

# BMD ENG 301 Quantitative Systems Physiology (Nervous System)

Somatosensation  
2022\_v1

Professor Malcolm A. MacIver

**FIGURE 9.1** Somatosensory afferents convey information from the skin surface to central circuits

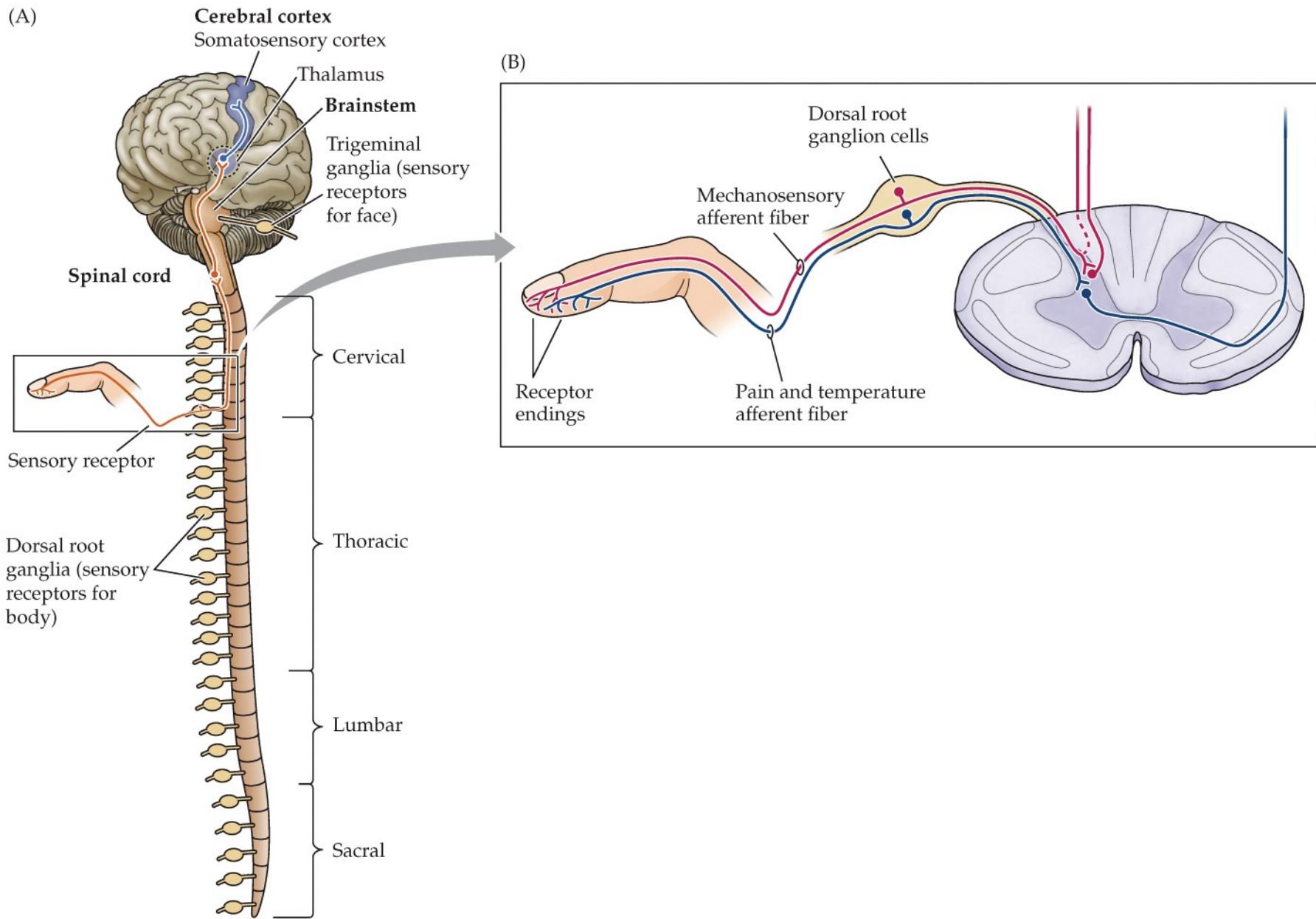


FIGURE 9.2 Transduction in a mechanosensory afferent

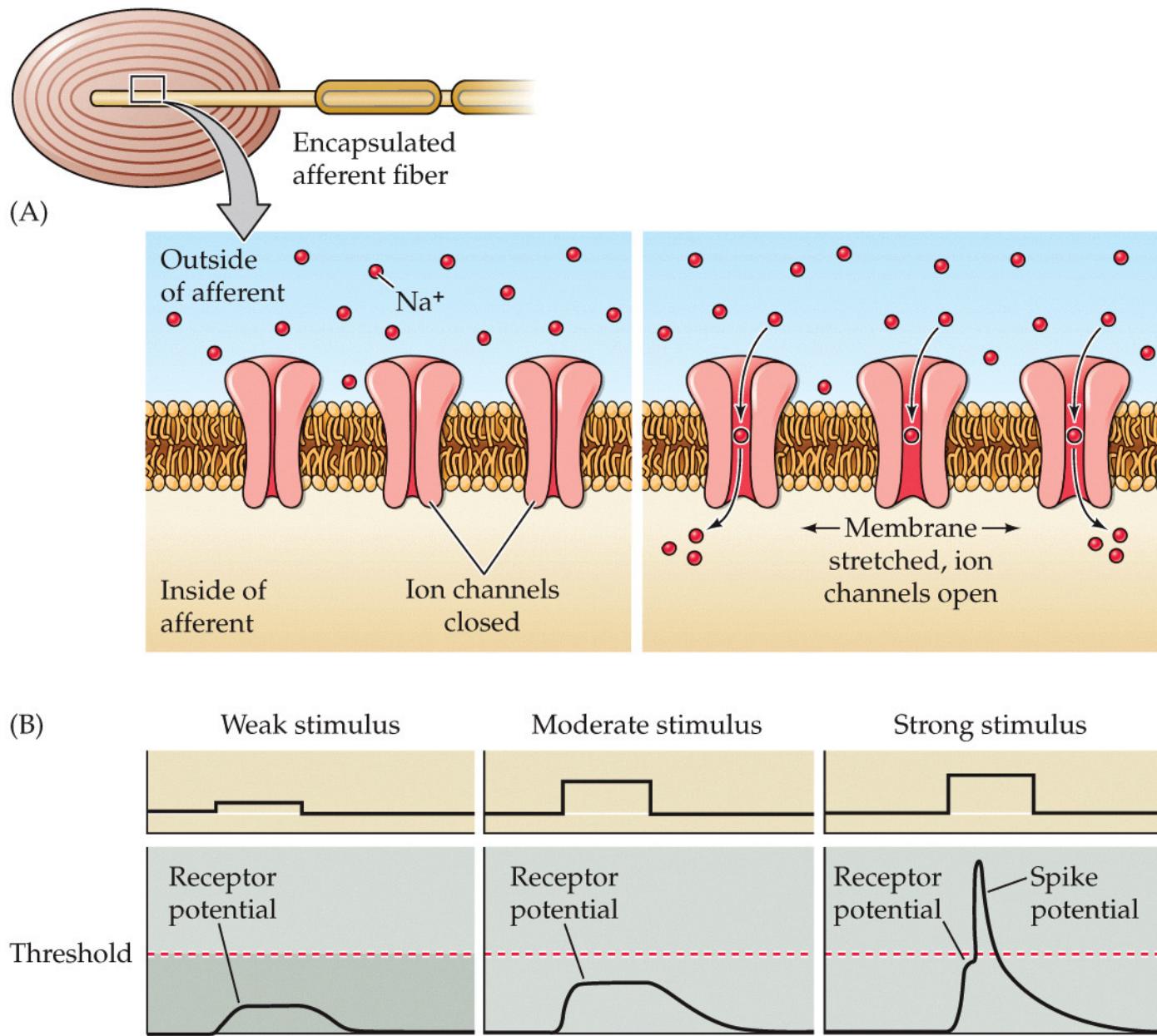


FIGURE 9.2 Transduction in a mechanosensory afferent (Part 1)

