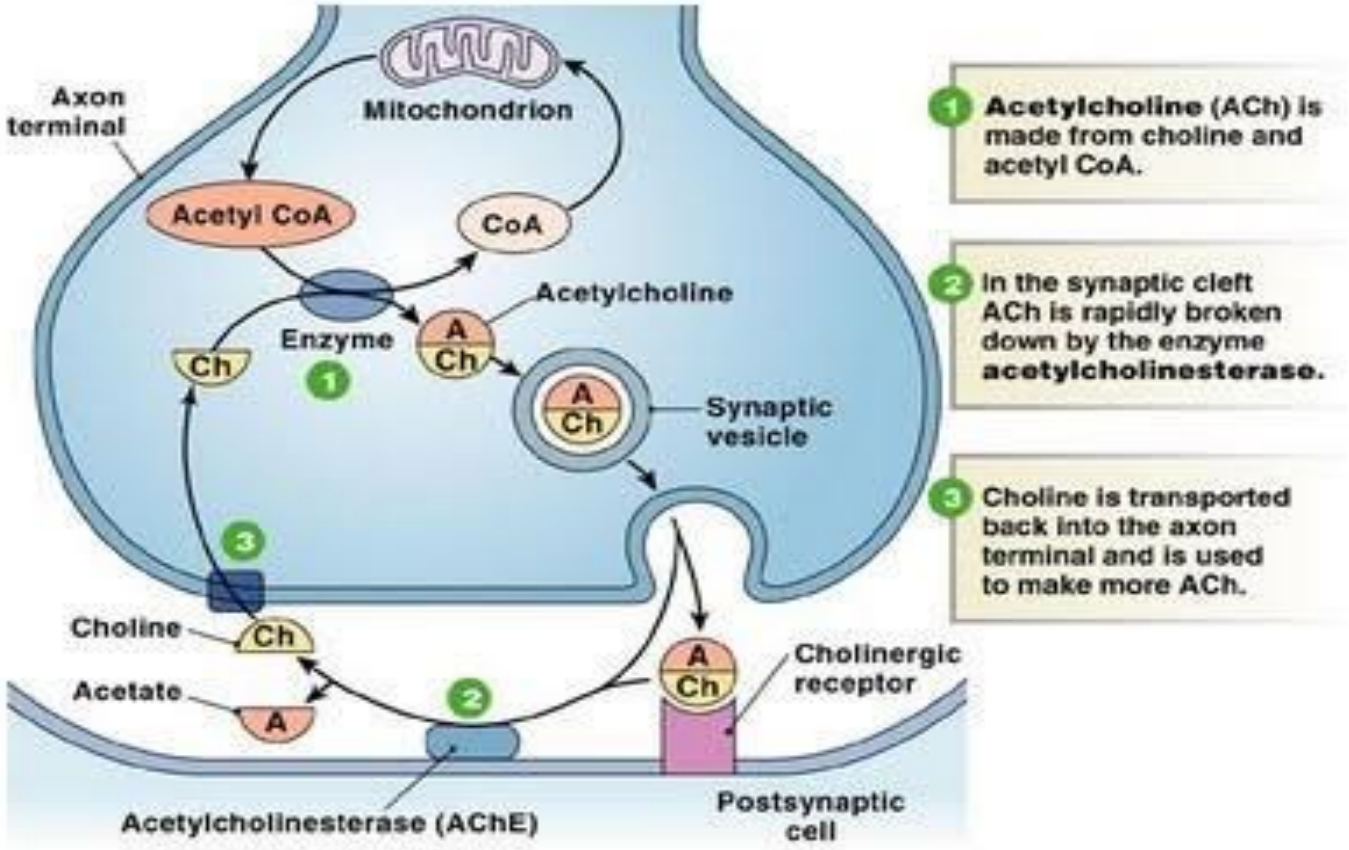
Autonomic Effects on Various Organs of the Body

