



The Autonomic Nervous System

Responsible for control of visceral effectors and visceral reflexes:

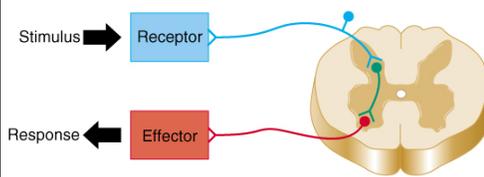
- smooth muscle, glands, the heart.
- e.g. blood pressure, cardiac output, plasma glucose

The autonomic system is often considered a motor system for control of **autonomic (visceral) effectors**. These effectors include smooth muscle, glands, and the heart. It also utilizes sensory inputs as part of **visceral reflexes** and independently as part of broader control mechanisms.



Comparison of Voluntary and Autonomic Divisions

- Single motor neuron from CNS to effector
 - Excitatory neurotransmitter at effector is ACh.

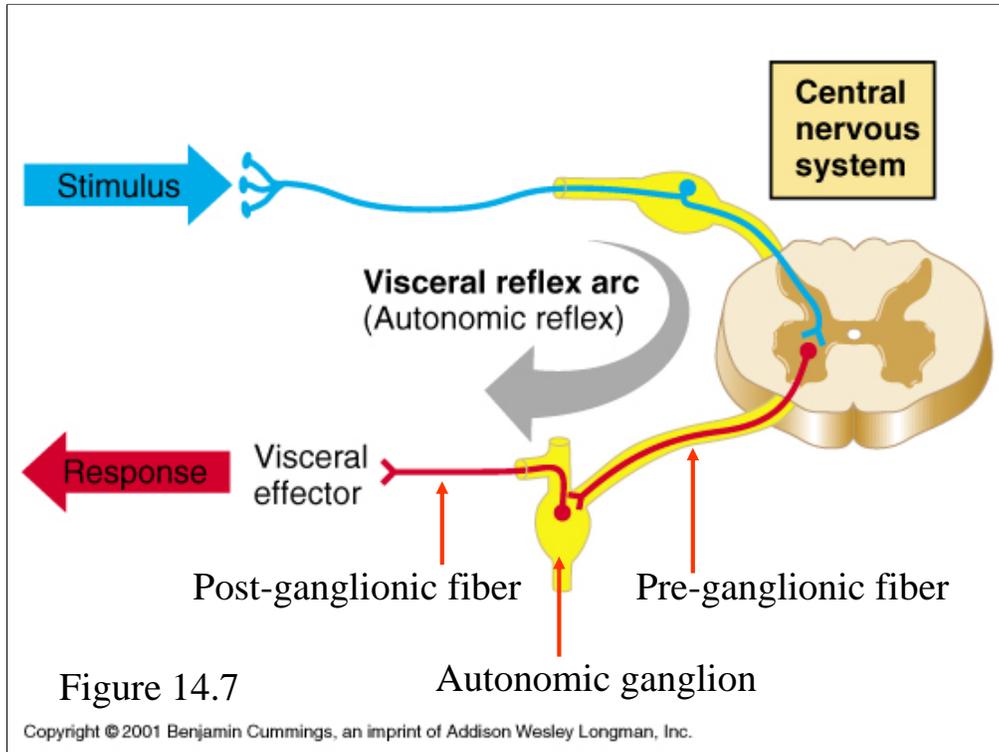


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- Two motor neurons between CNS and effector.
- Autonomic ganglion where motor neurons connect.
- ACh neurotransmitter at A.G.
- Other neurotransmitters at effector organ

Comparison of the autonomic and somatic (voluntary) nervous systems: See **Figure 14.2**. Both systems involve reflexes and connections to the CNS utilizing unipolar and multipolar sensory neurons, interneurons, and motor neurons.

But while the motor neuron in a somatic pathway travels directly to the skeletal muscle effector, in the autonomic nervous system there are **two motor neurons** which synapse at an **autonomic ganglion**. The neurotransmitter also may vary with the parasympathetic division mostly using acetylcholine at both pre and post ganglionic fibers, while the sympathetic division utilizes mostly norepinephrine at the post ganglionic fibers.





