MEDICAL UNIVERSITY - PLEVEN
FACULTY OF MEDICINE
DEPARTMENT OF NEUROLOGY AND NEUROSURGERY
DIVISION OF NEUROLOGY

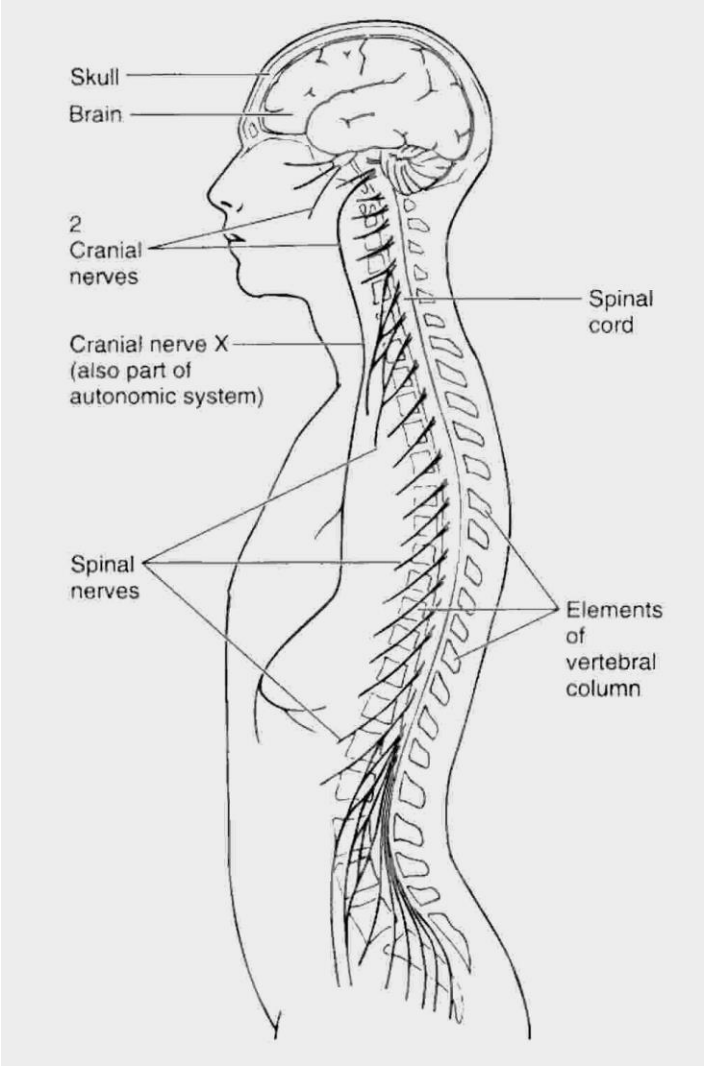
Lecture № 6

PERIPHERAL NERVOUS SYSTEM

Syndromes of spinal root, spinal nerve, plexuses and peripheral nerve lesions

Assoc.Prof. Maya Danovska, M.D.
Department of Neurology

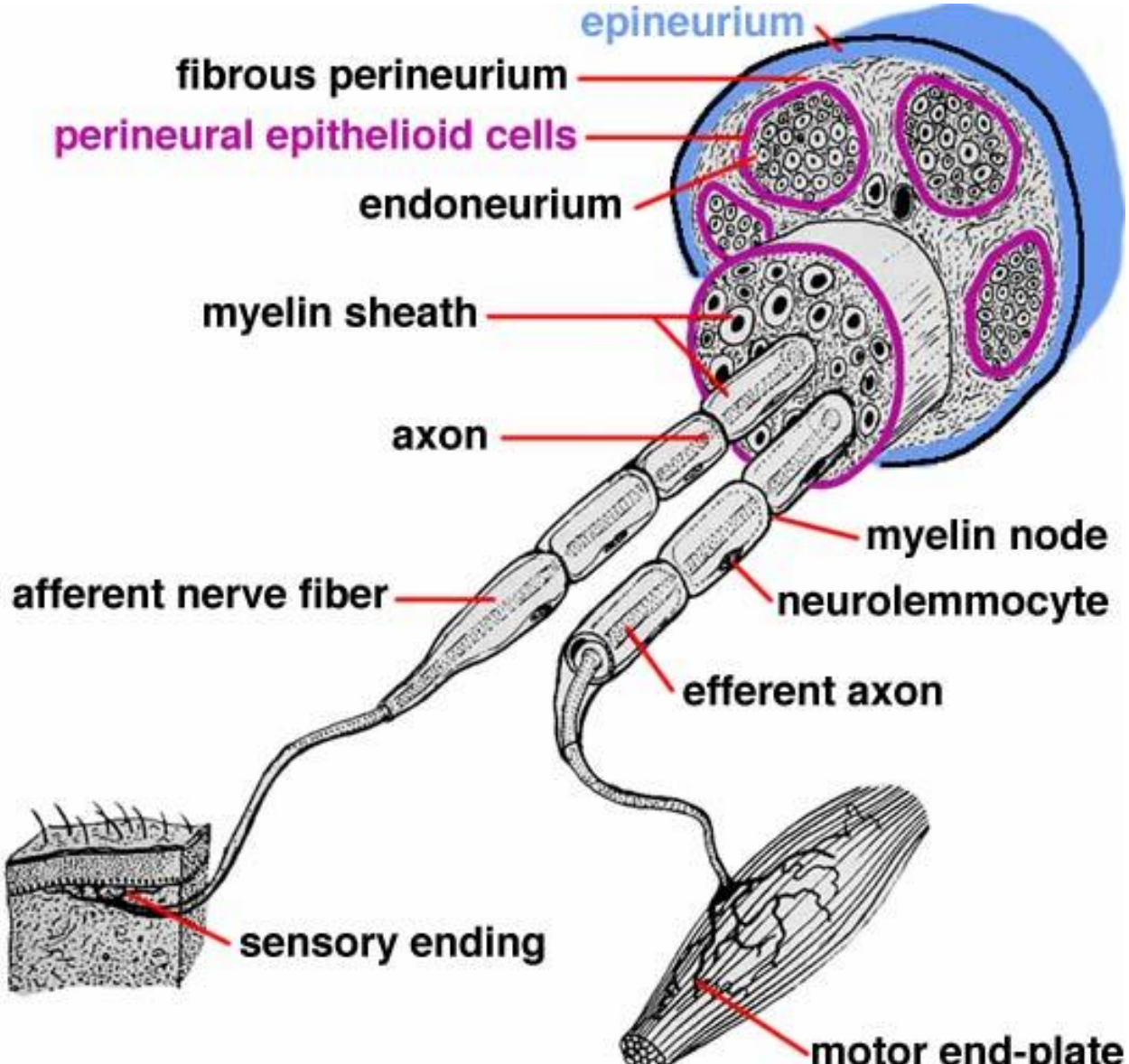
PERIPHERAL NERVOUS SYSTEM



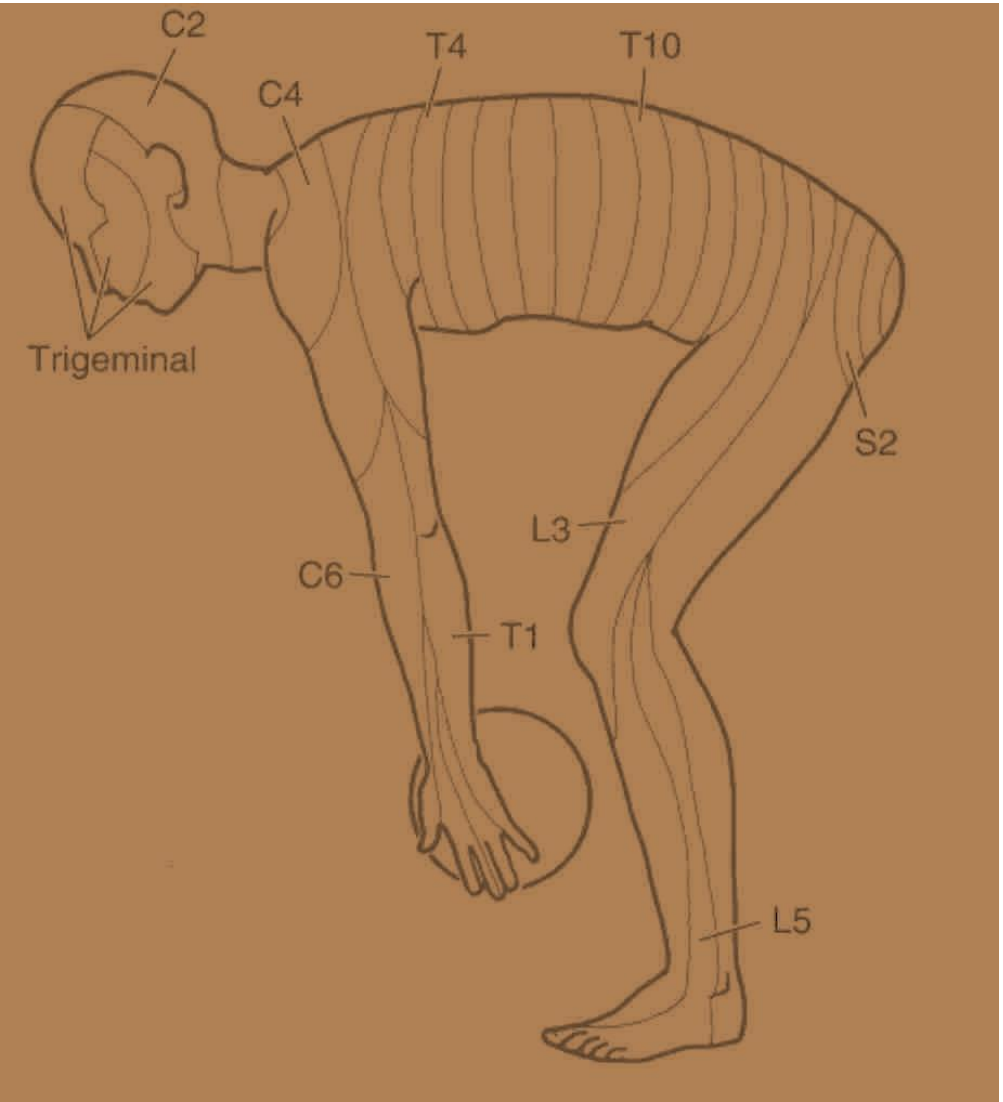
INTRODUCTION

- The function of the Peripheral Nervous System (PNS) is to carry impulses to and from the CNS
- **PNS** is comprised of structures that lie outside the pia membrane of the brainstem and the spinal cord
- **PNS constitutes of** cranial and spinal nerves;
- **Each segment of** the spinal cord pertains to a specific spinal nerve and contains four roots
- **The spinal nerves are 31 pairs**: **8** cervical, **12** thoracic, **5** lumbar, **5** sacral and **1** coccygeal;
- **Each spinal nerve contains** efferent (motor) neurons and afferent (sensory) neurons;
- **Further subdivided into** somatic nervous system (SNS) and autonomic nervous system (ANS),
- **Spinal nerve** (mixed peripheral nerve= funiculus): dorsal and anterior roots

Peripheral nerve

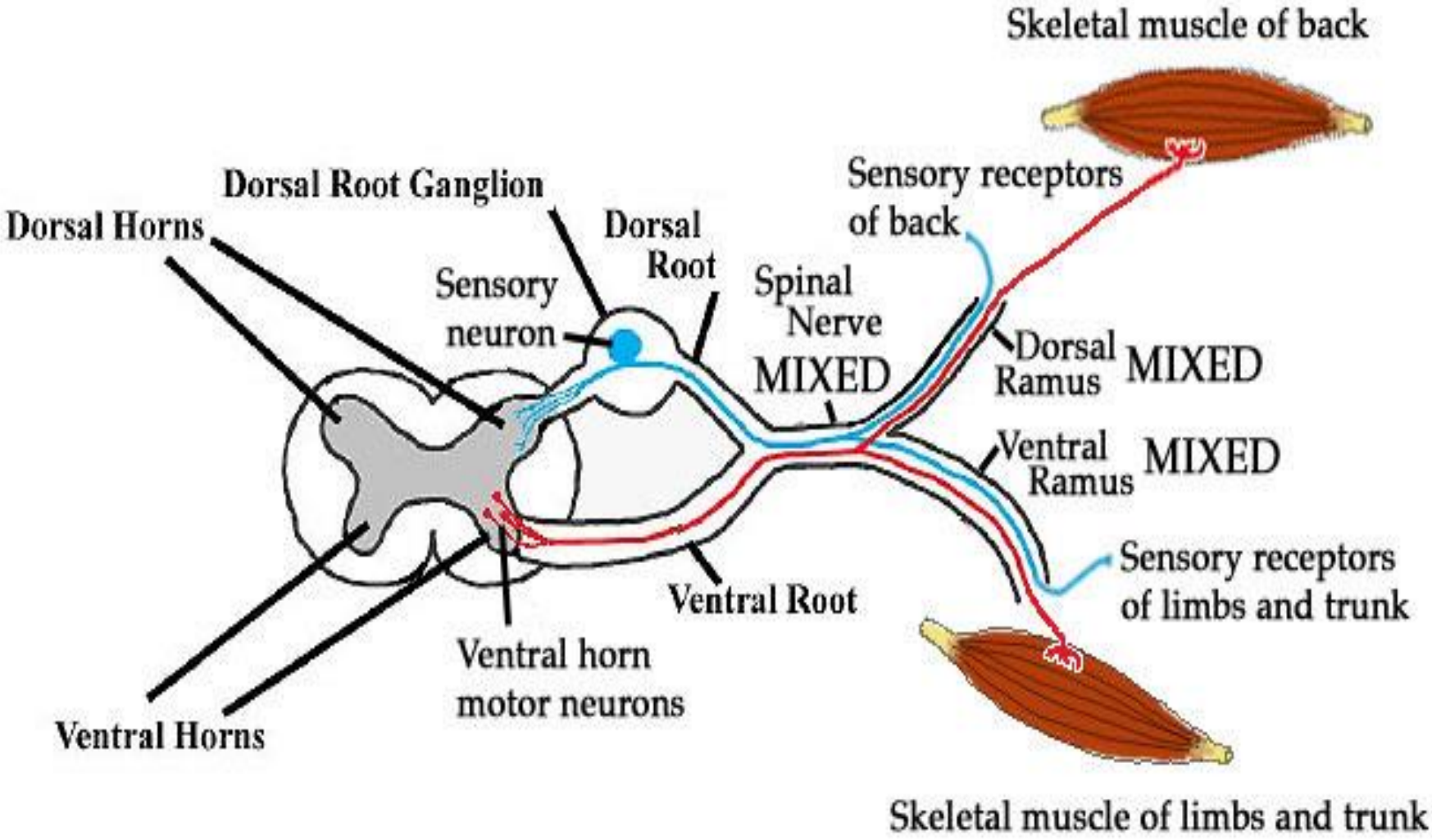


PERIPHERAL NERVOUS SYSTEM

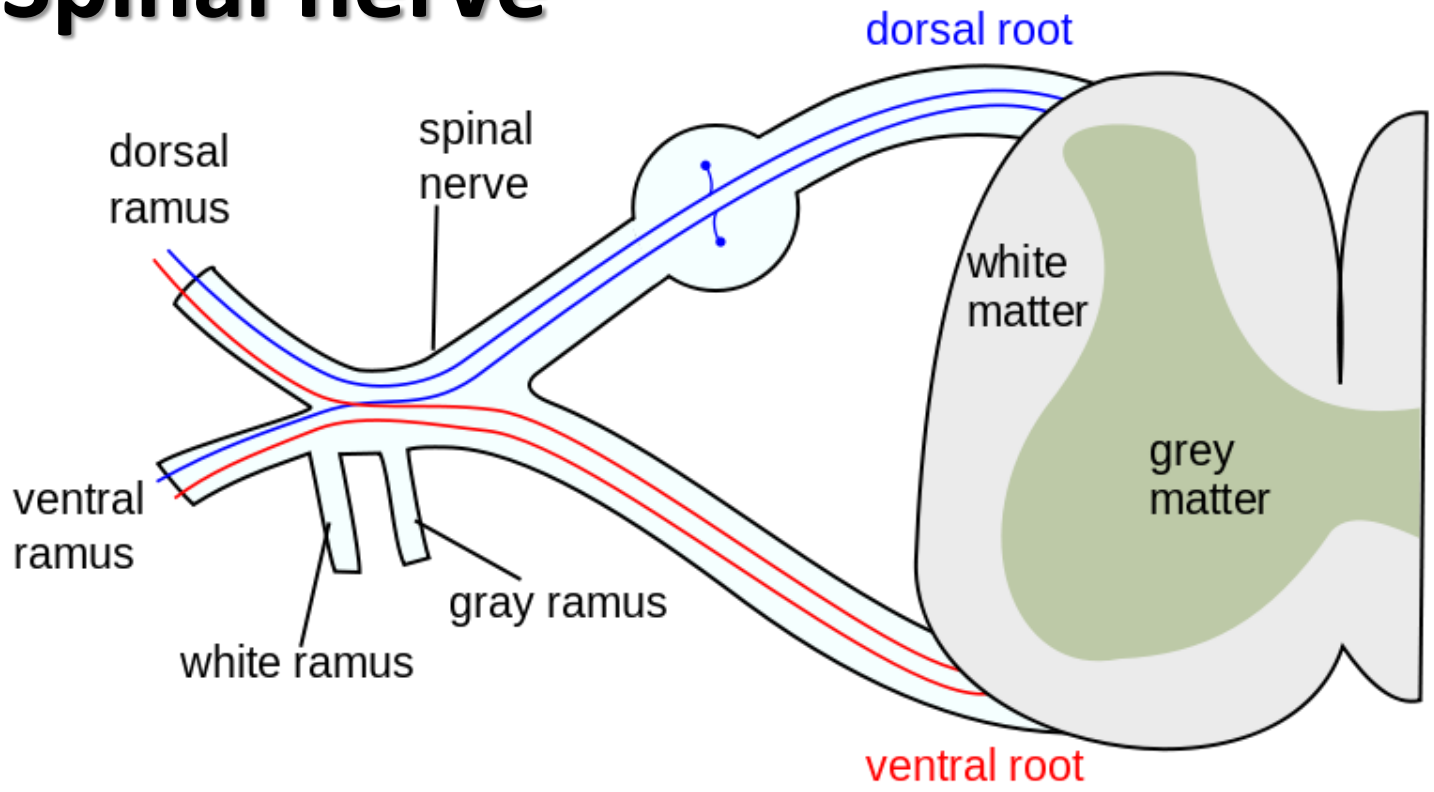


DERMATOMES AND MYOTOMES

- **Dermatome:**
  - Sensory component of each spinal nerve distributed to dermatome
- **Myotome:**
  - Refers to skeletal musculature innervated by motor axons in a given spinal root

