FOODS

HOW TO STOP OVEREATING

THAT

AND EAT LIKE A NORMAL PERSON

LIE

LIBBY MARAMA GRACE

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How to Stop Overeating and
Eat Like a Normal Person

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I am deeply grateful to all of those whose work is referenced within.

Behavior Change Requires a Change of Mind

I spent years dieting, losing weight, gaining weight, restricting, binge eating, and everything in between. Then I spent years trying to *stop* dieting, yet somehow failed at this, too. Through it all, I became fatter, sicker, and more and more ashamed. At last, drowning in a pit of despair and feeling as though the situation might very well be hopeless, a sequence of ideas slotted together in my mind, and I suddenly saw the way out. As a consequence, returning to a healthy weight became not only achievable but *easy*.

The method did not involve resisting cravings or suffering feelings of deprivation. It did not involve restricting calories, carbohydrates, fats, or proteins. Nor did it involve exercise routines, nutritional supplements, or forced 'habit change.' Instead, something quite simple happened: what I thought about certain foods changed. And as a consequence, *I no longer wanted them*.

It wasn't so much a miracle as it was a light turning on. There *is* a way to end food-related obsession, maintain a healthy weight, and feel completely normal around food again. It requires learning something new about what I call 'deceptive foods.'

To understand what we are trying to achieve, consider the case of a man who knows that cigarettes are killing him. This man may hate the effects of the cigarette, despise himself for continuing to smoke, and know very well that his health and life depend upon a behavioral change. Yet, the problem is he doesn't know how to make himself *do* it. You see, although he hates the *effects* of the cigarette, he simultaneously *likes smoking*. Thus, whenever he attempts to stop, he feels deprived – as though he is missing out on something good. Even if he desperately yearns to be free of the negative health consequences of smoking and the shame his continued behavior brings, as long as he *still wants the cigarette,* he remains ensnared in an internal battle of wills.

The issue is not that the smoker doesn't know what to do (stop smoking) or even that he doubts this is the best course of action. The problem is that part of him *doesn't want to do it*.

What the smoker needs is not so much a practical method of stopping, but a new way of looking at the situation – a more accurate way – so that he *no longer desires the cigarette*.

The moment he achieves this mindset, the jaws of the trap open, and walking away from the cigarette becomes not only possible, but *easy*. This is because, as the great stop-smoking guru Allen Carr discovered, leaving behind something that you no longer want is no hardship at all.

Of course, in the case of overeating, the situation is not nearly so clear. Unlike smoking, it isn't widely accepted that anything in the food supply is addictive at all – nor is it obvious what this addictive element might be. For example, if sugar is the culprit, why do so many studies tout the benefits of eating fruit? If refined carbohydrates are to blame, why do many populations consuming large amounts of white rice remain lean?

Furthermore, unlike smoking, it isn't at all clear whether abstinence is the best approach. Attempting to abstain from every 'problematic' food can seem impractical, unworkable, or downright impossible. In short, when it comes to overeating, neither the culprit nor the cure is clear.

We will get to these questions soon. For now, just imagine that someone *could* wave a wand and take away every speck of desire within you for certain foods. Can you see that this would immediately solve the problem?

The moment you no longer want the thing that is harming you, you're free.

Changing Your Mind Requires New Information

Desire is not a fixed, constant state. Your desire for any particular item fluctuates as your knowledge of a situation changes. The human brain is responsive and adaptive, calculating and recalculating needs so that you are primed to take the best course of action at any given moment.

To understand how new information can alter the way you respond to the same circumstance, consider the following thought experiments:

- You are walking alone through a park at sunset. Upon hearing a rustling in the bushes, your heart starts to race, as you imagine a predator lurking. When a rabbit bounds out of the undergrowth, fear instantly transforms into relief.
- You are at an office party, seated opposite an attractive colleague whom you have been dreaming of for months. When they begin to play footsies under the table, you feel a rush of euphoria. This emotion ceases immediately when you discover it is not your crush but the office sleaze.
- You have a dull ache in your side after pulling a muscle. The ache is annoying but not severe, and you mention this in passing when seeing your doctor about

something unrelated. After examining you, the doctor says there is a small chance the discomfort is caused by a tumor rather than a strain. Immediately, the dull ache throbs and swells into a panic-filled pain.

These examples illustrate that it is more than possible to respond to the *exact same stimuli* in a different way when new information comes to hand. There is nothing you can do to *will* yourself to think about food differently unless this is accompanied by new information that reorganizes your existing interpretation of the world. Behavioral change occurs when *what we know* changes – when new information shifts or dismantles prior beliefs and understandings.

This book offers a new way of looking at eating behavior – a more accurate way. It explains how sensory deception within the food supply provokes measurable changes within taste and smell receptors and how this undetected bodily manipulation leads us to *misinterpret what is happening*.

It can seem impossible to contemplate at the outset, but there *is* a way to escape the endlessly demoralizing cycle of losing and regaining weight. It involves changing how you define and view the substances that are to blame.

This approach works because all addictions have at their root the same fundamental error in perception. And when this error is corrected, you are free.

Who am I?

I am a mother from New Zealand. I have no relevant work experience or nutritional qualifications (I have two degrees in a field completely unrelated to nutrition). What I do have, however, is almost two decades entangled in what can only be described as a dietary nightmare…and the complete and utter joy of being free of it.

This is not my autobiography, but by way of introduction, I will offer a brief summation of my dietary history and the events leading up to the moment when the final pieces of the puzzle fell into place.

I began dieting at age seventeen, abstaining from breakfast and lunch on school days without my parents noticing. Such strategies are now known as 'intermittent fasting' or 'time-restricted feeding,' but back then, I knew it simply as *not eating*. My parents did not own a bathroom scale, so I could not easily measure my weight loss progress, and I soon gave up on this endeavor and returned to eating as I had always done.

My next serious dieting attempt began at age nineteen while at university. I had little nutritional knowledge (there was no internet in those days to conduct research, and I was too embarrassed to borrow weight loss books from the library). From popular magazines, I learned that fat has more calories per gram than carbohydrates or protein and was informed that restriction in both calories and fat was the answer (it is not). For breakfast, I poured a drizzle of fat-free milk upon manufactured cereal and stirred it around so the bowlful became mildly damp. I purchased scales, drew a graph, and tracked my weight loss weekly. I lost 37 pounds (17 kilograms) in three months. This left me at the very bottom of the normal BMI range. I was not thin enough to qualify as anorexic, but I no longer menstruated, needed a heater even in summer to keep warm, and was once so fatigued that I passed out in the shower.

At age 20, I embraced vegetarianism, combining this with strict calorie counting. I had read that 1,200 calories was a good daily target for a dieting female (it is not – to put this ridiculous total in perspective, this is fewer calories than is needed to sustain many active 2-3 year old children).[1] Wanting to ensure that I did not exceed this intake, I decided to eat 1,200 *kilojoules* instead (this is approximately 290 calories). I rationalized that this would help me lose weight faster. During this period, I became intimately familiar with the calorie value of virtually every food.

For obvious reasons, consuming a daily target of 290 calories was doomed to fail, and this is where my appetite really seemed to get 'out of control.' During dietary lapses, I would consume anything I could get my hands on, eating vast quantities of food in horrifying combinations.

I played out versions of the above over and over again until age 23, when I introduced exercise. At one point, I ran every single day for 409 days in a row, often for more than an hour at a time. Sometimes, my eating would feel 'under control,' at other times, it would not.

During this period, I began reading frantically, devouring every diet-related book I could find. I also read about those with eating disorders and discovered the rather terrifying notion that *something might be wrong with me*.

In the years to come, I broadened my reading to cover topics about depression, behavior, decision-making, and addiction. With the advent of the internet, I began scouring websites, blogs, forums, and scientific papers for anything that might offer a clue as to how I could get my eating and my weight 'under control.' At various points, I tried diet pills (the kind that purportedly fill your stomach with fiber), hypnosis, extended fasting, and low-carbohydrate diets.

Eventually, at age 28, I thought I had stumbled upon the holy grail. I finally understood the value of nutrition and had worked out that feeding my body wholesome, natural foods from all food groups allowed me to eat until I was satisfied while losing weight. I devised a home exercise plan, coupled with a running schedule, and at last became fit and lean in a way that felt manageable. I consumed a meat and fat-rich diet, along with lavish quantities of fruits, vegetables, full-fat milk, eggs, nuts, and whole grains.

Much of the knowledge I had acquired by this stage was invaluable, but I still had the enemy squarely in the wrong corner. I considered the problem to be an addiction to refined carbohydrates, and I believed that addiction meant a *lack of control over these things*. I feared that if I consumed just a little white sugar, white rice, or white flour, I would tumble spectacularly from the wagon and eat much, much more. I believed this because, on the rare occasions that I consumed these things, this is exactly what I did.

About a year after the birth of my first child, by which time I had fallen from the wagon and gained weight once more, I began eating a 'normal' diet combined with reasonable quantities of whole foods and fresh smoothies.

Suspecting that something in my eating behavior had gone horribly wrong and not wanting to introduce disordered eating patterns to my children, I vowed, with increasing fervor, to eat *normally*, aiming to consume the generally wholesome (but imperfect) diet that I had eaten as a young child.

Unfortunately, this strategy did not reliably result in weight loss, and there seemed to be no clear definition of what 'normal' *was*. As such, I eventually resorted to restricting my intake. And, as with every attempt prior, I soon put all the weight back on and more.

Finally, I abandoned the idea of *any form of dietary restriction*. By this stage, I felt as though I hated dieting with every cell in my body. Yet, despite attempts to repeatedly nourish myself for years on end, it seemed as though I had acquired a persistent overeating problem – a behavior that gripped me in a way that only felt like an addiction.

After the birth of my second child, by which time I was at my highest weight ever, I had a permanent tug-of-war in my brain.

As the years passed, attempts to reform my eating became fewer and farther between. It seemed increasingly difficult to summon the strength to start again. And, as my weight climbed, despondence, shame, and self-hatred grew.

At last, after years of desperate research and personal trial and error, the final pieces of the puzzle began to fall into place. A key insight came in the aftermath of a personal health scare brought on by my poor diet. As the health scare unfolded, I promised myself that this was *it*. I made a vow like I had never made before and prayed to God, despite not being religious, vowing with every speck of my being that, *this time*, I would change.

What horrified me was that I did *not* change. Although this event appeared directly attributable to my diet, I was soon continuing on as if it had made not an ounce of difference.

The utter horror that I would pass through such a situation and then *keep on going* with the same damaging behavior, with barely a blink of hesitation afterward, made it terrifyingly clear that nothing was going to stop me.

By that point, I felt as though I had exhausted all of the known nutritional strategies – had tried every viable weight loss approach known to man. It seemed, at some level, that I knew *what* to do (eat less junk food) but that I could not or would not do it.

For years, I had hoped that some external event might spur me into action because earlier dieting attempts were often made in response to a particular life change. But now it seemed evident that nothing was going to throw me from this awful rollercoaster that I had climbed upon.

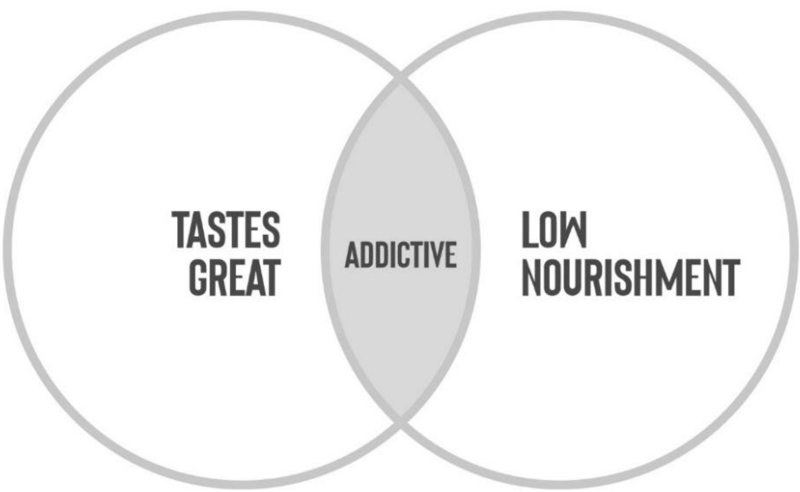
About a month after this event, by which time my junk food intake had escalated above previous levels once more, I came to the indisputable conclusion that if I wanted to fix this thing, it was going to have to be up to me. The world would not rearrange itself into a circumstance that would propel me to change. *I would have to do it.*

This prospect left me blanketed with fresh despair and hopelessness. It seemed, by this stage, that I had lost all shred of food-related self-discipline and willpower. I broke dietary promises to myself so frequently that I don't think I even believed my own word anymore.

