FOOD TASTE DESIGN

The taste of McDonald's french fries has long been praised by customers, competitors, and even food critics. James Beard loved McDonald's fries. Their distinctive taste does not stem from the type of potatoes that McDonald's buys, the technology that processes them, or the restaurant equipment that fries them. Other chains buy their french fries from the same large processing companies, use Russet Burbanks, and have similar fryers in their restaurant kitchens. The taste of a fast food fry is largely determined by the cooking oil. For decades, McDonald's cooked its french fries in a mixture of about 7 percent cottonseed oil and 93 percent beef tallow. The mix gave the fries their unique flavor — and more saturated beef fat per ounce than a McDonald's hamburger.

Amid a barrage of criticism over the amount of cholesterol in their fries, McDonald's switched to pure vegetable oil in 1990. The switch presented the company with an enormous challenge: how to make fries that subtly taste like beef without cooking them in tallow. A look at the ingredients now used in the preparation of McDonald's french fries suggests how the problem was solved. At the end of the list is a seemingly innocuous, yet oddly mysterious phrase: "natural flavor." That ingredient helps to explain not only why the fries taste so good, but also why most fast food — indeed, most of the food Americans eat today — tastes the way it does.

Open your refrigerator, your freezer, your kitchen cupboards, and look at the labels on your food. You'll find "natural flavor" or "artificial flavor" in just about every list of ingredients. The similarities between these two broad categories of flavor are far more significant than their differences. Both are man-made additives that give most processed food its taste. The initial purchase of a food item may be driven by its packaging or appearance, but subsequent purchases are determined mainly by its taste. About 90 percent of the money that Americans spend on food is used to buy processed food. But the canning, freezing, and dehydrating techniques used to process food destroy most of its flavor. Since the end of World War II, a vast industry has arisen in the United States to make processed food palatable. Without this flavor industry, today's fast food industry could not exist. The names of the leading American fast food chains and their best-selling menu items have become famous worldwide, embedded in our popular culture. Few people, however, can name the companies that manufacture fast food's taste.

The flavor industry is highly secretive. Its leading companies will not divulge the precise formulas of flavor compounds or the identities of clients. The secrecy is deemed essential for protecting the reputation of beloved brands. The fast food chains, understandably, would like the public to believe that the flavors of their food somehow originate in their restaurant kitchens, not in distant factories run by other firms.

The New Jersey Turnpike runs through the heart of the flavor industry, an industrial corridor dotted with refineries and chemical plants. Internationa] Flavors & Fragrances (IFF), the world's largest flavor company, has a manufacturing facility off Exit 8A in Dayton, New Jersey; Givaudan, the world's second-largest flavor company, has a plant in East Hanover. Haarmann & Reimer, the largest German flavor company (and a subsidiary of the chemist group Bayer) , has a plant in Teterboro, as does Takasago, the largest Japanese flavor company. Flavor Dynamics has a plant in South Plain-field; Frutarom is in North Bergen; Elan Chemical is in Newark. Dozens of companies manufacture flavors in New Jersey industrial parks between Teaneck and South Brunswick. Indeed, the area produces about two-thirds of the flavor additives sold in the United States.
The IFF plant in Dayton is a huge pale blue building with a modern office complex attached to the front. It sits in an industrial park, not far from a BASF plastics factory, a Jolly French Toast factory, and a plant that manufactures Liz Claiborne cosmetics. Dozens of tractor-trailers were parked at the IFF loading dock the afternoon I visited, and a thin cloud of steam floated from the chimney. Before entering the plant, I signed a nondisclosure form, promising not to reveal the brand names of products that contain IFF flavors. The place reminded me of Willy Wonka's chocolate factory. Wonderful smells drifted through the hallways, men and women in neat white lab coats cheerfully went about their work, and hundreds of little glass bottles sat on laboratory tables and shelves. The bottles contained powerful but fragile flavor chemicals, shielded from light by the brown glass and the round plastic caps shut tight. The long chemical names on the little white labels were as mystifying to me as medieval Latin. They were the odd-sounding names of things that would be mixed and poured and turned into new substances, like magic potions.

I was not invited to see the manufacturing areas of the IFF plant, where it was thought I might discover trade secrets. Instead, I toured various laboratories and pilot kitchens, where the flavors of well-established brands are tested or adjusted, and where whole new flavors are created. IFF's snack and savory lab is responsible for the flavor of potato chips, corn chips, breads, crackers, breakfast cereals, and pet food. The confectionery lab devises the flavor for ice cream, cookies, candies, toothpastes, mouthwashes, and antacids. Everywhere I looked, I saw famous, widely advertised products sitting on laboratory desks and tables. The beverage lab is full of brightly colored liquids in clear bottles. It comes up with the flavor for popular soft drinks, sport drinks, bottled teas, and wine coolers, for all-natural juice drinks, organic soy drinks, beers, and malt liquors. In one pilot kitchen I saw a dapper chemist, a middle-aged man with an elegant tie beneath his lab coat, carefully preparing a batch of cookies with white frosting and pink-and-white sprinkles. In another pilot kitchen I saw a pizza oven, a grill, a milk-shake machine, and a French fryer identical to those I'd seen behind the counter at countless fast food restaurants.

