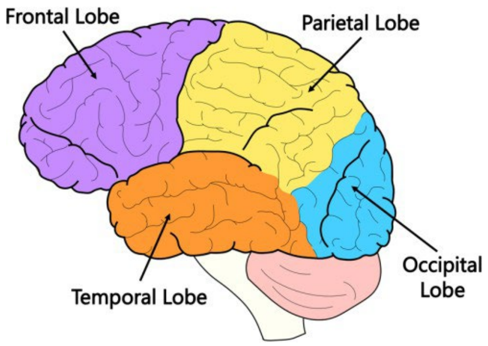
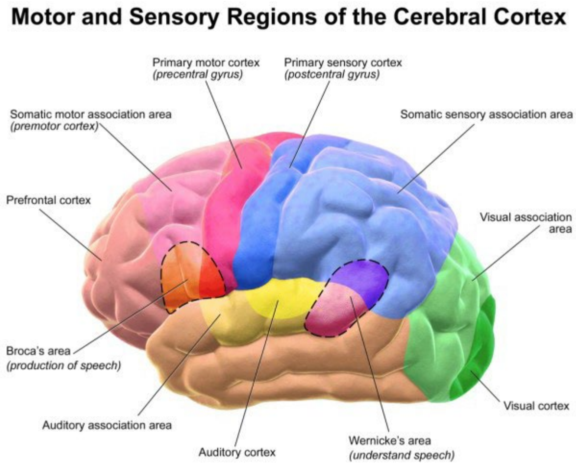
Neuroscience BIO-311 - Ramdya

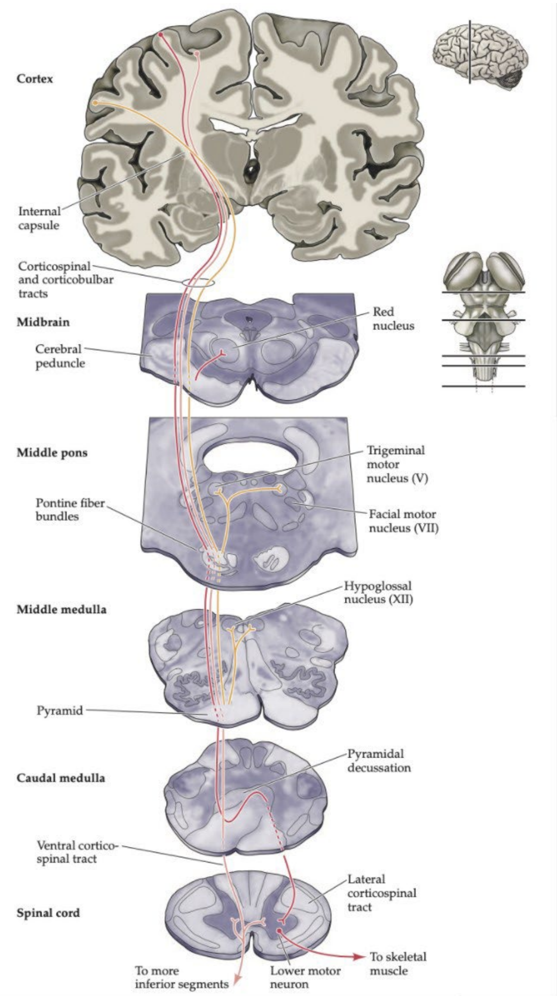
Exercice Solutions for: Movement control by motor cortex and basal ganglia

1) Make a rough drawing of the left human cortex. Indicate the positions of the somatosensory, visual and auditory primary cortices. Add the primary motor cortex and the premotor cortex. Indicate also the following regions: temporal lobe, frontal lobe, parietal lobe, occipital lobe.

