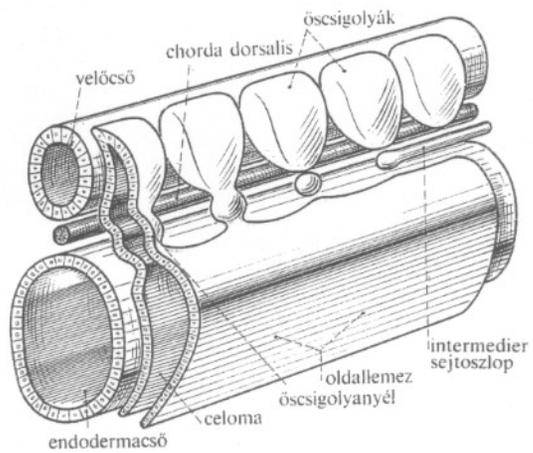
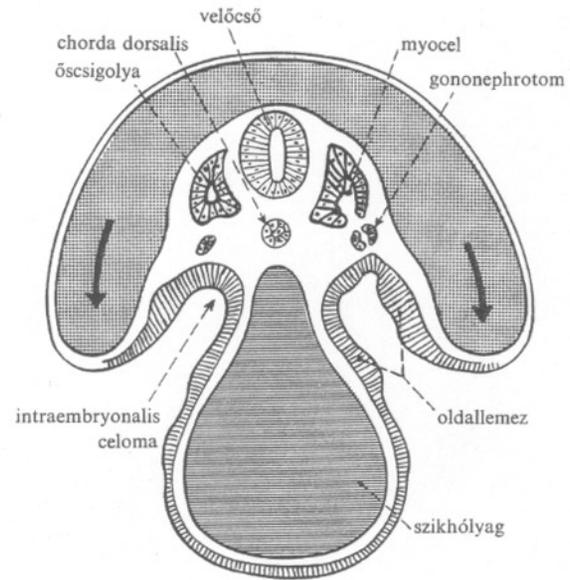
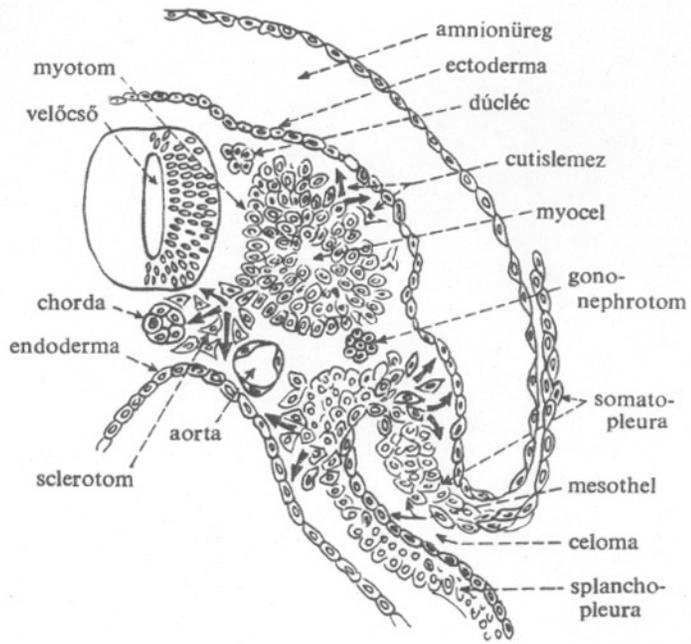
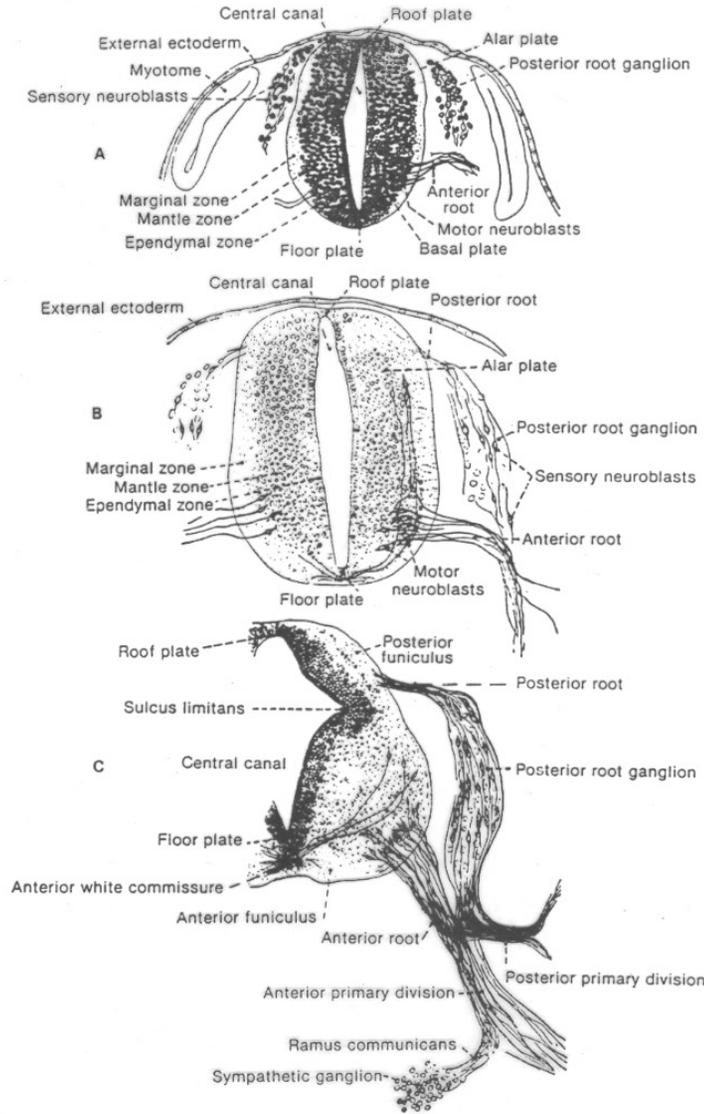


THE SPINAL CORD AND SPINAL REFLEXES





Cross section of the embryonic spinal cord and dorsal root to show the neurogenesis in the ventral horn and dorsal root ganglia

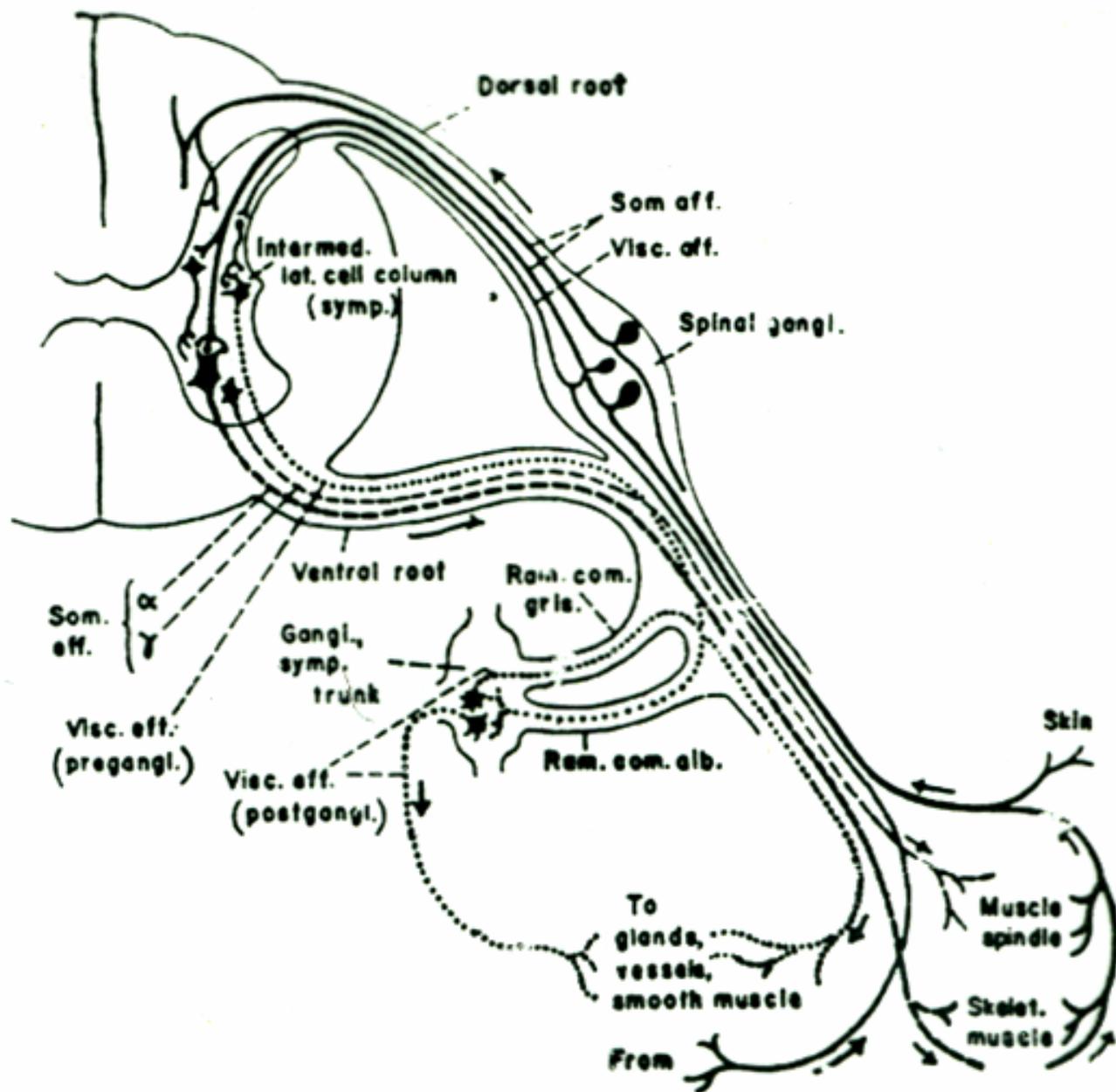
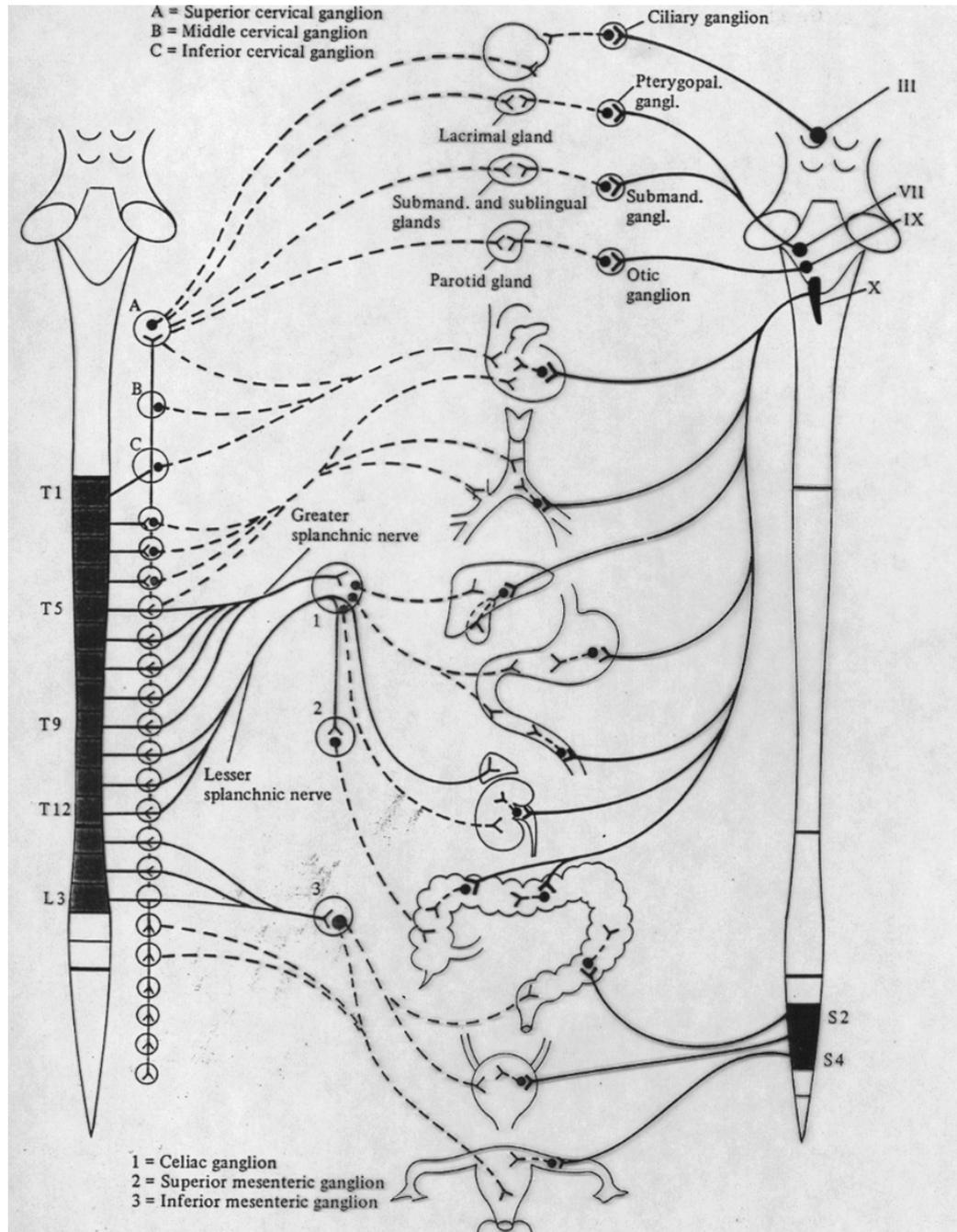
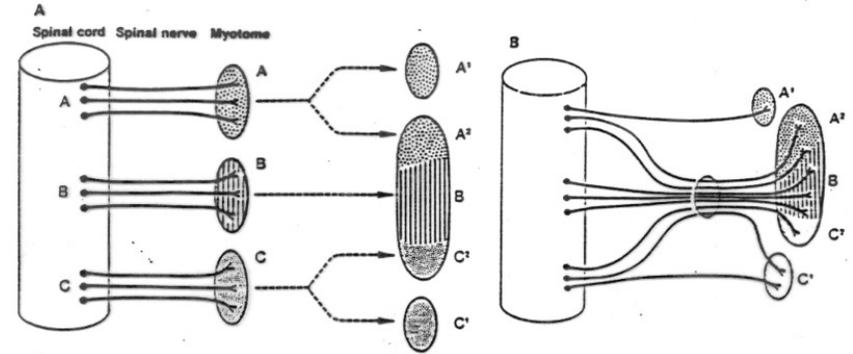
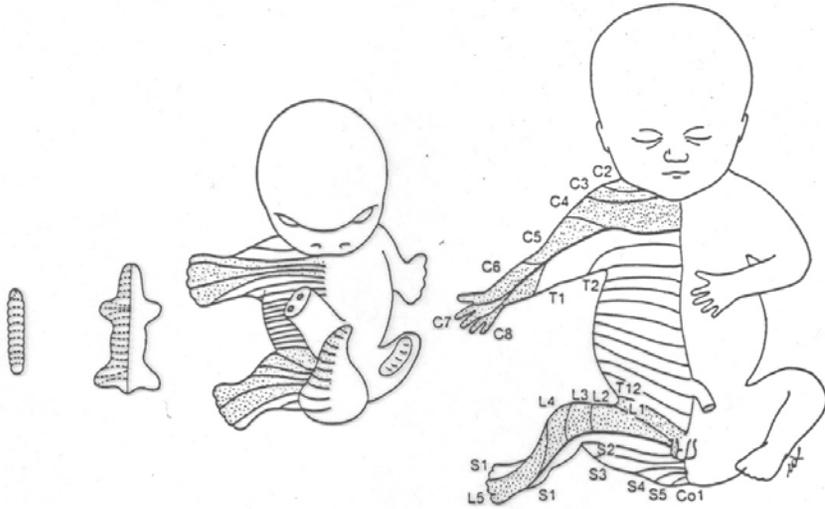


Fig. 1. Diagram of the fibre components of the spinal nerves.
Description in text.

THE SYMPATHETIC AND PARASYMPATHETIC NERVOUS SYSTEM

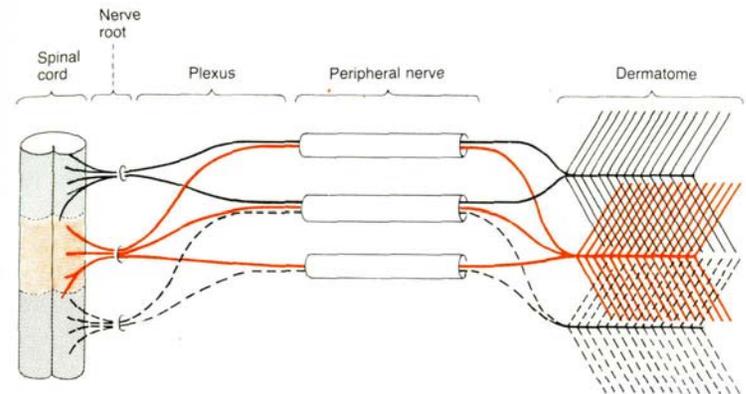


INNERVATION OF THE SOMITES, SOMATIC NERVE PLEXUS, DERMATOMES

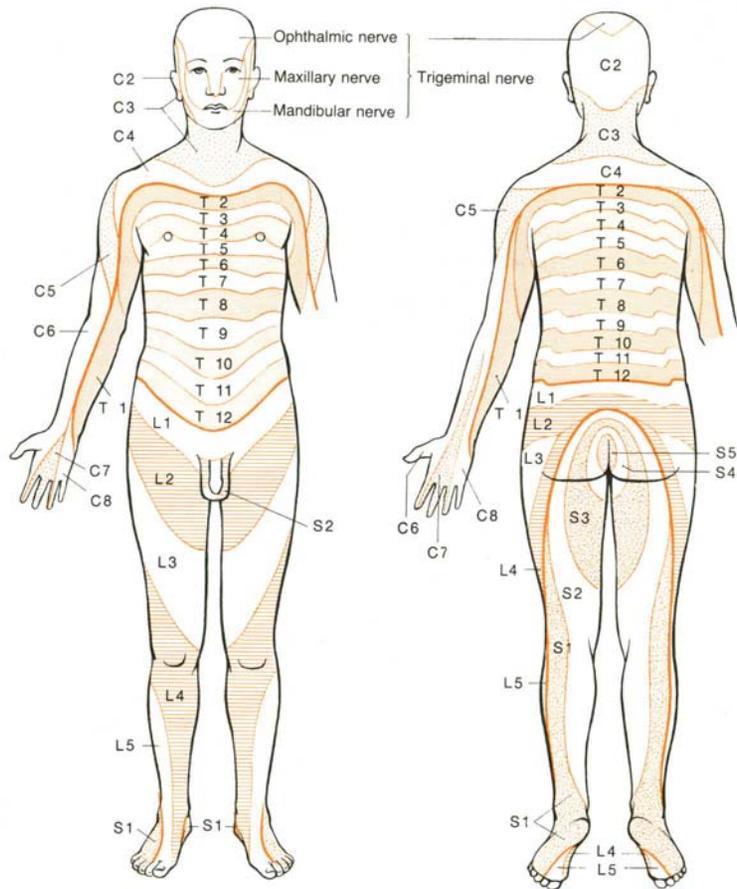


Nerve roots in plexus divide into peripheral nerves having segmental arrangement in the skin (dermatomes). The segments overlap.

