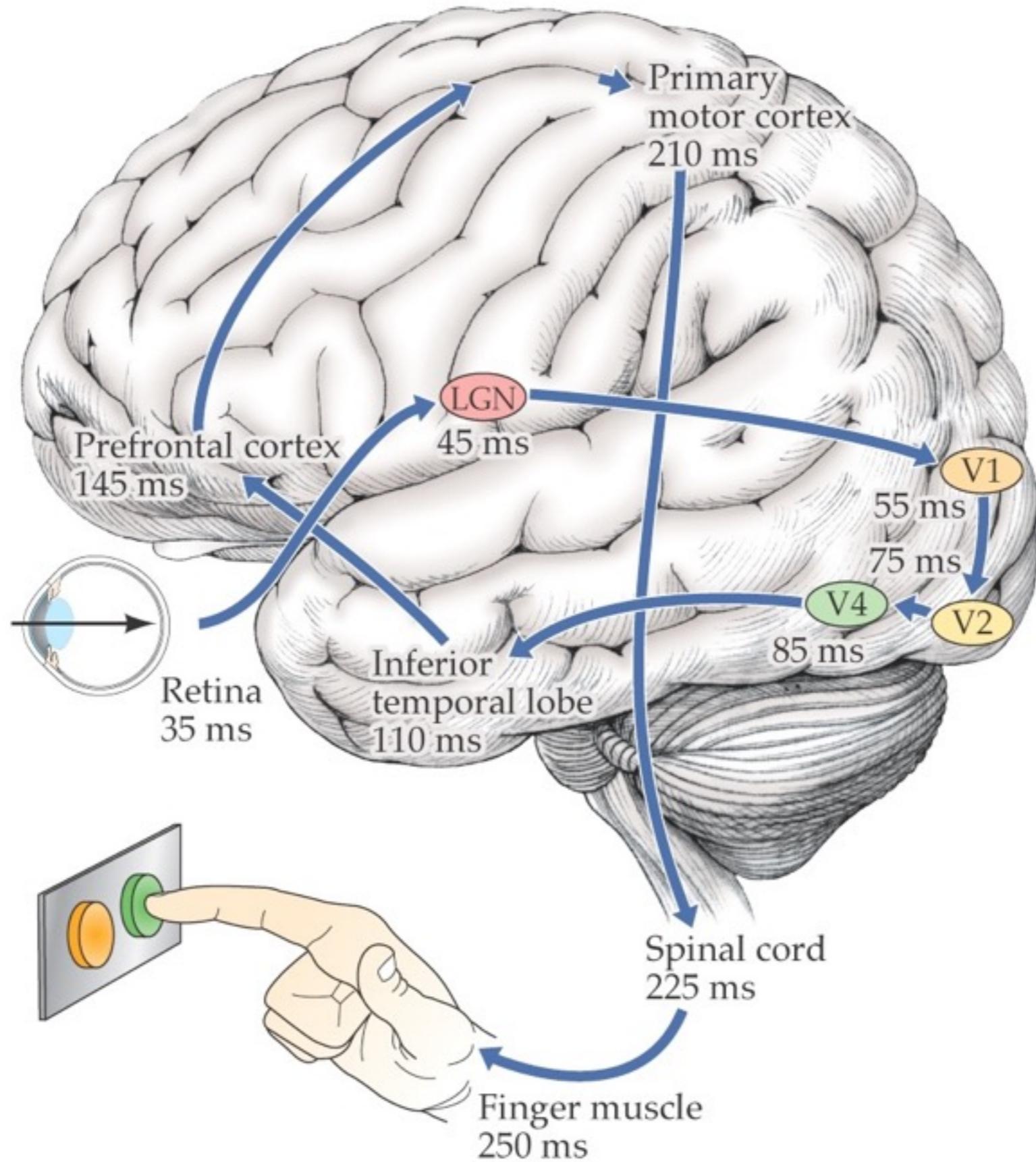


Today's topics

- Perception and action



Sensory Information

- What is it?
- Where is it? Now? Moving?
- What should I do about it?

Action types

- External
 - Space: Distal/proximal
 - Timing
- Internal

TABLE 8.1 *Classification of Sensory Systems*

Type of sensory system	Modality	Adequate stimuli
Mechanical	Touch	Contact with or deformation of body surface
	Hearing	Sound vibrations in air or water
	Vestibular	Head movement and orientation
	Joint	Position and movement
	Muscle	Tension
Photic	Seeing	Visible radiant energy
Thermal	Cold	Decrement of skin temperature
	Warmth	Increment of skin temperature
Chemical	Smell	Odorous substances dissolved in air or water in the nasal cavity
	Taste	Substances in contact with the tongue or other taste receptor
	Common chemical	Changes in CO ₂ , pH, osmotic pressure
	Vomeronasal	Pheromones in air or water
Electrical	Electroreception	Differences in density of electrical currents

Dimensions

- Exteroceptive
 - What's out there and where?
- Interoceptive
 - How'm I doin'?

Visual

- Electromagnetic radiation
- What is it?
 - Shape, size, surface properties (color, texture, reflectance, etc.)
 - Wavelength/frequency, intensity
- Where is it?
 - Position: Left/right; up/down; near/far
 - Orientation, motion
- What should I do about it?

Auditory

- Vibrations in air/water
- What is it?
 - Pattern of frequencies, amplitudes, durations
- Where is it?
 - Left/right; up/down; near/far
 - Orientation, motion
- What should I do about it?

Chemosensory

- Chemicals in mouth, nasal cavity
- What is it?
 - Mixture of chemicals
- Where is it?
 - Left/right; up/down; near/far
- What should I do about it?

Somatosensory

- Exteroceptive
 - Cutaneous (skin-based sensors)
 - Kinesthetic (joint, muscle sensors)
- Interoceptive

Cutaneous

- Thermal or mechanical stimulation of skin
- What is it?
 - Shape, size, smoothness, temperature, heft, deformability
- Where is it?
 - Position on skin/body
 - Position of body
- What should I do about it?

Interoceptive

- Hunger, thirst
- Temperature
- Mating interest
- Physical energy level
- Health/illness

Interoceptive

- Hunger/thirst
 - Receptors for nutrient, fluid levels
- Temperature
- Mating interest
 - Receptors for hormones, NTs
 - ANS responses

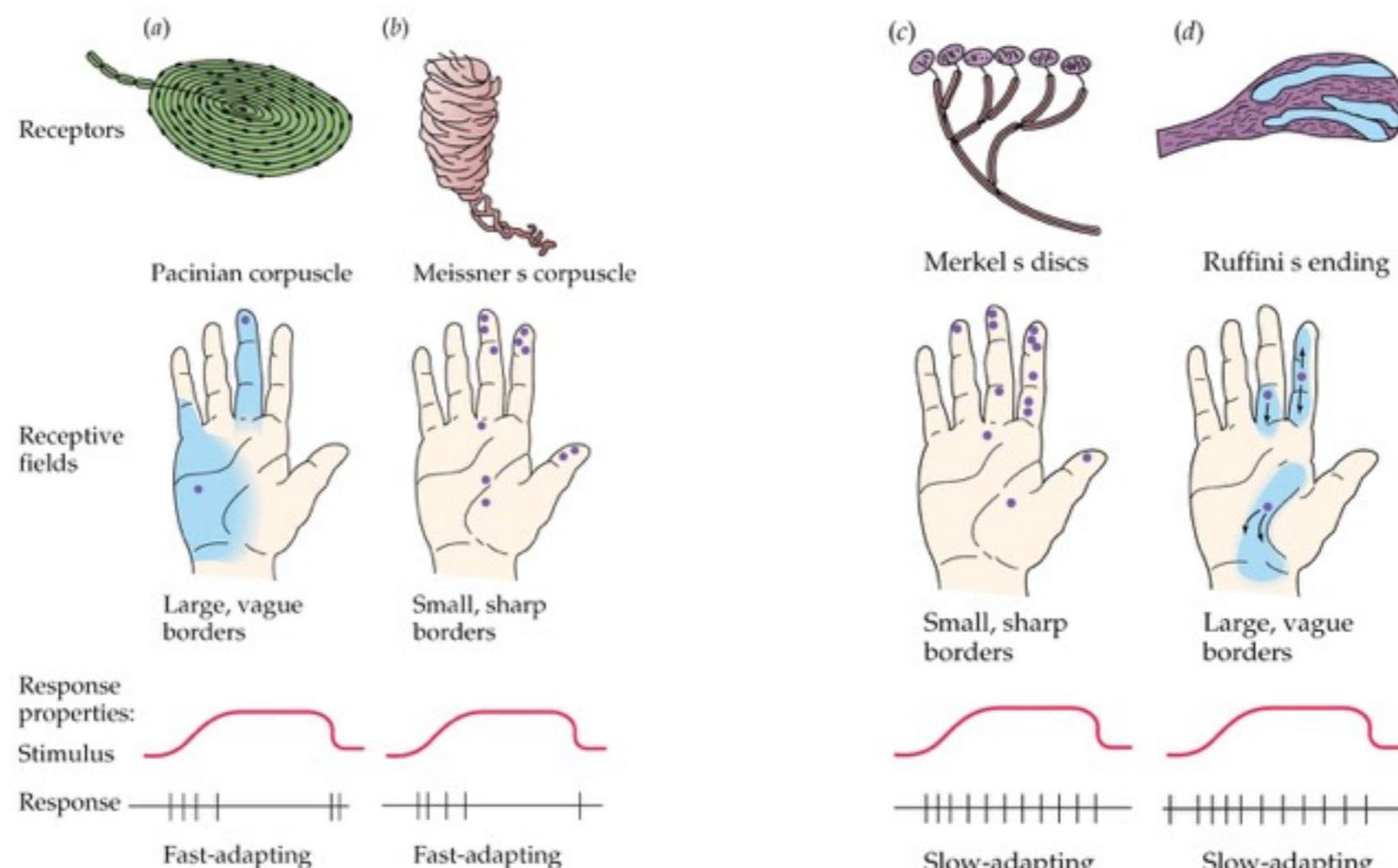
Interoceptive

- Physical energy level
 - ANS responses
 - Hormones, NTs, nutrients

Common Principles

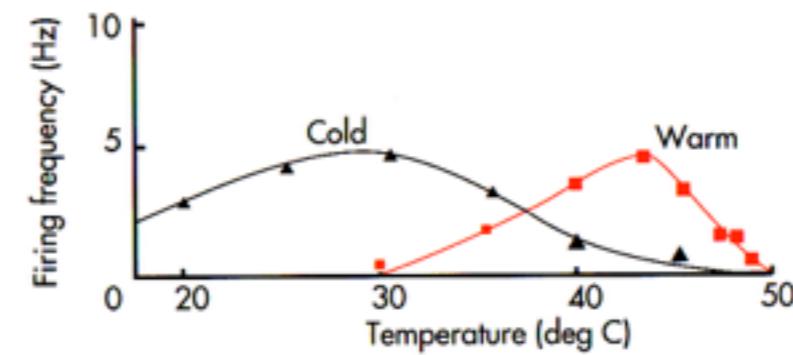
- Specialized receptors

Receptor specializations



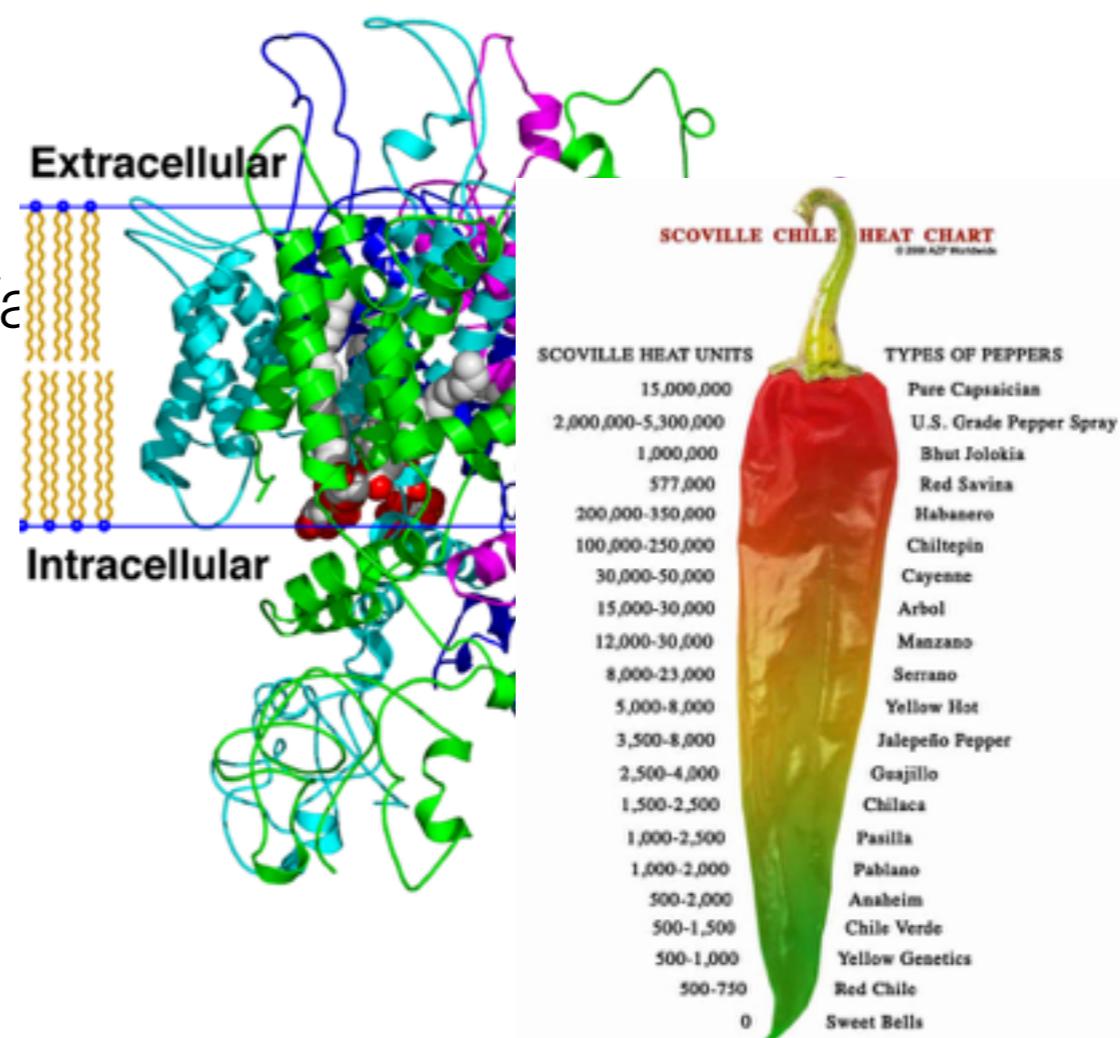
Skin receptors

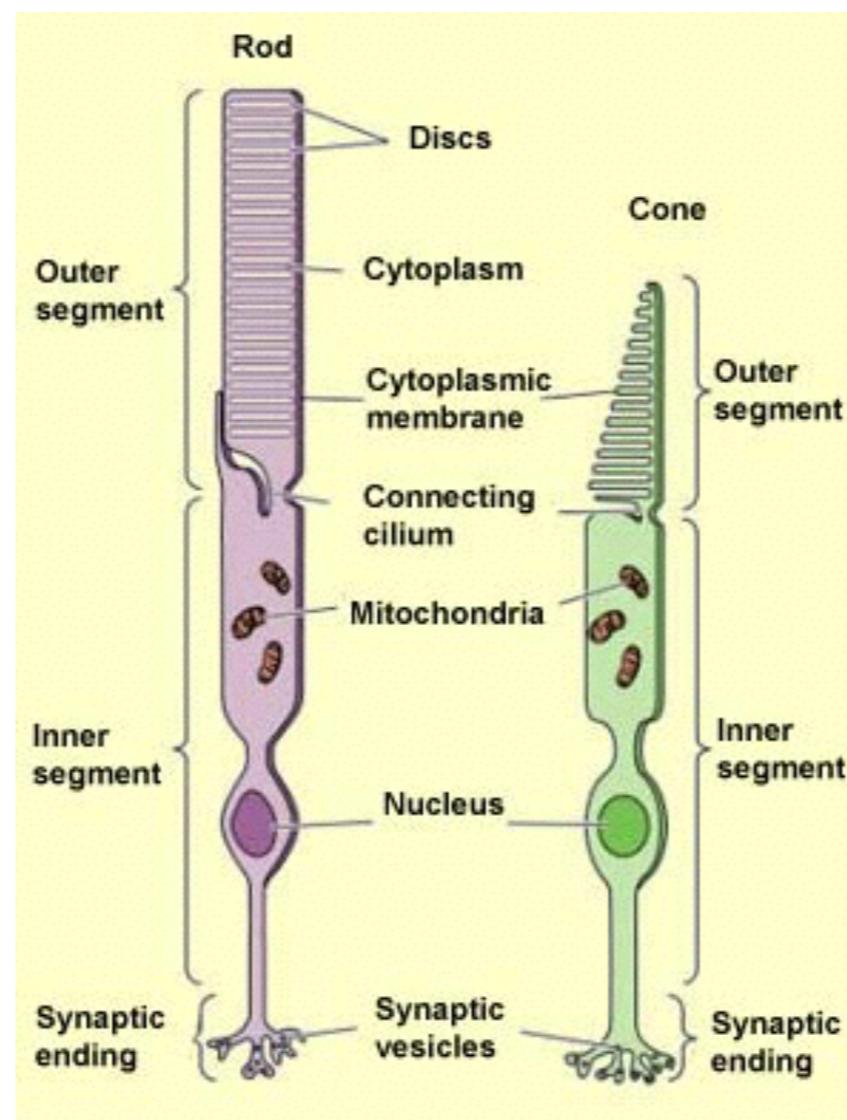
- Free nerve endings
 - Hot
 - Cold
 - Tissue damage (pain)
- Encapsulated endings
 - Stretching



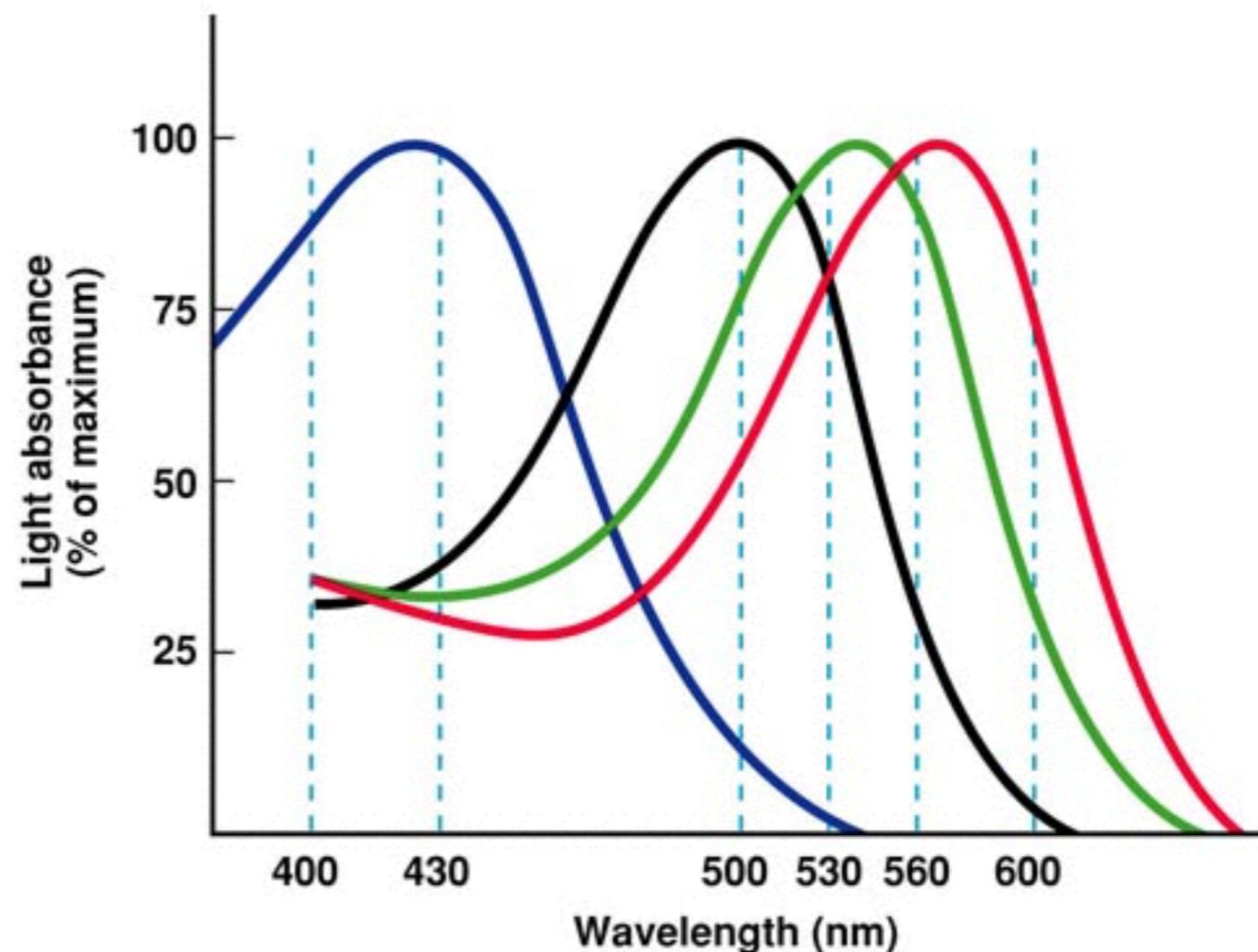
One receptor, many signals

- Transient Receptor Potential Vanilloid Receptor 1
- Thermoreceptor AND
- Chemoreceptor





http://thebrain.mcgill.ca/flash/d/d_02/d_02_m/d_02_m_vis/d_02_m_vis_1a.jpg



<http://www.d.umn.edu/~jfitzake/Lectures/DMED/Vision/Figures/Photoreceptors.jpg>

Features of sensory signals

- Tonic (sustained) vs. phasic (transient) responses
- Adaptation
 - Decline in sensitivity with sustained stimulation
 - Most sensory systems attuned to change

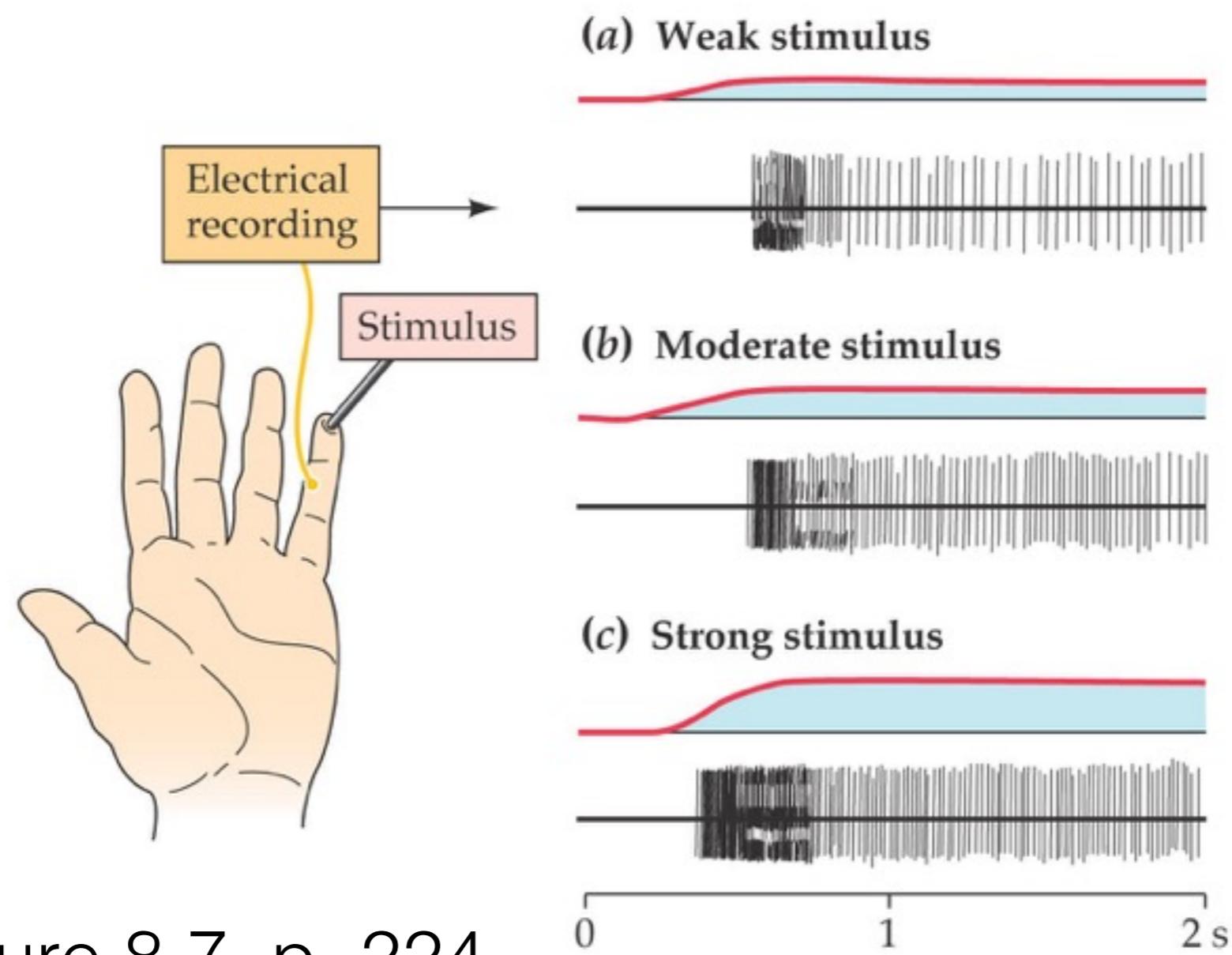


Figure 8.7, p. 224

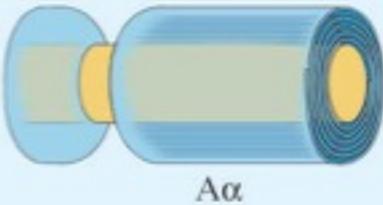
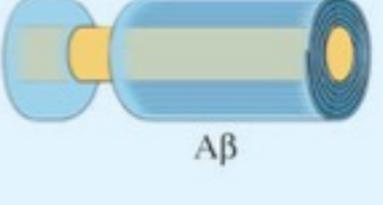
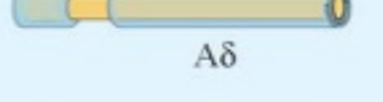
BIOLOGICAL PSYCHOLOGY, Fourth Edition, Figure 8.7 © 2004 Sinauer Associates, Inc.

