Clinical neuroscience module “C”: The human brain in health and disease
- Proposed by Bogdan Draganski –

The course will include a complete description of the healthy and diseased brain as well as a description of the acquisition and analysis tools to study brain structure, function and connectivity. Students can also benefit from participation in the clinical case presentations at the neurology service of the CHUV on Wednesday mornings. Upon successful completion of the course, students will have developed a broad knowledge of how modern neuroimaging techniques and their application improve our understanding of normal brain functions and disorders of the central nervous system. In particular they will:

- Have a good basic knowledge of brain anatomy / function and corresponding characteristic changes in neurological diseases.
- Be aware of the major recent developments in research in the area of neuroimaging.

Proposed schedule (6x4h= 2 ECTS): Wednesday mornings of each second week (please see “Program Overview” for detailed schedule)

Topic C1: Introduction to Neuroanatomy, Systems and Disease (B. Draganski)
Topic C2: Language – neuroanatomy, physiology, pathology and prediction of recovery using imaging (P. Michel & F. Kherif)
Topic C4: Hearing & vision – neuroanatomy, physiology, pathology and plasticity (E. Geisser & M. Saenz)
Topic C5: Memory – neuroanatomy, physiology, pathology and plasticity revealed by imaging (J-F. Demonet)
Topic C6: The Immune System & the Brain – neuroanatomy, physiology, pathology and plasticity (C. Granziera)

Student evaluation: Journal club presentation and essay
Content Summary

**Neuroanatomy (N)** The cortex; Basal ganglia; Skull base & spine; Vasculature

**Physiology & Function (PF)** CNS physiology; Functional systems

**Brain diseases (BD)** Pathophysiological studies in Epilepsy; Neurodegeneration; Inflammation & Infection; Stroke; Tumours, Movement disorders

**Learning Outcomes**

**Neuroanatomy (N)**
At the end of this module students will be able to identify the important anatomic structures of the brain and spinal cord. They will understand the vascular supply of the head and spine. The student should gain anatomical knowledge of white matter tracts and cortex-basal ganglia projections.

**Physiology & Function (PF)**
At the end of this module students will be able to understand the physiology of the CNS and the fundamentals of neuronal excitation and functional systems.

**Brain diseases (BD)**
After the lecture the students should be able to name pathological processes that commonly involve the brain (ischaemia, demyelination, tumours, neurodegenerative disorders) and be familiar with the clinical syndromes caused by lesions in particular locations. Students will be able to describe and explain the clinical presentation of paroxysmal, acute and chronic brain disorders in terms of function disruption within the nervous system.
**Topic C2: Language – plasticity and development**

**Content Summary**

<table>
<thead>
<tr>
<th>Pathology (PA)</th>
<th>Stroke, Small vessel disease; Treatment of ischaemic &amp; haemorrhagic stroke; Aphasia, Dysarthria</th>
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<tbody>
<tr>
<td>Plasticity (PL)</td>
<td>Language function recovery, Degeneracy hypothesis, Multilingualism and learning induced plasticity</td>
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**Learning Outcomes**

**Neuroanatomy & physiology (N&PF)**

Brief recapitulation on basic principles of brain anatomy and function emphasizing on the particular topic of interest.

**Pathology (PA)**

Focusing on pathology within the language networks the student will understand the main causes of ischaemic and hemorrhagic stroke in adults and be able to differentiate between ischaemic and hemorrhagic stroke and their relative frequency. They will also be familiar with the time course of the radiological appearance of ischaemic stroke on MRI with particular emphasis on diffusion weighted MRI. They will have an understanding of the mechanisms, epidemiology & prevention, and treatment of stroke, and have had an introduction to neurological rehabilitation and neurological outcome measurement.

The students will be able to differentiate various forms of speech and language problems according to lesion localisation. They will acquire knowledge about well-established and innovative concepts for aphasia treatment based on observational or interventional studies.

**Plasticity (PL)**

During the lectures and discussions students will become familiar with current concepts on the recovery of lost language related functions. The presented results of structural and functional imaging studies will demonstrate recent advances in the assessment of language impairment, the spatial distribution of inter-individually distinct nodes of language networks and their importance for recovery of function. Students will be confronted with evidence for structural and functional reorganisation of the healthy adult brain related to multi-lingualism and language acquisition.
**Topic C3: Sensorimotor system – pathology and plasticity**

**Content Summary**

**Pathology (PA)** The Sensorimotor system; Movement disorders - clinical presentation and diagnostic, pharmacological and surgical treatment; Motor control; Epilepsy - clinical presentation and diagnostic, pharmacological and surgical treatment

**Plasticity (PL)** Motor recovery after stroke, Training induced plasticity in Parkinson’s disease

**Learning Outcomes**

**Neuroanatomy & physiology (N&PF)**

Brief recapitulation on basic principles of brain anatomy and function emphasizing on the particular topic of interest.

**Pathology (PA)**

At the end of the module students will have been introduced to the motor system, and motor control theories; the use of MRI and Transcranial Magnetic Stimulation – TMS, for assessment of motor function and an understanding of the physiology & functional organization of the basal ganglia, the neuropathological basis of movement disorders, the pathogenesis and treatment of Parkinson’s disease, akinetic-rigid syndromes and choreiform disorders. Finally, the students will be able to differentiate and explain the root cause for variable clinical patterns and temporal evolution of pathological processes within the sensorimotor system.