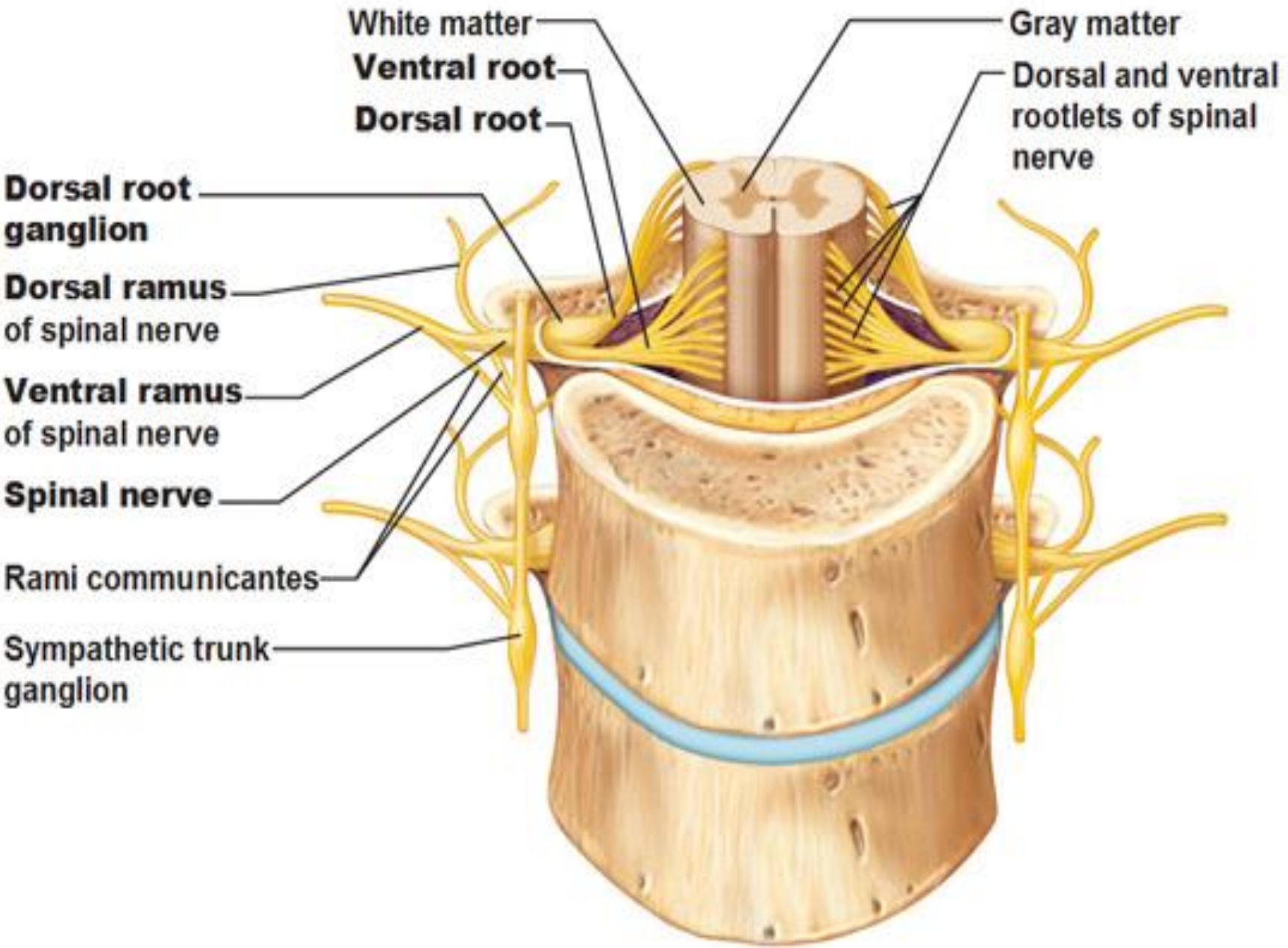

Skeletal muscle of back
Sensory receptors of back
Dorsal Root Ganglion
Dorsal Horns
Dorsal Root
Sensory neuron
Spinal Nerve
MIXED
Dorsal Ramus
MIXED
Ventral Ramus
MIXED
Sensory receptors of limbs and trunk
Ventral Root
Ventral horn motor neurons
Ventral Horns
Skeletal muscle of limbs and trunk

Spinal nerve



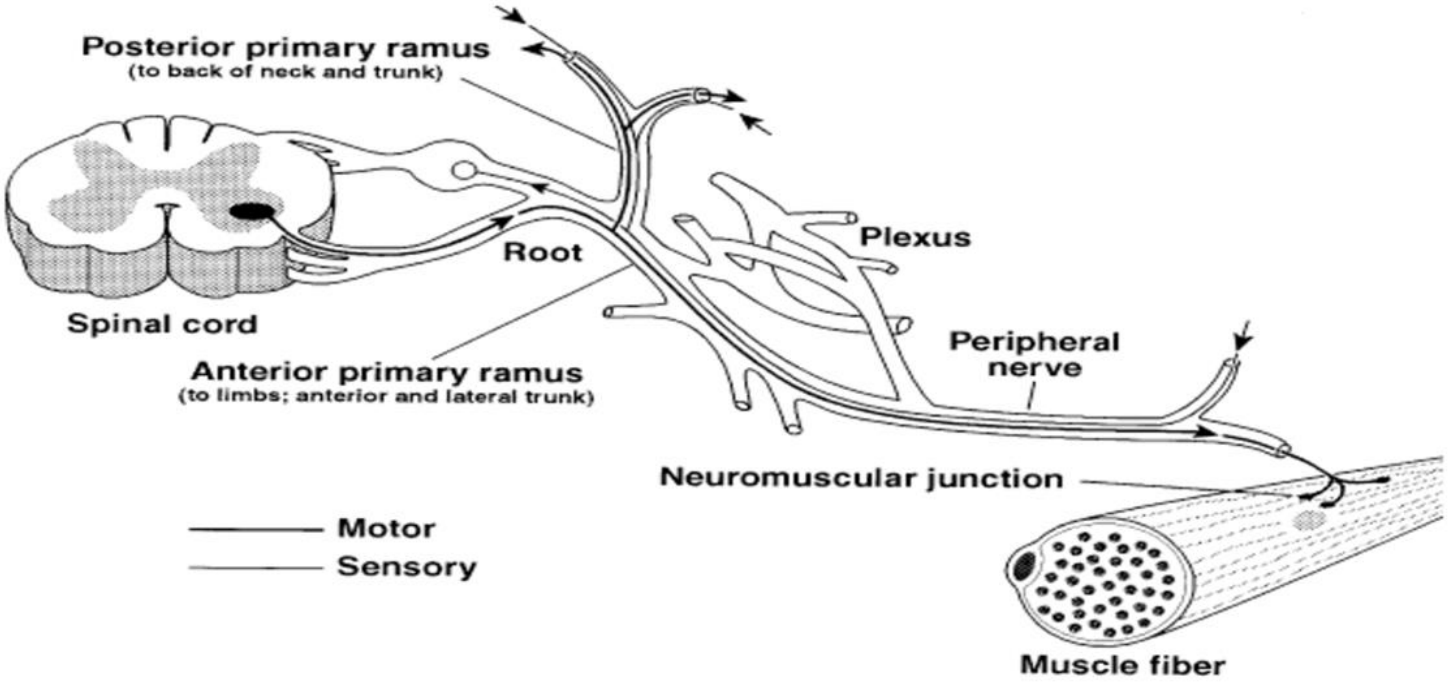
- **Dorsal ramus** – innervates skin and muscles of the spine;
- **Ventral ramus –** forms plexuses and peripheral nerves;
- **White communicating ramus** –preganglionic sympathetic fibers (Th1-L2);
- **Grey ramus** – postganglionic parasympathetic fibers for spinal nerves;
- **Meningeal ramus** – for meninges, venous and arterial vessels of the spinal cord

Spinal Nerves – Note position of dorsal root ganglion



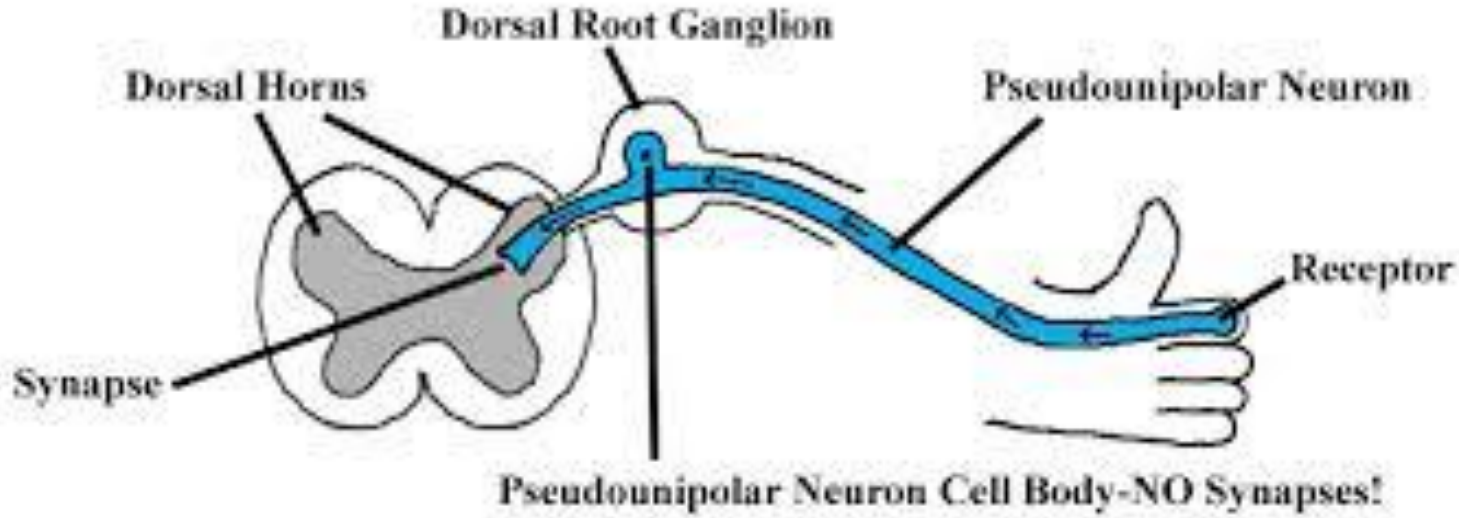
All ventral rami of the spinal nerves, except for thoracic nerves **T2-T11**, form **plexuses** with adjacent nerves on either side of the body. Spinal nerves **T2-T11** are called **intercostal nerves**