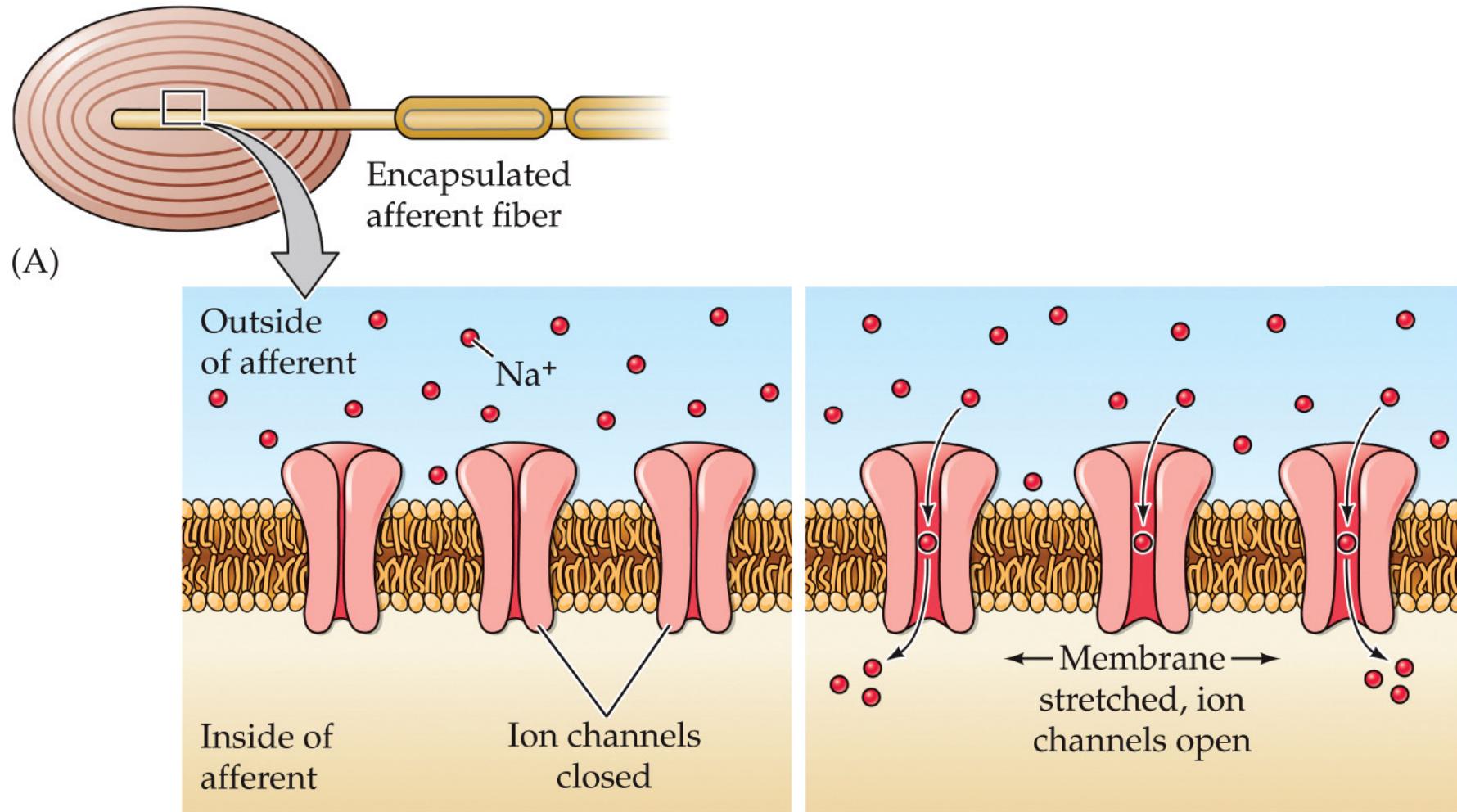
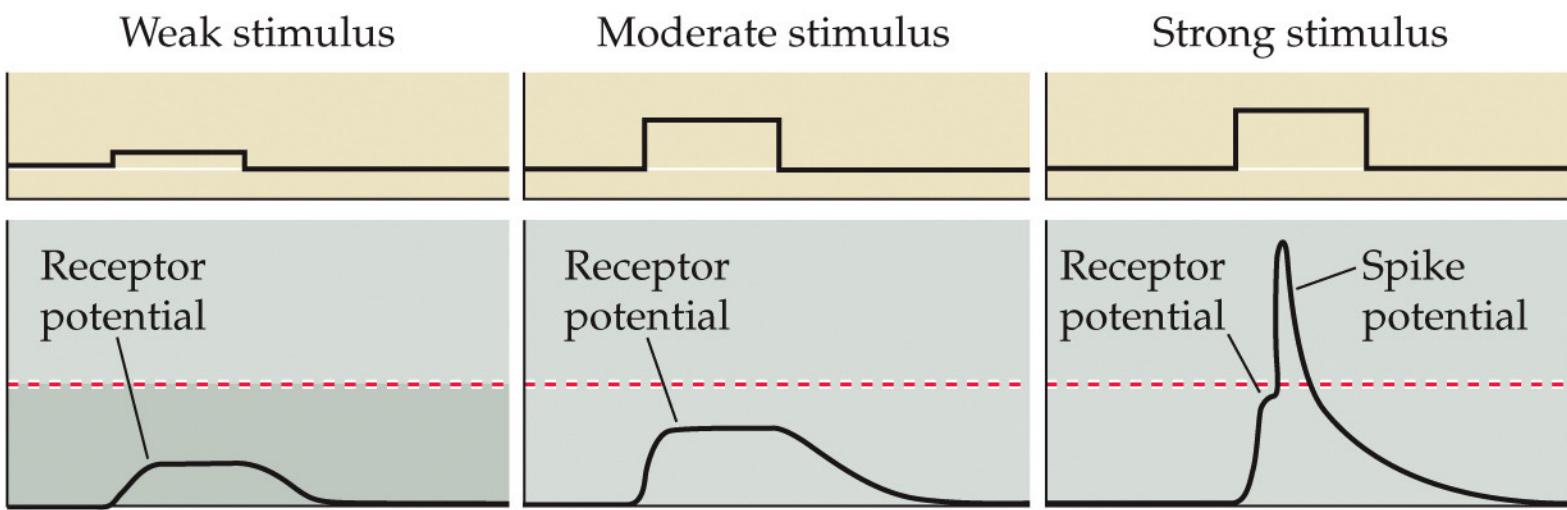


