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## Sensory-specific Satiety

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*New meat begets a new appetite—English proverb*

All animals, but especially omnivores such as rats and humans, face the seemingly daunting task of selecting a diet that supplies all of the essential nutrients. The complexity of factors that can affect food selection was outlined in a recent review which listed the following influences on the appetite for specific foods: metabolic influences (eg, caloric requirements, neurotransmitter levels, hormones); specific appetites (eg, NaCl when salt-deficient); disease states (eg, diabetes, cancer); pharmacological influences (eg, anorectic drugs); environmental influences (eg, temperature); social influences (eg, culture, religion); learned preferences and aversions; and hedonic factors (eg, palatability, taste, texture, odor).<sup>1</sup> The focus of this review will be the way in which hedonic factors can affect food selection, but it must be stressed that singling out one factor for analysis does not imply that this factor would normally act in isolation to affect consumption.

When confronted with a variety of different foods, the safest strategy for an animal to ensure adequate nutrition would be to consume a widely varied selection of foods. It appears that when more than one food is available there is a natural tendency to switch between foods rather than just consume the most preferred food. This is illustrated by studies conducted by Davis on newly weaned infants.<sup>2,3</sup> These babies, from 6 to 11 months of age at the start of the study, had little experience with the

foods offered and were protected from adult influences during the study. At meal times they were offered a variety of natural, nutritious foods. During the first week they tried most of the foods, and after that definite likes and dislikes emerged. Despite preferences, within any one meal they tended to consume several solid foods and a drink. Thus, their general strategy was appropriate for good nutrition in that a varied diet was selected rather than just the most preferred food. The children grew normally and developed no nutritional deficiencies. Davis concluded that "such successful juggling and balancing of the more than 30 nutritional essentials that exist in mixed and different proportions in the foods from which they must be derived suggests at once the existence of some innate, automatic mechanism for its accomplishment, of which appetite is a part."

For some wild predators, even highly attractive and abundant prey will rarely become the sole constituent of the diet as long as other food is encountered. It has been suggested that a special "switch" mechanism reduces responsiveness of a predator to a given prey that begins to form too large a part of the menu. Several mammals and birds, when presented exclusively with one palatable food item for a long time, will initially avoid that item when additional, normally less palatable food is also provided.<sup>4</sup>

There are a number of studies indicating that the reason for switching foods is that as a food is consumed, its palatability decreases, and therefore the preference for that food in relation to other foods declines. The first statement that satiety, or the cessation of consumption, is specific to a food that has been consumed appears to have been made by Katz in 1934,<sup>5</sup> who from observing chickens suggested that

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"when only one kind of food is offered, satiety very soon occurs, but this can be retarded by mixing the food with one or two other kinds." In 1940, Young published the results of a well-controlled study showing that the food preferences of rats could be reversed by controlled prefeeding.<sup>6</sup> Generally, when given a choice between sugar and wheat, rats prefer sugar. However, if rats are fed sugar before being tested, this preference reverses. Since these foods are both carbohydrates and therefore not very different in nutritive value, it appears that the oral stimulation associated with consumption leads to decreased intake of that food, or in other words satiety is specific to the sensory properties of foods. Thus intake of a particular food in a given period of time is determined by both a stimulating and inhibiting action of that food on its particular intake.

### Alliesthesia

Young's finding implies that as a food is eaten, its palatability decreases, but because he was studying rats, he could not directly address this. However, if human experiments are performed, the subjective sensations associated with consumption of a particular food can be assessed. In the early 1970s Cabanac proposed a theory that the pleasure derived from various sensations (alimentary, thermic, etc) depends on their physiological usefulness.<sup>7</sup> This theory was applied to eating behavior in that the pleasantness of the taste and smell of foods depended on a persons' state of repletion. Cabanac called this changing hedonic response alliesthesia, or "changed sensation."

