**Development of Complex Curricula for Molecular Bionics and Infobionics Programs within a consortial* framework****

**Consortium leader**

# PETER PAZMANY CATHOLIC UNIVERSITY

**Consortium members**

# SEMMELWEIS UNIVERSITY, DIALOG CAMPUS PUBLISHER

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**Molekuláris bionika és Infobionika Szakok tananyagának komplex fejlesztése konzorciumi keretben

***A projekt az Európai Unió támogatásával, az Európai Szociális Alap társfinanszírozásával valósul meg.

# BASICS OF NEUROBIOLOGY

**Neurobiológia alapjai**

# SPINAL CORD

**(Gerincvelő)**

**ZSOLT LIPOSITS**

## GROSS FEATURES

THE SPINAL CORD IS A CYLINDRICAL STRUCTURE SLIGHTLY FLATTENED DORSO-VENTRALLY

THE SPINAL CORD IS IN CONTINUITY WITH THE BRAIN AND DEVELOPMENTALLY IT DERIVES FROM THE CAUDAL PART OF THE NEURAL TUBE

THE SPINAL CORD IS LOCATED IN THE VERTEBRAL CANAL AND IT IS SURROUNDED BY VERTEBRAE. THE VERTEBRAL COLUMN IS COMPOSED OF BONES, CARTILAGE AND MEMBRANOUS STRUCTURES AND GIVES HIGH-LEVEL PHYSICAL PROTECTION FOR THE SPINAL CORD WHICH HAS A SOFT AND VULNERABLE HISTOLOGICAL TEXTURE

THE SPINAL CORD IS ENCLOSED BY THE MENINGES, BOTH THE PACHYMENINX AND THE LEPTOMENINX TAKE PART IN ITS ENSHEATING

THE CEREBROSPINAL FLUID CIRCULATING IN THE SUBARACHNOID SPACE ALSO SURROUNDS THE SPINAL CORD AND CONTRIBUTES TO ITS PROTECTION

THE SPINAL CORD IS SHORTER THAN THE VERTEBRAL CANAL, THEREFORE, IN ADULTS THE CORD ENDS AT THE LEVEL OF UPPER LUMBAR VERTABRAE (L1-L2)

FRACTURE OF THE VERTEBRAL COLUMN MIGHT SEVERELY DAMAGE THE CORD

## MRI IMAGING OF THE SPINAL CORD

MESENCEPHALON

PONS

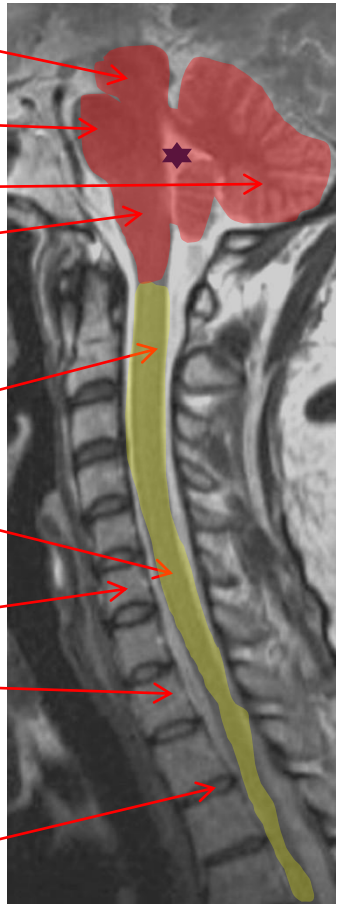
CEREBELLUM

MEDULLA

SPINAL CORD

VERTEBRAL COLUMN

INTERVERTEBRAL DISC



MEDIAN-SAGITTAL MRI IMAGE SHOWS THE BRAIN STEM (HIGHLIGHTED IN RED) AND THE SPINAL CORD (HIGH-LIGHTED IN GREEN).