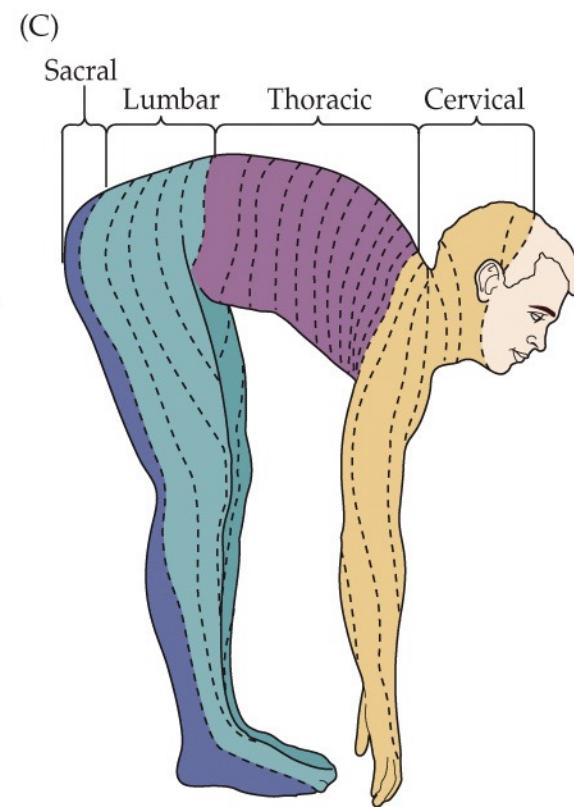
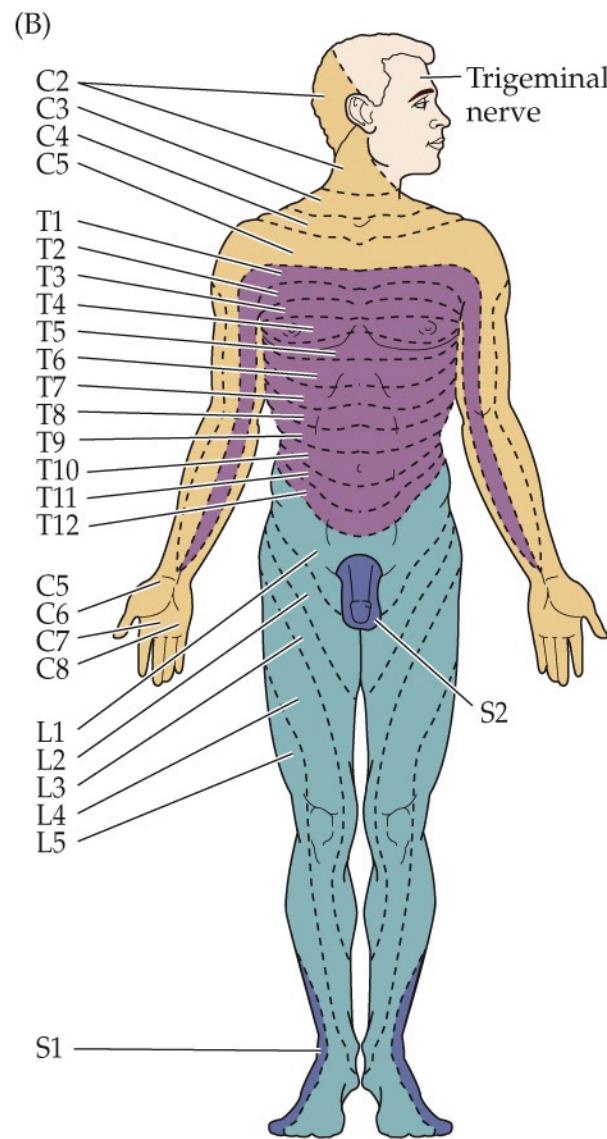
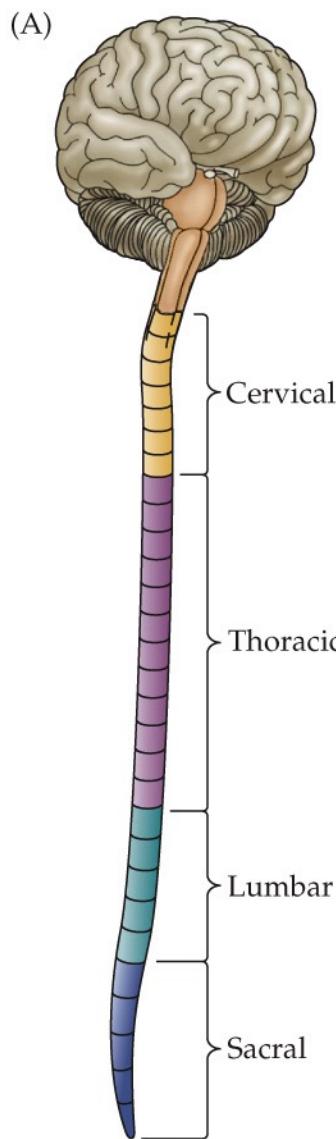
FIGURE 9.2 Transduction in a mechanosensory afferent (Part 2)

(B)



NEUROSCIENCE 6e, Figure 9.2 (Part 2)  
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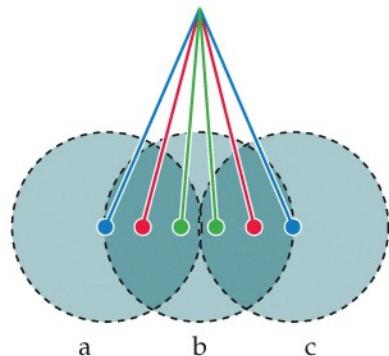
# CLINICAL APPLICATIONS Dermatomes



A after Rosenzweig et al. (2005) *Biological Psychology*, 4th Edition. Sunderland, MA: Sinauer Associates. B, C after Haymaker and Woodhall (1967) *Peripheral Nerve Injuries: Principles of Diagnosis*. Philadelphia: W. B. Saunders.

