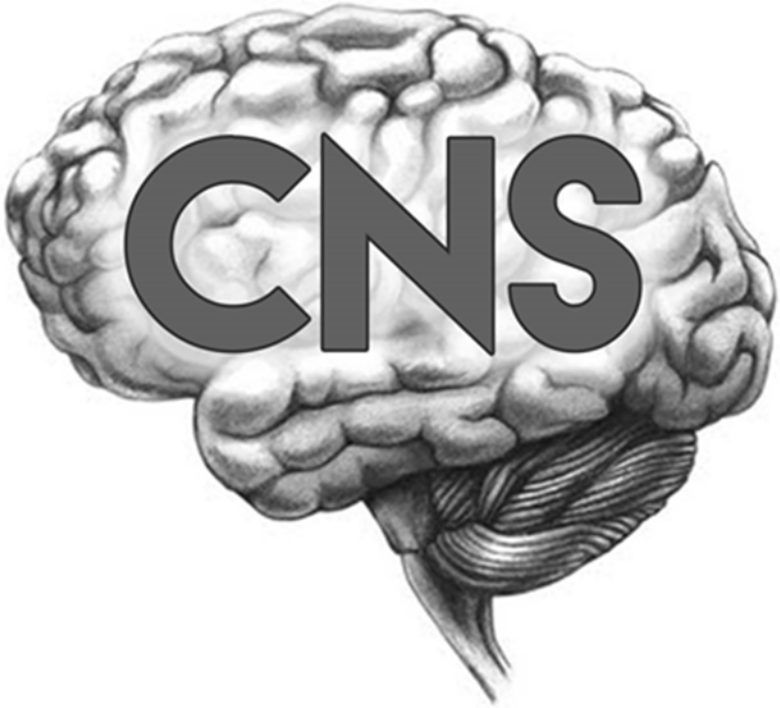


PHYSIOLOGY

○ Sheet ✓ Slide ○ Handout

Number

12

Subject

Somatic Sensations:

II. Pain, and Thermal Sensations

Doctor

Faisal Mohammed

Date: **00/00/2016**

Price:

Somatic Sensations:
II. Pain, and Thermal Sensations

Faisal I. Mohammed, MD, PhD

Objectives

- Define pain and classify it types (fast or slow, somatic or visceral)
- Describe the mechanism of pain and its receptors
- Follow its pathway to the cerebral cortex and characterize this pathway
- Explain pain suppression mechanism (endogenous opiate system and gate control theory)
- Describe the pathway for referred pain
- Create a complete picture of thermal sensation

Pain

- occurs whenever tissue is being damaged
- protective mechanism for the body
- causes individual to remove painful stimulus
- two types of pain, *fast pain* and *slow pain*
- *fast pain* felt within 0.1 sec of the stimulus and is *sharp, pricking, acute, electric* in character
- *slow pain* begins after a second or more and is *throbbing, aching, nauseous and chronic* in nature

Pain Receptors and Their Stimulation

- all pain receptors are free nerve endings (Three categories- **mechanical**, **thermal** and **polymodal** that respond to all besides chemical)
- can be stimulated by:
  - mechanical (stretch)
  - thermal
  - chemical
    - bradykinin, serotonin, histamine, potassium ions, acids, acetylcholine and proteolytic enzymes
    - prostaglandins and substance P enhance the sensitivity of pain endings but do not directly excite them- lowers threshold for pain

Pain Receptors and Their Stimulation

- pain receptors do not adapt to the stimulus
- the rate of tissue damage is the cause of pain (most individuals feel pain at 45^0 C)
- extracts from damaged tissue cause pain when injected under the skin
- bradykinin causes the most pain and may be the single agent most responsible for causing the tissue damage type of pain
  - also the local increase in potassium ion concentration and action of enzymes can contribute to pain

Rate of tissue damage as a source of pain

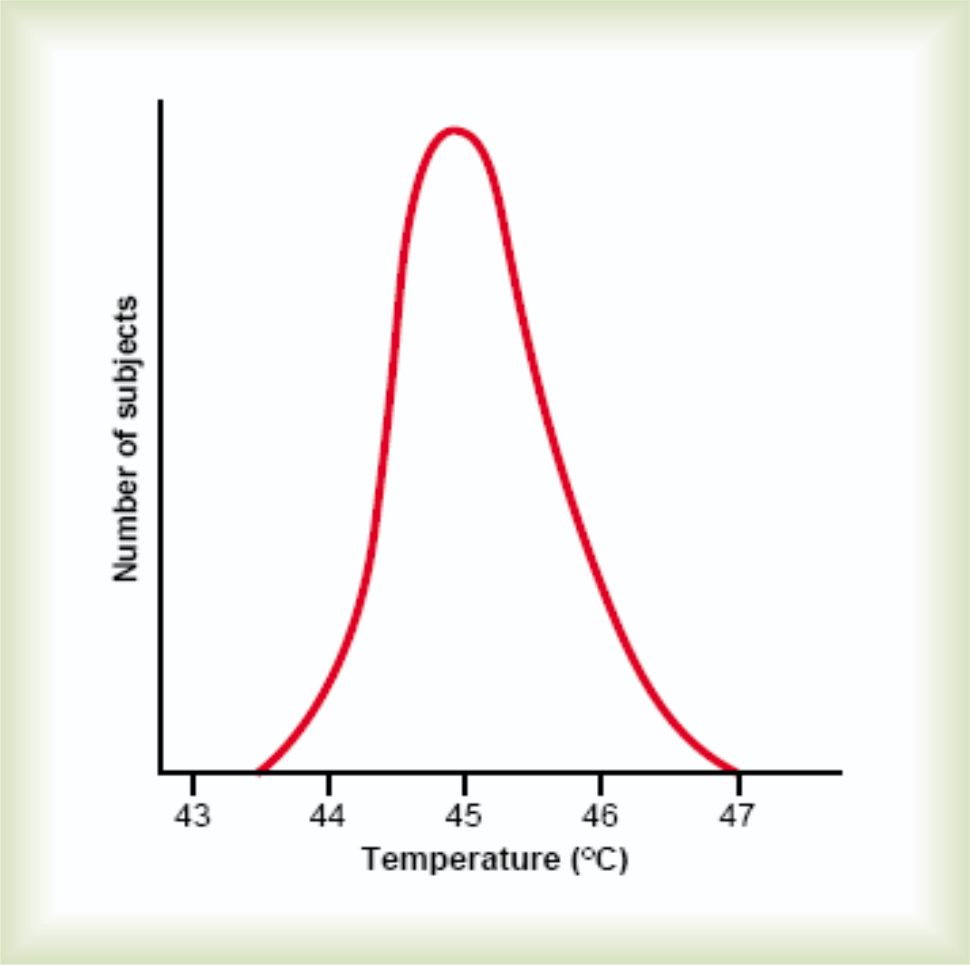


Figure 48–1

Distribution curve obtained from a large number of persons showing the minimal skin temperature that will cause pain. (Modified from Hardy DJ: Nature of pain. J Clin Epidemiol 4:22, 1956.)

