As we have seen, the physical texture of food first depends on whether it is based on raw ingredients that have retained some of the structure of their biological origins, whether assembled from different pure components—such as mixtures of oil, water, and extracts—or totally synthetic. Second, structure is a function of how it is processed in the kitchen or the factory. Finally, changes take place once the food is in our mouth, resulting either from chewing, a mechanical operation with the help of teeth, jaws, and tongue, or from chemical or chemical-physical changes due to saliva and temperature. Experiencing these changes often depends on how quickly we work on the food in our mouth.

These changes all affect how mouthfeel influences our judgment of the food’s quality. To understand the meaning of its texture, it might be useful first to take a look at the mechanical aspects of eating.

When We Chew, We Are Using the “Taste Muscles”

The muscles of the tongue and the jaws have developed to carry out a whole range of mechanical processes in the mouth. First, the incisors grasp the food firmly and cut off a piece, then the canines hold it in place, and finally the molars get to work crushing and grinding it so that taste and aroma substances are released and the food is in small enough particles to be swallowed together with some saliva. While this is happening, the tongue has to be able to carry out acrobatic movements to explore the food, turn it over, and swirl it around, especially if a liquid is involved, place it between the teeth, and finally search out bits that have gotten stuck between the teeth and the lips or cheeks. Chewing serves both to reduce the food into small pieces and to bind these together with saliva to form a ball of food (bolus) that is easy to swallow.

When we can tell from its mouthfeel that the food has been chewed sufficiently, the tongue takes over from the teeth and makes the definitive maneuver that pushes the ball of food back toward the pharynx. Here the most complicated and well-coordinated process is needed to ensure that the food
goes down into the gullet without ending up in the trachea. What happens quite automatically during swallowing is that we close our mouth, which triggers exhaling, and the last shot of the aroma substances enter the nose via the retronasal pathway. Throughout this mechanical process, which is controlled by the “taste muscles,” all senses are going full blast, not least that of mouthfeel.

Taking hold of, and biting, the food with the incisors and the canines is a symmetrical process. Surprisingly, the actual chewing of the food, which happens rhythmically between the molars, is asymmetric. We chew on one side, while balancing with the other, all while the tongue is moving the food around to be worked on by the chewing side and there is a sideways movement of the lower jaw. One of the several advantages of asymmetrical chewing is that it permits more force to be brought to bear on the food.

Initial preparation of the ingredients before they are consumed, for example, cutting them into small pieces or heating them, makes them easier to chew, less effort is required, and more nutritious substances are released. At the same time, salivary enzymes get to work to break down the molecules in the food, even before it is swallowed. The end result is less mechanical work.

As tough as leather

Fruit leather is plastic, in the physical sense, and so tough that it is easiest to cut it up using scissors. It is made from fruit purée cooked with a large quantity of sugar. The puree is spread on parchment paper in a pan to form a layer that is a little less than ¼ inch (6 mm) thick and then dried at about 122°F (50°C) for 10 hours, or until it is solid. The fruit leather has a very intense fruit taste, and it is difficult to find a food that is tougher to chew.

The stress-strain curve for a piece of food. When only a small force is applied to the food, the relationship between the force applied (stress) and the deformation (strain) is linear. If the force is increased considerably, the food will start to yield and will not return to its original form, even if the stress stops. When even more force is applied, the food will fracture and break up into pieces.
The texture that is detected by our teeth can largely depend on how uniform the structure of the food is, especially if there is a difference between the surface and the inner structure. Imagine a confection made up of a soft cream filling sandwiched between two chocolate wafers. When you first bite into it, it feels hard because the teeth have difficulty in breaking through the hard chocolate, even though the soft filling easily gives way. Then, imagine the reverse—a chocolate wafer between two layers of firm cream filling or foam. It is easy for the teeth to bite into the soft layer and the whole confection will feel soft, even after you have bitten into the chocolate wafer.
What Is Texture?