Disorders of the Peripheral Nervous System

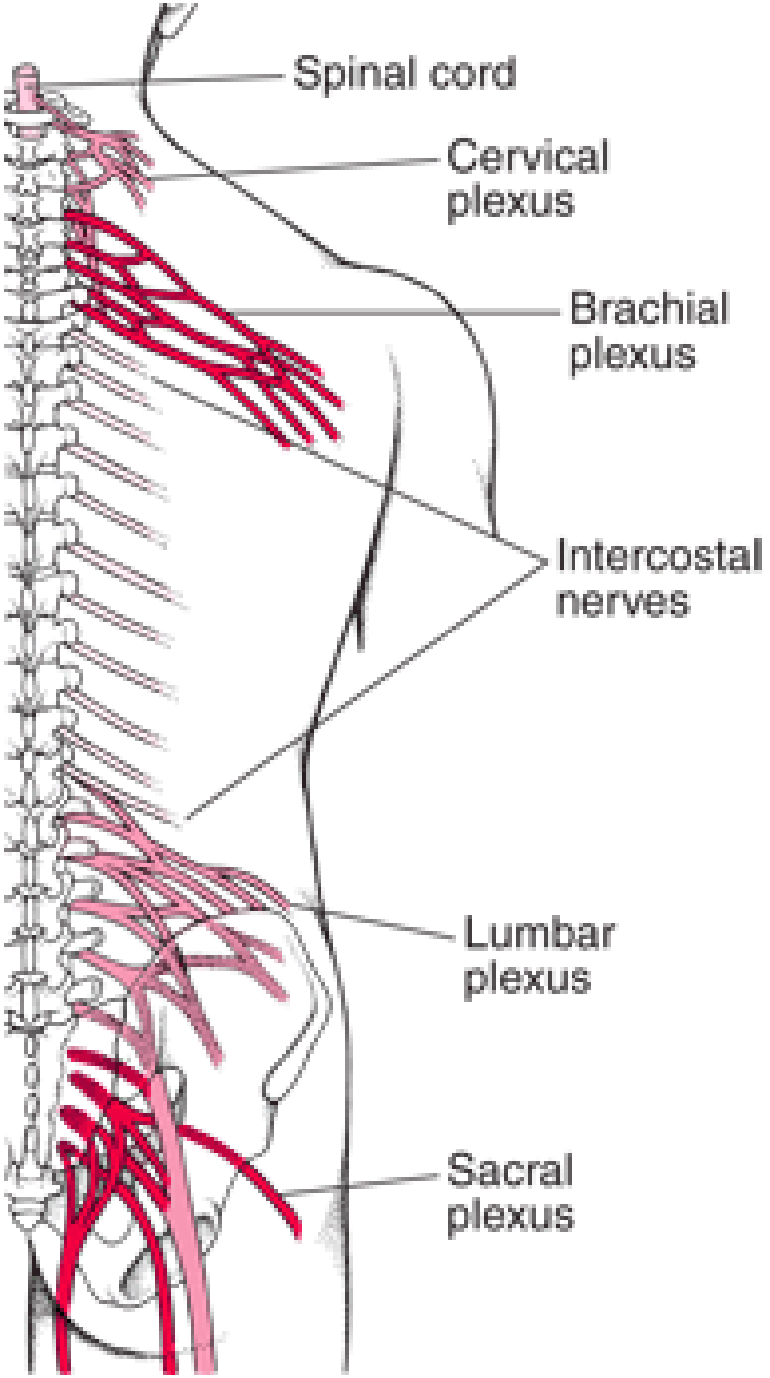


Syndrome of dorsal root damage – dermatomal type

- **Positive**: pain + paraesthesia
- **Negative**: hypoestesia and anaesthesia



VZV- lesion of the spinal ganglion: Herpes zoster

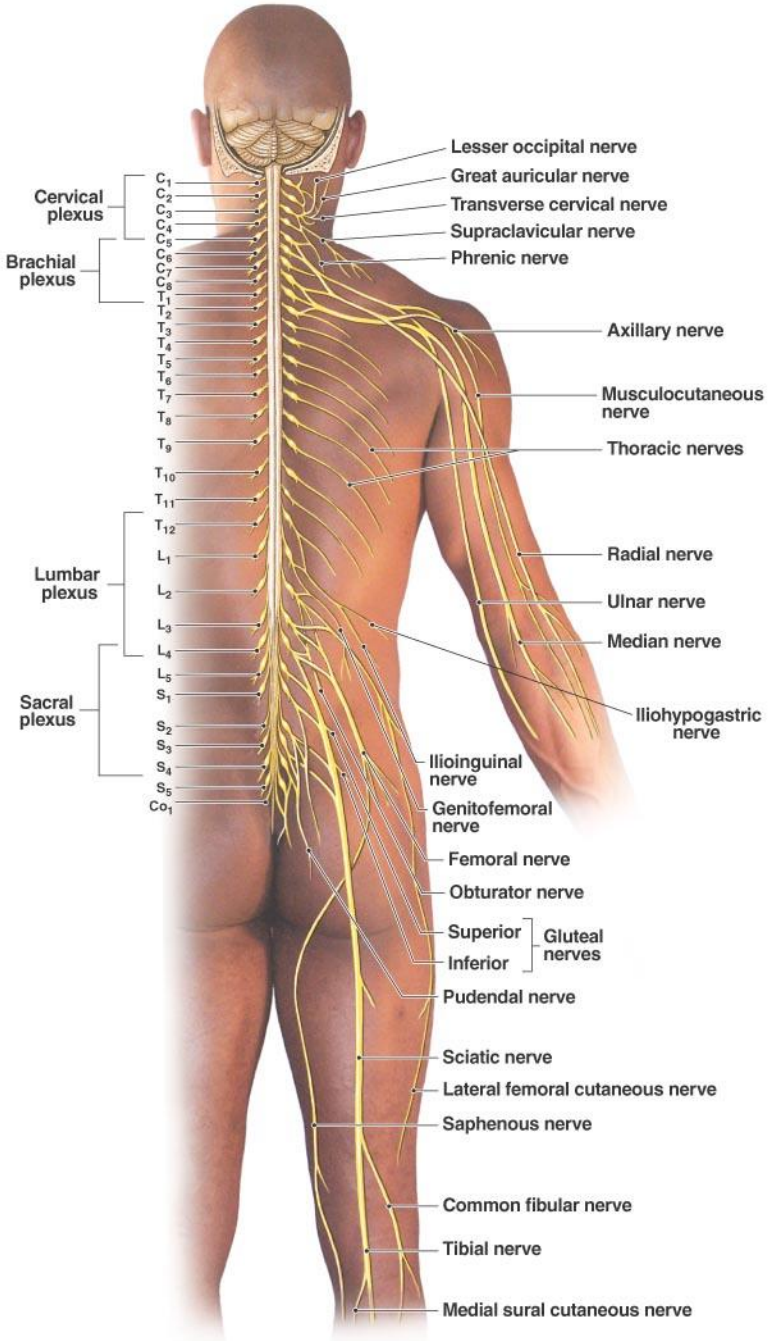


Plexus

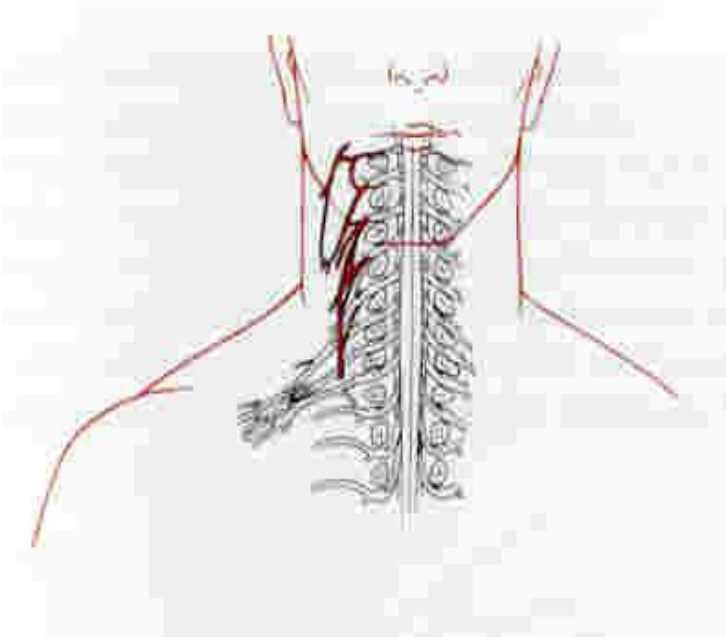
- Is a branching network of nerves
- **Cervical plexus** - serves the head, neck and shoulders
- **Brachial plexus** - serves the chest, shoulders, arms and hands
- **Lumbar plexus** - serves the back, abdomen, groin, thighs, knees, and calf muscles
- **Sacral plexus** - serves the pelvis, buttocks, genitals, thighs, calf muscles, and feet

Plexuses

- Cervical
- Brachial
- Lumbar
- Sacral



PERIPHERAL NERVOUS SYTEM



CERVICAL PLEXUS

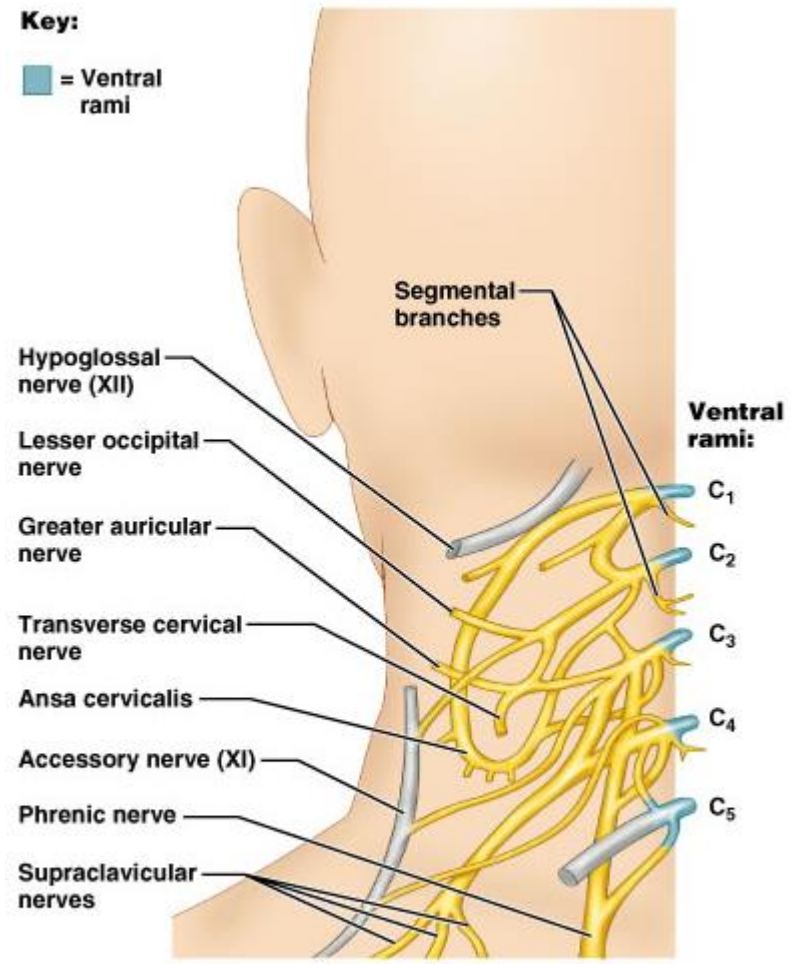
- Formed by spinal nerves C_1-C_4 with contributions from C_5
- Supplies skin and muscles of the head, neck, and upper part of the shoulders

CERVICAL PLEXUS

- **Cervical plexus** (C1-C4) branches
  - -Greater occipital nerve
  - -Lesser occipital nerve
  - -Greater auricular nerve
  - -Transverse nerve of neck
  - -Supraclavicular nerves

most important:

Phrenic nerve* (C3-C5) is the sole motor supply of diaphragm: neck injuries can be lethal (respiratory arrest = stop breathing)

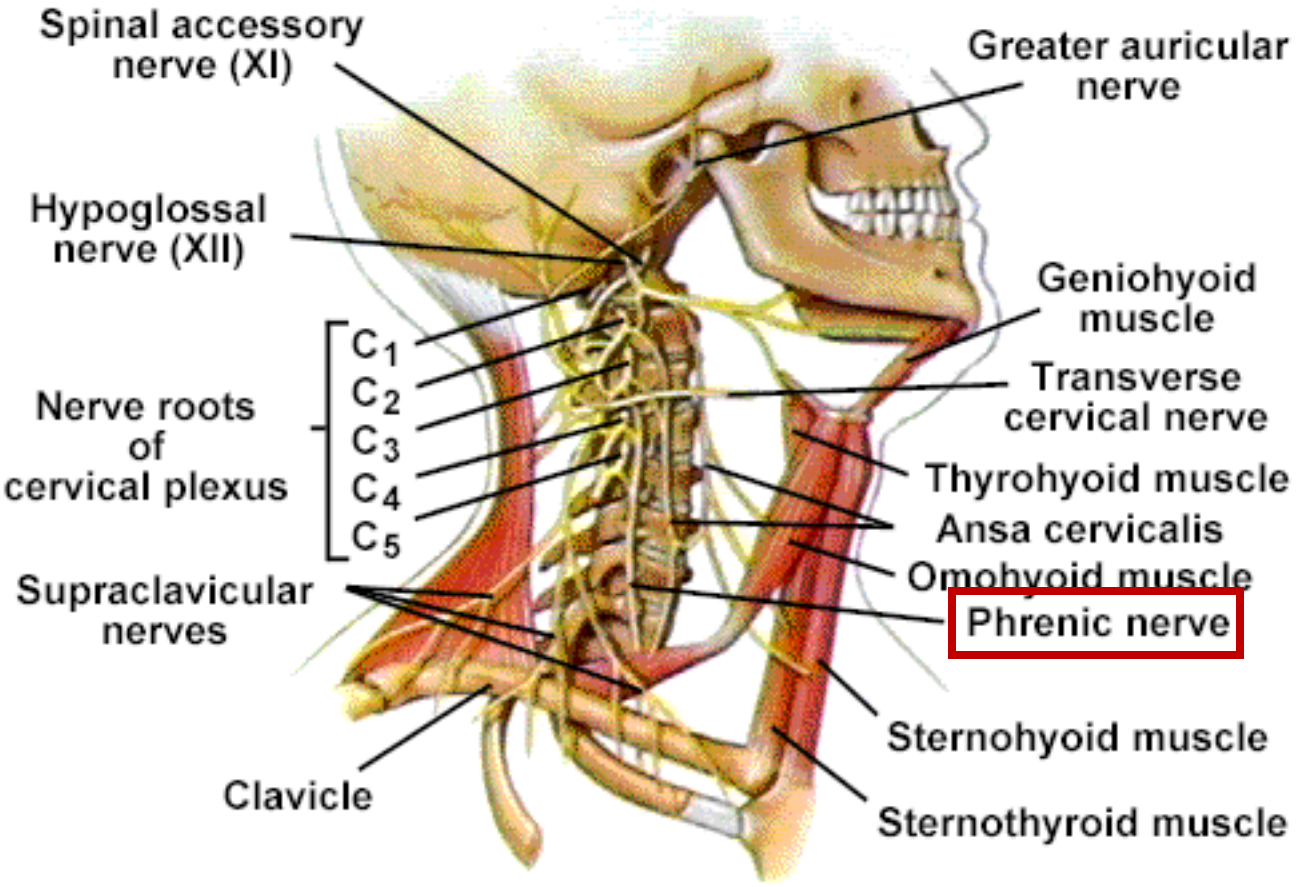


*

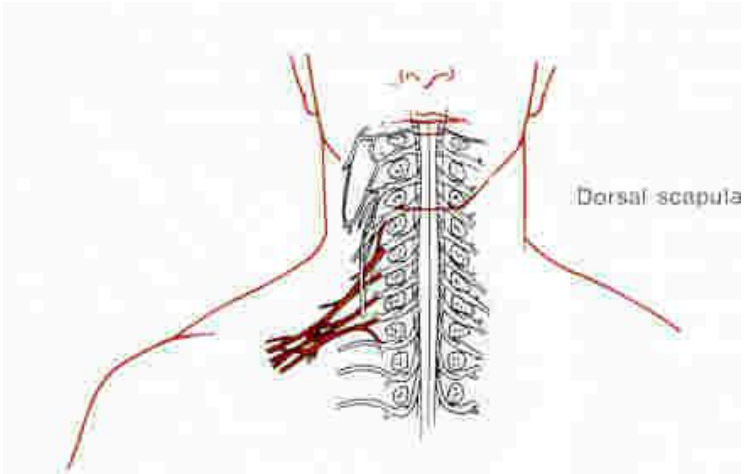
Cervical Plexus

Symptoms of Phrenic nerve lesion:

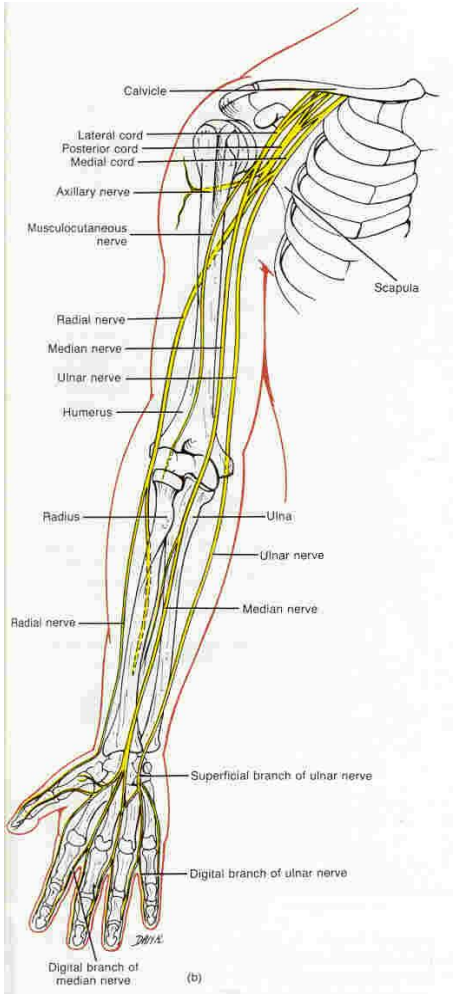
- ✓ Persistent singultus (hiccup)
- ✓ Unilateral paresis of the diaphragm
- ✓ Paradoxical movements of the diaphragm
- ✓ Bilateral lesion causes severe dyspnea



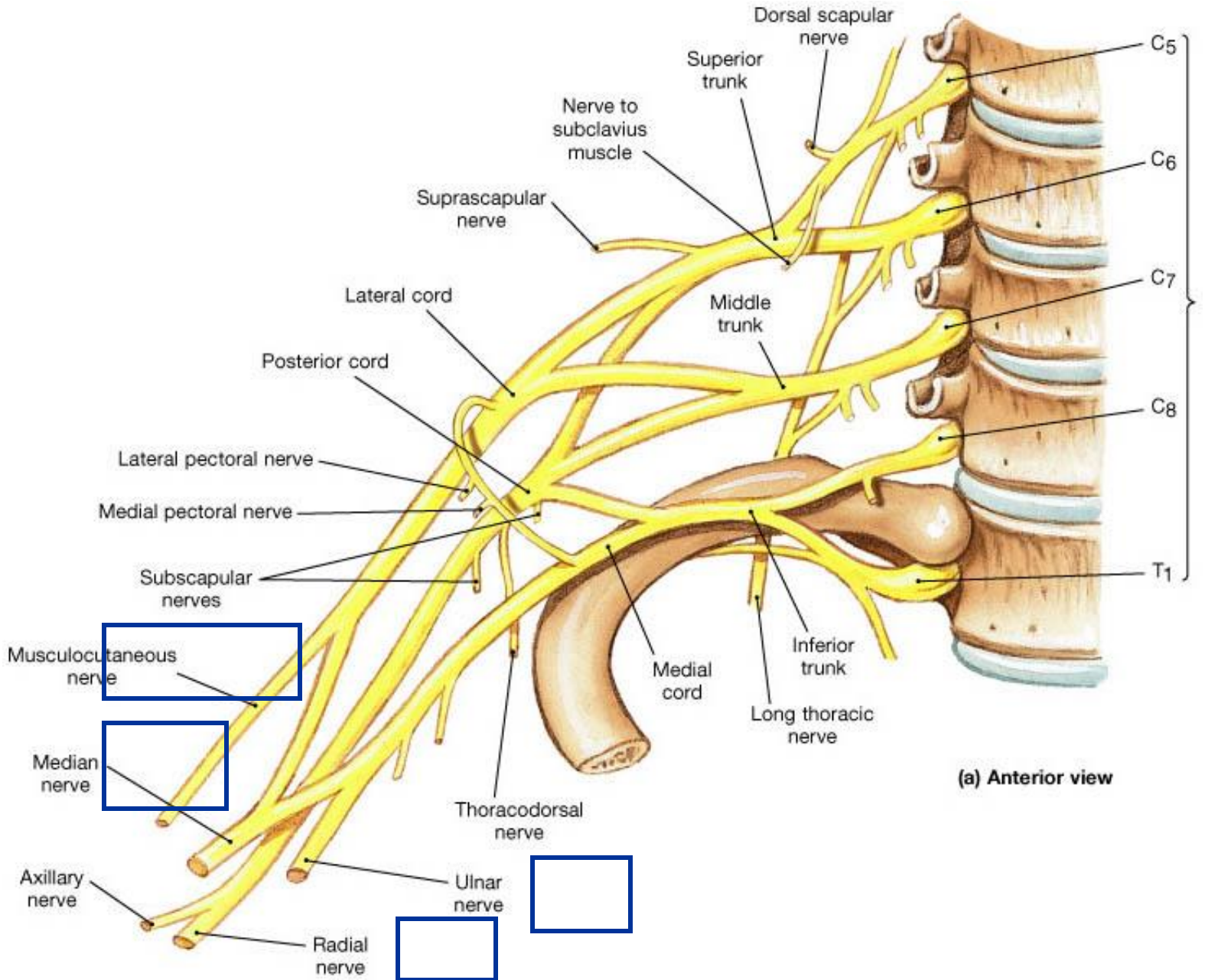
BRACHIAL PLEXUS



- Lies in the posterior triangle of the neck between the scalenus ant and medius muscles
- Formed by spinal nerves C_5-C_8 and T_1
- Constitutes the entire nerve supply for upper extremities and shoulder region

