Genetic components in taste recognition

Determined Tastes

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The genetic components of our sense of taste have been studied and described in some depth; however, human nutrition is also heavily influenced by civilization and culture

The publication of the human genome is regarded as the culmination of a certain stage of research. It is popularly understood to contain the total information on the structure of human DNA; while that is not far from the truth, the issue is rather more complex. Researchers have also been elaborating our functional understanding of the discovery, hinting at the existence of approx. 20,000 genes. That figure includes both known genes and DNA components with a structure corresponding to known genes. Work towards obtaining a full understanding of human DNA remains ongoing.

Senses in the genes

One of the open fields of genetic research is the study of human predispositions to recognizing flavors, which forms a part of the sensory system. Studies of the genetic encoding of the senses have brought two fascinating observations. First, our current understanding of the subject varies greatly with each sense; the genetic basis of vision and hearing was studied in depth in the late 20th century. Research into the genetics of gustatory receptors experienced a breakthrough thanks to the work of Richard Axel (New York) and Linda Buck (Seattle), jointly awarded the Nobel Prize in physiology or medicine in 2004. Although other research into the genetic foundations of taste has been most revealing, many questions remain unanswered. The second comparative observation is that there is a wide range of complexities of the genetic basis for sensory receptors. For example, genes responsible for vision form a relatively small group, with just three responsible for our color vision. The identification of the genes responsible for detecting blue, red and green light confirmed the solution to the color triangle proposed in the 19th century, providing an elegant example of complementary discoveries made using completely unrelated techniques. In contrast, studies into the genetic basis of hearing - focusing on hypoacusia - have led to the discovery of almost 100 genes involved in the hearing process. The genetic basis for recognizing different smells is different yet again.

Ten thousand odors

Axel and Buck discovered approx. 1000 genes encoding olfactory receptors. This means that a significant part of the human genome is involved with recognizing and memorizing the approximately 10,000 different odors. The proposed 1000 genes do not seem sufficient for this; therefore it can

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Taste preferences of children are largely determined by genetic factors, which in adults are outweighed by lifelong experiences

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There are five basic tastes: sweet, salty, bitter, sour, and umami. The latter is a type of savory taste; it was first proposed by Prof. Kikunae Ikeda, who also gave it its name

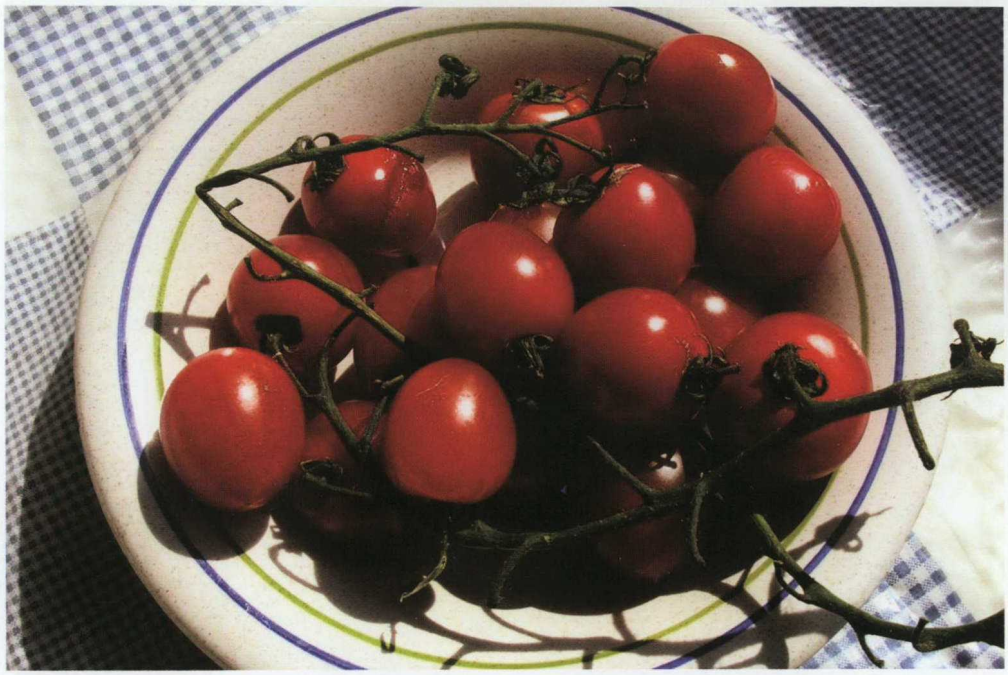
be assumed that the receptors form temporary combinations that broaden their range. The odor reception genes have always been known to be distributed across several chromosomes. This is likely to be due to an evolutionary process offering protection against deep functional defects which could result from damage to a single chromosome.

