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[Miscellany]

The Odor of Things

by Scott Sayare

Solving the mysteries of scent

Like many of the great perfumers, Jean Carles was a son of Grasse, a country town in the hills north of Cannes, on the French Riviera. Grasse, once a state unto itself, sits in a natural amphitheater of south-facing limestone cliffs, at the head of a valley of meadows sloping gently to the sea. The combined effect of this geography and the dulcet Mediterranean climate is a harvest of roses, jasmine, and bitter-orange blossoms that is exceptionally fragrant, and for hundreds of years the town has been known as the capital of the perfume trade. When Carles began his training, early in the twentieth century, a priesthood of Grassois perfumers presided over the industry. These so-called *nez,* or noses, were regarded with an awe of the sort that attaches, perhaps especially in France, to artistic genius. They were vessels of divine talent, their creations as wondrously perfect as the flowers of Grasse.

Would-be *nez* were initiated through an apprenticeship of several years, during which the secrets of the perfumer's method were carefully revealed. The language of perfume is borrowed largely from music. Perfumers are said to "compose" their fragrances, merging individual "notes" into sonorous "accords" and arranging those accords in "harmony." As his training progressed, Carles came to realize with some dismay that, for all its pretensions to art, perfumery proceeded almost entirely by trial and error. The noses selected ingredients by little more than instinct, and dosed them nearly at random. Perfumers worked, Carles later wrote scathingly, "in haphazard fashion, in the expectation of a potential miracle." Many of the best formulas had been discovered "almost by chance," he reported, "to the unfeigned surprise of their authors." He set out to systematize perfumery, to establish a comprehensive theory of fragrance creation.

Carles proposed to arrange the scent realm in an orderly grid. He began by decreeing the existence of two dozen categories: citrus, agrestic, minty, woody, jasminic, musky, animalic, and so on. He then sorted the scents of each group according to their behavior over time. The most volatile, those that were first to hit the nose but also first to vanish, he designated top notes; those of middling volatility and duration were the modifiers, or heart notes; those that were last to reveal themselves in full but longest to endure he called base notes.

He invented perfumes from the bottom up, like pyramids. For each level, he selected a harmonious accord of scent categories, then searched each category for appropriate ingredients. It was a simple method, but far more of a method than perfumery had ever known, and it seemed to be extremely effective. In the Forties, Carles created Ma Griffe and Miss Dior, two green-floral chypres that remain among the world's most celebrated fragrances. It is widely believed that, by that time, Carles had lost his sense of smell. The perfumes were works of memory and imagination, guided by the system he'd devised.

One version or another of the Carles method is now the standard curriculum for trainee perfumers, and the approach is treated with some of the same awe once reserved for the mystical anti-method it replaced. Carles, the un-smelling master, is likened to Beethoven gone deaf. Yet in the end, he was guessing just like everyone else. Natural as they may have seemed, his categories were basically arbitrary; he had invented them to match the auras as he knew them, not any underlying truths about the nature of scent. His taxonomy could not say what formulas would actually smell good, or why. At best, it could help to organize the process of trial and error that would inevitably precede the discovery of one that did. If Carles was able to compose perfumes without the use of his nose, it was because, before it gave out on him, he had run years and years of experiments, and remembered the results.

Carles's advice for perfumers was not less experimentation, but more. He urged them to dose ingredients at two, three, even ten times the levels that seemed reasonable, and then take a whiff. "One should never believe, before actually experimenting, that a formulation contains an excess of a given product," he said. "Such 'faults' have quite often been responsible for tremendous commercial success." The world's best-known perfume, Chanel No. 5, was said to be an accident of this sort, its famously bright and soapy aspect the result of an assistant's massive dosing error. That formula was conceived in 1920. At the time, the only reliable way to know how a novel mixture would smell was to prepare it and put it under your nose. Methodologically speaking, almost nothing has changed since.