Over the course of the years, the way in which food texture has been described has undergone many changes. To add to the confusion, the expressions texture and structure have been used almost interchangeably. Polish-born American food scientist Alina Surmacka Szczesniak is known as a pioneer in the study of texture and how it affects our choice of what to eat. She has tried to define texture, and concomitantly, mouthfeel as:

- A sensory quality of food, and consequently, a quality that only a human (or another living being) can recognize and describe. Only certain properties of texture can be measured by physical means and the results of these measurements require a sensory interpretation.
- A multifaceted quality that cannot be described by a single parameter, such as hard or creamy.
- A quality that depends on the structure of the food at all levels, from the molecular to the microscopic.
- A quality that is recognized by several senses, of which touch and pressure are the most important.

This definition has gained wide acceptance. The most authoritative work on texture, *Food Texture and Viscosity*, by Malcolm Bourne, has condensed the definition: “The textural properties of a food are that group of physical characteristics that arise from the structural elements of the food, are sensed primarily by the feeling of touch, are related to the deformation, disintegration, and flow of the food under a force, and are measured objectively by functions of mass, time, and distance.”

In accordance with this definition, we really ought to say “textural elements” to acknowledge that texture is a group of sensory properties. For the sake of simplicity, however, we will continue to use the word “texture” or “mouthfeel” in this book. In what follows we will examine the many different parameters that are involved in the description of texture. It will become evident that there is a wide range of textures and, similarly, that we use a large number of expressions to describe them.

What has made it so difficult to define texture and, along with it, mouthfeel is that some textural elements have measurable physical dimensions, whereas others take on meaning only in connection with human sensory impressions and perceptions of the structure of the food. Consequently, it is difficult to correlate the texture as it is experienced with physical properties that have been measured. About fifty years ago, food chemist H. G. Müller suggested that we should discard the term “texture” and instead refer to rheology, a branch of
physics concerned with the flow properties of a material, and haptahaesthesia, a branch of psychology that deals with the perception of the mechanical behavior of materials. The term “haptic” is now used mostly by sensory scientists to describe how we feel raw ingredients and the surface structure of food.

So Many Words for Texture and Mouthfeel

Some countries and cultures have a large number of words to describe texture and mouthfeel, while others have relatively few. It is hard to come up with a definite number, because words may have more than one meaning. Surveys have shown that the language with the richest vocabulary for texture is Japanese, with 406 discrete terms. In Austria, 105 words are used; in the United States, there were only 78. Despite these huge differences, there is a certain number that are common across many languages, which demonstrates that texture is an important concept in all parts of the world.

Swedish food researcher Birger Drake pointed this out in 1989; by studying twenty-two languages, he had found fifty-four words for textural elements that had an identical meaning. These words fall into six broad categories: viscous, plastic, elastic, compressible, cohesive, and adhesive.

The most frequently used word regarding texture, in the United States and in many European countries, is “crisp.” In Japan, the word that occurs most often is “hard.” “Crisp,” “juicy,” “soft,” “creamy,” “crunchy,” and “hard” are among the terms for texture most commonly used in the United States, Austria, and Japan.

The Importance of Texture

Experiments have shown that for a large range of raw ingredients that have been pureed, only about 40 percent of a group of younger, blindfolded test...
subjects were able to identify correctly the raw ingredient. In the case of older test subjects, the success rate fell to about 30 percent. There is a vast difference in the extent to which some of the ingredients were identified. For example, more than 80 percent of the younger test subjects were able to pick out pureed apples, strawberries, and fish, while the comparable numbers are 40 percent for beef, 8 percent for cucumber, and 4 percent for cabbage.

There are a number of socially driven and gender-related differences with respect to the weight placed on mouthfeel. It appears that well-educated, wealthy people, especially the women in that category, place the most emphasis on mouthfeel.

