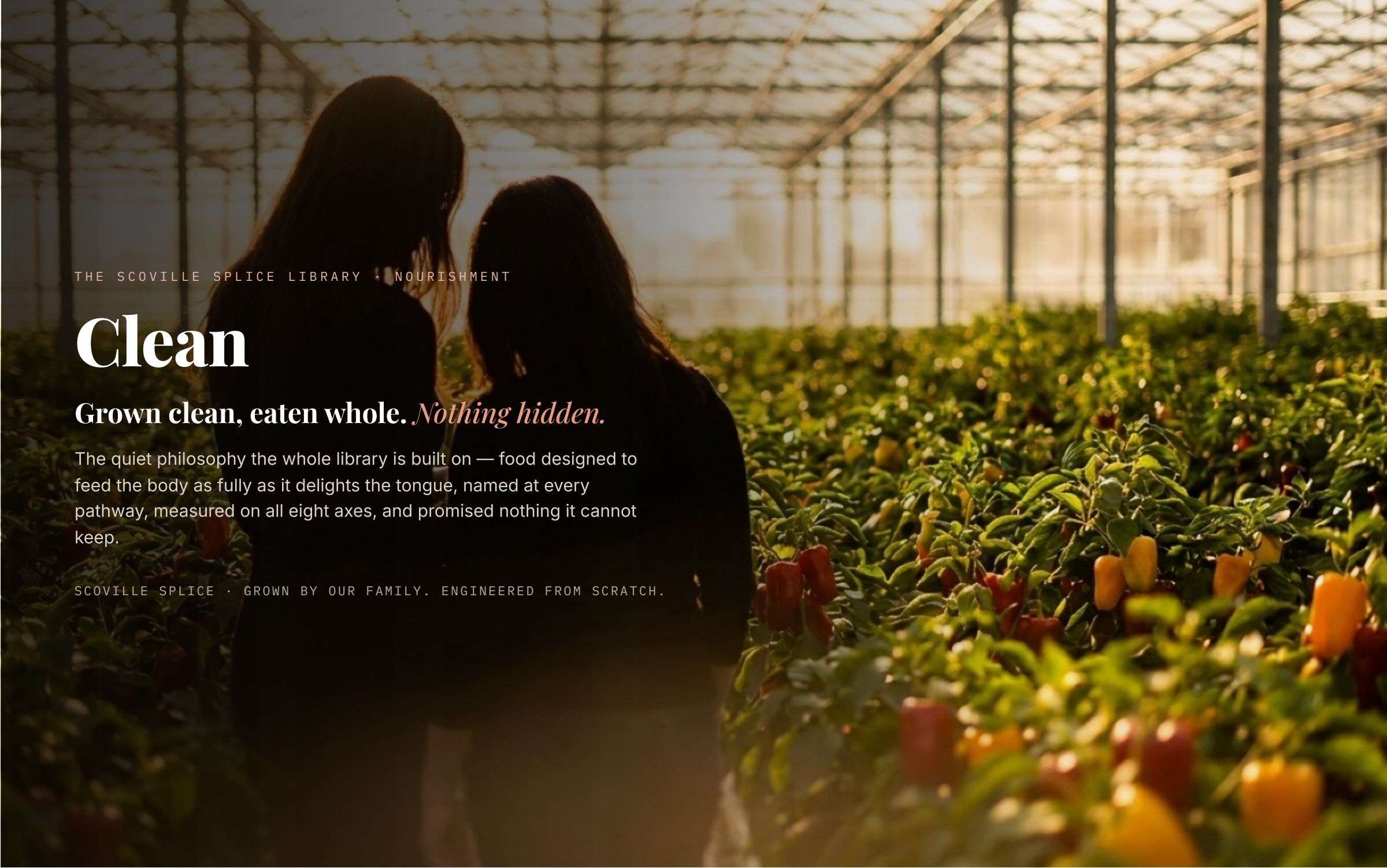

THE SCOVILLE SPLICE LIBRARY · NOURISHMENT

Clean

Grown clean, eaten whole. *Nothing hidden.*

The quiet philosophy the whole library is built on — food designed to feed the body as fully as it delights the tongue, named at every pathway, measured on all eight axes, and promised nothing it cannot keep.

SCOVILLE SPLICE · GROWN BY OUR FAMILY. ENGINEERED FROM SCRATCH.

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Opening essay · What we mean when we say clean

Clean is a word the grocery aisle has nearly worn out. It has been stamped on so many labels and asked to promise so many things that it has thinned into a feeling of virtue with no measurement behind it — a halo, floating free of the food that is supposed to carry it. We have wanted for a long time to say plainly what we mean by it, because *clean* is the word that sits under everything else in this library, quieter than heat and older than the Index. It is the oldest thing our family believed about food, and the last thing we learned how to measure.

For us it begins in the plant, before the kitchen, before the label. A tomato warm from the vine and split open at the table is not clean because of what we kept out of it. It is clean because of what we grew into it — and because there is nothing in it we could not name. That is the whole of our definition, and we hold to it exactly, as three load-bearing words: **clean food is food whose flavor and whose nourishment are grown in on purpose, measured honestly, and hidden nowhere.**



The greenhouse at the hour the light goes gold — the family among the plants, where the question that became this company first came up at our own table.

Take the three words one at a time, because the whole book lives in the spaces between them.

Grown in, because we do not bolt a flavor onto a plant from the outside, and we do not dust a nutrient into it after the fact. We go to the pathway that made the thing in the first place and turn it up at the source — the free glutamate the fruit already makes for itself, the sugars it was always meant to carry, the aromatics written into its own genome. Nothing new is introduced for the tongue to find; an existing signal is simply made louder. The consequence, which we did not have to design because the biology hands it to you, is a plant you can read all the way down to the root, with no foreign compound riding along and nothing on the label that needs a second, smaller line beneath it to explain itself.

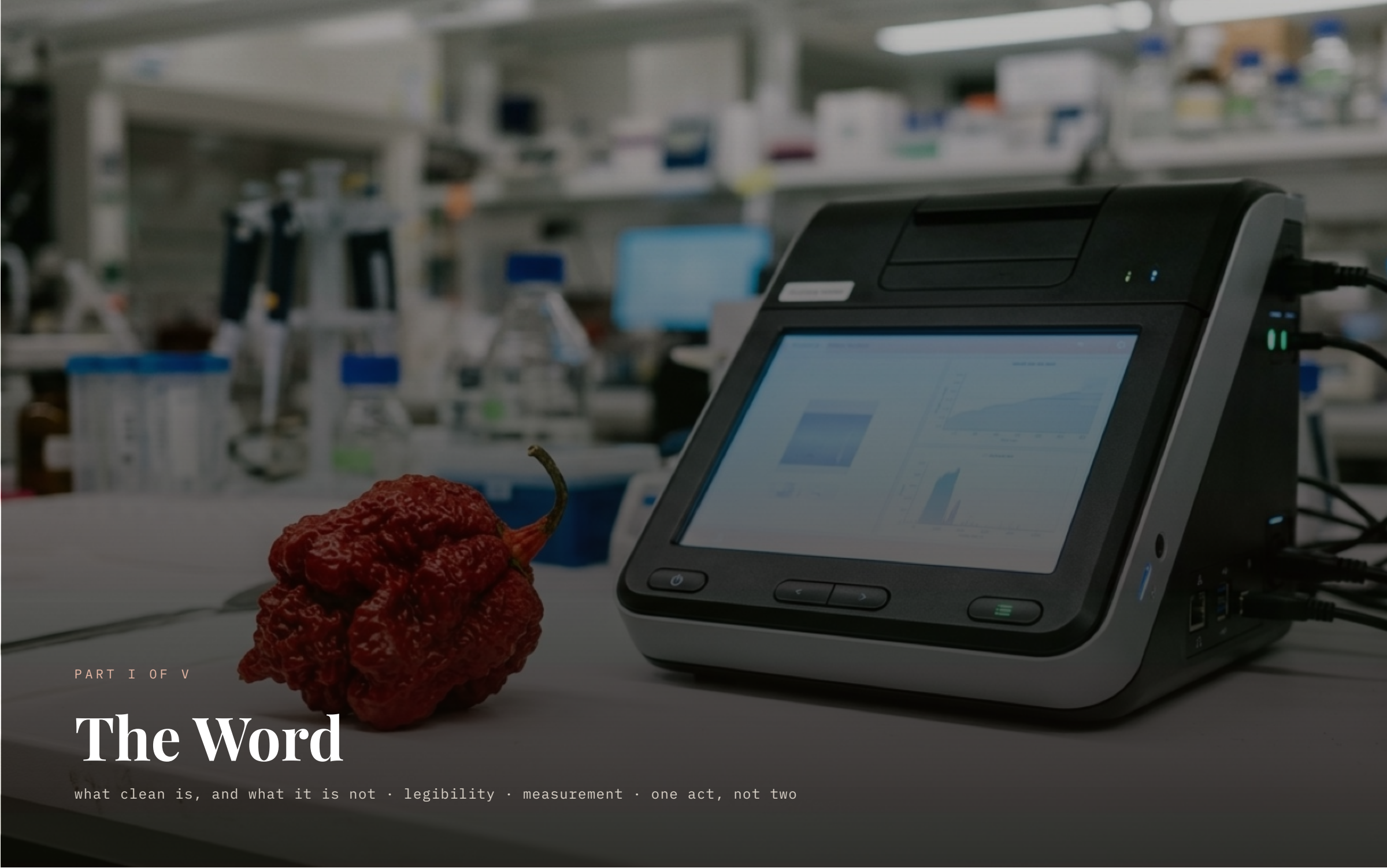
Measured, because a thing you cannot measure you cannot be honest about. Every taste is, underneath, a chemical conversation we spent most of human history unable to read: a molecule settling into a receptor on the surface of the tongue, a lock and key repeated a billion times a second, felt exactly and describable only in poetry. Every cultivar and every dish in this book carries its scorecard — the eight axes of the Iyengar Flavor Index, each a single number anchored to a receptor by the same plain line:

$$\mathbf{IFI(candidate) = 1{,}000 \times EC_{50}(reference) \div EC_{50}(candidate)}$$

EC_{50} is the concentration at which a stimulus drives its receptor to half of its full response — the molecular definition of *loud*. Invert it against a fixed reference, scale by a thousand, and loudness becomes a number a tomato, a head of broccoli, and a cup of coffee can be read against on one page. It is not a measure of how much of a compound a food holds; it is a measure of how loudly that compound *speaks*. The number is not there to replace the pleasure. It is there because you cannot design what you cannot measure, and because a measurement you will hand to a stranger is a form of respect — for the receptor, for the plant, and for the person who will eat the thing.

Hidden nowhere, because the pathways are named, the measurements are published — twenty-one peer-reviewed papers on Zenodo under a CC BY 4.0 license, three patents filed and therefore public by their nature — and the only proprietary thing we own is the work it took to find them. Clean, for us, is not a sealed box with a reassuring word printed on the outside. It is a box with the lid off.

There is a fourth idea the other three are reaching toward, and it is why this is the most personal book we have written. Somewhere in the last century food was supposed to feed you, and most of the era's cleverness went instead into making it survive a truck. We think flavor and nourishment were never two projects. The ripeness that carries a tomato's umami is the same ripeness that carries its lycopene and its vitamin C; the care that designs a taste designs a food worth eating. This book is about growing that care back in — and about the single discipline that keeps the word *clean* honest: we will tell you what we put into the plant, and we will tell you what we measured, and we will never tell you what it will do inside your body. That promise, kept, is what clean means to us. Everything after this is the long version of these few sentences — the receptors named, the pathways drawn, the numbers shown, and a table set at the end of it.



PART I OF V

The Word

what clean is, and what it is not · legibility · measurement · one act, not two

Chapter 1 · The emptied plant — *what a century quietly took out.*

Walk the produce aisle under its bright, forgiving light and everything reads as abundance — the stacked tomatoes, the waxed apples, the greens misted on the hour. It is one of the gentlest illusions in modern life. For most of the last hundred years, plant breeding asked a crop for everything except the way it tastes: for yield measured in tons per hectare, for a skin that would not bruise under a forklift, for uniform ripening so a field could be cleared in a single pass, for a shelf life counted in weeks, for a fruit that would survive a refrigerated journey across a continent picked green and gassed pink on arrival. Flavor was not on the form. Nourishment was not on the form. A tomato was asked to survive a journey, and it learned to, and it arrived hollow.



A cross-section of the restored tomato — the gel and placental tissue where free glutamate pools, the part a shipping cultivar quietly learned to keep empty.

The number we come back to most often is the tomato's. On the way to the truck it lost roughly **ninety-three percent** of its peak umami — the free glutamate that finds the mGluR1 receptor and the TAS1R1·TAS1R3 pair and tells the body, in the oldest language it knows, *here is protein, here is something that will feed you*. That signal did not leave alone. The same ripe metabolic state that pools the glutamate also builds the lycopene and holds the vitamin C; when the flavor was bred down, the nourishment went quietly out the same door, unmeasured because no one was measuring either.

It is worth being precise about how the loss happened, because there was no villain in it — only a form with the wrong boxes on it, filled out in good faith across thousands of careful breeding decisions. A plant has a finite metabolic budget. Every gram of sugar it holds in a fruit is a gram it did not spend on a firmer cell wall; every day it leaves a fruit on the vine to deepen is a day the fruit is not in a warehouse. When you select, season after season, for the fruit that ships best and holds longest and ripens all at once for the harvester, you are selecting *against* the metabolic states that make flavor — not because you dislike flavor but because you never put it on the scorecard. The trade was invisible precisely because only one side of it was ever measured.

There is a single, almost too-perfect example of how quietly it happened. For decades the industry prized a tomato that ripened to an even, pale green before it turned, because an unripe fruit of uniform colour is far easier for a machine and a crew to judge and to pick all at once. That uniform paleness came from one gene switched off — a regulator of the fruit's chloroplasts. The grower got the even field they were selecting for. What came along unasked, riding on the same switch, was a ripe fruit with fewer of the chloroplasts that build sugar and colour, and so a fruit measurably lower in both. A choice made entirely about the *look of the unripe fruit* reached forward and dimmed the taste and the substance of the ripe one — and nobody chose that, because nobody was measuring the far end of the trade.

