Lecture 6

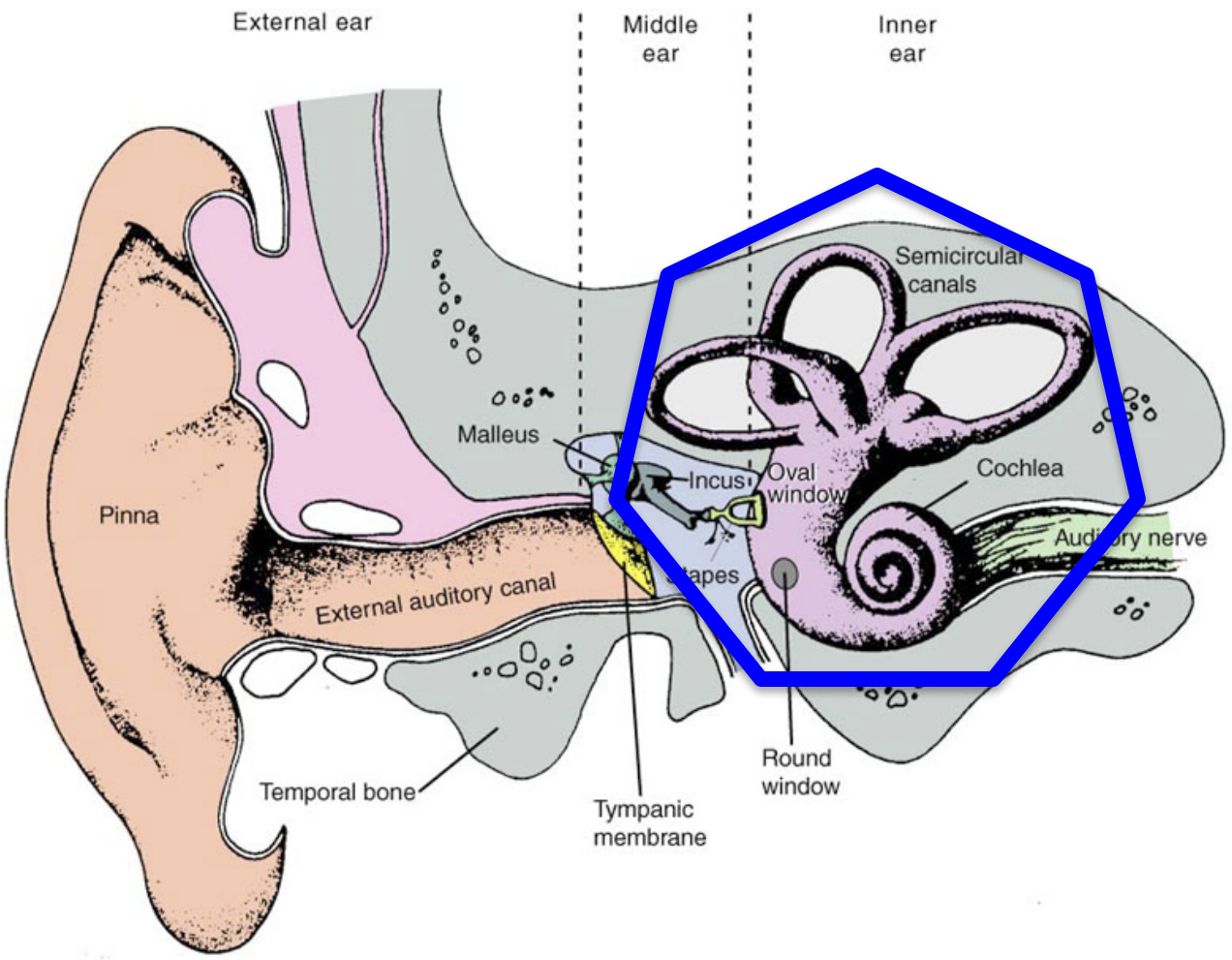
Other Sensory Systems

Cogs17 * UCSD

Vestibular System

Balance

Vestibular System in Inner Ear



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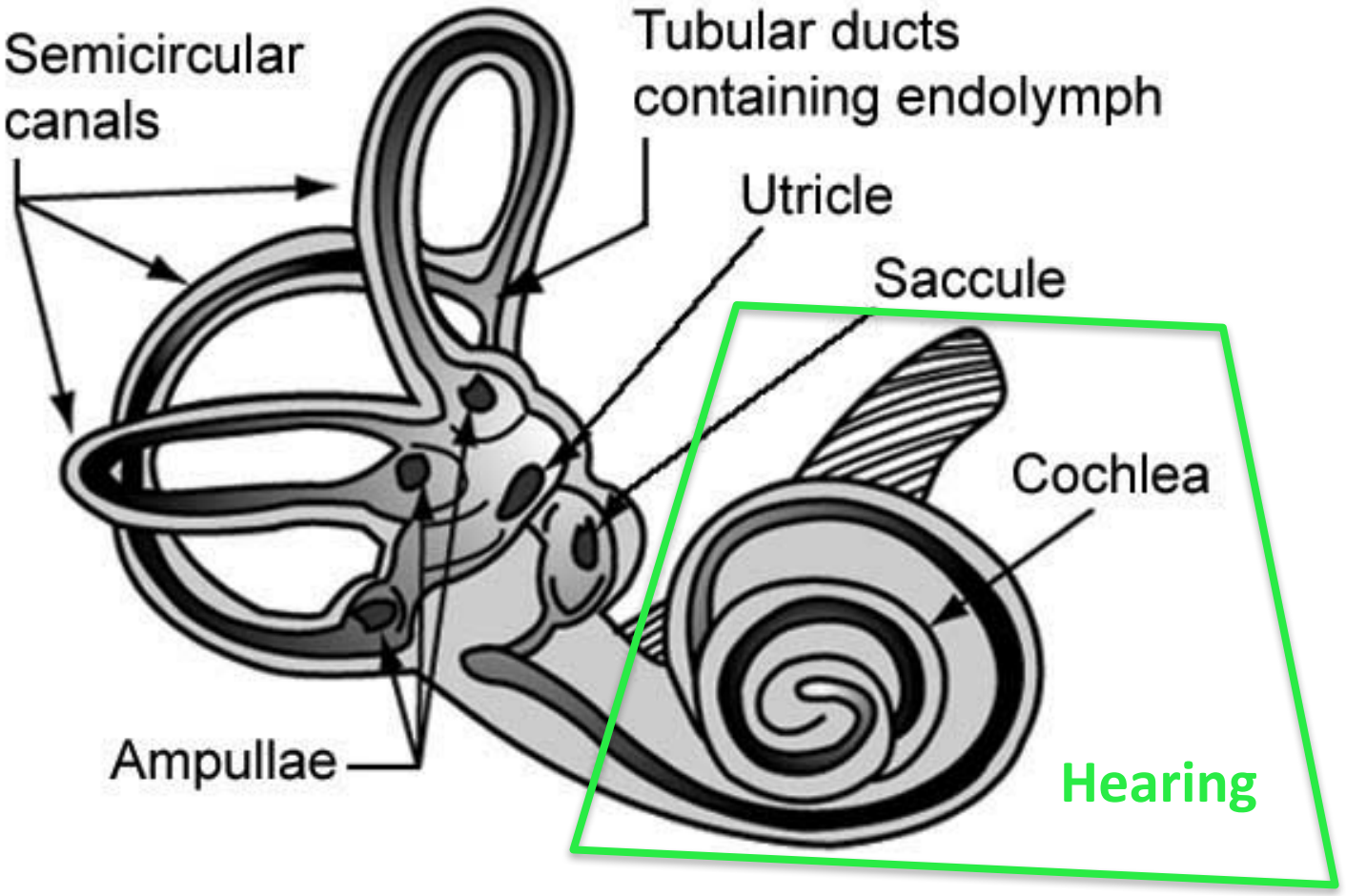
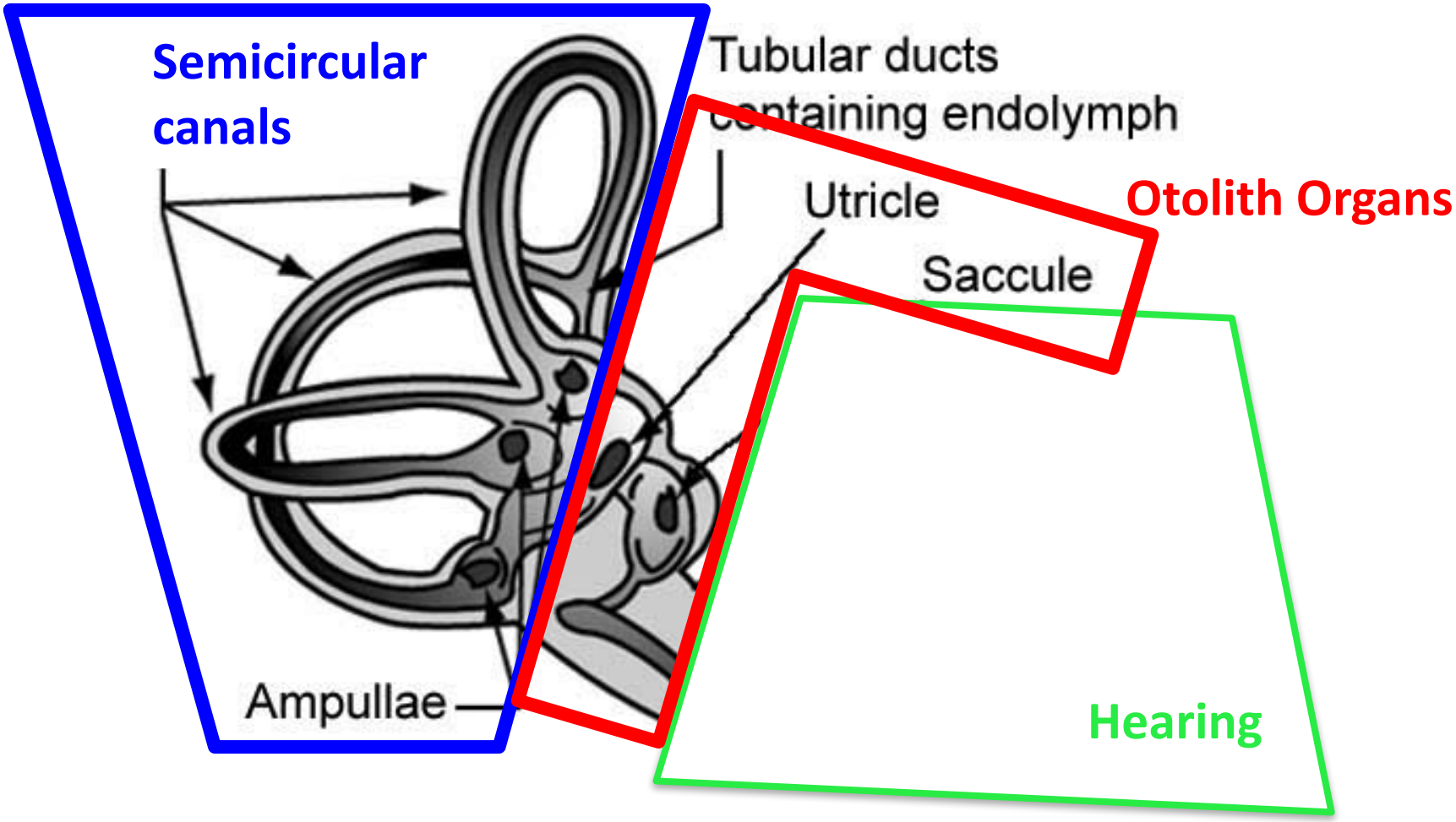
Inner Ear