When customers complain about products available in a grocery store or at the market or when diners in a restaurant express dissatisfaction with a dish, it can almost always be traced back to mouthfeel. We seldom complain that something tastes bad. Instead we might say that the soufflé has collapsed, the meat is too tough, the French fries have gone soggy, the bread is dry, the coffee is tepid, the mustard lacks bite, and so on. Or we simply say that it is insipid. It is much easier to describe an unfulfilled expectation related to texture than one that concerns chemical sensations, such as taste and aroma. In addition, texture is often associated with the freshness of the raw ingredients and their proper preparation.

Food Reviewers and Mouthfeel

Dan Jurafsky, a professor of linguistics and computer science at Stanford University, is an exponent of a new discipline known as computational gastronomy. Using computer applications, he mines the big data available on the Internet to extract information about food, recipes, and people’s eating habits. In one part of his book, *The Language of Food: A Linguist Reads the Menu*, Jurafsky describes the results of an analysis of a million online restaurant reviews, including those related to desserts.

It strikes one right away that the reviewers’ descriptions of the desserts are full of expressions that can be interpreted as having thinly veiled sexual connotations. This connection is made most strongly in the focus on mouthfeel, rather than those for aroma, taste, sound, or appearance. Some typical sensuously laden words that appear frequently include “silky,” “satin,” “juicy,” “wet,” “creamy,” “sticky,” “smooth,” “oozing,” “spongy,” “melting,” and “hot.”
AN EXPERIMENT: CAN YOU IDENTIFY PUREED FOOD?

There is a whole range of experiments designed to determine how easily people, when blindfolded, can identify, by taste alone, a food that has been pureed and then sieved. Young people in the normal weight range can generally identify only about 41 percent of the various foods; those who are overweight have better results, distinguishing 50 percent correctly. But older people in the normal weight range name the purees with only about 30 percent accuracy. The variations between different types of foods is enormous: about 80 percent of young people in the normal weight range can identify apples and fish, about 50 percent can identify carrots and lemons, and about 20 percent can identify rice and potatoes. But only 4 percent can identify lamb and cabbage. This last finding is especially surprising, as most people associate cabbage with a very characteristic taste.

You can easily perform a similar experiment with various juices to show the importance of texture for identifying a particular food.

Make five different jellies using five different raw ingredients, plus one with only pure water for comparison purposes.

Six Types of Jelly with Vegetables, Fruit, and Water

- Prepare a juice from each of the five different raw ingredients, so as to produce ½ cup (125 ml) of each juice. Separately measure out ½ cup (125 ml) of pure water.
- Add ⅛ teaspoon (0.6 g) of gellan gum to each juice and to the pure water and add the same color of food coloring to all. Bring each liquid to a boil and allow it to simmer for 2 minutes. Whip lightly, pour the warm liquid into a mold, and chill it. When they are cold and set, cut the jellies into small squares and serve with toothpicks.
- Now, try to determine whether you can identify, by taste alone, the raw ingredient from which each jelly is made. You might also repeat the experiment with different colors.

| Carrots       | Black kale     | Strawberries   | Beets        | Ginger     | Water       | ⅛ teaspoon (3.6 g) gel-   |
|---------------|----------------|----------------|--------------|------------|-------------| lan gum or agar          |
| Food coloring |                |                |              |            |             |                           |

Red jellies made from (clockwise from top left) water, carrots, black kale, strawberries, beets, and ginger.
Jurafsky also notes that female reviewers are more likely than male ones to mention the dessert menu, usually casting it in a positive light.

According to Jurafsky, the choice of words that relate to desserts in these reviews is in line with the typical vocabulary found in American advertisements. “Soft,” “sticky,” “creamy,” and “dripping wet” all emphasize the hedonistic element of the food.

### How to Describe Texture

What follows is a schematic overview of the various expressions used to describe texture and mouthfeel based on Alina Surmacka Szczesniak’s classification of texture. The table on the left illustrates the relationship between the physical and the sensory aspects of texture classification. With the help of examples, we will later describe how we determine the different properties of texture, as well as how we can enhance them and possibly alter them. The classification of the descriptions of texture is made more difficult by the fact that they often depend on whether they apply to a solid/semisolid or a liquid food. And as the borders between these phases are often blurred, these expressions may have more than one meaning.

