Chapter 13

Part 2

Integrative Physiology I: Control of Body Movement

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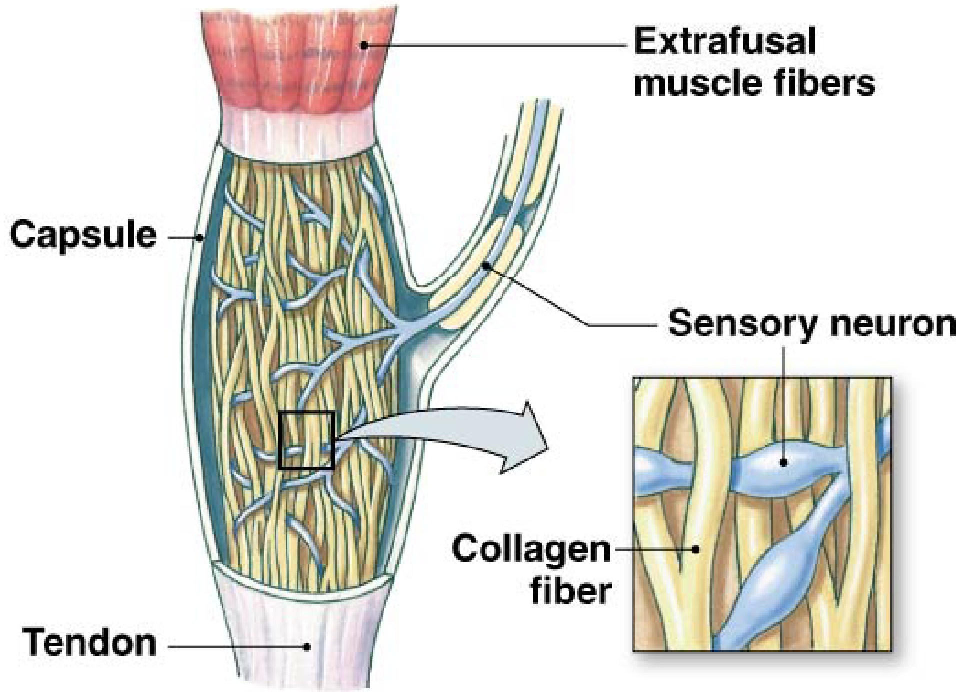
HUMAN PHYSIOLOGY

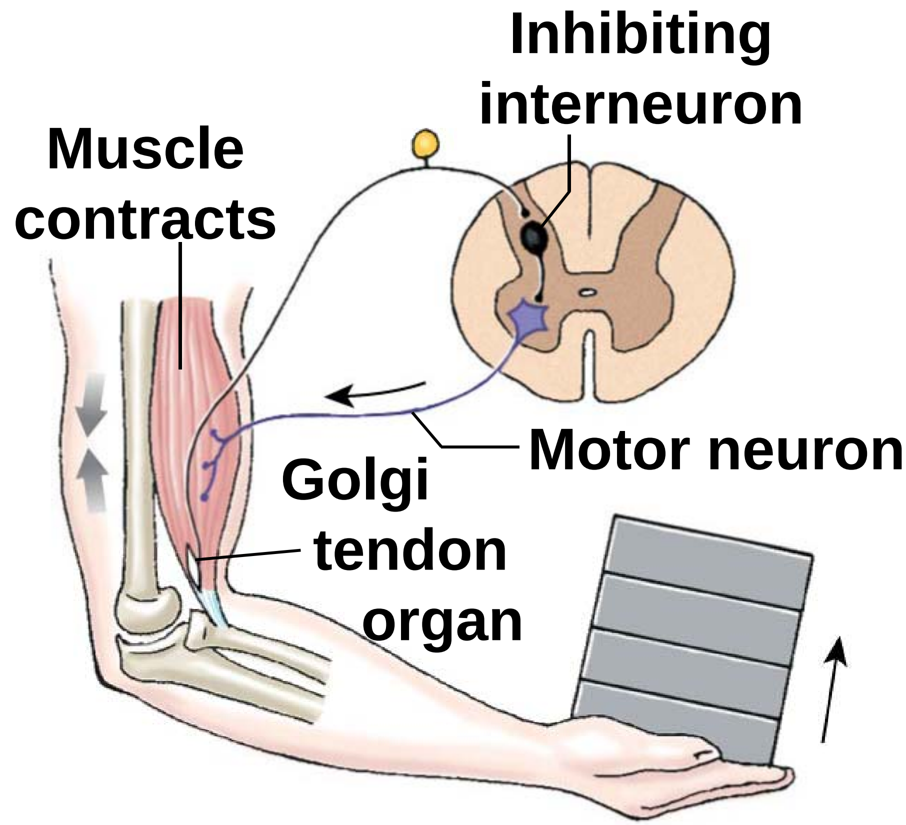
AN INTEGRATED APPROACH • 6E

Figure 13.2b (2 of 2)