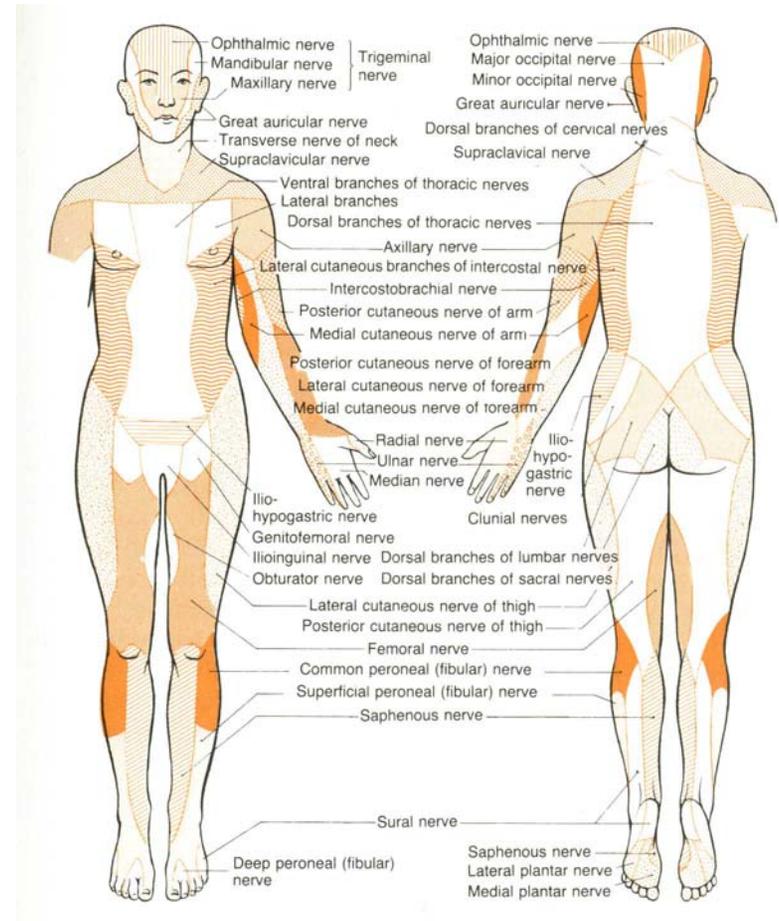
Transformation of dermatomes during the outgrowth of the limb buds. C- cervical; T-thoracic; L-lumbar; S-sacral.



Diagrammatic representation of plexus formation by spinal nerves. (A) Each myotome receives one spinal nerve, but the myotome may split to contribute to a composite muscle. (B) The axons that innervate a composite muscle still reach their original myotome but first run through a plexus to form a common nerve.

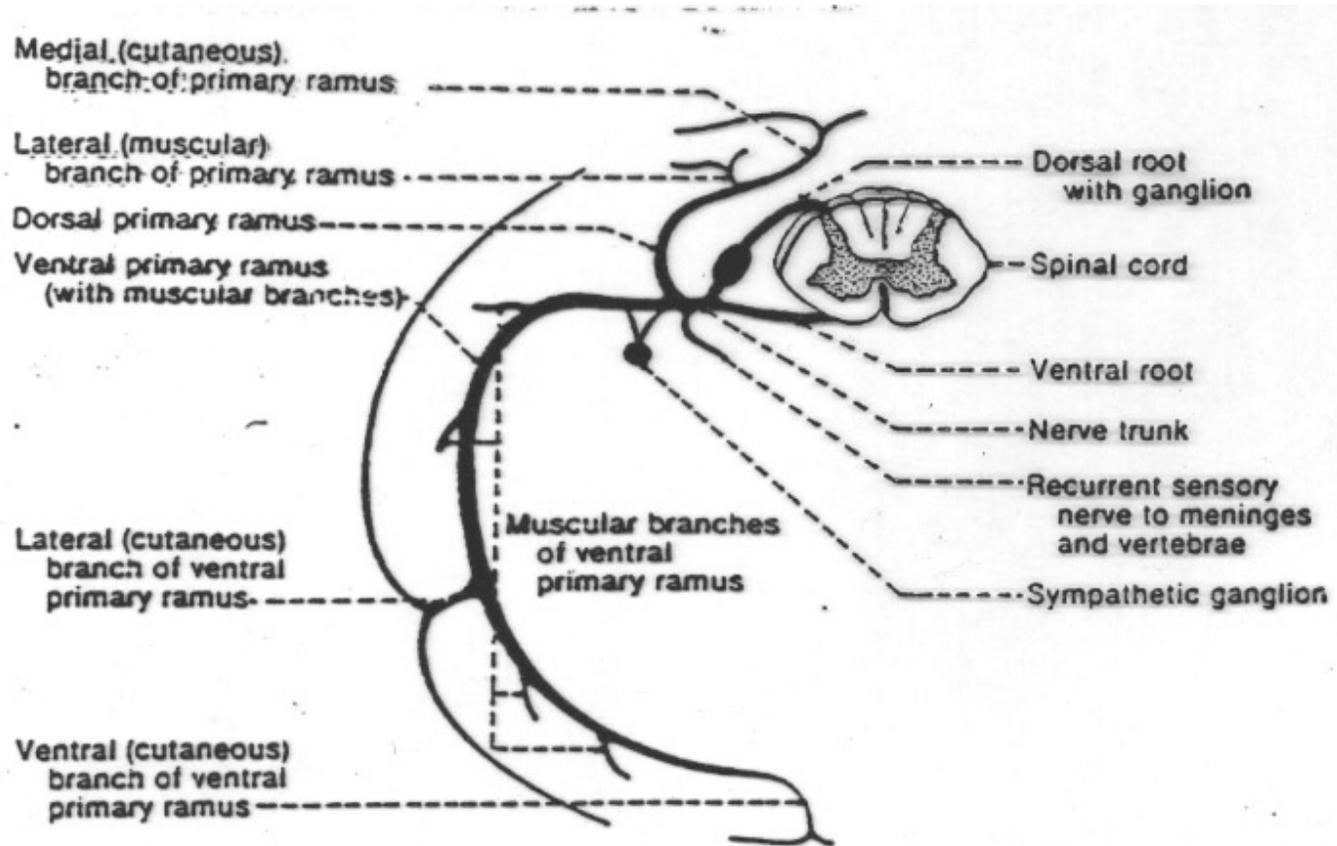


The segmental innervation of the skin (Duus)

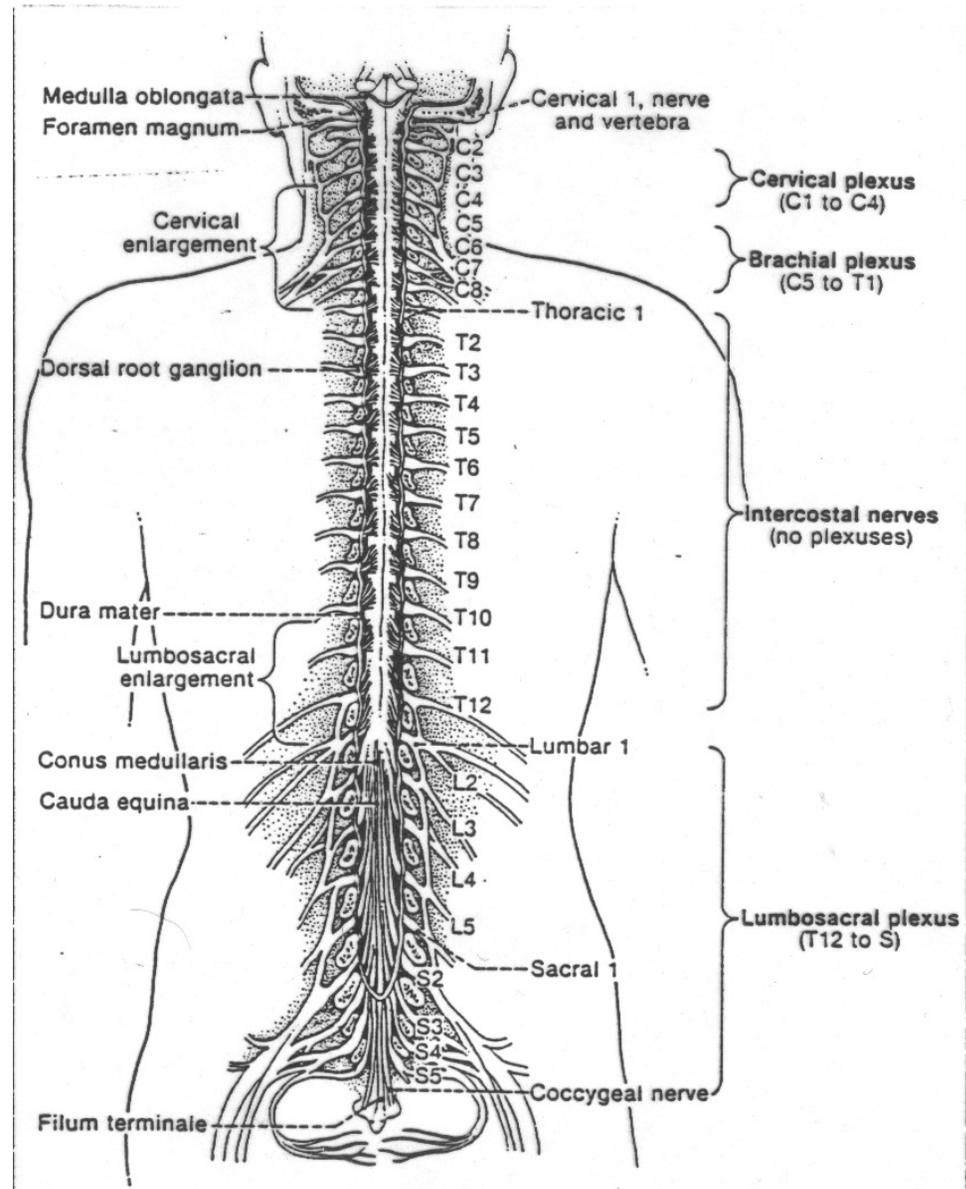


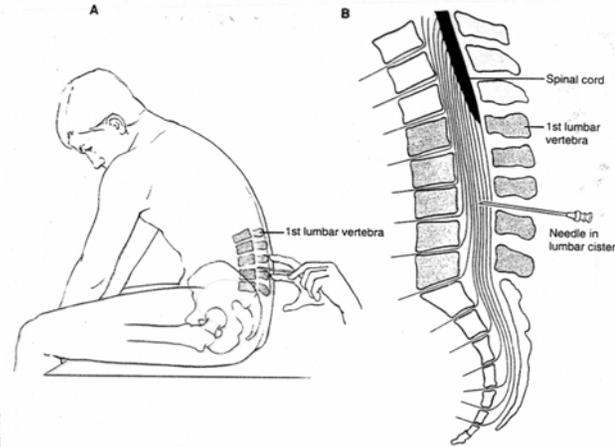
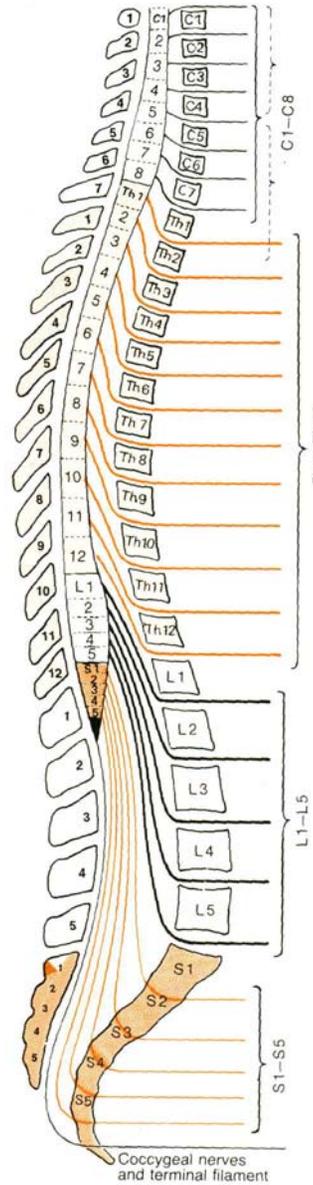
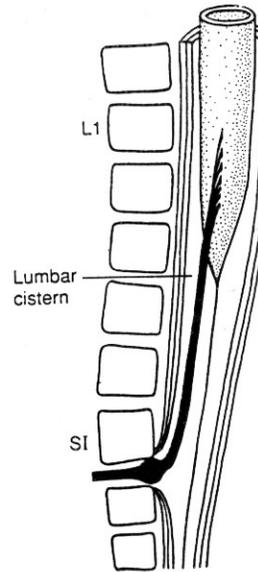
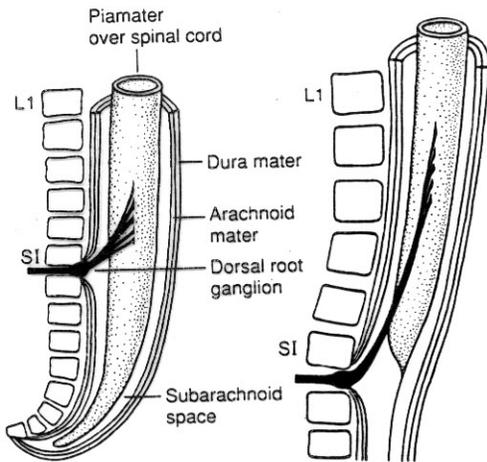
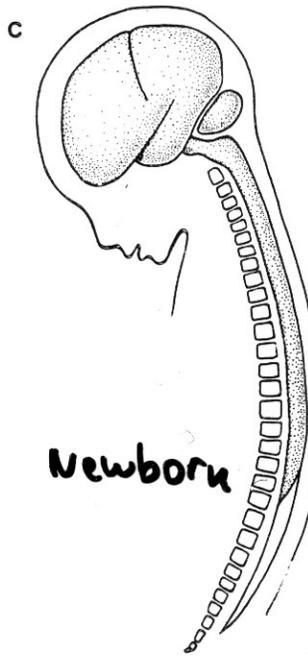
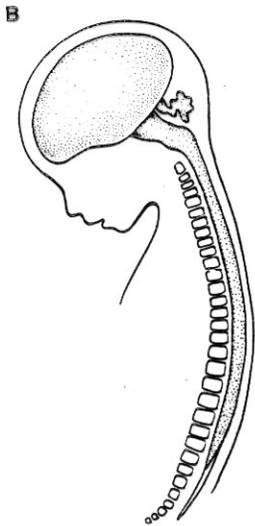
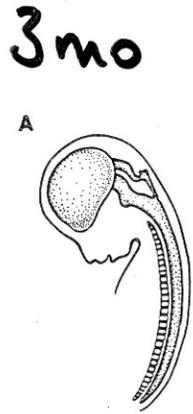
Pattern of innervation of skin by peripheral nerves (Duus)

Gross components of a prototypical peripheral nerve (thoracic level).



Dorsal view of the spinal cord and dorsal nerve roots in situ, after removal of the neural arches of the vertebrae.