We tend to experience the olfactory realm as a shapeless suffusion, forever shifting, eluding description the way fog eludes the grasp of one's hand. Smell does not produce objects in our minds so much as auras, but these can be the most vivid of our sensory experiences. Smell is the sense most deeply entangled with memory and emotion. It functions as a kind of psychic mortar, binding together all the richness of past experience, such that a familiar scent can instantly overwhelm us with remembrance and feeling. And yet we strain to describe even the simplest odors; we retreat into simile and metaphor, or cadge the terminology of other senses, or designate smells, rather prosaically, by their source. The scent of a rose is "soft," or "rosy," or perhaps "evocative of decorous passion," but none of these descriptions would let you imagine it if you didn't know it already. Nor does smell lend itself to quantification. Sound and light fall along well-defined spectra of wavelength and frequency, but we have no such scale for odor, no metric by which to relate the aroma of cinnamon, say, to that of burnt rubber, or that of old books.

Nor can we say with certainty why anything smells the way it does. Lucretius, the Epicurean polymath, believed that odor was a function of geometry. "You cannot suppose that atoms of the same shape are entering our nostrils when stinking corpses are roasting," he wrote, "as when the stage is freshly sprinkled with saffron of Cilicia and a nearby altar exhales the perfumes of the Orient." A number of alternative theories have since been advanced. Some have imagined odors as chemical reactions between the nose and the molecules that enter it. According to "vibrational" theories, a molecule's scent depends upon its infrared or ultraviolet emissions. Shape-based theories are still the most prevalent, though, and Lucretius is thought to have been basically right, apart from the correlation he imagined between harmoniousness of form and loveliness of smell. The scent of a rose is the combined effect of about 260 volatile compounds, some as jagged as the flower's thorns.

If shape does indeed account for smell, however, we are far from knowing exactly how. Molecules of widely divergent structure can smell nearly identical. Muscone and Helvetolide, for instance, both smell of musk, but one is shaped like a ring, the other a kinked chain. Conversely, molecules of nearly identical structure produce odors that are completely distinct. The compound L-carvone smells of spearmint, while its mirror image, D-carvone, smells of caraway seed. Certain substances have unrelated smells at different concentrations. Gamma-undecalactone generally smells fatty and aversive. Heavily diluted, it smells of ripened peach.

We speak of scent as if it were a property intrinsic to a given substance, but odor is not simply "out there." It is a co-creation of the nose. At the very top of the nasal cavity, up between the eyes, sits mucosal tissue known as the olfactory epithelium. It is dense with neurons, and embedded in these neurons are proteins known as odorant receptors. Odorant receptors bind the volatile compounds we inhale, converting them into electric signals that will, eventually, register in our consciousness as smell. The nature of these receptors—how many kinds there are, which molecules they respond to—is central to our experience of scent. It is also, for the most part, a mystery.

Throughout the twentieth century, the leading hypotheses about odorant receptors were variations on the "primary odor" theory. It was believed that there existed just a handful of receptor types, each corresponding with some fundamental odor quality; different smells were caused by the activation of these receptors at different levels and in different combinations. The American chemists Ernest Crocker and Lloyd Henderson, for instance, proposed a system of four receptor types, one accounting for the "fragrant" aspect of an odor, one for the "acid," one for the "burnt," and one for the "caprylic," or goaty. The Crocker-Henderson system represented smells as four-digit codes. Rose was 6423, being a fragrant (6) but generally mild odor; freshly roasted coffee was 7683, with strong fragrant (7), acid (6), and burnt (8) components, but a goatiness (3) equivalent to that of rose. Any smell could be imagined as a sort of piano chord, a combination of keys, each played with a specific degree of force. The code was its musical notation.

The Crocker-Henderson system carried an air of empirical rigor, but it wasn't much more scientific than Carles's, with which it was roughly contemporaneous. There was no evidence to suggest the existence of four receptor classes, rather than three, or five, or ten; nor was there any serious reason to believe that acidity and goatiness—but not, say, florality or putrescence—were fundamentals of odor. Until the end of the twentieth century, the problem for any theorist of olfaction was that no one had really been able to study the olfactory receptors, or even prove their existence. The nose was a black box, a piano of unknown size and mechanism: certain chemicals went in and certain smells came out, but it was impossible to say why.