#### Solid and Semisolid Foods

In the table to the left, the classification of the texture of solid or semisolid foods is divided according to mechanical, geometrical, and other parameters, as well as how it can be described in terms of the most frequently used popular expressions for texture.

#### Hardness

“Hardness” is a physical expression for the amount of force that must be applied to a material in order to deform it in a particular way. The harder the material, the more pressure is required. In sensory terms, “hardness” is an expression for the force that is required to compress solid food between the molar teeth or softer food between the tongue and the palate. “Softness” is the opposite and describes food that is easy to compress.

The meanings of the words “crisp,” “crunchy,” and “crackly” are difficult to define, and they are often used arbitrarily with regard to many different types.

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**Classification of the Textural Properties of Solid Food**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Popular expressions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mechanical</strong></td>
<td>Soft, firm, hard</td>
</tr>
<tr>
<td>Hardness</td>
<td>Crunchy, brittle, tender, tough, mealy, pasty, gummy</td>
</tr>
<tr>
<td>Cohesiveness</td>
<td>Thin, thick</td>
</tr>
<tr>
<td>Viscosity</td>
<td>Plastic, elastic</td>
</tr>
<tr>
<td>Springiness</td>
<td>Sticky, gooey</td>
</tr>
<tr>
<td><strong>Geometrical</strong></td>
<td>Grainy, coarse, fine, grating, sandy</td>
</tr>
<tr>
<td>Particle size</td>
<td>Fibrous, stringy</td>
</tr>
<tr>
<td>Spatial orientation of particles</td>
<td>Crystalline</td>
</tr>
<tr>
<td><strong>Other</strong></td>
<td>Dry, wet, watery, moist</td>
</tr>
<tr>
<td>Content</td>
<td>Oily, fatty, greasy</td>
</tr>
<tr>
<td>Fat content</td>
<td>Dry, wet, watery, moist</td>
</tr>
</tbody>
</table>

WHY ARE APPLES CRISP?

Unripe apples are normally firm and hard because their pectin is in a particular form, known as propectin. As the apple ripens, the propectin is converted into the water-soluble pectin by an enzymatic process of hydrolysis, caused by the presence of pectinase. The pectin binds together very firmly the cells of the apple, which have stiff cell walls, by forming a gel. Consequently, the apples stay firm until they ripen, but are now crisp instead of hard. About 25 percent of the volume of apples is air, which is evenly distributed throughout the cells and which also contributes to their crispness. By way of comparison, the air content of pears is only about 5 percent. Because they are crisp, apples initially resist the pressure exerted by teeth, but give way after sufficient force is applied and fracture as their juice spurts or seeps out of the burst cells. It is the mouth-feel of resistance to being broken up together with the release of juices that leads us to characterize an apple as crisp and juicy.

The pectin content of apples is greatest when they are fully ripe. When they are overripe, the pectin degrades into pectic acid that cannot form gels.

As the apples become more and more overripe, the decreasing amount of pectin has difficulty in holding the cells together, the air content forms large pockets, and the cells slide past one another more readily when we bite into the apple. It will feel soft. Because the cells do not break apart easily, but are simply displaced, when we bite into the apple, it will no longer feel juicy, but dry and mealy instead, even though the apple has lost none of its liquid content.

When we bake ripe or overripe apples whole and with their skin on we need to note that the large air pockets in them can expand suddenly with great force and may burst the skin.

of food. This is an indication that our perception of the hardness of a particular material links and mixes together tactile, visual, and auditive sensory impressions.

Terms of crispness are applied to thin yet hard ingredients (e.g., potato chips, bread crusts, and roasted seeds) as well as to a porous, hard material (e.g., a meringue). “Crisp,” “crunchy,” and “crackly” are often used randomly
for both dry and brittle foods (e.g., potato chips, toast, cookies, and breakfast cereals), for materials that are either wet or dry (e.g., raw or lightly steamed vegetables, and raw fruits, such as apples and pears), and for materials that are harder on the outside than on the inside (e.g., crusty bread, French fries, pies, and quiches).

