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A Fake of a Different Flavour

In the mid-nineteenth century, very few Americans had ever eaten an actual, physical banana. The fruit was introduced in 1876 during the Philadelphia Centennial, a six-month-long celebration of the 100-year anniversary of the signing of the Declaration of Independence. Held in Philadelphia's extensive Fairmont Park, the Centennial attracted something like 10 million visitors, featured exhibits from 37 countries, and showed off a plethora of novel inventions and technologies. The event was also an opportunity for visitors to try new-fangled, exotic foods and flavours like Heinz tomato ketchup and Hires root beer. And, as history would have it, bananas.

One of the exhibits in the Centennial's Floral Hall showcased a cluster of green, leafy banana trees in a wooden crate from Central America where people could buy a banana for a dime. Although most visitors would have been eating the fruit for the first time, plenty of them would already have known what a banana tasted like – artificial banana flavour had been readily available to consumers for more than a decade.

Before the Centennial, bananas were a luxury food found only in affluent households. However, after the event, the public's demand for bananas skyrocketed in mere decades; bananas quickly became the first fruit to be commercially available year-round. By 1929, bananas comprised 50 per cent of United States imports from Central America. (In 1917, the Fruit Dispatch Company – an arm of the mega-conglomerate United Fruit Company – published a pamphlet for consumers called 'The Food Value of a Banana', which offered pragmatic and

nutritional reasons to eat the fruit. 'Put up and sealed by nature in a germ-proof package.' 'Always in season.' 'Available everywhere.' 'The poor man's food.' 'Endorsed by physicians.') However, the increasing popularity of the fruit did little to diminish the appeal (as it were) of artificial banana flavour.

Thanks to the growing popularity of artificial flavours in the mid-nineteenth century, Americans had come to expect a certain sticky-sweet taste from any banana-flavoured food. Chemists, pharmacists and early flavour tinkerers found that the chemical compound isoamyl acetate could elicit a broadly 'fruity' flavour when it was added to foodstuffs like sweets and puddings. Today, isoamyl acetate is in fact recognised as one of the main banana esters – one of the primary components – that characterises banana flavour. The first formulas for synthetic banana flavouring date to the 1860s, and advertisements for 'fruit essences' that could be used to create flavours – including banana – go back to as early as the 1850s.

By the mid-nineteenth century, American chemical suppliers began to market the isoamyl acetate compound as 'banana flavour' to pharmacists and confectioners who were looking to expand the scope of manufactured flavours; consequently, the sensory association between isoamyl acetate and bananas quickly became entrenched in American consumers. So, when visitors to the Philadelphia Centennial plunked down 10 cents for a banana, they found that the banana tasted like, well, a banana. The fruit, with its high concentration of isoamyl acetate, confirmed to consumers that the artificial banana flavour tasted like the Real Thing. Decades later, when flavourists were able to match specific chemical compounds to specific flavours of foodstuffs, isoamyl acetate was one of the first chemical compounds used in artificial flavour that was confirmed to exist in actual fruit as well.

Today, it's hard to imagine that the sickly-sticky-sweet-synthetic banana flavour of Laffy Taffy sweets has anything to do with real bananas because they taste so different from the fruit. However, today's particular taste discrepancy has more to do with the bananas we consume in the twenty-first century and less to do with the assumption that synthetic banana flavour is a poor approximation of the real fruit.

When bananas became significant imports in the early twentieth century, the Gros Michel banana quickly came to dominate the banana industry. Purportedly from the Caribbean island of Martinique (north-west of Barbados), the Gros Michel was an ideal banana for shipping to international markets, because Gros Michels had a long ripening period, and a thick, leathery peel that ensured that the fruit wouldn't easily bruise; the individual bananas in a Gros Michel bunch also grew very close together, giving exporters the most cost-effective banana to shipping space ratio. Consequently, when someone was talking about a banana in the early twentieth century, they were by default talking about a Gros Michel banana.

However, only one variety of banana at a time is cultivated for the global market, despite there being more than 1,000 varieties of banana around the world. This strategy is efficient, yes, but it's extremely risky. With everything riding on one banana type, that one banana type is very susceptible to disease. Midway through the twentieth century, the Gros Michel banana effectively went extinct, when growers became unable to combat the fungal plagues that wiped out the variety. The Cavendish banana, with its iconic bright yellow skin, replaced the Gros Michel as the mono-cultivated banana crop, and today Cavendishes are the most common bananas in the global banana market. However, due to the way that Cavendishes are cultivated – they're seedless and therefore sterile – they are essentially

clones and highly susceptible to disease, since they have no genetic diversity to fall back on. Today, the Cavendish banana is under threat from disease, and scientists consider that the question of its extinction is not ‘if’ but ‘when’.

But – and this is significant to the story of artificial banana flavour – not all bananas taste the same. The Gros Michel and the Cavendish are in fact very different-tasting varieties of banana. Gros Michels contain more isoamyl acetate compound than Cavendishes, making Gros Michels taste more ‘banana-y’. Consequently, tasting synthetic banana flavour, codified when the Gros Michel was the commercial banana *de jour*, is like tasting a relict banana from the last century. Even though contemporary flavour scientists would be able to more accurately copy the flavour of today’s bananas, consumers expect artificial banana flavour to be what it’s always been.

When the Cavendish banana goes extinct and is replaced by some other banana variety, the cultural perception of banana flavour will evolve yet again. ‘The fake fruit flavors that we encounter in some of the most common frozen treats, and sugary candies, and cheap sodas, kind of take us back to the early days of synthetic flavor,’ flavour historian Nadia Berenstein explains in an online interview with NPR’s *Science Friday* programme. ‘They give us a kind of glimpse into the flavor worlds of the past.’