Two Autonomic Divisions

Parasympathetic Division: produces the “normal” response of effectors.

- Craniosacral CNS connection
- Autonomic ganglion on or near effector
- Uses ACh as both pre and post-ganglionic neurotransmitter: termed **cholinergic**.
- Produces localized and specific effects.

The **Parasympathetic Division** - See Figure 14.4. This division originates (has its CNS connection) in either the **cranial** or sacral portions of the CNS. That means it utilizes **cranial nerves** (remember III, VII, IX, X) or **sacral spinal nerves** (the pelvic splanchnic nerves). Its autonomic ganglia are located on or near the effector organ. It utilizes acetylcholine as both the pre-ganglionic and the post-ganglionic neurotransmitter (we call that **cholinergic**). The post-ganglionic neurotransmitter is most important because this is the transmitter actually released at the effector organ and which stimulates its receptors. The parasympathetic division has **localized and specific effects** which can mostly be described as producing the "**normal**" responses, i.e. non-stress responses, of its effectors.



“Fight or Flight”

Sympathetic Division: mostly stress responses.

- Autonomic ganglion in lateral chain near the spinal cord.
- Thoracolumbar CNS connection.
- ACh is preganglionic neurotransmitter; norepinephrine is predominant post-ganglionic neurotransmitter at effectors: termed **adrenergic**.
- May experience general or mass activation.

Adrenergic – name comes from **adrenaline**, commonly called **epinephrine**; also applies to **norepinephrine**.

The **Sympathetic Division** - See Figure 14.5. This division has its origin in the **thoracolumbar** portion of the spinal cord. Its autonomic ganglia are located in a chain of ganglia (called the **lateral chain ganglia**) located near the spinal cord. There are also plexuses which allow multiple connections between different components of the division. The sympathetic division uses ACh at its autonomic ganglia, but mostly uses norepinephrine at the effector organ (**adrenergic**). This permits an entirely different effect on many of the same effectors as the parasympathetic division. In addition the sympathetic division often exhibits a **general activation** rather than local effect. The sympathetic division often acts as a "**stress response**" system. The alliteration "**Fight or Flight**" is sometimes used to describe the way in which the sympathetic division becomes activated to mobilize the body's resources.



Comparison of Autonomic vs. Somatic N.S.