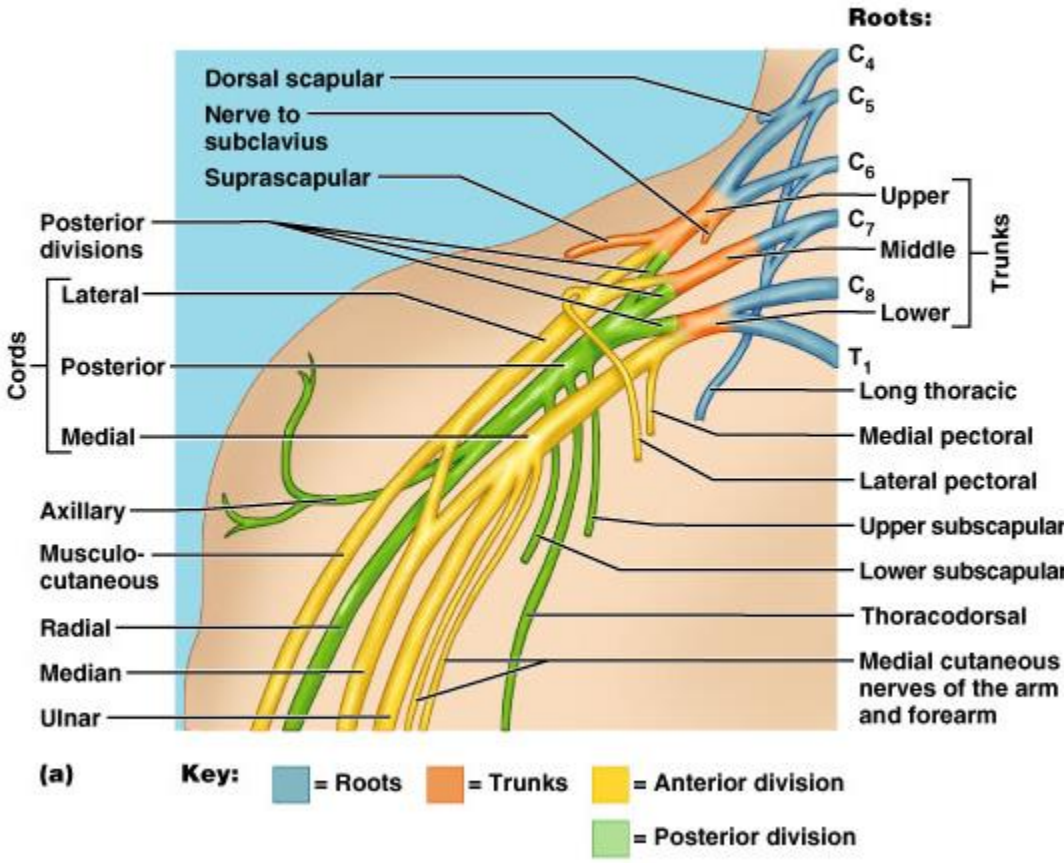


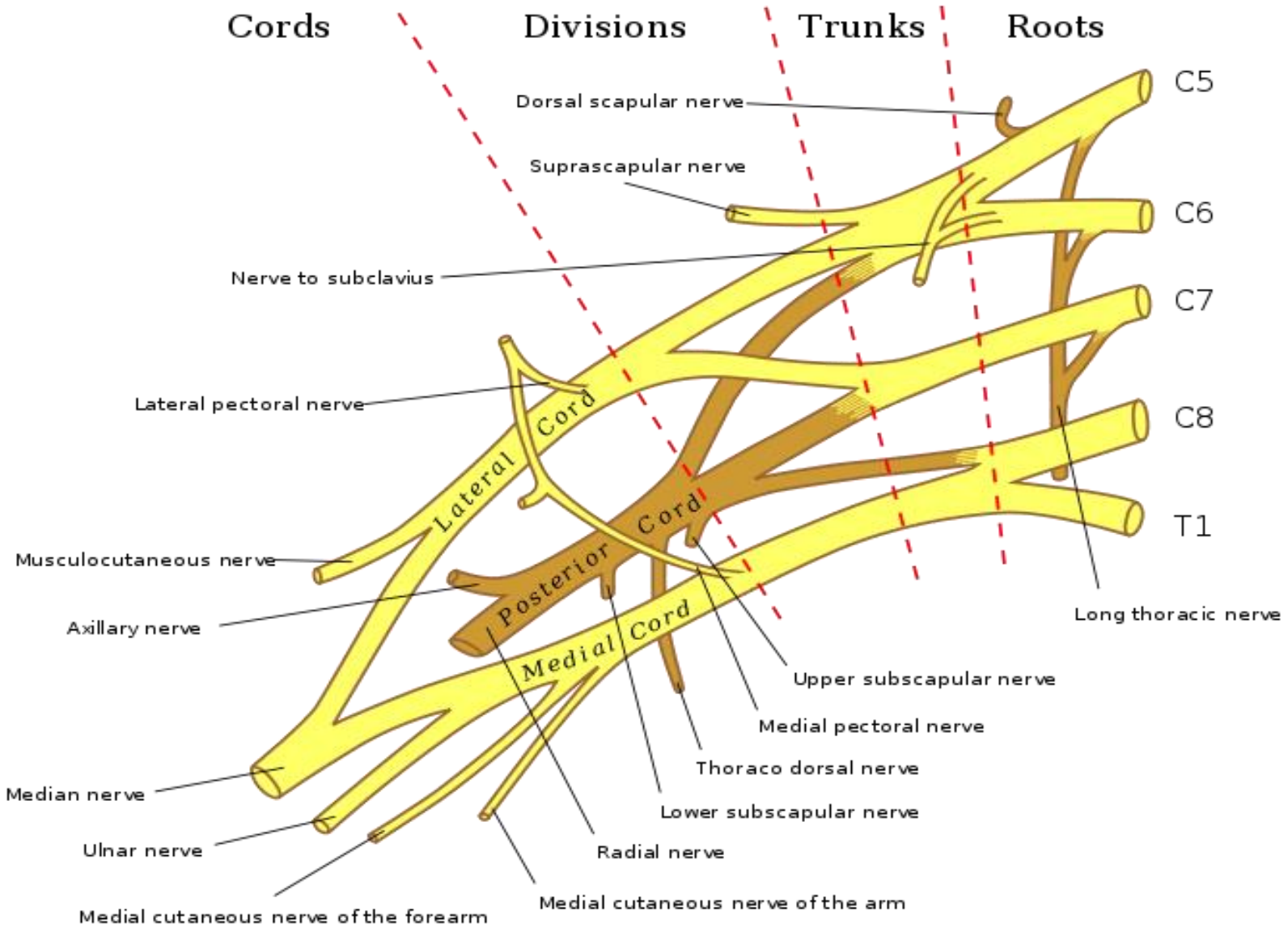
Brachial Plexus

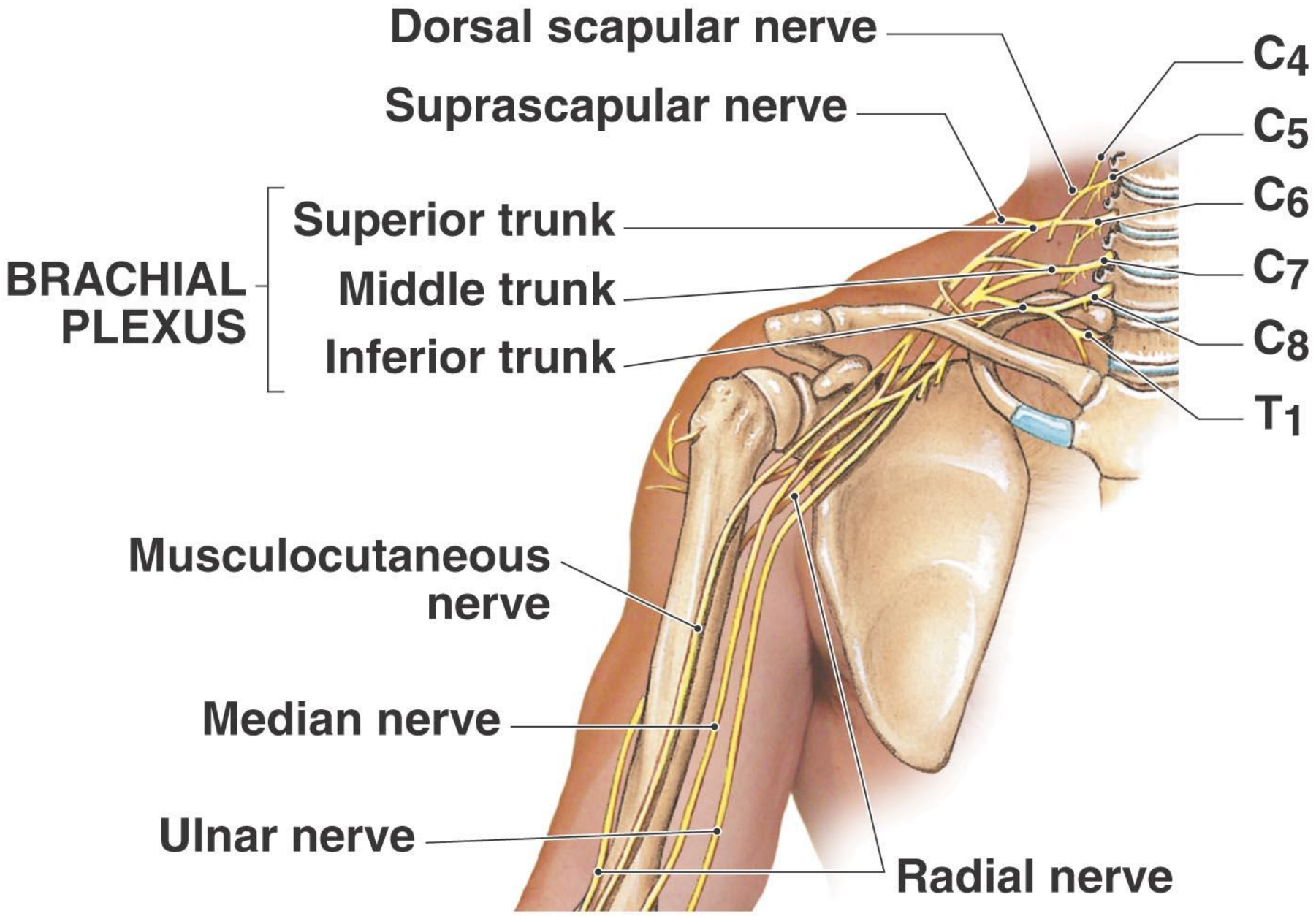


Brachial plexus

- Undivided ant. primary rami;
- **Trunks**: upper, middle, lower;
- Divisions of the trunks: anterior and posterior;
- **Cords**: lateral, posterior and medial;
- **Main nerves** (be able to label):
  - **Musculocutaneous** – to arm flexors
  - **Median** – anterior forearm muscles and lateral palm
  - **Ulnar** – anteromedial muscles of forearm and medial hand
  - **Axillary** – to deltoid and teres minor
  - **Radial** – to posterior part of limb



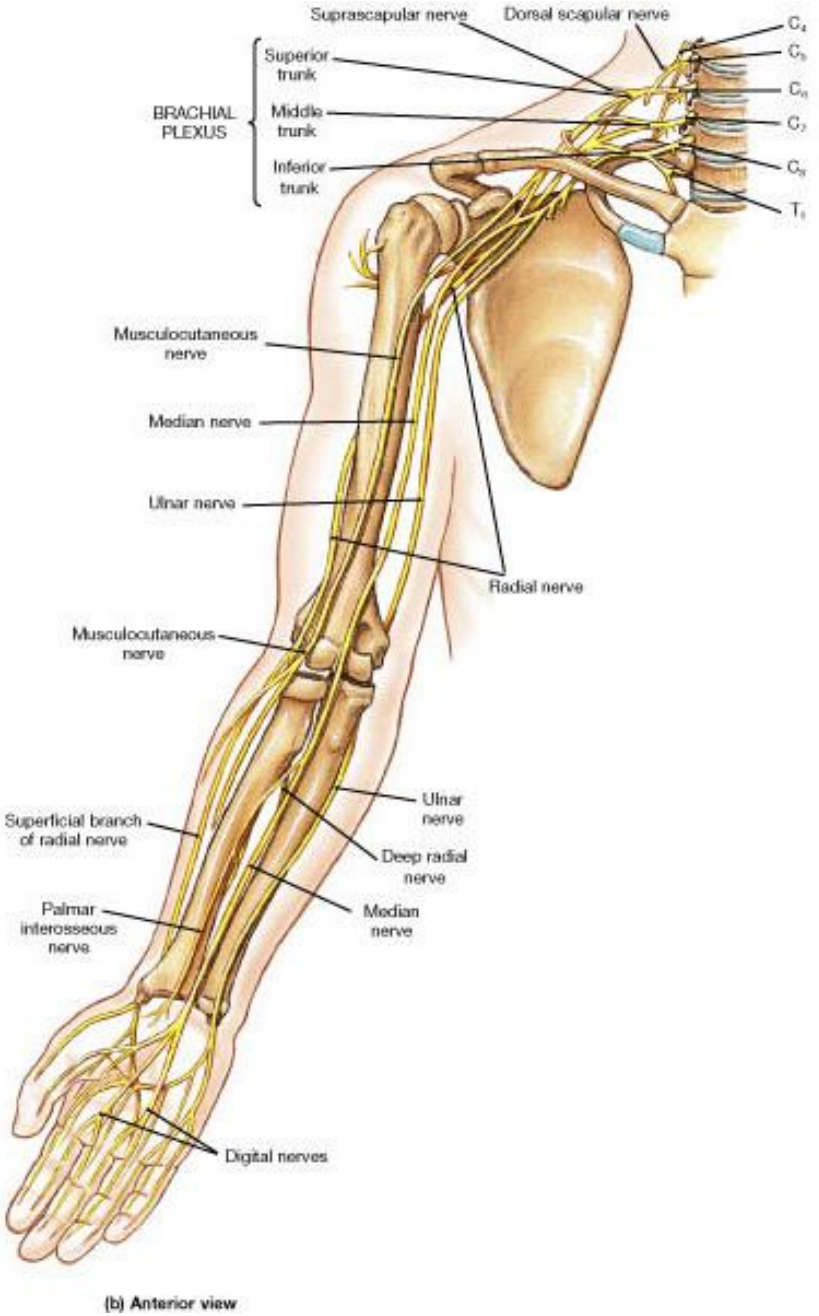

Cords
Divisions
Trunks
Roots
C5
C6
C7
C8
T1
Dorsal scapular nerve
Suprascapular nerve
Nerve to subclavius
Lateral pectoral nerve
Lateral Cord
Posterior Cord
Medial Cord
Musculocutaneous nerve
Axillary nerve
Median nerve
Ulnar nerve
Medial cutaneous nerve of the forearm
Radial nerve
Medial cutaneous nerve of the arm
Lower subscapular nerve
Thoraco dorsal nerve
Medial pectoral nerve
Upper subscapular nerve
Long thoracic nerve

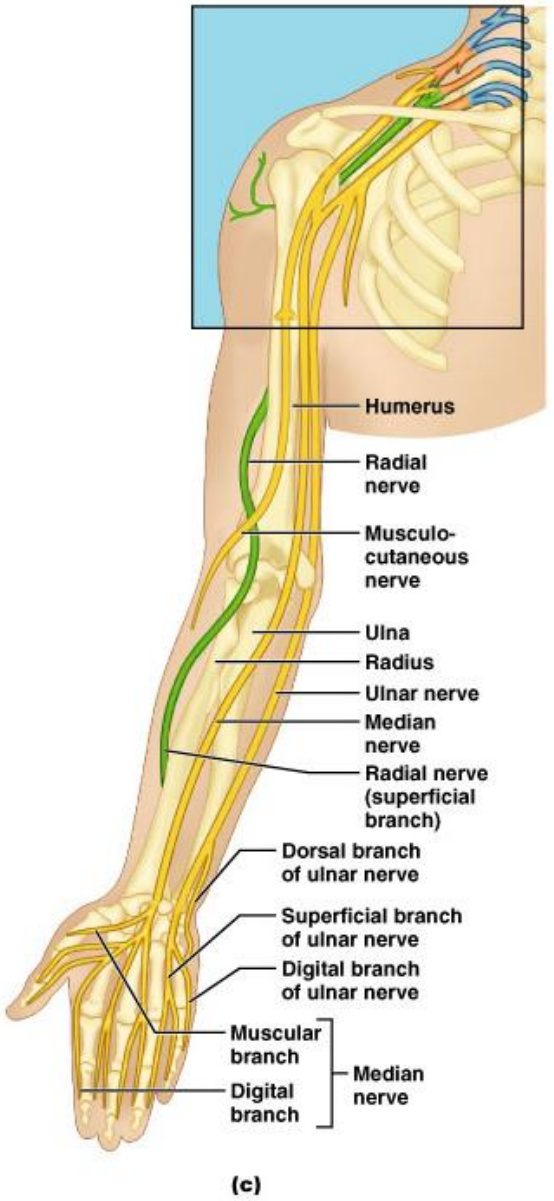


(b) Anterior view

Nerves of the Arm

- **Musculocutaneous nerve** – innervates biceps and brachialis muscles
- **Median nerve -** innervates lateral flexors
- **Ulnar nerve -** innervates medial flexors
- **Radial nerve -** innervates forearm extensors