From the research perspective, taste is important in physiology, neurology, nutrition and genetics. The olfactory and gustatory systems are closely linked with the function of the digestive system. There is agreement as to the original function of the gustatory system, adapted at an early evolutionary stage to recognize toxins in food. The five specific tastes are sweet, salty, bitter, sour, and umami. The latter is a type of savory taste; it was first proposed by Prof. Kikunae Ikeda, who also gave it its name. It has been proposed recently that the classification should also include a "fat" taste. Taste is perceived by receptors located in taste buds. They are mainly distributed in the mouth, with the greatest concentration across the tongue, although they are also present in the top part of the esophagus. The mechanisms of taste recognition are generally well understood; taste is perceived by sodium, potassium and calcium ion channels, as well as gustatory G protein-coupled receptors. Model compounds are used to study the biological function of individual receptors associated with specific tastes. Examples include isothiocyanates, polyphenols or sulfamides for bitter taste or glucose, and sucrose, glycine and artificial sweeteners for sweet taste. Umami taste is perceived by receptors of L-glutamate and its derivatives. Signals collected by the receptors are transmitted to the brain via the nervous system.

Bitter sweet

Sweet taste receptors have been found to belong to the TRI gene family, encoding G proteins located on chromosome 1. The location of three genes for sweet taste receptors - TAS1R1, TAS1R2, and TAS1R3 - has been identified as the short arm of chromosome 1 on band 36. Extensive research into the structure of these genes, conducted on individuals of Asian, Native American, African and European origins, indicates structural variation of the genes with a particular emphasis on TAS1R2; this may provide an explanation for different taste preferences linked to ethnic background. Recent work conducted by a research team in Finland indicates an additional locus on chromosome 16, also responsible for the perception of sweet taste.

The genetics of bitter taste receptors is rather more complex. In 2011, the TAS2R gene family, encoding transmembrane G proteins, numbered 25-30 genes, located on chromosomes 5, 7 and 12. It is possible that the high number of genes encoding for bitter taste receptors is the result of their



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previously mentioned function of identifying toxins. The function of detecting bitterness as a way of preventing overeating has also been noted. The genes also show structural variation; the structure of the TAS2R38 gene, showing especially high variability, has been the subject of the most in-depth studies. Research conducted on a group of Italian men indicates that certain structural variants of the TAS2R38 gene are associated with an increased density of taste buds; this correlation may explain a heightened taste sensitivity in this subgroup. Using molecular technologies to study the structure of the human genome allows researchers to identify individuals with a higher sensitivity to taste, so that they can be trained to use their ability to work as food tasters. Studying the TAS2R16 gene in various populations made it possible to identify its frequent occurrence in European and certain African (Pygmy) populations, in contrast to populations from the Middle East and southern China. This fits into the human evolution model describing continents being settled by migrants from Africa, and the accompanying progressive and permanent genetic variation.

To warn and to balance

The encoding of sour taste receptors is less well known. However, there can be no doubt that being able to recognize this taste was essential in early hunter-gatherer tribes: sour taste serves as a warning that food may have gone off, since it can indicate rotting, fermentation, and so on. Detection of sour taste involves the depolarization of calcium ions and their flow into receptor cells. Taste buds of mice have been found to contain PKD2L1 and PKD1L3 proteins, which may function as sour taste receptors. State-of-the-art *in vitro* experiments have confirmed their reactivity to acidic compounds and an absence of response to model compounds of other tastes. However, analogues of these proteins in humans are yet to be found.

