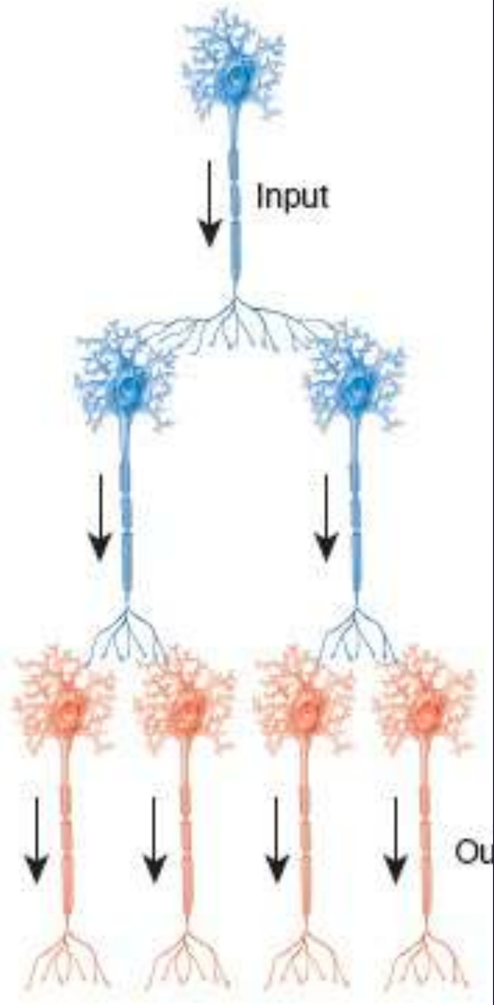
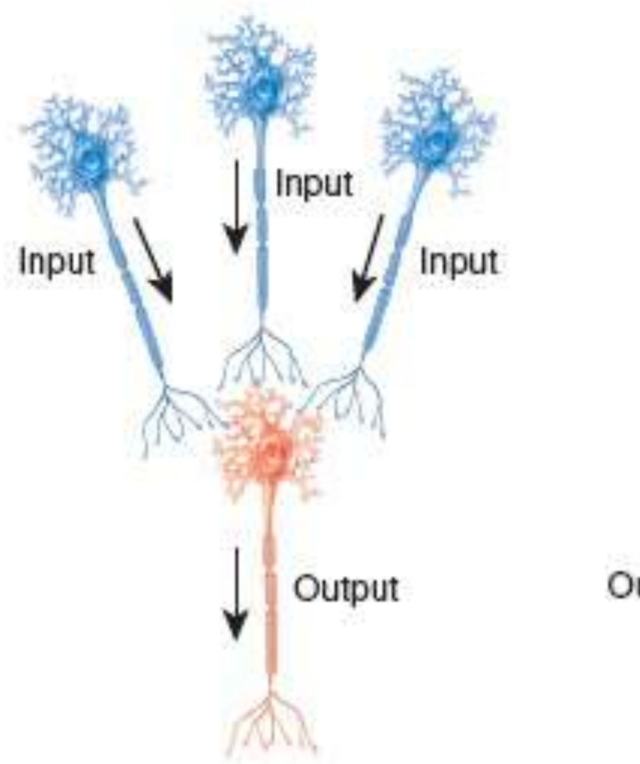
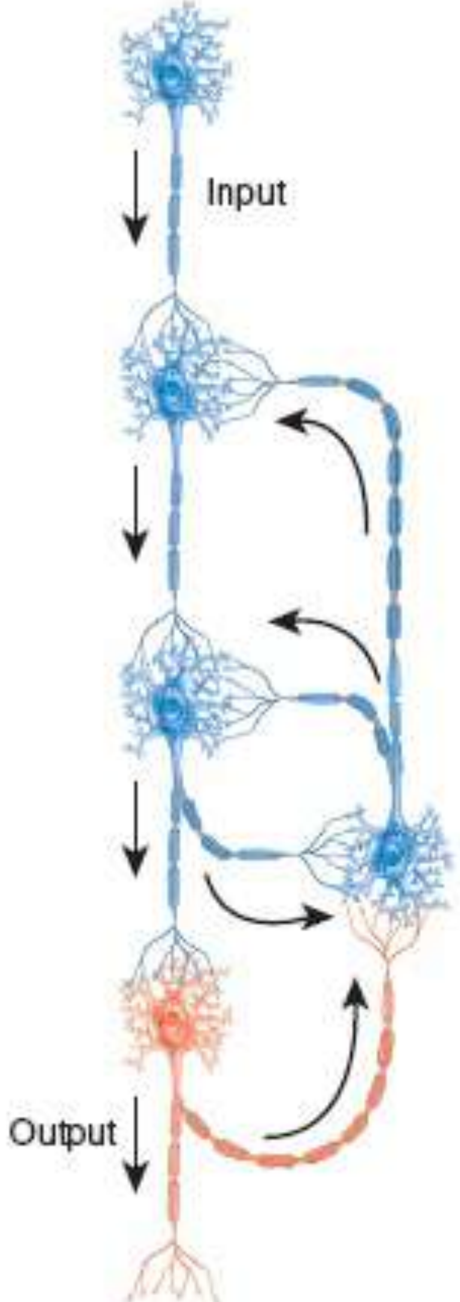
Neuronal Circuits and Neuronal Pools



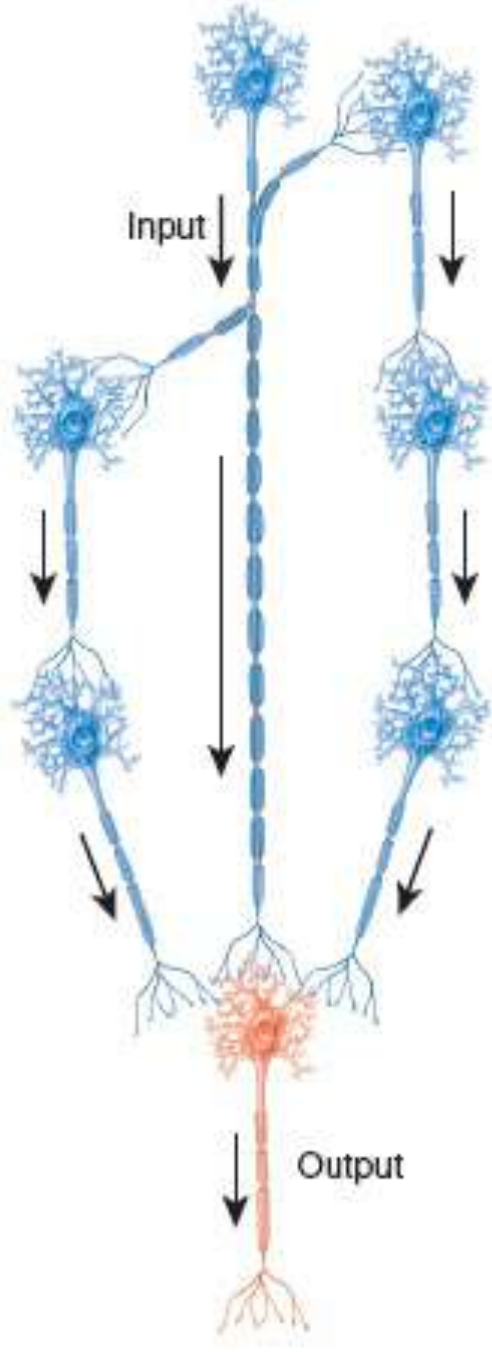
(a) Diverging circuit



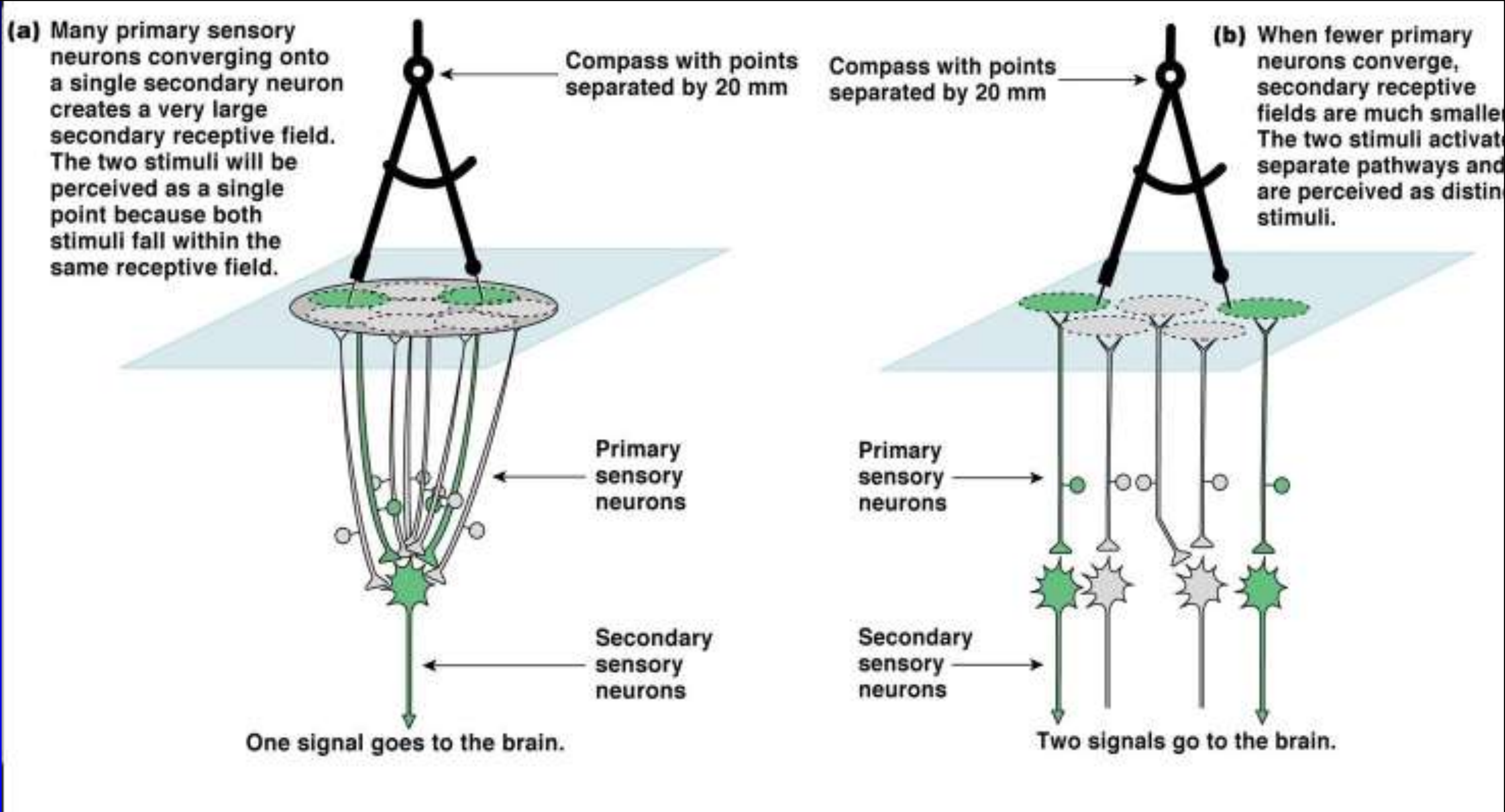
(b) Converging circuit



(c) Reverberating circuit



(d) Parallel after-discharge circuit


(a) Many primary sensory neurons converging onto a single secondary neuron creates a very large secondary receptive field. The two stimuli will be perceived as a single point because both stimuli fall within the same receptive field.
Compass with points separated by 20 mm
Primary sensory neurons
Secondary sensory neurons
One signal goes to the brain.
Compass with points separated by 20 mm
(b) When fewer primary neurons converge, secondary receptive fields are much smalle
The two stimuli activat
separate pathways and
are perceived as distin
stimuli.
Primary sensory neurons
Secondary sensory neurons
Two signals go to the brain.