Gary Marr entered the perfume trade without the customary sense of romance. In the Seventies, he was playing bass guitar in a band when, in need of a paycheck, he stumbled into a job mixing chemicals. He was an Englishman from gray East London; he had never heard of a *nez*. But he found he had a knack for remembering chemicals by their odors, and his new employer, a fragrance company, offered to train him to make scents of his own. At the same time, he was beginning to realize that he wasn't much of a musician. "I got wise," Marr, now sixty-two, told me recently. Perfumery was the path of good sense.

Marr, who is tall and hale and well coiffed, is now a master perfumer at Firmenich, a Swiss company that figures among the fragrance industry's "big four," alongside Givaudan, also Swiss; International Flavors and Fragrances, headquartered in New York; and the German firm Symrise. Fine fragrance is the most prestigious work these companies do—they create most of the perfumes sold by designer brands—but it is hardly all. Marr designs scents for the workaday side of the perfumery business, a vast and, in many ways, more demanding assignment. "I know fine fragrance perfumers won't agree with me on this," said Marr, "but I've always said that fine fragrances are relatively easy. It's all about making nice, harmonious, round fragrances. Whereas you come to home care/body care—the fragrances have to perform." Dishwashing scents must "bloom" when they hit water, but also slough off surfaces immediately, so your tableware doesn't leave your food smelling of perfume; bleach can be made to smell nice, but the perfumer's task is complicated by the fact that sodium hypochlorite tends to destroy everything it touches.

Perfume is far more present in our lives than we tend to acknowledge. The substances we use to clean our homes, our clothes, and our bodies are perfumed, as are Play-Doh, plant fertilizer, makeup, and, it is widely speculated, the electronics manufactured by Apple. Airlines, department stores, hotels, and taxicabs perfume their air. So do coffee shops, with the artificial scent of roasted beans, and movie theaters, with the artificial scent of popcorn. Our experience of flavor is mostly attributable to our sense of smell, not taste, and flavored foods can rightly be called perfumery products, too. The fragrance and flavor industry brings in an estimated $30 billion each year. Firmenich claims that its products reach more than half the world's population every day.

It is a common misconception, in Marr's view, that one must have a particularly refined nose to become a perfumer. Sensitivity comes with training. (Early on, Marr noticed the sharpening of his olfactory sense on the highway. He suddenly found he could tell, with his windows closed, whether a driver ahead of him was smoking a cigarette, even if the driver's windows were closed too.) Most critical is that a perfumer's experience of smell be normal, at least by the standards of the target market: she must smell what her clients smell. "We have to know what makes our fragrances tick with those consumers," Marr said. "And it helps if you have a nose—I think I'm doing myself a misjustice now—but it's a nose that is really in line with the lowest common denominator out there in the masses."

Olfaction is the sensory system with the most genetic variability by far. No two noses are alike. Some people find that cilantro smells of soap; others cannot detect the sulfur compounds responsible for the unpleasant odor of "asparagus pee." The steroid androstenone can accumulate in the meat of uncastrated pigs to produce a repulsive smell known as boar taint, but it only bothers those with particular genes. The composition of the same person's nose also evolves from day to day. Olfactory sensory neurons are the only neurons directly exposed to the outside world, and the only ones that are replaced when they die. They complete their life cycle every month or two, but it is not always the same type that grow back; over time, fewer grow back at all. Smell evolves, and weakens, with age.

This is not to say that genes are everything. Despite his democratic nose, Marr does not necessarily enjoy the same scents as his clients, and like most artisans he is occasionally obliged to design products he abhors. He finds one of his air-freshener scents, a faux-raspberry aroma, offensive to the point of pain. "It actually hurts—it hurts my nose," he said. But it sells exceptionally well. Responses to odor vary strongly by culture. Europeans have been found to be indifferent to maple syrup, averse to Concord grape, and repelled by root beer, all of which North Americans tend to love. Familiarity is a strong predictor of olfactory approval; we like what we know. Southern Europeans like the smell of lavender in their laundry products; Americans like laundry products that are advertised as lavender but smell like vanilla. "Nothing to do with lavender," one of Marr's colleagues told me. "Not a thing."