But despite fearing that the situation was hopeless, I sat down, pulled out a piece of paper, and began to bullet-point the things about the situation that I believed were true.

You see, the one thing I clung to was that something so *fundamental to life as eating* could not possibly be so complicated that it was beyond me. I had excelled academically, had a great childhood, and a rewarding career. It seemed infeasible that I could not do something so basic as feed myself appropriately. I desperately clung to the notion that *there must be something I wasn't understanding*.

And as I jotted down ideas on that piece of paper, one tiny fact poked its head out at me – something that, until that moment, I had not seen. Fleshing the idea out further, I drew a diagram with two overlapping circles. Inside one circle, I wrote, 'tastes great,' and inside the other, 'low nourishment.'



As I stared at that diagram, it occurred to me that all the foods that were killing me were in the central overlapping region.

Of course, during my extreme dieting phases, I had binged on anything and everything I could get my hands on. For example, I once ate an entire week's supply of fruit in one sitting, followed by a whole cooked chicken. On other occasions, I ate entire batches of fat-free, sugar-free muffins and whole loaves of freshly baked bread. This is just the tip of the embarrassing iceberg. However, since abandoning food restriction completely, my overeating focused predominantly upon items in the central region of the graph. I no longer overate fruit, salmon, or chicken. Nor did I binge upon bland, low-nourishment items, such as bowls of white rice or plain white bread. And despite experts telling me that sugar was the dietary equivalent of cocaine, I never once took a cupful of sugar from the cupboard and chowed it down. Instead, my overeating centered, almost exclusively, upon foods that were both low in nutrition *and* tasted great.

As I stared at that diagram, I realized that this implied the problem had *something to do with flavor*.

I thought about how almost all the experts were preoccupied with the balance of macronutrients (fats, proteins, and carbohydrates) or the effect of a single ingredient (such as refined sugar) on the body. Yet very few people appeared to consider the fact that whether or not we seek out or enjoy a particular food *depends upon how it tastes*.

As I contemplated this, a whisker of hope emerged.

I knew, at this point, that something about my behavior mimicked the patterns I saw in other addictions. I was familiar with the great work of Allen Carr, whose stop-smoking method allows people to instantly (and most importantly *happily*) end a lifetime's addiction to nicotine. I had also read extensively about alcoholism, drug addiction, and emerging research about pornography and gaming addiction. Yet, at this point, two things remained very unclear.

Firstly, I didn't know what the addictive element in food *was,* and none of the popular theories seemed to make sense. Secondly, I didn't know what addiction even *meant*.

Of course, I could recognize the familiar pattern – the growing obsession, the escalating usage, the withdrawal period, the endless broken promises – but nowhere had I read of a universal theory or convincing explanation as to *why* this pattern of behavior played out in certain circumstances.

As I studied those two overlapping circles, I sensed that flavor and nutrition were not *all* that mattered. For example, I suspected it would not suffice to take a plateful of chocolate, sprinkle vitamin pills over the top, and call this a 'tasty, high-nourishment meal.'

I suddenly wondered whether the flavor and nutrition *had to be in the right place*. In other words, I suddenly questioned whether flavor had a *purpose*. Perhaps, in some way, flavor was acting as a *signal*, telling my body what kind of nutrition a food contained. For instance, BBQ-flavored crisps, chips, or crackers seem to promise the appearance of protein with their savory aroma, yet the protein never comes.

I thought back to how I had initiated diets, escalating hunger, and then tried to satisfy this elevated hunger using foods spiked with manufactured flavors. Perhaps this had muddled the stream of flavor signals that my body was using to regulate food intake, such that my body could *no longer reliably predict what type of nutrition was coming in.*

This new possibility soon led to a dramatically different way of viewing and perceiving food. The most miraculous part is not just that weight began to fall off me, but that the near-constant food-related obsession that had haunted me for decades lifted. And in its absence, a glorious peace returned – a blissful space for *life* to move back in.

As my health and weight normalized, I began documenting these ideas on a website, www.eatlikeanormalperson.com, in an effort to establish exactly why this change had been so dramatic and different from all dietary approaches I had tried before.

As I documented these ideas, I continued to research the role of flavor. Important insights came from Mark Schatzer's book, *The Dorito Effect* (2016), which introduced me to the research of Fred Provenza and Clara Davis, whose findings further support the critical importance of the relationships between flavor and nutrition.

It was when I finally understood the impact of intermittent reinforcement (the mechanism at the heart of gambling machines, whereby a single action *sometimes* leads to a reward and sometimes does not) that I realized I had stumbled across a hypothesis that explained not only the obesity epidemic but *every single addiction*.

Some Warnings

This is not a typical 'diet' book. Nor is it a typical 'stop dieting' book. It is a logic-based explanation of what causes overeating and how to stop.

The premise is that deceptive flavor signals and other forms of molecular mimicry within the food supply create intermittent reinforcement, provoking a cascade of short-term bodily adaptations that increase appetite and drive overeating – including the overeating of genuine, nourishing foods. As such, this book presents a solution for overeating of all kinds.

It is important to note that 'deceptive food' is not necessarily synonymous with 'junk food.' Many individuals who believe they consume quite nourishing fare unwittingly take in a large number of deceptive flavor molecules. On the other hand, many foods that are commonly thought to be 'fattening' are not deceptive at all.

This book explains how ongoing exposure to deceptive foods promotes 'disordered' eating behaviors – particularly when deceptive foods are encountered during a state of extreme hunger, such as in the wake of a conventional diet. It provides a simple blueprint for normalizing eating patterns, extinguishing dietary obsession, and achieving an optimal weight that can be maintained for the rest of your life.

From a practical perspective, the method involves prioritizing nourishing, 'flavor-honest' foods (those that do not deceive the sensory system) and eating until full at regular meals, providing the body with a reliable stream of flavor cues that rapidly resets appetite to normal levels.

The method does not require 'giving up' anything. Rather, it involves seeing deceptive foods in a different light, such that you *no longer want them* (improbable as this prospect may seem at the outset). With this new mindset, deceptive foods are no longer sought out and are avoided where possible – sidestepping the practical dilemmas that often accompany moderation and abstinence. Consequently, the intake of misleading molecules falls close to zero, leaving you feeling unbelievably *free*.

The cure is informational. That is, it works by communicating something new so that you view both food and yourself in a different way.

If you have ever tried to convince someone of a new idea – particularly when that viewpoint is novel or controversial – you will know that reciting a single fact rarely does the trick. What is needed is a careful sequence of arguments, each building upon the previous one, so that the person gradually comes around to seeing things in a new light, with all doubts and uncertainties laid to rest.

For this reason, chapters in this book are designed to be read in the order given. Furthermore, since behavior change requires reframing how you think about the situation, you cannot expect to turn to a single page and find the 'solution.' Skipping to the end will be about as useful as a smoker who reads that the solution is to *stop smoking*. Of course, understanding where the deception hides is slightly more complex than in the case of nicotine, but the real power of this book is found in the cumulative sequence of ideas that work together to change your mind.

Please be aware that this book includes material that some individuals may find offensive or controversial, such as descriptions of graphic animal experiments and passing references to pornography. It also includes discussion of many other addictions unrelated to food. This is because it is often easier to identify the error in another's behavior than it is our own.

This book is the culmination of over twenty years of my own personal research into this topic. It synthesizes ideas from multiple scientific fields, presenting a new way of understanding eating behavior and addiction. While I have endeavored to ensure that ideas are well-referenced, scientific knowledge is constantly evolving and often subject to debate, with numerous conflicting arguments advanced by individuals on all sides. It is almost impossible to produce a treatise that remains 100% accurate in every tiny detail across every scientific discipline at all times. Furthermore, as the concepts in this book have been woven together over the course of two decades, there may be instances where I have inadvertently misattributed an idea or failed to give credit where it is due. If you discover an error, please get in touch via libby@eatlikeanormalperson.com, and I will endeavor to update subsequent editions as necessary.

However, as you read, please remember that many of the concepts presented here are not only novel but challenge the conventional assumptions about addiction, obesity, and eating disorders. If you encounter something that *seems* incorrect, do not automatically assume that it is. For example, while reviewing an earlier draft of this manuscript, some beta readers initially found the emotional eating material difficult to accept. Yet, by the end of the book, many of these same readers had tearfully changed their minds. In short, please allow me the opportunity to lay out the argument in full before you decide whether the ideas have merit. Importantly, *keep an open mind* and consider the possibility that if all other strategies have not worked, *a new way of looking at things might help*.

The book begins with a general discussion about behavior and decision-making. This material may initially seem rather abstract and unrelated to eating issues. Some readers may fear they have opened an obscure scientific textbook and find themselves impatient to get to the topic at hand. Rest assured that these brief introductory passages provide a vital foundation for the understanding of eating behavior that is to follow. As you continue to read, the pieces of the puzzle will gradually fall into place, and everything will become clear.

To fully grasp a problem, we must start at the beginning.

Behavior

> At some point, a particular arrangement of particles got so good at copying itself that it could do so almost indefinitely by extracting raw materials from its environment. We call such particle arrangement *life*. – Max Tegmark, *Life 3.0* (2017)

To grow, repair, and move, humans must obtain a supply of chemicals from the environment. Some of these chemicals are known as *nutrients*. We typically extract these nutrients from other lifeforms, such as plants, animals, and fungi.

Nutrients are required in particular quantities and combinations. People who attempt to survive on only lean protein, for example, with insufficient fat, eventually die from protein poisoning. Those who consume the wrong variety of plants (poisonous mushrooms, for instance) or prepare an item incorrectly (such as failing to soak or cook kidney beans) may suffer adverse health effects. Complicating matters further, items that are beneficial in smaller amounts can be dangerous when consumed to excess. For example, overdosing on nutmeg leads to convulsions, hallucinations, pain, and delirium,[2] yet small amounts appear to offer anti-inflammatory,[3] antioxidant, and antimicrobial[4] benefits. Similarly, while vitamin C is essential for immune function and collagen synthesis, excessive vitamin C supplementation can lead to diarrhea, nausea, and acute kidney failure.[5] [6]

Not only are particular quantities and combinations of these nutrients needed in order to thrive, but the optimal range varies with the individual and circumstance, fluctuating according to a myriad of factors, including age, nutritional status, the presence of injury or illness, circadian rhythm, parasite load, level of exertion, pregnancy/breastfeeding needs, and so on. Yet, despite this complexity, your ancestors somehow managed to carry out this task without the benefit of modern science.

To get an idea of just how skillful lifeforms are at optimizing their food supply, consider the case of a bonsai tree. Bonsai trees are ordinary trees grown in shallow plant pots. With only a small area of soil and limited room for growth, you might suspect the tree would wither and die. Instead, it becomes a perfectly formed miniature tree.

Something similar happens when certain breeds of baby mice are fed a nourishing yet low-calorie diet immediately after weaning. Instead of growing into thin, bony, full-sized adults, they become perfectly formed miniature mice.[7] These tiny mice live longer and in greater health than controls. Such studies are often cited as evidence that low-calorie diets lead to an increased lifespan; however, it is worth noting that these miniature mice now consume, on average, 30% more per gram of body weight than the controls. In other words, these brilliant mice adapt so well to the reduced food supply that *they are no longer deprived*.

Even newly weaned human babies, with limited vocabulary and zero formal nutritional knowledge, self-select appropriate foods when given the chance. In the 1920s, a Chicago pediatrician called Clara Davis set out to see if children possessed the capability to choose appropriate foods.[8] Davis cared for fifteen children in an orphanage (aged 6-11 months at the outset), recording every item they ate for up to four and a half years while tracking their height, weight, and other health parameters. At each meal, the children were presented with an array of food, including fresh fruit, vegetables, oats, wheat, meat, fish, liver, brains, bone jelly, bone marrow, cod liver oil, sea salt, water, orange juice, and milk. The adults did not comment on food intake nor direct the children toward particular items. At every meal, the children were free to consume as much or as little as they desired.