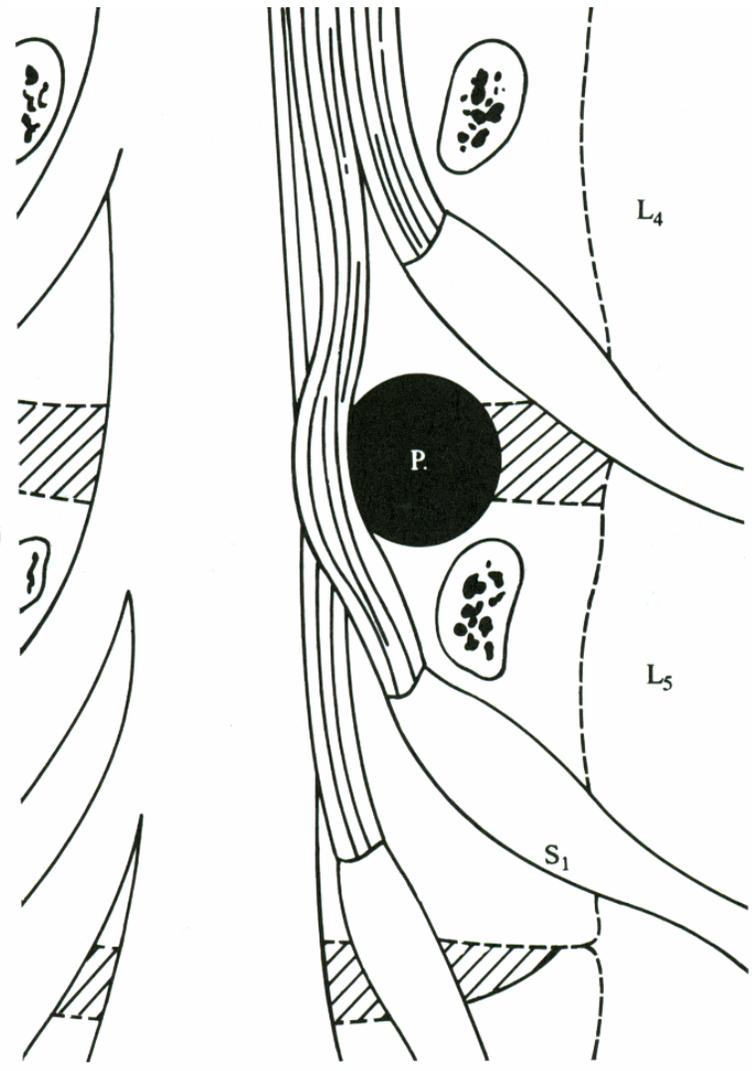
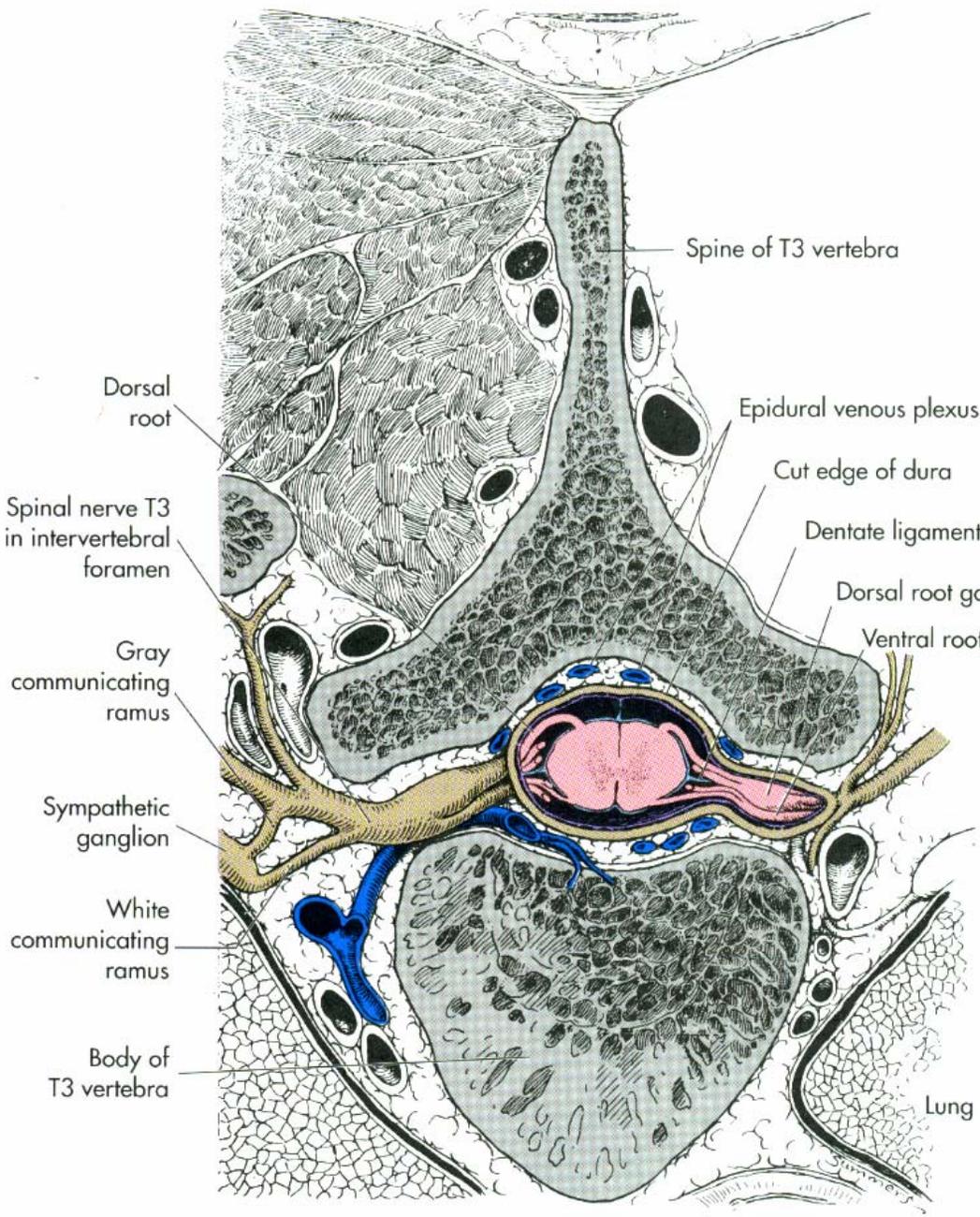




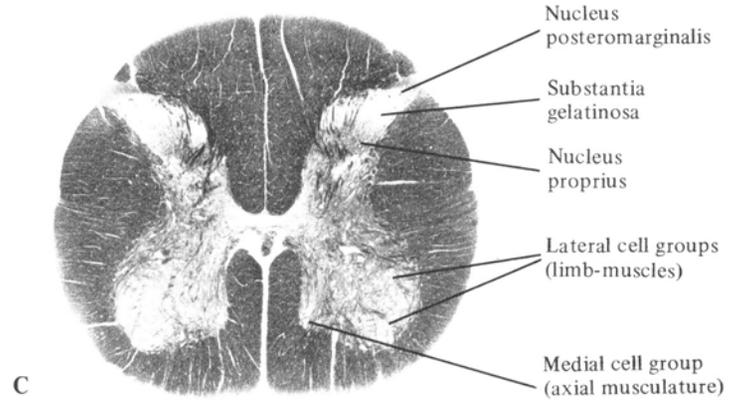
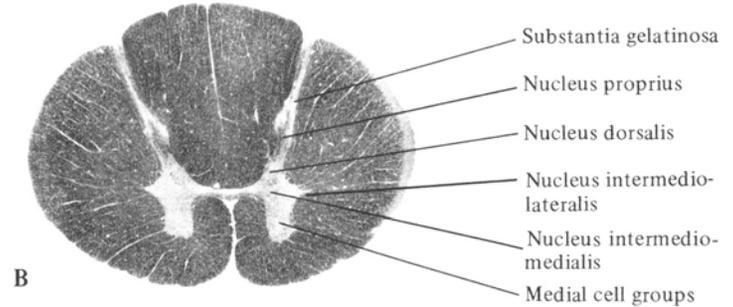
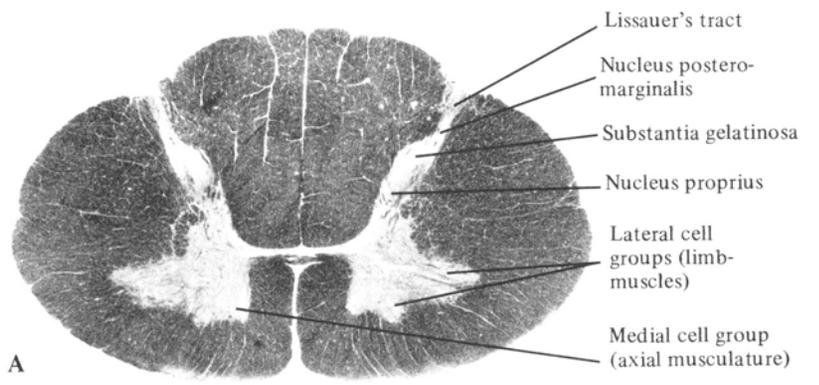
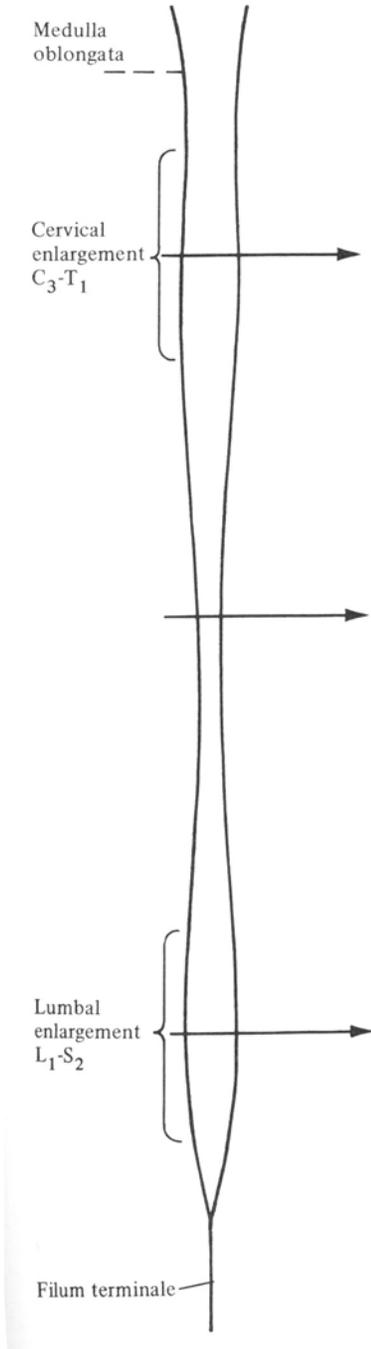
CSF is obtained by inserting a Needle into the lumbar cistern between the 3rd and 4th or 4th and 5th lumbar spinal processes.

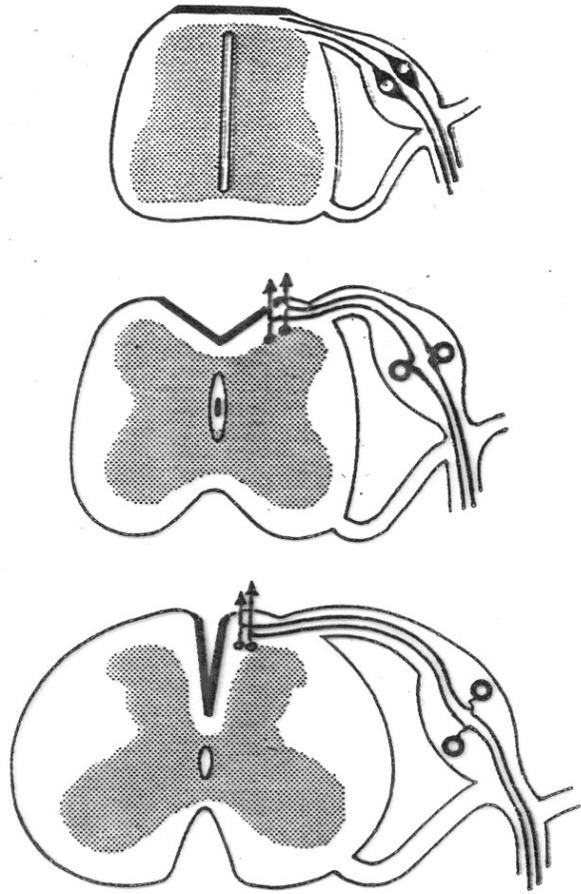
adult

Schematic drawings showing the relationship between the spinal cord and the vertebral column at various stages of development.

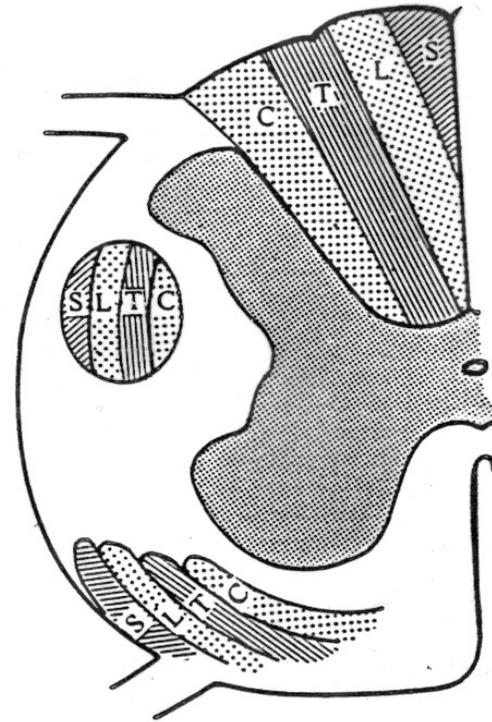


The cross-sections of the spinal cord are wider at the level of the cervical and lumbar enlargements than elsewhere. Note that relative amount of gray and white matter is also different at different levels. The amount of white matter decreases gradually in caudal direction, since the long ascending and descending fiber tracts contain fewer axons at successively more caudal levels of the spinal cord. The main nuclear groups of the gray matter have been indicated in the right halves (Heimer)

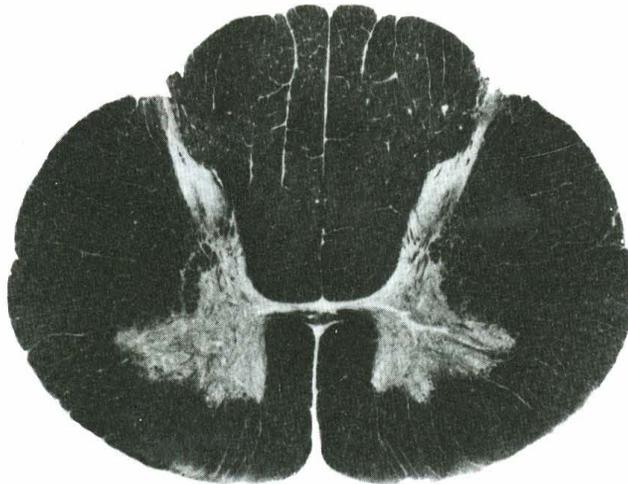




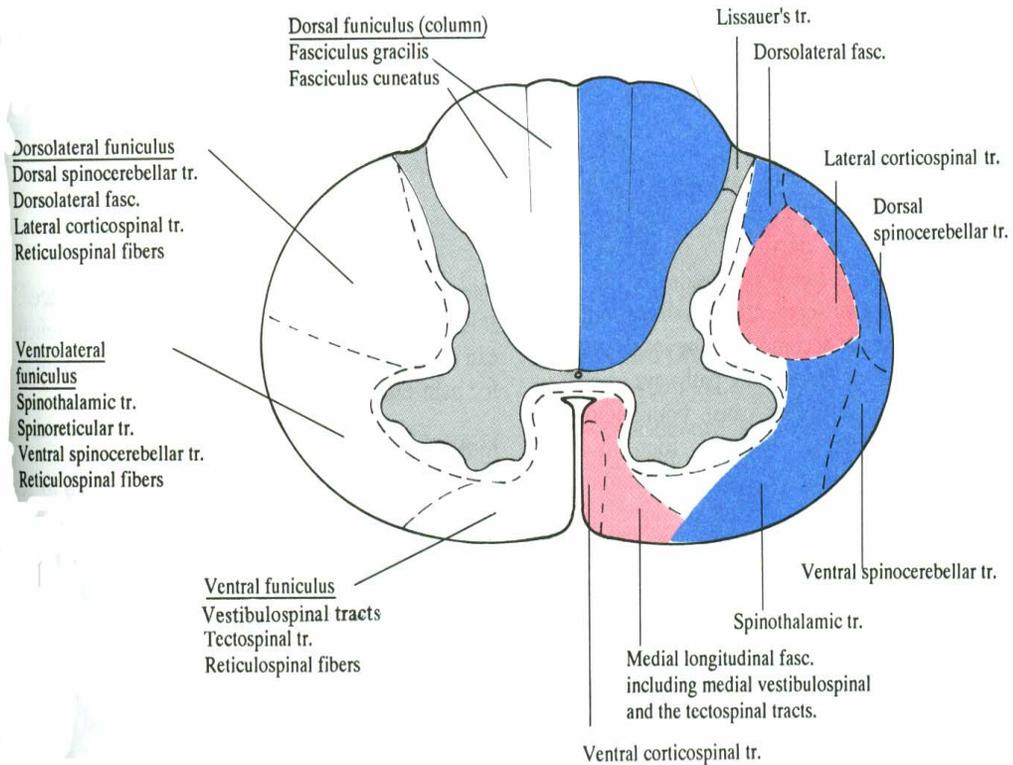
The development of the septum medianum posterior and the dorsal columns (Szentagothai)

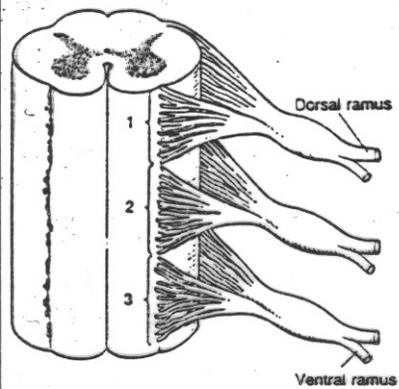
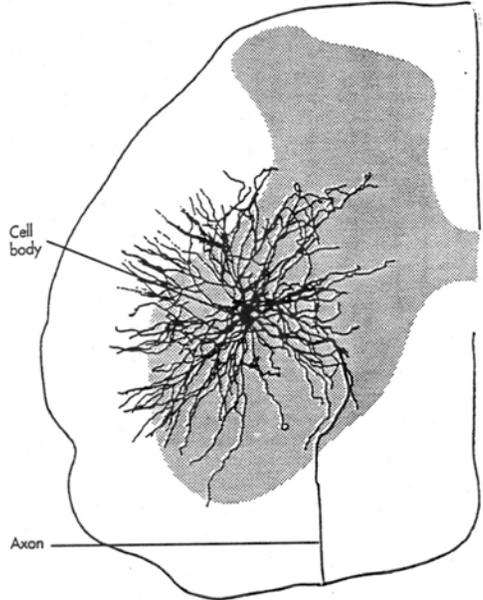