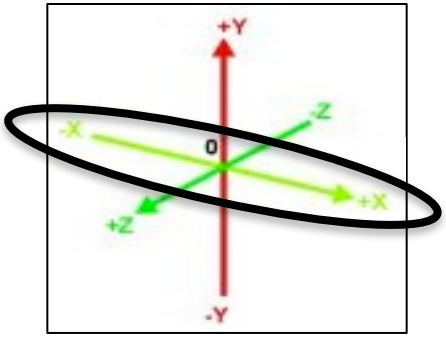

Semicircular canals
Tubular ducts containing endolymph
Utricle
Saccule
Cochlea
Ampullae
Hearing

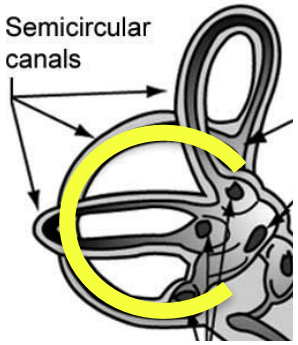
Vestibular System

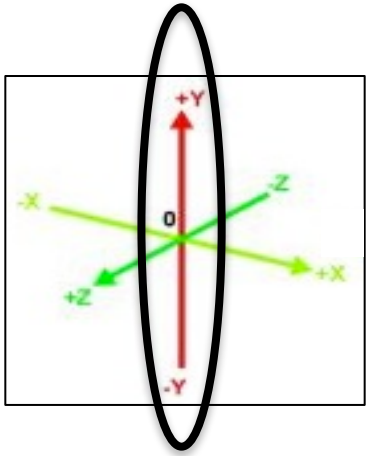


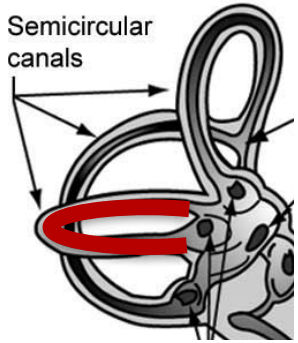
Semi-Circular Canals - ROTATION

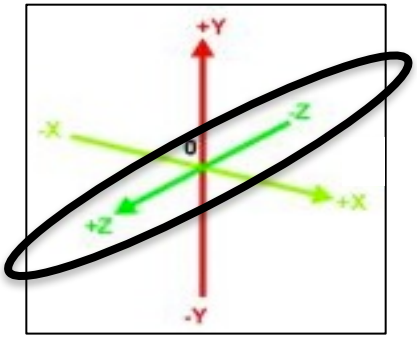
At 0 facing X…

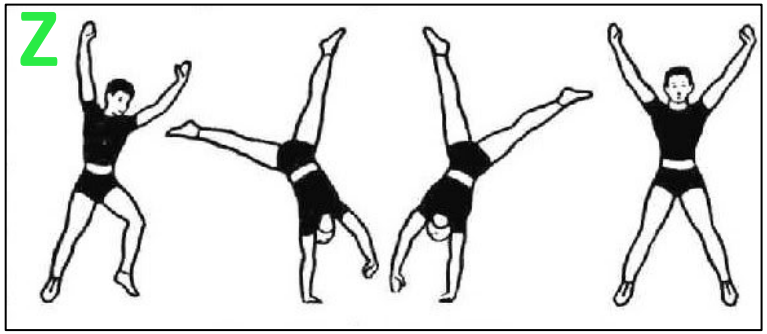


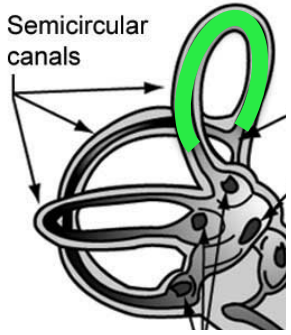




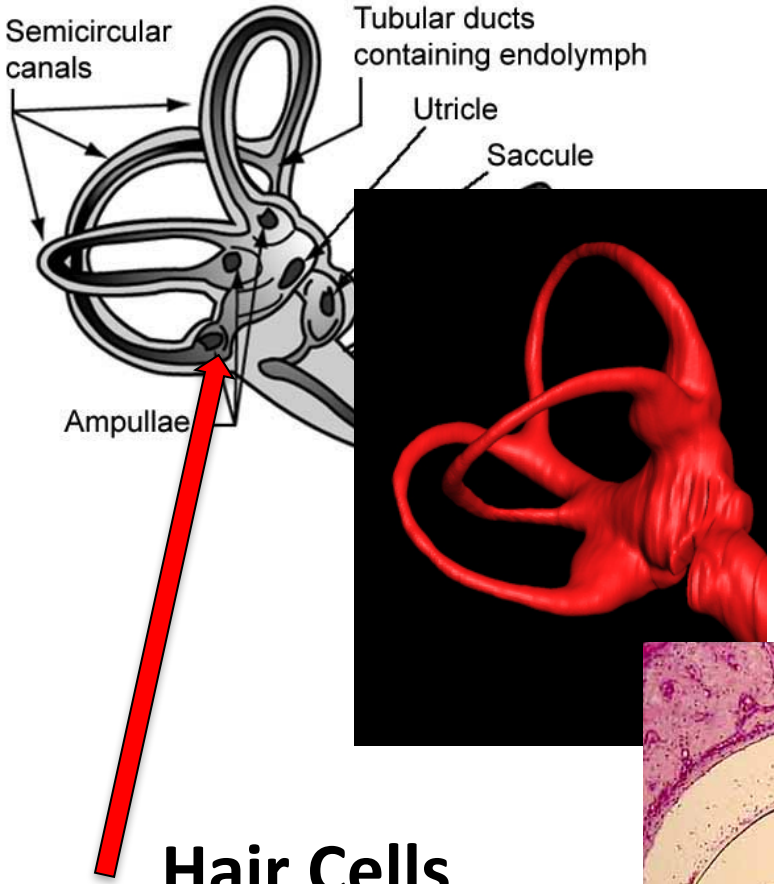






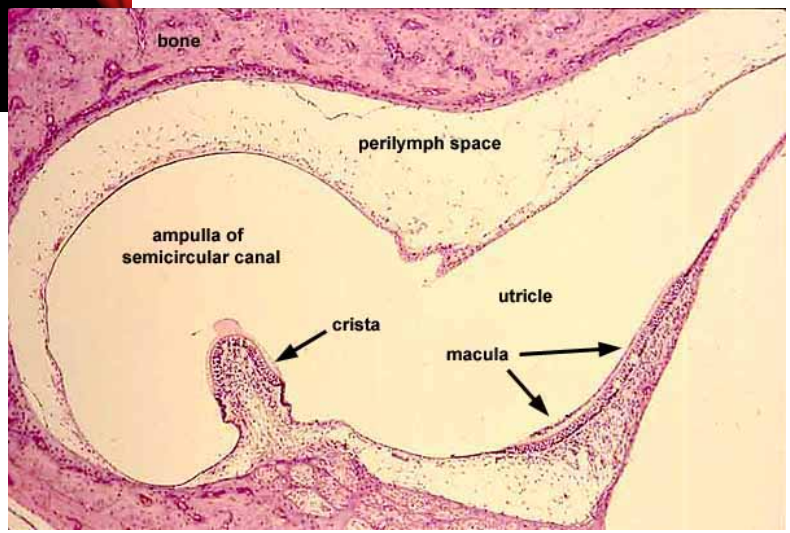


Semi-Circular Canals

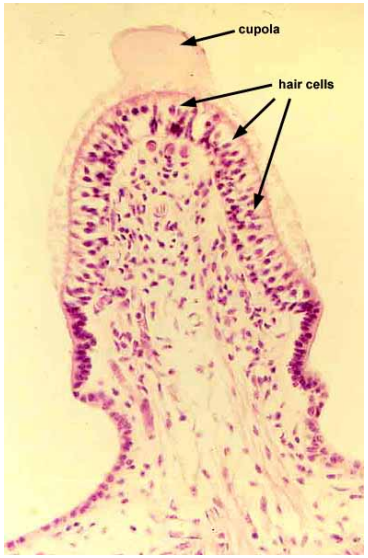


Tubes filled with K+ rich
Endolymph

Hair Cells
(Vestibular Receptor Cells)
in the **Ampullae**
at the base of the canals



Ampulla



Crista ampullaris

Semi-Circular Canals

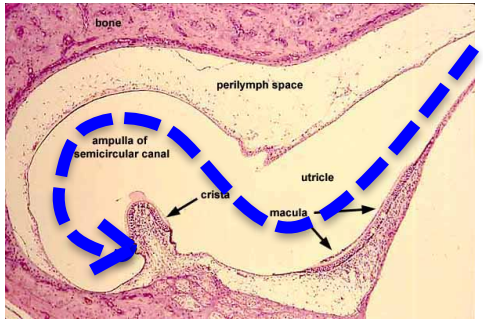
Cillia of

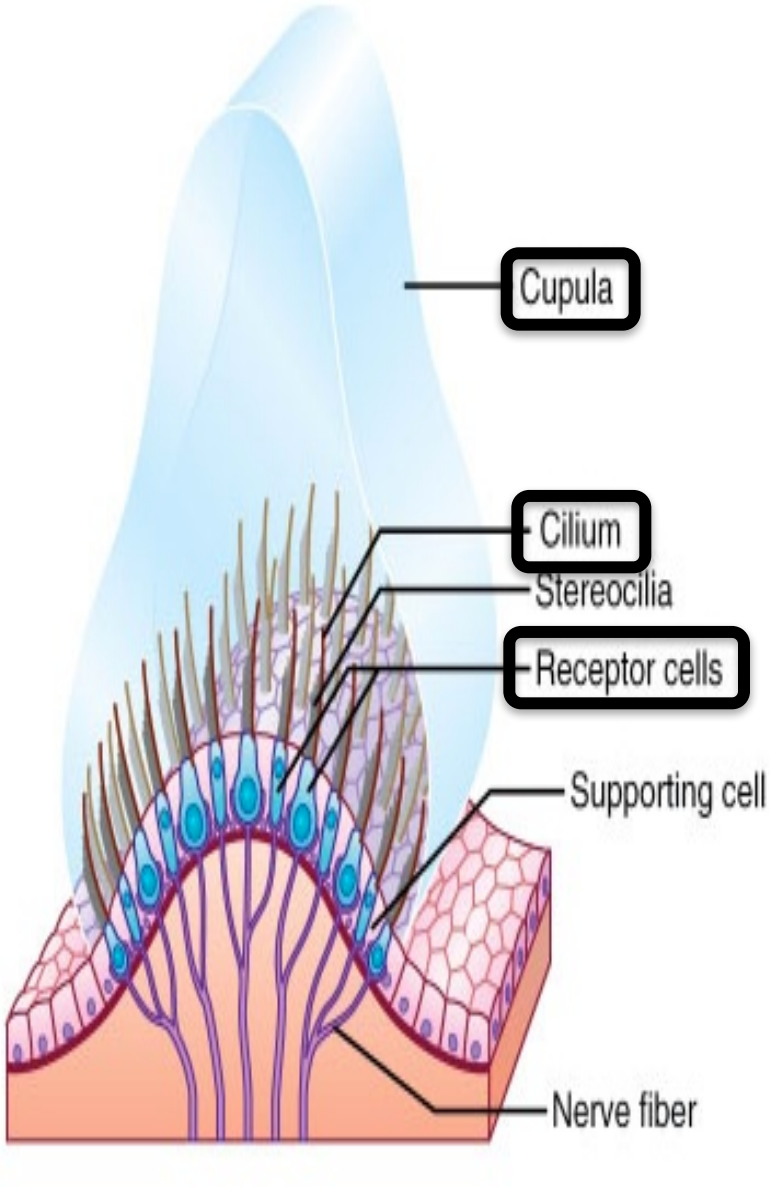
Hair Cells

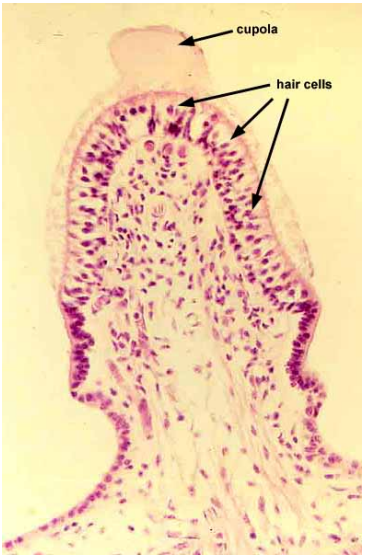
embedded in gelatonous Cupula, are bent by flow of

