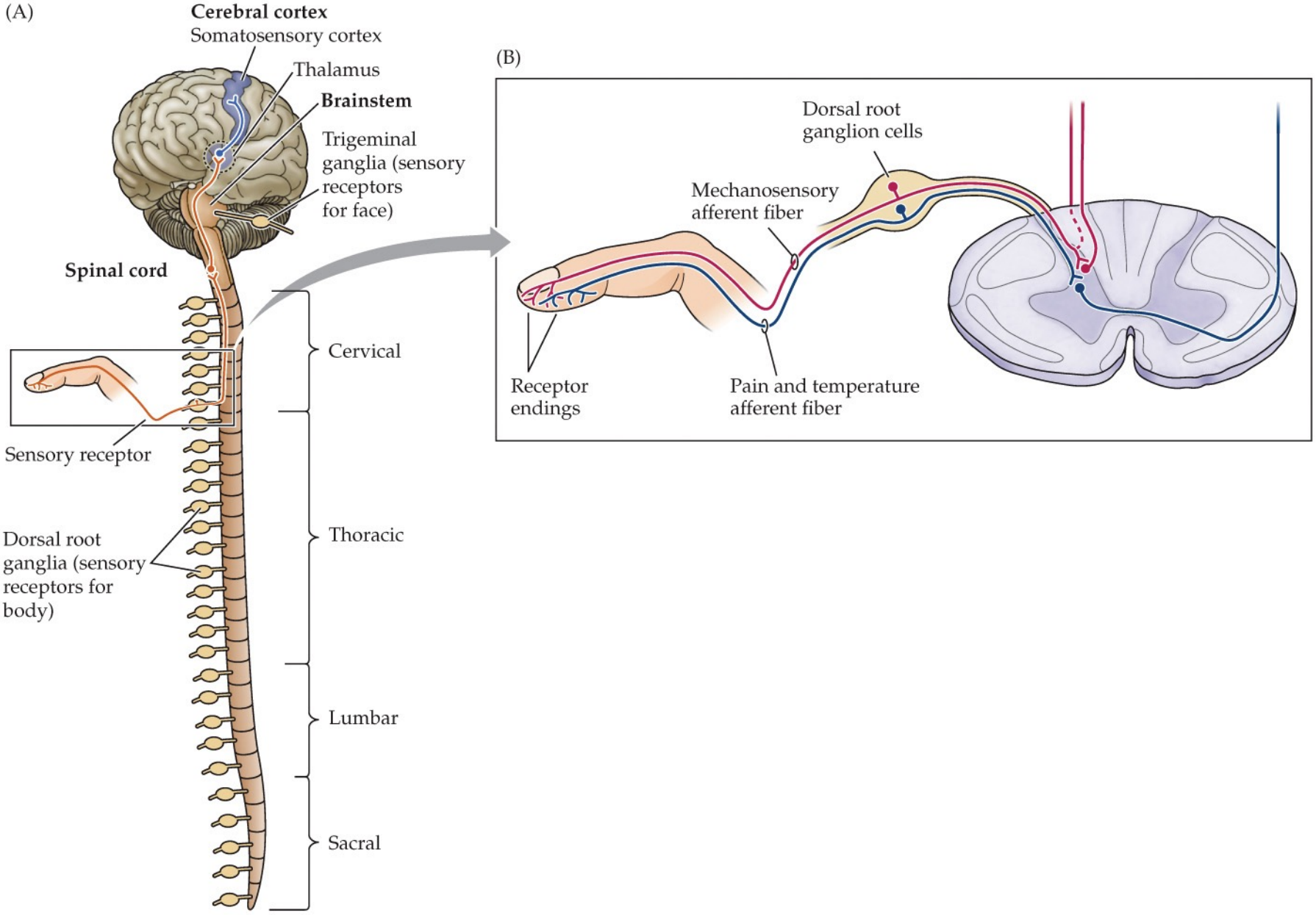
BMD ENG 301Quantitative Systems Physiology (Nervous System)