The Anterolateral (spinothalamic) pathway

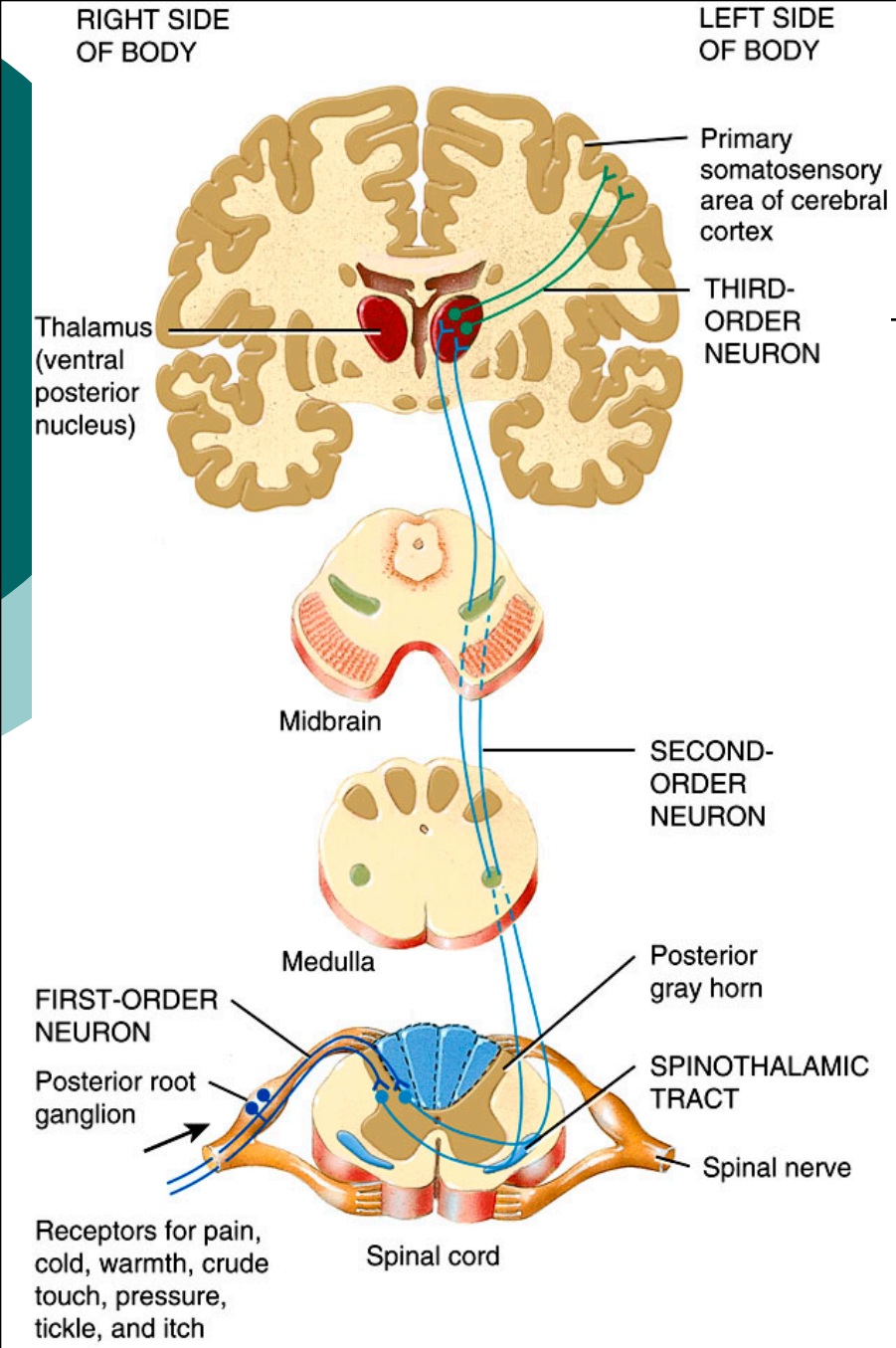


Figure 16.06 Tortora - PAP 12/e

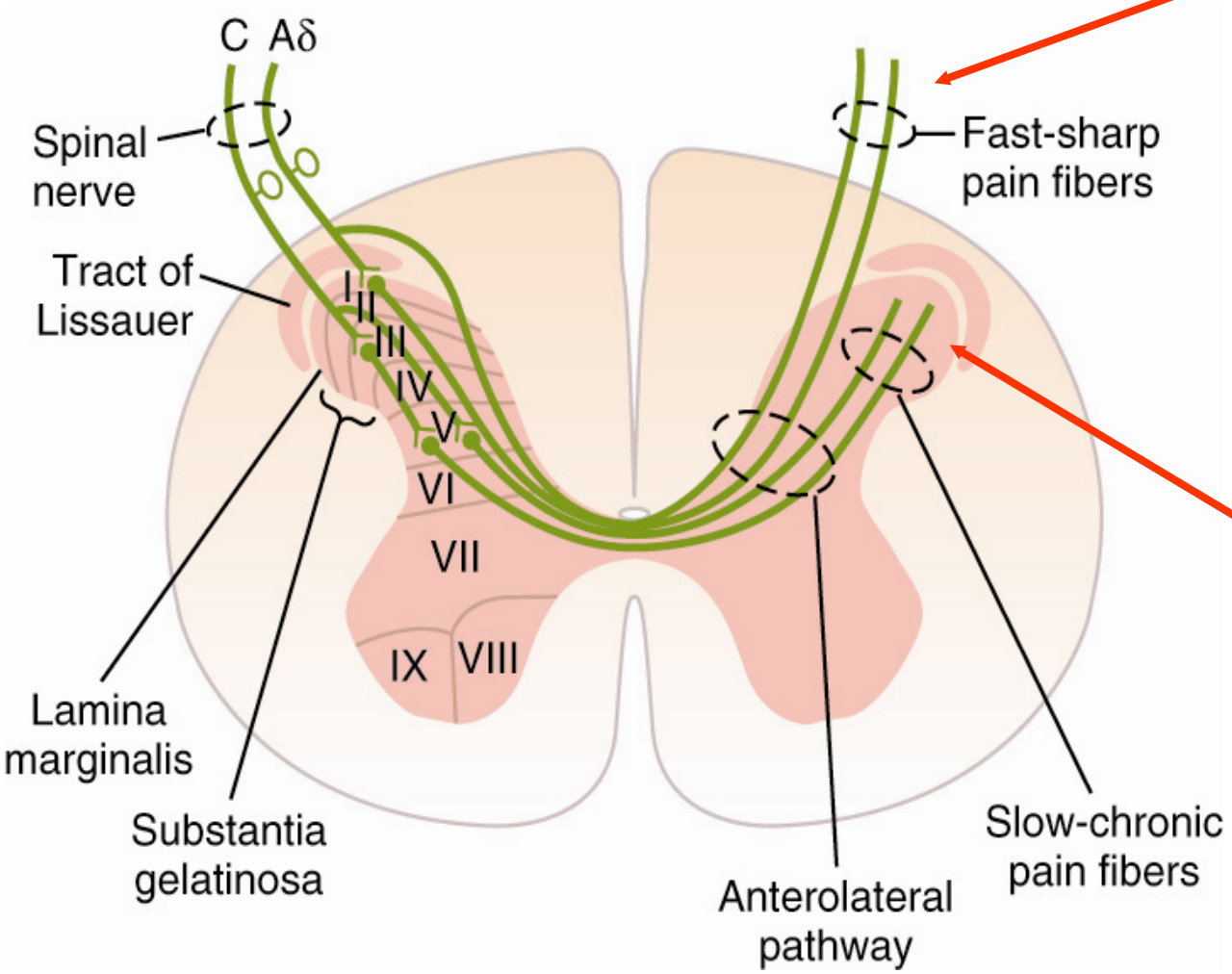
- Conveys nerve impulses for crude touch (poorly localized), crude pressure, pain, cold, warmth, itch, and tickle from the limbs, trunk, neck, and posterior head to the postcentral gyrus of the cerebral cortex.

Dual Pain Pathways

- Fast pain is transmitted by *type Aδ* fibers (velocity 6-30 m/sec).
- Slow pain is transmitted by *type C* fibers (0.5 - 2 m/sec).
- Fast pain fibers are transmitted in the *neospinothalamic tract.*
- Slow pain fibers are transmitted in the *paleospinothalamic tract.*

Characterization of fast and slow pain

Fast Pain	Slow Pain
Occurs on stimulation of mechanical and thermal nociceptors	Occurs on stimulation of polymodal nociceptors
Carried by small, myelinated A-delta fibers ($A\delta$).	Carried by small, unmyelinated C fibers
Produces sharp, prickling sensation	Produces dull, aching, burning sensation
Easily localized	Poorly localized
Occurs first	Occurs second, persists for longer time, more unpleasant



Neo-spinothalamic tract

Paleo-spinothalamic tract

Neospinothalamic Tract

- On entering the cord, pain fibers may travel up or down 1-3 segments and terminate on neurons in the dorsal horn.
- 2nd neuron crosses immediately to the opposite side and passes to the brain in the anterolateral columns.
- Some neurons terminate in the *reticular substance* but most go all the way to the *ventrobasal complex of the thalamus*.
- 3rd order neurons go to the cortex.

Neospinothalamic Tract (cont'd)

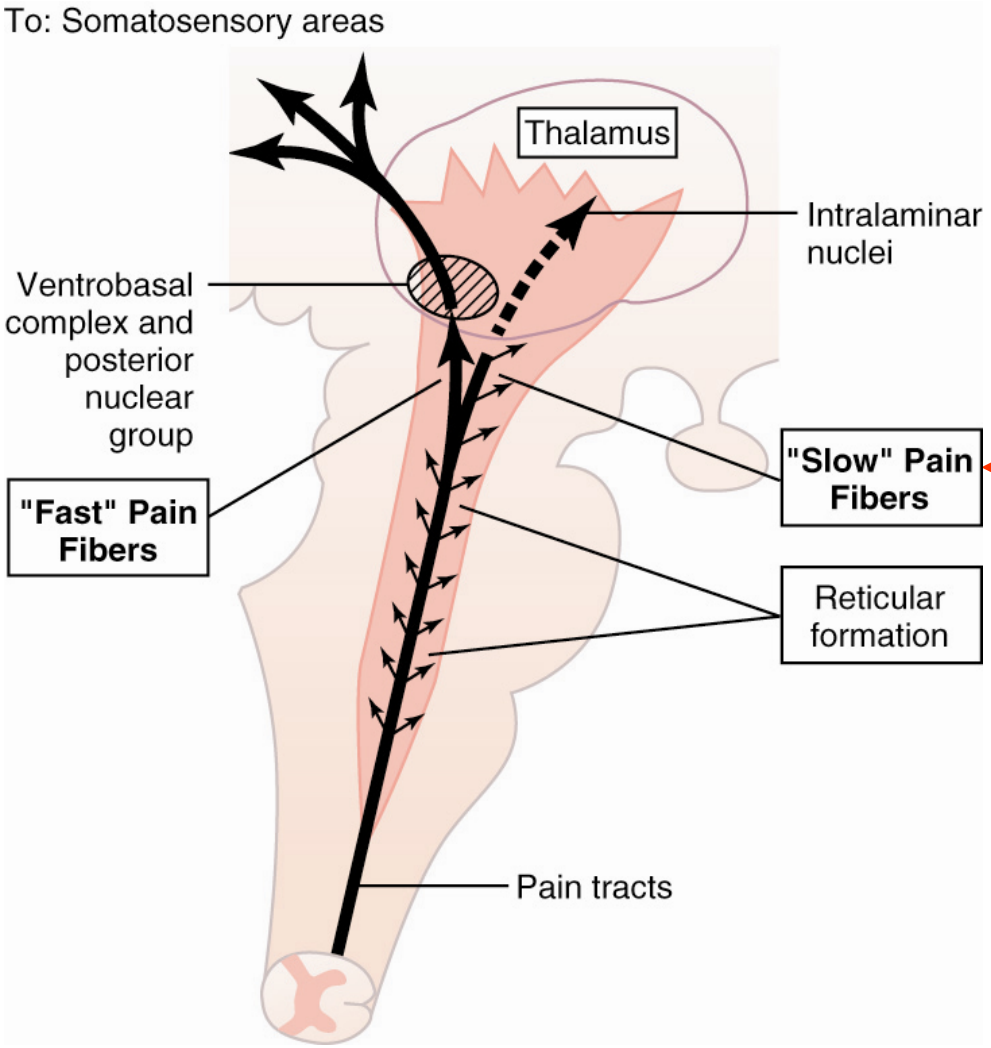
- Fast-sharp pain can be localized well.
- However, fast pain fibers must be stimulated with other tactile receptors for the pain to be highly localized.

Paleospinothalamic Tract

- Type C pain fibers terminate in laminae II and III of the spinal cord and make one or two local connections before giving rise to 2nd order neurons which cross immediately and pass to the brain in the anterolateral columns.
- Only 10 to 25 % of the fibers terminate in the thalamus.
- Most terminate diffusely in the:
  - reticular nuclei of the medulla, pons and mesencephalon
  - ***tectal area of the mesencephalon***
  - ***periaqueductal gray region*.**

Paleospinothalamic Tract

- lower terminations important to appreciate the suffering type of pain
- from the lower reticular areas of the brain stem neurons project to the intralaminar nuclei of the thalamus, hypothalamus and other basal brain regions
- poor localization of slow pain, often to just the affected limb or part of the body



