Control of Movement (cont.)

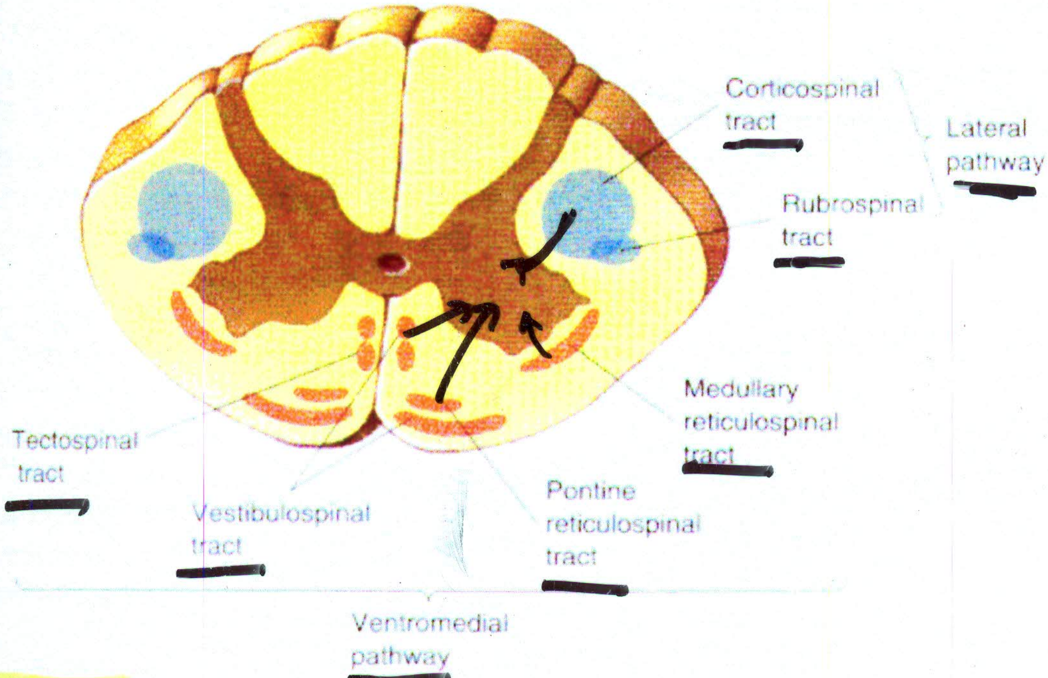
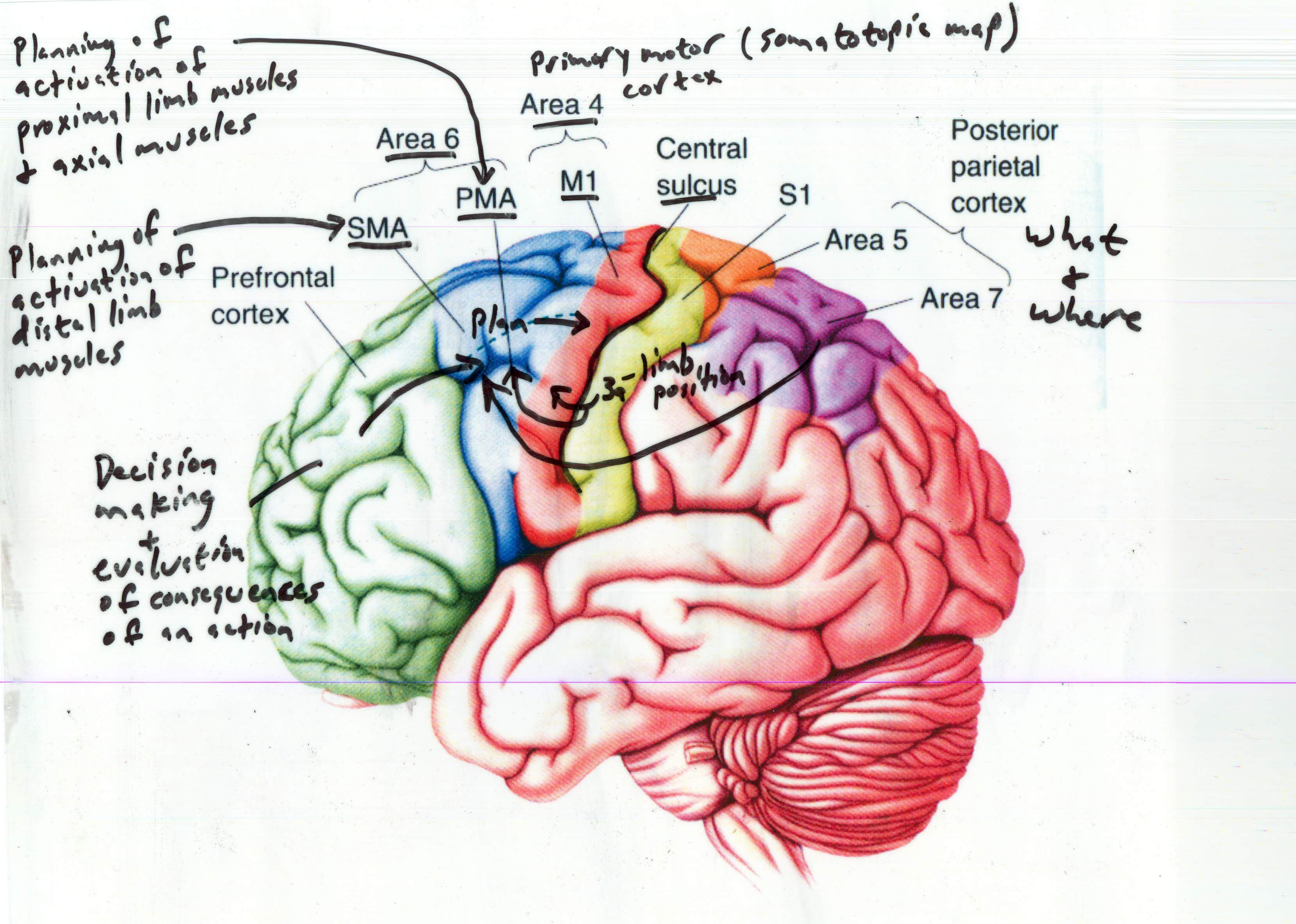