Somatosensation
2022_v2

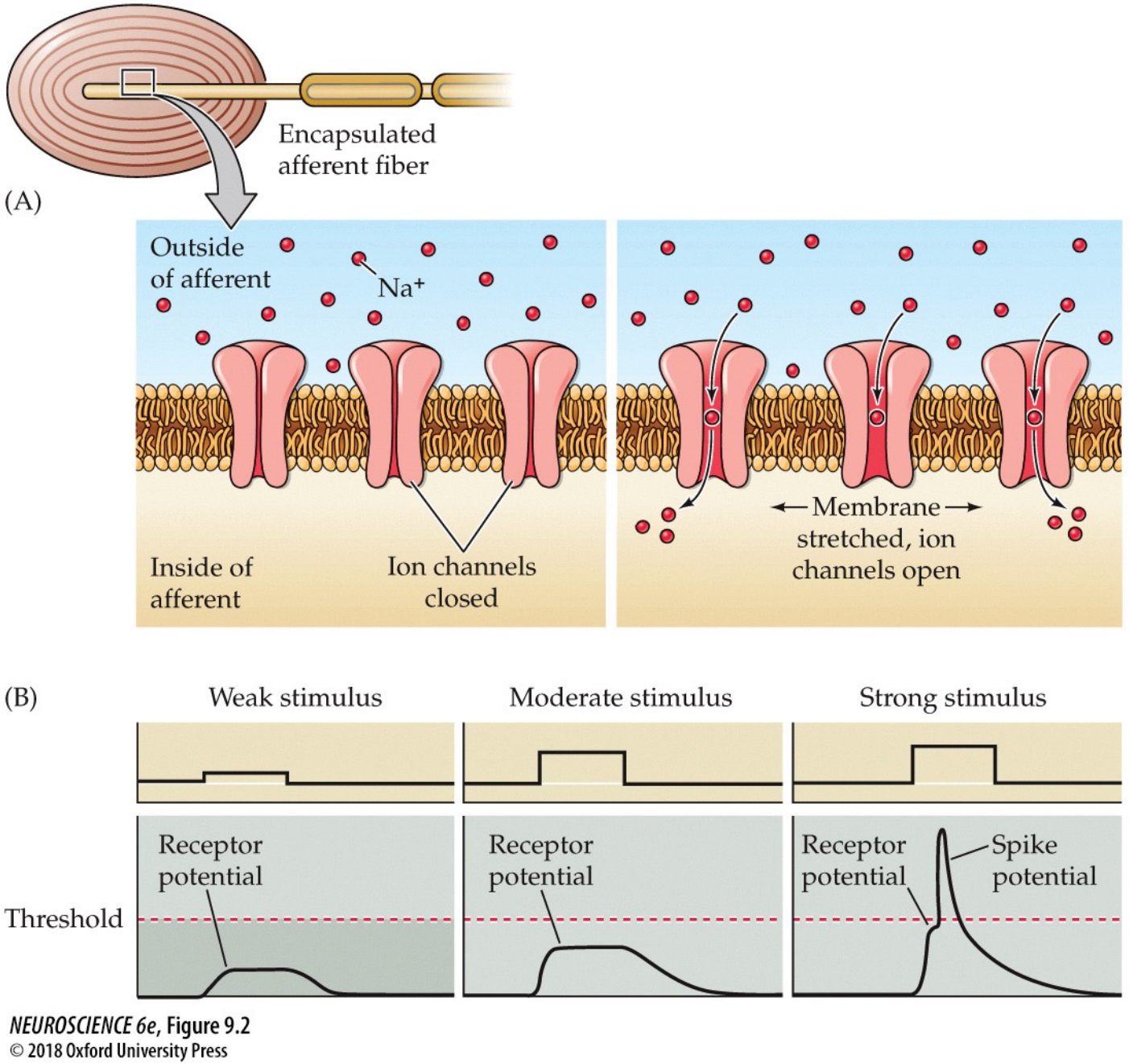
Professor Malcolm A. MacIver

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



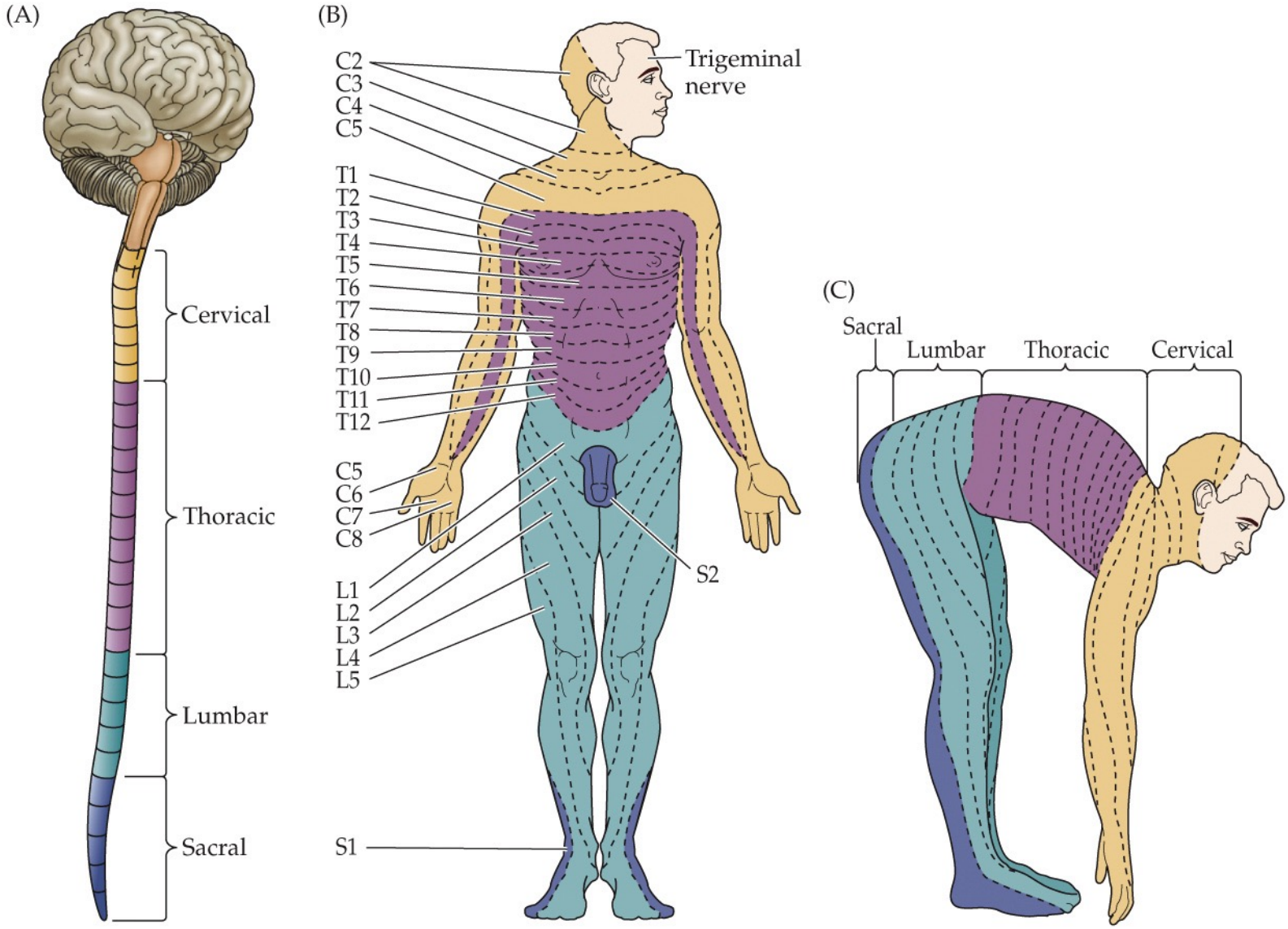
NEUROSCIENCE 6e, Figure 9.1

FIGURE 9.2 Transduction in a mechanosensory afferent



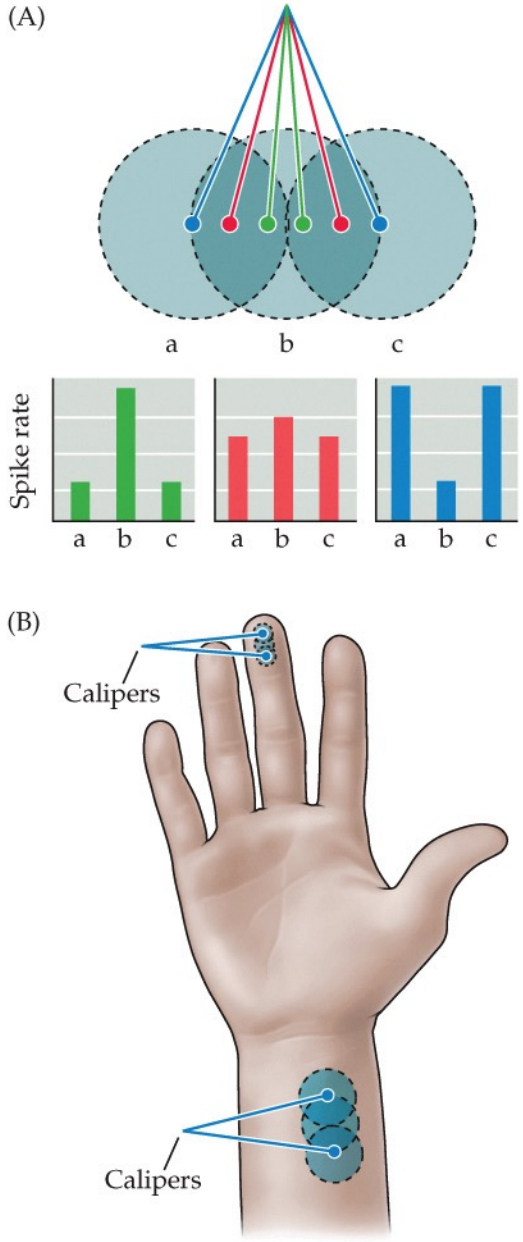