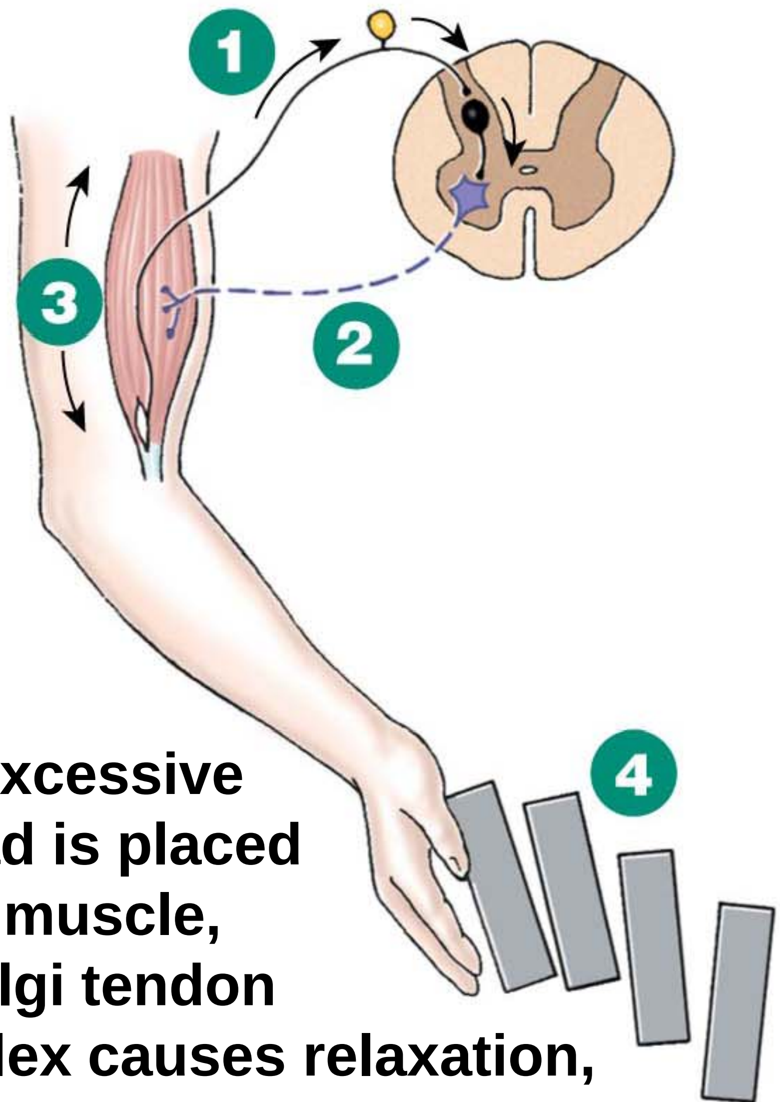
(b) Golgi tendon organ consists of sensory nerve endings interwoven among collagen fibers.



http://www.ualberta.ca/~aprochaz/research_interactive_receptor_model.html



(d) Muscle contraction stretches Golgi tendon organ.



(e) If excessive load is placed on muscle, Golgi tendon reflex causes relaxation, thus protecting muscle.

1. Neuron from Golgi tendon organ fires.
2. Motor neuron is inhibited.
3. Muscle relaxes.
4. Load is dropped.

Figure 13.6

THE PATELLAR TENDON (KNEE JERK) REFLEX

The patellar tendon (knee jerk) reflex illustrates a monosynaptic stretch reflex and reciprocal inhibition of the antagonistic muscle.