This consumer-based commitment to what Berenstein calls ‘heirloom synthetic flavors’ offers a reminder that flavour – especially synthetic flavour – is complex and its history even more so. Although ‘natural’ and ‘artificial’ carry specific meanings in the flavour and regulatory industries, finding where natural flavour leaves off and non-natural flavour picks up requires a willingness to believe that the flavour of something can change and evolve.

The story of flavour actually begins with an understanding of taste as well as how people perceive the phenomenon of flavour. How something tastes is part biochemistry, part neurophysiology, and a very large part history and culture.

On a biological level, taste is one of the traditional five human senses, and when taste is combined with smell and cranial nerve stimulation, we experience flavour. The tongue is covered with thousands of bumps called papillae – invisible to the naked eye – and each papilla is filled with hundreds of taste buds. Other taste buds are located on the roof and sides of the mouth, as well as in the throat, and when we put food in our mouths it reacts chemically with the taste receptor cells in our tongues. People with a much higher than average number of papillae on their tongues are known in the world of flavour science as ‘supertasters’; the extra taste receptors make them much more sensitive to nuances of flavours in different foods than non-tasters, those with average taste buds. Taste status – like odour sensitivity – is heritable. (In fact, in the 1930s some scientists advocated using a taste test as a paternity test, although this didn’t really catch on.) In addition to the chemical reactions of taste in papillae, taste also depends on our smell as well as stimulation of the trigeminal nerve (the largest cranial nerve), which in turn processes how food’s texture and temperature register as a sensation within the mouth.

More than 2,300 years ago, the philosopher Aristotle postulated that the two most basic taste sensations were sweet and bitter. This short list of taste categories has expanded in the subsequent millennia to include sweet and sour, bitter and savoury, salty and – although this is still under debate – fat. Recent flavour researchers would also include ‘umami’, which means ‘delicious taste’, first described by the Japanese researcher Kikunae Ikeda at the beginning of the twentieth century. (Umami is generally taken to mean savoury, brothy or meaty.) Other types of

taste sensation include coolness, numbness, metallicness, astringency, pungency, calcium, heartiness and starchiness. Taste research has even shown that temperature plays a key role in determining the taste of a particular flavour.

For decades, flavour experts thought that people tasted sweet at the front of the tongue, bitter at the back and sour at the side, in a pattern called a 'tongue map'. However, recent research has shown that every taste bud is responsive to all five of the basic tastes. The issues – misconceptions – with the tongue map can trace their history back to a mistranslation from German that first appeared in Edwin Boring's 1942 popular psychology textbook. Biochemical research has identified that bitter, sweet and savoury depend on G-protein-coupled receptors – however, the receptor for sour remains unknown and undefined.

Although the same biochemical processes are at work in every person's body, there are several genetically determined differences in what a person tastes and how they perceive certain chemical compounds. For example, for some people cilantro (or coriander) tastes fragrant or citrus-like, while for others it tastes soapy. Some people are able to detect bitterness in foods on a more sensitive scale than others. Something like one in every two people is unable to smell androsterone (a particularly pungent steroid derived from testosterone) and estimates put 35 per cent of the world's population registering androsterone as an incredibly unpleasant smell similar 'boar-taint' flavour. Roughly 1 per cent of the world's population is unable to smell vanilla. In short, for all of the biochemistry that goes into how taste works in the human body, there is an awful lot of genetic variation in just how those taste receptors fire.

Speculation about the role that flavour – taste – has played in human evolutionary history runs rampant. 'Human taste abilities have been shaped, in large part, by

the ecological niches our evolutionary ancestors occupied and by the nutrients they sought,' geneticist Paul Breslin offers in an article about the evolution of food and human taste in *Current Biology*. Some researchers have suggested that parsing flavour was crucial to determine foods that were safe to eat and those that weren't. Plants with poisonous toxins would taste bitter, for example. Rotting meat would have tasted so noxious to our evolutionary ancestors, anthropologist Richard Wrangham argues, that the taste would have served as a deterrent to eating meat before it was properly cooked.

Although poor preservation often stands as a yardstick of meagre culinary hygiene, rotting meat doesn't necessarily indicate a failure of food or taste. Contemporary anthropologists have found numerous instances where fermented and rotted animal foods, like the stomach contents of certain ungulates and birds, are – or at least were until very recent history – dietary staples vital to the success of foraging groups in extreme northern climates. Consequently, archaeologists have begun to speculate that putrid meat and fish may have played a significant role in the culinary history of Europe's Middle Palaeolithic for both Neanderthals and *Homo sapiens*, between 45,000 and 300,000 years ago. (That, dear reader, is a genuinely authentic paleo diet.) Regardless of anything else, it's clear that flavour, cuisine and diet occupy an ever-changing balance in what humans eat and why they eat it.

What is particularly unique, however, to mammalian evolution – and an evolutionary harbinger to flavour – is the mammalian nose, an organ that can detect volatile odours. Although smell does not seem to be as significant in primate evolutionary history as vision, olfaction is the oldest evolutionary part of the sensation of taste. Even the eighteenth-century naturalist Carl Linnaeus, famous for devising a classification system for the world's plants and animals, invented a taxonomy for odours, arguing that all

odours could be categorised as fragrant, spicy, musky, garlicky, goaty, repulsive or nauseating.

Today, flavourists who focus on olfaction suggest that there are four dimensions of smell; namely, fragrant, acid, burnt and goaty. ‘Smell is an involuntary ubiquitous sensation. Waking or sleeping, eyes shut or open, we cannot help but smell with inspiration,’ molecular evolutionary anthropologist Kara Hoover says in an overview of the evolutionary significance of olfaction in the 2010 *Yearbook of Physical Anthropology*. ‘The other senses can be stopped manually (closing the eyes or plugging the ears), but we cannot stop breathing; even mouth-breathing will impart a weak sense of smell.’ While it’s incredibly easy to build up plausible stories about how ‘our flavour sense may have played a large role in making humans into the species we are,’ the significance of flavour to human evolution – and specifically, of flavour preferences, trends and histories – is a very recent branch of evolutionary and flavour research.