THE CONSTITUENTS OF THE BRAIN STEM ARE DISCERNABLE, THE 4$^{TH}$ CEREBRAL VENTRICLE IS VISIBLE (ASTERISK)

NOTE THE VERTEBRAL COLUMN CON-TAINING THE SPINAL CORD

THE INDIVIDUAL VERTEBRAE ARE SEPA-RATED BY INTERVERTEBRAL DISCS

## SPINAL MENINGES

THE PACHIMENINX IS FORMED BY THE DURA MATER. IN CASE OF THE SPINAL CORD, THE DURAL SAC HAS TWO LAYERS THAT DEFINE THE EPIDURAL SPACE

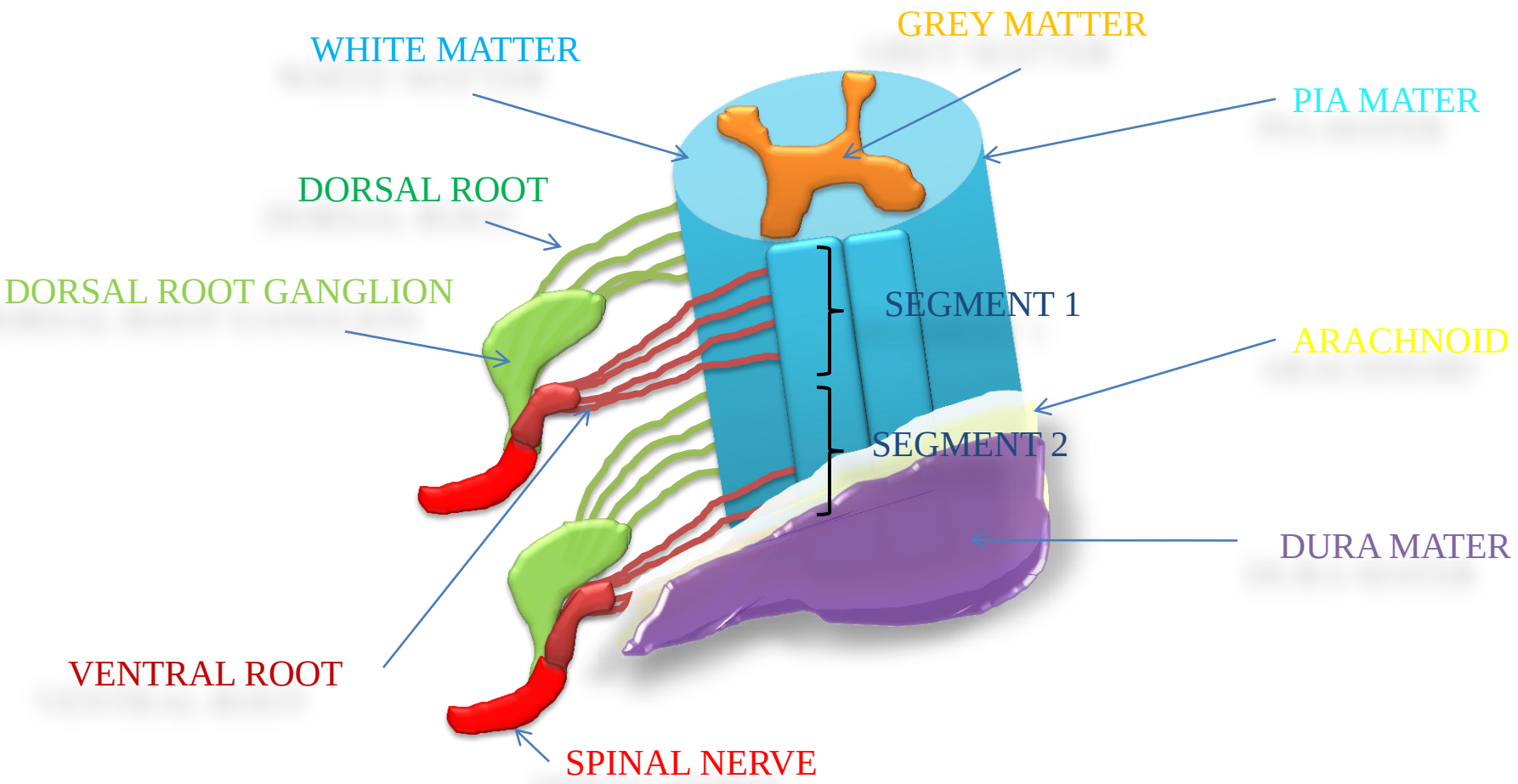
THE INJECTION OF LOCAL ANESTHETICS INTO THE EPIDURAL SPACE CAN PRODUCE A POWERFUL PARAVERTEBRAL BLOCKADE OF NEURAL TRANSMISSION AND CAUSE ANALGESIA