Common principles

- Information propagates at different rates

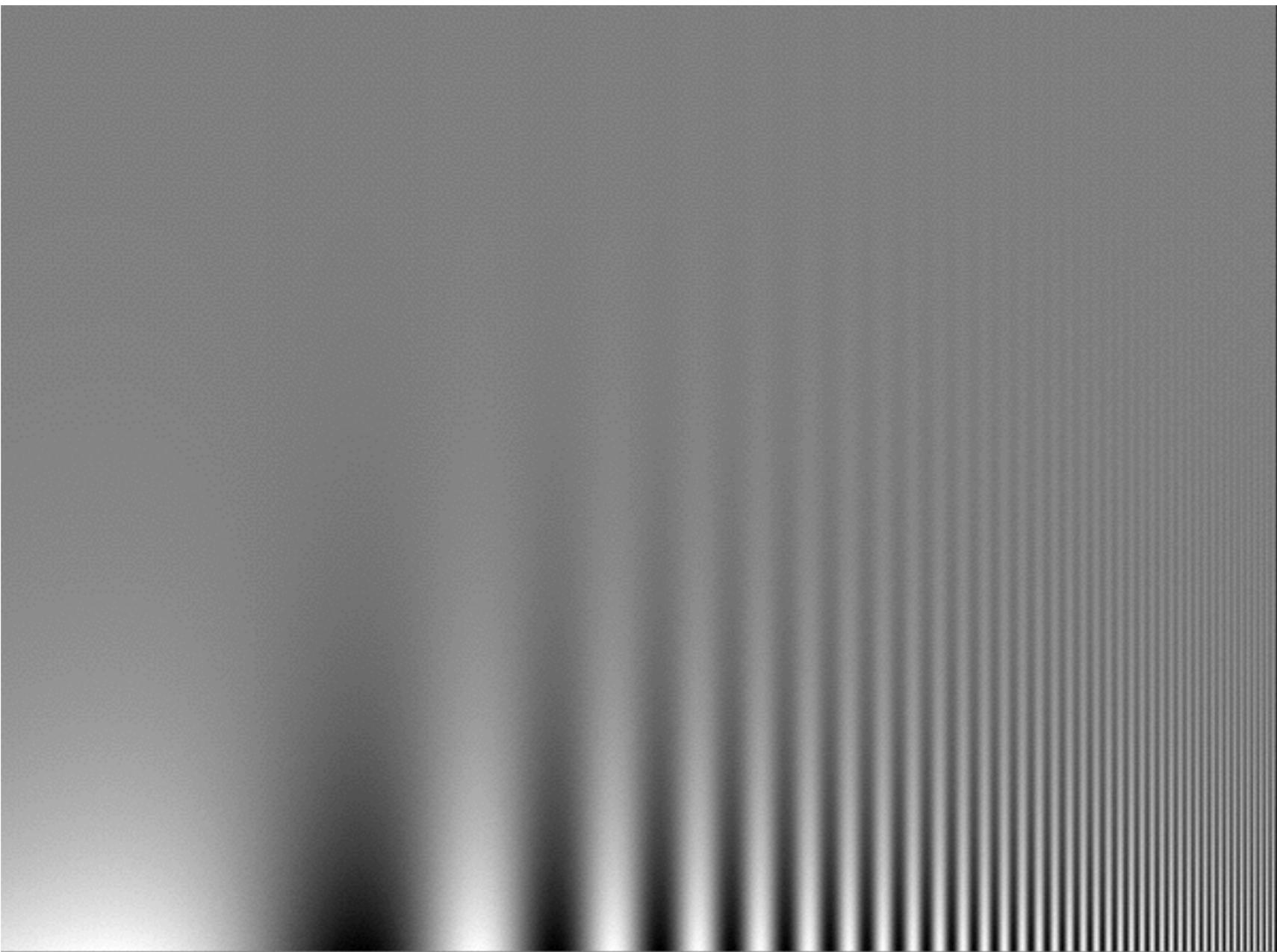
Why you flinch before saying

TABLE 8.2 *Fibers That Link Receptors to the CNS*

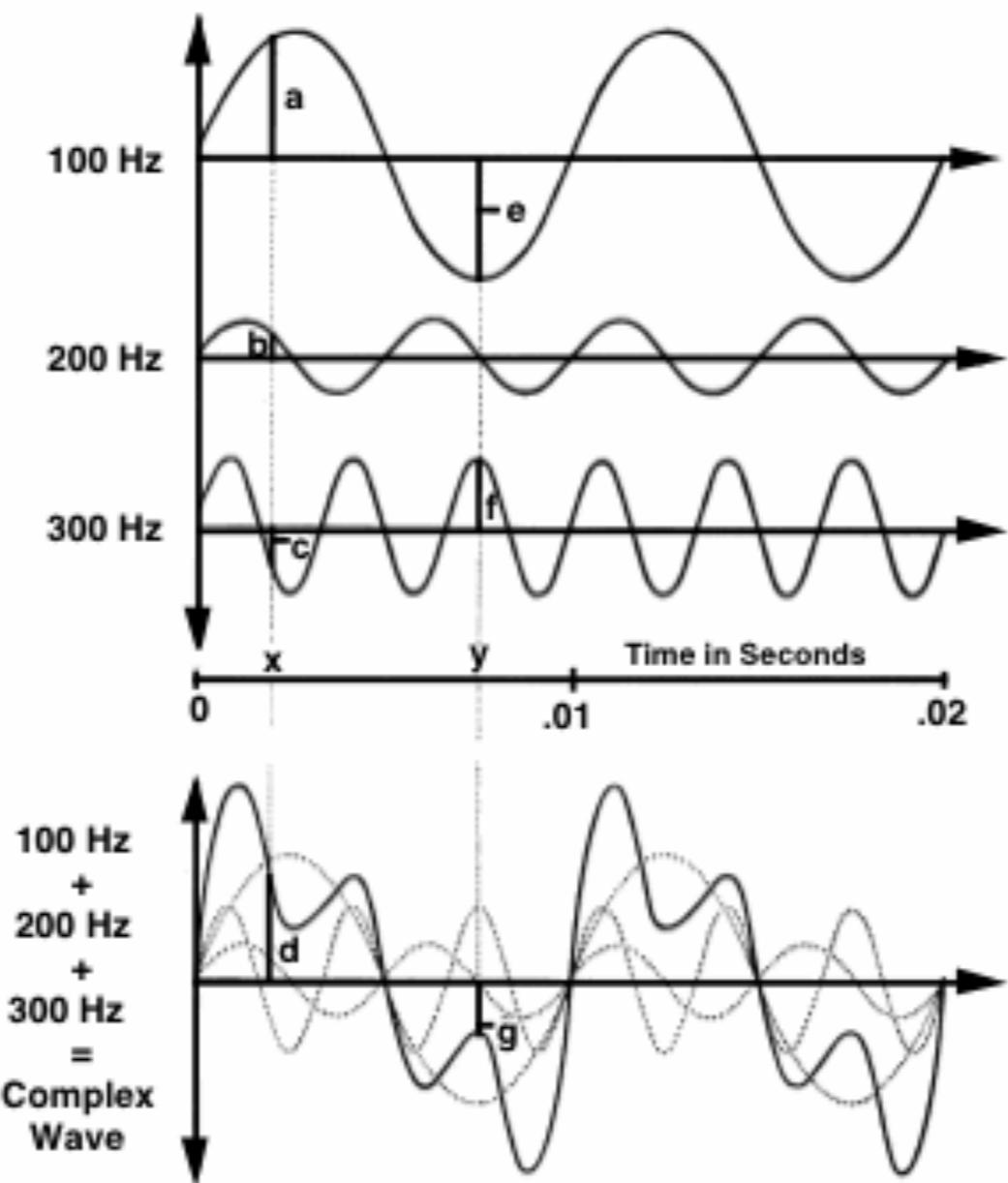
Sensory function(s)	Receptor type(s)	Axon type	Diameter (μm)	Conduction speed (m/s)
Proprioception (see Chapter 11)	Muscle spindle	 A α	13–20	80–120
Touch (see Figures 8.12 and 8.13)	Pacinian corpuscle, Ruffini's ending, Merkel's disc, Meissner's corpuscle	 A β	6–12	35–75
Pain, temperature	Free nerve endings; VR1	 A δ	1–5	5–30
Temperature, pain, itch	Free nerve endings; VR1, CMR1	 C	0.02–1.5	0.5–2

Common principles

- Repeating patterns (spatial/temporal frequency)
- Triangulating on position (2 sensors)



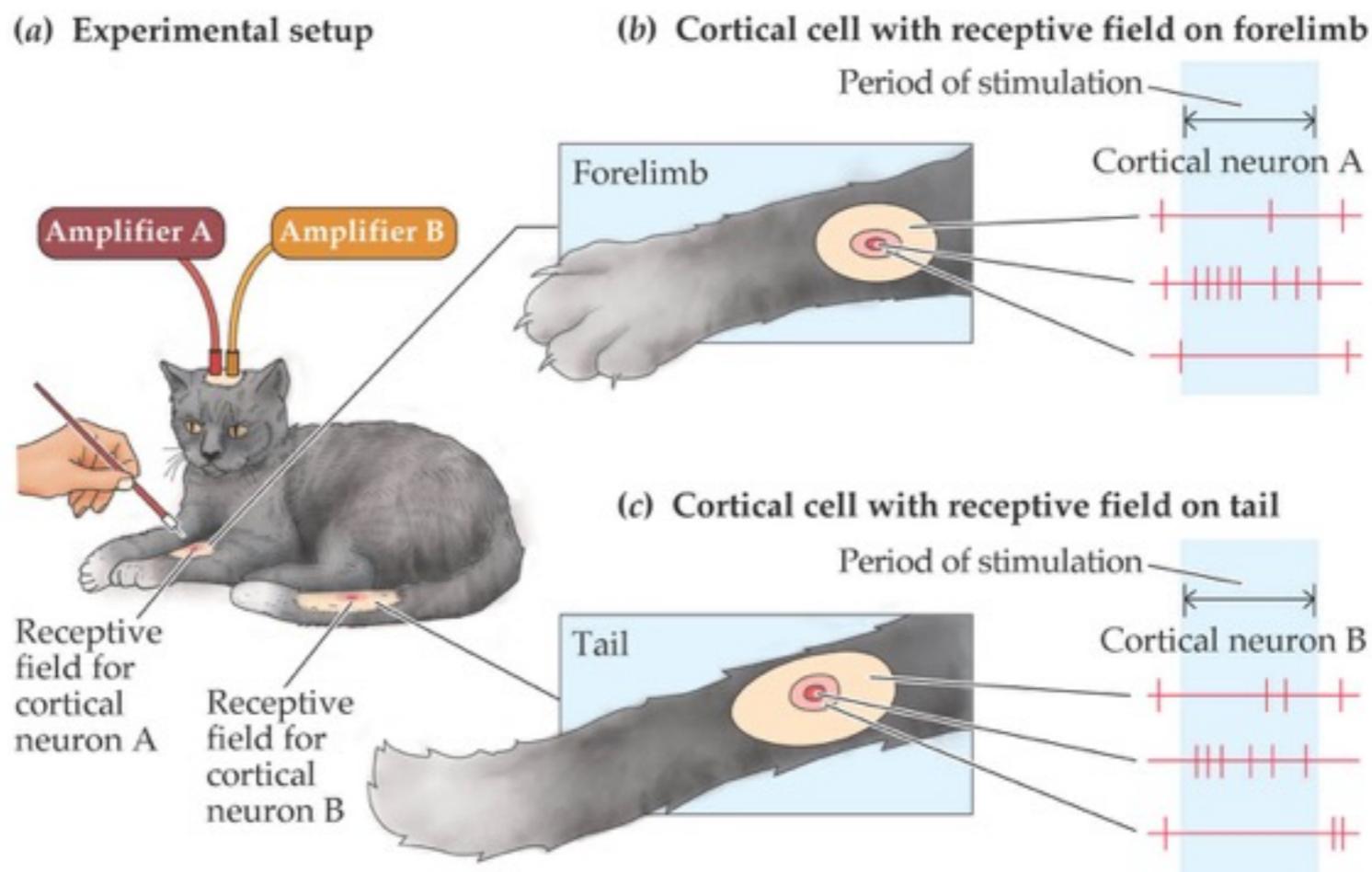
http://fourier.eng.hmc.edu/e180/lectures/figures/csf_image.gif



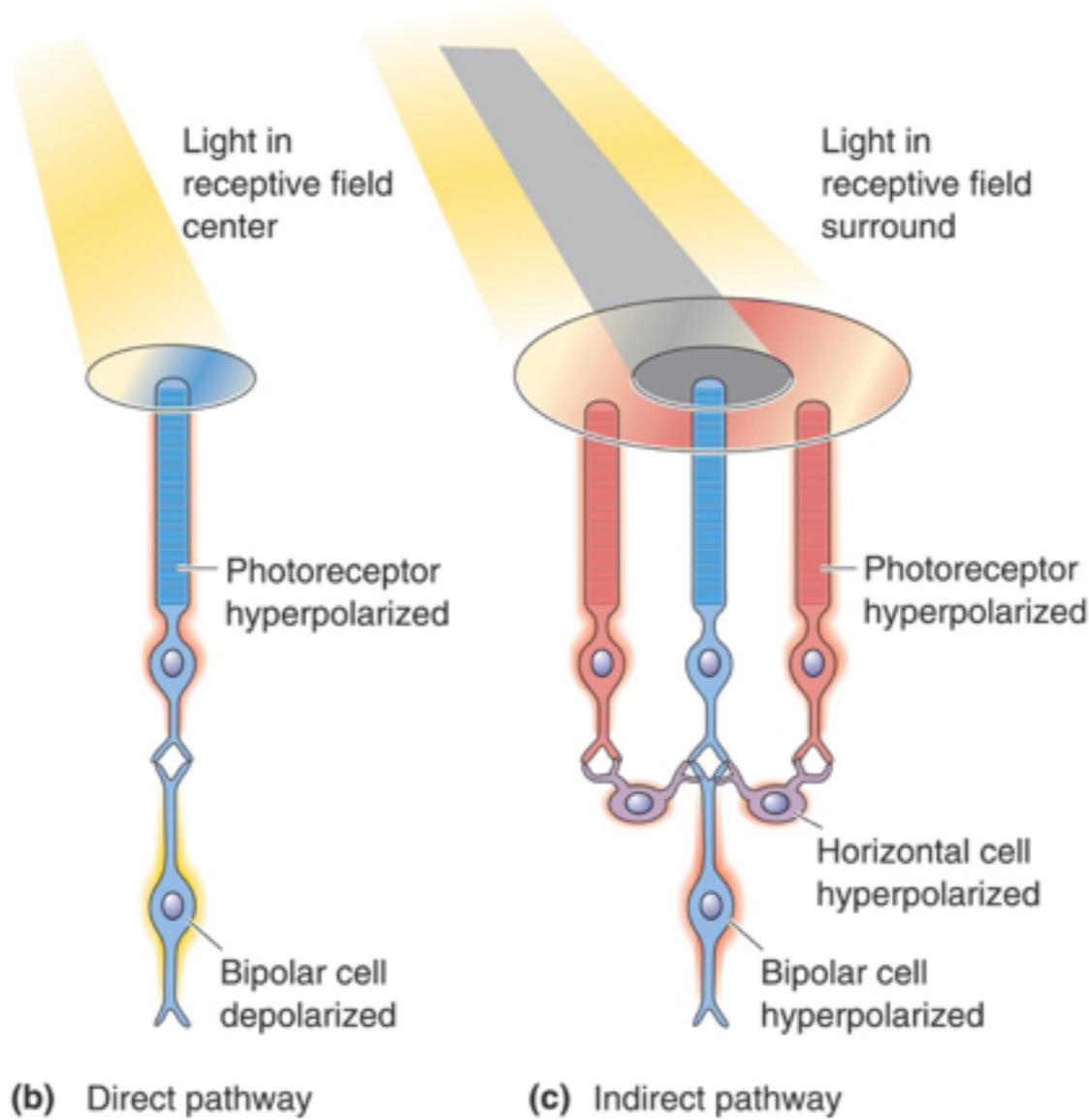
[http://hearinghealthmatters.org/wayneeworld/files/2012/06/
Fourier-Analysis.gif](http://hearinghealthmatters.org/wayneeworld/files/2012/06/Fourier-Analysis.gif)

Common principles

- Receptive fields
- Area on sensory surface that changes neural activity

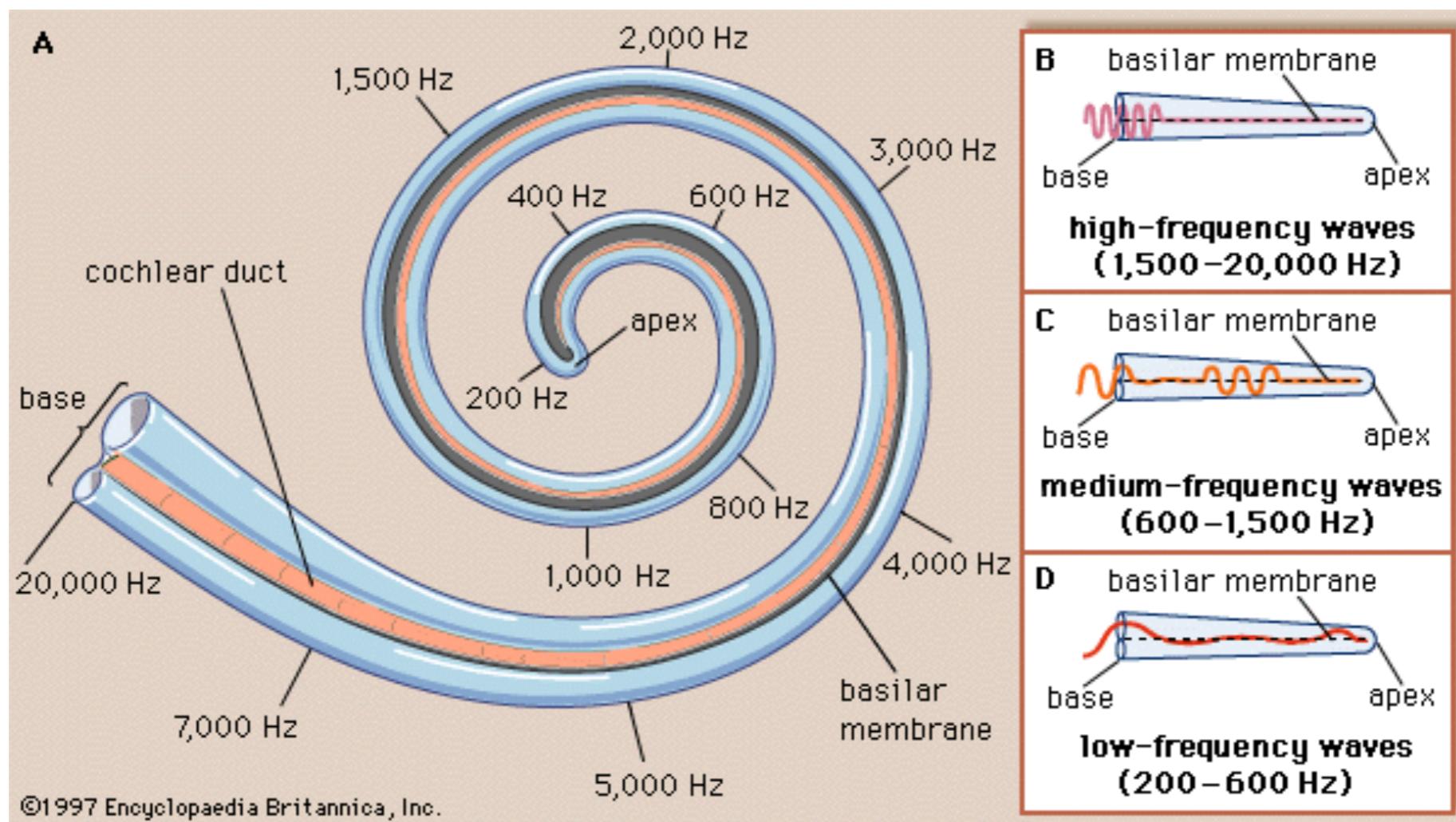


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Neuroscience: Exploring the Brain, 3rd Ed. Bear, Connors, and Paradiso Copyright © 2007 Lippincott Williams & Wilkins

https://classconnection.s3.amazonaws.com/594/flashcards/1450594/png/untitled_picture51356035996428.png



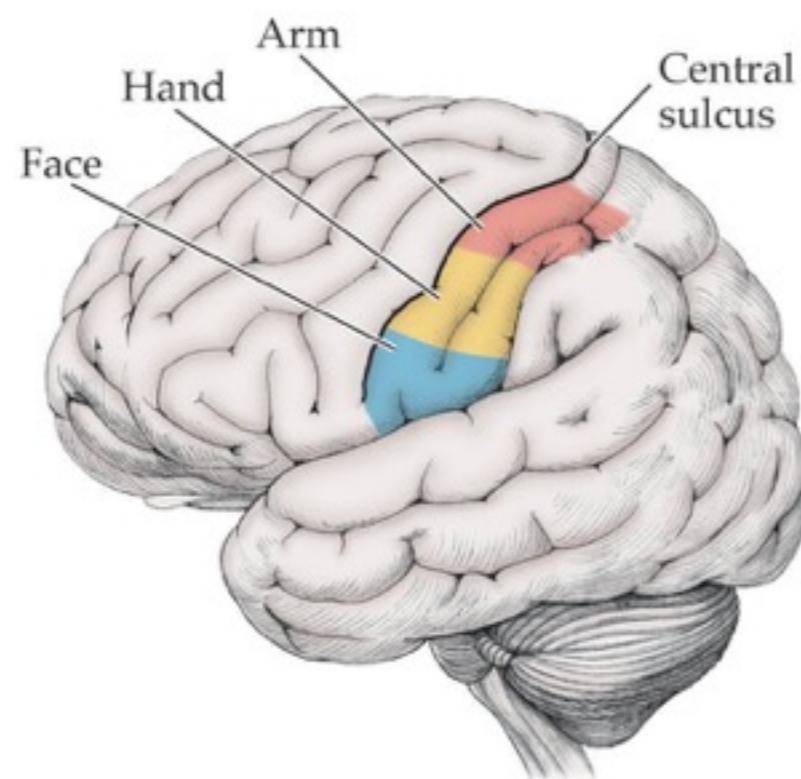
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Common principles