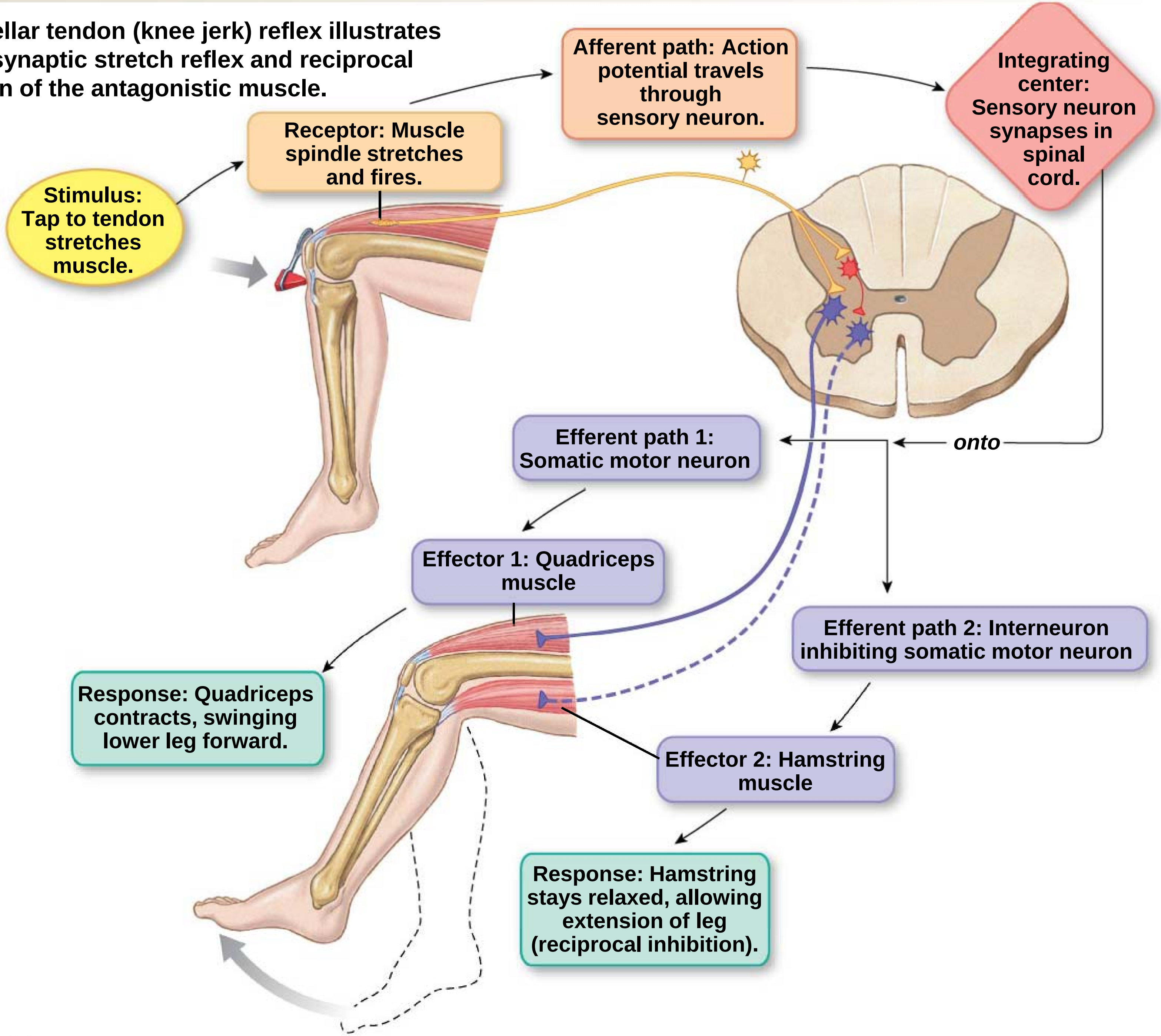
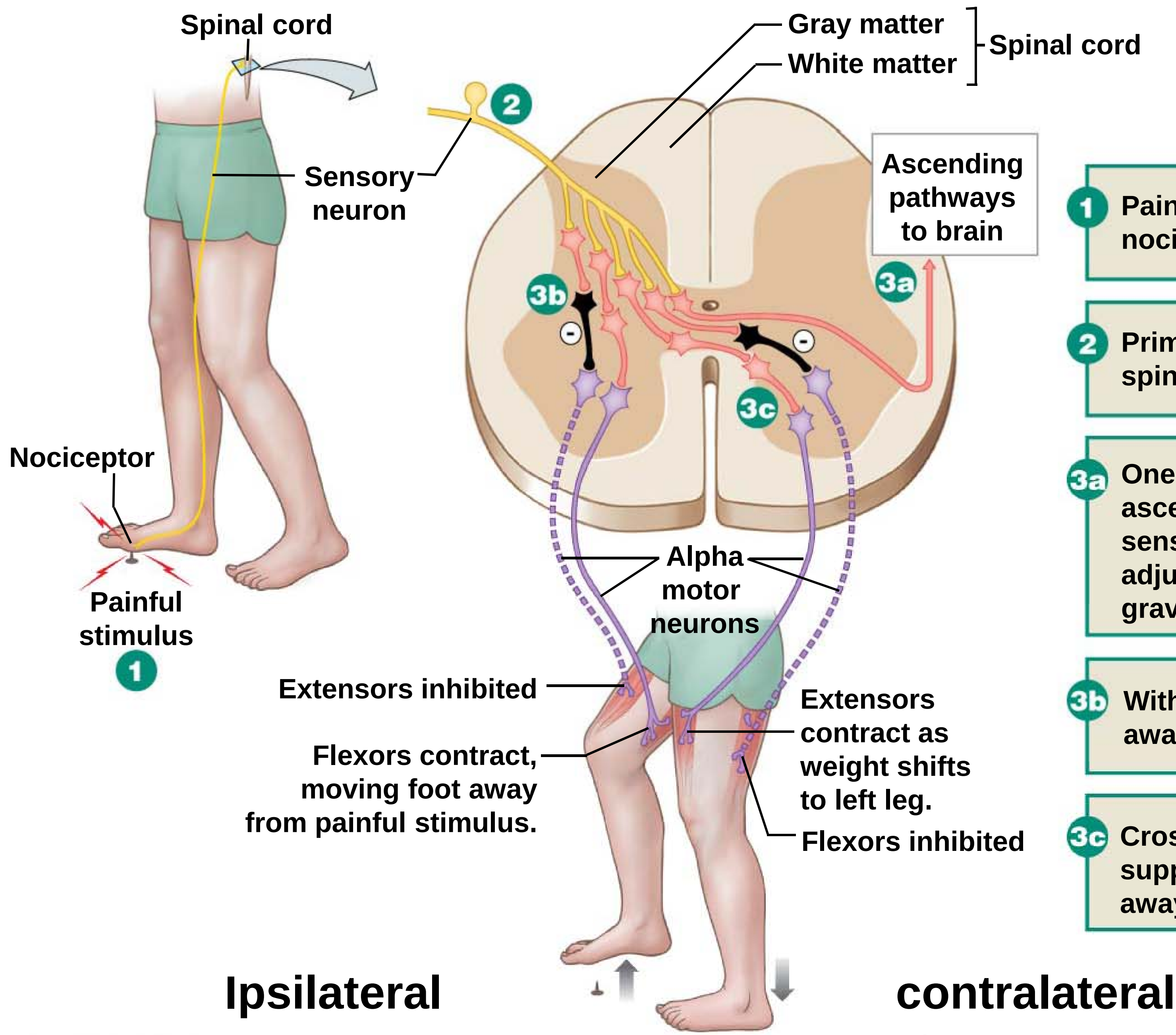