In addition to being the world's largest flavor company, IFF manufactures the smell of six of the ten best-selling fine perfumes in the United States. It makes the smell of Estée Lauder's Beautiful, Clin-ique's Happy, Ralph Lauren's Polo, and Calvin Klein's Eternity. It also makes the smell of household products such as deodorant, dishwashing detergent, bath soap, shampoo, furniture polish, and floor wax. All of these aromas are made through the same basic process: the manipulation of volatile chemicals to create a particular smell. The basic science behind the scent of your shaving cream is the same as that governing the flavor of your TV dinner.

The aroma of a food can be responsible for as much as 90 percent of its flavor. Scientists now believe that human beings acquired the sense of taste as a way to avoid being poisoned. Edible plants generally taste sweet; deadly ones, bitter. Taste is supposed to help us differentiate food that's good for us from food that's not. The taste buds on our tongues can detect the presence of half a dozen or so basic tastes, including: sweet, sour, bitter, salty, astringent, and umami (a taste discovered by Japanese researchers, a rich and full sense of deliciousness triggered by amino acids in foods such as shellfish, mushrooms, potatoes, and seaweed). Taste buds offer a relatively limited means of detection, however, compared to the human olfactory system, which can perceive thousands of different chemical aromas. Indeed "flavor" is primarily the smell of gases being released by the chemicals you've just put in your mouth.

The act of drinking, sucking, or chewing a substance releases its volatile gases. They flow out of the mouth and up the nostrils, or up the passageway in the back of the mouth, to a thin layer of nerve cells called the olfactory epithelium, located at the base of the nose, right between the eyes. The brain combines the complex smell signals from the epithelium with the simple taste signals from the tongue, assigns a flavor to what's in your mouth, and decides if it's something you want to eat.

Babies like sweet tastes and reject bitter ones; we know this because scientists have rubbed various flavors inside the mouths of infants and then recorded their facial reactions. A person's food preferences, like his or her personality, are formed during the first few years of life, through a process of socialization. Toddlers can learn to enjoy hot and spicy food, bland health food, or fast food, depending upon what the people around them eat. The human sense of smell is still not fully understood and can be greatly affected by psychological factors and expectations. The color of a food can determine the perception of its taste. The mind filters out the overwhelming majority of chemical aromas that surround us, focusing intently on some, ignoring others. People can grow accustomed to bad smells or good smells; they stop noticing what once seemed overpowering. Aroma and memory are somehow inextricably linked. A smell can suddenly evoke a long-forgotten moment. The flavors of childhood foods seem to leave an indelible mark, and adults often return to them, without always knowing why. These "comfort foods" become a source of pleasure and reassurance, a fact that fast food chains work hard to promote. Childhood memories of Happy Meals can translate into frequent adult visits to McDonald's, like those of the chain's "heavy users," the customers who eat there four or five times a week.

The human craving for flavor has been a largely unacknowledged and unexamined force in history. Royal empires have been built, unexplored lands have been traversed, great religions and philosophies have been forever changed by the spice trade. In 1492 Christopher Columbus set sail to find seasoning.

Today the influence of flavor in the world marketplace is no less decisive. The rise and fall of corporate empires — of soft drink companies, snack food companies, and fast food chains — is frequently determined by how their products taste.

The flavor industry emerged in the mid-nineteenth century, as processed foods began to be manufactured on a large scale. Recognizing the need for flavor additives, the early food processors turned to perfume companies that had years of experience working with essential oils and volatile aromas. The great perfume houses of England, France, and the Netherlands produced many of the first flavor compounds. In the early part of the twentieth century, Germany's powerful chemical industry assumed the technological lead in flavor production. Legend has it that a German scientist discovered methyl anthranilate, one of the first artificial flavors, by accident while mixing chemicals in his laboratory. Suddenly the lab was filled with the sweet smell of grapes. Methyl anthranilate later became the chief flavoring compound of grape Kool-Aid. After World War II, much of the perfume industry shifted from Europe to the United States, settling in New York City near the garment district and the fashion houses. The flavor industry came with it, subsequently moving to New Jersey to gain more plant capacity. Man-made flavor additives were used mainly in baked goods, candies, and sodas until the 1950s, when sales of processed food began to soar. The invention of gas chromatographs and mass spectrometers — machines capable of detecting volatile gases at low levels — vastly increased the number of flavors that could be synthesized. By the mid-1960s the American flavor industry was churning out compounds to supply the taste of Pop Tarts, Bac-Os, Tab, Tang, Filet-O-Fish sandwiches, and literally thousands of other new foods.