Laminar arrangement of the white matter of the spinal cord. S-sacral, L-lumbar, T-thoracic, C, cervical (Szentagothai)

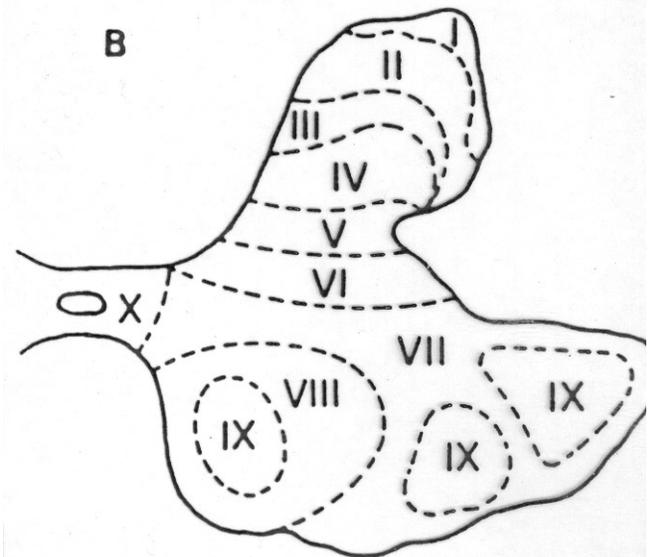
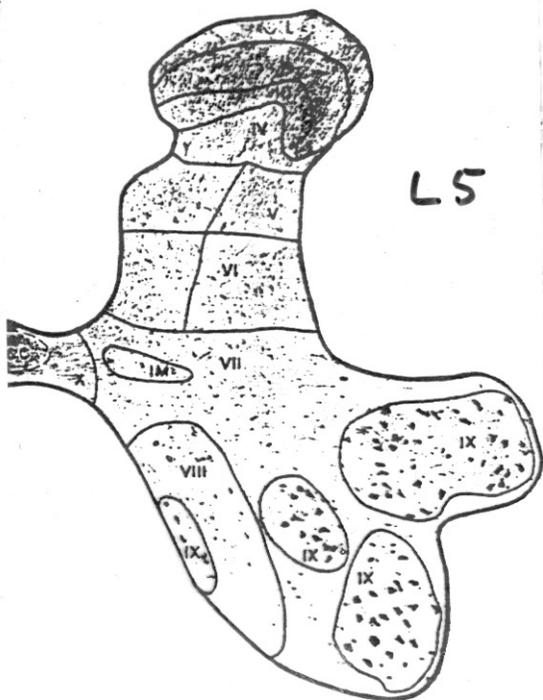


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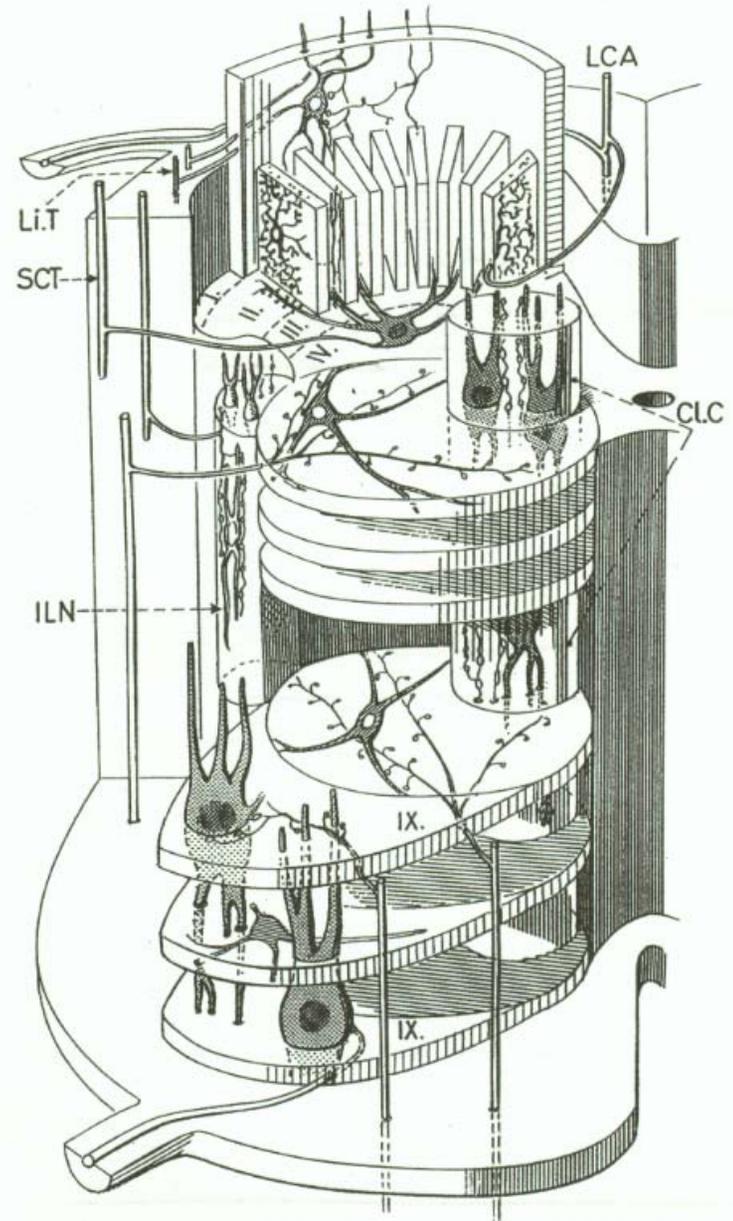
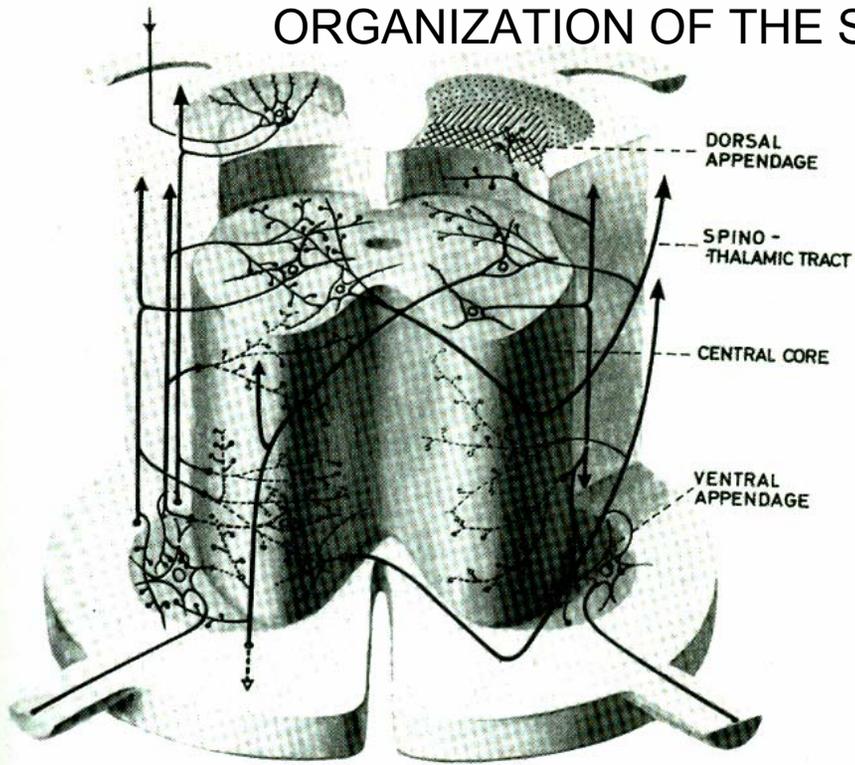


Root segments

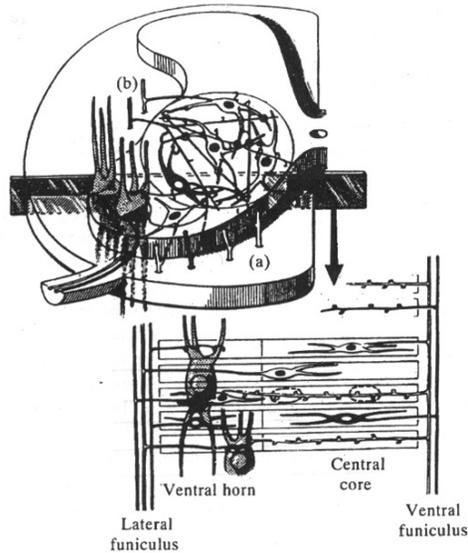


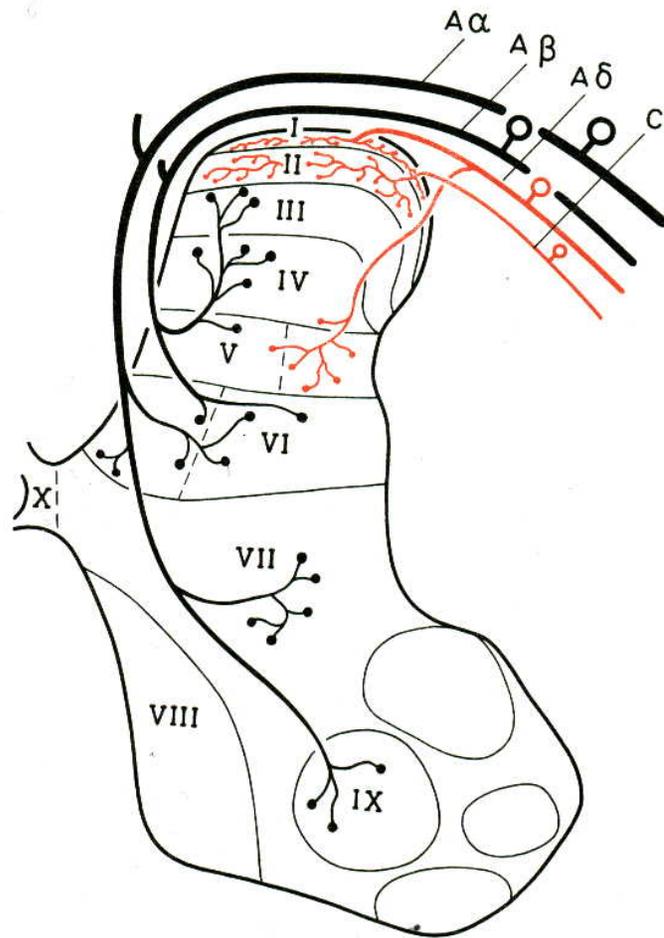
	Dorsal horn		Intermediate horn		Ventral horn						
	Substantia gelatinosa	Dorsal horn proper	Nucleus dorsalis of Clarke	Intermediolateral nucleus	Intermediomedial nucleus	Sacral parasympathetic nucleus	Medial motor nucleus	Lateral motor nucleus	Retrodorsolateral motor nucleus	Phrenic nucleus	Spinal accessory nucleus
C1	█	█					█				█
2	█	█					█				
3	█	█					█				
4	█	█					█				
5	█	█					█				
6	█	█					█				
7	█	█					█				
8	█	█					█				
9	█	█					█				
10	█	█					█				
11	█	█					█				
12	█	█					█				
L1	█	█					█				
2	█	█					█				
3	█	█					█				
4	█	█					█				
5	█	█					█				
S1	█	█					█				
2	█	█					█				
3	█	█					█				
4	█	█					█				
5	█	█					█				
Co1	█	█					█				

ORGANIZATION OF THE SPINAL GRAY

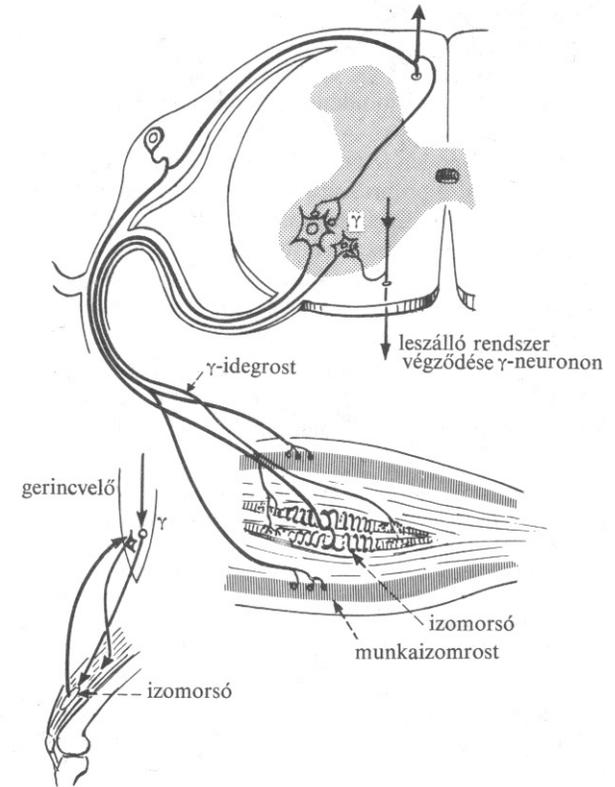
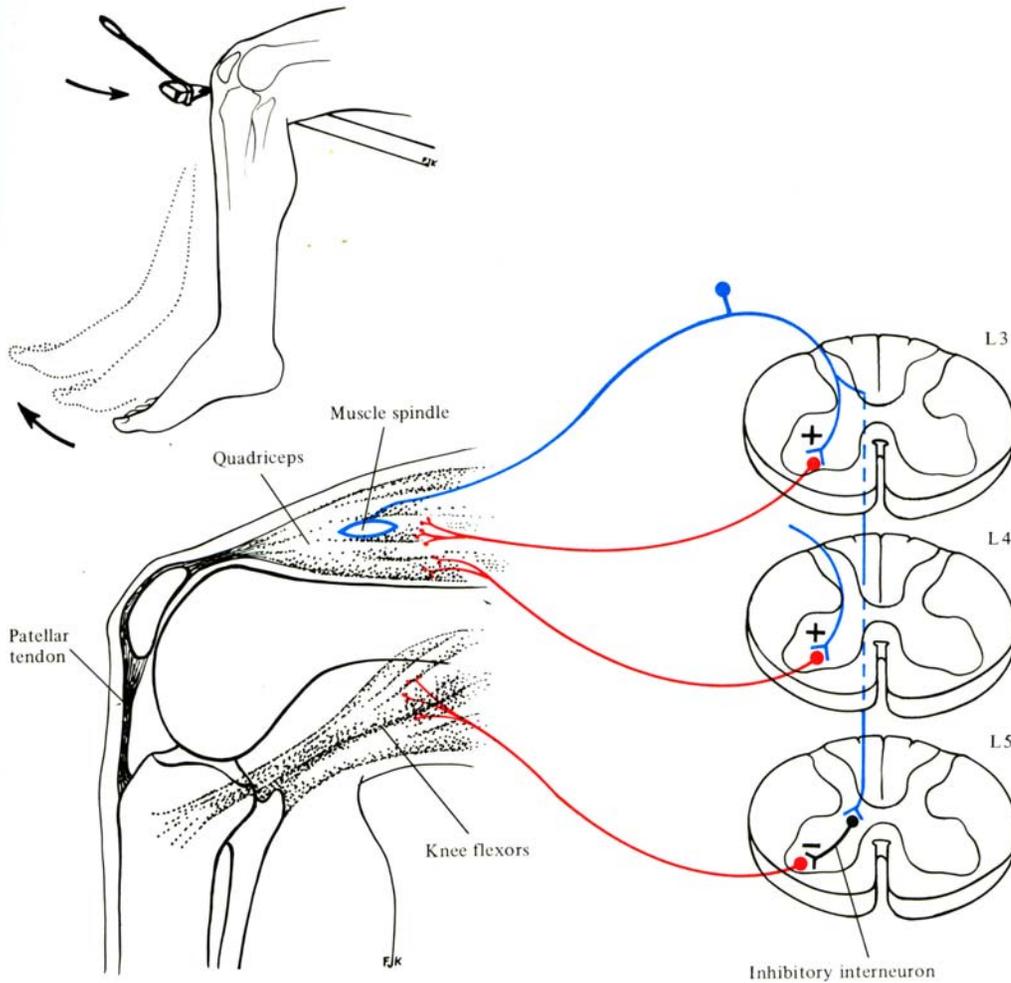


Various models to show the dendritic and axonal arborization pattern by J. Szsentagothai (1912-1994)



