Non-Pharmacological Pain Management Using Acupuncture

Learning Objectives

- Discuss the latest evidence for non-pharmacological management of chronic pain for cancer survivors using a multi-disciplinary approach.

Pain

- Unpleasant sensory and/or emotional experience associated with actual or potential tissue damage.
- Most common reason for patients to seek health care.
- Major symptom in many medical conditions and can significantly impact a person’ s quality of life and general functioning.
- In 2017 draft standards, the Joint Commission recommends nonpharmacological pain treatment.
- Pain is one of the most common symptoms in cancer patients. It is present in more than 85 % of cancer patients terminally ill.

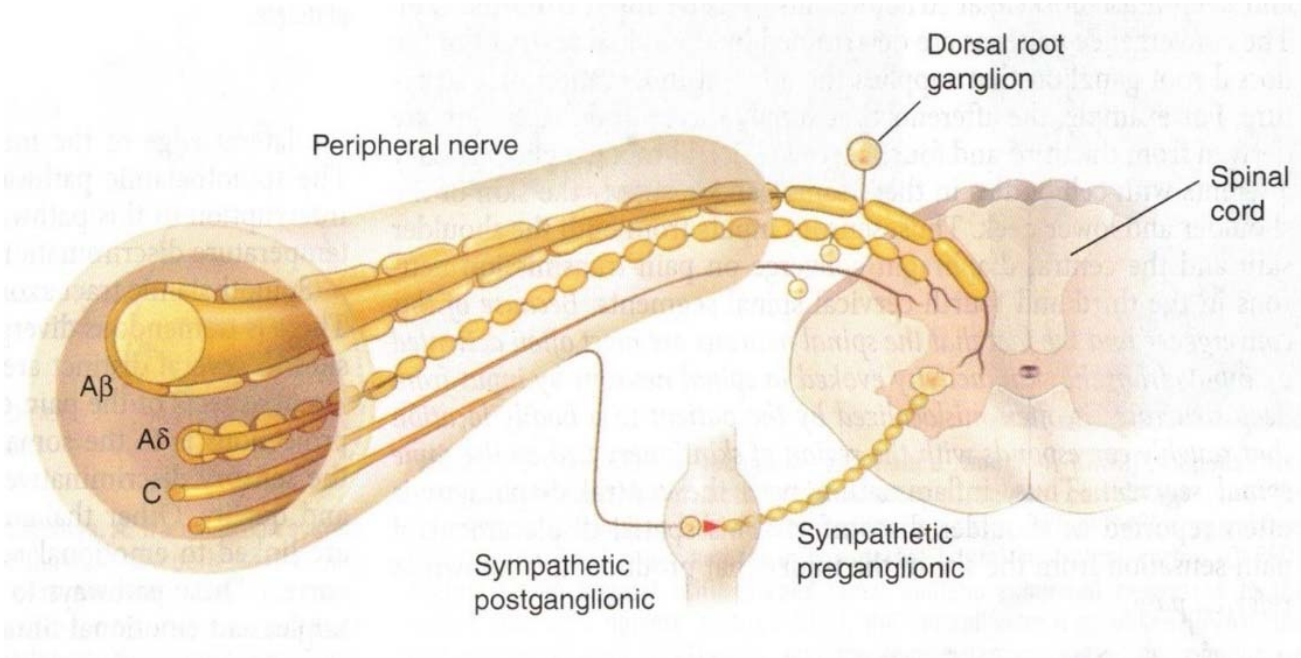
Types of Pain

- Nociceptive
  - Somatic- result of direct mechanical or chemical stimulation of nociceptors and normal neural signaling to the brain. It tends to be localized, aching, throbbing, and cramping. Classically found in bone metastases.
  - Visceral- caused by nociceptors in gastrointestinal, respiratory, and other organ systems. Deep or colicky type of pain classically associated with pancreatitis, myocardial infarction, or tumor invasion of viscera.
- Neuropathic- arises from disordered nerve signals. It is burning, electrical, or shock-like pain. Classic examples include post -stroke pain, tumor invasion of the brachial plexus and herpetic neuralgia.
- When acute, pain is characteristically associated with behavioral arousal and a stress response consisting of increased blood pressure, heart rate, pupil diameter and plasma cortisol levels. In addition, local muscle contraction (e. g. limb flexion abdominal wall rigidity) is often present.

Primary Afferent Nerves

- A **peripheral nerve** consists of the axons of three different types of neurons: **primary sensory afferents, motor neurons, and sympathetic postganglionic neurons.**
- Primary afferents are classified by their diameter, degree of myelination, and conduction velocity. The largest diameter afferent fibers, A-beta, respond maximally to light touch and/or moving stimuli; they are present primarily in the nerves that innervate the skin. The activity of these fibers does not produce pain in normal individuals. There are two other classes of primary afferent nerve fibers; the small diameter myelinated A-delta and the unmyelinated (C) axons. These fibers are present in the nerves of the skin and in the deep somatic and visceral structures. Most A -delta and C fiber afferents respond maximally to intense (painful) stimuli and produce the subjective experience of pain when they are activated; this defines them as primary afferent nociceptors (pain receptors). Primary afferent nociceptors of individual can respond to different types of noxious stimuli.