**Cohesiveness**

“Cohesiveness” is a physical expression for the cohesive forces in a material and, hence, the extent to which it can be deformed before it breaks. In sensory terms, the cohesiveness of a food means how much it must be compressed before it goes to pieces. Some types of cohesiveness are described as “tough” or “gummy.” “Leathery” is applied to food that is both gummy and very tough. “Tender” is used to characterize food that has little resistance to being chewed into pieces. “Firm” denotes food that is able to withstand chewing to a moderate degree. “Crunchy” is used when the food can be broken down into smaller pieces a little at a time, such as a cookie, and the pieces have less resistance with each successive bit of chewing. “Crunchy” and “crisp” are often used interchangeably.

“Tough” is a physical term related to the energy required to chew a piece of food before it can be swallowed. It is not possible to separate toughness from hardness and springiness. In sensory terms, toughness relates to the time required to chew a given piece of food at a constant rate.

“Gummy” is a physical term related to the energy required to chew a solid piece of food into small pieces. Gummy foods are not very hard, but have a great deal of cohesiveness. In sensory terms, gumminess characterizes the resistance of a pliable food to being reduced to smaller pieces. Hence, it relates to the amount of time required to chew a piece of food before it is reduced to pieces that are small enough to swallow.

**Viscosity**

“Viscosity” is a physical expression for the internal rubbing of the molecules against one another in a liquid that is flowing; that is to say, it is a statement about the material’s rheological properties. Another way to define viscosity is by the tendency of a liquid to resist flowing when a shearing force is applied to it. The viscosity of a food cannot be dissociated from its texture and mouthfeel. It may seem a little odd to talk about flow in materials other than liquids, but for the vast majority of foods there is no clear boundary between liquid and solid. This condition stems from the fact that raw ingredients and foods are mostly composed of soft materials
that can have characteristics of both, depending on how quickly force is applied to them externally. And, naturally, mouthfeel is always bound up with subjecting food to the movements of the mouth, tongue, and teeth. For example, when we draw liquid from a spoon into our mouth, we notice a major difference between water and honey.

That viscosity on its own is not sufficient to describe the mouthfeel of a foodstuff can be illustrated by comparing crème fraîche and Greek yogurt, which are virtually equally viscous but have a different mouthfeel. The viscosity of a liquid can sometimes behave in a curious way—for example, ketchup, which is thickened with complex carbohydrates (xanthan gum), will have less viscosity when it is shaken and subjected to large forces.

### Springiness

“Springiness” is a physical expression for the speed with which a material that has been deformed returns to its original shape when the force is removed. In sensory terms, “springiness” refers to how quickly the food returns to its original shape after pressure, for example, from the tongue, has stopped.

### Adhesiveness

“Adhesiveness” is a physical expression for how well a material sticks to another or, conversely, how easily one material can be pulled from another to which it is sticking. In sensory terms, adhesiveness indicates how easy it is to remove food that is sticking to the tongue, teeth, or palate.

### Liquid Foods

The description of the texture of food that is in liquid form is divided into a series of categories. There are a number of typical expressions for texture that are used for foods in each of the categories. Many of these expressions reflect the complexity of the sensory experience and incorporate psychological and physiological factors.

<table>
<thead>
<tr>
<th>Material</th>
<th>Viscosity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whipping cream</td>
<td>0.02</td>
</tr>
<tr>
<td>Raw egg yolk</td>
<td>0.09</td>
</tr>
<tr>
<td>Syrup</td>
<td>0.96</td>
</tr>
<tr>
<td>Crème fraîche</td>
<td>2.9</td>
</tr>
<tr>
<td>Greek yogurt</td>
<td>3.0</td>
</tr>
<tr>
<td>Mayonnaise</td>
<td>12.1</td>
</tr>
<tr>
<td>Honey</td>
<td>18.3</td>
</tr>
<tr>
<td>Nutella</td>
<td>28.1</td>
</tr>
<tr>
<td>Toothpaste</td>
<td>43.8</td>
</tr>
<tr>
<td>Marmite</td>
<td>43.9</td>
</tr>
</tbody>
</table>

Note: Viscosity is expressed in units of Pa × s⁻¹ and is measured at 10 Hz and 25°C.