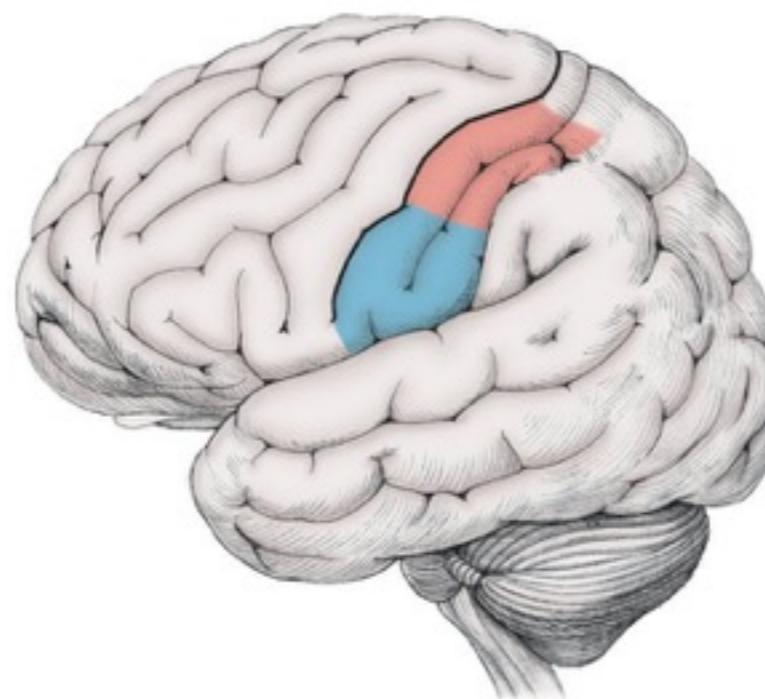
- Topographic maps

Sensorv mans in cortex

(a) Normal somatosensory cortex



(b) Somatosensory cortex
reorganized after loss of hand

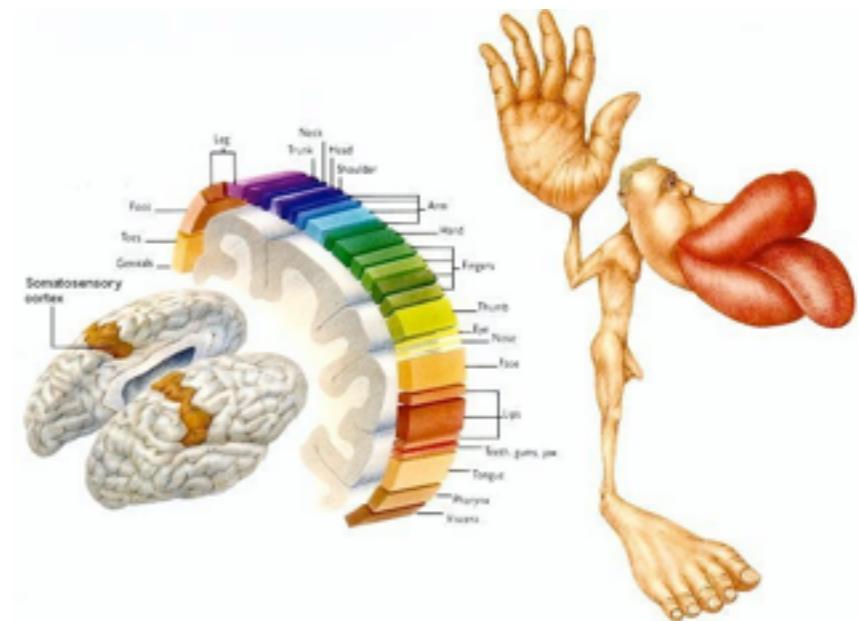
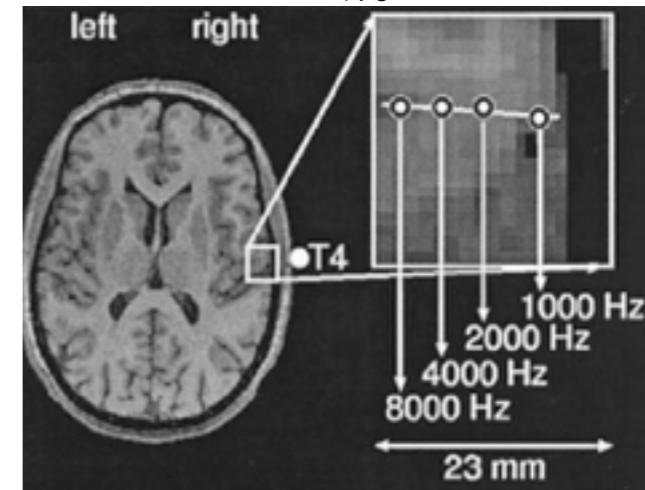


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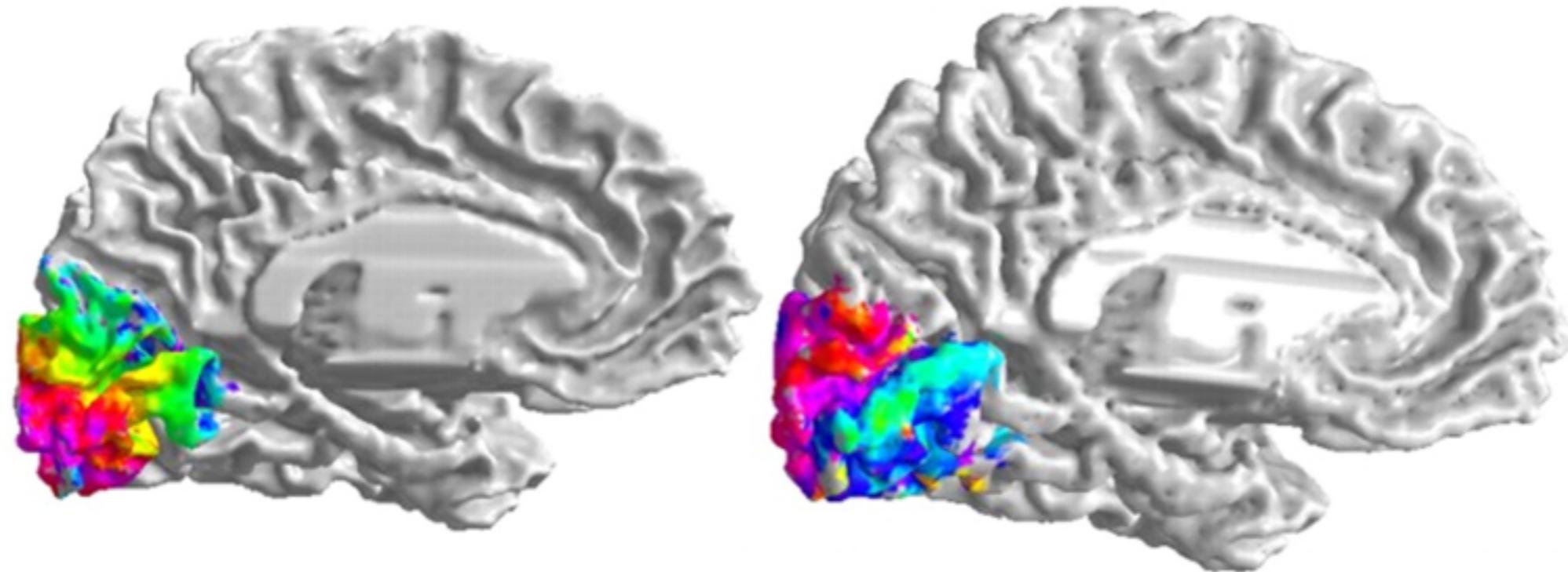
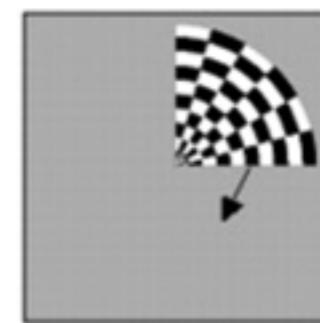
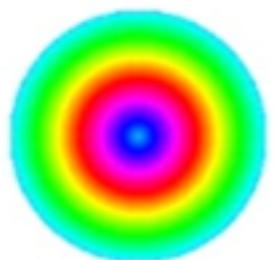
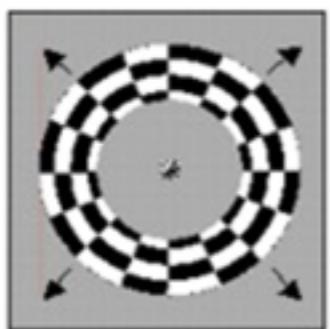
Topographic maps

- Retinotopy
- Tonotopy
- Somatotopy
 - Somatosensory
 - Motor
- Chemo?
- Place fields?

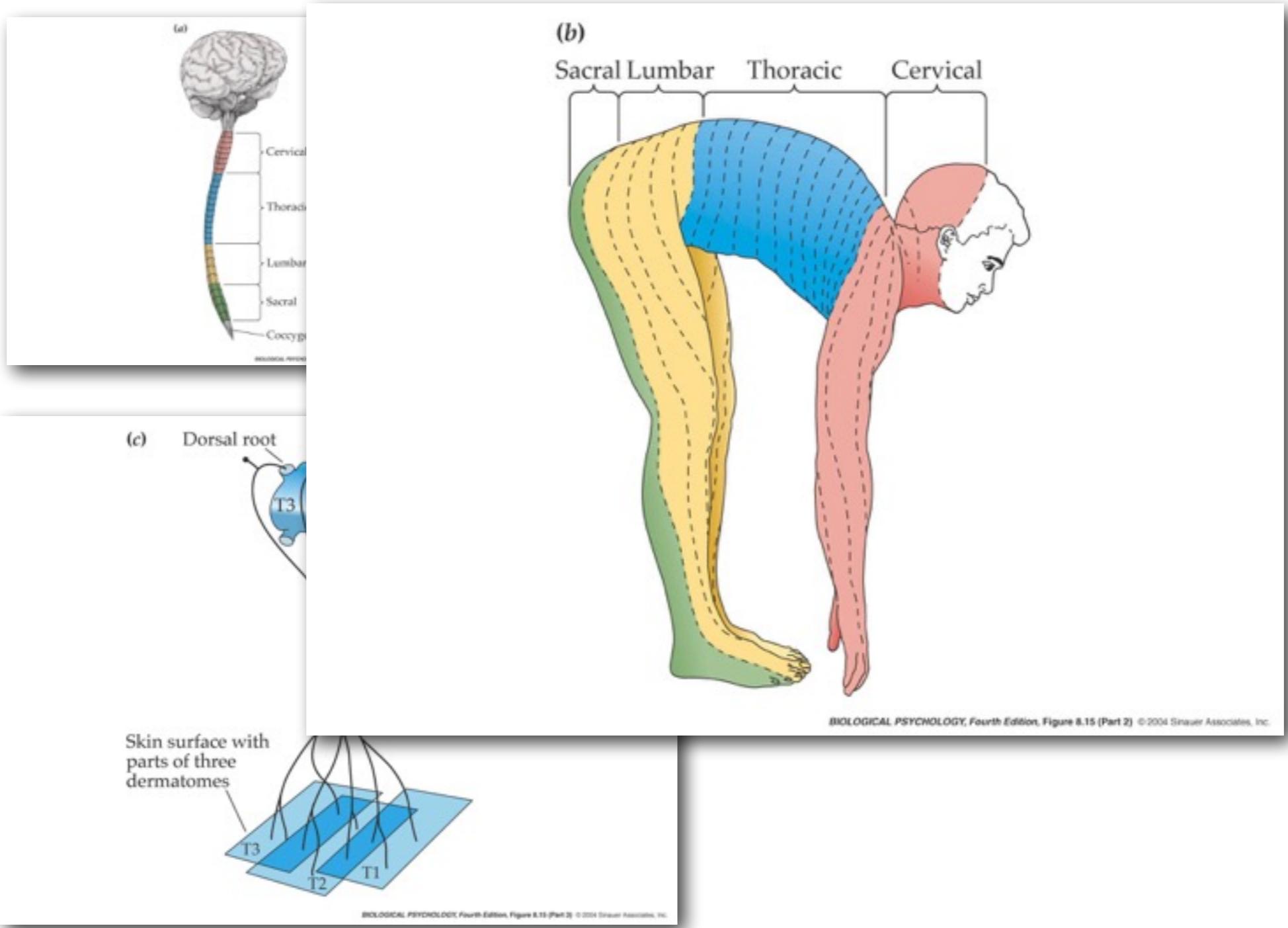
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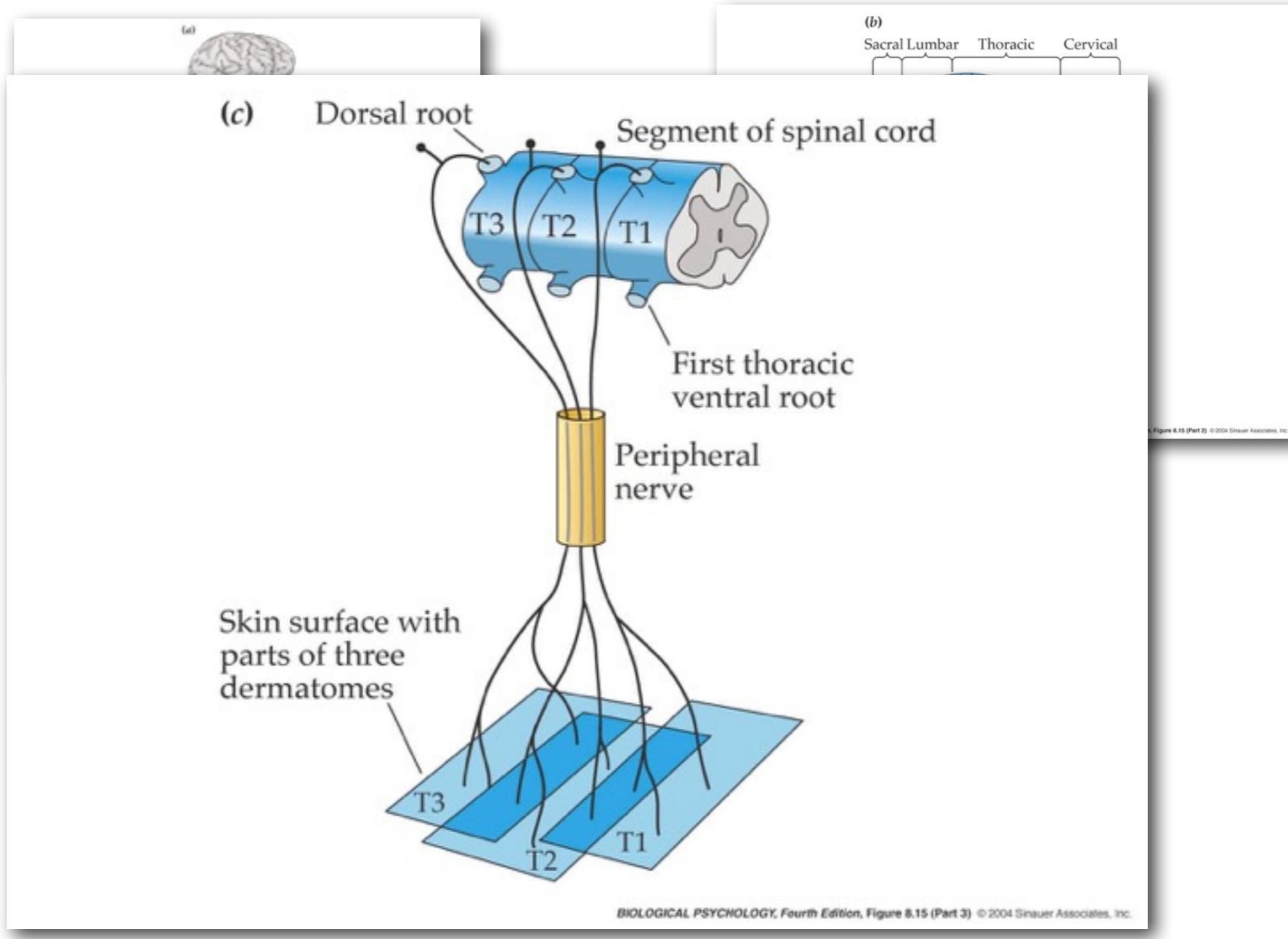


<http://universe-review.ca/I10-13-homunculus.jpg>



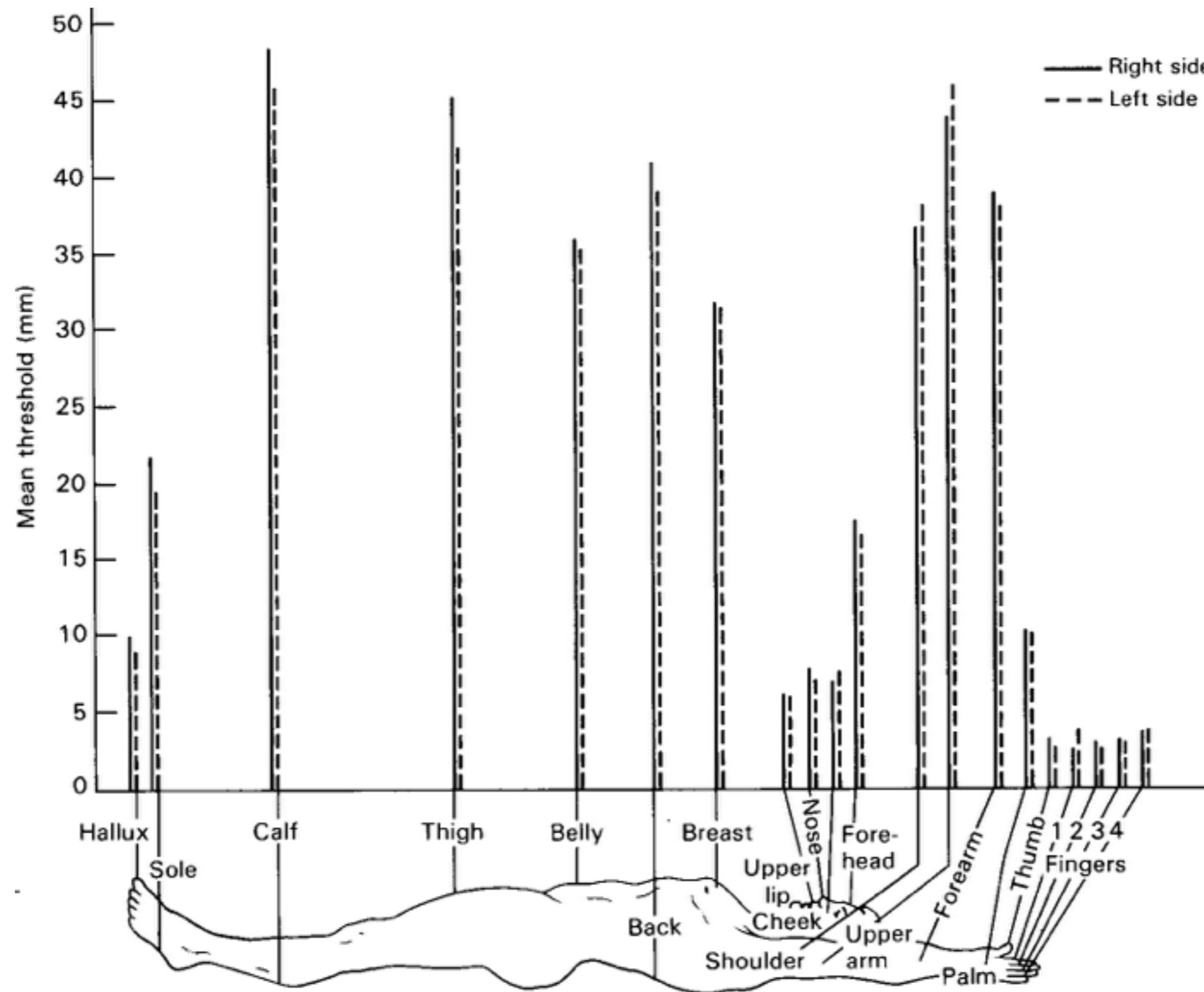
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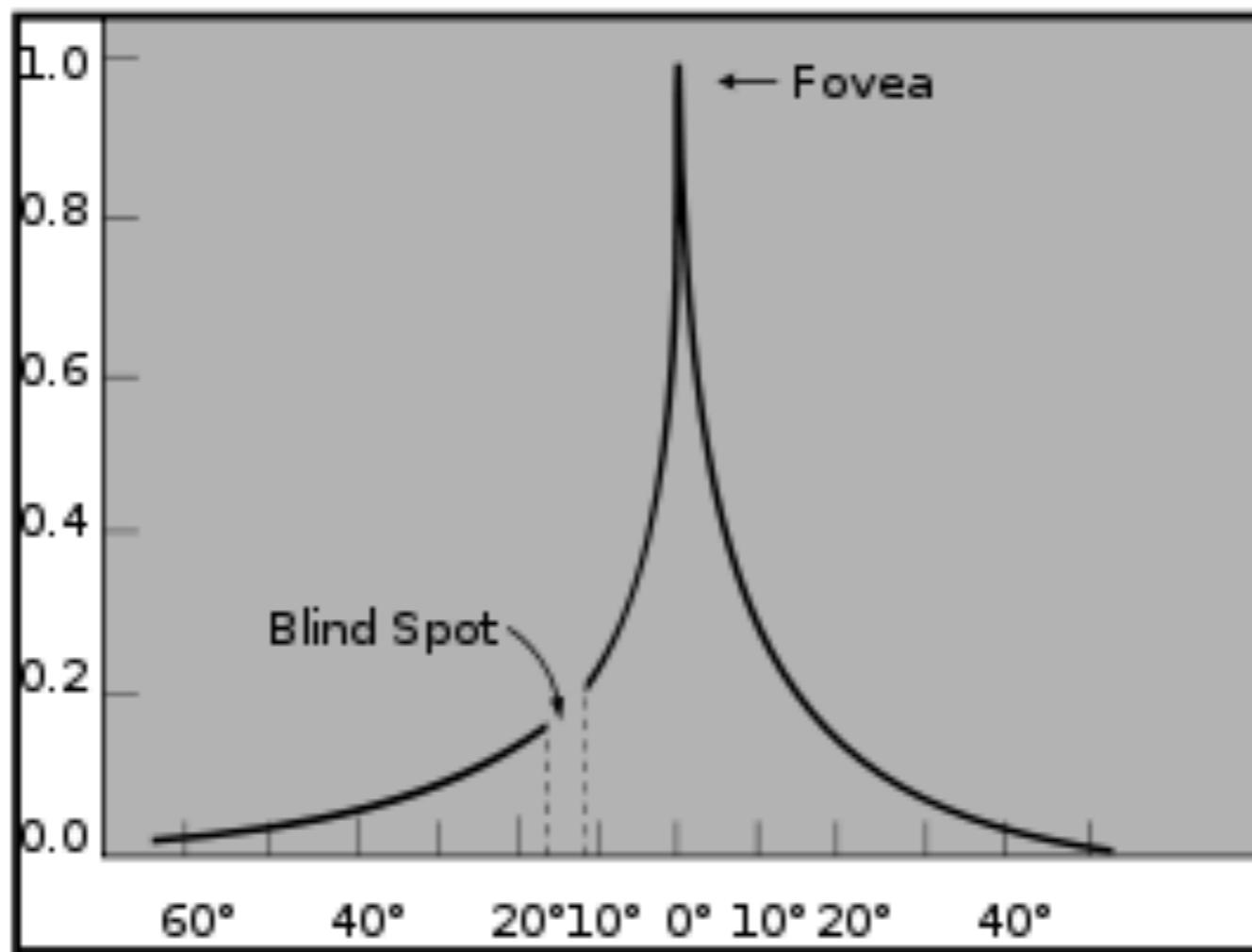




