Neurophysiology

Pain

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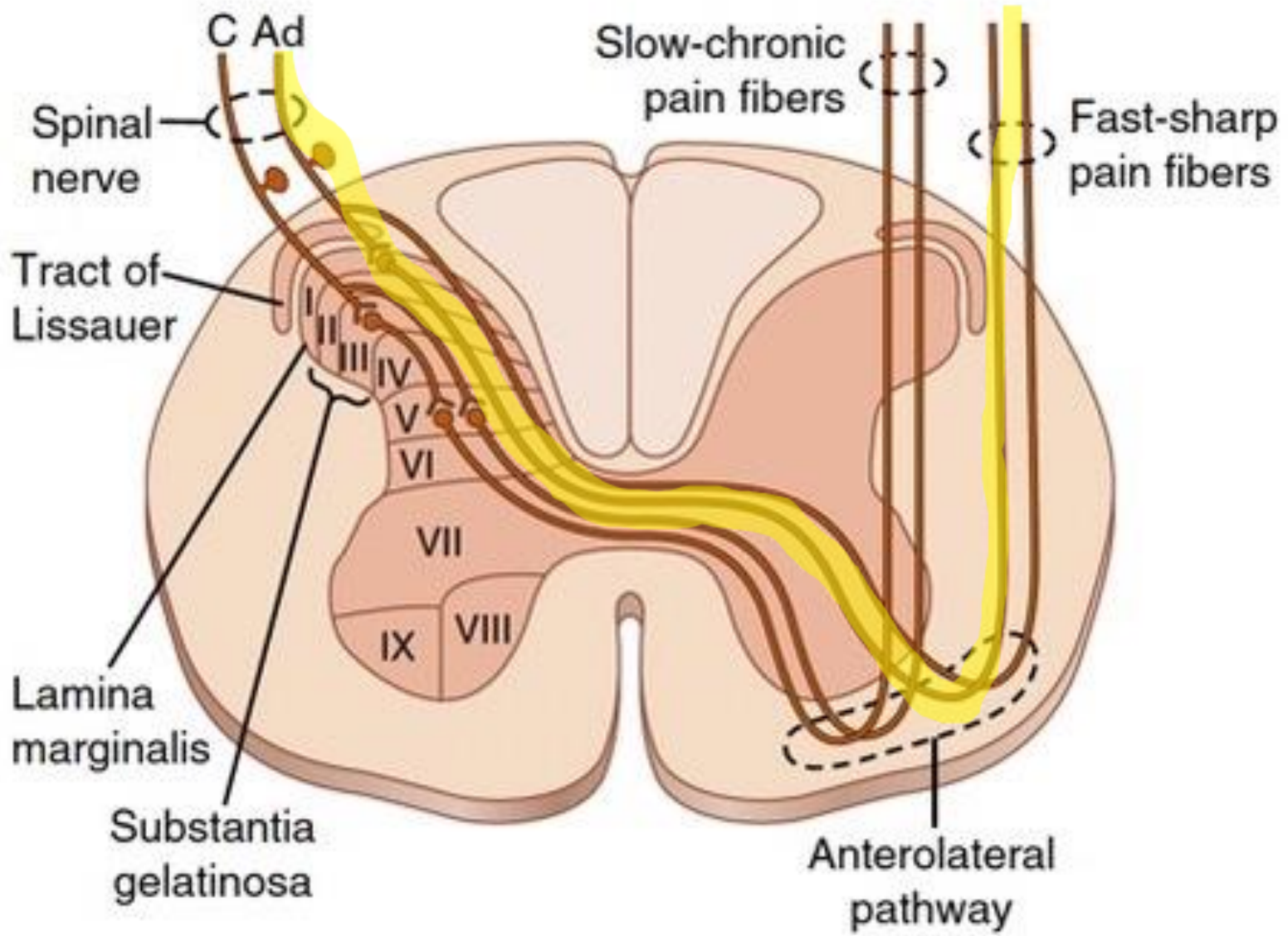
Pain Classification

- **Fast vs Slow**

- Stimulus
- Receptor
- Nerve fiber
- Neurotransmitter
- Ascending Pathway
- Localization
- Character of pain
- Significance

