CHAPTER 2

AS YOU LIKE IT

A rose by any other name would not smell as sweet.

—(*not*) SHAKESPEARE

When I was seven years old we moved to Montreal. The move was difficult for me because it rode on the heels of several international relocations, during which time I had acquired expert knowledge of the cruelty of children toward the outsider. Our move to Montreal was to be permanent and I longed to integrate into the schoolyard cliques, but the more apparent I made my wish for friendship, the more rejection was heaped upon me. Suffice it to say that I spent my first year in Montreal feeling lonely and frustrated. One afternoon, during those first few months, a salesman rang our doorbell—he was selling hair products from some new company. I remember being startled that my mother actually purchased this particular shampoo and conditioner, as it was unlike her to spend money spontaneously on door-to-door sales. And I remember that the word *aquamarine* was in the product name. The rest of the details are a blur,

but that purchase changed my life, and the ensuing experience became indelibly imprinted in my memory.

The night of the purchase I asked to try the new hair products. I was captivated by the shiny exotic bottles and eager to experiment, to experience something pleasurable and atypical in my day. I remember squeezing the translucent turquoise shampoo into my hand and lathering it into a bubbly and delicious foam in my hair, but most of all what I remember is the exquisite scent that arose from the bubbles. I had never smelled anything like it before—sweet, piney, watery, and mysterious—and it seemed to me to be the most sublime aroma on Earth. While drenching myself in my parents' pink tile and chrome shower, which I was allowed to use only on special occasions, for that first hair-washing experience with this superb new smell, I became intensely happy for the first time in a long time. I don't think my parents were particularly impressed by these hair products since they stayed in their shower diminishing very gradually for almost a year. While they lasted, I would periodically ask to use them so that I could relive that wonderfully transporting fragrance experience. I also began to realize that if I wanted to feel better after a bad day in the schoolyard, all I needed to do was open the lid of one of the bottles and inhale its sublime scent. After the last fragrant drops were spent, I would pester my mother now and then to buy those special hair products again, but no one ever returned to our house to sell them, and they were not available in any stores. That one bottle of shampoo and conditioner were all I ever knew, and though I have tried many times over the intervening years to find them, I have never

had any luck. Nevertheless, ever since that first experience with "aquamarine," if I smell anything that has any resonance with that aroma, I instantly love it and will go out of my way to buy it or find a way to use it.

As I confessed in the preface to this book, another scent that I truly enjoy is the smell of skunk. Although I wouldn't choose a shampoo with this aroma, when I am out in the country and the scent of this animal is carried on the breeze, I find it very pleasurable. This is more unusual than liking a shampoo fragrance but there are many others who, when feeling safe enough, admit to me that they share this unusual preference. And it isn't that I like all smells. I find creosote—that smell of asphalt being laid down—extremely unpleasant.

Why am I so fond of certain specific aromas and dislike others? Why are you? Are we born liking and disliking various smells, or do our aroma preferences come about in another way? The general assumption, though never scientifically proven, is that we have an innate, hardwired predisposition to like or dislike various odors. This presumption is largely based on the fact that our responses to tastes, particularly those to sweet and bitter, are innately positive and negative to us, respectively, and preferences for scents have been presumed to follow suit. This popular notion is further exacerbated by the incorrectly blurred distinction between the senses of smell and taste.

I disagree with the view that we come into this world with a set of odor likes and dislikes—that the scent of rose is good and skunk, bad—and, rather, I am convinced that our aroma preferences are all *learned*. Now let me convince you.

If one wanted to prove that the liking or disliking of odors was innate, the best place to start would be with infants, because if anyone is going to show spontaneous innate reactions, it would have to be newborns, since they haven't learned much yet. Several researchers have examined newborn odor preferences and have found that infants' responses to smells do not match the responses of adults to those same scents. For example, infants like the smell of feces and are equally indifferent to scents that adults view as negative or positive, respectively, such as rancid cheese and banana. In fact, it is not until children are about eight years old that they start to show odor preferences that match the responses of the adults in their culture. It turns out that there is *no* data that infants show predictable—innate—reactions to smells. But there is considerable evidence that what infants and children like to smell is due to their experiences; in other words, learning, and this learning begins even before birth.

Our olfactory system is the first sense to develop. In fact, we have a fully functioning sense of smell by the time we are twelve weeks in the womb. This is in stark contrast to our visual system, which takes several years after we are born to become fully mature. The fact that we have a completely functioning sense of smell when we are just three months postconception means that we can begin to learn about odors well before we are born; and we do. The way we come to know various aromatic chemicals during this prebirth period is through what our mothers consume. Amniotic fluid, which surrounds the developing fetus, is composed of what is in the mother's body as well as the fetus's body. So what a mother ingests becomes chemically present in her amniotic fluid, and whatever

aroma molecules are there can be perceived by her developing child.