Neo-spinothalamic tract

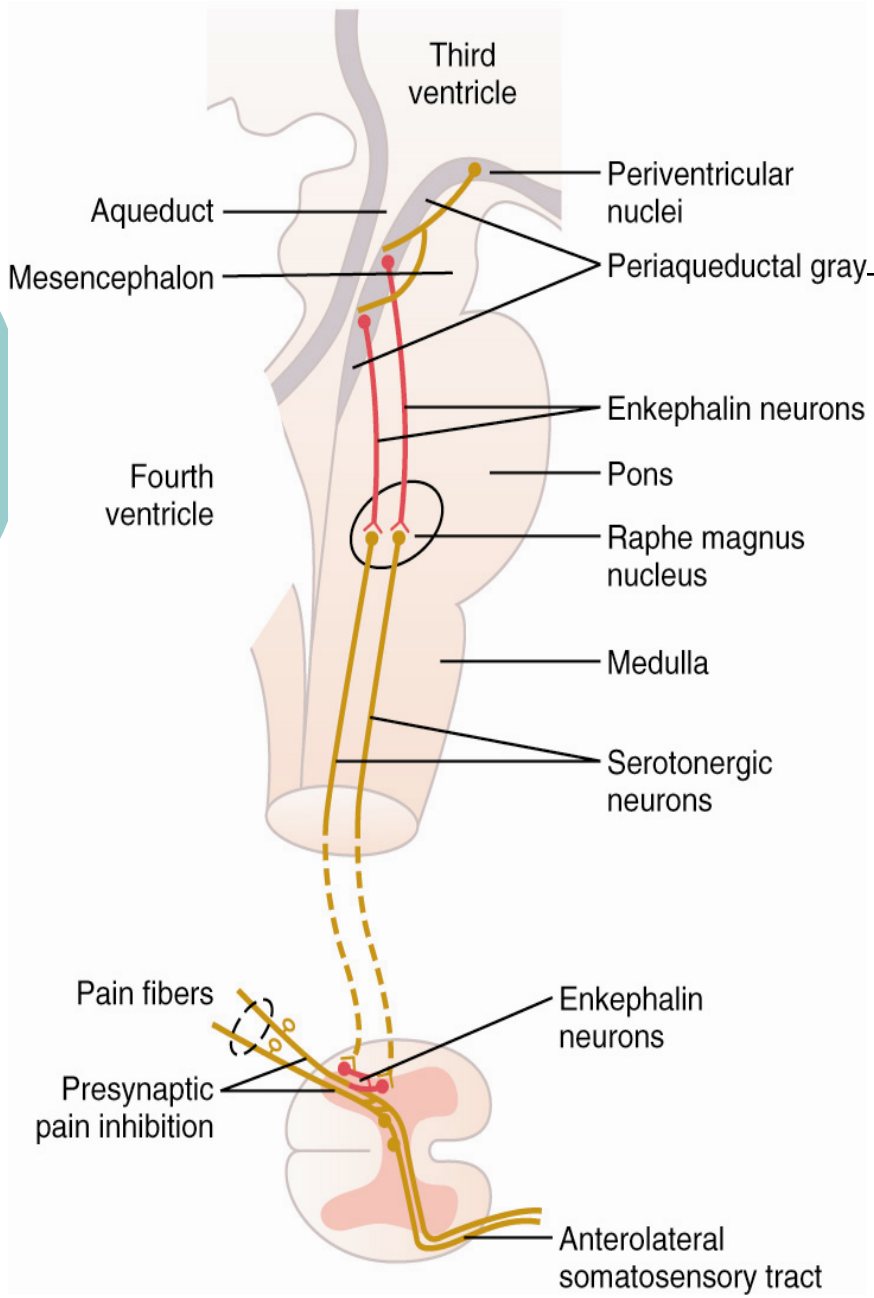
Paleo-spinothalamic tract

The Appreciation of Pain

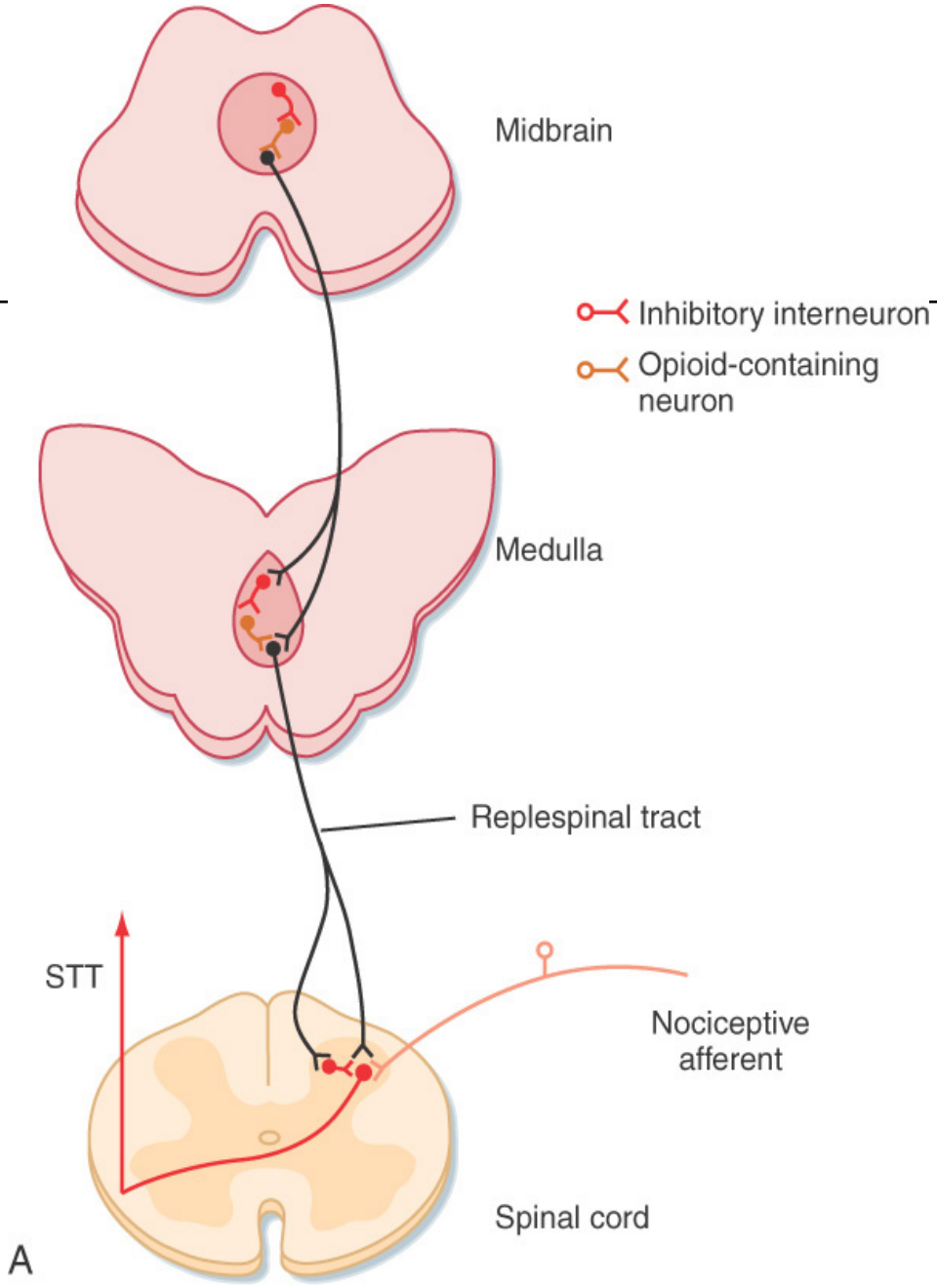
- Removal of the somatic sensory areas of the cortex does not destroy the ability to perceive pain.
- Pain impulses to lower areas can cause conscious perception of pain.
- Therefore, cortex probably important for determining the *quality* of pain.
- Stimulation of the reticular areas of the brain stem and intralaminar nuclei of thalamus (where pain fibers terminate) causes widespread arousal of the nervous system.

Analgesia System of the Brain and Spinal Cord

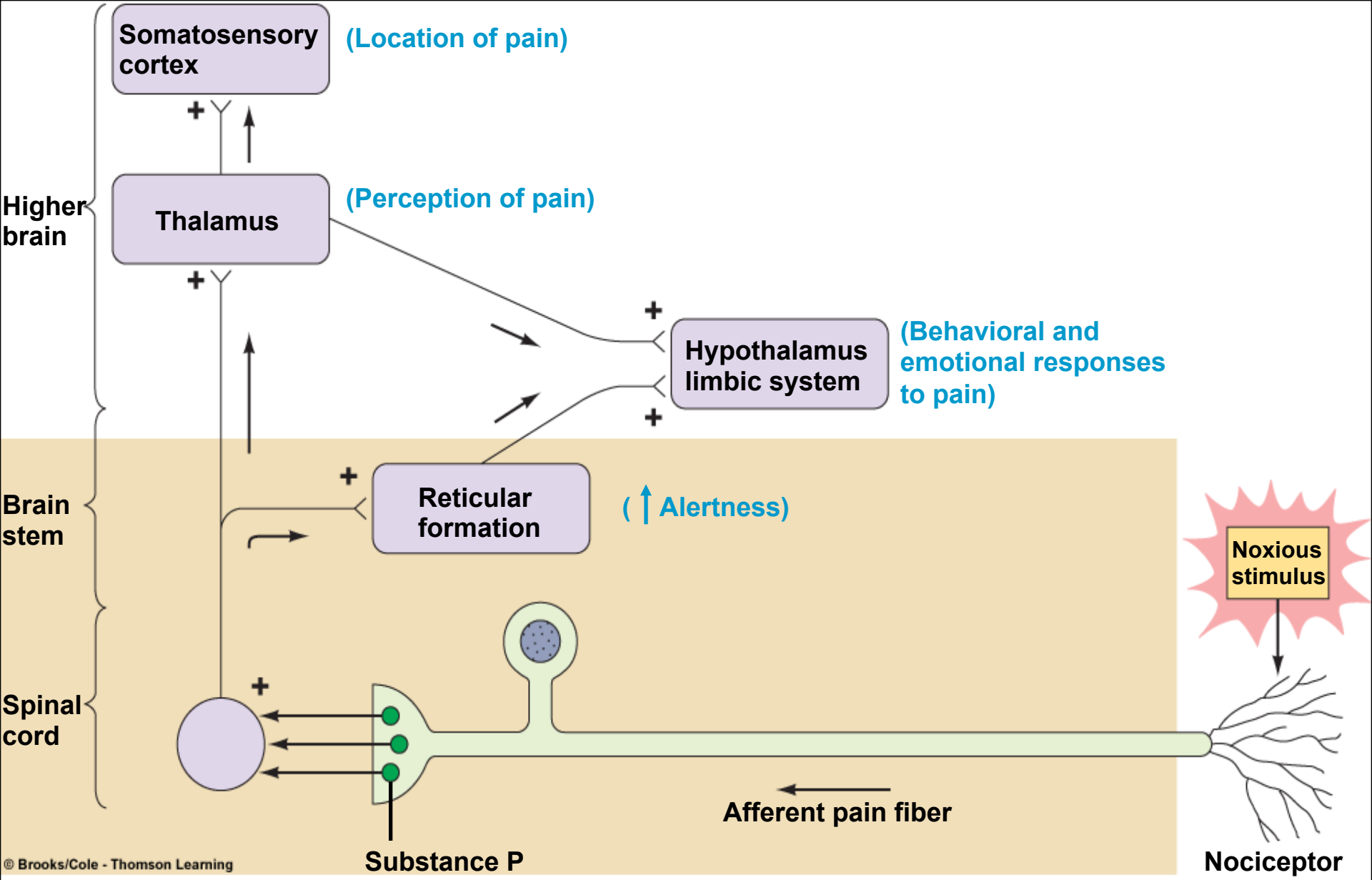
- The brain has the capability to suppress pain fibers.
- ***Periaqueductal gray area*** neurons send axons to the ***nucleus raphe magnus*** and the ***nucleus paragigantocellularis.***
- ***Raphe magnus*** and ***paragigantocellularis*** neurons send axons to the dorsal horns of the spinal cord.
- These neurons activate a pain inhibitory complex in the spinal cord.

