מבוא לנוירוביולוגיה מערכתית (1501.1005)
System Neuroscience

Dr. Pablo Blinder
Dr. Yuval Nir
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סמסטר א', שלישי 13:00-16:00 תשע"ה
נפתלי, 001

Week	Date	Lecture
1	28.10	Block 1: System Neuroscience principles - Dr. Pablo Blinder Lesson 1 – Systems, systems everywhere! Key concepts in system biology and their usage in system neuroscience 1. The concept of "system" 2. An overview of regulatory networks and their outputs (a) Feedforward excitation/inhibition (b) Recurrent excitation/inhibition (c) Convergence/Divergence (d) Feedback inhibition 3. Brain organization from the network perspective
2	4.11	Lesson 2 – What are the bits of neuronal information? Neuronal coding 1. Rate coding 2. Temporal coding 3. Population coding 4. Pattern generation **Mandatory Reading** • Kandel, E. R., Schwartz, J. H., Jessell, T. M., Siegelbaum, S.A., and Hudspeth A.J. (eds.) Principles of neural science (5th Ed.). New York, Chicago, San-Francisco: McGraw-Hill Companies. Chapter 21, "Sensory Coding", pp. 449-474; • Appendix F, Theoretical Approaches to Neuroscience: Example from Single Neurons to Networks **Additional suggested reading:** • Borst, A., & Theunissen, F. E. (1999). Information theory and neural coding. *Nat Neurosci*, *2*(11), 947–957. • Brown, E. N., Kass, R. E., & Mitra, P. P. (2004). Multiple neural spike train data analysis: state-of-the-art and future challenges. *Nature Neuroscience*, *7*(5), 456–61.

3	11.11	Lesson 3 – Motor output within a whisker of sensory processing Scaling from local circuits to a sensory system - the whisker system 1. The cortical column micro-circuit 2. Pathways of sensory information processing 3. Tight link between sensor and motor areas 4. Active sensation **Mandatory Reading** • Kandel, E. R., Schwartz, J. H., Jessell, T. M., Siegelbaum, S.A., and Hudspeth A.J. (eds.) Principles of neural science (5th Ed.). New York, Chicago, San-Francisco: McGraw-Hill Companies. Chapter 22, "The somatosensory system", ONLY pp. 488-495 • Chapter 23, "Touch", ONLY pp. 498-529 **Additional suggested reading:** 1. Kleinfeld, D. & Deschênes, M. Neuronal basis for object location in the vibrissa scanning sensorimotor system. *Neuron* **72,** 455–68 (2011). 2. Brecht, M. *et al.* The neurobiology of Etruscan shrew active touch. *Philos. Trans. R. Soc. Lond. B. Biol. Sci.* **366,** 3026–36 (2011).
4	18.11	Lesson 4 – I want to ride my bicycle! Motor Systems 1. Fundamentals of motor systems and interaction with our environment 2. Spinal and Peripheral motorics 3. Motor planning and execution 4. Motor output modulation **Mandatory Reading** • Kandel, E. R., Schwartz, J. H., Jessell, T. M., Siegelbaum, S.A., and Hudspeth A.J. (eds.) Principles of neural science (5th Ed.). New York, Chicago, San-Francisco: McGraw-Hill Companies. Chapter 36 “Locomotion” pp812-834; • Chapter 37 “Voluntary Movement: the primary cortex” 835-864
5	25.11	Block 2: Learning, memory and cognition - Dr. Segev Barak Lesson 5 – How do we learn new tricks? Terminology and measurement of psychological variables 1. What are learning, memory and cognition 2. What are we measuring? Performance and its interpretation Neural substrates of learning 1. Brain systems underlying: (a) Classical (Pavlovian) conditioning (b) Operant (instrumental) conditioning (c) Spatial learning (d) Motivations, drives and learning: Goal-directed learning and habits 2. Summary: From molecules to systems Reading: **Obligatory Reading:** • Kandel, E. R., Schwartz, J. H., Jessell, T. M., Siegelbaum, S.A., and Hudspeth A.J. (eds.) Principles of neural science (5th Ed.). New York, Chicago, San-Francisco: McGraw-Hill Companies. Chapter 65, "Learning and memory", Pp. 1441-1460

