

by Sorahae via cheatography.com/176418/cs/36921/

Nervous system

Two major subdivisions:

1. Central nervous system (CNS; the brain and spinal cord)

Peripheral nervous (PNS; neuronal tissues outside the system CNS).

Anatomically divided into the:

1. Autonomic

2. Somatic

Autonomic nerves can also influence cancer development and progression.

ANATOMY OF THE AUTONOMIC NERVOUS SYSTEM

Two major portions:

- 1. Sympathetic (thoracolumbar) division
- 2. Parasympathetic (traditionally "craniosacral").

- a. The **sympathetic preganglionic fibers** leave CNS through the *thoracic, lumbar, and sacral spinal nerves.*
- b. The parasympathetic preganglionic fibers leave the CNS through the *cranial nerves* (3rd, 7th, 9th, and 10th).

for Sympathetic	
PARAVERTEBRAL	PREVERTEBRAL
Most thoracic and lumbar sympathetic preganglionic fibers are SHORT and terminate in ganglia located in here.	Most of the remaining sympathetic preganglionic fibers are somewhat LONGER and terminate
*Short	*Longer

For PARASYMPATHETIC:

- -Preganglionic parasympathetic fibers terminate in parasympathetic ganglia located outside the organs innervated:
- 1.Ciliary
- 2. Pterygopalatine
- 3. Submandibular
- 4. Otic ganglia.

	vs	

digestion.

Autonomic nervous system (ANS)

Somatic nervous system (SNS)

It is concerned with control and integration of visceral functions necessary for life such as cardiac output, blood flow distribution, and Motor portion of the somatic subdivision is largely concerned with movement, respiration, and posture.

Largely independent (autonomous) in that its activities are not under direct conscious control.

Both have important afferent (sensory) inputs that provide information regarding the internal and external environments and modify motor output through reflex arcs of varying complexity.

Vagus nerve, also influences immune function and some CNS functions such as seizure discharge.

Major difference CNS vs ANS

Presence of a GANGLION in ANS

Differentiating divisions of ANS

a. Sympathetic Nervous System	b. Parasympathetic Nervous System	c. Enteric Nervous System
-Prepares body for intense "- FIGHT OR FLIGHT" response.	-Relaxes body and inhibits or slows many high energy functions	-Large and highly organized collection of neurons located in walls of GI system.
FIGHT OR FLIGHT (F/F	REST OR DIGEST	THIRD DIVISION OF ANS
-	-	Control motor activity of colon

ENS includes:

- 1. MYENTERIC PLEXUS or the Plexus of Auerbach
- 2. SUBMUCOUS PLEXUS or the Plexus of Meissner



By Sorahae

cheatography.com/sorahae/

Published 6th February, 2023. Last updated 6th February, 2023. Page 1 of 6. Sponsored by **ApolloPad.com**Everyone has a novel in them. Finish
Yours!
https://apollopad.com



by Sorahae via cheatography.com/176418/cs/36921/

ENS neuronal networks

- 1. Myenteric plexus (the plexus of Auerbach)
- 2. Submucous plexus (the plexus of Meissner).

Neurotransmitters		
	Location	NT
Preganglionic		Ach
Postganglionic	a. Parasympathetic	Ach
	b. Sympathetic	NE & few locations Ach

Receptors		
	Туре	
Parasympathetic	Ν	Excitatory
	M	Excitatory or Inhibitory
Sympathetic	Alpha	Excitatory
	Beta	Excitatory or Inhibitory

Figure 6–1		
Parasy- mpathetic	Cardiac and smooth muscle, gland cells, nerve terminals	Ach/M
Sympat- hetic	Sweat glands	Ach, M
Sympat- hetic	Cardiac and smooth muscle, gland cells, nerve terminals	ΝΕ, α, β
Sympat- hetic	Renal vascular smooth muscle	NE, D/α, D1
Somatic	Skeletal muscle	Ach, N