Several studies have shown that what a mother consumes while she is pregnant will influence her baby's flavor* preferences after he or she is born. Julie Mennella, a longtime researcher on the development of flavor preferences, and her colleagues at the Monell Chemical Senses Center in Philadelphia found that mothers who ate garlic, drank alcohol, or smoked cigarettes while they were pregnant had infants who preferred these scents compared with infants who had not been exposed to these smells during their gestation. The infants' preferences for these scents even superseded their liking for vanilla, which is often believed to be an ubiquitously favored aroma. Breast-feeding can similarly influence the development of flavor preferences, including for healthy foods. Julie found that mothers who drank carrot juice while breast-feeding had infants who liked carrot flavor when later exposed to it as "baby food" much more than infants who did not have this early exposure.[1] The implication is that one could have a child who likes liver and spinach if the mother eats liver and spinach during these early moments. It also so happens that these early learned flavor preferences can carry on into adulthood and have subtle long-lasting effects on our culinary orientations.

E. P. Köster, a smell researcher in the Netherlands, knew that children in Germany who were fed with formula experienced a vanilla-flavored drink—and that this product had been used for

*Flavor is a combination of basic tastants (salt, sour, sweet, bitter) plus smell, and it predominantly relies on smell. See Chapter 7 for more details.

several decades. To see how this early experience with the flavor of vanilla might have impacted later flavor preferences, he conducted a clever study at a fair in Frankfort, Germany. In the late 1990s, Köster and his colleagues set up a booth of ketchup samples. One cup contained regular ketchup and another cup contained ketchup flavored with vanilla. One hundred and thirty-three men and women in their late twenties and early thirties came to sample the two versions of ketchup. From a questionnaire distributed to the fair attendees when they first entered the grounds, Köster's group knew who had been bottle-fed and who had been breast-fed as infants. Köster found that those who were bottle-fed had a striking preference for the vanilla-flavored ketchup compared with those who had been breast-fed.[2] A new idea for Heinz? Endless commercial possibilities could be exploited if flavor companies knew all our earliest flavor experiences.

PERHAPS YOU ACCEPT MY ARGUMENT that children's responses to odors are learned and variable, but still question whether adult responses to "very bad" odors could really be due to learning; *how could anyone find the smell of rotting bodies okay?* But adults across this planet do not agree on what smells good and what smells bad—even for the stench of death. Culture, which conveys another form of learning, explains how and why.

The adage that *one man's meat is another man's poison* has its origins in astute observations of reality. Asians consider the smell of cheese to be hideous, yet Westerners regard it as anything from comfort food to a sumptuous indulgence. In contrast, the Japanese enjoy a meal for breakfast called "natto," a fermented soybean dish,

which this North American couldn't bear to bring near her mouth. Natto smells like burning rubber to me, and although burning rubber may not be an unpleasant scent to some, it is not an aroma that I connect in any way with eating. The fruit durian (also called jackfruit), which is found throughout Southeast Asia, is a local delicacy there, but when Westerners smell it they are repelled. In *A Natural History of the Senses,* Diane Ackerman described the scent of durian as a cross between "a sewer and a grave"[3]—a vividly ghastly combination—and yet thousands of people consume it daily and *like* it. If you're thinking that the example odors I have been mentioning really aren't *that* bad, and that there must be consensus on truly horrid stenches, this also doesn't seem to be the case. Fecal smells are not high on most North Americans' best smells list, but the Masai like to dress their hair with cow dung as a cosmetic color treatment, and to the U.S. military's great surprise, it has been impossible to develop a universal "stink bomb" to use for crowd dispersal, as a safer alternate to tear gas. In a recent study undertaken by the U.S. military, no odor tested, including "U.S. Army issue latrine scent," was found to be unanimously unpleasant across people from a range of ethnic groups.*

*The most recent research on stink bomb creation by Pamela Dalton of the Monell Center suggests that if you mix a cocktail of "noxious" and unfamiliar odors together, you are more likely to get unanimous dislike than if you use only one scent. The reasoning is that (1) it is harder to acclimatize to a mixture than to a single scent, and (2) if you have at least one odor in the mixture that is unfamiliar to at least one group of people, the mixture will probably also smell unfamiliar and hence be more likely to be considered objectionable. The key here is that what is *unfamiliar* will be more readily disliked than liked.

The scent of carrion has also been touted as one to which there *must* be innate abhorrence, but again we find that culture, in this case defined historically, refutes the presumption. In Europe, before the invention of refrigeration, rotted meat and fish were often sold. Although many recipes of the time offered suggestions for disguising the taste of spoiled meat, perhaps because of its prevalence or out of necessity, historical accounts indicate that many people actually *preferred* their meat putrid so that when it was served it gave off a strong, "high" aroma and therefore signified a richer and more robust meal.

So why is it that I like the smell of skunk while an Asian will categorically refuse Roquefort and others find the aroma of rotting meat and human waste acceptable? And how is emotion involved? A theory first formulated by Trygg Engen, the father of psychological research on smell, proposes that before you have experienced an odor it is inherently meaningless, a *tabula rasa,* a blank slate; however, once you experience it, the context (place, situation, person, or event) in which you perceive it and, most important, the emotional value of that context become attached to that aroma, and henceforth the odor takes on that emotional significance and meaning and becomes liked or disliked accordingly. The smell of coffee is stimulating and pleasant because the physical and emotional effects of drinking coffee have become attached to its aroma. This theory for how we acquire odor hedonic responses is called *odor-associative learning.*

Here is a classic example of odor-associative learning in action. Suppose that you have to undergo an unpleasant, anxiety-producing event, such as a surgical procedure in a hospital.