NEUROSCIENCE 6e, Figure 9.2

CLINICAL APPLICATIONS Dermatomes



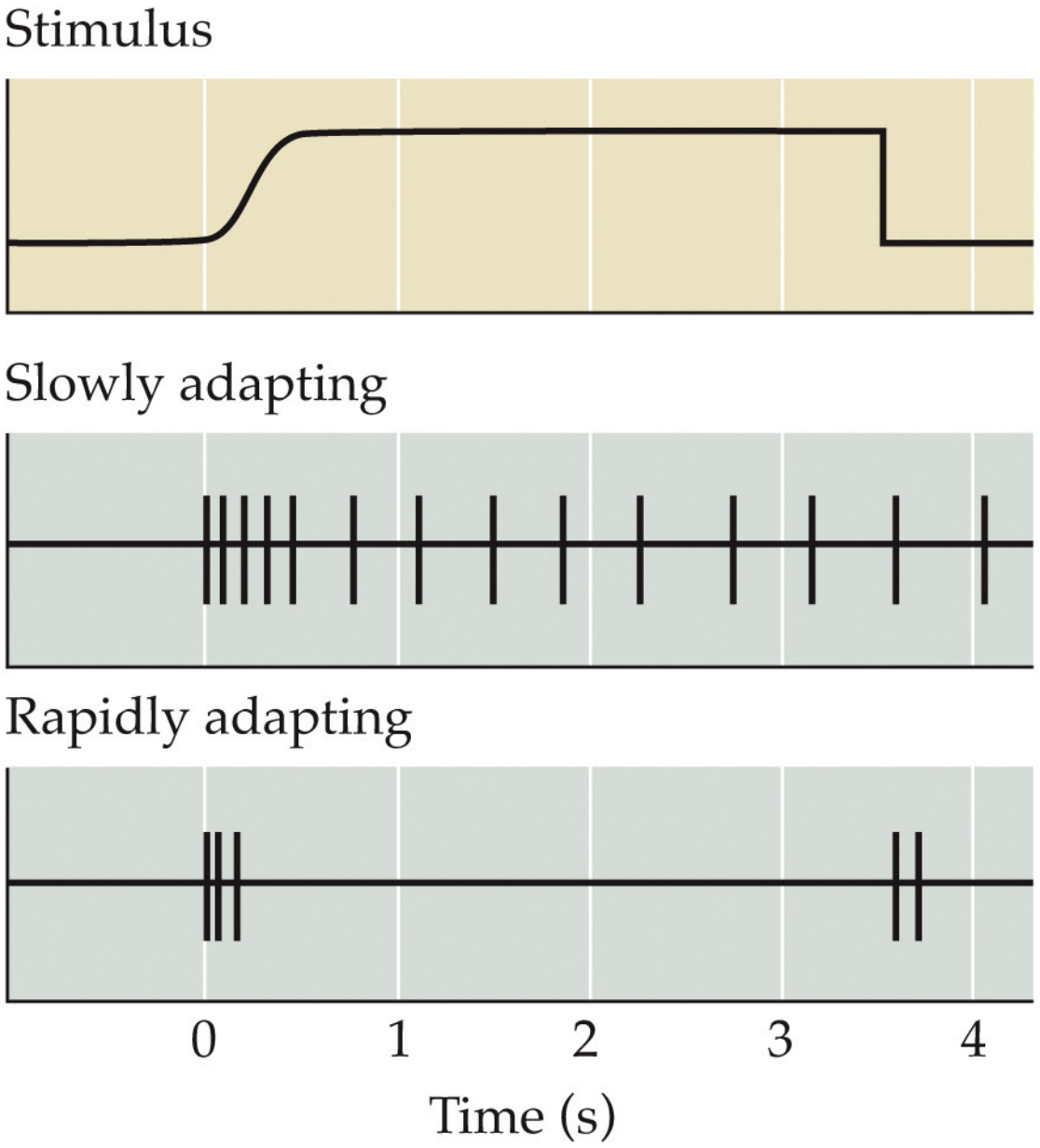
A after Rosenzweig et al. (2005) *Biological Psychology*, 4th Edition. Sunderland, MA: Sinauer Associates. B, C after Haymaker and Woodhall (1967) *Peripheral Nerve Injuries: Principles of Diagnosis*. Philadelphia: W. B. Saunders.