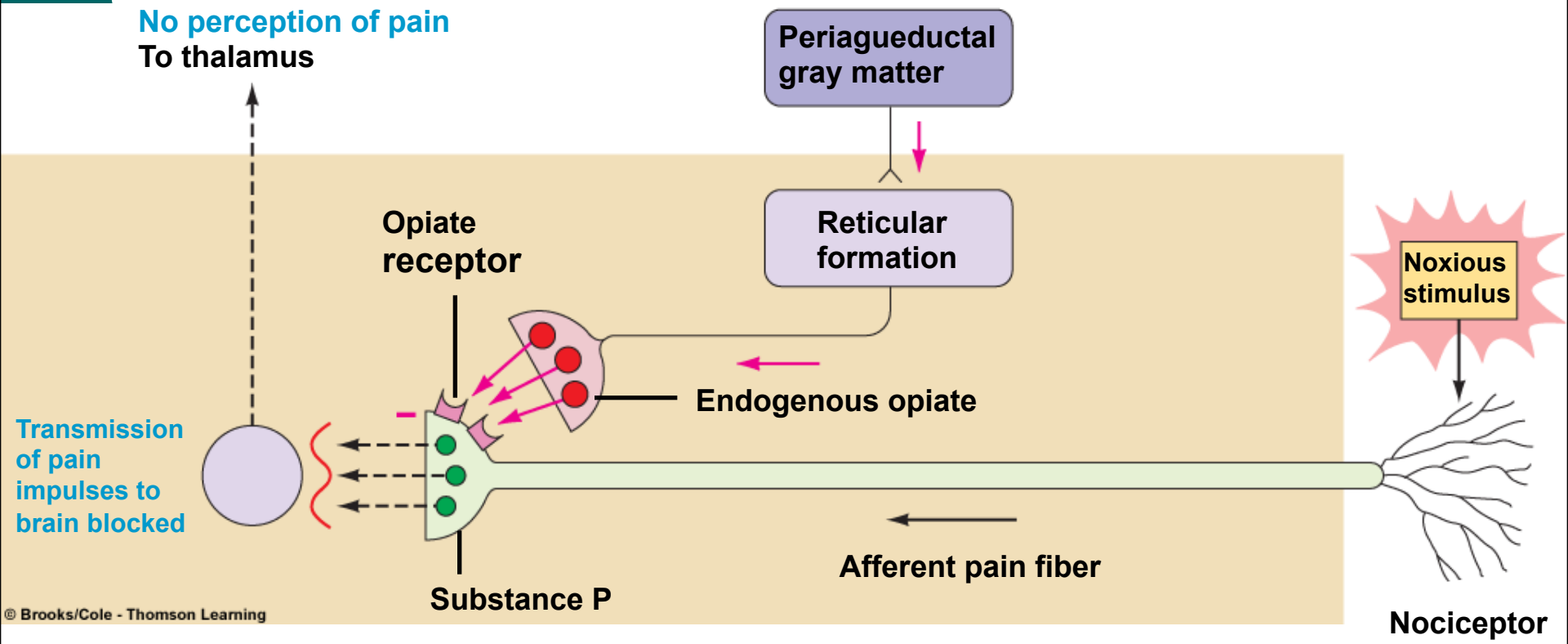


Analgesia system of the brainstem and spinal cord- Ipsilateral system



(Redrawn from Henry JL. In Porter R, O'Connor M [eds]: Ciba Foundation Symposium 91. London, Pitman, 1982.)


Somatosensory cortex
(Location of pain)
Higher brain
Thalamus
(Perception of pain)
Hypothalamus limbic system
(Behavioral and emotional responses to pain)
Brain stem
Reticular formation
(↑ Alertness)
Noxious stimulus
Spinal cord
Afferent pain fiber
Substance P
Nociceptor
© Brooks/Cole - Thomson Learning


No perception of pain
To thalamus
Periagueductal gray matter
Reticular formation
Opiate receptor
Noxious stimulus
Endogenous opiate
Transmission of pain impulses to brain blocked
Afferent pain fiber
Substance P
Nociceptor
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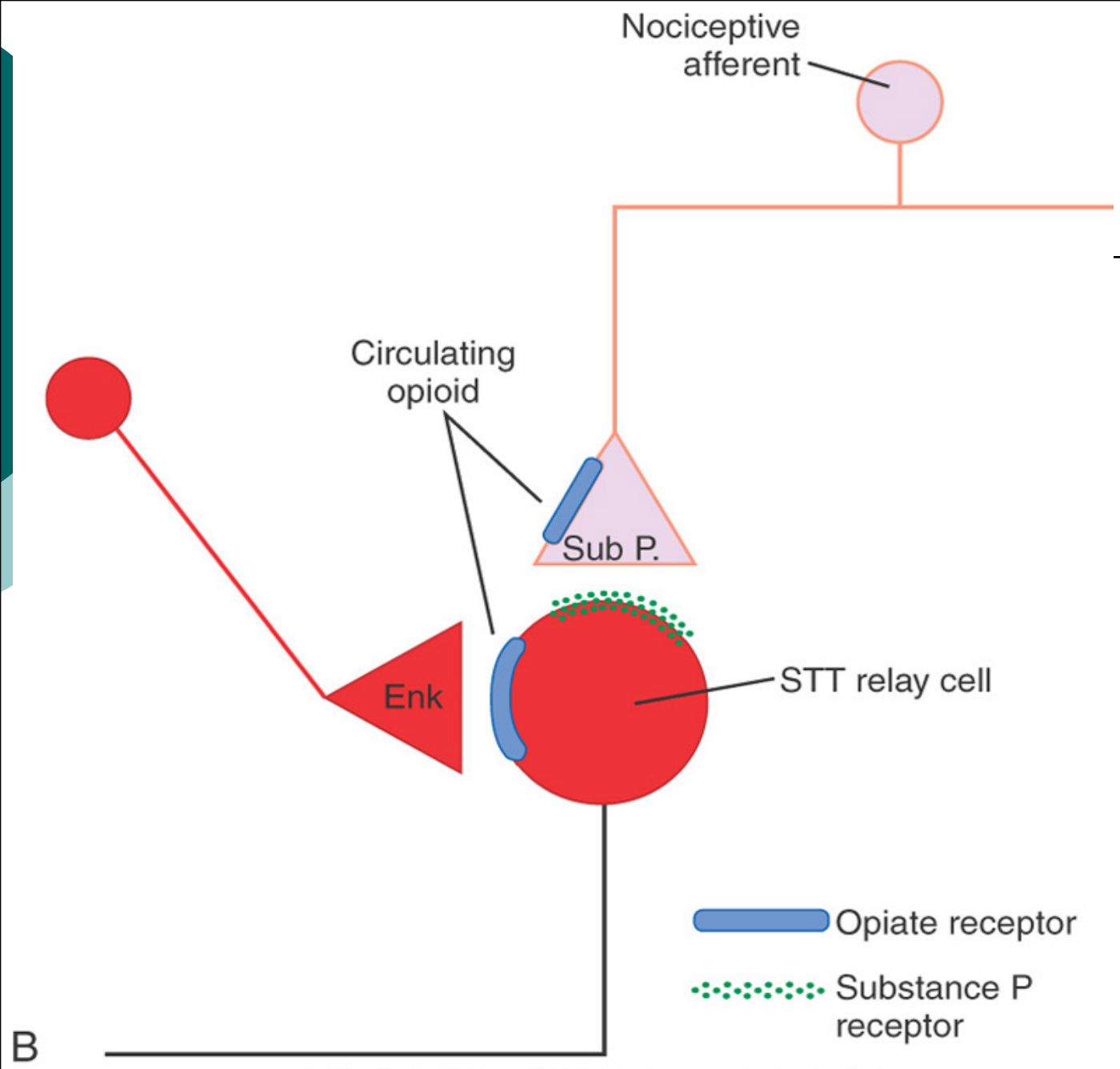


(Redrawn from Henry JL. In Porter R, O'Connor M [eds]: Ciba Foundation Symposium 91. London, Pitman, 1982.)

Analgesia System of the Brain and Spinal Cord

- Higher brain levels, the *periventricular nuclei of the hypothalamus* and the *medial forebrain bundle* can activate the *periaqueductal gray* region and suppress pain.

Pain Suppression Mechanism

- Nerve fibers in the ***periventricular*** nucleus and the ***periaqueductal*** gray secrete *enkephalin* at their nerve endings.
- Nerve fibers from the ***raphe magnus*** secrete serotonin at their nerve endings.
- The serotonin causes the local neurons to secrete *enkephalin*.
- Enkephalin is believed to cause both pre- and post-synaptic inhibition of type C and type Aδ pain fibers where they synapse in the dorsal horns.

Endogenous Opiate Systems

- In the early 1970's it was discovered that an injection of minute quantities of morphine into the area around the third ventricle produced a profound and prolonged analgesia.
- This started the search for "morphine receptors" in the brain.
- Several "opiate-like" substances have been identified. All are breakdown products of three large molecules; proopiomelanocortin, proenkephalin, and prodynorphin.

Endogenous Opiate Systems

- The major opiate substances; *β endorphin, met-enkephalin, leu-enkephalin, dynorphin*
- The enkephalins and dynorphin are found in the brain stem and spinal cord.
- The *β* -endorphin is found in the hypothalamus and the pituitary.

