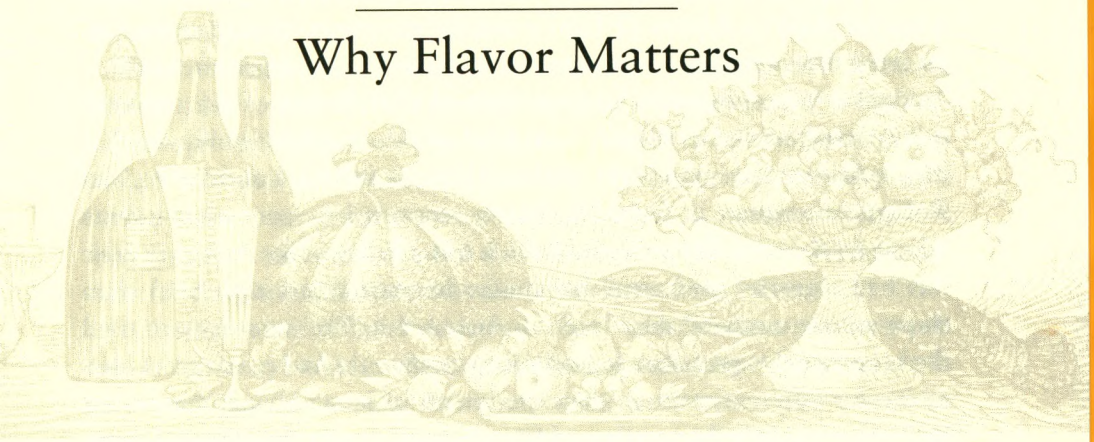
CHAPTER TWENTY-SEVEN

Why Flavor Matters



For many readers, the evidence presented in this book will be useful in giving personal insights into how "flavor" exists not in our food but in the way it is created by our brains. It should stimulate new insights for chefs, food critics, consumers of fast food, and families around the dinner table.

In addition to these personal rewards, knowledge of how the brain creates flavor has important implications for public policies on food and nutrition. A possible advantage of a new term like *neurogastronomy* is that it can help focus public policy more effectively in applying advances in brain science to issues related to food and flavor. These issues are with us from conception to old age. In Shakespeare's *As You Like It*, the philosopher Jacques describes the seven ages of man; here, we will describe the six ages of flavor.

Flavor Effects in the Womb

Both animal experiments and human studies show that the flavors of a mother's food are transmitted through the amniotic fluid in the womb to the fetus, and that after birth this transmission can influence later flavor preferences and dislikes. We learned about this in animals from Patricia Pedersen when she joined our lab in 1980. In her dissertation work with Elliott Blass at Princeton, she showed that an odorous substance injected into the amniotic fluid became a preferred cue for suckling by

the rat pups after birth. Others showed that substances injected into the amniotic fluid or flavors of food eaten by the pregnant rat become associated with preferred or nonpreferred foods much longer after birth.

Similar experiments in humans showed that flavors of the mother's diet are transmitted to the amniotic fluid and the mother's milk, and that they influence the infant's preferences. Benoist Schaal, Luc Marlier, and Robert Soussignan in Nouzilly, France, reported in 2000 that infants whose mothers consumed anise (which has a licorice-like flavor) in their diet had a greater preference for anise when tested just after birth than those whose mothers' diets had not included it. The investigators used the same facial expressions for indicating preference and rejection as used to test for different tastes in the experiments of Jacob Steiner mentioned in chapter 13. Julie Mennella and Gary Beauchamp at the Monell Chemical Senses Center in Philadelphia have explored this question in depth. In a typical study reported in 2011, "infants whose mothers were randomly assigned to drink carrot juice during the last trimester of pregnancy enjoyed carrot-flavored cereals more than infants whose mothers did not. . . . Thus, like other mammals, prenatal experiences with food flavors transmitted from the mother's diet to amniotic fluid lead to greater acceptance and enjoyment of these foods during weaning." Other studies have used stronger foods, such as garlic, in the mother's diet to show its presence in the amniotic fluid and its influence on after-birth preference lasting into childhood.