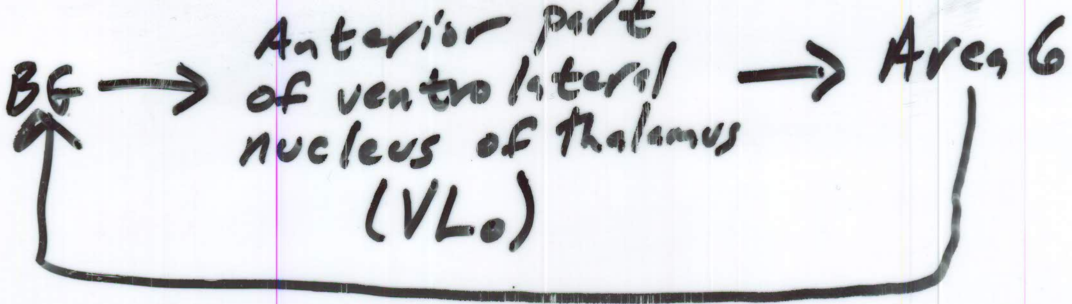
Figure 14.2

The descending tracts of the spinal cord. The lateral pathway, consisting of the corticospinal and rubrospinal tracts, controls voluntary movements of the distal musculature. The ventromedial pathway, consisting of the reticulospinal, vestibulospinal, and tectospinal tracts, controls postural muscles.

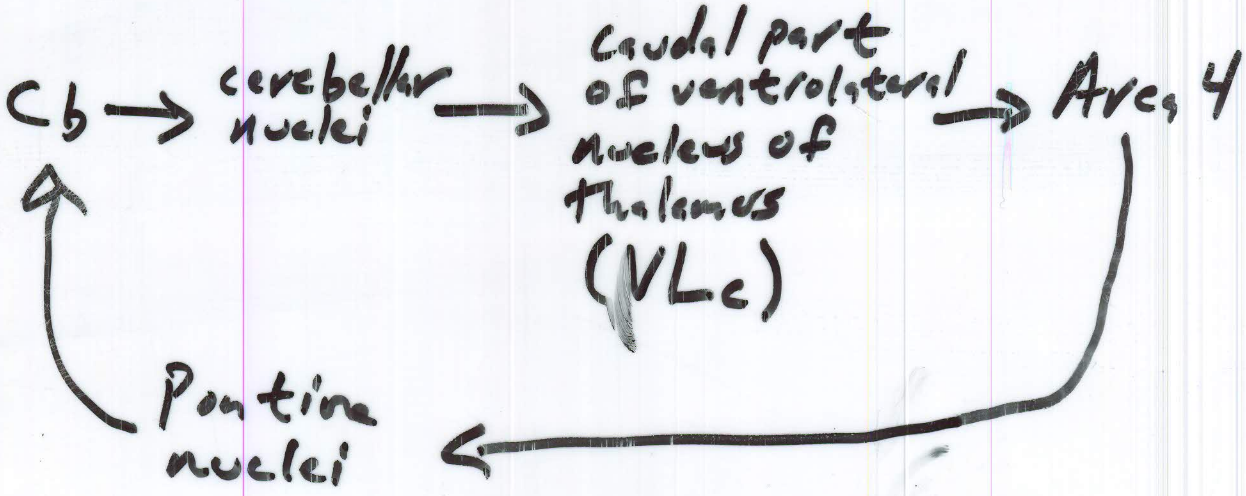

Planning of activation of proximal limb muscles & axial muscles
Primary motor (somatotopic map) cortex
Area 4
Area 6
M1
Central sulcus
Posterior parietal cortex
PMA
S1
SMA
Area 5
Planning of activation of distal limb muscles
Prefrontal cortex
Area 7
what & where
Plan
3a-limb position
Decision making + evaluation of consequences of an action

Major subcortical inputs to motor cortexi

— Basal ganglia (BG)



— Cerebellum (Cb)



The feedback loops created by the subcortical inputs to motor cortex play an important role in the regulation and initiation of voluntary movements.