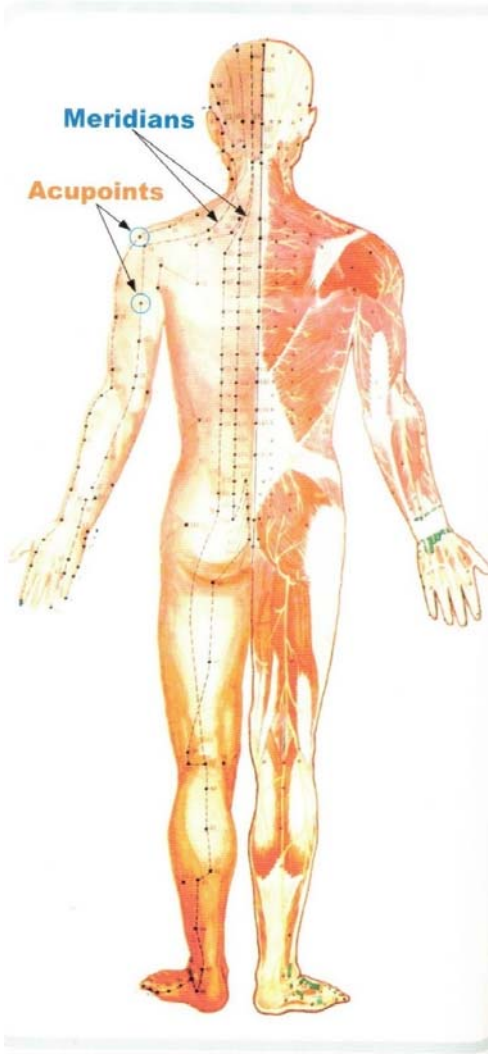
The Primary Afferent Nociceptor

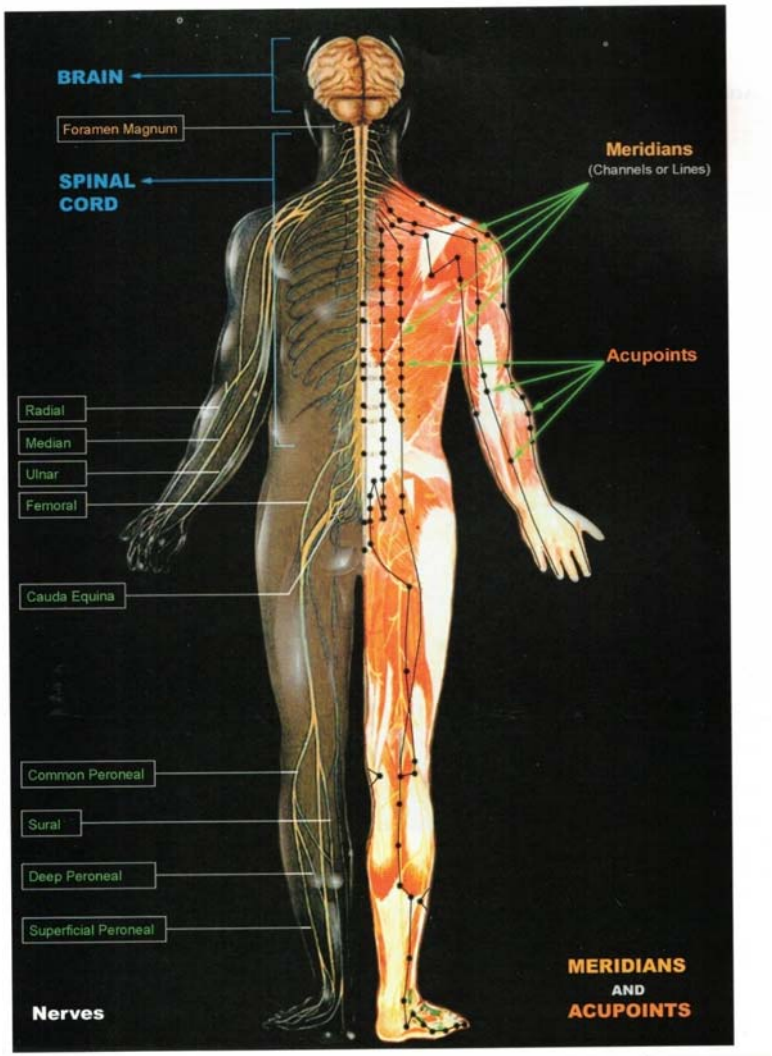


Peripheral Nerves are overlaid with acupoints

- It has been suspected that the acupuncture points and meridians (channels or lines) are part of the peripheral nervous system, coinciding with **nerve endings** or points of bifurcation.

- Some studies have suggested that the majority of acupoints (approximately 305) are located directly over the peripheral nerves while another major group (approximately 285) are located in close proximity to the peripheral nerves.


Meridians
Acupoints


BRAIN
Foramen Magnum
SPINAL CORD
Meridians
(Channels or Lines)
Acupoints
Radial
Median
Ulnar
Femoral
Cauda Equina
Common Peroneal
Sural
Deep Peroneal
Superficial Peroneal
Nerves
MERIDIANS
AND
ACUPOINTS

