CS 322/PSY 314/BIO 324-Paradigms in Brain Function

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Course URL (if any)	

Course Teaching Methodology

- Teaching Methodology: Synchronous lectures
- Lecture details: In Collaboration with LUMSx - All lectures will be recorded in the online-friendly format

Course Basics				
Credit Hours	3			
Lecture(s)	Nbr of Lec(s) Per Week	2	Duration	75 minutes
Recitation/Lab (per week)	Nbr of Lec(s) Per Week	0	Duration	0
Tutorial (per week)	Nbr of Lec(s) Per Week	0	Duration	0

Course Distribution	
Core	No

Elective	Yes
Open for Student Category	Juniors, Seniors and Graduate Students
Closed for Student Category	Students with no background in Neuroscience

Course Description

This course aims to give its students a foundational understanding of fundamental paradigms of brain functions. It also explores functional organization of the brain and the hierarchies and constituencies within the mind. The course will systematically highlight how this foundational understanding of brain will help in designing better human<->computer/machine interaction.

The course examines organizational, cellular and molecular neuroscience of perception, cognition, sleep, memory, movement, and processing of information gathered by the sensory organs. It explores how consciousness and reality are constructed and builds an understanding of the physical, chemical and molecular basis of consciousness. It examines why consciousness is both a hard and a soft scientific problem. The course looks at how contextualizing and building a reference library from memory are both critical for and a hindrance to creativity and how knowledge workers - which is all of us - can ensure optimum functioning of the brain.

This multidisciplinary course will also equip students to find scientific questions from their own fascination with the world and how to convert that experience into working hypotheses which can be explored further with scientific methods of experimentation. The course teaches how to work in teams and how to build intra and cross-disciplinary collaborations, which are essential to a career in science.

The course comprises a series of lectures paired with in-class activities, presentations, discussions, case studies, and a semester-long project with applied value. The course requires a basic working knowledge of the function of the nervous system which can be gained by reading the assigned prerequisite reading.

Specialty experts will be invited throughout this course to share their experiences with projects for scientific and clinical impact. Students will get to know of the people working in the field both locally and internationally. They will get a chance to work in multidisciplinary teams and partner with members of the field to research, understand, brainstorm and prototype solutions to problems outlined in the sustainable development goals.

Course Prerequisite(s)

- *Ganong's Review of Medical Physiology* (24th Ed) chapters on neurophysiology
- *The girl who kicked the hornet's nest* by Stieg Larsson
- *The man who mistook his wife for a hat* by Oliver Sacks
- *The gods themselves* by Isaac Asimov

Pass a quiz on *Ganong's* chapters
Watch the movies Matrix, 13th Floor, Avatar, Fisher King, A beautiful mind

Course Objectives

CLO1:	Learn paradigms of brain function at a high level and understand functional organization of the brain so as to trigger novel fundamental research in neurosciences.
CLO2:	Apply this conceptual understanding to design in health-tech and in disciplines other than medicine.
CLO3:	Learn how to identify novel scientific questions in neuroscience. Learn how to do background research for identified novel questions.

CLO4: CLO5 CLO6 CLO7	 Learn how to design logistics for methods and materials for a study to examine the identified novel question in a collaborative group environment. Collaborate with team members of other disciplines and clinical partners. Inculcate a fascination with novel questions in science in general and in neuroscience in particular and find a way to channel that fascination into meaningful actions in working lives.

Examination Details	
Grading Scheme	Quizzes + CP: 20% Individual novel question identification: 10% Individual background research on novel neuroscience question and its presentation: 10% Framework of group novel question: 10% Midterm - 20% Final Group project: 25% Logging exercise: 5%
Midterm Exam	Yes
Final Exam	NO
Final Group Project	Yes
Assignments	
	Course Teaching Methodology • In person course
	Harassment Policy SSE, LUMS and particularly this class, is a harassment free zone. There is absolutely zero tolerance for any behavior that is intended or has the expected result of making anyone uncomfortable and negatively impacts the class environment, or any individual's ability to work to the best of their potential. In case a differently abled student requires accommodations for fully participating in the course, students are advised to contact the instructor so that they can be facilitated accordingly.