Basal Ganglia

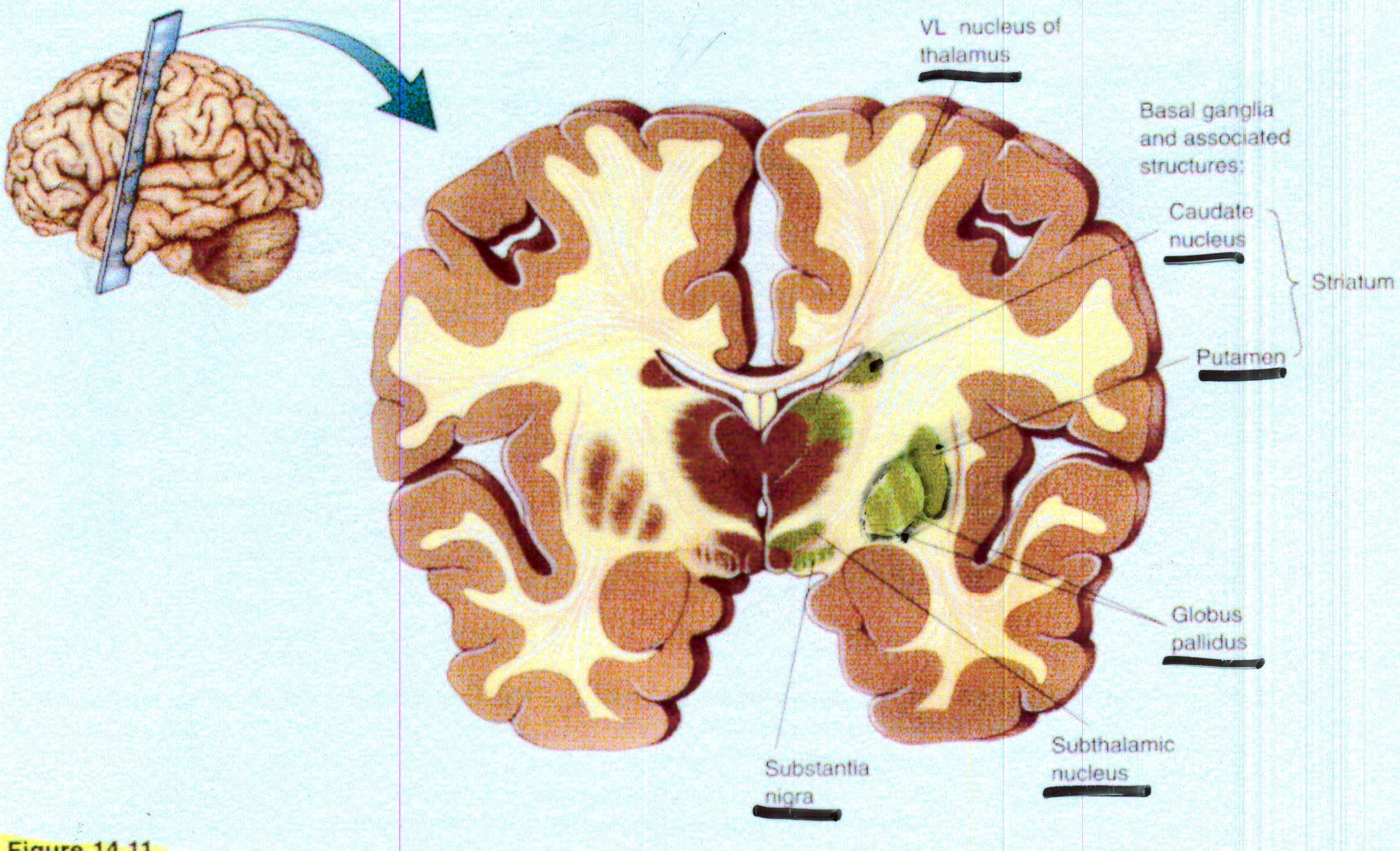


Figure 14.11
The basal ganglia and associated structures.

Basal ganglia is involved in the release + termination of motor commands from area 6. Diseases involving the BG result in movement disorders: Disruptions of initiation of movement or termination of movement.

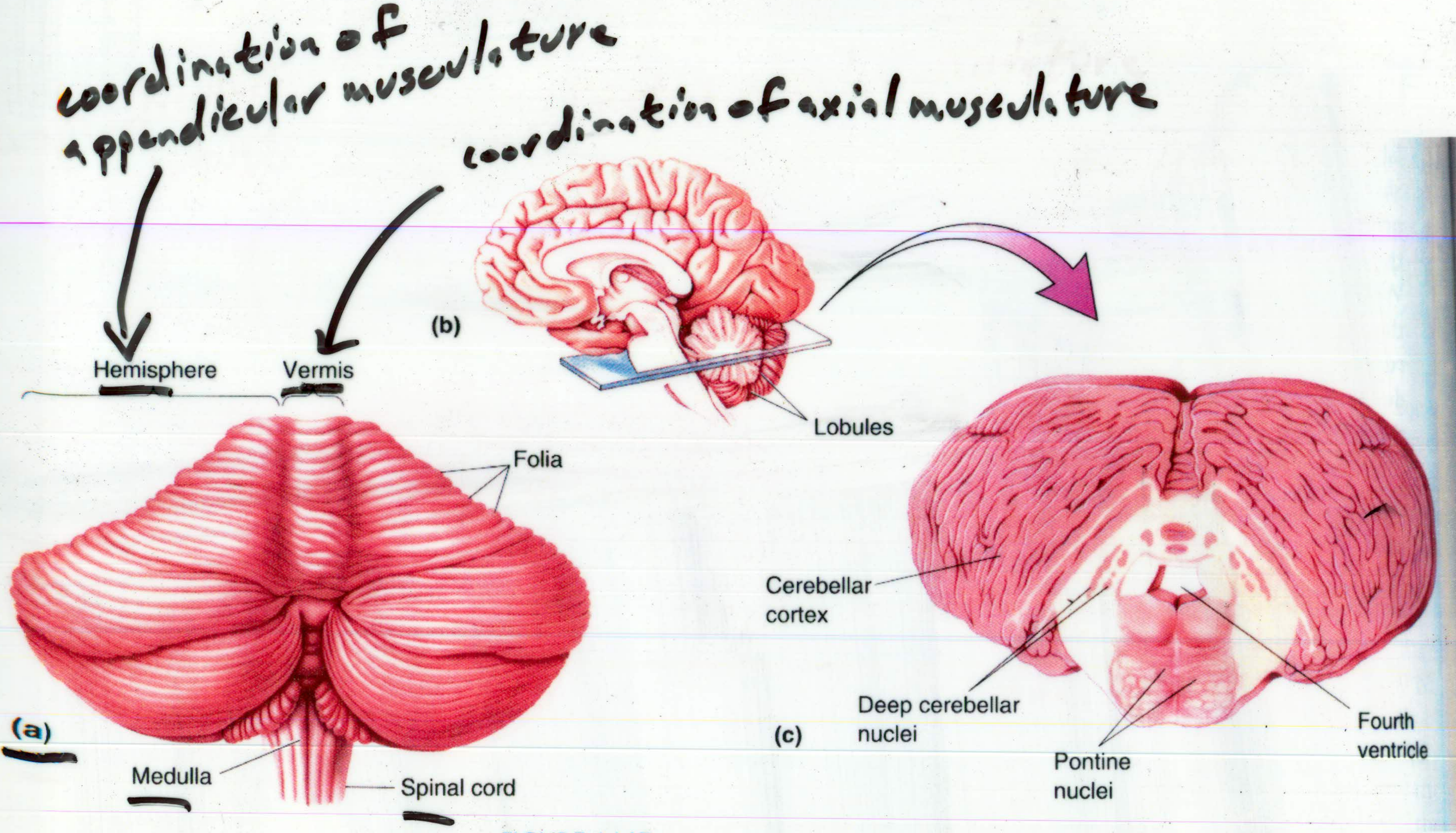
Hypokinesias or Akinesias - reduced or lack of movement.

Parkinson's Disease - due to death in dopaminergic neurons in the substantia nigra

Inputs from substantia nigra to other parts of the BG are mixed, but overall loss of the dopaminergic neurons of the substantia nigra is a decrease in output of the BG → results in difficulty initiating voluntary movements.