Nerve Ending and Neural Signal Transduction

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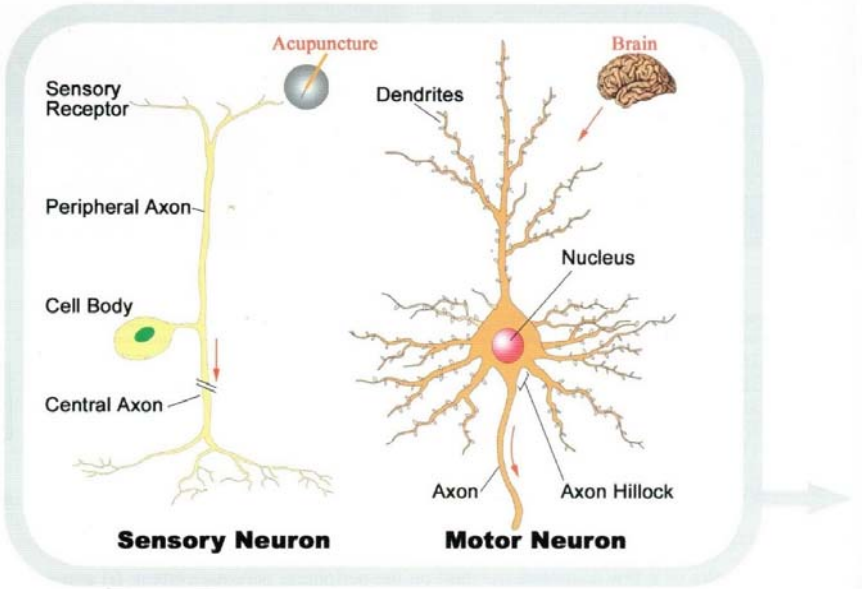
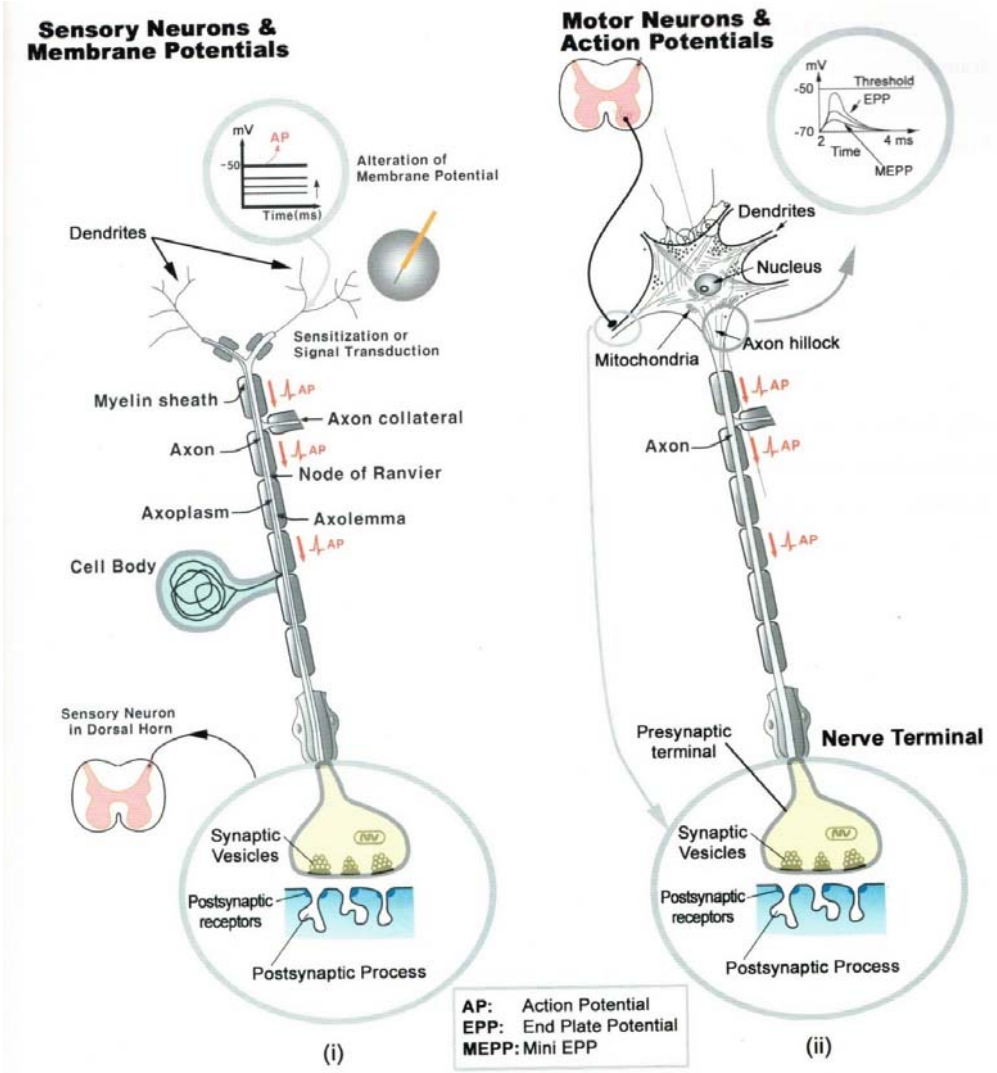
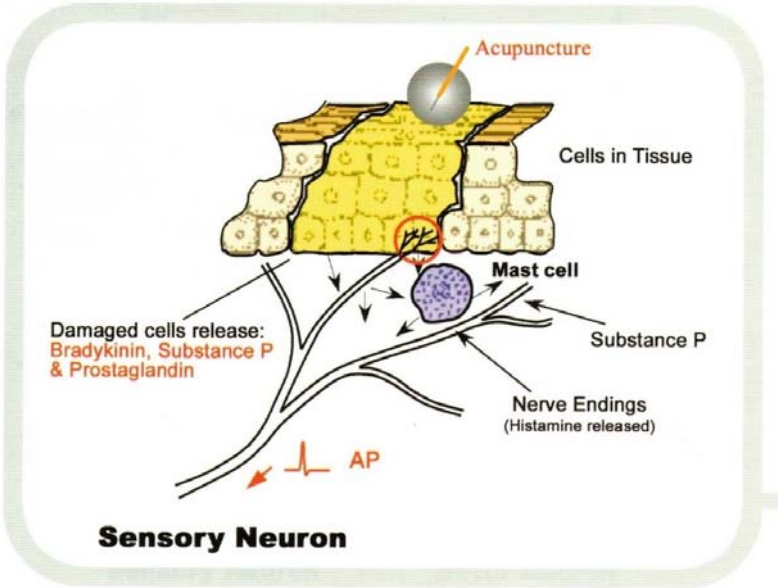
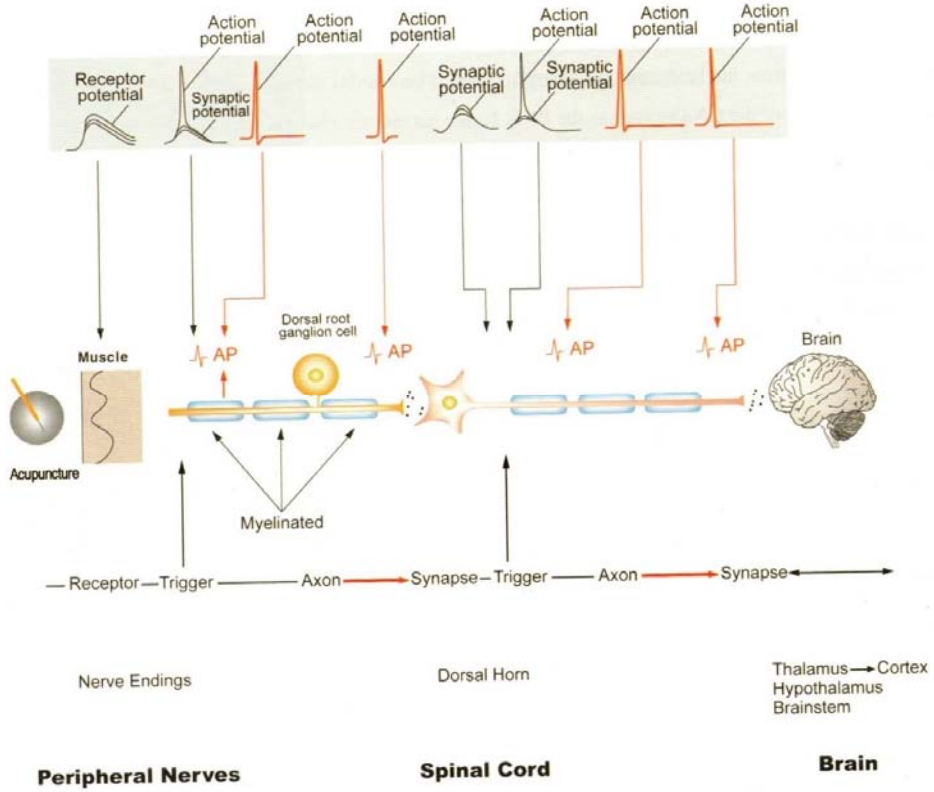
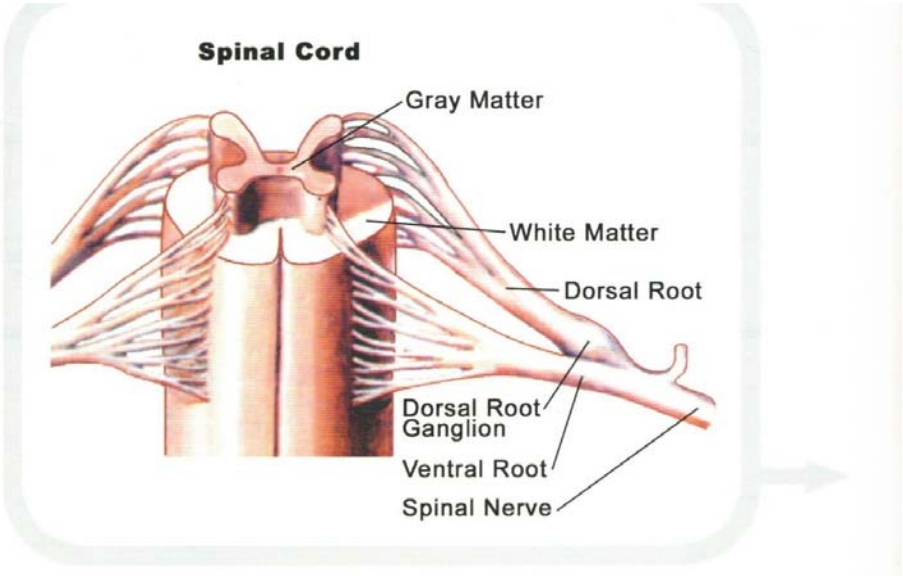
• How are the acupuncture signals projected to the brain? This question is the most interesting and it is central for understanding the mechanism of acupuncture. What are the routes by which acupuncture stimulation can reach the brain?