This is the first time that you have been to a hospital, apart from your birth, and when you enter it you notice its distinctive and *novel* aroma. First encounters, that is, novelty, are especially important in the development of odor preferences because if a smell is already familiar to you, you would already have associations with it. The issue of novelty is also why most of our odor preferences seem to come from childhood, because this is a time when most of our sensory experiences are new. Anytime in life that we encounter a new smell, emotional odor-associative learning can take place to determine our hedonic responses to it.

Forty years ago in the United States, "hospital odor" was typically a combination of standard-issue disinfectants, medicines, body odors, and ether. "Hospital smell" does not have to be the same concoction across time and place; the only requirement is that the aroma be unfamiliar before your visit to the hospital. The point is that although this scent is not inherently good or bad, the context you are in when you first consciously experience it is bad, and therefore this initially meaningless odor acquires the negative valence of your feelings. "Hospital scent" becomes associated to hospital feelings and through this emotional connection acquires its emotional and hedonic significance—*unpleasant*. Whenever you smell this scent again, your feelings of hospital aversion resurface, and since the location you are most likely to smell it in is a hospital where negative things are likely happening, this unpleasant odor association is further reinforced.

Hospital smell, and the general loathing of hospitals it brings, is well known to hospital administrators; as a means to counteract this, a tactic currently being used by some hospitals

is to utilize cleaning and deodorizing scents that are already familiar and "pleasant" to us. This is intentionally done to eliminate the formation of bad feelings attached to hospital smell. What is clever about this idea is that it is quite difficult to form a new association to a scent once it has been learned and first associations have already been made. Olfaction is unique among the senses in the strength with which first associations interfere with forming new ones. In practice, therefore, the familiar scent of vanilla would be difficult to pair with and then elicit "surgery worry."

The central tenet of odor-associative learning is that how you *feel* when you first encounter a particular scent determines your future hedonic perception of it. Odors that we like are ones that we first encountered in a situation where we were happy or are connected to something with positive meaning, and odors that we dislike were first encountered when we were in a negative emotional state or are connected to something with unpleasant meaning. Perhaps the best example to illustrate how emotional learning is behind our aroma preferences is the story told to me by a young woman who explained that she hated the smell of roses because the first time she smelled them was at her mother's funeral.

We can use the infants who like garlic to dissect this process in detail. These babies had mothers who ate a lot of garlic during their pregnancy and/or while they were breast-feeding, and thus their infants' first encounters with this scent were with Mama and with food. Eating has critical motivational value and so does Mama herself, signifying love, protection, affection, and nourishment. Therefore, when Mama is paired with a scent,

this scent becomes positive. These early maternal experiences also underlie why vanilla is typically touted as a scent with universal appeal. To the extent that this is true it can be explained by the fact that vanilla is a volatile flavor component of human breast milk as well as many milk formulas.

The fact that maternal diet can influence a newborn's flavor preferences also means that cultural differences in response to foods and aromas can set their roots prior to birth. A culture with a diet rich in spices will produce babies wanting curry with their mashed bananas, whereas a culture in which the diet is relatively spice free will produce babies who snub foods with seasonings.

So where do my responses to aquamarine, skunk, and creosote come from, and how do they fit the odor-associative learning explanation? The "special occasion-ness" of it all—being able to use my parents' deluxe shower and the pleasure of the new exotic shampoo that I had never experienced before—clearly initiated my love of aquamarine scent. Moreover, the escape from the gloom that I usually felt during those days made the happy feelings especially salient. Similarly, when I was in the car on that lovely summer afternoon and my mother exclaimed, "Oh, I love that smell," a link between my feelings for my mother, the bucolic context, and that specific aroma was formed. And so I love the smell of skunks. By contrast, creosote is unpleasant to me because of another car trip where I felt very queasy and hot and we were stuck in traffic while asphalt was being poured. The association between nausea and creosote scent instantly bonded. If the creosote and skunk car ride situations were reversed, I am sure I would love the smell of creosote and be nauseated by the scent of skunk.

CULTURE AND CONTEXT

Imagine the smell of burning leaves (my apologies to those readers who did not grow up knowing this scent). The smell of burning leaves is such a well-liked aroma to many that Christopher Brosius, the eccentric perfumer and founder of Demeter Fragrances, known for creating naturalistic and unusual perfumes, such as Dirt, concocted the fragrance Burning Leaves due to customer demand.* However, the real smell of burning leaves is actually full of noxious toxins and pollutants, which is why it is now illegal to burn them in most U.S. states. How can it be that so many people like such an unhealthy brew? The answer is in your past. Hearken back to your childhood and try to recall your first experiences with this scent to figure out why *you* like it. Perhaps it was connected to the fun of Halloween. Or it signaled the family festivity and food of Thanksgiving. Or maybe it was linked with a special time you shared with a parent or grandparent. Or it was simply the background aroma of carefree afternoons when the weather turned cool and beautiful colors stippled the trees. Have I struck a chord?