The significance of salt taste has no direct links to toxicity; however, salt levels play a crucial role in maintaining the electrolyte balance in systemic fluids and, indirectly, in organs supplied by them. The nutritional significance of salty foods has been studied in newborns. In their earliest days, infants show a positive response to sweet taste only; however, after a few weeks, they start responding well to salt. This seems unexpected, since breast milk contains salt in trace quantities only; the conclusion is that after a certain age, babies may feel an instinctive need to start ingesting low levels of salt. This explains the importance of sodium and potassium ion channels. Results of research conducted in mouse models have yet to be replicated in humans.

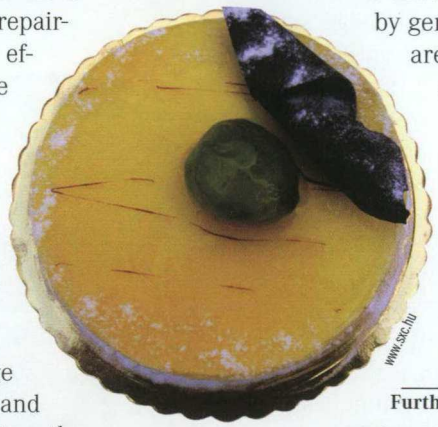
So far, the only gene found to be responsible for encoding the receptors for umami taste is TAS1R; however, it is possible to precisely indicate sequence variations of the same genes that heighten the sensitivity to umami taste.

A number of researchers have proposed that fat should be added to the existing list of basic tastes. In terms of nutritional requirements, it reflects the human body's need for high-energy foods. Researchers have discovered that we are able to detect fatty acids even at low concentrations, which supports the concept. Mice have been found to have the CD36 receptor whose analogue is present on the long arm of chromosome 7 in band 11. In humans, this gene is designated CD36.

Whence the variety?

After having presented the basic assumptions of taste receptor genetics, we should now ask why different people show different levels of sensitivity to different tastes. The answer, of course, is multifaceted. in terms of physiology, it is due to the density of taste buds. In terms of genetics, the issue is studied from the perspective of genetic polymorphism. Firstly, errors may be introduced during DNA replication; secondly, we are constantly subject to a number of physical and chemical factors that can potentially damage DNA. While our bodies have an effective system for repairing damaged DNA, its effectiveness is limited. The damage may remain, and become fixed in the form of a mutation. If the mutation has a significant negative effect on health, it may result in the death of the individual. However, many mutations change the structure of the gene and have a quantitative effect on the function of the encoded protein. Certain mutation variants become preserved in certain ethnic groups, which may explain the variation in the perception and preference for individual flavors between populations.

The study of human predispositions to recognizing flavors is one of the more open fields of genetic research



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Illnesses with a genetic basis are no longer considered purely in terms of genetic polymorphisms. There are many disorders whose symptoms include problems with absorbing nutrients. In the majority of cases, they result in the individual rejecting food or overeating, and the importance of recognizing different tastes is not taken into consideration. Disorders of taste perception may be acquired, and they often accompany other pathologies. One example is people with a long history of alcoholism going on to avoid sweet tastes. This observation was first made a long time ago, with a potential explanation provided by the fact that genes responsible for the metabolism of alcohol and the perception of the sweet taste are located close together in the human genome.

Taste habits

When discussing taste preferences, we must consider the genetics involved, paying particular attention to the fact that nutrition is not simply about sustenance. Rather, it has deep social and cultural roots which foster certain customs and lead certain dishes to be characterized as sophisticated and others as downmarket. Social and cultural experiences were taken into consideration when studying nutritional preferences of parents and their children. Genetic material is passed down the generations following the principles of Mendelian inheritance; while taste preferences of children are largely determined by genetic factors, in adults they are outweighed by lifelong experiences. The sense of taste has taken a long evolutionary journey from a basic yet essential warning system to shaping our pleasure and enjoyment, becoming almost a hedonistic sense. ■

Further reading

Phillips D.H., Venitt S. (1995). *Environmental Mutagenesis*. Bios Scientific Publishers, Oxford Press.

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