Huntington's Chorea - neurons in the striatum which are responsible for inhibiting activity in the basal ganglia die resulting in hyperkinesis or chorea

Cerebellum – timing and coordination
of muscle activation



Cerebellum is also important in learning to coordinate movements required to carry out a new motor task.

To learn a new motor task the cerebellum compares the motor commands coming from the motor cortex to the information it receives from the muscle spindles via the spinocerebellar connections.

Involuntary Actions carried out by smooth muscle of the body.

Controlled by the Autonomic Nervous System (ANS)

3 parts:

- Sympathetic subdivision - Prepares the body for action

  "Fight or Flight" subdivision

- Parasympathetic subdivision - Prepares the body for rest + digest processes

- Enteric subdivision — located in the wall of the digestive tract, regulates movement of food along digestive tract.

All three subdivisions interact in regulation of involuntary body functions.

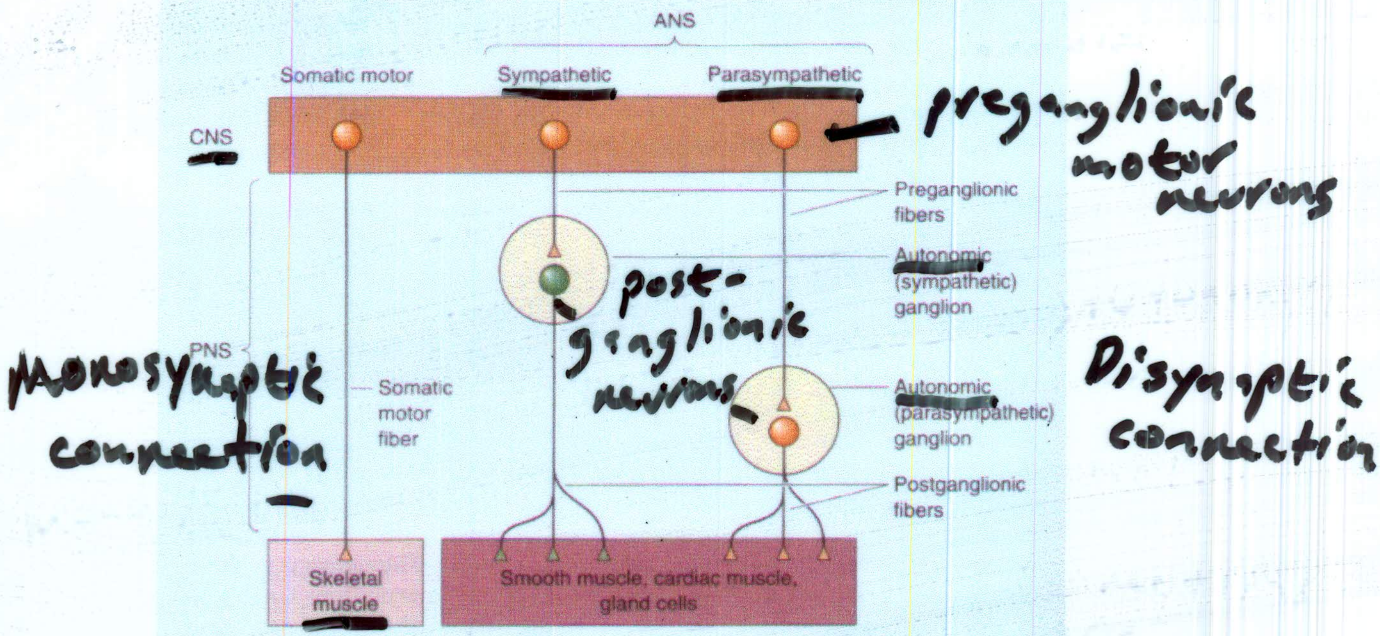


Figure 15.8
Organization of the three neural outputs of the CNS. The sole output of the somatic motor system is the lower motor neurons in the ventral horn of the spinal cord and the brain stem which Sherrington called the final common pathway for the generation of behavior. But some behaviors depend instead on the ANS, such as salivating, sweating, and genital stimulation. These visceral motor responses depend on the sympathetic and parasympathetic divisions of the ANS, whose lower motor neurons (i.e., postganglionic neurons) lie outside the CNS in autonomic ganglia.

Preganglionic neurons use ACh as their neurotransmitter that acts on nicotinic receptors on post-ganglionic neurons.

Post-ganglionic neurons of sympathetic subdivision use NE as their neurotransmitter that acts on adrenergic receptors on the target tissue.

Post-ganglionic neurons of parasymp. subdiv. use ACh as their neurotransmitter acting on muscarinic receptors on target tissue.

The main regulator of the preganglionic neurons of the ANS is the hypothalamus, specifically in the periventricular zone.