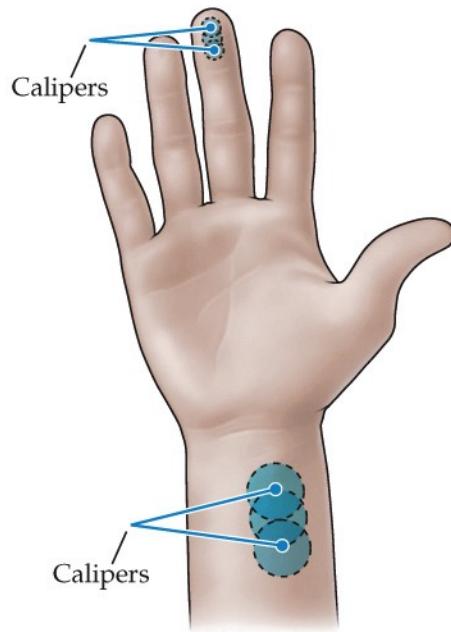
FIGURE 9.3 Receptive fields and the two-point discrimination threshold

(A)

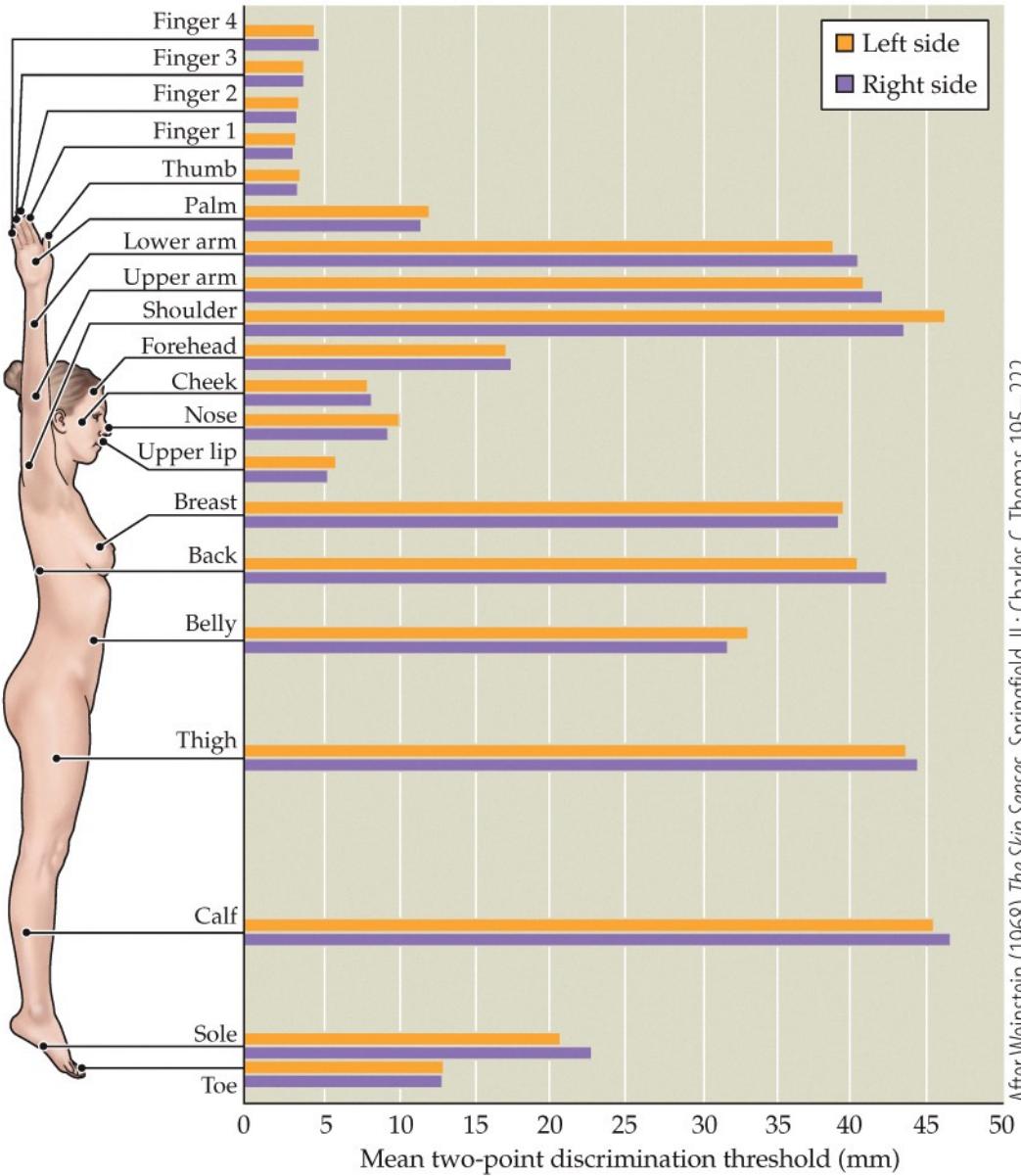


Spike rate

(B)



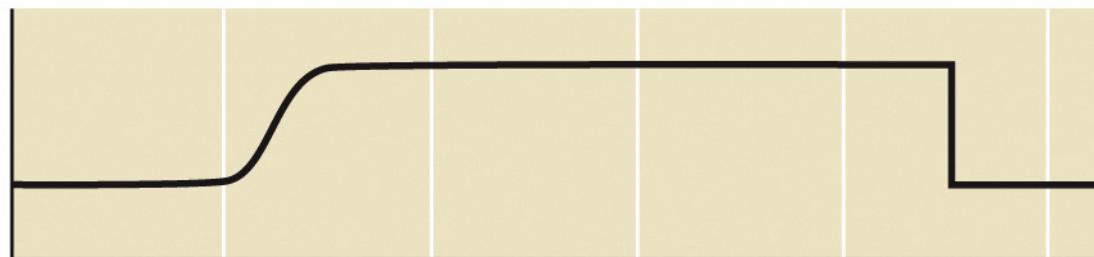
(C)



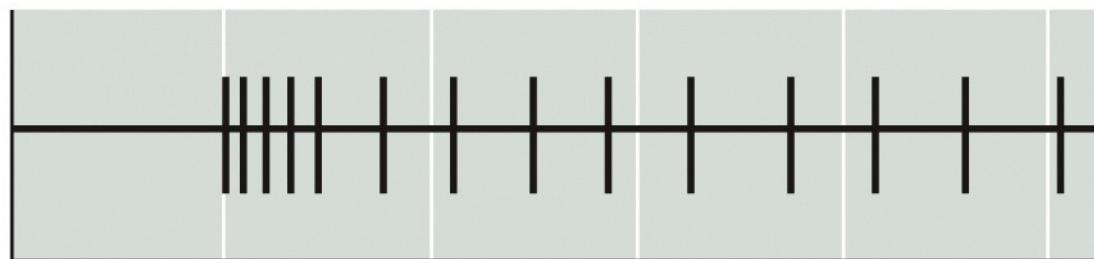
After Weinstein (1968) *The Skin Senses*. Springfield, IL: Charles C. Thomas, 195–222.

FIGURE 9.4 Slowly and rapidly adapting mechanoreceptors provide different information