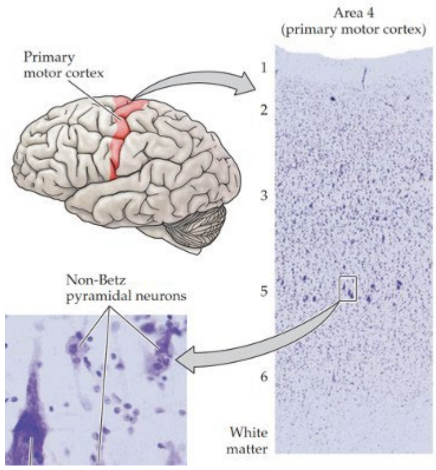




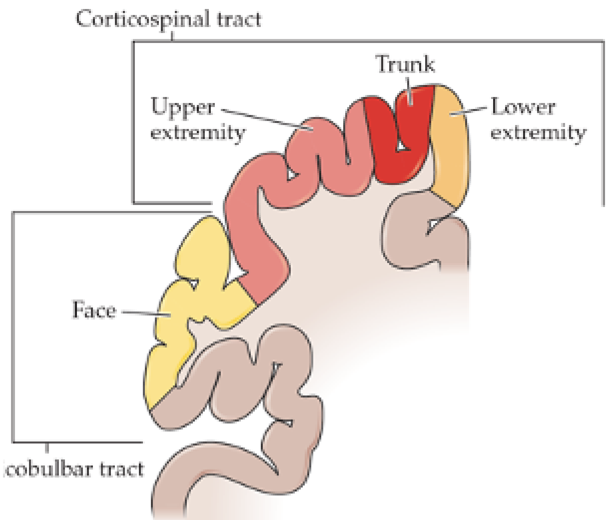
2) Recapitulate the principal anatomy of the lateral corticospinal tract (include a drawing). What are lower and upper motor neurons? Indicate the typical location of their cell bodies in the drawing.

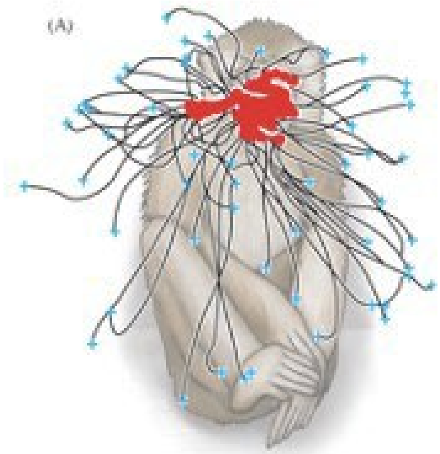


The upper motor neurons originate in the cerebral cortex and travel down to the brainstem or spinal cord, while the lower motor neurons begin in the spinal cord and go on to innervate muscles and glands throughout the body.



3) i) Explain how the motor somatotopic maps are made. ii) Does the brain explicitly control single muscles, or does it control complex movements?