Figure 13.7

The FLEXION WITHDRAWAL REFLEX and the CROSSED EXTENSOR REFLEX

A flexion reflex in one limb causes extension in the opposite limb. The coordination of reflexes with postural adjustments is essential for maintaining balance.



1 Painful stimulus activates nociceptor.

2 Primary sensory neuron enters spinal cord and diverges.

3a One collateral activates ascending pathways for sensation (pain) and postural adjustment (shift in center of gravity).

3b Withdrawal reflex pulls foot away from painful stimulus.

3c Crossed extensor reflex supports body as weight shifts away from painful stimulus.

Table 13.2 Types of Movement

Types of Movement

Table 13.2

	Reflex	Voluntary	Rhythmic
Stimulus that initiates movement	Primarily external via sensory receptors; minimally voluntary	External stimuli or at will	Initiation and termination voluntary
Example	Knee jerk, cough, postural reflexes	Playing piano	Walking, running
Complexity	Least complex; integrated at level of spinal cord or brain stem with higher center modulation	Most complex; integrated in cerebral cortex	Intermediate complexity; integrated in spinal cord with higher center input required
Comments	Inherent, rapid	Learned movements that improve with practice; once learned, may become subconscious ("muscle memory")	Spinal circuits act as pattern generators; activation of these pathways requires input from brain stem