In early experiments on alliesthesia, sweet solutions were tasted and rated before and after 50 g glucose loads given either orally or intragastrically. After these preloads of sugar, the sweet solutions became gradually less pleasant to taste over 45 to 60 minutes.<sup>7</sup> Food-related smells also became less pleasant, but salty tastes were unaffected by the sugar preload. Sweet tastes were unaffected by an intragastric salt preload, which decreased the pleasantness of the taste of salty solutions.<sup>8</sup>

Because of the slow time course of the hedonic changes, and because they occurred following intragastric preloads, it was thought

that sensory stimulation by the preloads at the oropharyngeal level had little influence on the changes; they were presumed to be due to an alteration in physiological need for particular substances. The receptors detecting such changes in need were thought to be in the duodenum, since glucose produced a more intense and more rapid change in the hedonic response when tubed directly into the duodenum than when tubed into the stomach. Post-absorptive changes seemed not to be involved in alliesthesia because intubation of mannitol, a nonabsorbable sweetener, into the stomach reduced the pleasantness of sweet solutions,<sup>9</sup> whereas injections of glucose into the superior mesenteric artery were without effect.<sup>10</sup> Thus Cabanac found that the pleasantness of food-related tastes and odors is modulated by internal signals such as stimulation of the duodenum by food.

### Physiological Need and Food Selection

Let us consider what effect, if any, alliesthesia might have on food selection. Cabanac did not observe changes in the pleasantness of sweet solutions until 20 minutes after a glucose load. It seems unlikely that such slow changes would have a major influence on either food selection or food intake *within* most meals. Booth et al<sup>11</sup> concluded that gastrointestinal or postabsorptive effects of glucose do not influence food intake until about 15 minutes after consumption. During the first 15 to 20 minutes of a meal the sensory properties of foods would be the main influence on intake. Cabanac did not perform experiments to relate the hedonic changes to subsequent food intake or selection, so it is not clear how important alliesthesia is in such regulatory behavior. It should be noted that the changes observed after glucose ingestion were not highly specific (for example, meat and fish smells were affected).<sup>9</sup> However, Duclaux et al<sup>12</sup> found that after free consumption of a mixed meal (eg, ham, bread, french fried potatoes, milk, orange) all food-related odors tested 15 to 120 minutes after the meal decreased in pleasantness, with a maximal change after 60 minutes.

Since there is little evidence concerning the role of alliesthesia in food selection, let us consider the broader issue of whether the postab-

sorptive consequences of eating are likely to affect food selection in a meal or in the next meal. For example, it is possible that changes in blood glucose or insulin following eating could affect food choices. Mayer-Gross and Walker<sup>13</sup> found that preference for 30 percent sucrose solutions was related to blood glucose level in a group of schizophrenics treated with large doses of insulin. They postulated that this effect was due to changes in the perception of the sweet taste. Recently, Rodin and Spitzer<sup>14</sup> have questioned whether ingestion of fructose or glucose, which have different effects on plasma glucose and insulin, have different effects on food intake and selection in a subsequent meal just over 2 hours later. They found that, whereas total food intake was related to the effects of the sugars on plasma glucose and insulin, there were no differences in the proportions of carbohydrate, protein, or fat selected. The differences in plasma glucose and insulin would have been much smaller than in the insulin therapy study, but nevertheless these data do not support the notion that meal-to-meal food selection is based on physiological need for particular nutrients. Perhaps alterations in nutrient selection are only apparent when either very severe or chronic deficiencies or excesses of nutrients or metabolites occur. This cannot be decided until more well-controlled studies of human food selection in relation to physiological changes have been conducted.

It is unlikely that food selection *normally* depends on specific appetites resulting from deficiencies. We know from our studies of ad libitum water intake in humans that fluid intake anticipates deficits in the body fluids.<sup>15</sup> Similar studies have not been performed on food intake, but food selection in most individuals probably takes place in an environment of excess nutrition rather than specific depletions. Although it is possible that there is a specific receptor for each essential nutrient, and a way of detecting these nutrients in foods so that deficits can be replenished, it is unlikely that food selection is organized in this way. Recall that in discussing the excellent nutritional status of self-selecting infants, Davis speculated that there must be some innate, automatic mechanism directing food selection.