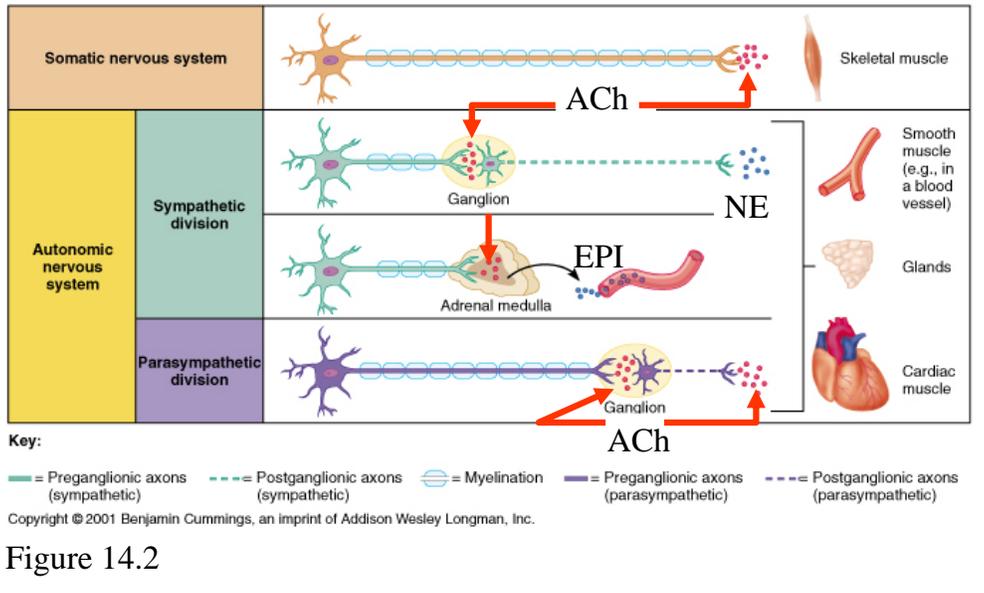
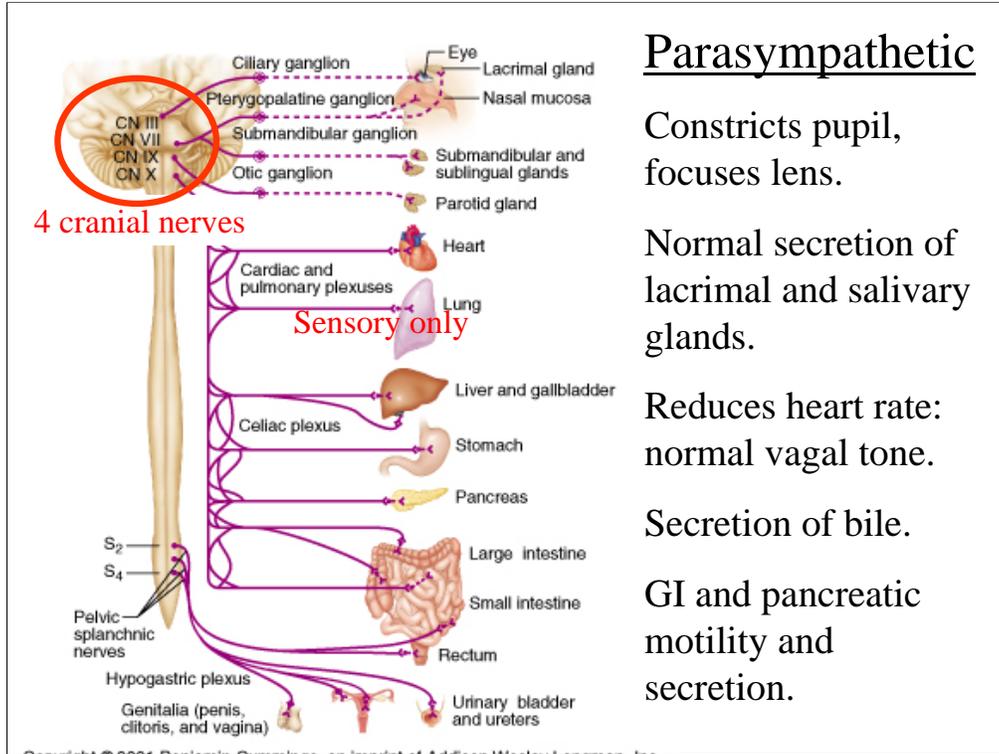
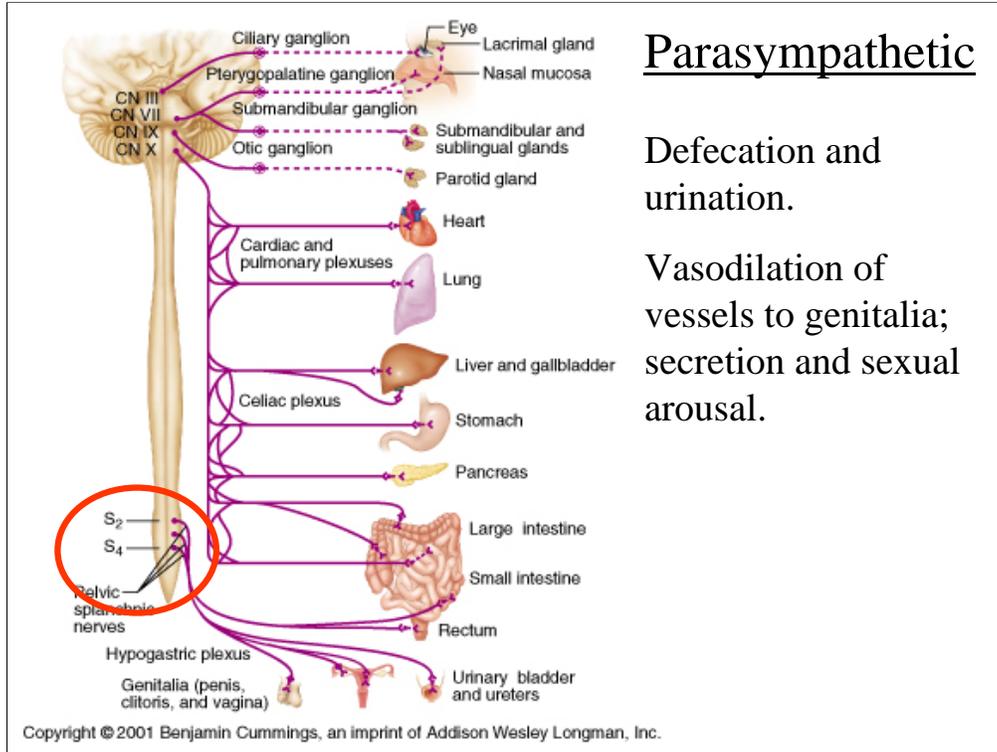