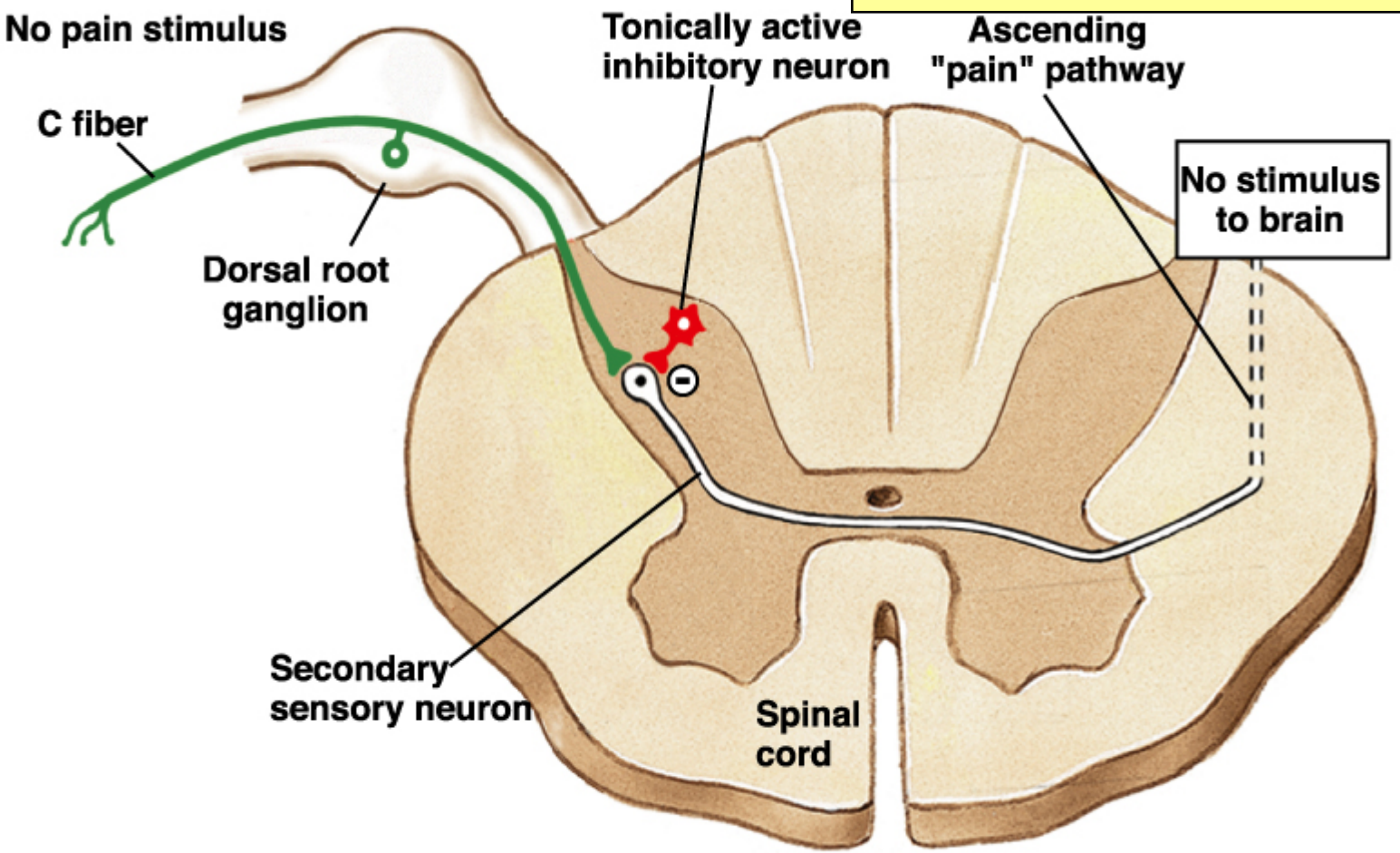
Function of the Opiate System

- pain suppression during times of stress
- an important part of an organism's response to an emergency is a reduction in the responsiveness to pain
  - effective in defense, predation, dominance and adaptation to environmental challenges

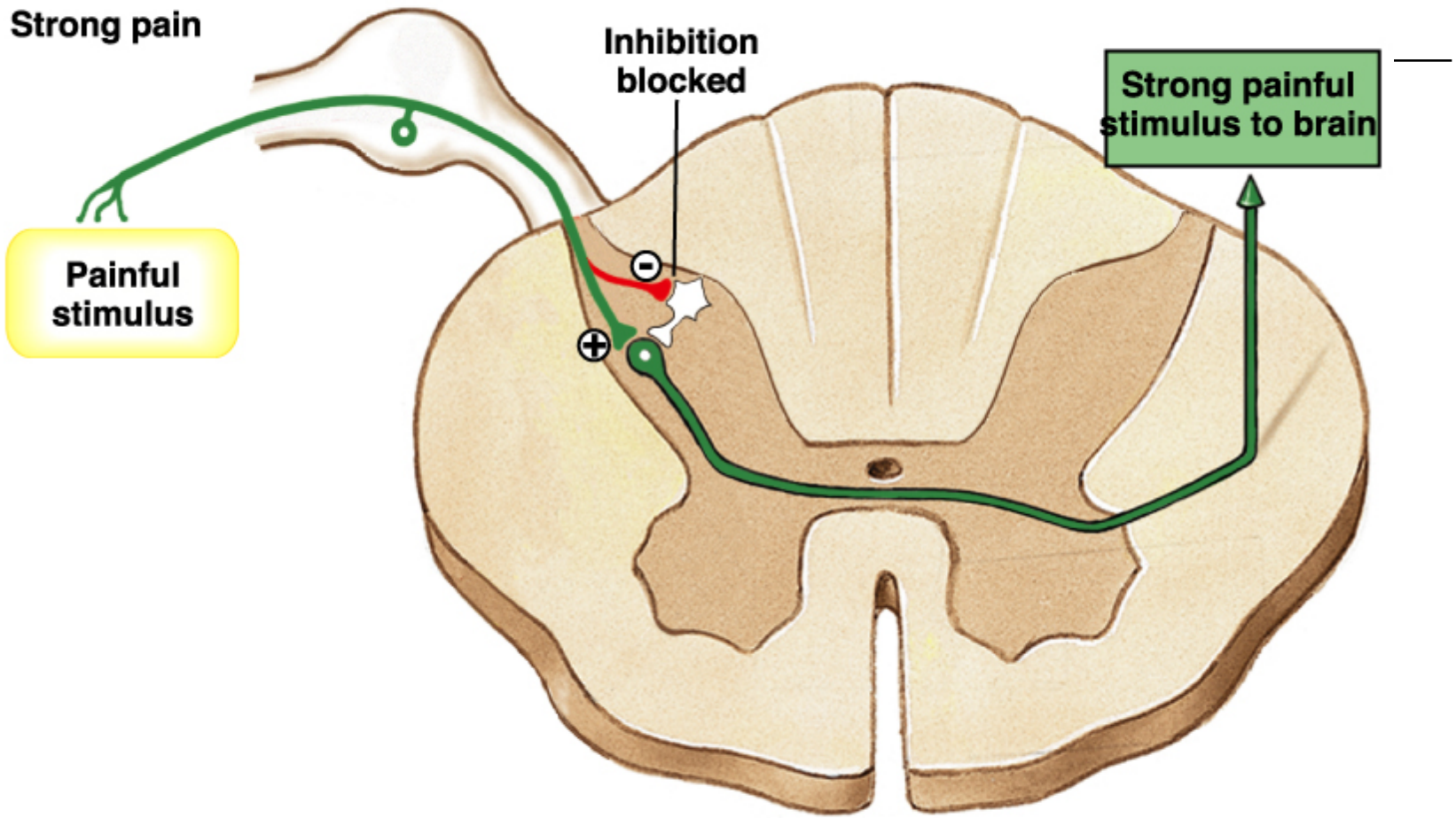
Pain and Tactile Fibers

- Stimulation of large type A β sensory fibers from peripheral tactile receptors can depress the transmission of pain signals, “the gate control hypothesis”.
- Mechanism is a type of lateral inhibition of the pain fiber by the sensory fiber.
- Mechanism of action of massage, liniments, electrical stimulation of the skin