Clearly, if the subjects were adults we could have argued that they had learned about good nutrition and responded accordingly. The infants in the Davis study could have learned that some foods made them feel better than others, but this seems unlikely to have been the basis for their selections, with the exception of the child who selected cod liver oil to reverse rickets. The intake of a variety of foods is more likely to have been the key to their nutritional status. A major factor ensuring that a variety is consumed is sensory-specific satiety.

### **Sensory-specific Satiety**

What is sensory-specific satiety? The notion of sensory-specific satiety has already been introduced in discussing early animal experiments, particularly those of Young,<sup>6</sup> who showed that food preferences could be reversed by prefeeding a particular food. In humans, sensory-specific satiety refers to the changing hedonic response to the sensory properties of a particular food as it is consumed. It is assessed by asking individuals to rate the subjective pleasantness of the taste, smell, texture, or appearance of a food before and after consumption of that food. The changes in these subjective responses with consumption can be compared to those for other foods which are not consumed. It is usually found that the pleasantness of the sensory properties of the eaten food decreases significantly more than the pleasantness of uneaten foods.

There is now some confusion in the literature over the difference between sensory-specific satiety and alliesthesia. Indeed, in a recent review sensory-specific satiety was referred to as a form of negative alliesthesia.<sup>16</sup> There is a need to retain a distinction between sensory-specific satiety and alliesthesia. Alliesthesia refers to a change in sensations resulting from a change in the internal state or in the physiological need for substances. The hedonic changes develop slowly during the hour after consumption, are relatively unspecific in that all food odors decrease after a sugar load, and the origin of the changes is thought to be in the duodenum. Just tasting foods without ingesting them, and the ingestion of noncaloric foods

or drinks have no effect on alliesthesia.

Sensory-specific satiety has different characteristics, as shown in a series of experiments in which normal-weight, nondieting individuals were offered test meals of ordinary commercially available foods.<sup>17-19</sup> The standard test procedure was to have moderately hungry subjects taste and rate the pleasantness of the sensory properties of small portions of eight or nine foods. Following these initial ratings, one of the foods was offered as a meal and subjects ate as much as they wanted. At various times following this test meal they tasted and rated the eight or nine foods tasted initially. Within 2 minutes after eating the test meal the pleasantness of the taste, smell, texture, and appearance of the eaten food decreased significantly more than for the uneaten foods. When the magnitude of these changes was followed over the hour after eating, the changes tended to be greatest 2 minutes after the meal, with a gradual recovery in pleasantness over the next hour. It is clear that the largest changes in the hedonic response to foods occurred before most of the meal was absorbed. It is possible that the presence of some food in the gut could have contributed to the changes, but if the physiological usefulness of the food were the major influence on palatability, the change in the eaten food should have continued to decline after 2 minutes. Instead the very rapid decline in the pleasantness of foods indicates that the major influence on the hedonic response to foods is their sensory properties.

Another way to determine the importance of the internal state for the changing hedonic response is to compare the effects of nutritive and non-nutritive foods. Wooley et al found that ingestion of a noncaloric sweet solution of cyclamate was just as effective after 15 minutes in decreasing the pleasantness of 20 percent sucrose as was glucose.<sup>20</sup> Since it is not clear how relevant studies using sweet solutions are to normal eating, we conducted a study using foods with similar sensory qualities (appearance, smell, texture, and taste) but which differed markedly in energy density.<sup>19</sup> Two different kinds of test foods were used — tomato soup (high calorie, 0.49 kcal/g; low calorie, 0.07 kcal/g), and orange jello (0.54 vs 0.09