FIGURE 9.3 Receptive fields and the two-point discrimination threshold



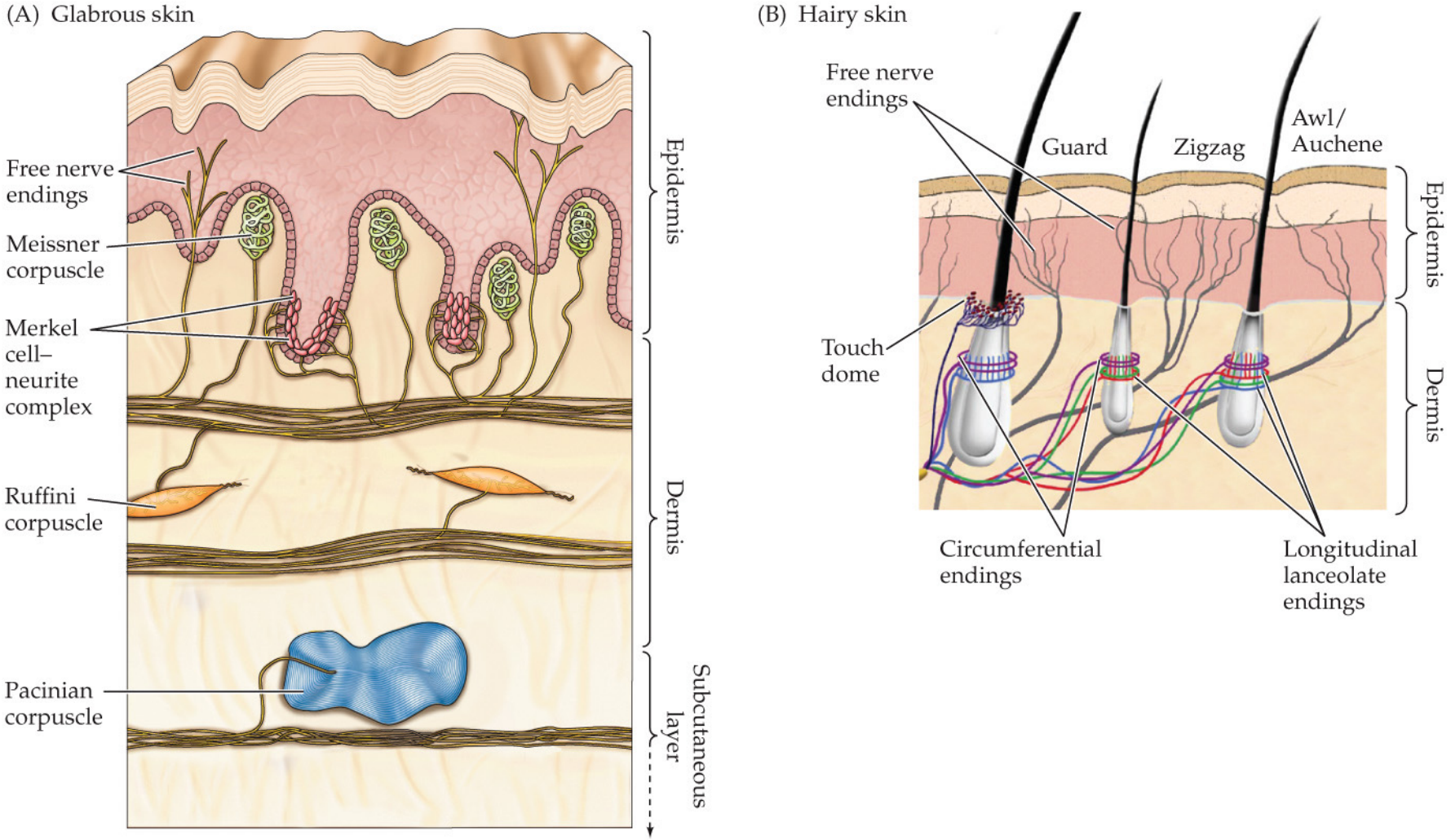
NEUROSCIENCE 6e, Figure 9.3

FIGURE 9.4 Slowly and rapidly adapting mechanoreceptors provide different information