As explained in chapter 13, the neural system for the basic hedonic responses to taste, in terms of attraction or repulsion, is in the brain stem and is active in the newborn. The learning of these preferences in utero and their emotional expression are therefore incorporated into this hardwired system.

Flavor and Infants

This evidence indicates that flavor preferences of the mother affect flavor preferences of the infant. This influence is also carried in the mother's breast milk. In furthering their study, Beauchamp and Mennella had mothers consume carrot juice while breastfeeding during their infants' first three months. When weaning later took place, the infants showed

a preference for carrot juice, a result similar to that of the in utero experiments.

These authors have also found a sensitive learning period when infants can be trained to different flavors. They demonstrated this by feeding infants either standard formula or a protein-rich, less flavorful formula. Up to six months of age, infants learn to accept the latter, as judged by the facial expressions of acceptance; but their acceptance changes to rejection after six months, when the infants start showing a high preference for the particular taste on which they have been trained.

Beauchamp and Mennella conclude that "infants form a relatively precise flavor image which, when later matched, enhances intake and elicits pleasure." This *flavor image* for infants is the same term we have used for the adult. Because the infant brain lacks most of a functioning cerebral cortex, more research is needed to understand the extent of the developing human brain flavor system at these early stages of life.

Flavor in Childhood

There is widespread consensus that flavor has a powerful effect on young children. In fact, they are so vulnerable to flavors that Mennella has proposed that "children live in a different sensory world than adults." There is growing evidence that children prefer intense sweet, sour, and salty tastes and, if they are supertasters, are more sensitive to bitter tastes. This makes them especially vulnerable to the main culprits we have identified as leading to overeating—sweet foods, salt, and fat—through sensations that overwhelm the brain's control systems (see figure 22.1).

The nation's food producers and food providers of course understand this well. As noted in chapter 21, Eric Schlosser has documented how every item on fast-food menus is there to maximize the sensory stimulation and accompanying calorie overload. The fact that fast food appeals especially to kids means that with their preferences built into their flavor circuits at an early age by the plasticity we have discussed in chapter 23, costumers are guaranteed for life.

Perhaps no children's flavor item has been more targeted than sweet. This is a basic taste for the energy it provides, perhaps the most obvious and least sophisticated of the flavors. It is only as one grows up that the

bitters—coffee, chocolate, beer—become favorites by their variety and deeper complexity. Kids are being overwhelmed by the sugar in soft drinks. When I was a kid, a standard Coke in a bottle or served by a soda jerk at the counter was 7 ounces (0.2 liter). Then Pepsi offered 12 ounces (0.35 liter, or, as the radio commercials sang, "twice as much for a nickel too"). Now the adult size of a soft drink is 16 or 20 ounces (around 0.5 or 0.6 liter), and 12 ounces is the children's size, almost twice the original adult size. Another example is dry cereal breakfast food. Nowadays it is difficult to find one that is not sugared. A blizzard of advertising—using cartoon characters, games, and television and online commercials—is aimed at children to eat them. In chapter 15, we noted that bright colors have a big effect on flavor, and this is especially so for children. Attempts are being made to regulate this advertising aimed at children by requiring the products to contain reduced amounts of sugar, salt, and fat.

More research is needed on children's brain flavor system in order to understand what makes it vulnerable. Using the control system in figure 22.1 as a guide, this research needs to test critical questions such as whether in children there is too high a sensitivity to the desired flavor image, too strong a memory of it, or an undeveloped prefrontal lobe system to control the motivation to acquire the desired foods. Research is also needed on the converse—that is, strong, hard-to-change aversions by some children to specific foods.

Flavor and Adolescents

The vulnerabilities of childhood continue into adolescence, magnified by new developments. Puberty brings a rush of hormones that loosen control as young people explore their newly developing worlds. Adolescents evolve from being largely dependent on their parents to having various degrees of partial and complete independence, gaining confidence to hang out with friends and make their own decisions. And, of course, they begin to have their own purchasing power to express their independence.