Neospinothalamic pathway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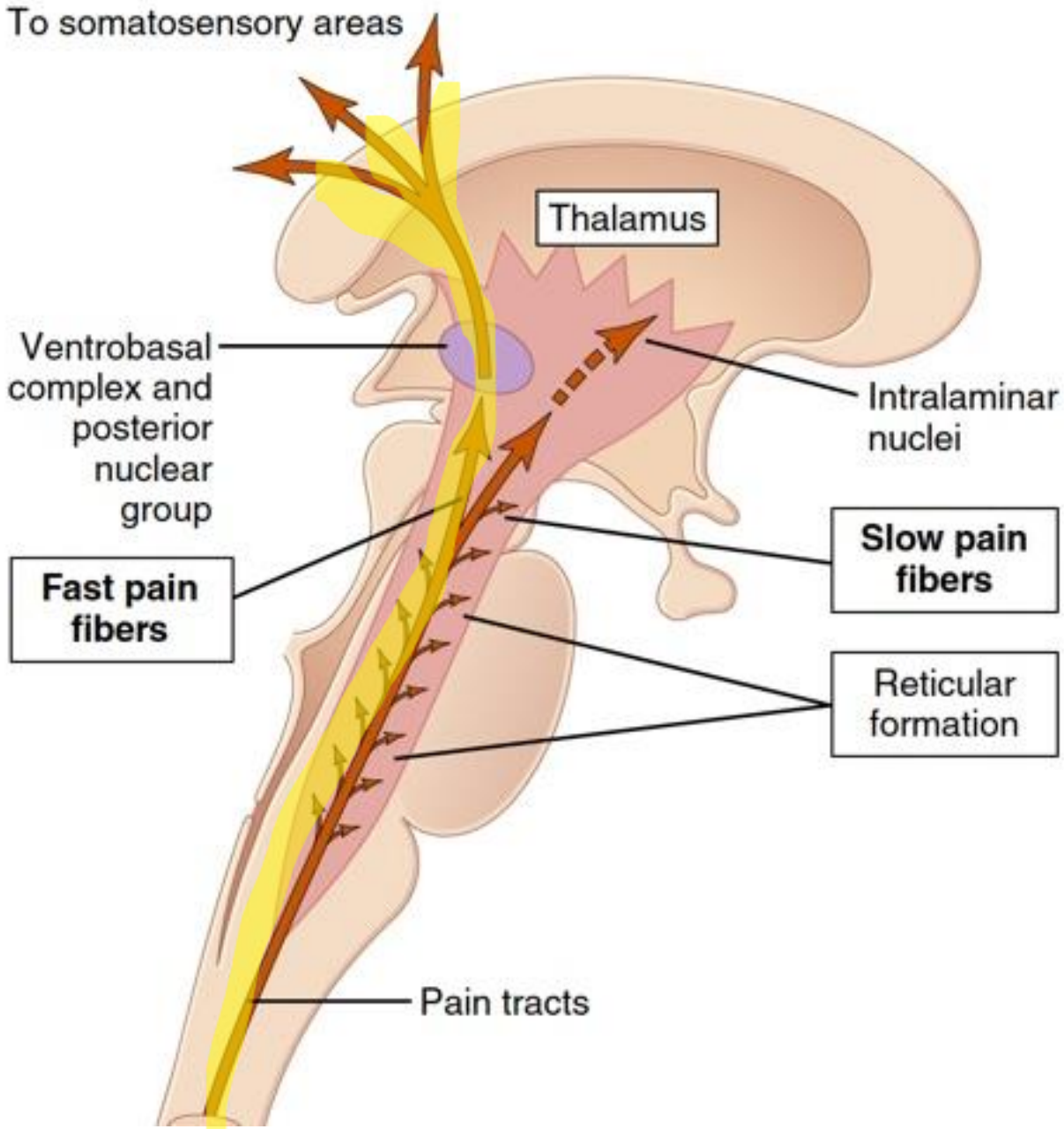
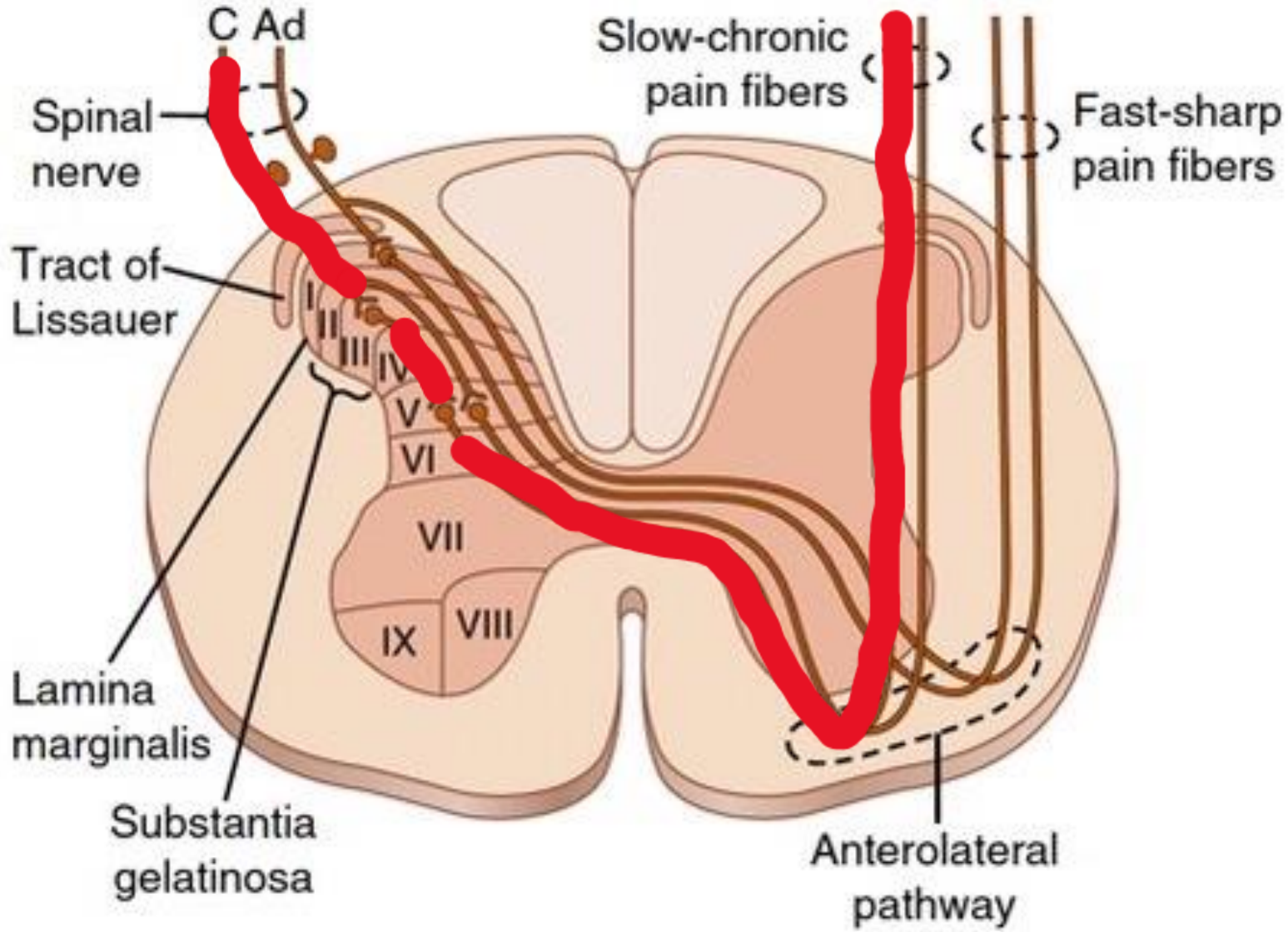
Spinal nerve
Tract of Lissauer
I
II
III
IV
V
VI
VII
VIII
IX
Lamina marginalis
Substantia gelatinosa
Slow-chronic pain fibers
Fast-sharp pain fibers
Anterolateral pathway


To somatosensory areas
Thalamus
Ventrobasal complex and posterior nuclear group
Intralaminar nuclei
Slow pain fibers
Fast pain fibers
Reticular formation
Pain tracts