NEUROSCIENCE 6e, Figure 9.4

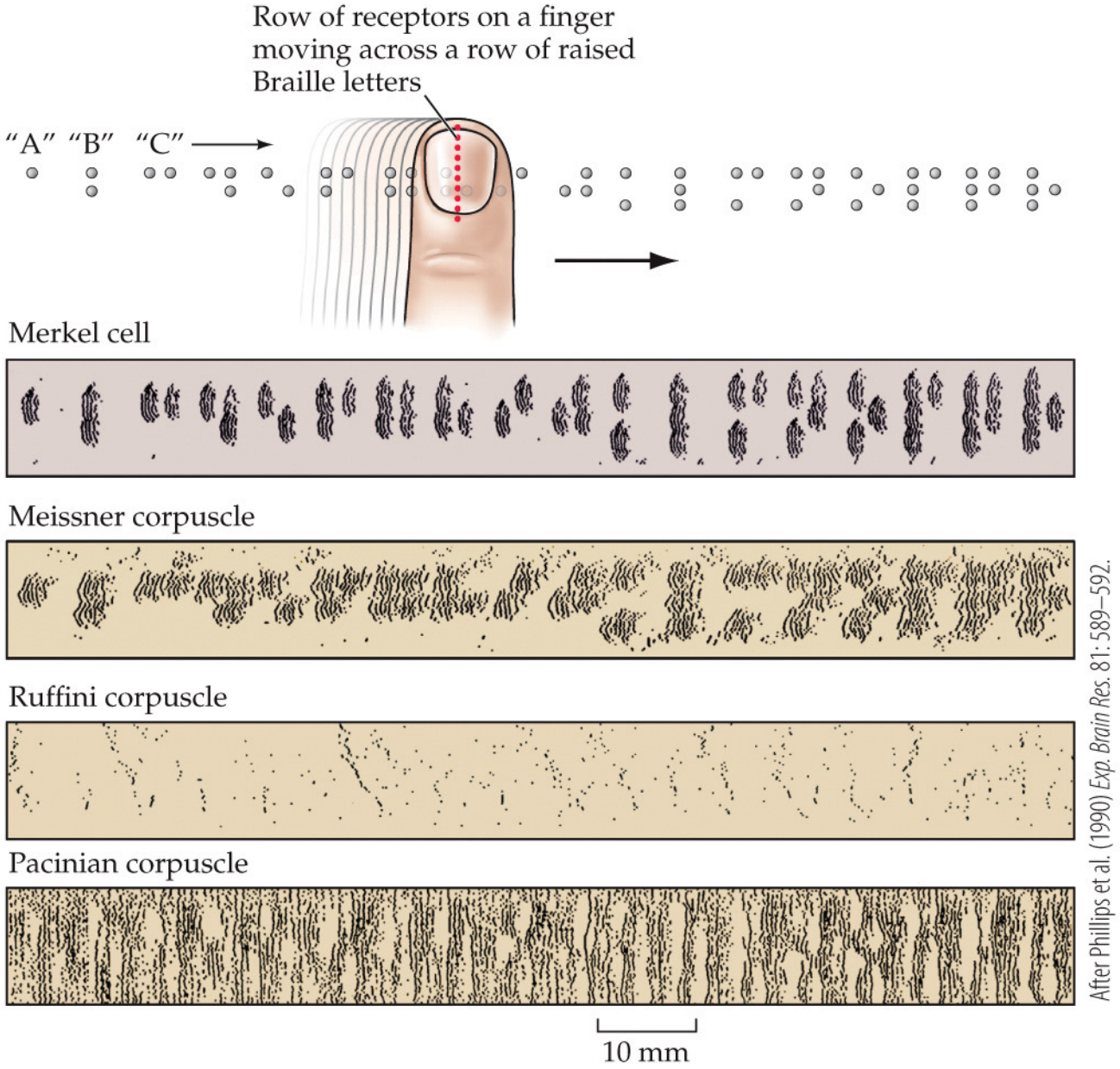
FIGURE 9.5 The skin harbors a variety of morphologically distinct mechanoreceptors