Since it is now illegal to burn leaves in most U.S. states, children growing up in America today are unlikely to encounter this scent, and if they do, they will probably know that burning leaves emits harmful chemicals—and therefore is "bad." If we

*Demeter's Burning Leaves is now called Bonfire.

fast-forward twenty years into the future and give young adults the smell of burning leaves to evaluate, would they like or dislike it? Would they even know what it was? Will there be any demand for Demeter's perfume of burning leaves in twenty years?

In addition to learning through our own experiences, culture provides a general umbrella under which a variety of our proclivities are acquired, and the differences between cultures don't need to be large for large differences in aroma preferences to be seen. Consider Britain and the United States. A supermarket poll reported by the *Times* of London (January 2004) revealed that in Britain the top ten favorite smells were: fresh bread, frying bacon, coffee, ironing, cut grass, babies, the sea, Christmas trees, perfume, and fish and chips. We may agree with some of this list, but I can guarantee that someone from Britain won't agree with an American top ten. Wintergreen mint is a favorite American scent, yet it is highly disliked in the United Kingdom.

Why don't the British like the smell of wintergreen candy, while Americans do? In the mid-1960s, a study was conducted in the United Kingdom where adult respondents were asked to provide pleasantness ratings to a battery of common odors.[4] A similar study was conducted in the United States in the late 1970s.[5] Included in both studies was the odor methyl salicylate, the scent of wintergreen. In the British study, wintergreen was given one of the lowest pleasantness ratings out of a sample of many odors, whereas in the American study it was given the highest rating of the whole sample set. How could it be that two cultures separated by a common language could show such big differences in odor preferences? The answer lies in history. In Britain, the scent of wintergreen is used in various medicaments, and

particularly for the participants in the 1966 study was characteristic of rub-on analgesics that were popular during World War II. Conversely, in the United States, the smell of wintergreen is almost exclusively found in candy and gum, items with sweet, positive experiences attached to them. The British don't like wintergreen because it brings up feelings and associations connected to medicines and wartime, whereas North Americans like it because it conjures associations of sweetness and treats.

Cultural differences in experience also explain why a candidate aroma for the universal stink bomb has not been found. Imagine that you lived in a culture where modern sewage systems didn't exist; you would be very familiar with aromas such as "U.S. Army issue latrine scent," and they may signify nothing more than daily life—and be as ubiquitous as the smell of gasoline is for us. This "ubiquity" is in fact why Beijing lost the bid for the 2004 Olympics. In 1993, when the bid was made, only 30 percent of Chinese homes had private toilets. Instead, public toilets were the norm and unlike the restroom in your local park, these public lavatories were pits in the ground, in an open, walled-in room, with no individual stalls and no running water. A consequence of the omnipresent public lavatory is that the air that hung over Beijing was conspicuously heavy with toilet aroma; imagine what it would be like in the summer. After the bid loss and realization of the need to renovate the conditions of public lavatories, the Chinese government began spending taxpayers' money on installing modern toilets. Surprisingly, many people complained that their money would be much better spent elsewhere. In other words, the average Chinese citizen really didn't mind the stench, not to mention the lack of privacy. The

public outcry was ignored, and by 2004 many public lavatories had been eliminated and 80 percent of homes boasted private facilities. The Chinese government has vowed that by 2008 no one in Beijing will be more than an eight-minute walk from a flush toilet.

How about an even more dreadful example—the smell of a burning body? This is a scent that most Westerners could never conceive of liking. But what if you live in a country where public cremations are the typical ritual for laying the dead to rest, such as in India? In this case the scent of a burning body would be familiar, and as indicated in the previous example, odor familiarity is highly correlated with odor acceptance. Moreover, many ritual cremations are accompanied by celebration—like being at an Irish wake—and if this were your experience, festive emotions would become attached to this smell, and hence you would have actually learned to like it.

By contrast, lack of personal history or cultural connotations offers a glimpse into one's "natural" response to an odor, and I recently had the opportunity to observe this with my favorite contentious aroma—skunk. A few summers ago some skunk-naïve Swedish colleagues were visiting me in Rhode Island and we walked down a street where a skunk had recently declared his presence. Although the degree of liking varied, none of my visitors said that they found the scent unpleasant. People from Europe, where skunks are not indigenous, typically do not find this odor to be bad unless previously warned.

You may be wondering how an animal whose natural defense against its predators is to repel them with its "bad" smell would not elicit this reaction from us. The reason is because

the skunk's natural predators are hardwired to be repelled from this scent, but we are not one of them. What makes an animal have a hardwired scent response or not has to do with what kind of ecological habitat it calls home. We are "generalists," animals who can successfully exploit any habitat on Earth, and as such we have to *learn* what is good and what is bad. The scent of "poison mushroom" in one locale could be the scent of "nutritious food" in another. However, animals who are "specialists," who live in defined and specific ecological niches, are born knowing what scent to approach and what scent to avoid, as you will soon see. The skunk and its natural predators are specialists, and to aid the skunk's survival it evolved a mechanism to deter its would-be menacers—that aromatic spray. There is, however, a feature of skunk spray that will automatically repel us, too, but you have to be up close and personal. Skunk spray contains chemicals that activate the tactile pain system around our face. Skunk spray in your eyes will burn and encourage you to get away from it, but not because of the smell per se.