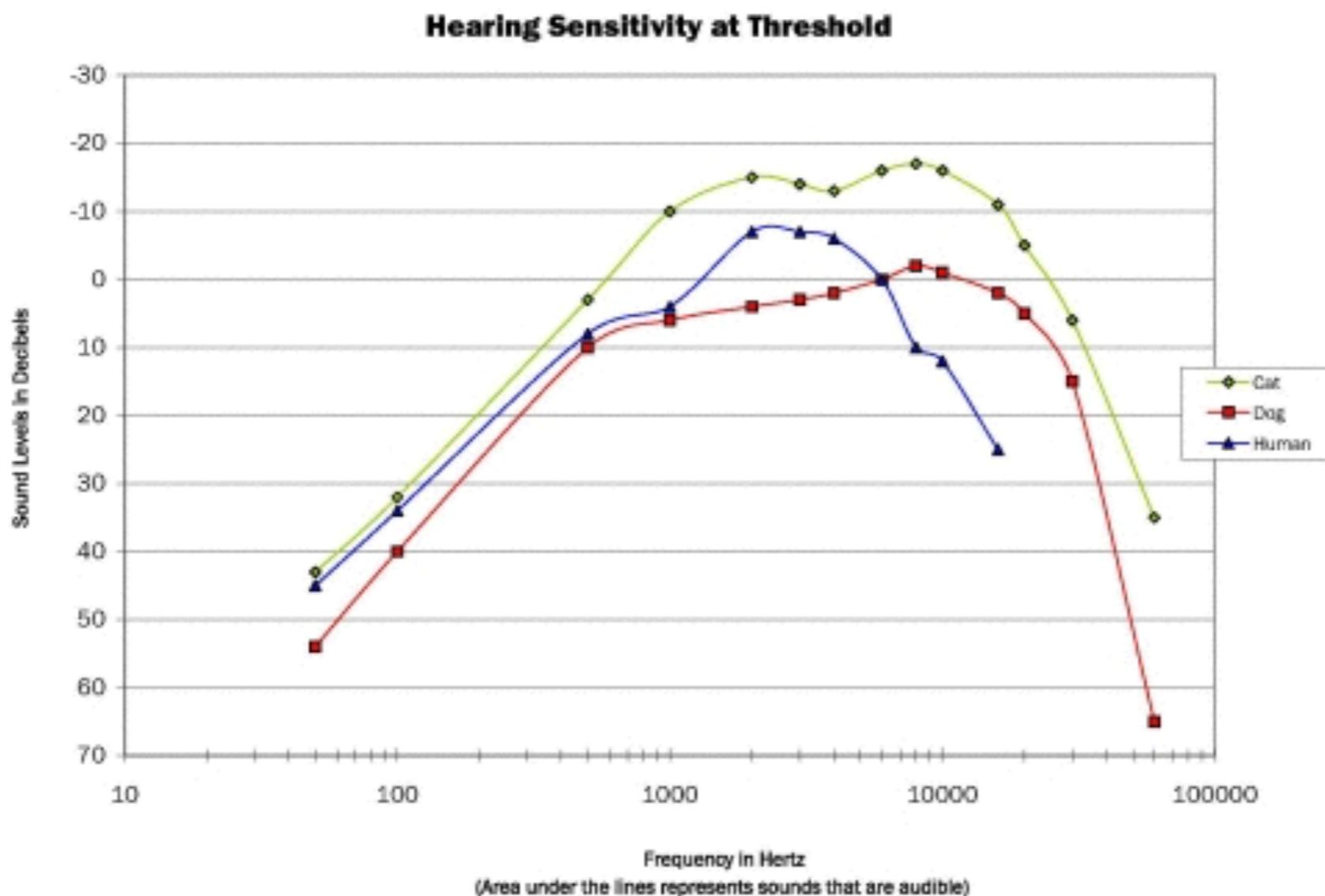
Common principles

- Sensitivity non-uniform





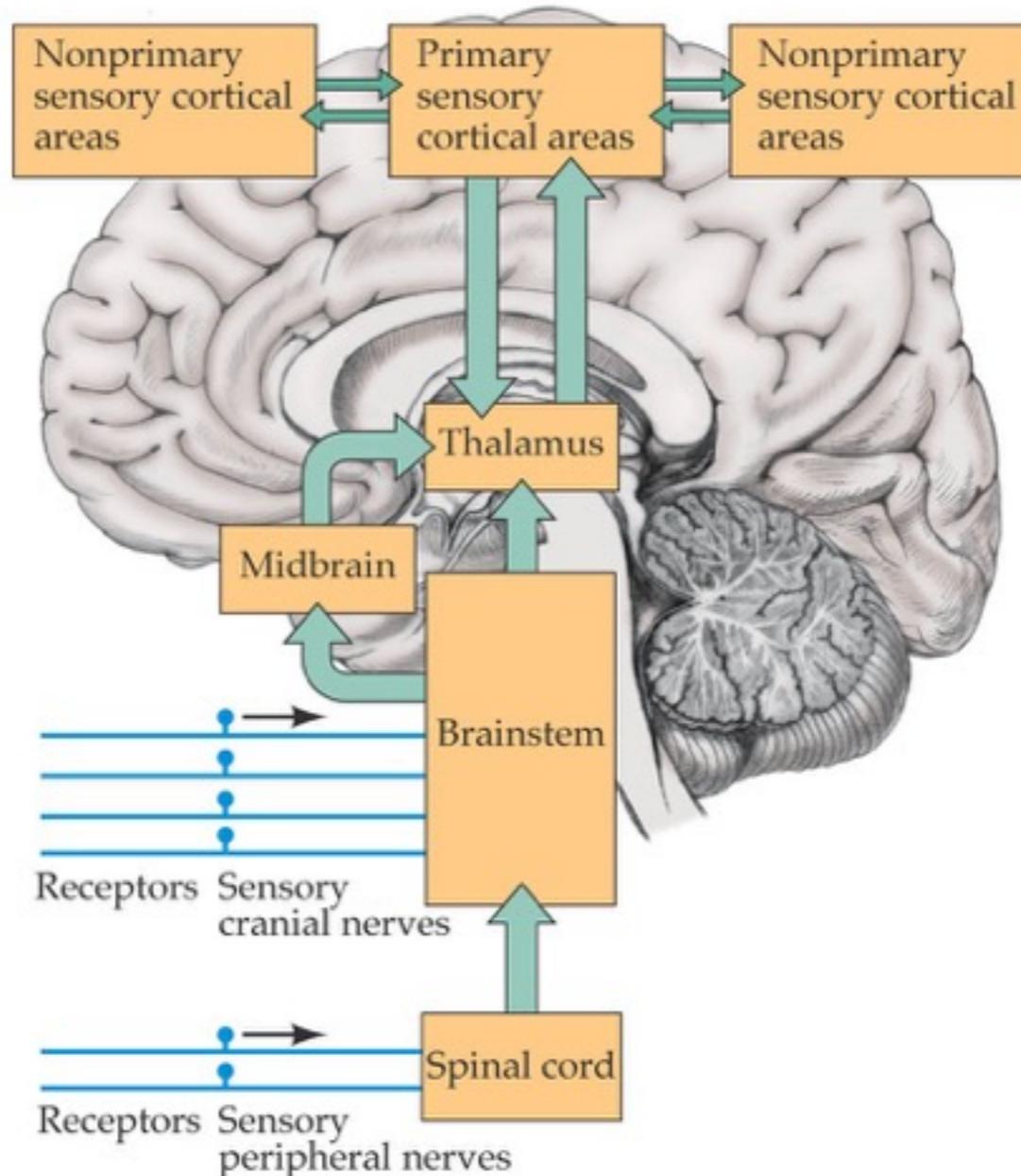
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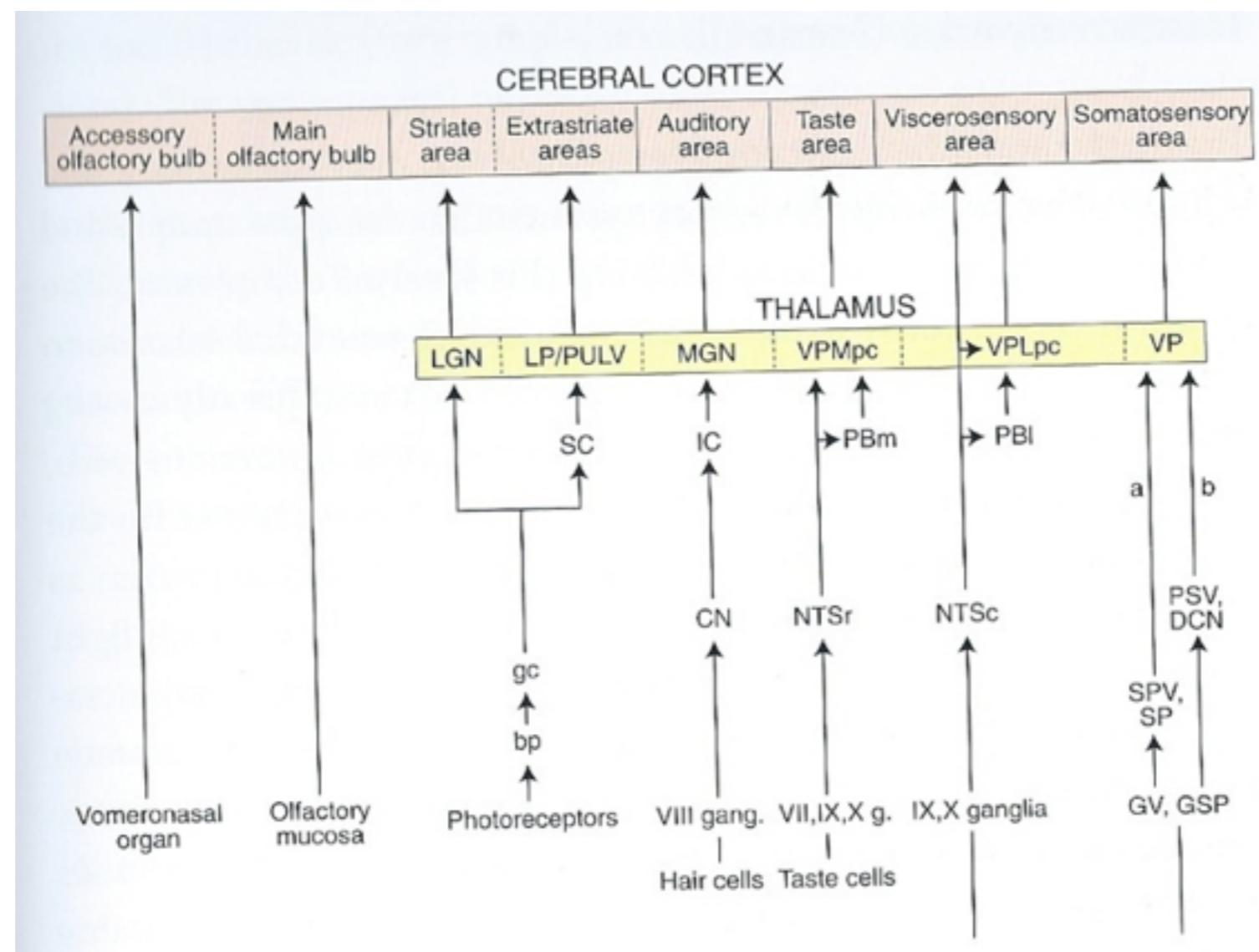
http://www.hearforever.org/userfiles/image/tools_to_learn/SS4_Hearing_Sensitivity.jpg

Parallel processing

- Receptors
- Brainstem
- Thalamus
- Cerebral cortex



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Swanson 11.4

Action

Components

- Somatic
- Autonomic
- Neuroendocrine

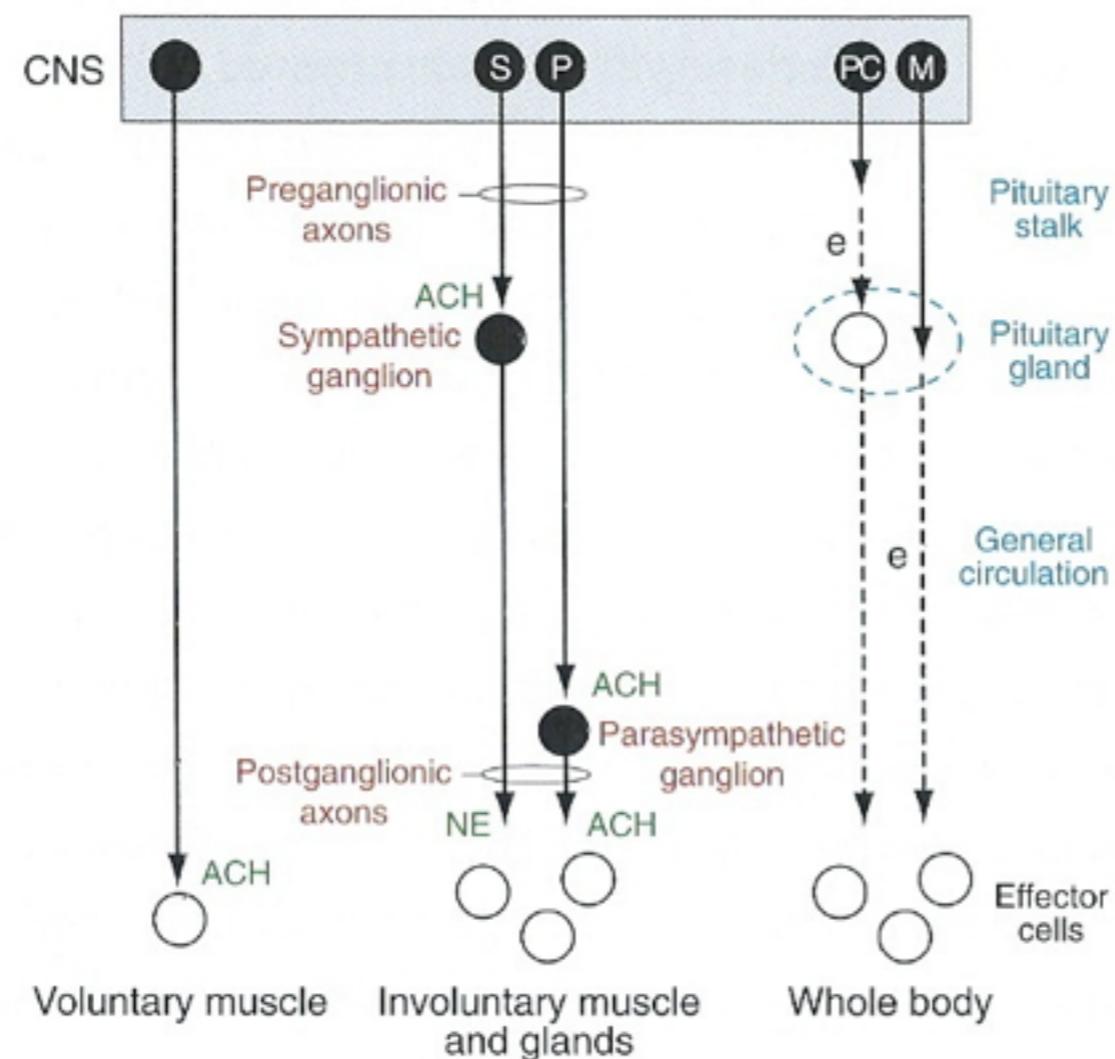
Action types

- Locomotion
- Reaching, grasping, manipulating
- Postural control
- Signaling

“Symphony of behavior”

- Hierarchy of motivated behaviors
- Hierarchy of central pattern generators, initiators, and controllers
- Motor neuron pools
 - Excitatory, inhibitory innervation
 - Flexors and extensors
 - Agonist and antagonist muscles
- Target organs of autonomic, endocrine signals

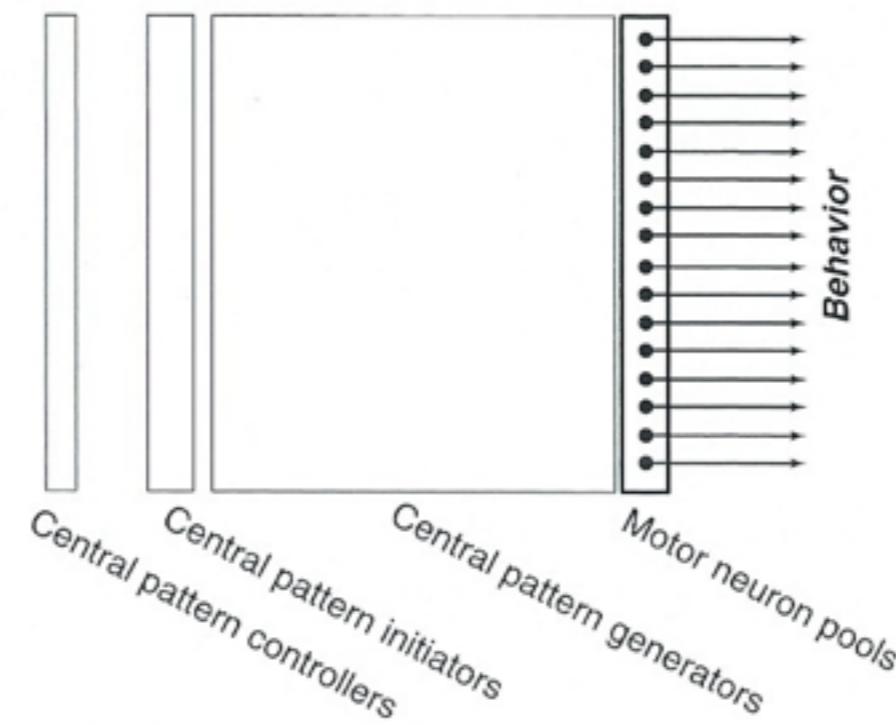
(a) Somatic: synaptic **(b) Autonomic:** paracrine **(c) Neuroendocrine:** endocrine



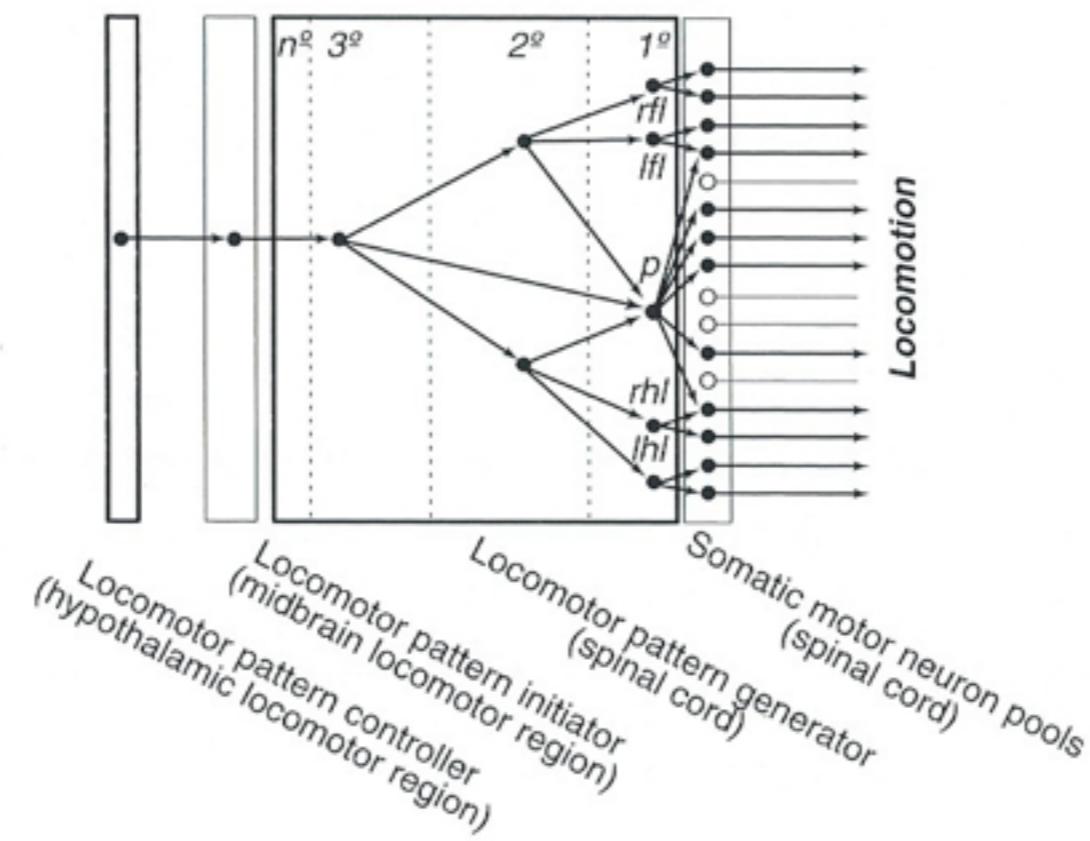
Swanson 8.1

Swanson 8.7

(a) THE SOMATIC MOTOR SYSTEM HIERARCHY



(b) LOCOMOTOR BEHAVIOR

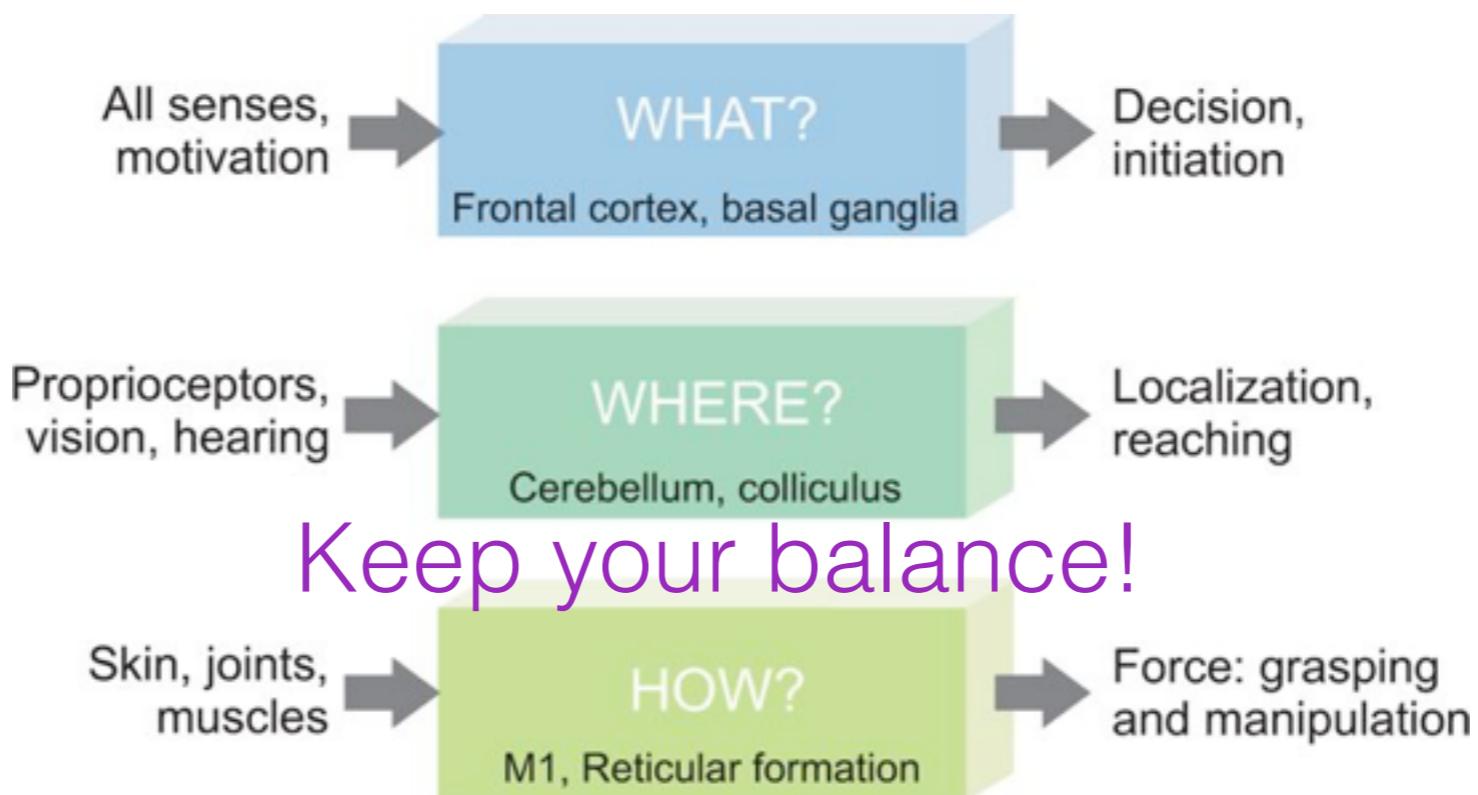




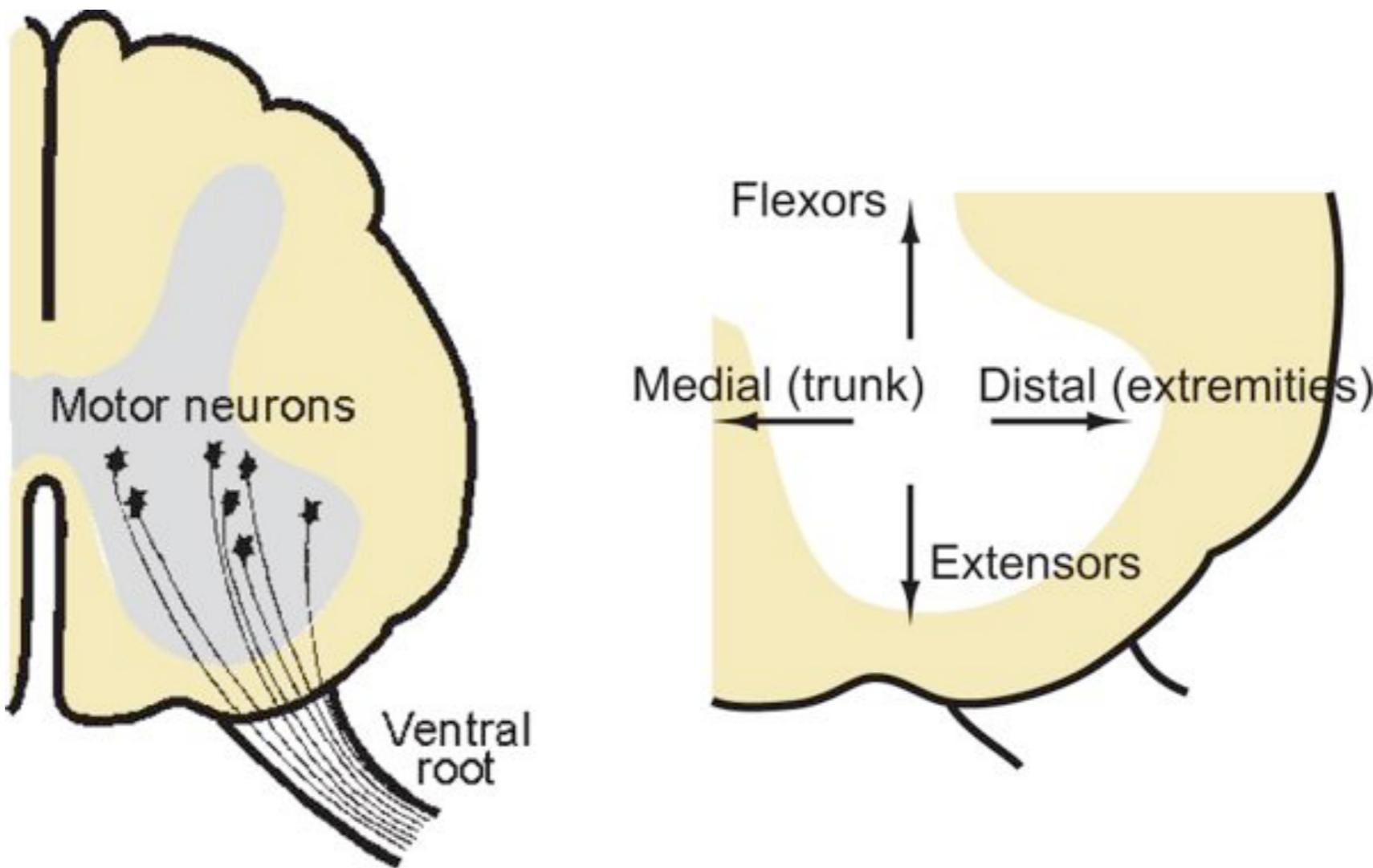
Decide, initiate
Basal ganglia, frontal cortex