To begin with, the babies gnawed or chewed on virtually every item within reach (including the plates, spoons, trays, and so forth). However, they soon began to exhibit distinct preferences.

Although the food combinations were sometimes unusual – for example, one baby chose liver and orange juice for breakfast – all the children thrived. They recovered from illnesses quickly and spontaneously increased their intake of beef, beets, and carrots while recovering from glandular fever. One child entered the experiment with rickets – a bone disease caused by insufficient vitamin D – and voluntarily swigged down cod liver oil (a known cure for rickets) until his body healed. The participants were evaluated as being "uniformly well-nourished, healthy children."[9]

Just as these children somehow knew how to seek out the nutrition they needed, animals, too, hunt out specific substances to medicate, nourish, or heal themselves. Sheep, who seem, to our ill-informed human eyes, to eat only 'grass,' carefully select from hundreds of different plant species, each of which interact and combine in potentially harmful or beneficial ways.[10] When cats, dogs, geese, bears, bonobos, chimpanzees, and gorillas are infested with worms, they consume extra-fibrous plant matter to flush out the digestive tract and expel the worms.[11] Even primarily herbivorous animals turn to animal food sources when a particular nutrient is lacking.

Although human knowledge is expanding at an unprecedented rate, we remain novices in the field of nutrition.[12] Some doctors are adamant that a vegan diet is optimal; others advocate 100% carnivorism. The entire spectrum in between is filled with various competing strategies, all marketed by seemingly intelligent, well-educated folk who are convinced they are right.

To put our novice status in perspective, humans only realized that vitamins existed in 1911.[13] There are likely many aspects of our food supply that we have not even identified, let alone researched or understood, such as the function or impact of the hundreds of 'secondary compounds' present in the plants we eat.

Luckily, our novice status in this area does not have to prohibit health. The fundamental processes for regulating food intake must operate perfectly without the direction of modern man.

In case it is not obvious, wandering around aimlessly and hoping that whatever enters the mouth will do the job is not a viable survival strategy. The business of knowing what and how much to eat is far too important to be left to the mercy of chance. You, like all lifeforms, carry within you an inbuilt system for finding and consuming the raw materials you need.

This book presents the argument that human food intake is regulated by *relationships between flavor and nutrition* – that eating behavior, like all behavior, is driven by pattern and prediction.

The Survival Game

> The goal of behavior is to make the right choices; to choose the course of action that maximizes the survival of the organism's genetic code. – Paul Glimcher, *Decisions, Uncertainty, and the Brain* (2004)

Eating is a type of behavior. To alter an eating behavior, it helps to first understand the principles that govern *all* behavior.

It can often appear that human actions are mysterious, carried out according to some deep and unknown personal whim. But, as you will soon see, behavior follows rules. This is very good news because it means that eating behavior, no matter how excessive, disordered, or 'out of control' it may seem, can be understood, predicted, and changed.

In a very real sense, life is a survival game. Whether you consider yourself to be the result of billions of years of trial and error or the creation of a wise and all-knowing God (or some combination of the two), one thing is certain: your genes are good at this game.

Across the vast, dangerous expanse of history, every single one of your ancestors survived at least until childbearing age. Every single ancestor conceived viable offspring. Every maternal ancestor gave birth to at least one live child: a squalling, defenseless infant who somehow managed to grow up and do the same thing all over again. This long, unbroken chain of survivors managed to achieve this miraculous feat without any scientific studies, formal nutritional guidelines, or books.

Whether your ancestors made it through each round of this brutal and rather unforgiving game depended, in very large part, upon their behavior.[14] Although luck, fate, and circumstance play a role, *the way you act* enormously impacts your odds of survival. Once the cards are dealt, so to speak, what matters next is *how you play*. In fact, as any good card player knows, when several rounds of a game are played, *skill at playing the game becomes the most important variable of all.*

This means that *behavior* cannot be a trivial aspect of this survival game. If your genes are optimized to survive across time (which they must be), your behavior cannot be a random, happenstance affair. It must follow rules.

To understand eating behavior, therefore, we must first understand the rules of the game. And there are only three:

1. **Seek survival rewards**: things that improve the odds of your genes surviving and replicating across time – sought in order of priority. (This includes seeking nutritious food that provides energy and building blocks for growth, reproduction, and health.)
2. **Avoid survival threats**: things that reduce the odds of your genes surviving and replicating across time – avoided in order of priority. (This includes avoiding

unnecessary, harmful, or contaminated foods that lead to sickness or death.)

3. **Ignore everything else**.

The third rule sounds unimportant, but it is vital because misdirected attention compromises performance in the first two areas and quickly becomes a survival threat itself. In a world where resources are limited and competition is fierce, time and energy spent on the wrong thing can be the difference between surviving or not.

> In the game of life, life must win every moment of every day, while death has to win only once. – Martin Seligman, Peter Railton, Roy Baumeister, Chandra Sripada, *Homo Prospectus* (2016)

Even if an individual does not die outright from a tendency to pursue the wrong thing at the wrong time, subpar performance is not a mild survival issue. Unhealthy lifeforms are less able to escape predators or produce viable offspring. They are less desirable mates and less able to select optimal partners. In short, those who do not wish to play this game, or who play it badly, are outcompeted by better players over time.

Suppose there were two otherwise identical species, but one behaved so that *every* action was predicted to improve their odds of survival, whereas the other only did so 80% of the time. Which species would be more likely to outperform the other?

Unsurprisingly, lifeforms who spend a greater percentage of their time behaving in such a way that improves their odds of survival are *more likely to survive*.

It can be hard to fathom, but *all* of your actions – from choosing what food to put on your plate to the microscopic cellular responses in the body – aim to improve your genetic odds in this survival game. Of course, not every action achieves this outcome or is the right thing to do. But it is implemented – whether you know it or not – with this as the goal. This is very important to understand because it means that no matter how bizarre or irrational your feeding behavior may appear, there is *logic at the heart of it*. And when you understand this logic, you can see how to change.

Even single-celled organisms follow the rules of this game. Their outer cellular membranes detect changes in the nearby environment, such as adjustments in temperature, light, or chemical concentrations, allowing them to rotate their tail-like appendages, tumbling toward things that are likely to benefit their survival and away from things that are not.[15]

> A bacterium does not bounce around in its world like a ball in a pinball machine. [...] They can sense where there is food and propel themselves to that spot. Similarly, they can recognize toxins and predators and purposely employ escape maneuvers to save their lives. – Bruce Lipton, *The Biology of Belief* (2016)

Humans are complex creatures, it is true. But our goal is the same: move toward survival rewards; move away from survival threats; ignore everything else.

To make *good* decisions, the brain has an inbuilt system for identifying and prioritizing survival rewards and threats, predicting what to pursue or flee at any one moment. This system also determines which foods are *desired* or *avoided*.

Emotions

What we call an *emotion* is the feeling of a carefully calibrated chemical signal that is crafted for a specific survival-related function. Emotions are the mechanism by which the brain prods the cellular teams that make up the body this way and that.

If the brain detects the presence of a survival reward in the nearby vicinity, such as a piece of ripe fruit on a tree, it issues a chemical signal that we call *desire*. Desire depends upon one's interpretation of the situation (see chapter 1: *Changing Your Mind Requires New Information*) as well as the need for that item. Hence, what is desirable to one person is not necessarily desirable to another.

If the acquisition of a survival reward is impeded, attention is refocused on the task with a chemical signal that we call *craving*.

As the reward draws closer and its acquisition appears more likely, a chemical signal that we call *anticipation* or *excitement* is issued, ensuring we maintain a state of high alertness and attention until the reward is captured.

When the reward is obtained or brought within the body, a chemical signal that we call *pleasure* is issued. It is essential to note that *pleasure is not the reward itself* but rather a *signal* that a predicted reward has arrived. The reward is the *genuine survival benefit obtained* (such as nutrients arriving in the gut), and it is this that shapes the behavior going forward. We 'like' pleasure because this sensation coincides with the prediction of a survival win.

> Men have generalized the feelings of good things and called them pleasure and the feelings of bad things and called them pain, but we do not give a man pleasure or pain, we give him things he feels as pleasant or painful. – B.F. Skinner, *Beyond Freedom and Dignity* (1971)

If subsequent examination of the situation deems that the reward really did arrive in the anticipated and necessary volume, a chemical signal that we call *satisfaction* arises. Satisfaction is the instruction to disengage, to end the pursuit. *Enough.*

If the acquisition of survival rewards is reliable and successful across time, a chemical signal that we call *happiness* is issued. Happiness implies one's rules of operation are accurate; position in the game is tracking upward;[16] the world is understood.

Pattern and Prediction

Although the rules of the game are simple, following them is no easy matter. The business of navigating in and around survival rewards and threats is complicated due to the sheer volume of potential data. Each decision involves an enormous array of fluctuating variables. Consider the stream of information coming in via the senses (sight, sound, smell, taste, and touch) and the vast array of internal data the body must keep track of (temperature, glucose load, nutrition status, and so on). Numerous external factors must also be evaluated and monitored, such as the accessibility of tools, availability of resources, impending weather conditions, and so on. Complicating matters further, each survival reward is required in a particular quantity at a particular time, with both deficiencies and overdoses posing a threat. Too much oxygen, you die. Too little oxygen, you die. The same applies to water,[17] heat, nutrients,[18] and almost every other survival reward that exists.

To avoid carrying out immense and paralyzing calculations at every turn, lifeforms act according to *predictive behavioral rules* that summarize reliable relationships between action and outcome.

Without reliable links between behavior and its consequences, navigating the world would be impossible. If the world were not comprised of cause-and-effect relationships, we would have no idea what to do. In fact, life could not exist. But when something *reliably occurs* (that is, when a particular outcome can be predicted with a reasonable degree of certainty), lifeforms can estimate the impact of a particular action and *select behavior accordingly*.

Operating using predictive behavioral rules speeds up the decision-making process and frees the brain from the burden of continual analysis.[19] Behavioral rules condense experiential data into a useful, short-hand format, allowing energy and attention to be reserved for unfamiliar situations that may harbor a reward or threat or for deciphering challenging environmental circumstances that still need to be attended to and understood.

Behavioral rules that are inherited across generations are called *instincts* or *reflexes*. These are passed down from parent to offspring, giving each new organism the best chance of survival.[20] Long-lived lifeforms, like ourselves, however, are vulnerable unless these rules can be updated and adjusted via experience. If behaving in a certain way does not result in the anticipated outcome, and such variation is not within the expected margin of error, *adjustment of the behavioral rule is required*.

Recalibration of the Rules

If behavioral rules were not updated, a lifeform would be stuck with an inappropriate rule whenever the environment changed. To act appropriately in a rapidly changing world, therefore, we must possess a method for updating the rules.

To achieve this, the brain carefully monitors key survival consequences after particular actions occur, automatically adjusting the relevant behavioral rule upward, downward, or extinguishing the rule altogether, based on the new value of the survival rewards or threats received.[21] In this way, behavioral rules are constantly updated to reflect the current anticipated outcome.

Because survival is fraught with risk, and errors are costly, behavioral rules are maintained with mathematical precision. As complicated as this sounds, this process operates without conscious awareness and has been observed in a wide range of animal species. [22] [23]

> The surprise isn't so much that choices track consequences in some way. (Imagine how haywire things would be if they didn't.) What was eye-opening were the mathematically consistent and elegant ways in which they did so across so many species, consequences, and behaviors. – Susan Schneider, *The Science of Consequences* (2012)

It turns out that lifeforms assign *precise statistical estimations* to behavior, reflecting the anticipated consequences upon survival (positive or negative). These behavioral rules translate relevant prior and inherited experiences[24] into a single numerical estimation (a kind of running average), predicting whether a particular action is likely to help or hinder survival, and to what degree.[25] [26] These mathematically precise rules govern every decision you make, including *what to put into your mouth*.

When updating behavioral rules, recent outcomes are most important and are weighted more heavily in the calculation.[27] This is because things that occur *today* are more likely to accurately reflect the current environment than things that happened weeks, months, years, decades, or generations ago.