Fast forward millions of years in mammalian evolution and we come to researchers studying the neuroscience of flavour, working out how chemical compounds translate into flavour experiences. So taste is about biology, of course. Biochemistry, great. But how the brain – or mind, if you prefer – interprets flavour input is the final component of flavour perception. ‘In other words, it is as much a matter of what is in the *mind* of the person doing the tasting as what is in the *mouth* or on the plate,’ flavour and sensory scientist Charles Spence points out. In *Gastrophysics: The New Science of Eating*, Spence relates a story about star chef Heston Blumenthal who, in the late 1990s, created a crab-flavoured ice cream to accompany his popular crab risotto main dish. The savoury ice cream really worked for Blumenthal as a quirky but savvy complement to the rest of the meal. But a crustacean-flavoured ice cream dessert did not, shall we say, go over well with diners.

Part of the problem, it turns out, was that the ice cream was pinkish-red in colour – a hue that people have come to expect to be associated with sweet, fruity flavours. Blumenthal's diners presumably thought that they were going to taste something sweet, and what they bit into was the complete flavour opposite. 'In other words,' Spence wryly noted, 'they were expecting strawberry and got frozen crab bisque instead!' In a series of experiments, psychologist Martin Yeomans has shown that it is possible to influence a person's perception of liking a frozen pink dessert by simply telling them that it is savoury to begin with – or giving the food a different name. The crab-flavoured ice cream tasted vile, Yeomans' research showed, in large part because it was so completely different from what a person expected the flavour to taste like. If people's expectations of flavour weren't disappointed, then the flavour tasted 'better'.

Likewise, flavour is affected by a food's provenance. It turns out that when people like the story of their food's origin, they are more likely to think that it tastes better. One recent study that Spence cites offered identical samples of meat (like beef jerky or ham) to study participants, telling them that the meat was either factory farmed or free range. Those who were told that their meat was factory farmed 'rated it as tasting less pleasant, saltier and greasier'; they ate less of it, and said that they would be less willing to pay high prices for it. Crucially, this pattern held up throughout three separate studies, including one that found the inverse effect – people who believed that they were eating free-range, organic meats consistently thought that the meat tasted better. In blind taste tests, however, consumers cannot – for the most part – tell the difference. To that end, research has found that oysters taste better with the sound of the seashore playing in the background. 'So what this means in practice is that if you shell out for

some organic, free-range, hand-fed food, you should be sure to let your guests know its provenance if you want them to be able to taste the difference,' Spence quipped.

So, biology, great. Biochemistry, of course. Neuroscience, indisputably. But taste – and flavour – also depends very much on the culture consuming it. Although the perception and expectation of flavour happens on an individual level, culture writ large facilitates our expectations of what we think something 'ought' to taste like. A classic example would be temperature-mediated taste – in the United States, soft drinks 'ought' to taste cold, regardless of season or anything else. And since the culture surrounding the production and consumption of foodstuffs changes, it's not a reach to conclude that flavour changes over time as well.

Since taste changes over time in the ever-evolving nature of a food's flavour, there is often a gap between how food tastes and how people think it ought to taste – particularly for contemporary audiences. Most flavourists and food historians describe this phenomenon as gastronomic nostalgia – a wistfulness for the storied provenance of the food. This is how people long for something to taste authentic, even if they've never had the 'real' or the 'original' flavour.

When people lament that food tastes differently than it did in previous generations, 'people usually mean that fruits, vegetables, bread, beer and meats are not what they once were – not as tasty, not as authentically what they are supposed to be,' historian of science Steven Shapin observed in a formal lecture called 'Changing Tastes', given at Uppsala University in Sweden in 2011. Shapin offered several historical reasons for why flavours have changed over time. New varieties of foodstuff, for example, might not be bred for exactly the same tastes as ones from earlier centuries, or cultures may have lost the art of preparing certain foods in ways that enhance particular flavours.

Some foods – like certain varieties of apples and pork – have effectively disappeared from contemporary food supplies. Other foods have changed what we think they ought to taste like. But these factors don't stop people mourning their loss – or more appropriately mourning what they think has been lost, because so much of flavour and taste have to do with nostalgia more than anything else. 'Gustatory nostalgia is very much on the late modern menu,' Shapin points out.

Culture gives us the surrounding ethos of taste and how it is created, cultivated and considered – culture is how taste is transmitted and how flavours are formalised into everyday expectations.

Flavour has always been guided – engineered – to carry specific messages about taste and status to consumers. For Europe of the late Middle Ages and early modern period – the fourteenth, fifteenth and sixteenth centuries – spices were the most significant factor in shaping food tastes. Over these three centuries, spices were valued commodities in European markets and were the impetus for Europe's maritime expansion. (Say it with me Frank Herbert and *Dune* fans, 'The spice must flow.') The twentieth-century French philosopher Pierre Bourdieu referred to the phenomena as *habitas* – the physical embodiment of cultural capital. Thanks to spices, flavour curried a certain cultural cachet.

But how did these seasoning flavours come to shape European cuisines and economies so decisively? One older, popular opinion holds that spices were used to preserve meat as well to hide the taste of rotting foodstuffs during the period when Europe was struggling to eke its way out of its medieval past. Other food historians argue that Europe's interest in spices lay in the demarcation of social

distinctions – the idea that aristocrats higher up on society’s socioeconomic ladder would be able to buy and ply spices in a way that mere peasants couldn’t. Still other experts suggest that the West learned about spices from Arab cultures during the Crusades, and when crusaders brought the spices back to Europe and, subsequently, to European cooking. Regardless of precisely why, spices became a significant component in the shaping the mid-millennia tastes of European food, proof that flavour could be both altered and directed.