Reach
Cerebellum, PMA

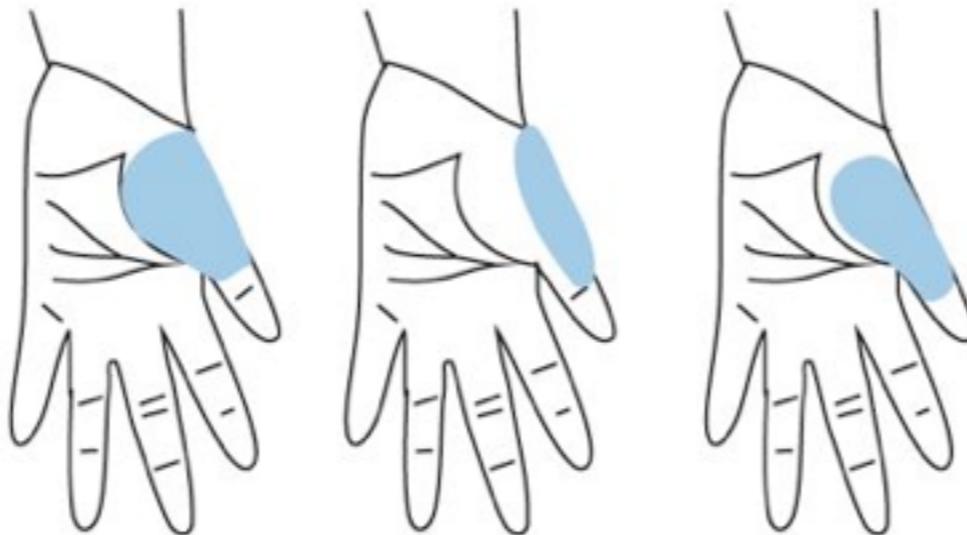
Grasp
Primary motor cortex



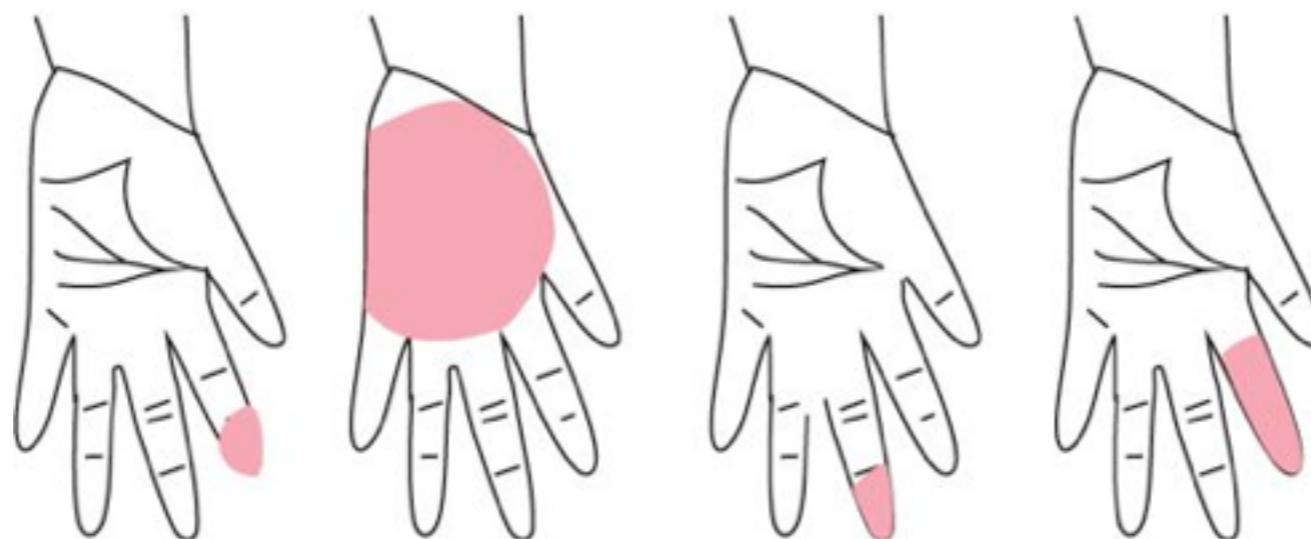
Topographic maps



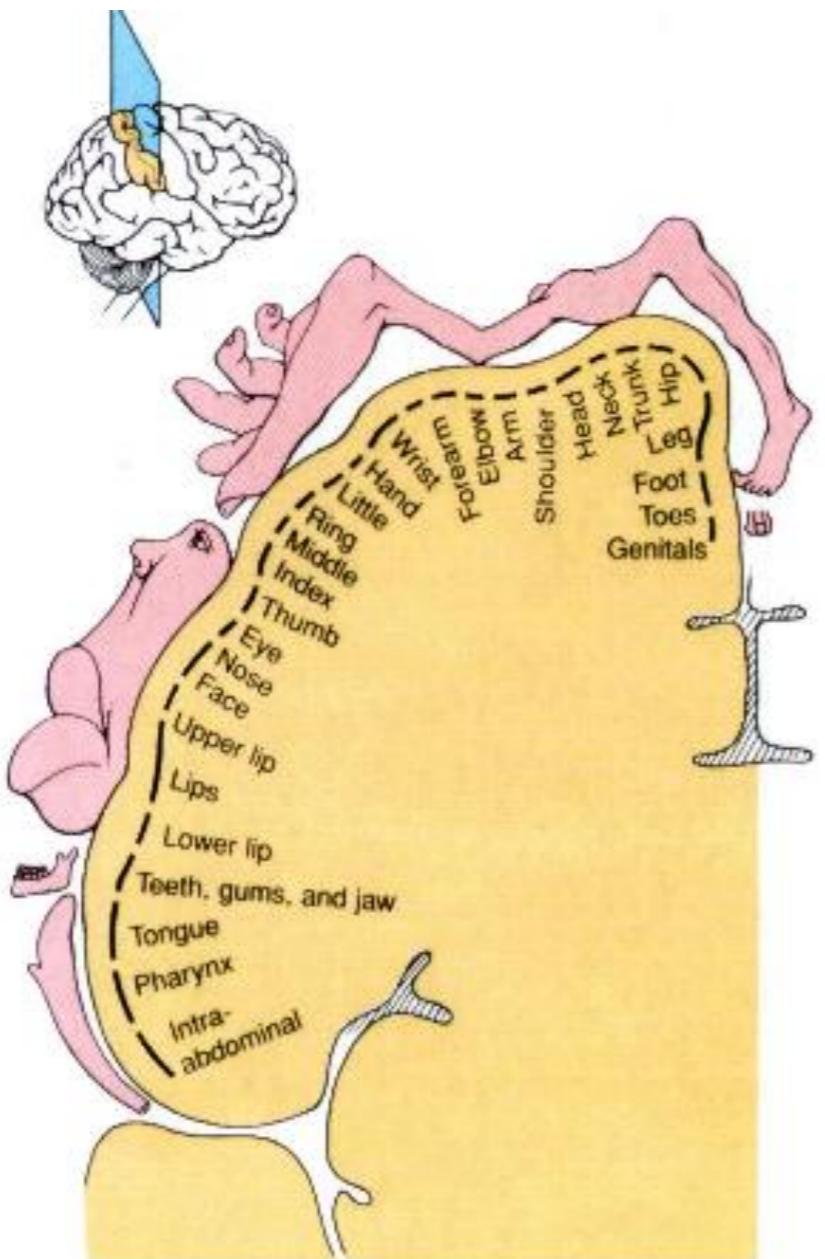
Cutaneous sensory fields of monkey pyramidal cells



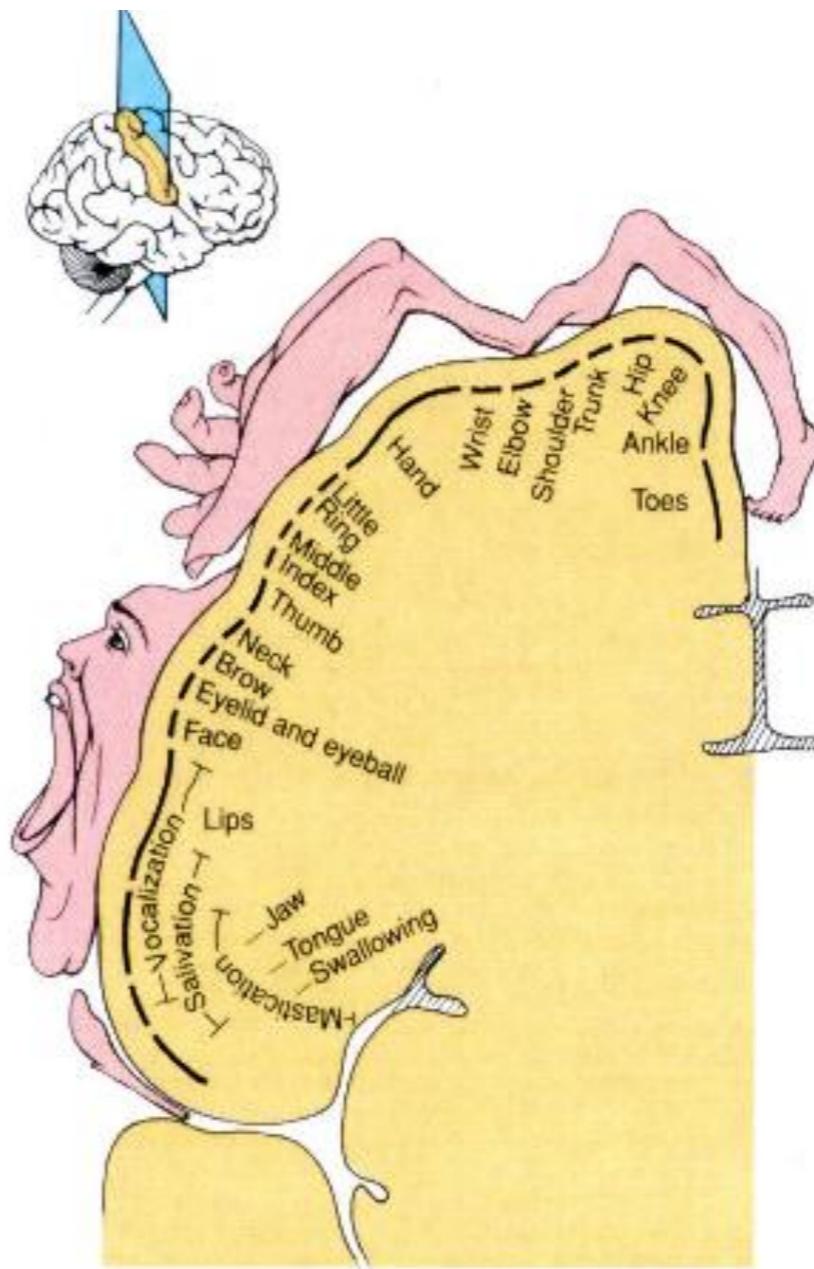
Pyramidal cells generating thumb flexion



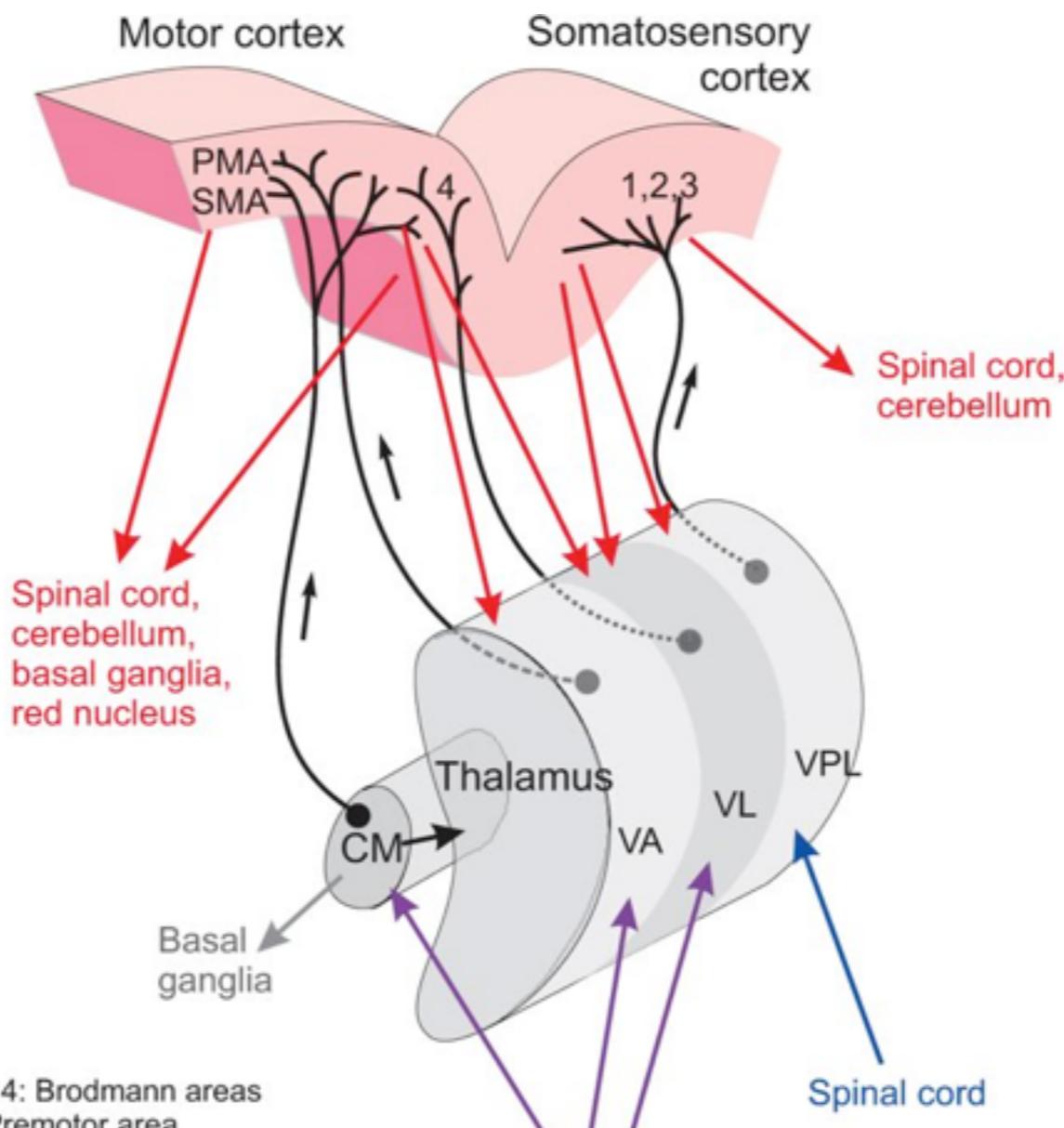
Pyramidal cells generating digit flexion



(a) Somatosensory cortex in right cerebral hemisphere



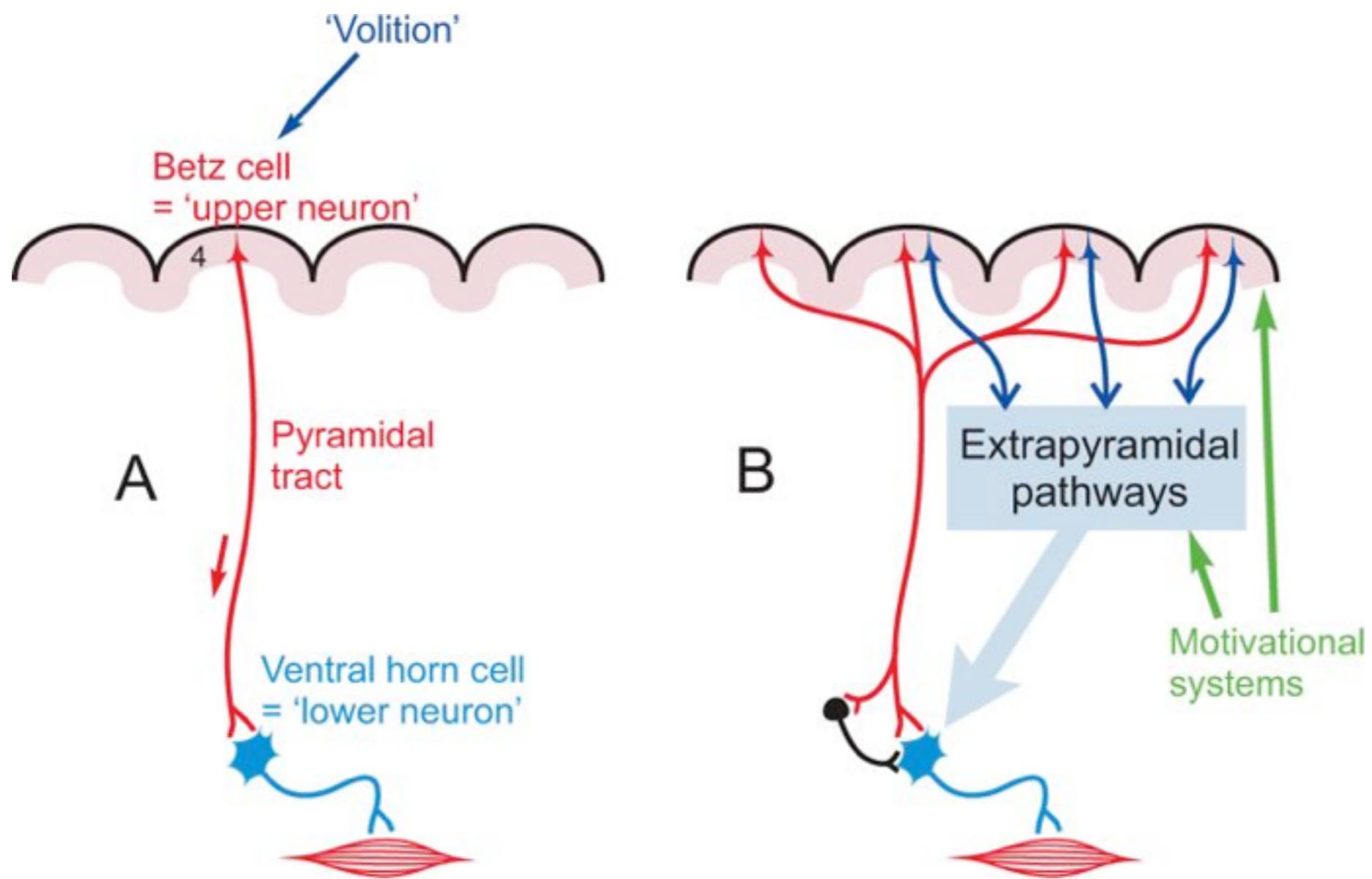
(b) Motor cortex in right cerebral hemisphere

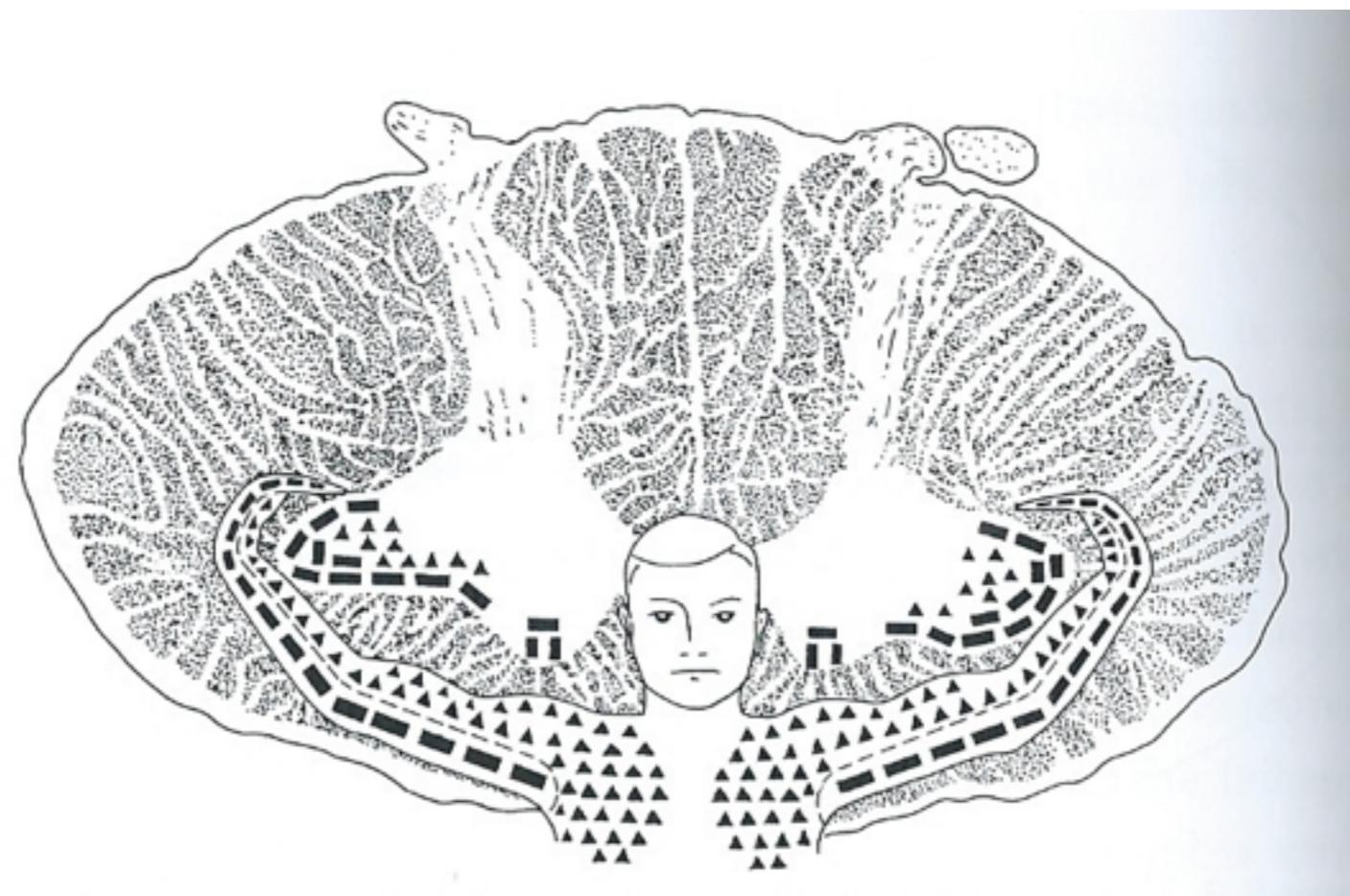


Key:

- 1, 2, 3, 4: Brodmann areas
- PMA: Premotor area
- SMA: Supplementary motor area
- VA: Ventroanterior
- VL: Ventrolateral
- VPL: Ventroposterolateral
- CM: Centromedian