Focusing on pathology within the sensorimotor system the student will gain familiarity with the clinical forms of epilepsy and should be able to name a number of neuroradiological findings encountered in patient with epilepsy such as hippocampal sclerosis, cortical heterotopia, arteriovenous malformations (AVMs), cavernomas, benign and malignant brain tumours. At the end of the module the students will have an understanding of epilepsy disorders of the CNS, their pathophysiology and treatment.

**Plasticity (PL)**

At the end of this presentation the students will have acquired knowledge about current concepts of motor function recovery supported by neuroimaging studies. Controversial aspects of inter-hemispheric interactions after unilateral lesions of the motor system will be understood and critically discussed.

Students will be able to discuss existing evidence about structural and functional reorganisation of the adult human brain following sensori(motor) training.
**Topic C4: Hearing and Vision – pathology and plasticity**

**Content Summary**

<table>
<thead>
<tr>
<th>Pathology (PA)</th>
<th>The visual system; auditory system; vestibular system; tinnitus; presbyacusis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plasticity (PL)</td>
<td>Auditory/visual hallucinations; Training induced plasticity</td>
</tr>
</tbody>
</table>

**Learning Outcomes**

**Neuroanatomy & physiology (N&PF)**

Brief recapitulation on basic principles of brain anatomy and function emphasizing on the particular topic of interest.

**Pathology (PA)**

At the end of the module students will also have an understanding of cognitive processes including early visual processing, face recognition and prosopagnosia. They should be able to describe primary and secondary visual and auditory perceptive areas both in terms of anatomical location and function.

**Plasticity (PL)**

At the end of this presentation students will have acquired knowledge about current concepts of functional reorganisation of the visual and auditory system in health and disease supported by neuroimaging studies. They will be able to grasp recent evidence for spatial organisation of retinotopy and tonotopy in the human brain. Novel ideas about treatment of dysfunction in these systems will be debated.
**Topic C5: Memory – pathology and plasticity**

**Content Summary**

**Pathology (PA)** Memory system; Alzheimer’s disease; Amyloid cascade hypothesis; Multisystem Atrophy (MSA), Motor Neuron Disease (MND) Progressive Supranuclear Palsy (PSP), and Fronto-Temporal Lobar Degeneration (FTLD)

**Plasticity (PL)** Working memory training, Neuroenhancement

**Learning Outcomes**

**Neuroanatomy & physiology (N&PF)**
Brief recapitulation on basic principles of brain anatomy and function emphasizing on the particular topic of interest.

**Pathology (PA)**
At the end of this module students will be able to demonstrate an understanding of the cellular mechanisms in predominantly affected brain regions in Alzheimer’s Disease (AD), Multisystem Atrophy (MSA), Motor Neuron Disease (MND) Progressive Supranuclear Palsy (PSP), and Fronto-Temporal Lobar Degeneration (FTLD). They will also become familiar with the age of onset and long-term prognosis for each of the above diseases. Students will be able to understand the role of imaging in the clinical context as well as the role of special techniques such as fluid registration and VBM for advanced diagnosis. They will also have an understanding of cognitive processes including early visual processing, face recognition and prosopagnosia, memory and the hippocampus, the limbic system, language and language abnormalities, executive functions, and cortical connectivity and cognition.

**Plasticity (PL)**
After this topic students will acquire knowledge about the link between neuroimaging biomarkers of neurodegeneration and age- or disease-related cognitive decline. They will learn about the impact of amyloid burden, white matter hyper-intensities and local brain atrophy on cognition, particularly on episodic and working memory – most vulnerable domains in “normal ageing” and Alzheimer’s disease. Finally, students will be able to challenge the concept of cognitive reserve in “supernormal ageing” by evidence for preservation of neurochemical, structural and functional brain integrity in old age rather than recruitment of “reserves” for maintaining cognitive abilities.
Topic C6: The Immune System & the Brain – pathology and plasticity

Content Summary

**Pathology (PA)** Demyelination; White matter lesions; Magnetisation Transfer, DTI & Spectroscopy in imaging Multiple Sclerosis; Spinal cord, Neuro HIV

**Plasticity (PL)** Function recovery, Immuno-modulatory treatment

Learning Outcomes

**Neuroanatomy & physiology (N&PF)**
Brief recapitulation on basic principles of brain anatomy and function emphasizing on the particular topic of interest.

**Pathology (PA)**
At the end of this module students will be familiar with the clinical forms of multiple sclerosis and typical imaging appearance (McDonald criteria). They will be able to identify factors that can cause vasculitis of the cerebral vessels (SLE, TB, drug use). They will be familiar with the common neurological manifestations of AIDS and aware of the changing pattern of Neuro-Aids with the introduction of highly active anti-retroviral therapy (HAART). At the end of this module students will be able to understand the role of imaging in the clinical context as well as the role of special techniques such as DTI, perfusion, MT, qMT, and spectroscopy, particularly for assessment of cognitive reserve.

**Plasticity (PL)**
At the end of this topic students will have acquired knowledge about current concepts of the interaction between chronic inflammation and neurodegeneration in MS supported by neuroimaging studies. They will be able to discuss controversial aspects of immuno-modulatory treatment in MS and its impact on function recovery as assessed by sophisticated MRI techniques.