The American flavor industry now has annual revenues of about $1.4 billion. Approximately ten thousand new processed food products are introduced every year in the United States. Almost all of them require flavor additives. And about nine out of every ten of these new food products fail. The latest flavor innovations and corporate realignments are heralded in publications such as *Food Chemical News, Food Engineering, Chemical Market Reporter,* and *Food Product Design.* The growth of IFF has mirrored that of the flavor industry as a whole. IFF was formed in 1958, through the merger of two small companies. its annual revenues have grown almost fifteenfold since the early 1970s, and it now has manufacturing facilities in twenty countries.

The quality that people seek most of all in a food, **its** flavor, is usually present in a quantity too infinitesimal to be measured by any traditional culinary terms such as ounces or teaspoons. Today's sophisticated spectrometers, gas chromatographs, and headspace vapor analyzers provide a detailed map of a food's flavor components, detecting chemical aromas in amounts as low as one part per billion. The human nose, however, is still more sensitive than any machine yet invented. A nose can detect aromas present in quantities of a few parts per trillion — an amount equivalent to 0.000000000003 percent. Complex aromas, tike those of coffee or roasted meat, may be composed of volatile gases from nearly a thousand different chemicals. The smell of a strawberry arises from the interaction of at least 350 different chemicals that are present in minute amounts. The chemical that provides the dominant flavor of bell pepper can be tasted in amounts as low as .02 parts per billion; one drop is sufficient to add flavor to five average size swimming pools. The flavor additive usually comes last, or second to last, in a processed food's list of ingredients (chemicals that add color are frequently used in even smaller amounts). As a result, the flavor of a processed food often costs less than its packaging. Soft drinks contain a larger proportion of flavor additives than most products. The flavor in a twelve-ounce can of Coke costs about half a cent.

The Food and Drug Administration does not require flavor companies to disclose the ingredients of their additives, so long as all the chemicals are considered by the agency to be GRAS (Generally Regarded As Safe). This lack of public disclosure enables the companies to maintain the secrecy of their formulas. It also hides the fact that flavor compounds sometimes contain more ingredients than the foods being given their taste. The ubiquitous phrase "artificial strawberry flavor" gives little hint of the chemical wizardry and manufacturing skill that can make a highly processed food taste like a strawberry.

A typical artificial strawberry flavor, like the kind found in a Burger King strawberry milk shake, contains the following ingredients: amyl acetate, amyl butyrate, amyl valerate, anethol, anisyl formate, benzyl acetate, benzyl isobutyrate, butyric acid, cinnamyl isobutytate, cinnamyl valerate, cognac essential oil, diacetyl, dipropyl ketone, ethyl acetate, ethyl amylketone, ethyl butyrate, ethyl cinnamate, ethyl

heptanoate, ethyl heptylate, ethyl lactate, ethyl methylphenylglycidate, ethyl nitrate, ethyl propionate, ethyl valerate, heliotropin, hydroxyphrenyl-2-butanone (10 percent solution in alcohol), α-ionone, isobutyl anthranilate, isobutyl butyrate, lemon essential oil, maltol, 4-methylacetophenone, methyl anthranilate, methyl benzoate, methyl cinnamate, methyl heptine carbonate, methyl naphthyl ketone, methyl salicylate, mint essential oil, neroli essential oil, nerolin, neryl isobutyrate, orris butter, phenethyl alcohol, rose, rum ether, γ-undecalactone, vanillin, and solvent.

Although flavors usually arise from a mixture of many different volatile chemicals, a single compound often supplies the dominant aroma. Smelled alone, that chemical provides an unmistakable sense of the food. Ethyl-2-methyl butyrate, for example, smells just like an apple. Today's highly processed foods offer a blank palette: whatever chemicals you add to them will give them specific tastes. Adding methyl-2-peridylketone makes something taste like popcorn. Adding ethyl-3-hydroxybutanoate makes it taste like marshmallow. The possibilities are now almost limitless. Without affecting the appearance or nutritional value, processed foods could even be made with aroma chemicals such as hexanal (the smell of freshly cut grass) or 3-methyl butanoic acid (the smell of body odor).