6. Lateral inhibition

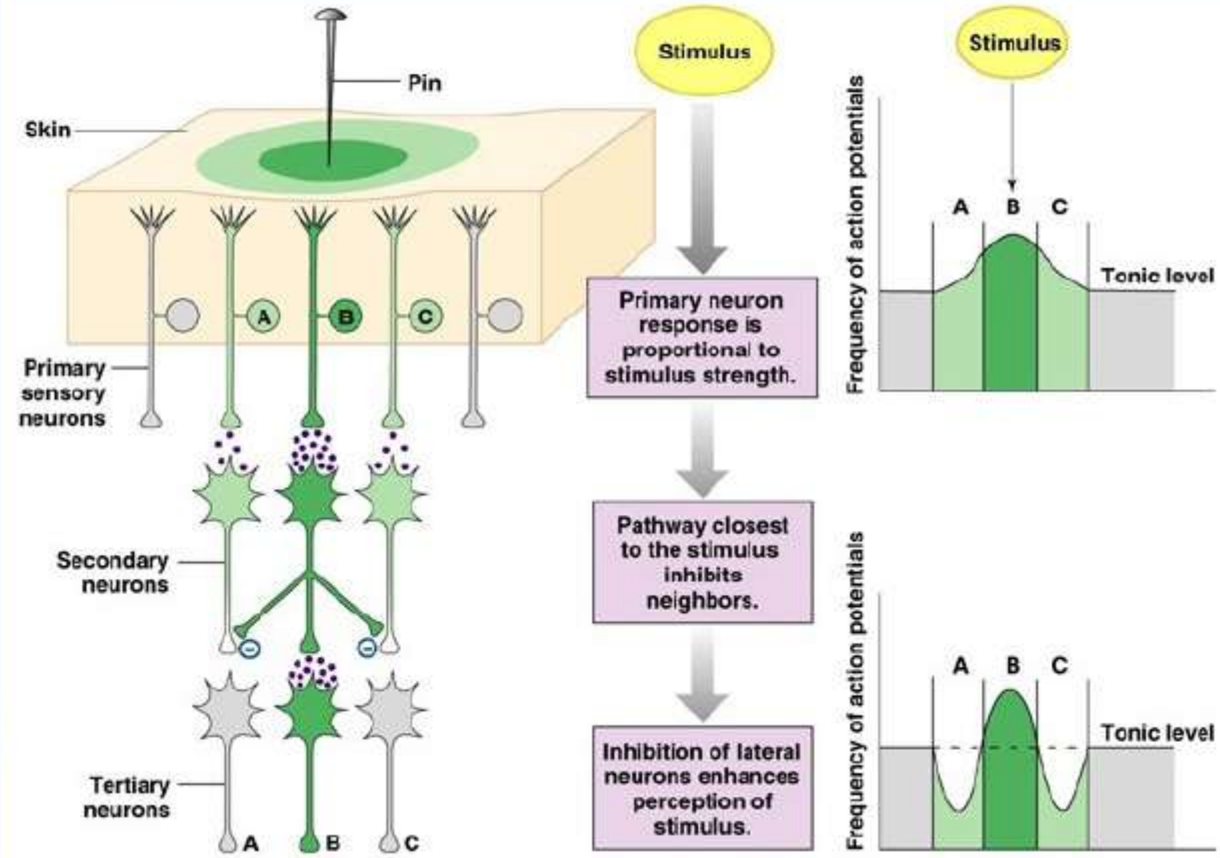


Fig. 10-6

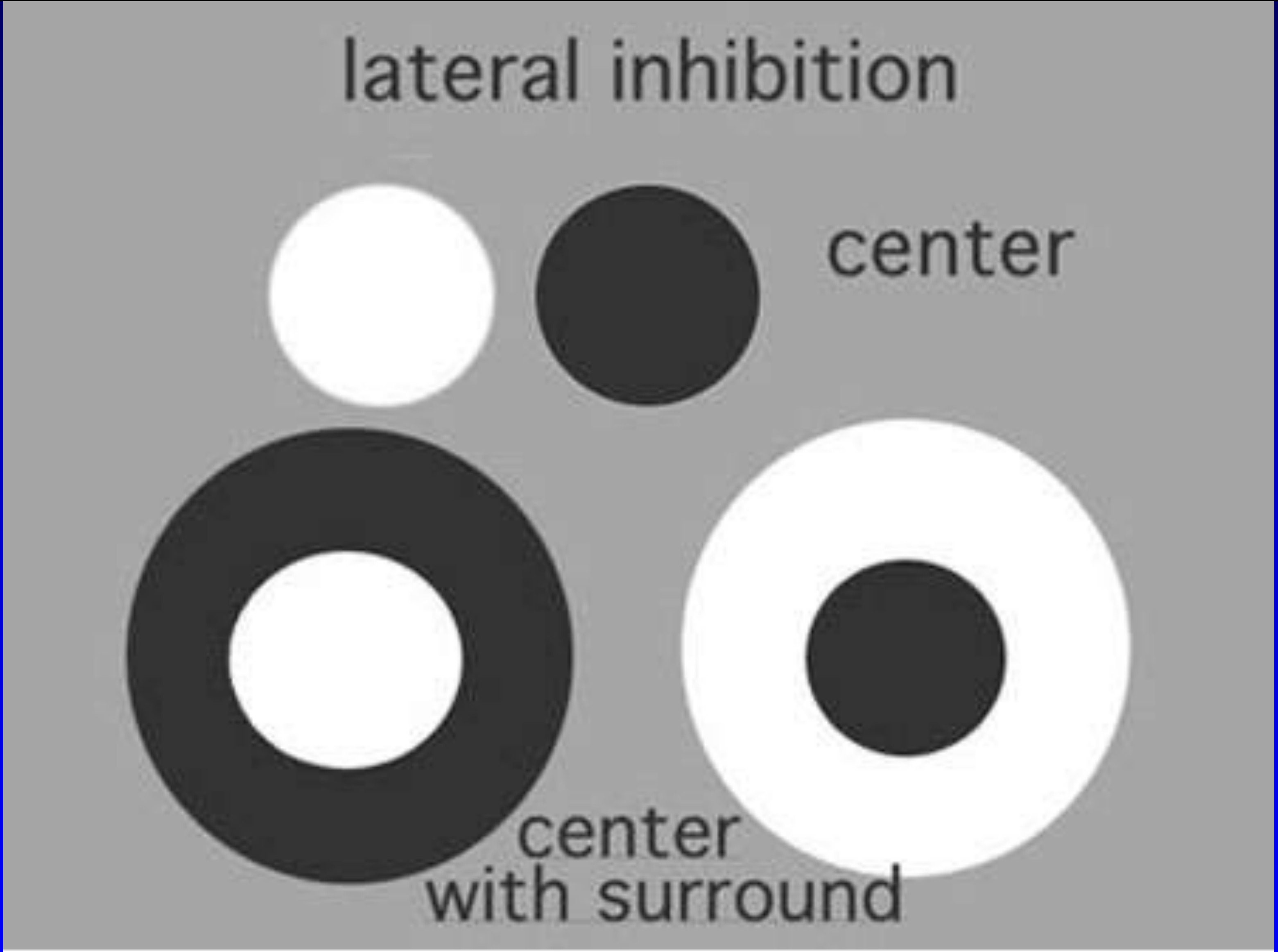
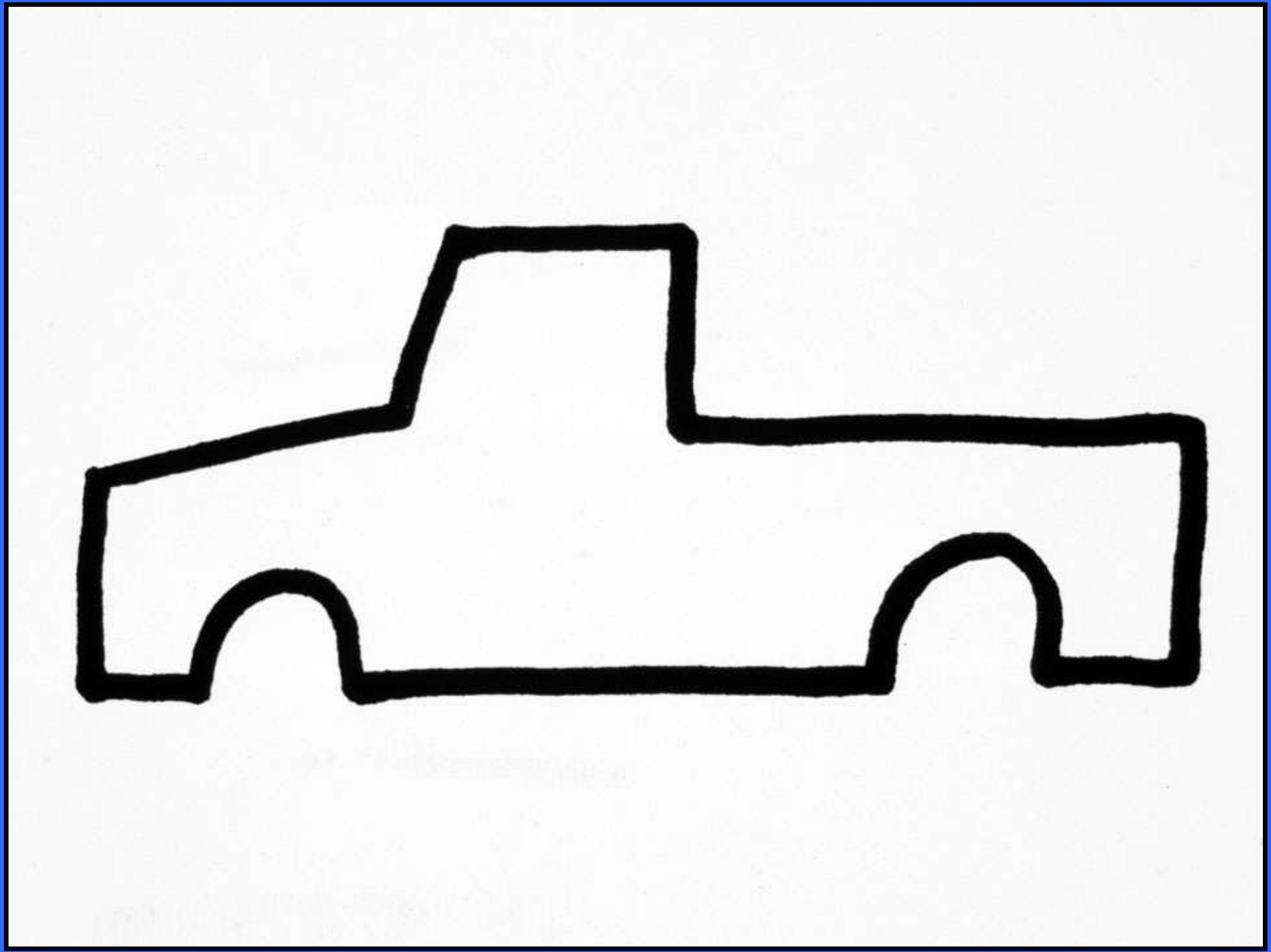
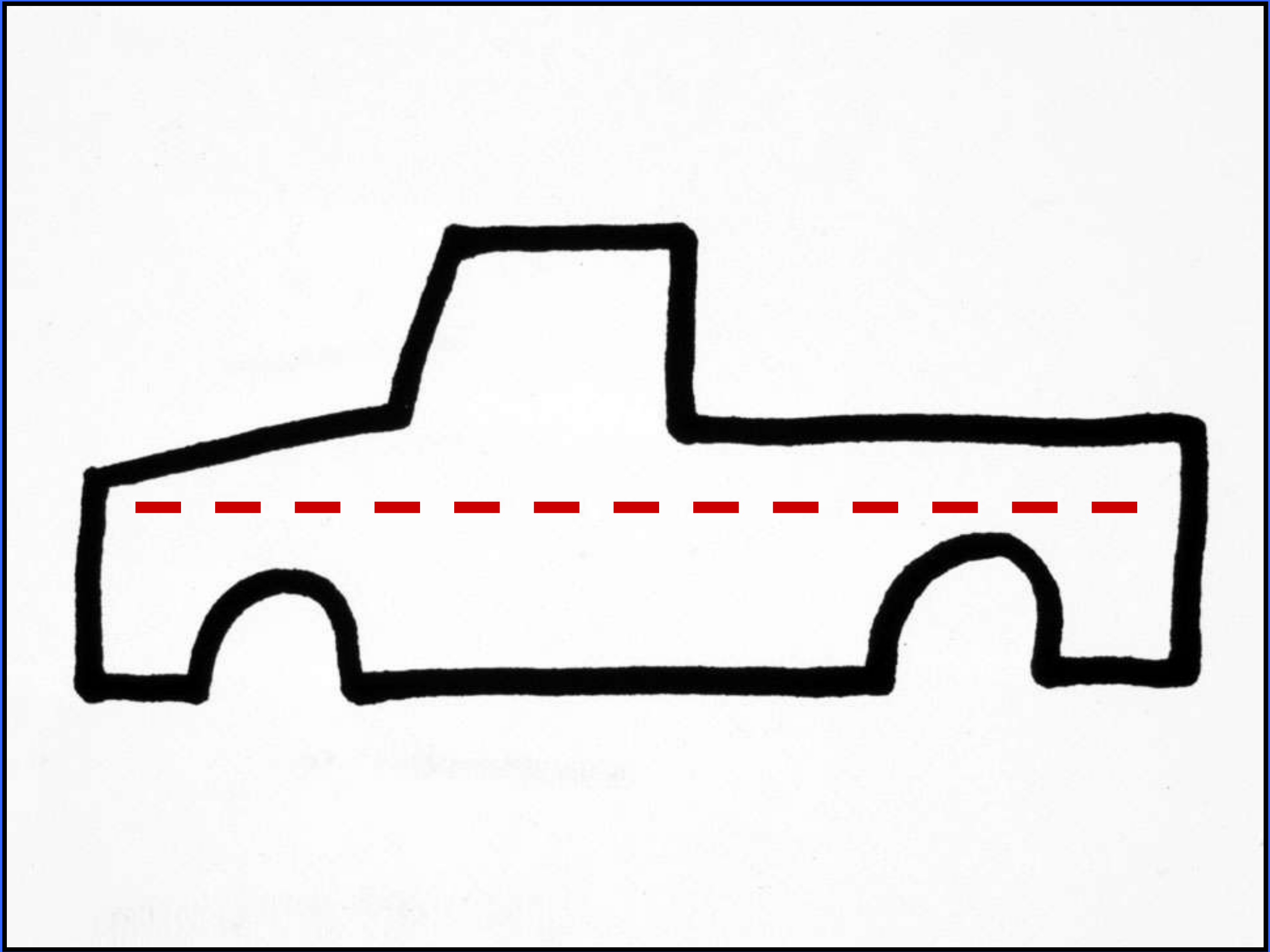
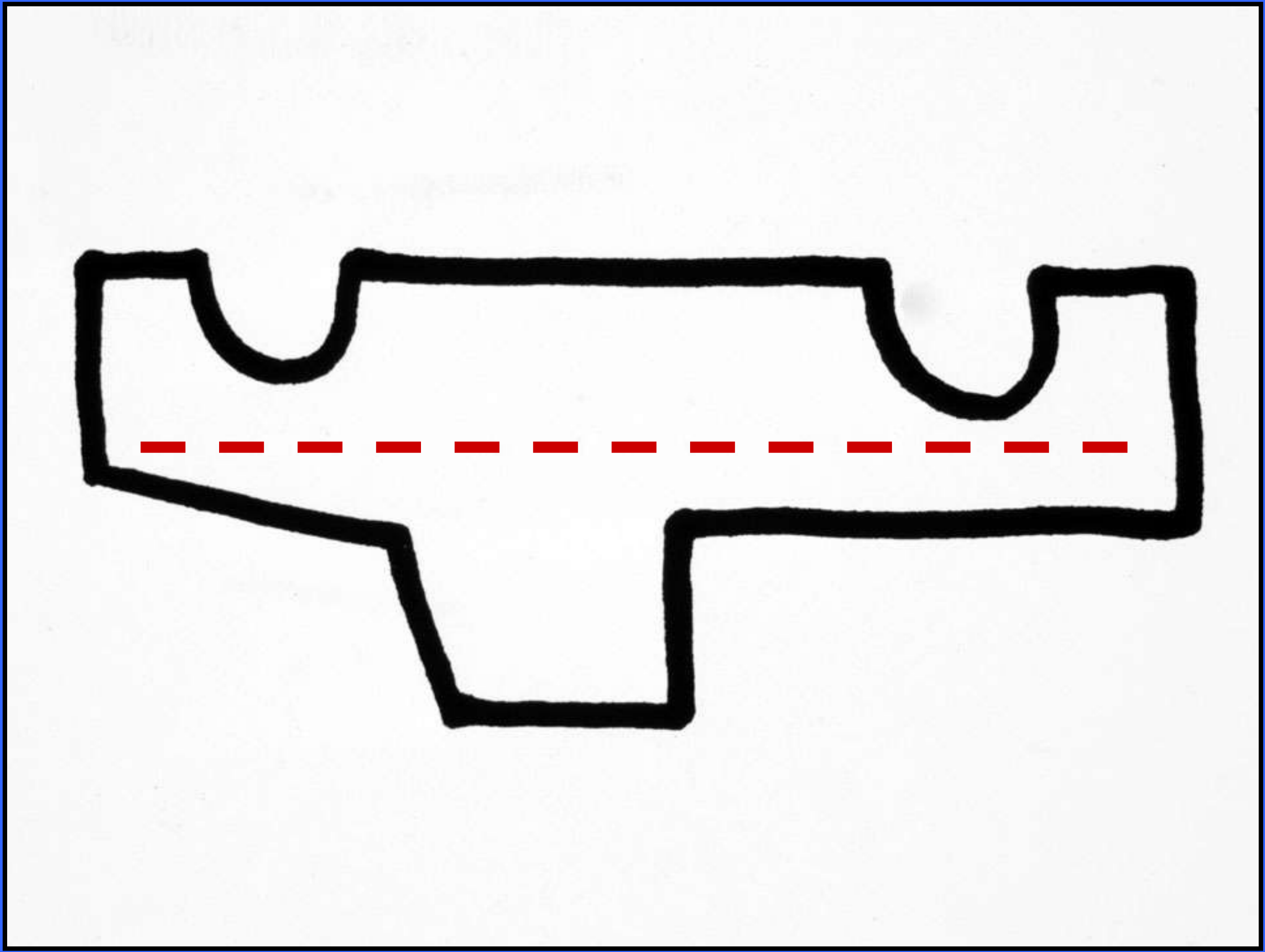


Fig. 10. Center-surround receptive fields can be ON center or OFF center with the oposite sign annular surround.