THE ARACHNOID AND THE PIA MATER FORM THE INNER ENVELOPES. THEY ESTABLISH THE LIQUOR-FILLED SUBARACHNOID SPACE

THE INNERMOST PIA MATER SMOOTHLY AND TIGHTLY COVERS THE ENTIRE SURFACE OF THE SPINAL CORD. ARISING FROM THIS MEMBRANE ONE CAN FIND SERRATED LIGAMENTS ON BOTH SIDES OF THE SPINAL CORD THAT ATTACH THE CORD TO THE DURA MATER. ACTUALLY, THE SPINAL CORD IS SUSPENDED AND FLOATS IN THE CSF

CAUDAL TO TERMINATION OF THE SPINAL CORD, THE MENINGES SURROUND THE BUNDLES OF THE DORSAL AND VENTRAL ROOTS (CAUDA EQUINA) OF LUMBO-SACRAL SEGMENTS. THIS IS THE PREFERRED LOCUS OF LUMBAR PUNCTURE

## SPINAL SEGMENTS



## SPINAL SEGMENTS

THE GREY MATTER IS LOCATED CENTRALLY WITHIN THE SPINAL CORD. IT IS BUTTERFLY-SHAPED AND COMPOSED OF NEURONS AND GLIAL CELLS

THE WHITE MATTER HAS A PERIPHERAL LOCATION SURROUNDING THE GRAY MATTER. IT CONSISTS OF FIBER BUNDLES, SO-CALLED TRACTS AND GLIAL CELLS

IN TERMS OF GROSS ANATOMY, THE GRAY AND WHITE MATTER CONSTITUENTS OF THE SPINAL CORD ARE NOT SEGMENTED, BOTH ESTABLISH COLUMNAR, CONTINUOUS ORGANIZATIONS

THE INCOMING SENSORY FIBERS AND THE OUTGOING MOTOR AXONS DEFINE PARTICULAR REGIONS OF THE SPINAL CORD CALLED SEGMENTS. THESE ARE 1-3 cm HIGH DIVISIONS OF THE CORD

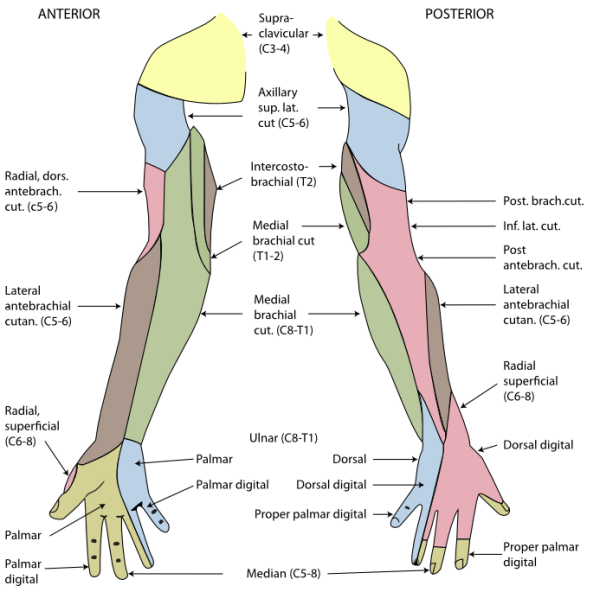
THERE ARE 31 SEGMENTS: 8 CERVICAL, 12 THORACIC, 5 LUMBAR, 5 SACRAL AND 1 COCCYGEAL

THE DORSAL ROOT AND ITS GANGLION CONVEY SENSORY INFORMATION

THE FIBERS OF THE VENTRAL ROOT EXECUTE MOTOR COMMANDS

THE DORSAL AND VENTRAL ROOTS JOIN AND FORM THE SPINAL NERVE THAT AFTER A SHORT JOURNEY SPLITS INTO VENTRAL AND DORSAL RAMI

