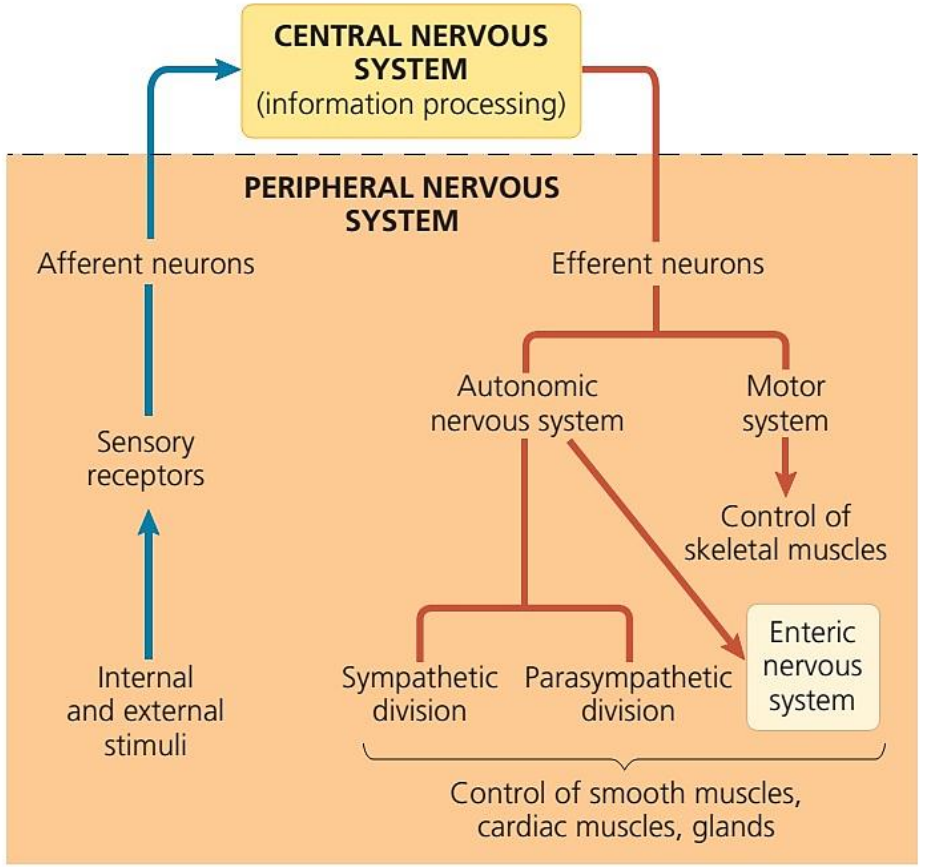
The Peripheral Nervous System

The PNS transmits information to and from the CNS and plays a large role in regulating an animal's movement and its internal environment. Sensory information reaches the CNS along PNS neurons designated as **afferent** (from the Latin, meaning "to carry toward"). Following information processing within the CNS, instructions then travel to muscles, glands, and endocrine cells along PNS neurons designated as **efferent** (from the Latin, meaning "to carry away"). Note that most nerves are bundles of both afferent and efferent neurons.

The PNS has two efferent components: the **motor system** and the **autonomic nervous system.** The neurons of the motor system carry signals to skeletal muscles. Motor control can be voluntary, as when you raise your hand to ask a question, or involuntary, as in the kneejerk reflex controlled by the spinal cord. In contrast, regulation of smooth and cardiac muscles by the autonomic nervous system is generally involuntary. The **sympathetic** and **parasympathetic** divisions of the autonomic nervous system regulate organs of the cardiovascular, excretory, and endocrine systems. A distinct network of neurons now known as the **enteric nervous system** exerts direct and partially independent control over the digestive tract, pancreas, and gallbladder.