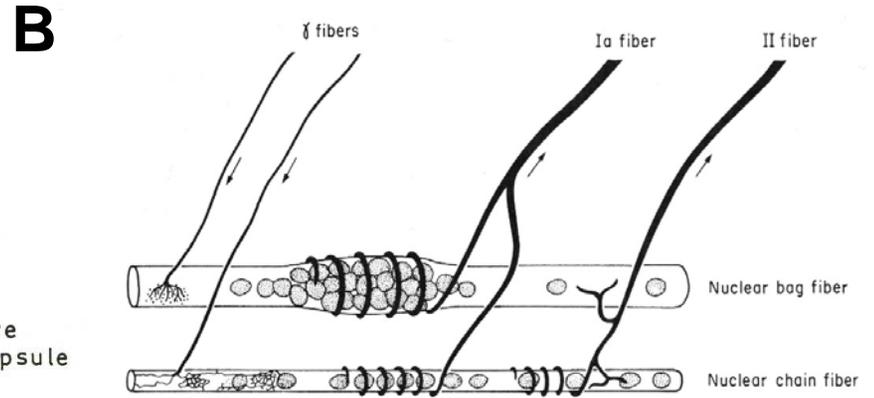
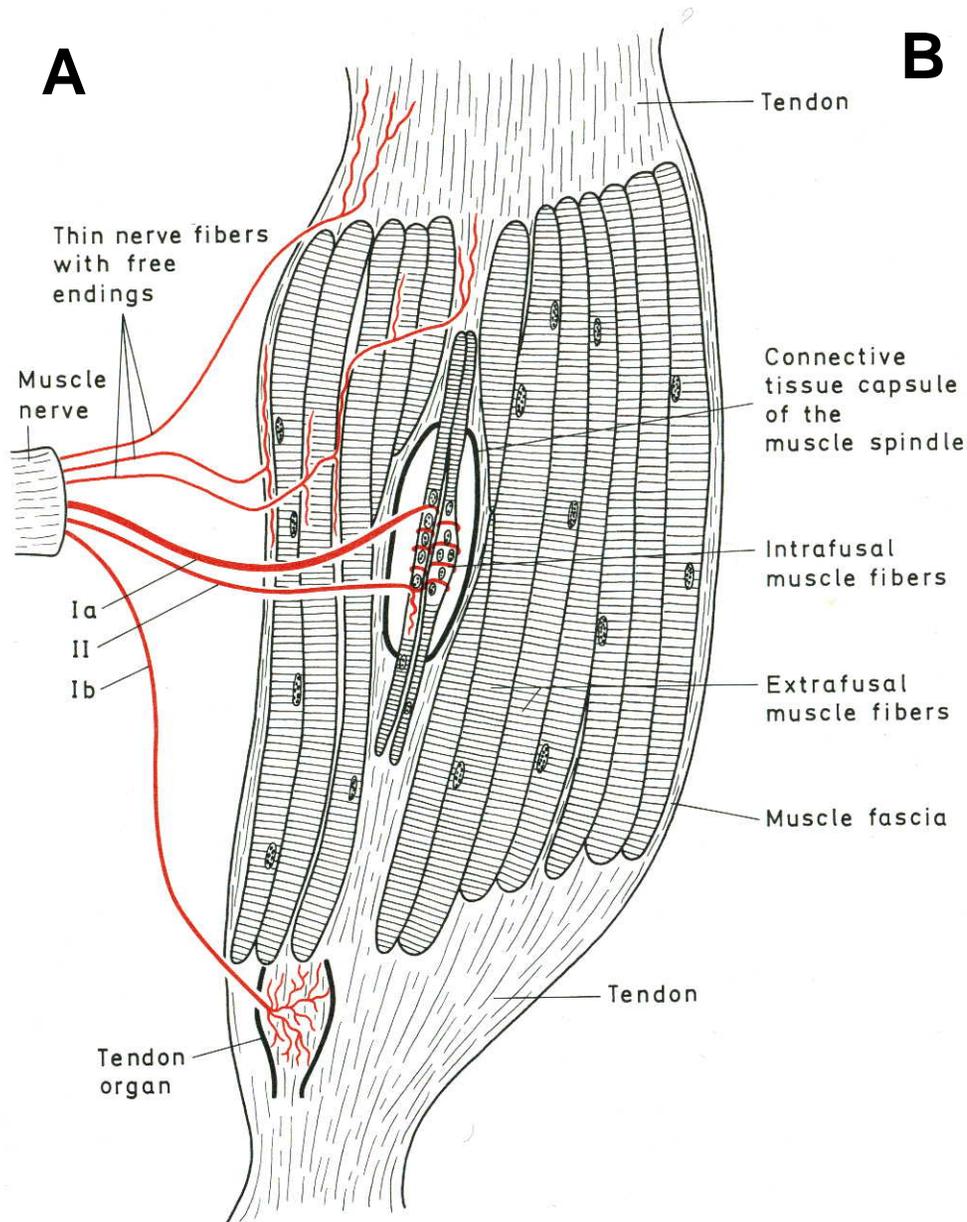


The terminal regions of the dorsal root fibers in the cord. The thickest myelinated fibers ($A\alpha$ form muscle spindles and tendon organs) end in the deep parts of the dorsal horn and partly also in the ventral horn. Thick myelinated fibers from cutaneous mechanoreceptors ($A\beta$) end in laminae III-VI. The thinnest myelinated and unmyelinated dorsal root fibers ($A\delta$ and C)- many of them leading from nociceptors end in laminae I, II, and parts of V. (Brodal)



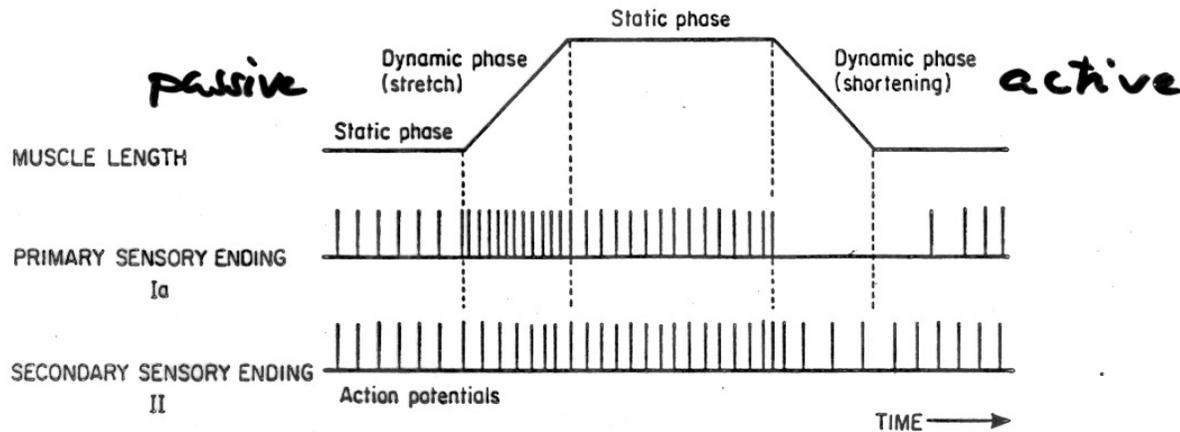
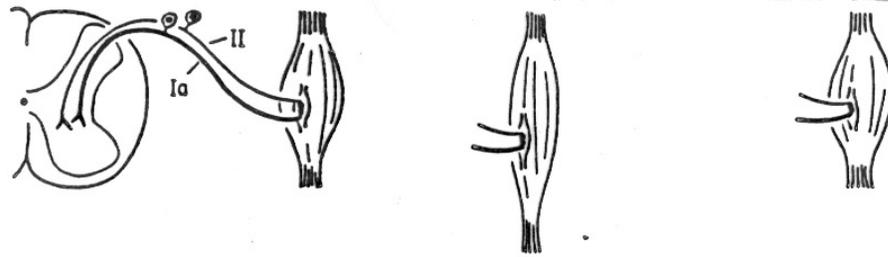
The knee jerk reflex. Striking the patellar tendon initiates a stretch reflex. It also causes inhibition, through an interneuron, of the motor neurons to the antagonist hamstring muscles

The mechanism of the gamma loop (Szentagothai)

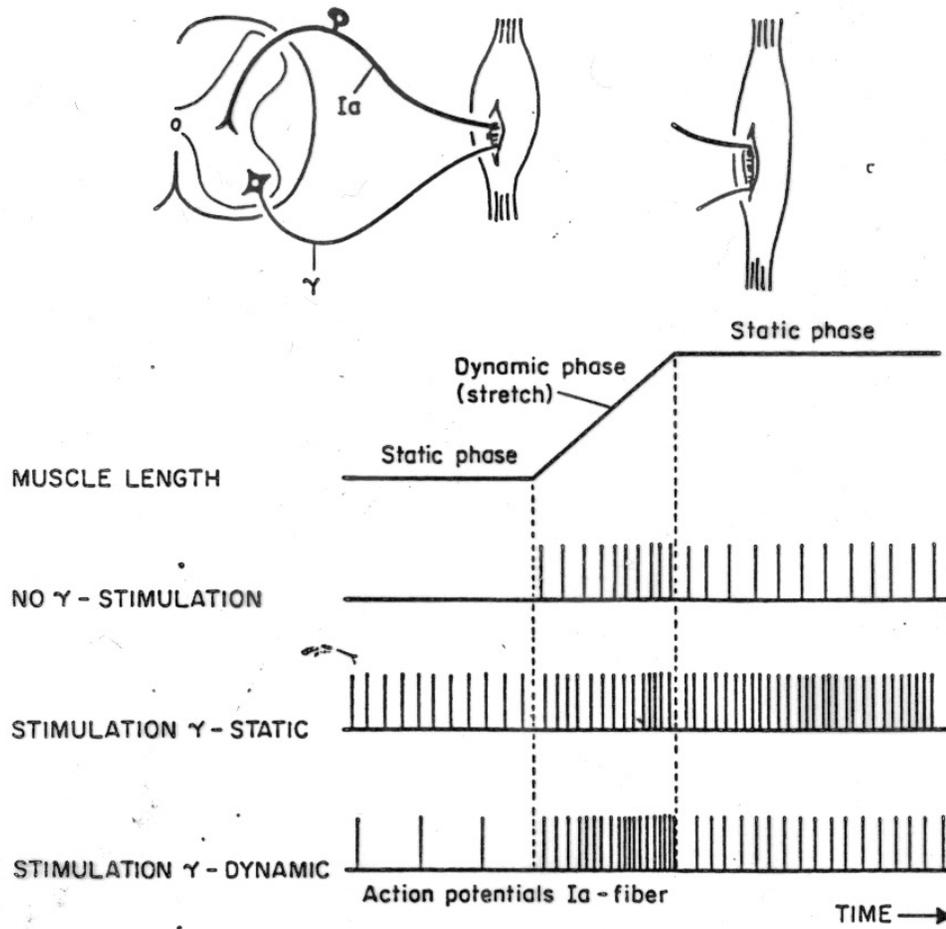


A: sensory innervation of skeletal muscles. The size of the receptors to the muscle exaggerated. Note that the muscle spindle is attached via connective tissue fibers to the tendons. Thus, muscle spindle wherever the whole muscle is stretched.

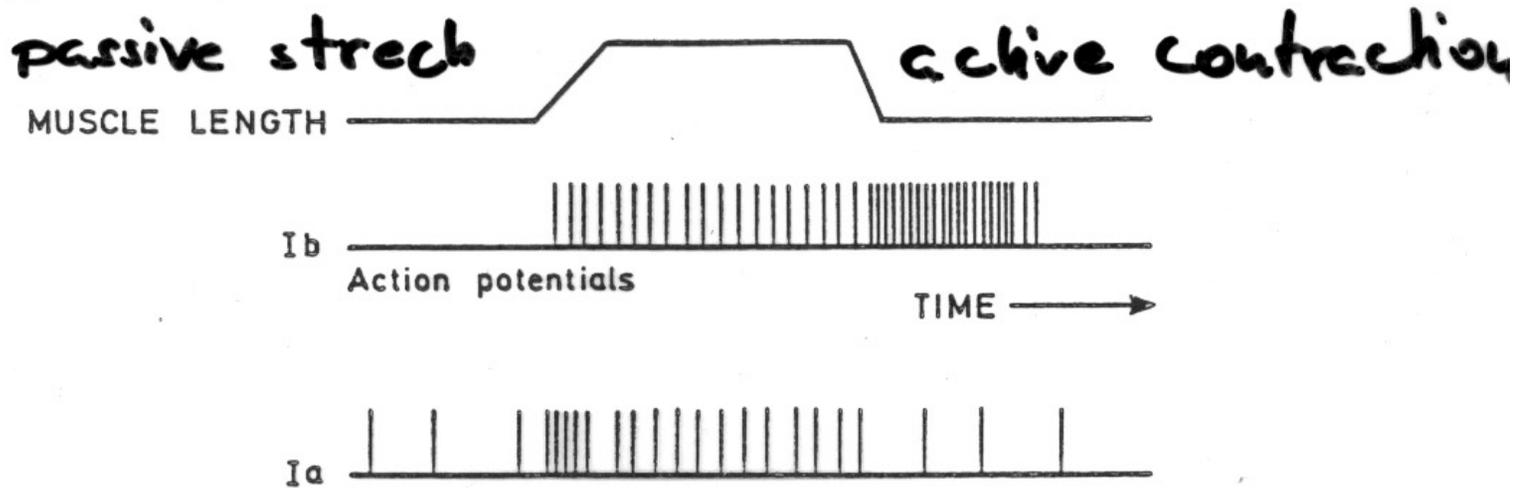
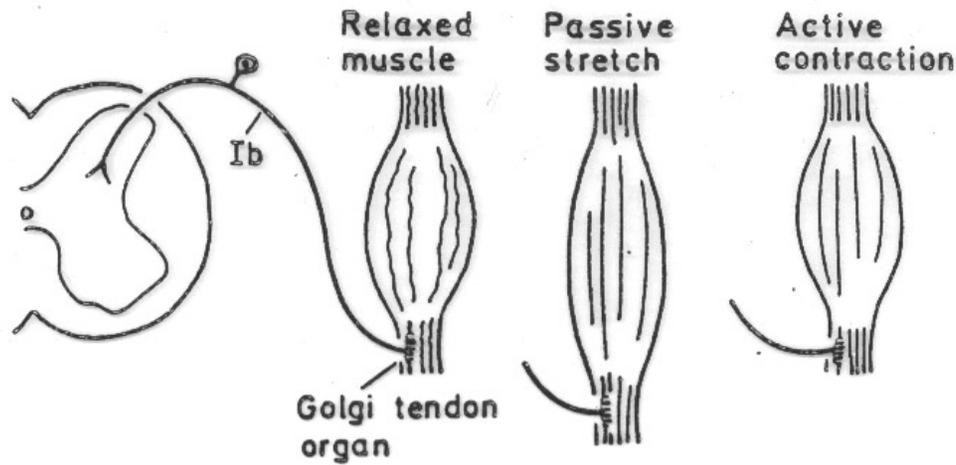
B: Schematic representation of the two kinds of intrafusal muscle fibers and their innervation (Brodal)



The functional properties of the muscle spindle. The diagram shows how both the primary and the secondary endings signal the static length of the muscle (static sensitivity), whereas only the primary ending signals the length changes (movements) and their velocity (dynamic sensitivity). The change of firing frequency of group Ia and group II fibers can then be related to static muscle length (static phase) and shortening of the muscle (Dynamic phases). The frequency of action potentials in the dorsal root fibers is indicated by the density of the vertical lines on the lower rows (Brodal)

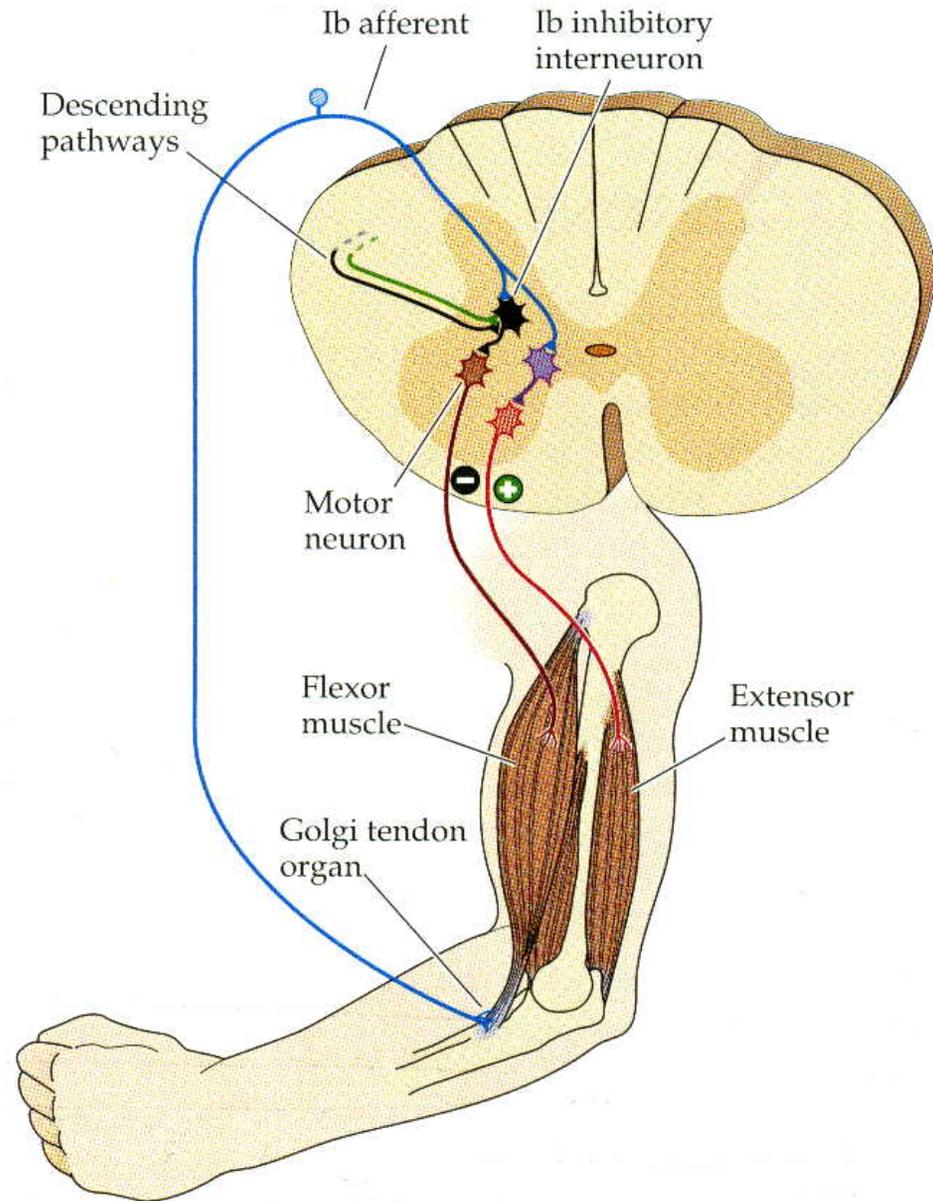
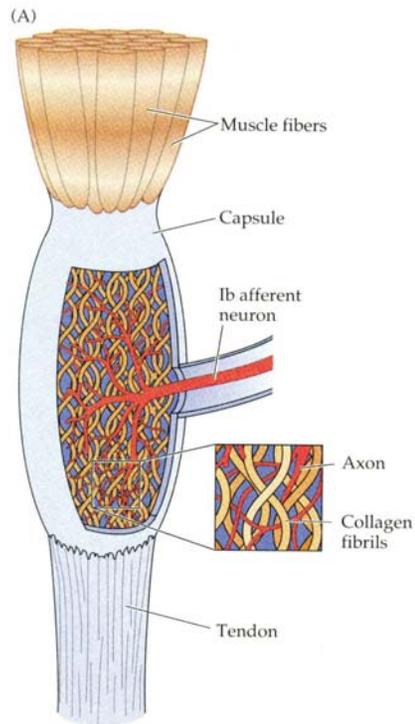


The action of gamma motorneurons on the muscle spindle. In this example, there is no firing of the Ia fiber at the resting length of the muscle when the gamma fibers are not stimulated. Stimulation of the static gamma fibers makes the Ia fiber fire even at the static resting length, and stretching the muscle to a new static length increases the firing frequency to a new stable level. Stimulation of dynamic gamma fiber increases the firing frequency of the Ia fiber mainly during the stretching phase.