B



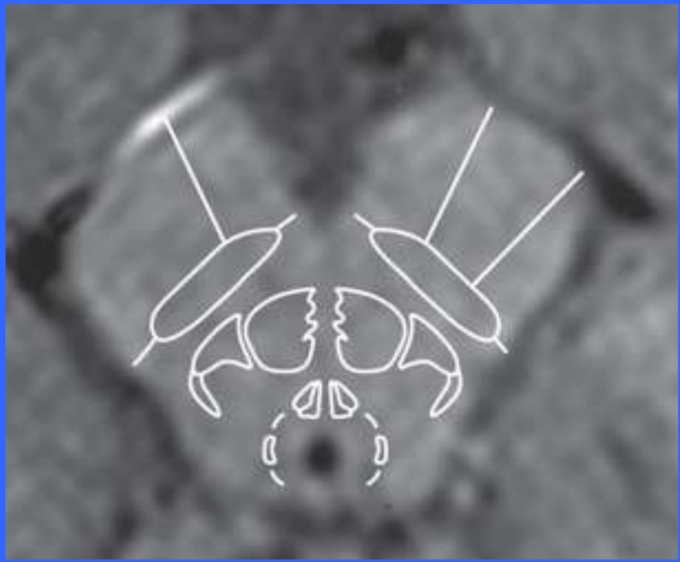


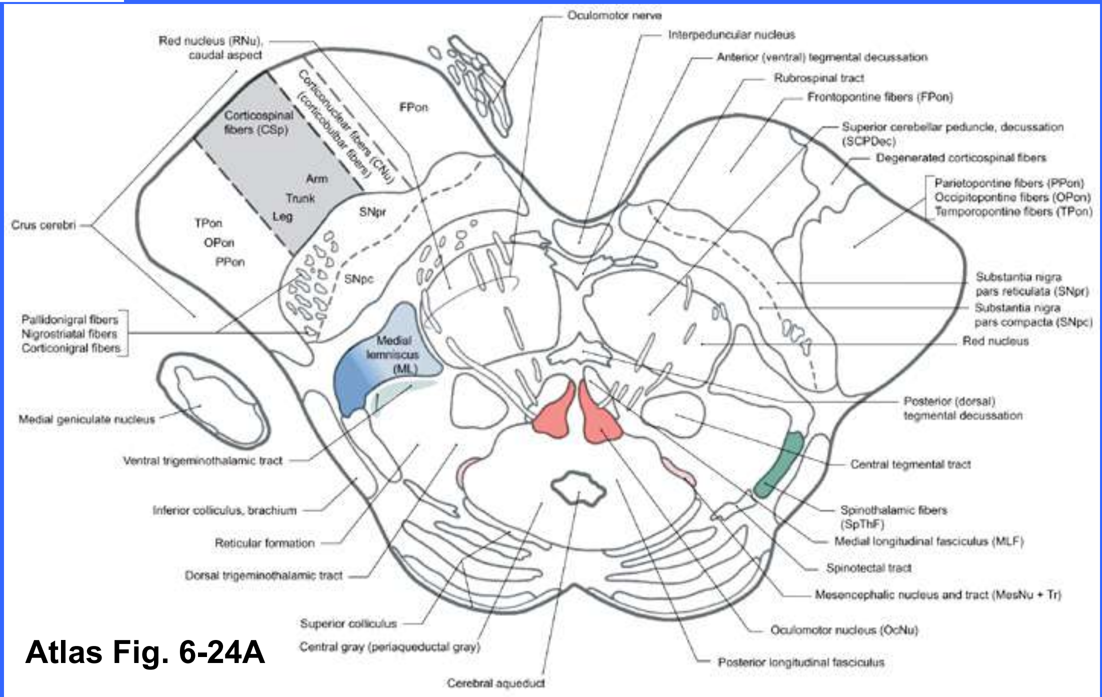



Anatomical Orientation


Clinical Orientation
Atlas Fig. 6-24

The Reality of the Clinical Environment

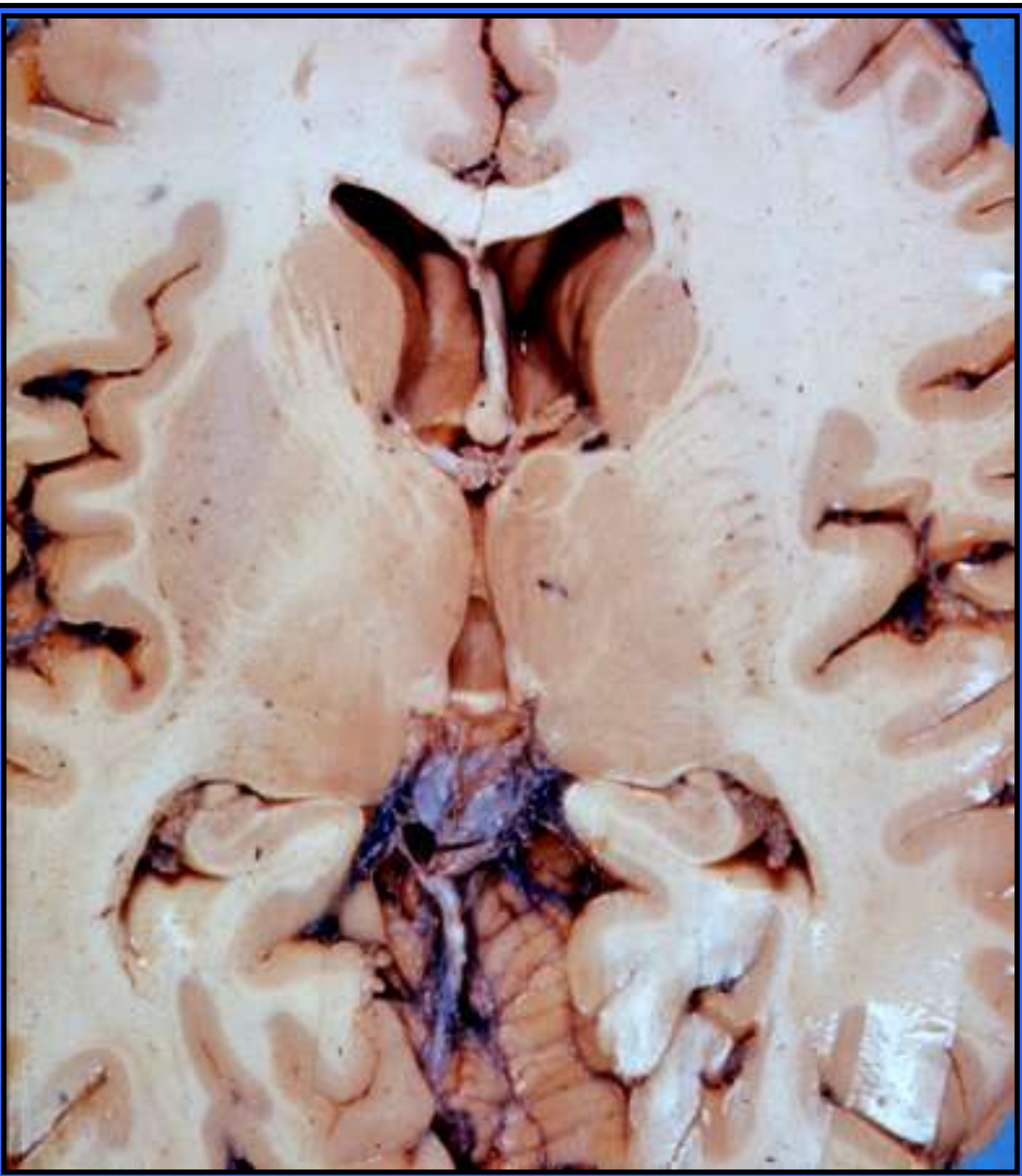


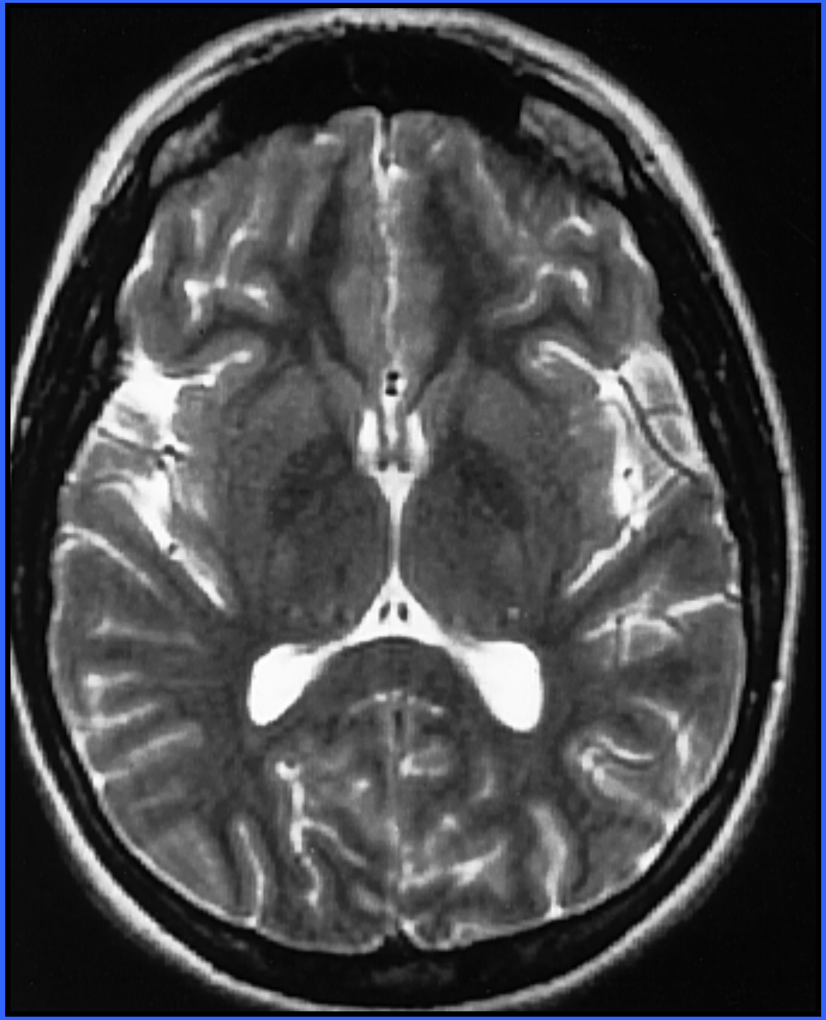


Atlas Fig. 6-24A

One Cardinal Plane to Learn AND Understand - Midsagittal

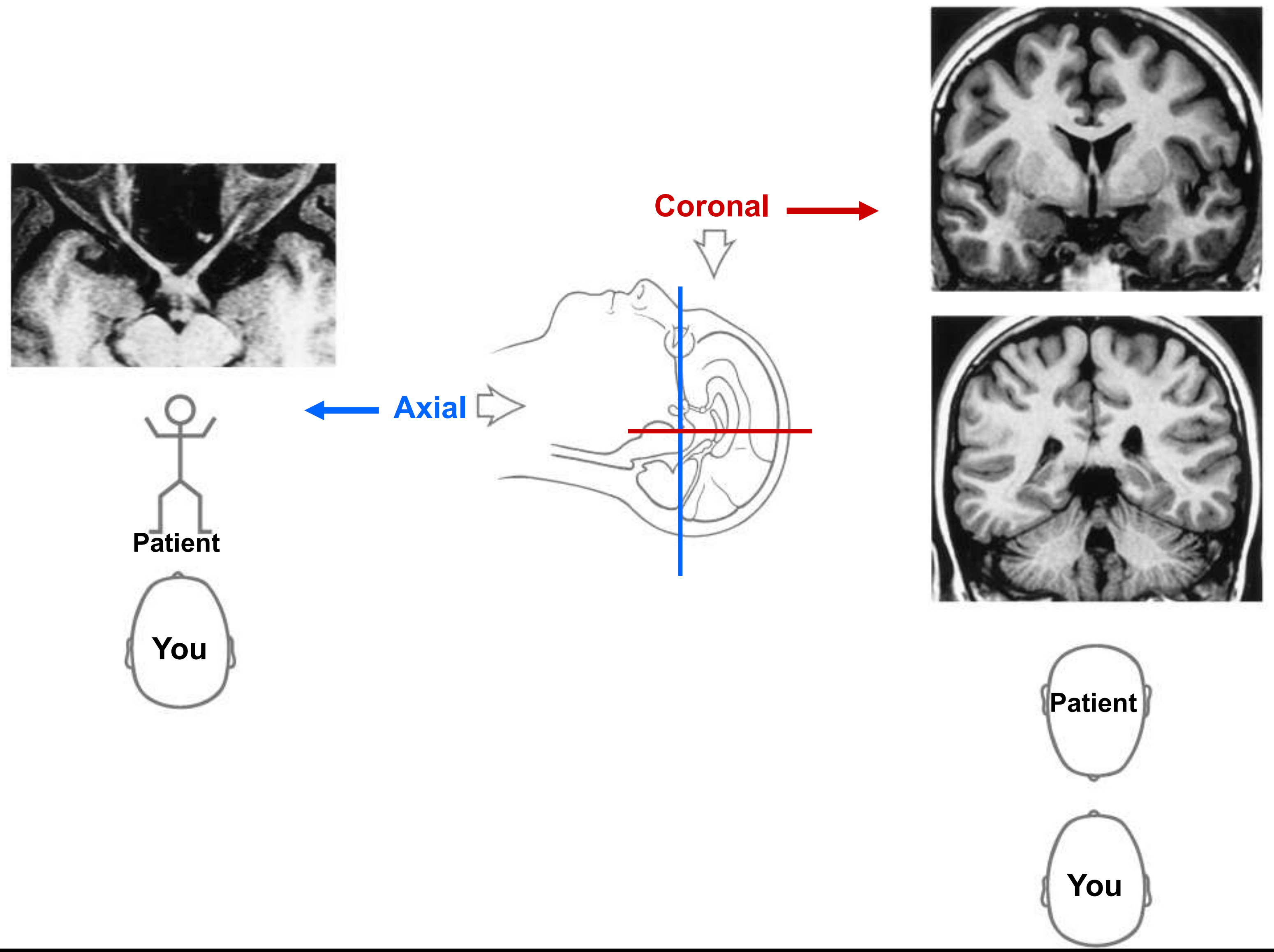
A Second Cardinal Plane to Learn AND Understand–Mid-Axial



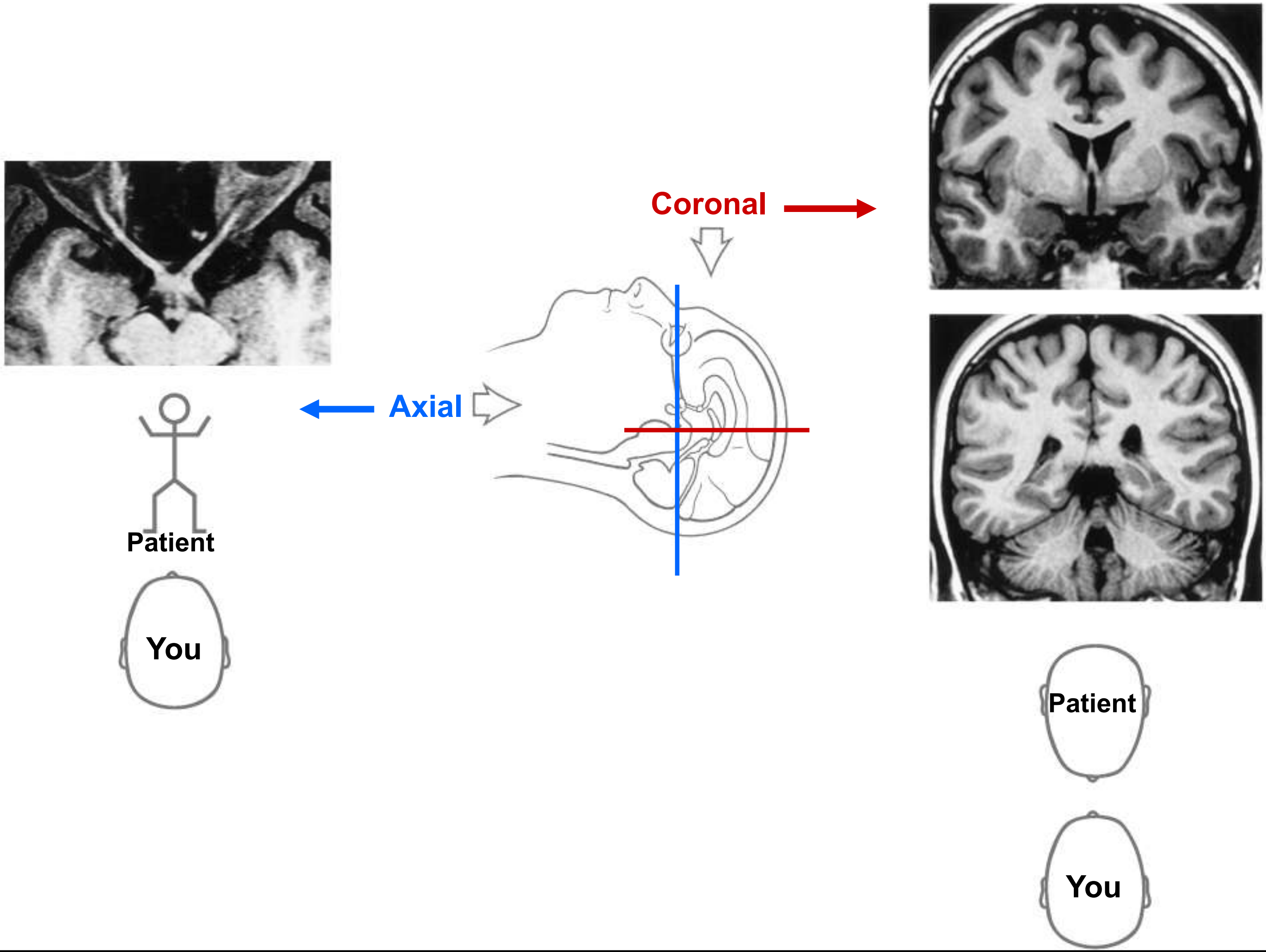


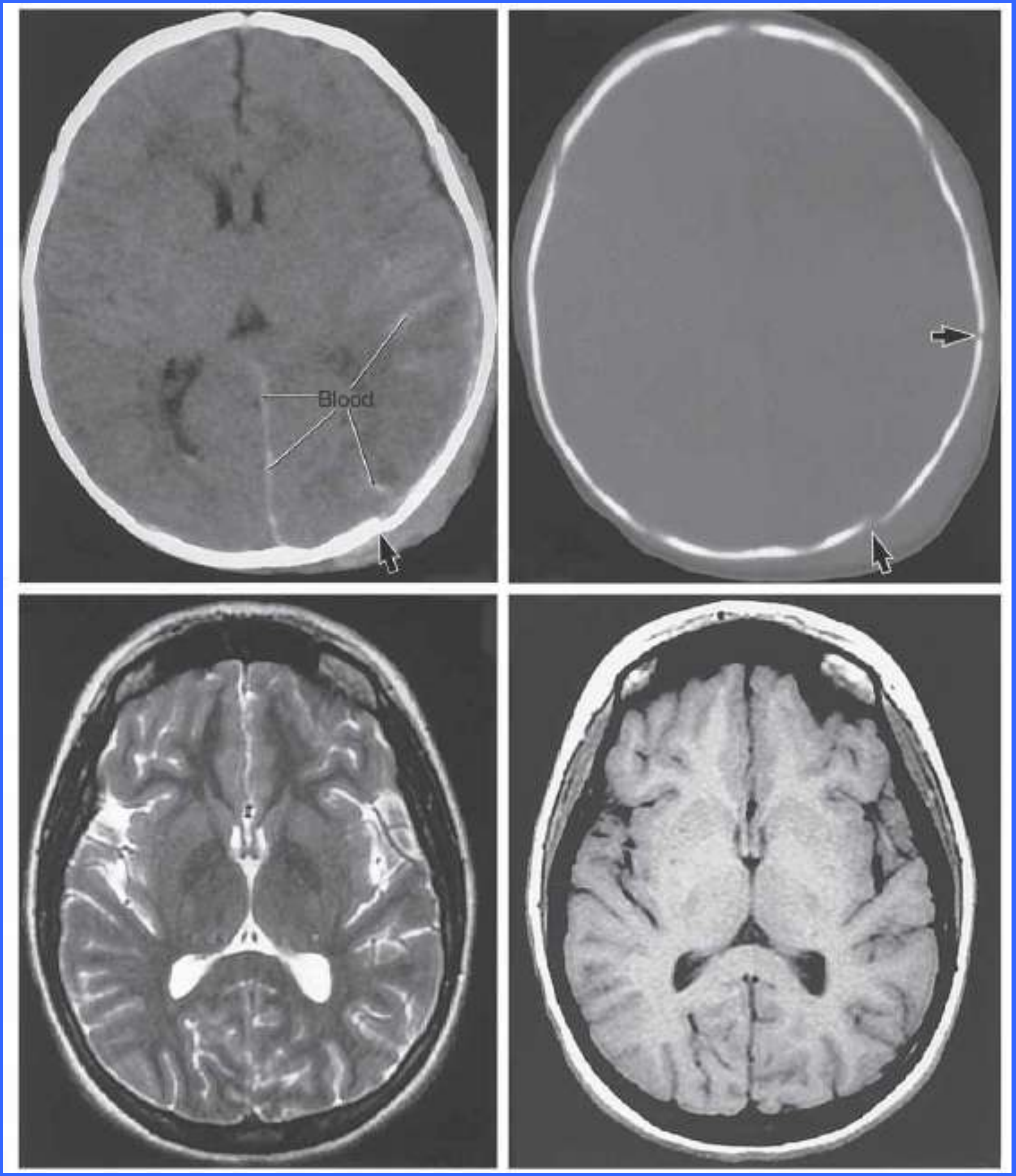
CT & MRI

Remember, Your Right is the Patient's Left



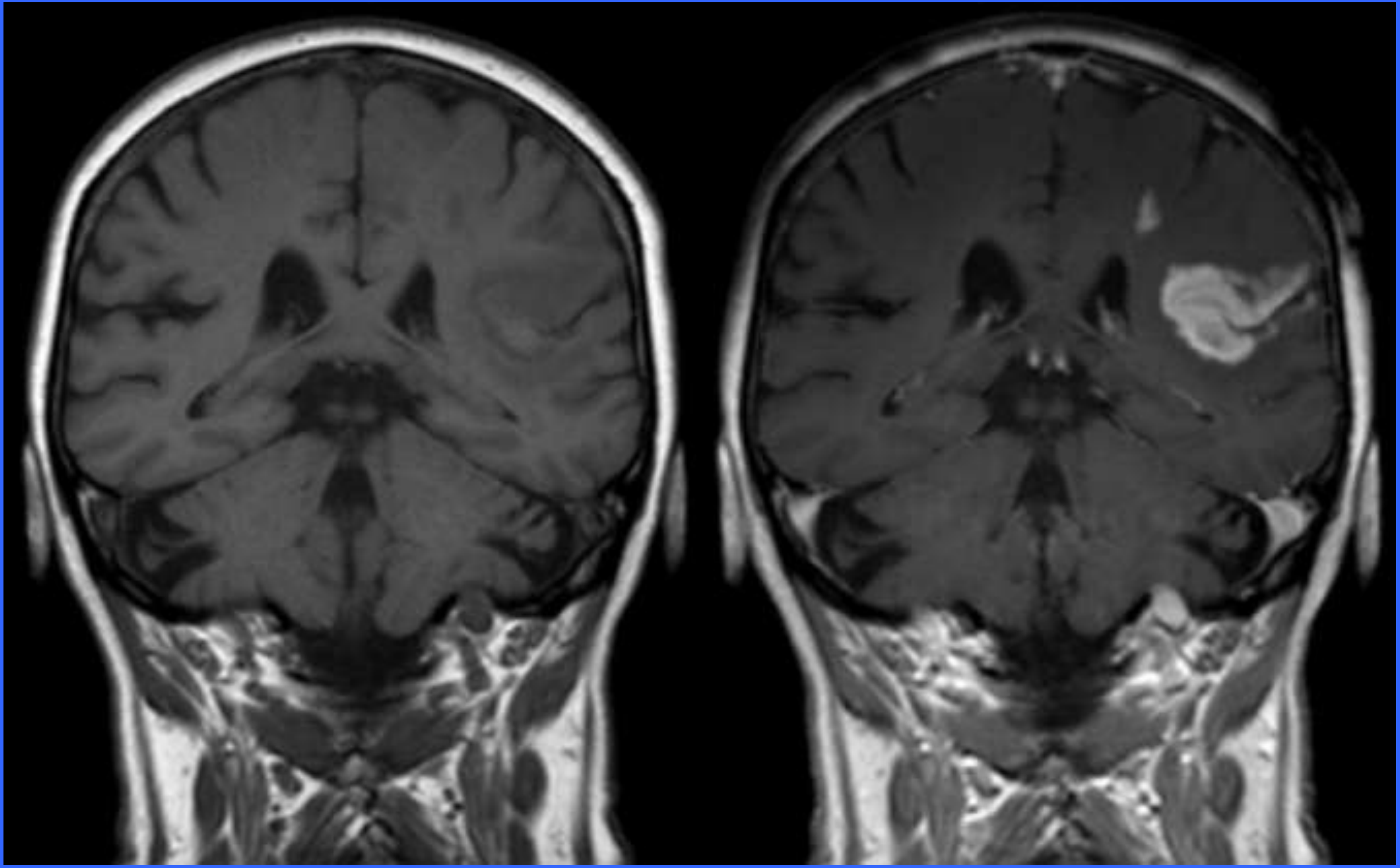
Remember, Your Right is the Patient's Left