Selecting behavior according to mathematically precise predictions sounds like an excellent plan. In fact, it is the best plan there is. It would work well in all circumstances…if it weren't for the loophole in the system.

You see, certain species have discovered that there is a tremendous survival advantage to be had in *manipulating the behavioral rules of another lifeform*.

Deception

In her book *Supernormal Stimuli* (2010), Deirdre Barrett describes the work of Nobel Prize-winning biologist Niko Tinbergen, who showed that animal behavior is often elicited in response to a narrow range of stimuli.

Tinbergen and others found that animals can be fooled into responding to artificial objects that mimic key cues in the natural environment with more enthusiasm than they show for the real thing (often with dire consequences). Supernormal stimuli are exaggerated versions of natural stimuli that provoke a stronger response than the natural item. This response can occur even when the fake object is absurdly unrealistic in other ways.

For example, herring gull chicks will beg for food more vigorously from red knitting needles with white bands painted around them than they will from a realistic 3D model of an adult herring gull head (adult gulls have a red spot on the yellow bill, and the chicks normally peck the red spot to signal that the mother should regurgitate her food). Similarly, small songbirds will sit on fake eggs that are much larger and more intense in pattern and color than their own. They will sit on fake eggs that are so large they repeatedly slide off them, ignoring their own paler, dappled eggs. Likewise, a Greylag goose will roll any nearby round-shaped object into her nest, even a doorknob or football-sized fake egg.

The supernormal stimuli effect occurs because nature prioritizes efficiency. If a lifeform can get away with an uncomplicated rule for survival (i.e., round shape = egg) and arrive at the correct behavior faster than a competitor who uses a more complex rule, the faster, more efficient strategy will win.

Because simple behavioral rules are prioritized and because all creatures rely on such rules to navigate the world, deception is a constant threat.

Cuckoos exploit the supernormal stimuli effect by laying their eggs in other birds' nests. The appearance of the cuckoo egg is similar to that of the victim species but is typically a little larger and brighter, ensuring it is preferentially warmed in the nest.[28] Once hatched, the cuckoo chick often develops a larger and redder beak than the victim species, so it monopolizes the food supply and is more likely to be fed by the unwitting foster mother.

Deception occurs when one lifeform mimics a feature of the environment that another is using as a cue to implement a behavioral rule. By mimicking key environmental stimuli, lifeforms can manipulate the behavior of another for their own gain.

Manipulation of this kind can offer tremendous survival rewards for the perpetrator, often for minimal effort. For this reason, deception is widespread within nature, as explained by evolutionary biologist Robert Trivers.

> When I say that deception occurs at all levels of life, I mean that viruses practice it, as do bacteria, plants, insects, and a wide range of other animals. It is everywhere. Even within our genomes, deception flourishes as selfish genetic elements use deceptive molecular techniques to over-reproduce at the expense of other genes. Deception infects all the fundamental relationships in life: parasite and host, predator and prey, plant and animal, male and female, neighbor and neighbor, parent and offspring, and even the relationship

> of an organism to itself. – Robert Trivers, *The Folly of Fools: The Logic of Deceit and Self-Deception in Human Life* (2014)

Trivers describes the eternal dance between the deceived and the deceiver. As deception arises, those individuals who can detect the mimicry have improved survival odds, and their offspring proliferates. Over time, the population fills with those who are better at detecting and avoiding that precise deception. In retaliation, the deceiving species acquire more cunning manipulation tactics. The balance thus continually oscillates, swinging back and forth between deceiver and deceived.

When faced with a deceptive circumstance, abandoning pursuit of a survival reward is not a viable option (just as ignoring a looming survival threat is untenable). A cuckoo victim, for example, cannot refuse to sit on all eggs without eliminating her own offspring in the process. A victim of deception thus remains at the mercy of their enemy *until they can reliably discern between the genuine item and the imposter*.

Until this happens, the victim remains trapped, operating via a faulty behavioral rule that now leads to *unpredictable outcomes*. Sometimes, sitting on an egg leads to hatching one's own offspring; sometimes, it leads to raising the offspring of the enemy.

Although it can be hard to comprehend, deception often presents a far more serious threat to survival than natural disaster or attack. This is because, in the act of being deceived, the victim is fooled into *willingly returning for more*.

Deception applies the illusion of a reward where it does not belong and thus dupes a lifeform into *pursuing a threat*. In other words, deception coerces a lifeform into *violating the rules of the game*.

The Role of Flavor

> When we eat, we attend to the concentration of chemical stimulus in our food (e.g., judging whether our food is too salty or contains a hint of onion). – Danielle Renee Reed and Antti Knaapila, *Genetics of Taste and Smell: Poisons and Pleasures* (2012)

The previous chapter introduced the idea that behavior stems from predicted associations between action and outcome. Let's now explore how this concept relates to eating.

We tend to think of 'chemicals' as artificial manufactured substances, but chemicals are the building blocks of life. James Kennedy, an Australian chemistry teacher, publishes posters illustrating the wide array of naturally occurring chemicals found in fruits and vegetables. His poster of a banana, for example, lists approximately 50 substances (this excludes pesticides, fertilizer residue, contaminants, and "thousands of minority ingredients").[29] In other words, every time you eat *anything,* you take in a very large number of chemicals.

As food enters the mouth, some of these chemicals slot into taste bud receptors, aided by chewing and the release of saliva. Taste buds are found in many locations within the oral cavity, such as on the tongue and throat. Each taste bud has 80-100 receptors,[30] which are activated by precise chemicals only – those with a specific molecular shape – just as a key fits into a lock. When a particular chemical activates a taste bud receptor, a signal is sent to the brain.[31] If many receptors are activated, a stronger signal is sent,[32] indicating a higher concentration of that particular chemical in the mouth. In this way, the type and quantity of chemicals within food can be estimated while you are eating.

Scientists describe the taste bud as a "complex signal processing unit."[33] There are currently five known types of human taste bud receptors (sour, salty, bitter, sweet, and umami),[34] each of which detects the presence of broad categories of food.[35] Umami sensors, for example, detect the presence of glutamate and ribonucleotides, which are commonly found in cooked and aged meats and other easily digestible protein sources.[36] New research also indicates that taste bud receptors for other substances, such as fatty acids,[37] starch, calcium, and water,[38] may soon be identified.

In addition to those chemicals sensed by taste buds, another important subset (those that vaporize and float through the air) are perceived as *smell*. These volatile chemicals enter the nasal cavity through the top of the mouth while chewing, as well as via the nostrils, and activate odorant receptors. Humans have approximately 350 – 400 types of odorant receptors,[39] which can be activated in various combinations, purportedly allowing us to distinguish between more than a trillion odors.[40] *Specific smells are associated with specific nutrients* and hence provide "important information about the nutritional makeup of foods."[41]

Although humans are not renowned for having an incredible sense of smell, Gordon Shepherd, emeritus professor of neuroscience at the Yale School of Medicine, argues that our sense of smell is far better than we realize. In his book *Neurogastronomy* (2013), Shepherd explains that there are two types of smell – 'orthonasal,' which occurs when *breathing in* chemicals from the outside environment, and 'retronasal,' which occurs when *breathing out,* whereby volatile chemicals released while chewing food are swept into the nasal cavity.[42]

Dogs are great at detecting and tracking smells in the outside environment (aided by a long snout close to the ground) and hence have an advanced sense of orthonasal smell. Shepherd argues that humans, on the other hand, have a particularly advanced sense of retronasal smell, *specifically to detect and analyze food flavors*. He suggests this advanced sense of smell is largely hidden from our conscious awareness because we perceive it to be *part of taste* (he notes that holding one's nose while eating makes it clear how much flavor perception is derived from smell).

Humans typically consume a much wider range of foods than other species due to the many ways we grow, store, and prepare food (such as cooking, preserving, and fermenting), as well as our tendency to inhabit vastly different environments. Shepherd believes that navigating this complex food environment and selecting between such a wide array of foods demands a highly advanced sense of retronasal smell.

The information gleaned via taste and smell receptors, along with other sensory data (such as the color, texture, and temperature of food), together creates our perception of flavor. And our perception of flavor *strongly influences how we act around a particular food*.

For example, an intense, undesirable flavor may trigger immediate rejection, such as spitting out or retching. A *pleasant* flavor, on the other hand, may initiate a cascade of digestive responses, such as increased saliva and gastric juices,[43] helping to prepare the digestive tract for the incoming nutrition.

The *reason* we have taste buds and smell receptors strategically positioned within the mouth and nasal cavity is to ensure that helpful or harmful chemicals are detected *before* they enter the body. In a very literal manner, smelling, chewing, and tasting the food lets sensory receptors carry out a complex chemical analysis, the result of which *directly influences whether a substance is permitted entrance to the body*.

Finding and acquiring nutrients (while avoiding toxins and other harmful chemicals) is essential to life. The rules governing eating behavior are thus just as deliberate and mathematically precise as all other behavioral rules. In fact, distinguishing between flavors is so important that there appear to be *more human genes dedicated to coding smell than to almost any other activity* (genes specific to the olfactory system are second in number only to those dedicated to the immune system).[44]

If flavor were a trivial detail, our brains would not pay so much attention to it. There is zero survival benefit in detecting and transmitting useless information (remember the third rule of the game). Cats, for example, cannot taste sweet flavors because their traditionally meat-based diets contain little sugar.[45] Chickens, who predominantly eat starchy grains, also have no functioning sweet receptors.[46] Aquatic mammals, on the other hand, often have very few taste receptors at all, presumably because visual cues and other sensory stimuli are more important when distinguishing between swimming prey that is swallowed in one gulp.[47]

Initial flavor rules are passed down as instincts. As such, babies emerge from the womb liking their mother's milk and disliking bitter tastes.[48] Toddlers are also predisposed to enjoy flavors present in their mother's milk and flavors consumed by the mother during pregnancy.[49] Moreover, inherited flavor preferences can reflect the local conditions where your ancestors resided.

> You are predisposed to prefer your own culture's culinary customs because following them, at least in the distant past, favored survival in the local habitat, which had its own unique variety of edible plants and animals and traditions for safely preparing them… – Kathleen McAuliffe, *This is Your Brain on Parasites* (2017)

Although we begin with inherited flavor rules, we do not depend on these alone. Lifeforms are sometimes flung from one habitat to another, such as following a natural disaster or the exhaustion of a prior food source – not to mention the constant adjustments due to changes in season, weather, and climate. To thrive, humans must be able to adapt to a new food environment quickly. Thus, flavor preferences can be shaped, molded, and extinguished via experience.

Flavor-Nutrition Relationships

Although foods contain hundreds or even thousands of naturally occurring chemicals, only *some* of these chemicals contribute toward our experience of flavor: those that slot into taste and smell receptors. This subset represents only a fraction of the food as a whole. Many chemicals (including those with nourishing properties) are not detected by the mouth or nose at all. To establish whether an edible substance is beneficial for survival, therefore, the brain makes a *prediction* about what is entering the body based on the flavor profile detected.[50] To do this, flavor at the mouth is linked with the subsequent nutrition (or harmful substances) that arrive in the gut.[51] In this way, flavor acts as a *nutritional marker* or *environmental cue*, alerting the body that a particular set of chemicals is coming in.

Flavor detection thus has a very specific survival-related function. A *delicious* flavor indicates that a *beneficial* set of chemicals appears to be arriving (i.e., nutrients that you need); a *revolting* flavor indicates an incoming survival threat (such as the ingestion of toxins or parasites).

Positive flavor responses can be learned, even if a flavor is initially disliked – as long as consuming that flavor reliably leads to needed nutrients. This is how people ‘acquire’ tastes for things and why parents are encouraged to feed their children a new food several times to ensure that adequate exposure to the flavor has occurred.