Drinks that incorporate different textural elements derived from more semisolid food and carbonation, formation of foam, gelation, and temperature differences can display surprising effects—for example, in a special laminar coffee.

**Consistency**

“Consistency” is a poorly defined expression that is used in many different contexts. It is often used as a synonym for “viscosity” and, on other occasions, to describe, in a general way, mouthfeel and all textural characteristics.

**Coating**

Mouth-coating texture is especially noticeable with fatty and oily foods, cream, oils derived from plants, animal fat, butter, margarine, coconut fat, cocoa butter, and rich, creamy cheeses. This texture is brought out to its fullest extent if its melting point is just under the temperature in the mouth.

**Juiciness**

Juiciness is traditionally linked to the ability of a fruit to release liquid when it is chewed, with respect to how quickly it yields to pressure, the amount of juice that flows, and how much it stimulates saliva production. This term is also used to characterize prepared meat that retains a great amount of its juice and liquid fats.

**Creaminess**

Creaminess is a textural characteristic that is hard to define, especially as it involves several of the senses—sight, smell, taste, and mouthfeel are all involved. It is possibly surprising to find sight on this list, but it is easy to demonstrate its effect. For example, a caramel that is matte and light-colored is perceived as being creamier than one that is smooth and dark-colored.

Creaminess is special in that the expression “creamy” is used to characterize many different types of food, yet its hallmark is that both food professionals and untrained tasters are mostly in agreement about whether something is creamy.

### Categories of Expressions of Texture for Liquid Foods

<table>
<thead>
<tr>
<th>Category</th>
<th>Typical expression</th>
</tr>
</thead>
<tbody>
<tr>
<td>Viscosity-related terms</td>
<td>Thick, thin, viscous, consistency</td>
</tr>
<tr>
<td>Feel on soft-tissue surfaces</td>
<td>Smooth, pulpy, creamy</td>
</tr>
<tr>
<td>Carbonation-related</td>
<td>Bubbly, tingly, foamy</td>
</tr>
<tr>
<td>Body-related</td>
<td>Heavy, watery, light</td>
</tr>
<tr>
<td>Chemical effect</td>
<td>Astringent, burning, sharp</td>
</tr>
<tr>
<td>Coating of oral cavity</td>
<td>Mouth-coating, clinging, fatty, oily</td>
</tr>
<tr>
<td>Resistance to tongue movement</td>
<td>Slimy, syrupy, pasty, sticky</td>
</tr>
<tr>
<td>Afterfeel: mouth</td>
<td>Clean, drying, lingering, cleansing</td>
</tr>
<tr>
<td>Aftereffect: physiological</td>
<td>Refreshing, warming, thirst-quenching, filling</td>
</tr>
<tr>
<td>Temperature-related</td>
<td>Cold, hot</td>
</tr>
<tr>
<td>Wetness-related</td>
<td>Wet, dry</td>
</tr>
</tbody>
</table>

Laminar Coffee Shots with Celeriac

Serves 5
1 celeriac

POWDER AND WHIPPING CREAM

- Soak the celeriac seeds for 6 hours.
- Cook the celeriac seeds in water for 30 minutes, then dry them in an oven or dehydrator at 150°F (65°C) for 2 hours.
- Toast the dried celeriac seeds on a dry skillet until they start to release their aroma; then add the instant coffee granules.
- Place the mixture in a spice mill and grind it to a fine powder.
- Whip the cream until it forms soft peaks, then refrigerate.