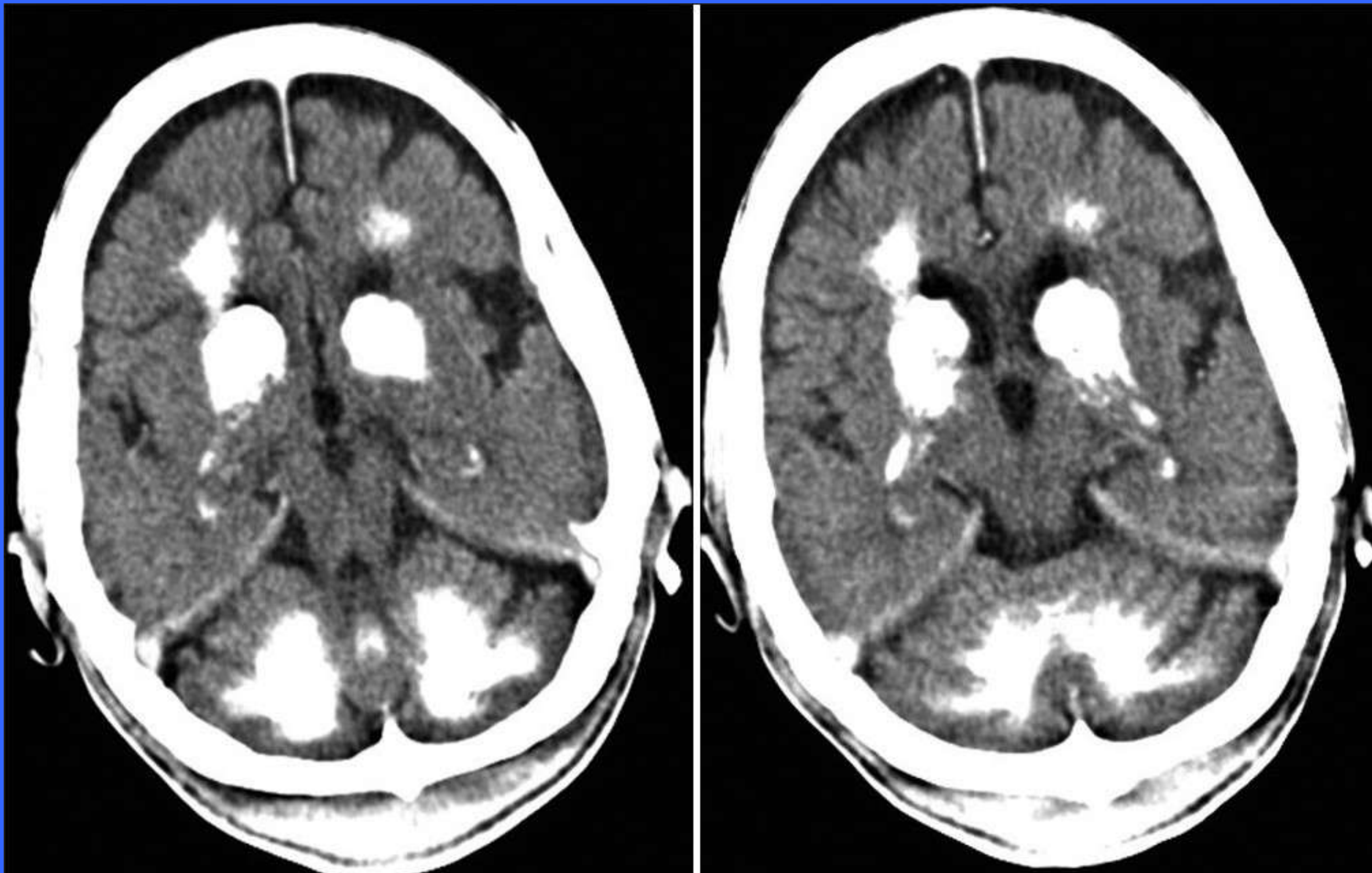



Blood

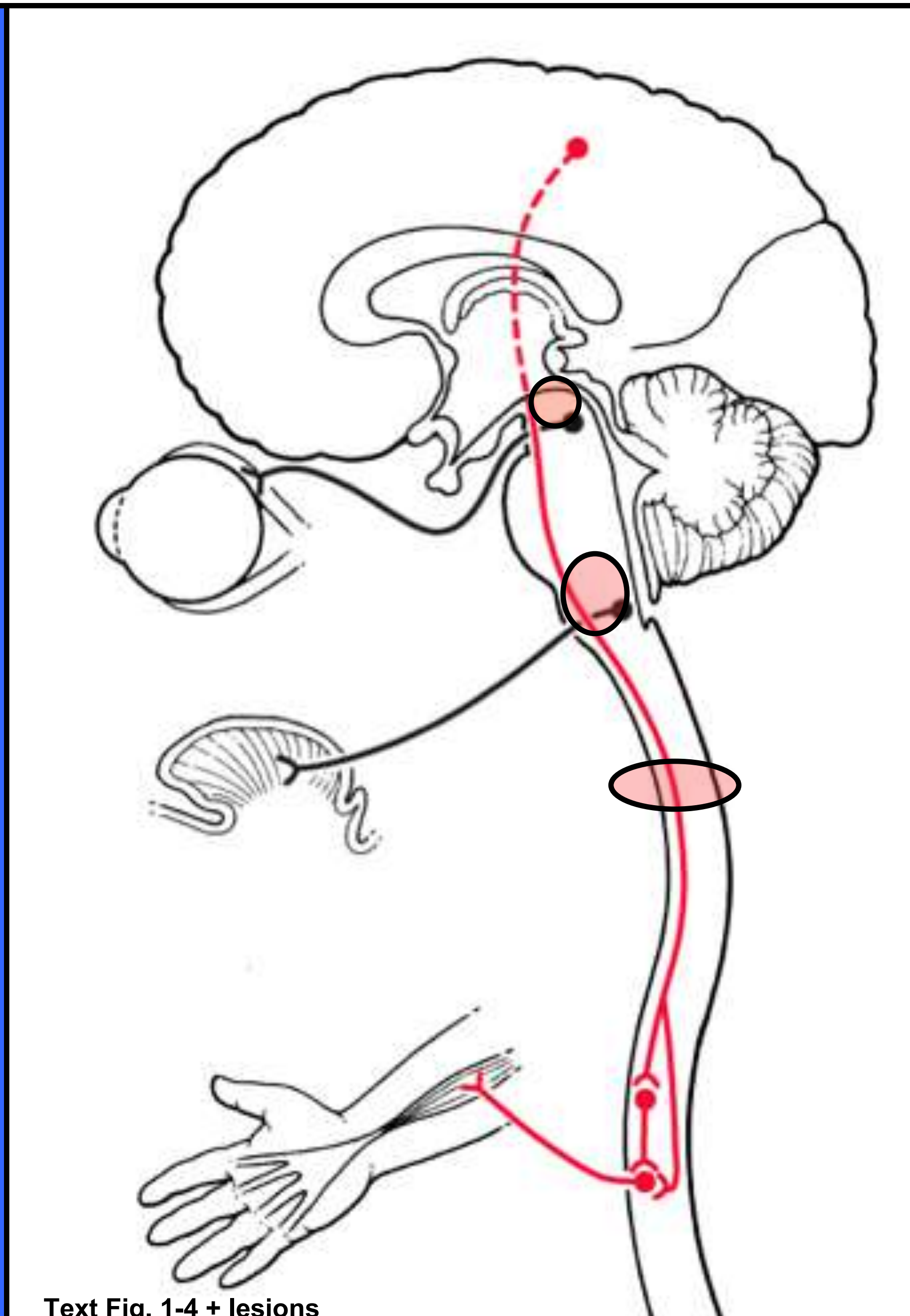
infarction

tumor





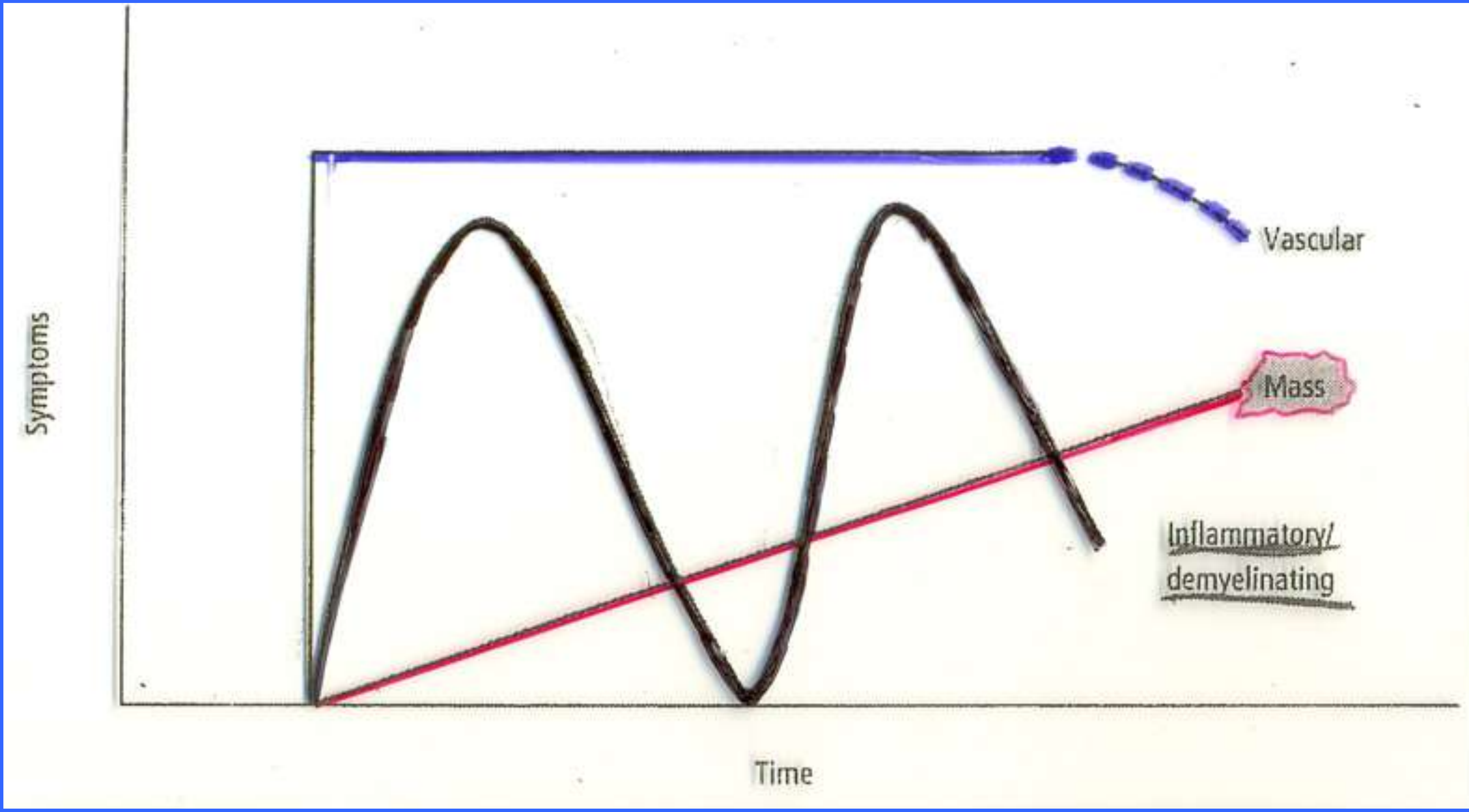
Lesions: localization and types in nervous system



Text Fig. 1-4 + lesions

You have been asked to neurologically test a 56 year old patient in a hospital room. Although he was open his eyes, he looked comatose and when you asked him questions he did not reply or do anything. However his wife told you that he usually communicates with her by blinking his eyes, and she asked her husband to blink once for “yes” and twice for “no”. Then you asked him if he were at home and he blinked twice. When you asked if he were in a hospital, he blinked once. Then you asked him to move his eyes, and he was able to look in your direction. However, when you asked him if he could move his arms or legs, he blinked twice. He also blinked twice when you asked if he could smile and when asked if he could feel someone moving his arm or leg. Which of the following is the most description of his lesion?

A. Uncal herniation bilaterally
B. Upward Cerebellar Herniation bilaterally
C. Bilateral internal capsule stroke
D. Bilateral Upper midbrain stroke
E. Bilateral pontine tegmentum stroke


Vascular
Mass
Inflammatory/
demyelinating
Symptoms
Time

Types of sensation

- types of sensations
  - General sensation
    - Somatic
    - visceral
  - Special senses
    - Smell, taste, vision etc

Types of sensation

- types of sensations

Types of sensation

- types of sensations
  - General sensation
    - Somatic → exteroceptor, proprioceptor
    - visceral
  - Special senses
    - Smell, taste, vision etc

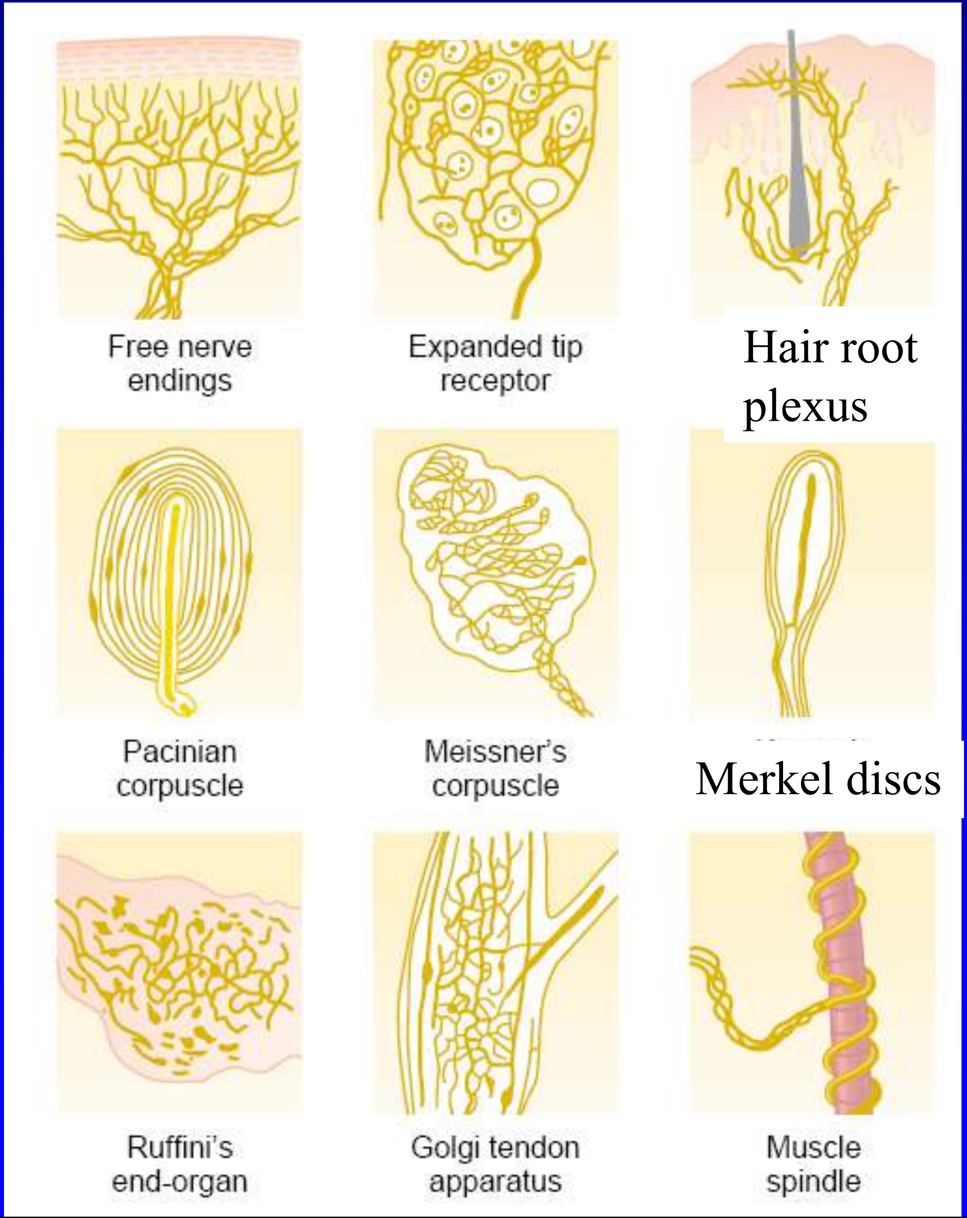
Types of sensation

- types of sensations
  - General sensation
    - Somatic
    - visceral
  - Special senses
    - Smell, taste, vision etc

exteroceptor

Proprioceptor : muscle length and tension, joint position and their motion

Sensations receptors



Types of Sensory Receptors

- Mechanoreceptors
  - detect deformation
- Thermoreceptors
  - detect change in temperature
- Nociceptors
  - detect damage (pain receptors)
- Electromagnetic
  - detect light
- Chemoreceptors
  - taste, smell

Classification of Somatic Sensations

- mechanoreceptive - stimulated by mechanical displacement.
  - tactile
    - touch
    - pressure
    - vibration
    - tickle and itch
  - position or proprioceptive
    - static position
    - rate of change

Classification of Somatic Sensations

- thermoreceptive.
  - detect heat and cold.
- nociceptive.
  - detect pain and are activated by any factor that damages tissue.