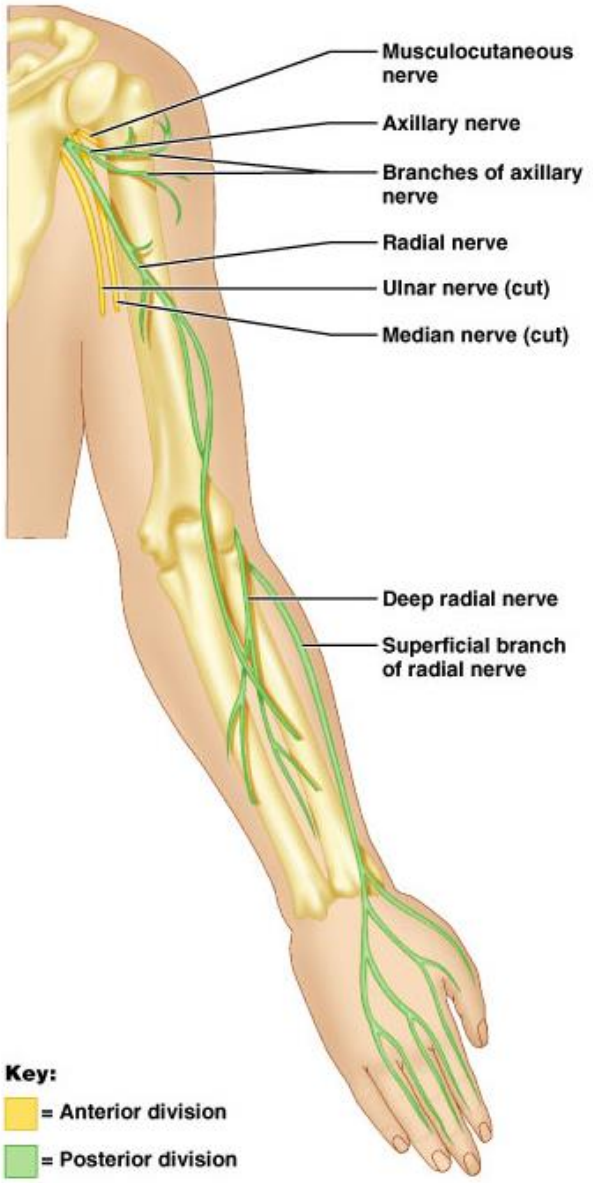
Musculo-cutaneous

Median

Ulnar

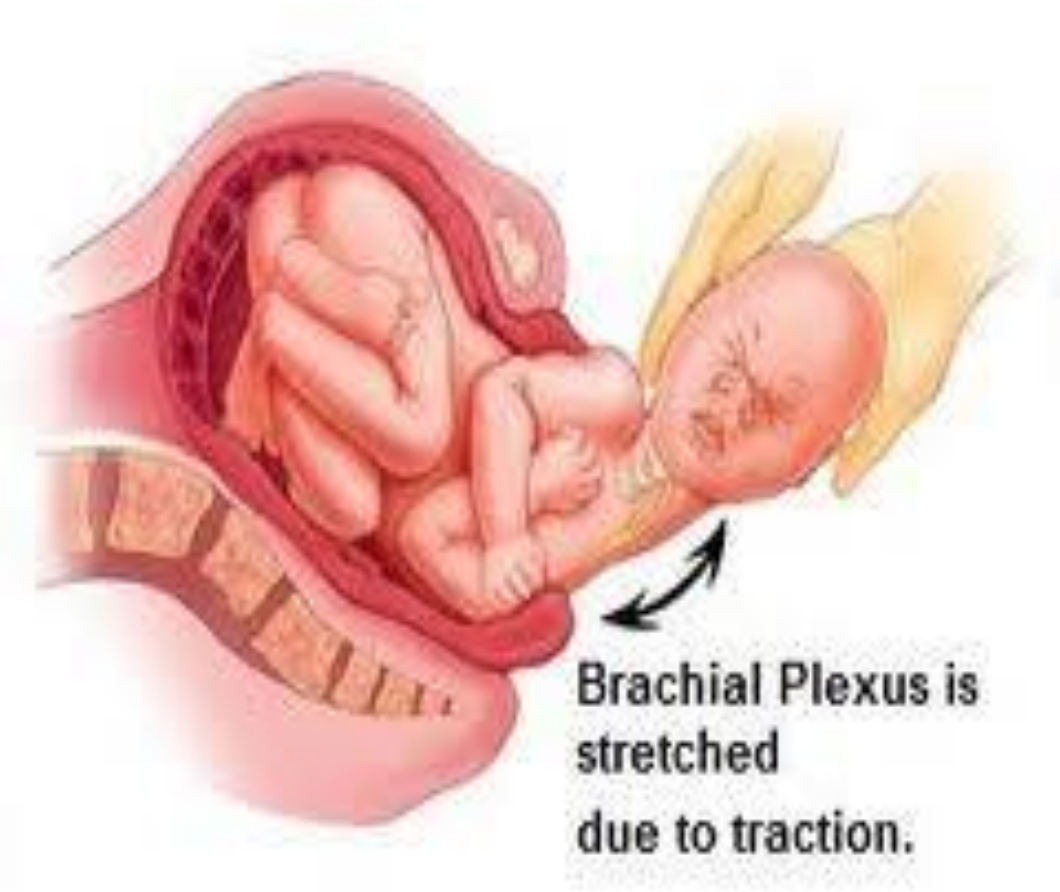
Axillary

Radial



- **Brachial plexus injuries**
  - Common in contact sports, a result from auto- or motorcycle accidents or falls;
  - In babies brachial plexus could be damaged during birth;
  - Other conditions: inflammation, tumors, may also affect the brachial plexus
  - Minor injuries may be resolved without specific treatment, severe brachial plexus injuries often require surgical repair

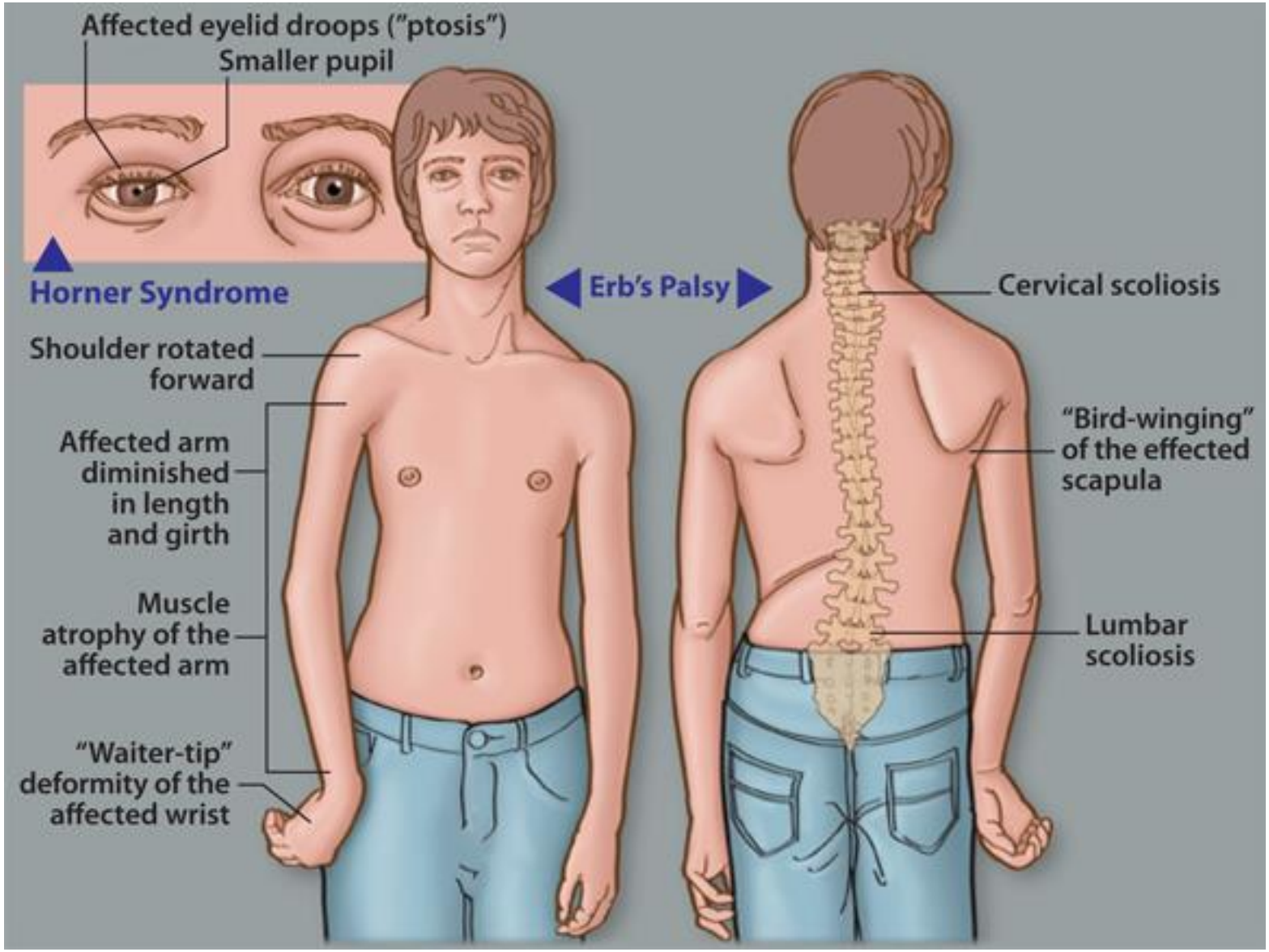
Erb's palsy



Erb's palsy

- **Erb's palsy** (**Erb-Duchenne Palsy**):
  - Paralysis of the arm caused by injury of the **upper trunk C5-C6** ;
  - A common complication from shoulder distortion during a difficult birth;
  - The paralysis is either **partial** or **complete**;
  - The signs of **Erb's palsy** include: loss of sensation in the arm and paralysis and atrophy of the deltoid, biceps, and brachial muscles;
  - In complete lesion of the plexus the arm hangs by the side and is rotated medially; the forearm is extended and pronated. The arm cannot be raised from the side; all power of flexion of the elbow and supination of the forearm is lost, commonly called "**waiter's tip."**

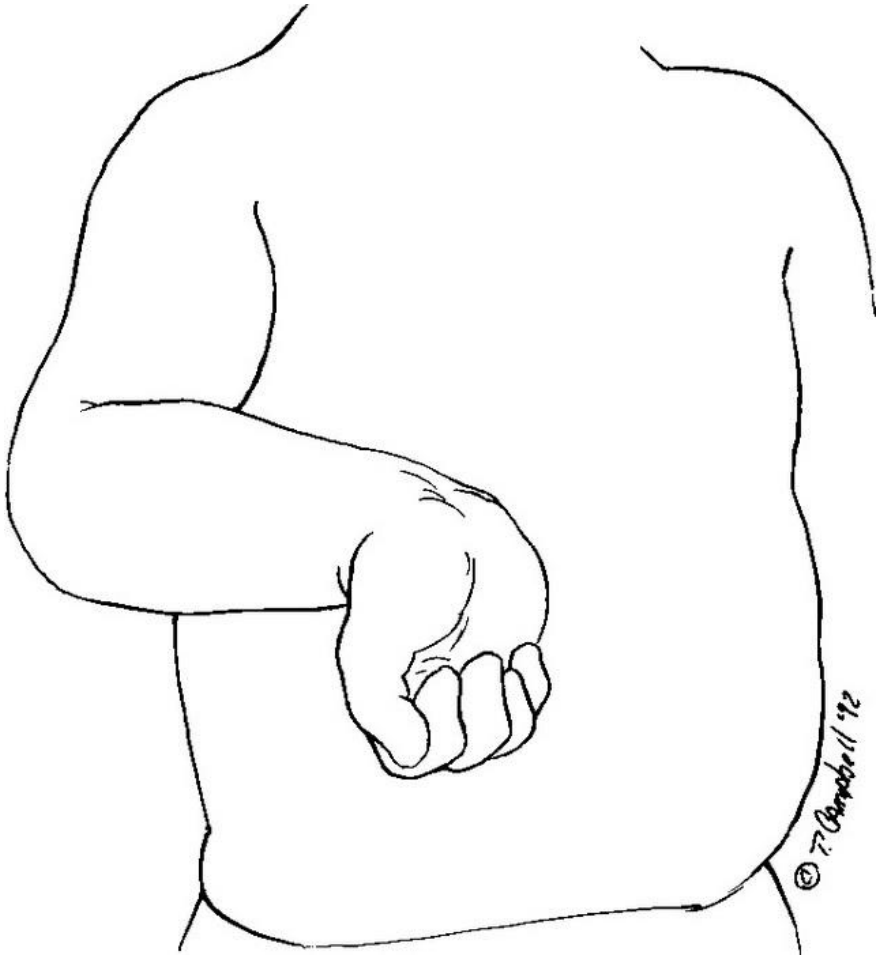
Brachial plexus injury



Klumpke's paralysis

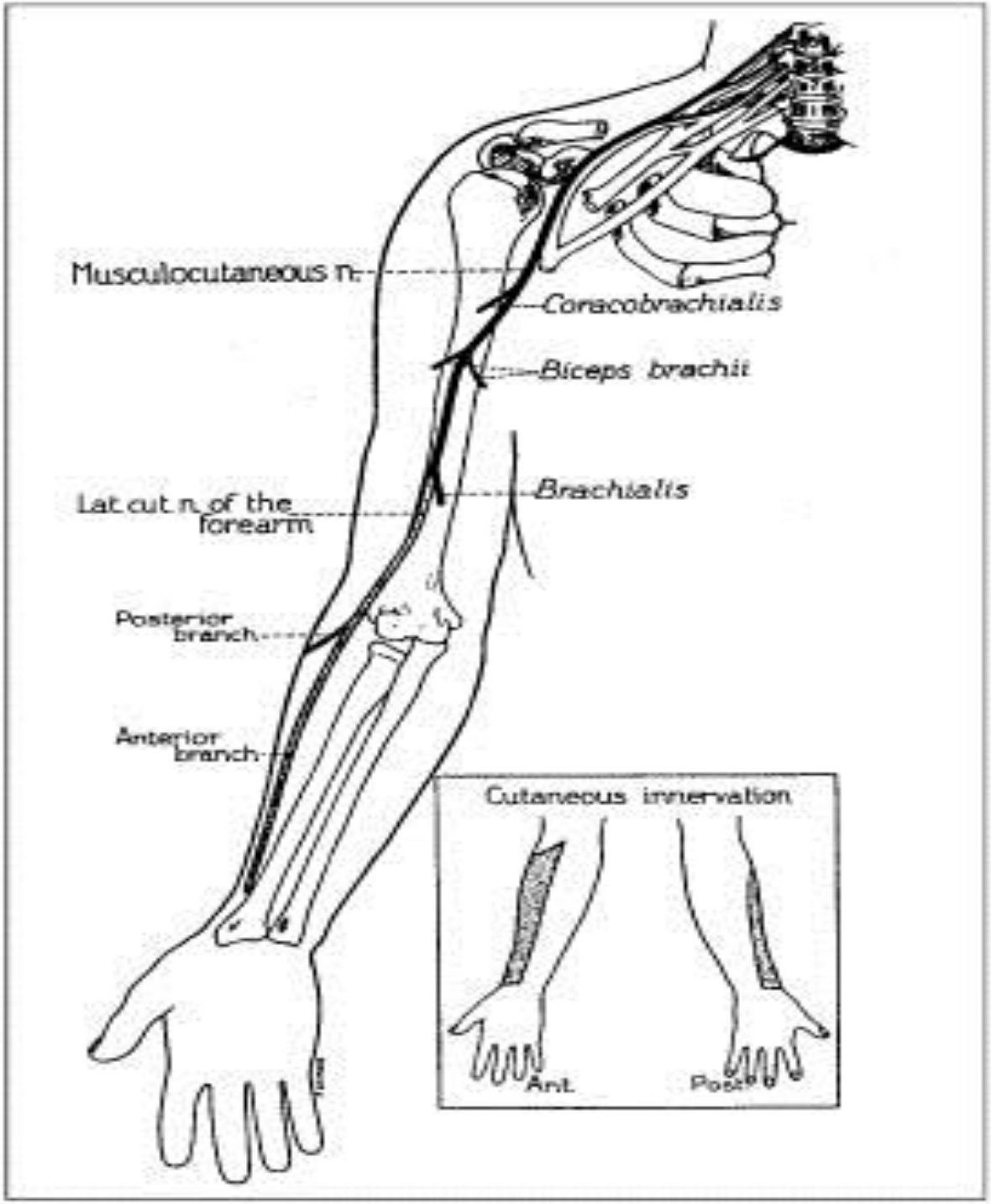
- **Klumpke's paralysis** is due to a brachial plexus injury involving **C8 and T1** roots of the **lower trunk**;
- The paralysis affects principally the intrinsic muscles of the hand and the flexors of the wrist and fingers;
- The injury can result from difficulties in childbirth: a traumatic vaginal delivery with shoulder distortion, especially when the infant is of large weight;
- Symptoms include ”**claw hand**”, paralysis of intrinsic hand muscles, and ulnar nerve distribution numbness.
- Involvement of **T1 may result in Horner's syndrome** with ptosis, miosis and enophthalmos.