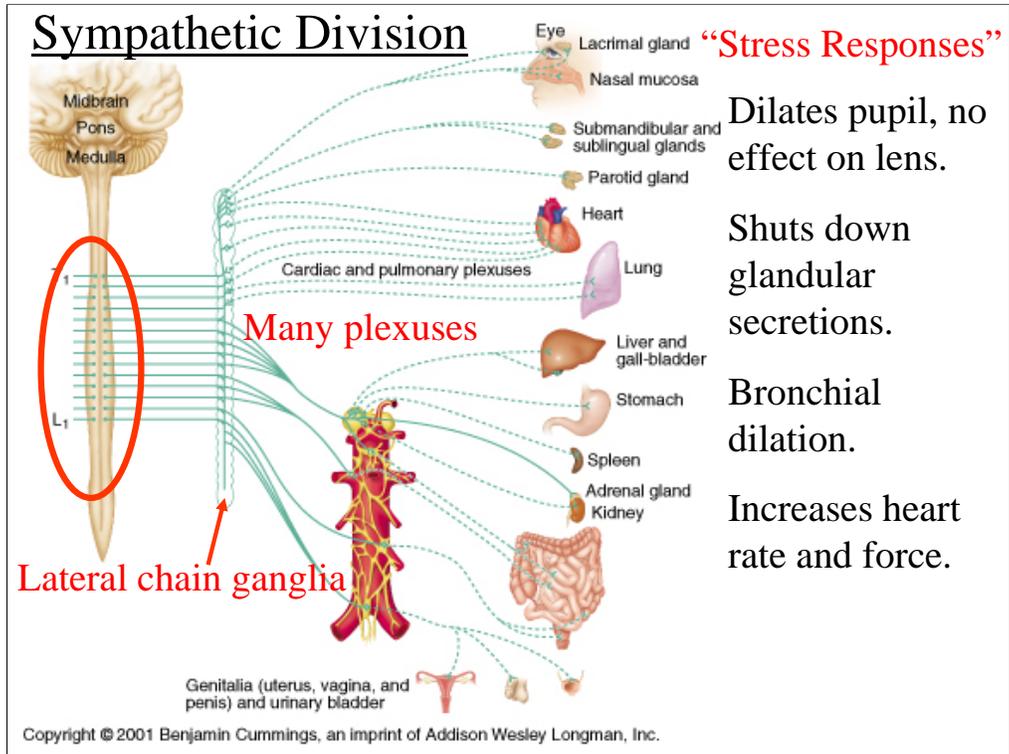
Figure 14.2

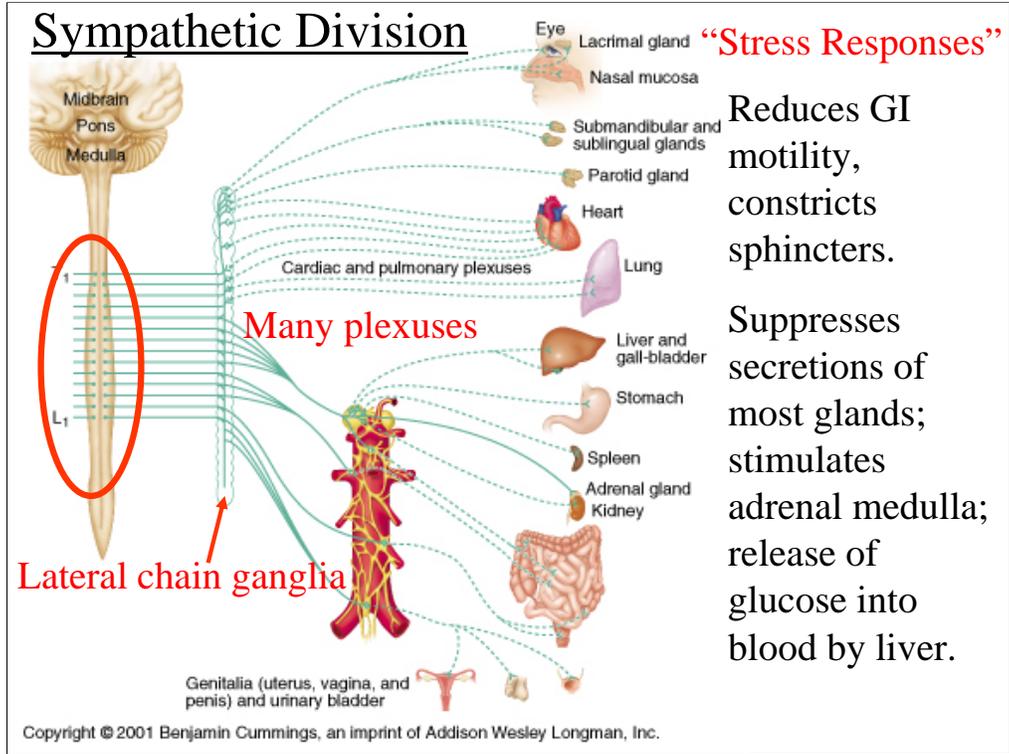
The **parasympathetic division** utilizes acetylcholine as both the pre-ganglionic and the post-ganglionic neurotransmitter (we call that **cholinergic**). The post-ganglionic neurotransmitter is most important because this is the transmitter