Paleospinothalamic pathway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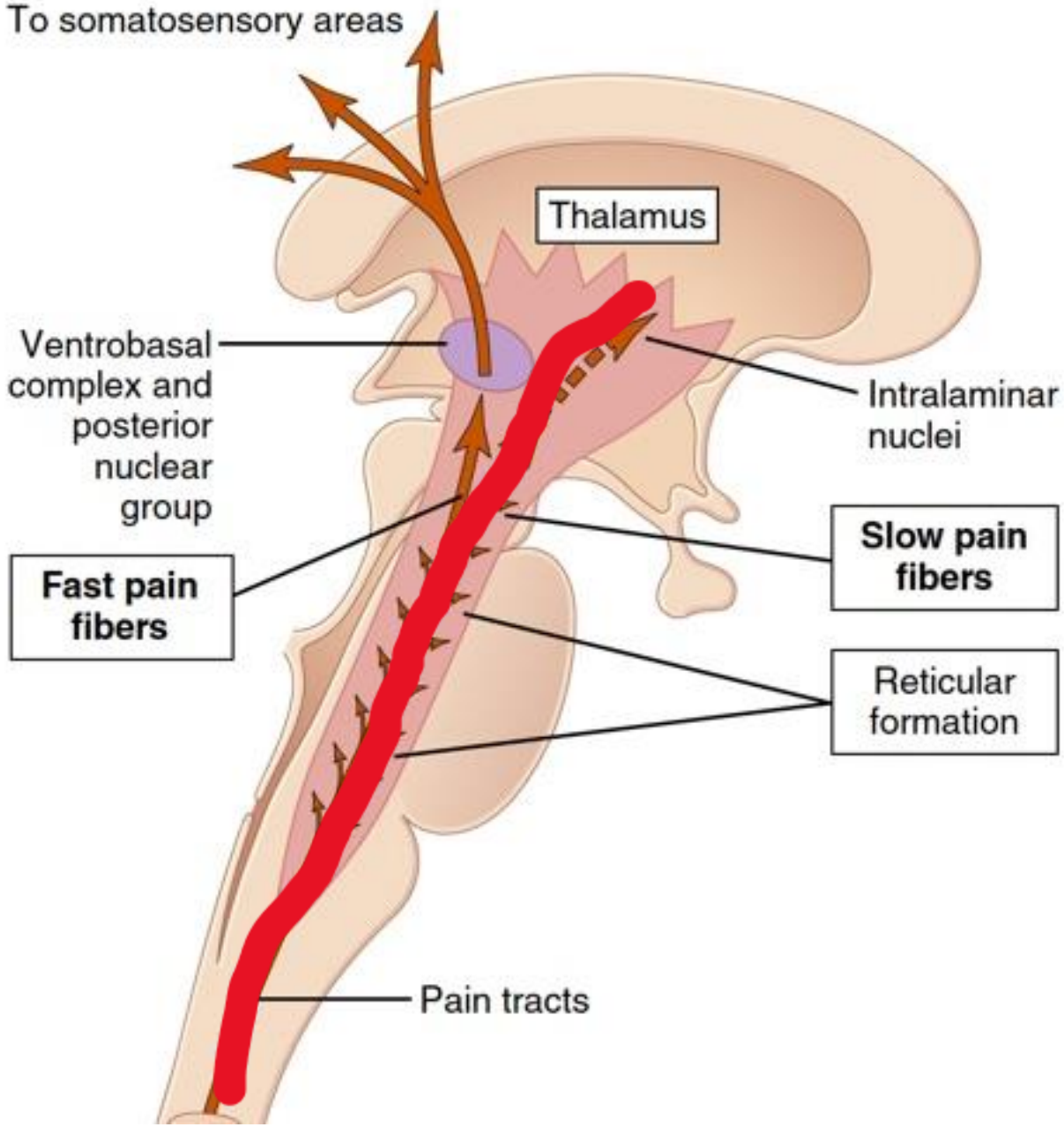
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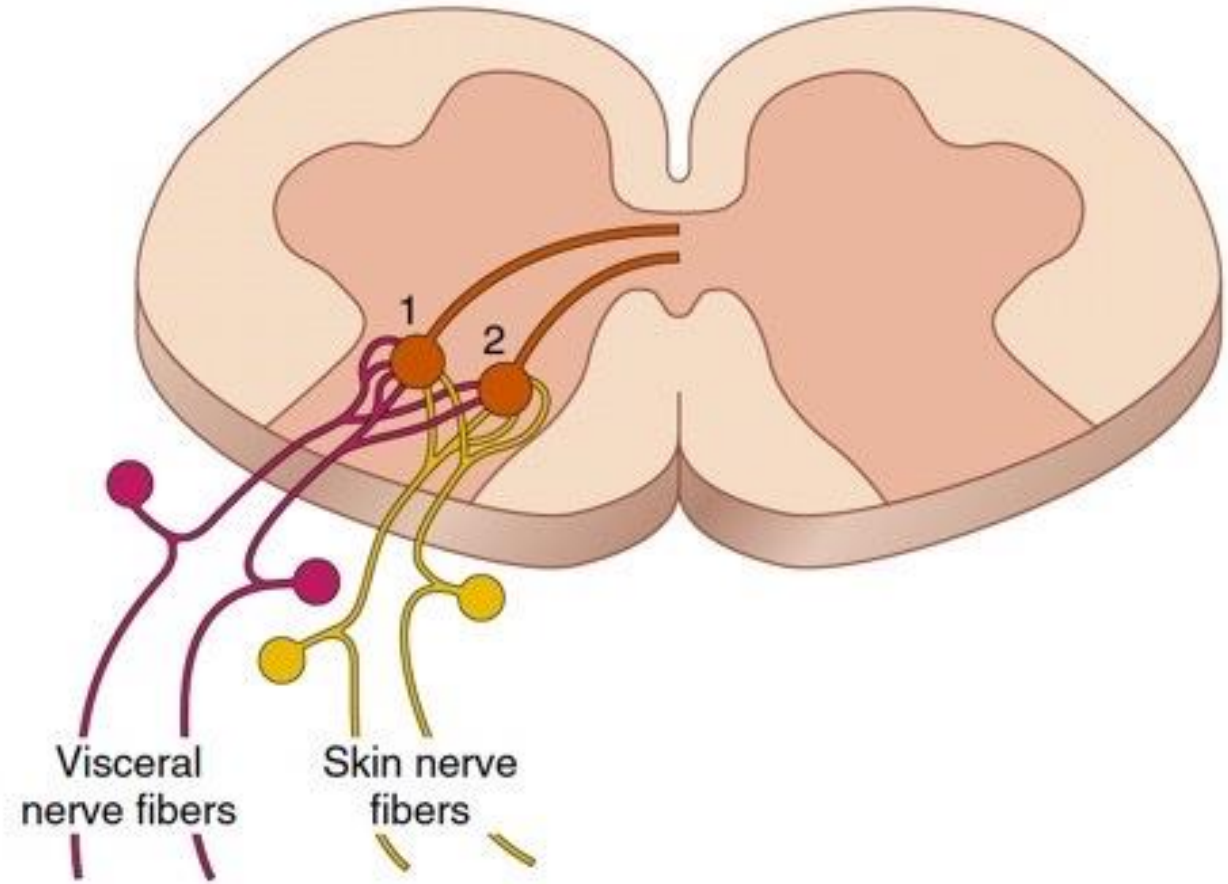
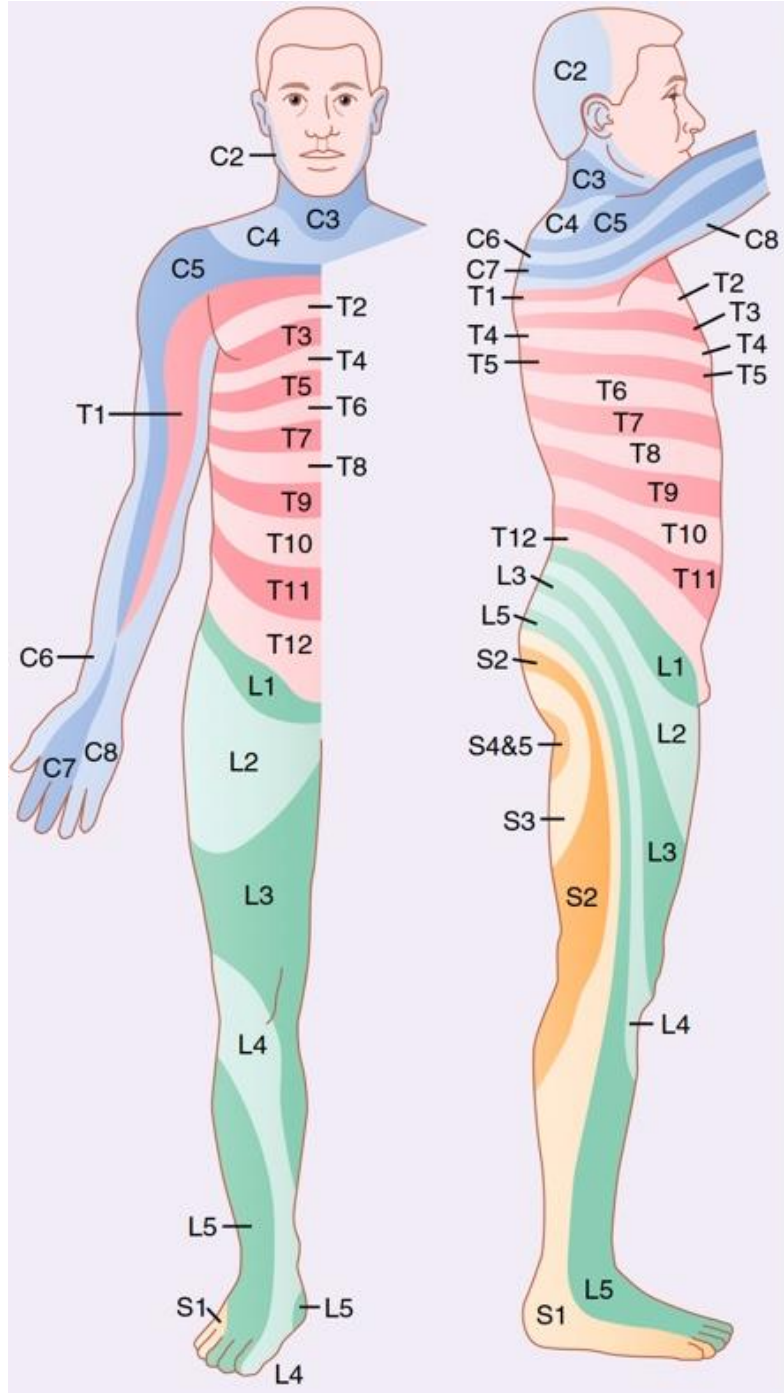
Pain Classification