	If you think that you may be a victim of harassment, or if you have observed any harassment occurring in the purview of this class, please reach out and speak to me. If you are a victim, I strongly encourage you to reach out to the Office of Accessibility and Inclusion at **oai@lums.edu.pk** or the sexual harassment inquiry committee at **shic@lums.edu.pk** for any queries, clarifications, or advice. You may choose to file an informal or a formal complaint to put an end to offending behavior. You can find more details regarding the LUMS sexual harassment policy here. To file a complaint, please write to **harassment@lums.edu.pk.**

Paradigms in Brain Function

Course Overview			
Lecture/ Module	**Topics**	**Recommended Readings**	**Objectives/ Application**
Week 1: Neuroscience: The big picture			
1.	Course Introduction: • What can you expect to learn from this course? • What do you need to know to gain the maximum from this course? • Structure of the course • Introductions of instructors and students Expectations from students: • Showing up • Class participation • Readings Deliverables for the course: Formulate a question that you find fascinating in neuroscience and do background research and design a study to push the research forwards on that question sleep, memory and dream logs	**Ganong's chapters on Neurophysiology (Chapters 4, 6 and 7) with details of neuronal cell excitation, principles of nerve conduction and chemistry of the synapse** **(*Prerequisite for the course*)**	*Excite the students about what they are about to learn* *Give them a clear idea of what is expected of them in the course*
2.	• Basic neurophysiology of the neuron, a	**Ganong's chapters on Neurophysiology (Chapters 4, 6 and 7) with details of neuronal cell excitation, principles of**	*To create a Functional map of brain in the*

Course Overview			
	spontaneous electricity generator • Difference between a neuron (a generator) and a receptor (a transducer) • explain the hierarchies within brain function shedding light on the redundancies and complementary collaborations within the brain	**nerve conduction and chemistry of the synapse** **(*Prerequisite for the course*)** **All of this is cell function and cell physics mediated by movement of ions and neurotransmitters**	*minds of the students* *To introduce them to the idea of vast varieties of intelligence in nature*
Week 2: Perception			
3	Brief introduction of vision and hearing Processing of vision and hearing • Neural pathways • Basic principles of stimulus recognition and processing • Transducers converting one form of energy into another	**Molecular structure of light-sensing proteins and morphing of rhodopsin** **Ganong's chapters on Neurophysiology (Chapters 9, 10)** **(*Prerequisite for the course*)**	*Appreciate how perception processing is sophisticated and complicated*
4	Brief introduction of touch, pain and proprioception Processing of Neural pathways Smell and Taste Higher order understanding of sensory perception, contextualizing the sensory input, giving meaning to the input • Stimuli are different, Conduction is the same, Destination is destiny • Conscious and subconscious perception • Sensory deprivation - The silent room, the black dunk • Relay centers Proprioception • 3D map of the body in the world • Reality is different from perception	**Chemistry of somatosensory receptors, ion channels and nerve conduction** *The girl who kicked the hornet's nest* **Ganong's chapters on Neurophysiology (Chapters 8)** **(*Prerequisite for the course*)**	*Understand how the general sensory perception makes us develop a 3D model of the world around us which we mistake for reality*

Course Overview			
	• Can we create new sensations? • Sensory extension • Hearing aids, brain-computer interface, eye glasses to hubble to electron microscope • Clothes, cars • Converting one sensation into another • Tracking stock market via vibration on your back • Example of complicated processing of space map in the brain - parallel parking • Multimodal Computing		
Week 3: Conjugation of Sensory Input and making sense of the world			
5	• Language, Speech and Communication • Design for Disabilities	Start with video clips Chimp Dolphin Human	Sapiens pp1-150
6.	Punishment and Reward • Philosophical understanding of pain - basic survival mechanism • Pain is an alarm • What makes pain unpleasant? • Neural pathways • Noxicity vs pain • Gamification (HCI)	**Molecular Neurochemistry of pain** **Ganong's chapters on Neurophysiology (Chapters 8)** **(*Prerequisite for the course*)**	
Deliverable:			
Week 4: Movement			
7	Movement is so effortless for the healthy that we don't automatically appreciate the complexity Thought Plan Execution	**Movement planning and execution** **Molecular basis of nerve-muscle junction** **Ganong's chapters on Neurophysiology (Chapters 12)**	

