Spital Thurgau

Nerve Physiology, Pathophysiology, Clinical exams

Elalim Zen Vukovic

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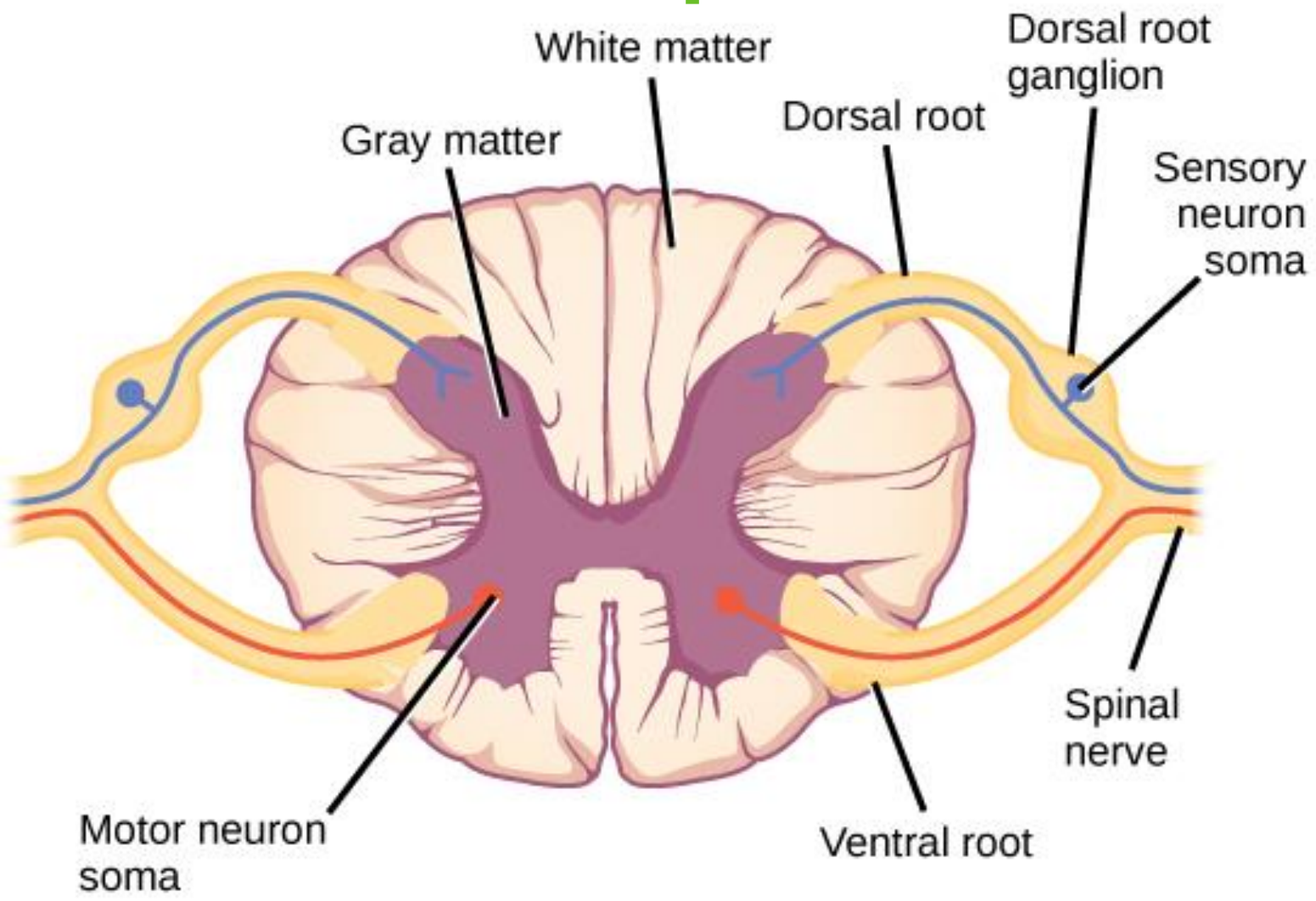
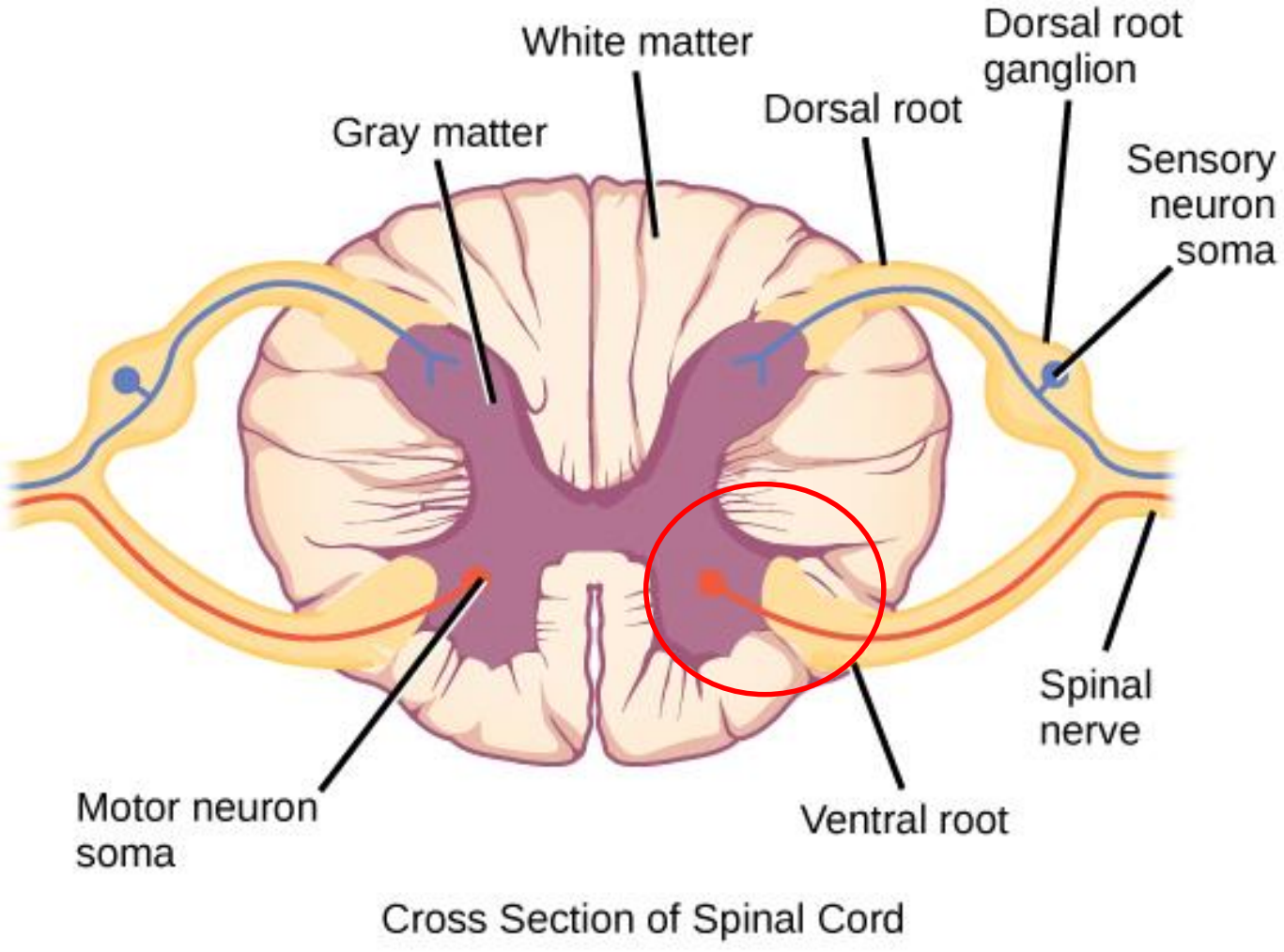
Anatomy