		• Chapter 66, "Cellular mechanisms of implicit memory storage and biological basis of individuality", pp. 1461-1486
6	2.12	Lesson 6 – Don't forget me on Valentine's day Neural substrates of memory 1. Classifications of memory: memory stores (iconic, STM, LTM), working memory, procedural *vs.* declarative (episodic, semantic). 2. In search of the Engram: Brain systems and circuits involved in memory processes 3. Memory processes: encoding, storage, retrieval, consolidation, reconsolidation, forgetting? 4. Summary: From molecules to systems **Obligatory Reading:** • Wang, S. H., & Morris, R. G. (2010). Hippocampal-neocortical interactions in memory formation, consolidation, and reconsolidation. Annual Review of Psychology, 61, 49-79. **Additional suggested reading:** • Barak, S., Liu, F., Hamida, S. B., Yowell, Q.V., Neasta, J., Kharazia, V, Janak P.H & Ron, D. (2013). Disruption of alcohol-related memories by mTORC1 inhibition prevents relapse. Nature neuroscience, 16(8), 1111-1117. • Kandel, E. R., Schwartz, J. H., Jessell, T. M., Siegelbaum, S.A., and Hudspeth A.J. (eds.) Principles of neural science (5th Ed.). New York, Chicago, San-Francisco: McGraw-Hill Companies. ; Chapter 67 "Prefrontal cortex, hippocampus, and the biology of explicit memory storage" pp.1487-1520.
7	9.12	Lesson 7 – Cogito ergo sum Neural substrates of higher cognitive functions 1. Cortical control, basal ganglia-thalamocorical circuits 2. Executive functions (mental flexibility, selective attention, integrative thinking etc.) 3. The elusive search for cognition enhancing drugs 4. Summary: From molecules to systems **Obligatory Reading:** • Kandel, E. R., Schwartz, J. H., Jessell, T. M., Siegelbaum, S.A., and Hudspeth A.J. (eds.) Principles of neural science (5th Ed.). New York, Chicago, San-Francisco: McGraw-Hill Companies. Chapter 43, "The basal ganglia", pp. 982-998; • Chapter 18, from "Goal-directed motor behavior is controlled in the frontal lobe", pp. 402-411 **Additional suggested reading:** • Schultz, W., Tremblay, L., & Hollerman, J. R. (1998). Reward prediction in primate basal ganglia and frontal cortex. Neuropharmacology, 37(4), 421-429.
8	16.12	Lesson 8 – Loosing your nerve? Dysfunctions in learning and memory: neuropsychiatric disorders and brain injuries 1. Dementias and Alzheimer's disease 2. Compulsive disorders and addiction 3. Strokes and brain injuries
9	23.12	Block 3 : Vision and sensory systems - Dr. Yuval Nir

		## Lesson 9 – To see or not to see What are visual stimuli? The eye and retina (quick re-iteration depending on prior courses/knowledge 1. Sensory transduction 2. Retinal basis of color vision (selectivity & tuning curves) 3. Ganglion cells and retinal output Visual pathways – from the retina to the brain 1. Blind spot 2. Optic nerve & optic chiasm 3. Superior colliculus, tectum / saccades, fixations 4. Thalamic relay: LGN, Magnocellular, Parvocellular 5. Optic radiation **Obligatory Reading:** • "Principles of Neural Science" (Kandel et al., 5th edition) pp.577-601 (retina) & pp.557-564 (pathways)
10	30.12	## Lesson 10 – More than meets the eye Primary visual cortex (specialization within regions) 1. Simple and complex cells, receptive fields, invariance 2. Spatial frequency 3. Retinal disparity 4. Color 5. Retinotopy, eccentricity, foveal magnification 6. Ocular dominance 7. Orientation selectivity 8. Cortical layers and signal propagation 9. Cortical columns, hypercolumns / blobs, modular organization, horizontal connections Extrastriate visual cortex 1. Hierarchy/abstraction 2. Specialization across regions: (a) Dorsal and ventral streams (b) Motion perception, MT (c) Face/place object recognition (d) Perception as an ’all or none’ non-linear process (e) Color vision (f) Prediction, ’filling-in’, meshing incoming input with prior knowledge (g) Attention (to spatial location , to specific features) (h) Free viewing conditions (i) Lesions and corresponding deficits (agnosias)