WHAT THE FORM ASKED FOR	WHAT FELL OFF THE FORM, UNPRICED
Yield (tons per hectare)	Free glutamate — the savory floor
Firmness, bruise resistance	Dissolved sugars at the ripe peak (Brix)
Uniform, simultaneous ripening	Chloroplasts — and the sugar and colour they build
Shelf life, cold-chain tolerance	The metabolic state that pools vitamins
Appearance under aisle light	The brief, perfect ripe hour itself

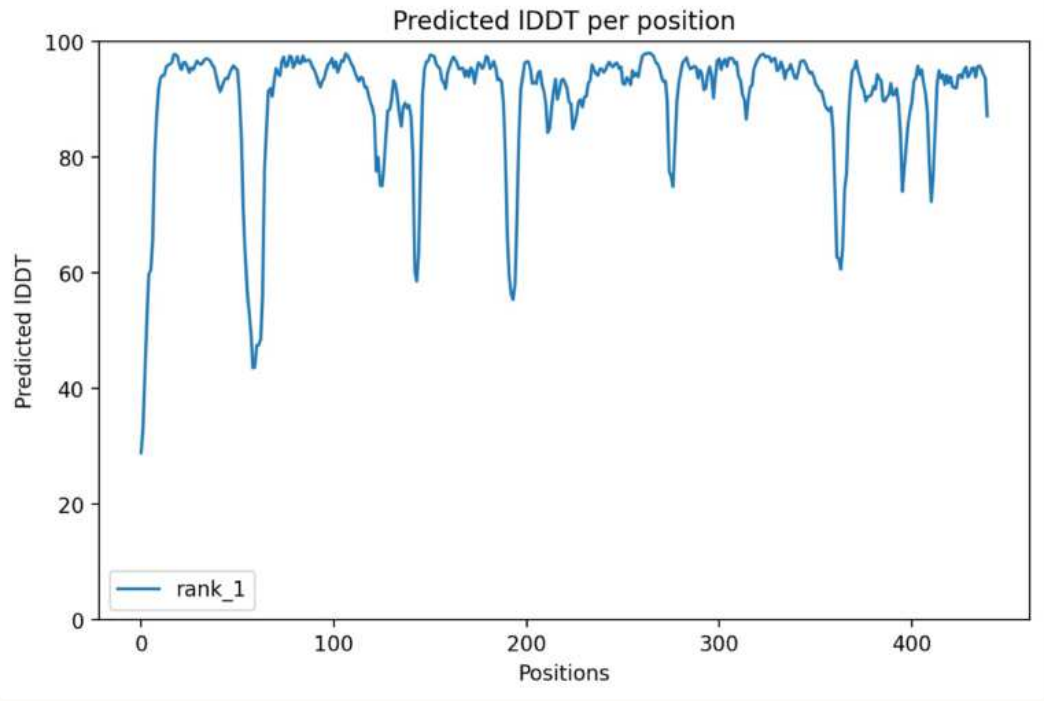
Read the right-hand column and you are reading a definition of flavor, and very nearly a definition of nourishment, bred away as the quiet cost of a fruit that would not go soft. The truck did not steal the flavor in transit. The flavor was gone before the seed went in the ground. And the proof is in the one fruit that escaped the bargain — the tomato from a grandparent's garden, grown for no market and shipped nowhere, that everyone over a certain age remembers and no supermarket can sell them. That tomato is not nostalgia. It is a control group. It is the plant with its full budget returned to the one thing a garden cares about, which is the taste of the fruit, and its loudness is the number the industrial fruit fell from.

We never believed the difference needed making up. It needed *restoring* — and restoring is a different verb entirely, with a different conscience. To make up a deficit is to add something from outside: a splash of stock, a spoon of sugar, a flavor from a jar, a line on a label. To restore one is to go back into the plant and give it permission, through its own biochemistry, to be as full as it always could have been. The first is a patch over an absence. The second

removes the absence. This whole book is an argument for the second verb, and the emptied plant is where the argument has to begin, because you cannot feel grateful for a restoration until you have grieved the loss. Most of us never knew to. We were simply handed the hollow fruit, told it was abundance, and asked to season our way out of the quiet.

Chapter 2 · Clean as legibility — *food you can read all the way down.*

The fastest way to tell whether *clean* is a value or a decoration is to ask what the company will show you. A label that says *clean* and shows you nothing is asking for trust it has not earned. We decided early that our answer had to be *everything that is ours to show* — and then we built the whole method so that there would be a great deal to show and nothing to hide.



We read a protein's structure before we ever touch the living plant — here, the Pun1/AT3 acyltransferase coloured by model confidence (pLDDT), the binding domain and active-site cleft resolved to near-atomic certainty before a single edit is made.

Clean, in its first and plainest meaning, is **legibility**: food you can read all the way down. Every stimulus on the tongue is a conversation between a molecule and a receptor — a protein on the surface of a cell, shaped to catch one kind of signal and report it to the brain — and the entire Iyengar Flavor Index is nothing more than a way of writing those conversations down, one per axis, so that a thing felt can also be known.

CODE	AXIS	RECEPTOR	THE CONVERSATION IT NAMES	ACCENT
IFI-H	Heat	TRPV1	capsaicin lowering the channel's heat threshold	#B0442F
IFI-S	Sweetness	TAS1R2 · TAS1R3	sugar-shaped molecules closing the sweet flytrap	#3E7D4F
IFI-U	Umami	mGluR1 · TAS1R1·R3	free glutamate reporting protein	#6B4E9E
IFI-B	Zero-Bitter	TAS2R38	an ancient warning, turned down 20–65%	#3A6B8C
IFI-K	Kokumi	CaSR	γ-glutamyl peptides, richness and continuity	#6E7A3A
IFI-C	Cool-Burn	TRPM8	menthol, a cold that is not cold	#2F7E8C
IFI-P	Pungency	TRPA1	allicin and mustard oil, the sharp edge	#C06A3A
IFI-A	Astringency	salivary PRPs	tannins drawing the mouth dry	#8C4A6B

Nothing in that table is a secret. The receptors are named in the literature of human physiology; the compounds are named in the chemistry; the formula is one line anyone with a calculator can run. When we publish a cultivar's scorecard, we are not asking you to feel reassured. We are handing you the means to check us.

The legibility runs deeper than the receptor's front door, all the way into the cell behind it, and the mechanism there is worth drawing because it explains why the eight axes are not eight independent dials. Three of the tastes — sweet, umami, and bitter — do not each own a private wire to the brain. They share one machine. When a sweet, umami, or bitter molecule binds its G-protein-coupled receptor, the receptor activates a taste-specific G-protein whose α-subunit is **gustducin**; the released **βγ pair** switches on the enzyme **phospholipase C-β2 (PLCβ2)**, which cleaves a membrane lipid to release **inositol trisphosphate (IP_3)**; IP_3 opens its receptor on the cell's internal calcium store; the freed calcium opens **TRPM5**, a channel that depolarizes the taste cell; and the depolarization drives ATP out through the **CALHM1** channel to the waiting nerve. Sweet, umami, bitter — three different front doors, one shared hallway. That shared hallway is why a pinch of salt makes a dish taste sweeter and less bitter without touching the sweet or bitter receptor at all: it changes how the common signal is weighed. To read a food down to this level is to understand not only what each molecule says but how the sentence is assembled. That is what we mean by legible.

It runs back into the plant, too, and this is where clean label stops being a marketing decision and becomes a consequence of the biology. Every vascular plant on earth runs the same quiet assembly line beneath its flavor, its colour, and its defenses — the **phenylpropanoid branch**, which begins when the enzyme **PAL** (phenylalanine ammonia-lyase) strips the amino group from phenylalanine to make cinnamic acid, then runs on through **C4H** (to *p*-coumarate), **4CL** (to the activated CoA thioester), and **HCT** and **COMT** toward the aromatics that give plants their smells, their colours, and their armor. We work inside that native branch, and inside the plant's own downstream routes, turning up signals the organism already knows how to make. Because nothing foreign is introduced, there is nothing foreign to list. The short ingredient line is not a thing we achieved by subtraction or by secrecy; it is what is left on the page when you have added nothing the plant did not already contain.

There is a quieter number we are just as proud of as any flavor score, and it belongs in a chapter about legibility because it is the thing that makes a published number worth the paper. A score you cannot reproduce is an anecdote. Ours are held to a batch-to-batch **coefficient of variation at or under seven percent** — the coefficient of variation being simply the standard deviation of a measurement divided by its mean, a unitless read on how tightly a thing repeats. At seven percent, a cultivar rated IFI-U 2,600 will land, lot after lot, within a couple of hundred points of that number, not swing between a good harvest and a disappointing one. Reproducibility is its own

kind of cleanliness. It means the food is the same food the second time, and the hundredth. And it is why we keep the science in the open rather than in a vault: the patents protect the *method* — which gene, which base, found how — because a patent is published by its nature, while the older industry instinct, the trade secret, protects by hiding, which is the opposite of what a clean label should mean. Across forty-two host organisms and eight axes, holding the line that tightly is most of the actual work. A company that asks you to trust its food should, we think, work to make the trust unnecessary: not *believe us*, but *here are the papers, here is the measure, here is the same result again*. Clean you cannot check is just a nicer word for hidden.

Chapter 3 · One act, not two — *flavor and nourishment, grown together.*

Here is the belief under all of it, said as plainly as we can manage: taste and nourishment are not two jobs a plant does. They are one job, and they rise together. The afternoon a strawberry reaches the sweetness of its one perfect ripe hour is the same afternoon it holds the most of what it was grown to hold. The glutamate that makes a broth taste like being cared for is, read chemically, the plant and the pot flagging their own protein. Flavor, understood honestly, is very often the body's oldest and most reliable report on whether a food will feed it — a sensory estimate of nutritional worth, refined over the whole length of our evolution, arriving before the first swallow.



A strawberry at its one ripe hour — the sweetness and the substance peaking on the same afternoon, through the same metabolism, because they were never two separate things.

That reading is not sentimental; it is biochemical, and it is close to a definition of the senses themselves. Of the five basic tastes, four are nutritional instruments and one is a warning bell. **Sweet** flags accessible energy — sugar, the quick fuel. **Salt** flags the sodium and minerals the blood runs on. **Sour** flags acid, the ripeness-or-spoilage boundary. **Umami** flags protein, the costliest and most essential class of nutrient, through the free glutamate that signals amino acids are present and available. And **bitter** flags the alkaloid and the toxin, tuned in the other direction to make us pause and reconsider. For

most of human history, to taste was to run a rapid, unconscious nutritional assay, and the pleasures and warnings of the mouth were the readout. The tongue is not a luxury organ. It is the body's first and fastest laboratory.

There is a reason the two rise together and not by coincidence. A fruit sweetens as it ripens precisely in order to be eaten at the moment it most wants to be eaten — when the seed is ready and the flesh is richest, the sugar and the colour and the aroma arriving as one advertisement. The plant and the animal struck this bargain across millions of years: the fruit pays in nourishment, and the sweetness and the savor are the honest receipt. A century of breeding did not tear up the bargain so much as forge the receipt — making fruit that *looks* ripe and ships like it, while the sugar and the glutamate and the carotenoids the ripeness was supposed to certify were quietly left behind. The un-tuned assay still works; it simply has less to read. A hollow tomato is not a broken sensor. It is a true reading of a fruit that has less to say.

You can watch the bargain keep itself in a single fruit. A fig or a plum is sour and tight and faintly bitter while its seed is still forming, and it sweetens, softens, and colours in the same few days the seed finishes — the plant withholding the reward until the payload is ready, then announcing readiness in sugar and aroma all at once. The animal that learns to wait for that signal is fed; the plant that sends an honest one is sown. Flavor, in other words, was never decoration laid over nutrition. It was nutrition's advertisement, evolved to be trusted, and a fruit bred to run the advertisement while skimping on the goods is a quiet breach of a very old contract. Restoring the flavor is, in the most literal sense, making the fruit honest again.

So when we design a plant toward its fullest flavor, we are — almost always, almost automatically — designing it toward its fullest nourishment, because we are tuning the plant's own pathways so that the signal the tongue reads and the substance the body takes move in the same direction, upward, at once. We do not treat them as a trade. We have never once had to choose between a tomato that tastes like more and a tomato that *is* more, because the restored nitrogen metabolism that pools the free glutamate is the same metabolism that pools the amino acids the glutamate is a sign of; the ripeness you taste is the ripeness you eat. The signal and the substance ride home on one cart.

The Index measures eight axes of the first thing, taste. It does not yet measure the second thing — how much of what a food carries the body is actually able to draw out and use. That second measure is the subject of the two books beside this one on the shelf, and it is the frontier this whole shelf points toward. We will come back to it near the end of this book, carefully, because it is the place where a family that loves to feed people has to be most disciplined about what it will and will not say. For now it is enough to state the conviction that lets us even go looking: that the delicious thing and the nourishing thing were never strangers, that a plant grown toward

one is a plant grown toward the other, and that the long apparatus of modern food forgot it somewhere between the field and the shelf. Clean is our name for remembering it on purpose.



PART II OF V

Without the Crutch

flavor that does not lean on sugar, salt, fat, or masking · TAS1R2·R3 · mGluR1 · CaSR · TAS2R38

Chapter 4 · Sweet, and nothing to answer for — *the body reads sweet.*

IFI-S · Sweetness · TAS1R2 · TAS1R3

Sweetness is a duet. The receptor is a single heterodimer, **TAS1R2·TAS1R3**, two subunits of the class-C G-protein-coupled family, each folded into the clasping shape physiologists call a Venus flytrap domain because it closes around its ligand the way the plant closes around a fly. Only when both halves are moved — the large flytrap of T1R2 shut around a sugar, the structure stabilized through T1R3 — does the cell finally fire and the brain hear *sweet*. That two-part architecture is the small mercy that makes the kindest axis possible, because a great many molecules can close that flytrap, and sucrose is only the most familiar of them.



Sugarcane — the native sweetness turned up where it is made, not poured in after the fact.

We can grow a plant toward real, legible sweetness without adding a single grain of sugar, because we are amplifying the plant's own sweet signals — a family of compounds that happen to be far better keys for the sweet lock than sucrose is. Three families matter, and each is made by an enzymatic route we can name.

The **steviol glycosides** of *Stevia rebaudiana* are diterpenes: the plant builds an *ent*-kaurene backbone through its MEP terpenoid pathway, oxidizes it to **steviol**, and then dresses that core in sugars using a small set of its own **UDP-glycosyltransferases** — UGT85C2, UGT74G1, and UGT76G1 — to make stevioside, Rebaudioside A, and the fully-glucosylated Rebaudioside M. Which glycoside you favor is a flavor decision with a receptor basis: the earlier glycosides carry a faint bitter and licorice off-note because they also brush a few of the bitter TAS2R receptors, while Reb M, wrapped in more glucose units, reads cleaner because the extra sugars shield it from those off-target locks. The **mogrosides** of monk fruit are cucurbitane triterpenes built along the parallel route — cucurbitadienol oxidized to mogrol, then glycosylated to **mogroside V**, five glucose units on a triterpene core. And the sweet *proteins* — **brazzein**, a fifty-four-residue protein from the West African plant *Pentadiplandra brazzeana*, along with **thaumatin** and **monellin** — work by a different geometry entirely: too large to fit inside the flytrap cleft, they bind the receptor's outer surface and its cysteine-rich stalk, the "wedge model," holding the trap shut from outside.

Put that potency on the Index. A molecule's loudness is the inverse of its EC_{50}, so a sweetener whose half-maximal concentration is two hundred times lower than sucrose's scores roughly two hundred times higher, and engineered stevia climbs past an **IFI-S of 3,000** on nothing but more of its own glycosides.

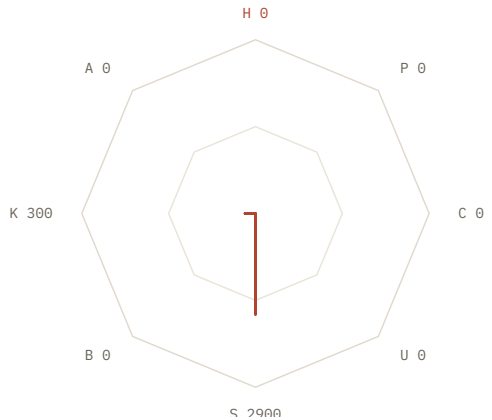
SWEET STIMULUS	MECHANISM	EC_{50} VS. SUCROSE (BY WEIGHT)	IFI-S BAND
Sucrose (reference)	closes TAS1R2·R3 flytrap from within	1×	~15
Rebaudioside A / M (stevia)	glycosylated steviol diterpene	~200–300× lower	2,400–3,100
Mogroside V (monk fruit)	cucurbitane triterpene	~250× lower	~2,900
Brazzein / thaumatin (sweet protein)	binds receptor surface (wedge model)	~500–2,000× lower	3,400–4,600

Why does potency translate so directly into grams saved? Because of the shape of the receptor's response, which is not a straight line but the sigmoid every pharmacologist knows, the **Hill equation**: $\theta = c^n / (EC_{50}^n + c^n)$, where θ is the fraction of the receptor's maximum response, c is the concentration your bite actually delivers, and n is the cooperativity of the curve. Set c equal to EC_{50} and θ is exactly one-half — the definition of EC_{50} read backward. The useful consequence is that to reach any chosen sweetness θ, the concentration c you need scales directly with EC_{50}. Lower the EC_{50} two-hundred-fold and you reach the same sweetness with a two-hundredth of the mass. That is the reformulation arithmetic, and it is clean because every term in it is checkable.