Like any commercial enterprise, perfumery is subject to trends but can also set them. The invigorating blue-green scent that Americans are likely to recognize as the standard for laundry detergent—think of Tide—is largely attributable to synthetic aldehydes that do not necessarily smell like anything in nature but are good at covering up the unattractive odor of cleaning products. Aldehydic fragrances were added to detergents beginning in the mid-twentieth century; before then, American "freshness" was likely to smell more plantlike, less abstract. (Tide's original scent was rose.) By a similar token, aloe vera has come to be associated with a soothing, green, lily-of-the-valley scent. "That's the code, that's the translation," one perfumer told me. "Except that no one knows what aloe vera actually smells like. Because aloe vera has no smell."

Lately, fruit scents have spread from North America across the world; twenty years ago, not so many of us bathed in pomegranate. The COVID-19 pandemic caused an explosion in the use of surface cleaners, and consumers everywhere have begun to look for similarly astringent "hygiene" notes in soaps and laundry products. The coronavirus has robbed many of its victims of their sense of scent, but it has changed the way the world smells for the rest of us too.

Not long ago, I visited Marr at Firmenich's laboratories in New Jersey, in an anonymous office park in the woods near Princeton. (The fine fragrance division is in Manhattan, on Madison Avenue.) Among the low-slung buildings is a plant that manufactures all sorts of fragrances, and I was met in the parking lot by a cloud of scent. It reminded me initially of pine freshener, but then seemed to morph into something sweet and rich and resinous, perhaps related to strawberry bubble gum. By the time I'd reached the entrance, the smell put me in mind of a candle shop at Christmas. In the past, the residents of a downwind subdivision had to sign an odor waiver. The air inside the company buildings is purified.

Marr was testing eco-friendly scents for a spray cleaner, a laundry perfume that smelled of tropical fruit, and a European brand of detergent that wanted to "modernize"; he is often at work on forty or fifty fragrances at once. Consumers tend to evaluate the efficacy and general appeal of all sorts of items on the basis of smell, and consumer goods companies are thus constantly adjusting the perfumes in their products. When Procter & Gamble or Unilever discover that a competitor's scent is out-testing one of their own, they turn to the fragrance houses. They are engaged in a permanent, low-grade perfumery war.

Among the fragrances Marr was testing was one I will call Magus, intended for an immensely popular international brand of detergent, which I will call X. X's current scent, made by a competitor, was, by broad consensus, exceptional; it had survived for years. "It's such a good fragrance," Marr said, sounding wistful. "It's this fruity, floral, woody scent. It's just in perfect harmony." A contract for such a fragrance could be worth tens of millions of dollars.

Magus was, already, the result of years of work. On a summer evening a decade earlier, Marr had been sipping a beer at an outdoor café on the Place du Bourg-de-Four, the oldest square in Geneva, where Firmenich is headquartered. A man walked by, trailing a scent that Marr found irresistible. "It was quite feminine," he recalled. "But it was *really* nice, *really* diffusive." He immediately recognized its two prime ingredients. The first was ionone-beta, a heart note with a voluminous freesia character, some woodiness, and a raspberryish background; the second was a salicylate, a tenacious lily-of-the-valley–type heart note. In experiments soon thereafter, Marr added a third note for a leafy, ethereal aspect. "Those three together just gave this wonderful fresh, clean, green, floral note that was very, very easy to smell," he said. "You didn't have to search for it, it just hit you straightaway."

Firmenich's laundry-testing laboratory resembles an immaculate laundromat, with white washing machines droning along white walls. Marr and a colleague, Miriam Coria, stood on two sides of a white countertop. Coria handed him a series of plastic shoeboxes, each containing piles of small white hand towels laundered with a different iteration of Magus. The towels undergo an identical wash regimen for every test: four two-and-a-half-hour cycles of hot-water decontamination followed by a warm-water wash with the test fragrance. (They are replaced every six months or so; the new towels require extra attention, as they are manufactured with some sort of protective treatment—a faint smell confound.)

Fragrances are evaluated first on machine-dried cloth, where the scents are weakest, so as not to "kill" the nose. Marr took one towel of each kind and brought them gently to his nostrils; Coria buried her nose in them. One scent was "much more sensorial," Marr remarked, another "more functional." Coria nodded. "I like all of these," Marr said. To me, the towels smelled like nothing at all.