In addition to controlling flavour, spices were used for medical and therapeutic purposes, giving certain foods medicinal distinction as well as being something to simply consume. (For example, according to *Le Thresor de Santé*, a 1607 French compilation of notes about health and medicine, cloves were purportedly good ‘for the eyes, liver, hearth, and stomach’, and pepper ‘facilitates urination ... cures chills from intermittent fevers and heals snake bites’.) Every spice in a medieval kitchen was originally imported for its medicinal qualities, and only later was it employed as a seasoning. Because spices were medicinal, the use of spices – and food they spiced – was also imbued with moralisms about health. Both health and flavour continue to shape how people think their food ought to taste, and also how their food obtains that flavour in the first place; this dualism of health and wellness helps enforce the idea that taste can have a higher moral purpose.

But what if we could shape flavour outside of such traditional methods like agriculture or spices? What if it was possible to synthesise – in a laboratory – flavours that had only ever been found in nature?

Beginning in the nineteenth century, flavour moved from being ‘guided’ to being outright manipulated, copied, replicated and invented. Flavour engineering in

the nineteenth century was a way of mimicking nature, of invoking familiar flavours and tastes, through chemical manipulation of what went into food.

By the turn of the twentieth century, flavour had become something that was copied or replicated from nature, domesticated nature though it might be. Flavour was distilled down to its chemical components, which were then codified into standard flavours that were, in turn, put into foods. With the emergence of foodstuffs that were designed to be produced and consumed on a massive population level – like tinned vegetables – the question of how to take the flavour from one food and effectively put it into another began to underscore flavour science. In the second half of the twentieth century, it wasn't enough to simply replicate nature's flavours – flavourists wanted to engineer flavours that were even better than their natural counterparts or to simply design new ones.

Synthetic flavours – more commonly called artificial flavours – were invented in the late nineteenth century, and were heavily tied to the perfume industry and the chemical research of artificial scents. 'Once an odor is experienced along with a flavor, the two become associated,' *Scientific American* explains of the two closely related sensations, 'thus smell influences taste and taste influences smell'. If you wanted to create artificial flavours, it would make sense to piggyback off research to do with artificial smells.

These new synthetic flavours were not invented to satisfy a pre-existing need, or only as inexpensive substitutes for the 'real thing'. As a result of advances in chemistry, the flavour of bourgeoisie foodstuffs could be distilled, created and infused into processed foods that were produced for long shelf lives and at a scale that could be widely available to the burgeoning middle class of

America. The story of synthetic flavours is one of industrial science, chemistry and mass-consumer economy – the stories of changing tastes.

Early flavour designers depended on the sensory research of perfume chemists and manufacturers of the late nineteenth century. While these scientists were interested in creating artificial smells that mimicked odours in the real world, their counterparts in the flavour world were starting to explore how to apply that chemical knowledge to transforming, enhancing and adding flavours to different foodstuffs. The flavour and perfume industries had long used ‘essential oils’ – made up of parts of a plant that could be distilled, extracted, then infused into something else, like food or fragrance. Archaeological evidence suggests that ancient Persians distilled essential oils as early as 3000 BC, and 2,000 years later Arab civilisations rediscovered and refined the process. The point is that the idea of distilling oil to its most essential building block and infusing it into something else is nothing new. Some of the first examples of an artificially created flavour came from using ‘ethers’, sometimes known in the industry as ‘fruit oils’, and both of these grew out of the tradition of distilling and utilising essential oils.

Combining chemistry with confectionary making was not an uncommon nineteenth-century practice. In 1855, for example, the confectioner Mr Samuel Simes of Philadelphia published an ad for artificially fruit-flavoured sweets made in his store – a four-storey building that took up the north-west corner lot on Chestnut and 12th Streets in Philadelphia. His retail drugstore was also a chemical manufacturing business – the flavours as well as the sweets were produced ‘in house’. The ad boasted that the fruit essences he manufactured ‘expressly for confectioners’ gave sweets ‘the rich and luscious flavours of the different fruits more decidedly than the fruits themselves’.

The synthetic flavours that Simes offered included Pineapple, Strawberry, Raspberry and Jargonelle Pear, as well as Vanilla, Orange and Blackberry. The story of Samuel Simes's synthetic flavours was in keeping with pharmacy flavour-making practices of the 1850s, as supply houses and chemical-supply catalogues began listing 'compound ethers' among their products – sometimes with a descriptive, easily understood 'apple oil' alongside the standard chemical name, like amyl valerate. The fruit smell associated with each flavour came to quickly define each compound scientifically as well as commercially.

Fast-forward six decades from Mr Simes's soda shoppe and we find ourselves with the invention of fake grape flavour. Nadia Berenstein tracked down the origin of today's fake grape flavour to 1910 or 1911, when a maker of flavouring extracts was riding a streetcar in Indianapolis and the scent of Concord grapes wafted from the perfume of a woman sitting next to him. According to Berenstein's archival sources, the flavour extract expert knew immediately that the smell of grape perfume could translate into grape flavour. 'This was important to him because he was a maker of flavoring extracts for bottled sodas and for soda fountains,' Berenstein explained in her *Science Friday* radio interview. 'So, he went through chemical catalogs, and he found the chemical in question, methyl anthranilate.'