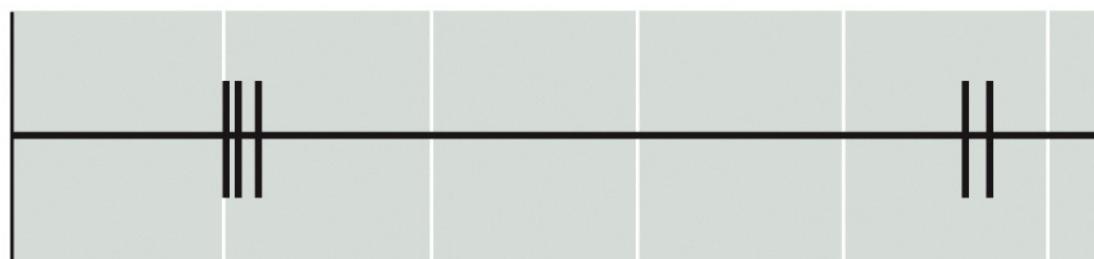
Stimulus



Slowly adapting



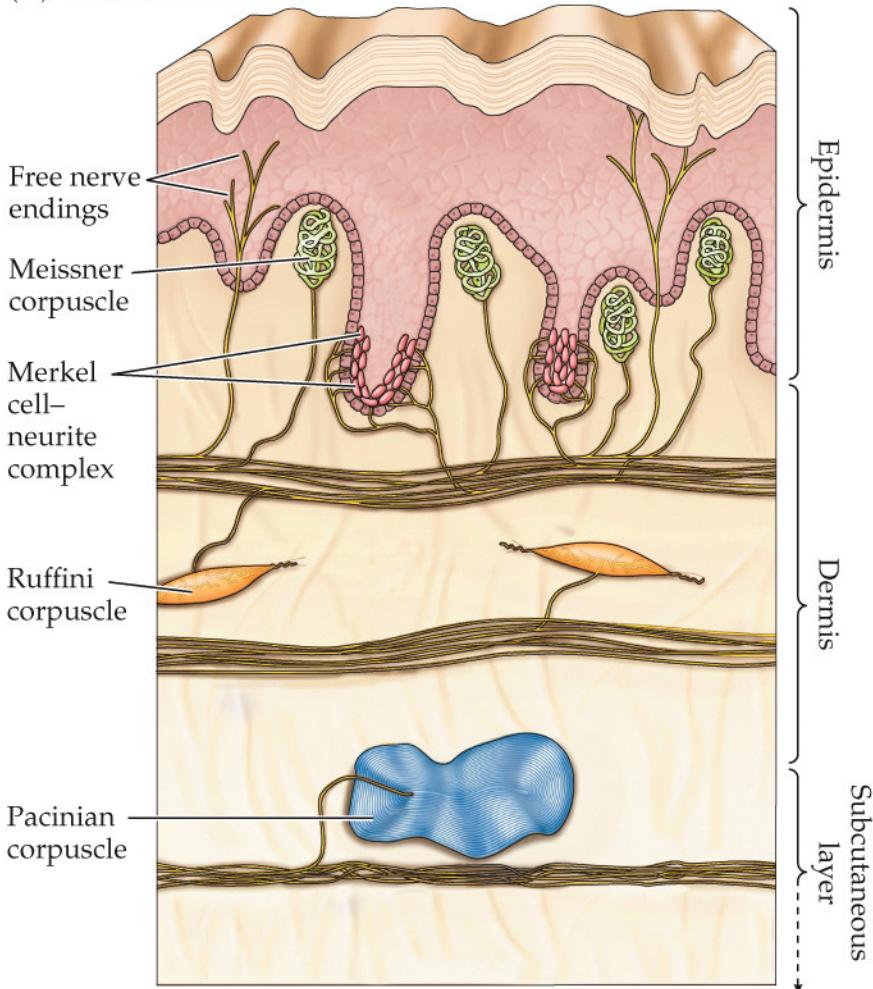
Rapidly adapting



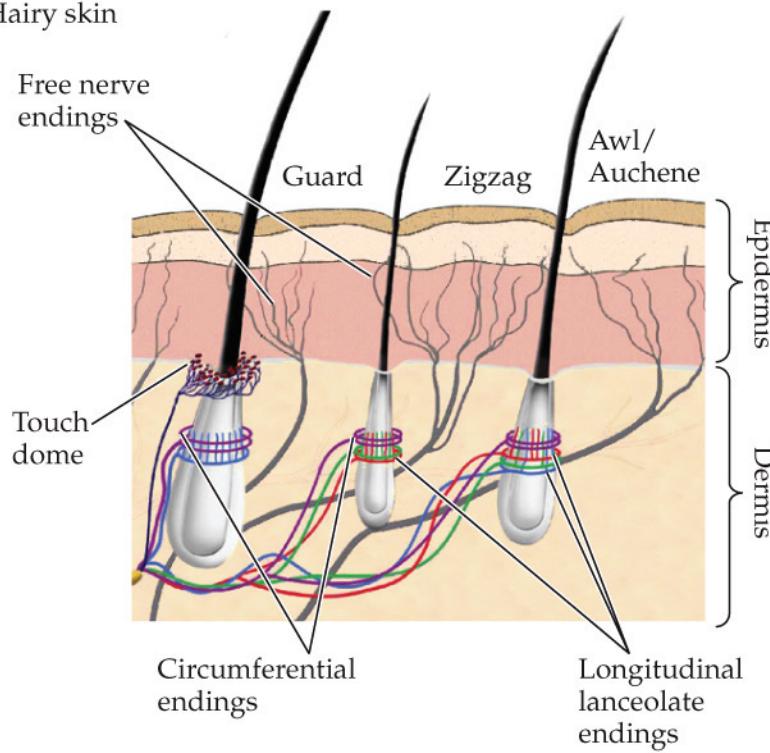
Time (s)