- **Somatic : Cutaneous, Deep**
- **Visceral** (not present in some tissues), Parietal (sharp, localized)
- **Neuronal** (hyperalgesia vs allodynia)

- Causes
- Localization and innervation density.
- Pain intensity and rate of tissue damage
- Autonomic responses

Referred Pain


1
2
Visceral
nerve fibers
Skin nerve
fibers


C2
C3
C4
C5
T1
T2
T3
T4
T5
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T7
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T9
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T12
L1
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L3
L4
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C6
C7
C8
S1
C2
C3
C4
C5
C6
C7
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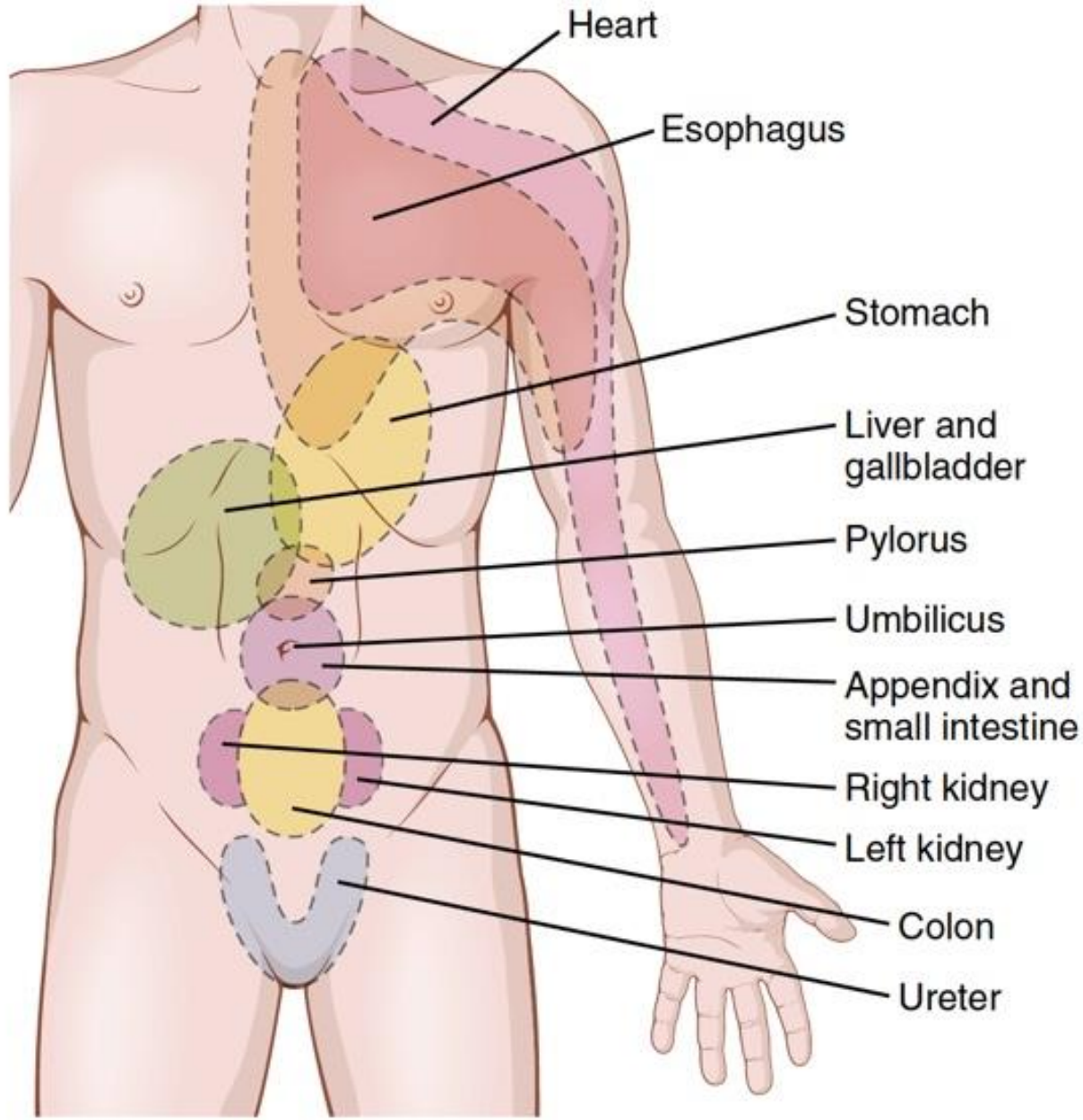
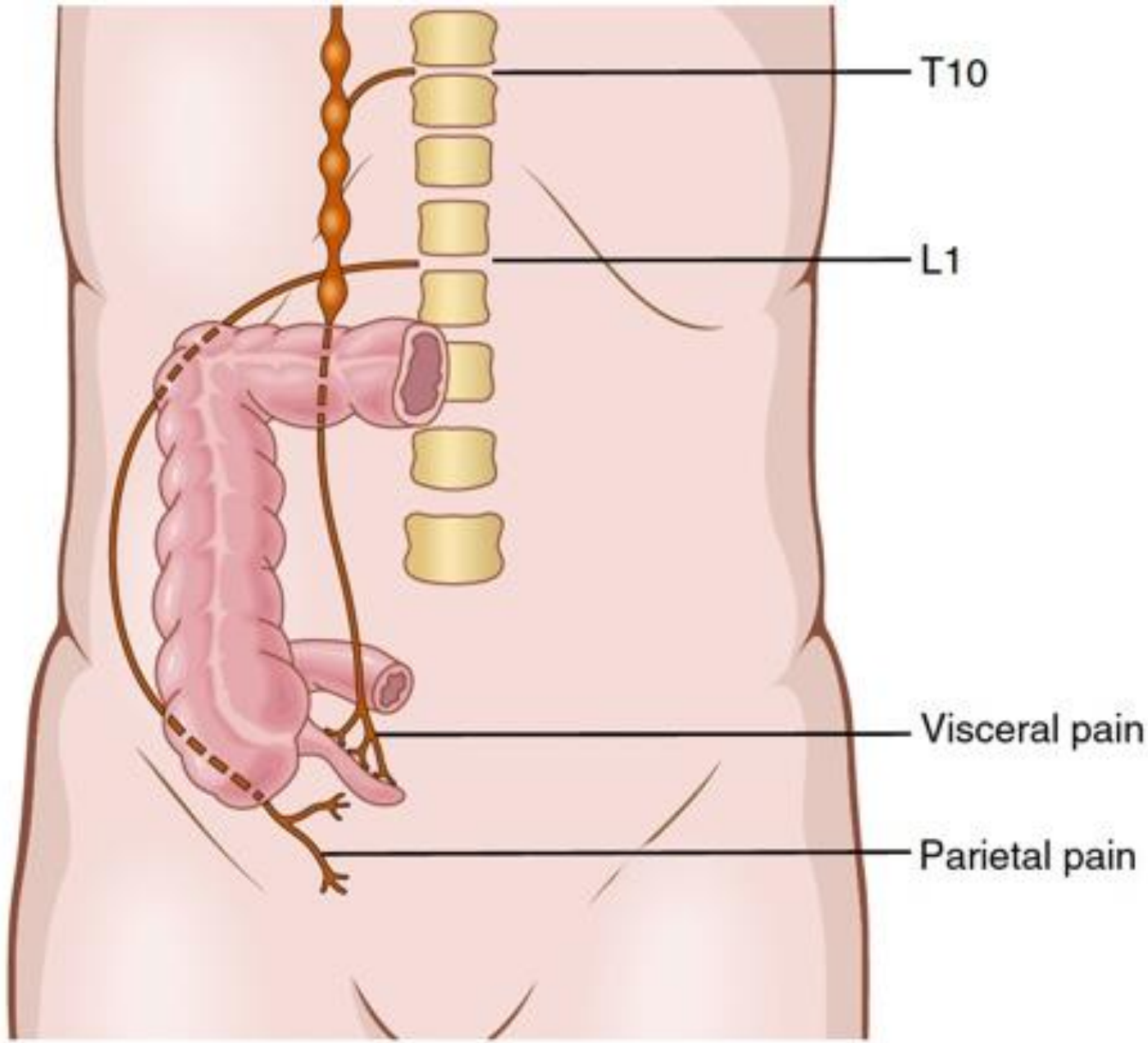
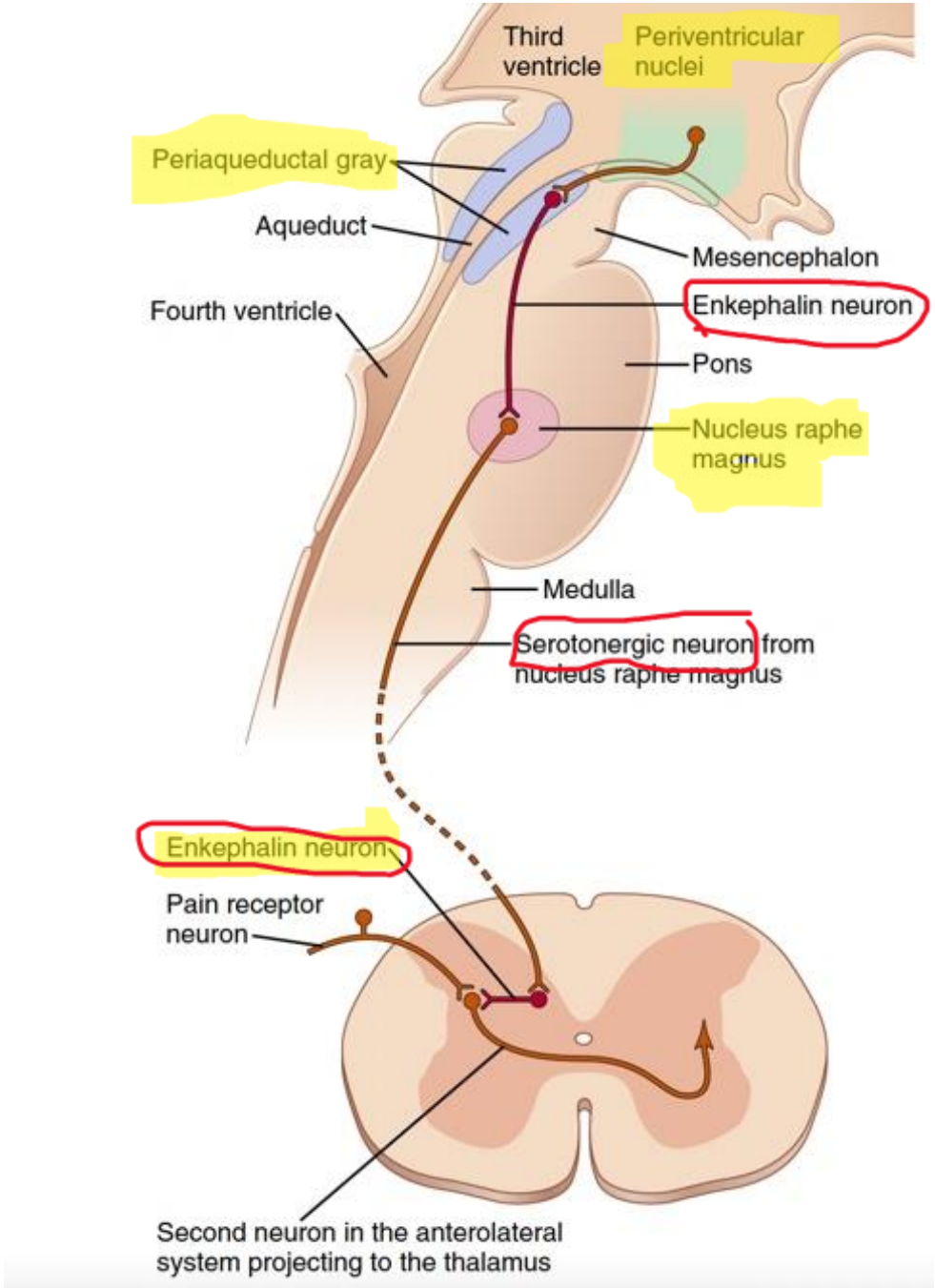