Endolymph

in Ampulla







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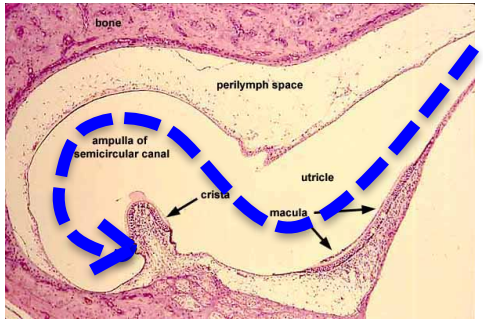
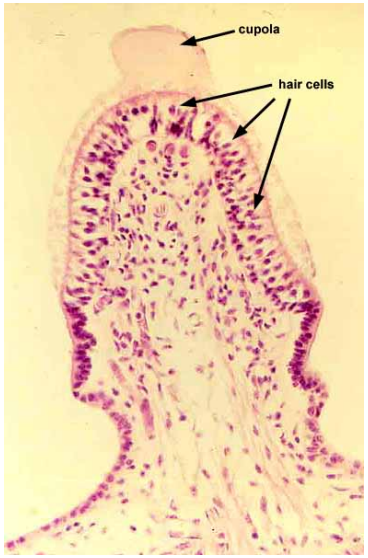


At **start** of rotation, fluid lags behind

At **end** of rotation, fluid overshoots



Crista ampullaris

As fluid pushes against Crista, one way, or the other, **Hair Cells** fire more, or less

Semi-Circular Canals

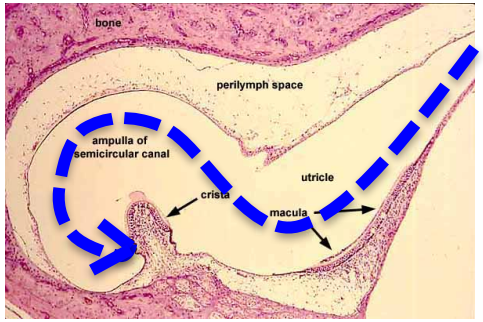
Cillia of

Hair Cells

embedded in gelatonous Cupula, are bent by flow of

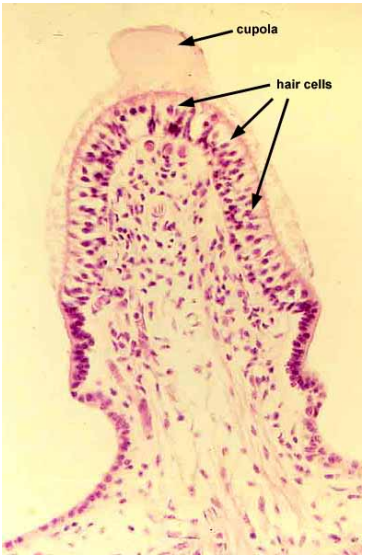
Endolymph

in Ampulla



Cells only react at <u>onset</u> and <u>offset</u> of motion, (or acceleration & deceleration), <u>not</u> during steady rotation

System detects CHANGE



Crista ampullaris

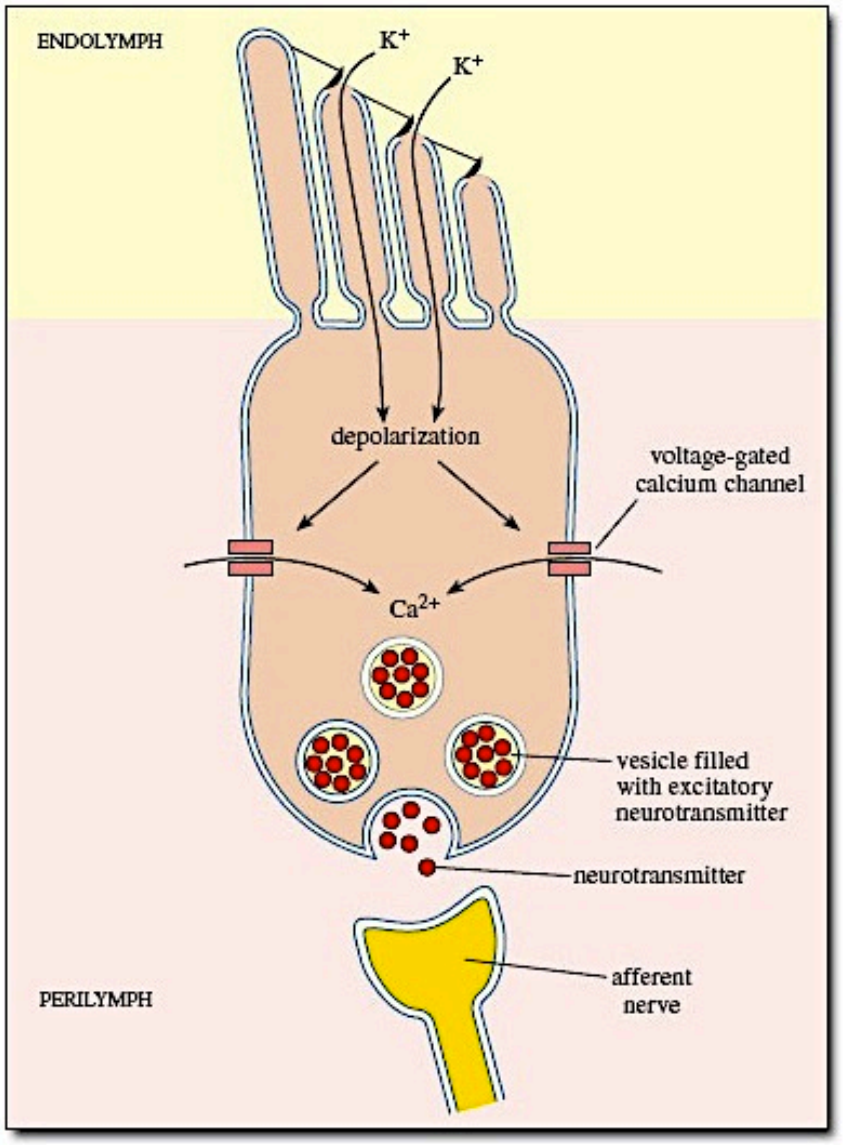
At **<u>start</u>** of rotation, fluid lags behind

At **<u>end</u>** of rotation, fluid overshoots

As fluid pushes against Crista, one way, or the other, **<u>Hair Cells</u>** fire more, or less

Vestibular Hair Calls

- Very similar to **Hair Cells** in auditory system
- High concentration of Potassium (K+) in Endolymph
- K+ in, Ca++ in, Neurotransmitter released
- BUT one important difference . . .



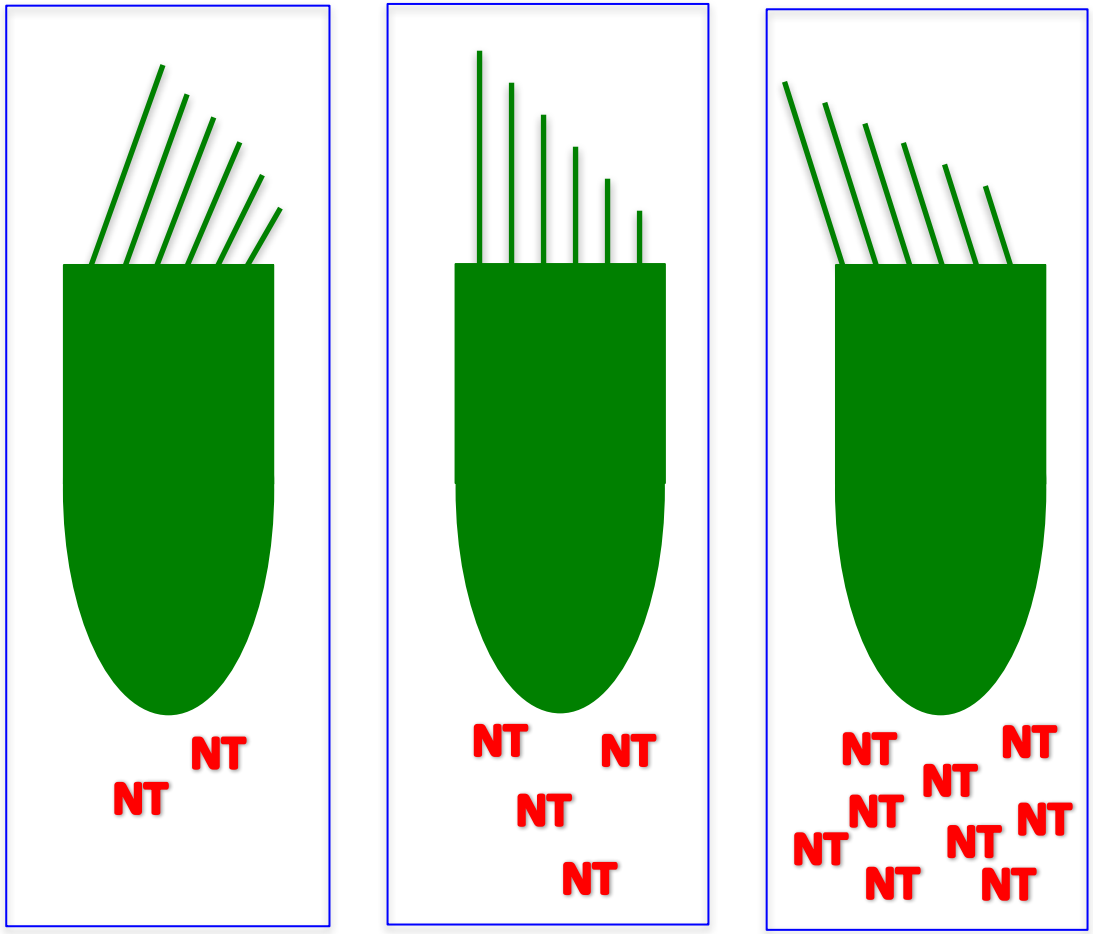
Vestibular Hair Cells

…have **Spontaneous** firing, in absence of input

That is, when <u>no rotation</u>, Hair Cell releases a base rate of neurotransmitter