PRODUCT	SUCROSE IT REPLACES	DESIGNED SWEETENER USED	SUGAR REMOVED
A tray of pots de crème	~200 g	~0.8 g Reb M	~200 g
A litre of a sweet drink	~100 g	~0.4 g mogroside V	~100 g
A batch of dark-chocolate ganache	~150 g	~0.6 g Reb M	~150 g

The right-hand column is a subtraction you can verify to the gram, and it is the only promise we make about it. The line we hold, and hold carefully, as a fact and never as a claim, is this: **the tongue reads sweet; the pancreas reads almost nothing.** We say what the receptor does — these molecules close the sweet flytrap — and we stop at the edge of the body, because the body is not ours to speak for, and because the moment a sweetener is sold on what it will or will not do to your metabolism, it has left the ground we are allowed to stand on. What we will say is the thing that is ours to say: for a family that believes in feeding people gently, an axis that lets a dessert taste like a dessert while asking so little of itself is the one we tune with the most tenderness. We will tell you the grams of sugar that left the recipe. We will not tell you what their absence does inside you. Sweetness, grown clean, is kindness you can measure — and the measuring stops, on purpose, at the mouth.

IFI PROFILE



IFI-H		0
IFI-P		0
IFI-C		0
IFI-U		0
IFI-S		2,900
IFI-B		0
IFI-K		300
IFI-A		0

Chapter 5 · The taste of being fed — *umami, restored.*

IFI-U · Umami · mGluR1 · TAS1R1·R3

Of all eight axes, umami is the one that feels like care. It is the savory round that makes a broth taste like being looked after, and it is the most direct nutritional message the tongue is capable of sending. The evidence is written into our first food: free glutamate is the single most abundant free amino acid in human breast milk, present at roughly twenty milligrams per hundred millilitres, far above any other — the first thing we are built to want is, measurably, a savory one. And it is written into every sickroom in every culture that ever kept one, where the food carried to the ailing is a broth, which is, chemically, a glutamate delivery system. We did not reason our way to broth-for-the-sick. We arrived at it because the body, offered savor, accepts nourishment it would otherwise refuse.



The restored tomato — IFI-U 300 → 2,600, the savory voice grown back through the fruit's own GAD and GDH1 routes, not added from any jar.

The world took the better part of a century to believe any of this, and the slowness is itself the argument for a number — each step added a piece the tongue had always known and the textbook had always refused.

YEAR	WHO	WHAT THEY FOUND
1908	Kikunae Ikeda	glutamate is the savory principle of kombu; names *umami*
1913	Shintaro Kodama	inosinate (IMP) is the savory principle of dried bonito
1957	Akira Kuninaka	guanylate (GMP) is the savory principle of dried shiitake
1960s	Kuninaka, Yamaguchi	the glutamate–nucleotide **synergy** is measured and quantified
2000–2002	Chaudhari; Nelson, Zuker, et al.	the receptors are cloned — taste-mGluR, then TAS1R1·TAS1R3

The receptor side is a pair of Venus flytraps. The first is **mGluR1**, a metabotropic glutamate receptor — the same family the brain uses to sense the glutamate it signals thoughts with — stationed on the tongue in a truncated, taste-specific form and tuned to answer free glutamate above almost anything else. The second is the **TAS1R1·TAS1R3** heterodimer, two proteins clasped permanently together as one receptor, sharing its R3 subunit with the sweet receptor of the last chapter — which is the quiet structural reason savor and sweetness so often travel together, and why a ripe tomato can carry both. One fact unlocks the whole axis: glutamate bound inside a protein is tasteless, because the receptor can only grip the *free* molecule. A raw soybean is dense with glutamate and tastes of almost nothing, nearly all of it locked in storage proteins; age that bean into miso, ripen a tomato on the vine, or simmer a bone for a day, and the glutamate comes loose and declares itself. Savor, biochemically, is the taste of protein coming apart into a form the body can use. (Its quiet companion, aspartate, carries about a thirteenth of glutamate's savor and rises alongside it, so to restore the glutamate pool is to widen the whole chord a little.)

The mechanism of the tomato's loss is almost tragic in its ordinariness. Free glutamate in a living fruit is produced and held through a small set of the plant's own enzymes. The central one is the **GABA shunt**: **glutamate decarboxylase (GAD)** converts glutamate into GABA (consuming the free glutamate pool), and the shunt returns carbon to the TCA cycle through succinic semialdehyde. Alongside it, **glutamate dehydrogenase (GDH1)** sits at the junction of carbon and nitrogen metabolism, running the reversible reaction 2-oxoglutarate + NH_4^+ + NAD(P)H ⇌ glutamate — building free glutamate from a TCA intermediate when it runs toward amination. In a vine-ripening tomato, the green fruit's stored GABA falls and free glutamate rises as these enzymes rebalance. Breeding for firmness and uniform, shippable ripening repeatedly selected against exactly the metabolic states that let that free-glutamate pool build. Nothing was removed on purpose. The savory floor was collateral.

Our restoration did not add a foreign gene to manufacture glutamate. We built a genome-scale metabolic model of the tomato — a **flux-balance** account of every reaction in the fruit — and solved it. Flux-balance analysis writes metabolism as a stoichiometric matrix **S**, imposes the steady-state condition **S·v = 0** (what goes into each metabolite pool must come out), bounds each reaction by its reversibility and the plant's real uptake limits, and then finds, by

linear programming, the distribution of flux **v** that maximizes a chosen objective — here, the free-glutamate pool. The model told us where the native route had been throttled and confirmed it was the pathway itself, not an upstream step, that limited the pool, so that an edit to the GABA shunt would actually move the output rather than pile substrate against a wall. Then we tuned the plant's own **GAD/GDH1 balance** so free glutamate accumulates and holds through ripening and storage, at a coefficient of variation at or below seven percent. **Two thousand and forty constructs** stand behind that single restored number — the supermarket fruit's **IFI-U of roughly 300** grown back to **2,600**, a factor of about 8.7.

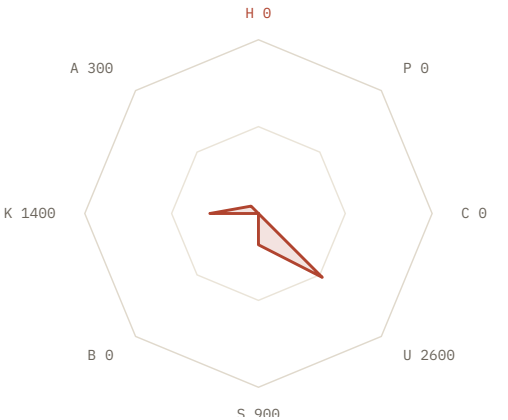
Work the factor through the formula and *loud* becomes exact. IFI-U 2,600 = 1,000 × EC_{50}(reference) ÷ EC_{50}(candidate), so EC_{50}(candidate) ≈ 0.385 × EC_{50}(reference): the restored fruit half-activates the glutamate receptor at a little over a third of the reference dose. By the Hill logic of the last chapter, that means a given savory intensity arrives in roughly an eighth of the grams — a cook who would need ninety grams of ordinary tomato to reach a satisfying savor reaches it in about ten grams of ours. And it means a dish built on it tastes full at a lower dose of *everything else*, salt included, because sodium ions lower the perceptual threshold at which the tongue registers glutamate. Restore the glutamate at the source and the salt stops *creating* the savory depth and starts merely *uncovering* one that was grown in. The shaker becomes a seasoning again instead of a crutch.

SOURCE	FREE GLUTAMATE (MG/100 G)	IFI-U	WHAT IT DOES ON A PLATE
Supermarket tomato (shipping cultivar)	20–40	~300	thin; needs salt and fat to read as food
Vine tomato, peak season	140–250	~900	the brief August fullness
Restored tomato · 2,040 constructs	240–280 (stable)	2,600	August, in February, on purpose
Dried shiitake	1,000–1,500	~1,900	the vegetarian stock in one ingredient
Kombu (reference savory benchmark)	1,200–3,400	~2,000	the sea's glutamate, our north star

There is one more piece of savory chemistry, and it is the most useful thing a clean kitchen can own, because it buys depth for free. Glutamate and the **5′-ribonucleotides** — inosine monophosphate (IMP) from aged tissue, guanosine monophosphate (GMP) from mushrooms — are not merely additive on the tongue. The ribonucleotide binds an adjacent site on the TAS1R1 subunit, near the hinge of the flytrap, and stabilizes the closed conformation, dropping glutamate's effective EC_{50} by nearly an order of magnitude. The classic measurement is stark: a one-to-one mix of glutamate and IMP tastes roughly **seven to eight times** as savory as the same total weight of glutamate alone. A restored tomato cooked with a pinch of dried mushroom is not two umami sources added together; it is one multiplied by the other — which is how a plant kitchen gets the depth of a long-braised stock out of twenty minutes and no bones at all. And because the free glutamate the tongue reads is the

same amino-acid signal the body feeds on, the savor we grow back is not a stand-in for nourishment. It is, as near as the mouth can report it, the thing itself.

IFI PROFILE



IFI-H	0
IFI-P	0
IFI-C	0
IFI-U	2,600
IFI-S	900
IFI-B	0
IFI-K	1,400
IFI-A	300

Chapter 6 · Richness without the cream — *kokumi, and what lingers.*

IFI-K · Kokumi · CaSR

Kokumi has no flavor of its own, which is why it took the longest to name. You cannot point to it on a spoon the way you can point to sweet or sour. It is mouthfeel made molecular — a family of **γ-glutamyl peptides** activating the **calcium-sensing receptor, CaSR**, a class-C G-protein-coupled receptor the body uses elsewhere to watch the calcium in the blood, repurposed on the tongue to report a particular fullness. What kokumi gives a dish is *continuity*: the sense that the food fills the whole mouth and stays a moment after you have swallowed, the quality a taster calls *depth* or *body* and cannot quite locate. It is why aged things and slow-cooked things taste complete, and why the fast version of the same dish so often tastes thin and short.



Garlic in cross-section — one of the plant sources of the γ-glutamyl peptides that give a dish its body without a pour of cream.

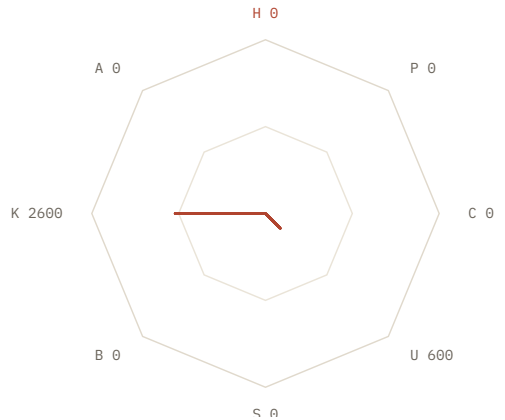
The chemistry is specific, and the specificity is what keeps kokumi from being a mystical word for *yum*. These peptides carry a **γ-glutamyl bond** — the glutamate linked through its side-chain carboxyl rather than the usual backbone position, a linkage that resists the ordinary digestive machinery and lets the peptide survive to reach the receptor. The classic kokumi substance is **glutathione**, γ-Glu-Cys-Gly, the small tripeptide every living cell carries as its chief antioxidant; the most potent yet characterized is **γ-Glu-Val-Gly**, which activates CaSR at strikingly low concentration. Here is the strange and useful part. These peptides do not act like a taste at all

— present them in water and you will swear the glass is empty — but introduce them alongside a sweet, a salt, or an umami stimulus and they *potentiate* it. CaSR sits on the taste cell as a **positive allosteric modulator**: the γ-glutamyl peptide binds the receptor's large flytrap domain near, not in, the orthosteric site, and raises the gain on the signals arriving through the neighbouring receptors, so the sweetness reads rounder, the savor reads longer, and the whole mouthful thickens and continues. Sensory panels name the change in four words — **intensity, mouthfulness, continuity, thickness** — and those four words are, almost exactly, what a cook means by *body*. On the Index we anchor **IFI-K** to the half-maximal activation of CaSR by a sample's γ-glutamyl peptide content, read against a glutathione reference, so a number that measures nothing you can taste alone still predicts, reliably, how *finished* a dish will feel.

Γ-GLUTAMYL PEPTIDE	PLANT / PROCESS SOURCE	CASR ACTIVITY	WHAT IT LENDS
Glutathione (γ-Glu-Cys-Gly)	yeast, alliums, most fresh tissue	moderate	the baseline round
γ-Glu-Val-Gly	formed in fermentation and ageing	very high	long, mouth-filling depth
γ-Glu-Cys / γ-Glu-Met	garlic, onion, maturing cheese and shoyu	moderate–high	the savory tail

For a kitchen that cooks clean, kokumi is the quiet hero, because it is the axis that lets richness arrive without being bought. Think about where "richness" usually comes from. Cream and fat give a dish body in two ways at once — a physical viscosity on the tongue, and a reservoir for the fat-soluble aromas that make a thing smell rich — and both are real, and both cost something: calories, heaviness, a plate that sits. Kokumi gives the *perception* of body by a different road, raising the gain at the receptor rather than thickening the liquid, so a dish can read full and long with far less fat beneath it. This is not a trick and it is not a substitute that announces itself; it is the plant's own mechanism for continuity, turned up. We raise the native γ-glutamyl peptides of vanilla, of garlic and onion, of yeast, so that *satisfying* no longer has to mean *heavy*, and so that a soup can taste like it was made with care and patience it did not, in fact, demand. The mouth reads a long, round, generous food; the plate was never asked to carry the fat and the cream it used to carry to get there. That is a kind of cleanliness, too — the fullest version of the thing, with the least standing in for it. Where umami is the floor a savory plate stands on and sweetness is its brightness, kokumi is the thing that makes a dish feel *whole* in the mouth, and it is, not by accident, the axis that most often lets the cook set down the cream.

IFI PROFILE



IFI-H		0
IFI-P		0
IFI-C		0
IFI-U		600
IFI-S		0
IFI-B		0
IFI-K		2,600
IFI-A		0

Chapter 7 · The kindest subtraction — *bitterness, turned down.*

IFI-B · Zero-Bitter · TAS2R38

The vegetables a child is told to finish are, almost all of them, the ones evolution built to taste like a warning. Bitterness is read by a family of some twenty-five **TAS2R** receptors — the only taste family tuned entirely to danger, a broad and sensitive alarm net strung to catch the alkaloid and the toxin that a plant uses to defend itself. The most studied of them, **TAS2R38**, answers to the thiourea and isothiocyanate compounds of the mustard-and-cabbage family, and it does its ancient job on broccoli and kale with no idea that the danger is gone. The signal still fires. The plate still comes back half-finished. And a vegetable left on the plate nourishes no one, however much is written on its behalf.