Heart
Esophagus
Stomach
Liver and gallbladder
Pylorus
Umbilicus
Appendix and small intestine
Right kidney
Left kidney
Colon
Ureter

Visceral vs Parietal Pain


T10
L1
Visceral pain
Parietal pain

Endogenous analgesia system


Third ventricle
Periventricular nuclei
Periaqueductal gray
Aqueduct
Mesencephalon
Enkephalin neuron
Fourth ventricle
Pons
Nucleus raphe magnus
Medulla
Serotonergic neuron from nucleus raphe magnus
Enkephalin neuron
Pain receptor neuron
Second neuron in the anterolateral system projecting to the thalamus

Pain control

- Lateral inhibition
- Acupuncture
- Pharmacological
- Surgical

Fast (acute) Pain

- The fast-sharp pain signals are elicited by either mechanical or thermal pain stimuli.
- Fast-sharp pain is not felt in most deep tissues of the body.
- They are transmitted in the peripheral nerves to the spinal cord by small type Aδ fibers at velocities between 6 and 30 m/sec.
- a fast-sharp pain is followed a second or so later by a slow pain.
- The sharp pain plays an important role in making the person react immediately to remove himself or herself from the stimulus.

Chronic (slow) Pain

- Slow pain can occur in the skin and in almost any deep tissue or organ.
- this type of pain is elicited mostly by chemical types of pain stimuli.
- It is transmitted to the spinal cord by type C fibers at velocities between 0.5 and 2 m/sec.
- This feeling is a dull, aching, poorly localized sensation that persists for a longer time and is more unpleasant.