Cerebellum,
basal ganglia,
reticular formation

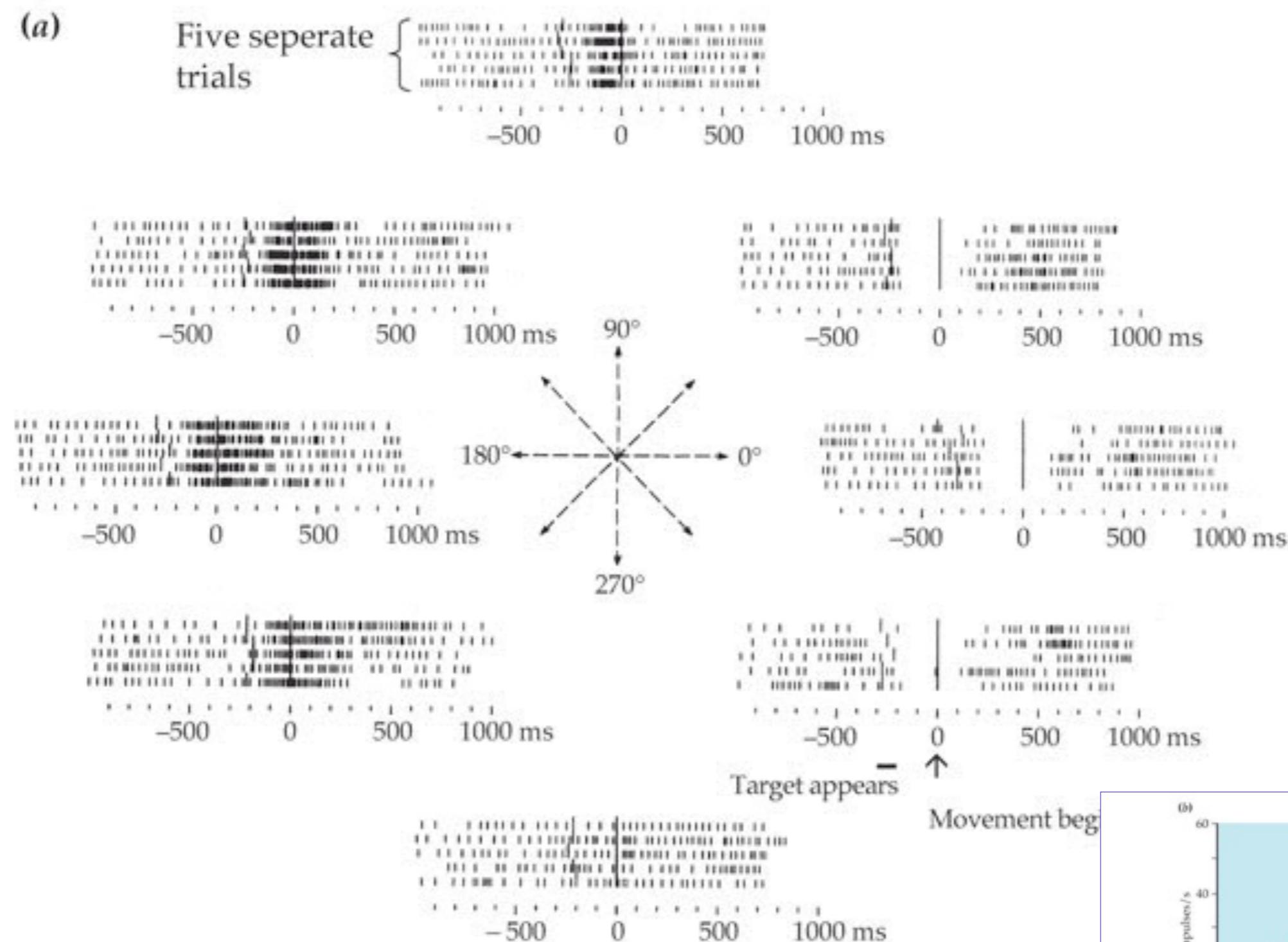




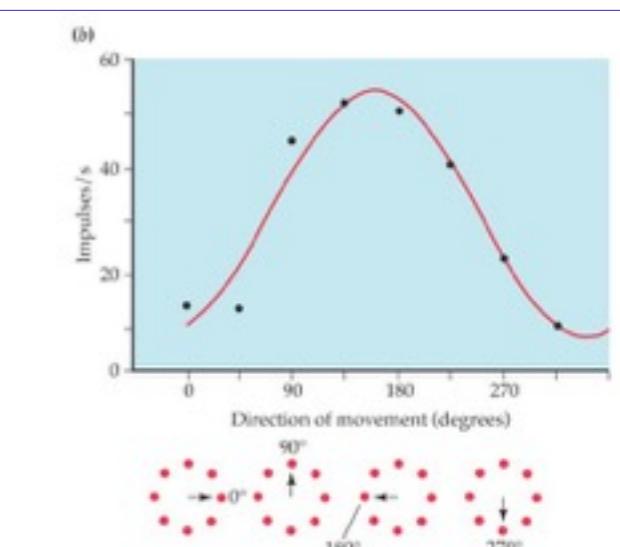
Swanson 8.3

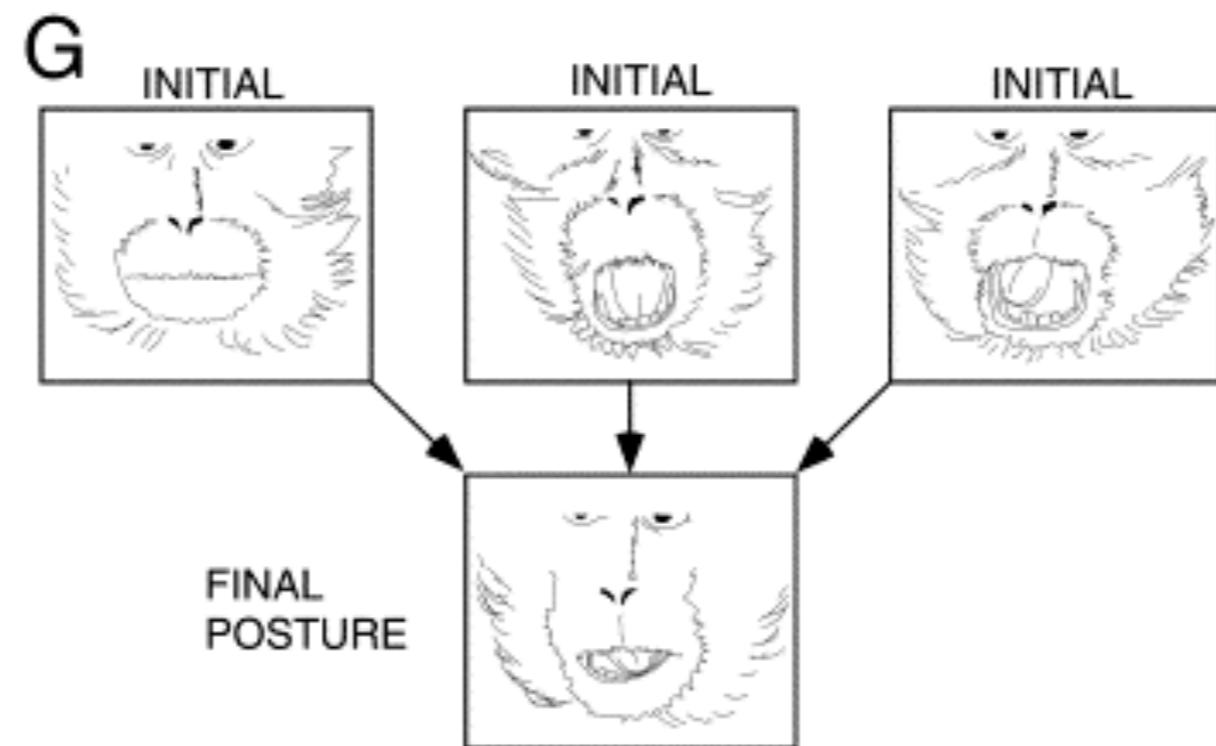
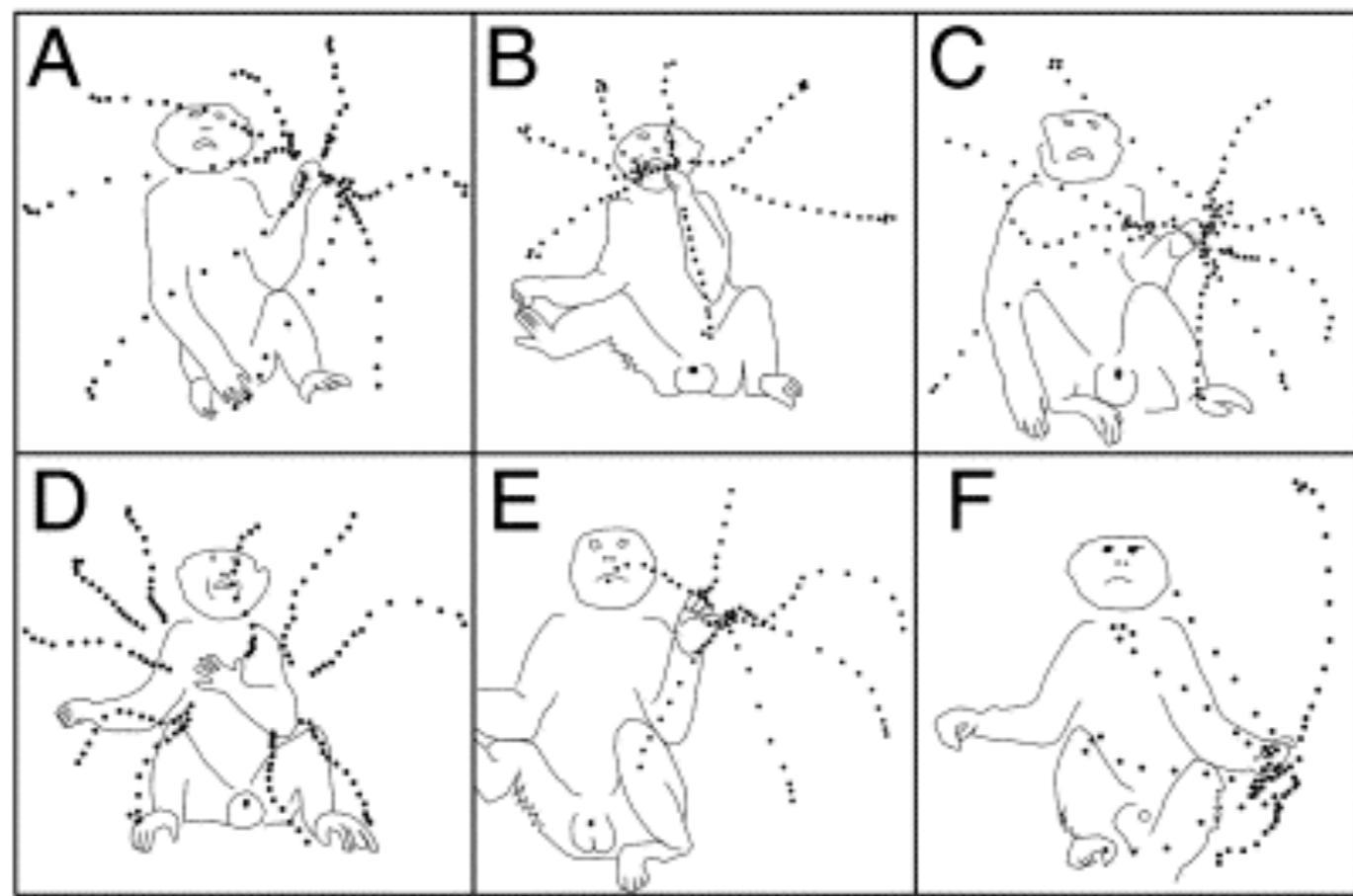
Encode muscles or
movements?

(a)



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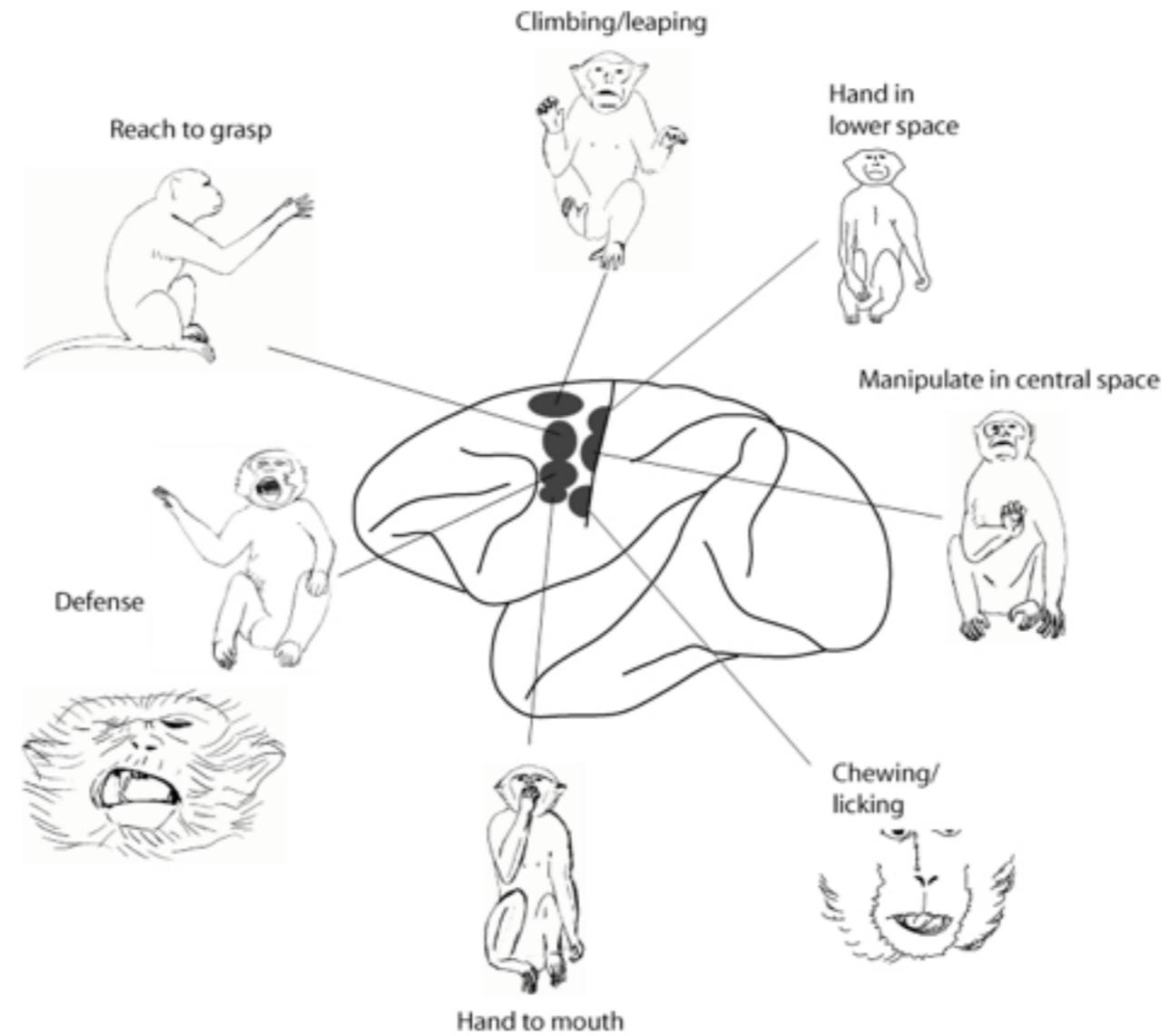


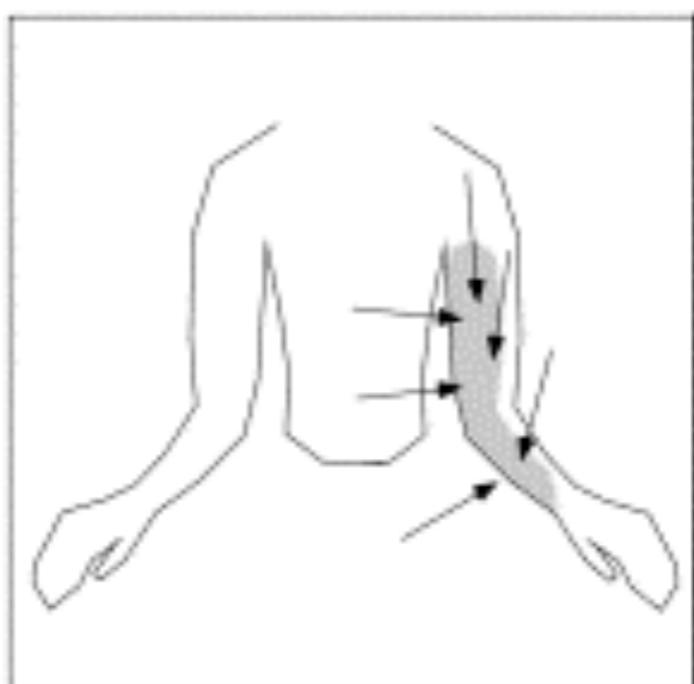
Figure 1: Seven common categories of movement evoked by electrical stimulation of the monkey motor cortex on a behaviorally relevant time scale.

<http://www.princeton.edu/~graziano/>

TACTILE AND VISUAL
RECEPTIVE FIELDS

EVOKED POSTURE

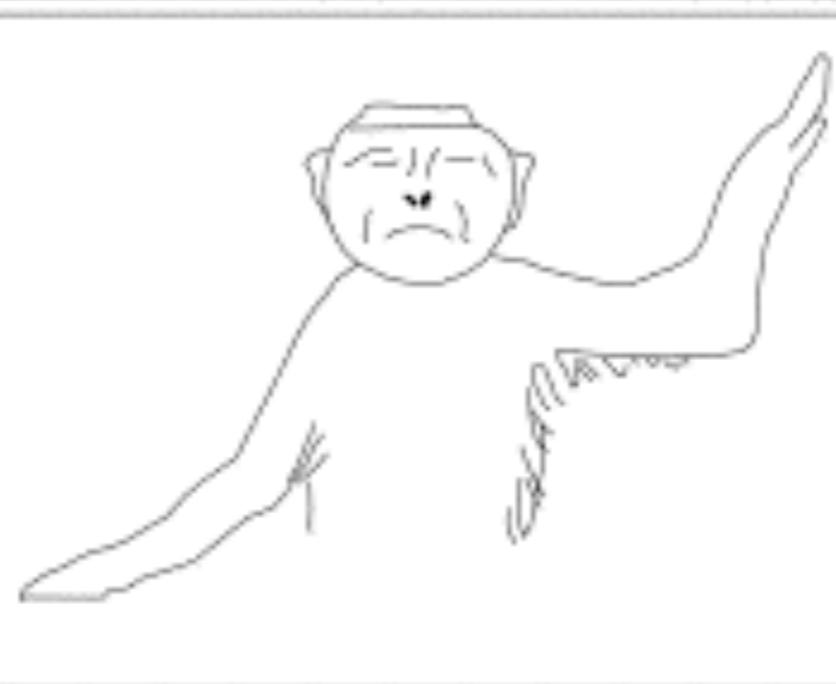
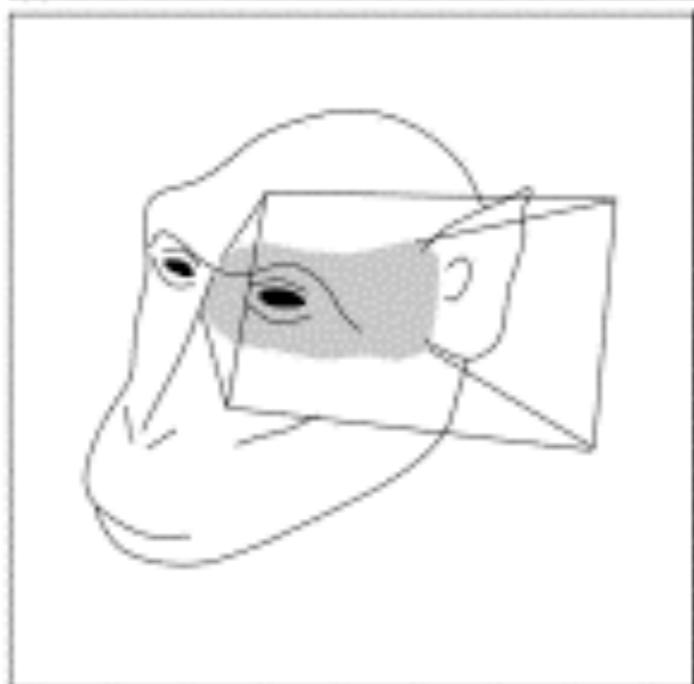
A



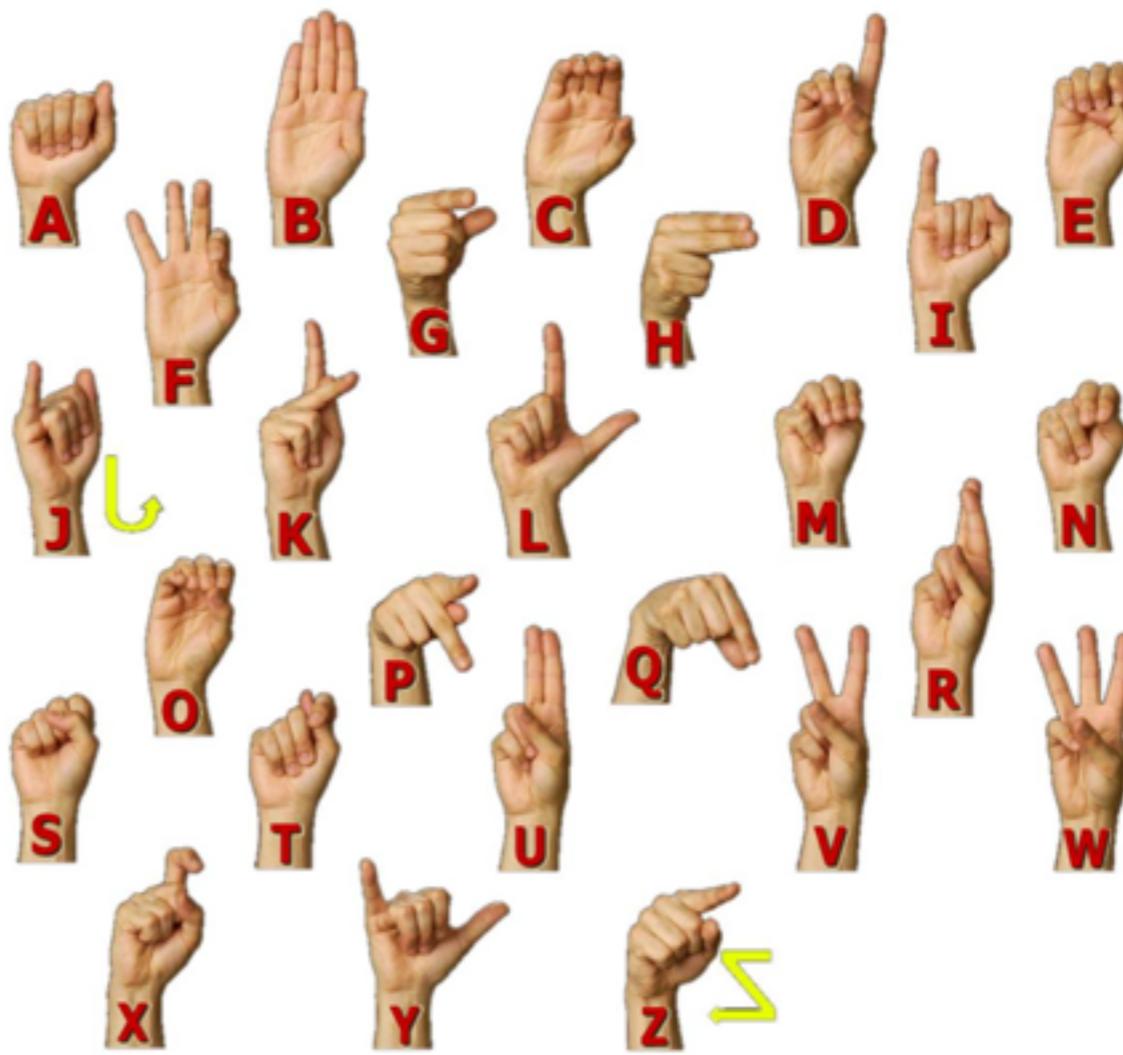
SIDE VIEW

BACK VIEW

B

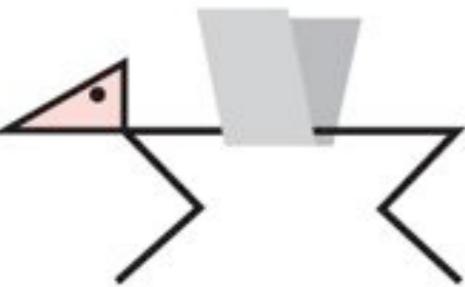
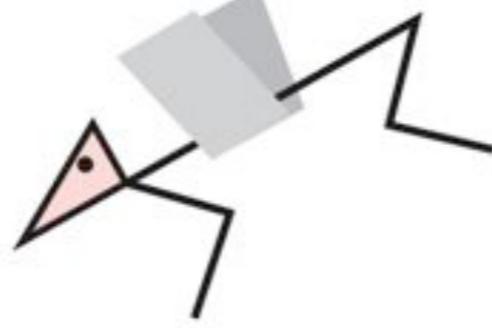
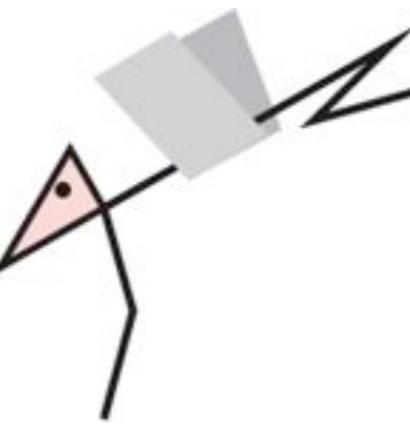