MY LABORATORY HAS DIRECTLY TESTED the odor-associative learning theory. In a recent study, we paired several unfamiliar odors with either a good or bad emotional experience: playing a frustrating computer game and losing play money, or playing a fun computer game and winning real money. We then compared people's ratings of the odors before and after the emotional association. The computer game experiences were hardly intense compared to real-life travails;

nonetheless, we found that after being paired with the annoying computer game, the odor was disliked more than it had been to start with, and after being paired with the winning game, it was liked more.[6] In another study examining physiological responses to smells, researchers found that the scent of eugenol, which is the "clove" odor found in dental cement, was evaluated more negatively and elicited autonomic fear responses, such as sweating and rapid heartbeat, among people who had bad experiences at the dentist, while unafraid, cavity-free participants showed no such reactions.[7] For fearful patients the association of the dentist's drill had become connected to the coincident smell such that eugenol itself could subsequently elicit fear reactions. For those participants who hadn't had any painful fillings, and hence bad associations with eugenol, this scent was just a neutral, nonmeaningful aroma.

Still have your doubts? You may be thinking, *how is it that I have opinions about odors that I have not had dramatic emotional encounters with, or for that matter, may have never even smelled?* Learning can still explain these responses, in these cases learning through social transmission and cultural norms. What your culture tells you is good or bad becomes incorporated into your perception lexicon, even if you haven't had direct experience with the object in question. An Asian may have never eaten a slice of cheese but will still believe that it smells bad. We have also implicitly learned the norms for basic safety and health through cultural transmission. You don't have to have been trapped in a burning house to know that the smell of smoke means fire. Learning that smoke signals danger is sufficient.

"Smell Arithmetic"

The British intellectual Sir Francis Galton (1822–1911), known for many eminent distinctions, including being the half cousin of Charles Darwin, decided to do a little experiment and taught himself to do "smell arithmetic." Galton associated specific smells with specific numbers,—for example 2 whiffs of peppermint = 1 whiff of camphor—and claimed that he could add and subtract quite well with imaginary scents, but that multiplication was too difficult.

EXCEPTIONS TO THE RULE

Despite all the evidence for odor-associative learning, a test ruling out the possibility of an innate response to *some* aroma or another, such as Grenouille's magical attractant elixir in the novel *Perfume*,[8] has not been done. Therefore, the theory of learned olfactory response is not irrefutable. Moreover, there are two physical factors that influence odor hedonic perception that also qualify odor-associative learning: trigeminal stimulation and genetic differences. Trigeminal stimulation refers to the fact that almost all odors have a *feel* to them as well as a smell. For example, menthol feels cool and ammonia feels burning. What produces these feelings are the temperature, touch, and pain fibers of the trigeminal system in our face and nose. Odors vary in the degree to which they stimulate the trigeminal system. Some, such as rosy floral scents, do so very mildly and are hardly felt at

all, while others, like skunk spray in your face, can be powerful enough to make you cry. Indeed the reason your eyes tear when you chop onions is because of activation of the trigeminal nerve, and this is why skunk spray near your eyes would be immediately repellent. The trigeminal system is also why you sneeze when you sniff pepper and why your mouth burns when you eat habaneros, and it is even involved in the intense pain of migraine headaches. "Smelling salts" are actually a heavy dose of trigeminal stimulation and are made from ammonia combined with eucalyptus oil. The trigeminal irritation from ammonia and eucalyptus is what revives a person from a stupor.

Trigeminally irritating odors that elicit pain concomitant with odor perception induce immediate avoidance responses and appear to us as instant scent disliking. However, this dislike-withdrawal from the odor is due to chemical pain becoming associated to the chemical's scent. Skunk spray "scent" isn't painful, but its trigeminal component is. Instantaneous withdrawal from stimuli that are trigeminally irritating is adaptive for us, as many toxic substances strongly activate a trigeminal response. It would be fascinating to do an experiment in which the trigeminal component could be subtracted from a chemical like ammonia to see how liking for the pure *odor* of ammonia might change.

A second consideration is the individual differences in our genetic makeup. Variability may exist in the specific genes that code for olfactory receptors between individuals. It is quite likely that you and I don't have the exact same olfactory receptors in action. We also know that some people suffer from "specific anosmias"—the inability to smell one particular scent with otherwise normal olfactory function. Because individuals can

differ with respect to the functioning of their olfactory receptors, biological (i.e., inborn) factors could be an influence in olfactory *perception*. Therefore, people who like the smell of skunk may do so in part because they are missing receptors for detecting some of the more pungent volatiles of its bouquet. Or because some of their receptors function differently, yielding a slightly different olfactory experience from those of people who insist that this scent is unquestionably offensive. In support of such a conjecture, Chuck Wysocki of the Monell Chemical Senses Center has found that identical twins always have the same immediate hedonic response to the smell of cilantro (also known as fresh coriander or Chinese parsley), either loving it or hating it, while fraternal twins do not. However, one of the snags with this finding is that the twins' past history with cilantro was not obtained. Identical twins tend to have more experiences and environmental influences in common than fraternal twins. Therefore, identical twins are likely to have shared a common past experience with cilantro, such as getting sick after eating a Mexican meal, and learning may still be at the root of this finding. Apart from this example, there is no evidence as yet for how or whether genetic differences might influence odor perception.