Organ	Effect of Sympathetic Stimulation	Effect of Parasympathetic Stimulation
Liver	Glucose released	Slight glycogen synthesis
Gallbladder and bile ducts	Relaxed	Contracted
Kidney	Decreased urine output and increased renin secretion	None
Bladder		
Detrusor	Relaxed (slight)	Contracted
Trigone	Contracted	Relaxed
Penis	Ejaculation	Erection
Systemic arterioles		
Abdominal viscera	Constricted	None
Muscle	Constricted (adrenergic α) Dilated (adrenergic β_2) Dilated (cholinergic)	None
Skin	Constricted	None
Blood		
Coagulation	Increased	None
Glucose	Increased	None
Lipids	Increased	None
Basal metabolism	Increased up to 100%	None
Adrenal medullary secretion	Increased	None
Mental activity	Increased	None
Piloerector muscles	Contracted	None
Skeletal muscle	Increased glycogenolysis Increased strength	None
Fat cells	Lipolysis	None

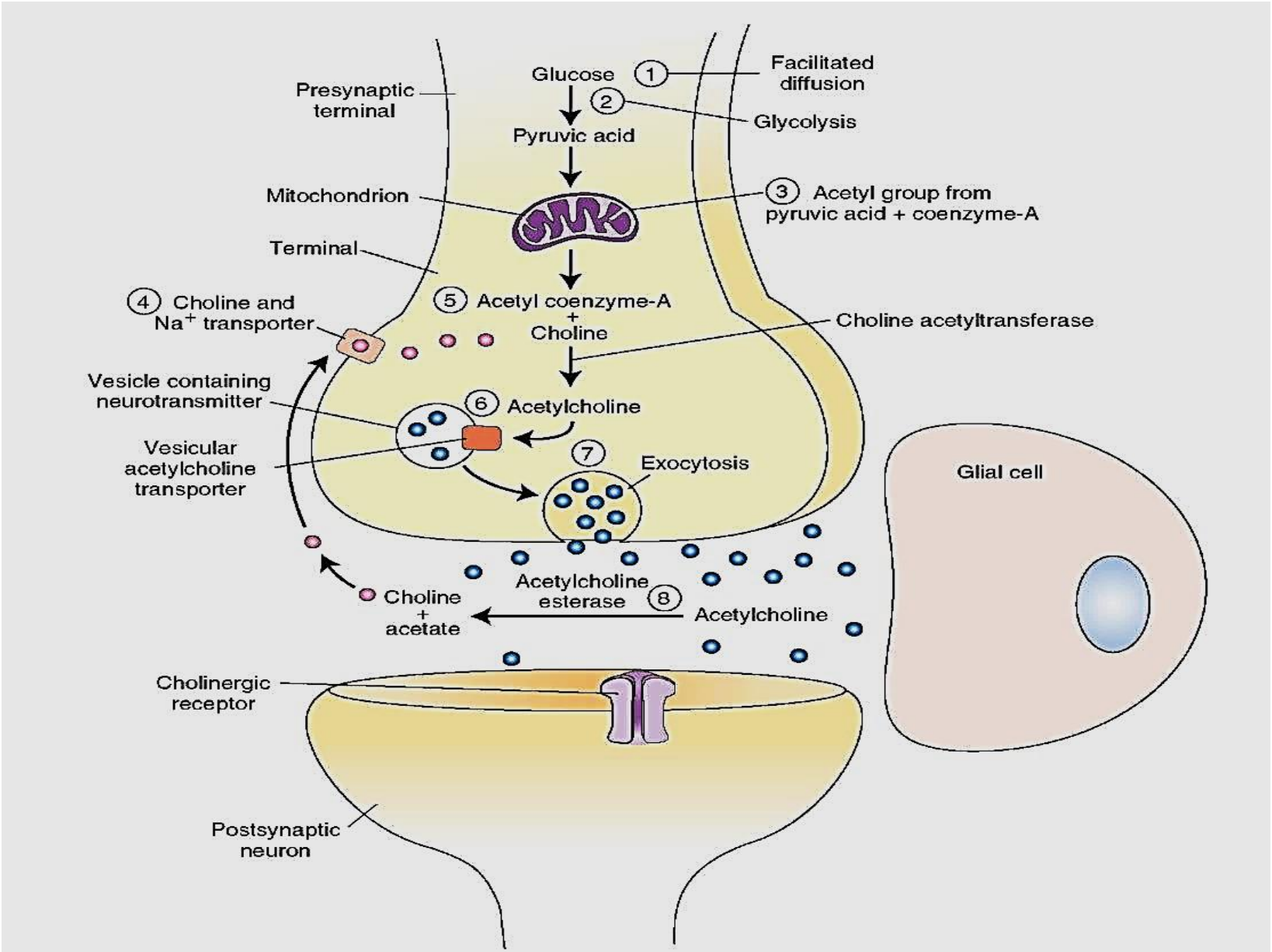
Cholinergic synapse: Synthesis, release and degradation of acetylcholine