The maturing human brain flavor system reflects all these trends. Perhaps one of the most important factors in this is that the highest cognitive levels of the brain—the areas in the prefrontal cortex that are

involved in making decisions on the basis of limited information, making plans with short-term as well as long-term consequences, and weighing immediate desires in the context of long-term goals—are still developing. This includes the areas of the human brain flavor system, which are still developing their key roles in creating flavor images and the images of desire for them. Little wonder that entry into the worldwide obesity epidemic begins in childhood and adolescence.

Advertisers for fast foods have known this continuing vulnerability for decades, and have targeted the baby-boomer youth culture to the greatest degree possible. As in the case of children, there needs to be a balance between the advertising and the nutrition of foods with desirable flavors. In response to Schlosser's book, most of the fast-food chains recalibrated their offerings. Regulations have evolved so that food packages in many Western countries contain data on calories, fat content, cholesterol, salt, and other ingredients, enabling even young people to begin to make informed choices. It was recently reported that a fast-food meal in Copenhagen contains just 0.012 ounce (0.35 gram) of trans fatty acids, whereas the same meal in New York contains more than 0.35 ounce (10 grams). There's still a long way to go.

Flavor and Diets

The hazards of too much flavor, of course, are endemic in the adult world. Flavor is much talked about but, as this book shows, inadequately understood. We are flooded with television programs about food, Web sites about food, and articles in the media about food. Good flavor is always the goal. Food critics provide many insights into food flavors. But how flavor is produced is usually in terms of what is in the food, rarely in terms of how the brain creates it. And so we continue to overeat and make ourselves vulnerable to obesity, diabetes, cardiovascular disease, stroke, and even certain cancers.

A key belief of most adults in controlling how much they eat is that they can do it through a diet. That is the basis, at least, for the ever-expanding diet industry. We are flooded with specialty diets, each carrying the name of its founder or its fad. Some focus on a basic nutrient—protein, carbohydrate, or fat—and either elevate or outlaw it. Others invoke a particular

food group or national cuisine or a supposed early human diet. Key the word *diets* into Google and you can get a list of 89 or more. All have a claim on some sliver of the truth. And for most people, all fail.

This is a book about flavor, not diets, but it should be clear that the key element missing from most discussions of diet is flavor. A great deal of evidence has been presented here that has a direct bearing on why too many people eat too much. Sensory mechanisms are sensitive mainly to changes in their stimuli; this leads directly to the ability to be stimulated by new flavors even though one is overstimulated by previous flavors. There are strong ties to memory, making a flavor too vivid in one's thoughts. Favors are tied strongly to emotions, making it hard to resist a food with a favorite flavor. Research is increasingly uncovering evidence that strong desires for flavors and strong desires for drugs of abuse activate similar brain mechanisms. Many other examples of brain mechanisms in flavor that play a key role in overeating are found throughout this book.

It is my hope that increased research on these brain mechanisms can give us better insight into why we have difficulty in controlling what we eat. For example, when nutrition experts formulate official guidelines, there needs to be recognition that the human brain flavor system is going to be guiding consumers toward, or away from, the foods being recommended.

It is fortunate that awareness of the critical role of flavor is on the rise. In his book *Food Fight: The Inside Story of the Food Industry, America's Obesity Crisis, and What We Can Do About It*, Kelly Brownell, a colleague at Yale University and an authority on the obesity epidemic, cites Anthony Sclafani at Brooklyn College for his current studies of the overstimulation caused by the wide variety in high-calorie, highly flavorful foods produced by the food industry, and Barbara Rolls, now at Penn State University, for her studies of sensory-specific satiety that drives overeating these differently flavored foods, as discussed in chapter 21.

An important perspective on relating flavor to nutrition is provided by a story told by the well-known chef Jacques Pépin in 2006, reminiscing about his arrival in the United States in 1959. He describes how he had been working in a three-star restaurant in France but paradoxically sought his first job in the United States with Howard Johnson, one of the main American restaurant chains in the mid-twentieth century, before the rise of fast-food chains. Pépin was fascinated by how Howard Johnson's goal

was to capture the essence of American meals, and he enthusiastically plunged into making such traditional American dishes as burgers, hot dogs, fried clams, macaroni and cheese, hash browns, ice cream sundaes, banana splits, apple pies, and specialty dishes such as beef burgundy stew, scallops in mushroom sauce, veal, and turkey—often prepared by the ton for thousands of patrons. He loved it!