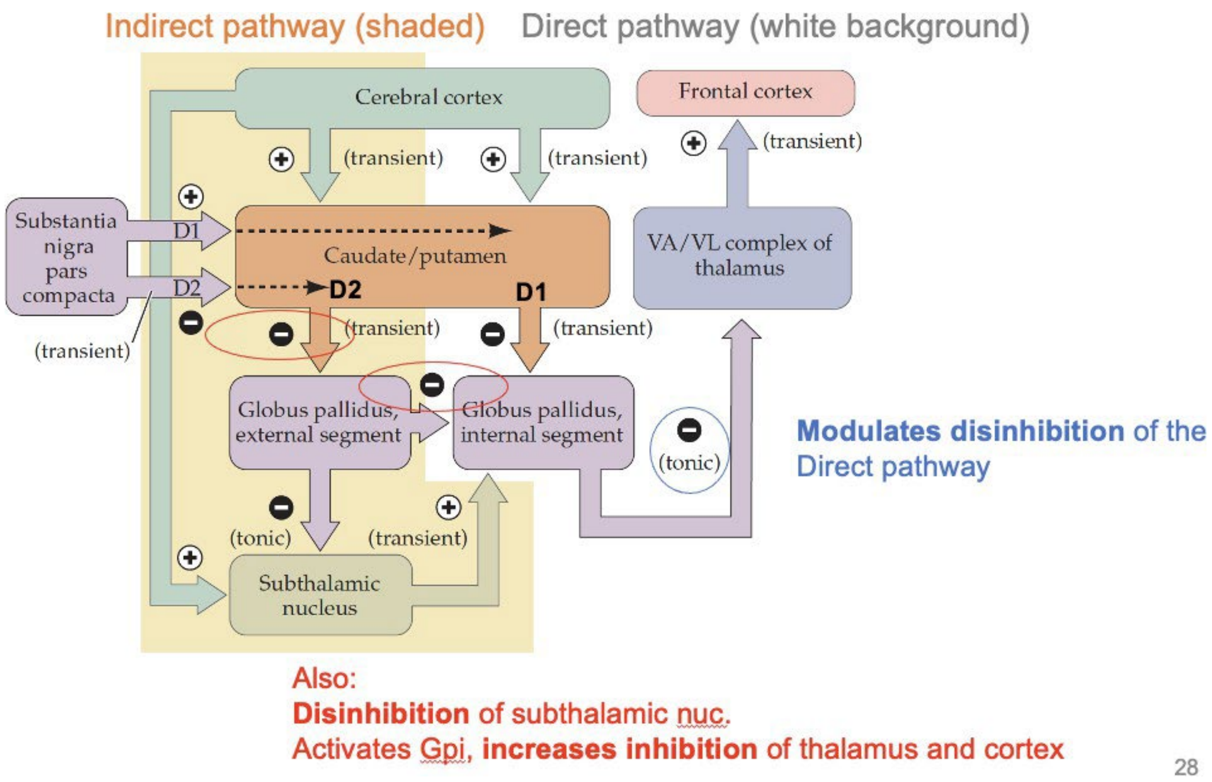


i) Early correlation (left figure) between stimulation of electrodes and location of contracted muscle has shown that the motor cortex is a fine-scale representation of individual muscles, much like it is in the somatosensory cortex. However, it has been shown (right figure) later that prolonged stimulation elicits coordinated movements of the hand and mouth. Even more recent results suggest that the motor cortex might instead encode intention of movement and action goal.

ii) Both! There are (fewer) examples of upper motor neurons projecting directly to lower motor neurons. This is mostly true for distal extremities, allowing skilled behaviours. On the other hand, the example of the direction-tuned population of neurons described in Purves (fig. 17.8) is an example of a behaviour involving many muscles coordinated together.

4) Taking inspiration from the examples of the Neuralink (this week), how would you proceed if you wanted to allow a patient to control a robotic arm after they lost their own (following an accident for instance). Which signal would you acquire and how would you do it? How would you process and communicate it?

5) i) Describe the indirect and direct pathways in the Basal Ganglia and how they differ. ii) Which structures are "input" and "output" structures? iii) State which neurotransmitter is used by the principal neurons in the BG brain structures.



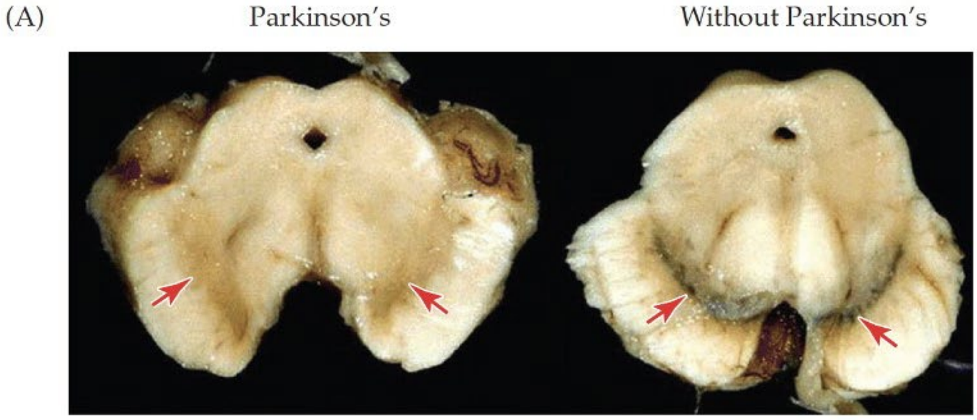
i) Direct pathway facilitates movement with Dopamine D1 receptors enabling inhibition of GPi that previously tonically inhibited the thalamus. This dis-inhibition enables the thalamus to excite the cortex.
Indirect pathway
Inhibition of GPe by Striatum hinders the inhibition of GPi, which tonically inhibits the thalamus. Moreover, the GPe cannot inhibit the subthalamic nucleus, which in turn excites the GPi. GPi inhibits the thalamus even more. The indirect pathway thereby modulates the direct pathway.