The ability to learn new flavor preferences is demonstrated in many species, including rats, chickens, sheep, goats, and humans. Fred Provenza, professor emeritus of Behavioral Ecology at Utah State University and author of *Nourishment: What Animals Can Teach Us about Rediscovering Our Nutritional Wisdom* (2018), discovered that sheep make “multiple flavor-feedback associations with minerals.”[52] In one experiment, Provenza fed a group of sheep a diet deficient in phosphorus. He then gave these same sheep maple-flavored feed for six days while simultaneously dosing them with phosphorus. The aim was to see whether the sheep would learn to associate maple flavor with phosphorus. When he subsequently gave these phosphorus-deficient sheep a choice between maple-flavored feed or another flavor, they ate the maple flavor enthusiastically, even though it contained zero phosphorus.[53] To ensure that sheep do not naturally prefer maple flavor, Provenza fed another group of sheep a *different* flavor along with a dose of phosphorous. When given the choice, these sheep preferred the *other* flavor. If phosphorus was subsequently associated with a different flavor altogether, the sheep changed their preference, avoiding the previously preferred flavor.

It takes only a few days for new flavor-nutrition associations to be learned, but *liking* a particular flavor can be extinguished immediately if nausea or vomiting follows ingestion (indicating a serious survival threat – such as the presence of a high level of toxins). Flavor aversions can endure for a lifetime if the perceived threat to survival is severe. Furthermore, when an aversive flavor is added to another food, this item is avoided too.[54]

Flavor aversions can occur even when multiple foods are consumed simultaneously. Provenza describes sheep eating four familiar grains as well as a new type of grain (and a capsule that induces nausea). In this circumstance, the sheep quickly learn to avoid the new grain only – and associate this with the onset of nausea.[55] Even inherited flavor preferences (such as liking sweet flavors) can be extinguished in some circumstances. This is necessary because not all sweet flavors are harmless, and not all bitter ones are dangerous.[56]

> …it is relatively easy to make the taste of sugar change from palatable to unpalatable. For example, experimental pairing of sugar taste with upper gastric malaise and nausea can render sugar unpalatable… – Paul A.S. Breslin, *An Evolutionary Perspective on Food and Human Taste* (2013)

Over time, the learned relationships between each particular flavor and the chemicals that subsequently arrive in the gut are adjusted and refined, so we are more likely to act appropriately when the flavor is next encountered. In other words, through repeated exposure, flavors are linked with their nutritional and metabolic consequences, and these learned associations *influence future eating behavior*.

Is it really plausible that flavor is the driving force behind food choices? Do humans really determine where nutrients are located based on the memory of a flavor in the mouth? Does the brain really have the capacity to track and monitor so many complex variables?

To get an idea of how adept the human brain is at remembering patterns, think of how many songs people can distinguish between. Each song is an arrangement of musical notes, yet many people can remember and hum these complex patterns with ease. Avery Gilbert, author of *What the Nose Knows (2015),* mentions that our interpretation of smell has been likened to a fingerprint or musical chord. As another example, think of how many words you can recognize. Each word is imbued with meaning, and relationships between words are incredibly complex. Nonetheless, most young children learn to master these verbal patterns with ease. Alternatively, consider how many faces you can keep track of. People are mobile collections of visual stimuli – mouths, eyes, hands, heads, limbs – all in slightly different shapes, colors, and sizes. Yet, you can probably distinguish between a great number of people. What is more, you can probably detect slight changes in the expressions on these faces and attribute meaning. Humans are exceptionally proficient at reading facial expressions because doing so, *just like finding the raw materials necessary to build and maintain the body,* is crucial for survival.[57]

Each unique smell (remember, smell is the largest component of flavor) creates a unique pattern of activity in the brain.[58] When we think of a food, we recall its flavor. This alone indicates the brain is capable of tracking and storing such information.

To successfully navigate through life, seeking nutritional rewards and avoiding dietary threats, we learn the patterns between flavor and nutrition.

People often view flavor as an inherent, fixed property of a particular food – a pleasant side-effect of eating. However, our flavor perception fluctuates according to the expected nutritional payload and *our need for that nutrition*.[59] [60]

Hunger and Satiety

The amount of food one consumes on any given occasion is influenced by both *hunger* (the signal to eat) and *satiation* (the signal to stop eating). As the supply of nutrients and energy is used up between meals, satiety decays until hunger is the predominant signal once more. Hunger for specific flavors rises and falls to ensure that, over time, the correct balance of nutrients is obtained.

Because hunger is often directed toward a specific flavor, it is possible to feel full of one food while hungry for another. *Sensory-*

specific satiety, as this phenomenon is known, is observed in numerous species. For example, when people consume bananas until satiation, the smell of bananas is no longer perceived as pleasant; however, the aroma of other foods remains appealing.[61] Similarly, protein-depleted individuals prefer savory over sweet foods.[62] Studies of the brain show that feeding to satiety on one flavor results in a decreased neuronal response to that flavor but not others.[63]

Sensory-specific satiety explains why people can feel like they still have room for dessert despite having eaten a full meal and also why buffet-style dining opportunities often result in a greater ingestion of food. 'Overeating' in this context is the sensible attempt to source the wide array of nutrients predicted by the many different flavor profiles.

When the body needs a particular nutrient, the brain signals a desire for flavors associated with that nutrient (this is the method by which the body then *obtains* that nutrient). As the need for a particular nutrient grows, hunger for the associated flavors becomes more pronounced, prompting the individual to take action and seek out that item. Hunger rises at regular mealtimes to focus attention on the necessary task of gathering nutrition at a time when food is predicted to be readily available.

If a desired flavor is accessible in the nearby environment, cravings mount to ensure you proceed toward the item and acquire the necessary nutrition.

As you bite into the food, flavor molecules slot into taste and smell receptors. If the appropriate flavor is detected, pleasure is issued to signal the arrival of an incoming nutritional reward.

Although seeing delicious food on a shelf or discovering a piece of ripe fruit on a tree may elicit a burst of excitement, the most reliable predictor of incoming nutrition is the *immediately preceding stimuli:*[64] flavor in the mouth. The initial mouthful is thus accompanied by an *increase in desire*, ensuring you are not distracted at this crucial moment and keep on eating until the optimal volume of nutrition is obtained.

> If we were to define hunger in terms of strength of behavior regardless of the presence or absence of discriminative stimuli, we should have to agree that a small amount of food increases it. – B.F. Skinner, *Science and Human Behavior* (1965)

In addition to the burgeoning signals of desire and pleasure, flavor in the mouth stimulates the release of "an extensive array of enzymes, hormones, and transporters,"[65] which help to prepare the body for digestion[66] and metabolic responses.[67]

Just as the mouth and nasal cavities are filled with sensory receptors, so too are the stomach, small intestine, and large intestine.[68] As food is digested and broken down into its molecular parts, the gut and the organisms that reside within (the microbiome) carry out a far more comprehensive and accurate assessment of the chemicals consumed.

If harmful toxins or bacteria are detected, the entire volume may be ejected via vomiting or hastened through the digestive tract as diarrhea.

Whereas pleasurable flavors act as a cue to initiate eating, signals from the stomach and intestine indicate when it is time to *stop*.

Despite the popular belief that it takes twenty minutes before fullness signals 'register,' alterations in fullness occur on an almost real-time basis. The combined influence of flavor at the mouth and chemicals in the gut "act concurrently shortly after a meal begins."[69] Consequently, nourishing, genuine foods taste progressively less appealing the more you eat of them. (If you wish to test how rapidly satiation can kick in, take a block of 100% butter from grass-fed cows and begin to eat. You will quickly discover that 'stop eating' signals can register in a very short space of time.)

When the gut detects that the optimal volume of nutrition has arrived (or when the presence of harmful substances indicates that continued consumption is unwise), hunger is terminated, satiation occurs, and the eating episode ends.

> ...the gut continuously sends information to the brain regarding the quality and quantity of ingested nutrients... [...] By acting not only on brainstem and hypothalamus, this stream of sensory information from the gut to the brain is in a position to generate a feeling of satisfaction and happiness as observed after a satiating meal... – H. Berthoud, *Vagal and hormonal gut-brain communication* (2008)

However, if the predicted nutrition does *not* arrive, the feeling of *wanting more* remains. It is, as you are probably quite aware, possible to have a full stomach and *still feel hungry*.[70]

Sham Eating

Note: The following sub-chapter discusses animal experiments that some readers may find unsettling. These are helpful for understanding the concepts within this book, but reader discretion is advised.

To understand the importance of the learned relationships between flavor and nutrition and the critical role of gut signals, it helps to examine a set of animal experiments that explore a concept known as *sham eating*. Sham eating refers to a kind of 'fake' eating experience in which an animal chews and swallows food, but the food does not reach the digestive system. This is accomplished by a surgical modification that allows the food to exit the body via the esophagus or stomach immediately after being swallowed. As you can imagine, these experiments result in much longer eating episodes than usual.

When rats undergo sham feeding after three hours of food deprivation (a standard length of time for a rat to go without eating), they consume about twice as much food as usual before giving up on the fruitless activity. The rats soon attempt to eat again, halving the typical gap between meals.[71]

If another sham eating episode follows, the rats eat even more and wait an even shorter time before attempting to feed again.

The most shocking outcomes occur, however, when *very hungry* animals are sham fed. When rats are subjected to 17 hours of food deprivation, they sham feed for *7.5 hours straight*. After not eating overnight, monkeys will also sham eat *continuously*.[72]

Hungry animals sham feed for extreme durations because starvation is a serious threat to survival. If the presence of flavor at the mouth indicates that nutrition has been found, it makes sense to grab the opportunity and persevere in the hope that the expected survival reward may eventually arrive. Severe hunger thus predisposes a lifeform to sham eat for an extraordinary length of time.

It might not sound particularly surprising that satiation does not occur when nutrition fails to arrive in the gut. After all, how can you feel full when the stomach is empty? But a lack of satiety occurs even when the procedure drains food out of the small intestine,[73] rather than the esophagus or stomach. In other words, even with a full stomach, satiation does not occur if the small intestine does not detect the required nutrients.

Human patients report similar findings. The following description was given of a woman who, in 1858, had an opening in her small intestine, through which most of her food drained out:

> …although the patient ate very large meals, she did not report feelings of satiation. When asked if eating such large meals was not at least momentarily satiating, this patient answered that her stomach was full but she still felt hungry. – Danielle Greenberg, *Satiation: From Gut to Brain* (1998)

Other sham eating experiments illustrate how accurately the digestive tract monitors nutritional reward. If only a *portion* of the food is removed from the stomach, the animal keeps eating until the withdrawn volume is replaced.[74] In such cases, nutrition arrives in the gut at a slower rate than is predicted by the input at the mouth, yet the animal keeps eating until sufficient nourishment is obtained.

Similar outcomes occur when nutrients are directly introduced to the first part of the small intestine during sham feeding. Nutrient infusion will bring sham feeding to a rapid halt in rats, rabbits, pigs, dogs, and humans, with the speed of satiation relating to the concentration of nutrients introduced.[75] In fact, termination of sham feeding with nutrient infusion occurs even after 17 hours of food deprivation.[76] In other words, *as soon as the required volume of nutrition arrives in the body, the eating behavior stops*.

Further sham eating experiments investigate what happens when the food is replaced with different substances, such as saline solution (salty water), so there is a *mismatch* between the flavor at the mouth and the chemicals arriving in the stomach. In these experiments, the stomach grows fuller while the animal eats, but satiation *still doesn't occur* (unless these solutions have an aversive quality – i.e., unless the digestive tract detects the presence of something harmful). This means that *volume alone* is not the crucial satiating factor[77] – and that 'feeling full' is not a simple matter of stretching the stomach.[78] This explains why drinking endless cups of water with meals to reduce appetite makes not an ounce of difference. (This is no surprise. If the digestive system were so primitive that it could not distinguish between water and nourishment, we would not last very long).