actually released at the effector organ and which stimulates its receptors.

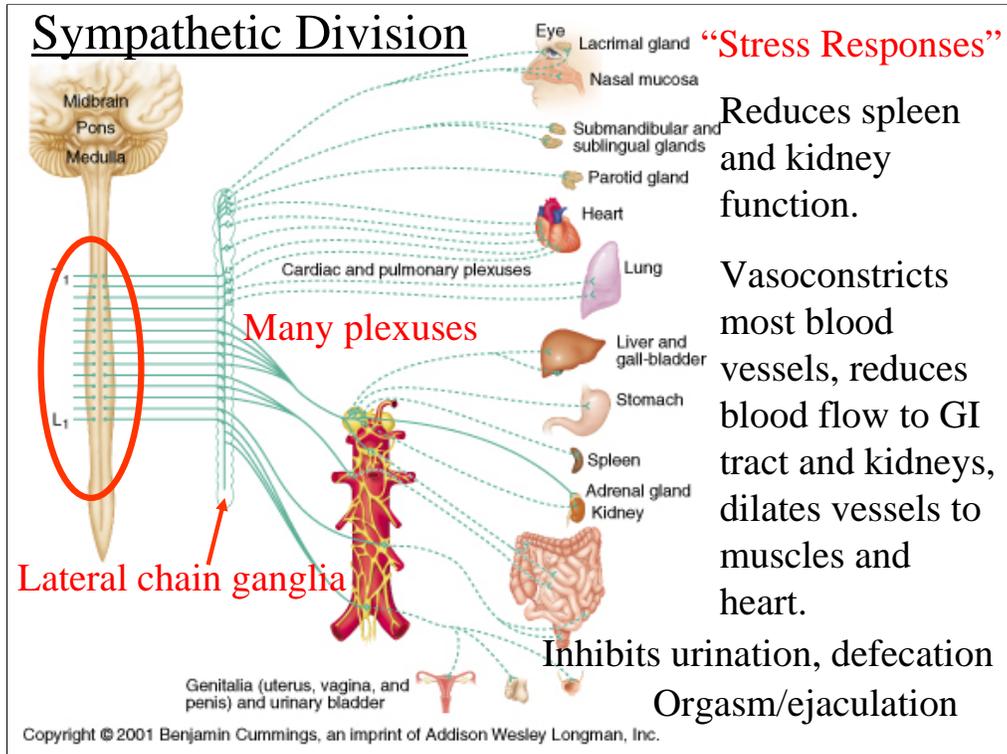
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The sympathetic system may cause mass activation or **GAS (General Activation Syndrome)**: many sympathetic effects occur together – e.g. in “Fight or Flight” response.