3rd ventricle

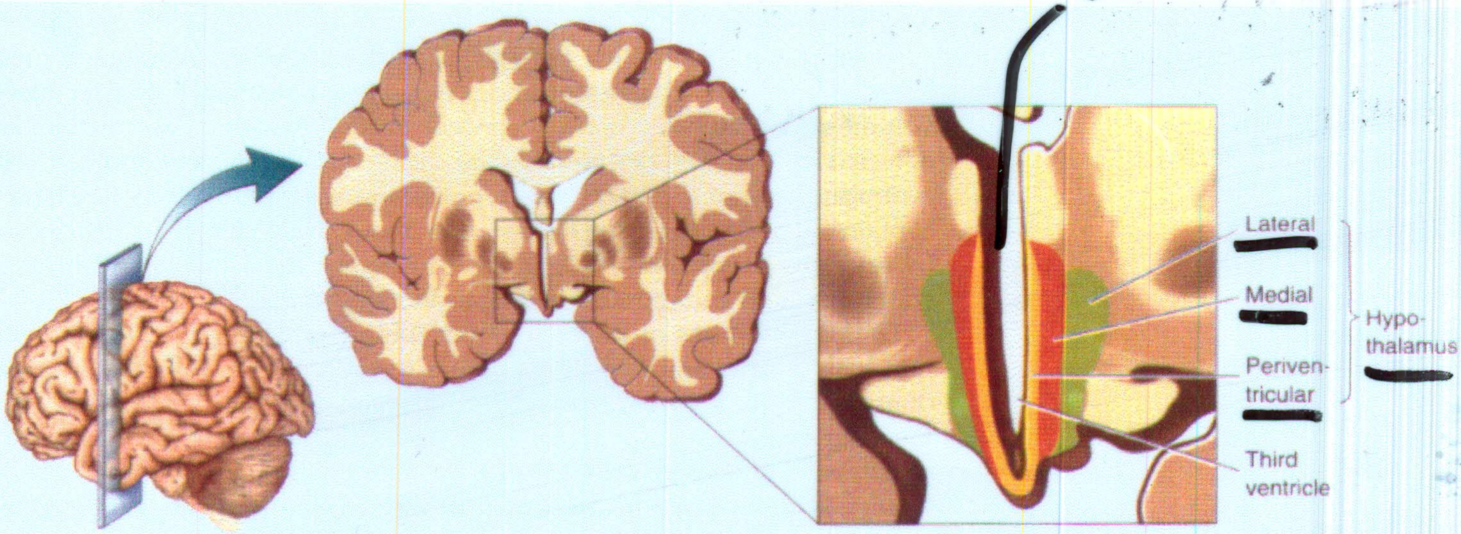


Figure 15.3

Zones of the hypothalamus. The hypothalamus is usually divided into three zones: lateral, medial, and periventricular. The periventricular zone receives inputs from the other zones, the brain stem, and the telencephalon. Neurosecretory cells in the periventricular zone secrete hormones into the bloodstream. Other periventricular cells control the autonomic nervous system.

Medial hypothalamus mediates affective aggression — posturing + threatening, but not physically attacking.

Lateral zone mediates predatory aggression — physically attacking and/or killing an "object".

Diffuse modulatory systems have diffuse, widely dispersed connections in the CNS.

Serve to modulate the activity levels of the neurons in the CNS.

These diffuse modulatory systems share 5 common features:

- They arise from a small set of nuclei in the brainstem + have wide connections in the CNS
- They release neurotransmitter into the extracellular fluid of the CNS rather than synapsing on specific neurons.
- Activate metabotropic receptors on neurons.

— They act on the CNS to modulate the overall activity level of neurons

— Alterations in the activity levels in these systems affect mood, and sleep/wake cycles.

Cocaine + amphetamines act on the dopaminergic and noradrenergic diffuse modulatory systems.

Both these systems increase the state of arousal, and these drugs act to stimulate these systems.

Depression is thought to be the result of decreased neurotransmitter release in the serotonergic and/or noradrenergic diffuse modulatory systems.

Prozac – acts by blocking the re-uptake of serotonin and norepinephrine in the brain

Limbic system – parts of the brain associated with emotions

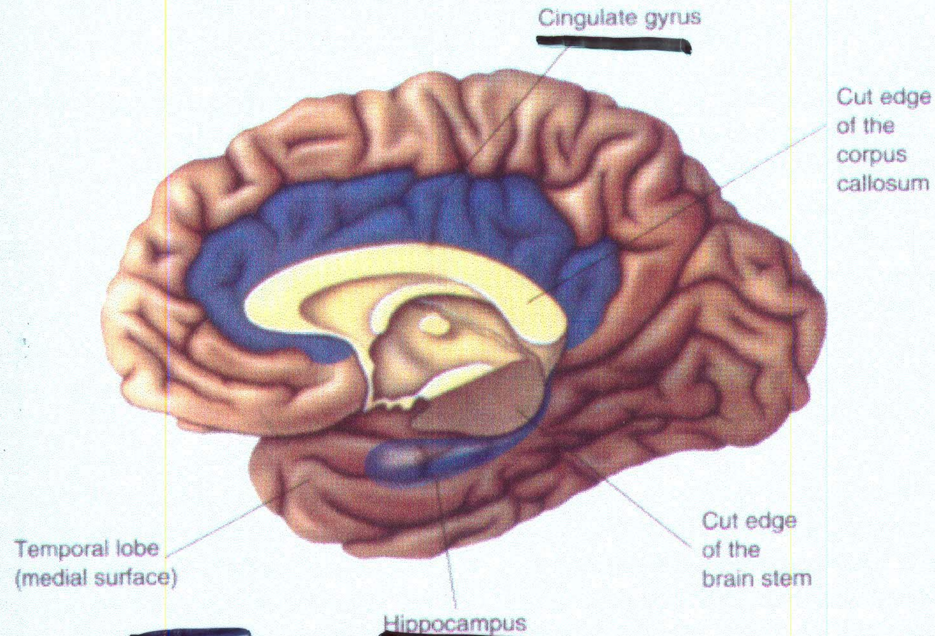


Figure [redacted]
The limbic lobe. Broca defined the limbic lobe as those structures that form a ring around the brain stem and corpus callosum on the medial walls of the brain. The brain stem has been removed in the figure so that the medial surface of the temporal lobe is visible.

1930's Papez noted that lesions involving Broca's limbic lobe resulted in emotional disturbances.