ICE-COLD, LIGHT, AND AIRY COFFEE WITH MILK AND CARAMEL

- Place a small pot over low heat, sprinkle the cane sugar over the bottom, and allow it to caramelize on low heat.
- Pour ½ cup (50 ml) of the warm espresso into the caramel and turn off the heat. Stir together to make a syrup and set aside to cool.
- Blend the milk with ¼ cup of the espresso. Flavor with three-quarters of the caramel syrup and set aside to cool.
- Chill the mixture by shaking with ice cubes just before serving and strain out the ice cubes.
- Sprinkle the xanthan gum in the milky coffee and blend with a hand mixer until the xanthan gum is completely dissolved. Set aside in the refrigerator.

HOT, DARK, CELERIAC COFFEE

- Peel the celeriac, cut it up into small pieces, and juice them to make ⅔ cup (100 ml) of juice.
- Mix the remaining ⅔ cup (100 ml) of the espresso with the celeriac juice. Add the remaining caramel syrup.
- Just before serving, warm the mixture to 194°F (90°C).

TO SERVE

- Place ¾ inch (2 cm) of the hot celeriac coffee in the bottom of each of five shot glasses. Next, carefully pour 1¼ inches (3 cm) of ice-cold espresso with milk and caramel syrup on top. Top with ¾ inch (2 cm) of whipped cream. Sprinkle the seed mixture on top.
This indicates that the feeling of creaminess is a very basic impression. Another distinctive feature is that, in contrast to other taste sensations, we can never seem to get enough of it.

Creaminess combines viscosity with the way in which the food flows and rubs against the mucous membranes and it is sometimes also described as smooth and velvety, but not as fatty, dry, or rough. Creaminess is also linked to the way and the speed with which the food mixes together with the saliva and the size of the ball of food that this forms. It is not possible to control creaminess in a food simply through viscosity, but increasing this aspect will normally lead to a creamier texture in foods that contain starch. It is probable that, in the

DO YOU LIKE OYSTERS?

Many people regard raw oysters eaten right off the half-shell as the ultimate appetite stimulant. Here the texture is what really counts, even though there are many who will not eat them at all because “they taste too much like the sea” or they have no wish to eat something that is still alive. But the most negative statement made about oysters is that they are slimy, the flesh sticks together, and it is unpleasant to bite into them. The mantles, gills, adductor muscles, and innards of the oysters are all eaten. This is in contrast to scallops, where we usually eat only the large adductor muscle and possibly the firm roe. The scallop has a firm, slightly jellylike, and homogeneous texture, which we associate with a pleasant mouthfeel.

It is not difficult to change the mouthfeel of raw oysters so that they do not feel as slimy, while leaving their fresh taste of the sea intact when we bite into them. The way to do it is to poach them lightly, causing the oysters to contract a little and giving them a firmer surface consistency, but not altering their insides, which are still raw. To poach them, simply drop the oyster flesh into boiling water or poach them whole in their own juices in a warm oven. The latter method preserves as much of their taste as possible.

A very simple way to have the taste of raw oysters in a fish dish, without having to worry about resistance to their texture, is to freeze the raw oyster and then grate it on top of the dish just before it is served.

The Japanese chef Koji Shimomura, owner of the two-star Restaurant Édition Koji Shimomura in Tokyo, has created an oyster dish that plays on different textures. Shimomura-san serves French cuisine, informed and inspired by Japanese techniques and raw ingredients. He is unusual in his decision to collaborate with researchers, especially Dr. Hiroya Kawasaki from the Japanese company Ajinomoto, to find new ways to prepare delicious, healthy food that is consciously based on scientific principles.

Shimomura-san places the poached oysters on a base of oyster cream and a broken gel made from seawater that is thickened with gelatin and seasoned with lemon. On top, he sprinkles a little bit of toasted wild nori, the seaweed that is used to make sushi rolls. The base is creamy, the jelly is soft and elastic, the poached oysters are both firm on the outside and slimy and creamy inside, and the seaweed flakes are crisp. Together they make up a whole symphony of texture.
course of evolution, we have been programmed to enjoy foods that are creamy because this can be an indicator that they may have a significant fat content and are rich in calories.