Broccoli in cross-section — the florets whose glucosinolate chemistry sounds an alarm the plant no longer needs.

The bitterness of a Brassica is not vague; it is a chemical event you can diagram. The leaf stores **glucosinolates** — sulfur-rich compounds such as **sinigrin** and **progoitrin** — in one set of cells and the enzyme **myrosinase** in another, kept apart like the two halves of a fuse. Cut or chew the leaf and the compartments break, myrosinase meets the glucosinolate, and hydrolysis fires off the pungent, bitter **isothiocyanates** — allyl isothiocyanate from sinigrin, goitrin from progoitrin — that TAS2R38 reads as a threat. How loud that threat sounds depends partly on who is tasting. The receptor comes in two common forms set by three coding changes in the

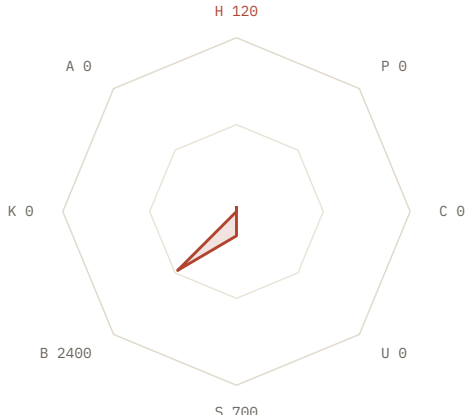
gene: the **PAV** haplotype of the taster (proline, alanine, valine at three positions), for whom raw kale is punishing, and the **AVI** haplotype of the person who barely registers it — the genetics behind the family argument over Brussels sprouts, and a reminder that there is no single "right" level of bitterness to design to, only a distribution of mouths. And it depends on context, because a healthy sweet, umami, and kokumi response actively *suppresses* bitterness in the shared transduction cascade we drew in Chapter 2: when a meal is rich on the other axes, the bitterness is held down; when it is thin, the bitterness steps forward uncovered. This is why the same cup of coffee can go from rounded to harsh depending on what surrounds it.

So on the most virtuous foods in the kitchen we do the gentlest thing in the whole library: we turn the warning down at its source. By rerouting the glucosinolate flux in the living plant, our model predicts we lower the bitter agonist itself — **twenty to sixty-five percent** — never to zero, never past the point where the thing stops tasting like itself, just far enough that the plant stops sounding an alarm it no longer needs. The verb matters, and it is the clean verb: we tune *what the receptor is given to read*, adjusting the plant's own flux through its own enzymes, rather than stripping the plant or masking it under sugar and fat and salt piled on top. What arrives is broccoli that reads sweet under a hard char, kale without the back-of-throat grip — a vegetable that gets *wanted*, and therefore gets eaten, and therefore does the one thing a vegetable has to do.

BITTER COMPOUND	SOURCE	READ BY	OUR MOVE
Sinigrin → allyl isothiocyanate	broccoli, mustard, cabbage	TAS2R38	reroute glucosinolate flux, −20–65%
Progoitrin → goitrin	kale, rapeseed, Brussels	TAS2R38	lower the agonist at source
Chlorogenic & caffeoylquinic acids	coffee, some Brassica	TAS2Rs (broad)	attenuate, do not mask
Flavan-3-ols (catechins)	cacao, tea	TAS2Rs + astringency	tune bitter; keep structure

We should be exact about where this sits, because it is the chapter where a clean conscience is most tested. We turn down a *perception*. We make no claim about what the plant's substance does inside a body — not about the compounds we tune, not about anything downstream of them, in either direction. What we will say, and all we will say, is the arithmetic that is plainly true in a kitchen: a vegetable that gets eaten delivers all of its nourishment, and one scraped into the bin delivers none, so the whole measurable gain of turning the warning down is simply *consumption* — a plate finished rather than abandoned. That is the entire argument, and it needs no health claim to make it. The kindest subtraction is not the one that takes something out of the food. It is the one that takes the alarm out of the signal, and leaves the food whole.

IFI PROFILE



IFI-H	120
IFI-P	0
IFI-C	0
IFI-U	0
IFI-S	700
IFI-B	2,400
IFI-K	0
IFI-A	0



PART III OF V

The Plant, Whole

the method, the named molecule, the sensations, and the day that grows them · nothing added to hide

Chapter 8 · Grown in, not bolted on — *nothing added to hide.*

There are two ways to make a plant taste like more, and the whole ethics of this library lives in the choice between them. You can spray a flavor onto the outside of a plant, or dust a nutrient into it after the fact — a thing added, a thing to list, a thing that reads forever as *almost*. Or you can go back to the pathway that made the flavor in the first place and turn it up at the source. We only ever do the second, and the reason is not purity for its own sake. It is that the second way leaves nothing to hide, and the first way, by its nature, always does.



A young plant lifted for transplant — the whole organism tended, so the signal is grown in rather than sprayed on.

Set the two approaches side by side and the difference stops being philosophical and becomes a list you can audit.

	THE ADDED APPROACH	THE GROWN-IN APPROACH (OURS)
Where the flavor comes from	sprayed, dusted, or blended on	the plant's own pathway, turned up
What appears on the label	each additive, named separately	the plant; nothing foreign to list
What a lab would find	a compound the plant never made	only compounds the plant makes
Batch-to-batch behavior	as even as the mixing step	held to a CV ≤ 7% in the genome
What you can read of it	the surface	all the way down to the root

The grown-in approach is possible because the machinery is already there in every plant, waiting to be asked. The phenylpropanoid branch — PAL to C4H to 4CL to HCT to COMT — runs in every vascular plant on earth; the native glutamate routes through GAD and GDH1 run in every fruit; the γ-glutamyl peptide pool, the sweet-protein genes, the glucosinolate flux all belong to the organism before we arrive. Our edits are small and precise by design. We write them with **CRISPR**, which does not install a foreign factory in the cell; it makes a targeted cut in a gene the plant already carries, and the cell's own repair knits the cut back with a small change — a base or a few bases altered, a throttle turned on a line that has run since the

plant's ancestors first crawled onto land. The important molecular fact is what is *not* left behind: an edit of this kind retains no foreign DNA, and the result is, at the level of sequence, a plant that could in principle have reached the same change by ordinary mutation and ordinary breeding, only without the decades of luck that would have taken. A lab examining the fruit finds the plant's own compounds, more of one of them, and nothing it did not make.

Take the restored tomato as the worked case. The edit we wanted was not a new gene but a quieter one: a small change in the control region of the fruit's own glutamate decarboxylase, enough to ease the GABA shunt's draw on the free-glutamate pool. A guide RNA directs the editing machinery to that one site; the cut is made and knit back with the small change in place; and then — this is the step that earns the word *clean* — we sequence the whole genome of the edited line and screen for anything the machinery might have touched by mistake, keeping only the lines that carry the intended change and nothing else. What goes forward is a tomato with one base-level adjustment in a gene it already had, no foreign DNA, and a free-glutamate pool that now holds through ripening. The precision is not a flourish. It is the difference between an edit you can read and an edit you merely hope is clean.

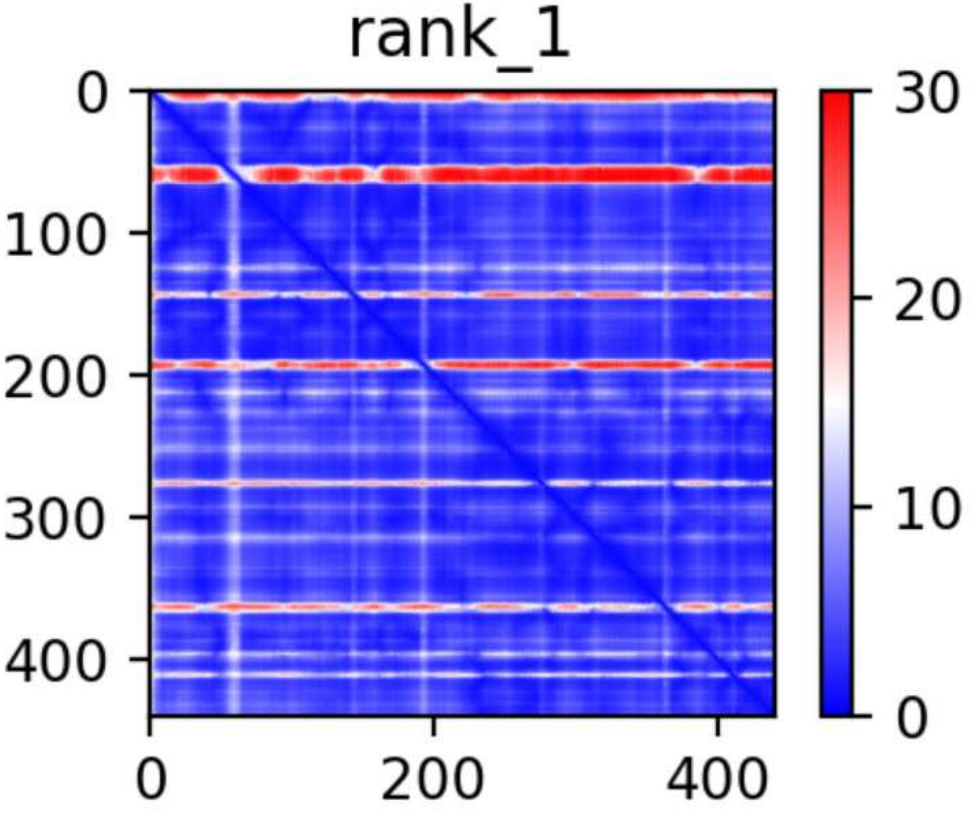
That molecular fact is also the whole of the compliance story, and we would rather tell it plainly than dress it up. Because the edit adds no novel DNA and the fruit contains nothing foreign, a growing number of regulatory frameworks treat such a plant as the plant it is rather than as a transgenic organism — a distinction we did not invent and do not lean on for cover, but which happens to line up exactly with how the food reads on a label and in a lab. We are not asking you to trust a proprietary blend, because there is no blend. The novelty we own and protect is the *method* — which gene, which base, found by which model — and the method is published; the fruit on the plate is, chemically, just the fruit.

This is why clean label, for us, was never a decision made in a marketing meeting. It falls out of the biology on its own. If you have added nothing foreign, there is nothing foreign to disclose; if the louder signal is the plant's own compound made in the plant's own way, then the ingredient line is honest at one word — the name of the plant — not because we were clever about what to leave off, but because there was never anything else on it. Clean, here, is not subtraction and it is not secrecy. It is the plant, turned up, and still entirely the plant.

Chapter 9 · The molecule, named — *capsaicin, drawn from gene to taste.*

IFI-H · Heat · TRPV1

If clean means *nothing you cannot name*, then the proof of it is the molecule we have followed most completely, from the gene that begins it to the receptor that reads it, with no step left dark. That molecule is capsaicin, and the heat it makes is the oldest work of this company — the place where we learned that a flavor could be designed at all. It belongs in a book about nourishment not because heat feeds you, but because heat was where we proved the method, and the method is the thing that lets the rest of the library stay clean.



The Pun1/AT3 model as a predicted-alignment-error map — the confidence, residue against residue, with which we read the enzyme's fold before we edit the gene that makes it.

Capsaicin finds **TRPV1**, a non-selective cation channel on the trigeminal nerve endings of the tongue — the same receptor gated by temperatures above 43 °C and by acid. The molecule does not warm the tissue by a single degree. It binds a pocket inside the channel, the vanilloid site, and lowers its thermal threshold, so the nerve reports a fire that is not there. Nothing is harmed; the tongue has only been told a true thing in an extravagant language. And because the body's response is so vivid — the flush, the sweat, the quickened pulse — it is easy to forget that the whole event is just chemistry, one molecule precisely shaped, fitting one lock.

That molecule is built, in the plant, along a route we can name enzyme by enzyme — the phenylpropanoid branch supplying one half, branched-chain fatty-acid metabolism the other, and a single acyltransferase marrying them.

STEP	ENZYME	SUBSTRATE → PRODUCT
1	PAL	phenylalanine → cinnamate
2	C4H	cinnamate → *p*-coumarate
3	4CL	*p*-coumarate → *p*-coumaroyl-CoA
4	HCT · C3H · COMT	→ feruloyl-CoA → **vanillin**
5	pAMT	vanillin → **vanillylamine** (the aromatic head)
6	BCAT · KAS	valine → **8-methylnonanoyl-CoA** (the fatty tail)
7	**Pun1 / AT3**	vanillylamine + acyl-CoA → **capsaicin**

Read the table as a sentence and you have the whole of heat: an aromatic head condensed with a fatty tail by the capsaicin synthase, **Pun1**. The length and saturation of that tail set the *shape* of the burn — capsaicin and its close cousin dihydrocapsaicin differ only there, and the balance between them decides whether the heat arrives sharp and clears fast or spreads slow and lingers.

Every prior breeding program chased heat by selecting the phenotype and hoping the genotype would follow. We inverted it. An **ESM2 protein language model** of 650 million parameters — a transformer trained across the whole known universe of protein sequences until it had learned, statistically, what a functioning enzyme looks like — scored every possible single-residue substitution in Pun1 by its predicted effect on catalytic efficiency multiplied by fold stability. A genome-scale **flux-balance model** predicted that flux control sits upstream in the phenylpropanoid pathway at 4CL and HCT, not at the terminal Pun1 step; Pun1 labels the product, it does not govern the rate. The ESM2 substitutions improve Pun1's catalytic efficiency and fold stability — reliability rather than raw ceiling. The top-ranked variants were then docked back against the enzyme's two substrates — the acyl-CoA and the vanillylamine — to confirm that the active-site geometry still welcomed them before anything was written into a living plant. Two Pun1 substitutions (S39L · L345G) emerged that no breeder had ever found because no cross would ever have combined them, and written in with CRISPR our model predicts peak output of approximately **2.95 million Scoville units** at a batch-to-batch coefficient of variation at or under seven percent — against forty-two percent in the wild-type. Precision is the whole difference between a flavor you can cook with and one you can only hope for.

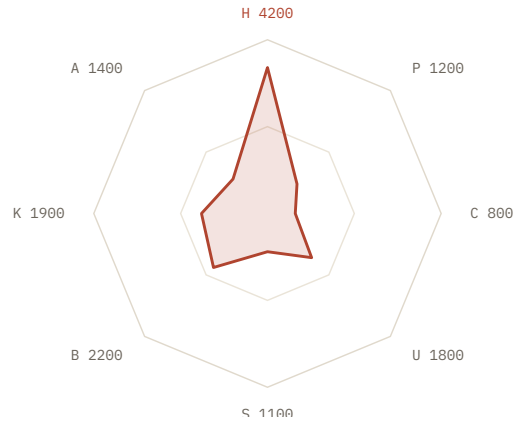
EDIT	EFFECT	ΔΔG (KCAL/MOL)
S39L	binding affinity ↑ (N-terminal)	−2.1
L345G	steric relief at the active-site cleft	−1.8
C175S	prevents a disulfide misfold *(structural annotation — not in shipped construct)*	−0.9

The ΔΔG column is the quiet proof the edits are sound: each is the predicted change in the enzyme's folding free energy, and each is negative, meaning the mutated protein folds *more* stably than the original — a stronger, steadier catalyst, not a fragile one. A word, too, on the two scales in play, because keeping them distinct is itself a form of legibility. **Scoville units** measure concentration — historically the dilution at which heat vanishes, today the capsaicinoid content read by HPLC, where roughly one part per million of capsaicinoids registers about fifteen SHU and pure capsaicin sits near sixteen million. **IFI-H** measures loudness at the receptor, the EC_{50} of the heat at TRPV1. They correlate, but they are not the same instrument — one counts molecules, the other measures how hard they knock — and we report both because a reader deserves to know which question a number is answering.