NATURAL HISTORY

Associative learning is the best explanatory model for our odor penchants. But why would it be that our responses to odors are learned and not innate? Does this make sense from an adaptive perspective? In other words, is it good for the survival of the species?

As mentioned earlier, "specialist" species live in restricted and specific habitats, eat only a few types of foods, and are prey to only a small set of local predators. The panda bear with his bamboo exclusive diet is one extreme example. From an evolutionary perspective, it would be adaptive for specialists to have hardwired responses to particular odors. If the panda didn't know that only bamboo was food, he would die from eating the wrong things. Evidence for specialist approach-avoid behavior has been found in a number of studies of animal behavior. For example, both lab-born and wild-reared ground squirrels show a discriminative defensive response to their natural predators, rattlesnakes, as compared to gopher snakes. This discrimination is made on the basis of subtle scent cues that differentiate the two snakes. The fact that this specific behavior is seen in both lab and wild squirrels suggests that their olfactory responses are innate.

In contrast to specialists, humans, along with rats and cockroaches, are the world's most successful "generalists"—animals that can exploit any habitat. If we were hardwired to only accept fishy smells as food, we would never have survived in the savannah. Thus for generalists, the adaptive response is to learn how to respond appropriately to a particular smell source when it is encountered, and not to follow a preprogrammed set of responses to particular odors. This is also important because the relationship between an aroma and a food or predator source can be random. From an evolutionary perspective it is adaptive for animals who are specialists to have innate olfactory responses to prey and predators, whereas animals who are generalists, such as us, should not be hardwired to know particular odors as food or poison or friend from foe. Rather, we should be

hardwired to rapidly and readily learn what scents signify good and what scents signify bad, based on experience.

One of the best natural examples of adaptive and very rapid odor learning is the case of *taste aversions*. Being sick just once after ingesting a certain food causes avoidance of the substance that triggered the illness, and especially its scent, for a long time thereafter. You may be familiar with your own personal story of such an occurrence. Here's mine. One night when I was about nine years old my parents were going out for the evening and my brother and I were allowed the special treat of pizza for dinner. My parents decided to choose pepperoni. I had never had it before but knew it was the top choice of my classmates and eagerly awaited the delivery. Minutes after the doorbell rang, my brother and I devoured the pizza with delight. Later that night I began to have stomach cramps, then diarrhea and vomiting, accompanied by a fever, and these symptoms persisted for several days (my brother was fine). Although I well understood the diagnosis of stomach flu and that the pizza hadn't been poisonous, I could not bring myself to go anywhere near pepperoni pizza for a very long time. Indeed, for years after, the smell of pepperoni pizza would drive me out of a room. And to this day I find myself bizarrely reluctant to eat a slice of pepperoni pizza if it is offered. No other pizza topping ever brings up that feeling of caution; indeed BBQ chicken pizza is one of my favorite treats.

Intellectually knowing that it isn't a particular food that has made one sick does not override the instinct to avoid something that has been paired in time with getting sick: specifically, stomach illness. The "irrational" override of intellectual knowledge is based on our primeval past. Our ancestors were more

likely to be eating a poisonous mushroom when they vomited after a mushroom feast than coincidentally getting the stomach flu. And you don't want to keep repeating the mistake of being poisoned. Rather, you should quickly *learn* that mushrooms with *that* smell should be avoided!

For generalists, as humans are, pepperoni or mushroom are not inherently meaningful smells in themselves; rather, their association to pleasure or pain is what then makes them interpreted as good or bad in the future. For generalists like us, it is evolutionarily adaptive that the olfactory system is *not* predisposed to like or dislike any particular odors, but rather very ready to become associated with what is good and what is bad based on experience.

The neuroanatomy of our sense of smell also shows how odors are inherently primed to become connected to emotional meaning. The piriform cortex, comprising the olfactory and limbic structures, is the area of the brain responsible for processing smell, and it is also the area of the brain where assigning positive or negative value to things takes place. Furthermore, the amygdala, which is directly connected to olfactory processing, is critical for emotional associative learning. In studies with another very successful generalist, the rat, it has been found that when the amygdala is eliminated, olfactory learning does not take place. A rat cannot learn the difference between a nutritious lemon drink and a poisonous strawberry drink without its amygdala.

If we have any innate response to odors, it is caution. Infants and young children show wariness when exposed to unfamiliar scents, regardless of whether these odors are classified as pleasant or unpleasant by the adults around them. This uneasiness in the face of uncertainty is adaptive. Without the predisposition for caution, our ancestors would not have survived. The reason we each like or don't like the scents in our world is because of our specific personal and cultural histories with these scents and how we then thusly characterize and connote them. *Nothing stinks, but thinking makes it so.*

PSYCHOLOGICAL TWISTS IN ODOR PERCEPTION

Learning provides the mechanism by which we come to know an odor as good or bad, but it is not the only factor that influences our perception of scents. Trigeminal stimulation and our genetic makeup may intercede, and as you might expect, psychological factors can play a role as well. Simply being in a good or bad mood can affect how pleasant you will find a smell to be. If you are in a good mood, a neutral* odor, such as rubbing alcohol, smells more pleasant than if you are in a bad mood. This is yet another example of the fundamental connectivity and interdynamics between emotion and olfaction.