Methyl anthranilate was marketed in Germany and Austria as the scent of orange blossoms, not grapes, in a bit of quirky cultural history that brings us back to the question of culture and perceptions of smell and taste. What was marketed as orange blossom scent in one cultural context could smell like grapes in another – and not just any grapes, but Concord grapes. 'I think the reason is that methyl anthranilate is a flavor compound in American grapes, in *Vitis labrusca* grapes, which include Concord grapes,' Berenstein offers. 'And it's not found in European grapes, in

Vitis vinifera grapes. So, the manufacturers of this synthetic compound in Germany and Europe wouldn't have noticed the resemblance with grapes because they were eating a different kind of grape.' Today, our fake grape flavour – codified forever in Americans' Jolly Ranchers and children's cough syrup – is this same chemical compound from the early twentieth century. Thus, the very real Concord grapes taste like fake grape and vice versa, reinforcing how taste and flavour are artefacts of past tastes.

Until the early twentieth century, there were a few, limited chemical compounds like amyl acetate, amyl valerate and butyric ether – pear oil, apple oil and pineapple oil respectively – that could claim to be legitimate substitutes for the 'real' fruit flavour taste that they invoked in their consumers. These ethers were little more than essences of fruits and other foodstuffs, and pharmacy trade journals readily published recipes and how-to guides for pharmacists interested in making artificial flavours. For example, Austrian chemist Vincenz Kletzinsky released his Table of Formulas for 'Artificial Fruit Essences' to the German-speaking world in 1865, and in translation to American chemists in 1867 – the table was Kletzinsky's latest pure and applied chemical research of distilling, and then replicating flavours.

The earliest artificial flavour recipes were discovered almost haphazardly, but were systematically studied and copied once their efficacy was demonstrated. For decades – between the middle and late nineteenth century well into the turn of the twentieth – chemists had a formalised and codified way to ensure that the artificial flavours they were making could be replicated by others.

Handbooks of artificial flavour recipes were compiled and sold. Books like *Elixirs and Flavoring Extracts: Their History, Formulae, and Methods of Preparation*, published in 1892 by J. U. Lloyd (professor of chemistry in the Eclectic

Medical Institute and former professor of pharmacy in the Cincinnati College of Pharmacy) were the early flavour industry's codification of how to create certain flavours. *Elixirs and Flavoring Extracts*, for example, had recipes for 'elixir of beef' as well as 'elixir of blackberry'. Both recipes called for extracts of the real food – be it beef or blackberry – and then directed the elixir maker to add 'simple elixir' with other chemical compounds like carbonate of magnesium. Many of the created flavours, like Coca-Cola, were originally formulated to treat everything from dyspepsia to headaches, and contained a variety of essential oils that included lemon, lime, orange, cinnamon and nutmeg in addition to cocaine, thus harkening back to the mid-millennia mix of health and flavour serving dual purposes.

A shift in flavour coincided with the mass production of foods in the United States and Western Europe. Over the twentieth century, artificial flavour became more important in making mass-produced foods more natural tasting and more palatable to consumers. No one expected these early flavour engineers to completely replace natural flavours – in part because they lacked the flavour technology to do so. The process of diagnosing, describing and creating artificial flavours became more formal as well as much more technical. Flavour quickly became an industry that was capable of producing taste and expectations of taste on a mass scale. In order to create synthetic flavours, however, flavourists need new tools, new methods and new instruments, like the liquid gas chromatograph, to keep pace with the industrialisation of flavour and the mass production of food. All of these moved the story of synthetic flavour from beyond the elixirs of the nineteenth century into the chemical industry of the twentieth.

In 1949, flavourists S. E. Cairncross and L. B. Sjöström of the Food and Flavor Laboratories of Arthur D. Little, Inc.

introduced the concept of ‘flavour profiles’ to the tenth annual meeting of the Institute of Food Technologists. This audience of flavourists had been grappling with how to describe created flavours for more than two decades. The idea of a flavour profile offered a descriptive analysis of flavour in a common language. ‘First introduced in the late 1940s, the flavor profile was both a technology of flavor measurement and a powerful tool for flavor design – one that claimed the unique ability to detect and predict the qualities that would make a flavor successful among consumers,’ Nadia Berenstein described in her PhD dissertation. ‘Produced by a specially selected, highly trained sensory evaluation panel, a flavor profile was understood to be an accurate, comprehensive record of a substance’s subjective sensory qualities.’

Now *de rigueur* foodie vernacular, flavour profiles were significant, formal tools in the mid-twentieth century. The labs of Arthur D. Little, Inc. quickly caught on to the idea that a flavour profile was both a concept of flavour and a method of measuring it. The flavour profile might be qualitative, but at least it would be consistent. Cairncross and Sjöström thought that they ought to describe where a flavour sat along a sort of flavour spectrum. A 1957 worksheet for profiling a malt beverage included a section about aroma and flavour by mouth, as well as the aftertaste. Respondents were asked to rate the intensity and amplitude of the fruity (that is, apple) aroma against the bitter (metallic) flavour and the CO₂ tingle. Other worksheets included descriptors like ‘eggy’ or ‘rubbery’, ‘cabbage-like’ or ‘skunky’, to describe a flavour’s naturally occurring odours due to sulphides and organic sulphur compounds. In a worksheet for beer, the flavourists had respondents grade the skunkiness of both the aroma and flavour as part of building the profile. To formalise a profile, one person in the panel of formally trained tasters, Cairncross and Sjöström suggested,

could act as a moderator and recorder to create a consensus of a group's responses. Putting together the responses of all of those trained flavourists – a group of 6–10 – meant creating a generally agreed upon formalisation of what a food – a strawberry, a raspberry, beer, whatever – tasted like.