Table 13.3 Neural Control of Movement

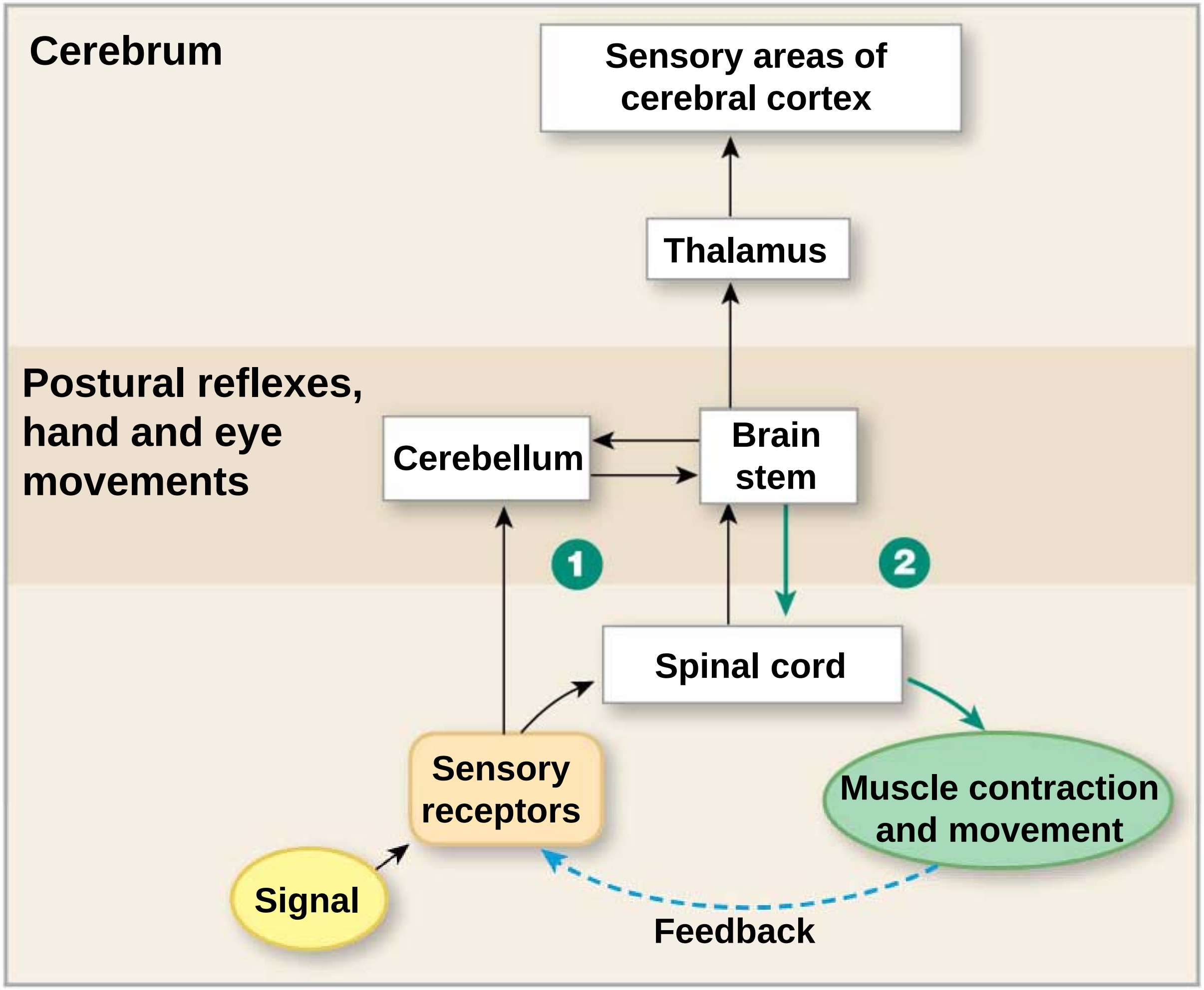
Neural Control of Movement

Table 13.3

Location	Role	Receives Input from:	Sends Integrative Output to:
Spinal cord	Spinal reflexes; locomotor pattern generators	Sensory receptors and brain	Brain stem, cerebellum, thalamus/cerebral cortex
Brain stem	Posture, hand and eye movements	Cerebellum, visual and vestibular sensory receptors	Spinal cord
Motor areas of cerebral cortex	Planning and coordinating complex movement	Thalamus	Brain stem, spinal cord (corticospinal tract), cerebellum, basal ganglia
Cerebellum	Monitors output signals from motor areas and adjusts movements	Spinal cord (sensory), cerebral cortex (commands)	Brain stem, cerebral cortex (Note: All output is inhibitory.)
Thalamus	Contains relay nuclei that modulate and pass messages to cerebral cortex	Basal ganglia, cerebellum, spinal cord	Cerebral cortex
Basal nuclei	Motor planning	Cerebral cortex	Cerebral cortex, brain stem

Figure 13.8

INTEGRATION OF MUSCLE REFLEXES



1 Sensory input (⟶) from receptors goes to spinal cord, cerebral cortex, and cerebellum. Signals from the vestibular apparatus go directly to the cerebellum.

2 Postural and spinal reflexes do not require integration in the cortex. Output signals (⟶) initiate movement without higher input.

Figure 13.9

PHASES OF VOLUNTARY MOVEMENT

Voluntary movements can be divided into three phases: planning, initiation, and execution. Sensory feedback allows the brain to correct for any deviation between the planned movement and the actual movement.