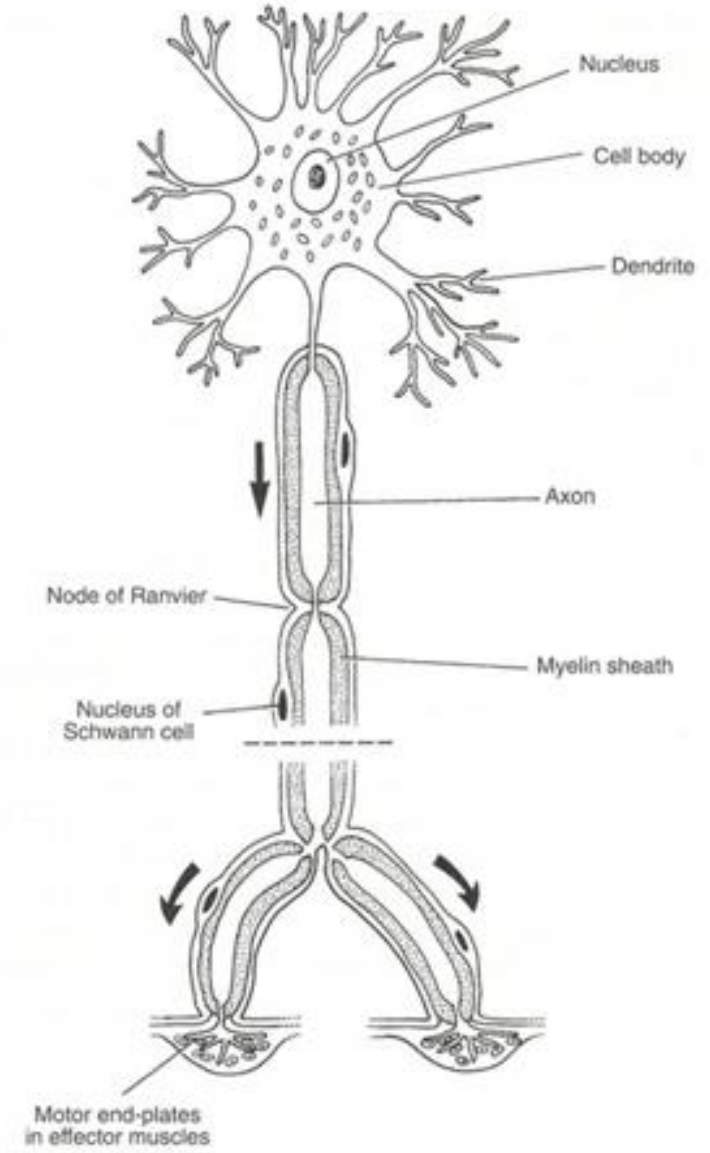
Cross section of the spinal cord



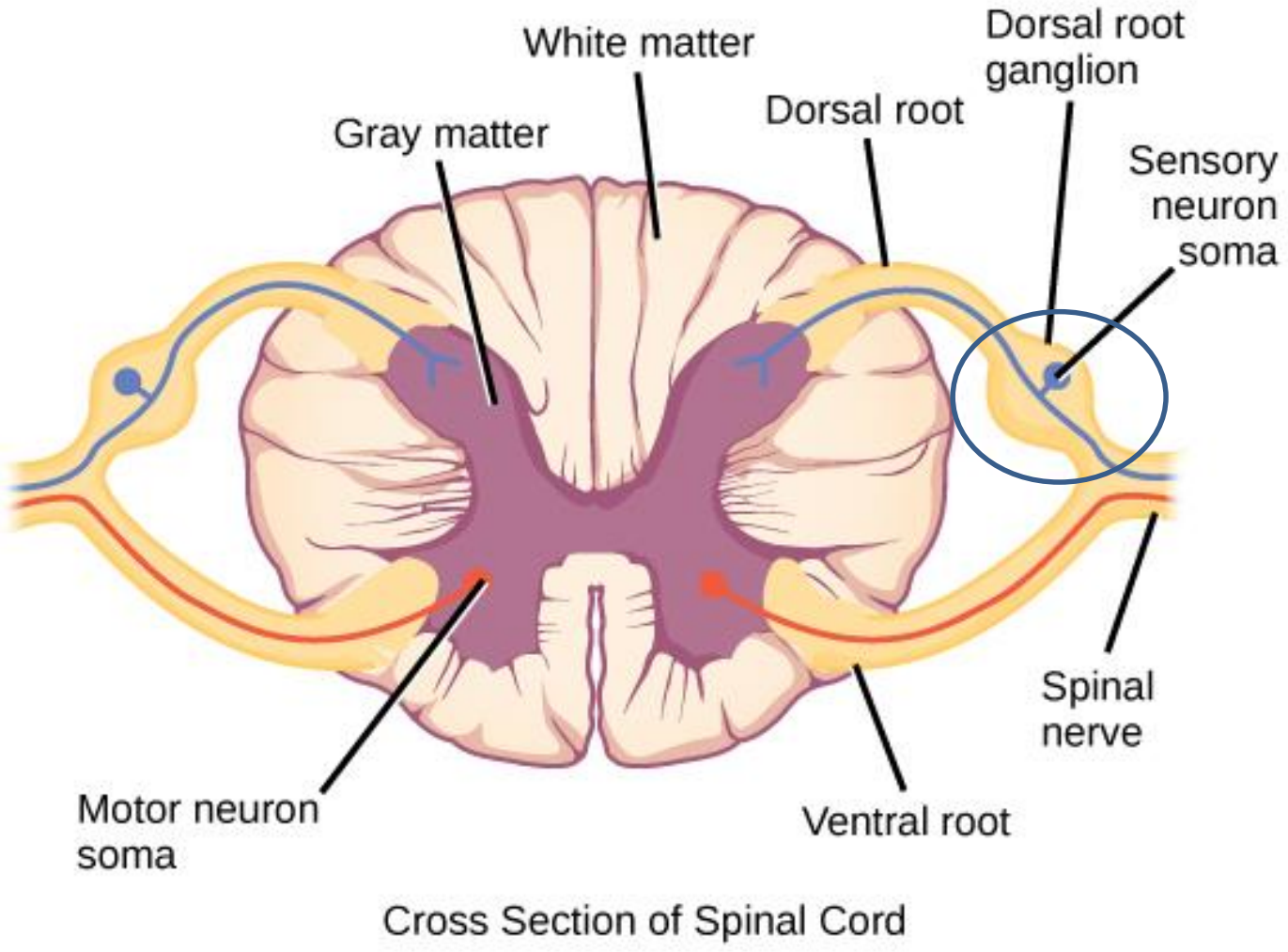
Motor fibers



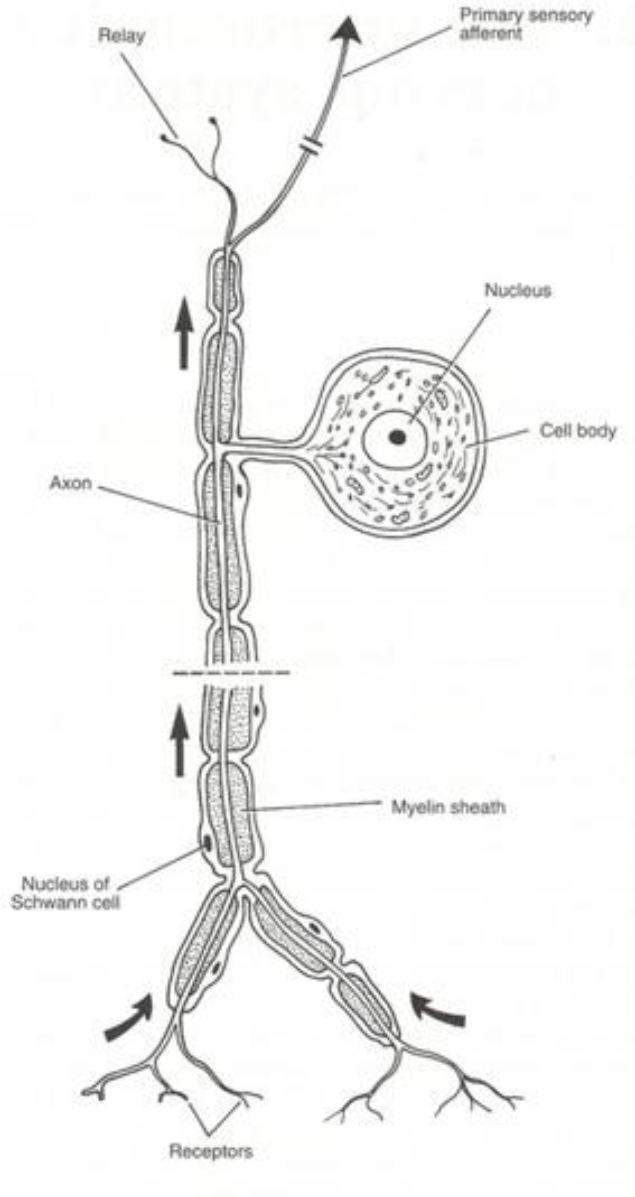
Cross Section of Spinal Cord



Sensory fibers



Cross Section of Spinal Cord



Sensitive pathways to the cortex I

	Dorsal (lemniscal) pathway	Anterolateral pathway
Velocity	35 – 75 m/s	8 – 40 m/s
Dinstinct spatial discrimination	Yes	No
Gradation of intensities	Wide range	Poor
Types of sensibility	• Fine touch • Fine pressure • Proprioception	• Pain • Temperature • Tickle • Itch

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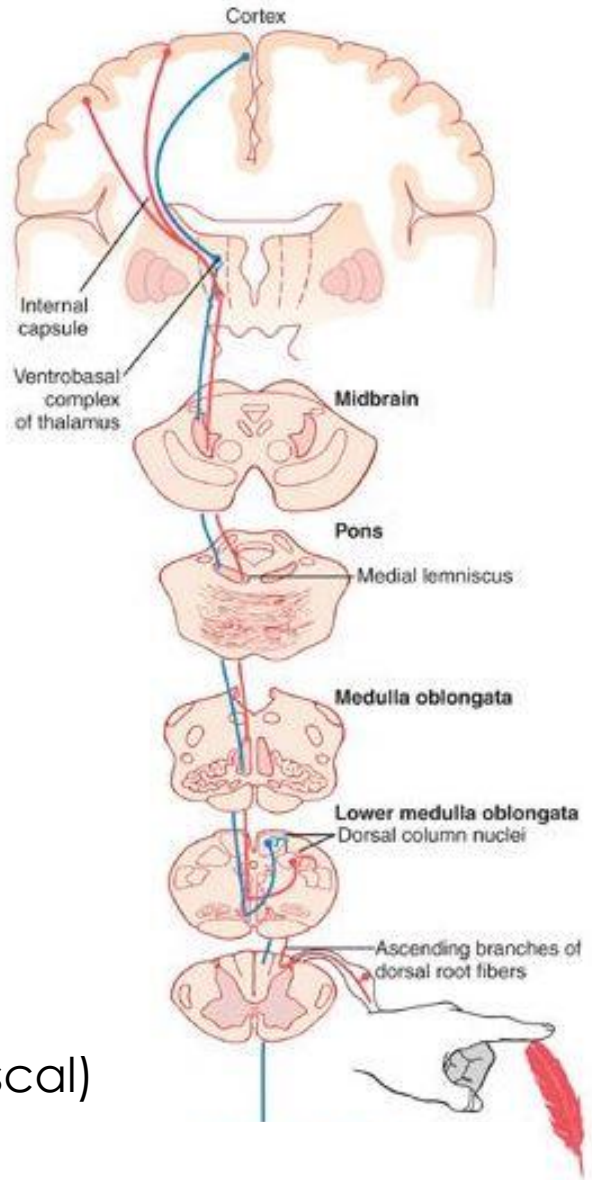
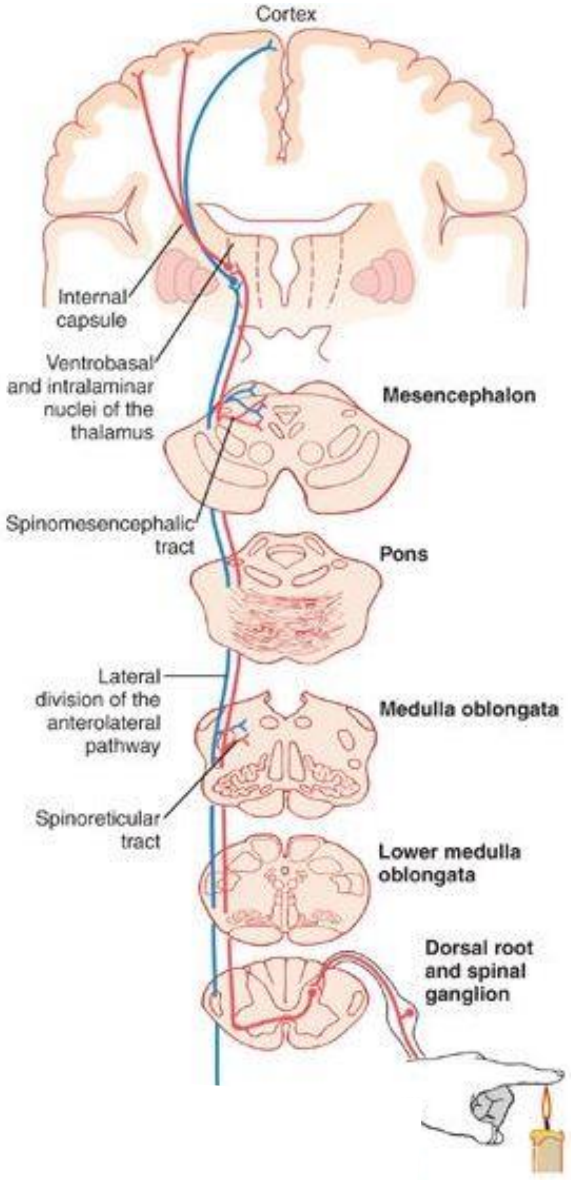
Sensitive pathways to the cortex II