Bend cillia one way,

<u>LESS</u> neurotransmitter is released

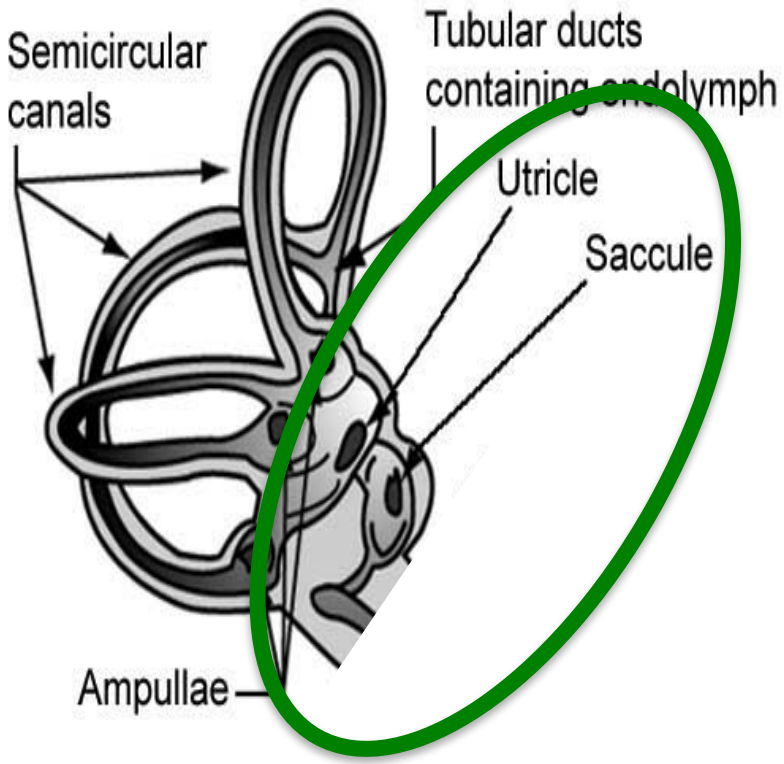


Base rate

Bend cillia other way,

<u>MORE</u> neurotransmitter is released

Otolith Organs - HEAD TITLT



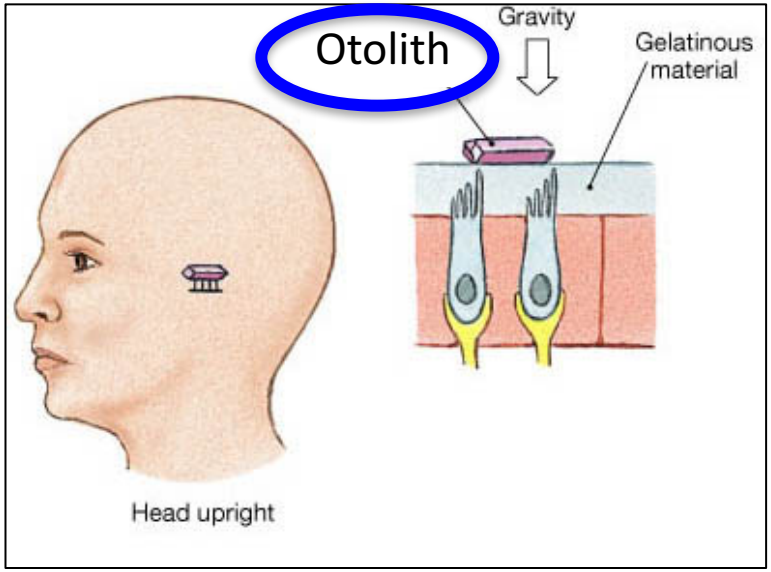
The **Macula**

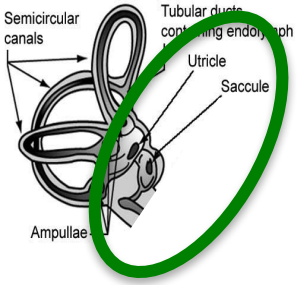
made of
the Utricle
and
the Saccule

Hair Cells

line the walls of these
Endolymph-filled chambers

Otolith Organs - HEAD TITLT

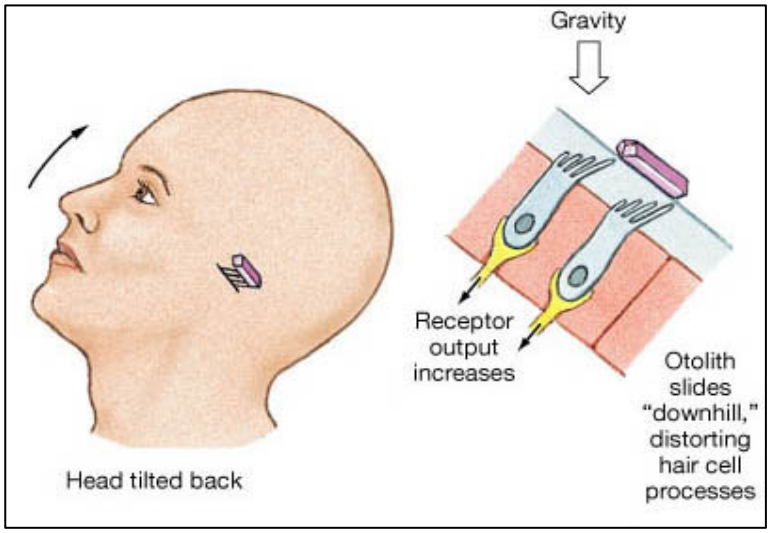




Otoliths

"Ear Stones"
calcium-carbonate crystals,
sit in gelatinous material
in which **Hair Cells** are embedded

When head is upright,
have base rate of firing

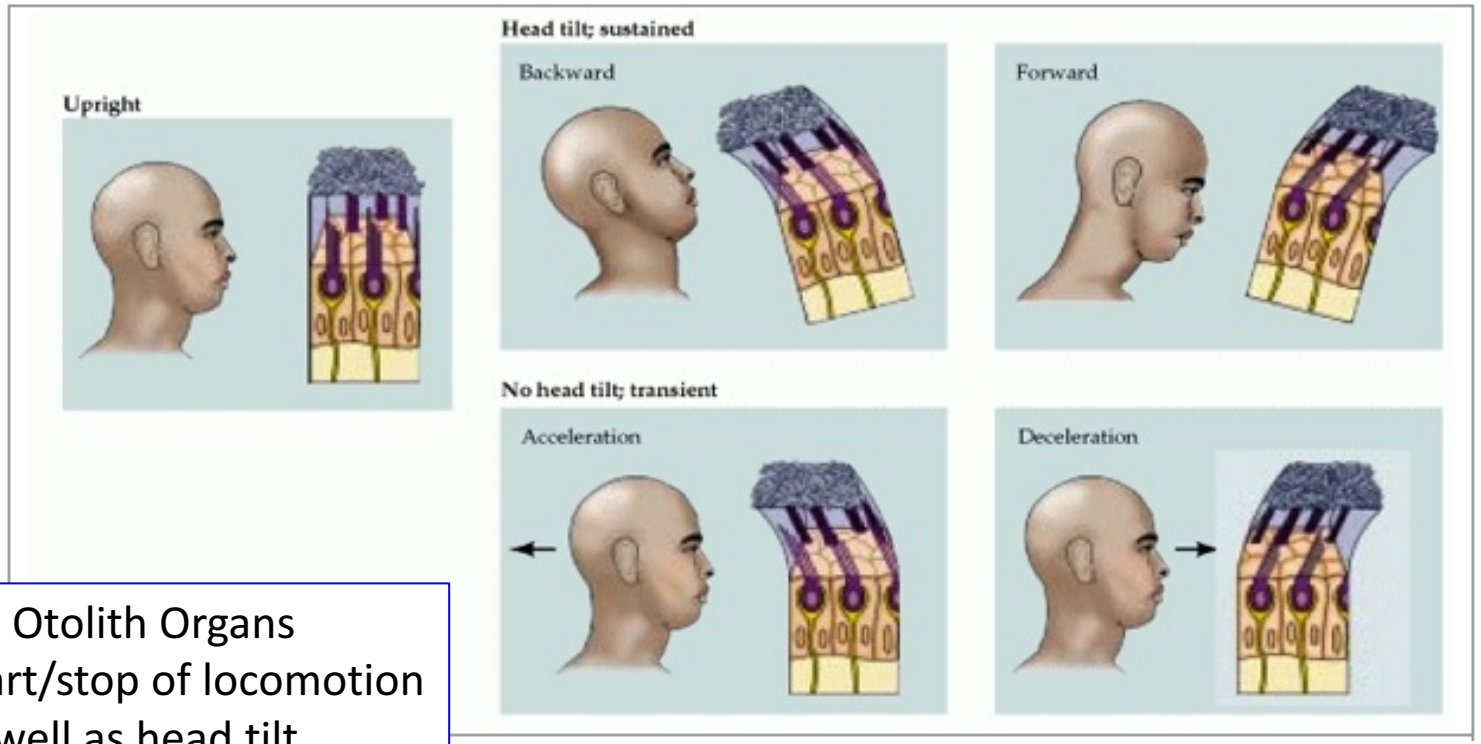


Whichever angle you tilt your head,
some **Otoliths** will weigh down
the cillia of some **Hair Cells**

Again, bend one way, fire more,
bend other way, fire less

Otolith Organs - HEAD TITLT

Note that **Acceleration** and **Deceleration** have same effect as **Tilt Backward** and **Tilt Forward**, respectively

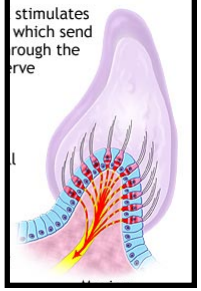


So, Otolith Organs
detect start/stop of locomotion
as well as head tilt

And again,
Vestibular System
only detects CHANGE

Vestibular Pathway

Hair Cells

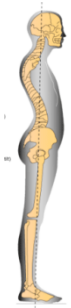


Vestibular Ganglion

8th Cranial Nerve

Vestibular Nuclei (Medulla)

Spinal Cord/Brain Stem (Posture)



Superior Colliculus

Temporal Lobe (???)

Coordinate w/ visual motion info

Cerebellum

Cranial Nerves 3,4,6 (Eye Movements)

Motion Sickness

Occurs when **Vestibular** and **Visual** systems are <u>not</u> coordinated as expected