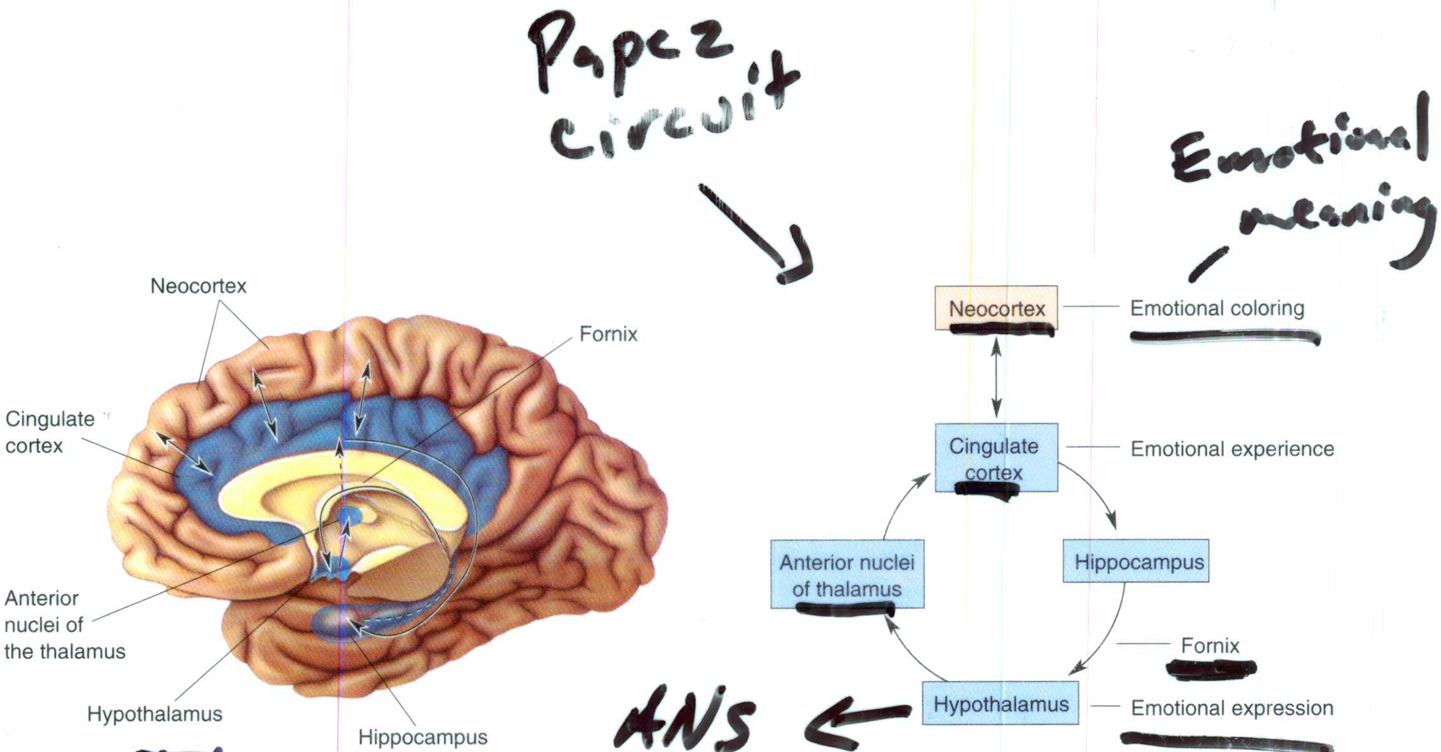


Figure [redacted]
The Papez circuit. Papez believed that the experience of emotion was determined by activity in cingulate cortex and, less directly, other cortical areas. Emotional expression was thought to be governed by the hypothalamus. The cingulate cortex projects to the hippocampus, and the hippocampus projects to the hypothalamus by way of the bundle of axons called the fornix. Hypothalamic effects reach the cortex via a relay in the anterior thalamic nuclei.

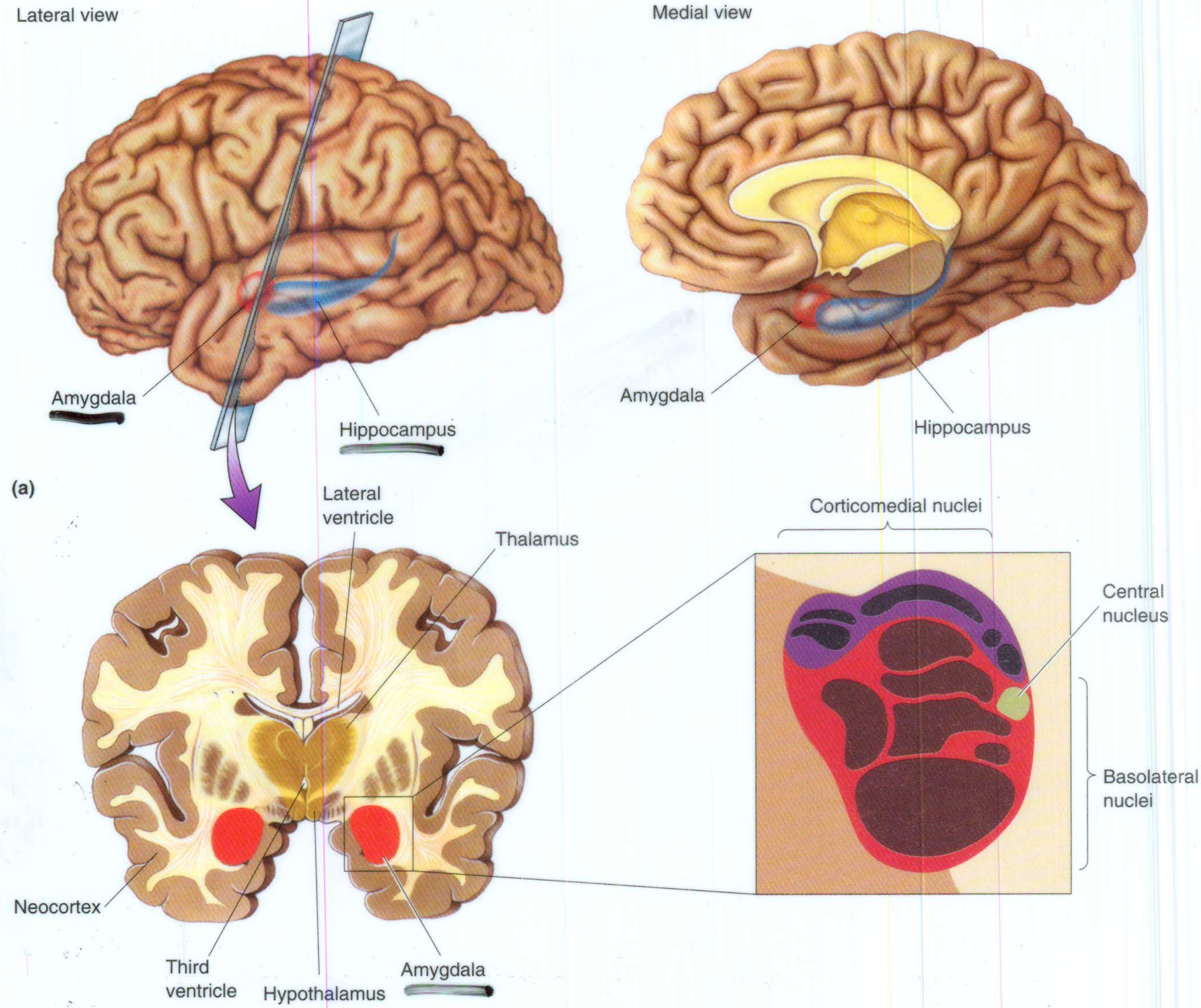


Figure [redacted]
Cross section of the amygdala. (a) Lateral and medial views of the temporal lobe showing the location of the amygdala in relation to the hippocampus. **(b)** The brain is sectioned coronally to show the amygdala. The basolateral nuclei (red) receive visual, auditory, gustatory, and tactile afferents. The corticomedial nuclei (purple) receive olfactory afferents.