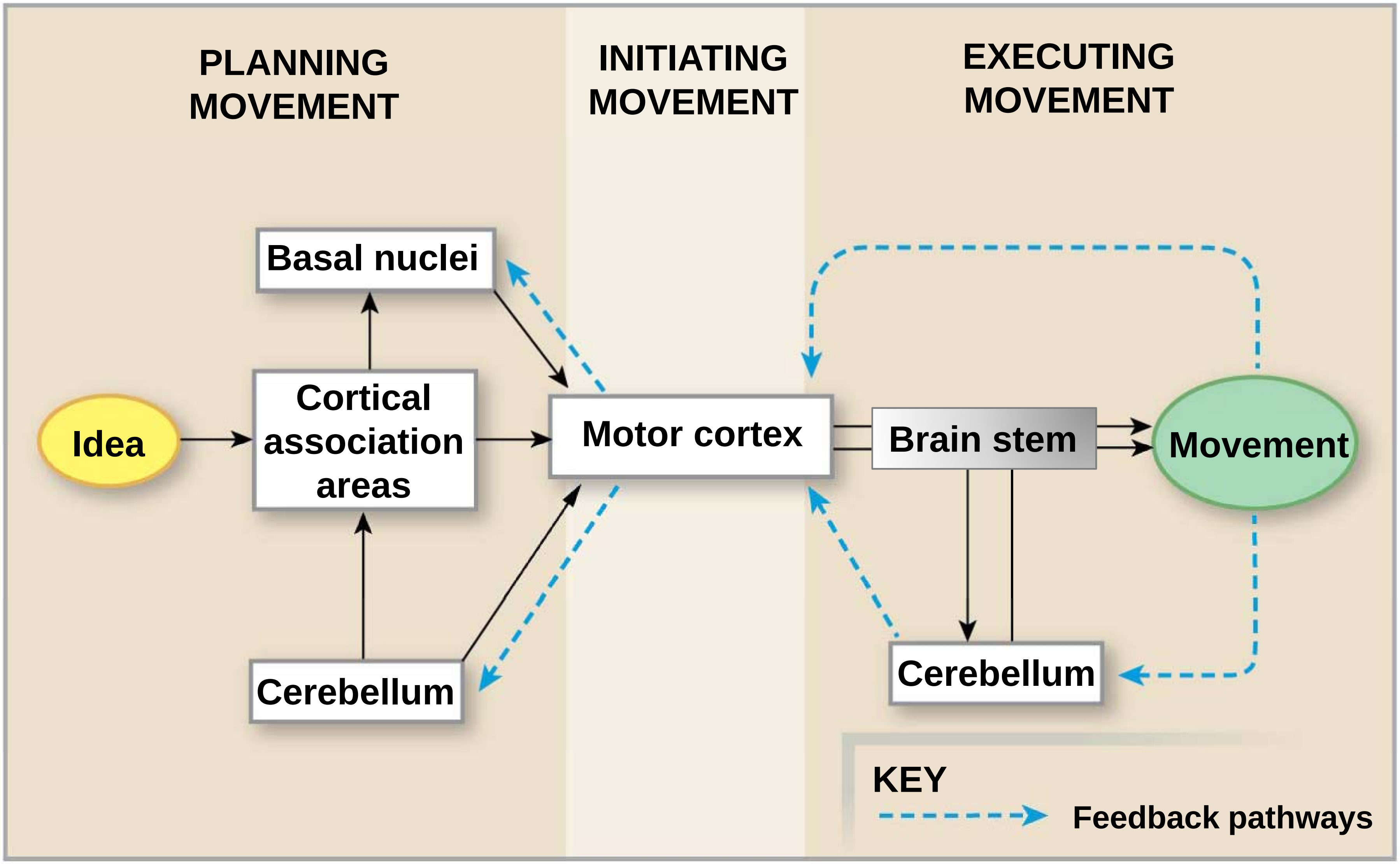
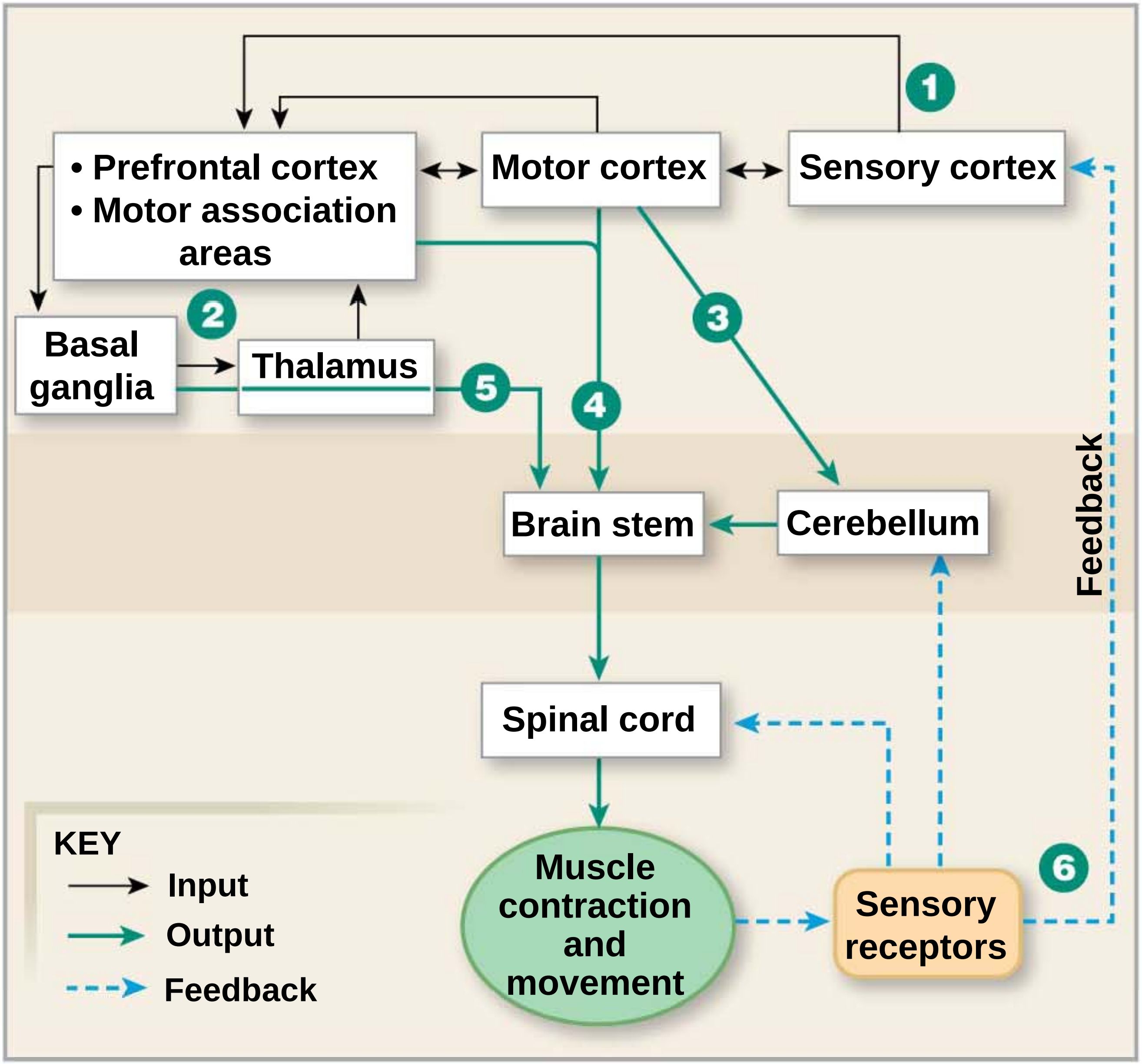