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**

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



NEUROSCIENCE 6e, Figure 9.6

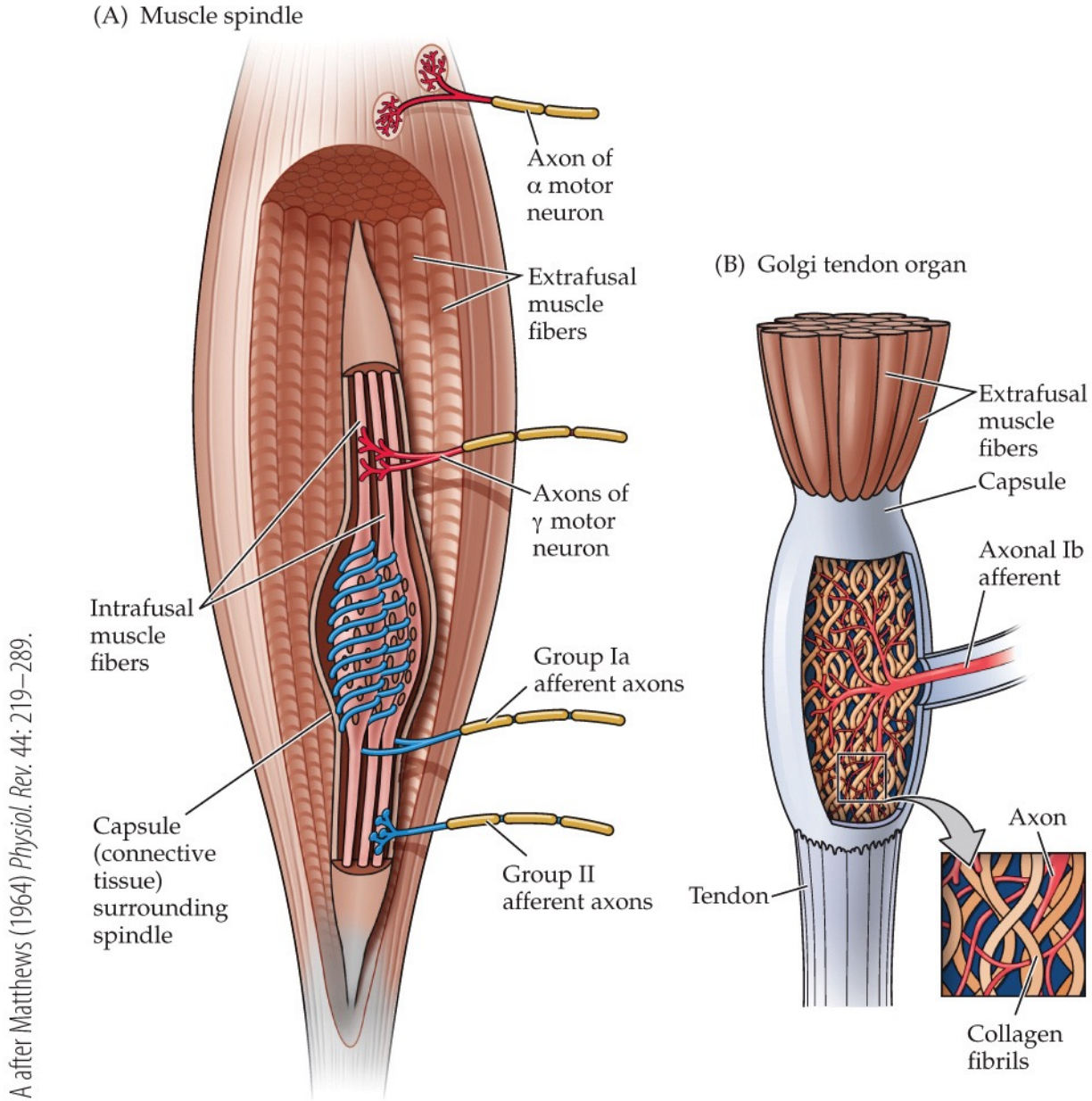
TABLE 9.2 ■ Afferent Systems and Their Properties

	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[a]	9 mm^2	22 mm^2	Entire finger or hand	60 mm^2
Innervation density (finger pad)	100/cm^2	150/cm^2	20/cm^2	10/cm^2
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
Threshold for rapid indentation or vibration:				
Best	8 μm	2 μm	0.01μm	40 μm
Mean	30 μm	6 μm	0.08 μm	300 μm

[a]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 after Matthews (1964) *Physiol. Rev.* 44: 219–289.