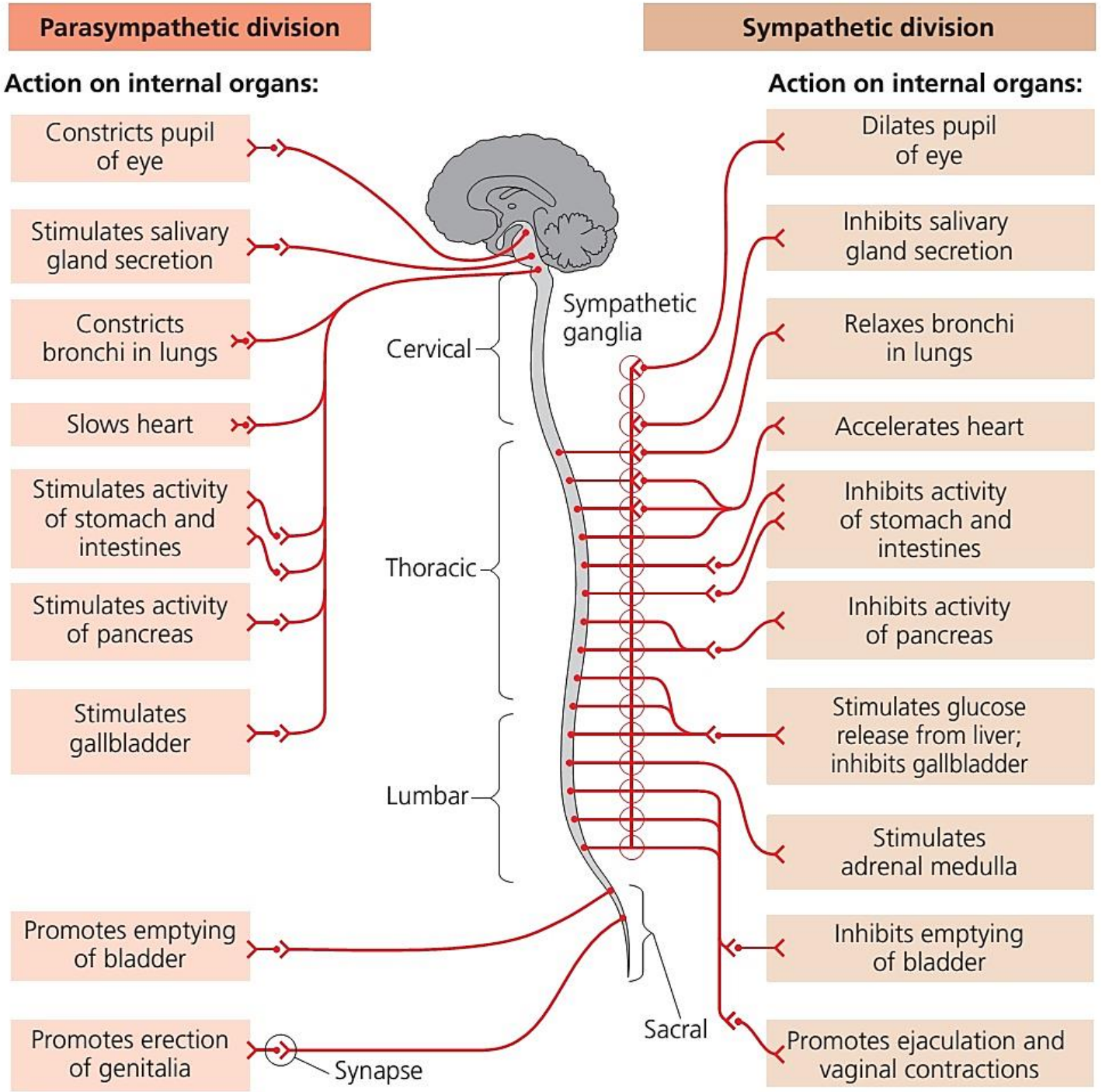
Homeostasis often relies on cooperation between the motor and autonomic nervous systems. In response to a drop in body temperature, for example, the hypothalamus signals the motor system to cause shivering, which increases heat production. At the same time, the hypothalamus signals the autonomic nervous system to constrict surface blood vessels, reducing heat loss. The sympathetic and parasympathetic divisions of the autonomic nervous system have largely antagonistic (opposite) functions in regulating organ function.

▼ Figure 49.6 Functional hierarchy of the vertebrate peripheral nervous system.



Activation of the **sympathetic division** corresponds to arousal and energy generation (the "fight-or-flight" response). For example, the heart beats faster, digestion is inhibited, the liver converts glycogen to glucose, and the adrenal medulla increases secretion of epinephrine (adrenaline).

Activation of the **parasympathetic division** generally causes opposite responses that promote calming and a return to self-maintenance functions ("rest and digest"). Thus, heart rate decreases, digestion is enhanced, and glycogen production increases. However, in regulating reproductive activity, a function that is not homeostatic, the parasympathetic division complements rather than antagonizes the sympathetic division.



▶ **Figure 49.7 The parasympathetic and sympathetic divisions of the autonomic nervous system.** Most pathways in each division involve two neurons connecting the CNS to target organs. The axon of the first neuron extends from a cell body in the CNS to a set of PNS neurons whose cell bodies are clustered into a ganglion (plural, *ganglia*). The axons of these PNS neurons transmit instructions to internal organs, where they form synapses with smooth muscle, cardiac muscle, or gland cells.

The two divisions differ not only in overall function but also in organization and signals released. Parasympathetic nerves exit the CNS at the base of the brain or spinal cord and form synapses in ganglia (A ganglion is a group of neuron cell bodies in the peripheral nervous system) near or within an internal organ. In contrast, sympathetic nerves typically exit the CNS midway along the spinal cord and form synapses in ganglia located just outside of the spinal cord.

In both the sympathetic and parasympathetic divisions, the pathway for information flow typically involves a preganglionic and a postganglionic neuron. The preganglionic neurons have cell bodies in the CNS and release acetylcholine as a neurotransmitter. In the case of the postganglionic neurons, those of the parasympathetic division release acetylcholine, whereas nearly all their counterparts in the sympathetic division release norepinephrine. It is this difference in neurotransmitters that enables the sympathetic and parasympathetic divisions to bring about opposite effects in organs such as the lungs, heart, intestines, and bladder.

▼ Figure 49.8 Comparison of pathways in the motor and autonomic nervous systems.