PHYSIOLOGY OF HIGHER NERVOUS FUNCTIONS
PHYSIOLOGY OF THE CENTRAL NERVOUS SYSTEM

Sensory division of the CNS
Motor division of the CNS
Autonomic division of the CNS

PHYSIOLOGY OF THE HIGHER NERVOUS FUNCTIONS

SLEEP AND WAKEFULNESS
EMOTIONS
MEMORY AND LEARNING
SPEECH
BRAIN LATERALITY – FUNCTIONAL SPECIALIZATION OF BRAIN HEMISPHERES
REFLEXES
SPINAL CORD - reflexes,
BRAIN STEM - breathing
blood pressure)
very quick stereotypic reactions
“brain of the snake”

EMOTIONS
PALEOCORTEX
SUBCORTICAL NUCLEI - life and
species preservation, survival
“brain of the horse”

COGNITIVE
Neocortex – the highest level of
brain functions – learning and
memory
cognition – homo sapiens
“brain of a man”
BRAIN – INFORMATION HIGHWAY

INFORMATIONS

COLLECTS (SENSES)
sensory Neurons

ORGANISES
association neurons

TRANSports
neurons

STORES

SENDs (MUSCLES, ENDOCRINE GLANDS)

motor neurons

3-level system: reflexive, emotional, cognitive

INPUT DECISION MAKING ANALYSIS

OUTPUT
ASSOCIATION AREAS OF THE BRAIN CORTEX

- Association motor cortex
- Primary motor cortex
- Primary sensory cortex
- Association sensory cortex
- Polymodal association cortex
- Primary auditory cortex
- Association auditory cortex
- Primary visual cortex
- Association visual cortex
- Prefrontal cortex
- Limbic cortex
**TALAMUS** relays information to:

- **AMYGDALA** – considering danger

- **SPECIFIC PROJECTION AREAS** for particular sensory modality

- **ASSOCIATION BRAIN CORTEX** predepolarizing association neurons
The case of Phineas Gage

„Pineas GAGE“, 1848

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prefrontal cortex damage – PREFRONTAL CORTICAL SYNDROMA

Behavioral disorder – impulsiveness, childish behavior, unsensitivity, loss of social rules, recklessness, uncontrolled emotions
Personality changes – capriciousness, unpoltleness, indecisiveness, moral insanity

Prefrontal lobes are site of „COMMON SENSE“ and human personality

The case of „Pineas GAGE“, 1848

Frontal lobotomy 1930 - 1960 therapeutic cut prefrontal areas with Other brain (Egaz Monitz, 1949)
MOTOR DIVISION OF THE CNS

PRIMARY MOTOR CORTEX
(gyrus praecentralis
In frontal lobe)
MOTOR HOMUNCULE

SENSORY DIVISION OF THE CNS

PRIMARY SENSORY CORTEX
(gyrus postcentralis
In parietal lobe)
SENSORY HOMUNCULE
PHYSIOLOGY OF THE SENSORY DIVISION OF THE CENTRAL NERVOUS SYSTEM
Registering of inputs, coding, integration and adequate response

1. Sensory receptors  -->  2. signal transduction  -->  3. Physiological response
Somatic Pathways

First-order neurons – soma reside in dorsal root or cranial ganglia, and conduct impulses from the skin to the spinal cord or brain stem.

Second-order neurons – soma reside in the dorsal horn of the spinal cord or medullary nuclei and transmit impulses to the thalamus or cerebellum.

Third-order neurons – located in the thalamus and conduct impulses to the somatosensory cortex of the cerebrum.

http://www.austincc.edu/rfofi/NursingRvw/PhysText/PNSafferentpt1.html
SENSORY DIVISION OF THE CNS

PRIMARY SENSORY CORTEX (gyrus postcentralis in parietal lobe)
SENSORY HOMUNCULE
reflection of peripheral sensitivity
TACTILE COGNITION – CORTICAL SYNDROMES

Dominance of the right hemisphere
Primary somatosensory cortex BA3
Secondary somatosensory cortex BA1, 2

People using Braille reading –
Enlargement of sensory-motor cortical representation

TACTILE AGNOSIA - inability to recognize objects by touch
ASTEREOGNOSIA – inability to recognize 3D objects by touch
APRAXIA – inability to do planned purposefull movements disorder of
eyes and movement integration
NEGLECT SYNDROME
Ignoring of contralateral eye stimuli, half of the self,
(autopatognosia)
(disturbance of association somatosensory areas on the right,
or bilateraly)
NEGLECT SYNDROME

Patient's right parietal lobe stroke damage

NEUROLOGIST: "Copy this."
Patient's drawing

"And now this."

