

Autonomic Nervous System

ANS Physiology:
G – protein Receptor Systems:
 • Receptors interact with G-proteins to trigger cellular event

A. Receptors:
 • 7 trans-membrane segments (each segment = similar α -helix sequences)

Interact with various G-proteins depending on sequence of 3rd intracellular loop

Wolfe – Figure 4.3

Autonomic Nervous System

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B. G proteins:
 • Composed of three unique sub-units (α , β , δ)
 • No intrinsic enzymatic activity; activates enzymes

G protein Activation:

- 1) Ligand binds to receptor
- 2) Receptor / G protein interact
 - GDP (α -subunit) replaced by GTP; dissociation occurs
- 3) α -subunit activates effector

Hydrolysis of GTP to GDP causes α -subunit to dissociate from effector and rejoin other subunits

Autonomic Nervous System

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C. Effectors:
A) Adenylyl cyclase (2nd messenger – cAMP)

Plasma membrane of liver cell

Stimulatory ligand: Epinephrine, Glucagon, ACTH

Inhibitory ligand: PGE₁, Adenosine

Activation of E

Inhibition of E

Receptor for stimulatory hormone

Receptor for inhibitory hormone

Activated by G_s proteins

Stimulatory G protein complex

Inhibitory G protein complex

Inhibited by G_i proteins

Adenylyl cyclase

ATP → cAMP

Lodish – Figure 20.20

Autonomic Nervous System

ANS Physiology:
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 • Receptors interact with G-proteins to trigger cellular event

C. Effectors:
A) Adenylyl cyclase (2nd messenger – cAMP)
 • Synthesizes cAMP from ATP

Methylxanthines (e.g., caffeine)

Inactivates cAMP

Adenylyl Cyclase

ATP → cAMP

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C. Effectors:
A) Adenylyl cyclase (2nd messenger – cAMP)
B) Phospholipase C (2nd messengers – IP₃ / DAG)
 • IP₃ activates release of Ca²⁺ (ER)
 • DAG activates protein kinase

plasma membrane

hormone or neurotransmitter

Receptor

G protein

phospholipase C

Diacylglycerol (DAG)

Inositol trisphosphate (IP₃)

phosphatidylinositol 4,5-bisphosphate (PIP₂)

Inositol 1,4,5-trisphosphate (IP₃)

Ca²⁺ released

protein kinase

Wolfe – Figure 6.6 / 6.9

Autonomic Nervous System

Nature of receptor dictates effects of NTs

ANS Physiology:
Receptor Types:
A) Adrenoreceptors (bind E / NE):
 • Located on target tissues of sympathetic NS
 • Divided into two types: α and β receptors

	α_1 receptors (most common)	α_2 receptors
Effect:	(+) Excitatory (+)	(-) Inhibitory (-)
Location:	Vascular smooth muscle - skin (constricts blood vessels) Gastrointestinal tract / bladder (constricts sphincters) Iris of eye (dilates pupil of eye)	Membrane of adrenergic axon terminals (inhibits NE release) Gastrointestinal tract (inhibits GI function) Pancreas (inhibits insulin secretion)
Mechanism of Action:	G protein coupled to phospholipase C	G _i protein coupled to adenylyl cyclase

Phenylephrine (α_1 agonist)

Autonomic Nervous System

Nature of receptor dictates effects of NTS



ANS Physiology:

Receptor Types:

A) Adrenoreceptors (bind E / NE):

- Located on target tissues of sympathetic NS
- Divided into two types: α and β receptors

G protein-linked receptor systems

β_1 receptors	β_2 receptors
Effect: (+) Excitatory (+)	Effect: (-) Inhibitory (-)
Location: Predominately in the heart (increases contraction rate / strength)	Location: Vascular smooth muscle - skeletal muscle
 Propranolol (β -blocker)	 Albuterol (β_2 agonist)
Mechanism of Action: G_s protein coupled to adenylylate cyclase	Mechanism of Action: G_s protein coupled to adenylylate cyclase

Additional info for β_1 receptors: Kidney (triggers renin (hormone) release)

Additional info for β_2 receptors: Lungs (dilates bronchioles), Gastrointestinal tract (relaxes GI tract)

Autonomic Nervous System

Nature of receptor dictates effects of NTS

ANS Physiology:


Receptor Types:

A) Adrenoreceptors (bind E / NE):