## FIGURE 9.5 The skin harbors a variety of morphologically distinct mechanoreceptors

(A) Glabrous skin



(B) Hairy skin

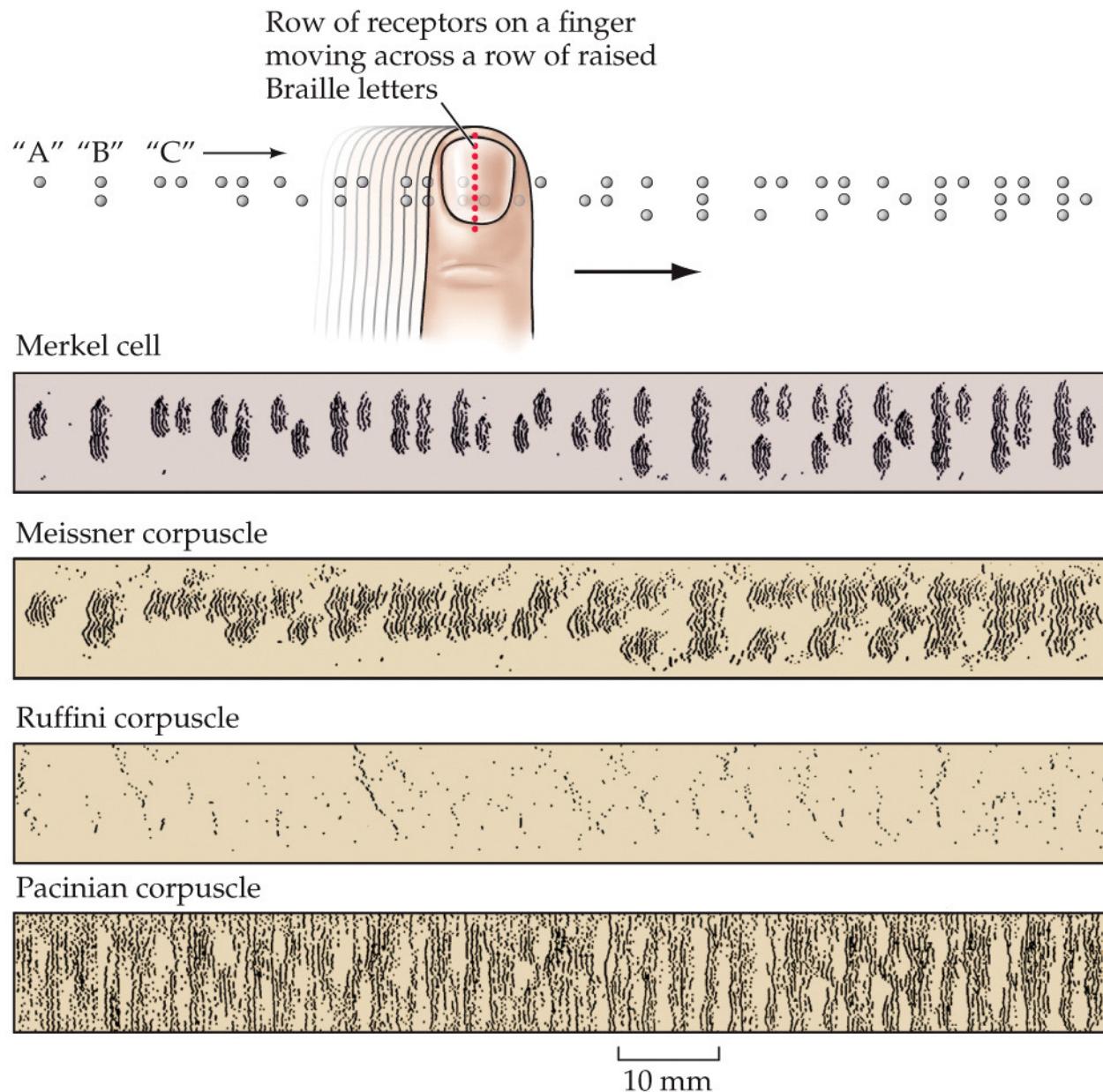


A after Johansson and Vallbo (1983) *Trends Neurosci.* 6: 27–32. B from Abraira and Ginty (2013) *Neuron* 79: 618–639.

NEUROSCIENCE 6e, Figure 9.5

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FIGURE 9.6 Simulation of activity patterns in different mechanosensory afferents in the fingertip



After Phillips et al. (1990) *Exp. Brain Res.* 81:589–592.

## TABLE 9.2 Afferent Systems and Their Properties

TABLE 9.2 ■ Afferent Systems and Their Properties

	Small receptive field		Large receptive field	
	Merkel	Meissner	Pacinian	Ruffini
Location	Tip of epidermal sweat ridges	Dermal papillae (close to skin surface)	Dermis and deeper tissues	Dermis
Axon diameter	7–11 µm	6–12 µm	6–12 µm	6–12 µm
Conduction velocity	40–65 m/s	35–70 m/s	35–70 m/s	35–70 m/s
Sensory function	Shape and texture perception	Motion detection; grip control	Perception of distant events through transmitted vibrations; tool use	Tangential force; hand shape; motion direction
Effective stimuli	Edges, points, corners, curvature	Skin motion	Vibration	Skin stretch
Receptive field area <sup>a</sup>	9 mm <sup>2</sup>	22 mm <sup>2</sup>	Entire finger or hand	60 mm <sup>2</sup>
Innervation density (finger pad)	100/cm <sup>2</sup>	150/cm <sup>2</sup>	20/cm <sup>2</sup>	10/cm <sup>2</sup>
Spatial acuity	0.5 mm	3 mm	10+ mm	7+ mm
Response to sustained indentation	Sustained (slow adaptation)	None (rapid adaptation)	None (rapid adaptation)	Sustained (slow adaptation)
Frequency range	0–100 Hz	1–300 Hz	5–1000 Hz	0–? Hz
Peak sensitivity	5 Hz	50 Hz	200 Hz	0.5 Hz
<b>Threshold for rapid indentation or vibration:</b>				
Best	8 µm	2 µm	0.01 µm	40 µm
Mean	30 µm	6 µm	0.08 µm	300 µm

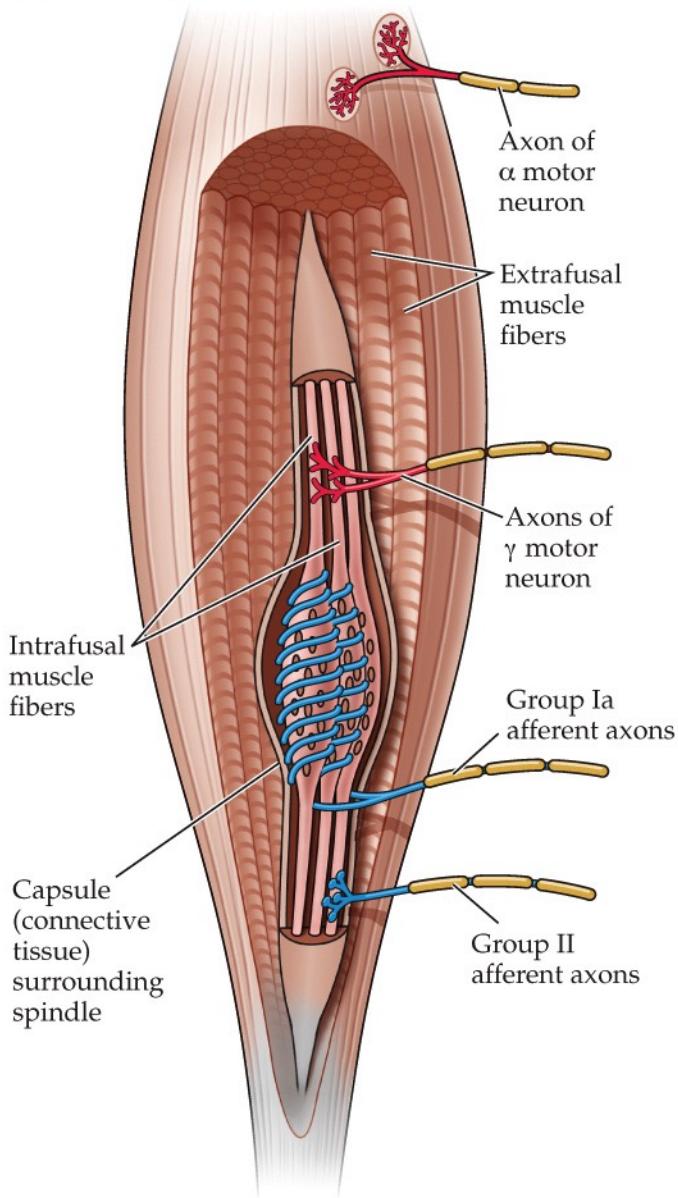
<sup>a</sup>Receptive field areas as measured with rapid 0.5-mm indentation.

(After K. O. Johnson, 2002.)

# FIGURE 9.7 Proprioceptors in the musculoskeletal system

(A) Muscle spindle

A after Matthews (1964) *Physiol. Rev.* 44: 219–289.