NEUROLOGIST: "Here's a circle. I've even added some hair. Now, draw me a face."

NEUROLOGIST: "Here's another circle. Draw me a sunflower."

"They're all complete? Is there anything wrong with any of the drawings?"

PATIENT: "No. That's a cross. A house. And a face -- I made his tongue stick out. And that's a sunflower with some leaves."

"Neglect" of left side of visual space

Zdroj: williamcalvin.org/bk7/bk7ch4.htm
VISUAL COGNITION – CORTICAL SYNDROMES

Associative fibers from visual areas 
OCCIPITOPARIETAL PATHWAY (magnosystem) – WHERE IS IT?

Disturbance of nerve fibers or projection areas in parietal lobe – lesion of visual - spatial perception

ALEXIA – DYSLEXIA (pure) inability to understand written speech, inability to couple graphems to phonems (left hemispheric dominance) 
Disturbance of left visual areas and disturbance of posterior part of corpus callosum 
Ethiology: genetic – dyslectic locus on chromosome 6 obtained 
(pre- a perinatal) disturbance of neuron migration (ektopic neurons), mikrogyria (diminishing of gyri), glial scars, reduction of fibers through corpus callosum

Alexia is often associated with AGRAFIA – DYSGRAFIA with memory disturbances, visual and auditory processing disturbances (left hemispheric dominance)
Association fibers from visual areas

**OCCIPITOTEMPORAL PATHWAYS**
(parvosystem) – WHAT IS IT?
Disturbance of nerve fibers or projection areas – medial parts of parietal and temporal lobes

**Consequences:**

a) **VISUAL AGNOSIA**
“SEE BUT NOT RECOGNIZE“ – cortical blidness
Inability to recognize and name Visually presented objects
Disturbances of recognition Of complex shapes in connection right hemispheric lesion

b) **CEREBRAL ACHROMATOPSIA**
Inability of color perception In undisturbed vision

c) **PROSOPAGNOSIA**
Inability to recognize common faces, And his/her own
Inferior areas of the right hemisphere
AUDITORY COGNITION – CORTICAL SYNDROMES

Primary auditory cortex – BA 41
Secondary auditory cortex – BA 42

Wernicke area for speech perception-
BA 22 – WERNICKE APHASIA (LEFT HEMISPHERIC DOMINANCE)

WORD DEAFNESS
„hear but does not understand“ also non-speech sounds

WORD AGNOSIA
„hear but does not understand“ but understands non-speech sounds
(\textit{left hemispheric dominance})

AMUSIA
Disturbance of recognition and reproduction of music (\textit{right hemispheric dominance})

MUSIC AGNOSIA
Inability to recognize musical instruments and human voice, inability to sing and to remember melodies (\textit{right hemispheric dominance})
PHYSIOLOGY OF THE MOTOR DIVISION OF THE CENTRAL NERVOUS SYSTEM
Motor homunculus is the unproportionate “man” drawn over the surface of the brain – over the primary motor cortex in precentral gyrus (gyrus praecentralis). Motor movements are governed from that part of the brain through pyramidal and extrapyramidal tracts.
MOTOR PATHWAYS

A Pyramidal tract
Direct connection from motor cortex to skeletal muscles through motor end plate
Tractus corticospinalis

B Extrapyramidal tracts
Indirect connections through basal ganglia, thalamus, cerebellum, brain stem
Tractus reticulospinalis
Tractus rubrospinalis
Peripheral nerve

Is composed of number of axons of efferent and afferent neurons, myelin sheets and connective tissues

Types of fibres:

A alfa – thick, quick to 120 m/s, movement
A beta – thinner, to 70 m/s, touch, pressure
A gama – thinner, do 30 m/s, muscle tone
A delta – thinner, do 30 m/s, pain, warmth
B – thin and slow, 2 m/s, autonomic fibres
C – thin and slow, autonomic fibres, pain
SPINAL CORD

PROTECTED BY BACKBONE
Gray matter – neurons – butterfly shaped
White matter – nerve fibers

Anterior horns – motor spinal nerve exit
From motor neurons
Alfa- motor neurons
Gama-motor neurons

Posterior horns – sensory spinal nerve entrance

Cross section of the spinal cord
Schwann cells – glial cells in PNS - the sheath of peripheral nerve fibres – made of Schwann cells. Multiple wrappings around axon of neuron form myelin sheath.

Nodes of Ranvier separate apart the Schwann cells and give rise to - saltatory transmission of action potentials

Myelin sheath serves for regeneration of cut nerves – the tube for growth of the proximal part of the axon.

Steps of regeneration of proximal part of an axon after injury
MOZOČEK - CEREBELLUM

ENSURES:
A) UPRIGHT POSITION AND BALANCE
B) FINE REGULATION OF MOVEMENTS AND POSITION, TIME MANAGEMENT OF MOVEMENTS
C) COORDINATION OF MUSCLE UNITS IN COMPLEX MOVEMENTS INCLUDING SPEECH MOVEMENTS MECHANISM (cerebelárna dysartria a dysfónia)
D) MOTOR LEARNING
AUTONOMIC NERVOUS SYSTEM IN BRIEF
The autonomic nervous system consists of sensory neurons and motor neurons that run between the central nervous system (especially the HYPOTHALAMUS and MEDULLA OBLONGATA and various internal organs:

- heart
- lungs
- viscera
- glands (exocrine and endocrine)

It is responsible for monitoring conditions in the internal environment and bringing about appropriate changes in them. The contraction of both smooth muscle and cardiac muscle is controlled by motor neurons of the autonomic system.
The actions of the autonomic nervous system are largely **involuntary** (in contrast to those of the sensory-somatic system). It also differs from the sensory-somatic system using two groups of motor neurons to stimulate the effectors instead of one.

1. **preganglionic neurons**, arise in the CNS and run to a ganglion in the body. Here they synapse with 2. **postganglionic neurons**, which run to the effector organ (cardiac muscle, smooth muscle, or a gland).

Two subdivisions of the ANS **sympathetic nervous system** and the **parasympathetic nervous system**.
MULTI UNIT SMOOTH MUSCLE OF IRIS

AUTONOMIC NERVOUS SYSTEM EFFECT ON MIOSIS AND MYDRIASIS

Antagonistic functions of sympathetic and parasympathetic activation
SYMPATHETIC STIMULATION – RELEASE OF NA

The release of noradrenaline
• stimulates heartbeat
• raises blood pressure
• dilates the pupils
• dilates the trachea and bronchi
• stimulates glycogenolysis — the conversion of liver glycogen into glucose
• shunts blood away from the skin and viscera to the skeletal muscles, brain, and heart
• inhibits peristalsis in the gastrointestinal (GI) tract
• inhibits contraction of the bladder and rectum

Stimulation of the sympathetic branch of the autonomic nervous system prepares the body for emergencies: for "fight or flight"

Activation of the sympathetic system is quite general because:
A) a single preganglionic neuron usually synapses with many postganglionic neurons
B) the release of adrenaline from the adrenal medulla into the blood ensures that all the cells of the body will be exposed to sympathetic stimulation even if no postganglionic neurons reach them directly.
PARASYMPATHETIC STIMULATION – RELEASE OF ACH or NO

Parasympathetic stimulation causes
• slowing down of the heartbeat
• lowering of blood pressure
• constriction of the pupils
• increased blood flow to the skin and viscera
• peristalsis of the GI tract

The parasympathetic system returns the body functions to normal after they have been altered by sympathetic stimulation. In times of danger, the sympathetic system prepares the body for violent activity. The parasympathetic system reverses these changes when the danger is over.