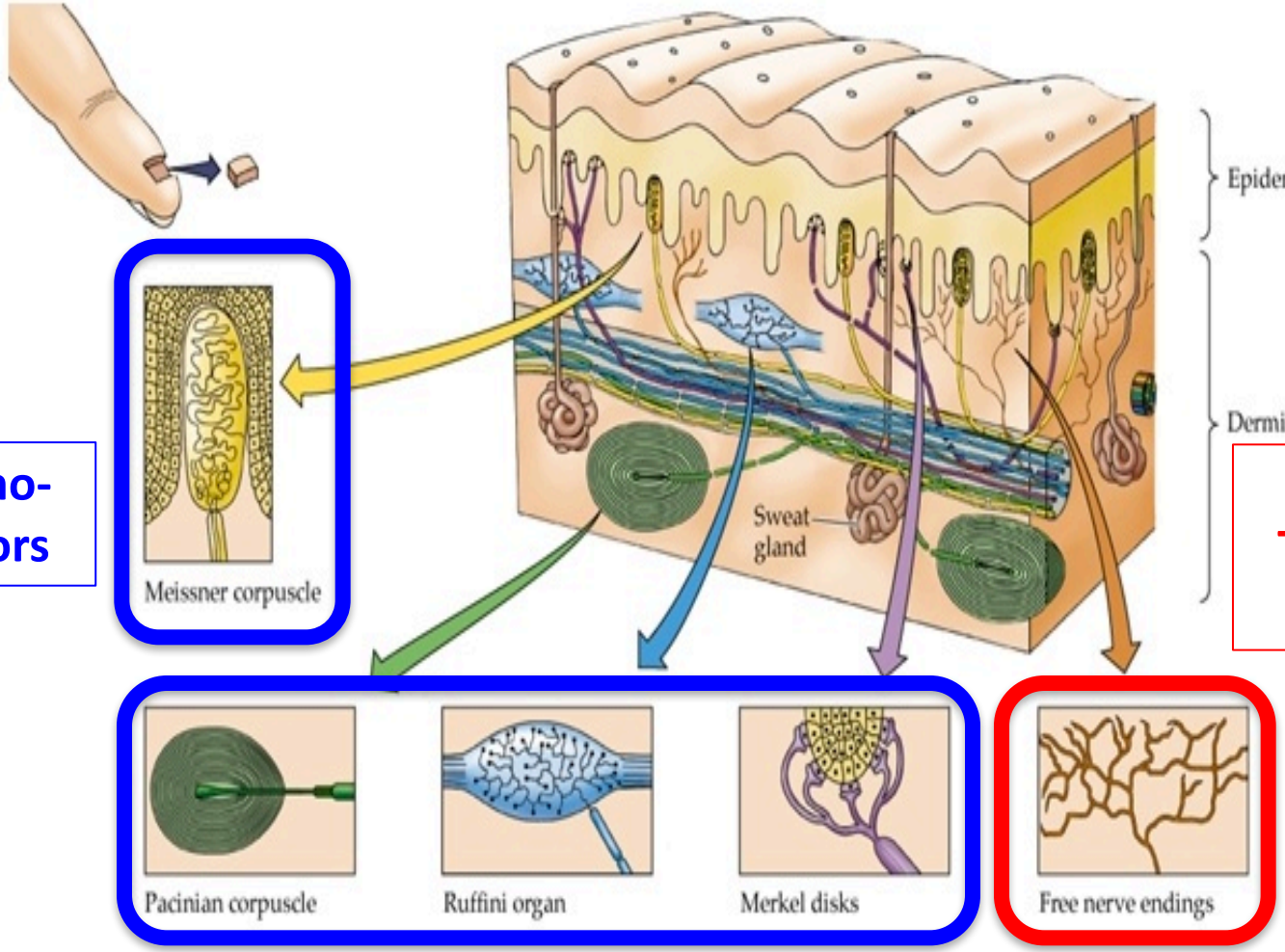
In a car

In space

Somatosensory System

The Skin Senses

Somatosensory Receptors



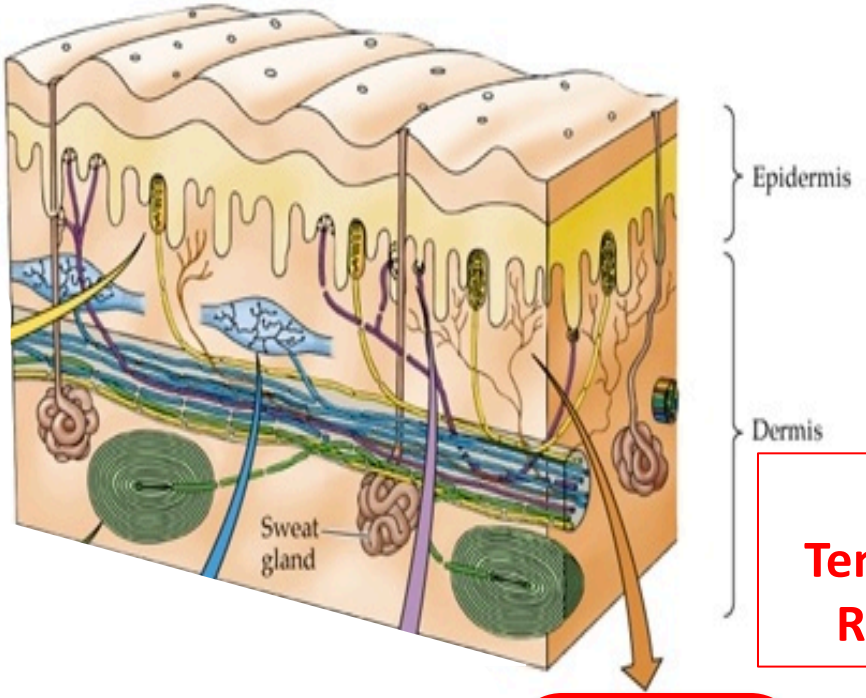
Mechano-Receptors

Pain & Temperature Receptors

Encapsulated Nerve Endings

Free Nerve Endings

Free Nerve Endings



Pain & Temperature Receptors

PAIN:

Nociceptor

(Pain, Itch, Extremes of temp)

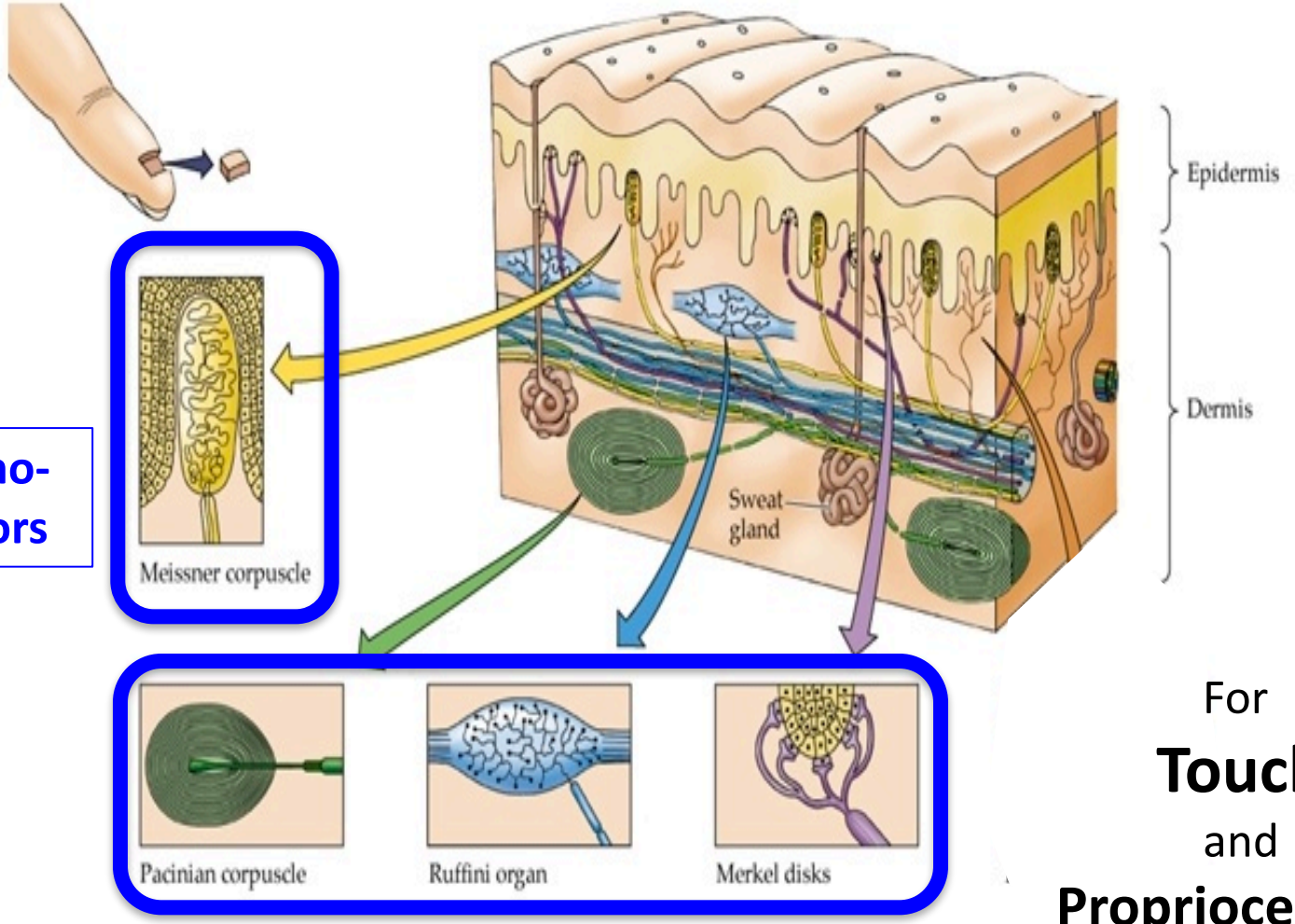
TEMPERATURE:

Thermoreceptors

(Warm-best & Cool-Best)

Free Nerve Endings

Somatosensory Receptors



Mechano-Receptors

Encapsulated Nerve Endings

For
Touch
and
Proprioception
(internal muscle and organ movements)

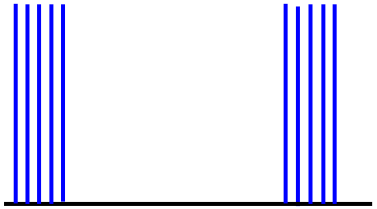
Mechano-Receptors

These receptors fire **ACTION POTENTIALS !**

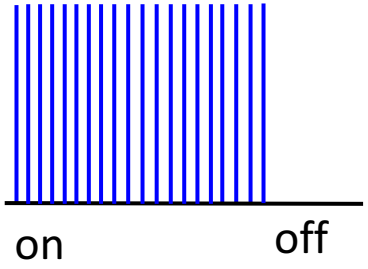
Small Receptive Field
1:1 for Details

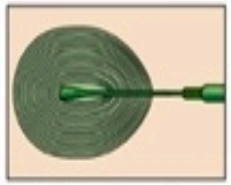
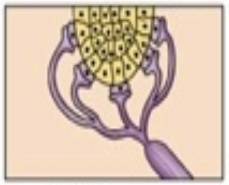
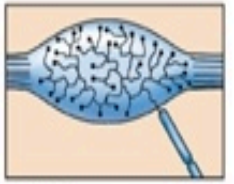
Large Receptive Field
Convergent

Fast Adapting

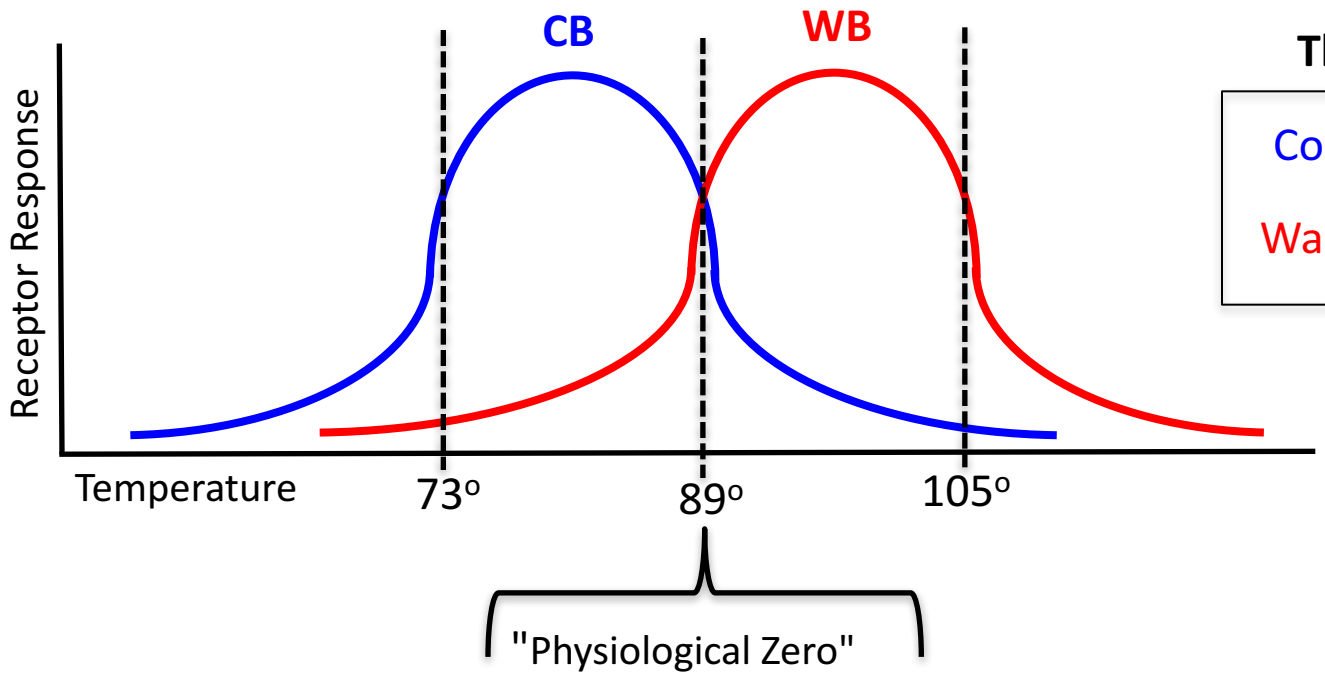


Slow Adapting



Meissner's Corpuscles Slippage  Meissner corpuscle	Pacinian Corpuscles Bending  Pacinian corpuscle
Merkel's Discs Reading Braille  Merkel disks	Ruffinni Endings Posture  Ruffini organ