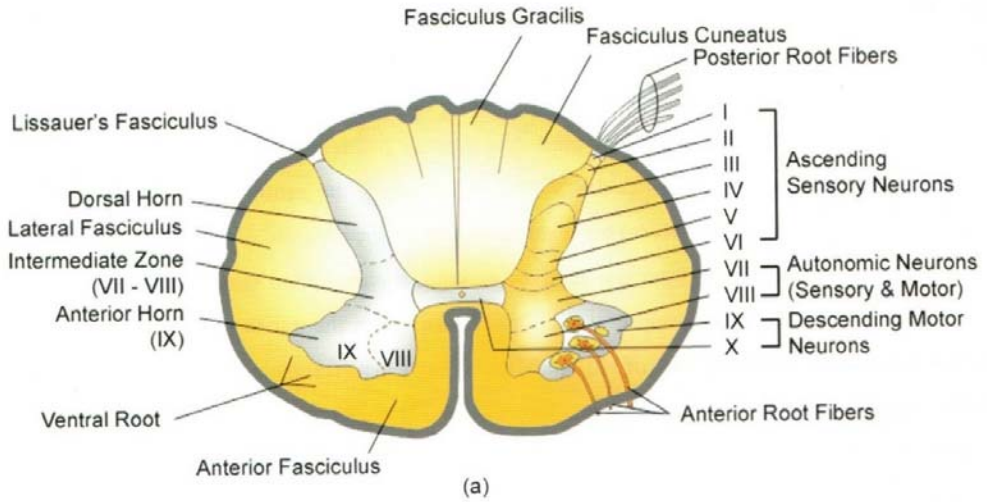

Acupuncture
Brain
Sensory Receptor
Dendrites
Peripheral Axon
Nucleus
Cell Body
Central Axon
Axon
Axon Hillock
Sensory Neuron
Motor Neuron


Sensory Neurons & Membrane Potentials
mV
AP
-50
Time(ms)
Alteration of Membrane Potential
Dendrites
Sensitization or Signal Transduction
Myelin sheath
AP
Axon collateral
Axon
Node of Ranvier
Axoplasm
Axolemma
Cell Body
Sensory Neuron in Dorsal Horn
Synaptic Vesicles
NV
Postsynaptic receptors
Postsynaptic Process
(i)
Motor Neurons & Action Potentials
mV
-50
-70
Threshold
EPP
2
Time
4 ms
MEPP
Dendrites
Nucleus
Mitochondria
Axon hillock
Axon
Presynaptic terminal
Nerve Terminal
Synaptic Vesicles
Postsynaptic receptors
Postsynaptic Process
(ii)
AP: Action Potential
EPP: End Plate Potential
MEPP: Mini EPP


Acupuncture
Cells in Tissue
Mast cell
Damaged cells release:
Bradykinin, Substance P
& Prostaglandin
Substance P
Nerve Endings
(Histamine released)
AP
Sensory Neuron

