1) Olfactory neural coding is more complex in that it does not pertain to a simple parameter such as wavelength or frequency like we see in the visual system. We study olfaction by first understanding that each odorant can activate different olfactory receptor neurons and that the combination of the responses that we get from the population of receptors gives us the neural code for the different characteristics of odors. It is also important to note that studying olfaction is very difficult because the odor stimuli cannot be given to a subject the way an auditory sound or visual stimuli could. Odorants diffuse in air very quickly so it is very hard to design experiments around it, which is another contrast between this system and other systems like auditory or vision.

2) The physical, neural, and perceptual spaces of odorants can be visualized in a multidimensional physicochemical odor space consisted of 1664 molecular descriptors, where each dimension is one feature of an odorant structure. An odorant is then mapped onto this space which can tell us about the similarities and differences between the various molecular odorants. When two odorants are mapped onto the physical odor space and are relatively close together, we can conclude that they are more similar in molecular structure than if they were farther apart. In the neural odor space, each axis represents the response of one receptor. If two odorants are close together in this space, it would tell us that they provoke a similar response pattern in the receptor repertoire. The perceptual odor space is hypothesized to work the same, where two odorants close to one another in perceptual space are close in perceptual quality.

4) Olfaction relies on the use of combinatorial coding in primary processing because rather than one measurable stimuli eliciting a response of one receptor, in the olfactory system one odorant can elicit the response of many different receptor types, and a single receptor can be evoked by many different odorants. Thus, odorants can then be characterized by different combinations of activated receptors. The advantage of combinatorial coding is the reduction in noise, whereas the disadvantage is the computational complexity that it gives towards encoding individual odorant information.

5) Sparse coding in olfaction is when an odor evokes very few action potentials from only a small portion of neurons, and these neurons also only respond to a small number of odors. We see from the example in the paper that projection neurons (second-order neurons) respond to many odors, whereas Kenyon cells (third-order neurons) respond to only a few. The reason this happens is because the third-order neurons only activate when they receive input from specific second-order neurons, as this is how similar
activation patterns in second-order neurons decorrelate. That is why when we see the contrast of activation patterns between second and third-order neurons, we can clearly see that the third-order neurons fire less.

6)

Pseudogenization happens when a mutation renders a gene nonfunctional. We see an example of this in aquatic vertebrate genomes like the dolphin. Both aquatic and terrestrial vertebrates carry olfactory receptors that are tuned toward water soluble odorants. However, terrestrial vertebrate genomes also carry a different class of olfactory receptors that are tuned toward hydrophobic odorants. Because dolphins don’t need to rely on the function of hydrophobic receptors, those genes are pseudogenized. I think that this phenomenon applies to other species like humans as well, just reversed. In a way, pseudogenization can be thought of as evidence that everything on earth started and evolved from organisms that lived in water.