CHEMISTRY IN FOCUS

Taste—It's the Structure That Counts

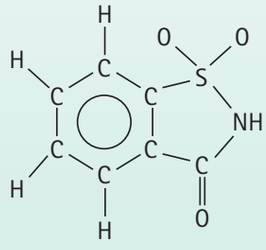
Why do certain substances taste sweet, sour, bitter, or salty? Of course, it has to do with the taste buds on our tongues. But how do these taste buds work? For example, why does sugar taste sweet to us? The answer to this question remains elusive, but it does seem clear that sweet taste depends on how certain molecules fit the "sweet receptors" in our taste buds.

One of the mysteries of the sweet taste sensation is the wide variety of molecules that taste sweet. For example, the many types of sugars include glucose and sucrose (table sugar). The first artificial sweetener was probably the Romans' sapa (see "Chemistry in Focus: Sugar of Lead" in Chapter 5), made by boiling wine in lead vessels to produce a syrup that contained lead acetate, $Pb(C_2H_3O_2)_2$, called sugar of lead because of its sweet taste. Other widely used modern artificial sweeteners include saccharin, sodium cyclamate, and aspartame, whose structures are shown in the accompanying figure. Note the great disparity of structures for these sweet-tasting molecules. It's certainly not obvious which structural features trigger a sweet sensation when these molecules interact with the taste buds.

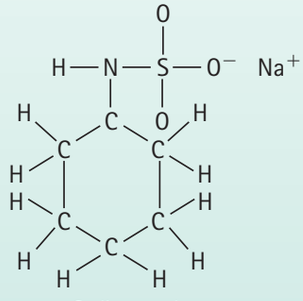
The pioneers in relating structure to sweet taste were two chemists, Robert S. Shallenberger and Terry E. Acree of Cornell University, who almost thirty years ago suggested that all sweet-tasting substances must contain a common feature they called a glycophore. They postulated that a glycophore always contains an atom or group of atoms that have available electrons located near a hydrogen atom attached to a relatively electronegative atom. Murray Goodman, a chemist at the University of California at San Diego, expanded the definition of a glycophore to include a hydrophobic ("water-hating") region. Goodman finds that a "sweet molecule" tends to be L-shaped with positively and negatively charged regions on the upright of the L and a hydrophobic region on the base of the L. To be sweet the L must be planar. If it is twisted in one direction, it gives a bitter taste. Twisting it in the other direction makes it tasteless.

The latest model for the sweet-taste receptor, proposed recently by Piero Temussi of the University of Naples, postulates that there are four binding sites on the receptor that can be occupied independently. Small sweet-tasting molecules might bind to one of the sites, while a large molecule would bind to more than one site simultaneously.

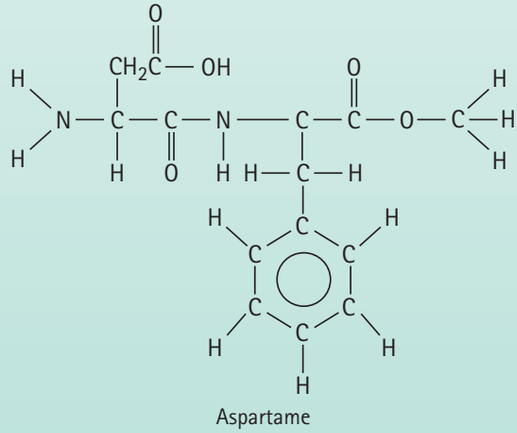
So the search goes on for a better artificial sweetener. One thing's for sure, it all has to do with molecular structure.



Saccharin



Sodium cyclamate



Aspartame
(Nutra-Sweet™)