NEUROSCIENCE 6e, Figure 9.7

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

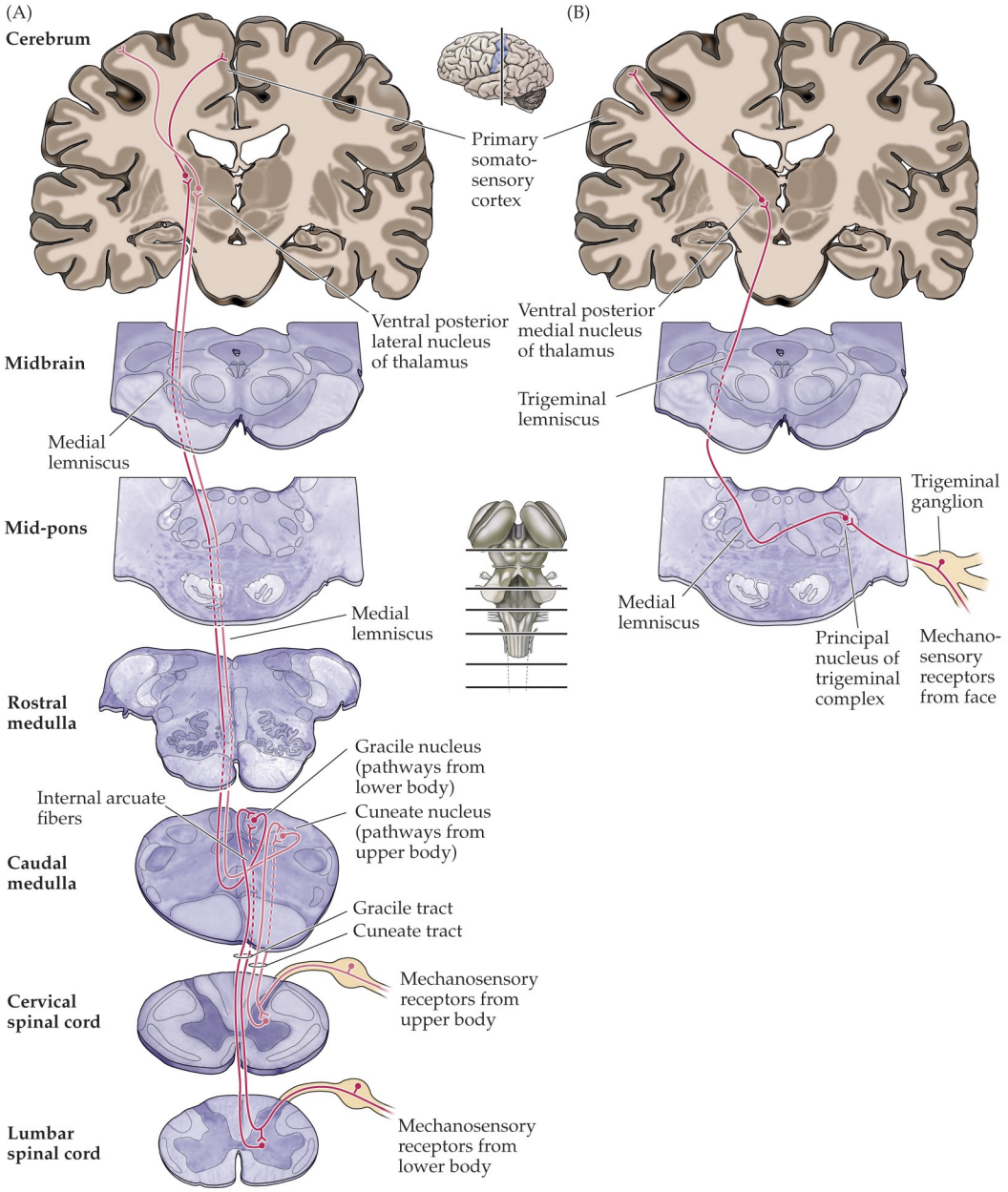
SENSORY FUNCTION	RECEPTOR TYPE	AFFERENT AXON TYPE[a]	AXON DIAMETER	CONDUCTION VELOCITY
Proprioception	Muscle spindle	 Ia, II	13–20 μm	80–120 m/s
Touch	Merkel, Meissner, Pacinian, and Ruffini cells	 Aβ	6–12 μm	35–75 m/s
Pain, temperature	Free nerve endings	 Aδ	1–5 μm	5–30 m/s
Pain, temperature, itch	Free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

[a]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 α (the fastest), β, and δ (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.)