Other sham eating experiments explore what happens if the nutrients arrive in the stomach or intestine *at the wrong time* – for example, if the chewing and digestion are disconnected by more than a few minutes. In this scenario, the nutrition *no longer appears plausibly connected to the flavor consumed at the mouth*, and satiation *still does not occur,* even if the nutrition arrives.[79] This has important implications for vitamin pills (which typically deliver nutrition without any preceding flavor profile) and is discussed in more detail in chapter 4: *Supplements and Fortification.*

Similar studies involve the insertion of valves or 'inflatable cuffs' between the stomach and small intestine. These control how long food remains in the stomach and allow signals from the small intestine to be isolated and analyzed separately from those of the stomach. It appears that both the stomach and intestine are responsible for sending separate, synergistic signals to the brain.[80] This is likely one reason why gastric bypass patients report a reduction in hunger in the weeks and months following surgery, as these procedures severely disrupt the complex and critical signaling from this region.[81] (It is worth noting that this reduction in hunger is often temporary and gastric bypass is not recommended for many reasons, as will be discussed in chapter 10: *Bariatric Surgery*). Furthermore, when the brain cannot receive signals from the stomach or small intestine at all (such as following a vagotomy procedure removing the vagus nerve, which connects the digestive tract to the brain), nutrient infusions do *not* halt sham eating.[82]

> It is as if the gut, with its myriad chemoreceptors, conducts an ongoing analysis and keeps a record of what is being consumed and secretes a specific cocktail of

> hormones into the blood in response. These hormones then customize the digestive process (the secretion of the proper digestive hormones and juices, and in the right concentrations and points in the process, and so on) to the meal being eaten, as well as inform the brain as to the total nutrient load consumed. At some point, the cumulative impact of these various factors stops the eating process. – Stephen C. Woods, *The Eating Paradox: How We Tolerate Food* (1991)

Sham eating experiments closely parallel those in which the *food itself* is manipulated – such as when a single food is altered to contain fewer calories than before while the flavor profile stays the same. In such circumstances, animals quickly learn to increase their intake to account for the reduction in expected energy.[83] [84]

To maintain accurate flavor-nutrition rules, the body tracks two kinds of sensory information: the flavor coming in at the mouth and the chemicals that subsequently arrive in the gut. Together, these two inputs create a predictive loop that guides future eating behavior.

Sham eating experiments offer insight into what has gone wrong with the modern food supply. Manufacturing processes have *disrupted the relationships between flavor and nutrition* so that the flavor at the mouth does not accurately reflect the nutrition coming in.

Deceptive Flavor

Because only *some* chemicals create the sensation of flavor, it is possible to dramatically change what a food tastes like without substantially altering the nutrition. Sometimes, only the aroma of a food needs to change for flavor perception to alter. Textural or thickening additives can also modify flavor perception, as can changes to visual stimuli. Some drinks, for example, have clouding agents added to mimic the natural juices after which they are named.[85] Many otherwise identical products are multi-colored to simulate variety, even though the core ingredients remain the same.

Refined sugar was one of the first chemical compounds to be isolated and used in food production. Extracted from cane or beets, refined sugar strengthens the flavor of any naturally sweet item. However, this flavor manipulation is child's play compared to the complex flavoring strategies now used in modern food manufacturing.

In *The Dorito Effect* (2016), Mark Schatzker describes how the invention of gas chromatography dramatically advanced our capability to mimic flavor. Along with tools such as mass spectrometers, gas chromatography allows manufacturers to identify the precise chemical compounds that contribute to a particular aroma, identifying the exact ingredient list down to the molecular level. By the mid-1970s, this technology was becoming automated and spreading throughout the world.[86] Consequently, flavor technologists can now imitate flavors in exceptionally convincing ways. As Morley Safer from *CBS News* explains, flavor chemists can travel to exotic fruit orchards, acquire flavor samples, and bring these back to the laboratory for simulation.[87]

Many of the flavor molecules used in this process are extracted from food sources. This is convenient, as it allows these additives to be described innocuously with 'clean label' wordings, such as *so-and-so extract* on the ingredient list. Non-food sources are also commonly used as these can be cost-effective, stable, and easier to produce in larger quantities. However, in terms of flavor, it makes little difference whether the additives are 'natural' or 'synthetic' in origin, because, at the molecular level, these are the same. The issue is not the origin of the molecule but the *misleading flavor signal* this sends to the brain.

Concealing Flavor

A common tactic used in modern food production is the concealment of unpleasant flavors that naturally exist in some ingredients. Such strategies include masking bitter or metallic aftertastes, hiding saltiness, down-playing sourness, or concealing a wide variety of 'off-notes.' This concealment process is known in the industry as "neutralizing the base."[88]

Neutralizing flavors is useful if ingredients have unpleasant tastes that are disliked by consumers. For example, pea protein – a popular ingredient used by manufacturers hoping to boost the protein content of plant-based foods – has an off-putting flavor that is often described as "grassy, beany, earthy, bitter and chalky."[89] Similarly, fruit juices may contain 'bitter notes' due to the pith, seeds, and peels being crushed during large-scale pressing.[90] Ingredients derived from aged fruits and vegetables consumed out of season may also have bitter flavors or off-notes. Unsurprisingly, these unpleasant flavors "deter consumers from craving"[91] these products. Some ingredients require "multiple masking solutions"[92] before they are accepted by customers.

Flavor-masking of this type benefits food manufacturers a great deal. It is much more cost-effective to mute an unpleasant flavor than to revamp a manufacturing plant or pay for higher-quality ingredients.[93]

Catering to these needs, many flavor-solution companies offer handy products, such as *astringent taste blockers* (which eliminate the mouth-puckering sensation derived from sour ingredients), individual *flavor maskers* (which conceal specific flavors, such as *stevia masker*), and a huge range of *bitter blockers*.[94] Bitter blockers work by overpowering an existing flavor or directly inhibiting the function of taste receptors so consumers cannot detect the presence of a bitter ingredient in the mouth.[95]

Another method of concealing bitterness involves hiding 'troublesome' ingredients within encapsulating technologies. Microencapsulation is the process of enclosing tiny particles or droplets of a substance within a coating or shell. These textural elements act like minuscule pills within the food and are often so small they can be consumed without being fully crushed by the teeth while chewing. This tactic is especially useful for concealing bitter substances such as caffeine within ice cream or for adding fish oil to orange juice. Microencapsulation technologies are widely used by modern food manufacturers[96] and allow "ingredients with unwelcome tastes to pass through the mouth without eliciting negative feelings."[97]

Strategies of altering, minimizing, hiding, or eliminating flavors are integral to the modern food industry – facilitating the use of cheaper, inferior, and less desirable ingredients. Unfortunately, identifying this kind of manipulation within products can be challenging, with additives often appearing on labels merely as a natural or artificial flavor, flavor 'enhancer,' 'taste modifier,' e-number, or chemical name.

Remember, an unpleasant flavor is not a trivial inconvenience to be muted at leisure. It is a vital survival signal, predicting the presence of something harmful that the body does not want or need.

By masking unpleasant flavors, food manufacturers disarm the natural taste alarm system, fooling consumers into eating substances their bodies would otherwise reject.

When unpleasant flavor signals are muted, taste and smell receptors cannot do their job properly nor warn you about what is coming in.

Transporting Flavor

> Spraying unfamiliar foods with a known and liked substance, such as molasses or high-fructose corn syrup, encourages livestock – and humans – to eat unfamiliar foods. For livestock, this trick works well to ease the animals into eating weeds such as thistles. – Fred Provenza, *Nourishment: What Animals Can Teach Us about Rediscovering Our Nutritional Wisdom* (2018)

Another common strategy used by food manufacturers is to uplift a flavor from one place and transport it to another. This usually involves taking cheap, bland ingredients (or a pre-neutralized base, as described previously) and making these things taste like something much better.

Mark Schatzker explains how original versions of the corn chip were considered a flop until flavors were added, at which point the market exploded.[98] Rather than eating a plain concoction of corn and oil, each mouthful now tastes as though it delivers numerous nutritious ingredients.

Similar deceptions occur with flavored drinks, sweets, savory crisps, crackers, and so on. These foods are a kind of chemical hoax.

> Would a seven-year-old girl be interested in drinking a bottle of water mixed with sugar? The answer is no. [...] But add some flavorings to sugar water and the child thinks it tastes like juice and will finish a whole bottle. – Mark Schatzker, *The Dorito Effect: The Surprising New Truth About Food and Flavor* (2016)

This kind of flavor manipulation fools consumers into believing they are eating a wide range of foods without it ever being obvious that the same few core ingredients are consumed over and over again. Flavor manipulation of this type creates a kind of sham eating experience, whereby the flavor at the mouth does not match the nutrition that arrives in the gut.

Wholesale transport of flavors is obvious trickery, but the real terror lies in much more subtle deception.

Strengthening Flavor

> Actual berries are quite expensive. Flav-R-Bites consist of flour, sugar, starch, flavorings, and just six percent blueberry solids, but enough so that the word "blueberry"

> can appear on the label. – Melanie Warner, *Pandora's Lunchbox: How Processed Food Took Over the American Meal* (2014)

The most convincing way that food manufacturers manipulate flavor is by taking an existing flavor and making it stronger. Butter, for instance, can be made even more intense and 'buttery' in flavor through the addition of diacetyl,[99] a compound known for its buttery aroma.

Flavor strengthening is widespread and found in almost all types of manufactured food. Crumbed chicken, orange juice, and pasta sauce, for example, often have 'natural flavors' or 'extracts' on the ingredient list. These flavoring agents contain a mixture of undisclosed chemicals that, in many countries, need not be declared or specified. Even fresh meats can be pre-soaked, injected, or marinated in flavoring solutions.[100]

It is worth noting that flavor concentration of this sort is a far cry from traditional methods. When a rich soup boils on the stove, water is evaporated, causing the flavor to intensify. In this case, the strengthened flavor *correctly signals the increased nourishment of the soup*. As each spoonful now contains less water, the concentration of nutrients is higher; thus, the strengthened flavor accurately 'labels' the meal. When manufacturers add a few drops of flavoring solution to a soup, however, the soup does not change in nutrient density at all.

Just as sugar strengthens the flavor of naturally sweet items, glutamates, responsible for the umami taste, amplify the flavor of savory foods. Synthetic monosodium glutamate (MSG) has received negative press in recent times; hence, these added glutamates often hide under a variety of guises, such as hydrolyzed vegetable proteins (which can contain 10-30% MSG), and extracts from yeast, tomatoes, and mushrooms.[101] Marketers of these products reassure consumers that the glutamates in these extracts are 'naturally occurring' and in far lower concentrations than pure MSG. Nonetheless, these additives artificially concentrate glutamates and are used predominantly for flavor manipulation.

Just as sugar water is unappealing, so too is plain rice with added MSG. Yet, if MSG is added to *fried* rice, the fried rice is perceived as tasting better than it did before.[102] In the latter case, the presence of the few genuine savory ingredients helps to cement the deception. As author Robert Greene explains, the best way to seduce a victim is to merge illusion and reality – to embellish and build fantasy upon the truth.[103]

Flavor-strengthened products have several advantages for the manufacturer. Firstly, the nourishing ingredients (which are typically the expensive ones) can be reduced, offering significant savings.

> ...why clog up your cold storage area with vats of real cream when you can use a 'powdery, homogeneous and free flowing cream to yellow powder with a cream taste

> and smell' that doesn't need to be chilled, and takes up a fraction of the factory space? – Joanna Blythman, *Swallow this* (2015)

Secondly, due to the reduced nutrition, consumers must eat more to meet survival needs (a win for the manufacturers). Thirdly, unlike complete sham foods, such as flavored drinks or sweets, flavor-strengthened items deliver both taste *and* satisfaction if enough is eaten. In fact, the boosted flavor is perceived as superior – because it predicts a heightened survival reward. It is thus no surprise that many of the most commonly craved foods contain trace amounts of nourishing ingredients, supplemented with a heavy dose of added flavor (cookies, pizza, ice cream, and so on).[104]

To understand the lengths that manufacturers go to in creating flavor-enhanced products, consider the case of a typical mass-produced pizza. A nationwide pizza chain in New Zealand,[105] for example, adds "natural flavor" to the dough; "maple flavor," "smoke flavor," and "flavor" to the bacon; "flavor" and "autolyzed yeast extract" (which contains glutamate) to the beef topping; "natural flavor" to the cheese; "hydrolyzed yeast protein," "autolyzed yeast extract," "color," and "flavor" to the BBQ and tomato sauces; and so on. These additives take the few scraps of nourishing ingredients – the trace amounts of meat, vegetables, and cheese – and exaggerate the flavor so that the sub-par nutritional reward is marketed under the illusion of tremendous gain.

As these misleading concoctions are eaten, flavor molecules slot into the taste and smell receptors, sending the brain the message that a *huge load of nutrition* is coming in. Because *some* nutrition arrives in the stomach (but far less than is predicted based on the strength of the flavor), these items eventually lead to satiety if enough is eaten.

If something tastes great and eventually leads to satiety (albeit delayed), what is the problem?