kcal/g). Following a test meal in which subjects consumed as much as they wanted of these foods, the time course and magnitude of the decrease in the pleasantness of the taste of the eaten foods were not affected by the calories consumed. Birch and Deysler also found in 2- to 5-year-old children that the decrease in preference for pudding following its consumption did not depend on its energy density.<sup>21</sup> Rolls and Rolls<sup>22</sup> and Drewnowski et al<sup>23</sup> also found that the pleasantness of the taste of solutions declines when they are tasted but not swallowed. Thus, sensory-specific satiety differs from alliesthesia in that it is not produced primarily by the state of repletion or the physiological need for particular nutrients. It is much more likely that the rapid changes in palatability that occur during and immediately after eating depend on the sensory properties of foods, or on some cognitive process which assesses that enough of a particular type of food has been consumed.

### **How Specific Is Satiety?**

Although the greatest changes in palatability that occur after eating involve the food consumed, other interactions cause some uneaten foods to decrease in palatability. Such interactions might occur because the foods have similar sensory properties, or because cognitively the foods are considered to be of the same type, or perhaps because the foods have the same macronutrient content.

It appears that if uneaten foods are similar in taste to eaten food, they may also decrease in palatability. For example, after consumption of one sweet food, other sweet foods declined in pleasantness, but savory (ie, salty and not sweet) foods were unaffected, whereas the consumption of savory foods decreased the pleasantness of other savory foods but not sweet foods.<sup>18</sup> Although such interactions may occur on the basis of taste or flavor, they may not be seen if other sensory properties of the foods are very different.

Foods of the same type also interact. For example, following a meal of orange jello, raspberry jello also declined in palatability. Similarly, following ingestion of tomato soup, consommé also decreased in pleasantness.<sup>19</sup> This type of interaction may be due to beliefs

about the similarities between foods, ie, the way in which foods are cognitively grouped together, as well as to similarities in their sensory qualities.

This technique of relating changes in palatability to the way foods interact is new and its potential has not yet been fully realized. It could provide a new method for meal planning. If the technique is used to find foods which show little interaction, it should be possible to maintain palatability at a high level throughout a meal. The pattern of meals in the West already stresses the importance of different sensory qualities of foods throughout a meal. A meal of soup or salad, followed by meat with two vegetables, and ending with dessert, with an emphasis on good color and textural contrasts, would reduce the possibility of specific satieties diminishing appetite during the meal.

### **Nutrient-specific Satiety**

Interactions between eaten and uneaten foods may take place not only because of similarities in sensory properties, but also because of similar macronutrient content. If the need for particular nutrients is an important factor in the hedonic response to foods, this type of interaction would be expected. There has been little work on the role of different macronutrients in the specificity of satiety or in changing hedonic response to foods. Ingestion of peanut oil does not modify the perception of other alimentary odors and tastes,<sup>24</sup> whereas proteins do so moderately.<sup>25,26</sup> Carbohydrates were found to produce the biggest changes in food-related tastes and smells.<sup>26</sup>

To determine the role of different macronutrients in the changing hedonic responses to foods, we offered subjects equicaloric amounts of foods high in one macronutrient and low in other major nutrients.<sup>19</sup> To test for interactions due to similarities in composition, each test food was paired with a food (tasted but not eaten) that was similar in nutrient composition but had different sensory properties. As expected, the largest change in the pleasantness of the taste occurred with the food eaten in the test meal. There was no significant difference among changes between uneaten food with the same composition as that eaten and foods with different nutrient composition.

All of the uneaten foods showed little change in palatability following the test meals. When a varied meal was offered 2 hours after these preloads, the type of nutrient in the load did not affect the proportions of nutrients selected. Thus, these data do not support the hypothesis that hedonic changes are due to the nutrient composition of the foods. Furthermore, there were no significant differences in the magnitude of the changes following the different nutrients. Therefore, the results do not support the earlier suggestion that some nutrients are more effective than others in modifying the hedonic response to foods.

