The molecules, receptors, and cells for taste perception

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The sense of taste is the gatekeeper of nutrition. It enables mammals to decide within seconds if a mouthful can be swallowed because it is safe and of nutritional value or is to be rejected because it contains potentially harmful substances. Errors could have serious health problems ranging from malnutrition to acute or chronic intoxication. Each of the five basic tastes, sweet, sour, salty, bitter, and umami, fulfills a specific subtask in evaluating the chemical composition of food. While the innately attractive sweet, umami, and salty tastes mediate detection and ingestion of macronutrients or electrolytes, sour and bitter tastes are innately repulsive protecting organisms from food intoxication. Segregated populations of oral sensor cells are specifically dedicated to detect molecules of only a single basic taste which provides the basis for the high discriminatory power across and the low discriminatory power within taste qualities. The oral sensors use specialized receptor types which convert chemical structures into biological responses.

Recognition mechanisms for salty and sour remain unknown but appear to involve ion channels whereas the numerous structurally diverse sweeteners surprisingly are recognized by a single sweet taste receptor. It forms an obligatory homodimer of two members of the class C GPCRs. Sweet molecules can occupy different binding sites at the receptor including venus-fly trap binding motifs (VFTBM) in the amino-terminal domains and binding sites formed by the seven transmembrane segments (7TM) and cysteine-rich domains connecting the VFTBM with the 7TM core. The umami receptor resembles the sweet receptor structurally and functionally.

In marked contrast bitterness is mediated by ~25 bitter taste receptors. Like the sweet receptor, bitter receptors are generally broadly tuned to detect countless chemicals with different structures but unlike the sweet receptor, however, the bitter taste receptors appear to accommodate their cognate bitter chemicals in a single binding pocket that is positionally conserved but distinctly composed across receptors. Their binding pockets are optimized to recognize many ligands at the expense of binding affinity for a specific substance. These findings provide the conceptual framework for the reception of the innumerable bitter compounds. Intriguingly, bitter receptors are susceptible to blocking agents present in the same food as the bitter compounds themselves, a phenomenon relevant for bitterness perception of food and for the discovery of taste-modulators alike. Even complex perceptual experiences such as the sweet-water taste phenomenon, saccharin's taste sensation or the pleasant taste of sweetener mixtures can be explained by the pharmacological properties of the sweet and bitter taste receptors.

Molecular and genetic dissection demonstrates an unexpected complex organization of the oral sensor cells for the recognition of bitter compounds and of the peripheral and central neurons that process bitterness. The system is characterized by multiple parallel extensively overlapping but functionally distinct pathways. This design minimizes the risk of a fatal block of bitter perception through the presence of bitter blockers in food or by adaptation during eating bitter food items. The functionally distinct pathways of bitter detection and processing could also represent different input channels into neural circuits that regulate appetitive and repulsive behaviours.