The nuclei of the amygdala receive inputs from all the sensory systems which are relayed from the sensory cortices of the cerebral hemispheres.

Primary output of the amygdala is to the hypothalamus.

Bilateral ablation of the amygdala results in decreased agressive behavior, and decreased expression of fear and anxiety.

Amygdala is also involved in "learned fear".

You can train a monkey to respond to a stimulus with fear by presenting the stimulus and giving an electric shock. Eventually they respond to the stimulus with fear without the electric shock.

Bilateral ablation of the amygdala removes the learned fear response.

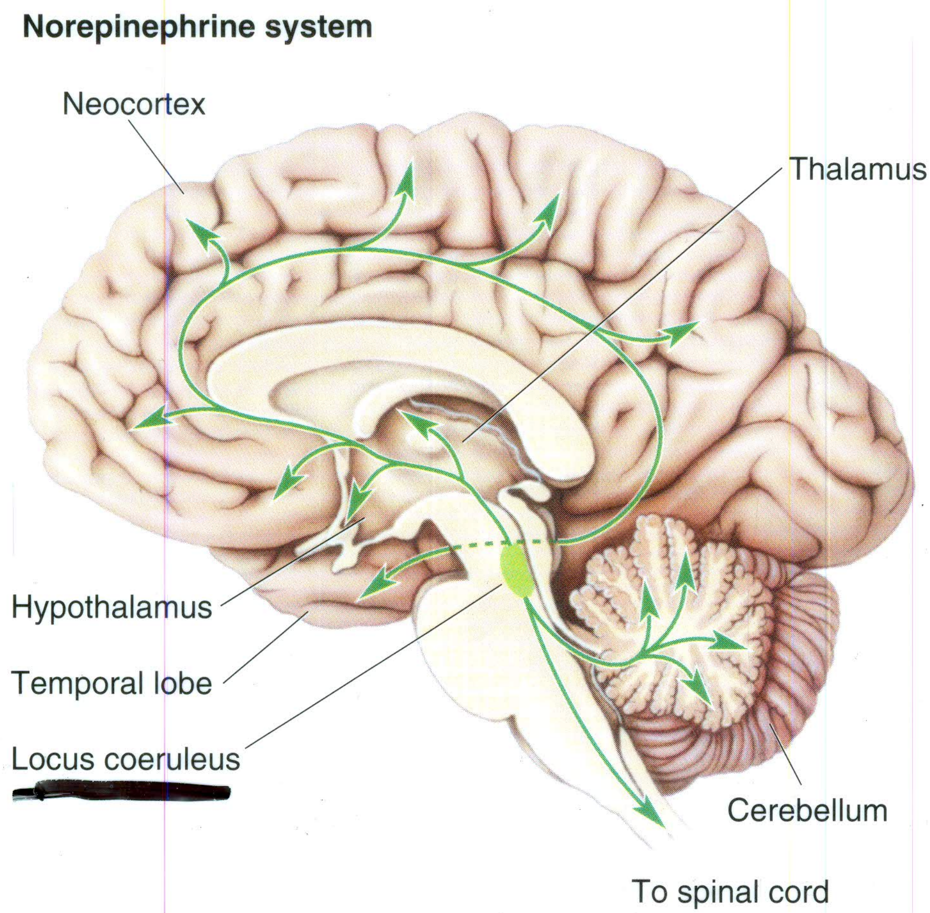


Figure 15.11
The noradrenergic diffuse modulatory system arising from the locus coeruleus. The small cluster of locus coeruleus neurons project axons that innervate vast areas of the CNS, including the spinal cord, cerebellum, thalamus, and cerebral cortex.

Dopamine system

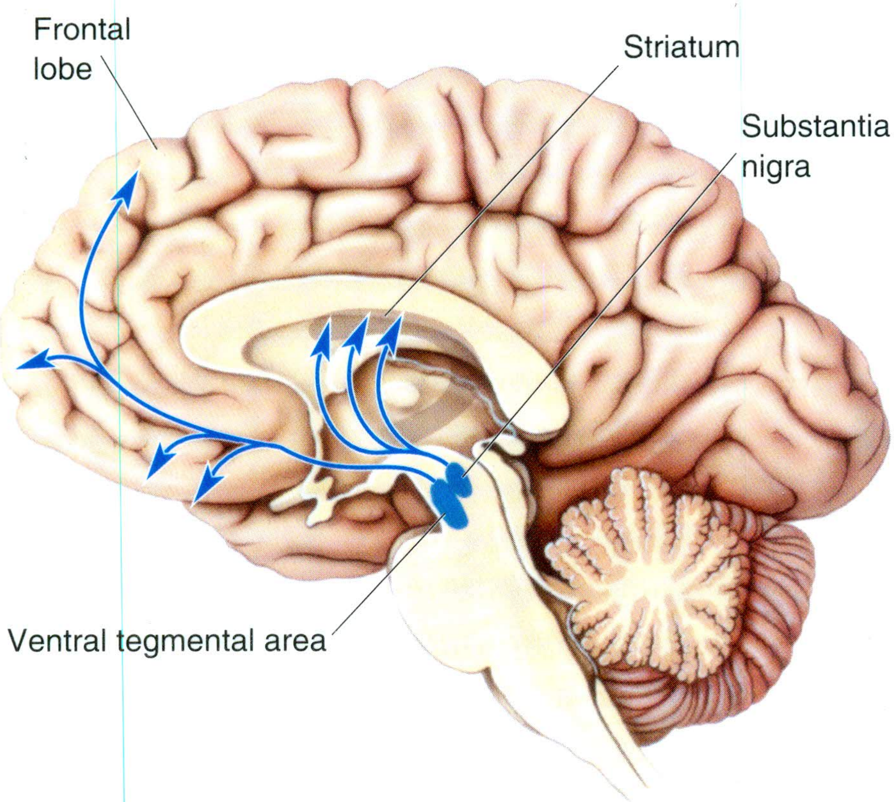


Figure 15.13
The dopaminergic diffuse modulatory systems arising from the substantia nigra and the ventral tegmental area. The substantia nigra and ventral tegmental area lie close together in the midbrain. They project to the striatum (caudate nucleus and putamen) and limbic and frontal cortical regions, respectively.