Figure 13.10

CONTROL OF VOLUNTARY MOVEMENTS



1 Sensory input

2 Planning and decision-making

3 Coordination and timing: cerebellar input

4 Execution: corticospinal tract to skeletal muscles

5 Execution: extrapyramidal influence on posture, balance, and gait

6 Continuous feedback

Figure 13.11

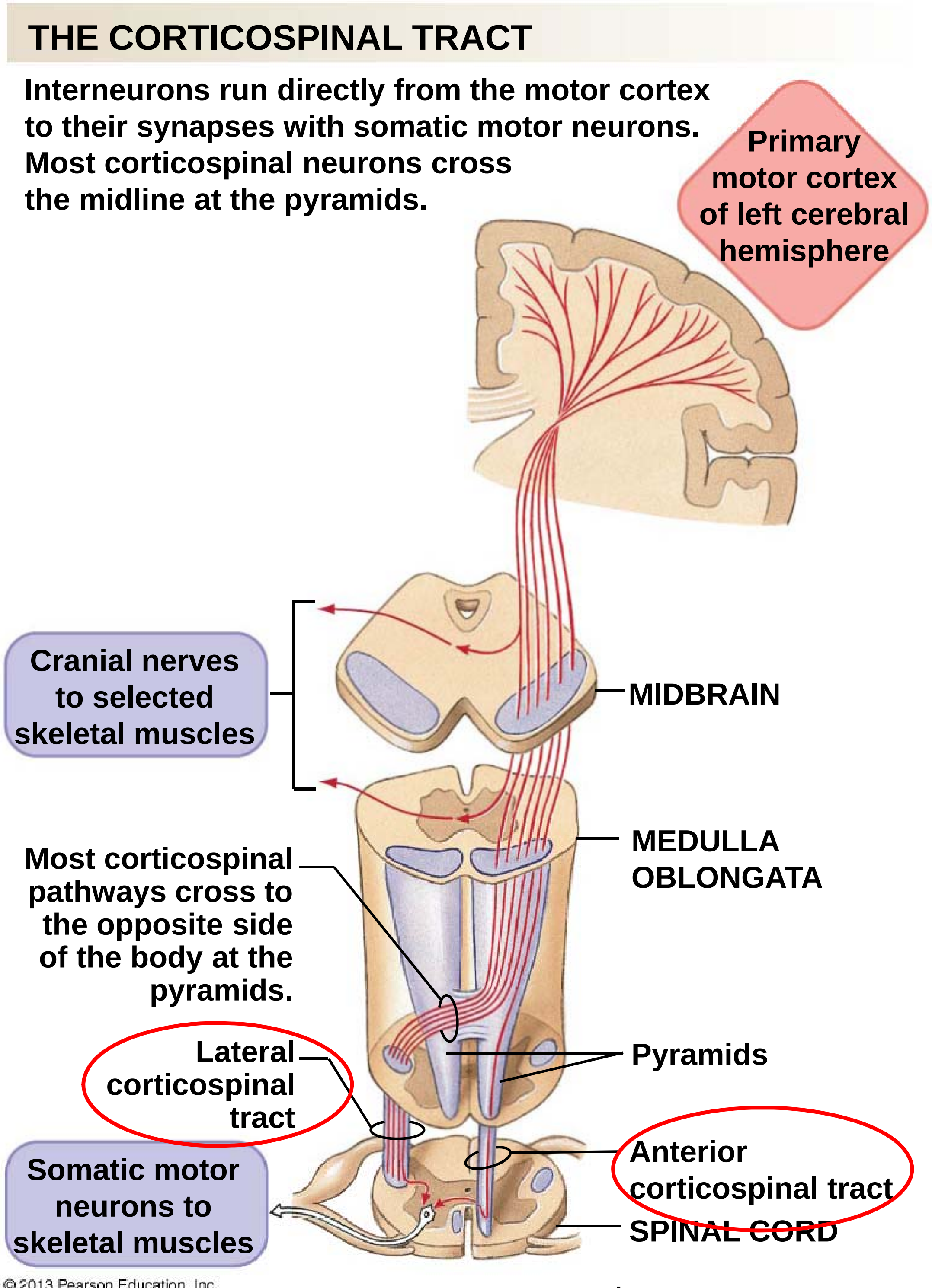

THE CORTICOSPINAL TRACT
Interneurons run directly from the motor cortex to their synapses with somatic motor neurons. Most corticospinal neurons cross the midline at the pyramids.
Primary motor cortex of left cerebral hemisphere
Cranial nerves to selected skeletal muscles
MIDBRAIN
MEDULLA OBLONGATA
Most corticospinal pathways cross to the opposite side of the body at the pyramids.
Lateral corticospinal tract
Pyramids