Cholinergic Receptors - respond to acetylcholine

Types depend on stimulation by nicotine or muscarine:

Nicotinic – found at all autonomic ganglia and as excitatory receptors for skeletal muscles.

Muscarinic – found at parasympathetic target organs and at certain sympathetic targets:
e.g. eccrine sweat glands (thermoregulation)
blood vessels to skeletal muscles (vasodilation)

The term **cholinergic** refers to those receptors which respond to the transmitter acetylcholine. Mostly these are parasympathetic. There are two types of cholinergic receptors, classified according to whether they are stimulated by the drug **nicotine** or by the drug **muscarine**. The significance is that certain clinical drugs can be used to stimulate or inhibit one type of cholinergic receptor without affecting other types.

1) nicotinic receptors are found at all autonomic ganglia, and at the neuromuscular junctions of skeletal muscles.

2) muscarinic receptors are found at parasympathetic target organs and at *certain sympathetic targets* - the **eccrine sweat glands** (which produces copious secretion in thermoregulation to release heat), and blood vessels in skeletal muscles (which are dilated).



Adrenergic Receptors - respond to norepinephrine

Found at most sympathetic target organs.

Alpha – mostly excitatory

e.g. vasoconstricts blood vessels, constricts GI sphincters, dilates pupils of eyes.

Beta – mostly inhibitory (except on heart where they increase rate and force)

e.g. vasodilation in heart and lungs, bronchial dilation, inhibition of muscles in GI tract.

Adrenergic receptors come in two basic types and each has subtypes. These are found at sympathetic target organs. **Alpha** receptors are mostly excitatory. They cause vasoconstriction of most blood vessels to raise the blood pressure, dilation of the pupils of the eyes, constriction of sphincters in the GI tract as part of its reduced function with sympathetic stimulation.

Beta receptors are generally inhibitory, except those to the heart. Beta receptors on the heart increase heart rate and force. But others dilate blood vessels to the heart and lungs, and dilate the bronchi. It is this effect used in anti-bronchitis drugs which are **sympathomimetic**. Beta receptors inhibit the muscles and glands of the GI tract.



Summary of Exceptions:

Sweat glands – only sympathetic innervation.

eccrine glands - cholinergic fibers which cause them to secrete copiously for thermoregulation.

apocrine glands - adrenergic fibers, secrete a viscous fluid containing pheromones in response to stress and sexual arousal.

Blood vessels to the sweat glands are adrenergic and dilate in response to sympathetic stimulation.

Alpha or beta?

beta

Exceptions to general rules (some of which have already been mentioned): The sweat glands are only innervated by sympathetic fibers. The eccrine gland are innervated by cholinergic fibers which cause them to secrete copiously for thermoregulation. The apocrine glands secrete a viscous fluid containing pheromones in response to stress and sexual arousal. These are controlled by adrenergic fibers. Blood vessels to the sweat glands are adrenergic and dilate in response to sympathetic stimulation.

Most blood vessels are innervated by sympathetic fibers only. (The exception is vessels to the genitalia which are dilated by parasympathetic stimulation) Mostly the sympathetic stimulation causes vasoconstriction to raise blood pressure, but to the vessels of the skeletal muscles, heart, and lungs vasodilation occurs as part of the need for more blood and oxygen during "Fight or Flight".



Exceptions (contd.)

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