Our personality predispositions also lace our responses to smell, as they do our responses to all sensory stimuli. People with emotionally unstable personalities, sometimes called *neurotic*, tend to be more sensitive to noise, pain, unpleasant scenes, and bitter tastes than emotionally stable individuals. These emotionally

*"Neutral" refers to the averaged rating of an odor being in the middle of a scale anchored by "very pleasant" and "very unpleasant." It does not mean that all people find the scent to smell neutral.

excitable types are also more responsive and sensitive to odors, finding them more delightful or disgusting than their calmer counterparts. However, some studies suggest that it depends on what the odor is and whether you are a man or a woman.[9]

I have already alluded to the fact that language plays an intricate role in our perception of scents. Its force can be subtle but also powerful. As you now know, skunk odor is particularly interesting to me, and so I recently conducted an informal survey among my American colleagues to see how they reacted to this scent and how they *described* it. I was amazed to find that in addition to the great variability in liking, no two people used the same words to describe what skunk smelled like to them. I heard everything from "it smells like lemonade" [*sic*] to "it smells like sweaty socks." My own personal description, which no one else seconded, is that it smells like "a mixture of chocolate and garlic." Does what I call chocolate-garlic actually smell the same as what another person calls sweaty socks or lemonade? At this time, we have no way of knowing.

This linguistic issue illustrates one of the central problems in our psychological understanding of odors. We don't learn about odors the way we learn about other objects and experiences in our world. Our parents and teachers very rarely give us any "smell and tell" lessons. Therefore, most of us have acquired idiosyncratic connections between scents and words. Even if you did receive various declarative labels for assorted odors, your name-odor connection may still be relatively random. Suppose one day when you were four years old, you were walking by a steam grate with your grandfather and he said "oh, that smells like laundry," or he could have said "that smells like chlorine," and then again he might have said "it smells like steam." Whatever word was supplied will go on to be the label you use to refer to that scent in the future, unless you happen to be corrected, which is unlikely. So you can see how the word that is attached to a scent can be arbitrary and knowing whether it is the word or the perceptual experience that is different between individuals is currently an empirical conundrum.

Our expectations and the situational context we are in can also drastically influence what we construe an odor to be and therefore what hedonic properties we assign it. If you are walking by a garbage Dumpster and encounter a particular aroma with a few sharp notes, you are likely to perceive the smell as unpleasant; however, that exact same mixture of chemicals hovering above the cheese plate at a French restaurant might inspire salivation. Mark Twain gives a striking literary anecdote to illustrate this point in *The Invalid's Story*.[10] In this short story, a stowaway takes actions that eventually lead to his untimely death, because he convinces himself that the sack beside him contains a dead body, when in fact all it contained was "a lot of innocent cheese." In this situation, a suspicious context, and a burlap sack of a particular but ambiguous shape, created a set of expectations that influenced odor perception and even inspired drastic behavior.

A real-life example of how visual context can dominate in odor perception that is well appreciated by the flavored-beverage industry is the *lack* of complaints that are received when the occasional color-flavor error occurs. For example, if the purple-colored "grape" drink is accidentally flavored with cherry (not grape), the phone almost never rings. A wonderfully

irreverent test of this same type of color deception even conned French wine experts. When the experts were given a white Bordeaux that had been adulterated with red food coloring to taste, they described it exactly as they would a fine red wine. And when the same white wine was given to them without any added coloring, they used all the descriptors they normally reserved for a lovely white Bordeaux. Helga Griffiths, a German conceptual artist who specializes in creating sculptural installations with scent, recently told me that casting a green light over a museum display emitting a grassy odor induced spontaneous remarks from spectators such as "this smells like grass," but when a red light was shone over the same display the scent provoked remarks like "this smells like strawberry."

LIKE VISUAL CUES, language also has powerful and unusual control over odor perception. My laboratory found that we could produce olfactory illusions by merely changing the verbal labels that were provided when someone smelled an odor. We tested five different odors and found that when we gave the same odor either a positive or negative name, such as, "Parmesan cheese" in one case and "vomit" in another,* we could induce entirely different perceptions of the scent and in essence create olfactory illusions. Not only did people react entirely differently to the odor based on its label, either saying they liked it very much and would eat it (in the Parmesan case) or that they were disgusted by it and wanted to leave the room

*For the mixture of iso-valeric acid and butyric acid.

(in the vomit case), they also would *not* believe that it was the same odor that they were smelling on both occasions.[11] So even though we may have initially learned that a certain scent is good because it is a tasty food, like cheese, that exact same scent can be turned into something bad simply by the associations evoked by the situation you are in, the words used to describe it, or the expectations you have while smelling it.

Why are we so easily deceived by words and visual context when it comes to the perception of smells? The reason is because scents are invisible and we are obsessed with identifying the objects in our world, and so with enigmatic smells we look to words and scenes for help. If the context offers a plausible explanation, we will go along with it to a greater extent than relying on the smell alone for what it is and whether or not we like it.