Klumpke's paralysis



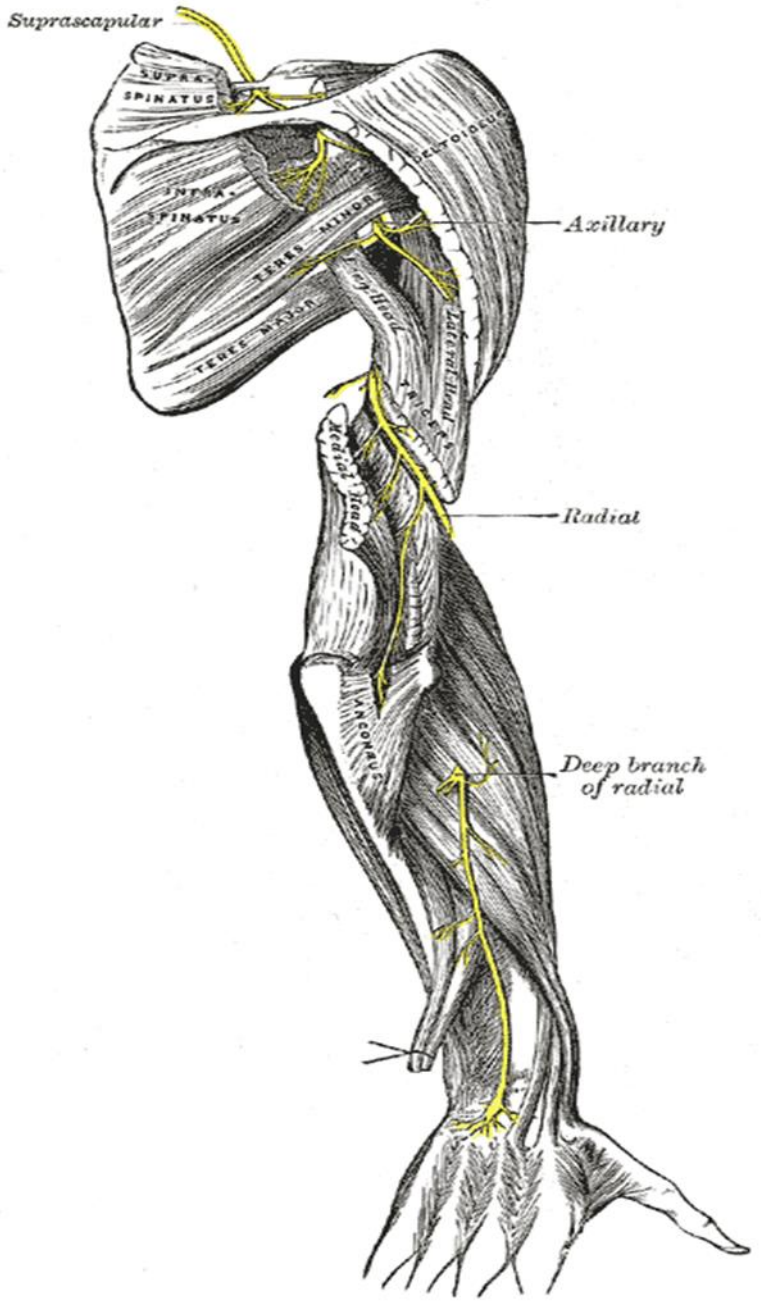
Musculocutaneous nerve

- The **musculocutaneous nerve** arises from the **lateral cord** (C5, C6, C7 roots);
- Innervates the Coracobrachial, Biceps brachial, and the greater part of the Brachial muscles;
- Musculocutaneous nerve can be compressed due to hypertrophy or entrapment between the biceps aponeurosis and brachial fascia or it may be injured through stretch as occurs in dislocations and sometimes in surgery;
- **Isolated injury causes:**
  - weakness of elbow flexion and forearm supination;
  - Depressed or absent Biceps reflex;
  - A discrete sensory disturbance is present on the radial side of the forearm;
- The nerve is usually involved in an upper brachial plexus palsy.


Musculocutaneous n.
Coracobrachialis
Biceps brachii
Brachialis
Lat.cut.n. of the forearm
Posterior branch
Anterior branch
Cutaneous innervation
Ant.
Post.

Radial nerve

- The **radial nerve** supplies the triceps brachial muscle of the arm and all 12 muscles in the posterior osteo-fascial compartment of the forearm, as well as the associated joints and overlying skin.
- It originates from the **posterior cord** of the brachial plexus (**C6, C7, C8**).
- Divides into a **deep branch** (which becomes the posterior interosseous nerve), and continues as the **superficial branch** which goes on to innervate the dorsum of the hand.




Radial nerve sensory distribution
Radial Nerve Sensory Innervation
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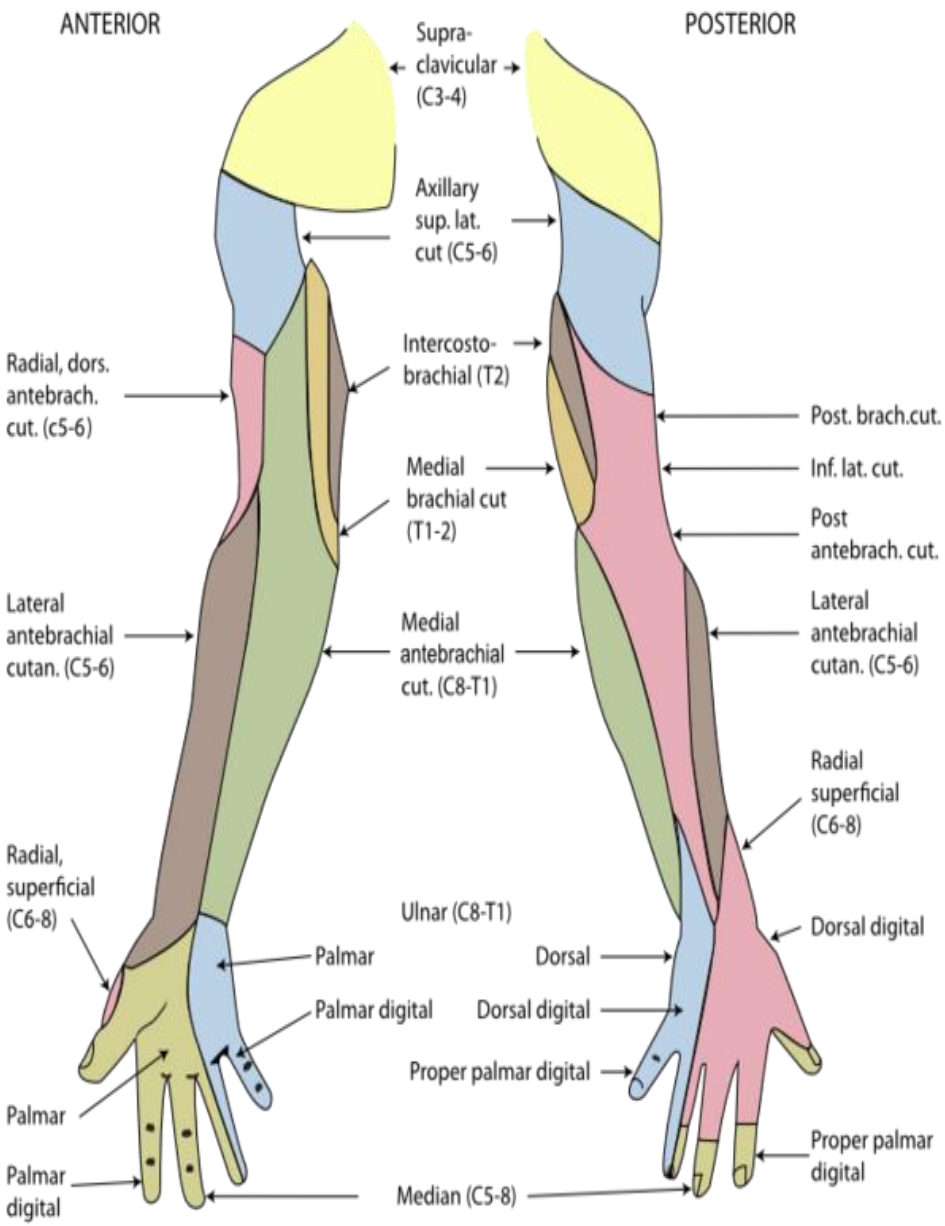
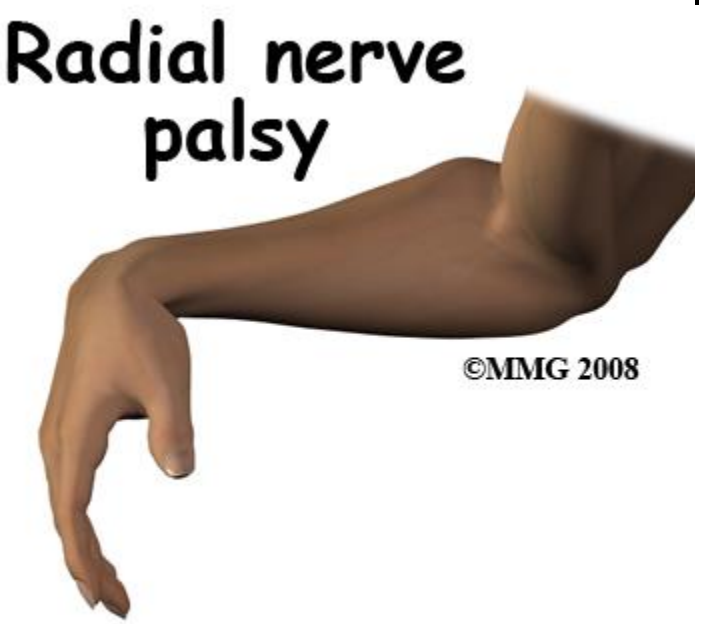
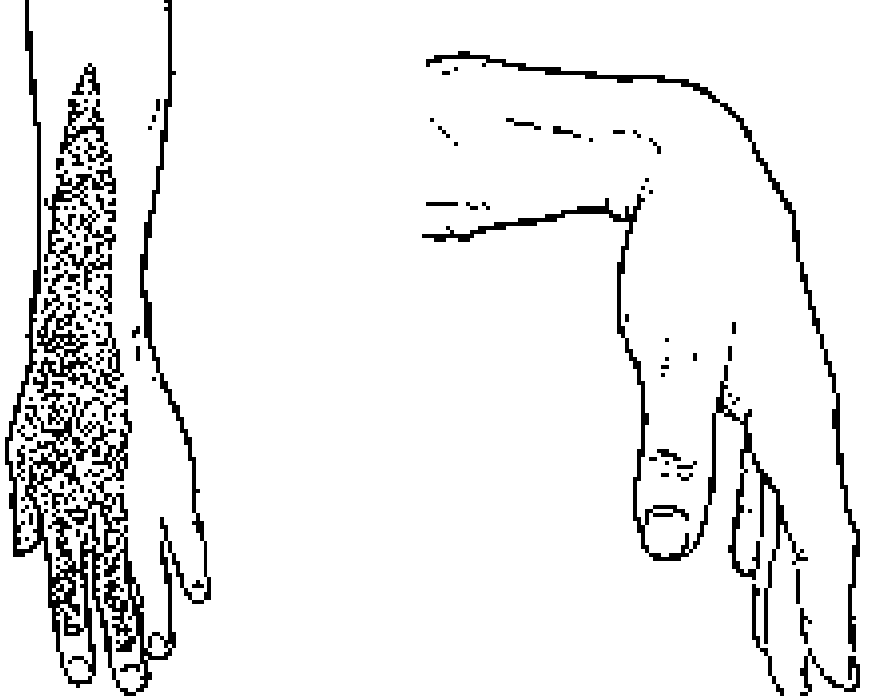

ANTERIOR
POSTERIOR
Supra-clavicular (C3-4)
Axillary sup. lat. cut (C5-6)
Intercosto-brachial (T2)
Radial, dors. antebrach. cut. (c5-6)
Medial brachial cut (T1-2)
Lateral antebrachial cutan. (C5-6)
Medial antebrachial cut. (C8-T1)
Radial, superficial (C6-8)
Palmar
Palmar digital
Palmar
Palmar digital
Ulnar (C8-T1)
Median (C5-8)
Post. brach.cut.
Inf. lat. cut.
Post antebrach. cut.
Lateral antebrachial cutan. (C5-6)
Radial superficial (C6-8)
Dorsal digital
Dorsal
Dorsal digital
Proper palmar digital
Proper palmar digital

Radial nerve injury

- **Injury**
  - "Crutch palsy," caused by improper use of crutches
  - Fracture of the humerus bone
  - Long-term or repeated constriction of the wrist (for example, from wearing a tight watch strap)
  - Pressure caused by hanging the arm over the back of a chair ("Saturday night palsy" if caused by drinking too much alcohol and falling asleep in that position)
  - Pressure to the upper arm from arm positions during sleep or coma
  - Pinching of the nerve during deep sleep, such as when a person is intoxicated
  - Long-term pressure on the nerve, usually caused by swelling or injury of nearby body structures





Wrist drop

Radial nerve injury symptoms

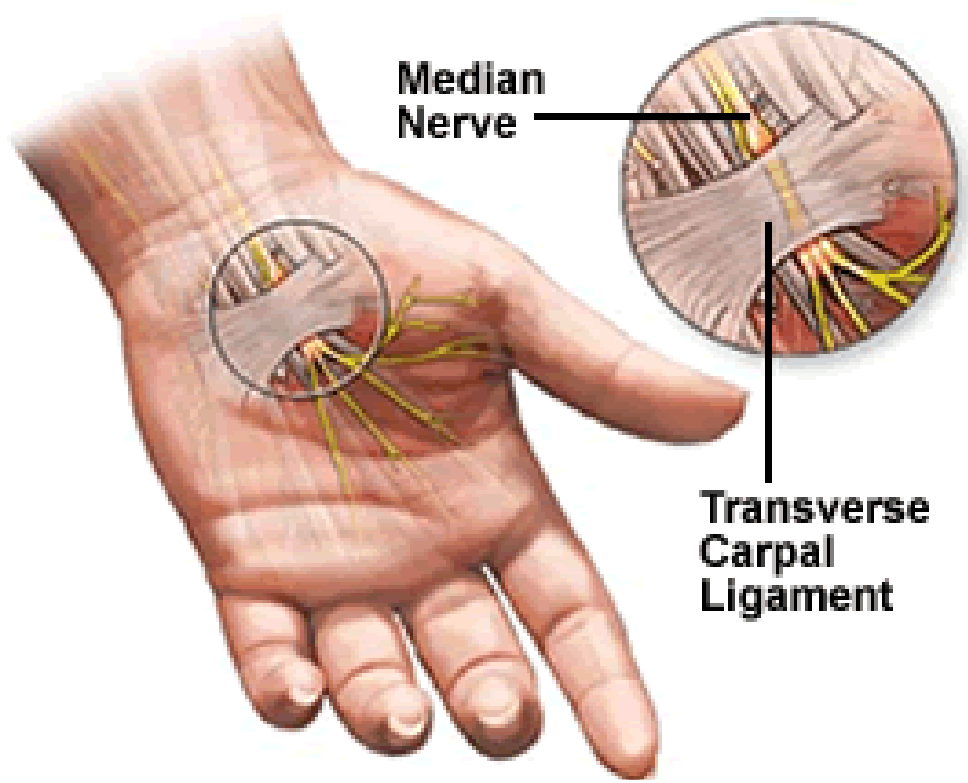
- Decreased ability to extend the arm at the elbow
- Decreased ability to rotate the arm outward (supination)
- Difficulty in lifting the wrist or fingers (extensor muscle weakness)
- Muscle loss (atrophy) in the forearm
- Weakness of the wrist and fingers
- Wrist or finger drop
- Abnormal sensations: Hand or forearm ("back" of the hand); "Thumb side" (radial surface) of the hand; Fingers nearest to the thumb (2nd and 3rd fingers)
- Numbness, decreased sensation, tingling, or burning sensation;
- Loss of Triceps reflex

Median nerve

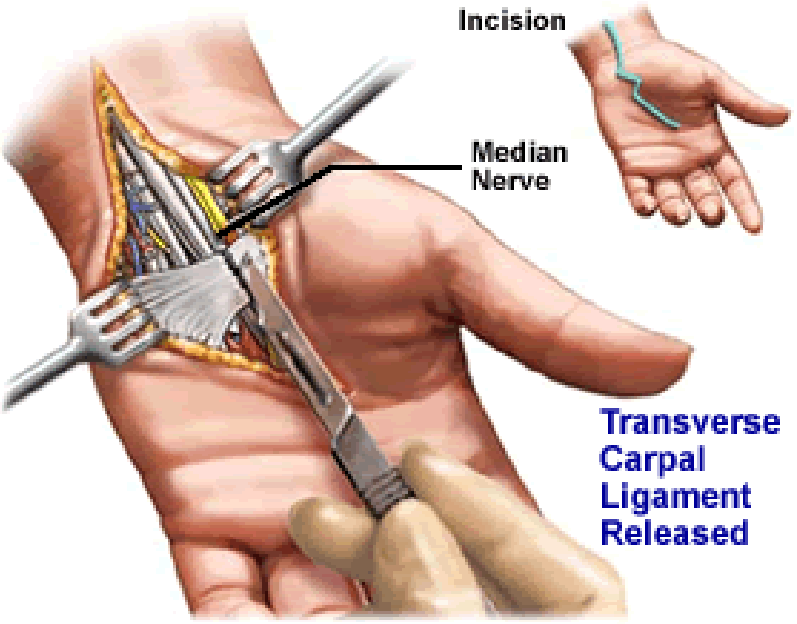
- One of the five main nerves originating from the brachial plexus.
- The median nerve is formed from **medial and lateral cords** of the brachial plexus, and continues down the arm to enter the forearm with the brachial artery (C7, C8).
- The median nerve is the only nerve that passes through the carpal tunnel, where it may be compressed to cause **carpal tunnel syndrome**.