The reason for mentioning this story is that Pépin emphasizes the essence of a traditional, pre-fast-food, American cuisine in its variety, flavor, and balanced nutritive values. Johnson and his chefs attempted to reproduce these qualities of the meal at home as closely as possible for the busy lunch-eater and the traveling motorist. They took great care in testing for flavor, using high-quality flavor ingredients, replacing margarine with butter, dehydrated onion with fresh onion, and frozen potatoes with real potatoes.

The menus contained a balance between the amount of the food and the flavor it contained. This meant that one became full from stretching the stomach in coordination with just the right amount of flavor before one's orbitofrontal cortex decided that one had enjoyed the pleasant flavor to satiety, before the food became aversive. Traditional cuisines have this balance; it is why they continue to be traditional. This balance is also the key to the principles of how the human brain flavor system should function.

Flavor and Old Age

In Shakespeare's play *As You Like It*, Jacques ends his soliloquy on the ages of man thusly:

> . . . Last scene of all,
> That ends this strange eventful history,
> Is second childishness and mere oblivion,
> Sans teeth, sans eyes, sans taste, sans everything.
>
> *Act 2, scene 7*

And, he could have added, sans flavor.

In Shakespeare's day, with no real medicines and the average life span probably around 40 years, old age left most people in a ravaged state. In

our day, there are many in their eighties and nineties still going strong. However, there are also many who are incapacitated or ill with one of the many infirmities of age. An overriding concern for their loved ones is a failure to thrive. This may have an organic cause, but in many cases its cause may be a loss of interest in food because of its lack of flavor. This afflicts many old people, both in hospitals and at home.

There is increasing interest in identifying these cases and treating them. In many cases we know the causes. On average, sensory abilities decline in later years. Some people fortunately may be little affected, but many suffer significant losses by natural ageing, quite apart from a disease process. Richard Doty of the Taste and Smell Center in Philadelphia has documented this with his Sniffin' Sticks tests and has shown a decline in smell sensitivity in the eighties and nineties. Diseases take their toll. It is now well documented that an early sign of Alzheimer's disease is a loss of smell, and the same occurs in other diseases such as Parkinson's. Given the key role of smell in flavor, it is therefore not surprising that many older and ill people lose their sense of flavor. We have noted in the introduction that a sudden loss of the sense of smell in younger adults can be devastating because of the loss of flavor, and there can be a similar effect in the aged. Failure to thrive can have many causes, but loss of flavor is one that is potentially treatable and should be checked first. Treating it depends on the person's natural preferences, but care has to be taken because some of the common ways of increasing flavor, such as adding salt, may be proscribed by the individual's medical condition.

Recent studies of Alzheimer's disease are revealing new and unexpected depths in its relation to the human brain flavor system. Jennifer Stamps and Linda Bartoshuk at the University of Florida have found, in studying flavor perception in a population of Alzheimer's patients, that some people who experienced a loss of taste also had a loss of retronasal smell for some foods, and that this loss reduced the flavor. Foods with strong associated touch sensations (nose-feel) were least affected. This suggested that it might be possible to enhance flavor in these subjects by specifically adding a "mouth-sense" stimulant such as pepper to the food. They found that adding the pepper to grape jelly as a test food gave an enhanced perception of the grape flavor because of the retronasal smell from the mouth, but it had no effect on the smell of the grape jelly when it was sniffed. This study thus adds to the ways that different senses can

interact with one another to produce the kind of supra-additive effects discussed in chapter 14, and it indicates a strategy for helping with patients who are failing to thrive. It is also a reminder that one needs to test for multiple sensory losses in the aging and ill.

In summary, in treating failure to thrive, a good rule of thumb may be to reactivate the food cravings of childhood, enhancing the senses that contribute to flavor with strong smells, strong tastes, crunchy texture, bright colors, pleasant music—and talking pleasantly together as you eat the shared meal. Understanding the human brain flavor system can be just as important for the end of life as for the beginning.