Not all odors are equally susceptible to illusory suggestion, however. The ease with which our noses can be deceived depends on how ambiguous the scent is. If I gave you *orange* to smell and told you it was "tangerine," you would likely believe me, but you might be a little skeptical if I called it "lemon," and you certainly would raise an eyebrow if I called it "garlic" or even a different type of fruit such as "banana." This is because the smell of orange is well rooted verbally and perceptually—it is not ambiguous. Odors with clear and obvious sources are less vulnerable to verbal illusory tricks. But odors that could be one thing or another depending upon the context you find them in can be perceptually twisted and turned in myriad directions.

Words not only create aromatic illusions; the absence of words can make real odors unsmellable. Several years ago, researchers in Britain did a test where an unusual odor, 5-alpha-

androstan-3-one, was pumped into the air of a laboratory and those exposed to it were monitored for any signs of detecting it. The researchers found that participants produced physiological signs that were consistent with having detected a scent, but when asked if there was any smell present, most of them denied smelling anything. Later when the same individuals were given the odor and told its chemical name, those who denied perceiving it earlier suddenly recalled having noticed it in the room.[12] Words can manipulate what it *is* that we smell and, when no words are available, we may not smell a real scent.

In all languages that have been studied, there are fewer words that refer exclusively to the experience of fragrance than there are for any other sensation.[13] In English, *stench, stink, redolent, aromatic, pungent, fragrant, smelly, odiferous,* and *scented* exhaust the dictionary of words that specifically describe odor experiences. More common terms like *floral* or *fruity* are references to the odor-producing objects (flowers and fruits), not the odors themselves. We also borrow terms from other senses—chocolate smells *sweet,* and grass smells *green*—to describe our aromatic encounters. But we do not need words to experience olfactory sensations or to know how to react appropriately to them. Our experience of aromas can reside in a pure wordless smell-scape, and in fact is often purer and more exquisite when it does so. Wine connoisseurs begrudgingly admit that ignorance can be more blissful than the weight of their knowledge. Having a rich vocabulary to describe the flavor nuances of a vintage can actually diminish the richness of the experience, because it forces the expert to dissect and analyze a sip into parts that are much less pleasurable than the whole.

The situation or context we are in is also important because it determines what odors we will accept where. Certain smells, like certain colors and certain sounds, go together with certain things, yellow goes with pineapple, rings go with telephones. But this is not an innate or absolute truth. What sights, sounds, and smells go *best* with what objects is based on learning. I learned that shampoos had sweet scents in certain perfume and outdoorsy categories. And although there are many other sweet smells that I like, chocolate chip cookies for one, because of my early education I wouldn't want cookie dough aroma in my shampoo. Just as with the individual vagaries in the acquisition of odor hedonics, conviction in the congruence between smells and things can be quite idiosyncratic and is often a mystery to the smeller herself.

Marilyn Singer, the children's book writer, recently sent me an e-mail asking why she likes floral-scented candles but not fruit-scented ones, even though she likes both floral and fruity aromas. I wrote back that my guess was that when she first experienced scented candles they were floral not fruit scented, and as a consequence she *learned* what scented candles *should* smell like. She likes floral candles because they smell "right"—what scented candles ought to smell like (for her)—and she dislikes fruity candles because they smell wrong. In the case of fruit-scented candles, the scent and object are not congruent for her.

And how is it that our likes and dislikes of odors stay the same over time? You like the scent of lilac and dislike cigarette smoke time and time again. The same associations of happiness or disgust are elicited each time. Or are they? Did you once find cigarette smoke appealing, say when, or if, you were a smoker,

but now as a nonsmoker find it offensive? Or maybe you disliked cigarette smoke as a child, but it became a scent marker for your father and it now elicits wistful and pleasant connotations. Intrinsic to the fact that we form associations to odors that determine our hedonic responses to them is that an association is a type of memory. An association can be vague and you may only *feel* that a certain smell is good or bad, with no specific recollection in mind, but it can also bring forth complex and intense personal memories. The association that made the scent of rose unpleasant for the woman who first experienced it at her mother's funeral is also a memory of her mother's funeral every time she smells it. And more than any of our other sensory experiences, smell is exceptional in its ability to conjure emotional memories and viscerally transport us in time and place.

CHAPTER 3

SCENTS OF TIME

Wherever I am in the world, all I need is the smell of eucalyptus to recover that lost world of Adrogue, which today no doubt exists only in my memory.

—JORGE LUIS BORGES

One day my cousin Amanda visited some friends whom she had not seen in a long time. The trip involved a considerable drive and it was decided that Amanda would stay the night. In return for her friend's hospitality, my cousin insisted on doing the dishes after dinner. As she bent over the soapy water and began the mundane task of scrubbing, Amanda was suddenly overwhelmed by inexplicable emotion. As if out of nowhere a bullet had hit her—so intense were her feelings that she found herself weeping. For several minutes her head hung over the sink as tears streamed down her face; she felt ridiculous, confused, and overcome with a strange nostalgic sadness all at once. Her friend watched, stunned and concerned; "*What's wrong? What's wrong?*" she kept asking. Suddenly, Amanda