The problem is not just that a larger volume must be consumed before fullness is achieved (delivering more calories than is optimal – not to mention the influx of harmful and unwanted chemicals) but that the *learned relationships between flavor and nutrition weaken*.

If flavor-enhanced foods are consumed on a regular basis, the strengthened flavor soon predicts the sub-par nutritional reward. Genuine flavors, by comparison, seem inadequate. To get ahead, food manufacturers must sell *even more* intensely flavored products.

Supplements and Fortification

Intensive farming techniques, modern agricultural practices, long shipping and storage times, unforgiving manufacturing processes, and a preference for cheap and durable ingredients can result in foods that are lower in nutrition than those our ancestors plucked fresh from the ocean, field, or tree. To compensate for this deficiency, modern humans are often advised to take vitamin and mineral supplements.

Some supplements are recommended to be taken on an empty stomach. In this case, the nutrition from the pill is *disconnected from any preceding flavor signal*. From the body's perspective, nutrients spontaneously arrive in the stomach without the ordinary forewarning, providing far less opportunity to release appropriate hormones and enzymes as required to digest and utilize the material. This may be one reason why some supplements cause gastrointestinal discomfort, nausea, or diarrhea when consumed on their own.[106]

Other nutritional supplements are recommended to be swallowed with meals, as this can improve absorption. For example, some nutrients are fat-soluble and are absorbed better when taken with a meal containing fat.

The problem with consuming supplements at meals, however, is that the nutrition from the pill is now *arbitrarily connected to the random assortment of flavors present in the accompanying meal*. As Provenza's sheep experiments might suggest (see chapter 3: *Flavor-Nutrition Relationships*), this adds infinite confusion to the learned relationships between flavor and nutrition.

Something similar happens when products are ‘enriched’ with vitamins or minerals without this being signaled by a corresponding change in flavor. In some countries, for example, certain brands of bread have folic acid added, while others do not – despite the loaves being indistinguishable in appearance and taste. Sporadic fortification between brands makes it very difficult for the body to predict when and where a nutrient will appear.

The muddling of flavor-nutrition relationships may help to explain why a number of vitamin and mineral studies report *worse health* in the cohort who supplement their diet.

> Betacarotene, when you get it in the form of a carrot, is undoubtedly good for you. When they took betacarotene out of the carrot and gave it as a supplement to patients with cancer, it actually seemed to make them worse. – Michael Mosley, *The Fast Diet* (2013)

Another reason why supplements may lead to detrimental outcomes is that the isolation of a particular compound can exclude other potentially beneficial elements found in the original food source, which are sometimes necessary for utilizing that particular vitamin.

> In addition to ascorbic acid, real vitamin C must include bioflavonoids like hesperidin, rutin, quercetin, tannins, along with other naturally occurring compounds. Mineral

> cofactors must be available in proper amounts. If any of these parts are missing, there is no vitamin activity. – Scott Treadway, quoted by Randall Fitzgerald, *The Hundred-Year Lie* (2007)

Others express legitimate concerns about the safety of additives included in these formulations. However, the primary issue with supplementation is that both the nutrients and any additives within the pill now arrive in the body without a reliable preceding flavor signal.

Nutrients can be harmful in elevated doses, with the optimal amount varying due to circumstance. Even if a test indicates that an individual is deficient in a particular nutrient, there is no way to know whether the test is reliable, the target amount optimal, or whether the proposed pill contains the solution. This leaves consumers reliant on the wisdom of marketers from the supplement industry,[107] who have a tremendous incentive to convince people that they cannot perform optimally without these products.

This does *not* mean that vitamin pills cannot deliver a tangible improvement in health in some circumstances. There are certainly occasions where emergency usage of vitamins or minerals is warranted. However, to acquire optimal nutrition on an ongoing basis, the body must have *a reliable method* for locating, acquiring, and monitoring the intake of each nutrient. Although supplementation can solve an emergency problem, it does not protect the body from enduring that same deficiency again. In fact, as the hypothesis presented within this book might suggest, supplementation is almost certain to confuse flavor-nutrition relationships further, hindering the body's ability to source the nutrition it needs going forward.

Your body already has an incredible system for hunting out and locating chemicals in this vast, complicated world: it learns the patterns between flavor and nutrition. Attempting to artificially remedy a deficiency by delivering a nutritional win that is disconnected from a preceding flavor cue can alleviate a short-term crisis, but it does nothing to restore a reliable method of acquiring that nutrient in the future.

Flavor: The Most Important Dietary Stimulus

Flavor compounds may deliver very little in the way of calories and can be added in tiny quantities – sometimes the very last item on the ingredient list. As such, they often fly under the radar. But flavor is the *driving force behind our food choices.*

If foods had no flavor and everything tasted the same, nothing would seem any more appealing than anything else. Eating would be boring – a chore. You wouldn't be able to distinguish the edible from the non-edible, let alone be able to hunt out and isolate the nutrients you need.

When it comes to the human food supply, flavor is king. If something looks odd but has a delicious flavor, the pleasing flavor almost always overrules the appearance. Greengage plums, for instance, are ripe when they are green. Those new to this variety of plum may eye them with distrust, convinced the fruit is unripe. However, once bitten, the flavor overrides any uncertainty.

Flavor is the crucial, defining characteristic of human food. Size, shape, location, and cultural wisdom may *suggest* that an item is suitable to eat – but only once it is within the mouth and subjected to a detailed chemical analysis via the taste and smell receptors, do we know for sure.

In a very real sense, it is as if the body is protected by a series of gatekeepers or guards. Cultural wisdom prevents most things from getting near the mouth at all. Rather than risking your life sampling any old plant, fungi, insect, or animal, you improve your survival odds by selecting only from those items that other trusted individuals verify are good to eat. (Interestingly, this is one reason why livestock shifted from one part of a country to another are more likely to die from a toxic overdose, as they haven't yet built up a repertoire of appropriate cultural wisdom about which local plants are optimal to eat.)[108]

Visual cues provide further information about whether something should be brought toward the mouth. If a food looks foul or has a soiled or dirty appearance, you may discard it outright rather than risk contaminating the body with rotten food, dangerous bacteria, or toxins. To clarify the age or status of a particular food, you might bring it nearer to the nose and sniff cautiously. In this way, the appearance, location, and external aroma act as preceding cues, helping you navigate toward or away from the substance as appropriate.

But if something passes all these tests and makes it into the mouth, the taste and smell receptors act as the final gatekeeper. Sensory receptors carry out a detailed chemical analysis, sending this vital information to the brain. Only once the mouth and nose have directly sampled the flavor does the brain have solid chemical data upon which to make a final prediction and act. In response, you know whether to spit the item out, continue chewing dubiously, or swallow in delight and begin to eat.

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[43] Institute for Quality and Efficiency in Health Care, *How does our sense of taste work?* (Updated 2016) https://www.ncbi.nlm.nih.gov/books/NBK279408/

[44] "It is now estimated that there are between 500-1000 odorant receptor genes in both humans and mice. This number of genes, specific to the olfactory system, comprises 1-2% of the 50,000 to 100,000 genes thought to make up the human genome. This number is second only to the receptors of the immune system." – John C. Leffingwell, *Olfaction* (2001) https://www.leffingwell.com/download/olfaction2.pdf

[45] "Nonhuman species provide evidence that the sense of taste has been shaped by evolution; for instance, cats and some other carnivorous species, in addition to chickens, have lost the function of their sweet receptor—they no longer need to taste "sweet" because the foods they eat, the flesh of other animals or starchy grains, contain little sugar." – Danielle Renee Reed, Antti Knaapila, *Genetics of Taste and Smell: Poisons and Pleasures* (2012) https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3342754/

[46] "Compared to mammals, chickens have fewer genes for taste receptors, e.g., lacking the taste receptor T1R2 for sweet..." – Hong-Xiang Liu, Prasangi Rajapaksha, Zhonghou Wang, Naomi E Kramer, Brett J Marshall, *An Update on the Sense of Taste in Chickens: A Better Developed System than Previously Appreciated* (2018) https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5951165/

[47] "Aquatic carnivorous mammals, such as sea lions [...] appear to have lost a large number of taste receptors, perhaps because most of their prey are swallowed whole and would not be tasted. In this case, the identification of swimming fish via visual recognition and the body and kinetic senses of pursuing prey may have replaced taste." – Paul A.S. Breslin, *An Evolutionary Perspective on Food and Human Taste* (2013) https://www.sciencedirect.com/science/article/pii/S0960982213004181

[48] Danielle Renee Reed, Antti Knaapila, *Genetics of Taste and Smell: Poisons and Pleasures* (2012) https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3342754/

[49] Richard D. Mattes, *Orosensory Considerations* (2012) https://onlinelibrary.wiley.com/doi/full/10.1038/oby.2006.299

[50] “Flavor is information. Compounds like phosphorus and vitamin C are stable. They don’t waft off food. So the

body senses what it can—those unstable floaty aromas—and associates them with the post-ingestive effects on our bodies." – Mark Schatzker, *The Dorito Effect: The Surprising New Truth About Food and Flavor* (2016

[51] "Flavor evaluation is influenced by learning from experience with foods. One main influence is flavor-nutrient learning (FNL), a Pavlovian process whereby a flavor acts as a conditioned stimulus (CS) that becomes associated with the postingestive effects of ingested nutrients (the US)." – Kevin P. Myers, *The convergence of psychology and neurobiology in flavor-nutrient learning* (2018) https://core.ac.uk/download/pdf/216950922.pdf

[52] "Sheep can make multiple flavor-feedback associations with minerals. We designed a study in which we made lambs deficient in one of three minerals – phosphorus, calcium or sodium – and gave them a choice of the three differently flavored foods. The lambs had previously ingested these flavored foods with one of the three minerals. Lambs preferred the flavor previously paired with repletion of the mineral – phosphorus, calcium, or sodium – they were lacking." – Fred Provenza, *Nourishment: What Animals Can Teach Us about Rediscovering Our Nutritional Wisdom* (2018)

[53] "He wanted to set up an "association" between the flavor of maple and the nutritional payload of phosphorus. A few days later, when these same phosphorus-deficient sheep were offered maple-flavored feed, they gobbled it

up, even though there wasn't so much as a speck of phosphorus in it. To their bodies, maple flavor meant one thing: phosphorus." – Mark Schatzker, *The Dorito Effect: The Surprising New Truth About Food and Flavor* (2016)

54 "...sheep trained to avoid cinnamon-flavored rice [previously paired with mild dose of lithium chloride] also avoid any cinnamon flavored food." – Fred Provenza, *Nourishment: What Animals Can Teach Us about Rediscovering Our Nutritional Wisdom* (2018)

55 "When sheep eat a meal of four familiar foods (alfalfa, barley, oats, and corn) and one novel food (rye), and then get an orally administered nauseating capsule of lithium chloride, they subsequently ignore the novel food, but not the familiar foods." – Fred Provenza, *Nourishment: What Animals Can Teach Us about Rediscovering Our Nutritional Wisdom* (2018)

56 Emily R. Liman, Yali V. Zhang, Craig Montell, *Peripheral coding of taste* (2015) https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3994536/

57 "You can get along with other people only if you can accurately gauge whether their intentions are benign or dangerous. Even a slight misreading can lead to painful misunderstandings in relationships at home and at work." – Bessel van der Kolk, *The Body Keeps the Score* (2015)

[58] “Our own studies have shown that sniffing in a smell gives rise to a spatial pattern of activity in the brain. These patterns function as images of smell, with different images for different smells, much as different faces form different images in our visual system. Human brains are very good at recognizing faces, which can be thought of as a highly developed form of pattern recognition. From our studies we think that the same ability occurs with the patterns laid down by smells—that is, the ability to recognize many different patterns representing as many different smells.” – Gordon Shepherd, *Neurogastronomy: How the Brain Creates Flavor and Why It Matters* (2013)

[59] “Importantly, flavor evaluation is neither innate nor fixed.” – Kevin P. Myers, *The convergence of psychology and neurobiology in flavor-nutrient learning* (2018) https://core.ac.uk/download/pdf/216950922.pdf

[60] “Our likes and wants are subjective properties we assign to food based on our past experiences, and our current state of satiation and satiety.” – J. Stanton, *What Is Hunger, and Why Are We Hungry?* (2012) https://www.youtube.com/watch?v=254L_Gr9s-4