		Obligatory Reading: • "Principles of Neural Science" (Kandel et al., 5th edition) pp.557-576 (V1) & pp. 602-637 (higher)
11	6.1	# Block 4: Neurobiology of sleep, waking and consciousness - Dr. Yuval Nir ## Lesson 11 – Wake up and smell the coffee States of sleep and wakefulness 1. Sleep as a distinct behavior 2. Sleep stages and EEG rhythms 3. Passive sleep vs. active sleep 4. Sleep across the animal kingdom & across the life span Brain centers (and neuromodulators) regulating wakefulness and sleep 1. Wakefulness • The Ascending Reticular Activating System (ARAS) • The cholinergic system, basal forebrain and arousal • Locus Coeruleus and noradrenergic system • Other neuromodulatory systems (Serotonin, Histamine, Hypocretin / Orexin, Dopamine) 2. NREM sleep • Hypothalamic sleep promoting system (VLPO area) 3. REM sleep • REM generating system / pons **Obligatory Reading:** • "Principles of Neural Science" (Kandel et al., 5th edition) pp. 1140-1144 (general) , pp. 1038-1055 (arousal brain centers) & p. 1150 (changes across age and species) • "Principles and Practice of Sleep Medicine" (Kryger/Roth/Dement), 5th edition, pp. 3-26 (general) and pp. 27-41 (in aging) **Reshut:** • Moruzzi, G. & Magoun, H. W. Brain stem reticular formation and activation of the EEG. Electroencephalogr Clin Neurophysiol 1, 455-473 (1949). • Cirelli, C. & Tononi, G. Is sleep essential? PLoS Biol 6,(2008) (species) • Siegel, J. M. Do all animals sleep? Trends Neurosci (2008) (species)
12	13.1	## Lesson 12 – Sleeping beauty Spontaneous neuronal activity in sleep 1. Unit studies in animals: wakefulness, NREM sleep, REM sleep 2. Metabolism and brain imaging (PET, EEG-fMRI) in humans 3. Intracranial studies Circadian Rhythms 1. The Suprachiasmatic nucleus

		2. Pineal gland and melatonin Why do we sleep? 1. Sleep homeostasis 2. Acute and chronic sleep deprivation in animals and humans, effects on specific brain circuits and behavior 3. Possible function(s) of sleep: sleep as a time filler / memory enhancer / brain restitution **Obligatory Reading**: • "Principles of Neural Science" (Kandel et al., 5th edition) pp. 1144-1147 • "Principles and Practice of Sleep Medicine" (Kryger/Roth/Dement), 5th edition pp. 360-419 (circadian), pp. 420-429 (melatonin, pineal gland), pp. 430-444(sleep homeostasis) and pp. 42-75 (sleep deprivation). • Nir, Y. et al, Sleep and consciousness. In Neuroimaging of Consciousness. Springer 2013, pp. 142-160 http://medicine.mytau.org/nir/wp-content/uploads/2011/08/Sleep-and-Consciousness.pdf **Reshut:** • Lulu Xie et al. (2013). "Sleep Drives Metabolite Clearance from the Adult Brain". *Science* 342 (6156): 373–377. • Stickgold R (2005). "Sleep-dependent memory consolidation". *Nature* **437** (7063): 1272–8. • Siegel, J. M. Sleep viewed as a state of adaptive inactivity. Nature Reviews Neuroscience 2009 • Tononi, G. & Cirelli, C. Sleep function and synaptic homeostasis. Sleep Med Rev 10, 49-62 (2006).
13	20.1	Lesson 13 – Beyond your wildest dreams Sleep, learning and memory 1. Reactivation (replay) of circuits during sleep 2. Sleep and non-declarative memories: perceptual and motor learning 3. Sleep and declarative memories 4. Potential mechanisms: hippocampus, cortex and their "dialogue" Sleep and consciousness 1. Dreaming and related brain activity 2. Processing of external sensory stimuli 3. Loss of consciousness in sleep and anesthesia Highlights of sleep disorders and their brain substrates 1. Insomnia 2. Sleep apnea 3. Narcolepsy / Cataplexy 4. Sleep paralysis 5. Sleep walking 6. REM sleep behavior disorder **Obligatory Reading**: • Diekelmann, S. & Born, J. The memory function of sleep. Nature Reviews

		Neuroscience 2011, 114-126, • "Principles of Neural Science" (Kandel et al., 5th edition), pp. 1151-1157 (disorders) • Nir Y, Tononi G. Dreaming and the brain: from phenomenology to neurophysiology. Trends in Cognitive Sciences 2010 http://medicine.mytau.org/nir/wp-content/uploads/2012/07/NirEtAl_TrendsCognitiveSciences_2010.pdf • Nir, Y., et al. Sleep and consciousness. In Neuroimaging of Consciousness. Springer 2013, pp. 160-172 http://medicine.mytau.org/nir/wp-content/uploads/2011/08/Sleep-and-Consciousness.pdf

הרכב הציון הסופי:
מבחן 100%

מועדי מבחן:
מועד א': 29.1.15
מועד ב': 8.3.15