Just as one set of flavourists in the industry was honing a method for how to describe flavour, other flavourists were busy actually creating flavours to add to food. Even today, there's an oft-cited theory that the human olfactory repertoire can detect something like 10,000 odorants, but that figure was simply based on an estimate with faulty assumptions from a chemical engineer at Arthur D. Little, Inc. in 1954. It's hard, in fact, to overemphasise the longstanding impact of flavour research from Arthur D. Little, Inc. in the early days of flavour synthesis.

Although flavour profiles were an important step in formally codified specific flavours, the introduction of gas chromatography (GC) in the 1950s allowed the new class of professional flavourists – as well as flavour chemists and perfumers – an increased ability to characterise and manipulate flavours and odours. Gas chromatography is a method of separating the different parts of complex compounds (like flavour) into their individual, molecular components. Most significant to the story of flavour, however, was the fact that, unlike traditional chromatography, gas chromatography used gas as a carrier agent to create the compound's molecular readout. Being able to analyse substances using gas meant that compounds that existed only in a vapour phase – like odour – were now available for flavourists to work with.

In short, gas chromatography translated the qualitative parts of a flavour profile and codified those components into a recipe of molecules. These were called 'flavour notes' in flavourist circles. When flavourists reproduce a flavour,

they are using chemicals known as 'flavoxates'. In the 1920s, there were something like 70 family-owned essential oil and aroma chemical-flavour companies in the United States, more than 50 in Lower Manhattan alone. By the 1970s, more than three-quarters of them were out of business, due in large part to the introduction of methods like flavour profiling and the industrialisation through the use of the gas chromatograph.

The implications of the use of gas chromatography for flavour research were immediate and far-reaching. Here was a way of creating flavour that could be chemically identical to what researchers had found in nature! 'Researchers understood gas chromatography as the hot new technique for unlocking nature's secrets, an understanding furthered by increasing access to gas chromatographs,' food studies specialist Christy Spackman summarises in her research. Here were all the essential chemical building blocks of taste, all set for flavourists to duplicate and manipulate them.

Parsing the complexity of notes found in flavours offered up some unexpected findings to mid-twentieth-century flavourists. There was so much more to a food's flavour than seemed to meet the taste buds. Early use of the gas chromatograph showed flavourists where they needed to add unexpected notes. Moreover, several artificial flavours require rather unappetising notes. Flavourists found that they needed to add 'sweaty notes', for example, which are essential to imitation rum and butterscotch. 'Faecal notes' offered a full-bodied edge to both cheese and nut flavours. Processed fruit flavours needed a 'burnt' undertone to best mimic the effects of cooked fruit, while artificial tinned tomato flavours must include the 'tinny' taste to meet audience expectations of what a tomato 'ought' to taste like.

It's easy to assume that once gas chromatography was combined with the technique of flavour profiling, creating particular flavours was both straightforward and routine.

Although gas chromatography might guide the creation of molecular compounds needed to recreate a particular flavour, it's not foolproof. It turns out that knowing what flavour notes make up the symphony of how a particular food tastes isn't enough to crank out a replica of its flavour.

Most flavourists tried to reproduce familiar flavours – or at least to inspire a taste of something that's familiar to consumers – and very few tried to create genuinely new flavours. 'In the 1960s, however, flavourists set out to recreate virtually the whole spectrum of food flavours, from fruits and vegetables to meats,' historians Constance Classen, David Howes and Anthony Synnott point out. 'They have not been completely successful: some flavours notably chocolate, coffee and bread, have eluded accurate simulation.'

Although the gas chromatographs gave researchers a readout of a flavour, it turns out that there are a lot of 'unnecessary' notes in the chemical make-up of flavours. Coffee, for instance, contains more than 800 different flavour compounds – only a small number of which are considered absolutely essential to coffee's characteristic flavour. Also, certain flavour notes might be missing, and proportions of compounds might be wrong – maybe the synthetic molecules flavourists are using contain impurities when they are synthesising the flavour, impurities perceptible to the nose but not the machine, for example. Flavours made by relying only on readouts from a gas chromatograph may functionally fail to perform as needed in foods – a flavour in nature may involve molecules that are highly unstable, prone to oxidise or degrade, or are super volatile. In other words, there's an awful lot of art to guide the science of flavour, just as there has been for millennia.

For most of the artificial flavour development of the 1950s–'60s, flavourists pushed the idea that it was possible

not only to replicate flavour found in nature, but also to improve it. An American flavour company bulletin from the 1950s announced, 'We are proud to announce our new improved cherry flavor, of course it is still no match for Mother Nature's.' But what if a flavour could be designed from the start? What if you could make a strawberry flavour taste more like strawberries than any garden-grown strawberry could? Or what about a flavour that had never been tasted before? What if, instead of copying nature's flavours, scientists could improve them?

This was an important turning point in the story of artificial flavour. No longer satisfied with humbly mimicking nature, mid-twentieth century flavourists set themselves up squarely in opposition to the natural world. Emboldened by decades of success, flavourists in the 1960s began to experiment with actively creating new flavours and driving consumers' expectations about what food ought to taste like. Mother Nature might have given us strawberries, the flavourists' logic went, but by golly there's no reason why we can't make strawberry flavour taste even more strawberry-like.

As consumer expectations about flavour changed throughout the decades of the twentieth century, flavourists rushed to help shape how we think food ought to taste. It's as if the flavour industry was taking directions from Willy Wonka's other-worldly flavour making – nothing, it would seem, was too fantastical to try. If you could envision the flavour, you could make it.