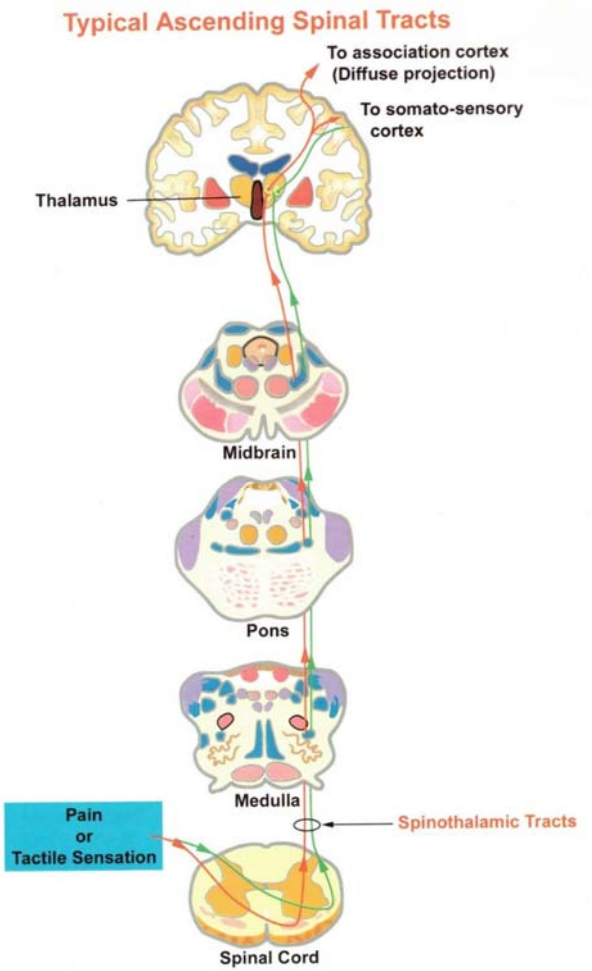

Action potential
Action potential
Action potential
Action potential
Action potential
Action potential
Receptor potential
Synaptic potential
Synaptic potential
Synaptic potential
Muscle
AP
Dorsal root ganglion cell
AP
AP
AP
Brain
Acupuncture
Myelinated
Receptor
Trigger
Axon
Synapse
Trigger
Axon
Synapse
Nerve Endings
Dorsal Horn
Thalamus → Cortex
Hypothalamus
Brainstem
Peripheral Nerves
Spinal Cord
Brain

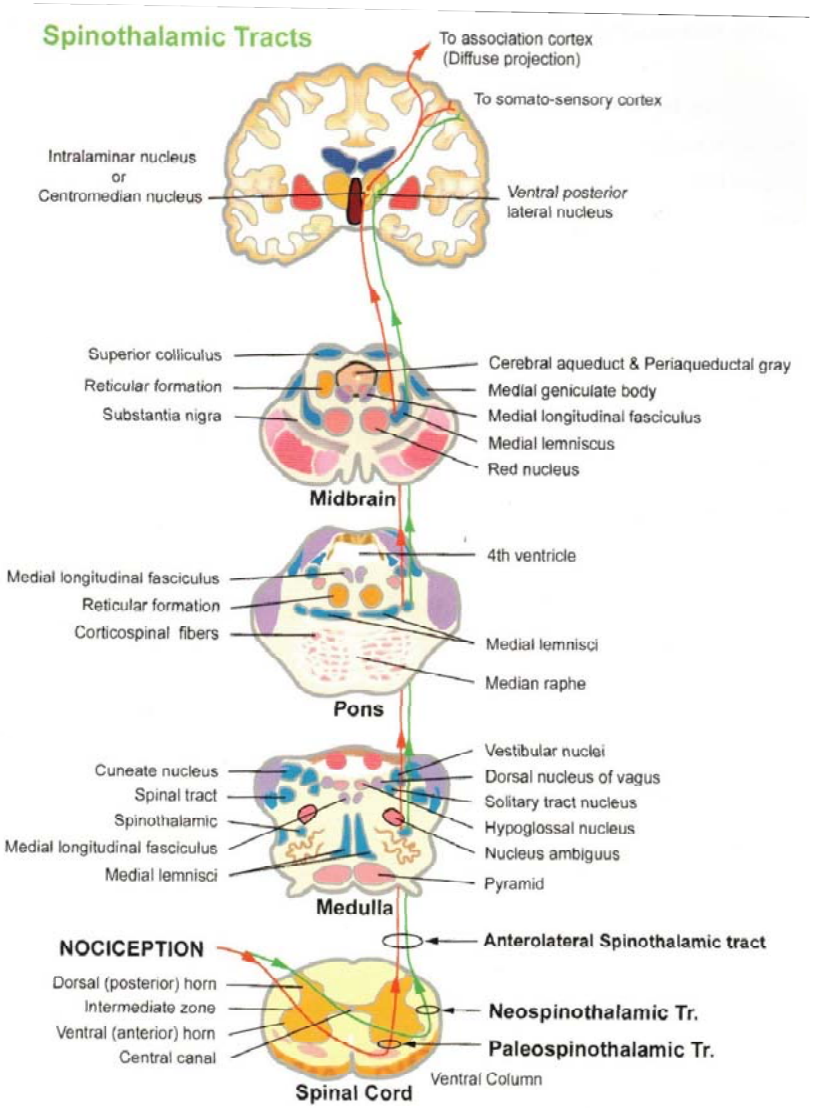

Spinal Cord
Gray Matter
White Matter
Dorsal Root
Dorsal Root Ganglion
Ventral Root
Spinal Nerve