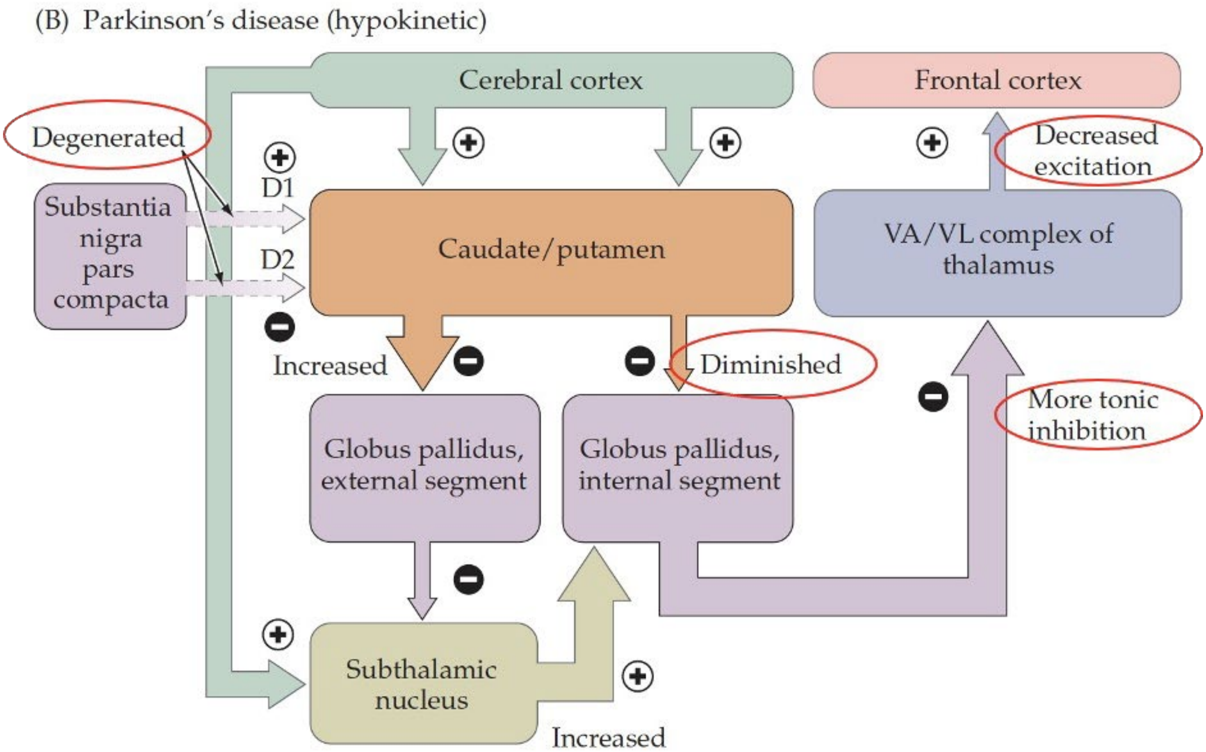
ii) input: striatum (caudate and putamen)

output: globus pallidus internal and external, substantia nigra pars reticulata

iii) The neurons in the basal ganglia mainly release GABA

6) Explain how the perturbation of the basal ganglia circuits result in hypokinetic or hyperkinetic activity in the examples of Parkinson's and Huntington's diseases.





(B) Huntington's disease (hyperkinetic)