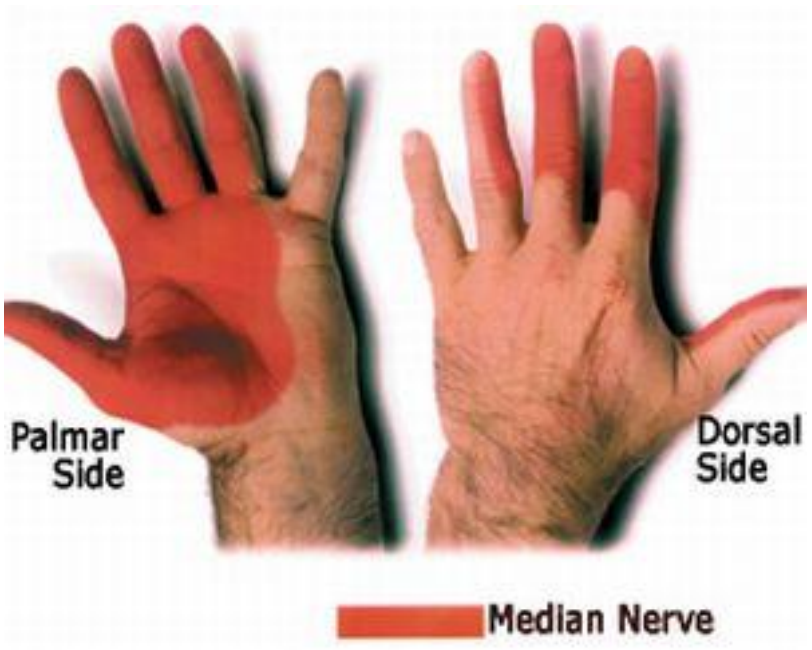
Carpal tunnel syndrome (CTS)

- The most frequent peripheral focal neuropathy
- Cause: Impairment of medial nerve in carpal tunnel


Median
Nerve
Transverse
Carpal
Ligament


Numbness
Pain
©MMG 2001

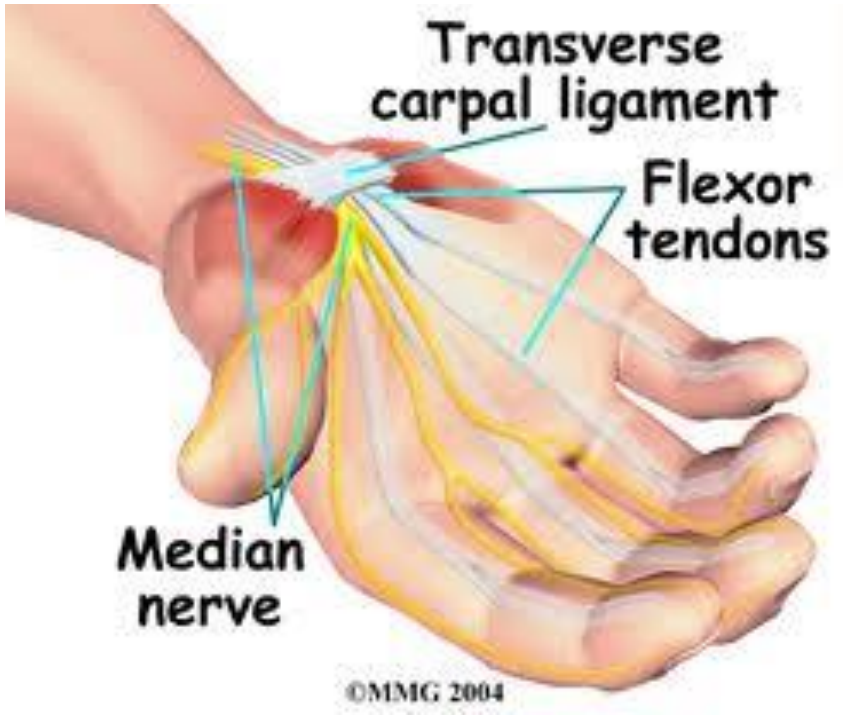

Incision
Median
Nerve
Transverse
Carpal
Ligament
Released


Palmar
Side
Dorsal
Side
Median Nerve

Median nerve

- It innervates all the flexors in the forearm except flexor carpi ulnaris and that part of flexor digitorum profundus that supplies the medial two digits. The latter two muscles are supplied by the ulnar nerve
- The main portion of the median nerve supplies the following muscles:
- ***Superficial group****:*
- Pronator teres
- Flexor carpi radialis
- Palmaris longus
- ***Intermediate group:***
- Flexor digitorum superficialis muscle
- The anterior interosseus branch of the median nerve supplies the following muscles:
- ***Deep group****:*
- Flexor digitorum profundus (only the lateral half)
- Flexor pollicis longus
- Pronator quadratus

- In the hand, the median nerve supplies motor innervation to the 1st and 2nd lumbrical muscles. It also supplies the muscles of the thenar eminence by a *recurrent thenar branch*. The rest of the intrinsic muscles of the hand are supplied by the ulnar nerve.
- The median nerve innervates the skin of the palmar side of the thumb, the index and middle finger, half the ring finger, and the nail bed of these fingers. The lateral part of the palm is supplied by the palmar cutaneous branch of the median nerve, which leaves the nerve proximal to the wrist creases. This palmar cutaneous branch travels in a separate fascial groove adjacent to the flexor carpi radialis and then superficial to the flexor retinaculum. It is therefore spared in carpal tunnel syndrome.


Transverse carpal ligament
Flexor tendons
Median nerve
©MMG 2004


Median nerve sensory distribution via carpal tunnel
Median nerve sensory distribution via forearm
Median Nerve Sensory Innervation
www.fpnotebook.com

- **Injury of the median nerve at different levels causes different syndromes.**
  - at a level above the elbow results in loss of pronation and a reduction in flexion of the hand at the wrist.
  - at the level of the elbow or the proximal forearm could be due to the ***pronator teres syndrome***.
- **Lesions or compression of the Median nerve can also lead to <u>Median Nerve Palsy</u>**
  - Injury of the anterior interosseous branch in the forearm causes the ***anterior interosseous syndrome***.
  - Injury by compression at the carpal tunnel causes ***carpal tunnel syndrome.***
  - Severing the median nerve causes **median claw hand** (also called the "**Benedictine hand**"): In the hand, thenar muscles are paralyzed and will atrophy over time. Opposition and flexion of the thumb are lost. The thumb and index finger are arrested in adduction and hyperextension. This appearance of the hand is collectively referred as **'ape hand deformity'.**

Ulnar nerve

Muscular

- The ulnar nerve and its branches innervate the following muscles in the forearm and hand:
- In the forearm, via the muscular branches of ulnar nerve:
  - Flexor carpi ulnaris
  - Flexor digitorum profundus (medial half)
- In the hand, via the **deep branch** of ulnar nerve:
  - hypothenar muscles
    - Opponens digiti minimi
    - Abductor digiti minimi
    - Flexor digiti minimi
  - The third and fourth lumbrical muscles
  - Dorsal interossei
  - Palmar interossei
  - Adductor Pollicis
- In the hand, via the superficial branch of ulnar nerve:
  - Palmaris brevis

Ulnar nerve

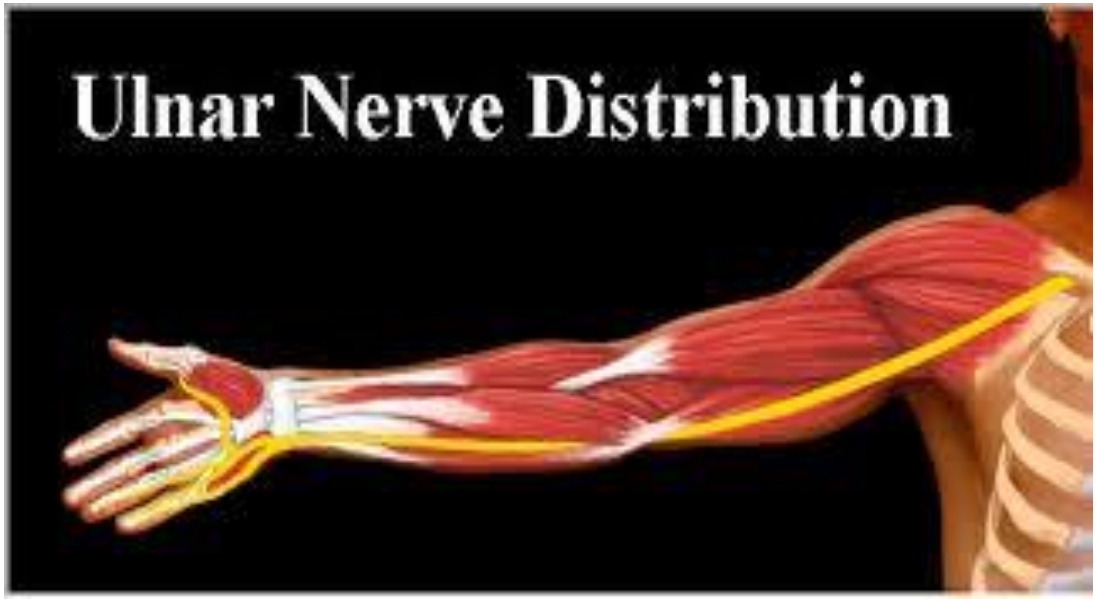
Cutaneous

- The ulnar nerve also provides sensory innervation to the fifth digit and the medial half of the fourth digit, and the corresponding part of the palm:
- Palmar branch of ulnar nerve - supplies cutaneous innervation to the anterior skin and nails
- Dorsal branch of ulnar nerve - supplies cutaneous innervation to the posterior skin (except the nails)

Syndrome of lesion of the ulnar nerve (cubital tunnel syndrome)

paraesthesiae (tingling) in the fourth and fifth digits**.**

ulnar claw


Ulnar Nerve Distribution

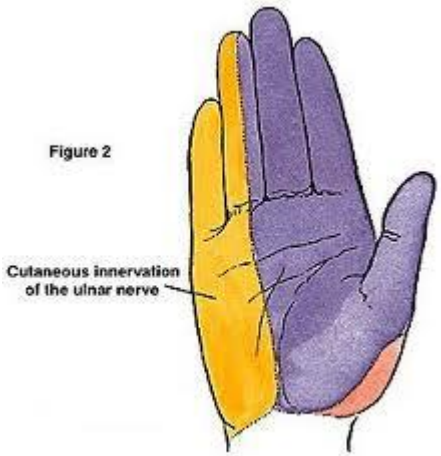
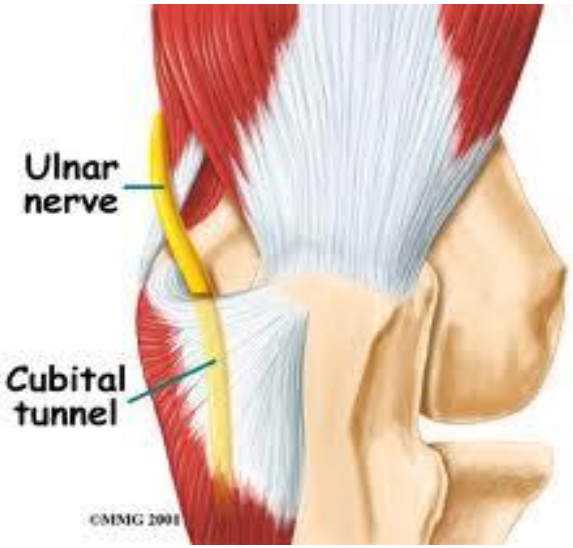
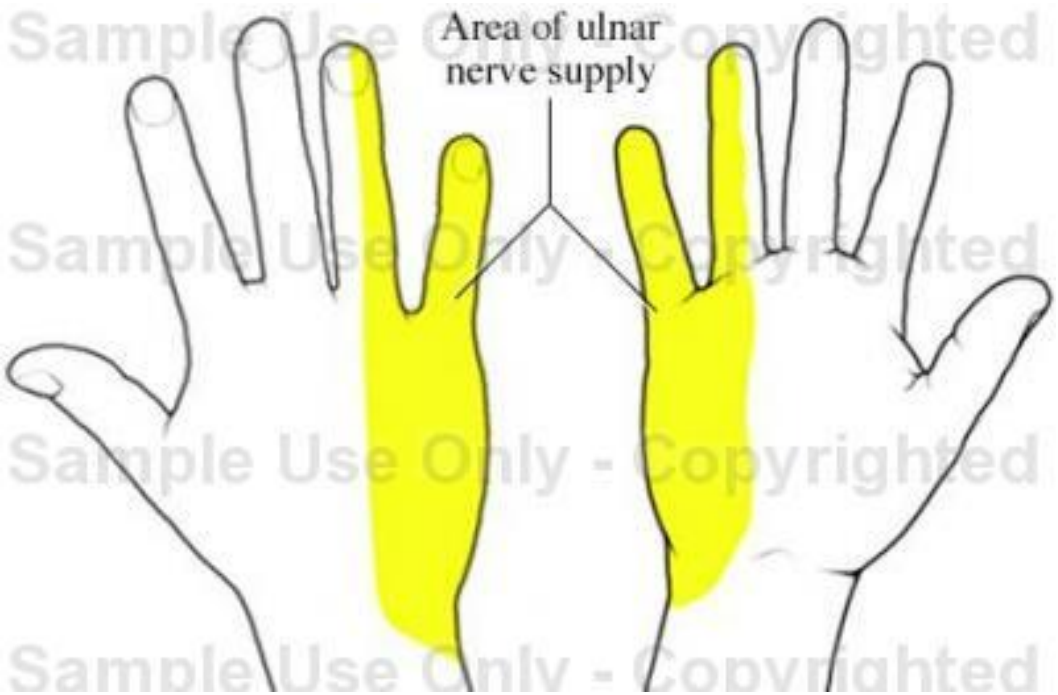
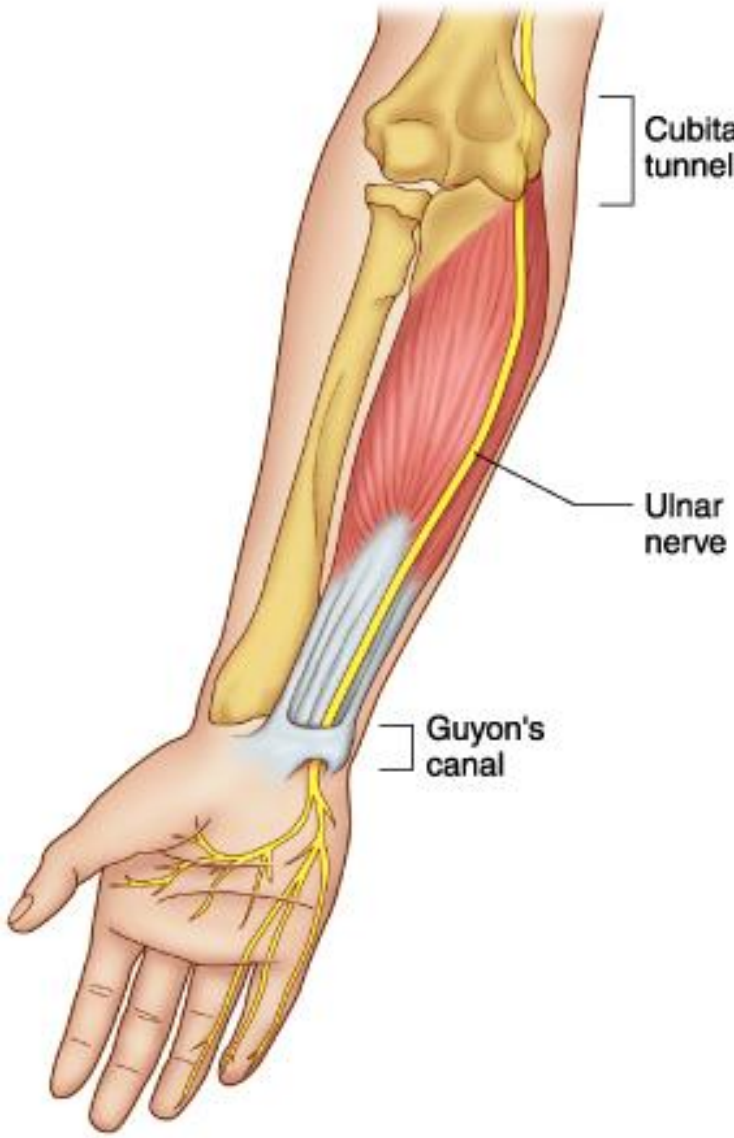