They moved on to damp cloth, the critical stage for detergents, where scents open up. Marr took a towel washed with X, held it up several inches from his face, and inhaled admiringly. "It fills the air around you," he said. "And it's that effect—if you can create that, you're halfway there." Marr sniffed the Magus towels in various sequences. He liked an iteration dubbed Magus 61, which he found to be pleasingly full-bodied. Coria preferred Magus 60, for its spice. Marr thought it might be possible to get both effects at once. He went upstairs to make adjustments.

On his computer, in a spare office overlooking the forest, Marr pulled up the formula for Magus 61, and began working his way down the list of chemicals and doses, making adjustments in a new column, Magus 610, as he went. He boosted the levels of citronellol, which smells of rose, and Clearwood, a patchouli-like base; he reduced the coumarin and cut Melonal altogether. Most critical was the addition of a particular musk and a particular aldehyde, which in combination would, in principle, generate a fresh, peppery note. Marr would not identify either ingredient to me, even off the record. "The last thing I want—I'm in competition with these guys here, with the other perfumers!" he said. Secrecy is the defining feature of the perfume industry, and follows from our inability to predict the scent a given combination of ingredients will produce. Even within Firmenich, colleagues cannot access one another's formulas without authorization.

A week later, Marr and Coria were testing his new version of Magus, alongside a few other options. They smelled in silence for a while. "One here I like an awful lot," Marr said cautiously. Coria kept smelling. Finally she pointed to a box of towels: "That's the one you like as well? I love it!" Marr smiled. "Yeah, that's the best one," he said. "That's really good. It's got a richness, it's got some pepper." "It's fruity, modern, fresh, clean," Coria said. "I could use it every day on everything. I want to smell it all the time!" It was Magus 610.

Marr turned to me. "I *know* when I smell a good fragrance," he said. "You just instantly know. It probably happens once every two years—when you know for sure that you've just got to wait for the right moment to come along, and it will sell."

What perfumery lacks, like smell in general, is a tool of precise measurement. If you want to know whether a scent is damask rose, say, or rather *rose de mai,* the best way is to ask a trained perfumer to smell it for you. They are the closest we've come to an all-purpose olfactometer, though technologies do exist to determine what chemicals a given smell is made of. Gas chromatography–mass spectrometry has been in use in the perfume industry for several decades, for instance. Early on, perfumers fretted that GC-MS would be able to divine the precise formula of any scent, and that the secrecy of their craft would be irremediably punctured. But the technology is far less powerful than that.

Not infrequently, the most pronounced aspect of a smell will be caused by substances present in amounts far below the threshold of detectability for GC-MS. The smell of corked wine, for instance, is typically caused by 2,4,6-trichloroanisole. Humans start smelling trichloroanisole at a concentration of just a few parts per trillion; by the calculation of Ann-Sophie Barwich, of Indiana University Bloomington, a single ounce of it would be sufficient to ruin the annual harvest of all the vineyards on earth. And yet in the average GC-MS analysis, a good bottle and a corked bottle are likely to both register simply as wine.

Conversely, the substances GC-MS does detect are not necessarily the ones we smell. The world is awash in volatile compounds; in a sense, the role of our odorant receptors is to filter most of them out, to pull meaning from chemical noise. Paul Feinstein, a professor of biology at Hunter College, offered the example of a forest fire. "Fire is going to make lots of odors," Feinstein said. "Maybe some of those odors are wood. But if you smell wood, if you smell the forest, that's going to suck for you."

Odorant receptors were finally identified, using newly available genetics technologies, in 1991. Since then, scientists have imagined using them to construct an artificial nose, one that would measure smells not as they are but as we experience them—a device that would record an odor's unique pattern of receptor activation. Contrary to expectations, however, there were not just a few human receptor types, but somewhere on the order of four hundred. In the lab, they turned out to be almost impossible to work with. After an initial burst of enthusiasm, progress toward an artificial nose has been markedly slow.