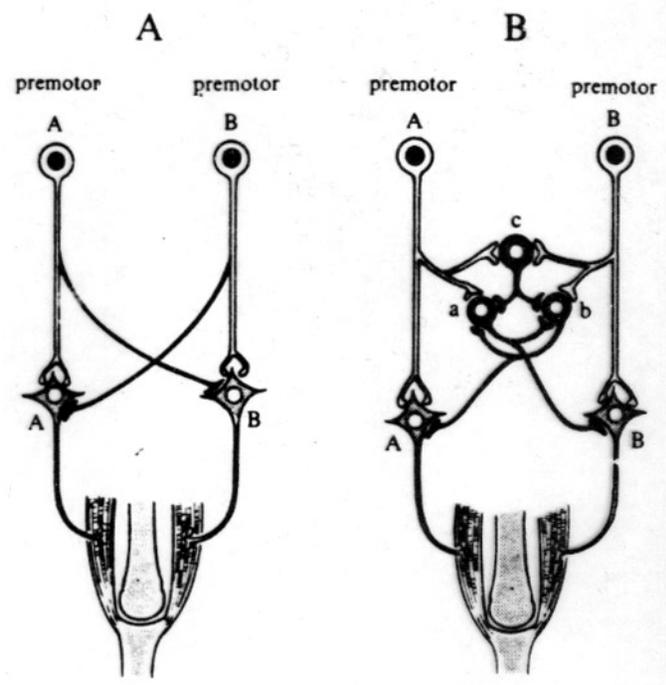
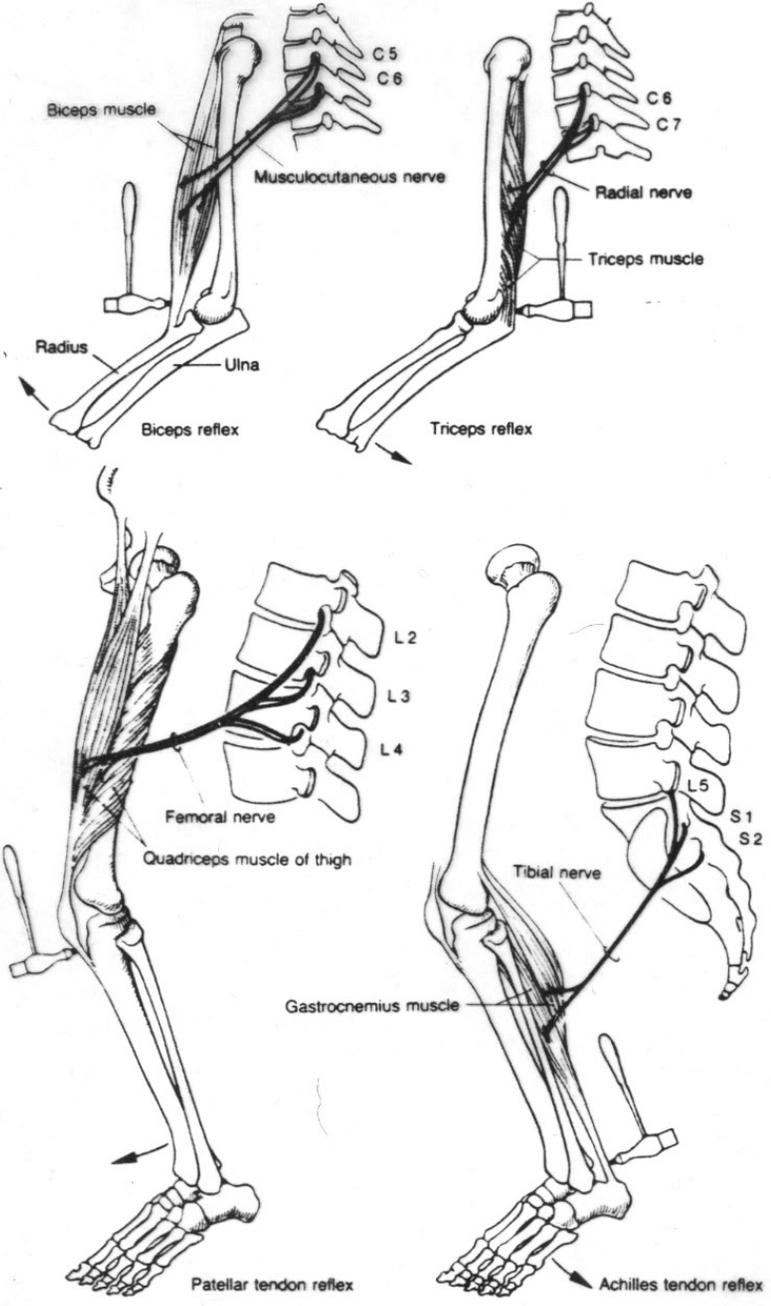


Functional properties of the tendon organ. Both passive stretching and active contraction of the muscle increases the firing frequency of the Ib fiber, but active contraction produces the greater increase. The firing frequency of a Ia fiber during the same experiment is shown for comparison.

Negative feedback regulation of muscle tension by Golgi tendon organs. Ib afferents from tendon organs contact inhibitory interneurons that decrease the activity of alpha motorneurons innervating the same muscle. Ib inhibitory interneurons also receive descending input. This arrangement prevents muscles from generating excessive tension. (Purves)



C

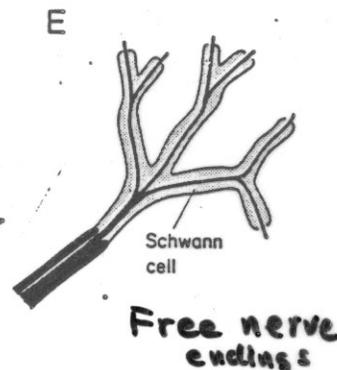
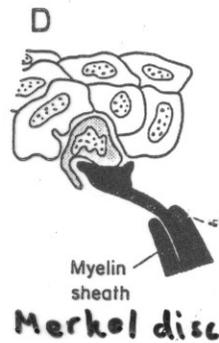
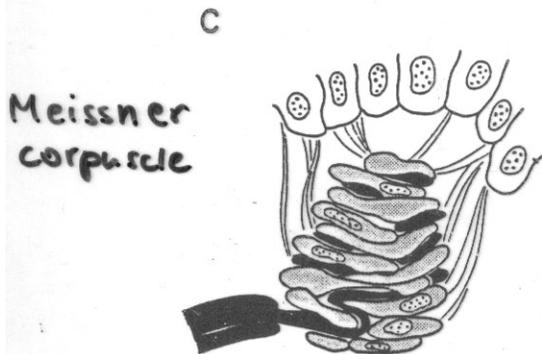
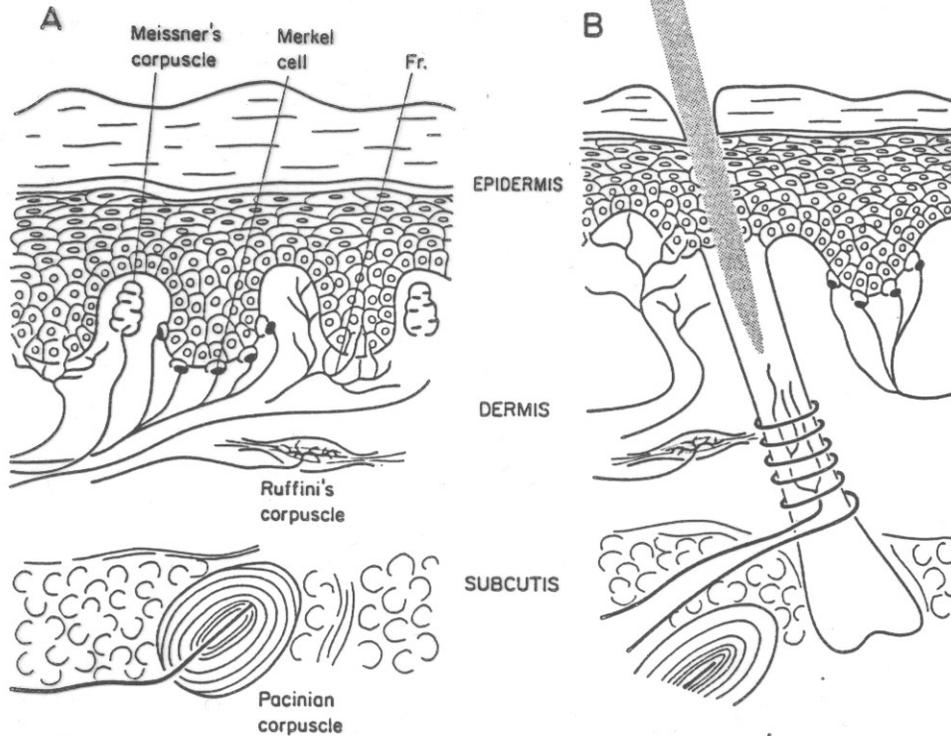


Mechanism of reciprocal inhibition. A: classical explanation. In this case either A or B motorneuron active in an exclusive fashion. B: involvements of inhibitory interneurons A and B motorneuron can work antagonistically or synergistically. Interneuron c is only active if both A and B premotor neurons are active, in this case c inhibits the inhibitory action of a and b inhibitory neurons, thus the stimulation of the premotor neurons A and B activate A and B motorneurons (Szentagothai).

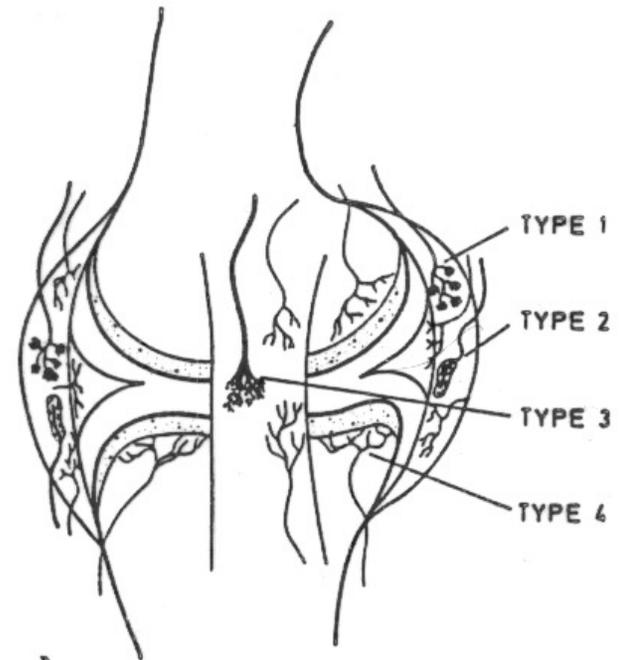
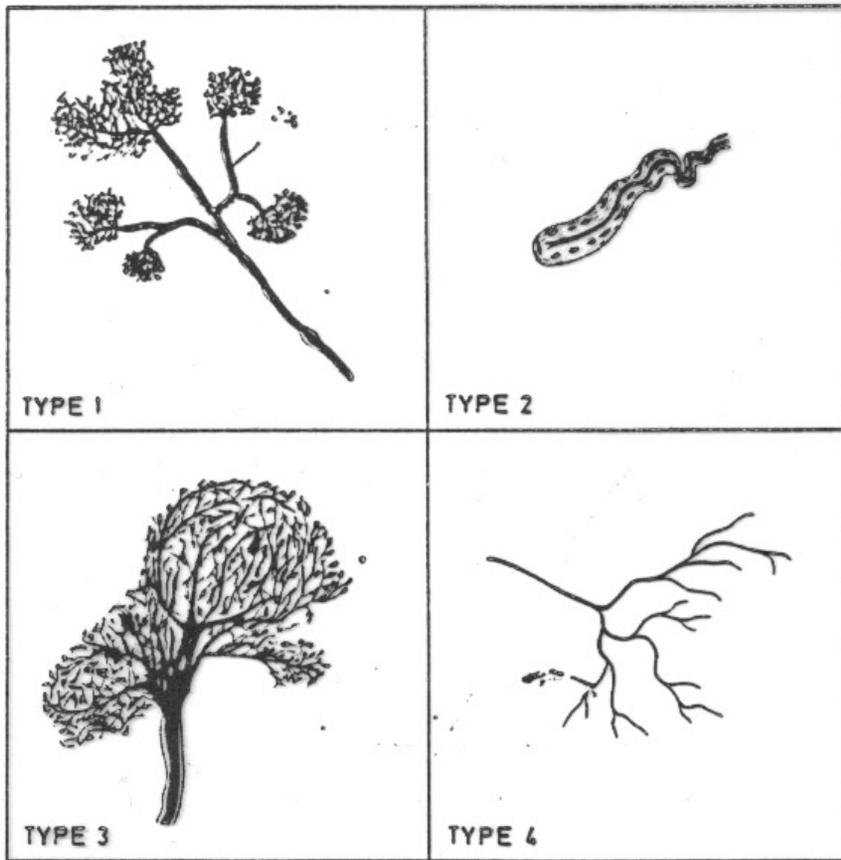
The most important proprioceptive reflexes (Duus).

Cutaneous receptors

Schematic drawing of cutaneous receptors in the (A) glabrous skin (palm of the hands and soles of the feet) and (B) hairy skin. Nerve endings in hairy skin wind around the hair follicles and are activated by the slightest bending of the hair. Free nerve endings are covered by Schwann cells except at their tips, where, presumably, the receptor properties reside (Brodal)