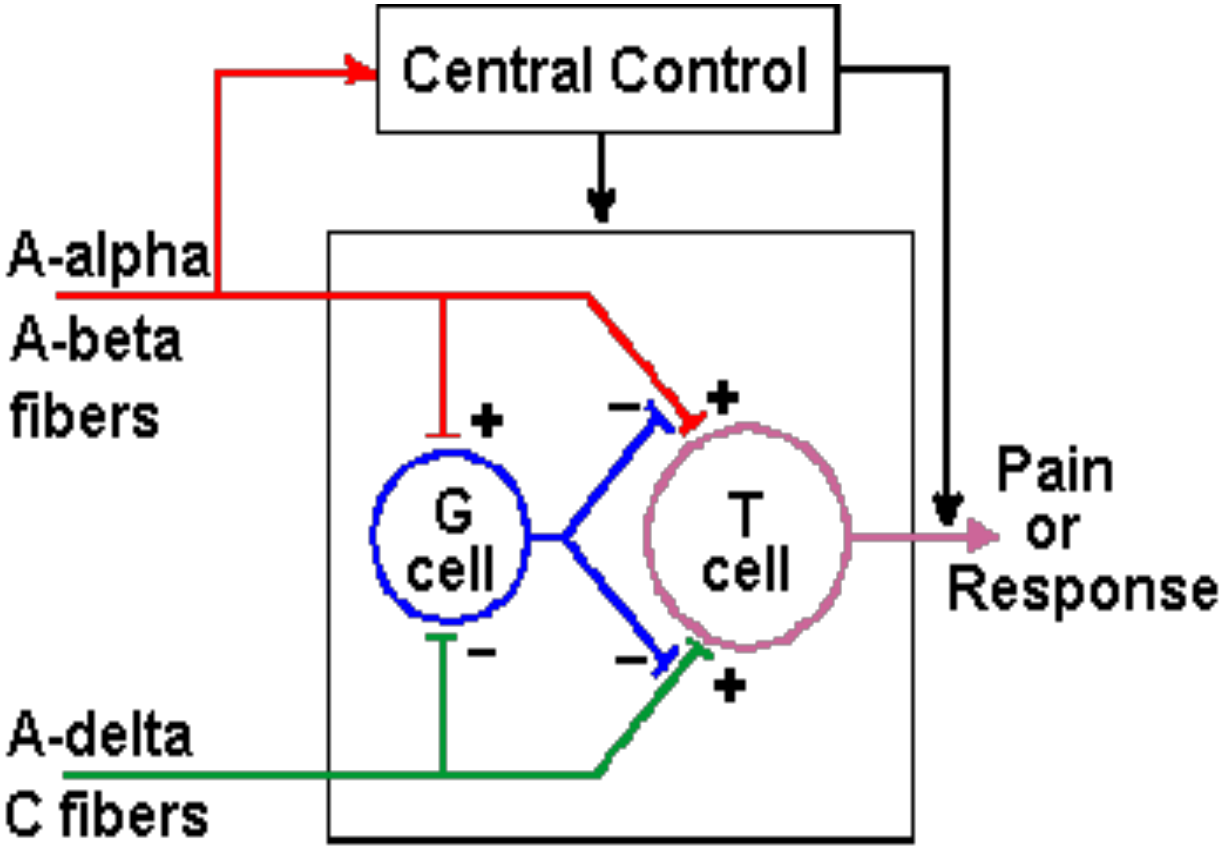
Pain Pathway



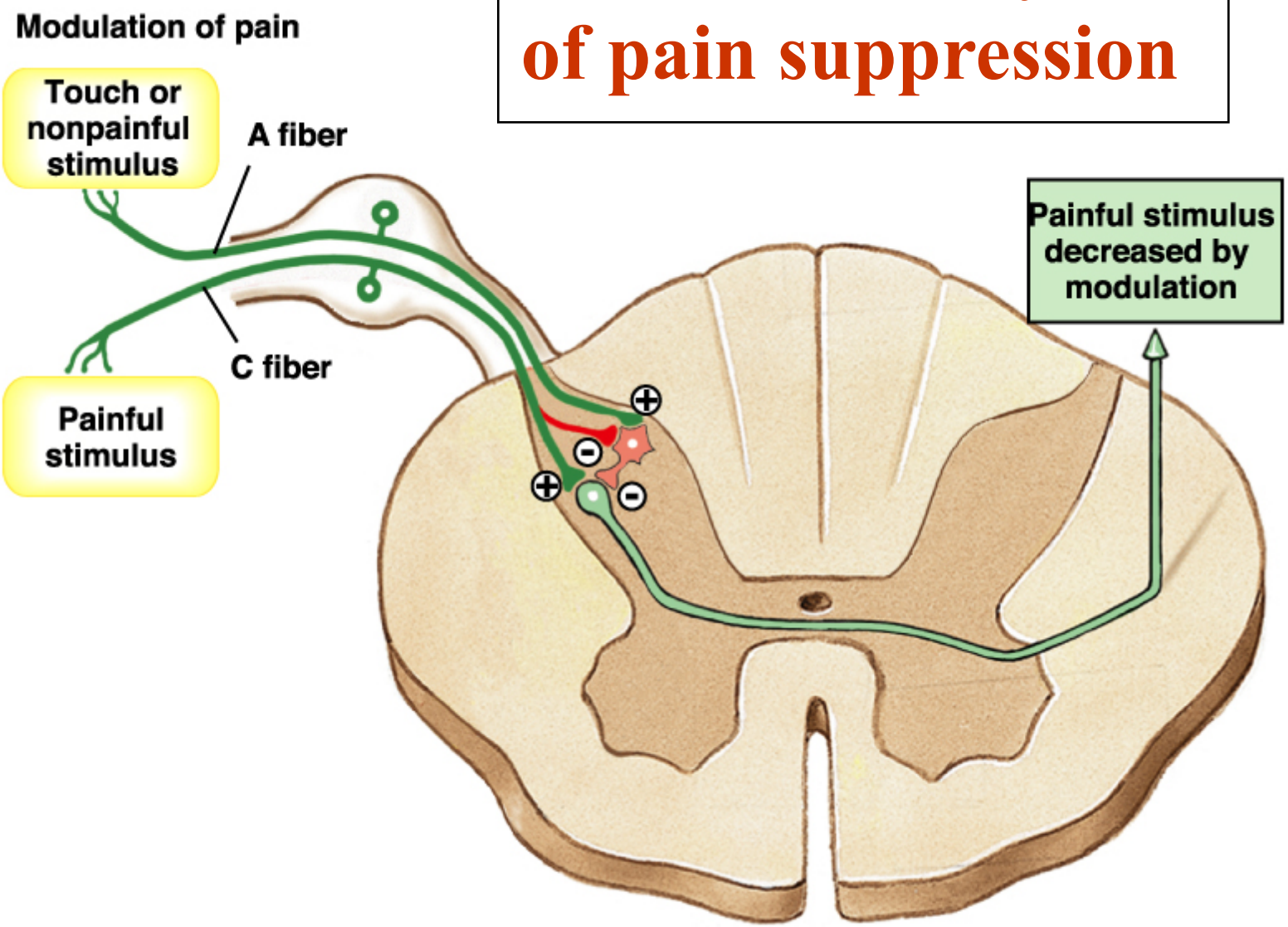
Pain Pathway



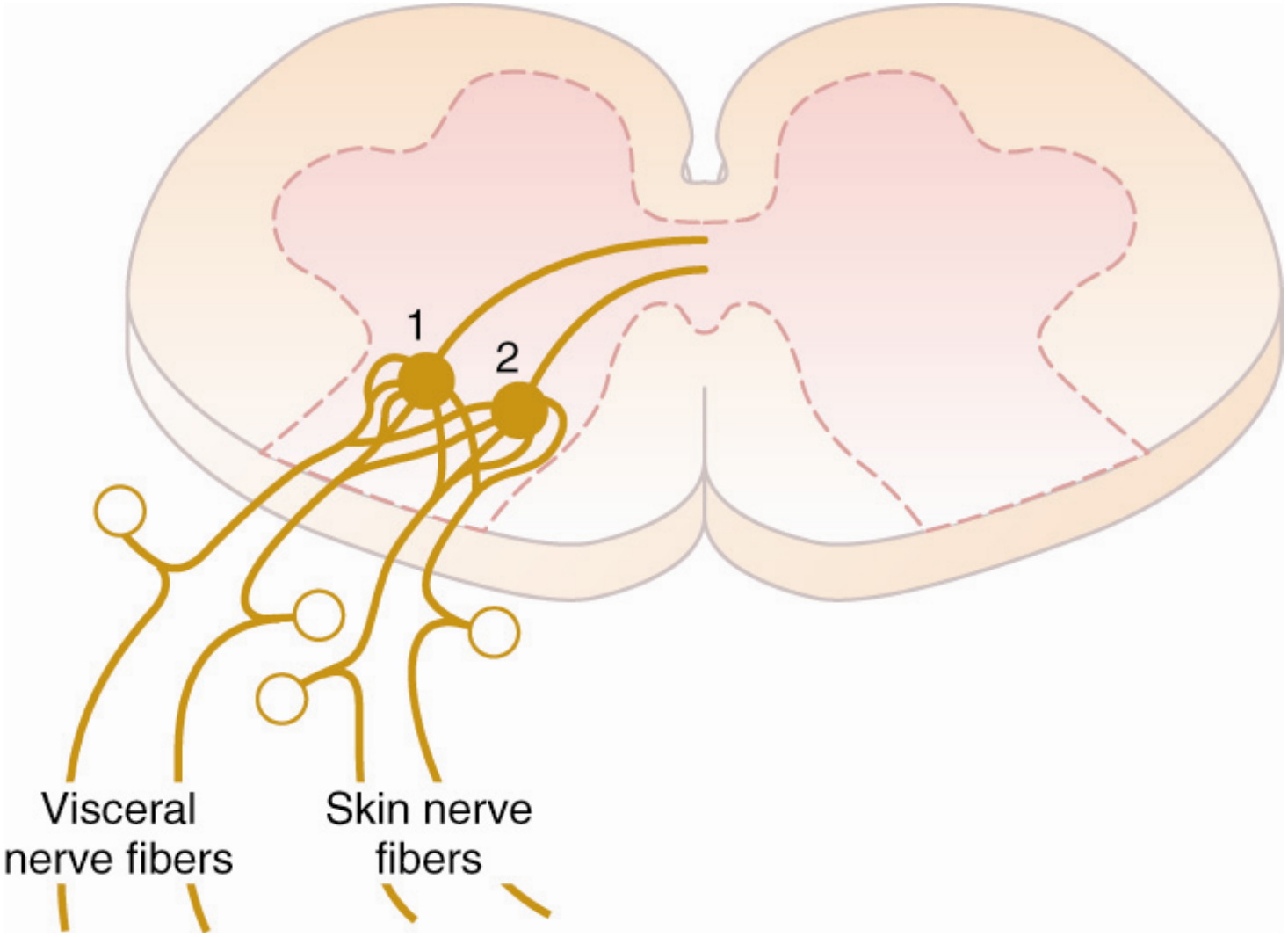
Gate Control Theory of pain suppression

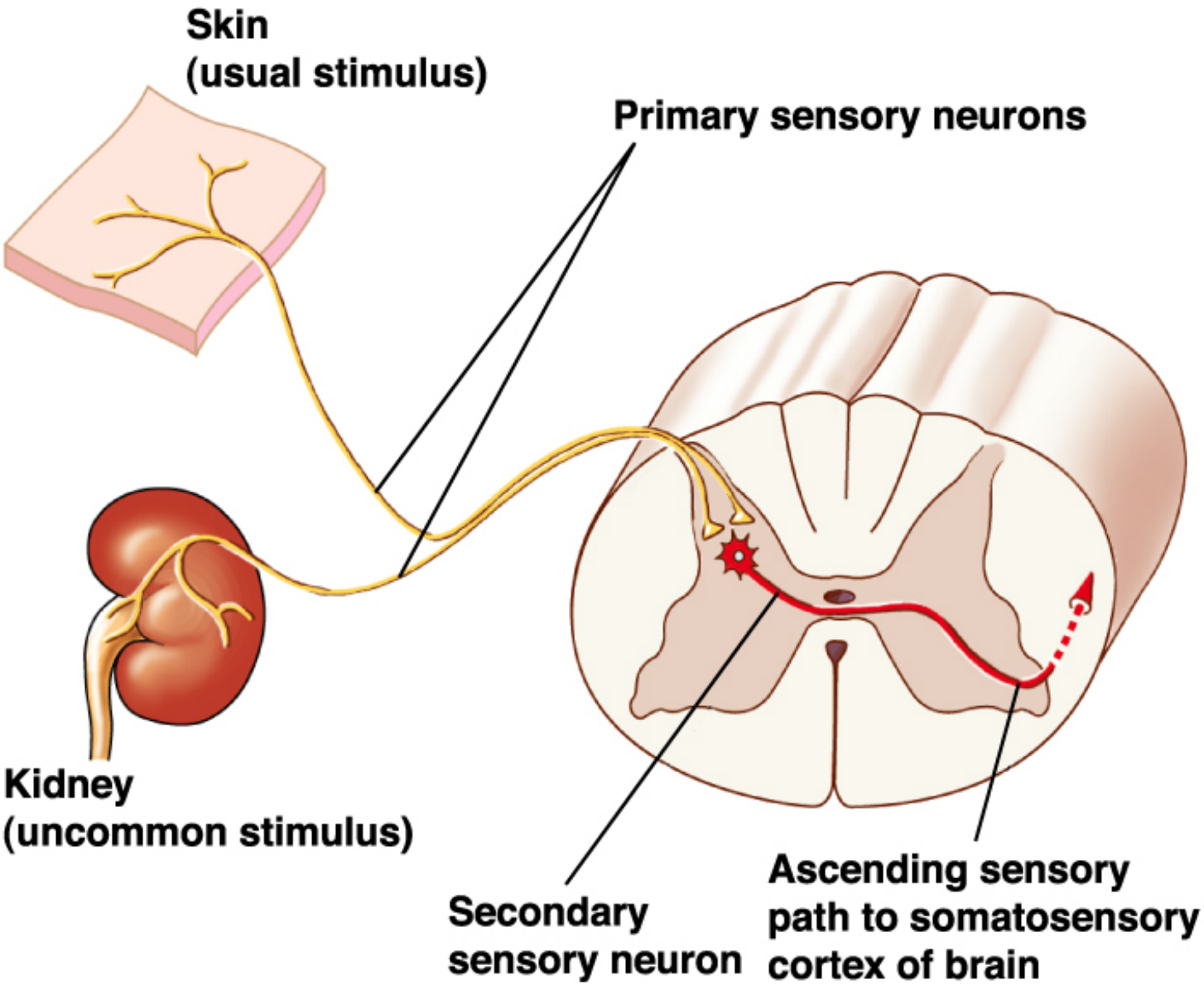


Gate theory of pain suppression

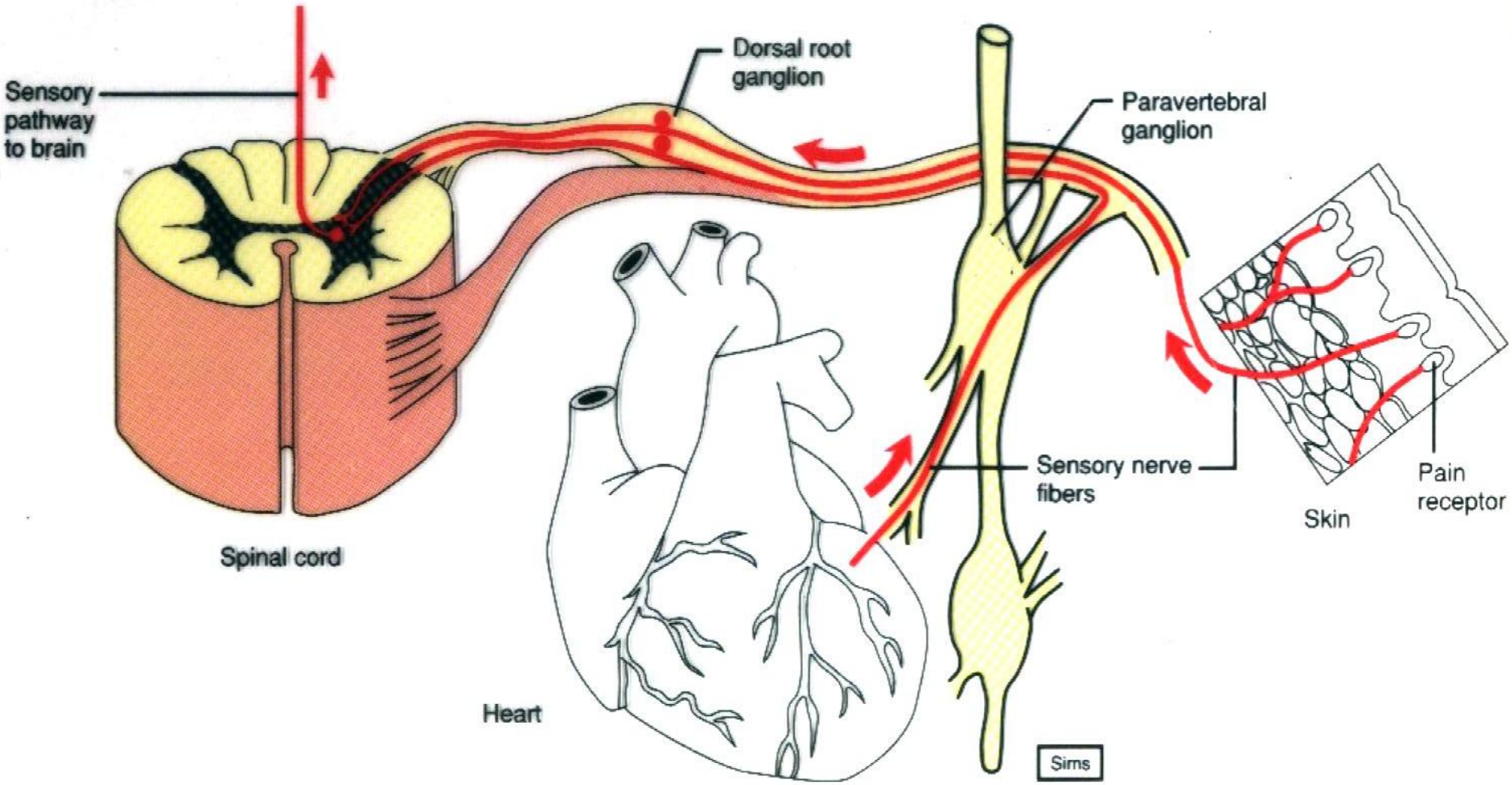


Proposed Neuronal Circuit for Referred Pain




Skin
(usual stimulus)
Primary sensory neurons
Kidney
(uncommon stimulus)
Secondary
sensory neuron
Ascending sensory
path to somatosensory