The 1960s were the heyday of artificial flavors. The synthetic versions of flavor compounds were not subtle, but they did not need to be, given the nature of most processed food. For the past twenty years food processors have tried hard to use only "natural flavors" in their products. According to the FDA, these must be derived entirely from natural sources — from herbs, spices, fruits, vegetables, beef, chicken, yeast, bark, roots, etc. Consumers prefer to see natural flavors on a label, out of a belief that they are healthier. The distinction between artificial and natural flavors can be somewhat arbitrary and absurd, based more on how the flavor has been made than on what it actually contains. "A natural flavor," says Terry Acree, a professor of food science technology at Cornell University, "is a flavor that's been derived with an out-of-date technology." Natural flavors and artificial flavors sometimes contain exactly the same chemicals, produced through different methods. Amyl acetate, for example, provides the dominant note of banana flavor. When you distill it from bananas with a solvent, amyl acetate is a natural flavor. When you produce it by mixing vinegar with amyl alcohol, adding sulfuric acid as a catalyst, amyl acetate is an artificial flavor. Either way it smells and tastes the same. The phrase "natural flavor" is now listed among the ingredients of everything from Stonyfield Farm Organic Strawberry Yogurt to Taco Bell Hot Taco Sauce.

A natural flavor is not necessarily healthier or purer than an artificial one. When almond flavor (benzaldehyde) is derived from natural sources, such as peach and apricot pits, it contains traces of hydrogen cyanide, a deadly poison. Benzaldehyde derived through a different process — by mixing oil of clove and the banana flavor, amyl acetate — does not contain any cyanide. Nevertheless, it is legally considered an artificial flavor and sells at a much lower price. Natural and artificial flavors are now manufactured at the same chemical plants, places that few people would associate with Mother Nature. Calling any of these flavors "'natural" requires a flexible attitude toward the English language and a fair amount of irony.

The small and elite group of scientists who create most of the flavor in most of the food now consumed in the United States are called "flavorists." They draw upon a number of disciplines in their work: biology, psychology, physiology, and organic chemistry. A flavorist is a chemist with a trained nose and a poetic sensibility. Flavors are created by blending scores of different chemicals in tiny amounts, a process governed by scientific principles but demanding a fair amount of art. In an age when delicate aromas, subtle flavors, and microwave ovens do not easily coexist, the job of the flavorist is to conjure illusions about processed food and, in the words of one flavor company's literature, to ensure "consumer likeability." The flavorists with whom I spoke were charming, cosmopolitan, and ironic. They were also discreet, in keeping with the dictates of their trade. They were the sort of scientist who not only enjoyed fine wine, but could also tell you the chemicals that gave each vintage its unique aroma. One flavorist compared his work to composing music. A well-made flavor compound will have a "top note," followed by a "dry-down," and a "leveling-off", with different chemicals responsible for each stage. The taste of a food can be radically altered by minute changes in the flavoring mix. "A little odor goes a long way," one flavorist said.

In order to give a processed food the proper taste, a flavorist must always consider the food's "mouthfeel" — the unique combination of textures and chemical interactions that affects how the flavor is perceived. The mouthfeel can be adjusted through the use of various fats, gums, starches, emulsifiers, and stabilizers. The

aroma chemicals of a food can be precisely analyzed, but mouthfeel is much harder to measure. How does one quantify a frencb fry's crispness? Food technologists are now conducting basic research in rheology, a branch of physics that examines the flow and deformation of materials. A number of companies sell sophisticated devices that attempt to measure mouthfeel. The Universal TA-XT2 Texture Analyzer, produced by the Texture Technologies Corporation, performs calculations based on data derived from twenty-five separate probes. It is essentially a mechanical mouth. It gauges the most important rheological properties of a food — the bounce, creep, breaking point, density, crunchiness, chewiness, gumminess, lumpiness, rubberiness, springiness, slipperi-ness, smoothness, softness, wetness, juiciness, spreadability, spring-back, and tackiness.

Some of the most important advances in flavor manufacturing are now occurring in the field of biotechnology. Complex flavors are being made through fermentation, enzyme reactions, fungal cultures, and tissue cultures. All of the flavors being created through these methods — including the ones being synthesized by funguses —are considered natural flavors by the FDA. The new enzyme-based processes are responsible for extremely lifelike dairy flavors. One company now offers not just butter flavor, but also fresh creamy butter, cheesy butter, milky butter, savory melted butter, and super-concentrated butter flavor, in liquid or powder form. The development of new fermentation techniques, as well as new techniques for heating mixtures of sugar and amino acids, have led to the creation of much more realistic meat flavors. The McDonald's Corporation will not reveal the exact origin of the natural flavor added to its french fries. In response to inquiries from *Vegetarian journal*, however, McDonald's did acknowledge that its fries derive some of their characteristic flavor from "animal products."