That peak belongs to **Phoenix**, SS-0096 — the end of a ladder, not a stunt, the furthest the method has yet been pushed. The ten proof-of-concept superhots climb it in even steps, and the reason to show them in a book about clean nourishment is the last line of the table: at the very top, the heat does not stand alone.

CULTIVAR	SKU	SHU	IFI-H	AXES
Ember	SS-0087	866K	1,570	2/8
Cinder	SS-0088	1.05M	2,290	3/8
Blaze	SS-0091	1.72M	2,630	4/8
Wildfire	SS-0092	1.96M	2,930	5/8
Scorch	SS-0093	2.21M	3,220	5/8
Firestorm	SS-0094	2.47M	3,490	6/8
Solara	SS-0095	2.72M	3,980	6/8
Phoenix	**SS-0096**	**2.95M**	**4,200**	**8/8**

IFI PROFILE



IFI-H	4,200
IFI-P	1,200
IFI-C	800
IFI-U	1,800
IFI-S	1,100
IFI-B	2,200
IFI-K	1,900
IFI-A	1,400

Read Phoenix's whole profile and you find company on every pathway: umami and kokumi grown in beneath the burn, bitterness held low, a measured astringent finish. Even the hottest fruit we have ever specified was designed to carry a whole meal's worth of signal, not a single assault. That is the point of naming the molecule all the way down — once you can read the heat exactly, you can give it company exactly, and a thing that could have been only fierce becomes, instead, legible and whole. The method that found two Pun1 substitutions in a capsaicin synthase is the same method that restores a tomato's glutamate and turns down a broccoli's alarm. Heat was only where we learned to read.

Chapter 10 · The sensations that are touches — *heat shaped, cool, sharp, and dry.*

IFI-H · IFI-C · IFI-P · IFI-A

Four of the eight axes are not tastes at all. They are touches — sensations read not by the taste buds but by the nerve endings woven among them, the trigeminal system that reports temperature, pressure, and irritation. Where a taste fires fast and fades, a trigeminal signal has its own slower kinetics — it builds, it blooms, it lingers and clears on its own clock — which is exactly why these four axes are the *drama* of a plate, the parts that move and change while you chew. A clean kitchen uses them the way a composer uses dynamics: not to overwhelm a dish but to give it shape, an arrival and a finish. Clean does not mean mild. It means every sensation on the plate is there on purpose and can be read.



Ginger in cross-section — a plant whose sharp warmth works the trigeminal nerve, not the taste buds.

Heat, as a shape. We met capsaicin and TRPV1 in the last chapter as a molecule and a lock; here is what the cook actually designs, which is not the size of the burn but its *shape* — where it lands, how it blooms, how cleanly it leaves. A heat you can taste *through* is a heat that lets the rest of the plate speak: the onset gentle enough that the first flavors arrive before the warmth, the bloom wide rather than stabbing, the clearance clean so the finish is the food and not the fire. We tune that shape through the saturation of the capsaicinoid's acyl chain — sharper and faster, or slower and more spreading —

and through the company we give it on the other seven axes, because a burn with umami and sweetness beneath it is read by the mind as warmth, and a burn with nothing beneath it is read as pain. Same TRPV1, same molecule; a different experience entirely, built by what else is on the plate.

Cool, the cold that is not cold. Menthol finds **TRPM8**, the receptor the body uses to sense genuine cold below about 26 °C, and binds it so that it reports a chill that is not there — the mirror image of what capsaicin does with heat. Mint builds menthol along a compact pathway of a handful of its own enzymes: **limonene synthase** cyclizes geranyl diphosphate into (–)-limonene; **limonene-3-hydroxylase**, a cytochrome P450, oxidizes it to *trans*-isopiperitenol; a short relay of dehydrogenases and reductases carries it through isopiperitenone and pulegone, where **pulegone reductase** and then **menthone reductase** bring it down, at last, to (–)-menthol. On the Index, **IFI-C** is anchored to menthol's EC_{50} at TRPM8, and in a clean kitchen the cool axis is a finish and a brightener — the thing that wakes a palate, lifts a sweet, and makes a dish feel washed rather than heavy.

Sharp, the pungency that climbs the nose. Pungency is read by **TRPA1**, the irritant-sensing channel, and it works by a chemistry unlike the others: its agonists are *electrophiles* that form a reversible covalent bond with cysteine residues on the channel's inner face, which is why the sensation is so immediate and so penetrating. The agonists are some of the oldest seasonings we have — **allicin**, formed when a cut clove of garlic lets alliin meet the enzyme alliinase; **allyl isothiocyanate**, the mustard-and-wasabi molecule from the same glucosinolate chemistry whose bitterness we turn down elsewhere; **cinnamaldehyde**, the warmth of cinnamon. Unlike heat, pungency lifts up and off quickly, climbing into the nose and clearing, which is why a single pass of raw garlic over hot toast is a seasoning and not a subject. **IFI-P** measures the loudness of that sharp edge, and a clean kitchen uses it in flickers: present, rarely pungent, a brightness at the top of the bite.

Dry, the structure of a finish. Astringency is the strangest of the four, because it is barely a signal at all — it is the *loss* of one. Tannins, the condensed polyphenols of tea and grape and fine chocolate built through enzymes like **ANR** (anthocyanidin reductase) and **LAR** (leucoanthocyanidin reductase) into catechin, epicatechin, and their polymers, bind the **proline-rich proteins** that lubricate saliva and precipitate them out of solution, so the mouth goes briefly rough and dry. That roughness is not a taste; it is a texture, read by touch when the lubrication fails. **IFI-A** measures how strongly a sample draws the mouth dry, by a precipitation assay against those salivary proteins, and astringency's clean job is architecture: it gives a sweet or a rich dish a spine and a finish, the structure that keeps lushness from turning cloying. A little grip is the difference between a dessert that *ends* and one that merely stops.

AXIS	RECEPTOR	CLEAN AGONIST	ITS JOB ON THE PLATE
IFI-H (shape)	TRPV1	capsaicin, dihydrocapsaicin	warmth with an arrival and a clearance
IFI-C	TRPM8	menthol	the bright, washing finish
IFI-P	TRPA1	allicin, allyl isothiocyanate, cinnamaldehyde	the sharp top-note, up and gone
IFI-A	salivary PRPs	catechin, epicatechin, tannins	the dry spine, the structured end



Grape in cross-section — the skin and seed where the tannins that structure a finish are built.

Put the four together and you have the architecture of a bite in time. Taste arrives first and fast — the sweet and the savor reported almost at the moment of contact — and then the touches unfold on their slower trigeminal clock: pungency spiking early and clearing up into the nose, cool blooming and washing the palate, heat rising behind the flavor and spreading wide, astringency drawing the finish dry and giving the whole thing an end. A dish designed on all eight axes is really a dish designed in two tenses — the tastes in the present, the touches in the unfolding — and a cook who can read both can write a bite that opens, develops, and closes rather than one that merely lands. That composition in time is the clean kitchen's quiet craft: not more sensation, but sensation *placed*.

The four touches are where a clean plate earns the word *pleasure*. Taste tells you what a food *is*; the touches tell you what it is *doing*, moment to moment, and a dish designed on all eight axes is one that moves — warmth, brightness, sharpness, structure arriving in their turn — rather than sitting still. We measure the touches as exactly as the tastes, because a sensation you can read is a sensation you can give a shape, and a shape is the difference between heat as an event and heat as an assault, between a finish and an afterthought.

Chapter 11 · Clean ground — *the plant is only as clean as its day.*

A genome is a promise a plant makes about what it could become. The day decides how much of the promise it keeps. You can design a tomato toward its fullest umami and its fullest substance and still lose most of it to a thirsty week, a tired soil, a light that came too weak and left too soon. Clean is not only a thing we write into the seed. It is a thing the growing either honors or spends, every day, between the planting and the plate.



A plant in the controlled chamber, its day kept honest — the light, the water, and the root medium given on purpose and in the right amount.

So we grow with the same intention we design with, and in a controlled environment the plant's day stops being weather and becomes a set of numbers a grower can read and hold. The light is counted, not hoped for: its intensity as **PPFD**, the micromoles of usable photons falling on a leaf each second, and its total over a day as the **daily light integral**, the moles per square metre that decide whether a plant merely survives or has the surplus energy to build sugar and savor. The air is held at a **vapour-pressure deficit** that keeps the plant drinking and transpiring steadily rather than closing its pores against stress. The root solution's **EC and pH** — its dissolved-nutrient strength and its acidity — are measured and corrected, so the plant is neither starved nor pushed, and so it is not pulling up a load of whatever happens to be in a tired or contaminated ground and carrying it, unasked, into the fruit. Each of these is a dial, and each is read.

The reason the dials matter is the same reason the genome matters: the ripe metabolic state that pools the glutamate and holds the sugars is a state a plant can only reach when its energy budget is full and its stress is low. A shaded or thirsty plant spends its chemistry on defense instead of on flavor and substance, and the fruit comes up short of what its genes could have made. So a controlled environment is not a sterile one; it is a *measured* one, where the inputs are known and the outputs can be checked against them, and the coefficient of variation we hold in the genome is matched by a consistency in the growing. The genome sets the ceiling of what a plant could taste and hold; the day decides how

close to that ceiling the fruit actually comes. A design held to a CV of seven percent and then grown under a careless sky is a promise made precisely and kept loosely.

The arithmetic of a single day makes the point. Two sibling fruits from the same edited line — one grown at a daily light integral its leaves can actually use, one a third short of it — will not taste the same, because the darker-grown fruit never earned the surplus energy to lay down the sugar and the glutamate its genome stood ready to make. The ceiling was identical; the realized fruit was not. This is why we treat the growing as measurement rather than husbandry: read the light, read the vapour-pressure deficit, read the strength and acidity of the root solution, correct each against a target, and the number on the scorecard describes the fruit in the box rather than the fruit we were hoping for.

There is a companion to this book that is only about this — the long, patient craft of growing food to hold everything it was built to hold, and the one beside it on designing nourishment into the plant in the first place. We keep them close on the shelf for a reason. A clean plant poorly grown is just a good idea that did not make it to the table; a clean design on tired ground is a promise half-kept. The reverence we have for what we engineer, we owe again, every single day, to what we grow — and the growing is where the word *clean* either becomes true or stays a label. We think it has to be earned in the soil before it is allowed on the page.

Chapter 12 · The ninth measure — *what the body actually takes.*

There is a number this library does not yet have a column for, and it is the one we think about most. The eight axes measure taste — how loudly a food speaks to the tongue. They do not measure the thing that happens next, after you have swallowed: how much of what the food carries the body is actually able to draw out and use. Call it uptake; call it bioavailability. It is the ninth measure, and it is where this entire shelf points. It is also the place where a family that loves to feed people has to be the most careful about what it is allowed to say.



Spinach — green, dense, and nourishing; the kind of plant whose worth is not only in what it holds but in how much of it the body can reach.

The idea is easy to state and hard to earn, and the chemistry of it is specific enough to be honest about. A vitamin or a mineral is only as good as the body's ability to reach it, and whether the body can reach it is a property of the food's own structure. Iron and zinc can be bound up by a plant's own **phytate** — *myo*-inositol hexakisphosphate, the seed's phosphate store — and carried straight through, unabsorbed. A provitamin-A carotenoid locked inside a rigid, intact cell wall passes where the same molecule, freed by a little chopping and heat and a trace of fat to dissolve into, is taken up. A folate held as the plant's natural polyglutamate behaves differently from the synthetic monoglutamate on a supplement label. None of this is mysterious, and none of it shows on a nutrition panel, which counts only what is *present* and says nothing about what is *available*. So the work this shelf is building toward is a plant that both carries more of what nourishes *and* gives it up more readily — the mineral held but not locked behind phytate, the carotenoid present and in a matrix the gut can open — assayed in a defined, standardized digestion model and reported as a number, the way we reported the first eight axes.

The assay we are building toward is not a promise about a gut; it is a bench model of one. The field has a standard for this — a static laboratory digestion that walks a food through the mouth, the stomach's acid and pepsin, and the small intestine's bile and pancreatic enzymes, then measures how much of a given nutrient

has been freed into a form that could, in principle, cross the gut wall. That freed fraction is a property of the food, measurable and reproducible, and it is exactly the kind of number this library knows how to hold. A carotenoid that reads *present* on a nutrition panel but stays locked inside an intact cell reads *low* in the digestion model; free it by breaking the matrix and the same molecule reads higher. We can design toward the higher reading, and publish it, and stop there — at the food's measured availability, never at anyone's health.

We are building toward it exactly as we built the Index: slowly, from measured quantities, without getting ahead of what we can show. And here is the discipline that the whole book has been circling, stated at its sharpest. We can tell you we are designing for uptake, and we can tell you the direction we are designing in. We will not tell you an outcome in your body, because your body is not ours to promise for. The ninth measure, when we have it, will be a measure of the *food* — a property of the plant, assayed in a digestion model and published — and not a claim about the person who eats it. That restraint is not a limit on the ambition. It is the shape of it. We measure what we can measure, we publish it, and we leave the rest where it properly belongs: with your body, and with the people whose training is medicine rather than flavor.

It would be easy, and dishonest, to let the ninth measure drift into a promise. The whole genre of *clean* food is littered with that drift — the quiet slide from *this plant carries more of a nutrient in a more available form* to *this plant will do something for you*, a slide that sells a great deal and earns nothing. We will not take the step. Not because we think little of nourishment — it is the subject of this entire shelf, the thing our family cares about most — but because we think enough of it to refuse to cheapen it with a promise we have no right to make. The ninth measure is a measure of the food. When we can make it honest and reproducible, we will publish it, and it will say exactly that much, and stop. That stopping point is not where our ambition runs out. It is where our integrity begins.



PART IV OF V

The Clean Table

from the tray to the plate · where the whole argument becomes dinner · recipes, scored on the eight axes

Chapter 13 · The clean plate — *letting the flavor do the work.*

Everything in this book was abstract until it reached a table, and then it was the least abstract thing in the world. The daily practice of clean, for us, is not a regimen and not a rule posted on the refrigerator. It is a rhythm: cook from whole plants grown toward their fullest selves, keep the plate honest, let the flavor do the work the salt and the fat used to be asked to do, and sit down together while it is hot. The whole apparatus of the Index — the receptors, the EC_{50} math, the two thousand constructs behind a single tomato — exists so that a plate can be *simpler*, not more complicated: so that a cook can set down the stock pot and the sugar and the cream, and trust the ingredient to arrive already full.



A head of broccoli, charred hard — the vegetable that gets wanted, and therefore eaten, and therefore does its one job.

A clean plate is usually a short one. This is the counterintuitive gift of designing flavor at the source: when the tomato carries its own umami and the broccoli has had its warning turned down and the sweetness comes clean off the receptor, a dish needs *fewer* ingredients, not more, because each one is doing the whole of its job rather than half of it with a crutch propping up the rest. The long ingredient list of a conventional recipe is often a list of compensations — the sugar that rescues a flat tomato, the cream that lends a thin soup a body it lacks, the cheese that buries a bitter vegetable. Restore the ingredient and the compensations fall away, one line at a time, until what is left on the page is close to just the food.