cortex of brain

Referred Pain



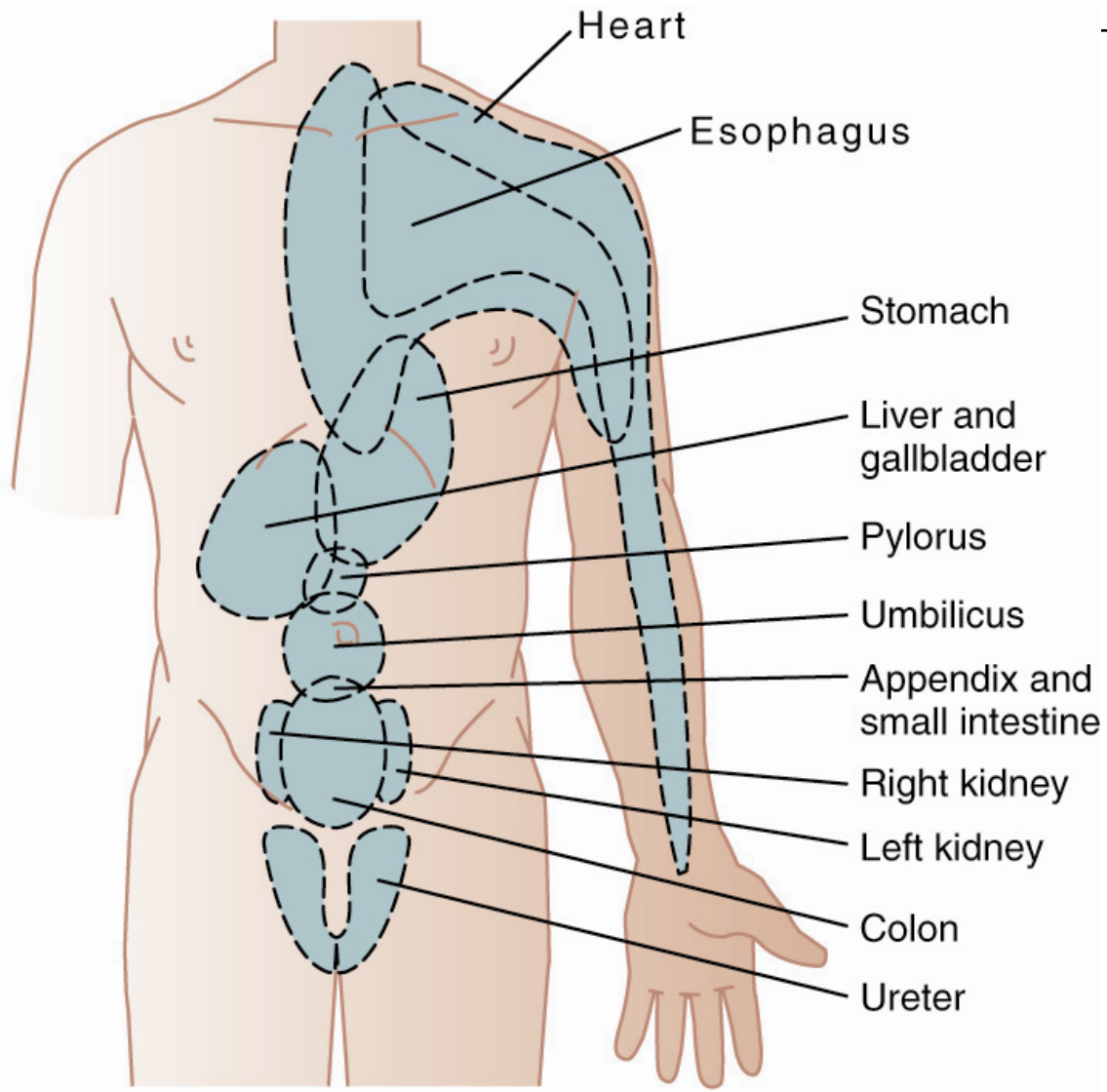
Referred and Visceral Pain

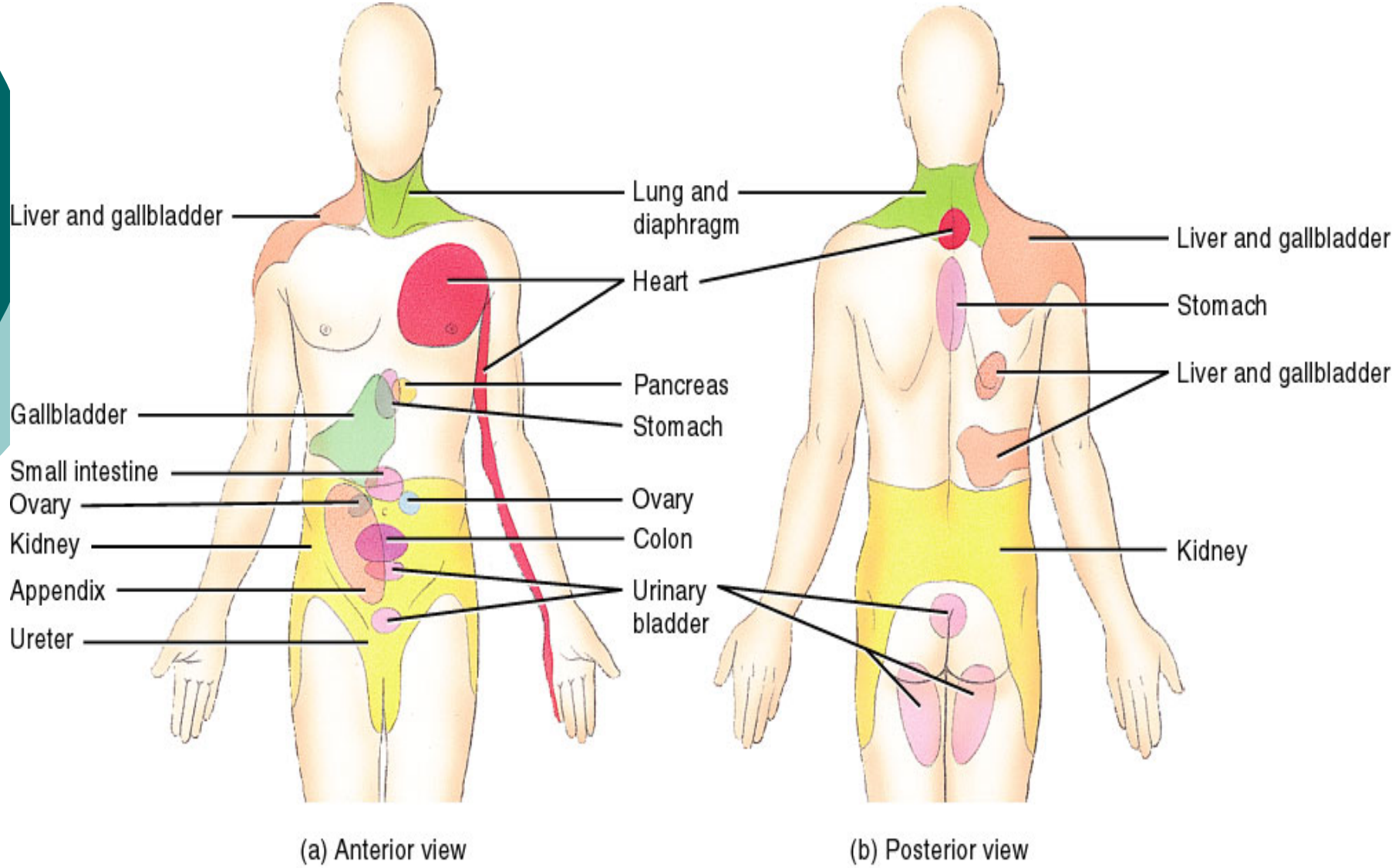
- Pain from an internal organ that is perceived to originate from a distant area of the skin.
- Mechanism is thought to be intermingling of second order neurons from the skin and the viscera.
- Viscera have few sensory fibers except for pain fibers.
- Highly localized damage to an organ may result in little pain, widespread damage can lead to severe pain.