TABLE 6-1 Some of the tra nonadrenergic	nsmitter substances found in autonomic nervous system, enteric nervous system, and noncholinergic neurons. ¹
Substance	Functions
Acetylcholine (ACh)	The primary transmitter at ANS ganglia, at the somatic neuromuscular junction, and at parasympathetic postganglioric nerve endings. A primary excitatory transmitter to smooth muscle and secretory cells in the ENS. Probably also the major neuron-to-neuron ("ganglionic") transmitter in the EMS.
Adenosine triphosphate (ATP)	Acts as a transmitter or cotransmitter at many ANS-effector synapses.
Calcitorin gene-related peptide (CGRP)	Found with substance P in cardiovascular sensory nerve fibers. Present in some secretomotor ENS neurons and interneurons. A cardiac stimulant.
Cholecystokinin (CCK)	May act as a cotransmitter in some excitatory neuromuscular ENS neurons.
Dopamine	A modulatory transmitter in some ganglia and the ENS. Possibly a postganglionic sympathetic transmitter in renal blood vessels.
Enkephalin and related opioid peptides	Present in some secretomotor and interneurons in the ENS. Appear to inhibit ACh release and thereby inhibit peristalsis. May stimulate secretion.
Galanin	Present in secretomotor neurons; may play a role in appetite-satiety mechanisms.
GABA (γ-aminobutyric acid)	May have presynaptic effects on excitatory ENS nerve terminals. Has some relaxant effect on the gut. Prob- ably not a major transmitter in the ENS.
Gastrin-releasing peptide (GRP)	Extremely potent excitatory transmitter to gastrin cells. Also known as mammalian bombesin.
Neuropeptide Y (NPY)	Found in many noradreneegic neurons. Present in some secretomotor neurons in the ENS and may inhibit secretion of water and electrolytes by the gut. Causes long-lasting vasoconstriction. It is also a cotransmitter in some parasympathetic postganglionic neurons.
Nitric oxide (NO)	A cotransmitter at inhibitory ENS and other neuromuscular junctions; may be especially important at sphinc- ters. Cholinergic neurons innervating blood vessels appear to activate the synthesis of NO by vascular endo- thelium. NO is not stored, it is synthesized on demand by ninitic noide synthasis, NOS; see Chapter 19.
Norepinephrine (NE)	The primary transmitter at most sympathetic postganglionic nerve endings.
Serotonin (5-HT)	An important transmitter or cotransmitter at excitatory neuron-to-neuron junctions in the ENS.
Substance P, related tachykinins	Substance P is an important sensory neurotransmitter in the ENS and elsewhere. Tachykinins appear to be excitatory cotransmitters with Ach at PKS neuromuscular junctions. Found with CGSP in cardiovascular sen- sory neurons. Substance P is a vasodilator (probably) via release of ristric castle.
Vasoactive intestinal peptide (VIP)	Excitatory secretomotor transmitter in the ENS; may also be an inhibitory ENS neuromuscular cotransmitter. A probable cotransmitter in many cholinergic neurons. A vasodilator (found in many perivascular neurons) and cardios stimulant.

TABLE 6-1	
Substance	Functions
Acetyl- choline (ACh)	The primary transmitter at ANS ganglia, at the somatic neuromuscular junction, and at parasympathetic postganglionic nerve endings. A primary excitatory transmitter to smooth muscle and secretory cells in the ENS. Probably also the major neuron-to-neuron ("ganglionic") transmitter in the ENS.
Adenosine tripho- sphate (ATP)	Acts as a transmitter or cotransmitter at many ANS-effector synapses.
Calcitonin gene-r- elated peptide (CGRP)	Found with substance P in cardiovascular sensory nerve fibers. Present in some secretomotor ENS neurons and interneurons. A cardiac stimulant.
Cholecyst- okinin (CCK)	May act as a cotransmitter in some excitatory neurom-uscular ENS neurons.
Dopamine	A modulatory transmitter in some ganglia and the ENS. Possibly a postganglionic sympathetic transmitter in renal blood vessels.
Enkephalin and related opioid peptides	Present in some secretomotor and interneurons in the ENS. Appear to inhibit ACh release and thereby inhibit peristalsis. May stimulate secretion.



By **Sorahae** cheatography.com/sorahae/

Published 6th February, 2023. Last updated 6th February, 2023. Page 2 of 6. Sponsored by **ApolloPad.com**Everyone has a novel in them. Finish Yours!
https://apollopad.com



by Sorahae via cheatography.com/176418/cs/36921/

TABLE 6	–1 (cont)	TABLE 6-1 (cont)		
Galanin	Present in secretomotor neurons; may play a role in appetite-satiety mechanisms.	Norepinep- hrine (NE)	The primary transmitt nglionic nerve ending	er at most sympathetic postga- s.
GABA (γ-ami-	May have presynaptic effects on excitatory ENS nerve terminals. Has some relaxant effect on the gut. Probably		An important transmit	ter or cotransmitter at excitatory ctions in the ENS.
nob- utyric acid)	not a major transmitter in the ENS.	Substance P, related tachyk-	,, , , , , , ,	
Gastri- n-rele- asing peptide (GRP)	Extremely potent excitatory transmitter to gastrin cells. Also known as mammalian bombesin.	inins	•	und with CGRP in cardiovascular ostance P is a vasodilator of nitric oxide)
	(GRP) Neurop Found in many noradrenergic neurons. Present in some eptide secretomotor neurons in the ENS and may inhibit secretion of water and electrolytes by the gut. Causes	Vasoactive intestinal	•	tor transmitter in the ENS; may ENS neuromuscular cotransmi-
Neurop eptide Y		peptide (VIP)	·	nsmitter in many cholinergic or (found in many perivascular stimulant.
(NPY)		CHOLINER	GIC TRANSMISSION	
Nitric oxide			nthesized by Choline erase (ChAT)	-Acetyl-CoA synthesized in mitochondria
(NO)	Cholinergic nerves innervating blood vessels appear to activate the synthesis of NO by vascular endothelium. NO			Choline transported into the neuron
	is not stored, it is synthesized on demand by nitric oxide synthase, NOS; see Chapter 19.			Blocked by hemicholinium (blocks uptake of choline)