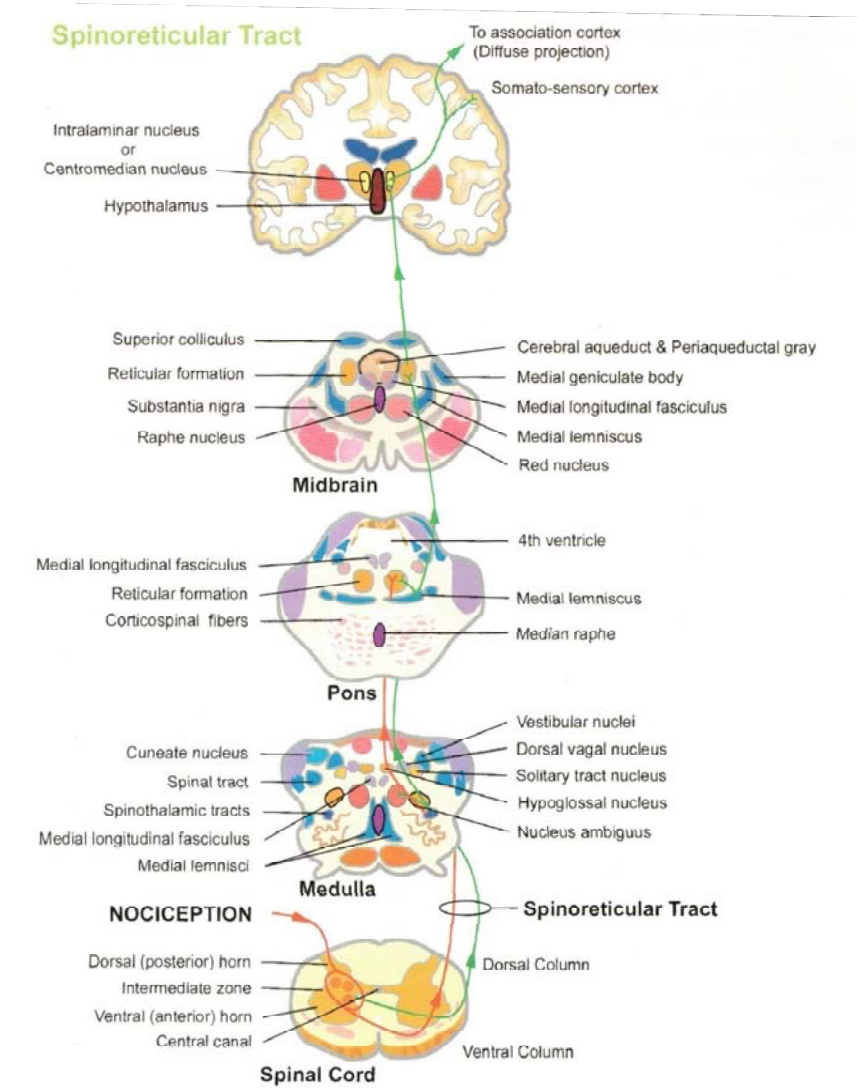

Fasciculus Gracilis
Fasciculus Cuneatus
Posterior Root Fibers
Lissauer's Fasciculus
Dorsal Horn
Lateral Fasciculus
Intermediate Zone
(VII - VIII)
Anterior Horn
(IX)
IX
VIII
Ventral Root
Anterior Fasciculus
I
II
III
IV
V
VI
Ascending
Sensory Neurons
VII
VIII
Autonomic Neurons
(Sensory & Motor)
IX
X
Descending Motor
Neurons
Anterior Root Fibers

(a)