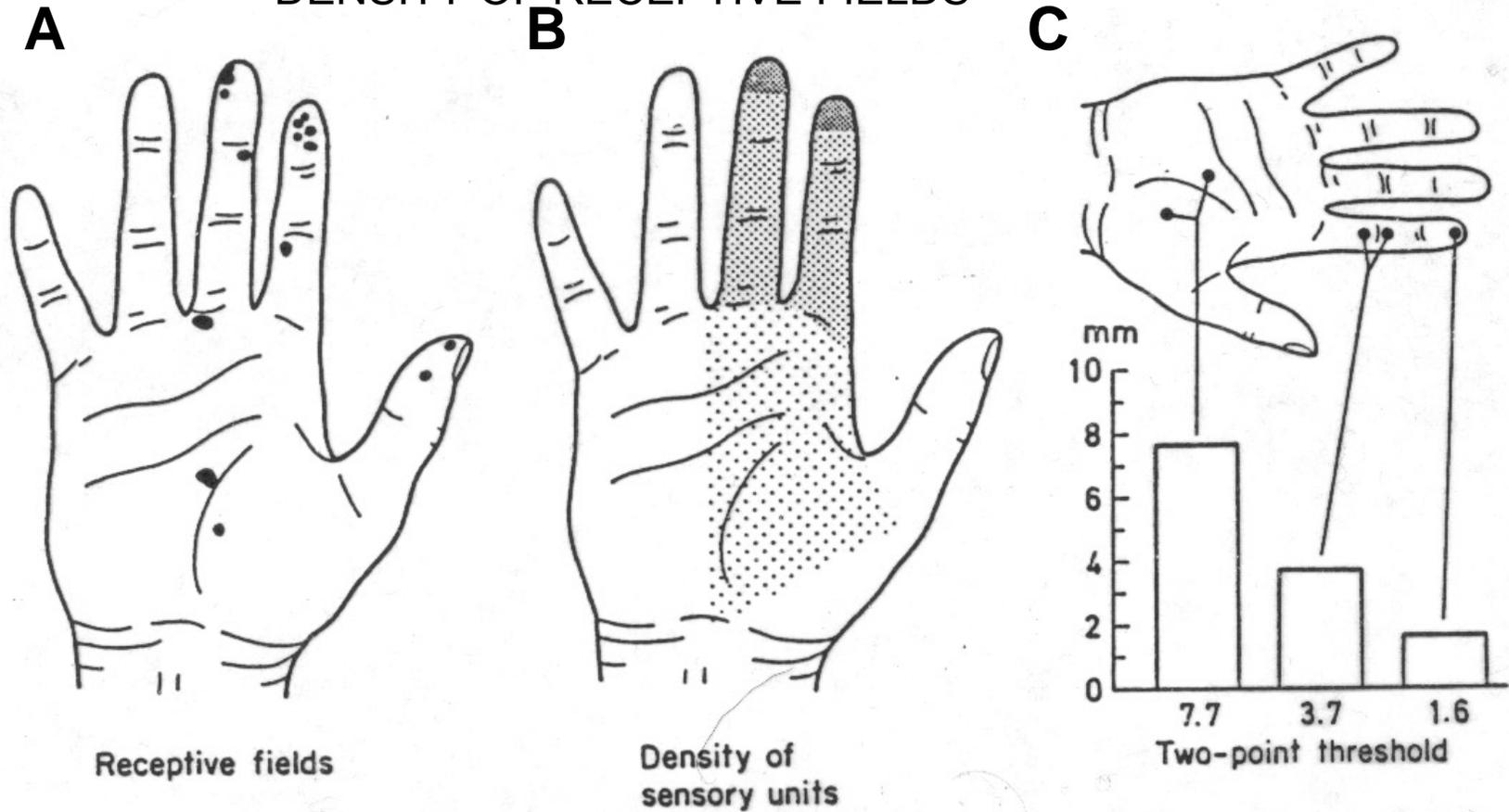


JOINT RECEPTORS



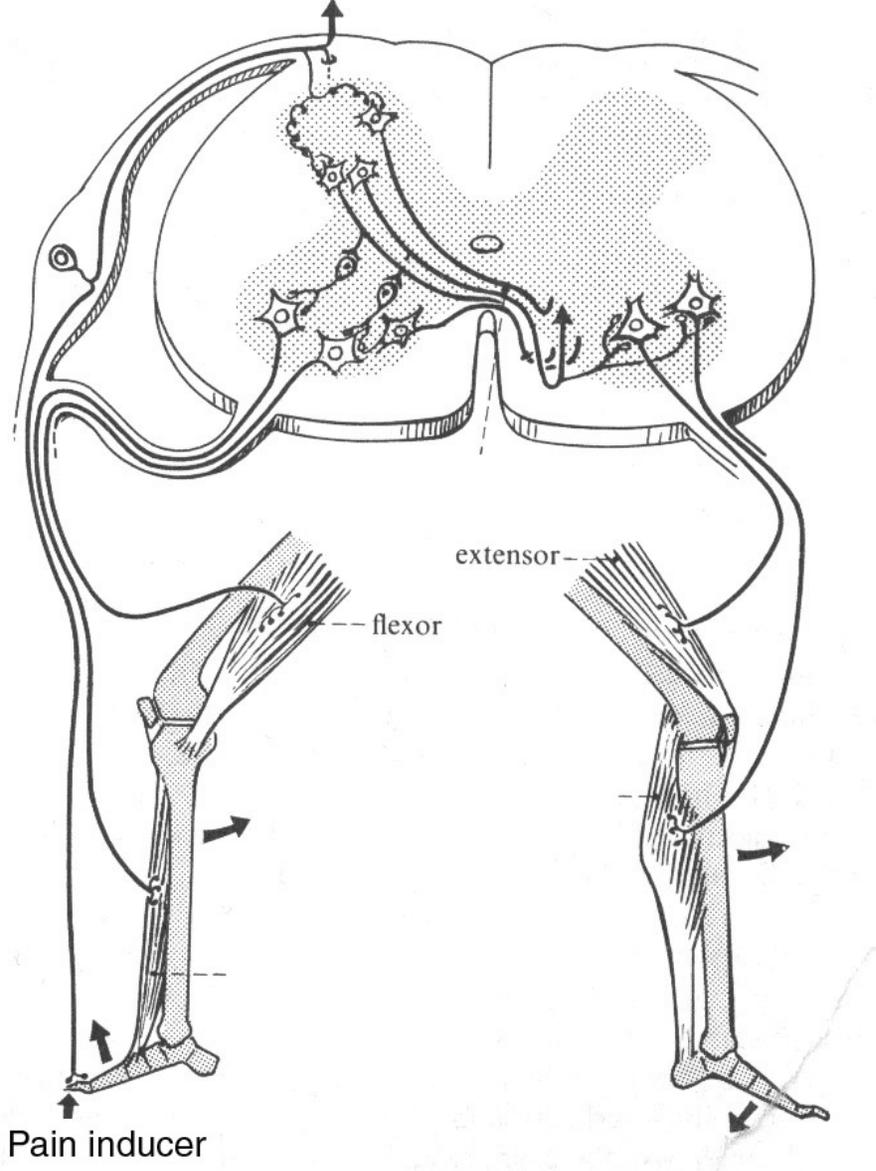
Joint innervation. A knee joint, showing the distribution of the various kinds of joint receptors, to the left shown in more detail (Brodal).

DENSITY OF RECEPTIVE FIELDS



A: Receptive fields. Size and locations of the receptive fields of 15 sensory units, determined by recording from the median nerve. All of these sensory units were rapidly adapting and were most likely conducting from Meissner-corporcles. Within each receptive fields there are many Meissner corpuscles, all supplied by the same axon. **B:** Relative density of sensory units conducting from Meissner corpuscles (that is, # of sensory units supplying 1 cm²). Note that the density increases distally and is highest at the volar aspect of the fingertips. **C:** Two-point discrimination. The numbers give the shortest distance between two points touching the skin that can be identified by the experimental subject as two. Based on 10 subjects (From Brodal).

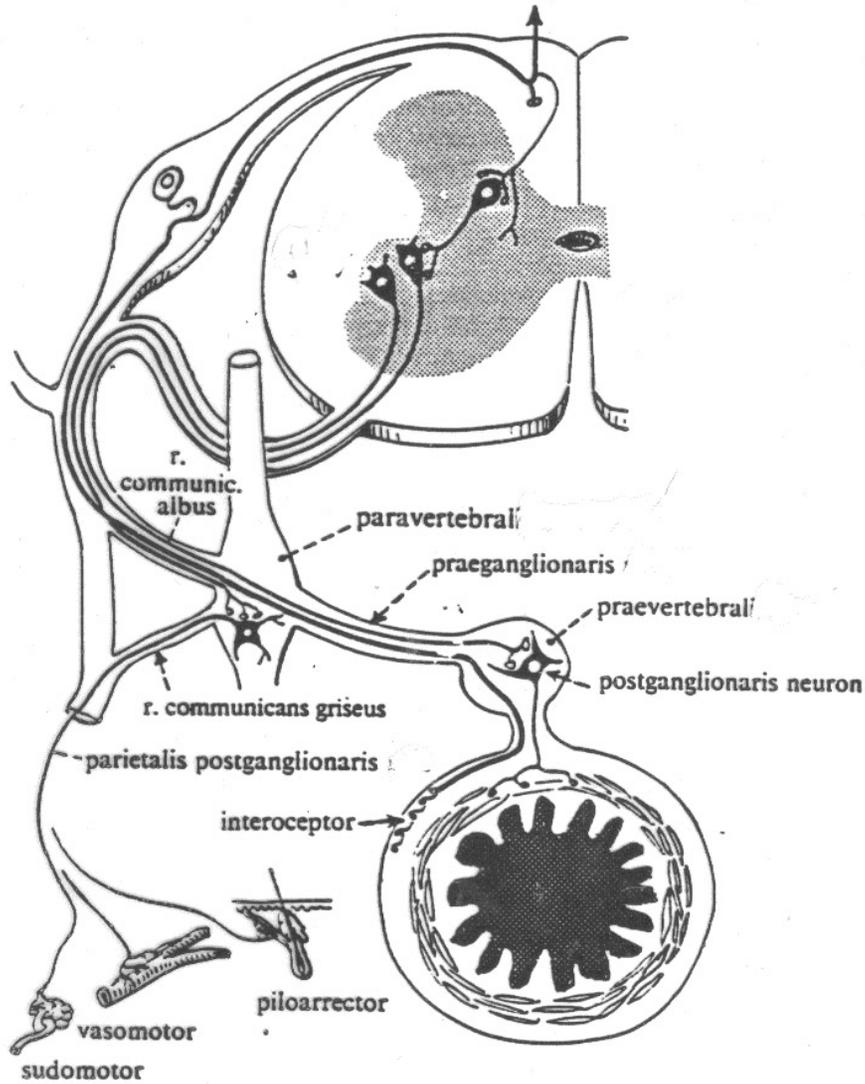
FLEXION-CROSSED EXTENSION REFLEX



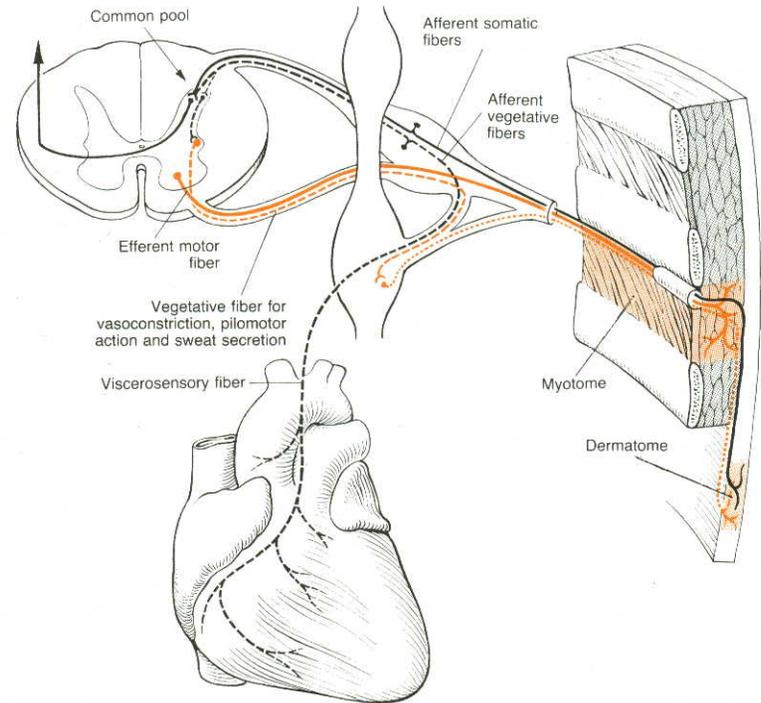
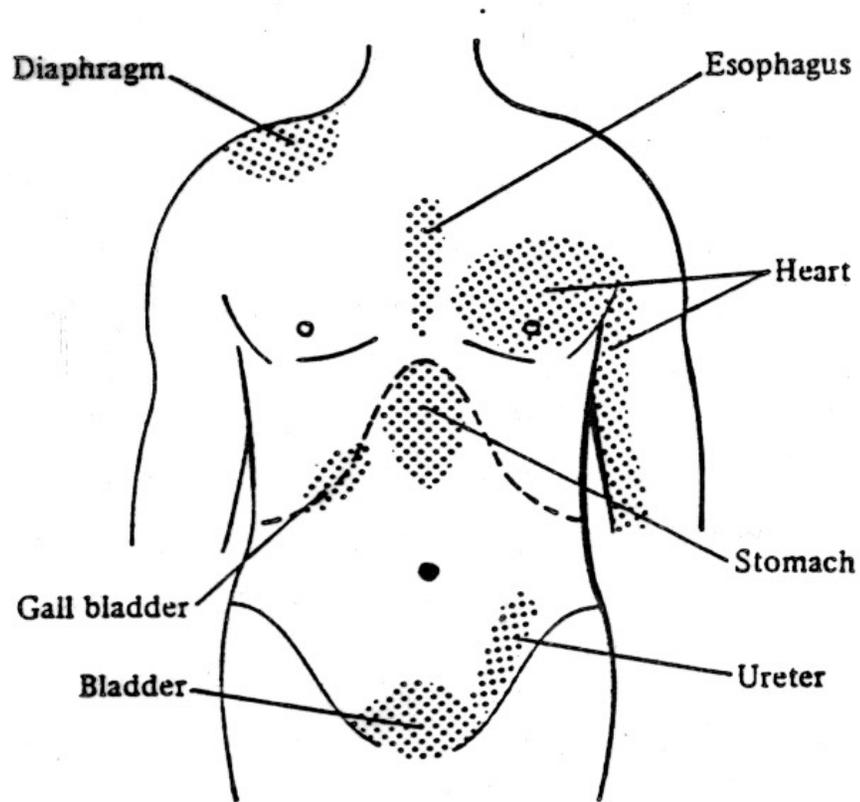
Stimulation of cutaneous receptors in the foot leads to activation of spinal cord circuits that withdraw (flex) the stimulated extremity and extend the other extremity to provide compensatory support (Szentagothai)

THE VEGETATIVE REFLEX

The vegetative reflex
(Szentagothai).



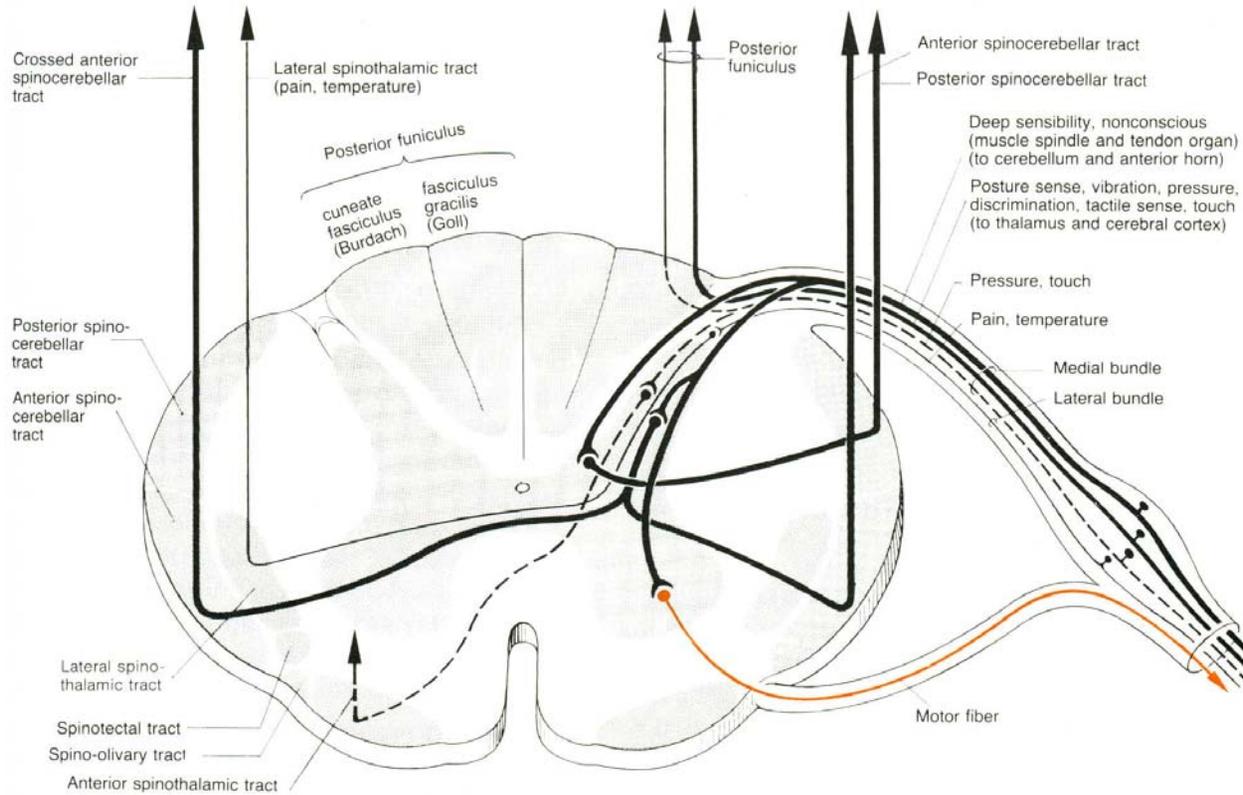
REFERRED PAIN



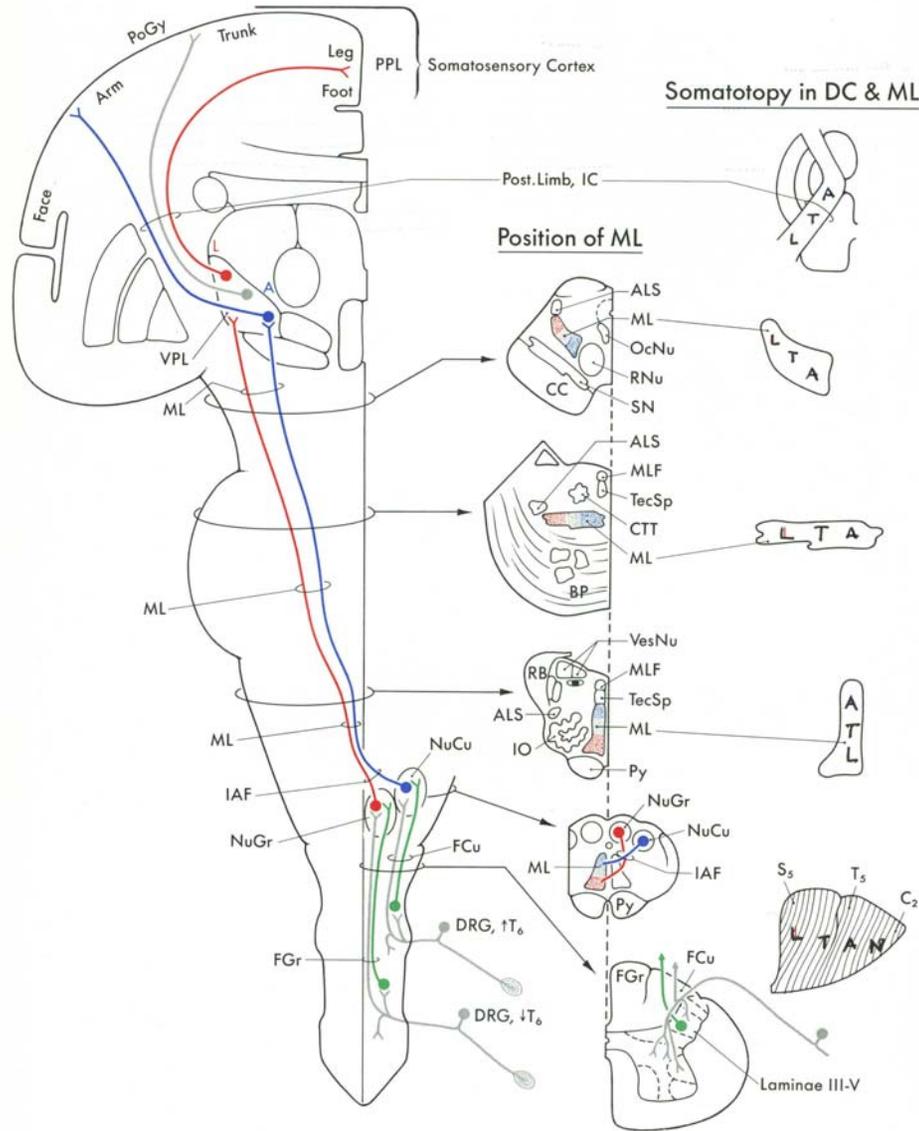
Referred pain. Diagram showing cutaneous sites of reference of visceral pain commonly encountered in medical practice. (Heimer)