Pain

- Even though all pain receptors are free nerve endings, these endings use two separate pathways for transmitting pain signals into the central nervous system.

- The two pathways mainly correspond to the two types of pain:
- a fast-sharp pain pathway.
- a slow-chronic pain pathway.

Neospinothalamic tract

- A few fibers of the neospinothalamic tract terminate in the reticular areas of the brain stem, but most pass all the way to the thalamus without interruption, terminating in the ventrobasal complex along with the dorsal column–medial lemniscal tract for tactile sensations.

- A few fibers also terminate in the posterior nuclear group of the thalamus. From these thalamic areas, the signals are transmitted to other basal areas of the brain, as well as to the somatosensory cortex.

Localization of fast pain

- The fast-sharp type of pain can be localized much more exactly in the different parts of the body than can slow-chronic pain.

- When tactile receptors that excite the dorsal column–medial lemniscal system are simultaneously stimulated, the localization can be nearly exact.

- It is believed that glutamate is the neurotransmitter substance secreted in the spinal cord at the type Aδ pain nerve fiber endings.

Paleospinothalamic pathway

- The slow-chronic paleospinothalamic pathway terminates widely in the brain stem.

- Only 10% to 25% of the fibers pass all the way to the thalamus. Instead, most terminate in one of three areas:
- (1) the reticular nuclei of the medulla, pons, and mesencephalon.
- (2) the tectal area of the mesencephalon deep to the superior and inferior colliculi.
- (3) the periaqueductal gray region surrounding the aqueduct of Sylvius.

Paleospinothalamic pathway

- These **lower regions of the brain** appear to be important for feeling the **suffering types of pain**.

- From the brain stem pain areas, multiple short-fiber neurons relay the pain signals upward into the intralaminar and ventrolateral nuclei of the thalamus and into certain portions of the hypothalamus and other basal regions of the brain.

Paleospinothalamic pathway

- Electrical stimulation in the reticular areas of the brain stem and in the intralaminar nuclei of the thalamus, the areas where the slow-suffering type of pain terminates, has a strong **arousal effect** on nervous activity throughout the entire brain.

- This explains why it is almost impossible for a person to sleep when in severe pain.

Paleospinothalamic pathway

- **Localization** of pain transmitted via the paleospinothalamic pathway is **imprecise**.
- For example, slow-chronic pain can usually be localized only to a major part of the body, such as to one arm or leg but not to a specific point on the arm or leg.

- This phenomenon is in keeping with the **multisynaptic, diffuse connectivity of this pathway.** It explains why patients often have serious difficulty in localizing the source of some chronic types of pain.

Visceral pain

- Essentially all visceral pain that originates in the thoracic and abdominal cavities is transmitted through small type C pain fibers and, therefore, can transmit only the chronic, aching, suffering type of pain.

- One of the most important differences between surface pain and visceral pain is that highly localized types of damage to the viscera seldom cause severe pain.

- Conversely, any stimulus that causes diffuse stimulation of pain nerve endings throughout a viscus causes pain that can be severe.

Visceral pain

- Any stimulus that excites pain nerve endings in diffuse areas of the viscera can cause visceral pain.

- Such stimuli include ischemia of visceral tissue, chemical damage to the surfaces of the viscera, spasm of the smooth muscle of a hollow viscus, excess distention of a hollow viscus, and stretching of the connective tissue surrounding or within the viscus.

Visceral pain

- A few visceral areas are almost completely insensitive to pain of any type.
- These areas include the parenchyma of the liver and the alveoli of the lungs
- Yet, the liver capsule is extremely sensitive to both direct trauma and stretch, and the bile ducts are also sensitive to pain. In the lungs, even though the alveoli are insensitive, both the bronchi and the parietal pleura are very sensitive to pain.

Visceral Pain

- True visceral pain is transmitted via pain sensory fibers in the autonomic nerve bundles, and the sensations are referred to surface areas of the body that are often far from the painful organ.

- Pain from the viscera is frequently localized to two surface areas of the body at the same time because of the dual transmission of pain through the referred visceral pathway and the direct parietal pathway.

Parietal pain

- When a disease affects a viscus, the disease process often spreads to the parietal peritoneum, pleura, or pericardium.

- These parietal surfaces, like the skin, are supplied with extensive pain innervation from the peripheral spinal nerves.

- parietal sensations are conducted directly into local spinal nerves from the parietal peritoneum, pleura, or pericardium, and these sensations are usually localized directly over the painful area and sharp.

Referred pain

- When visceral pain is referred to the surface of the body, the person generally localizes it in the **dermatomal** segment from which the visceral organ originated in the embryo, not necessarily where the visceral organ now lies.

- For example, the heart originated in the neck and upper thorax, so the heart’s visceral pain fibers pass upward along the sympathetic sensory

Mechanism of referred pain

- branches of visceral pain fibers are shown to synapse in the spinal cord on the same second-order neurons that receive pain signals from the skin.

- When the visceral pain fibers are stimulated, pain signals from the viscera are conducted through at least some of the same neurons that conduct pain signals from the skin, and the person has the feeling that the sensations originate in the skin.

Pain suppression

- The degree to which different **people react to pain varies** tremendously.

- This variation results partly from a capability of the brain itself to suppress input of pain signals to the nervous system by activating a pain control system, called an **analgesia system**.

The endogenous analgesia system

- (1) The periaqueductal gray and periventricular areas of the mesencephalon and upper pons. Neurons from these areas send signals to
- (2) the raphe magnus nucleus, located in the lower pons and upper medulla, and the nucleus reticularis paragigantocellularis, located laterally in the medulla. From these nuclei, second order signals are transmitted down the dorsolateral columns in the spinal cord to
- (3) a pain inhibitory complex located in the dorsal horns of the spinal cord. At this point, the analgesia signals can block the pain before it is relayed to the brain.

The endogenous analgesia system

- Several transmitter substances, especially **enkephalin and serotonin**, are involved in the analgesia system.

- The enkephalin is believed to cause both **presynaptic and postsynaptic inhibition** of incoming type C and type Aδ pain fibers where they synapse in the dorsal horns.

Pain control

- Electrical stimulation either in the periaqueductal gray area or in the raphe magnus nucleus can suppress many strong pain signals entering via the dorsal spinal roots.