(B) Golgi tendon organ

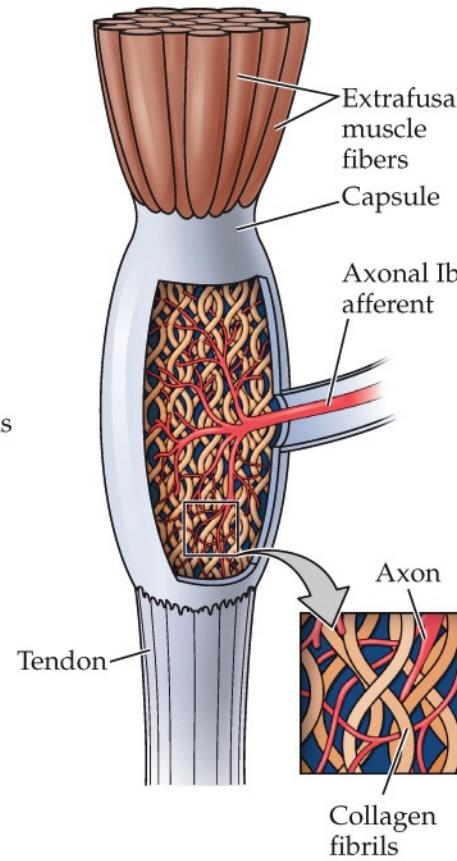
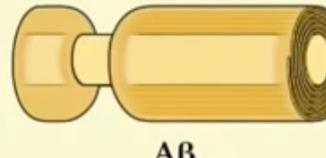
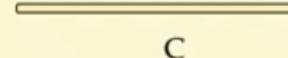


Table 9.1

**TABLE 9.1 Somatic Sensory Afferents that Link Receptors to the Central Nervous System**

SENSORY FUNCTION	RECEPTOR TYPE	AFFERENT AXON TYPE <sup>a</sup>	AXON DIAMETER	CONDUCTION VELOCITY
Proprioception	Muscle spindle	 Ia, II	13–20 μm	80–120 m/s
Touch	Merkel, Meissner, Pacinian, and Ruffini cells		6–12 μm	35–75 m/s
Pain, temperature	Free nerve endings		1–5 μm	5–30 m/s
Pain, temperature, itch	Free nerve endings (unmyelinated)		0.2–1.5 μm	0.5–2 m/s

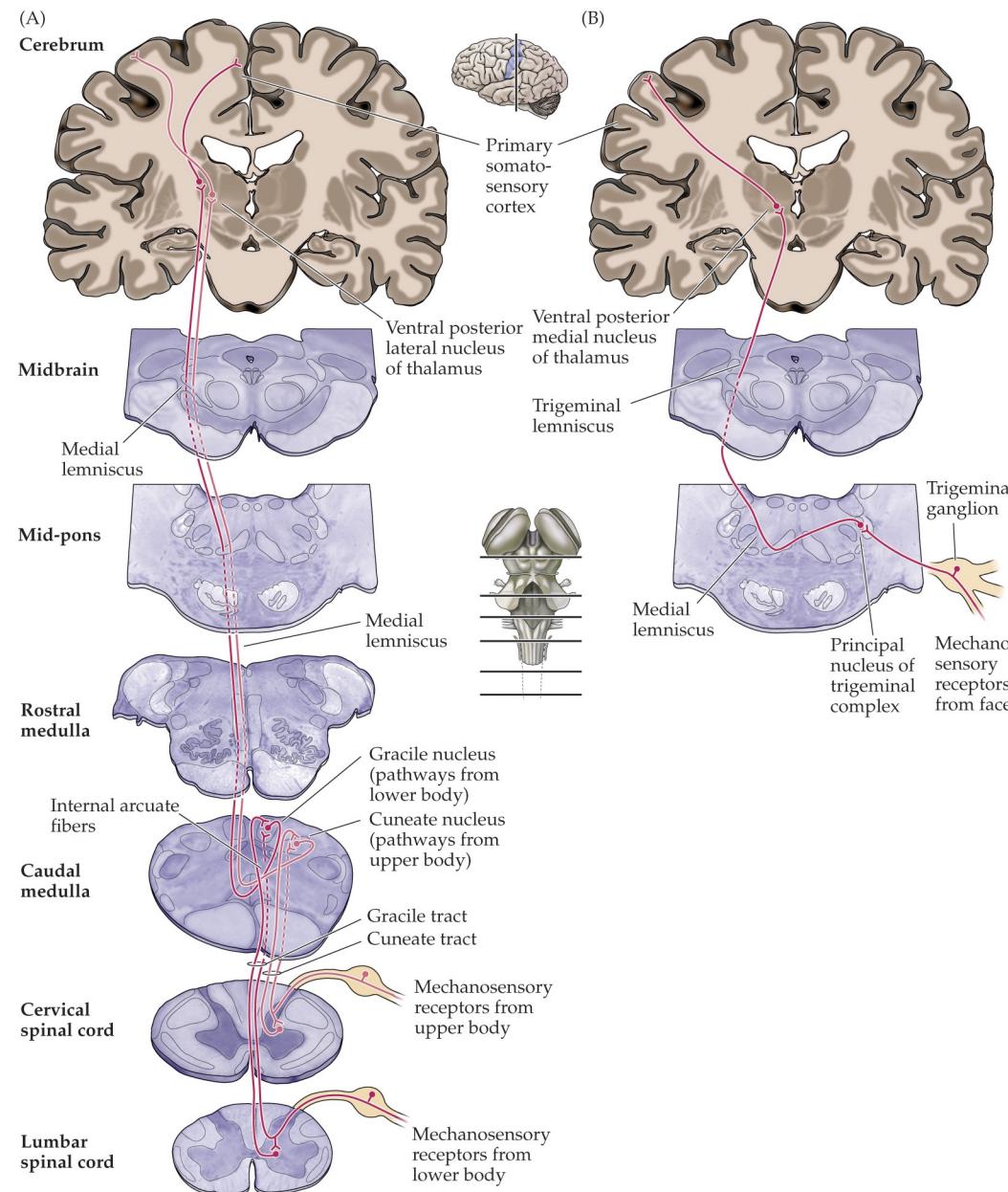
<sup>a</sup>During the 1920s and 1930s, there was a virtual cottage industry classifying axons according to their conduction velocity. Three main categories were discerned, called A, B, and C. A comprises the largest and fastest axons, C the smallest and slowest. Mechanoreceptor axons generally fall into category A. The A group is further broken down into subgroups designated  $\alpha$  (the fastest),  $\beta$ , and  $\delta$  (the slowest). To make matters even more confusing, muscle afferent axons are usually classified into four additional groups—I (the fastest), II, III, and IV (the slowest)—with subgroups designated by lowercase roman letters!

(After Rosenzweig et al., 2005.)