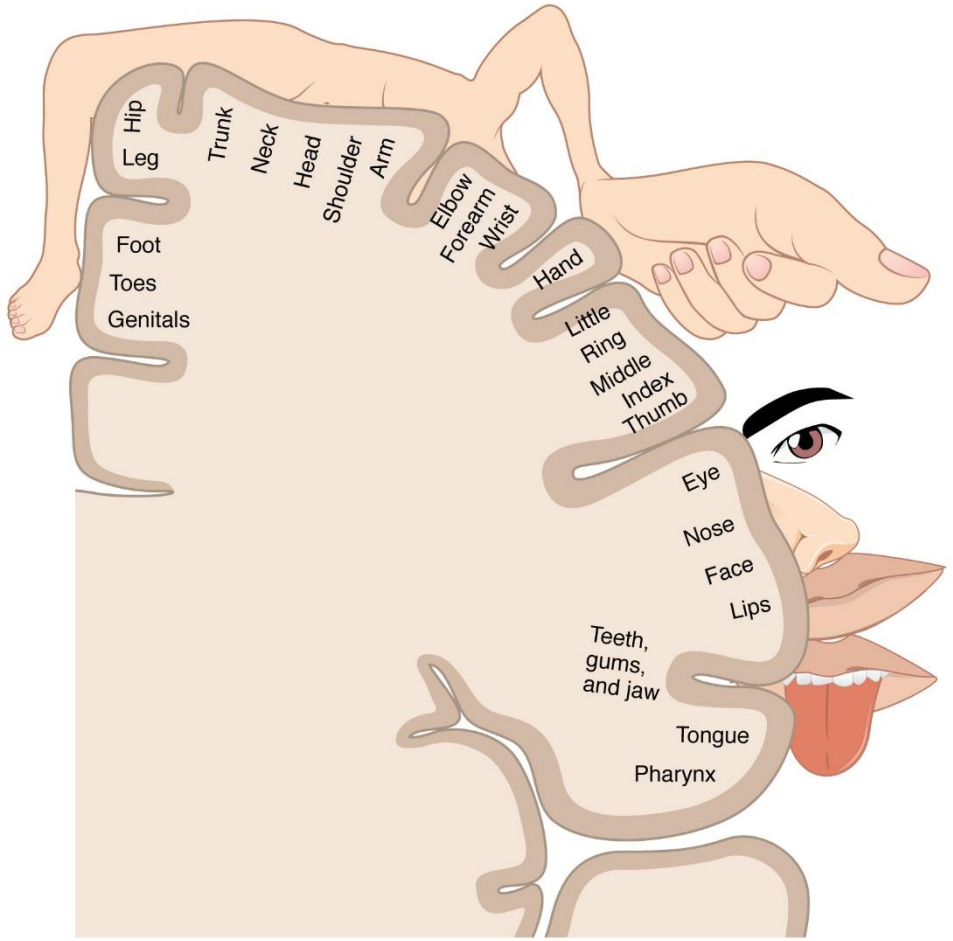


Dorsal (lemniscal) pathway



Anterolateral pathway

Sensory homunculus



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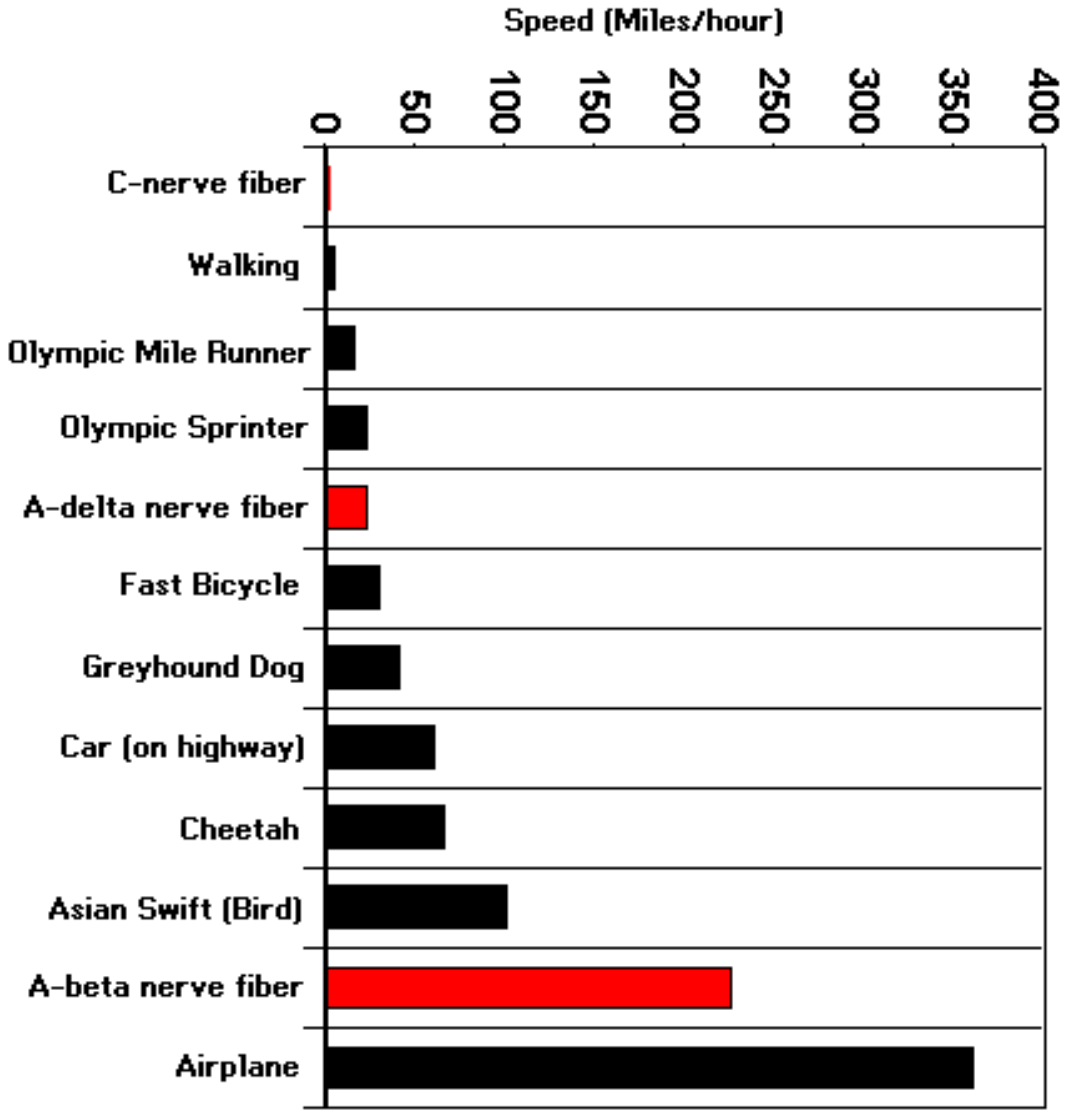