By **Sorahae** cheatography.com/sorahae/

Published 6th February, 2023. Last updated 6th February, 2023. Page 3 of 6. Sponsored by **ApolloPad.com**Everyone has a novel in them. Finish
Yours!
https://apollopad.com



by Sorahae via cheatography.com/176418/cs/36921/

CHOLINERGIC TRANSMI	ISSION (cont)
STEP 2: Ach transported into SMALL CLEAR VESICLES	Transporter can be blocked by vesamicol (prevents storage or depletes transmitter storage)
STEP 3: Release of transmitter is Calcium-d-ependent	-triggered by action potentials
	-ACh release blocked by botulinum toxin
STEP 4: ACh binds to receptors	(cholinoceptors)
STEP 5: Catabolized by acetylcholinesterase (AChE)	-breaks ACh into choline and acetate
	terminate action of transmitter
	half-life of ACh is very short
	AChE in other tissues (eg. RBC)
	Butyrylcholinesterase (pseudo-)

5	KEV	EEATI	IRES O	E NELIBO	TPANSMIT	TER FUNCTION

ChAT and AChE used during synthesis and degradation of ACh.

- 1. Synthesis
- 2. Storage
- 3. Release
- 4. Termination Of Action Of The Transmitter
- 5. Receptor Effects

Acetylcholine Synthesis

- 1. ACh made from choline + acetyl CoA
- 2. In synaptic cleft, ACh is rapidly broken down by enzyme Acetylcholinesterase
- 3. Choline is transported back into axon terminal and used to make more ACh.

STEPS in ADRENERGIC TRANSMISSION

STEP 1	Synthesis of catecholamines (Dopamine, NE)
STEP 2	Uptake into storage vesicle
STEP 3	Release of NT
STEP 4	Binding to receptor
STEP 5/6	Degradation of NE

Termination of NORADRENERGIC TRANSMISSION

- 1. Simple diffusion away from receptor site (with eventual metabolism in plasma or liver
- 2. Reuptake into the nerve terminals by NET or into perisynaptic glia or other cells

BIOSYNTHESIS OF CATECHOLAMINES

1. Tyrosine convert to DOPA by	can be inhibited by metyrosine
Tyrosine hydroxylase	(a tyrosine analog)
2. DOPA convert to Dopamine by	-
Dopa decarboxylase	
3. Dopamine convert to NE by	In most sympathetic postgangl-
Dopamine-β-hydroxylase	ionic neurons, NE is the final
	product)
4. NE convert to Epinephrine by	Methylated form

Phenylethanolamine-N-methyltransferase

Additional

- a. Tyrosine metabolized by L-Amino acid decarboxylase to form **TYRAMINE** (the product of metabolism of tyrosine).
- b. Tyramine metabolized by *Dopamine-β-hydroxylase* to **Octopamine**
- c. Octopamine metabolized by hydroxylase (from the liver) to form NE



By Sorahae cheatography.com/sorahae/ Published 6th February, 2023. Last updated 6th February, 2023. Page 4 of 6.

Sponsored by ApolloPad.com Everyone has a novel in them. Finish https://apollopad.com



by Sorahae via cheatography.com/176418/cs/36921/

WAYS OF STOPPING NEUROTRANSMITTER

1. DIFFUSION	-
2. DEGRAD- ATION	metabolic enzyme process (eg. AChE metabolize ACh)
7111011	motabolizo / torr)
3 DELIDTAKE	into the noradrenergic neuron/ adrenergic neuron

NT CHEMISTRY OF THE ANS

CHOLINERGIC FIBERS	NORADRENERGIC (ADRENERGIC) FIBERS
releasing Ach (Acetylcholine)	release Norepinephrine (NE)/ Noradrenaline

AUTONOMIC RECEPTOR (NT, R)

PARASYMPATHETIC	SYMPATHETIC
NT: ACh (Cholinoceptors)	NT: NE (Adrenoceptors)
R=N/M	R= α,β, D
Nicotinic receptors= NN/NM	α= 1/2
Muscarinic receptors= M1 to M5	β= 1-3
	D= (D1-D5)

AUTONOMIC RECEPTOR

Alkaloids	Muscarine and	Nicotino
Alkalolus	<i>Muscarine</i> and	NICOLITIE

The sensory fibers in the nonadrenergic, noncholinergic systems are probably better termed "sensory-efferent" or "sensorylocal effector" fibers because, when activated by a sensory input, they are capable of releasing transmitter peptides from the sensory ending itself*, from local axon branches, and from collaterals that terminate in the autonomic ganglia.