Synthesis of acetylcholine

$$\text{Acetyl-CoA} + \text{Choline} \xrightarrow{\text{Choline acetyltransferase}} \text{Acetylcholine}$$



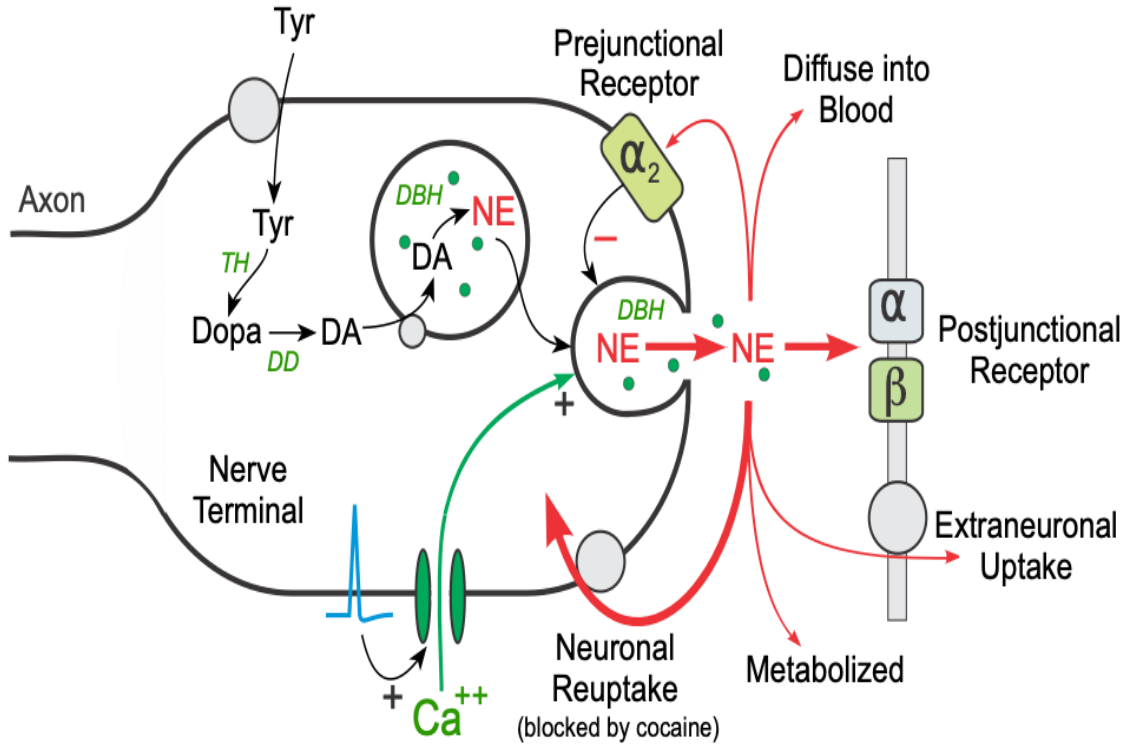
Cholinergic synapse: synthesis, release and degradation of acetylcholine



Synthesis , release and termination of action of NE

Termination of action of NE

- Reuptake into the adrenergic nerve endings by an **active transport process**, accounting for removal of 50 to 80% of the secreted norepinephrine
- Diffusion away from the nerve endings into the surrounding body fluids and then into the blood
- Destruction of small amounts by tissue enzymes (one of these enzymes is monoamine oxidase (MAO), which is found in the nerve endings, and another is catechol-O-methyl transferase (COMT), which is present diffusely in the tissues especially the liver).



Tyr, tyrosine; *TH*, tyrosine hydroxylase; *DD*, DOPA decarboxylase; *DA*, dopamine; *DBH*, dopamine β-hydroxylase; *NE*, norepinephrine