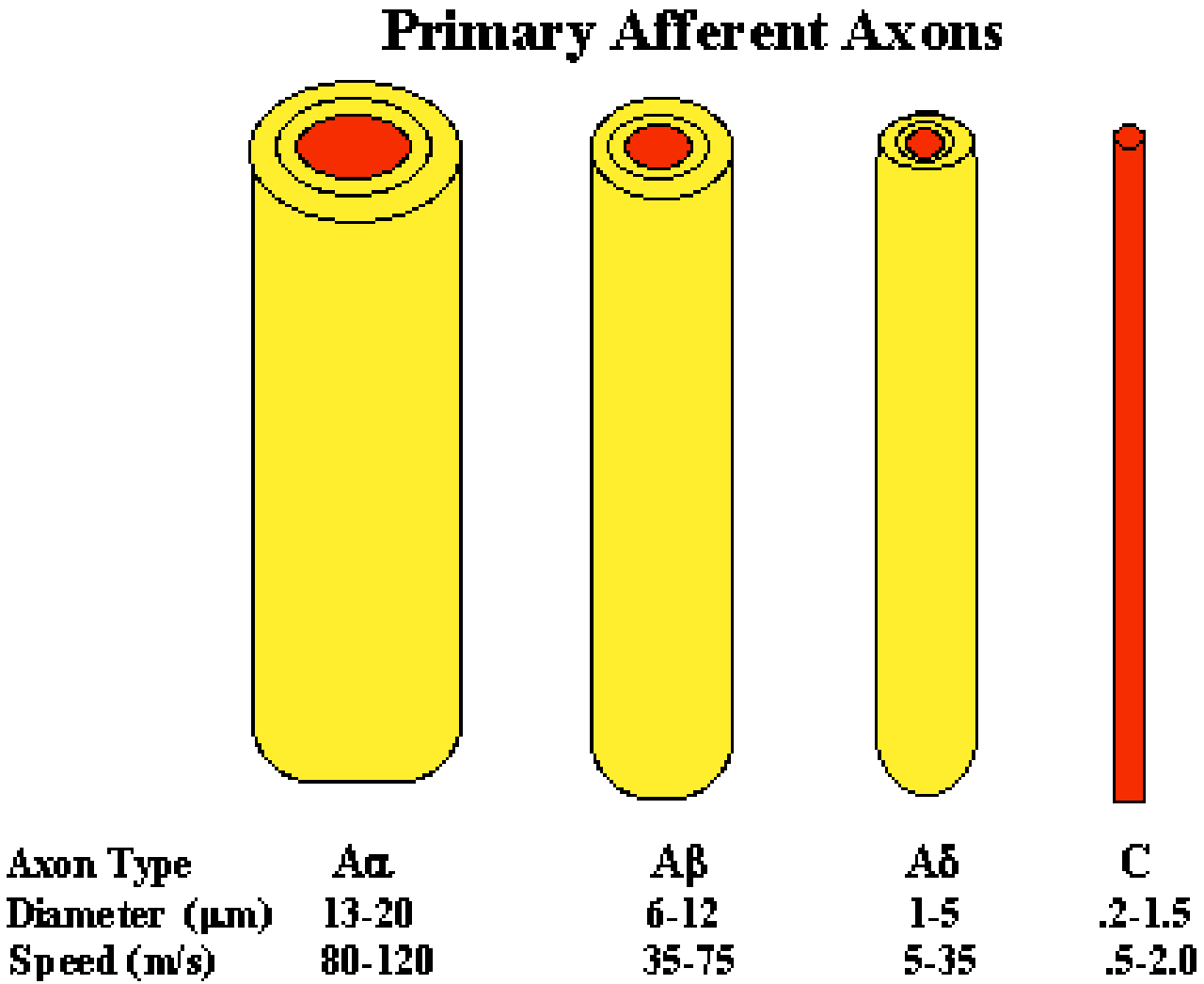
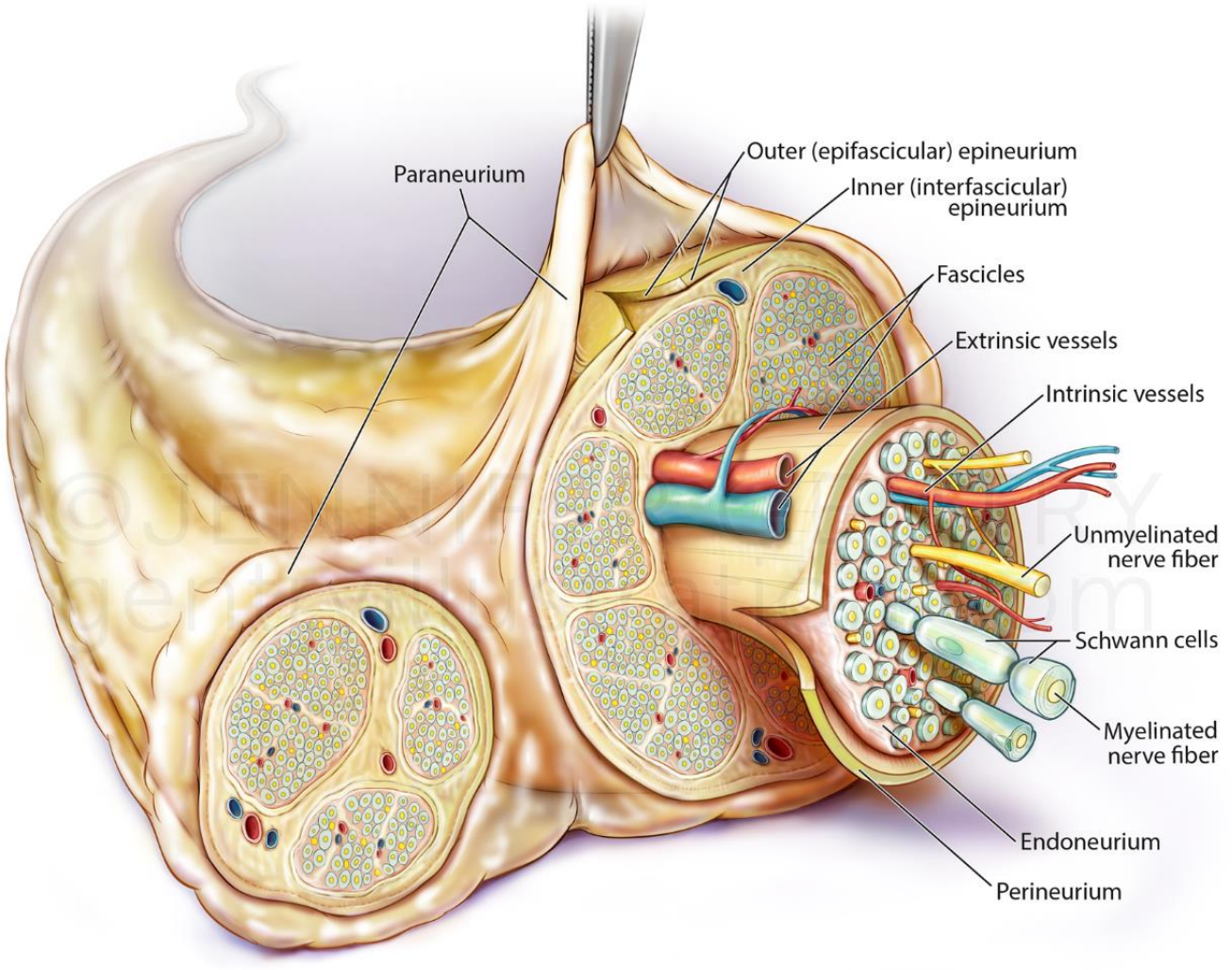
Types of nerve fibers





Nerve anatomy I



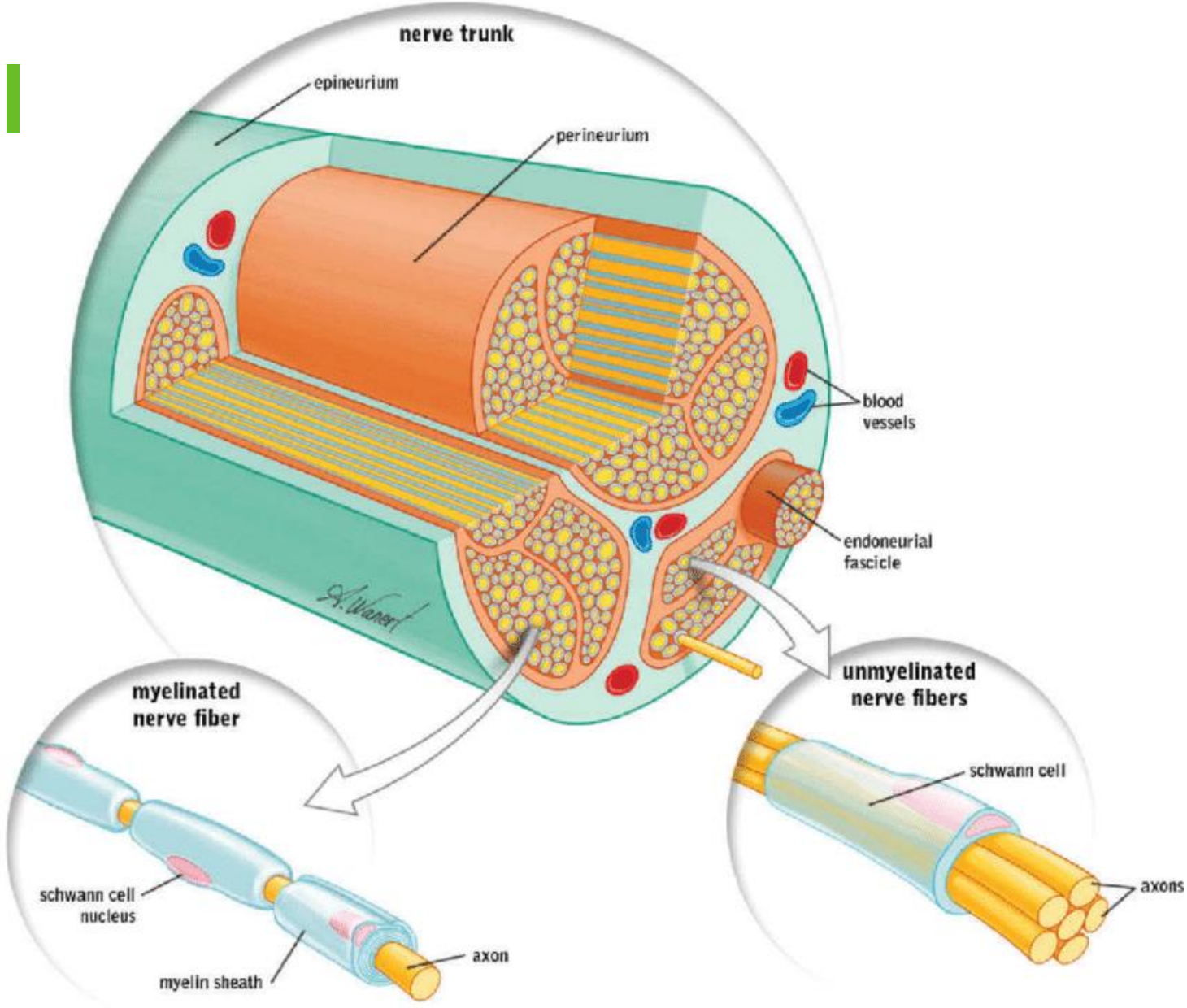
Nerve anatomy II

Myelinated nerve fibers:

- Fast conduction
- Types A

Unmyelinated nerve fibers:

- Slower conduction
- Type C



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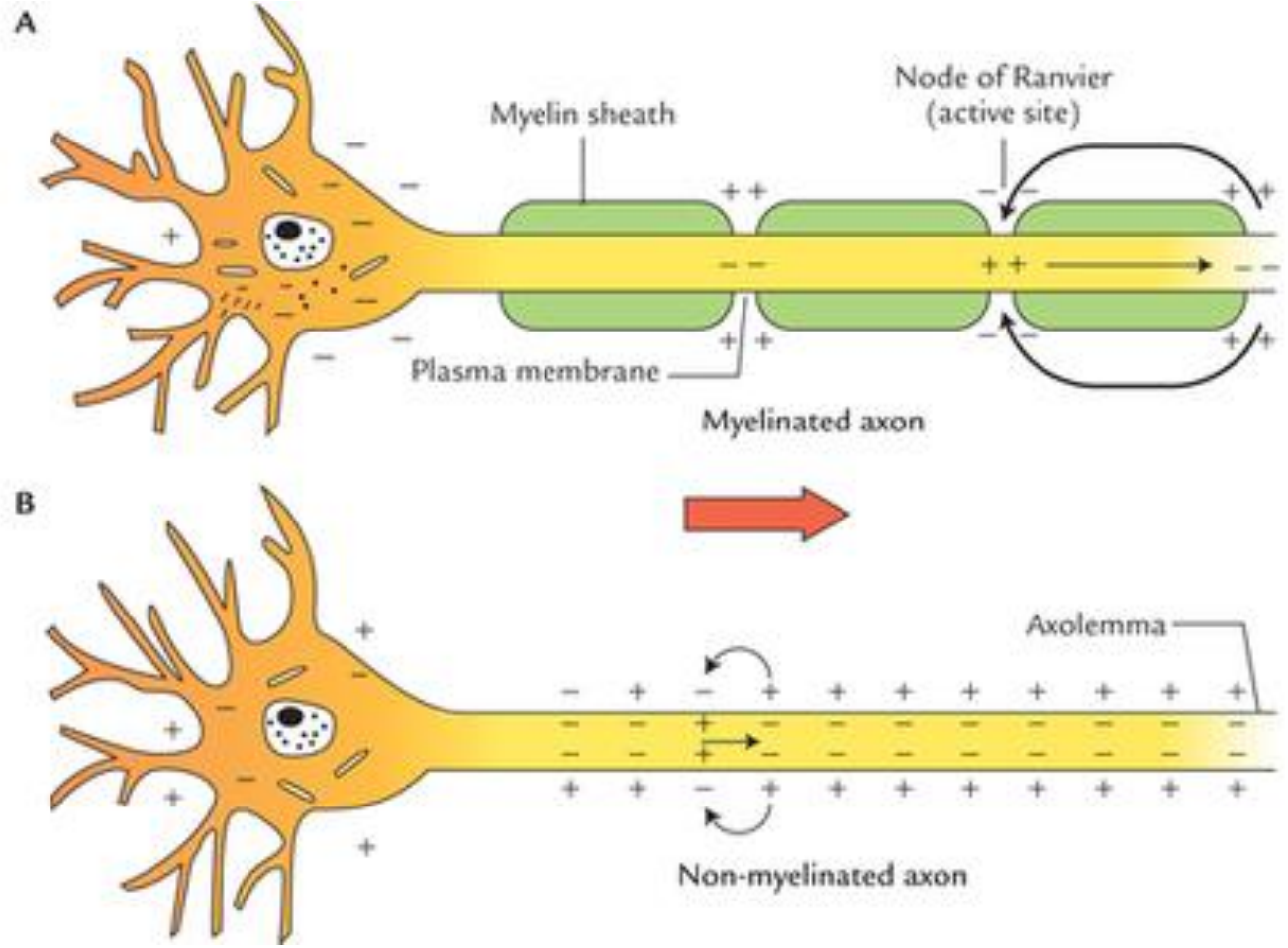
Physiology

Physiology of an action potential



Physiology of the axonal transport

Rate class	Average rate	Moving structures	Composition (selected examples)
Fast components			
Fast anterograde	200–400 mm day^{-1} (≈2–5 µm s^{-1})	Golgi-derived vesicles and tubules (secretory pathway)	Synaptic vesicle proteins, kinesin, enzymes of neurotransmitter metabolism
Bi-directional	50–100 mm day^{-1} (≈0.5–1 µms^{-1})	Mitochondria	Cytochromes, enzymes of oxidative phosphorylation
Fast retrograde	200–400 mm day^{-1} (≈2–5 µm s^{-1})	Endosomes, lysosomes (endocytic pathway)	Internalized membrane receptors, neurotrophins, active lysosomal hydrolases
Slow components			
Slow component 'a'	0.3–3 mm day^{-1}	Neurofilaments, microtubules‡	Neurofilament proteins, tubulin, spectrin, tau proteins
Slow component 'b'	2–8 mm day^{-1} (≈0.02–0.09 µm s^{-1})	Microfilaments, supramolecular complexes of the cytosolic matrix	Actin, clathrin, dynein, dynactin, glycolytic enzymes

*Data compiled from REFS 1,41,44. ‡ In some neurons, microtubule proteins are transported in slow component 'b' as well as slow component 'a'.

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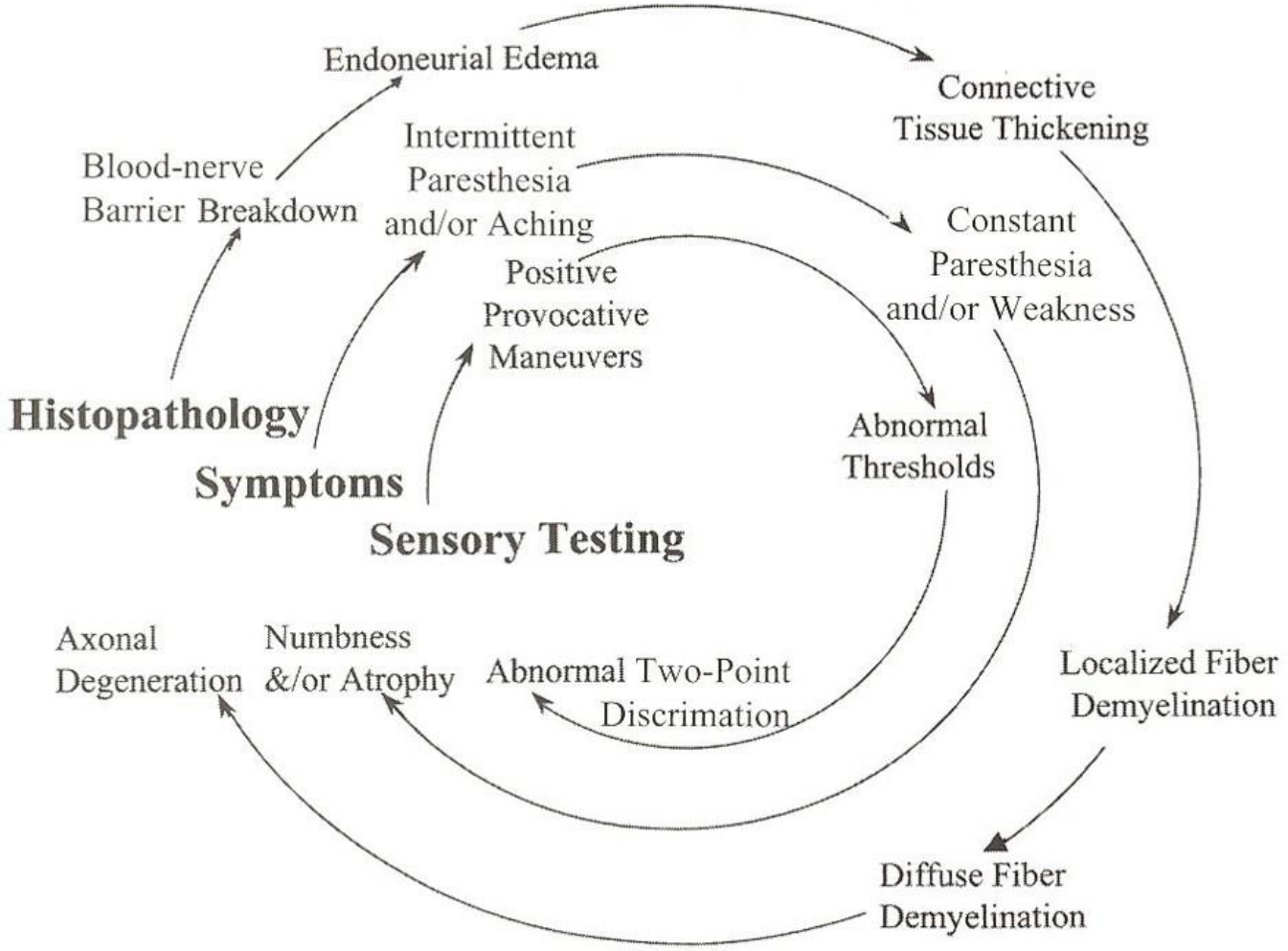
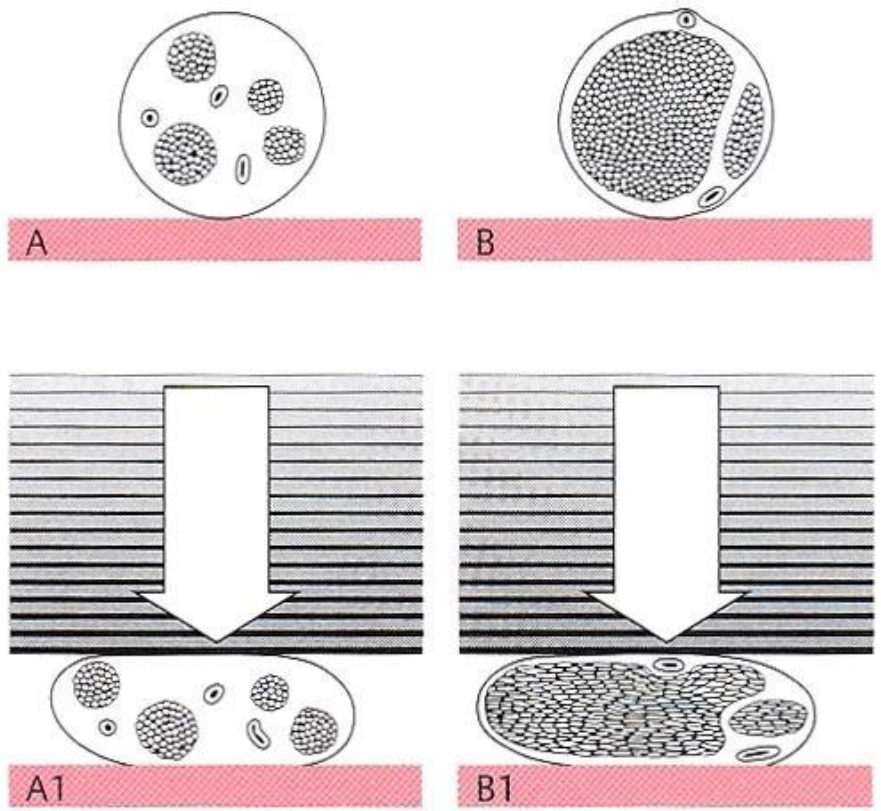
Pathophysiology