Viscerocutaneous reflex arc with myotome, dermatome and enterotome and somatic and autonomic connections for the explanation of referred pain (Duus)

ORIGIN OF ASCENDING PATHWAYS IN THE SPINAL CORD

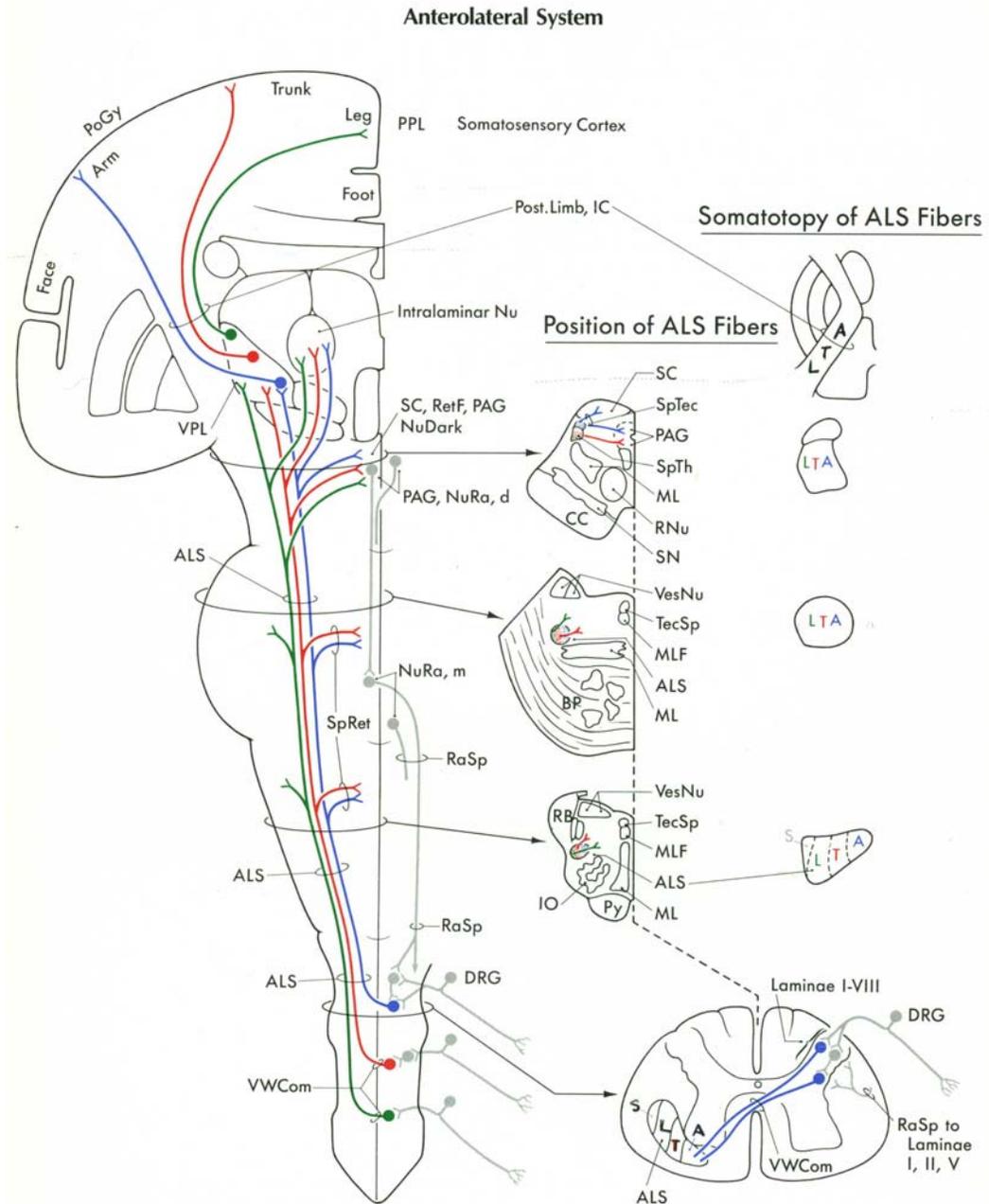


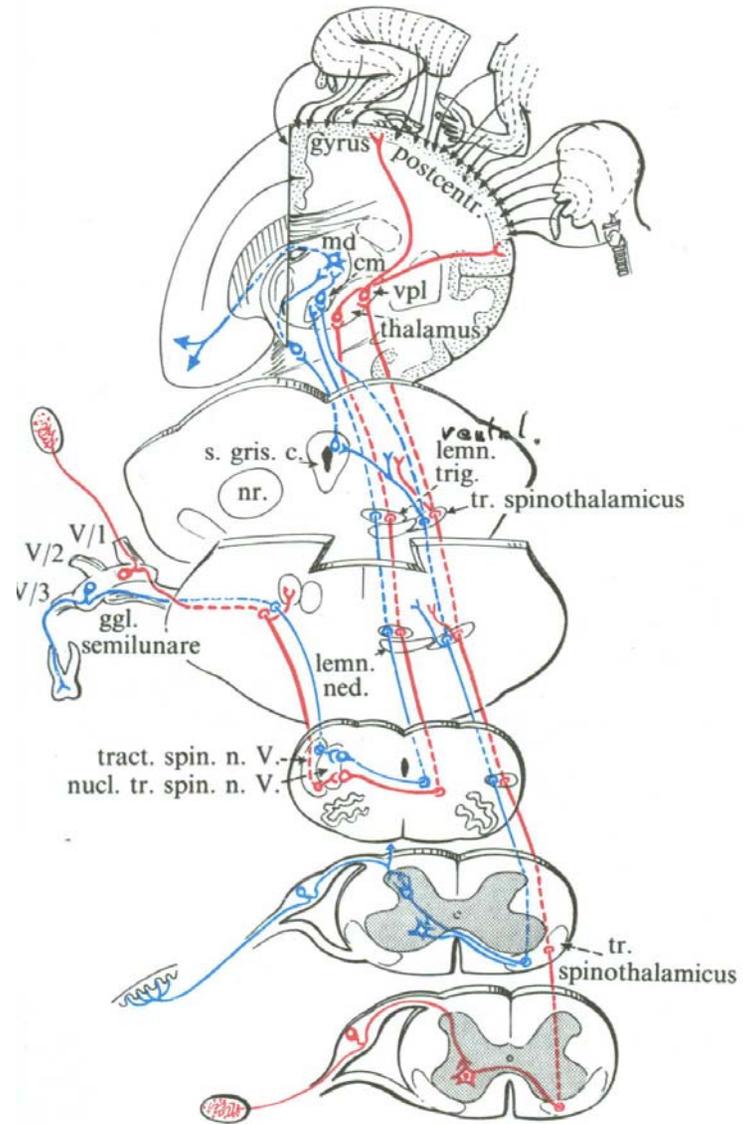
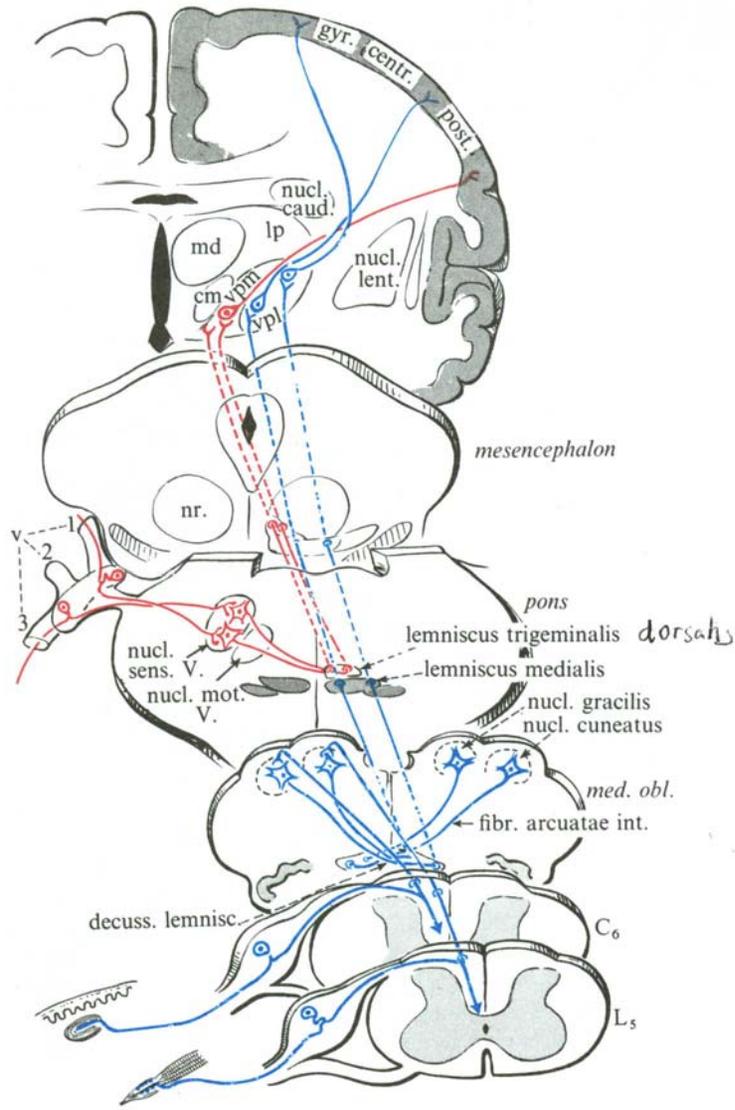
Dorsal Column-Medial Lemniscus System



The origin, course and distribution of the dorsal column-medial lemniscus system for tactile, vibratory and proprioceptive impulses (Haines).

The origin, course and distribution of the anterolateral system, carrying pain and temperature information (Haines)

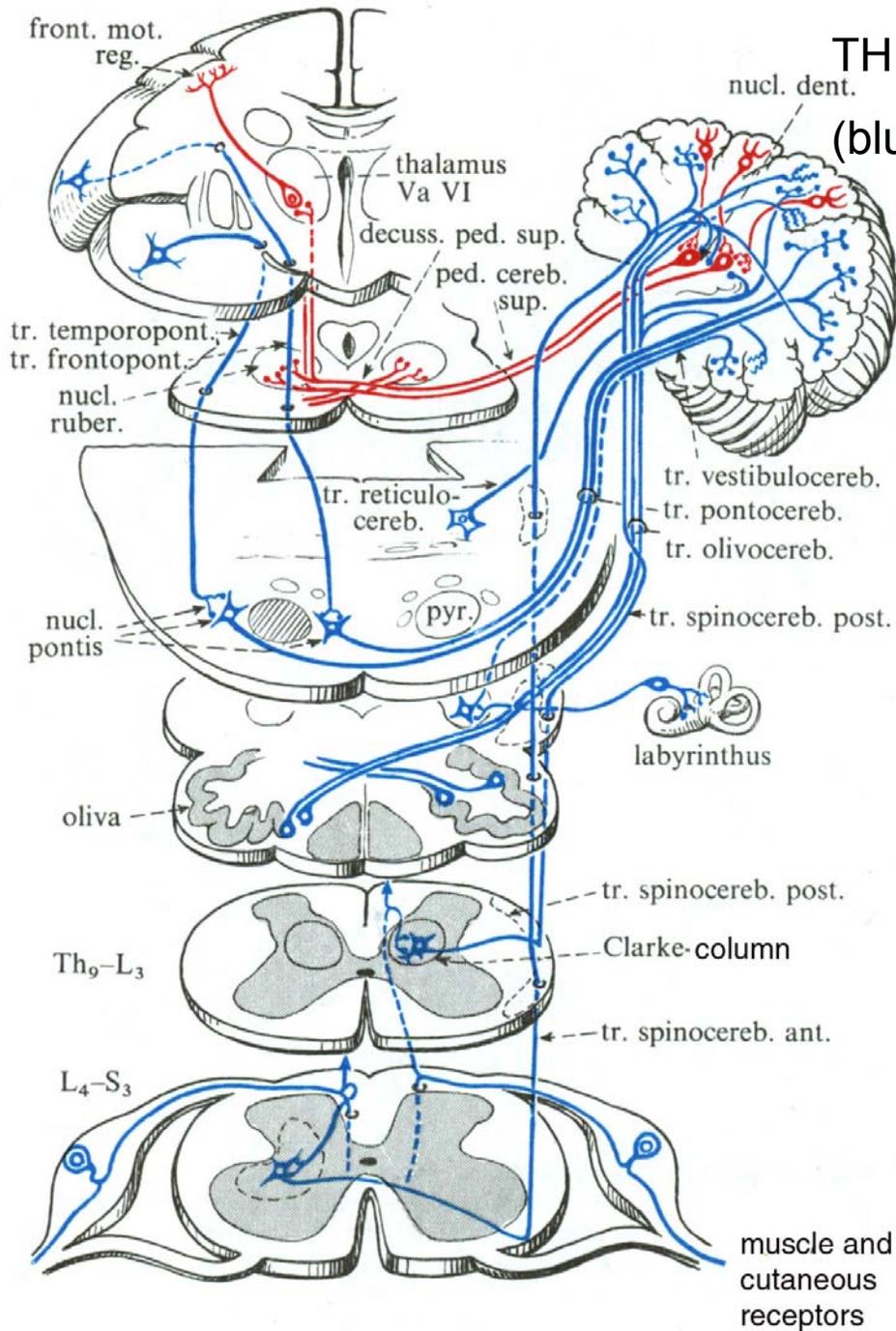


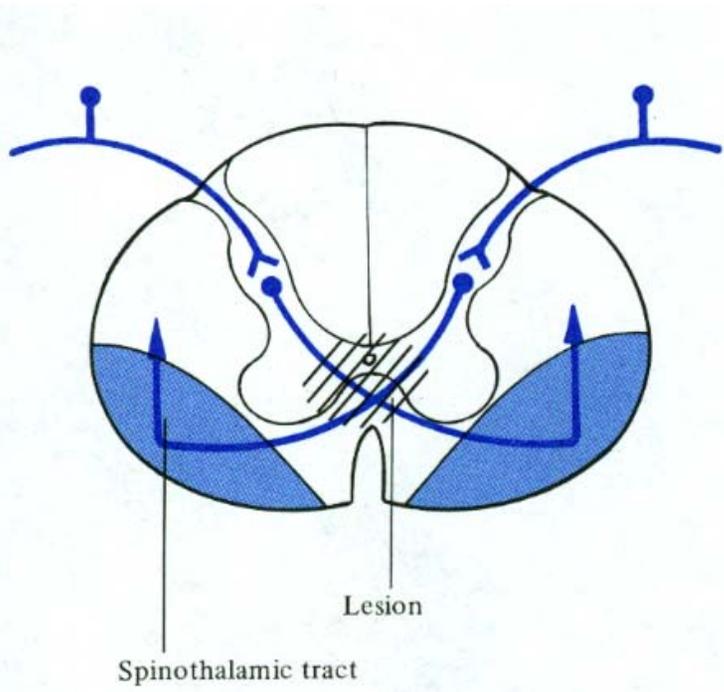


The dorsal column-medial lemniscus (left) and the spinothalamic systems (right). In the left figure the temperature sensitive axons are in blue, the pain-conducting fibers and the trigeminal system in red (Szentagothai)

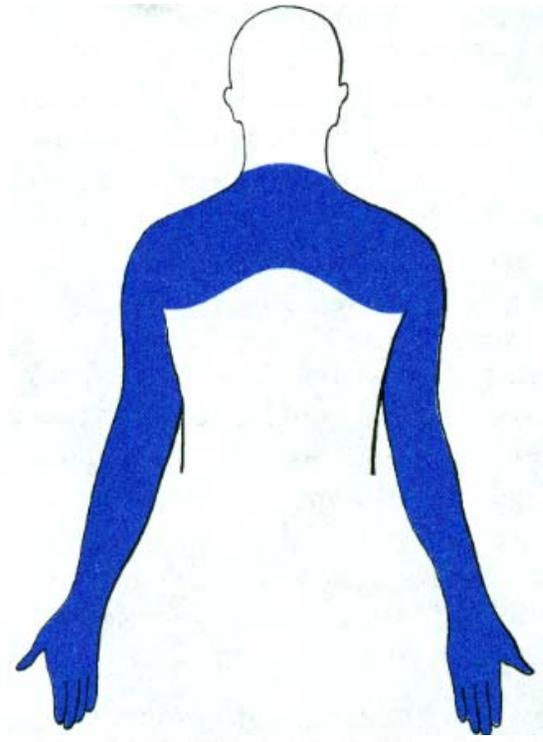
THE SPINOCEREBELLAR PATHWAYS

(blue) [SZENTAGOTHAJ]

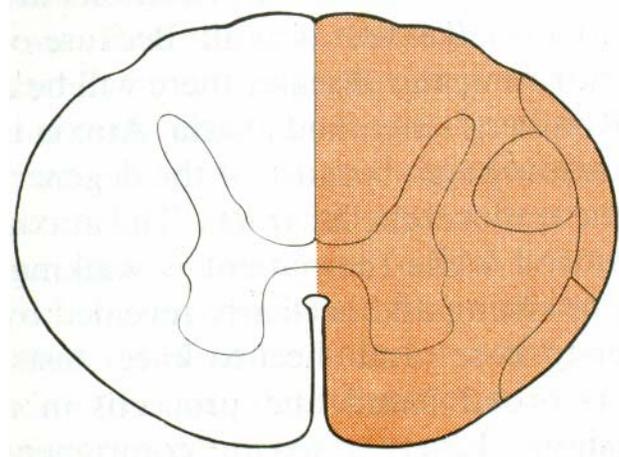




Syringomyelia
(Heimer)



Brown-Sequard syndrome (Duus)



Analgesia,
thermanesthesia