# SEGMENTAL INERVATION OF THE SKIN




DERMATOMES OF THE UPPER LIMB

THE SENSORY COMPONENTS OF A GIVEN PAIR OF SPINAL NERVES INNERVATE WELL-DEFINED AND SHAPED SEGMENTED REGIONS OF THE SKIN CALLED DERMATOMES

IN GENERAL, THE INNERVATION OF THE SKIN FOLLOWS THE SEGMENTAL MOTOR NERVE SUPPLY TO THE UNDERLYING MUSCLES

THE DERMATOMES ALTHOUGH SEEM TO OVERLAP

EXAMINATION OF THE DERMATOMES GIVES A VALUABLE INFORMATION FOR THE PHYSICIAN BY REFLECTING THE INTEGRITY AND ACTUAL OPERATION OF GIVEN SEGMENTS OF THE SPINAL CORD

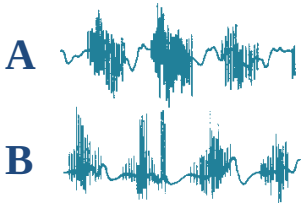
THE ILLUSTRATION ON THE LEFT SIDE DEPICTS THE DERMATOMES OF THE UPPER LIMB WITH NAMES OF THE CORRESPONDING NERVES AND SEGMENTS

# INNERVATION OF MUSCLES. ELECTROMYOGRAM

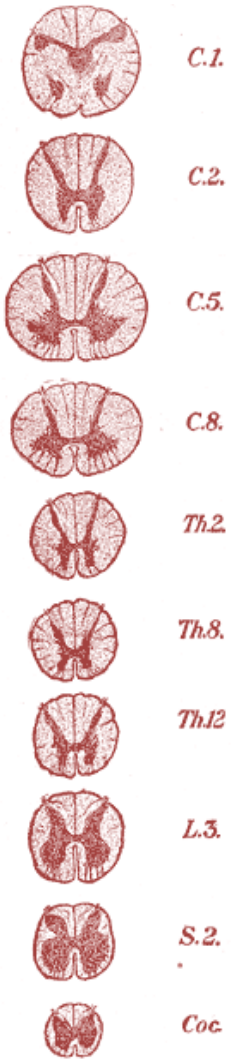
SKELETAL MUSCLES OF THE BODY DEVELOP PREDOMINANTLY FROM MYOTOMES THAT ARE DERIVATIVES OF THE MESODERM LAYER. MYOTOMES PROVIDE MYOGENIC CELLS THAT GENERATE THE MUSCLES

THE MYOTOMES ARE SEGMENTED STRUCTURES. ACCORDINGLY, MUSCLES DEVELOPING FROM GIVEN SEGMENTS ARE INNERVATED BY SOMATIC MOTONEURONS DEVELOPING IN THE VENTRAL HORN OF THE SPINAL CORD OF THE SAME SEGMENTS. THESE NEUROMUSCULAR CONNECTIONS ARE ESTABLISHED EARLY. AS MUSCLES MIGRATE TO THEIR FINAL DESTINATION THEY PULL THE MOTONEURON AXONS WITH THEMSELVES

THE FUNCTION OF THE MUSCLES AND THEIR INNERVATING NERVES CAN BE EXAMINED BY ELECTROMYOGRAPHY (EMG). EMG IS PERFORMED USING INSTRUMENT CALLED ELECTROMYOGRAPH, TO PRODUCE A RECORD CALLED AN ELECTROMYOGRAM. THE ELECTROMYOGRAPH DETECTS THE ELECTRICAL POTENTIAL GENERATED BY THE MUSCLE WHEN IT IS ACTIVE




ELECTROMYOGRAMS OF ANTAGONIST FLEXOR (A) AND EXTENSOR (B) MUSCLES RECORDED DURING ALTERNATING FLEXIONS AND EXTENSION OF THE ARM




## SEGMENTAL DIFFERENCES WITHIN THE SPINAL CORD

THE RATIO OF WHITE/GREY MATTER VOLUME CHANGES ACCORDING TO THE CRANIO-CAUDAL POSITION OF THE SEGMENT. CRANIALLY, THE CERVICAL SEGMENTS ARE LARGER WITH MUCH MORE WHITE MATTER IN THEM IN COMPARISON WITH CAUDAL, SACRAL SEGMENTS

