Test-Exam for **Neuroscience BIO-311 (2021 - 2022** Mathis / Schneggenburger)

- This test exam shows you example questions. It covers 8 Units randomly, and is therefore about 60% of the true exam

- The true written exam (03.02.2022, 8:15 - 11:15; PO01) will cover all 14 Units of the course

- For each Unit there will be:
  - 1 short / multiple choice question (1 point)
  - a short essay questions (1.5, or 2, or 2.5 points to be earned)

There will be a total of ~ 42 - 48 Points to be earned.

Important: for the real exam …

- **Write your name on top of each page (first name + last name)**

- Bring a small **non-programmable calculator (with logarithmic functions**) with you (*no other electronic devices allowed!*)

- If there is not enough space, please continue writing on the reverse page, for each Unit.

- page intentionally left blank -

Unit 2: Ion channels and electrical excitability

Briefly explain what is meant by the term "electrical excitability" (**1 Point**)

Describe the experiments which Hodgkin & Huxley performed to discover voltage-gated Na^+ current and voltage-gated K^+ currents in the axon. i) Which cellular preparation did they use, and what type of measurements did they perform? ii) Describe the most important properties of "gating" (i.e. activation, de-activation, and inactivation) and of ion permeation of Na^+- and K^+ currents which Hodgkin & Huxley found in these experiments. iii) Finally, describe how the properties of Na+- and K^+ currents create an action potential in the axon (**2.5 Points**).

- continue here to answer the previous question of Unit 2 if necessary - :

Unit 5: The somatosensory system.

Briefly describe the concept of a "somatotopic map" in the primary somatosensory cortex (**1 Point**)

Explain the process of primary sensory transduction in a touch receptor, that is, how the primary mechanical stimulus is transduced into a membrane potential response of the corresponding cell. In which cells, and in which compartment of those cells, does this process take place? (**2 Points**)

- continue here to answer the previous question of Unit 5 if necessary -

Unit 7: The auditory system

Identify the two correct statements about the connectivity of inner - and outer hair cells:
 Inner hair cells release glutamate onto dendrites of spiral ganglion neurons
 The efferent fibers originating from the superior olivary complex release acetylcholine onto the inner hair cells to regulate their sensitivity to sound
 Inner hair cells release acetylcholine onto dendrites of spiral ganglion neurons
 The efferent fibers originating from the superior olivary complex release acetylcholine onto the outer hair cells to regulate their function as a cochlear amplifier
 Outer hair cells release acetylcholine onto efferent fibers originating from the superior olivary complex
(**1 Point**)

Explain the principle of a hearing aid of the "cochlear implant" type. Explain how the cochlear implant is engineered to transmit information about the incoming sound frequencies, and which property of the cochlea is critically important for this (**2 Points**).

- continue here to answer the previous question of Unit 7 if necessary -

Unit 8: Intro to sensorimotor systems: + spinal cord and cerebellum

Which two of the following are not fundamental components of the passive stretch reflex pathway:
□ Muscle spindle
□ Alpha motor neuron
□ Ib sensory neuron
□ Ia sensory neuron
□ Golgi tendon organ
(**1 Point**)

Describe and draw the anatomical structure of the neuromuscular junction. Which neurotransmitter type and receptor type are found in this synapse? (2 points)

- continue here to answer the previous question of Unit 8 if necessary -

Unit 9: Vision - the retina

Identify the two correct statements about ON and OFF bipolar cells
 ON bipolar cells depolarize in response to light, because they express AMPA/kainate receptors that inverse the light response of the photoreceptors.
 ON bipolar cells depolarize in response to light, because they express AMPA/kainate receptors that transmit the light response of the photoreceptors.
 ON bipolar cells depolarize in response to light, because they express a metabotropic glutamate receptor that inverses the light response received from the photoreceptors.
 OFF bipolar cells hyperpolarize in response to light, because they express a metabotropic glutamate receptor that will be activated by light.
 OFF bipolar cells hyperpolarize in response to light, because they express AMPA/kainate glutamate receptors that are less activated in the presence of light.
 OFF bipolar cells hyperpolarize in response to light, because they express AMPA/kainate glutamate receptors that are more activated in the presence of light.
(**1 Point**)