Receptor Excitation

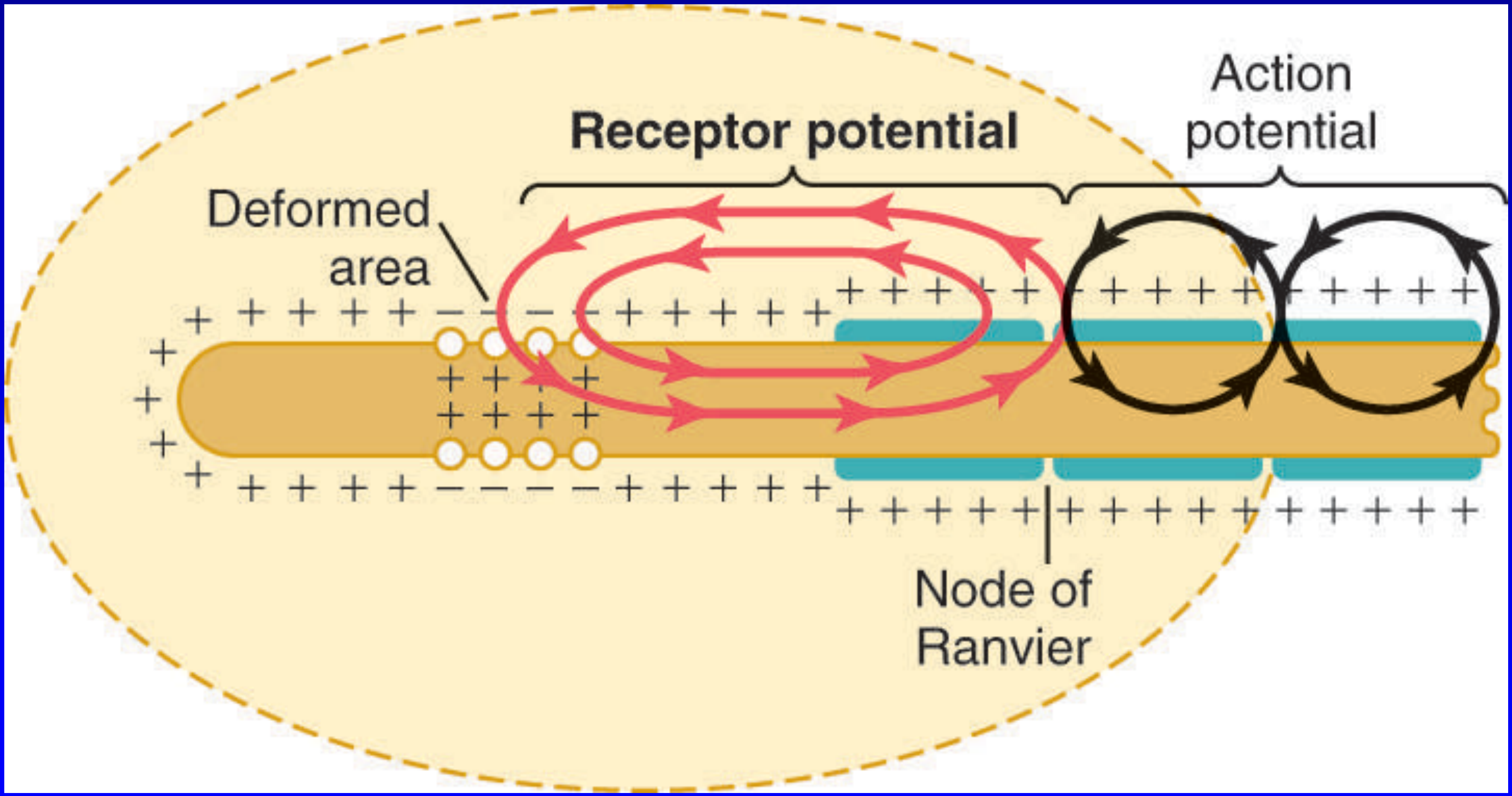


Figure 46-03

Receptor Potential

- the membrane potential of the receptor.
  - excitation of the receptor results from a change in this potential.
  - when the receptor potential rises above the threshold, action potentials appear and the receptor is active.
  - the greater the intensity of the stimulus, the greater the receptor potential, and the greater the rate of action potential generation.

Relationship between receptor potential and action potentials

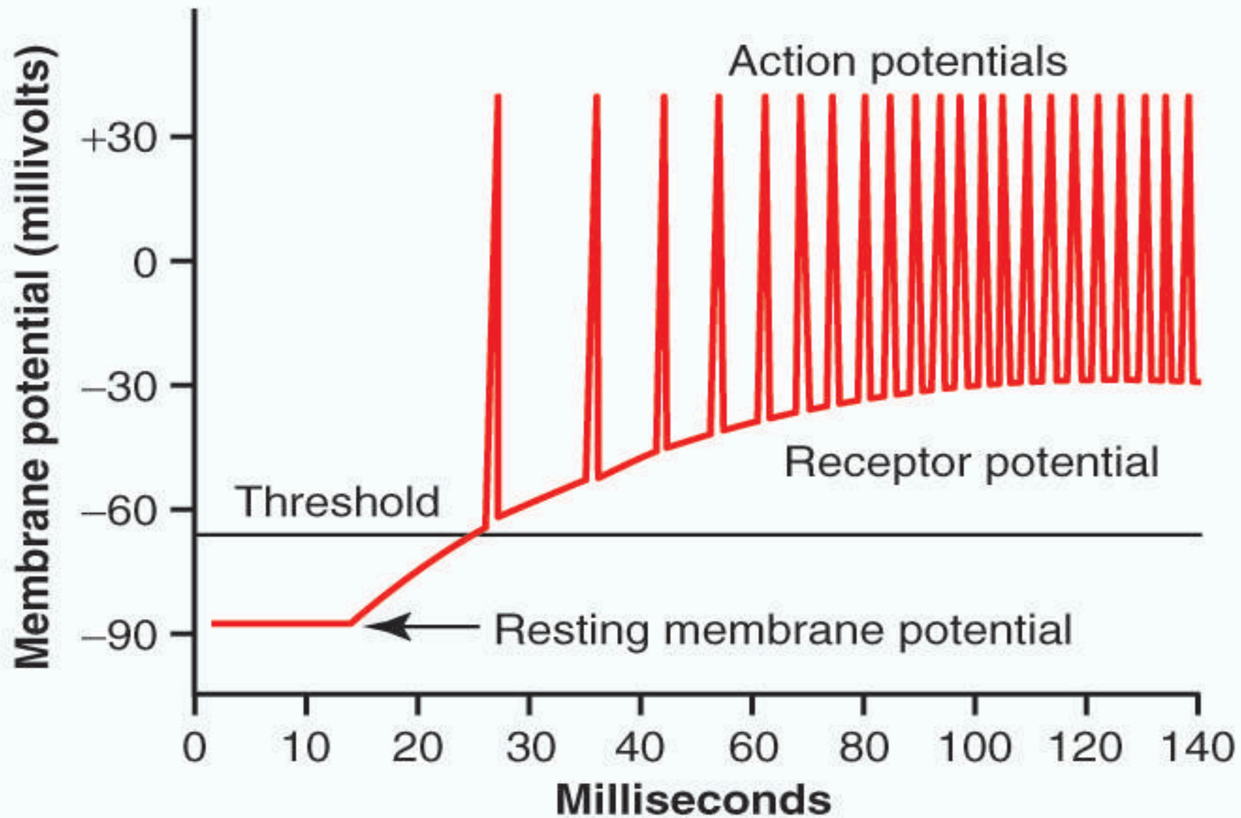


Figure 46-2

Adaptation of Receptors

- when a continuous stimulus is applied, receptors respond rapidly at first, but response declines until all receptors stop firing.

Adaptation of Receptors

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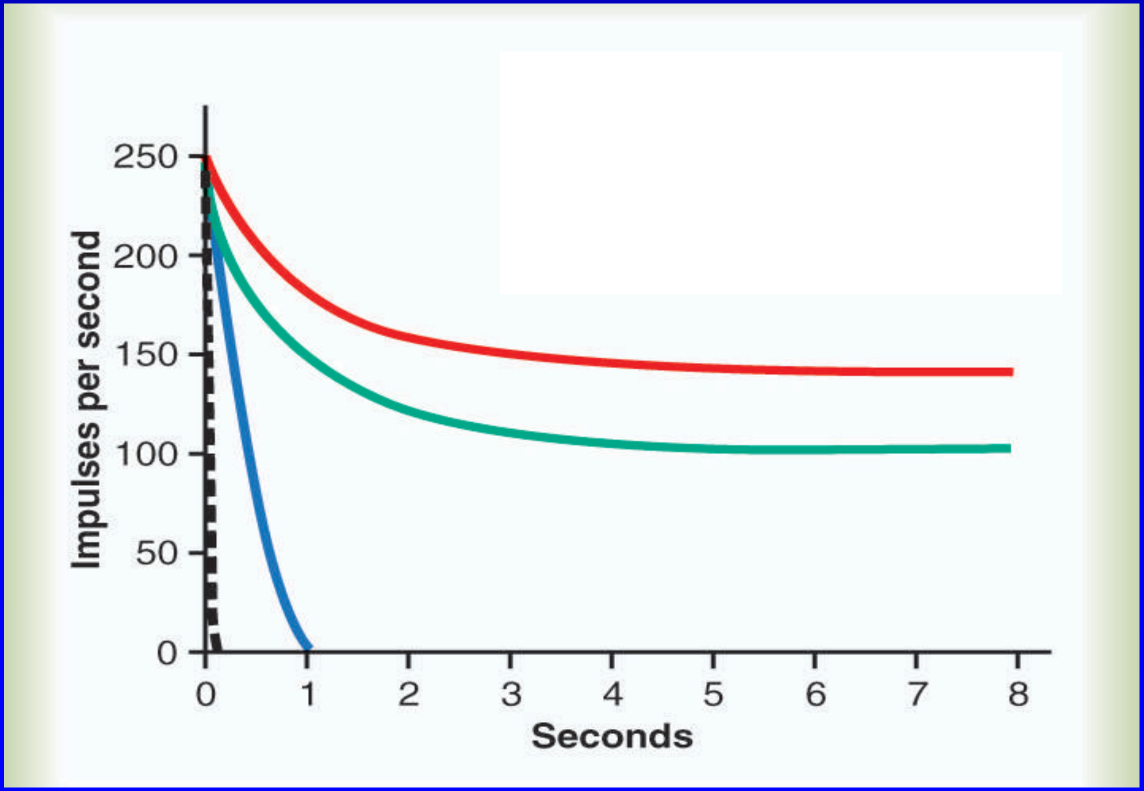
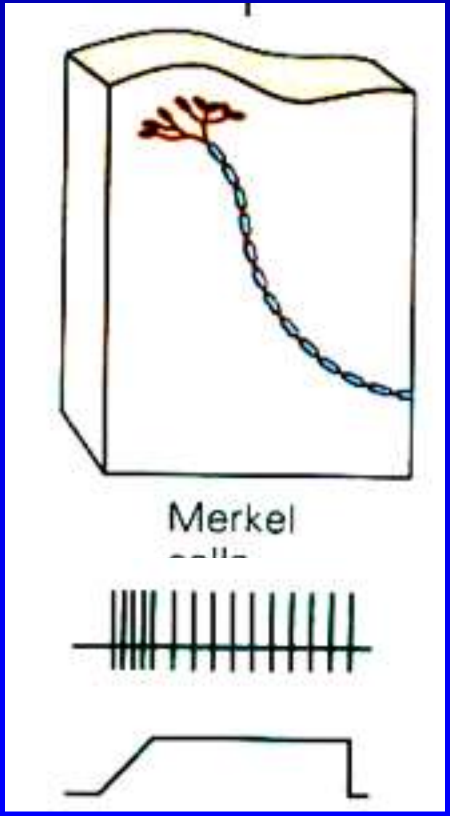


Figure 46-5

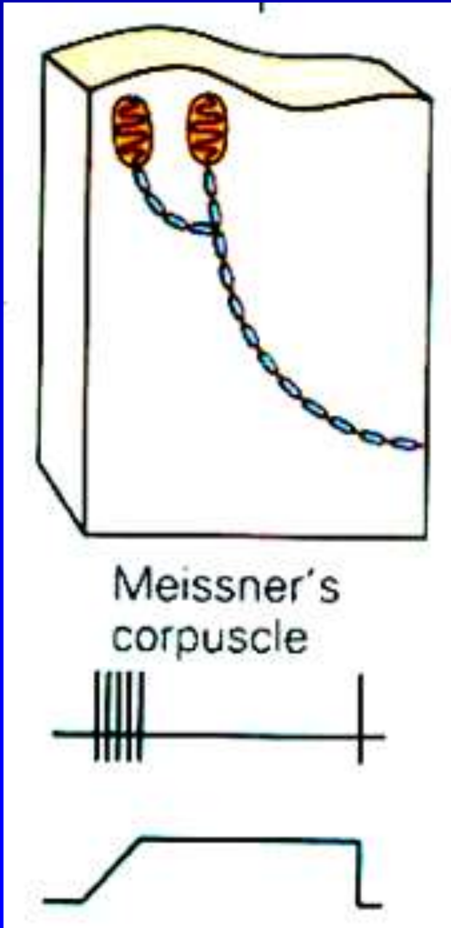
Slowly Adapting (Tonic) Receptors

- continue to transmit impulses to the brain for long periods of time while the stimulus is present.
- keep brain apprised of the status of the body with respect to its surroundings.
- will adapt to extinction as long as the stimulus is present, however, this may take hours or days.

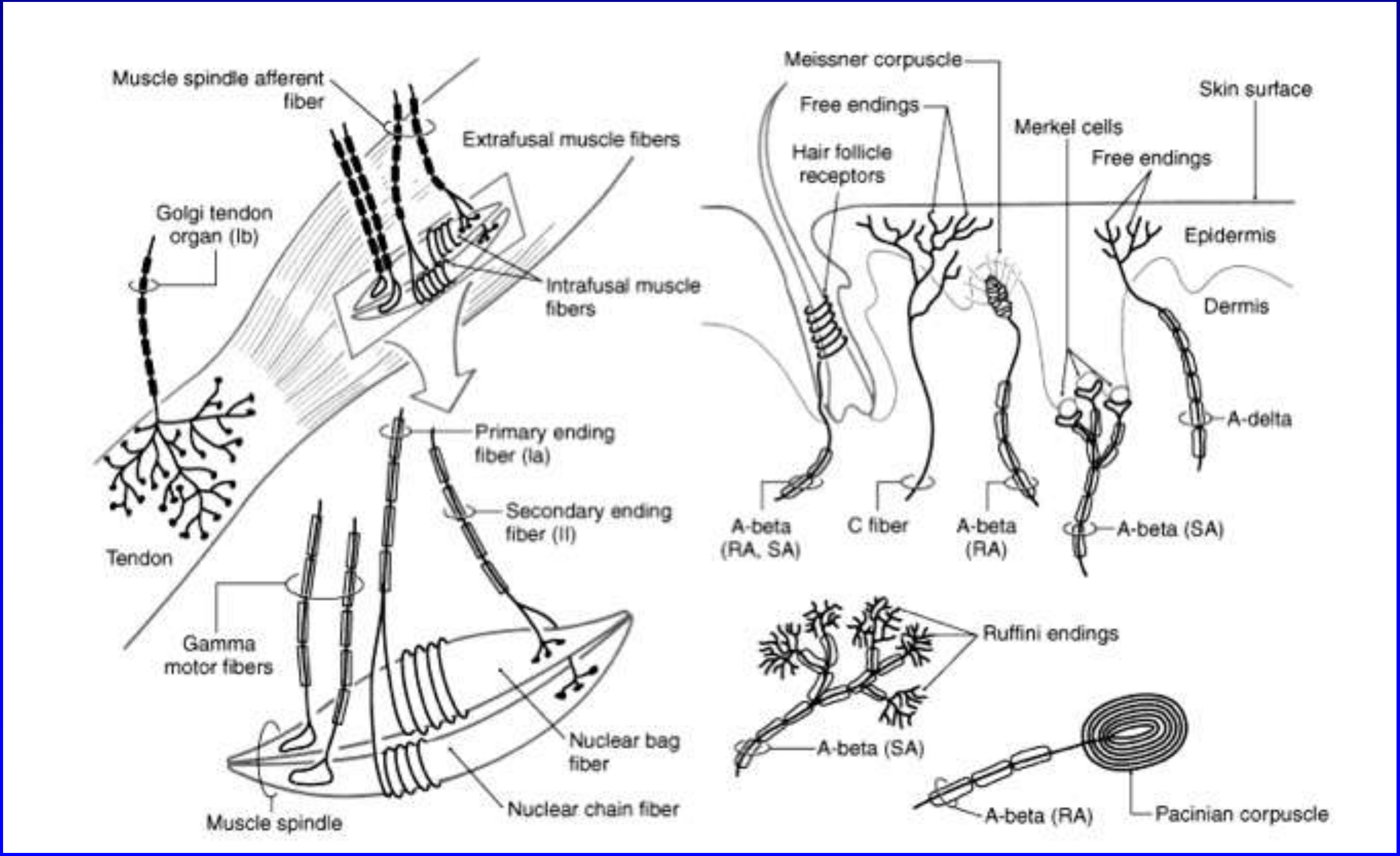


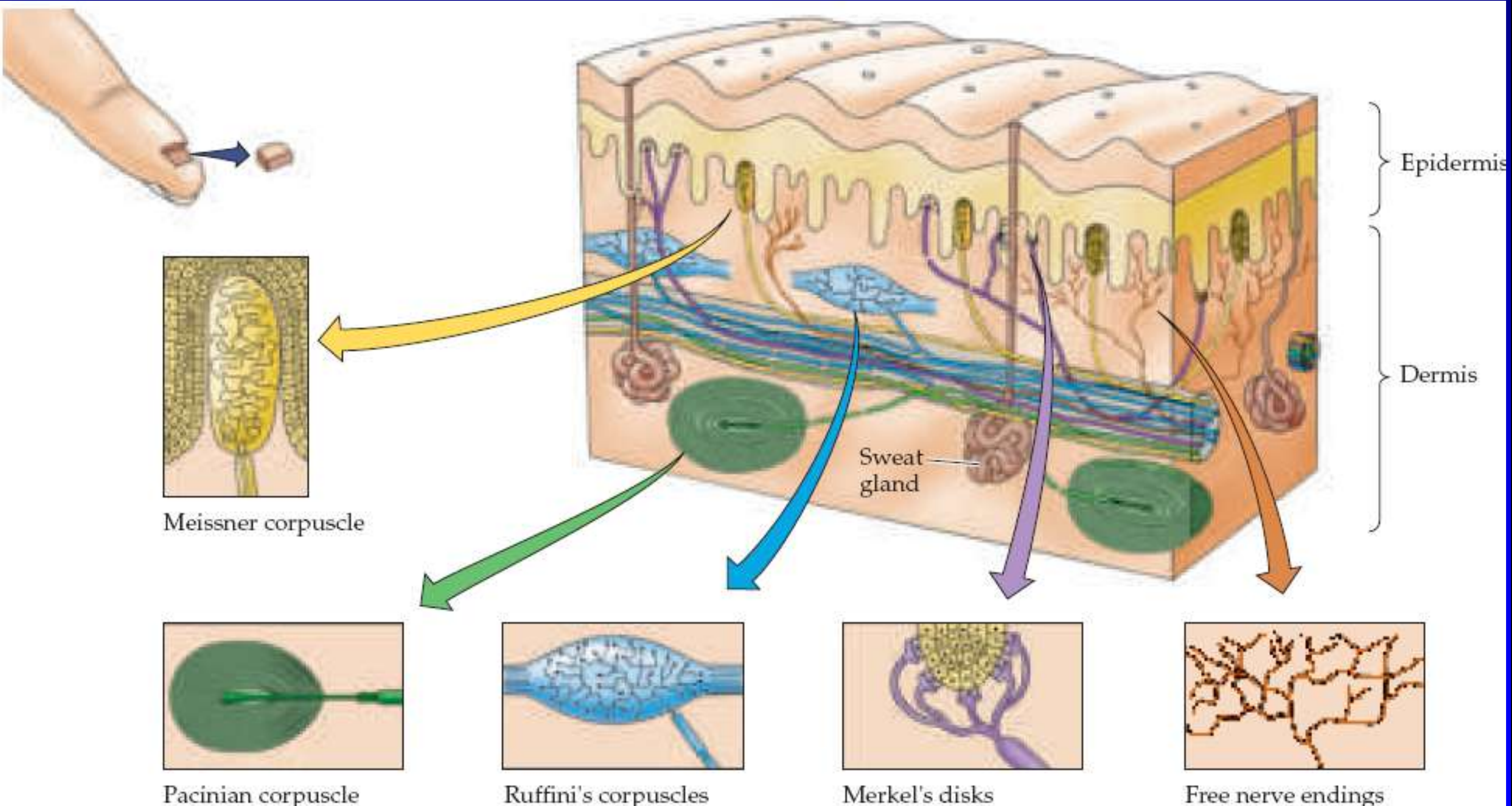
Rapidly Adapting (Phasic) Receptors

- respond only when change is taking place.
- rate and strength of the response is related to the rate and intensity of the stimulus.
- important for predicting the future position or condition of the body.
- very important for balance and movement.