### **Variety and Food Intake**

If satiety is specific to particular properties of foods, then more should be consumed during a meal if a variety of foods are available instead of just one food. Variety in a meal can increase energy intake. Although varying just one sensory property of the foods can enhance intake, the more different the foods are, the greater the enhancement will be.<sup>18,27-31</sup>

Variations in the flavor of food can enhance intake. Successive courses of cream cheese sandwiches with very distinctive flavors (salt, curry, and combined lemon and saccharin) enhanced intake by 15 percent compared to another test when subjects were offered only the favorite flavor. It is perhaps critical that the sandwiches were basically of different tastes since no enhancement was seen with three different flavors of yogurts or with three different flavors of chocolates when the other sensory properties of these foods such as texture and appearance were the same. The lack of effect could have been because all the foods were sweet and of the same type.<sup>30</sup>

Variations in the shape of the food, affecting both the appearance and mouth feel, can also affect intake. Intake was enhanced by 14 percent with successive courses of three different shapes of pasta compared with successive presentation of the favorite shape. When just the appearance of a food was different, as in a test in which children were offered different colored candies, neither the successive or simultaneous presentation of the variety of colors enhanced intake.<sup>30</sup>

Thus, when just the flavor or shape of foods

was varied, the enhancement of intake was around 15 percent over three successive courses. When more properties of the foods differed, the enhancement was greater. When four successive courses of sandwiches with very different fillings were offered, intake was about one third more than when the same filling was consumed throughout.<sup>31</sup> Even though the sandwiches differed in appearance, texture, smell, flavor, and nutritional composition, they were still the same type of food, ie, sandwiches. An even greater enhancement of intake was seen when four successive courses of very different foods were presented.<sup>18</sup> In a four-course meal of sausages, bread and butter, chocolate dessert, and bananas, intake was 60 percent more than the mean of the intakes when just one of the foods was presented. These foods differed in basic type, nutrient composition, appearance, smell, texture, and taste. Thus it is clear that the greater the differences between foods, the greater the enhancement of intake. The results indicate that if the purpose of a meal is to maximize food intake, the available foods should vary along as many dimensions as possible. On the other hand, if intake is to be kept low, the foods should be similar.

Several studies indicate that intake is enhanced by variety because of sensory-specific satiety. During meals of different foods in successive courses, it has been found that the pleasantness of the taste of the foods not eaten declined little even when two or three courses had already been consumed.<sup>18</sup> However, after the food was eaten, it became less pleasant. These specific changes in the pleasantness of foods appear to be related to how much of a food is eaten subsequently. For example, if a food was eaten in a previous course and became less pleasant, then little of it was eaten in the next course. In contrast, if a food had not been eaten in a previous course, then relatively more of it was eaten in the next course. The correlation between pleasantness changes and the amount eaten was significant.<sup>17,18</sup> These findings are consistent with the view that one way in which food intake is controlled is by a reduction in its pleasantness as eating takes place. It should be emphasized that sensory-specific satiety does not operate

in isolation to affect food intake and selection. During the course of normal eating the hedonic responses to foods will interplay with the complex environmental and physiological influences on intake so that in some situations the palatability of foods may be the major influence on intake, while in others it may have little impact.

### **Monotony in the Diet**

Up to this point we have been considering hedonic responses to foods during a meal and for several hours after a meal. Let us look beyond daily consumption and consider changes in food preference that can develop over longer periods. People tire of particular foods and this, of course, means that they stop eating them. There is little understanding of why the preference for particular foods declines over time, but one obvious possibility is that eating a food too often can affect acceptance. Studies of the effects of consumption of monotonous army rations indicate that repeated presentation of some foods can lead to a very persistent decrease in the pleasantness of these foods. For example, with repeated consumption canned meats became very unpalatable and continued to be disliked for 3 to 6 months after the study. Canned meats were not rated as very palatable at the start of the study, and the effects of repeated consumption appear to be different for staple foods and foods of initial high palatability. For example, in the army studies repeated consumption did not change the palatability of desserts, sweets, canned fruits, cereal, or staples such as dairy products, bread, or coffee.<sup>32,33</sup> We also found no decline in the rating of pleasantness of the taste, appearance, texture, or smell or either a confectionery or a savory corn snack after they had been eaten every day for 3 weeks.