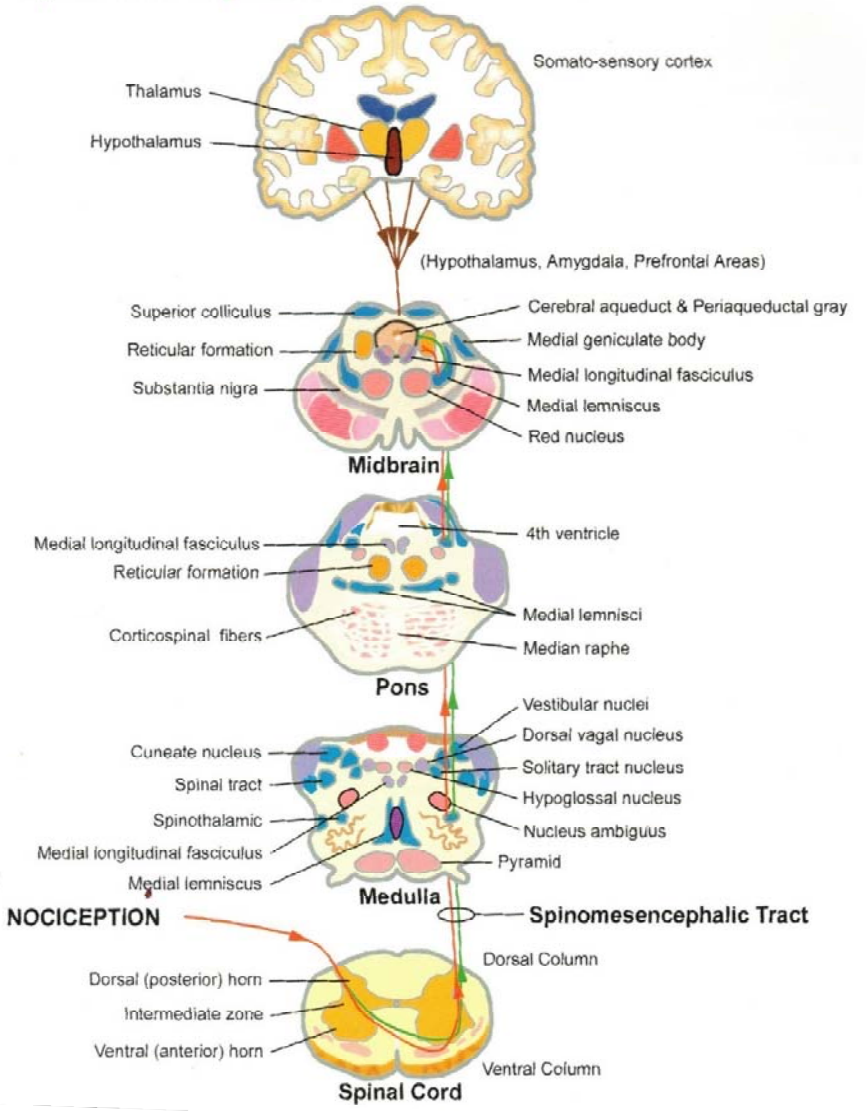
Sensory Signal Pathways of Spinal Cord

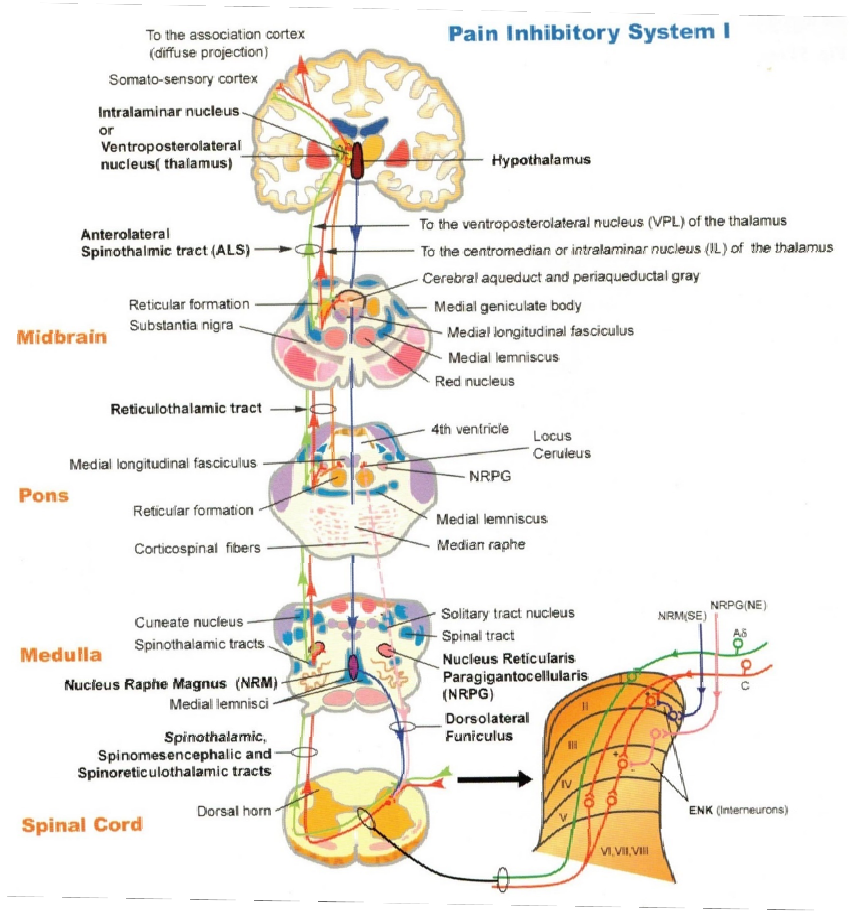


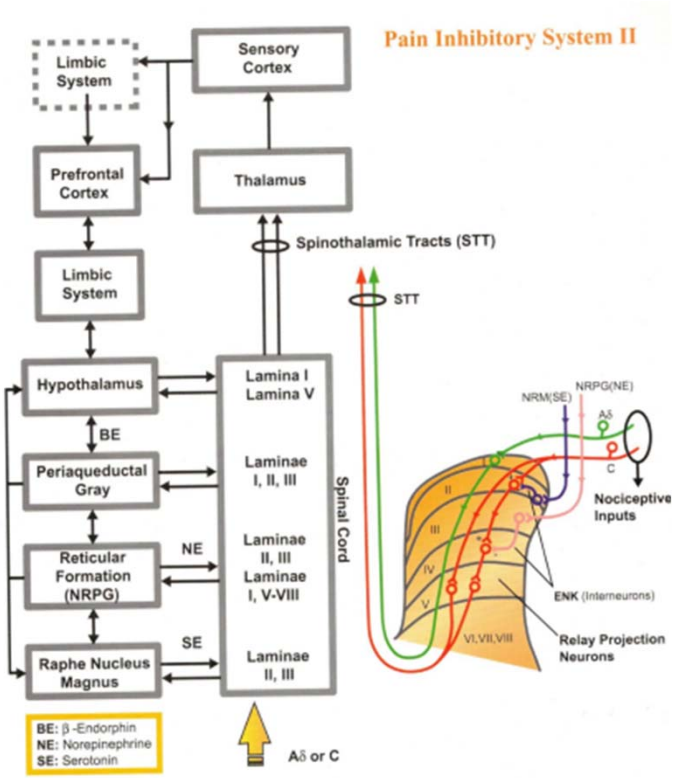

Spinothalamic Tracts
To association cortex
(Diffuse projection)
To somato-sensory cortex
Intralaminar nucleus
or
Centromedian nucleus
Ventral posterior
lateral nucleus
Superior colliculus
Reticular formation
Substantia nigra
Cerebral aqueduct & Periaqueductal gray
Medial geniculate body
Medial longitudinal fasciculus
Medial lemniscus
Red nucleus
Midbrain
4th ventricle
Medial longitudinal fasciculus
Reticular formation
Corticospinal fibers
Medial lemnisci
Median raphe
Pons
Vestibular nuclei
Cuneate nucleus
Dorsal nucleus of vagus
Spinal tract
Solitary tract nucleus
Spinothalamic
Hypoglossal nucleus
Medial longitudinal fasciculus
Nucleus ambiguus
Medial lemnisci
Pyramid
Medulla
Anterolateral Spinothalamic tract
NOCICEPTION
Dorsal (posterior) horn
Intermediate zone
Neospinothalamic Tr.
Ventral (anterior) horn
Paleospinothalamic Tr.
Central canal
Ventral Column
Spinal Cord