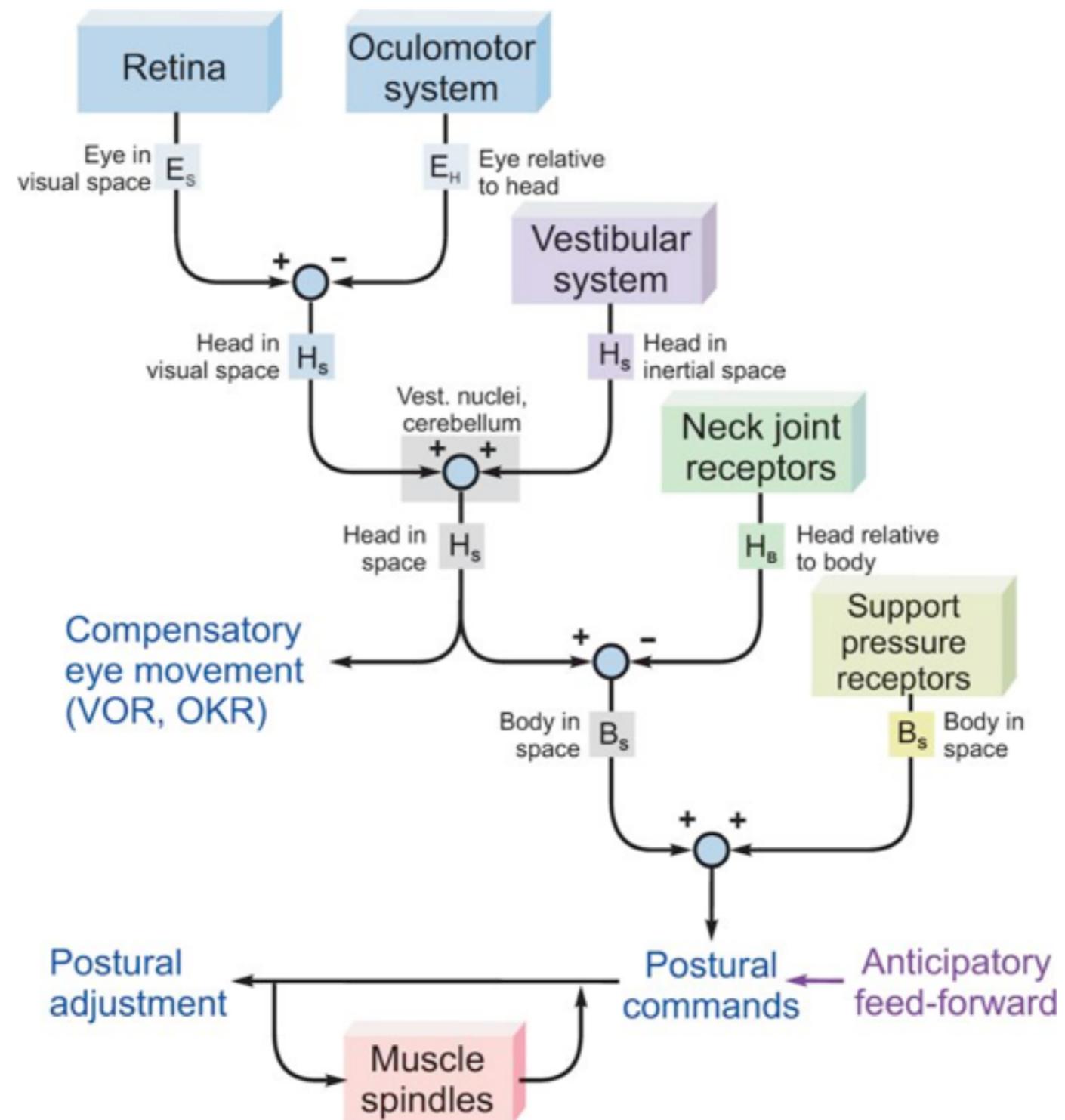
Fine vs. coarse control

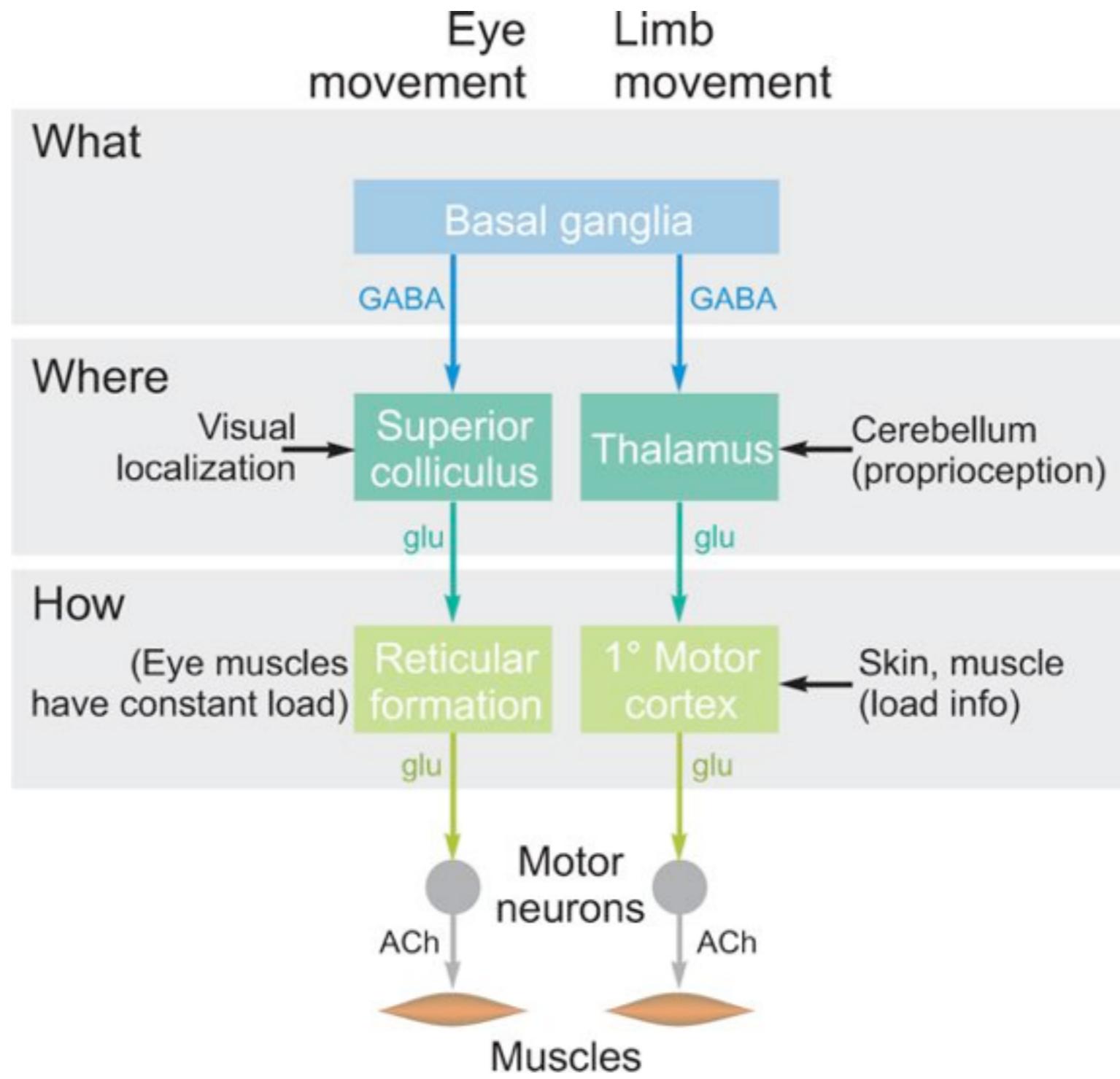


Processing hierarchy

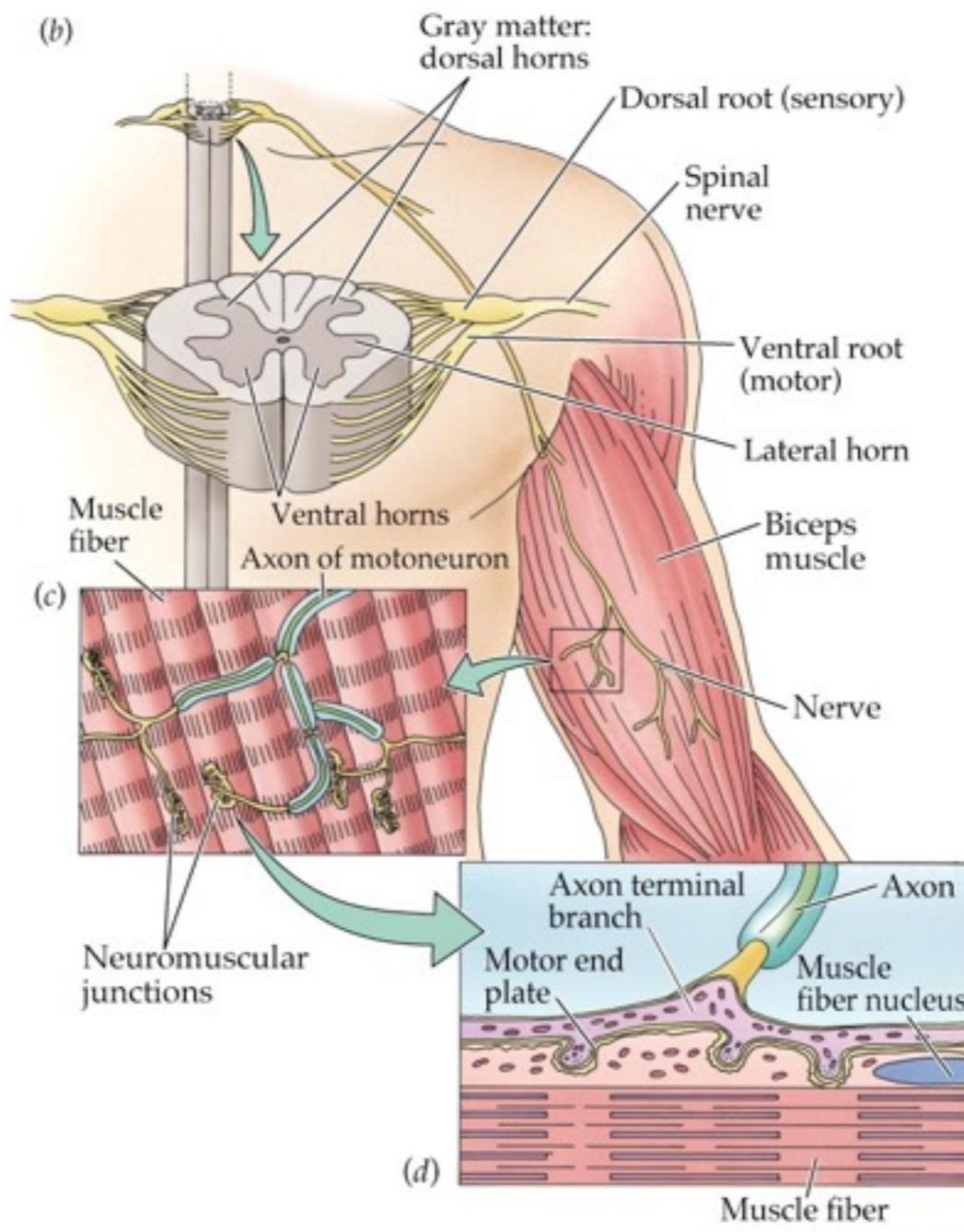
Posture

- Pre
- Vestibular receptors
- Change body, limb, neck, eye position

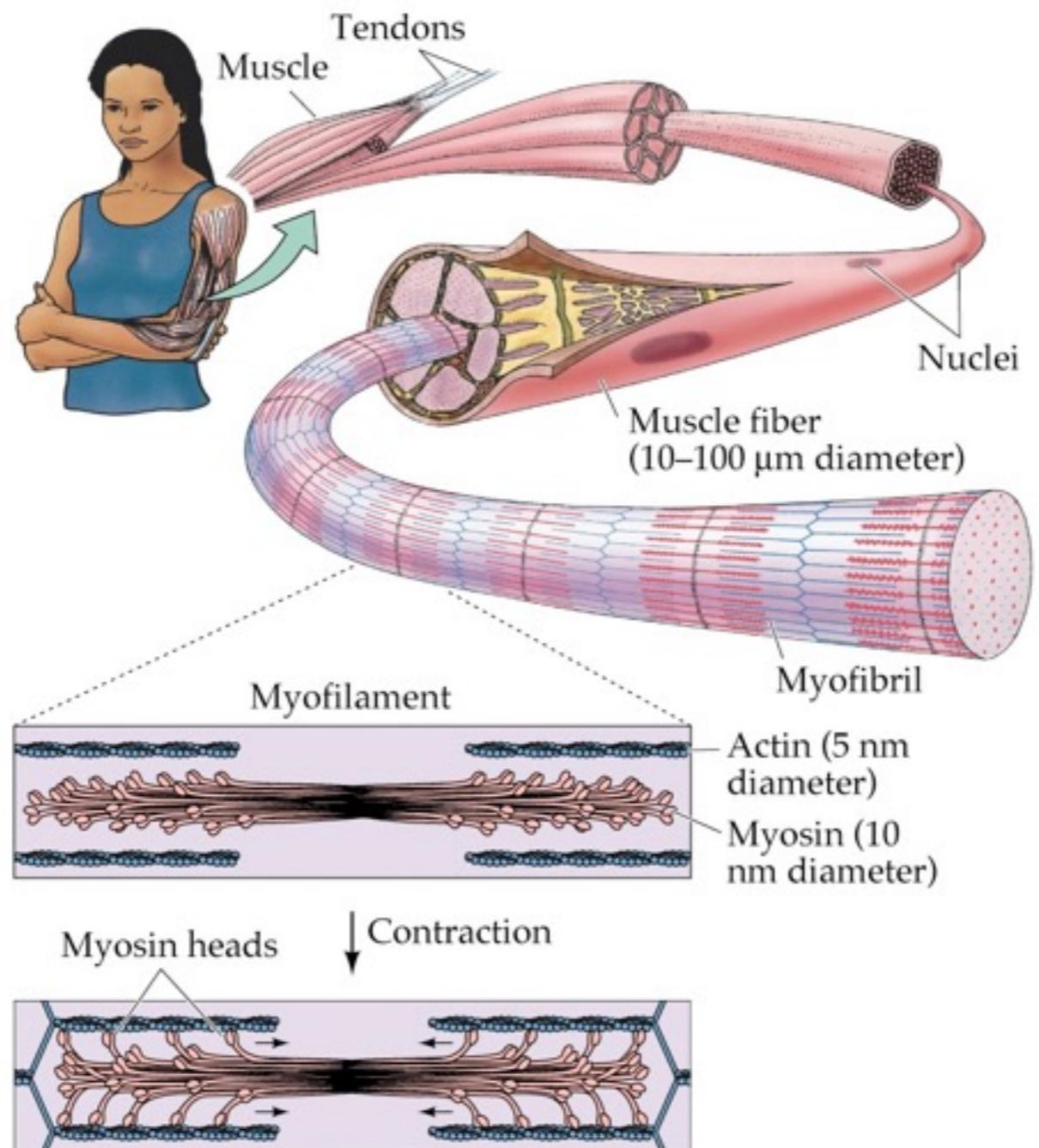




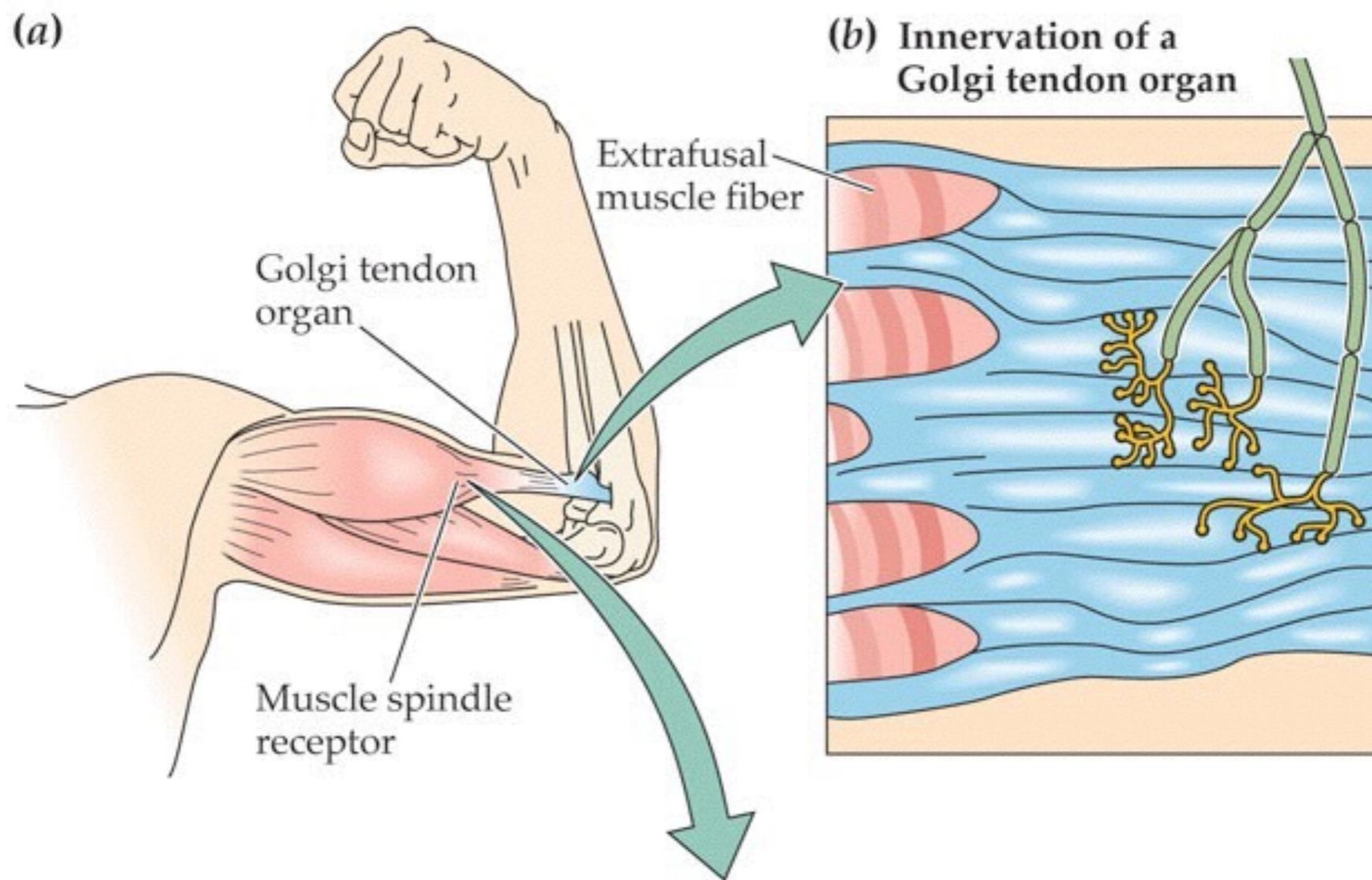
Sensorimotor
feedback

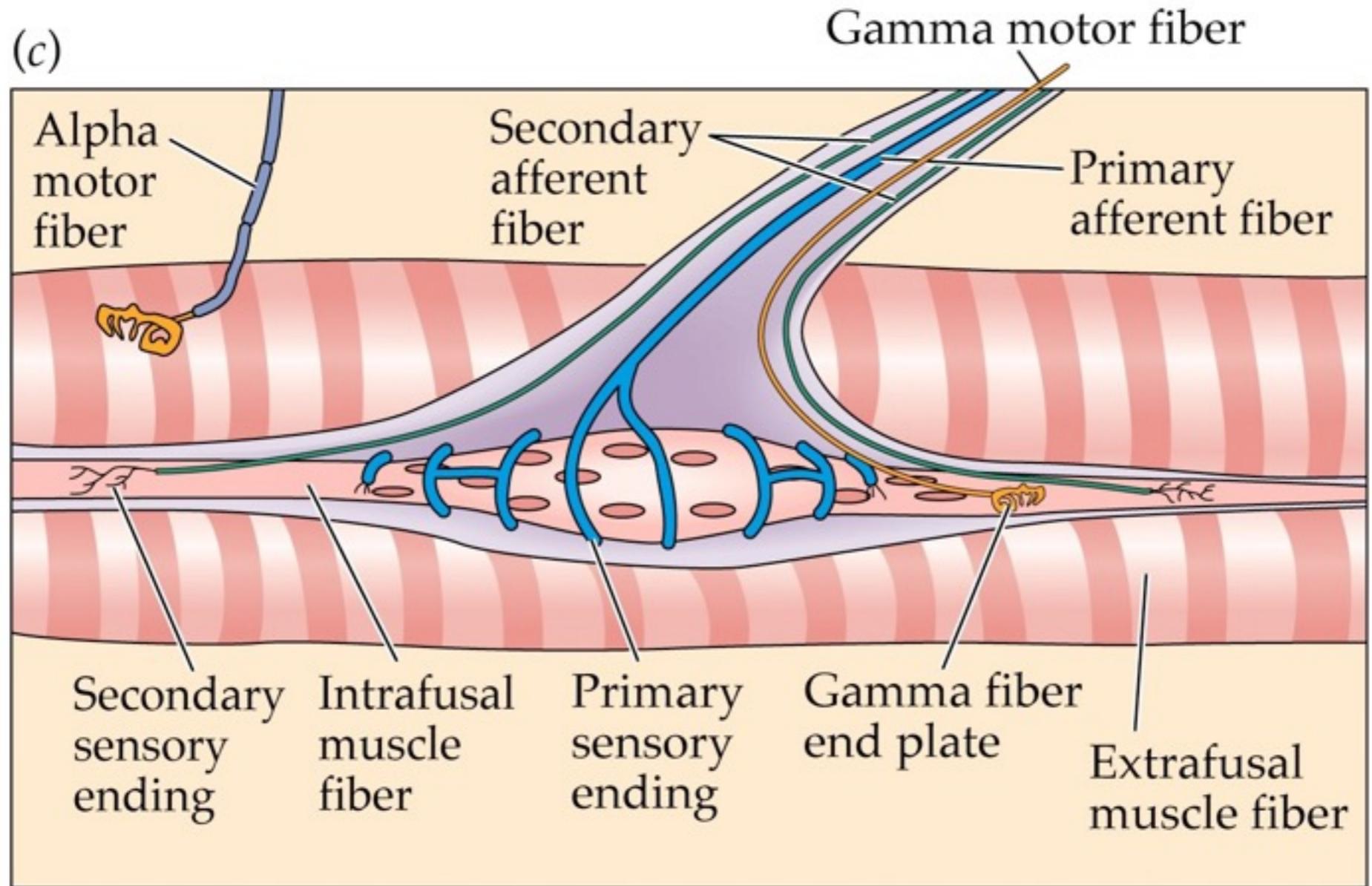


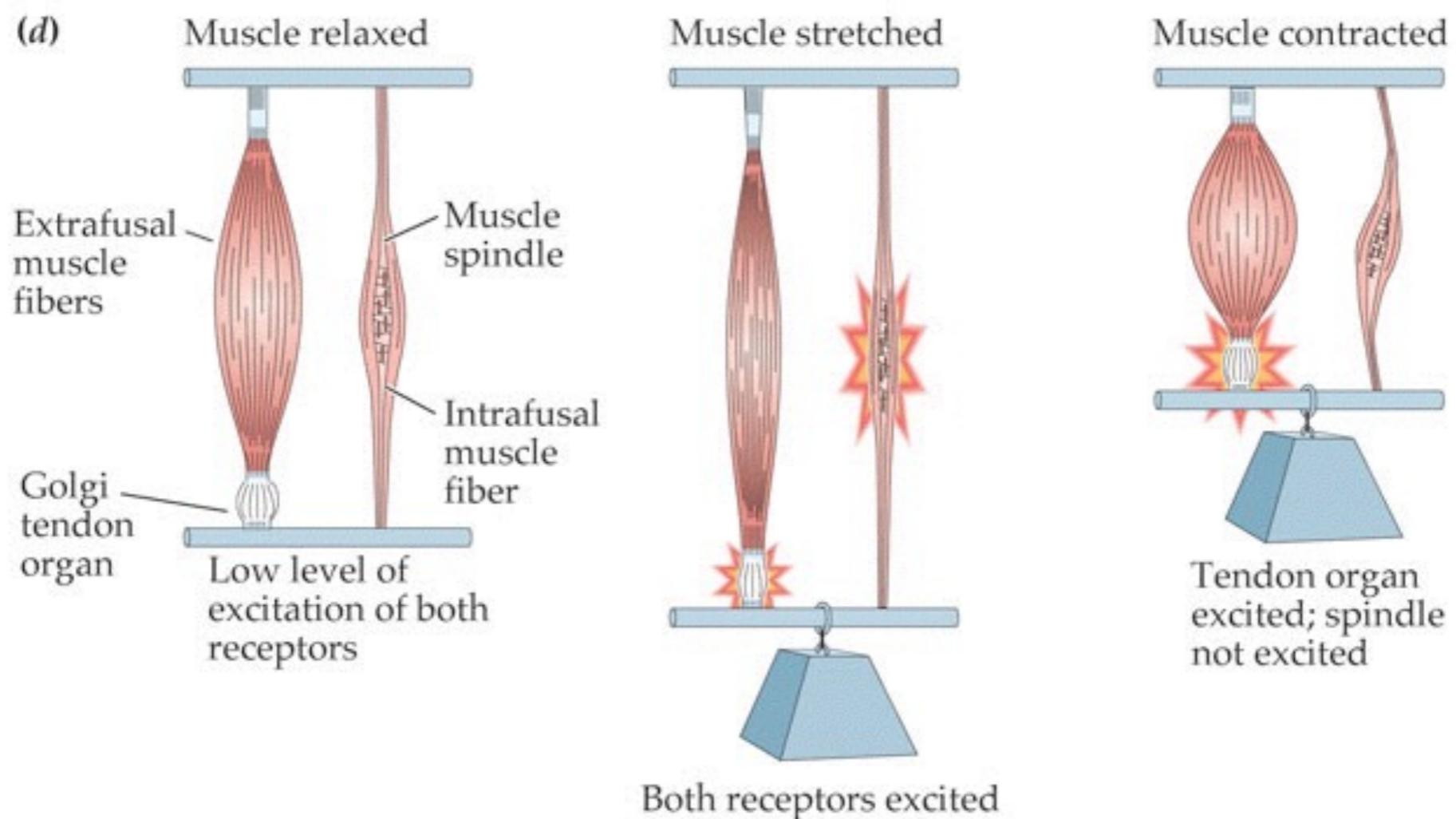
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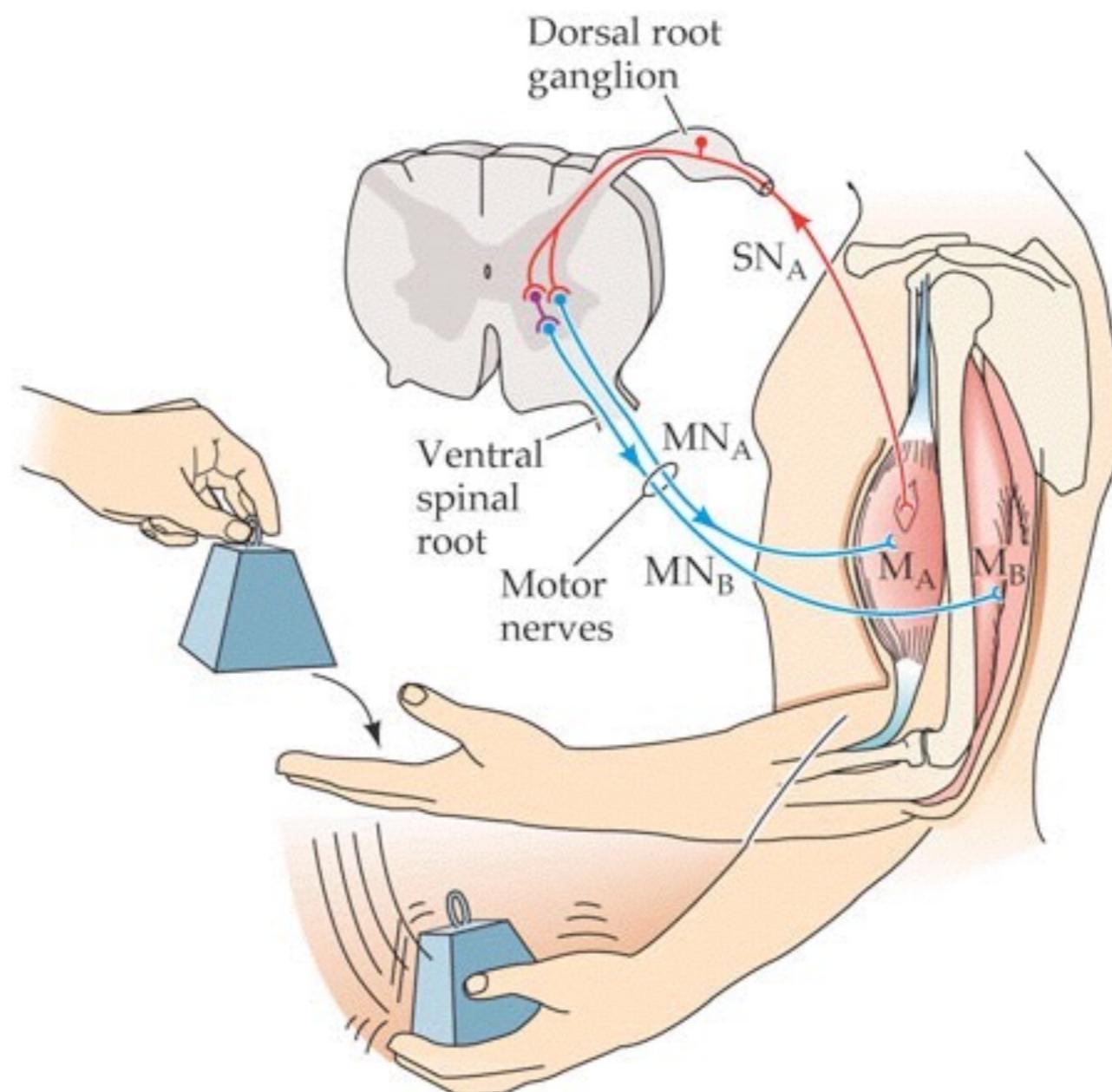