Sensations receptors





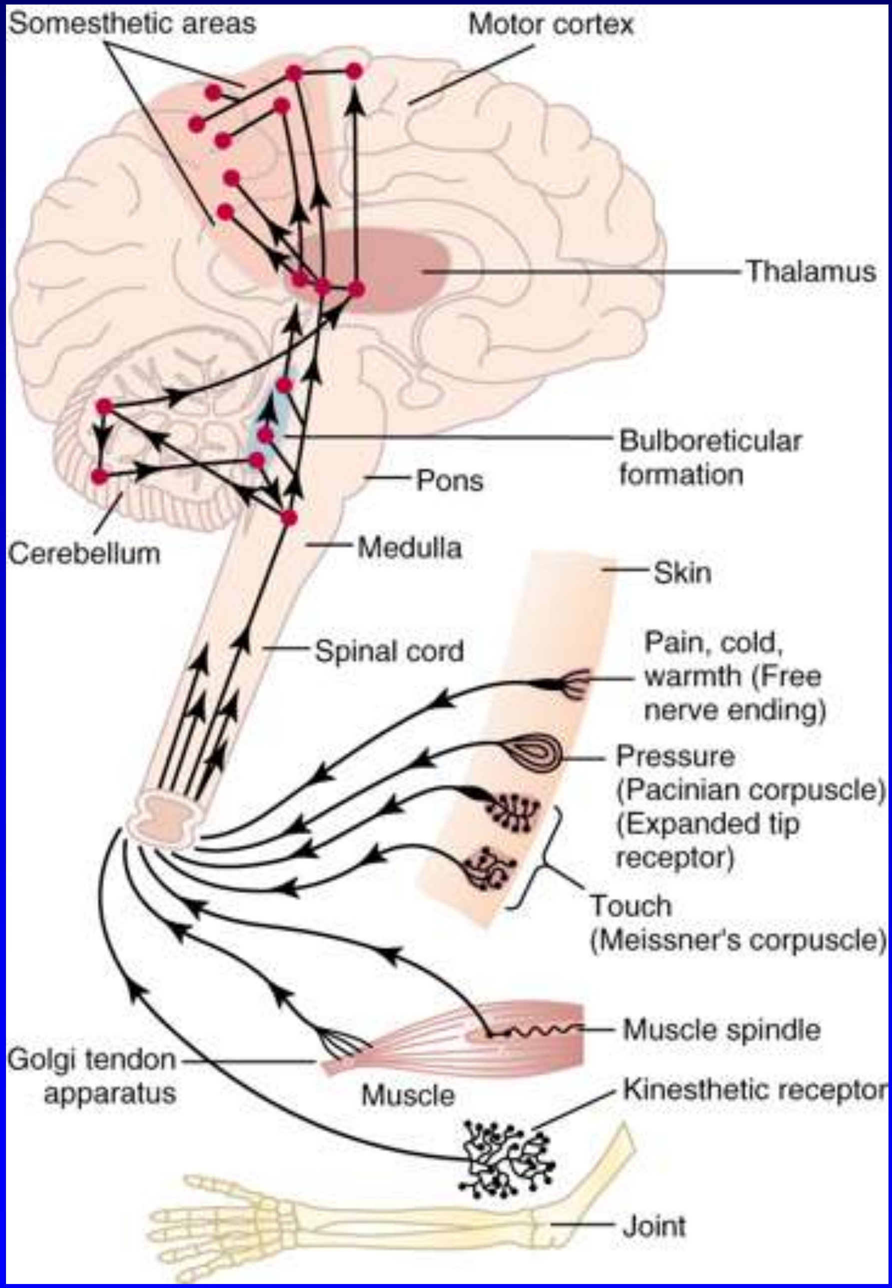
Epidermis
Dermis
Sweat gland
Meissner corpuscle
Pacinian corpuscle
Ruffini's corpuscles
Merkel's disks
Free nerve endings

TABLE 8.1

The Major Classes of Somatic Sensory Receptors

Receptor type	*Anatomical characteristics*	*Associated axons[a] (and diameters)*	*Axonal conduction velocities*	*Location*	*Function*	*Rate of adaptation*	*Threshold of activati*
Free nerve endings	Minimally specialized nerve endings	C, Aδ	2–20 m/s	All skin	Pain, temperature, crude touch	Slow	High
Meissner's corpuscles	Encapsulated; between dermal papillae	Aβ 6–12 μm		Principally glabrous skin	Touch, pressure (dynamic)	Rapid	Low
Pacinian corpuscles	Encapsulated; onionlike covering	Aβ 6–12 μm		Subcutaneous tissue, interosseous membranes, viscera	Deep pressure, vibration (dynamic)	Rapid	Low
Merkel's disks	Encapsulated; associated with peptide-releasing cells	Aβ		All skin, hair follicles	Touch, pressure (static)	Slow	Low
Ruffini's corpuscles	Encapsulated; oriented along stretch lines	Aβ 6–12 μm		All skin	Stretching of skin	Slow	Low
Muscle spindles	Highly specialized (see Figure 8.5 and Chapter 15)	Ia and II		Muscles	Muscle length	Both slow and rapid	Low
Golgi tendon organs	Highly specialized (see Chapter 15)	Ib		Tendons	Muscle tension	Slow	Low
Joint receptors	Minimally specialized	—		Joints	Joint position	Rapid	Low

Physiology of the sensory system



Somesthetic areas
Motor cortex
Thalamus
Bulboreticular formation
Pons
Cerebellum
Medulla
Skin
Spinal cord
Pain, cold, warmth (Free nerve ending)
Pressure (Pacinian corpuscle)
(Expanded tip receptor)
Touch (Meissner's corpuscle)
Muscle spindle
Golgi tendon apparatus
Muscle
Kinesthetic receptor
Joint

Types of Sensory Receptors

- Mechanoreceptors
  – detect deformation
- Thermoreceptors
  – detect change in temperature
- Nociceptors
  – detect damage (pain receptors)
- Electromagnetic
  – detect light
- Chemoreceptors
  – taste, smell

Receptor Excitation

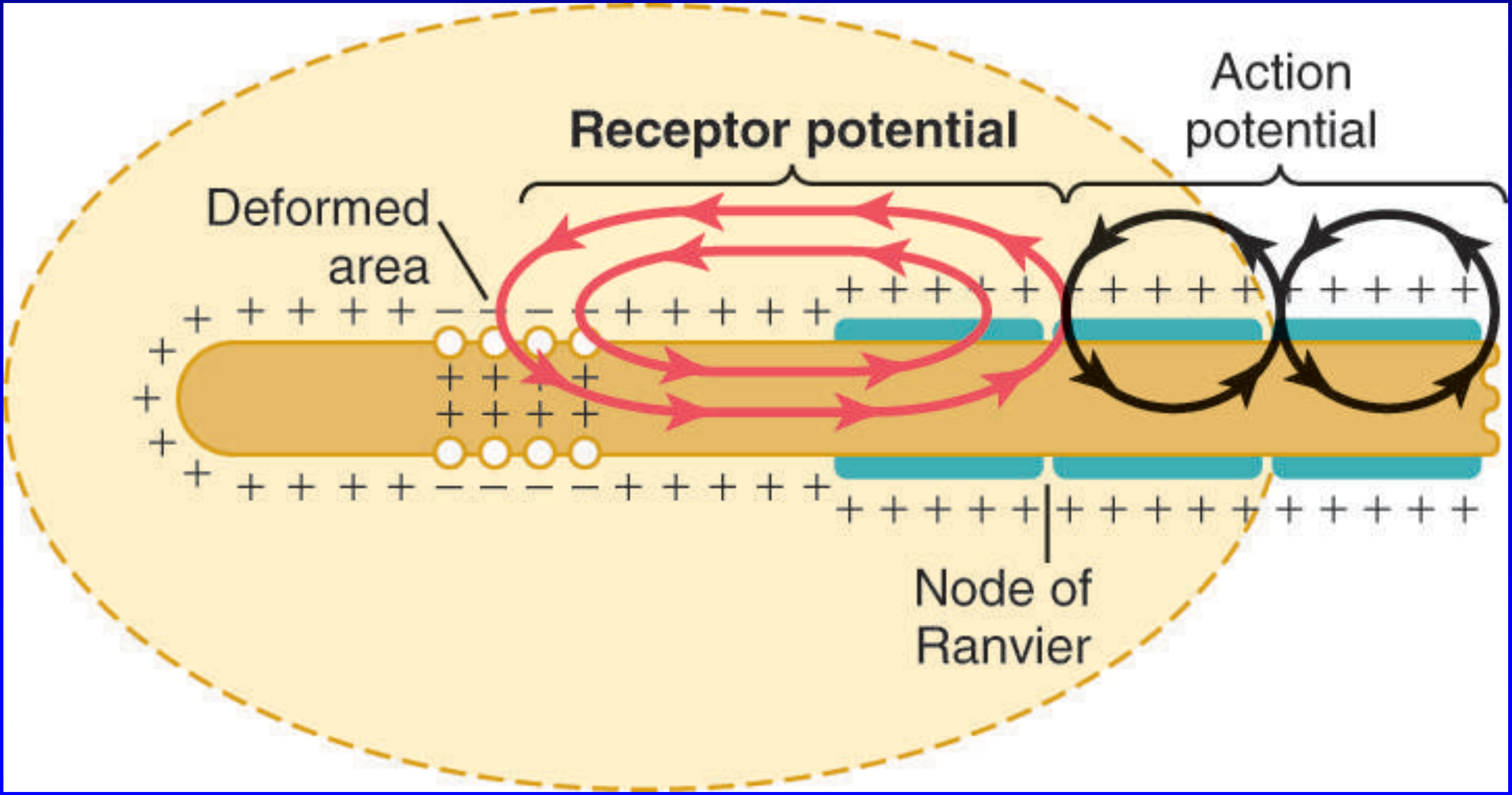


Figure 46-03

Receptor Potential

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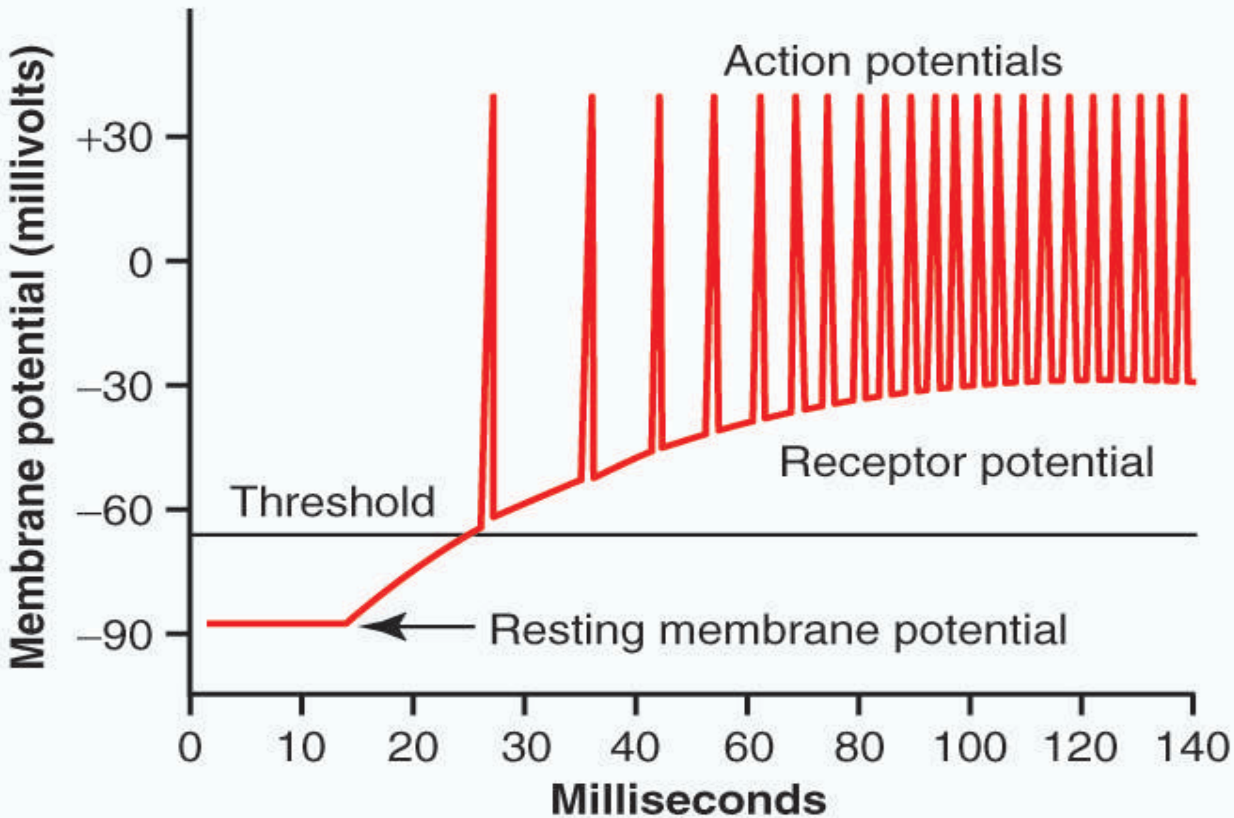
Relationship between receptor potential and action potentials



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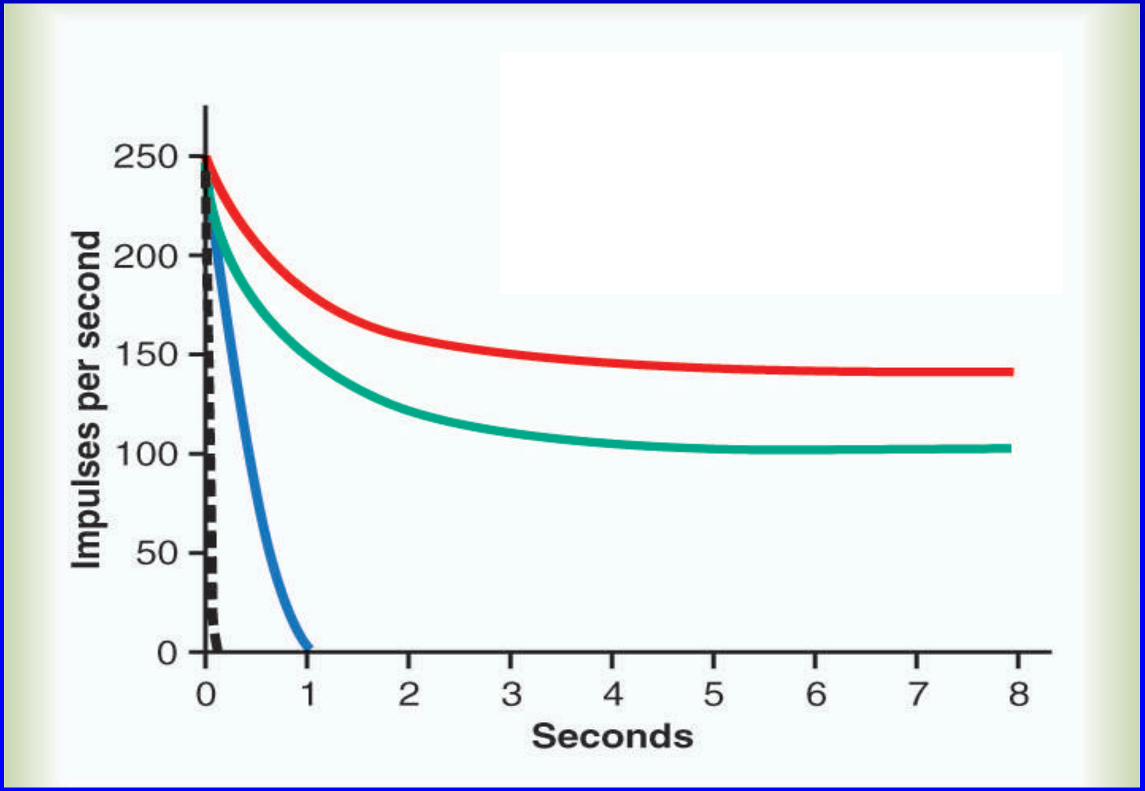