Across Fiber Coding



Thermoreceptors

Cool-Best Receptors

Warm-Best Receptors

Code for 89° : **WB** = **CB**

Code for 73° : **WB** < **CB**

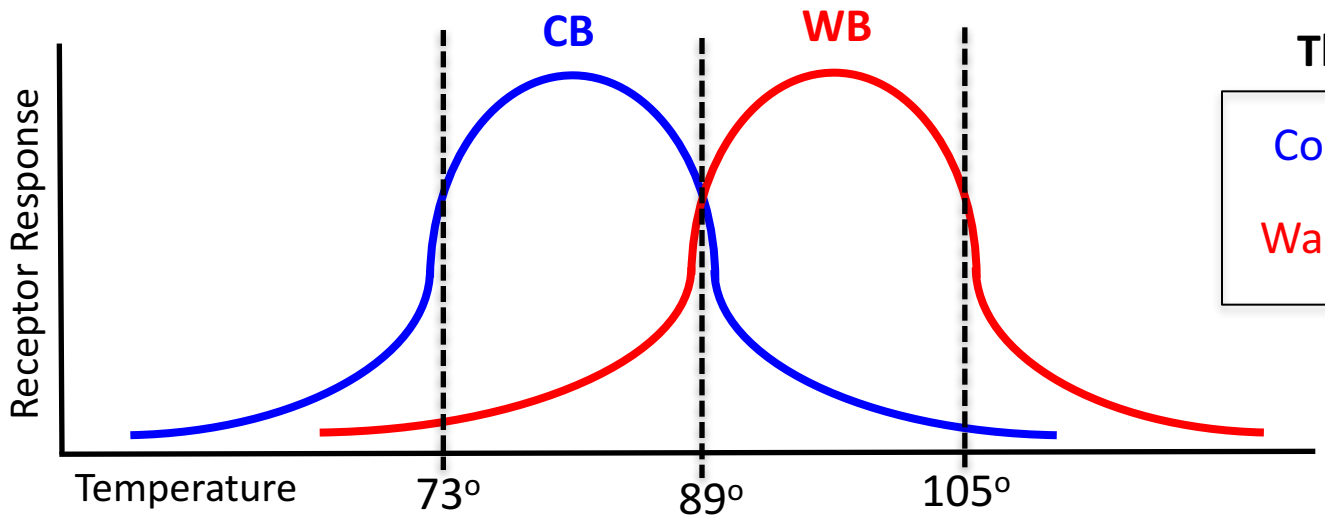
Code for 105° : **WB** > **CB**

So, its the

relative proportion

of activity across fibers that codes for a given temperature

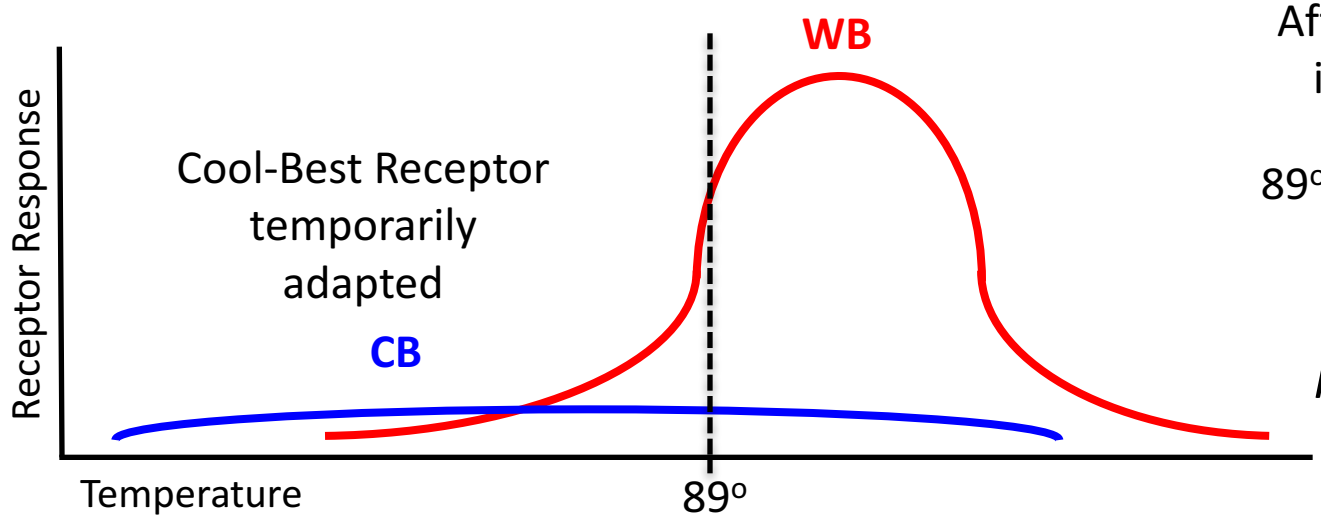
Across Fiber Coding



Thermoreceptors

Cool-Best Receptors

Warm-Best Receptors

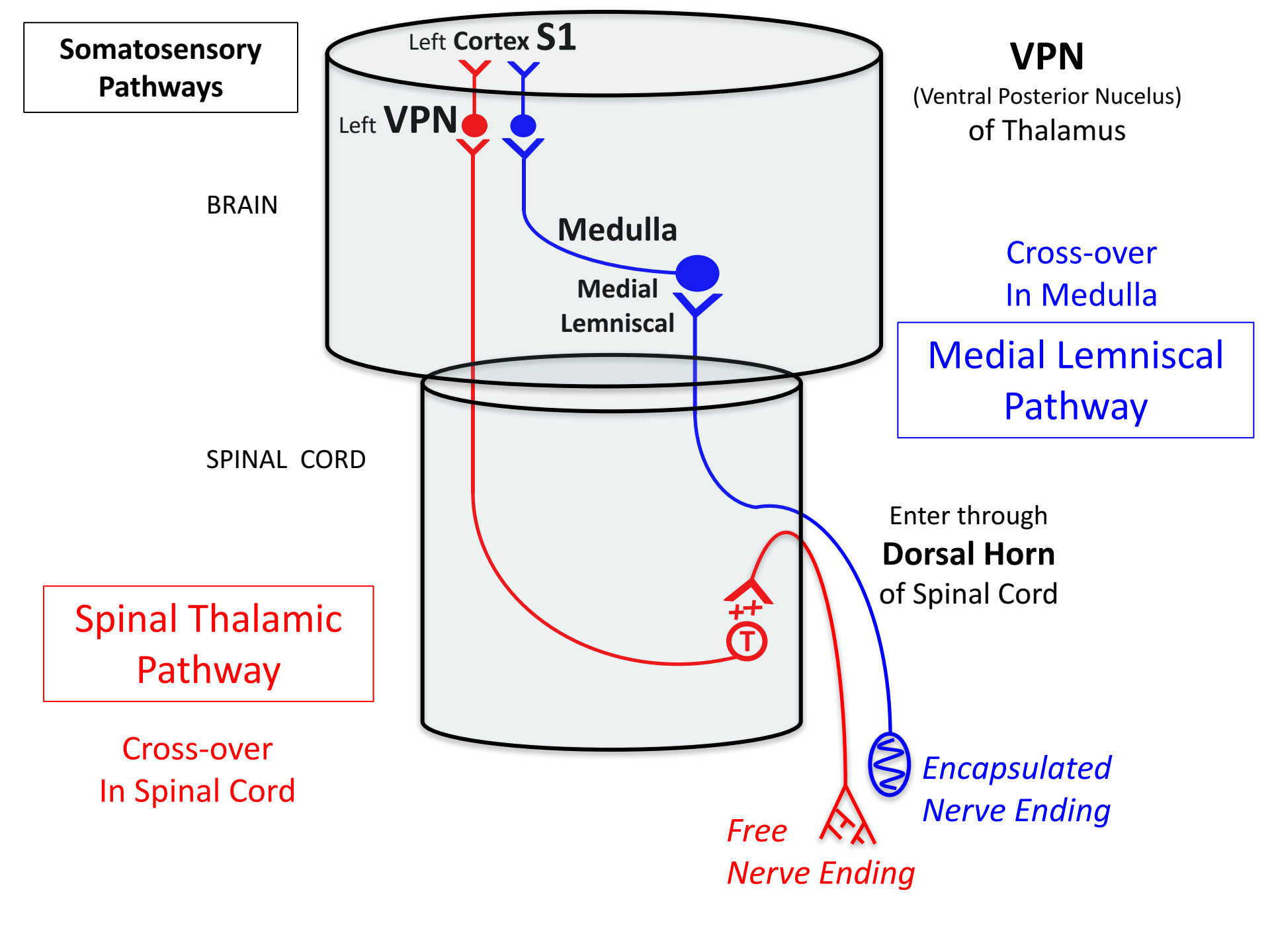


After adapting to ice cold water

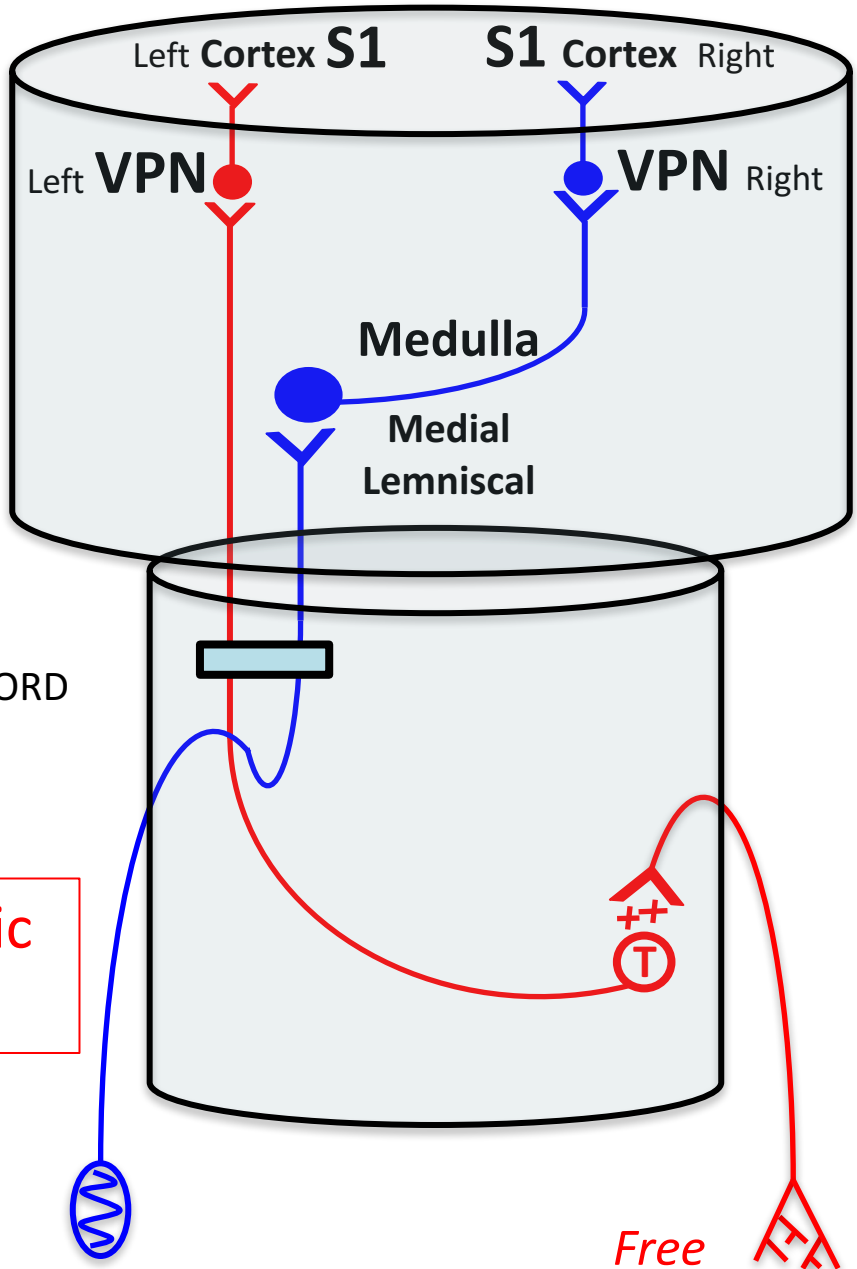
89° is **<u>miscoded</u>** as 105°

(**WB** > **CB**)

Feels warm!


Somatosensory Pathways