Pathophysiology of nerve compression



Compression on different nerve types



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Clinical exams

Clinical presentation

- Patient history
- Physical examination
  - General
  - Hand surgical
- Nerve studies
- Diagnostic imaging

Patient history

- Onset of symptoms
- Type of symptoms
  - Pain
  - Paresthesia: numbness, tingling, burning
  - Paresis: weakness, muscle atrophies, impaired dexterity
- Personal history
- Family history

Physical examination

Inspection, Palpation:

- Cervical spine → elbow → wrist → hand
  - Posture, muscle atrophies, scars
  - Painful areas
  - Mobility: active and passive

Motor function

M 0	No active range of motion, no palpable muscle contraction
M 1	No active range of motion, palpable muscle contraction only
M 2	Reduced active range of motion – not against gravity, no muscle resistance
M 3	Full active range of motion, no muscle resistance
M 4	Full active range of motion, reduced muscle resistance
M 5	Full active range of motion, normal muscle resistance

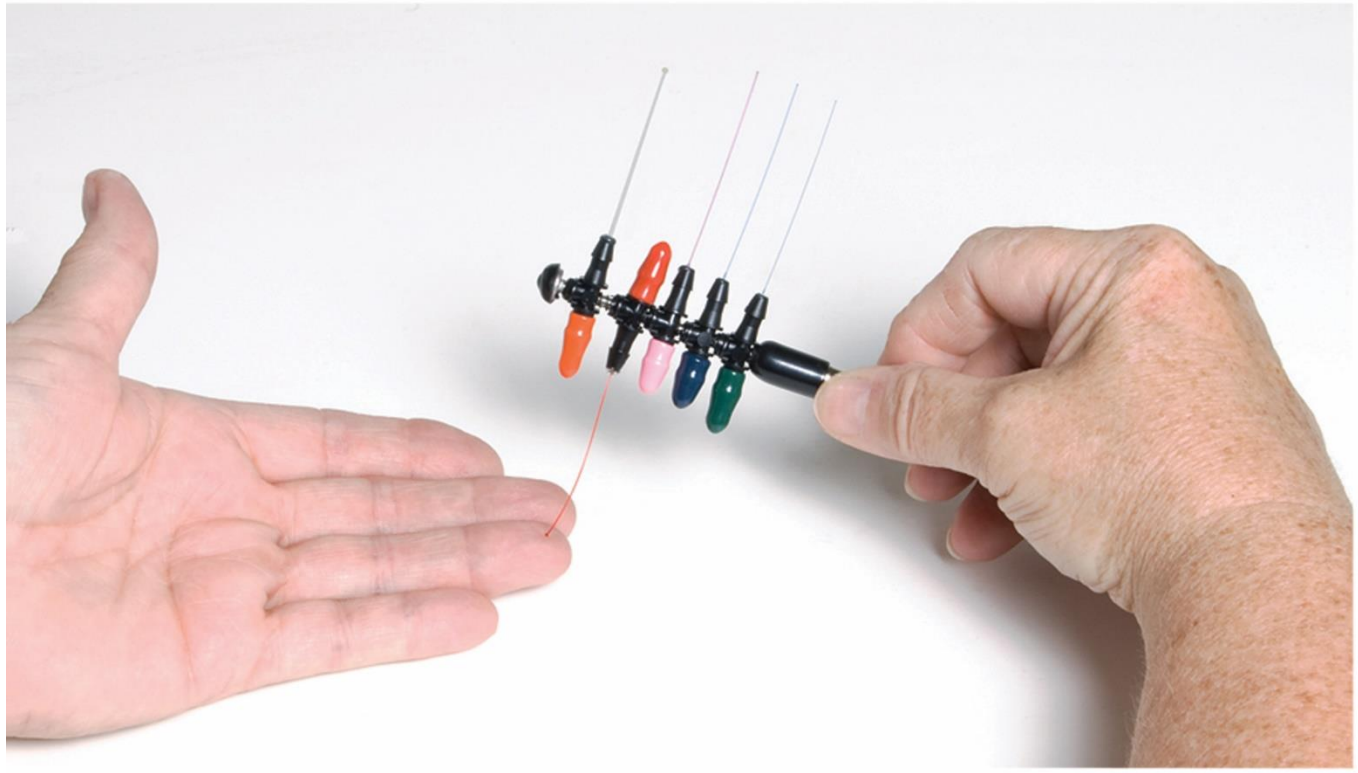
Sensory function

S 0	No sensibility autonomous zone of nerve
S 1	Deep cutaneous pain sensibility
S 2	Some superficial cutaneous pain and tactile sensibility within autonomous area
S 2 +	Rough 2 PD (> 15 mm)
S 3	Pain and superficial tactile sensibility
S 3 +	2 PD 7 – 15 mm
S 4	Normal sensibility, 2 PD 2 – 6 mm

Functional physical examination: sensibility I

Threshold:

Semmes – Weinstein monofilament



Functional physical examination: sensibility II

Spatial discrimination:

Two-point-discrimination (2PD)

Functional physical examination: sensibility III

Object recognition:

Shape texture identification (STI)

Provocative tests

- Percussion/compression tests
  - Tinel sign
  - McMurtry test, Durkan test

  → stimulation of damaged nerve areas

- Wrist flexion test and wrist extension test
  - Phalen test
  - Reverse Phalen test

  → morphological change of the carpal canal and/or carpal canal pressure change due to positions of the wrist and/or finger joints

- Pneumatic-tourniquet test and wrist elevation test

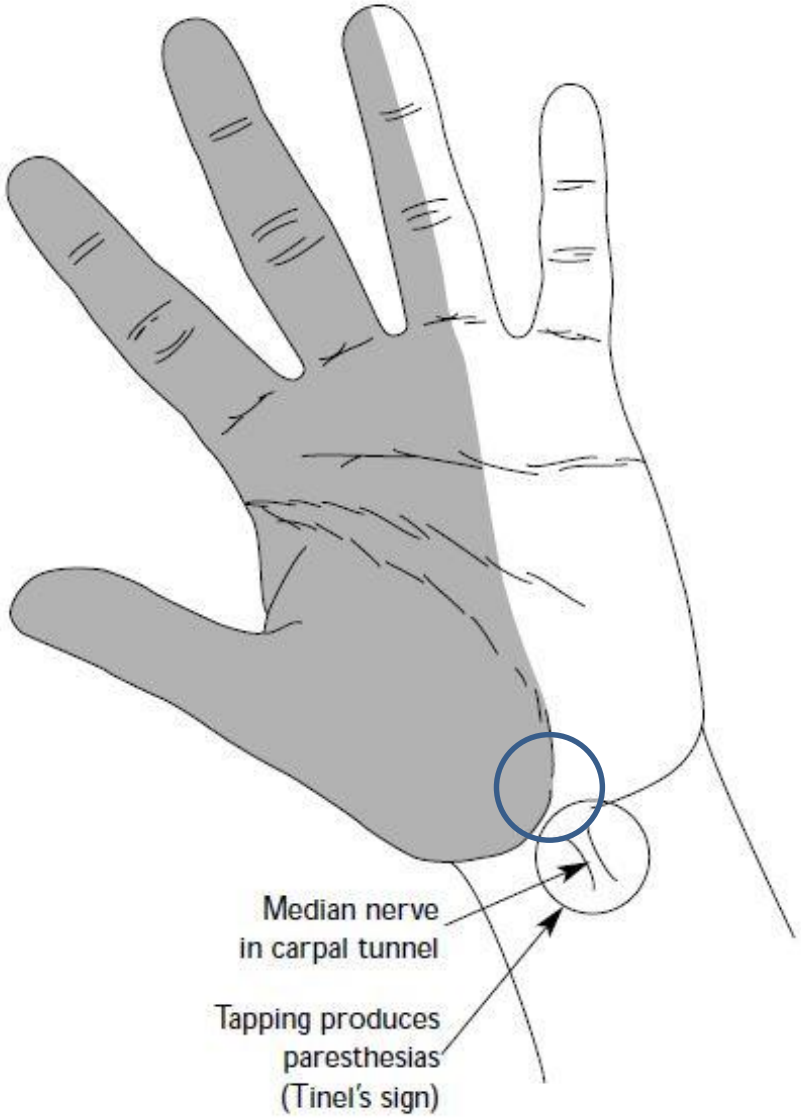
  → ischaemia to the carpal canal

Provocative tests
→ Hoffmann – Tinel sign

Jules Tinel, Oct 1915

Paul Hoffmann, Mar 1915

- Abnormal mechanosensitivity of the involved nerve → afferent discharge at the level of the regenerating nerves → pins and needles sensation
- Abnormally excitable cell membrane