Explain the principle of color vision. i) How many, and which types of opsins are involved in color vision? ii) In which type of photoreceptor cells are these opsins expressed, and how many types of photoreceptors can we distinguish in primates and humans? iii) Briefly explain in which further two pathways, after the relevant photoreceptor cells, color is processed within the retina, and mention the implicated bipolar cells and retinal ganglion cells. (**2.5 Points**)

- continue here to answer the previous question of Unit 9 if necessary -

Unit 10: Vision part 2 - system & circuits

Identify two correct statements about central visual pathways:
□ Axons of retinal ganglion cells project to the visual cortex
□ Axons of retinal ganglion cells project to the visual thalamus
□ Axons of photoreceptor cells project to the visual thalamus
□ Axons originating from the retina never cross to the other brain side
□ Axons originating from the temporal part of the retina cross over to the other brain side
□ Axons originating from the nasal part of the retina cross over to the other brain side
(**1 Point**)

i) Explain how a typical receptive field of a neuron in the primary visual cortex looks like.
ii) Draw the pathway from the retina to V2, iii) describe the major cells types found in LGN lateral geniculate body (= visual thalamus). iv) describe the layered structure in visual cortex (V1) and mark the major input and output layers (**2.5 points**)

- continue here to answer the previous question of Unit 10 if necessary -

Unit 11: Movement control: cortex, basal ganglia

Identify the two correct statements regarding the corticospinal tract:
- ☐ Neurons in layer 5 of the primary motor cortex (M1) project to the thalamus
- ☐ Neurons in layer 5 of the primary motor cortex (M1) project to the brainstem and to the spinal cord
- ☐ Neurons in layer 2/3 of the primary motor cortex (M1) project to the brainstem and to the spinal cord
- ☐ Neurons in layer 5 of the primary motor cortex (M1) are called "upper motor neurons"
- ☐ Neurons in layer 2/3 of the primary motor cortex (M1) are called "upper motor neurons"

(**1 Point**)

i) Explain how the direct - and indirect pathway of the basal ganglia influence movement. ii) Which two neuron types are in the "direct" and "indirect" pathway of the Striatum? (**2 Points**)

- continue here to answer the previous question of Unit 11 if necessary -

Unit 12: Learning & memory

Identify the two correct statements about long-term plasticity (LTP) at a typical glutamatergic synapse in the hippocampus:
☐ The NMDA-type glutamate receptor functions as a coincidence detector of pre- and postsynaptic activity, because it is permeable to Na^+ and K^+
☐ The NMDA receptor functions as a coincidence detector of pre- and postsynaptic activity, because its block by Mg^{2+} is relieved by membrane depolarization
☐ The AMPA-type glutamate receptor functions as a coincidence detector of pre- and postsynaptic activity, because its block by Mg^{2+} is relieved by membrane depolarization
☐ Ca^{2+} is an important second messenger during LTP, and during LTP additional $GABA_A$ receptors are inserted into the postsynaptic membrane.
☐ Mg^{2+} is an important second messenger during LTP, and during LTP, additional glutamate receptors of the AMPA-type are inserted into the postsynaptic membrane
☐ Ca^{2+} is an important second messenger during LTP, and during LTP additional glutamate receptors of the AMPA-type are inserted into the postsynaptic membrane.
(**1 Point**)

To treat his severe epilepsy, patient H.M. underwent a bilateral resection of the hippocampus, amygdala and parts of the temporal lobe, at age of 27. i) State the results of this surgery on the memory of H.M., and explain which form of memory was severely affected in H.M. ii) Explain the general concept of how the temporal lobe and the hippocampus on the one hand, and the association cortices on the other hand, are involved in the relevant form of memory. (**2 Points**)

- continue here to answer the previous question of Unit 12 if necessary -