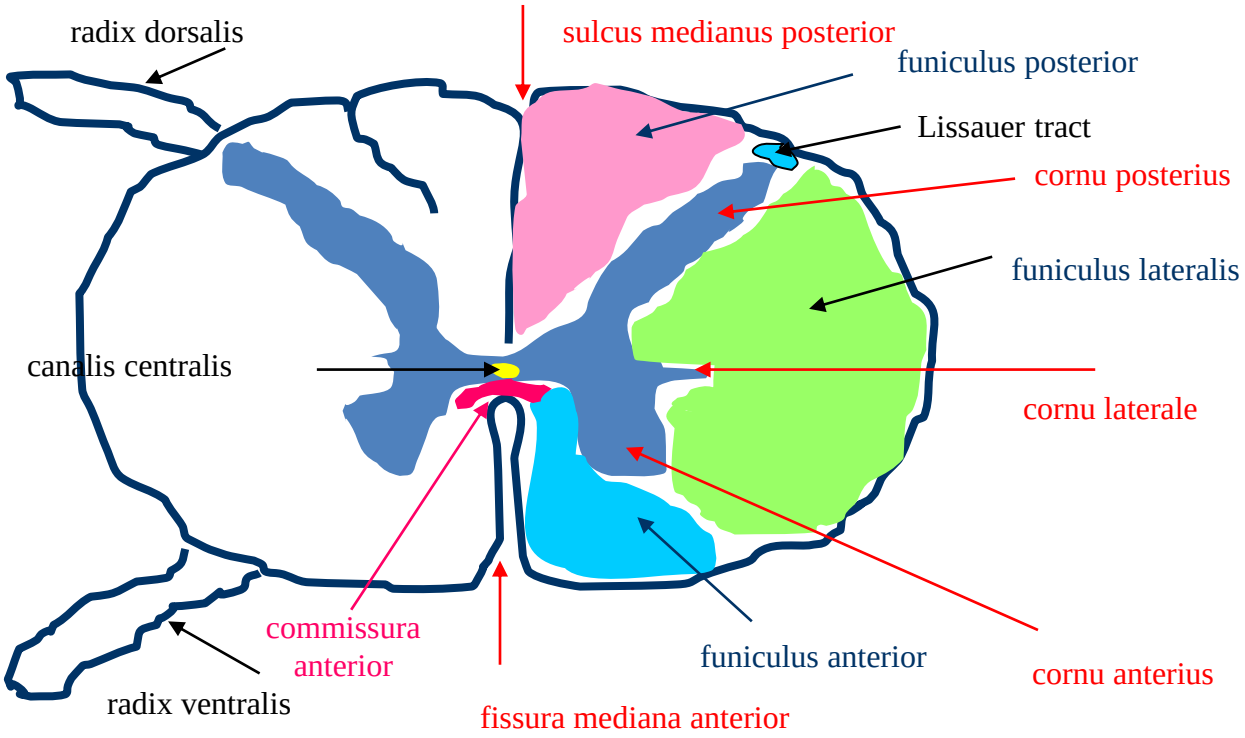
THE SPINAL CORD SHOWS TWO ENLARGEMENTS

THE CERVICAL ENLARGEMENT INCLUDES SEGMENTS C5-T8. THESE SEGMENTS GIVE RISE TO THE BRACHIAL NERVE PLEXUS THAT SUPPLIES THE UPPER EXTREMITIES

THE SECOND ENLARGEMENT IS AT THE LUMBO-SACRAL LEVEL FROM WHERE THE LUMBAR (L1-L4) AND SACRAL (L5-S3) PLEXUSES TAKE THEIR ORIGIN AND PROJECT TO THE LOWER EXTREMITIES TO SUPPLY THEM

NOTE, THAT THE CROSS-SECTIONAL PROFILE OF THE GREY MATTER IS HIGHLY CHARACTERISTIC FOR THE SEGMENT

## SCHEMATIC ILLUSTRATION OF THE CROSS-SECTIONED SPINAL CORD




THE GRAY MATTER IS ORGANIZED INTO DORSAL, LATERAL AND VENTRAL HORNS. THE FIBER TRACTS OF THE WHITE MATTER RUN IN THE POSTERIOR, LATERAL AND ANTERIOR FUNICULI