Moskowitz<sup>34</sup> has described time preference curves for different food types. These indicate that foods not consumed for about 3 months are highly desired, but those eaten the day before may not be desired at all. Foods such as meat and shellfish, foods with a heavy fat content, or foods that carry the meal such as the entree have steep curves and are greatly desired if not eaten for a very long period, but recent consumption eliminates the desire for

such foods. Items that do not carry the meal and do not have a high fat or protein content such as bread, salad, potatoes, and some desserts have a much flatter function and can be eaten every day with no loss of preference.

A recent study<sup>35</sup> of food preference of Ethiopian refugees illustrates the importance of understanding the effects of monotony on food intake. The refugees reported that the taste of the three foods that they had been eating for approximately 6 months was less pleasant than that of three new foods. Refugees who had been eating the usual diet for only 2 days found its taste as pleasant as that of the new foods. The monotonous diet affected the refugees in that they would often trade the staple diet for small quantities of less nutritious foods, and they would stop preparing the monotonous foods adequately. This effect could possibly have been overcome by the simple expedient of adding spices to vary the flavor, as is the practice when people subsist on diets consisting primarily of one food such as rice.

It appears that decreases in palatability can extend beyond a meal to affect general acceptability of some foods. It seems unlikely, however, that this is the same phenomenon as sensory-specific satiety. Sensory-specific satiety occurs rapidly after eating, and tends to be fairly short-term. The food industry refers to decreases in acceptance of foods in the long term as "wear-out." It seems likely that wear-out is partly due to cognitive satiety. That is, a person knows a lot of a particular food has been consumed and desires a change. It is possible that eating too much of a food or being forced to eat a food can contribute to cognitive satiety. Supporting this cognitive hypothesis is the finding that, in a study of factors affecting food monotony, self-selection of the items to be included in a repetitive diet reduced dissatisfaction with the diet. Thus overall satisfaction with a 3-day, self-planned menu cycle was the same as with a 6-day cycle chosen by someone else.<sup>36</sup> Making people eat foods that they have not selected themselves can decrease the preference for those foods. This is supported by studies of young children, in which foods they were forced to eat to gain rewards decreased in preference.<sup>37</sup> Clearly, much more work is needed to understand what

makes foods change in desirability.

### **Variety, Monotony, and Body Weight**

Body weight maintenance may depend to some extent on the availability of a varied and palatable diet. In studies of the effects of consumption of a monotonous liquid diet, it was found that both obese and normal-weight individuals voluntarily restricted intake and lost weight.<sup>38,39</sup> There is also some evidence that if freely available diets are varied and palatable there may be excessive weight gain. In studies of caloric regulation in obese and normal-weight subjects confined to the hospital, a plentiful and varied supply of food led to overeating and weight gain over 3- to 6-day periods.<sup>40,41</sup>

It is difficult to conduct long-term controlled studies of the effects of variety and palatability on human body weight. It is therefore worth considering the literature on animals. In recent years there have been several reports of obesity in rats given free access to a variety of palatable, high-energy foods.<sup>42,43</sup> In most of these studies the obesity could have been due to the high palatability and high energy content of the foods as well as their varied sensory properties. However, in one study the effect of variety per se was examined by using foods of similar energy density which were eaten in similar amounts in pilot studies (ie, they appeared to be of similar palatabilities).<sup>44</sup> Rats were offered either laboratory chow alone, chow plus one palatable food, or chow plus three palatable foods (cookies, crackers, chocolate) in succession (changed every 12 hours), or simultaneously, for 7 weeks. All rats offered the palatable foods ate more than the chow-fed controls. Rats given the simultaneous but not the successive variety ate more than the other palatable food groups and had significantly greater body weight gains and more body fat at the end of the 7 weeks. Thus the effect of variety on food intake can extend beyond a single meal and can contribute to the development of obesity. It seems likely that, in affluent societies where there is continual appetite stimulation by both successive and simultaneous variety within and between meals, there will be little opportunity to compensate for overeating due to variety without conscious limitation of intake.