Distilling out the components of flavour – to describe flavour in its chemical or molecular components – is one thing. Being able to pare down that chemical compound to its essential parts is another. It turns out that, 'Nature has a way of decoying its secrets with unnecessary ingredients,' as flavourist Charles Wiener suggested in the 1980s. It was his job, as was that of his contemporary flavourists, to parse

what parts of foods yielded what sorts of flavours and how best to reproduce them. ('I think that is the best blueberry flavor that's ever been made,' Wiener told journalist Ellen Ruppel Shell when she toured his laboratory at International Flavors & Fragrances Inc. for a profile she wrote for *Smithsonian Magazine* in May 1986. 'And there's not a scrap of blueberry in it.') For consumers, it wasn't – isn't – enough to reproduce flavour as the exact chemical make-up that exists in natural foods. It must also match what consumers expect something to taste like. This required a new, specific, formal set of methods for creating and describing flavour.

This shift in consumer flavour expectations underscored that flavour is anything but static. Once a specific flavour was catalogued – say, 'D & O 5210 Strawberry' – then that flavour became the industry standard for what constituted a flavour. (Historically, in 1939, when flavour researchers were first working out the chemistry of strawberry flavour, researchers started by pressing out 445kg [980lb] of juice from physical strawberries to determine a strawberry's essential chemical components.) However, just because a flavour became codified through a formula, this didn't mean that flavourists wouldn't still tinker with it. It turns out that strawberries, like so many complex flavours, are in fact incredibly complicated to create because they don't have just one or two dominant notes in their flavour, and new flavour notes are still being discovered.

In 1992, prominent flavourist James Broderick pointed out that although the 1950s' D & O 5210 Strawberry was the industry standard, he and his colleagues were attempting to match a slightly different strawberry symphony. Creating a 'new' industry standard for strawberry meant introducing 'green' notes to the flavour compound. 'The demand for "natural" flavors and the availability of "natural" ingredients (such as ethyl butyrate, ethyl 2-methyl butyrate,

diacetyl ...) enable the flavorist to produce a “natural” strawberry with a minimum of juice or fruit extractives,’ Broderick explained in his writings. He concluded by pointing out that aldehyde C16, once thought to be essential to the manufacture of strawberry flavour, was no longer considered necessary. So, according to Broderick, we take out the aldehyde C16, add some green notes and *voilà!* we have a new – but still natural – strawberry flavour. A strawberry’s flavour profile was thus then considered a mix of fruitiness, balsamic, rose-honey, greenness, rose, butter, straw and sour. Synthetic strawberry was strawberry to begin with, but now it was even more so.

In a 2009 *New Yorker* profile of the twenty-first-century flavour business, journalist Raffi Khatchadourian’ pointed out that flavourists were still tinkering with strawberry flavour. ‘There is a note that adds overripe to strawberries,’ flavourist Michelle Hagan told Khatchadourian. She pointed out that a flavour note labelled ‘2-OCTEN-4-ONE’ from her laboratory supplies was in fact a recently ‘discovered’ compound in physical strawberries and thus a significant, but previously unknown, component of strawberry taste.

The line between natural and artificial flavour – in terms of what that flavour tastes like – has become more and more fuzzy. Less than a decade ago, the molecule was considered artificial, but it was chased down in the natural world and its status changed. ‘2-OCTEN-4-ONE’ is now natural – a powerful reminder that the boundary between artificial and natural is both fluid and arbitrary.

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There are few foods that dance around the ever-evolving gradient of flavour engineering quite the way that Jelly Belly jelly beans do.

In 1866, Gustav Goelitz immigrated to the United States from Germany. Three years later, with the help of his two brothers, he started the Gustav Goelitz Candy Company in Belleville, Illinois – today, we know the company as Jelly Belly. The Gustav Goelitz Candy Company started out making ‘mellowcreme’ candies, and at the turn of the twentieth century was widely credited with the invention of candy corn. In the early 1960s, the company (then called the Herman Goelitz Company, after the fourth-generation descendant of Gustav) expanded its inventory to include gummies and jelly beans, crafting a small ‘natural’ flavoured jelly bean, and in 2001 it renamed itself outright as the Jelly Belly Candy Company. It’s hard to imagine that when Goelitz started out in 1869, he could have conceived of a world where, 150 years later, that same company would have created more than a hundred flavours of jelly beans, and where Booger and Vomit flavoured jelly beans would not only sell – but would sell well.

Jelly Belly beans are not just any old jelly beans. The jelly beans got their start in 1965, when Goelitz started manufacturing the Mini Jelly Bean, a small sweet that had ‘natural flavour’ infused into the centre of each piece, setting these beans apart from those of other confectioners, who only flavoured the outer shells of jelly beans, and those outer shells were artificially flavoured at that. In 1976, a confectioner named David Klein began collaborating with Herman Rowland of Goelitz to create a jelly bean that would use a ‘natural puree’ to fill the jelly beans. Those first Jelly Belly flavours were Tangerine, Green Apple, Grape, Very Cherry, Lemon, Liquorice, Root Beer and Cream Soda. (Very Cherry remains a perennial favourite and for more than two decades has been the most popular bean.) Klein referred to his confectionary creations as Jelly Belly beans and to himself as Mr Jelly Belly.

By 1980, Klein had sold the Jelly Belly trademark to the Herman Goelitz Company for \$4.8 million and the company's revenue doubled from \$8 million to \$16 million. The bean quickly reached a celebrity zenith by confectionary standards in the early 1980s, when President Ronald Reagan's affectation for the sweets became the stuff of legend. (Air Force One had special jelly-bean holders to combat turbulence during flights, and Reagan even surprised the astronauts of NASA's STS-7 mission with Jelly Belly beans by having them put on the mission's shuttle in 1983.) A portrait of Reagan, made from 10,000 Jelly Belly beans, hangs in his presidential library in Simi Valley, California.