Referred and Visceral Pain

- localized to the dermatome of embryological origin
- heart localized to the neck, shoulder and arm
- stomach localized to the above the umbilicus
- colon localized to below the umbilicus

Referred Pain from the Viscera




Liver and gallbladder
Gallbladder
Small intestine
Ovary
Kidney
Appendix
Ureter
Lung and diaphragm
Heart
Pancreas
Stomach
Ovary
Colon
Urinary bladder
(a) Anterior view
Liver and gallbladder
Stomach
Liver and gallbladder
Kidney
(b) Posterior view

15.03

Dermatomes

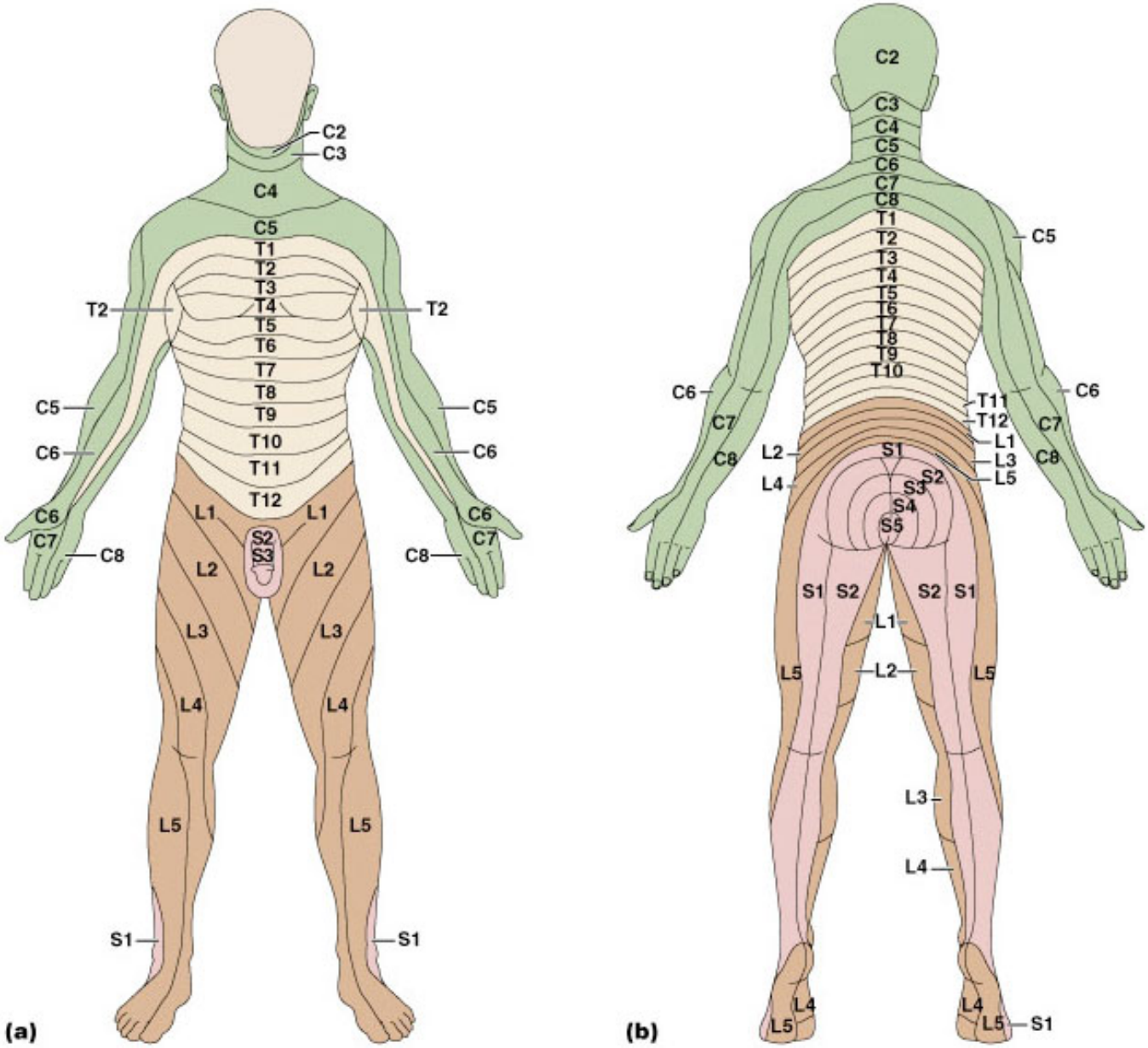


Figure 13.12

Causes of Visceral Pain

- ischemia
- chemical irritation
- spasm of a hollow viscus
- overdistension of a hollow viscus

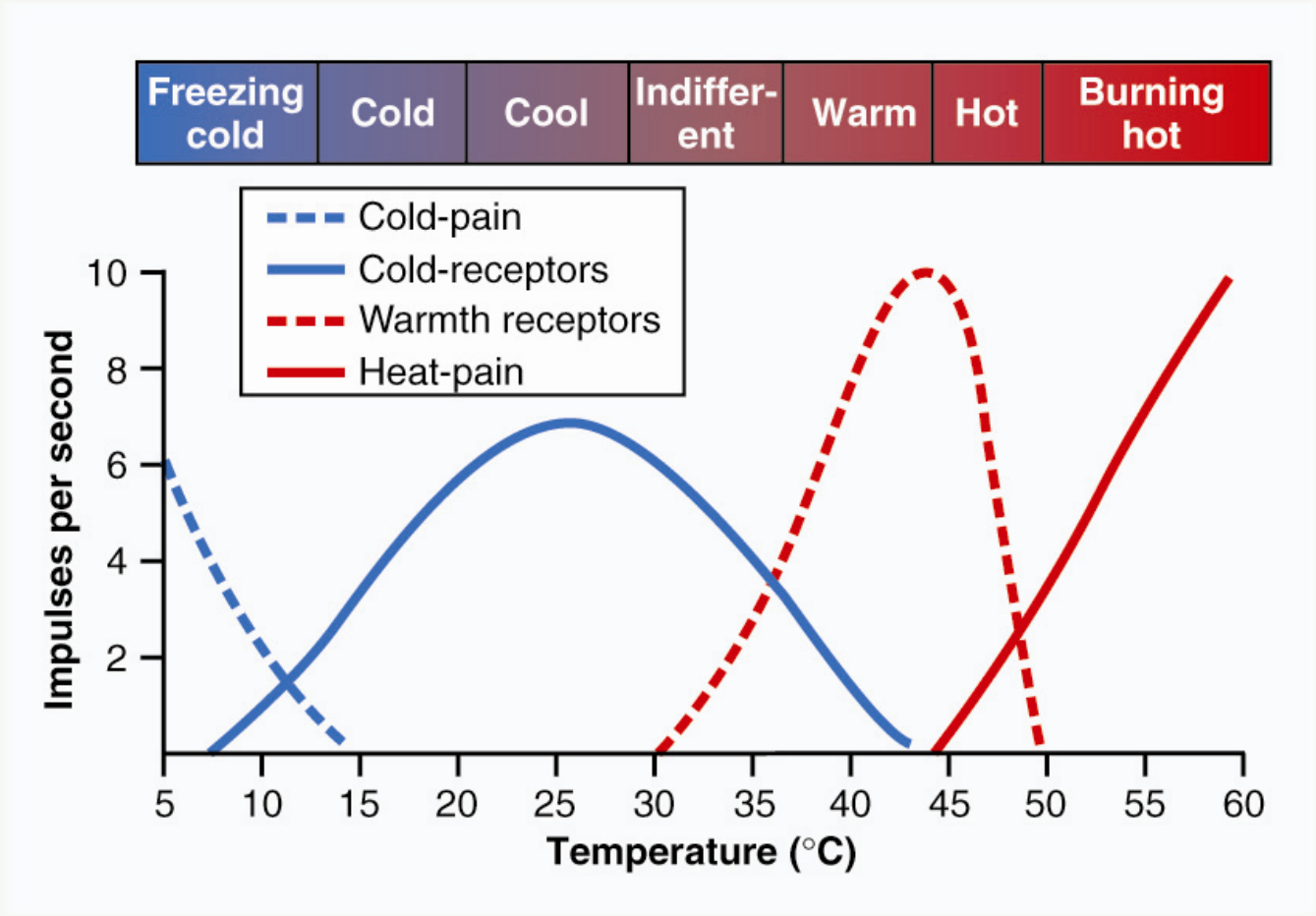
Thermal Sensations

- many more cold receptors than warm receptors
- density of cold receptors varies
  - highest on the lips, lowest on the trunk
- freezing cold and burning hot are the same sensation because of stimulation of pain receptors

Stimulation of Thermal Receptors

- Cold receptors respond from 7 to 44° C with the peak response at 25° C.
- Warm receptors respond from 30 to 49° C with the peak response at 44° C.
- The relative degree of stimulation of the receptors determines the temperature sensation.
- Thermal receptors adapt to the stimulus but not completely.

Stimulation of Thermal Receptors



Mechanism of Stimulation

- Cold or warm is thought to change the metabolic rate of the receptor.
- This changes the rate of intracellular reactions.


Thank You