These peptides are **potent agonists** in many *autonomic effector tissues*.

METABOLISM OF CATECHOLAMINES by COMT & MAO

Catech- ola- mines	COMT/MAO	Product 1	COMT/MAO	Product 2
EPINEP HRINE	=MAO	Dihydroxy- mandelic acid	COMT	3-Methoxy- 4-hydrox- ymandelic acid (VMA)
	=COMT	Metane- phrine	MAO	3-Methoxy- 4-hydrox- ymandelic acid (VMA)

METABOLISM OF CATECHOLAMINES by COMT & MAO (cont)				
NE	=MAO	Dihydroxy- mandelic acid	COMT	3-Methoxy-4 hydroxymandelic acid (VMA)
	=COMT	Normetane- phrine	MAO	3-Methoxy-4 hydroxymandelic acid (VMA)
DOPAMINE	=MAO	Dihydroxy- phenylacetic acid	COMT	Homovanillic acid
	=COMT	3-Methoxy- tyramine	MAO	Homovanillic acid

Read

Read Katzung CH. 6 (P.99) **TABLE 6-2 Major autonomic receptor types**

FUNCTIONAL ORGANIZATION OF AUTONOMIC ACTIVITY

A. Integration of Cardiovascular Function

Mean the primary controlled variable in cardiovascular function arterial pressure

-changes in any variable contributing to mean arterial pressure (eg, a drug-induced increase in peripheral vascular resistance) evoke powerful homeostatic secondary responses

Homeostatic response may be sufficient to reduce the change in mean arterial pressure and to reverse the drug's effects on heart rate.

Example: Slow infusion of NE

Increased baroreceptor activity causes the *decreased central sympathetic outflow* and *increased vagal outflow*.

Net effect of ordinary pressor doses of norepinephrine in a normal subject is to produce a **marked increase** in *peripheral vascular*

An increase in mean arterial pressure, and often, a slowing of heart rate.

NEGATIVE FEEDBACK RESPONSE is present.



Published 6th February, 2023. Last updated 6th February, 2023. Page 5 of 6. Sponsored by **ApolloPad.com**Everyone has a novel in them. Finish
Yours!
https://apollopad.com



by Sorahae via cheatography.com/176418/cs/36921/

B. Presynaptic Regulation

Autoreceptors Presynaptic receptors that respond to the primary transm-

itter substance released by the nerve ending

usually inhibitory, but in addition to the excitatory β receptors on noradrenergic fibers, many cholinergic fibers, especially somatic motor fibers, have excitatory nicotinic autoreceptors.

Hetero

respond to many other substances

receptors

> activated by substances released from other nerve terminals that synapse with the nerve ending

Principle of negative feedback control is also found at the presynaptic level of autonomic function.

-have been shown to exist at most nerve endings

C. Postsynaptic Regulation

Can be considered 1. Modulation by previous activity at the primary

from two perspectives:

2. Modulation by other simultaneous events.

FIRST

MECHANISM

Up-regulation and down-regulation are known to occur in response to decreased or increased activation, respectively, of the receptors.

Extreme form of up-regulation occurs after denervation of some tissues, resulting in denervation supersensitivity of the tissue* to activators of that receptor type.

C. Postsynaptic Regulation (cont)

ex: Nicotinic receptors are normally restricted to the end plate regions underlying somatic motor nerve terminals.

ex: Prolonged administration of large doses of reserpine, a norepinephrine depleter, can cause increased sensitivity of the smooth muscle and cardiac muscle effector cells

SECOND MFCHANISM

Involves modulation of the primary transmitter-receptor event by events evoked by the same or other transmitters acting on different postsynaptic receptors.

ex: Ganglionic transmission

Postganglionic cells are activated (depolarized) due to binding of an appropriate ligand to a neuronal nicotinic (NN) acetylcholine receptor.

Resulting:

a. Fast excitatory postsynaptic potential (EPSP) evokes a propagated action potential if threshold is reached.

Continued

- b. Often followed by a small and slowly developing but longer-lasting hyperpolarizing afterpotential—a slow inhibitory postsynaptic potential (IPSP).**
- 1. Hyperpolarization involves opening of potassium channels by M2 cholinoceptors.
- 2. Small, slow excitatory postsynaptic potential caused by closure of potassium channels linked to M1 cholinoceptors.
- 3. Late, very slow EPSP may be evoked by peptides released from other fibers.



By Sorahae cheatography.com/sorahae/ Published 6th February, 2023. Last updated 6th February, 2023. Page 6 of 6.

Sponsored by ApolloPad.com Everyone has a novel in them. Finish

https://apollopad.com