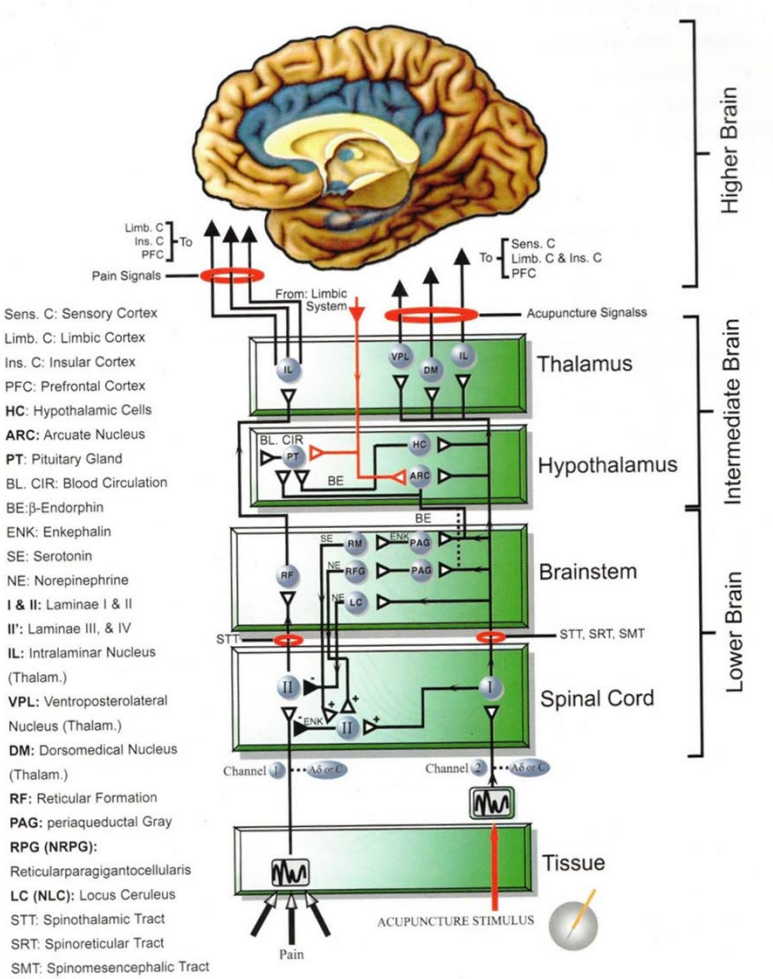

Spinoreticular Tract
To association cortex
(Diffuse projection)
Somato-sensory cortex
Intralaminar nucleus
or
Centromedian nucleus
Hypothalamus
Superior colliculus
Reticular formation
Substantia nigra
Raphe nucleus
Cerebral aqueduct & Periaqueductal gray
Medial geniculate body
Medial longitudinal fasciculus
Medial lemniscus
Red nucleus
Midbrain
4th ventricle
Medial longitudinal fasciculus
Reticular formation
Corticospinal fibers
Medial lemniscus
Median raphe
Pons
Vestibular nuclei
Cuneate nucleus
Dorsal vagal nucleus
Spinal tract
Solitary tract nucleus
Spinothalamic tracts
Hypoglossal nucleus
Medial longitudinal fasciculus
Nucleus ambiguus
Medial lemnisci
Medulla
NOCICEPTION
Spinoreticular Tract
Dorsal (posterior) horn
Dorsal Column
Intermediate zone
Ventral (anterior) horn
Central canal
Ventral Column
Spinal Cord

Spinomesencephalic Tract




Pain Inhibitory System I
To the association cortex (diffuse projection)
Somato-sensory cortex
Intralaminar nucleus or Ventroposterolateral nucleus(thalamus)
Hypothalamus
To the ventroposterolateral nucleus (VPL) of the thalamus
Anterolateral Spinothalmic tract (ALS)
To the centromedian or intralaminar nucleus (IL) of the thalamus
Cerebral aqueduct and periaqueductal gray
Reticular formation
Substantia nigra
Medial geniculate body
Medial longitudinal fasciculus
Medial lemniscus
Red nucleus
Midbrain
Reticulothalamic tract
4th ventricle
Locus Ceruleus
Medial longitudinal fasciculus
NRPG
Pons
Reticular formation
Medial lemniscus
Corticospinal fibers
Median raphe
Cuneate nucleus
Solitary tract nucleus
Spinothalamic tracts
Spinal tract
Nucleus Reticularis Paragigantocellularis (NRPG)
Nucleus Raphe Magnus (NRM)
Medial lemnisci
Medulla
Dorsolateral Funiculus
Spinothalamic, Spinomesencephalic and Spinoreticulothalamic tracts
Dorsal horn
Spinal Cord
NRM(SE)
NRPG(NE)
Aδ
C
ENK (Interneurons)
VI,VII,VIII


Pain Inhibitory System II
Limbic System
Sensory Cortex
Prefrontal Cortex
Thalamus
Limbic System
Spinothalamic Tracts (STT)
STT
Hypothalamus
Lamina I
Lamina V
BE
Periaqueductal Gray
Laminae I, II, III
Reticular Formation (NRPG)
NE
Laminae II, III
Laminae I, V-VIII
Raphe Nucleus Magnus
SE
Laminae II, III
Spinal Cord
BE: β -Endorphin
NE: Norepinephrine
SE: Serotonin
Aδ or C
NRM(SE)
NRPG(NE)
Aδ
C
Nociceptive Inputs
ENK (Interneurons)
Relay Projection Neurons
VI,VII,VIII


Higher Brain
Intermediate Brain
Lower Brain
Limb. C
Ins. C
PFC
To
Pain Signals
From: Limbic System
To
Sens. C
Limb. C & Ins. C
PFC
Acupuncture Signalss
Sens. C: Sensory Cortex
Limb. C: Limbic Cortex
Ins. C: Insular Cortex
PFC: Prefrontal Cortex
HC: Hypothalamic Cells
ARC: Arcuate Nucleus
PT: Pituitary Gland
BL. CIR: Blood Circulation
BE:β-Endorphin
ENK: Enkephalin
SE: Serotonin
NE: Norepinephrine
I & II: Laminae I & II
II': Laminae III, & IV
IL: Intralaminar Nucleus (Thalam.)
VPL: Ventroposterolateral Nucleus (Thalam.)
DM: Dorsomedical Nucleus (Thalam.)
RF: Reticular Formation
PAG: periaqueductal Gray
RPG (NRPG): Reticularparagigantocellularis
LC (NLC): Locus Ceruleus
STT: Spinothalamic Tract
SRT: Spinoreticular Tract
SMT: Spinomesencephalic Tract
Thalamus
IL
VPL
DM
IL
Hypothalamus
BL. CIR
PT
HC
ARC
BE
BE
Brainstem
SE
RM
ENK
PAG
NE
RPG
PAG
RF
NE
LC
STT
STT, SRT, SMT
Spinal Cord
II
I
ENK
II
Channel 1
Aδ or C
Channel 2
Aδ or C
Tissue
ACUPUNCTURE STIMULUS
Pain

References

- 1. Harrison's Principles of Internal Medicine, 21st edition. 2022.
- 2. Neuro-Acupuncture, Vol.1, Z.H. Cho, E.K. Wong, J.H. Fallon. 2001.

THANK YOU