The recipes that follow are deliberately plain — most of them four or five ingredients, most of them vegetarian, because a plant kitchen is where designed flavor has the most to give and where our family has always cooked. The meat and the seafood, when they come, are written with the same respect and the same restraint, not as an exception and not as an apology. Every dish carries its scorecard, so you can taste the intention and read it on the same page.

Recipe · Restored Tomato on Toast, the Way We Mean It

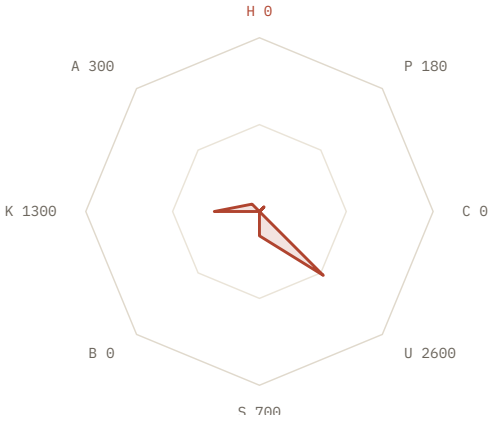
Serves 2 · 12 minutes · the dish we hand to anyone who assumes designed food must taste designed.

```
2            ripe restored tomatoes (the best umami-restored fruit you
have)
2  thick     slices country bread
1  clove     garlic, halved
             good olive oil · flaky salt
```

1. Toast the bread hard — dark at the edges, almost too far. While it is still hot, drag the cut face of the garlic across the rough crust; the toast takes what it needs and leaves the rest. This is pungency used as a seasoning, not a subject — a flicker of allicin on TRPA1, present and gone.
2. Halve the tomatoes and grate the cut sides against the coarse holes of a box grater, down to the skin left flat in your palm. You will have a loose, bright pulp that smells like a greenhouse at noon.
3. Spoon the tomato over the toast so it just soaks in. Olive oil, generously. Flaky salt at the very end, so it stays loud on top.
4. Eat immediately, before the toast surrenders.

Why it works — The restored tomato carries **IFI-U 2,600**, roughly three times the free glutamate of a shipping fruit, pooled through the plant's own GAD/GDH1 route and not added from anywhere. The salt here does not *build* the savory depth; it *unmasks* one that was grown in, because sodium ions lower the threshold at which the tongue registers glutamate. Four ingredients, and the whole thesis of the book sits on one piece of toast.

IFI PROFILE



IFI-H	0
IFI-P	180
IFI-C	0
IFI-U	2,600
IFI-S	700
IFI-B	0
IFI-K	1,300
IFI-A	300

A note on salt and savor — It is worth knowing *why* the last pinch of salt does so much here, because it is the same reason a clean kitchen reaches for the shaker less, not more. Sodium does two things at once on a bite of tomato. It lowers the perceptual threshold at which the tongue registers free glutamate, so the umami that was grown into the fruit reads louder for the same amount; and through the shared transduction cascade, it quiets what little competing bitterness is present, lifting the sweet and the savory by clearing their background. A flat, shipping tomato needs a great deal of salt

because the salt is being asked to *build* a savor that is barely there. A restored tomato needs a bare flake because the savor is already present, and the salt is only turning up a light that was already on.

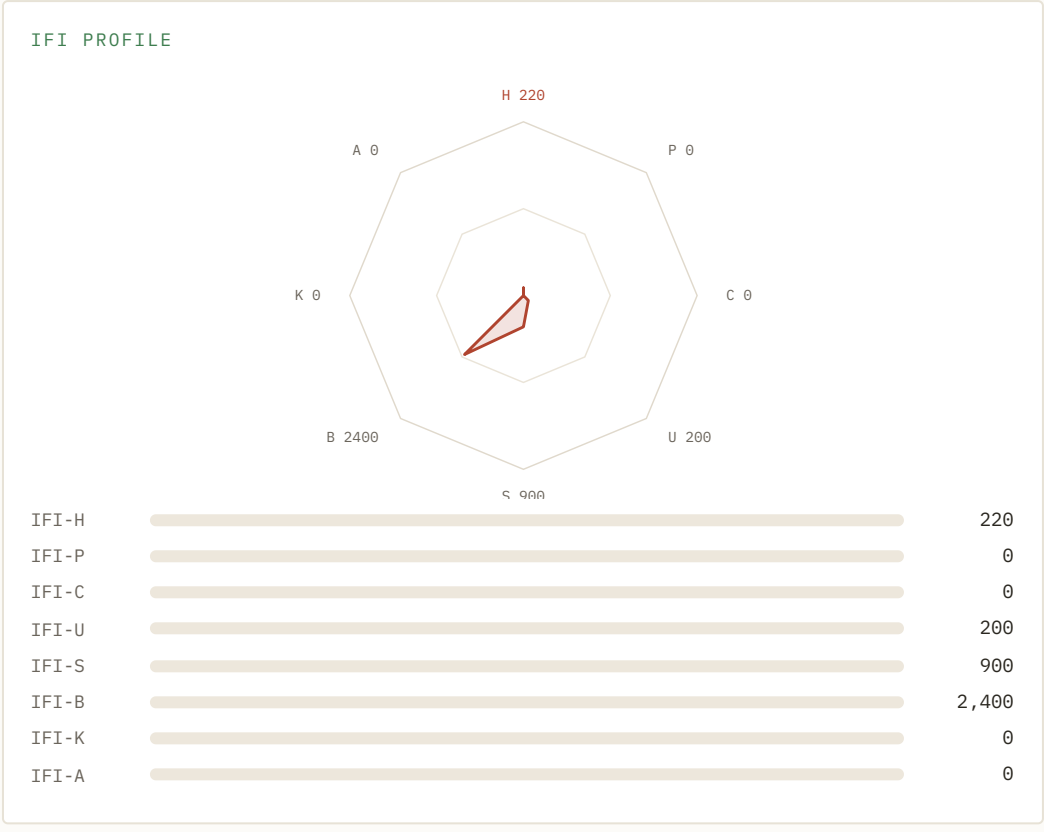
Recipe · Charred Low-Bitter Broccoli, Lemon and Flake

Serves 4 · 20 minutes · the vegetable that comes back from the table empty.

1	large	head low-bitter broccoli, in long spears with the stem
3	tbsp	olive oil
1		lemon, half in juice and half in wedges
		flaky salt · a pinch of mild chili flake

1. Heat a heavy pan or a grill until it is genuinely hot. Toss the broccoli with the oil and a little salt.
2. Lay the spears down and leave them — do not fuss — until the undersides are charred dark and blistered, four or five minutes, then turn once and char the other side.
3. Off the heat, squeeze over the lemon, scatter the flake and the chili, and eat warm, with the wedges alongside.

Why it works — In an ordinary head of broccoli the char would deepen the bitterness, piling a roasted edge onto a glucosinolate warning the TAS2R38 receptor already reads as a threat; the usual rescue is a blanket of cheese. Here the warning was turned down **20–65 percent** at the source, so the char reads as *sweetness* — the plant's own sugars stepping into the space the alarm used to hold — and the lemon's brightness and a flicker of heat finish it. No cheese, no sugar, no masking. The vegetable gets to taste like itself, at last, and the plate comes back clean.



Recipe · Silky White Beans with Slow Alliums, No Stock

Serves 4 · 40 minutes, mostly unattended · body without a bone in the pot.

2	tins	white beans, with their liquid (or 500 g home-cooked, with broth)
1		onion, diced fine · 6 cloves garlic, sliced
5	tbsp	olive oil, plus more to finish
1	sprig	rosemary or sage
		flaky salt · lemon · bread to serve

1. Warm the oil gently and sweat the onion and garlic with the herb until soft, sweet, and barely coloured — fifteen patient minutes. This is the kokumi base, the γ-glutamyl peptides of the alliums building the body of the dish; rushing it is the only way to fail.
2. Add the beans and their liquid and a long pinch of salt. Simmer twenty minutes, crushing a few against the side of the pot so the liquid goes creamy.
3. Off the heat, a last thread of raw oil, a squeeze of lemon, salt to taste. Serve over bread, or with it.

Why it works — A dish like this is usually built on stock and often finished with cream, both of them borrowed richness. Here the body comes from the alliums' own kokumi — γ-glutamyl peptides lifting the **CaSR** signal the mouth reads as continuity and fullness — so the beans taste long and complete on their own starch and a good oil.

Nothing was simmered for an afternoon and no animal was asked into the pot; the richness was grown in and then coaxed out, slowly, with patience standing in for cream.

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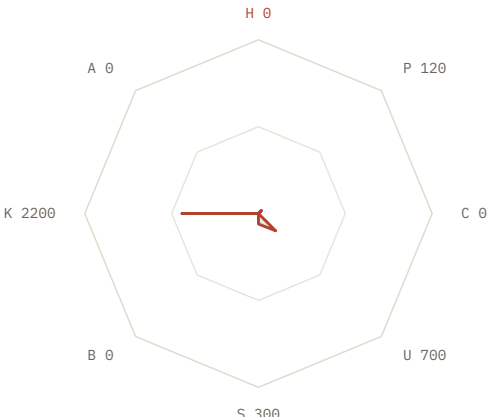

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IFI-P	120
IFI-C	0
IFI-U	700
IFI-S	300
IFI-B	0
IFI-K	2,200
IFI-A	0

Chapter 14 · A week of clean suppers — *plant-first, and nothing missing.*

The plant kitchen is where a clean cook has the most room, because it is where the Index gives the most back. Meat arrives pre-loaded with free glutamate and the ribonucleotides that multiply it; a plant was told, for a century, that it would always be working at a deficit, borrowing savor from butter and cheese and stock. That was never a law of nature. It was a gap left by a breeding program that never thought flavor was its job. Close the gap at the source — in the living plant, through its own biochemistry — and the deficit does not get hidden. It disappears. These are the suppers we actually cook on the ordinary nights, each one leaning on an axis grown back where it belongs.



Kale — bitterness turned to a hum, so the leaf gets eaten rather than argued with.

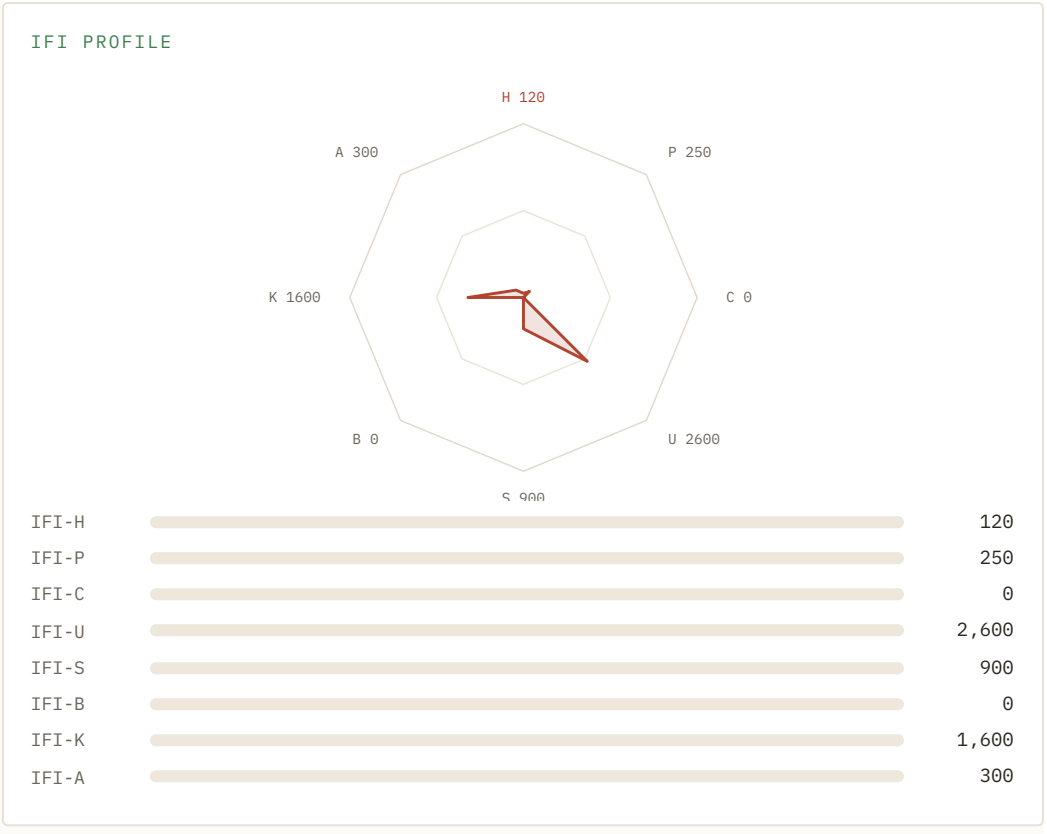
Recipe · Twenty-Minute Tomato Sugo That Tastes Braised

Serves 4 · 25 minutes · no stock, no sugar, no afternoon on the stove.

800 g	restored tomatoes, grated (or 1 tin good whole tomatoes, crushed)
4 cloves	garlic, sliced · ½ onion, diced fine
5 tbsp	olive oil
	basil · flaky salt · a pinch of mild chili flake (optional)

1. Warm the oil and sweat the onion and garlic until soft and sweet, not coloured — eight minutes. This is the kokumi floor.
2. Add the tomato and a long pinch of salt. Raise the heat and let it bubble hard for twelve minutes, stirring, until it glosses and pulls from the pan.
3. Off the heat, tear in basil and a last thread of raw oil. Taste: it will not want sugar, because the sweetness was grown in, and it will not want stock, because the umami was.

Why it works — A long sugo is a technique invented to coax savor out of a tomato that did not have enough to give — hours of reduction to concentrate a little free glutamate by driving off water. Start at **IFI-U 2,600** and the target is already met in the raw fruit, so twelve minutes of hard bubbling is about texture, not rescue. The slow alliums underneath add the kokumi that makes a quick sauce taste long.



The synergy, drawn — The sidebar worth keeping from this chapter is the one piece of savory arithmetic a plant cook should own. Glutamate and a 5′-ribonucleotide are not additive on the tongue; they multiply. Add a little inosinate or guanylate to a fixed amount of glutamate and the perceived savor does not climb in a straight line — it leaps, because the ribonucleotide drops glutamate's effective EC_{50} nearly tenfold, so the same glutamate now drives its receptor far harder. The classic figure is a near eightfold jump in savor from a one-to-one mix versus glutamate alone. The practical reading: a

tomato (glutamate) and a mushroom (guanylate), or a tomato and a scrap of dried seaweed, in the same pot, do not add their depths — they compound them, which is the whole reason this sugo can skip the stock the tradition insists on.

Recipe · Red Lentil Dal, Bloomed Spice, Low-Bitter Greens

Serves 4 · 35 minutes · the vegetarian-first supper our family has cooked the longest.

250 g	red lentils, rinsed
1	onion, diced · 4 cloves garlic · a thumb of ginger, all grated
2 tsp	cumin · 1 tsp turmeric · 1 tsp coriander · a pinch of chili
1 tin	tomatoes, or 300 g restored tomatoes, grated
2 handfuls	low-bitter kale or spinach, shredded
4 tbsp	ghee or oil · salt · lemon · rice to serve

1. Simmer the lentils in plenty of water until collapsing, 20 minutes; keep them loose.
2. In a second pan, bloom the cumin, turmeric, and coriander in the hot fat until fragrant, then add the onion, garlic, and ginger and cook down to a soft, sweet base. Stir in the tomato and cook until jammy.
3. Fold the spiced base into the lentils with a good pinch of salt. Add the greens and let them wilt in, five minutes.
4. Finish with lemon. Serve over rice.

