Question 1: Most tastes are some combination of the five basic tastes. What other sensory factors can help define the specific perceptions associated with a particular food?

Answer: The taste of each food is made unique by triggering different combinations of the five basic tastes and smell is an important contributor to taste. In addition, taste depends on several qualities of the way food feels, including texture, temperature, and pain.

Question 2: The transduction of saltiness is accomplished, in part, by a Na^+-permeable channel. Why would a sugar-permeable membrane channel be a poor mechanism for the transduction of sweetness?

Answer: The taste of salt is mostly the taste of the cation Na^+ so a Na^+-permeable channel is an efficient way to detect it. The taste of sugar, on the other hand, arises from many different sweet tastants with different chemistries, some natural and some artificial. It would be necessary to devise many different sugar-permeable membrane channels to accomplish what is done very efficiently by two members of the T1R family, T1R2 and T1R3. Many different chemicals can stimulate these receptors to result in the sensation of sweetness.

Question 3: Chemicals that have sweet, bitter, and umami tastes all activate precisely the same intracellular signaling molecules. Given this fact, can you explain how the nervous system can distinguish the tastes of sugar, alkaloids, and amino acids?

Answer: The sweet, bitter, and umami tastes comprise G-protein coupled receptors and that are exactly the same second messenger pathways that transfer signals to the afferent axons. But these three basic taste receptors are expressed in different taste cells. Each taste cell expresses only one class of taste receptor proteins and is connected to different gustatory axons receiving information for only one type of taste cell. The gustatory axons deliver

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messages of umami, sweetness, or bitterness to the brain separately. The activity of different gustatory axons reflects only the chemical sensitivities of the taste cells that drive them. The nervous system distinguishes the tastes of sugar, alkaloids, and amino acids because separate transmission lines carry information for each taste.

Question 4: Why would the size of an animal's olfactory epithelium (and consequently the number of receptor cells) be related to its olfactory acuity?

Answer: The olfactory epithelium is a thin sheet of cells high up in the nasal cavity. Sniffing brings air through the nasal passages and a small percentage of that air passes over the olfactory epithelium, triggering the sense of smell. The surface area of the olfactory epithelium is larger in some animals than others. For example, the surface area of the olfactory epithelium of dogs is over 170 cm^2 but only 10cm^2 in humans. Moreover, dogs have about a hundred times more receptors in one square centimeter than humans. The increased area and receptor density of the dog olfactory epithelium makes it possible for dogs to detect (and recognize) a few molecules left by someone who has passed by hours before. A much higher concentration of molecules is necessary for humans to detect most odorants.

Question 5: Receptor cells of the gustatory and olfactory systems undergo a constant cycle of growth, death, and maturation. Therefore, the connections they make with the brain must be continually renewed as well. Can you propose a set of mechanisms that would allow the connections to be remade in a specific way, again and again, over the course of an entire lifetime?

Answer: The new connections might follow a chemical trail left by the processes of the dying cells. In addition, connections might follow a chemical gradient set up by substances

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diffusing from the target structures. Different chemicals might specify different targets. Neuronal firing patterns could also have an influence on growing pathways, so new axons would target structures that have similar patterns of electrical activity.

Question 6: If the olfactory system does use some kind of spatial mapping to encode specific odors, how might the rest of the brain read the map?

Answer: The rest of the brain would not be looking for spatial patterns of olfactory stimuli because olfactory localization is relatively crude, but the brain might use neural odor maps to distinguish between chemicals. Alternatively, spatial maps may simply be a mechanism for forming appropriate connections between related sets of neurons, and have no other functional importance.

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