**NEUROSCIENCE 5e, Table 9.1**

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# FIGURE 9.8 The main touch pathways



# FIGURE 9.9 Proprioceptive pathways for the upper and lower body

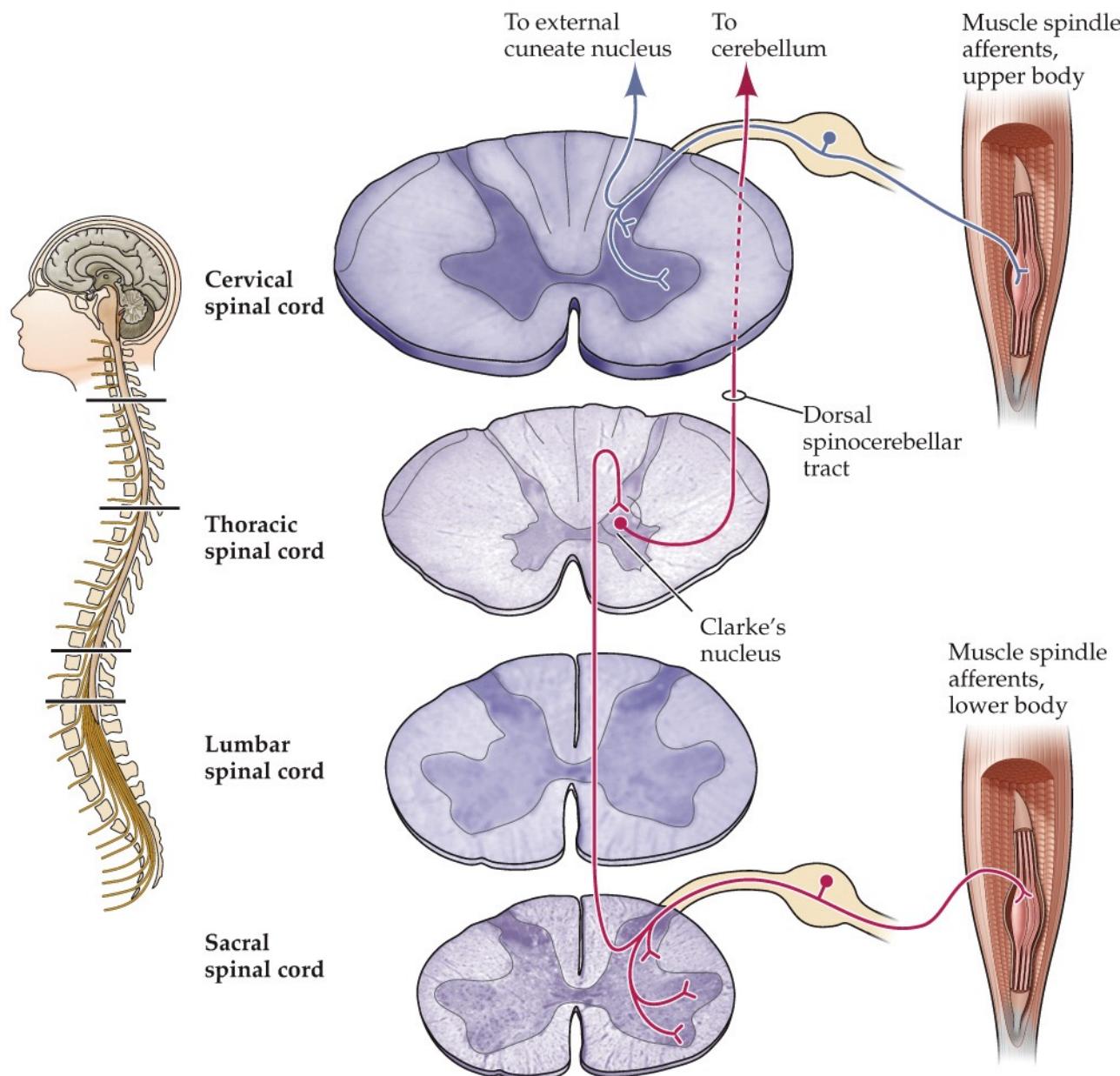
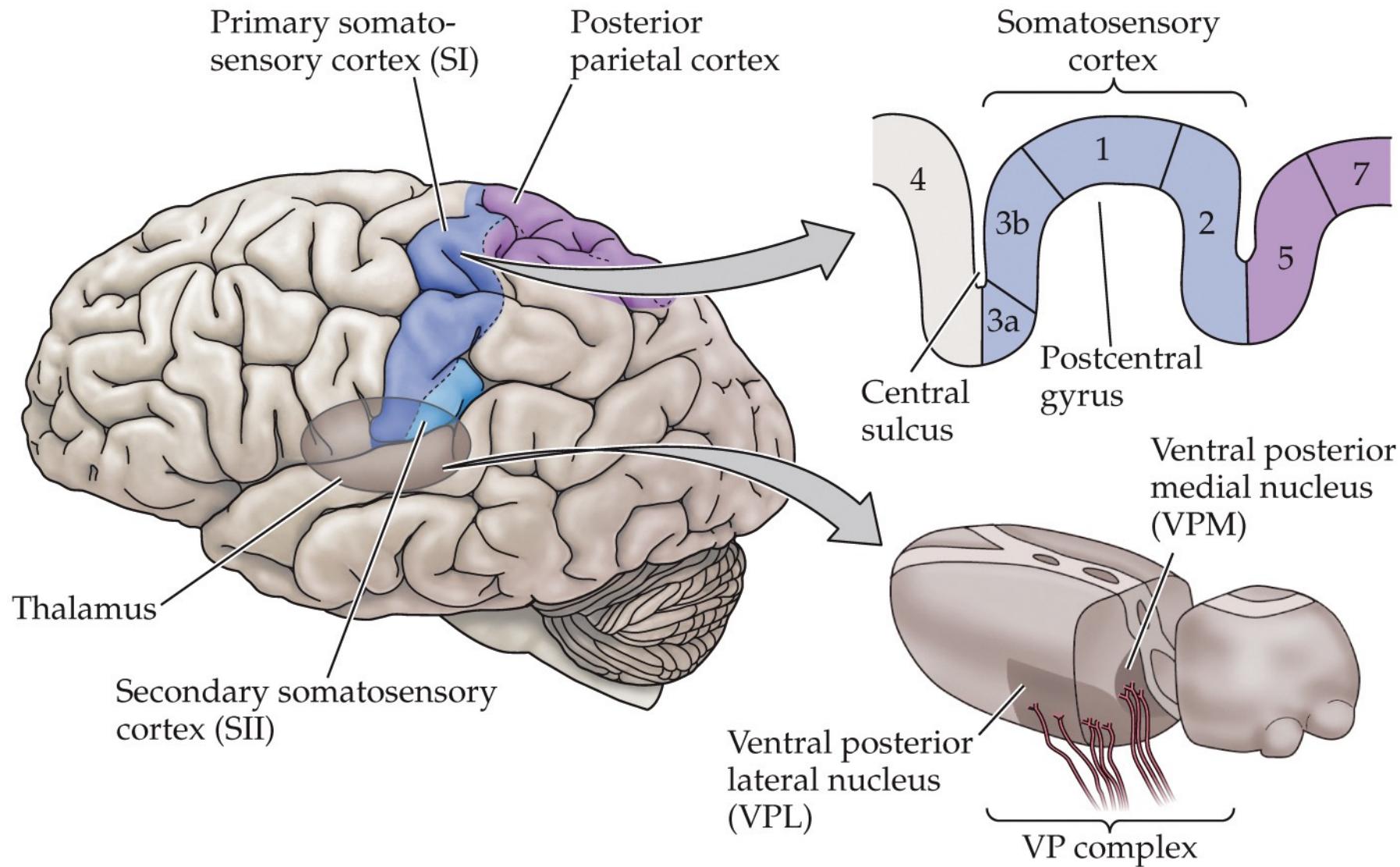


FIGURE 9.10 Somatosensory portions of the thalamus and their cortical targets in the postcentral gyrus



After Brodal (1992) and Jones et al. (1982).