- Also, stimulation of areas at higher levels of the brain that excite the periaqueductal gray area can also suppress pain. Such as the periventricular nuclei in the hypothalamus.

Pain control

- Stimulation of large-type Aβ sensory fibers from peripheral tactile receptors can depress transmission of pain signals from the same body area.

- This effect presumably results from local lateral inhibition in the spinal cord.

Pain control

- Acupuncture is based on the idea that vital energy called qi (pronounced chee) flows through the body along pathways called meridians.

- According to one theory, acupuncture relives pain by activating sensory neurons that ultimately trigger the release of neurotransmitters that function as analgesics such as endorphins, enkephalins, and dynorphins.

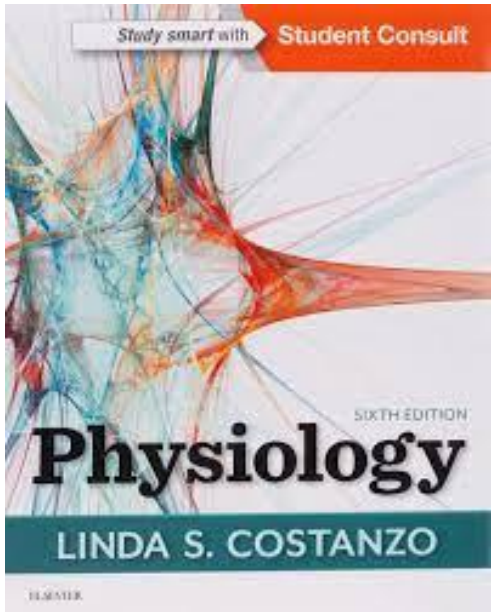
Pain Assessment

Mnemonic :- SOCRATES

- **S** - Site
- **O** - Onset
- **C** - Character
- **R** - Radiates
- **A** - Associated Symt
- **T** - Time/duration
- **E** - Exacerbating
- **S** - Severity

Doctors-online

References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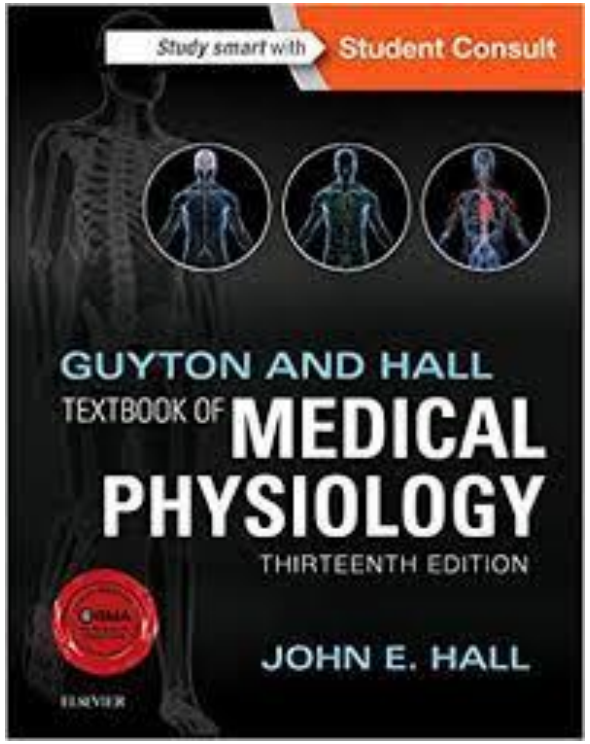
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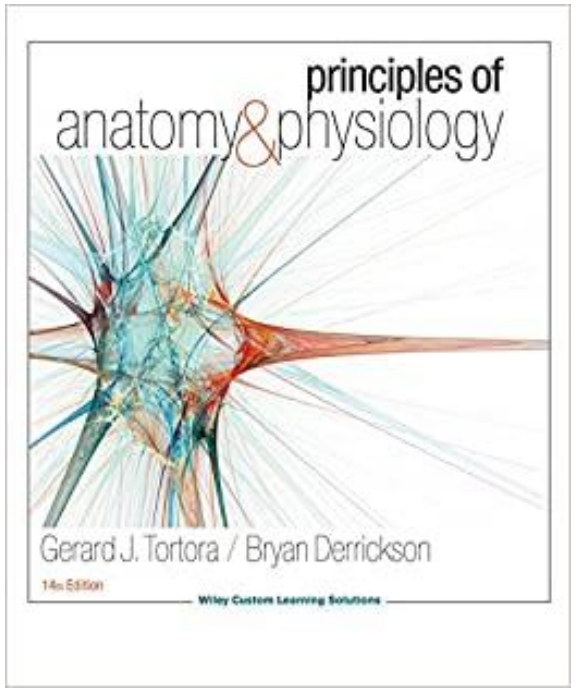
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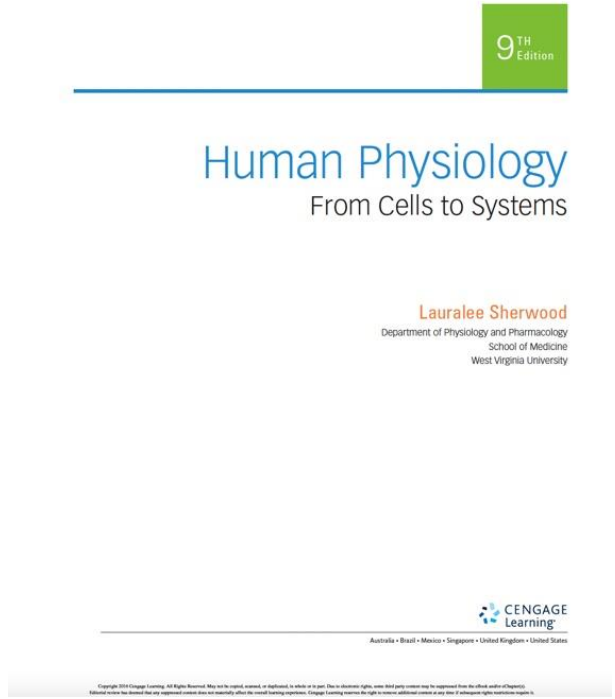
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