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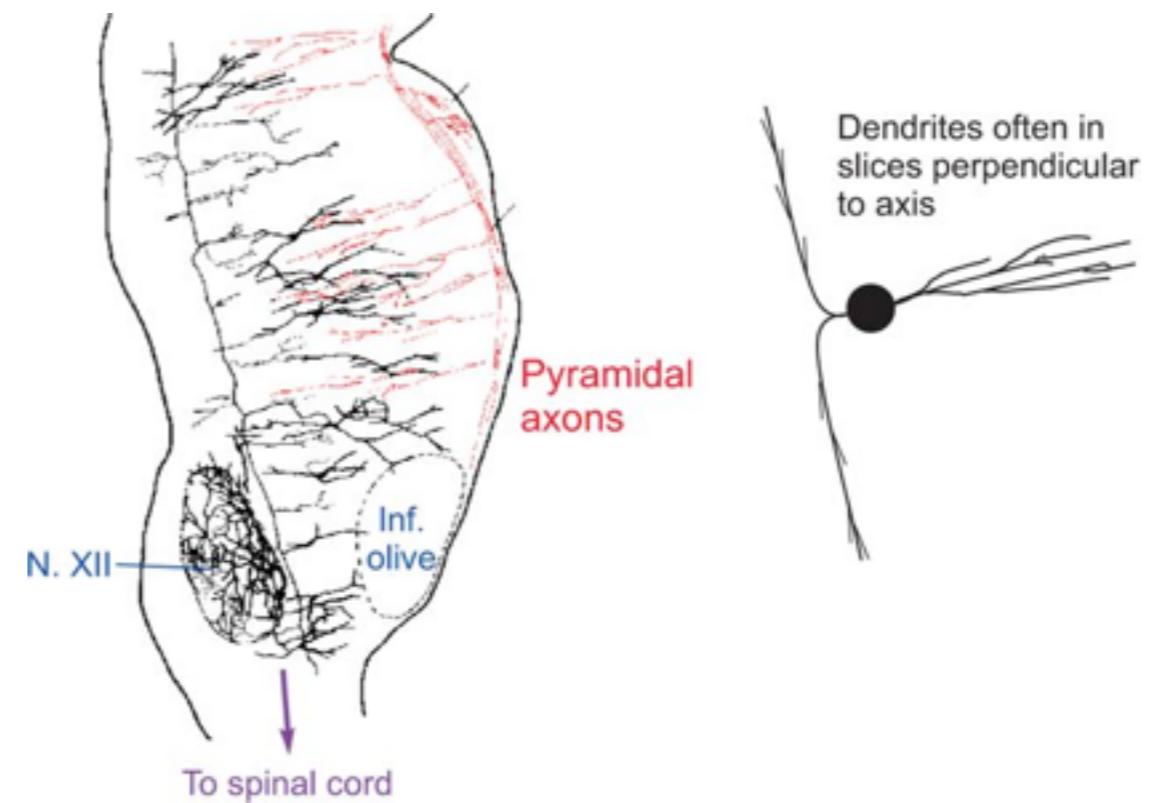
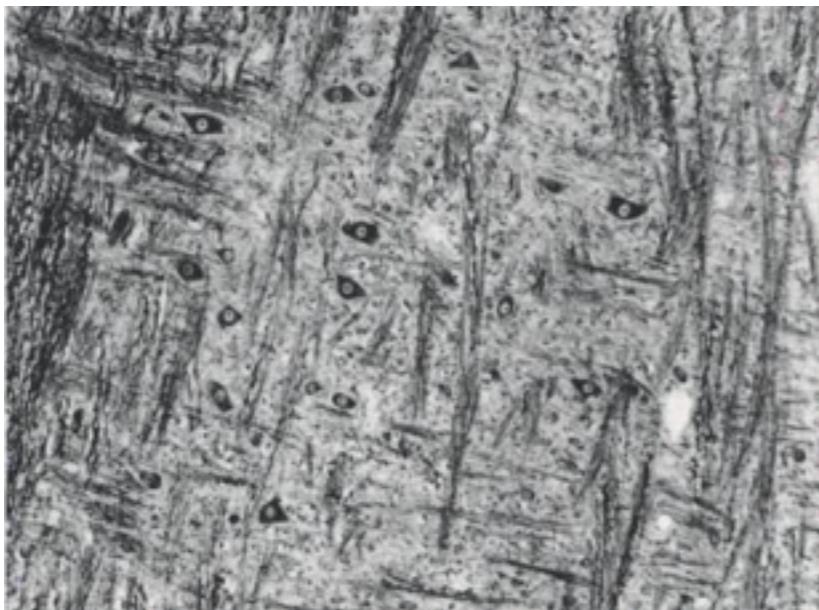
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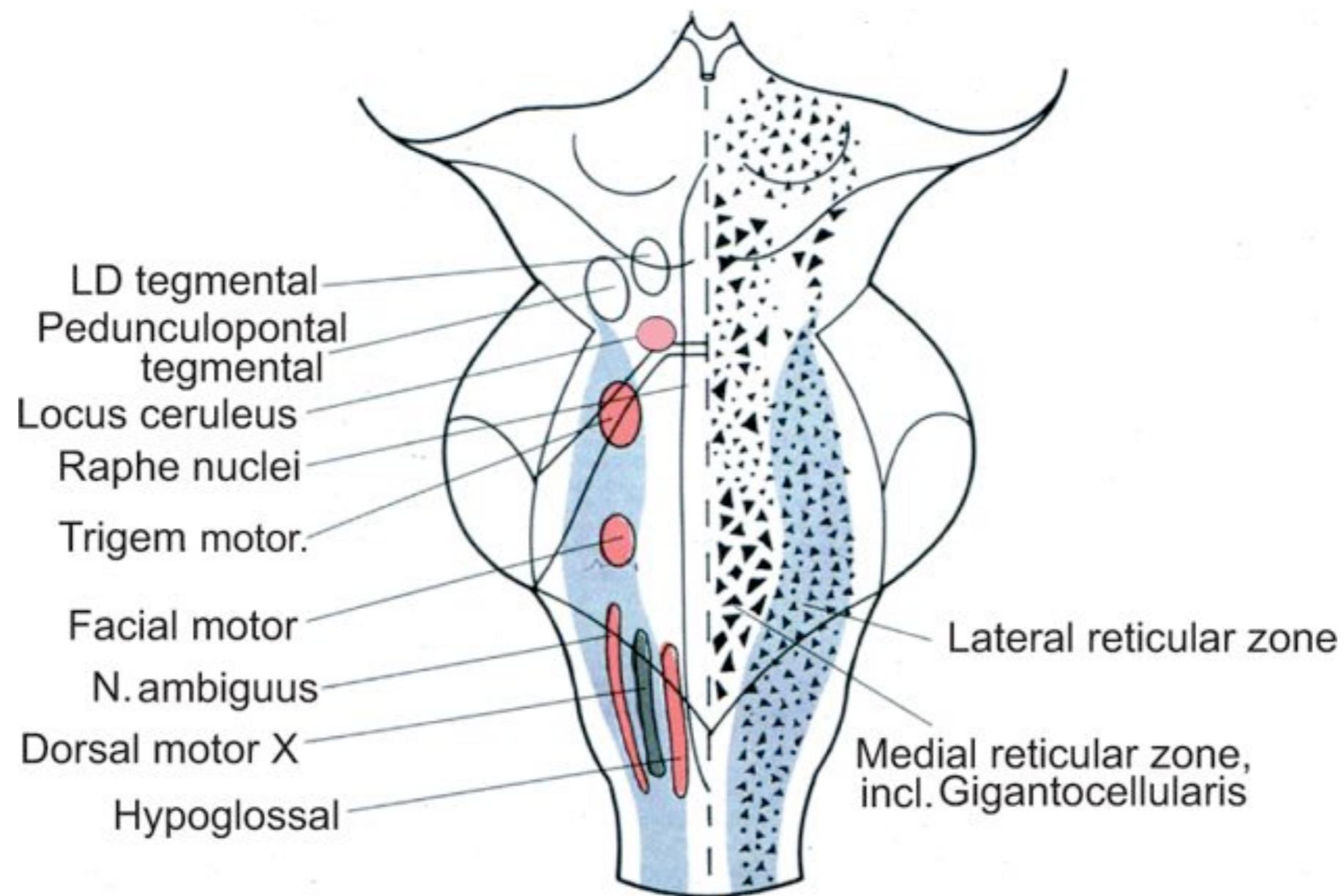
Autonomic

Autonomic controllers

- Hypothalamus
- Cranial nerve nuclei
- Reticular formation

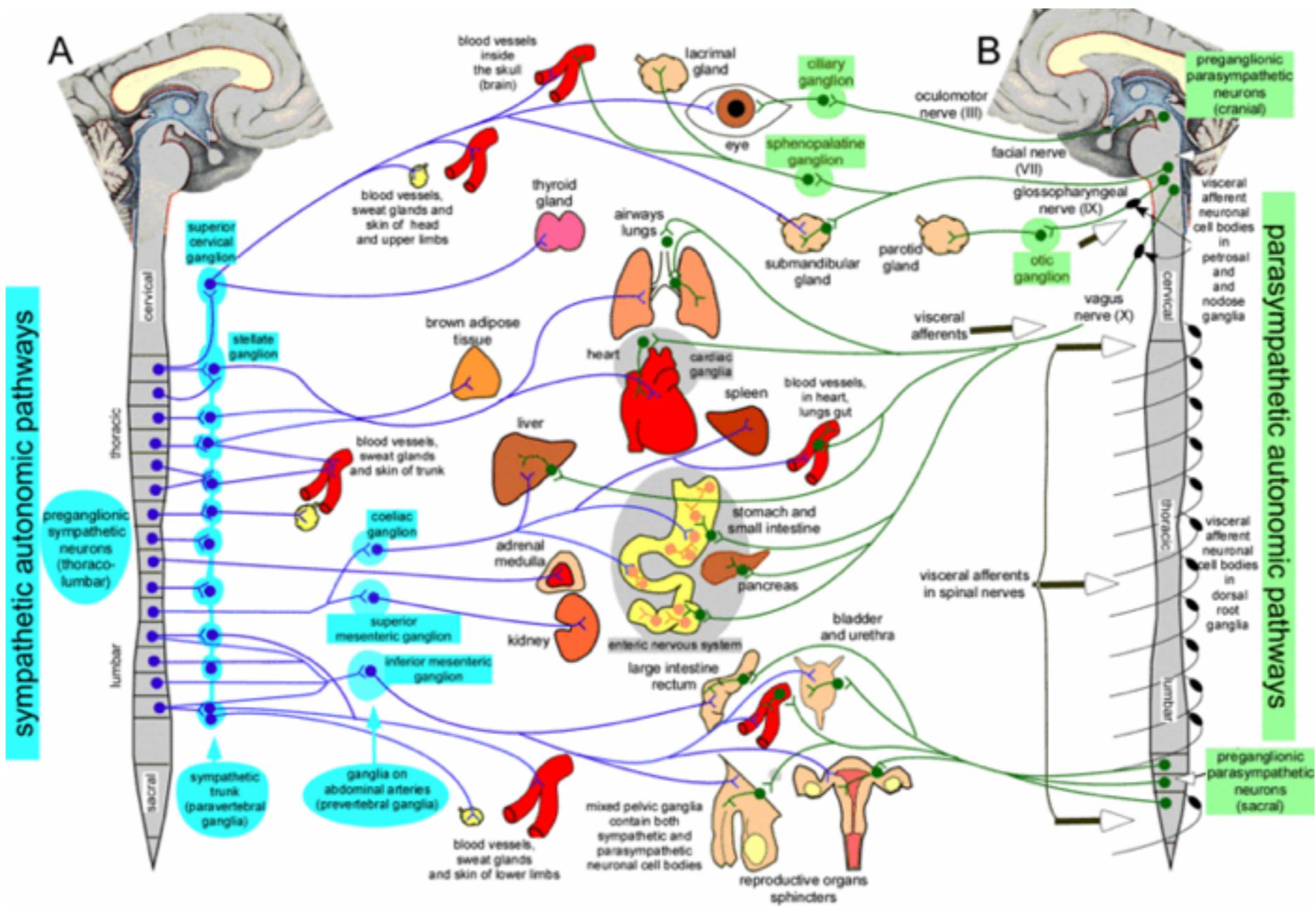
Brainstem reticular formation





Reticular formation

- Noradrenergic (norepinephrine, NE) projection to forebrain
 - Locus ceruleus
- Serotonergic projections to forebrain, spinal cord
 - Raphe nucleus



Neuroendocrine

Hormones...

- Are chemicals secreted into blood
- Act on specific target tissues
- Produce specific effects

Principles of hormonal action

- Gradual action
- Change intensity or probability of behavior
- Behavior <-> hormones
- Multiple effects on different tissues

Principles of hormonal action

- Produced in small amounts; released in bursts
- Levels vary daily, seasonally
- Effect cellular metabolism
- Influence only cells with receptors

Behaviors under hormonal influence

- Ingestive (eating/drinking)
 - Fluid levels
 - Na, K, Ca levels
 - Digestion
 - Blood sugar levels



Behaviors under hormonal influence

- Reproduction
 - Maturation
 - Mating
 - Birth
 - Care giving



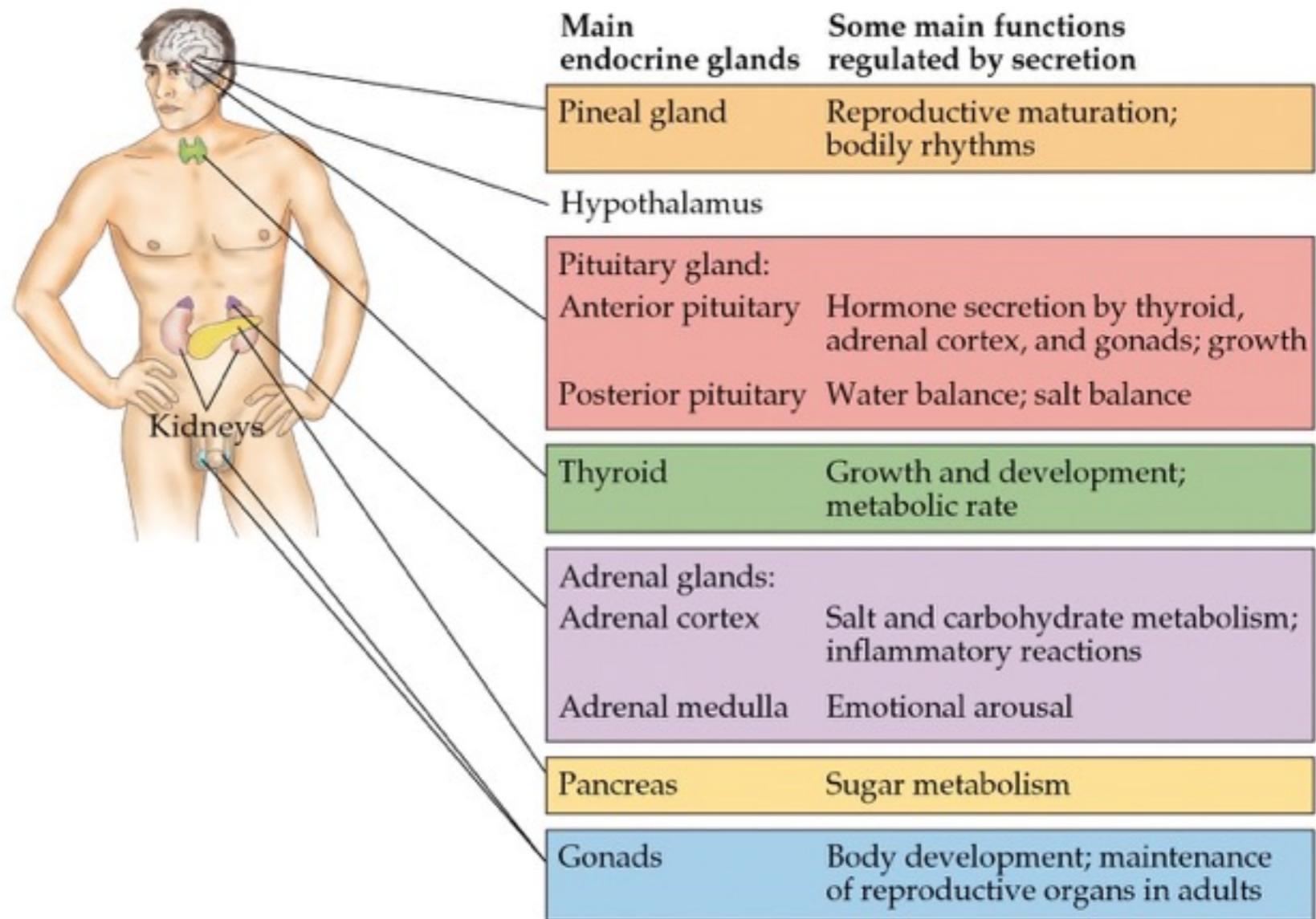
Behaviors under hormonal influence

- Responses to threat/challenge
 - Metabolism
 - Heart rate, blood pressure
 - Digestion
 - Emotional arousal



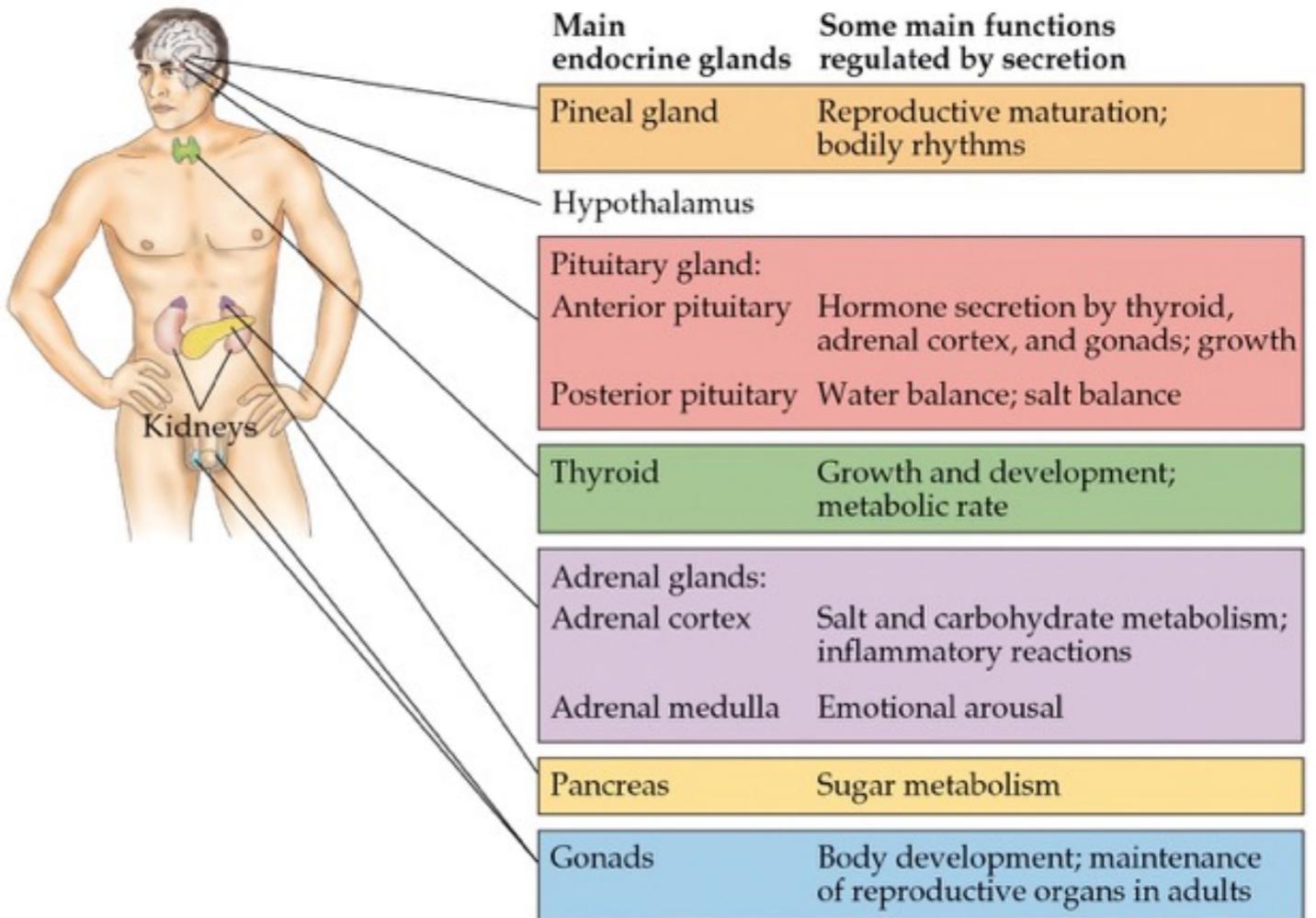
Where are hormones released?

- CNS
 - Hypothalamus
 - Pineal gland
- Pituitary
 - Posterior
 - Anterior



Where are hormones released?

- Thyroid
- Adrenal glands
 - Adrenal Cortex
 - Adrenal Medulla
- Pancreas
- Gonads (testes/ovaries)

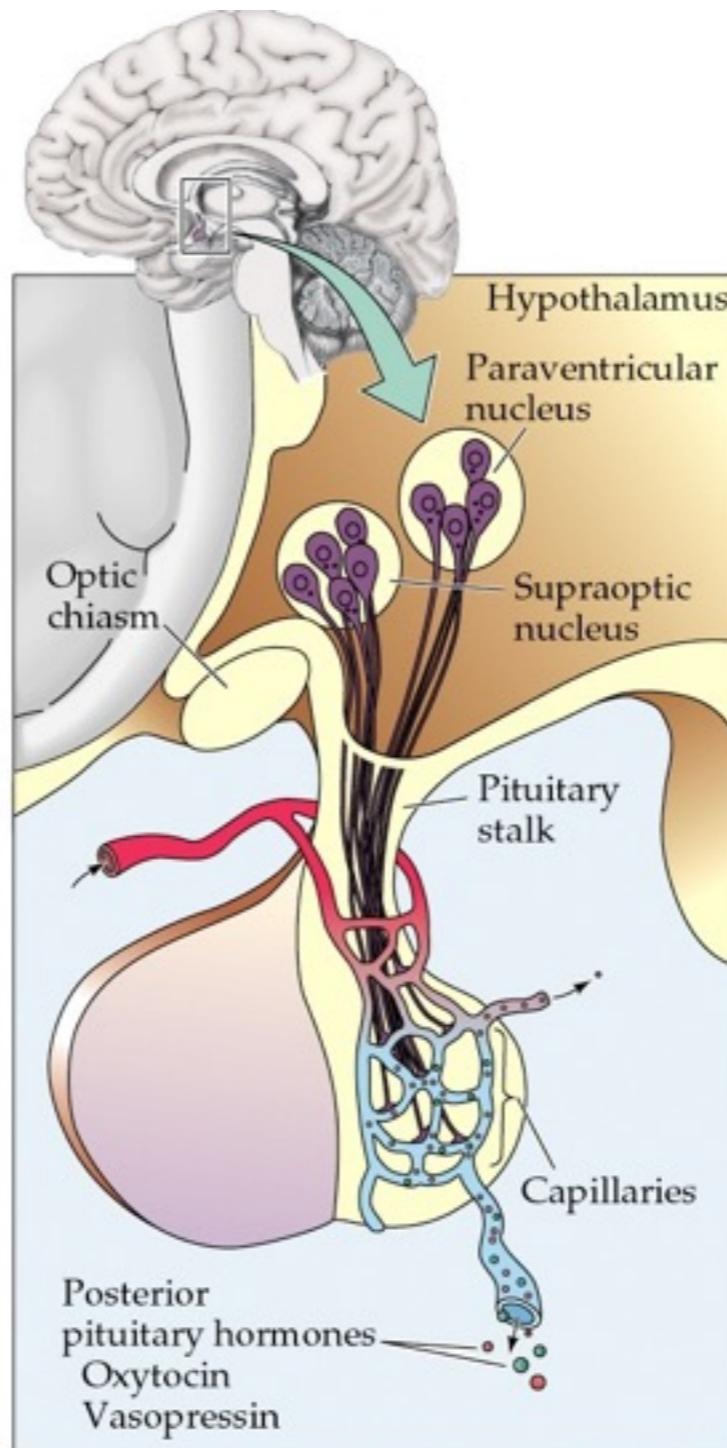


What hormones are released where?

Hypothalamus

- Direct: Oxytocin, vasopressin
- Indirect: Via releasing hormones
 - Signal anterior pituitary to release hormones
 - Thyrotropin releasing hormone (TRH)
 - Corticotropin releasing hormone (CRH)
 - Gonadotropin releasing hormone (GnRH)
 - Others...

Posterior pituitary



Anterior pituitary