Figure 46-5

Sensations receptors

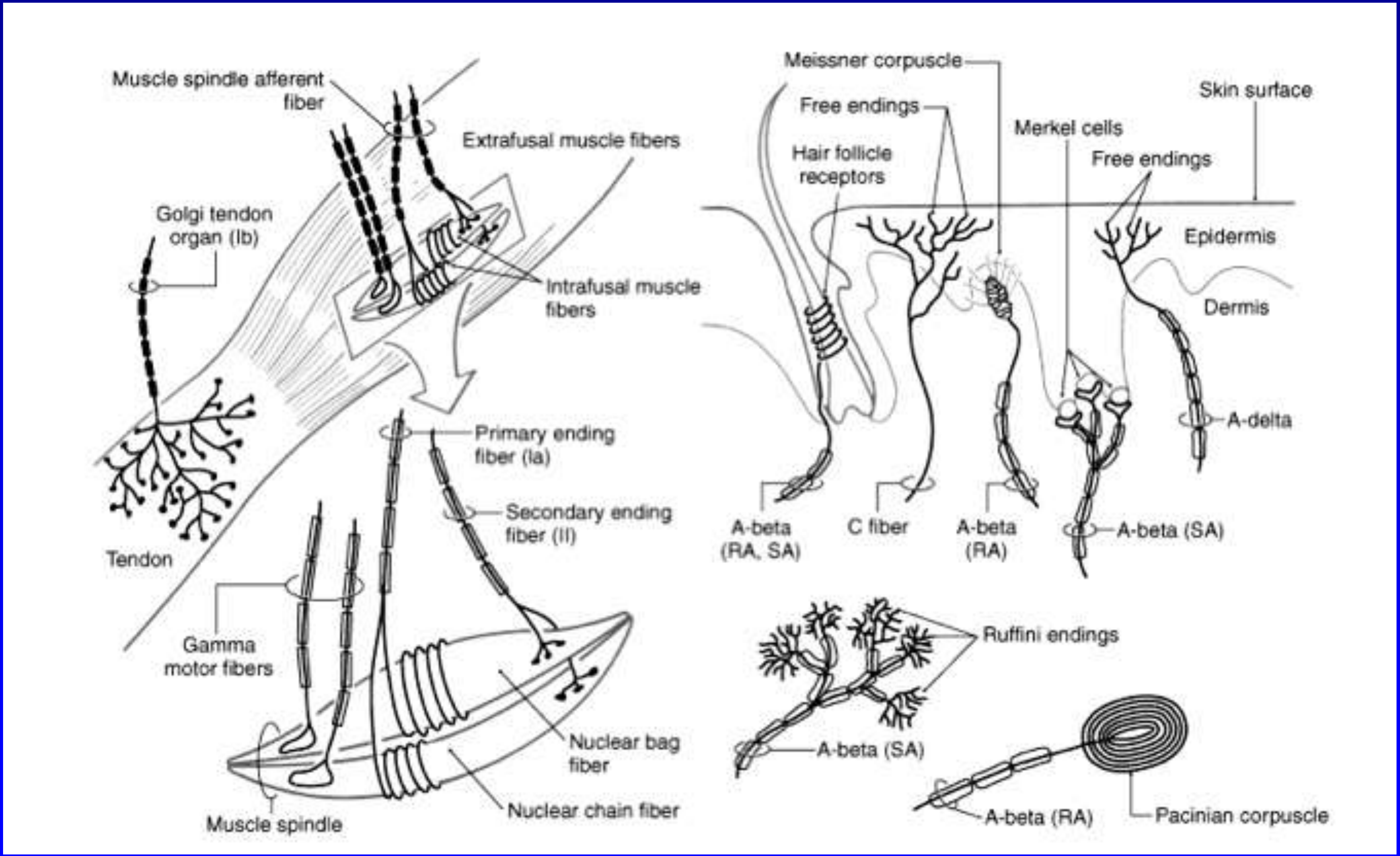


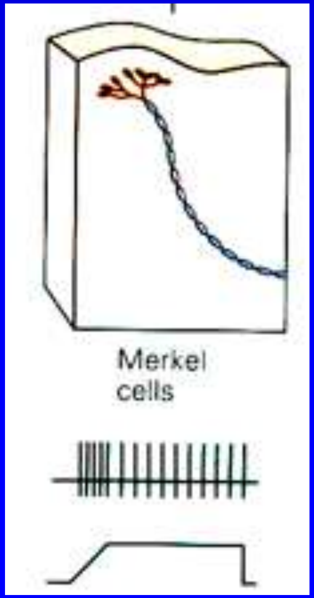
TABLE 16.2

Summary of Receptors for Somatic Sensations

RECEPTOR TYPE	RECEPTOR STRUCTURE AND LOCATION	SENSATIONS	ADAPTATION RATE
TACTILE RECEPTORS			
Meissner corpuscles (Corpuscles of touch)	Capsule surrounds mass of dendrites in dermal papillae of hairless skin.	Touch, pressure, and slow vibrations.	Rapid.
Hair root plexuses	Free nerve endings wrapped around hair follicles in skin.	Touch.	Rapid.
Merkel (tactile) discs (Type I cutaneous mechanoreceptors)	Saucer-shaped free nerve endings make contact with Merkel cells in epidermis.	Touch and pressure.	Slow.
Ruffini corpuscles (Type II cutaneous mechanoreceptors)	Elongated capsule surrounds dendrites deep in dermis and in ligaments and tendons.	Stretching of skin.	Slow.
Pacinian (lamellated) corpuscles	Oval, layered capsule surrounds dendrites; present in dermis and subcutaneous layer, submucosal tissues, joints, periosteum, and some viscera.	Pressure and fast vibrations.	Rapid.
Itch and tickle receptors	Free nerve endings in skin and mucous membranes.	Itching and tickling.	Both slow and rapid.
THERMORECEPTORS			
Warm receptors and cold receptors	Free nerve endings in skin and mucous membranes of mouth, vagina, and anus.	Warmth or cold.	Initially rapid, then slow.
PAIN RECEPTORS			
Nociceptors	Free nerve endings in every tissue of the body except the brain.	Pain.	Slow.
PROPRIOCEPTORS			
Muscle spindles	Sensory nerve endings wrap around central area of encapsulated intrafusal muscle fibers within most skeletal muscles.	Muscle length.	Slow.
Tendon organs	Capsule encloses collagen fibers and sensory nerve endings at junction of tendon and muscle.	Muscle tension.	Slow.
Joint kinesthetic receptors	Pacinian corpuscles, Ruffini corpuscles, tendon organs, and free nerve endings.	Joint position and movement.	Rapid.

Tactile Receptors

- Merkel's discs.
  - respond rapidly at first and then slowly adapt, detect the "steady state"
  - found on hairy as well a glabrous skin.



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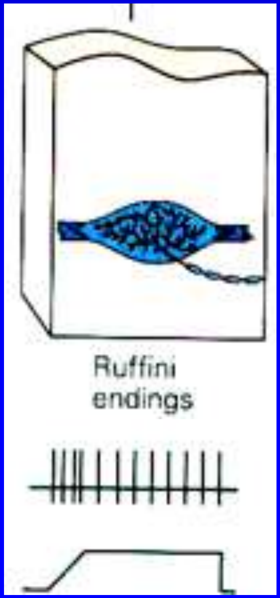
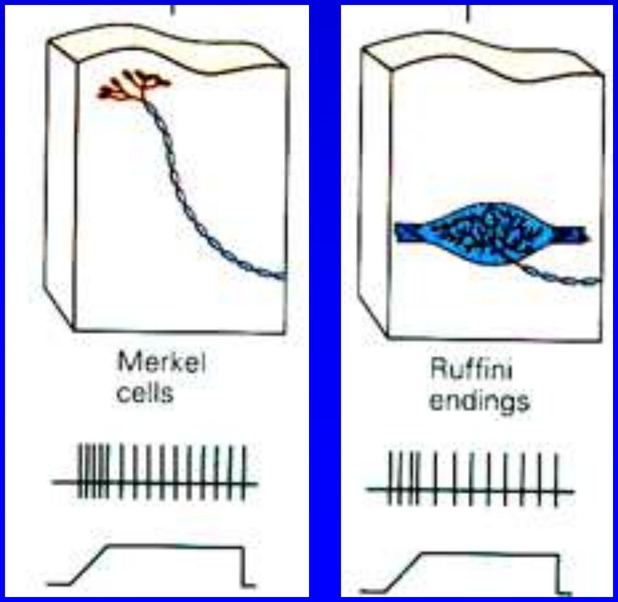
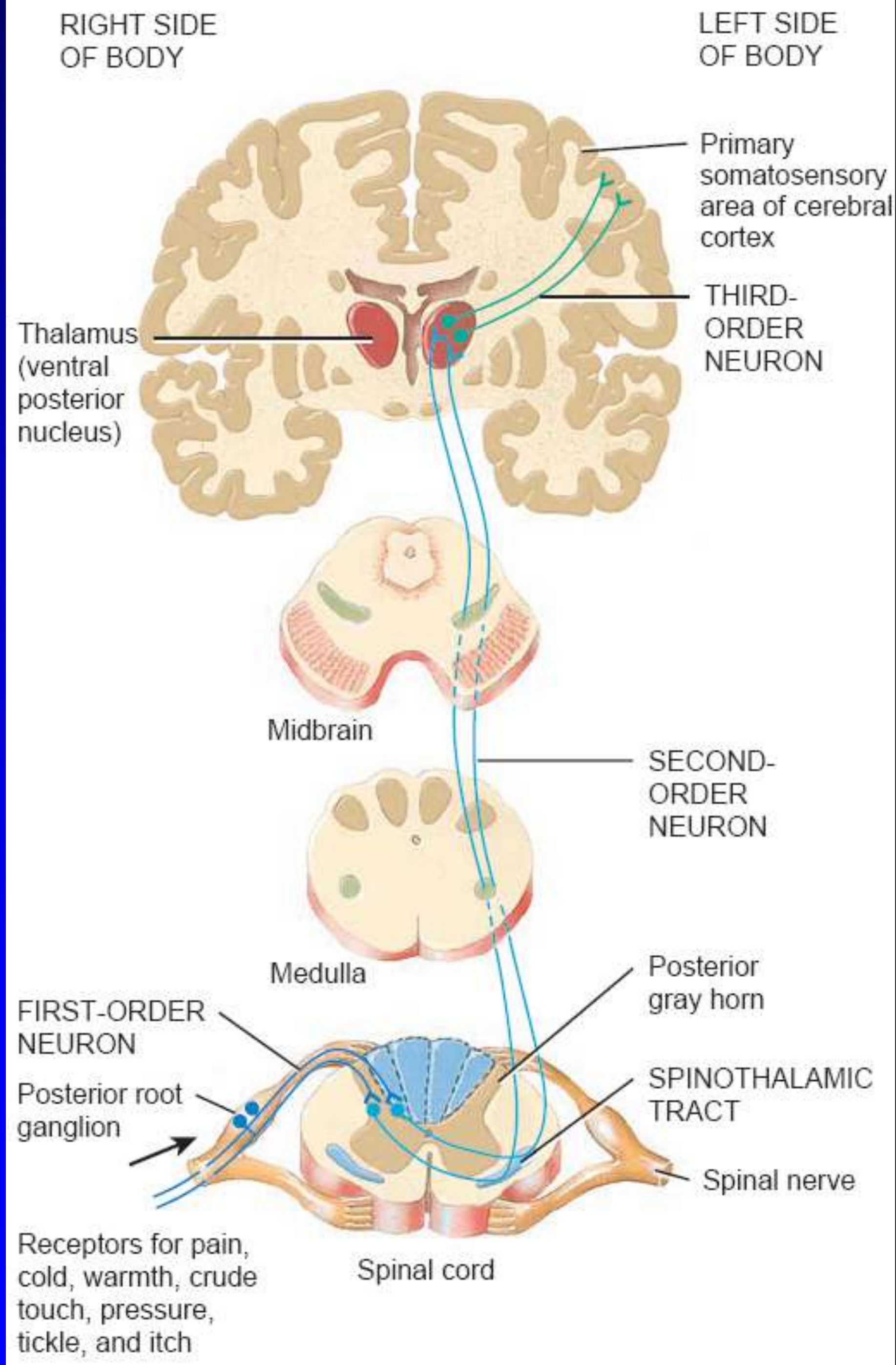


Tactile Receptors

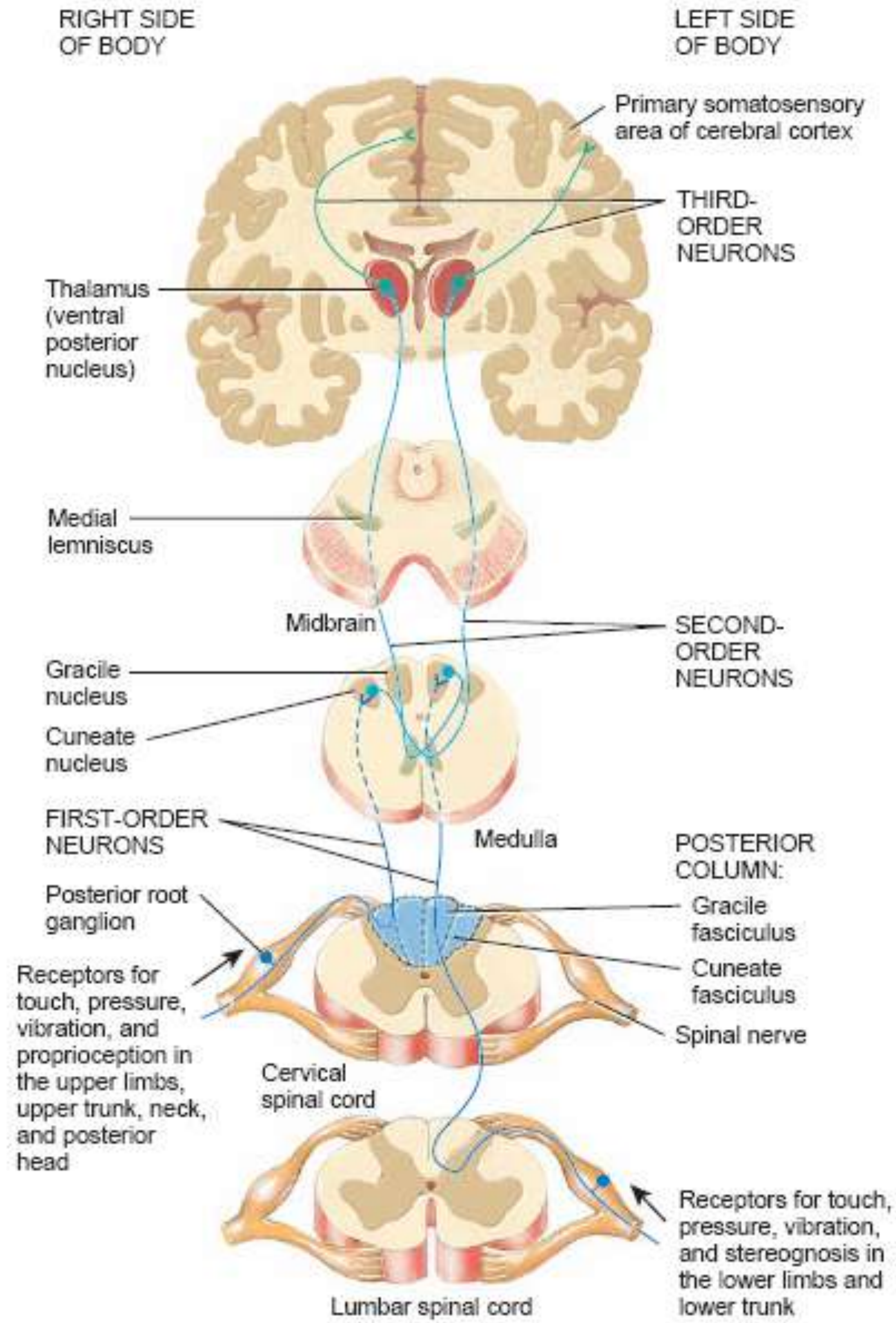
- Merkel's discs.
  - respond rapidly at first and then slowly adapt, detect the "steady state"
  - found on hairy as well a glabrous skin.
- Ruffini's end organ.
  - slowly adapting and respond to continual deformation of the skin and joint rotation.