Why it works — This is a dish of layered axes: pungency from the ginger and garlic (TRPA1) lifting the top, heat from the chili (TRPV1) warming the middle, umami from the restored tomato (mGluR1) grounding the whole pot, and — the quiet move — kale whose bitterness was turned down at the source, so the greens fold in as sweetness and body rather than as a note the eater has to forgive. Blooming the spices in the hot fat matters: the aromatic molecules of cumin and coriander are fat-soluble, and the fat both unlocks them and carries them across the dish. The spices decorate a base that was already full.

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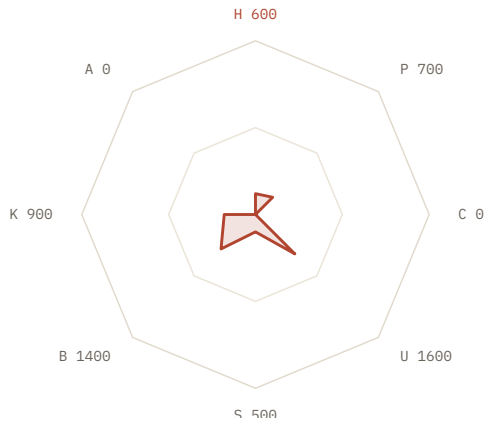

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IFI-P		700
IFI-C		0
IFI-U		1,600
IFI-S		500
IFI-B		1,400
IFI-K		900
IFI-A		0

Recipe · Mushroom-and-Tomato "Braise" over Soft Polenta

Serves 4 · 30 minutes · the synergy chapter, made edible.

400 g	mixed mushrooms, torn
400 g	restored tomatoes, grated (or 1 tin, crushed)
4 cloves	garlic, sliced · 1 shallot, diced
	thyme · 5 tbsp olive oil · salt
	soft polenta, to serve · a little hard cheese, optional

1. Sear the mushrooms hard in oil, in batches so they colour rather than steam; set aside with salt.
2. Soften the shallot and garlic with thyme, add the tomato, and simmer to a glossy sauce, ten minutes. Return the mushrooms and warm through.
3. Spoon over soft polenta. Cheese only if you want it; the dish does not need it.

Why it works — This is the ribonucleotide multiplier on a plate. The restored tomato brings free glutamate; the mushrooms bring **GMP**, a 5′-ribonucleotide that binds the TAS1R1 subunit and drops glutamate's effective EC_{50} nearly tenfold — so the two together taste **seven to eight times** as savory as either alone. Searing the mushrooms hard, rather than stewing them pale, drives off their water and concentrates that guanylate, which is why the browning is not optional. A dish that eats like a long meat braise, built in half an hour from two plants and their shared chemistry.

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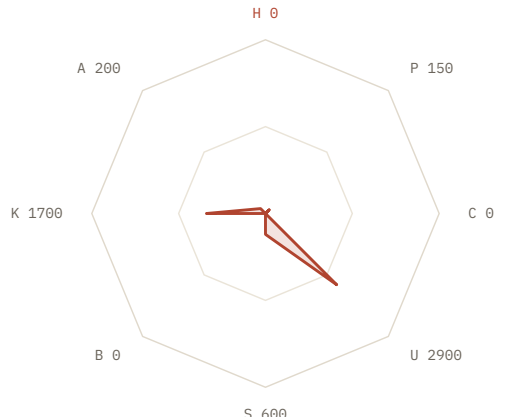


IFI-H		0
IFI-P		150
IFI-C		0
IFI-U		2,900
IFI-S		600
IFI-B		0
IFI-K		1,700
IFI-A		200

Chapter 15 · Meat and seafood, with equal respect — *the same restraint, the same reading.*

We have cooked without meat our whole lives, and we write the meat and seafood here with the same reverence we bring to a tomato, because respect for what you cook is not a thing you ration. A clean kitchen that includes an animal does not do it with apology and does not do it with excess. It does it the way it does everything else: let the thing be what it is, read it on the eight axes, and use designed plants to give it company — heat with a shape, umami grown in rather than salted on, a cooling herb to lift the richness — so that less salt and less fat are asked to carry the plate. The animal is seasoned with intention, not drowned in it.



Pepper in cross-section — heat laddered by design, so a little warmth joins a dish without taking it over.

Here is the one piece of chemistry that makes seasoning meat with restraint possible rather than merely virtuous. Muscle, as it ages and cooks, does on its own exactly what we engineer a plant to do: it frees glutamate from its proteins, and it carries, already, the inosinate (IMP) that multiplies that glutamate — so meat arrives with the umami synergy pre-assembled inside it. Browning adds another layer, the Maillard reaction knitting amino acids and sugars into hundreds of savory aromatic molecules. The cook who understands this reaches for the salt less, because the depth the salt is usually

chasing is already present; the salt's real job is only to unmask it and to quiet the background, the same job it does on a restored tomato. Treat the animal as an ingredient that is already full, give it a little heat with a shape and a cool herb to lift its fat, and the plate comes out seasoned rather than salted into submission.

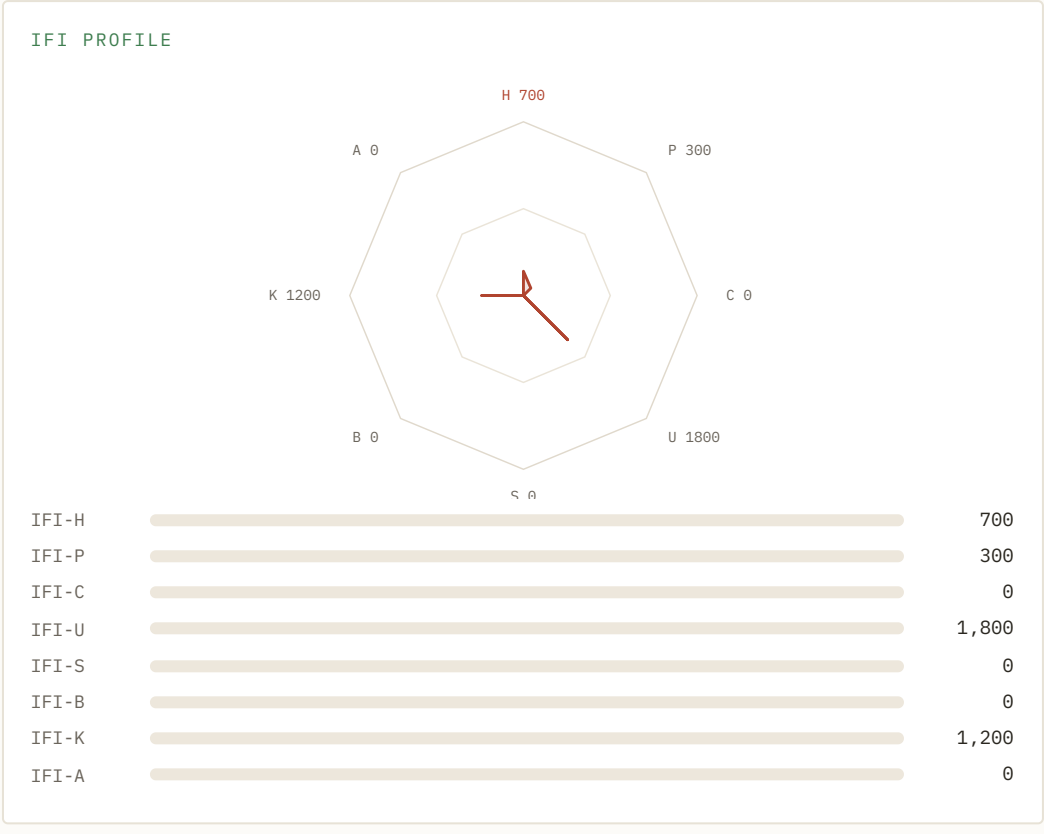
Recipe · Roast Chicken, Herb Butter, Heat Laddered

Serves 4 · 90 minutes · one bird, seasoned with a reading rather than a shaker.

```
1            whole chicken
3  tbsp      soft butter, mashed with lemon zest, thyme, and 1 clove
grated garlic
             a scrape of a single flagship chili, or ½ tsp mild flake
             flaky salt — less than you think · olive oil
             lemon halves for the cavity
```

1. Loosen the skin and work the herb butter underneath, over the breast and thighs. Rub the outside with oil, a measured amount of salt, and the faintest scrape of chili.
2. Lemon in the cavity. Roast at 200 °C until the juices run clear and the skin is deep gold, about an hour and a quarter, resting fifteen minutes before carving.

Why it works — Chicken already carries free glutamate and the inosinate that multiplies it, so it needs less salt than habit says — the savor is in the bird, waiting, with the two-part umami synergy already assembled inside the meat. The heat is laddered on purpose: a scrape, not a handful, so capsaicin at TRPV1 warms the skin without burning through the flesh. The herb butter's garlic gives a flicker of pungency; the lemon lifts the fat. Restraint, here, is the whole technique.



Recipe · Seared Fish, Cool-Herb Salsa

Serves 2 · 15 minutes · a cold finish on a hot pan.

2	fillets firm white fish, skin on
	olive oil · flaky salt
— salsa —	
	a handful of mint and parsley, chopped fine
1	green chili, deseeded and minced small
½	cucumber, diced tiny · lime · olive oil · salt

1. Dry the fish well, salt the skin, and sear skin-side-down in a hot pan without moving it until the skin is crisp, then turn off the heat and let the flesh finish in the residual warmth.
2. Stir the salsa together and spoon it cool over the hot fish just before serving.

Why it works — The salsa is built on the **cool axis**: mint's menthol at TRPM8 reports a chill against the hot fillet, a true contrast of temperatures that wakes the palate, while the chili gives a bright pungent lift and the lime a clean acid. The fish needs almost no salt because the contrast does the work seasoning usually does — a lesson a clean kitchen learns on a tomato and carries, unchanged, to the sea.

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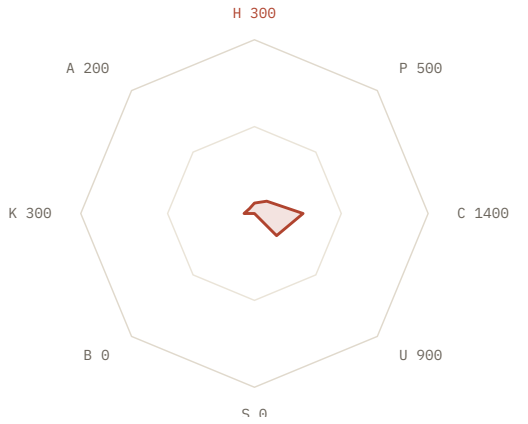

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IFI-P	500
IFI-C	1,400
IFI-U	900
IFI-S	0
IFI-B	0
IFI-K	300
IFI-A	200

Recipe · Grilled Lamb, Herb-and-Spice Rub, Low-Bitter Char

Serves 4 · 30 minutes plus a rest · the aromatics doing the seasoning.

4	lamb chops, or a butterflied leg piece
— rub —	
2 tsp	cumin · 1 tsp coriander · 1 tsp dried oregano
½ tsp	cinnamon · 1 tsp thyme · a pinch of flagship chili, or flake
	flaky salt — measured · olive oil · lemon to finish

1. Grind the rub coarse and work it into the lamb with a little oil and a measured amount of salt. Rest at room temperature twenty minutes so the spice settles in.
2. Grill or sear hard over high heat to a deep crust, turning once, until medium-rare within. Rest ten minutes before slicing.
3. Squeeze lemon over at the table.

Why it works — Lamb carries its own free glutamate and fat-borne aroma, so the rub is not there to add a savor it lacks but to give the meat a *shape*: the cinnamon and coriander lifting a warm top-note, some of it pungency at TRPA1; the chili a laddered heat at TRPV1 that stays behind the meat rather than in front of it; the char a Maillard depth that reads as savory, not bitter. The salt is measured because the depth is already in the lamb — its job is to unmask, not to build. Lemon at the end cuts the fat and lengthens the finish.

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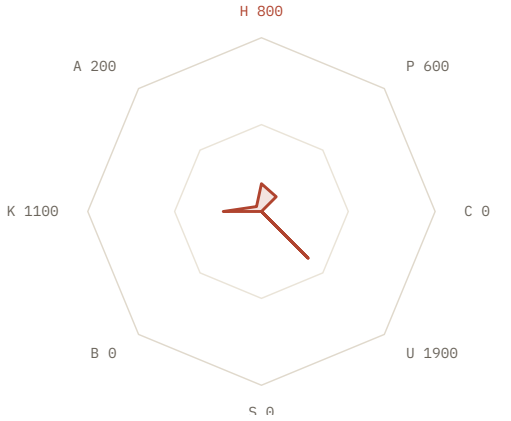

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IFI-C	0
IFI-U	1,900
IFI-S	0
IFI-B	0
IFI-K	1,100
IFI-A	200

Chapter 16 · Sweet, clean, and the cooling finish — *dessert and the glass.*

A clean kitchen does not give up dessert; it gives up the crutch under the dessert. Sweetness grown off the receptor rather than poured from the bag lets a pudding taste like a pudding while asking almost nothing of itself, and the touch axes — a little heat, a little cool, a little astringent grip — give sweetness the structure that keeps it from cloying. The end of a clean meal is not an absence. It is a composition, read on the same eight axes as everything that came before it.



Cocoa — bitterness tuned, sweetness clean, the astringent grip kept for structure.