[61] Zata Vickers, Flavor, *Satiety and Food Intake* (2017)

[62] Cees de Graaf, Sanne Boesveldt, *Flavor, Satiety and Food Intake* (2017)

[63] “In the orbitofrontal cortex, feeding to satiety with one food decreases the responses of these neurons to that

food, but not to other foods, showing that sensory-specific satiety is computed in the primate (including human) orbitofrontal cortex." – Edmund Rolls, *Brain mechanisms underlying flavour and appetite* (2006) https://www.ncbi.nlm.nih.gov/pubmed/16815796

[64] "...dopamine neurons come to respond with bursts to stimuli that immediately precede and reliably predict the reward..." – Roy A. Wise, Mykel A. Robble, *Dopamine and Addiction* (2020) https://www.annualreviews.org/doi/full/10.1146/annurev-psych-010418-103337

[65] Richard D. Mattes, *Orosensory Considerations* (2012) https://onlinelibrary.wiley.com/doi/full/10.1038/oby.2006.299

[66] Keri McCrickerd, *Flavor, Satiety and Food Intake* (2017)

[67] Paul A.S. Breslin, *An Evolutionary Perspective on Food and Human Taste* (2013) https://www.sciencedirect.com/science/article/pii/S0960982213004181

[68] Christopher H Hawkes, *Smell and Taste Disorders* (2018)

[69] "As ingestion continues, the various inhibitory effects of the ingested food and digestive products accumulating in the stomach and small intestine begin to slow the rate of

eating and finally stop it. Since orosensory and postingestional stimuli act concurrently shortly after a meal begins...” John D. Davis, Gerard P. Smith, *The conditioned satiating effect of orosensory stimuli* (2009) https://www.sciencedirect.com/science/article/abs/pii/S0031938409001401

[70] “Eating two oranges made participants feel physically full, but they were still mentally hungry – looking for or wanting something else to eat.” – Zata Vickers, *Flavor, Satiety and Food Intake* (2017)

[71] “The behavioural sequence of satiety occurred after the first sham-fed meal, but meal size doubled and the intermeal interval was about 50% shorter than was observed in the preceding real feeding test.” – Gerard P. Smith, *Satiation: From Gut to Brain* (1998)

[72] “...after 17 hours of food deprivation, sham feeding continued for 7.5 hours in rats without the occurrence of the behavioural sequence of satiety (Young et al.,). Continuous sham feeding has also been observed in rhesus monkeys after overnight food deprivation.” – Gerard P. Smith, *Satiation: From Gut to Brain* (1998)

[73] “The observation of absence of satiety when food drained out of the upper small intestine has been confirmed in monkeys...” – Danielle Greenberg, *Satiation: From Gut to Brain* (1998)

[74] "Both experiments confirmed previous results – intake was equivalent to the volume of gastric contents withdrawn." – Gerard P. Smith, *Satiation: From Gut to Brain* (1998)

[75] "The infusions elicited the complete behavioral sequence for satiety, and the reductions in sham feeding were related to the chemical concentration of the nutrient infusions." – Danielle Greenberg, *Satiation: From Gut to Brain* (1998)

[76] "The duodenal infusion had been shown to stop sham feeding and elicit the behavioural sequence of satiety after 17 hours of food deprivation (Liebling et al., 1975)." – *Gerard P. Smith, Satiation: From Gut to Brain* (1998)

[77] "The satiating effect of intestinal nutrient infusions in the sham-feeding preparation indicates, however, that gastric distention is not necessary for the inhibition of meal size." – Danielle Greenberg, *Satiation: From Gut to Brain* (1998)

[78] "Equivolumetric infusions of saline did not suppress sham feeding and did not elicit behaviors typical of satiety. Thus, in the monkey as well as in the rat and humans, the mechanical stimuli produced by the volume of saline infusions did not produce a satiating effect." – Danielle Greenberg, *Satiation: From Gut to Brain* (1998)

[79] "If intestinal infusions were given 6-12 minutes before sham feeding was initiated, no suppression of intake was

observed. Maximal suppression of sham feeding was obtained when the [nutrient] infusion began 12 minutes after the onset of sham feeding." – Danielle Greenberg, *Satiation: From Gut to Brain* (1998)

[80] "…a synergistic interaction between post-pyloric and gastric stimuli in the control of compensatory intake…" – Gerard P. Smith, *Satiation: From Gut to Brain* (1998)

[81] "Roux-en-Y gastric bypass surgery (RYGB) and other bariatric procedures alter gastrointestinal processing of food in a number of ways. Thus, it is plausible that these procedures alter post-oral unconditioned stimuli that support flavor-consequence learning, leading to altered food selection, amount eaten, and affect. Surprisingly, however, there is almost no research on the role of flavor-consequence learning in the effects of bariatric surgery on appetite. This issue urgently warrants investigation." – Lori Asarian, Nori Geary, *RYGB and flavor-consequence learning* (2020) https://www.sciencedirect.com/science/article/abs/pii/S0195666319305732

[82] "…total subdiaphragmatic vagotomy abolished the suppression of sham feeding elicited by intestinal infusion of sodium oleate." – *Danielle Greenberg, Satiation: From Gut to Brain* (1998)

[83] "When the caloric density of their food was cut in half, after a few days rats doubled the volume of food that they ate. Other labs found similar results." – Seth Roberts,

What makes food fattening (2005) https://sethroberts.net/wp-content/uploads/2018/12/whatmakesfoodfattening.pdf

[84] “However, studies in which food has been calorically diluted (i.e., by the addition of nonnutritive bulk so that more volume must be eaten to achieve the same caloric load) have shown that animals easily adapt to this manipulation by increasing their meal size (Adolph, 1947; Janowitz & Grossman, 1949). They readily consume a larger volume to get their calories, which suggests that gastric capacity is rarely a factor in normal consumption.” – Stephen C. Woods, *The Eating Paradox: How We Tolerate Food* (1991) https://www.appstate.edu/~steelekm/classes/psy5150/Documents/Woods1991.pdf

[8585] “A soft drink with low natural juice content may require a clouding agent to boost the turbidity in order for it to resemble the cloudy natural juice of the fruit it is named after.” – Joanna Blythman, *Swallow This: Serving Up the Food Industry's Darkest Secrets* (2015)

[86] Avery Gilbert, *What the Nose Knows* (2015)

[87] “When they see something they like, they extract its flavor molecules from the fruit on the tree. Then, back in the lab, they mimic mother nature’s molecules with chemicals.” – Morley Safer, CBS News, *Tweaking tastes and creating cravings* (2011) https://www.youtube.com/watch?v=a7Wh3uq1yTc [2:30]

[88] Glanbia Nutritionals, *Flavor Masking Challenges and How to Solve Them* https://www.glanbianutritionals.com/en/nutri-knowledge-center/nutritional-resources/flavor-masking-challenges-and-how-solve-them

[89] Jeff Gelski, *Eliminating the pea flavor in pea protein*, (2018) https://www.foodbusinessnews.net/articles/11344-eliminating-the-pea-flavor-in-pea-protein

[90] "Sweetness is used to mask not only bitter but also acidic tastes. This is important in wines or fruit juices, especially citrus juices that can contain strong-flavored volatile oils from pith, seeds, and peels that are the result of large-scale juice operations." – Florentine Hilty-Vancura, *New Strategies For Masking And Modifying Flavor* (2017) https://www.preparedfoods.com/articles/120329-new-strategies-for-masking-and-modifying-flavor

[91] "The biggest challenge in plant-based protein product development today is overcoming the unwanted or off flavor that comes from these sources. For example, a beany soy flavor or bitter pea protein flavor can deter consumers from craving plant-based products." – Innova Flavors, *Understanding Flavor Masking Agents: 5 Things You Need to Know* (2021) https://www.innovaflavors.com/blog/understanding-flavor-masking-agents-5-things-you-need-to-know

[92] Innova Flavors, *Understanding Flavor Masking Agents: 5 Things You Need to Know* (2021) https://www.innovaflavors.com/blog/understanding-flavor-masking-agents-5-things-you-need-to-know

[93] "Trying to block bitter flavours is far more practical than, say, trying to remove any of the vast range of compounds that can make food taste unpleasant. And only tiny amounts of bitter blockers are required to stop the bitter signal reaching the brain." – Celeste Biever, *Bitter pills banished by taste-blocking compounds* (2003) https://www.newscientist.com/article/dn3433-bitter-pills-banished-by-taste-blocking-compounds/

[94] Danielle Andrews, Smita Salunke, Anne Cram, Joanne Bennett, Robert S. Ives, Abdul W. Basit, Catherine Tuleu, *Bitter-blockers as a taste masking strategy: A systematic review towards their utility in pharmaceuticals* (2021)

https://www.sciencedirect.com/science/article/abs/pii/S0939641120303179

[95] Celeste Biever, *Bitter pills banished by taste-blocking compounds* (2003) https://www.newscientist.com/article/dn3433-bitter-pills-banished-by-taste-blocking-compounds/

[96] "Microencapsulation is a technology that is extensively used in foods…" – Nitamani Choudhury, Murlidhar Meghwal, Kalyan Das, *Microencapsulation: An overview on concepts, methods, properties and applications in*

foods (2021)
https://onlinelibrary.wiley.com/doi/10.1002/fft2.94

[97] Florentine Hilty-Vancura, *New Strategies For Masking And Modifying Flavor* (2017)
https://www.preparedfoods.com/articles/120329-new-strategies-for-masking-and-modifying-flavor

[98] Mark Schatzker, *The Dorito Effect: The Surprising New Truth About Food and Flavor* (2016)

[99] "Dutch chemists soon discovered that the compound diacetyl, produced either synthetically or by microorganisms, could add a "buttery" flavor to foods. Creameries then started adding a chemical that doesn't naturally occur in butter to actual butter in order to make it taste more like...butter." – Alison Herman, *The Absurd History of Artificial Flavors* (2015)
https://amp.firstwefeast.com/drink/2015/06/the-absurd-history-of-artificial-flavors

[100] "Enhanced or value-added meat and poultry products are raw products that contain flavor solutions added through marinating, needle injecting, soaking, etc. The presence and amount of the solution will be featured as part of the product name, for example, "Chicken Thighs Flavored with up to 10% of a Solution" or "Beef Steak Marinated with 6% of a Flavor Solution."" – United States Department of Agriculture, *Water in Meat and Poultry* (2013) https://www.fsis.usda.gov/food-safety/safe-food-

handling-and-preparation/food-safety-basics/water-meat-poultry

101 "Monosodium glutamate (MSG) is perhaps the most common of the glutamates added to foods. Many consumers, however, have been avoiding MSG when it appears on a label. But extracts and concentrations of tomatoes and mushrooms, rich in natural glutamic acid compounds, are stepping up to take MSG's place." – Florentine Hilty-Vancura, *New Strategies For Masking And Modifying Flavor* (2017) https://www.preparedfoods.com/articles/120329-new-strategies-for-masking-and-modifying-flavor

102 "MSG enhancement of flavour appears to require some existing umami-like element to be present: thus when MSG is added to boiled rice alone, it elicits either neutral or negative palatability ratings, but when added to fried rice, palatability ratings increase." – Martin R Yeomans, *Flavor, Satiety and Food Intake* (2017)

103 "The perfect illusion is one that does not depart too much from reality, but has a touch of the unreal to it, like a waking dream. Lead the seduced to a point of confusion in which they can no longer tell the difference between illusion and reality." – Robert Greene, *The Art of Seduction* (2003)

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(18 %), pizza (18 %), ice cream (16 %), and French fries (14 %). These foods correspond to the most often craved foods identified in previous studies on food craving." – Adrian Meule, Ashley N. Gearhardt, *Five years of the Yale Food Addiction Scale: Taking stock and moving forward* (2014) https://link.springer.com/article/10.1007/s40429-014-0021-z

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[106] Tod Cooperman, *Which supplements should be taken with food?* (2021) https://www.consumerlab.com/answers/which-supplements-should-be-taken-with-food/supplements_taken_with_food/

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[108] Fred Provenza, *Nourishment: What Animals Can Teach Us about Rediscovering Our Nutritional Wisdom* (2018)