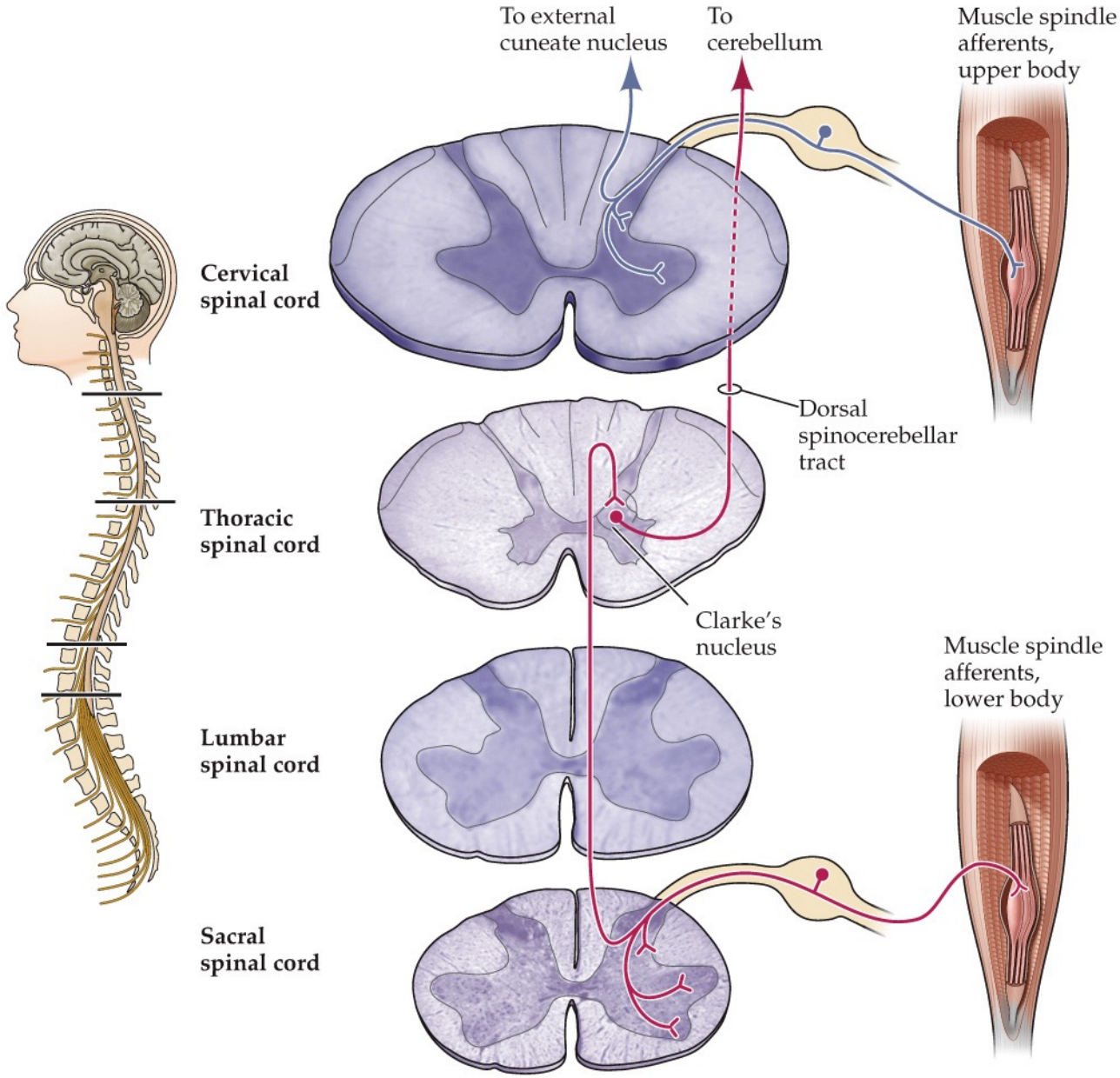
***NEUROSCIENCE 5e*, Table 9.1**

FIGURE 9.8 The main touch pathways



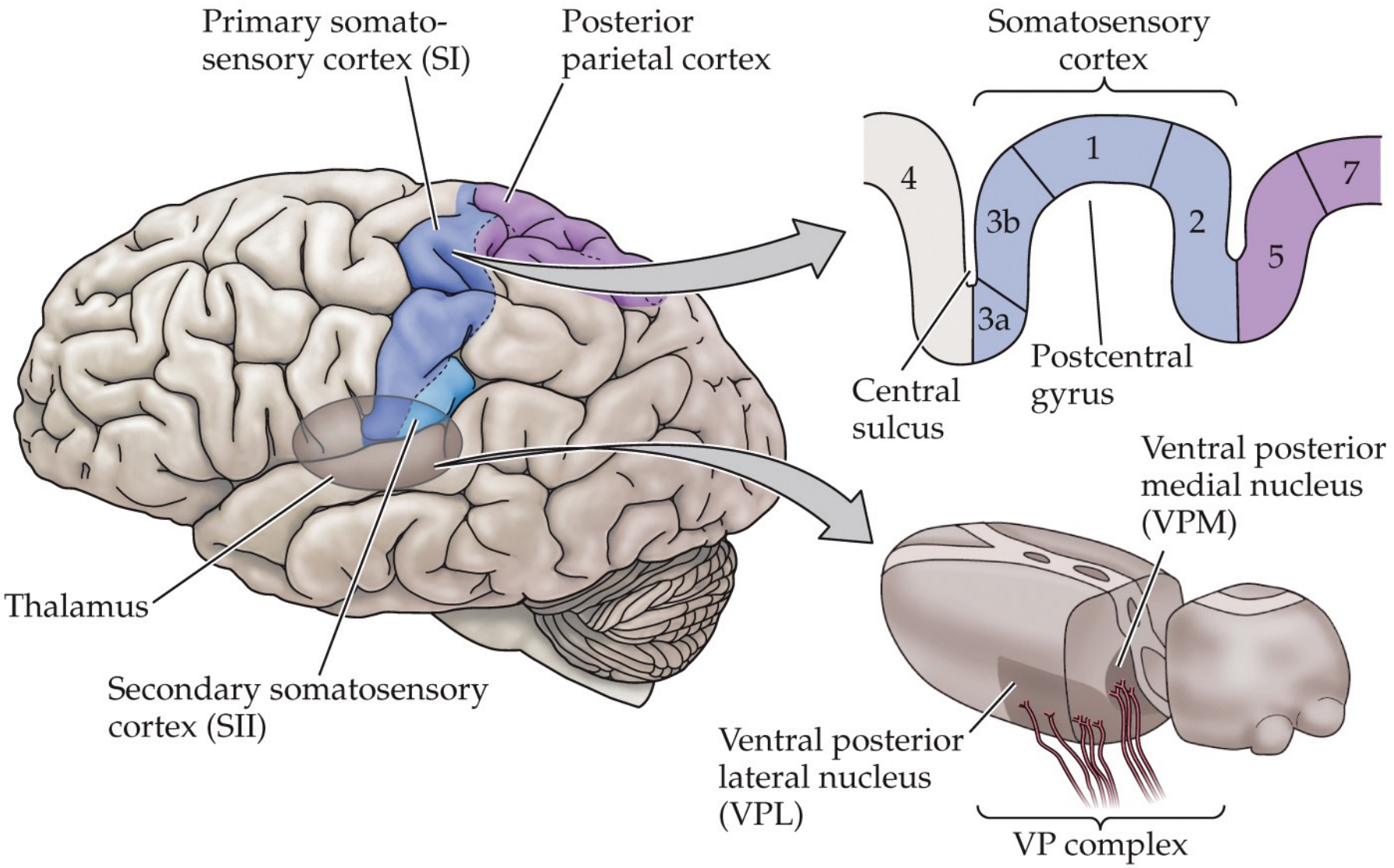
NEUROSCIENCE 6e, Figure 9.8

FIGURE 9.9 Proprioceptive pathways for the upper and lower body



NEUROSCIENCE 6e, Figure 9.9

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



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

NEUROSCIENCE 6e, Figure 9.10