Anterior corticospinal tract
SPINAL CORD
Somatic motor neurons to skeletal muscles
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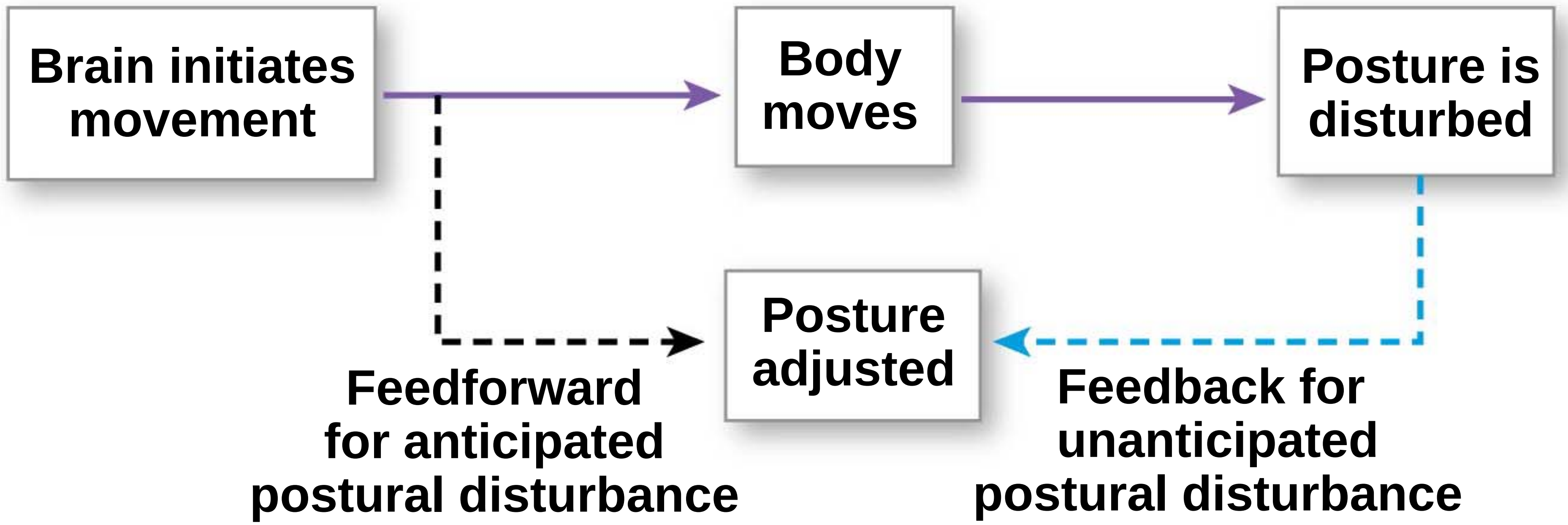
Figure 13.12

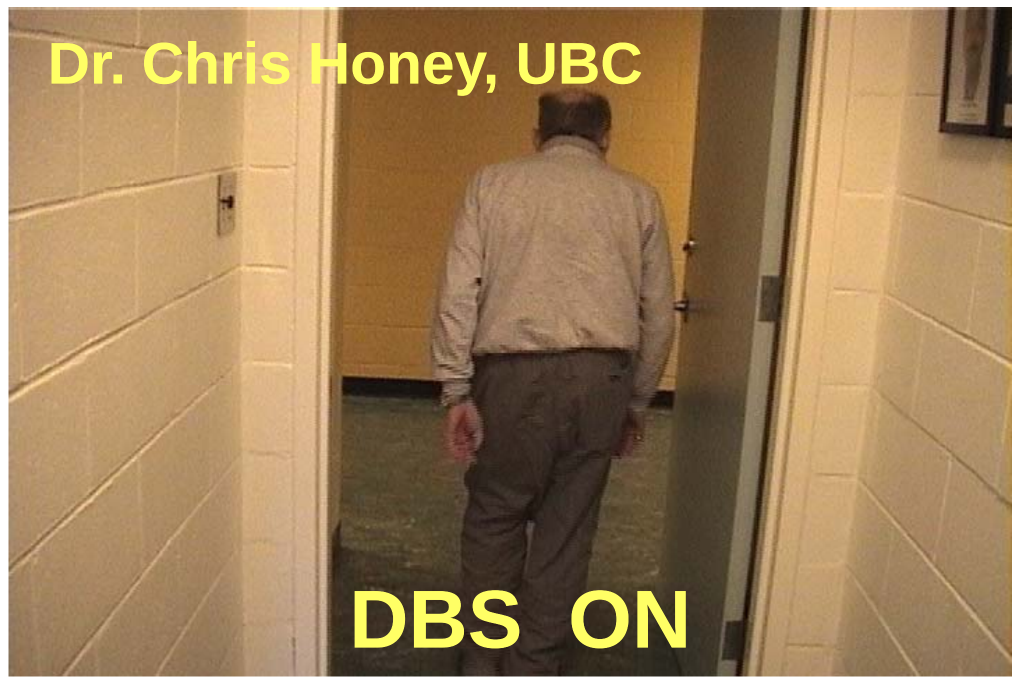
Feedforward and reflex feedback of information during movement



Can you give an example of a neuron that carries feedforward information?

Parkinson's Disease

- Progressive neurological disorder
- Characterized by difficulty to initiate movements, tremor, slow movements, speech difficulties and cognitive changes
- Loss of basal ganglia neurons that release dopamine
- Diminished extrapyramidal influence on posture, balance and gait



Summary

- Neural reflexes
- Autonomic reflexes
- Skeletal muscle reflexes
- Integrated control of body movement