Lately, though, researchers have made headway. Feinstein, for instance, has developed a method for growing human receptor proteins in mice, extracting them, and then measuring their response to various odors; Firmenich, whose receptor program is reputed to be the fragrance industry's most extensive, does the same with receptors grown in vitro. No one seems yet to have managed to build a comprehensive nose on a plate, with all four hundred human receptors, but given the secrecy in perfumery, it is impossible to be sure. (Firmenich declined to tell me how many types of receptor it now grows.)

In a prototypical nose on a plate, receptors are placed in a gridded array of small circular wells, each one reserved for receptors of a different type. The grid is covered and a scent is fed in, as if the device were inhaling; if the scent activates the receptors in a particular well, it fluoresces. What results is a distinctive pattern of dots, a few glowing brightly, a few more dimly, most not at all: an odor, as recorded by the nose. If all its microwells were placed in a long row, an artificial nose would resemble a piano keyboard, the illuminated keys forming the chord of the scent in question.

Until the advent of organic chemistry, perfumes were made only of natural materials. Musk was obtained from the preputial gland of a shy, fanged deer native to the mountains of East and Central Asia; ambergris, a grayish expulsion of the sperm whale, was collected from the seashore; drops of floral absolute were extracted from great piles of rose and jasmine. Traditional ingredients such as these are still in use, but since the late nineteenth century they have been complemented and sometimes replaced by an ever-growing repertoire of synthetic molecules. Like other major fragrance houses, Firmenich began as a chemical company, and the development and sale of new perfume ingredients remains a significant portion of its business. No aspect of perfumery is more dependent on trial and error.

In Geneva, Firmenich's chemists synthesize hundreds of novel substances every year. Of these, an average of only three or four go on to become new ingredients; all told, each will have cost hundreds of thousands of dollars to develop. Francois-Raphaël Balestra, the perfumer who oversees the selection process, smells each new molecule and records his impressions. "I use my nose," Balestra told me. "I don't have any other technique."

Receptor technologies will simplify this process. Scents of the same tonality often involve the activation of a characteristic receptor. Lily-of-the-valley ingredients, for instance—a permanent focus of the perfume houses, because the flower itself is a *fleur muette,* or "silent flower," almost impossible to extract any scent from—come in all sorts of molecular shapes, but what seems to give them their distinctive character is that they activate the OR10J5 receptor. Firmenich has begun to use the receptor to imagine and screen for new molecules.

Aversive smells, too, can be linked to particular receptors, and malodor has lately been a major subject of inquiry for Firmenich. (In a sense, it has always been the perfumer's central preoccupation. Before perfumery, Grasse was known for tanning, and its foul smell; the first Grassois perfumers were glovemakers who scented their leathers to mask the stink.) In particular, the company has devoted considerable resources to the study of the scent of human waste, a project cosponsored by the Bill and Melinda Gates Foundation. Open defecation is a major cause of disease in parts of the world without sewers; even when latrines are installed, they often go unused because they smell so vile. The Gates Foundation was interested in finding a solution.

It is understood that certain chemicals block certain receptors, occupying their binding sites such that no other volatile molecules can reach them. These antagonists might have smells of their own—they activate other receptors—but, in principle, they will dampen or eliminate the smells that depend on the receptors they block. Such aromachemicals could be used not simply to cover up the stink of a latrine, but, in essence, to prevent it from being smelled at all.

Researchers at Firmenich established the primary chemical components of the aroma of sewage, and then determined which odorant receptors they activate. Then they tested perfumery ingredients against these sewage-linked receptors. To their surprise, they found hundreds that blocked them. "One of the big contributions that our team has made, in the last few years, has been to show that, actually, blocking of receptors seems to be about as common as activation of receptors," Ben Smith, a research director at Firmenich who has worked on the company's receptor program, told me. Perfumers often find that the addition of a new ingredient mysteriously causes a fragrance to go "flat." Blocking is almost certainly why.

Among the more effective blockers were several lily-of-the-valley–type ingredients. Firmenich designed a fragrance around two of them. When mixed with latrine scent—the company concocted its own for testing purposes—the perfume kept its white floral aspect, while the sewage seemed to fade away. Bill Gates reported the finding on his blog. "I took a whiff of the future of sanitation," he wrote, "and it smells pretty good."