Left Cortex S1
Left VPN
VPN
(Ventral Posterior Nucelus)
of Thalamus
BRAIN
Medulla
Medial Lemniscal
Cross-over In Medulla
Medial Lemniscal Pathway
SPINAL CORD
Enter through
Dorsal Horn
of Spinal Cord
Spinal Thalamic Pathway
Cross-over In Spinal Cord
Encapsulated Nerve Ending
Free Nerve Ending

Somatosensory Pathways



Cross-over In Medulla

Medial Lemniscal Pathway

Spinal Thalamic Pathway

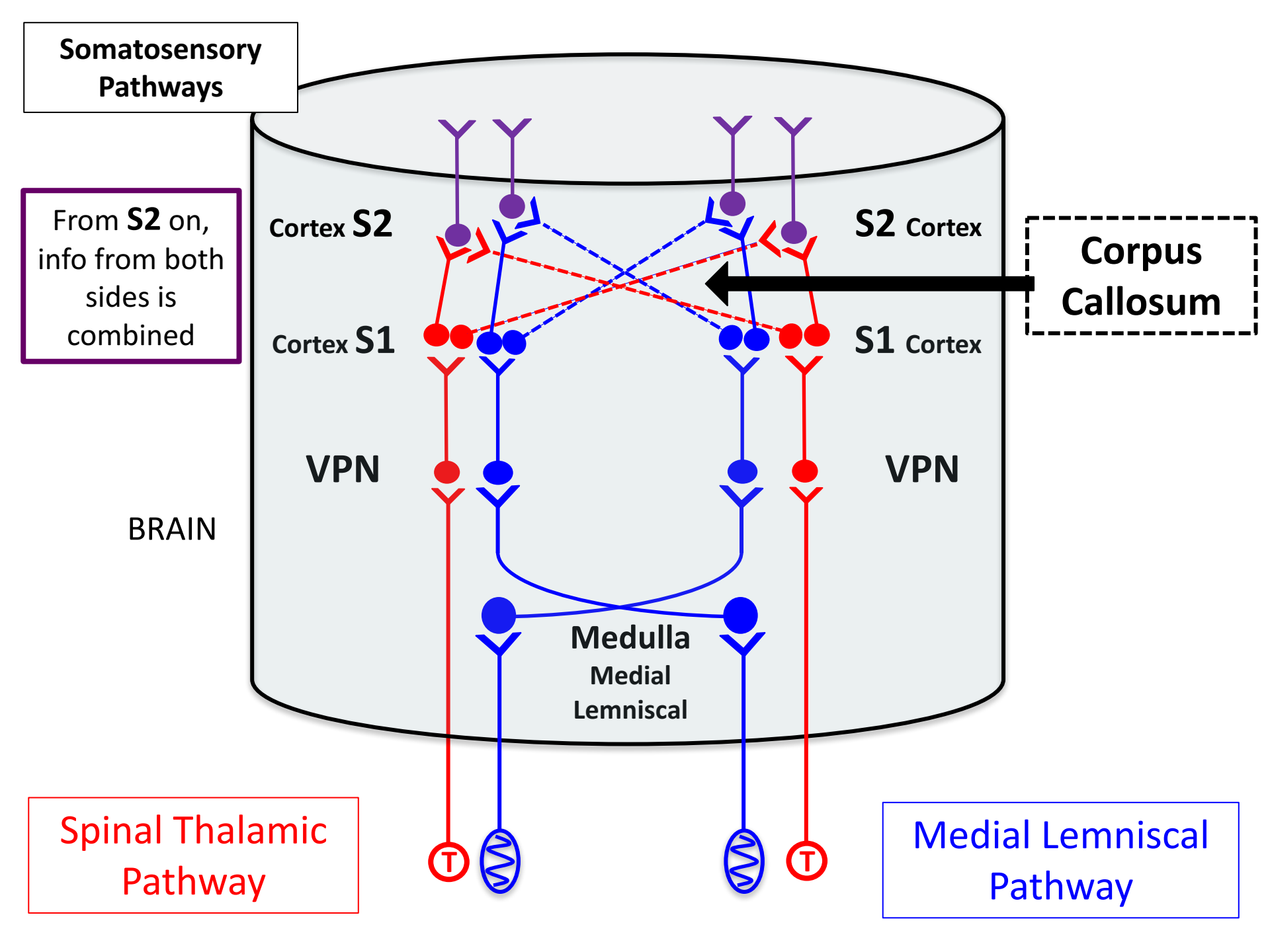
Cross-over In Spinal Cord

Brown-Sequard Syndrome

Damage to only one side of spinal cord >>

Loss of **Touch** on IPSI-Lateral side

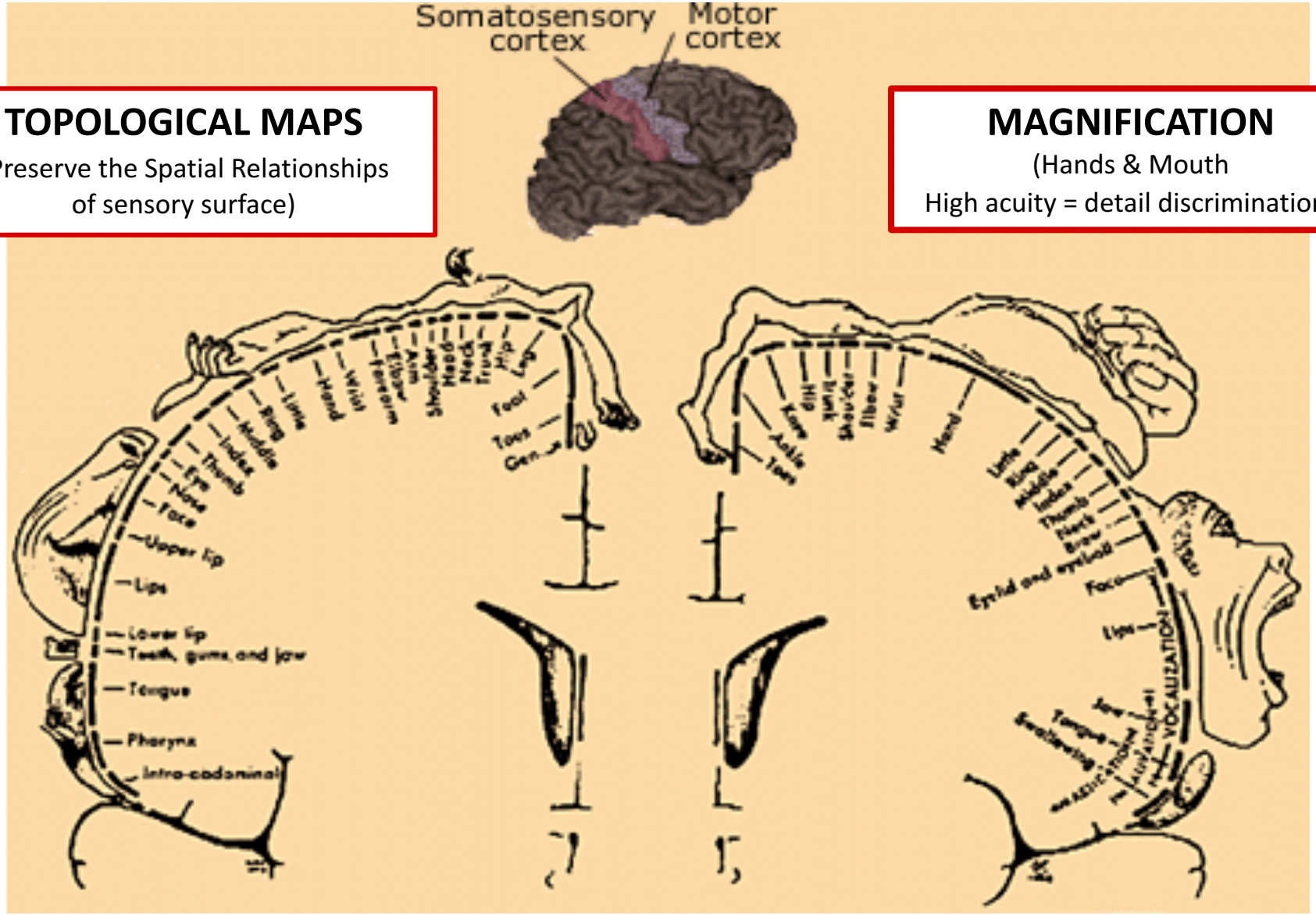
Loss of **Temp/Pain** on CONTA-Lateral side