Course Overview			
	Fine tuning Continuous correction 1. How the brain is basically a movement simulator BA •	**(*Prerequisite for the course*)**	
8	Motor systems NA a. Output is ONLY motor - Brain is tuned to execute motor responses as the only evidence of being conscious b. Fine tuning of execution Robotics – Human Robot Interaction		
Deliverable:			
Week 5: Sleep & Dreams			
9	Sleep 1. Why do we need sleep and its critical role in memory modification and active forgetting a. Sensory sorting b. Neurochemical basis of Sleep Designing for wellbeing (Sleep apps, tracking apps, healthcare apps)	**Electrical activity of the brain, sleep-wake states, & circadian rhythms** **Ganong's chapters on Neurophysiology (Chapters 14)** **(*Prerequisite for the course*)**	
10	Dreams a. Neurochemical basis of dreams b. Pathological dreams c. Lucid dreams d. Why do we dream? Dreams and Virtual Reality		
Week 6: Mid term - Presentations of selected individual questions and what research into them shows.			
Week 7: Memory			
13	emory Forms of memory – gene pool, epigenetic, individual, registration, recall	Required Reading: *The man who mistook his wife for a hat* by Oliver Sacks Movie *Avatar* (not the Anime *Avatar, the last air-bender*)	

Course Overview			
	Where is the knowledge of the world located? Memory Pathways and processing in the brain Neurochemistry of Long-term vs Short-term	**Learning, memory, language, & speech** **Cellular and molecular processing of Memory** **Ganong's chapters on Neurophysiology (Chapters 15)** **(*Prerequisite for the course*)**	
14	a. Deterioration of Memory b. Memory enhancement c. Memory, Knowledge and Wisdom d. Cyber philosophy and the memory network of Gaia & bee hive	Watch the Star trek episode on introduction of Borg	
Week 8: The Emotional Brain			
15 May be will become 2 lectures	Neurochemical basis of emotional underpinning of all brain function - evolutionary reason The mismatch between the speed of human evolution and humanity's dominance on the planet. Emotions color perception and its understanding, the cognition The Deceiving Brain - how emotional states can make us *believe* and change our reality (not a different perspective, not a different stimulus, not a different neural pathway - but still a different understanding) Neurological underpinnings of decision making Intuition Vs Emotion Design and Emotions Affective Computing	**Molecular basis of emotions and mood** **Association of feelings with perception**	
16	Anxiety and depression	**Molecular basis of depression and anxiety**	

Course Overview			
	a. Networks and their chemicals, the neurotransmitters b. Chemical and electrical (and magnetic) tweaking of these circuits c. External physical manifestations of emotional states d. Anxiety and depression tracking apps Post chemo cessation of neurogenesis in the hippocampus		
Week 9: The (*ill*-)Logical Brain			
17	Brain hierarchies and neuro decision-making Parallel tracks & combined function enhances performance Role of Safety Pleasure and Pain in decision making Connectome Cerebral decision making Respiratory decision Motor decision	Required Movies: *The 13th Floor* *Matrix* *Big history selected portions* *https://www.bighistoryproject.com/home* *Books: Griffith Lecture Series at Univ Glasgow*	
18	Nature of Reality - How is reality constructed - Is reality really agreed upon?? Perception of Reality - Context and its role in normal life - Schizophrenia: Disturbance of this construct From reality to virtual reality – Interaction of mind, body and technology	Movies: *Fisher King* *A Beautiful Mind*	
Week 10: Brain Health			

Course Overview			
19	Optimal Functioning of the Brain (BA) Optimal metabolic pathways for the brain Plumbing system of the brain Brain nutrition Neuronal stressors		
20	Where does creativity come from Inspiration Awake master with sleep EEG waves	Introduction of The Dancing Vu Li Masters by *Gary Zukav*	
Deliverable:			
Week 11: AI and VR Required Reading:			
21	Intelligence and AI		
22	Reality and AR/VR		
Week 12: The Grand Unification - Consciousness			
23	Consciousness 1 (NA) a. Hard and soft scientific problem (*Consciousness about being conscious*) Soft Problem: Solvable Hard Problem b. Revisiting Gaia: Is the earth conscious? c. Universal consciousness d. Transcendental or mystic consciousness	*The gods themselves* by Isaac Asimov **Chemistry of neural correlates of consciousness**	
24	Consciousness 2 e. Life vs consciousness f. Objective determination of consciousness g. Locked-in Syndrome Vs Persistent Vegetative State h. Death and transplantation	**Philosophical basis of the "Hard Problem"**	

Course Overview			
	The Final Frontier… grounds for the grand unification of all sciences		
	Week 13: Presentations of Group Projects.		

Textbook(s)/Supplementary Readings
No dedicated book! Chapters, articles from different books and sources mentioned above.