Paresthesia over the innervated area of the involved nerve after stimulating it by percussion

Provocative tests → McMurtry's test

Robert Y. McMurtry, 1987

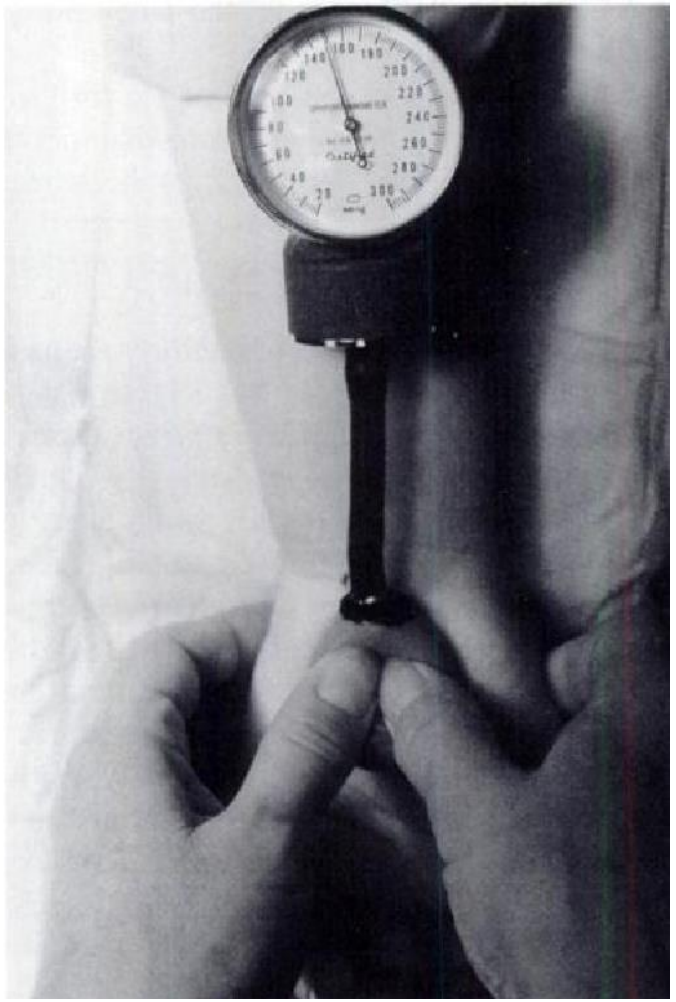
- Increase of pressure over the carpal tunnel causes paresthesia in median nerve distribution area

The wrist is supinated and extended and the examiner applies direct pressure over the carpal tunnel: the test is positive if paresthesia occurs after 15 – 20 seconds.

Provocative tests → Durkan's test

John A. Durkan, 1991

- To be performed when the patient is not able to move the wrist (pain or stiffness)
- Increase of pressure over the carpal tunnel causes paresthesia in median nerve distribution area

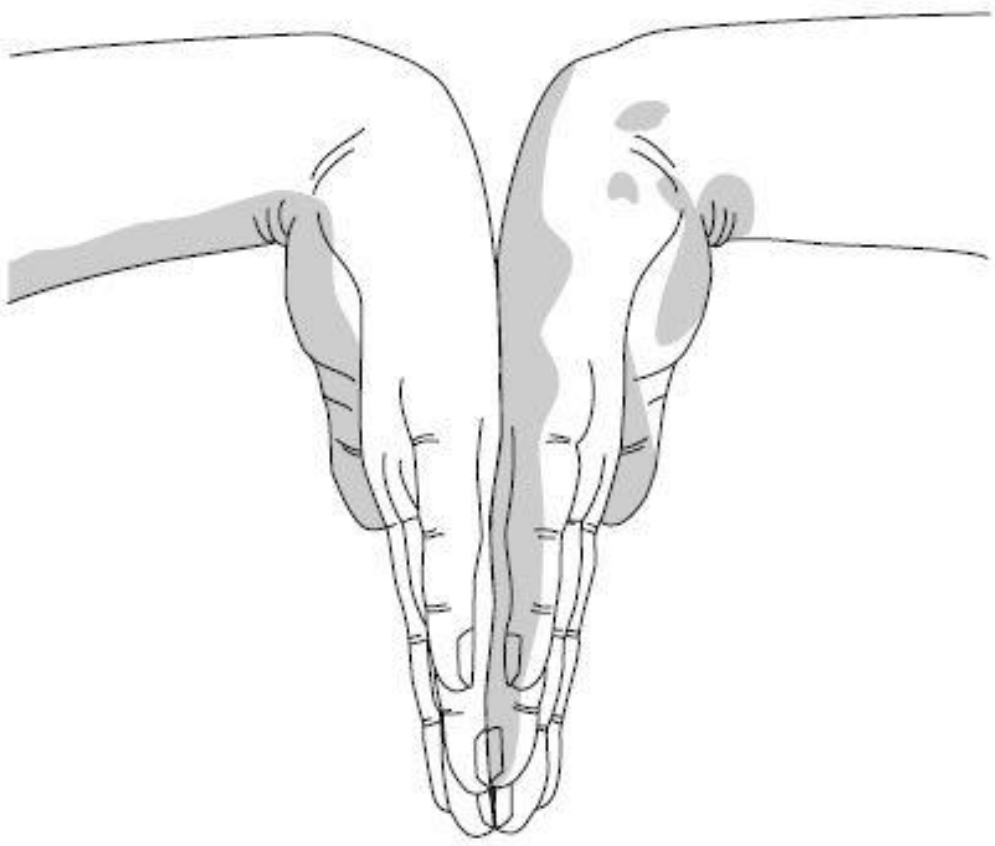


Standardized pressure of 150 mmHg applied over 30 s over the carpal tunnel will cause paresthesia in the distribution area of the median nerve if positive.

Provocative tests
→ Phalen's maneuver

George S. Phalen, 1966

- Preexistent increased pressure in the carpal tunnel due to the pathology is exacerbated by the wrist flexion.
- Preexistent abnormally sensitive nerve fibers due to the pathology cause paresthesia when the transverse carpal ligament is compressed at wrist flexion.

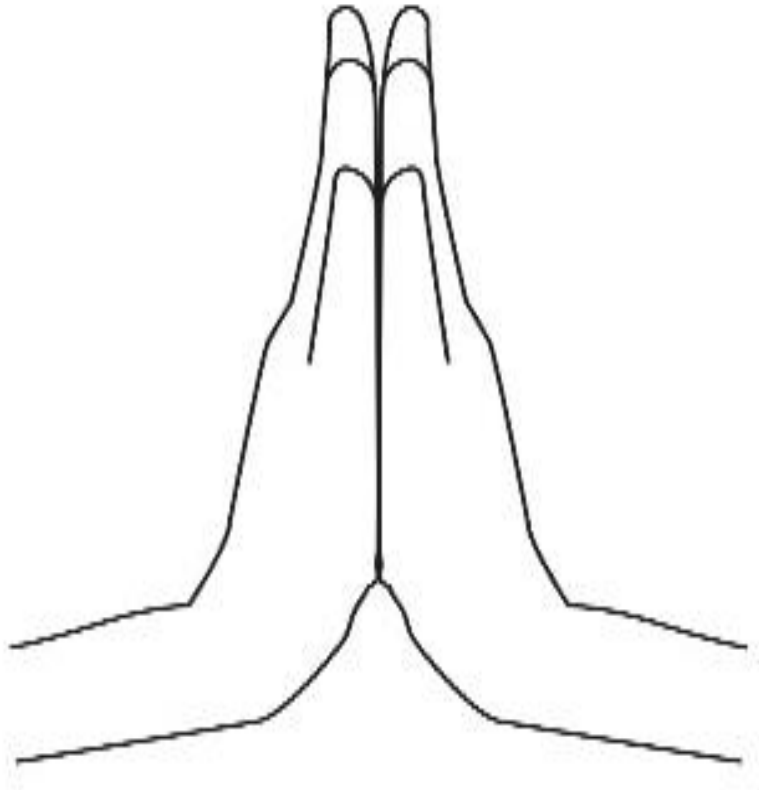


A positive response to Phalen's maneuver produces paresthesias in the distribution of the median nerve when hands are held in forced flexion for 60 s or more.

Provocative tests
→ Reverse Phalen test

Robert A. Werner, 1994

- Same pathophysiology as the Phalen maneuver
- Preexistent increased pressure in the carpal tunnel due to the pathology is exacerbated by the wrist extension.
- Preexistent abnormally sensitive nerve fibers due to the pathology cause paresthesia when the transverse carpal ligament is compressed.