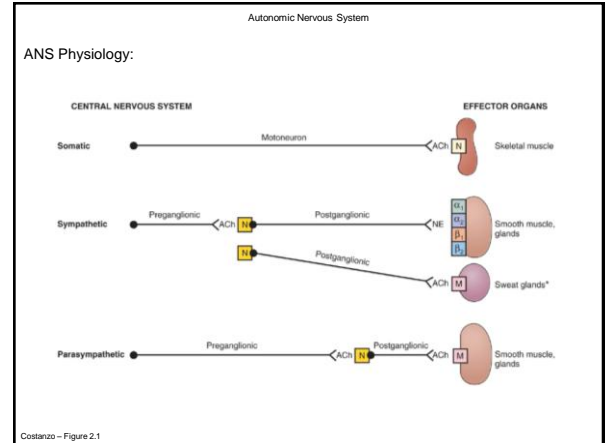
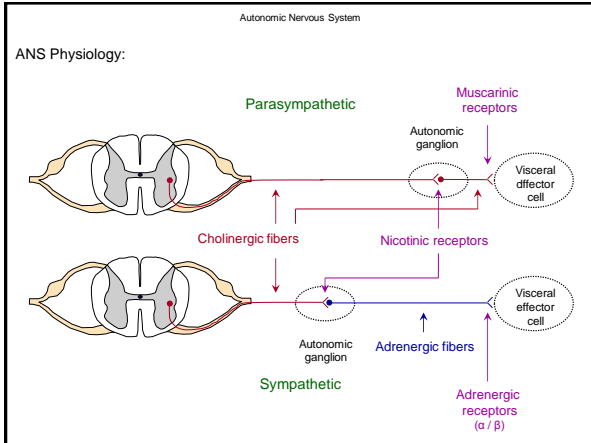
- Activated by nictines

B) Cholinereceptors (bind ACh):

- Activated by toxins from toadstools
- Located on postganglionic neurons / target tissues of parasympathetic NS
- Divided into two types: nicotinic & muscarinic


atropine (muscarinic antagonist)

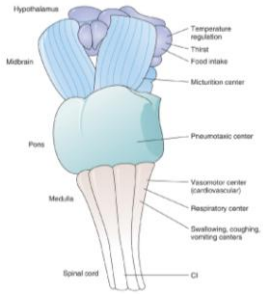
Nicotinic	Muscarinic
Effect: (+) Excitatory (+)	Effect: (+) Excitatory (+) & (-) Inhibitory (-)
Location: Motor end plate – skeletal muscle (contracts skeletal muscle)	Location: Parasympathetic organs – sans heart (excites organ activity)
All postganglionic neurons (activate postganglionic neurons)	G protein coupled to K^+ channel... \rightarrow Heart (inhibits heart rate)
Chromaffin cells – adrenal medulla (triggers release of E / NE)	Sweat glands – sympathetic NS (activates sweat glands)
Mechanism of Action: Ligand-gated ion channel	Mechanism of Action: G protein coupled to phosphorylase C (Majority of locations)



Autonomic Nervous System

ANS Physiology:

Control of Autonomic Functioning:



A) Brain stem / Spinal cord

- Vasomotor center (cardiovascular)
- Respiratory center
- Micturition center (urination)
- Swallowing / coughing / vomiting

B) Hypothalamus

- Main integration center
 - Body temperature
 - Water balance
 - Food intake
- Links emotion with ANS

C) Cortical control

- Links emotional past with ANS
- Voluntary cortical ANS control possible

Additional info: Temperature regulation, Thirst, Food intake, Micturition center, Pneumotaxic center, Vasomotor center (cardiovascular), Respiratory center, Swallowing, coughing, vomiting centers, GI

Costanzo – Figure 2.4

Autonomic Nervous System

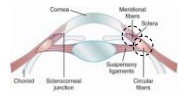
Sympathetic = "fight or flight"
Parasympathetic = "rest and digest"

ANS Physiology:

Interactions of Autonomic Divisions:

A) Antagonistic Interactions: Systems do not 'compete' with each other; coordinated by nervous system

- Pupil:
 - Parasympathetic = Constriction (circular fibers)
 - Sympathetic = Dilation (meridional fibers)
- Heart (sinoatrial node):
 - Parasympathetic = Decrease heart rate
 - Sympathetic = Increase heart rate



B) Synergistic Interactions:

- External genitalia
 - Parasympathetic = Vasodilation of blood vessels (erection of tissue)
 - Sympathetic = Smooth muscle contraction (ejaculation / reflex contraction)

*** Tone:**

- Basal rate of activity present in a system
- Allows increase / decrease by single system

Additional info: Blood vessels under sympathetic tone
Decrease output = vasodilation of vessel
Increase output = vasoconstriction of vessel