Acetylcholine system

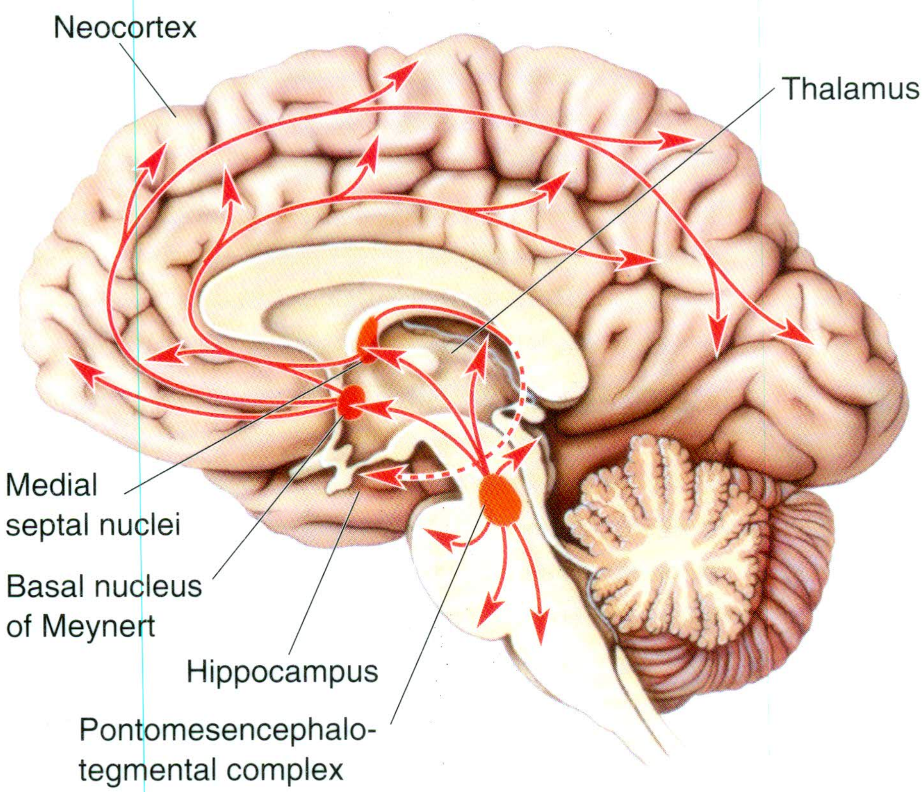


Figure 15.14
The cholinergic diffuse modulatory systems arising from the basal forebrain and brainstem. The medial septal nuclei and basal nucleus of Meynert project widely upon the cerebral cortex, including the hippocampus. The pontomesencephalo-tegmental complex projects to the thalamus and parts of the forebrain.

Serotonin system

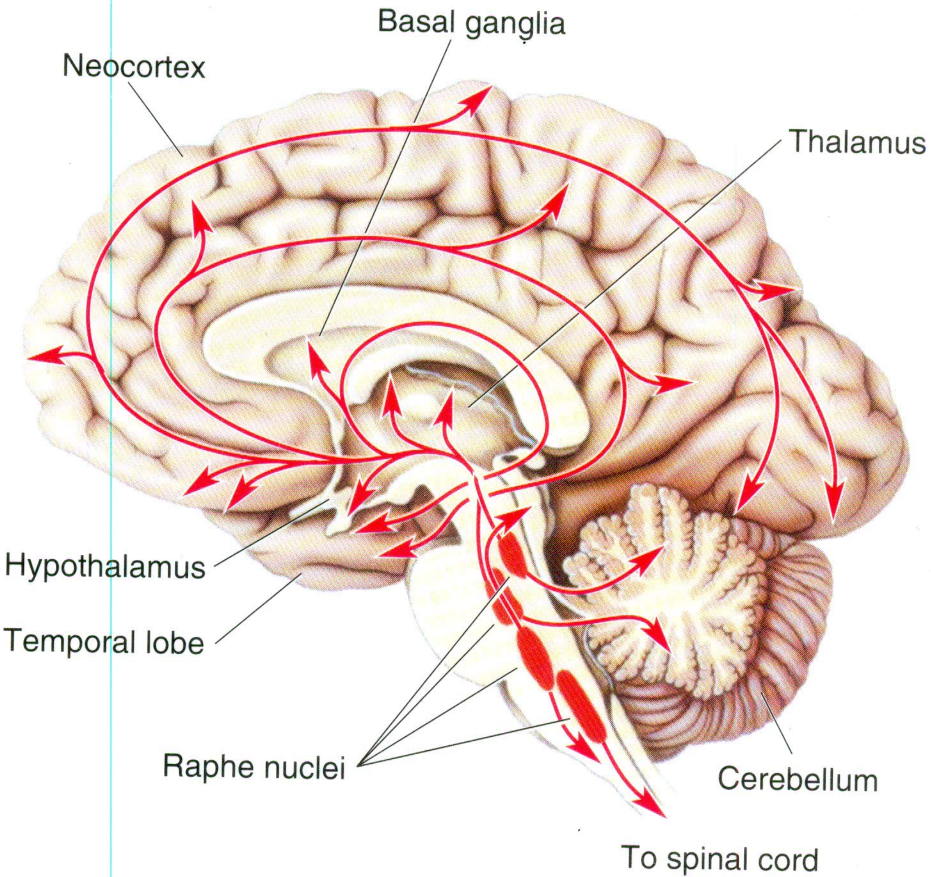


Figure 15.12
The serotonergic diffuse modulatory systems arising from the raphe nuclei. The raphe nuclei are clustered along the midline of the brain stem and project extensively to all levels of the CNS.