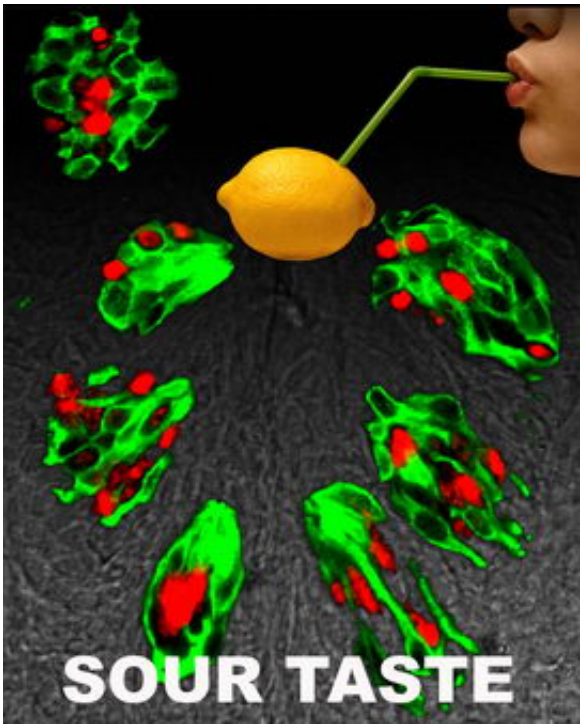
Scientists Discover How We Detect Sour Taste

August 23 2006



Tongue with bitter, sweet and umami receptors in green and sour receptors in red. Credit: Nicholas Ryba, NIDCR and Charles Zuker, UCSD

A team headed by biologists from the University of California, San Diego has discovered the cells and the protein that enable us to detect sour, one of the five basic tastes. The scientists, who included researchers from the National Institute of Dental and Craniofacial Research, suggest that this protein is also the long-sought sensor of

acidity in the cerebrospinal fluid.

The study, featured on the cover of the August 24 issue of the journal *Nature*, reports that each of the five basic tastes is detected by distinct taste receptors—proteins that detect taste molecules—in distinct cells. The team previously discovered the sweet, bitter and umami (savory) receptors and showed that they are found in separate cells, but some researchers have argued that sour and salty tastes, which depend on the detection of ions, would not be wired in the same way.

“Our results show that each of the five basic taste qualities is exquisitely segregated into different taste cells” explained Charles Zuker, a professor of biology at UCSD and a Howard Hughes Medical Institute Investigator, who headed the study. “Taken together, our work has also shown that all taste qualities are found in all areas of the tongue, in contrast with the popular view that different tastes map to different areas of the tongue.”

To determine if the taste cells and receptors for sour were separate from the receptors for the other basic tastes, the researchers tested mice in which they had genetically ablated the cells containing the sour taste receptors. The mice could not taste sour, but had completely normal sweet, bitter, umami and salty tastes. Therefore, although the salt taste receptor has not yet been discovered, it and the four identified receptors must each be segregated into distinct taste cells.

In addition to being found in the taste buds, the researchers discovered that the sour protein receptor, PKD2L1, is also found along the entire length of the spinal cord in nerve cells that surround and reach into the central canal. Because sourness is a reflection of the acidity, or the pH of a solution, the researchers suspected that the spinal neurons with PKD2L1 might be responsible for monitoring the pH of the cerebrospinal fluid.

Electrical recordings taken from these spinal neurons showed that they were able to detect and respond to very small changes in pH, confirming their role as pH detectors.

“There have been many claims for pH detectors that monitor the health of different body fluids, but the nature of the circuit and the receptors has been unknown,” said Zuker. “Therefore it is significant to discover that the same protein that detects sour tastes also functions as a sentinel of pH in the central nervous system.”

To discover the sour taste receptor, the researchers first turned to bioinformatics. According to Angela Huang, a graduate student working with Zuker and the lead author of the Nature paper, they started with three simple assumptions and then hunted the entire genome.

“First, we expected the taste receptors to be embedded in the cell membrane where they could be in contact with taste molecules on the tongue,” explained Huang. “Therefore, we narrowed the search down to genes for proteins with a structure that would allow them to be in a cell membrane. Second, we ruled out candidates that were found in many different tissues and focused on those mainly in the taste cells. Third, we looked for a candidate that was made in select populations of taste cells, rather than all taste cells.”

The three assumptions resulted in just a handful of possible candidates. PKD2L1 stood out because it was strongly produced in select cells in all of the different types of taste buds. PKD2L1 is a member of a family of proteins called polycystic-kidney-disease-like ion channels. Mutations in some members of this protein family lead to kidney failure, but according to Zuker, the cause of failure has been an open mystery.

“We don’t know if the other members of the protein family work in the same way as PKD2L1, but our findings could be an exciting and

unexpected entry into understanding these devastating kidney disorders," he said.

In addition to Zuker and Huang, the contributors to the study were Nicholas Ryba and Mark Hoon at NIDCR and Xiaoke Chen, Jayaram Chandrashekar, Wei Guo and Dimitri Tränkner at UCSD.

Source: University of California, San Diego