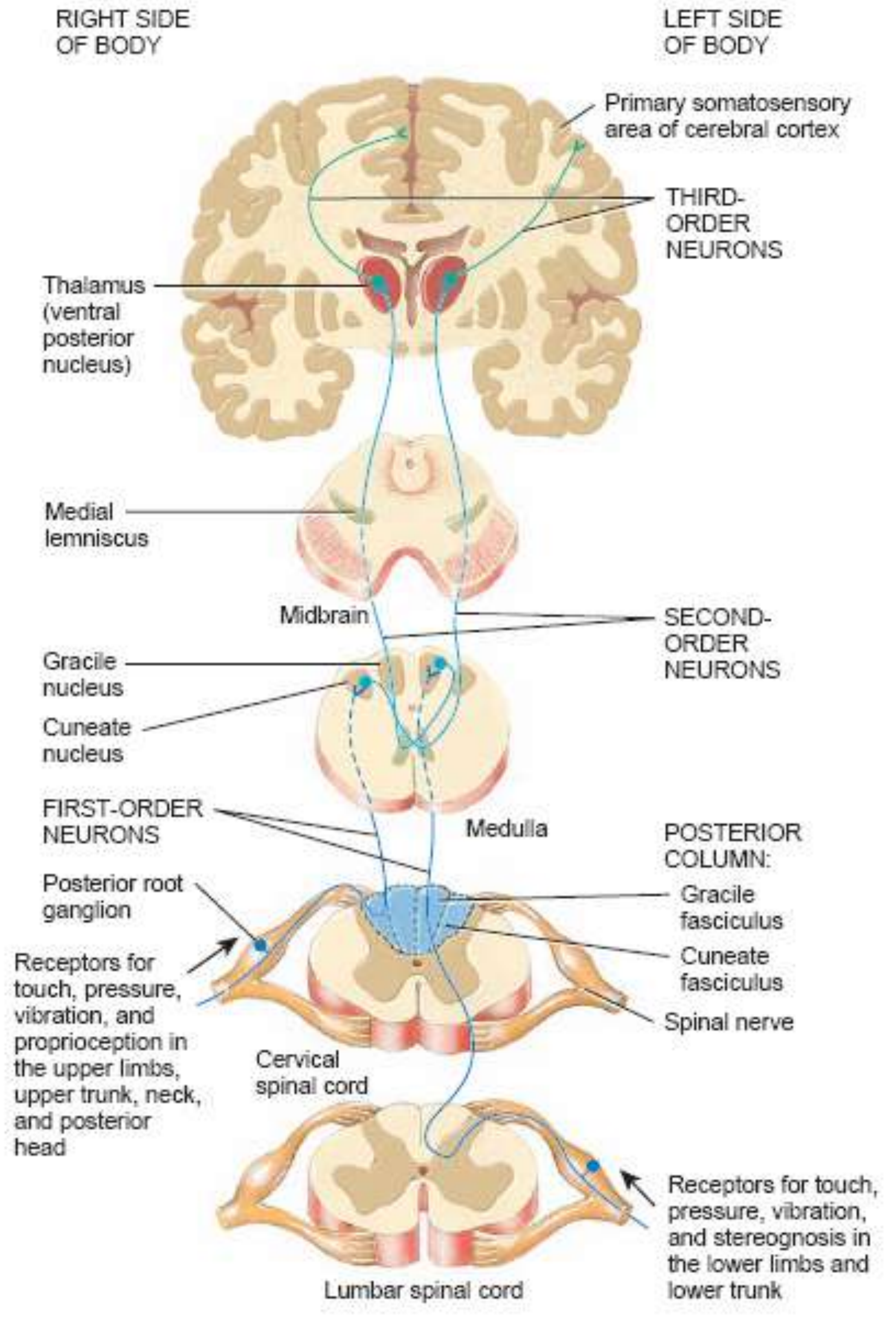


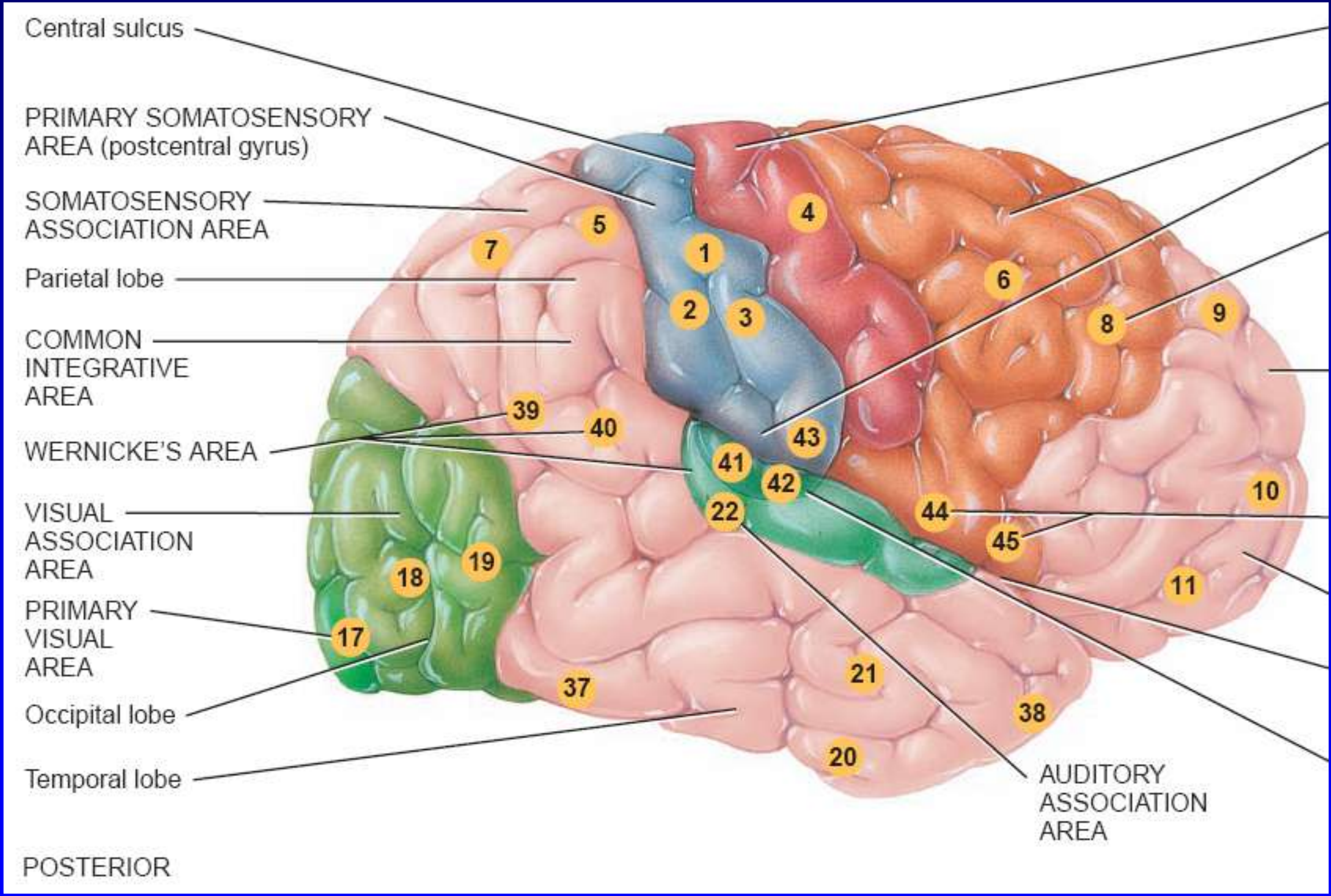
ALS Pathway



RIGHT SIDE OF BODY
LEFT SIDE OF BODY
Primary somatosensory area of cerebral cortex
THIRD-ORDER NEURON
Thalamus (ventral posterior nucleus)
Midbrain
SECOND-ORDER NEURON
Medulla
Posterior gray horn
FIRST-ORDER NEURON
Posterior root ganglion
SPINOTHALAMIC TRACT
Spinal nerve
Receptors for pain, cold, warmth, crude touch, pressure, tickle, and itch
Spinal cord


RIGHT SIDE OF BODY
LEFT SIDE OF BODY
Primary somatosensory area of cerebral cortex
THIRD-ORDER NEURONS
Thalamus (ventral posterior nucleus)
Medial lemniscus
Midbrain
SECOND-ORDER NEURONS
Gracile nucleus
Cuneate nucleus
FIRST-ORDER NEURONS
Medulla
POSTERIOR COLUMN:
Gracile fasciculus
Cuneate fasciculus
Posterior root ganglion
Receptors for touch, pressure, vibration, and proprioception in the upper limbs, upper trunk, neck, and posterior head
Spinal nerve
Cervical spinal cord
Receptors for touch, pressure, vibration, and stereognosis in the lower limbs and lower trunk
Lumbar spinal cord


RIGHT SIDE
OF BODY
LEFT SIDE
OF BODY
Primary somatosensory
area of cerebral cortex
THIRD-
ORDER
NEURONS
Thalamus
(ventral
posterior
nucleus)
Medial
lemniscus
Midbrain
SECOND-
ORDER
NEURONS
Gracile
nucleus
Cuneate
nucleus
FIRST-ORDER
NEURONS
Medulla
POSTERIOR
COLUMN:
Gracile
fasciculus
Cuneate
fasciculus
Posterior root
ganglion
Spinal nerve
Receptors for
touch, pressure,
vibration, and
proprioception in
the upper limbs,
upper trunk, neck,
and posterior
head
Cervical
spinal cord
Receptors for touch,
pressure, vibration,
and stereognosis in
the lower limbs and
lower trunk
Lumbar spinal cord


Central sulcus
PRIMARY SOMATOSENSORY AREA (postcentral gyrus)
SOMATOSENSORY ASSOCIATION AREA
Parietal lobe
COMMON INTEGRATIVE AREA
WERNICKE'S AREA
VISUAL ASSOCIATION AREA
PRIMARY VISUAL AREA
Occipital lobe
Temporal lobe
POSTERIOR
AUDITORY ASSOCIATION AREA
1
2
3
4
5
6
7
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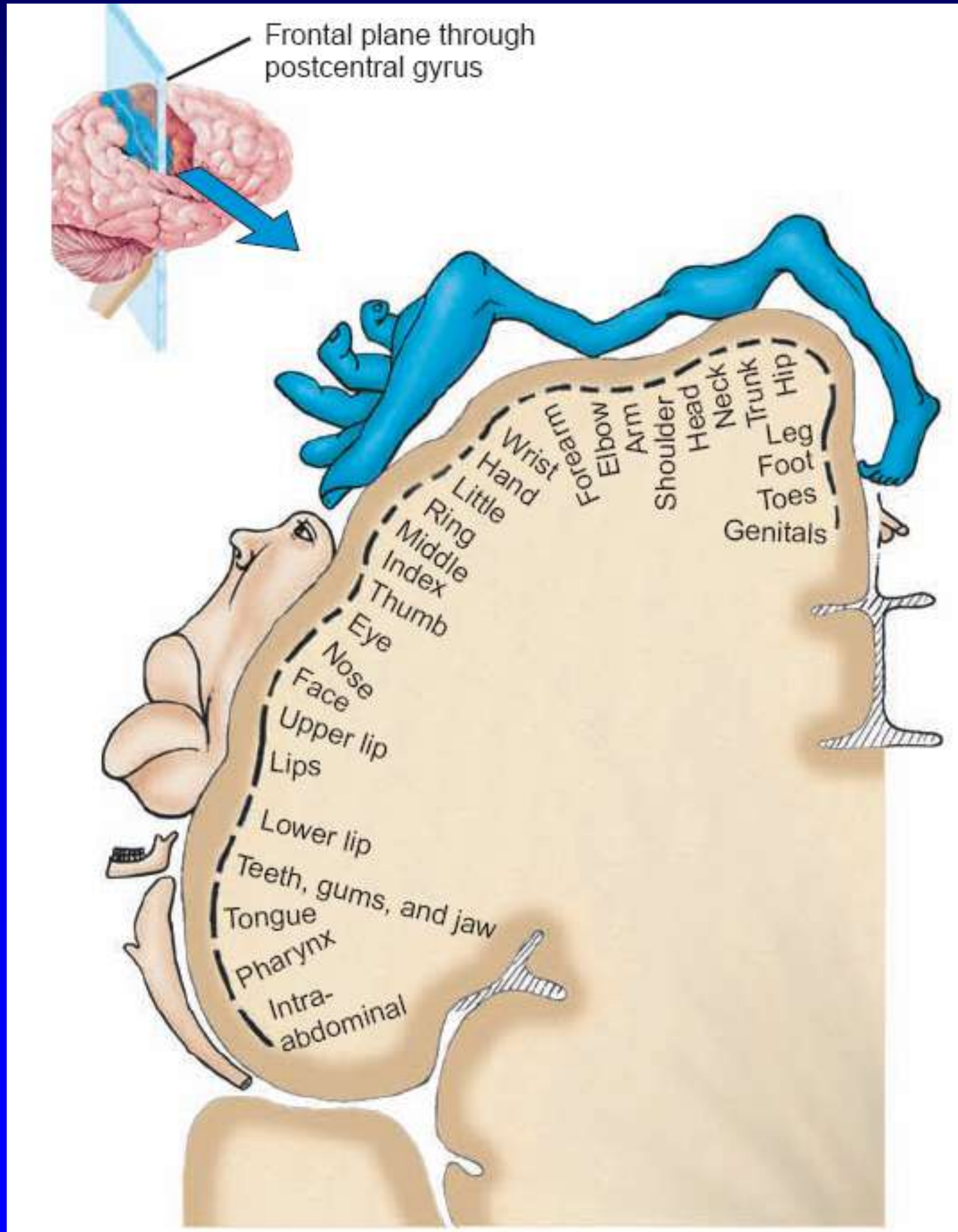
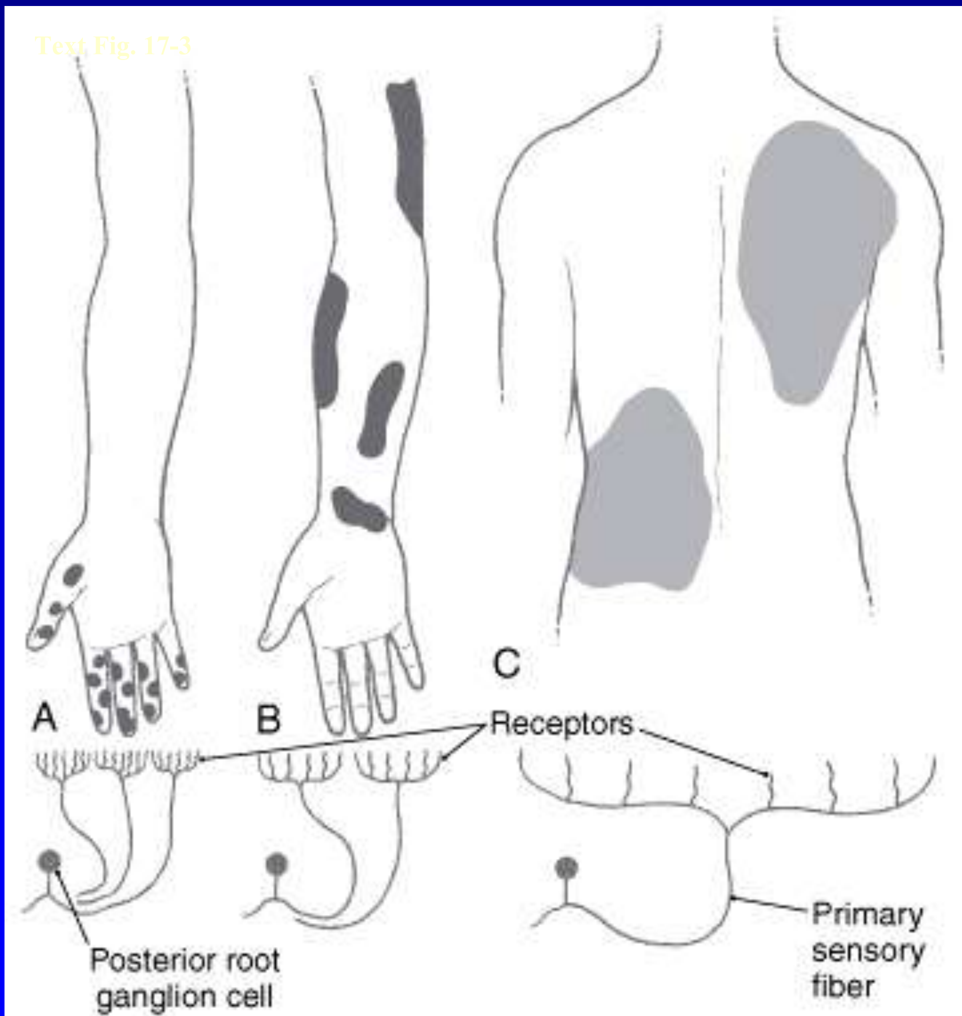


Frontal plane through
postcentral gyrus
Wrist
Hand
Little
Ring
Middle
Index
Thumb
Eye
Nose
Face
Upper lip
Lips
Lower lip
Teeth, gums, and jaw
Tongue
Pharynx
Intra-
abdominal
Forearm
Elbow
Arm
Shoulder
Head
Neck
Trunk
Hip
Leg
Foot
Toes
Genitals

Relationship Between Receptive Fields and Cortical Representation



Smaller the receptive fields, greater the density of receptors.
This relationship allows for greater discrimination in sensory inputs.

Inverse relationship in the cortex.
Smaller the receptive fields larger the cortical area
Larger the receptive fields smaller the cortical area

Conduction speed

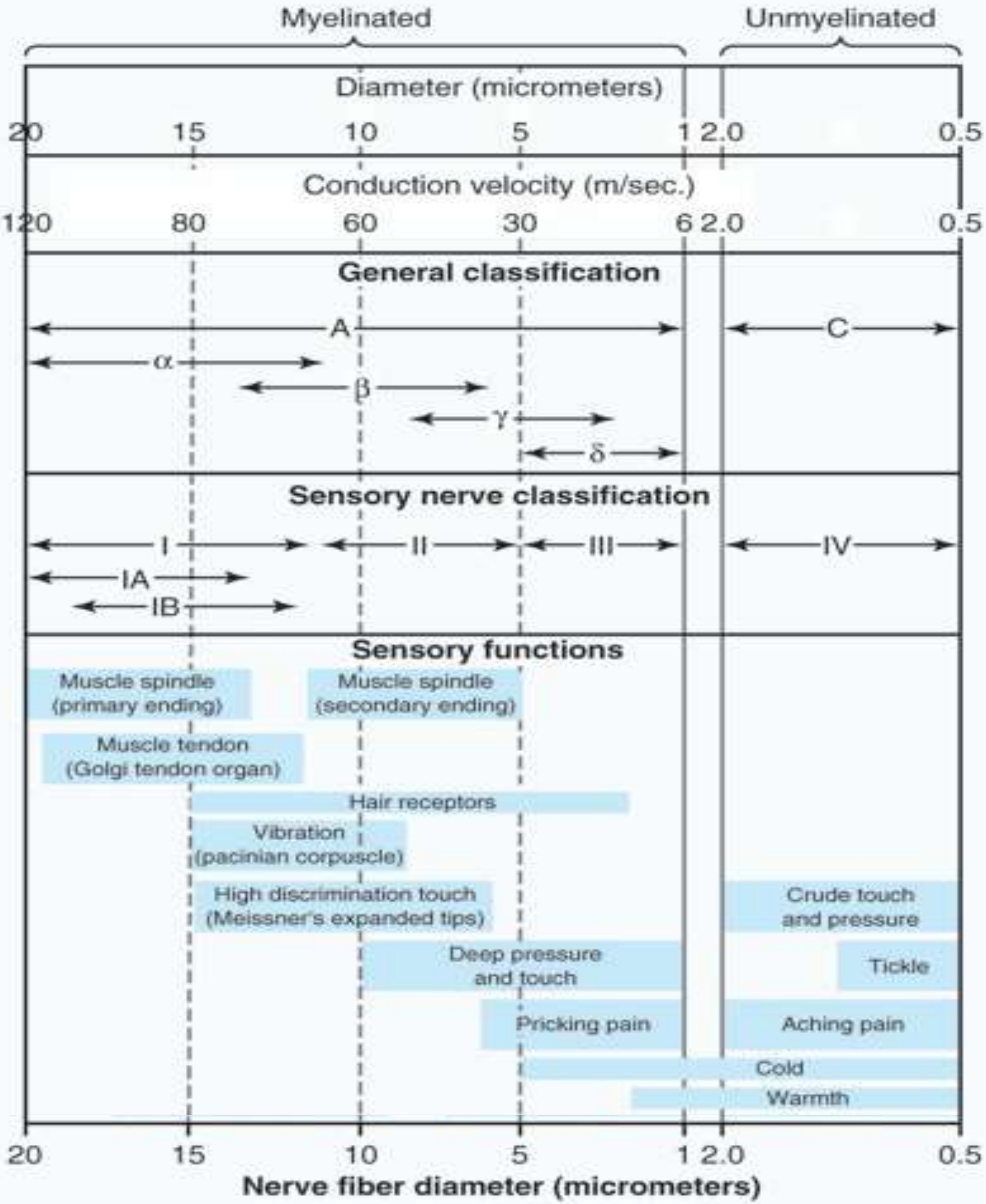
- **Number of synapses**

Conduction speed

- **Number of synapses**
- **Myelination**

Conduction speed

- **Number of synapses**
- **Myelination**
- **Nerve axon size**



Myelinated
Unmyelinated
Diameter (micrometers)
20 15 10 5 1 2.0 0.5
Conduction velocity (m/sec.)
120 80 60 30 6 2.0 0.5
General classification
A
C
α
β
γ
δ
Sensory nerve classification
I
II
III
IV
IA
IB
Sensory functions
Muscle spindle (primary ending)
Muscle spindle (secondary ending)
Muscle tendon (Golgi tendon organ)
Hair receptors
Vibration (pacinian corpuscle)
High discrimination touch (Meissner's expanded tips)
Crude touch and pressure
Deep pressure and touch
Tickle
Pricking pain
Aching pain
Cold
Warmth
20 15 10 5 1 2.0 0.5
Nerve fiber diameter (micrometers)