Most people associate creaminess with the fat content of a food, but this is not necessarily the case. For example, it is possible to make dairy products that have an equally creamy texture even though their fat content varies widely. The taste impression is driven by the way in which the fats spread out over the surfaces in the mouth, especially the tongue, and how the volatile aromatic substances are released from the membranes of the fat molecules. The fat content has to be sufficient, but not excessive, as that will result in a fatty texture instead of a creamy one.
of a creamy one. In the field of neurogastronomy creaminess is regarded as a complex textural property. In addition to the tactile sensing of viscosity, it also encompasses smell, color, and possibly a perception of how the fats are organized in the food in the form of small spheres.

In dairy products, creaminess is associated with the small fat particles found in the milk. As the fats are also where many aroma substances are dissolved, it can be difficult to separate the experience of creaminess from that of taste and smell. In addition, fats have their own taste. It has been suggested that an essential physical component of creaminess is linked to the ability of the small fat particles to slide past one another when the food is moved around in the mouth. This effect has been compared to the function of ball bearings. Reaching the desired degree of creaminess in low-fat dairy products poses a special challenge.

Research has shown that the perception of creaminess in liquids and semi-solid foodstuffs, such as cream cheese, is dominated by tactile elements of their texture, whereas in firmer types of foods, such as yogurt and pudding, it is primarily driven by taste and smell. For this reason, taste and aroma substances that are associated with creaminess, such as vanilla, can enhance the perception of creaminess in puddings. In all cases, we most often associate creaminess with a mouthfeel that both is smooth and has a rich aftertaste.

Finally, it is not possible to separate creaminess from the changes that occur in the mouth when the food is reduced to small pieces. A good drinkable yogurt is experienced as creamy, whereas other liquid foods—for instance, water, lemonade, cranberry juice, and suspensions of powders where one is aware of and feels the individual particles—are not considered creamy.

This description is, to a large extent, idealized and many types of food behave in a much more complex and nonlinear fashion. In some circumstances, the food behaves like an elastic or a plastic solid and under others like a liquid that can flow. This is known as viscoelasticity. When exposed to rapid forces of short duration, a viscoelastic substance will behave like a solid, while when subjected to force slowly and over a long period of time, it will flow or creep like a viscous liquid. Once such a material has started to flow it will not return to its original shape when the force is removed. Viscoelastic behavior is especially common in those materials that are composed of polymers, long-chain molecules that are intertwined with one another. When force is applied quickly, the molecules do not have time to disentangle and the material will behave in elastic fashion. But if the force is applied slowly and over a longer period of time, the molecules are able to slip past one another, the material will flow, and the deformation is permanent. Hydrogels are a good examples of how this works. Complex mixtures of fats, water, and air can also be viscoelastic. In these cases, it is their microstructure that can alter itself irreversibly and
flow when force is applied over a long period of time. Margarine, baked cakes, ice cream, vegetables, fruits, and some cheeses can exhibit viscoelasticity.

Changing Texture

An overarching goal of the culinary arts is to alter the properties of the food so that it fractures when chewed, to the extent that it breaks up into pieces, thereby enhancing its taste and maximizing its nutritional value. The best example is cooking raw ingredients so that they are easier to chew. In the case of both vegetables and meat, the cellular structure in the connective tissue is ruptured but, paradoxically, this is not why they are easier to chew. Cooked vegetables deform more readily when chewed because the cooking process has softened the cellulose in the plant fibers making them less stiff. On the contrary, meat that has been heated becomes stiffer because the connective tissue, collagen, denatures, and it is easier to break it apart. We often say that the meat has become more tender. Naturally, there are some types of meat that have so much connective tissue that the teeth are able to tear it to pieces only with the help of a great deal of force to cause deformations.