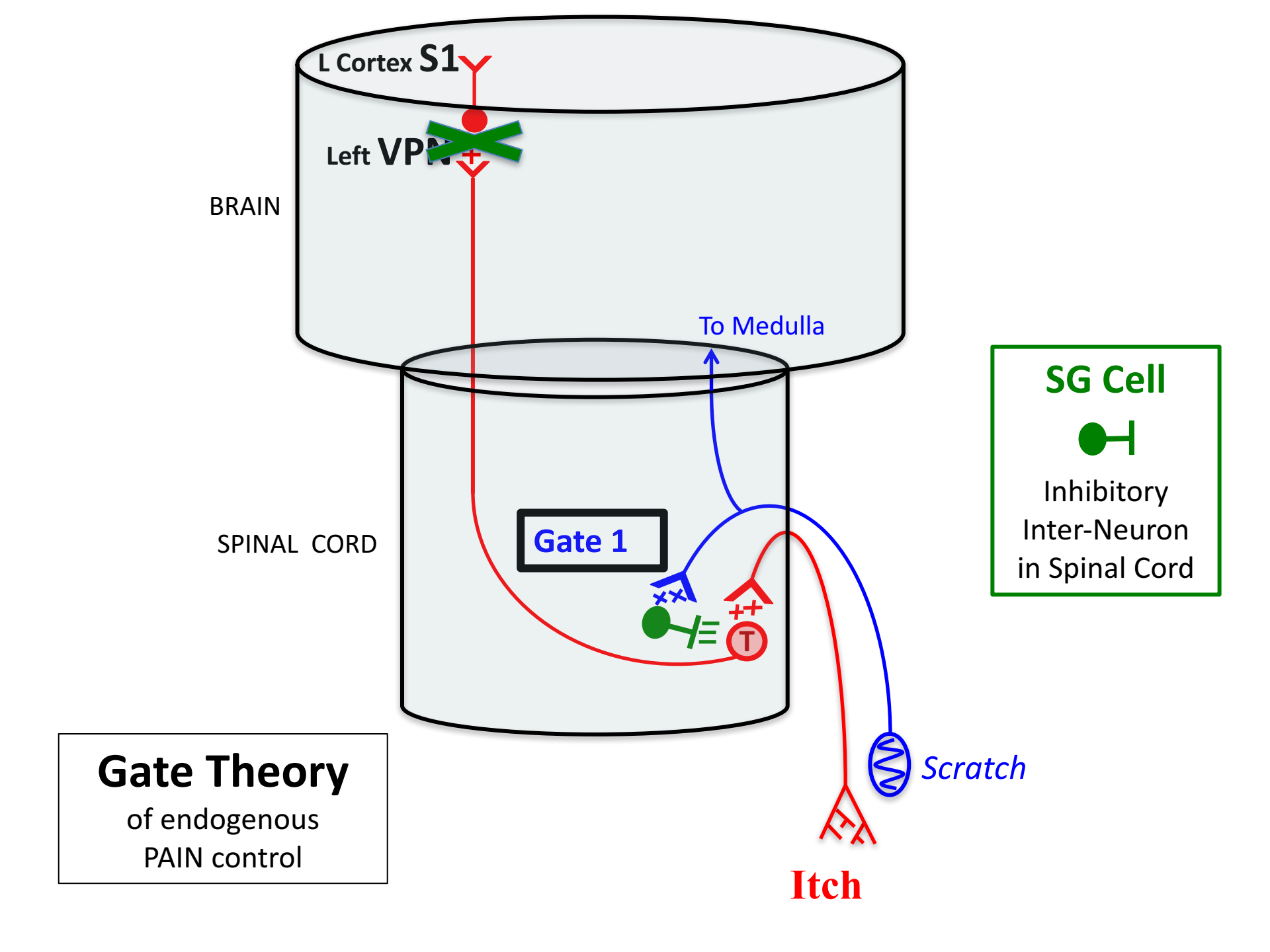

Somatosensory Pathways
From S2 on, info from both sides is combined
Cortex S2
S2 Cortex
Corpus Callosum
Cortex S1
S1 Cortex
VPN
VPN
BRAIN
Medulla
Medial
Lemniscal
Spinal Thalamic Pathway
Medial Lemniscal Pathway

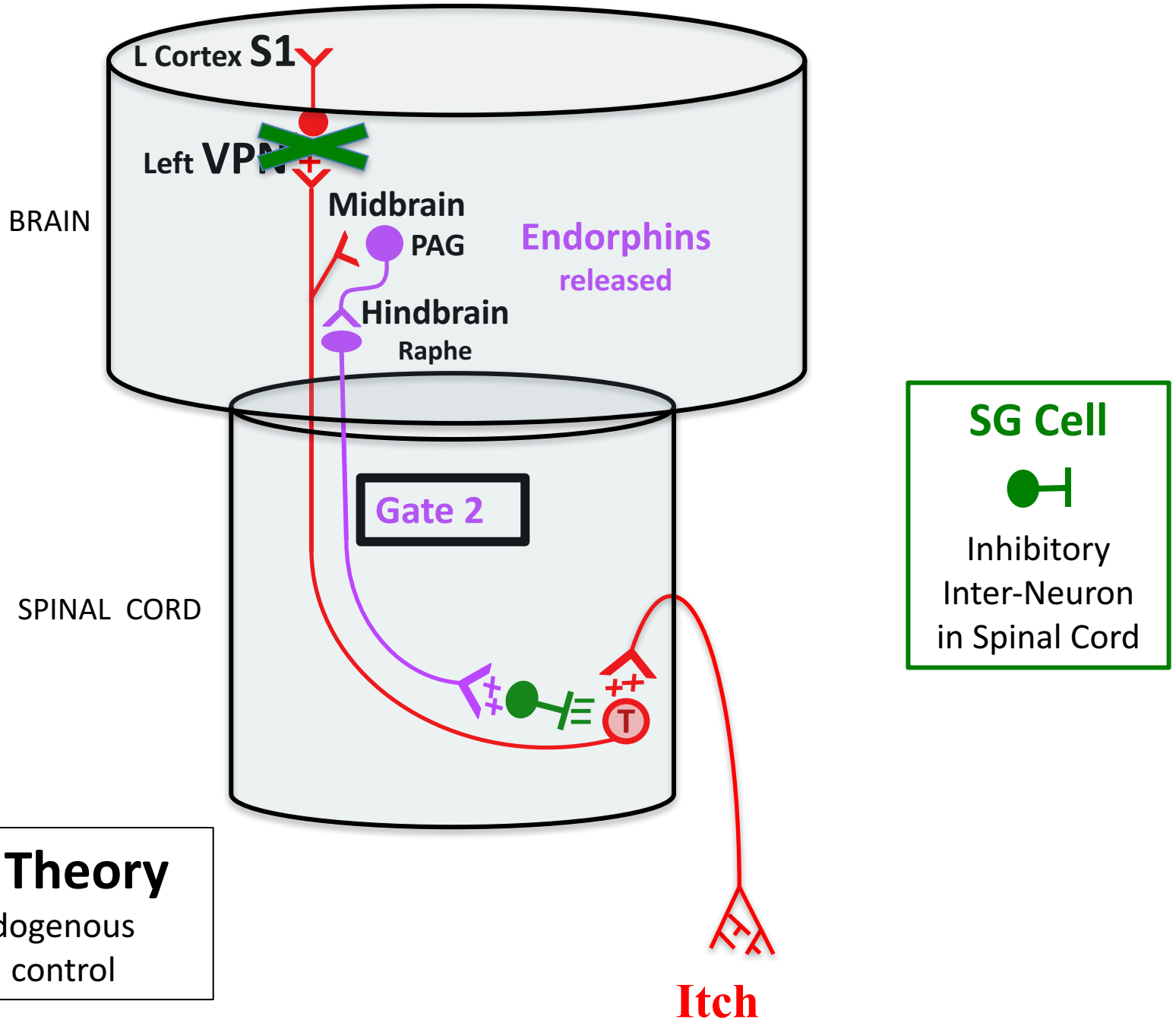
Somatonsensory Cortex PENFIELD MAP

TOPOLOGICAL MAPS
(Preserve the Spatial Relationships of sensory surface)

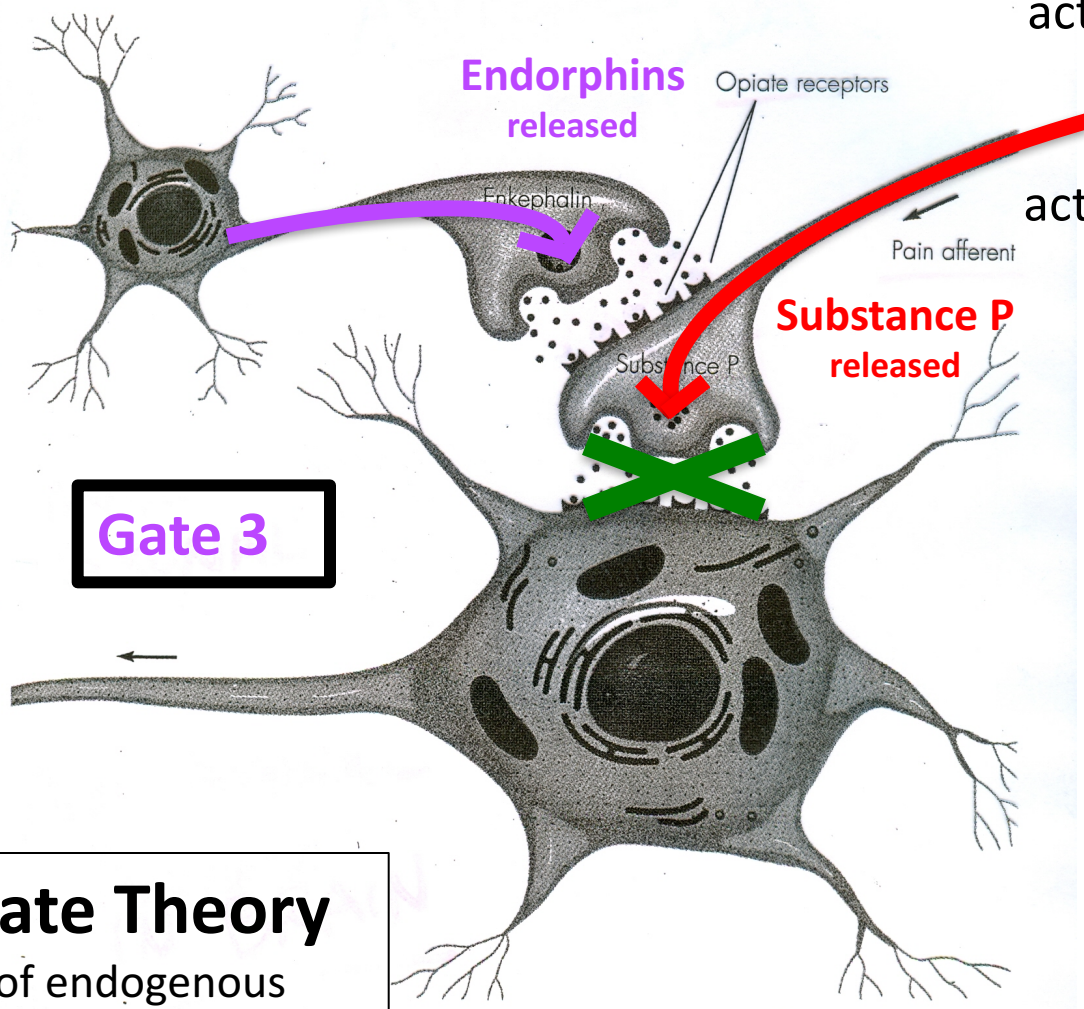
MAGNIFICATION
(Hands & Mouth
High acuity = detail discrimination)




L Cortex S1
Left VPN
BRAIN
To Medulla
SPINAL CORD
Gate 1
T
Scratch
Itch
SG Cell
Inhibitory
Inter-Neuron
in Spinal Cord
Gate Theory
of endogenous
PAIN control


L Cortex S1
Left VPN
BRAIN
Midbrain
PAG
Endorphins
released
Hindbrain
Raphe
Gate 2
SPINAL CORD
T
Itch
SG Cell
Inhibitory
Inter-Neuron
in Spinal Cord
Gate Theory
of endogenous
PAIN control

Gate Theory - In Brain



In brain,
activity along Pain pathways

Provokes
activity from Endorphin cells

Receptor sites
on <u>Terminal</u> of pain cell
responds to Endorphins

Inhibits release of
Substance P

Gate Theory
of endogenous
PAIN control