Perfumery is, at its heart, deduction. When imagining a new fragrance, the perfumer draws on her knowledge of the scents already known to be agreeable; then, line by line, she assembles a formula that ought to produce the fragrance in her mind. Stated in general terms, she calculates a desirable output, then back-calculates the requisite input. The fragrance industry is beginning, uneasily, to embrace this computational view of its craft.

Lately, artificial intelligence has made significant inroads into perfumery. Givaudan has introduced formula-writing software that automatically suggests ingredients. Symrise, working with IBM Research, has commercialized two AI-designed perfumes. CK Everyone, an AI-assisted perfume made by Firmenich for Calvin Klein, launched early last year. A few months later, with help from Microsoft, the company introduced what it called the "world's first AI-created flavor," a "lightly grilled beef taste for use in plant-based meat alternatives." It is, the press release asserted, "delicious."

Just as for a human perfumer, the central difficulty for an AI algorithm is the unpredictability of odor, and like a human, it must rely on data about smells and the chemicals that make them. That data has always had a gaping hole where the odorant receptors are. With the receptor-activation patterns it records, an artificial nose could help fill it. In principle, if an AI program knew the activation pattern of a smell it wished to imitate, it could simply scan its list of ingredients for chemicals that would add up to that pattern, and be assured that its concoction would smell just as desired. "It's going from an empiric mode of creation, where the perfumer has an idea, and then, by trial and error, works out how to reach this idea, to a more predictive mode," Odile Pelissier, a senior vice president for creation and development at Firmenich, told me. "Because you can start almost from the end. You can say now, to the computer, 'I would like it to smell like *this.*' And then you retrofit how the formula should look." The company has begun feeding its own receptor data into an AI system.

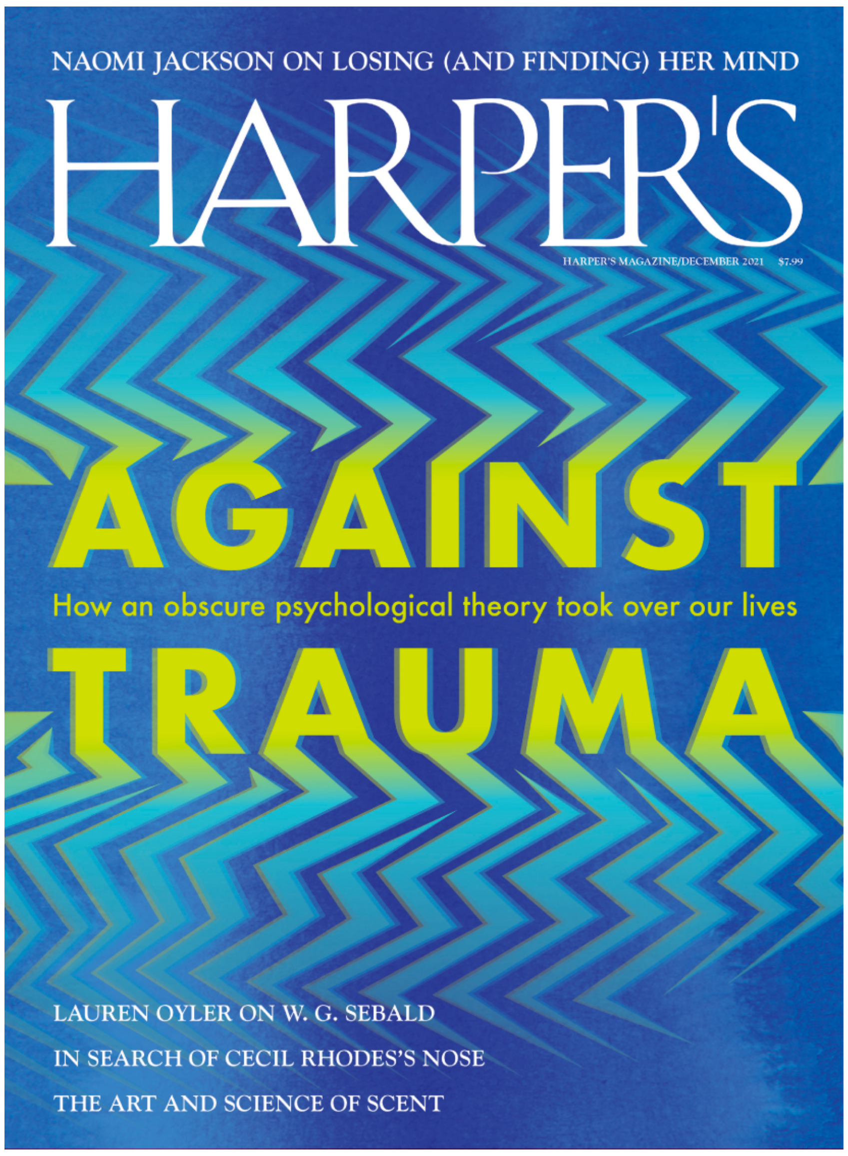
Firmenich's first AI experiment was a five-ingredient piña colada scent. "We said, 'You have five lines, you have to do a piña colada, computer,' " Pelissier said. " 'What will you do?' " Typically, a perfumer would select ingredients to match those of the drink: one or two to evoke coconut cream, others for pineapple, another for rum. The ingredients selected by the AI had nothing to do with most of these—it did not know what actually goes into a piña colada—but in combination they worked. If a scent is nothing more than a pattern of activated receptors, and those receptors respond to a wide variety of molecules, then there ought to be any number of combinations that produce the same effect. A human perfumer is unlikely to discover these alternate mixtures except by accident; to a computer, all paths to a piña colada are equally valid.