## **Mechanisms of Sensory-specific Satiety**

Is the decrease in the palatability of foods that accompanies consumption simply because of sensory adaptation or habituation? In other words, does the perceived intensity of foods decrease with consumption? In a study conducted by Mower et al on the effect of a meal on olfactory stimuli, decreases were found in the pleasantness of the odors, but there were no changes in the perceived intensity of the stimuli.<sup>45</sup> In another study it was found that the decrease in the pleasantness of the taste of particular foods was associated with only minor changes in the intensity of the taste of those foods.<sup>46</sup> It would not be adaptive to have food consumption lead to a decreased ability to taste foods. Indeed, we all know that we can still taste and smell foods after they have been consumed. It is more likely that sensory-specific satiety involves a change in a mechanism concerned particularly with the reward or hedonic value of food.

Electrophysiological studies of brain cells in monkeys are clarifying the mechanisms of sensory-specific satiety. The electrical activity of single cells has been recorded while monkeys ate particular foods to satiety. When recordings were made in areas of the brain concerned with the sensory analysis of taste stimuli (the nucleus tractus solitarius and the opercular cortex) or visual stimuli (the inferior visual temporal cortex and the amygdala), satiety had no effect on the responses of the cells.<sup>47,48</sup> This finding is in marked contrast to the effects of consumption on cells in the lateral hypothalamus, an area of the brain involved in the control of motivational state and reward.<sup>48</sup> It was found that when a monkey was hungry, cells in the lateral hypothalamus responded to the sight or taste of food, but as it consumed a food the neurons became less responsive to it and acceptance for that food gradually decreased. However, if the monkey was then offered another food, the neuron responded and the monkey then accepted this food. Thus, sensory-specific satiety does not appear to be related to changes in sensory processing of responses to foods, but it is related to brain areas controlling motivation and the reward value of foods.

To further define the neuronal basis of sen-

sory-specific satiety, Rolls and colleagues followed taste processing from the primary (opercular) taste cortex into a secondary gustatory area in the caudolateral orbitofrontal cortex, which in turn has connections to the lateral hypothalamus.<sup>49</sup> Sensory-specific satiety is paralleled by the responses of single neurons in this caudolateral orbitofrontal cortex taste area. A neurophysiological basis for this, in terms of altering responsiveness of specifically tuned neurons in this area of gustatory cortex as a food is eaten, has been proposed.<sup>49</sup>

It is likely that cognitions contribute to sensory-specific satiety. People seem to learn how much of a particular food they can eat in a meal.<sup>50</sup> It may be that when this limit is exceeded, food becomes unpleasant. Learning about the caloric value of foods and appropriate amounts for consumption depends on the sensory properties of the foods. Since cognitions about foods depend on sensory properties of foods, it will be difficult to determine whether sensory-specific satiety and cognitive satiety are distinct phenomena.

## **Conclusion**

During consumption of a food the pleasantness of its taste, appearance, smell, and texture decrease. The pleasantness of other foods not consumed decreases much less or remains unchanged. Such responses to foods occur very rapidly, within 2 minutes after a meal, and appear to depend more on the sensory properties of foods than the caloric content, hence the term "sensory-specific satiety." Sensory-specific satiety helps to ensure the consumption of a varied, and therefore balanced, diet. Thus, when a variety of foods is available, there will be a tendency to switch from one food to another because of the decrease in palatability in any one food after consumption.

Sensory-specific satiety can also affect the amount of food consumed in a meal, so that the more varied a meal, the greater the intake will be. Since sensory-specific satiety is one of many factors controlling food intake and selection, its influence depends on the context in which eating takes place. An understanding of factors that affect the hedonic response to foods is important, for this response potentially

influences both appetite and the acceptability of foods. □

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