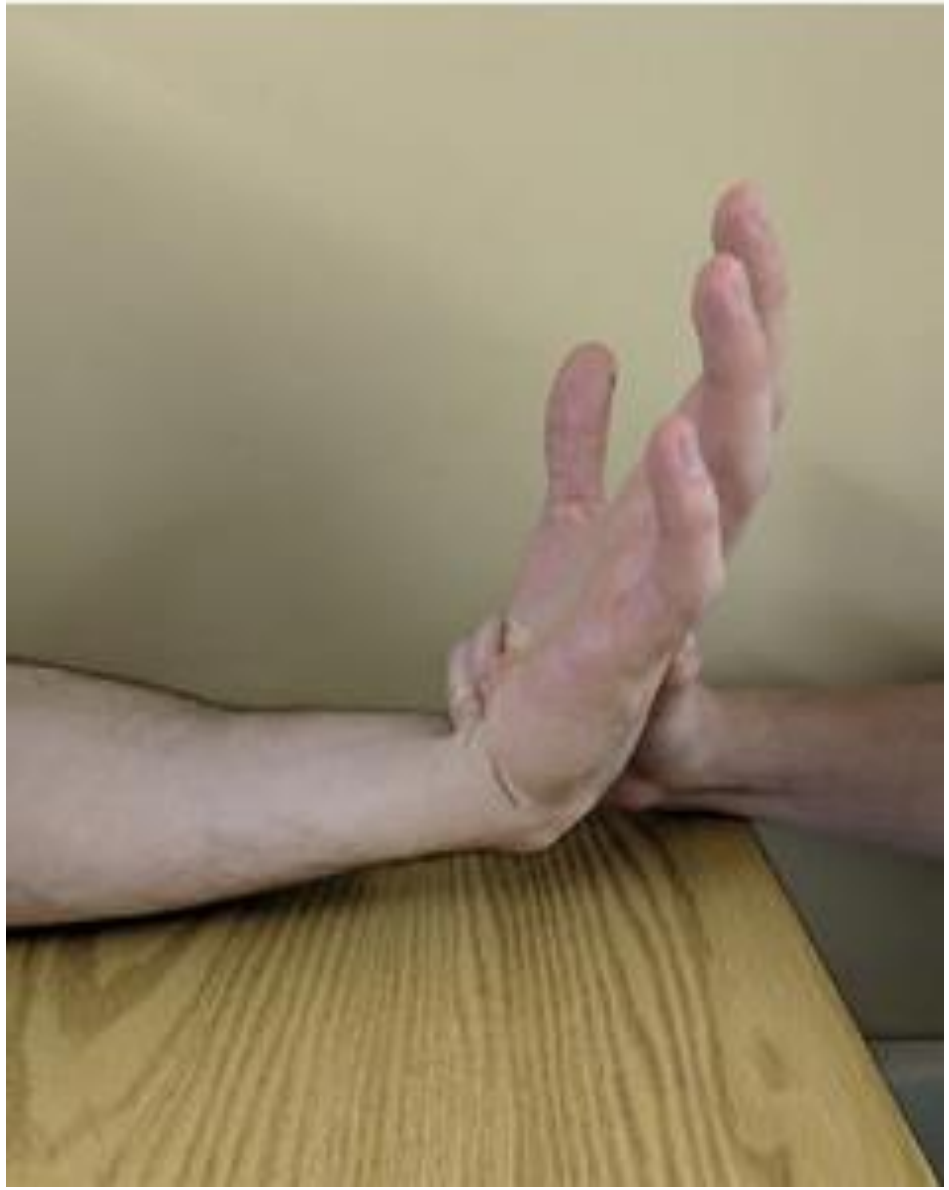


The test is considered positive if after 2 minutes of active wrist extension, paresthesias occur in the innervation area of the median nerve.

Provocative tests → Tetro's sign

A. Marc Tetro, 1998

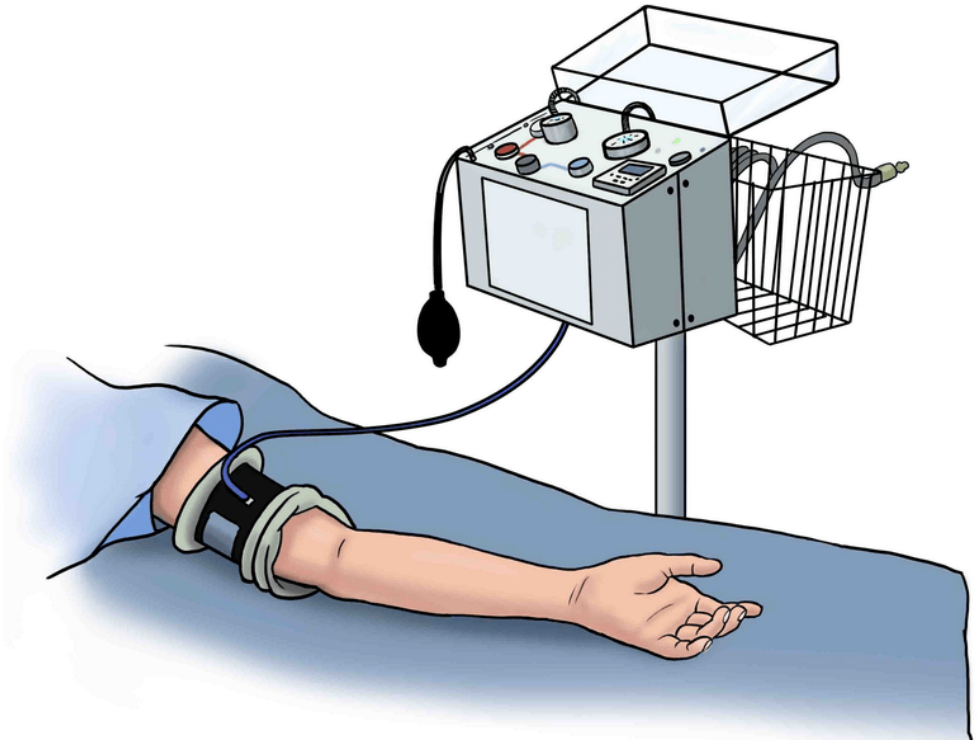
Phalen maneuver + McMurtry's test



Provocative tests
→ Gilliatt's test

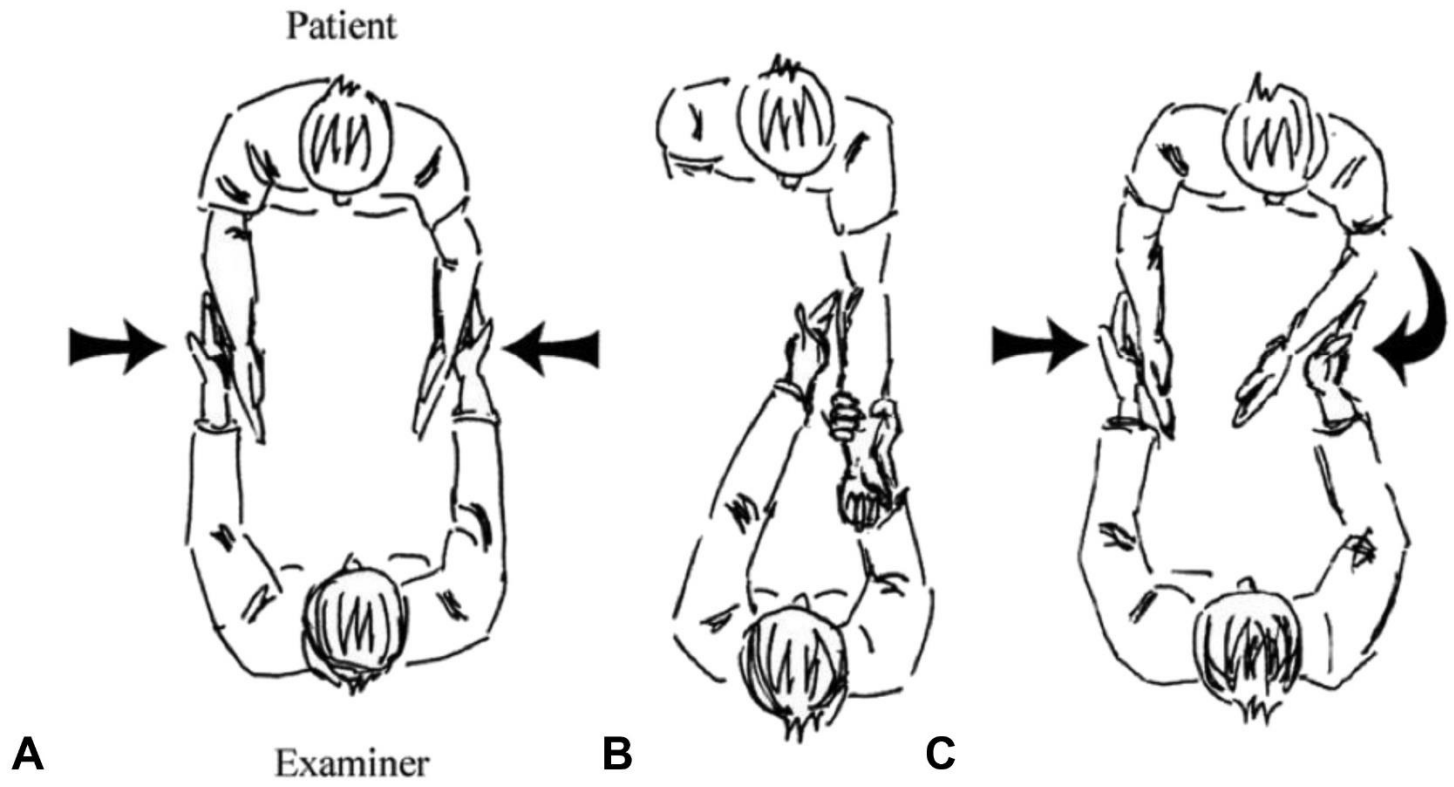
R. W. Gilliatt, 1953

- Temporary ischemia to the median nerve vasa nervorum caused by a pneumatic tourniquet causes paresthesia in the distribution area of the nerve.
- The pressure of the tourniquet is slightly above the systolic blood pressure.



The test is considered positive if after the activation of a pneumatic tourniquet on the arm above the elbow, paresthesia occur after 60 seconds.

Provocative tests
→ Scratch – Collapse test



Cheng, Mackinnon, 2008

- Scratch = activation of A-alpha and A-delta → complex modulatory effects on upper limb motoneuron pools
- Collapse = A-delta fibers: protective spinal reflex → reduction of motor function in muscles involved in reaching and grasping, i.e. it protects the hand from harm

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Nerve studies

Diagnostic imaging

- **Ultrasound**
  - Morphology and course of the nerve
  - Points of compression

- CT – scan
  - Bone lesions
  - Myelo-CT for the brachial plexus

- MRI
  - Tumors
  - Lesions of the central nervous system

Thank you for your attention

References

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