The prospect of a rationalized perfumery is, understandably, a source of some trepidation among perfumers, though people in the industry insist that AI will never replace the traditional *nez.* "The idea is that the perfumer will focus on the idea and the creativity," Pelissier told me. "Without the human, all you get is a blend," the star perfumer Francis Kurkdjian recently opined. "If you told a machine you like blue, red, and pink, and then you asked the machine, you would never get a Mondrian!" Perfumery, one prominent Grassois perfumer impressed on me, is "a métier of emotion, of intuition, and of instinct, and artificial intelligence won't bring any of that." Jean Carles himself, who first set the industry on its rationalizing course, insisted that perfumery would forever be more art than science. The "essential qualities" of the successful perfumer could not be taught, Carles maintained, "any more than can be taught enthusiasm, the joy of living and of creating, and the love for one's calling."

Gary Marr finds these protestations to be a bit self-important, and a bit naïve. I got the sense that he viewed the advent of computer-made perfumes as a comeuppance for the industry's showier elements. "There's still a mystique that surrounds perfumery," he told me. "And that mystique doesn't just exist outside the fragrance industry."

Early in his career, Marr worked alongside an older perfumer who, like Carles, had lost his sense of smell. "But he had been doing it for so long, and he'd been so successful," Marr said, "he knew what made things work." On occasion, if he is busy, Marr will send off a new fragrance for testing without having to smell it first. Over the course of several decades of experimentation, he has intuited the rules of odor, and can use them to predict new smells. He sees no reason to believe that AI should not be capable of doing the same. "It has to!" he said. "It might not be for a hundred years. But if you've only got a thousand ingredients, there has to be a finite amount of mixtures. It might be in the billions. But you get computers big enough, eventually you should be able to predict every combination."

Like Carles, such an AI system would be unable to experience smell, but like Carles it would not have to. The computer would already know every odor a human nose could ever detect, and how to form it. It would know the scent of everything.



From the

December 2021 issue

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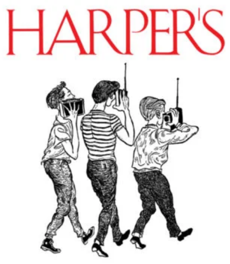

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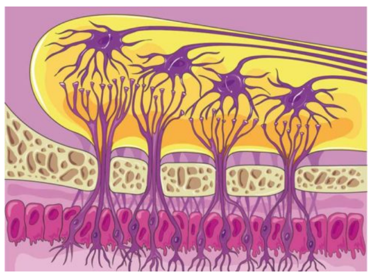

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