Figure 2
Cutaneous innervation of the ulnar nerve


Ulnar nerve
Cubital tunnel
©MMG 2001

Ulnar nerve


Area of ulnar
nerve supply


Cubita
tunnel
Ulnar
nerve
Guyon's
canal

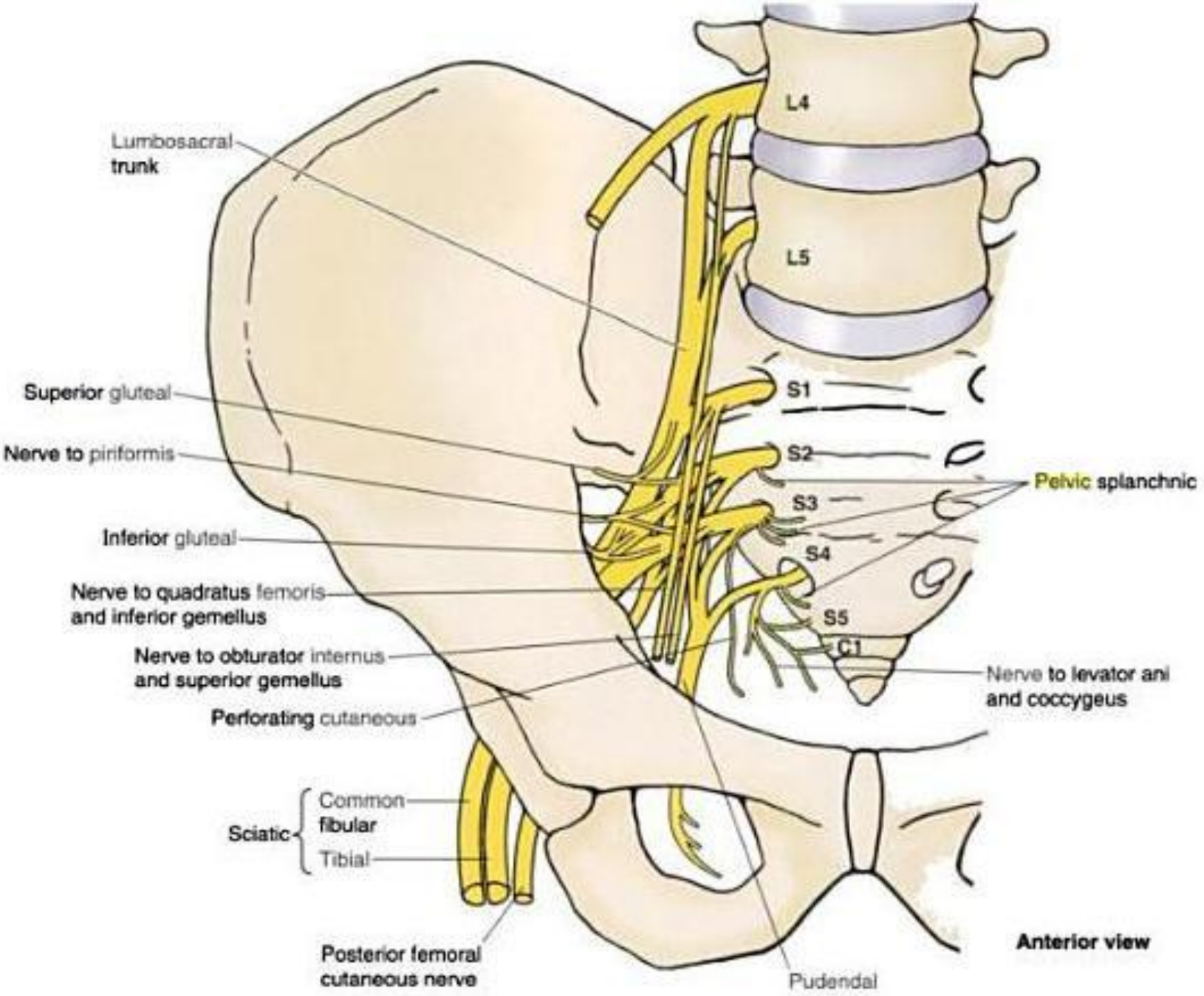
Lumbar and sacral plexuses

- **Lumbar plexus**: anterior primary rami of L1-L4
  - Undivided primary rami
  - 2 divisions-anterior and posterior

  Sacral plexus: L 4, L5, S1, S2, S3 and S4

  -Undivided primary rami

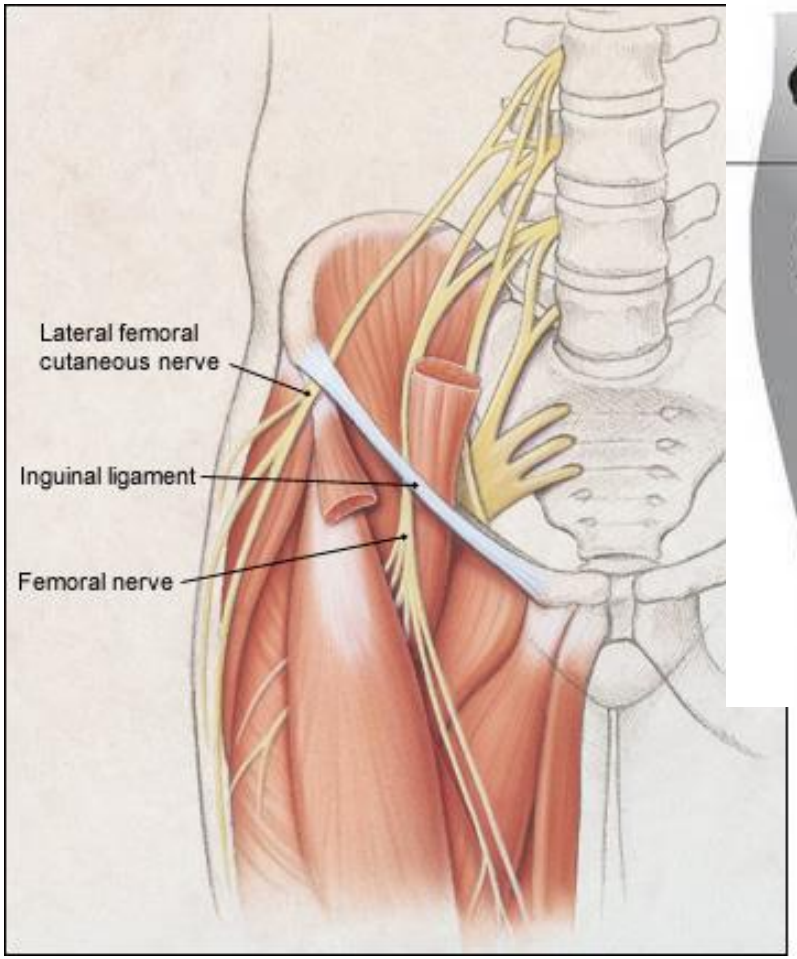
  - 2 divisions-anterior and posterior

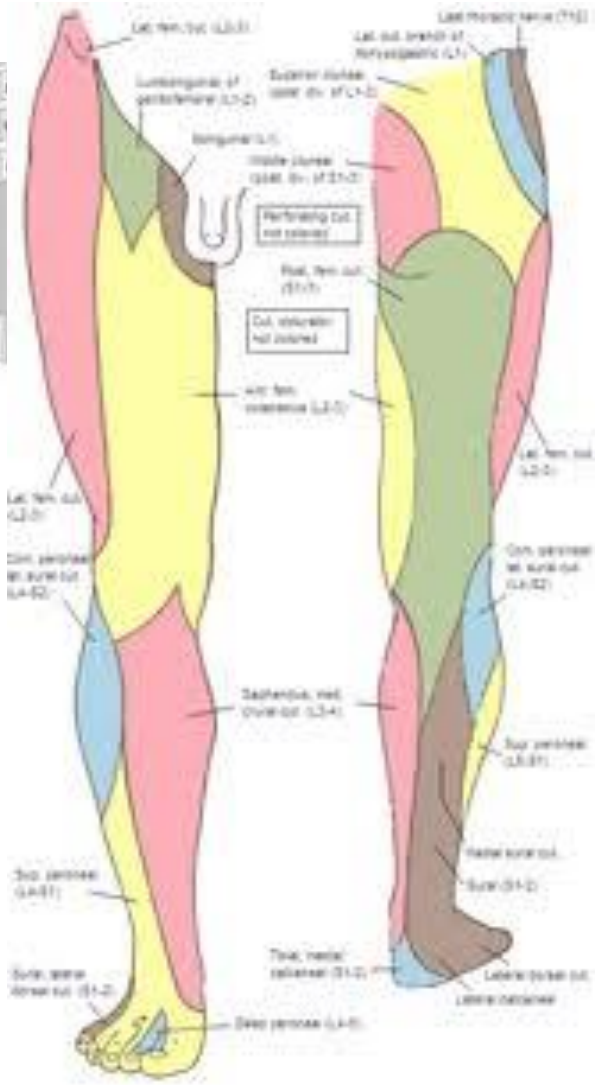

L4
L5
S1
S2
S3
S4
S5
C1
Lumbosacral trunk
Superior gluteal
Nerve to piriformis
Inferior gluteal
Nerve to quadratus femoris and inferior gemellus
Nerve to obturator internus and superior gemellus
Perforating cutaneous
Sciatic
Common fibular
Tibial
Posterior femoral cutaneous nerve
Pudendal
Pelvic splanchnic
Nerve to levator ani and coccygeus
Anterior view

Femoral nerve

- The **femoral nerve**, the largest branch of the lumbar plexus, arises from the **dorsal divisions of the ventral rami of the L2-L3-L4 lumbar nerves.**
- It descends through the fibers of the psoas major muscle, passes down behind the iliac fascia and then runs beneath the inguinal ligament, into the thigh, and splits into an **anterior** and a **posterior** division. Under the inguinal ligament, it is separated from the femoral artery by a portion of the psoas major.

Femoral nerve





In the abdomen: gives off small branches to the iliacus muscle, and a branch which is distributed upon the upper part of the femoral artery.

In the thigh:

Anterior division

- anterior cutaneous and muscular branches.
- Anterior cutaneous branches comprise: *intermediate cutaneous nerve* and *medial cutaneous nerve*.
- Muscular branches (rami musculares)

Posterior division

- saphenous nerve
- muscular and articular branches.

Femoral nerve injury

- Direct injury (trauma)
- Prolonged pressure on the nerve
- Compression or entrapment of the nerve by nearby parts of the body or disease-related structures (such as a tumor)
- Presents with weakness and sensory signs at the area of femoral nerve
- Loss of patella jerk reflex

Meralgia paraesthetica

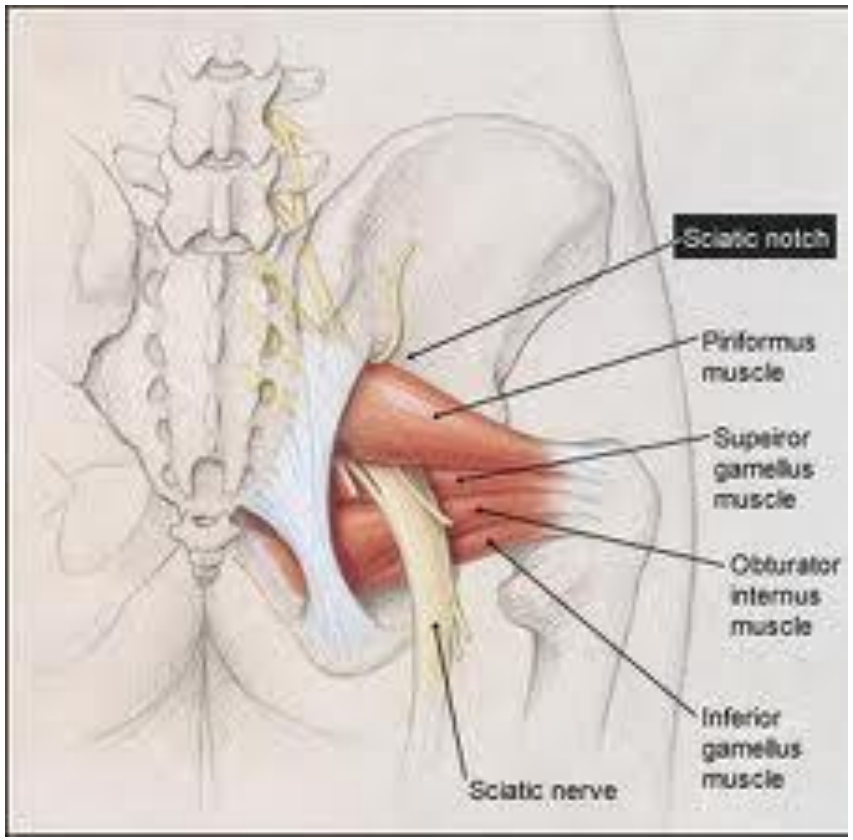
- Compression of ***Lateral cutaneous nerve of the thigh***

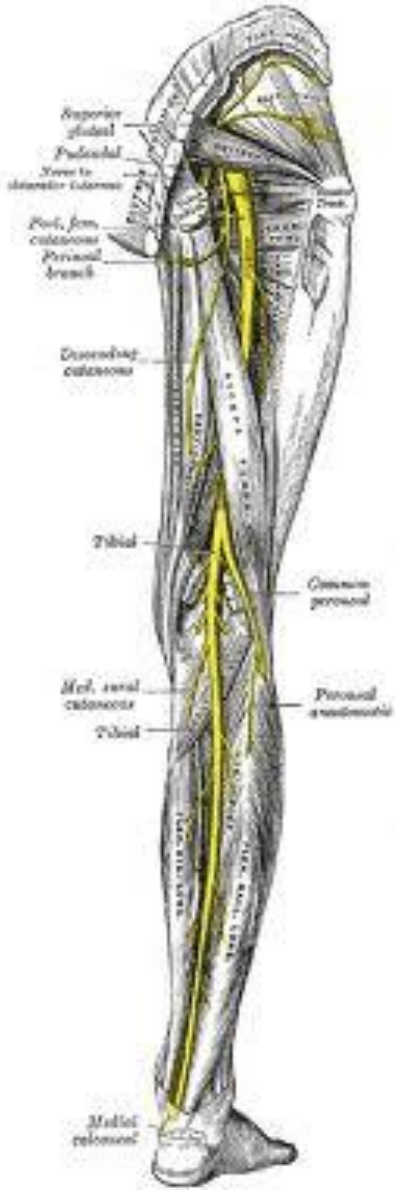
Sciatic nerve

- The **sciatic nerve** (also known as the **ischiadic nerve** and the **ischiatic nerve**) is the longest and widest single nerve in the human body;
- The sciatic supplies nearly the whole of the skin of the leg, the muscles of the back of the thigh, and those of the leg and foot;
- It derives from spinal nerves L4 through S3;
- It contains fibers from both the anterior and posterior divisions of the lumbosacral plexus.

- Pain caused by a compression or irritation of the sciatic nerve in the lower back is called **sciatica**;
- Common causes of sciatica include:
  - spinal disc herniation,
  - degenerative disc disease,
  - lumbar spinal stenosis,
  - spondylolisthesis.
  - muscle piriformis syndrome

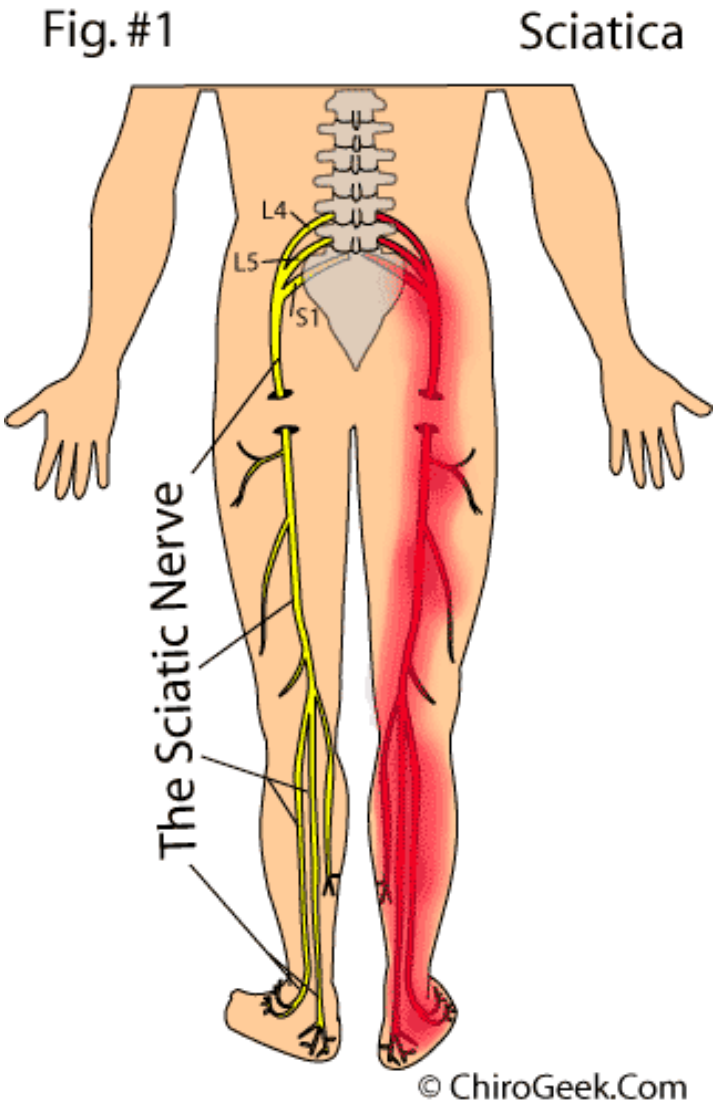
Sciatic nerve





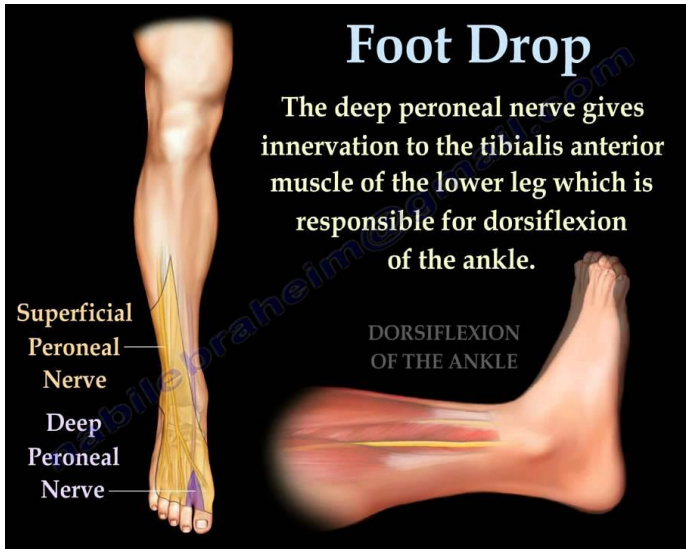
Sciatica

- Presents with wide variety of signs and symptoms due to sciatic nerve damage.
- Pain
- Paraesthesia, hypoestesia, hyperpathia
- Muscle weakness (flexors or extensors of foot).



Syndrome of common peroneal nerve lesion

- Foot drop: high steppage gait;
- Wasting of the muscles of the anterior compartment of the leg;
- Sensory loss over the lateral aspect of the leg and dorsum of the foot



Syndrome of tibial nerve lesion

- Weakness of plantar flexion and adduction of the foot;
- Incapability to walk tiptoe - pes calcaneus;
- Sensory loss involving the sole of the foot and dorsal-lateral aspect of the leg and outer side of the foot;
- Loss of ankle reflex;