Today, Jelly Belly produces enough beans every year to wrap around the Earth five times – something like 13 billion beans per year domestically with an additional two billion per year internationally. According to Jelly Belly official statistics, the company produces 136,000kg (300,000lb) per day, 1,250,000 beans per hour and 1,680 beans per second. But it's their flavours that pique particular interest and have vaulted them into a stratosphere-like level of celebrity in the confectionary world.

The company boasts that Jelly Belly beans are made with real ingredients, like 'fruit, peanut butter, and coconut' and 'not the six or seven usually artificial and often unidentifiable flavors' of regular jelly beans, as the company emphasised in a 2008 *New York Times* profile. These real ingredients give Jelly Belly jelly beans natural flavour and, logic implies, natural flavour outranks artificial flavour every time. Sarah Gencarelli, a confectionary reviewer for CandyAddict.com, described these other jelly beans with their lesser, limited artificial flavours to the *Times* as 'the kind that were probably stuck together in your grandma's candy dish'.

But Jelly Bellies are not your grandma's flavours.

Jelly Belly jelly beans come in Klein's original flavours, to be sure, but beans also come in flavours that range from Tabasco, to Bacon, to Margarita, to Egg Nog. Jelly Belly was the first company to debut a 'savoury' flavour candy – its signature Buttered Popcorn. Lychee-flavoured beans are available only via international orders (or at shops in Australia and China); jelly beans that taste like Green Tea can only be found on non-US sites like those in Greece or Germany. The now-discontinued Barbecue Banana flavour came in a box that proudly proclaimed, 'No Artificial Colours Or Flavours!'

At the turn of the twenty-first century, the Jelly Belly Candy Company upped its flavour game again by releasing a Harry Potter line of jelly beans and a plethora of 'unusual flavours' like Vomit, Earwax, Earthworm and Soap. To be fair, the Harry Potter line also included oddities that were, technically at least, based on actual foodstuffs like Sardine, Black Pepper, Grass, Horseradish, Spaghetti, Spinach, Sausage, Pickle and Bacon. (Charles Spence noted that the name of the flavour could heavily influence what we think a flavour tastes like – for example, the 'smelly cheese' and 'sweaty socks' share an odour chemical signature. One is perceived to be relatively pleasant; the other is the stuff of Jelly Belly's gross jelly bean line.) It's as if the flavours of Willy Wonka's three-course meal gum have come to life in a way that is more surreal than Roald Dahl could have ever imagined.

In 2008, the Jelly Belly Candy Company introduced BeanBoozled, a 'wild, risky adventure' where jelly beans looked 'normal' on the outside but had 'bizarre and gross' flavours on the inside. The gist was that consumers would be completely unable to tell what the flavour of a jelly bean would be – based on its colour – before popping it in their mouths for a quick chew. A white-coloured jelly bean, for example, could be Stinky Socks or Buttered Popcorn. A speckled one might be Birthday Cake or, perhaps, Dirty

Dishwater. The first edition debuted with Top Banana vs Pencil Shavings; Juicy Pear vs Booger; Liquorice vs Skunk Spray; Coconut vs Baby Wipes. The others could be Stink Bug, Dead Fish, Spoiled Milk, Toothpaste, Canned Dog Food and Mouldy Cheese. The list of repulsive flavours goes on and on. The game was a confectioner's way of asking customers if they feel lucky.

Playing BeanBoozled has, of course, turned into a genre of ironic YouTube performance art, and you can just picture a befuddled Gustav Goelitz stroking his handlebar moustache, outside his first Ye Olde Timey Candy Shoppe in Belleville, Illinois, trying to reconcile the idea of a company that started out inventing candy corn with a company whose website now boasts, 'JellyBelly.com is the best place to buy gross jelly beans, and we're constantly expanding our assortment to delight adventurous eaters!'

Fundamentally, the story of today's Jelly Belly is a story about flavour and all the chemistry, biology, history and culture that go into imagining and creating flavours, and then manufacturing sweets that carry those certain flavour expectations with them. Jelly Belly has built itself a rather artisanal foodie ethos, and how it markets the flavour of its beans is no small part of that story. 'We always start by sourcing the real thing. In the case of BeanBoozled, this is an interesting challenge,' Jelly Belly explained to me in an email interview. 'We have done things such as put used gym socks in a plastic bag for a couple of weeks or let milk spoil. The timeline for flavour development varies greatly by flavour. We constantly ask ourselves, did we get it as true to life as possible?'

But flavour is complex. And its history even more so. 'There are still luxury foods, like caviar and guinea hen, but there are no longer any luxury flavors,' a food manufacturer told Lucy Kavalier in her 1963 book, *The*

Artificial World Around Us. Kavalier's book, geared towards a young adult audience, follows how the world was remade by synthetic chemistry after the Second World War. With new, trendy twenty-first century flavours like Blue Raspberry and Acai, it would seem that new luxury flavours are being manufactured to take the place of those once held by nature. The excitement surrounding new chemistry-made flavours was much like that of laboratory-grown diamonds.

What makes a flavour natural? Real? Authentic? Biology. Biochemistry. Neurophysiology. History. Culture.

It's easy to think that flavour must be either 'natural' or 'artificial'. Certainly, the minutiae of contemporary food labelling, ingredient lists and legal regulations emphasises this distinction – natural and artificial mean very particular things in specifically legal circumstances, regardless of an individual flavour's history. This dichotomy is overtly and covertly translated into the consumer ethos that flavour is either real, or that it is fake and that that 'natural' is 'good' and 'artificial' is 'bad'. Fundamentally, flavour is about decisions and how the sensation of taste moves through the human experience.

But such rigid categories don't let flavour evolve. Like so many things, flavour isn't easily divided into two distinctly separate camps, let alone easily categorised as 'fake or not'. If history is any indication, what flavours we think are real and fake will change – and change again – in the decades to come.