Recipe · Dark Chocolate and Chili Pots

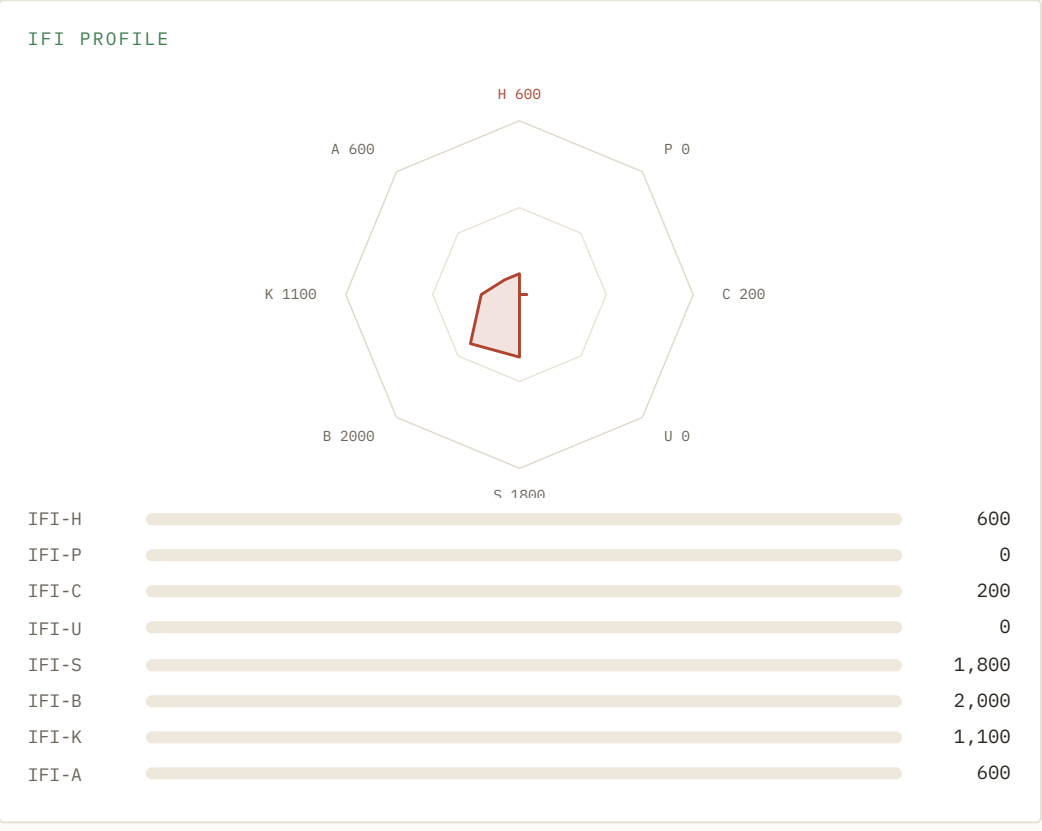
Serves 6 · 20 minutes plus chilling · the sweet-heat finish, built off the receptor.

```
200 g       dark chocolate (bitterness-tuned cacao), chopped
300 ml      whole or oat milk
2  tbsp     Reb M or mogroside sweetener, to taste (no sugar)
            a pinch of flaky salt · the faintest scrape of a flagship
chili
            cocoa nibs or a cooling mint leaf, to finish
```

1. Warm the milk to just below a simmer. Pour it over the chocolate, wait a minute, then stir smooth.
2. Whisk in the sweetener, the salt, and a barely-there scrape of chili. Taste and adjust — you want warmth arriving *after* the chocolate, not instead of it.
3. Pour into small pots and chill until set, two hours. Finish with nibs, or a mint leaf for a cool top-note.

Why it works — Three clean moves in one spoon. The cacao's bitterness was tuned down at the source, so the chocolate reads deep rather than harsh; the sweetness comes from a mogroside-class molecule at **200–300× the potency of sucrose by weight**, so a dessert tastes fully sweet with no sugar in it; and the chili's capsaicin arrives late and low, a warmth that lengthens the chocolate

rather than fighting it. The pinch of salt lifts the whole thing by quieting, through the shared cascade, what little bitterness remains. Sweet, with almost nothing to answer for.



A note on sweet proteins and heat — If you make these with a sweet *protein* rather than a glycoside, add it off the heat. Brazzein is unusually heat-stable for a protein, which is part of why it interests us, but monellin and some others unfold and lose their sweetness when held hot — a reminder that a sweet protein is a folded structure doing its work by shape, the "wedge" holding the receptor shut from outside, and a shape can be cooked loose. Glycoside sweeteners, being small and rigid, do not care about the pan. It is the kind of detail that only matters once, and then never catches you again.

Recipe · Strawberries, Sweet-Heat, Torn Mint

Serves 4 · 10 minutes · high summer, no cooking at all.

```
500 g       ripe strawberries, hulled and halved
            a scrape of mild chili, or a pinch of flake
            a few drops of good balsamic · flaky salt
            a handful of mint, torn
```

1. Toss the strawberries with the chili, a bare few drops of balsamic, and a pinch of salt. Let them sit five minutes to draw their juice.
2. Tear the mint over at the last second and serve, cool.

Why it works — A ripe strawberry is sweetness and a faint astringent grip already in balance; the chili adds a low warmth (TRPV1) that makes the sweetness read brighter by contrast, the balsamic a structured tannic edge (astringency, salivary PRPs), and the mint a cool lift (TRPM8) at the top. Four axes in a bowl of fruit, no sugar added, ten minutes start to finish.

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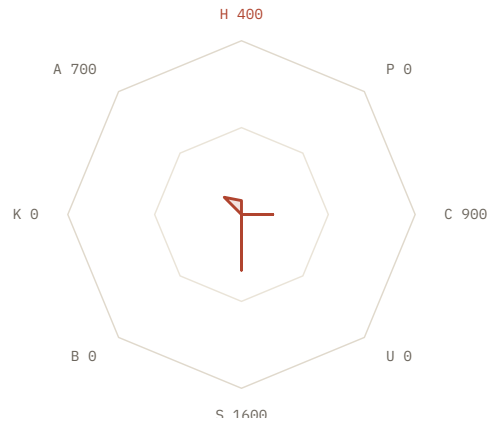

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IFI-C		900
IFI-U		0
IFI-S		1,600
IFI-B		0
IFI-K		0
IFI-A		700

Recipe · Cooling Citrus and Cucumber Cooler

Makes 2 · 5 minutes · the clean glass, alcohol optional.

	juice of 2 limes and 1 orange
½	cucumber, blended and strained
	Reb M or monk-fruit sweetener, to taste (no sugar)
	a few mint leaves, bruised · soda water · ice
	a whisper of green chili, optional

1. Shake or stir the juices, cucumber water, sweetener, and mint over ice.
2. Top with soda. For a grown-up version, the faintest trace of chili on the rim turns the cool into a cool-then-warm.

Why it works — Built entirely on the touch axes and a clean sweet. The mint and cucumber give a true cooling note at TRPM8, the citrus a bright acid, the sweetener a rounded body with no sugar, and — if you want it — a trace of capsaicin that arrives *after* the cool, so the glass finishes warm. A drink that refreshes without a spoon of sugar in it, read on the same index as a pepper.

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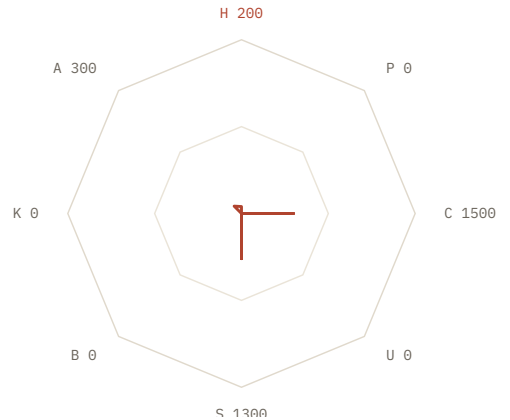

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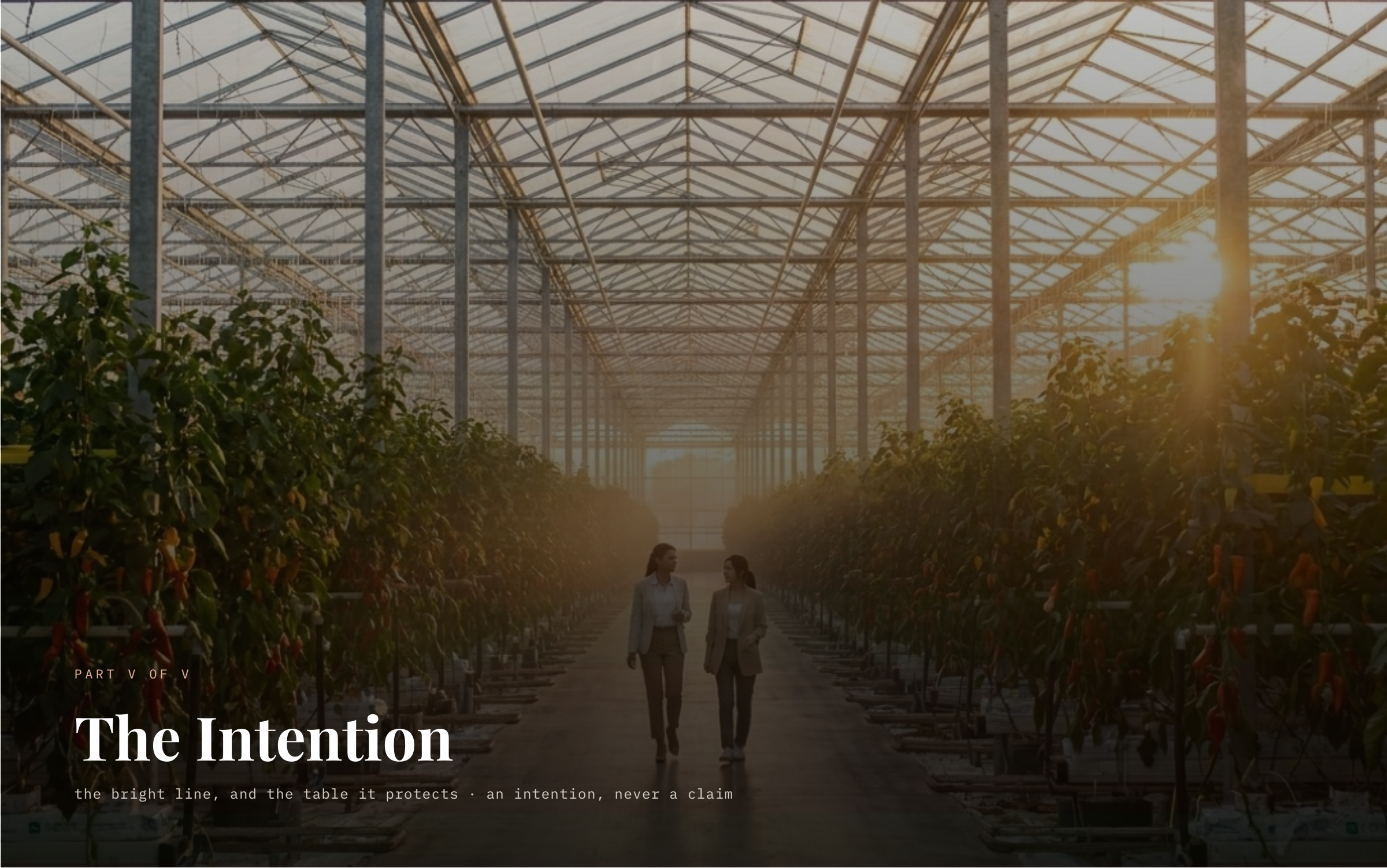
IFI-K	0
IFI-A	300



PART V OF V

The Intention

the bright line, and the table it protects · an intention, never a claim

Chapter 17 · What we will not promise — *an intention, never a cure.*

We should end the argument of this book by naming its edge, plainly, because the edge is what keeps the rest of it honest. There is a whole industry built on telling you what food will do inside your body — what it will cure, what it will flush, what it will protect you from, what it will *detoxify*. We will not join it. You will not find the word *cure* anywhere in this library, or *detox*, or a health halo hung over a plate to help it sell. Not because we think little of nourishment — it is the subject of this entire shelf, the thing our family cares about most in the world — but because we think enough of it to refuse to cheapen it with a promise we have no right to make.



What we will show you: a specimen, isolated and measured — the food, assayed, and nothing said about the person who eats it.

Here is the line, and it is bright. **We will tell you what we put into the plant** — the signal we amplified, through which of the plant's own pathways, with which small edit written where, and the method we found it by. **We will tell you what we measured** — the eight axes, the scores, the EC_{50} behind each one, the coefficient of variation, all of it published to Zenodo for anyone to check or to challenge. **We will tell you our intention** — to grow food that feeds the body as fully as it delights the tongue. And there we stop, at the body's door, which belongs to you and to the people whose training is medicine and not flavor.

There is a well-worn distinction we could hide behind and will not. The rules of food language draw a careful boundary between a claim about a food's makeup and a claim about what a food does to a body, and a clever writer can walk right up to that line and lean over it without technically crossing — *supports*, *promotes*, *helps maintain*, all the soft verbs that imply an outcome while reserving deniability. We have decided not to walk up to the line at all. We say what the molecule is and what the receptor does, and we do not reach for the soft verb, because the soft verb is a promise wearing a disguise, and the whole point of *clean* is that nothing here wears a disguise. The discipline is not a disclaimer we tacked to the bottom of a page. It runs the other way: the restraint came first, and the whole method was built to honor it. It is why we measure the *food* and never the eater; why the ninth measure, when it comes, will be a

property of the plant and not a claim about a person; why a sweetness chapter says what the receptor does and stops at the pancreas's door; why a bitterness chapter turns down a perception and makes no claim, in either direction, about what the plant's substance does downstream.

We hold the line because we have watched the alternative, and the alternative is how the word *clean* got worn out in the first place. Each small, unearned promise — *this will boost, this will protect, this will cleanse* — spends a little of the trust that honest food depends on, until the whole category reads as noise and a real measurement cannot be heard over it. We would rather say less and mean all of it. So we tell you the pathway and the number and the intention, and we let the food be food. Nourishment, for us, is a value and an intention, never a claim. Keeping that distinction is not the fine print of this book. It is the whole reason we were allowed to call it *Clean*.

Chapter 18 · Feeding the body right — *the heart of the whole library.*

Everything in this library points, in the end, at a table. This is a family company in the truest sense: the computing was one pair of hands at a keyboard, and the table it was all for belongs to the whole family — the questions that became cultivars came up over dinner, and the first taster of nearly everything here was someone we love, saying *more of that*, or *not quite*, with a fork still in their hand. We did not build the Index to win an argument. We built it so we could grow dinner on purpose, for the people we feed.



The family in the greenhouse at the hour the light goes gold — the quiet reason behind every number in the book.

So the daily practice of clean, for us, is not a rule and not a regimen. It is a rhythm anyone can keep: cook from whole plants grown toward their fullest selves; keep the plate honest and the ingredient list short; let the flavor do the work the salt and the fat used to be asked to do; and sit down together while it is hot. A bowl of the restored tomato torn over good bread; the charred broccoli that reads sweet; beans gone silky with slow alliums and no stock at all — plain food, scored on the same eight axes as everything else, because we measure what we feed the people we love with no less care than what we sell. Clean living, said simply, is this: feeding your body, and theirs, on purpose and with pleasure. We have never found a part of it worth preaching. We have only ever wanted to set the table.

And the table is getting longer. Forty-two host organisms are live today, each measured on the eight axes and each grown toward the fullest flavor — and the fullest nourishment — it can carry; sixty-four more are drawn on the roadmap, from a volcanic tomato to a sweet-heat strawberry, every one of them held to the same promise and the same bright line. The reach is wide because the biology is shared: the phenylpropanoid branch we worked out in a pepper runs in every vascular plant, so five of the seven platform modules transfer unchanged to any organism with a sequenced genome, and a method proven on heat becomes a method for savor, for sweetness, for the quiet turning-down of a warning. The library

grows the way a garden does, one plant at a time, toward the day when a cook can reach for any ingredient and know it was grown back to the most it could be. That is the direction of all of it. Not a bigger catalog. A fuller plate, a shorter label, a clearer number, and a family's table with room at it for yours.

A closing grace · Clean, and fully fed.

We did not write this book to sell you a feeling of virtue, and not to make you afraid of your own kitchen. We wrote it because we have always believed that the delicious thing and the nourishing thing were the same thing, grown with the same care, and that the whole long apparatus of modern food forgot it somewhere between the field and the shelf. Everything in this library — the eight axes, the restored tomato, the heat with a shape, the ninth measure we are still building toward and will not oversell — is one family's attempt to remember it on purpose, and to show our work the entire way.

Clean, in the end, is not a shorter ingredient list, though it gives you one. It is food you can read all the way down, grown toward the most it can carry, measured honestly, and promised nothing it cannot keep. Cook it for the people you love. Let the flavor be the proof and the nourishment be the point, and let the two of them be, as they always were, a single act. That was the reason we started measuring anything at all.

These are computational designs; Scoville Splice's cultivars and constructs have not been experimentally validated in a laboratory.