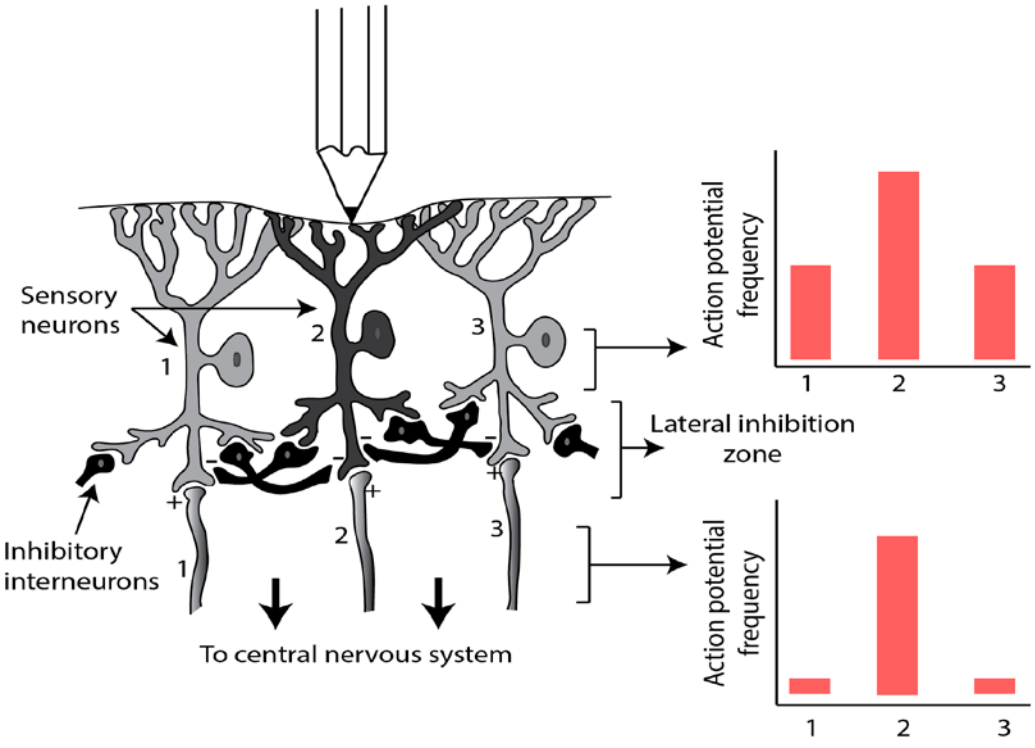
1) Describe the labeled line hypothesis of sensory perception. How is this hypothesis different than the across-fiber pattern hypothesis?

Individual sensory neurons usually respond maximally to a highly specific stimulus. The labeled line hypothesis holds that the CNS determines the type of stimulus based receiving input from all sensory cells activated by that stimulus. The across-fiber hypothesis holds that the coding of a particular stimulus is generated by a response across all cells rather than just those that respond maximally to a stimulus.

2) Define lateral inhibition and explain the neural circuitry required in the olfactory system. How are the response properties of cells modified by lateral inhibition? Can you give an example outside the olfactory system?

Lateral inhibition shapes sensory input by refining information between neighboring sensory cells via inhibitory connections. In the case of the olfactory system, the mitral/tufted cells (M/T cells) are connected with adjacent M/T cells through inhibitory synapses made by granule cells (GR). These inhibitory connections modify and sharpen the input information from the olfactory receptor neurons (ORN). The M/T output is more specific as a result of lateral inhibition than it would have been in the absence of these lateral inhibitory connections. Lateral Inhibition also occurs in the visual system to help detect edges.

3) In this generalized depiction of a somatosensory system, draw what you think the action potential frequency might be before and after lateral inhibition for this set of somatosensory Neurons and explain why.



Lateral inhibition sharpens the the signal in cell 2 after the lateral inhibition zone by reducing the excitation seen in cells 1 and 3 and further exciting cell 2.

4) Describe, in as much detail as possible, a G-protein-mediated receptor-second messenger cascade in an olfactory sensory neuron.

Binding of a molecule to its receptor causes a conformational change in the receptor. This allows binding of the G-coupled protein to the receptor. Receptor-G-protein binding causes the subunits of the G-coupled protein to dissociate from each other allowing the α subunit to interact with adenylate cyclase. This activates the synthesis of cAMP and subsequent elevation of intracellular levels of cAMP. cAMP causes the activation of a separate ion channel and thus a generator potential is produced.
Note that after the alpha subunit dissociates from the beta-gamma subunits there are many possible pathways targeted by the alpha subunit. The specific pathway targeted will depending on the specific type of olfactory neuron.