Biophotonic Signatures of Plant Vitality: From Herbalist Traditions to Coherence Measurement

Joel Thorarinson* Allison Hensgen† Iulia Koplik‡

June 2026

Abstract

For centuries, herbalist traditions across cultures have maintained that plants possess a measurable "vital force" that degrades with time, improper harvesting, and storage — and that this potency is the decisive factor in therapeutic efficacy. Modern pharmacology dismissed these claims as vitalist superstition, reducing plant quality to chemical constituent concentrations. We argue that both frameworks are incomplete. Recent biophoton experiments demonstrate that germinating seeds emit ultra-weak photon emission (UPE) with statistical properties — anomalous scaling, non-Poissonian photocount distributions, fractal temporal structure — that depart dramatically from thermal noise and vary systematically with biological state [Benfatto et al., 2021, 2023, Brouder and Cifra, 2015]. Applying Diffusion Entropy Analysis (DEA) to biophoton time series reveals transitions between temporal criticality and coherent dynamics that track germination progress with high sensitivity. We propose that the herbalists' "potency" corresponds to a measurable coherence signature in the biophoton emission of plant material, and that the five coherence operators from the Coherence Engine framework [Thorarinson et al., 2026b] — Persistence ($\mathcal{P}$), Adaptivity ($\mathcal{A}$), Repeatability ($\mathcal{R}$), Drift ($\mathcal{D}$), and Noise structure ($\mathcal{N}$) — provide the mathematical vocabulary to formalize what traditional knowledge described qualitatively. We survey the herbalist literature spanning 17th–18th century Russian manuscript herbals (*travniki*), Paul Sédir's occult botany, Scott Cunningham's herbal pharmacopoeia, and contemporary plant magic traditions, extracting specific testable claims about harvesting timing, storage degradation, and preparation-dependent potency. For each claim, we design a biophoton measurement protocol using the experimental methodology established by Benfatto et al. at INFN Frascati, and define the coherence operator values that would constitute confirmation or falsification. The paper bridges three literatures that have never been connected: ethnobotanical knowledge systems, biophoton physics, and coherence-based signal analysis. We conclude with a complete experimental design for a Food Coherence System — a biophotonic quality assessment protocol for plant-derived food and medicine — grounded in Koplik's research program on delayed luminescence in food quality.

Keywords: biophotons; plant coherence; ultra-weak photon emission; herbalism; diffusion entropy analysis; food quality; vital force; delayed luminescence; coherence operators

1 Introduction: The Potency Problem

Every herbalist tradition maintains a version of the same claim: plants have a quality beyond their chemical composition that determines their therapeutic power, and this quality is fragile — it depends on when the plant was harvested, how it was stored, and how it was prepared. The Russian *travniki* (manuscript herbals) of the 17th–18th centuries prescribe harvesting under specific lunar phases and drying in shade to preserve the plant's *sila* (force) [Ippolitova, 2005].

*Coherence Research Group. ORCID: 0000-0002-0553-842X. joel.thorarinson@conformalmaps.com
†Coherence Research Group. ORCID: 0009-0008-7247-0307
‡Coherence Research Group. ORCID: 0009-0005-3765-4811

Paul Sédir's *Magie des Plantes* (1902) describes a "vegetable Od" — an invisible emanation from living plants whose "color, quantity, and quality" depend on the plant's vitality [Sédir, 1902]. Scott Cunningham's *Herbal Witchcraft* systematically associates each plant with planetary influences and warns that plants "lose their magical properties" when improperly harvested or stored too long [Cunningham, 1985]. The contemporary Russian *Okkul'tnaya Sila Rasteniy* (Occult Power of Plants) describes "energy fields" around plants that can be diminished or enhanced by specific interventions [Erofeev, 2005].

Modern pharmacology replaced this language with constituent analysis: the active principles are identified molecules (salicylic acid in willow bark, digoxin in foxglove, quinine in cinchona), and "potency" reduces to their concentration. This reductionism is enormously productive — it gave us aspirin, digitalis, and chloroquine — but it systematically ignores a persistent empirical observation: whole-plant preparations sometimes outperform isolated constituents at equivalent concentrations, a phenomenon pharmacologists call the "entourage effect" and herbalists call synergy [Williamson, 2001, Wagner and Ulrich-Merzenich, 2009].

We propose that the herbalists are measuring something real, but their measurement instrument (human perception, ritual practice, traditional knowledge) produces qualitative reports that resist scientific operationalization. The biophoton literature provides the missing bridge.

1.1 Biophotons: The Physical Correlate

Since Gurwitsch's 1923 discovery that onion root tips emit ultraviolet radiation capable of inducing mitosis in neighboring cells [Gurwitsch, 1923], it has been established that all living organisms emit ultra-weak photon emission (UPE) in the visible and near-UV range (200–800 nm) at intensities of 10^1–10^3 photons per second per square centimeter of surface area [Popp et al., 1988, Cifra and Pospíšil, 2014]. This emission is distinct from bioluminescence (which requires specific enzymatic machinery present only in specialized organisms) and is instead an endogenous property of all metabolically active cells.

The critical question is whether this emission is mere noise — random photons from imperfect metabolic chemistry (the "imperfection theory") — or whether it carries information about the organism's biological state (the "coherence theory" advanced by Popp and colleagues) [Popp, 1992, De Paolis et al., 2024]. The Benfatto group at INFN Frascati National Laboratories, in collaboration with Grigolini, has provided the most rigorous evidence to date that biophoton emission is not thermal noise. Using Diffusion Entropy Analysis (DEA) on photon time series from germinating lentil and bean seeds, they demonstrated:

1. **Anomalous scaling.** The scaling index η departs from the ordinary value 0.5 throughout the germination process. Dark counts yield $\eta = 0.5$ (ordinary Brownian motion); germinating seeds yield $\eta > 0.5$, indicating temporal structure [Benfatto et al., 2021].

2. **Crucial events.** Early germination is dominated by non-ergodic "crucial events" — intermittent bursts following inverse power law waiting time distributions with index $1 < \mu < 3$ — characteristic of self-organized temporal criticality [Benfatto et al., 2019].

3. **Coherence transitions.** The biophoton signal transitions from crucial-event-dominated criticality to fractional Brownian motion (FBM) with stationary infinite memory as germination proceeds, suggesting the emergence of quantum coherence [Benfatto et al., 2021, Culbreth et al., 2021].

4. **Non-Poissonian statistics.** Photocount distributions during germination deviate from both Poisson (coherent state) and Bose–Einstein (thermal state) distributions, with variance-to-mean ratios indicating multi-mode super-Poissonian emission [Benfatto et al., 2023, Brouder and Cifra, 2015].

5. **Cross-organism consistency.** Lentil seeds, single beans, and other plant systems show qualitatively similar coherence signatures, supporting the universality of the phenomenon [Benfatto et al., 2023, De Paolis et al., 2024].

These results establish that biophoton emission from plants carries measurable temporal structure that varies with biological state. The question this paper addresses is: *does this temporal structure correspond to what herbalists call potency?*

1.2 What This Paper Proposes

We make three connected claims:

1. **Herbalist "potency" has a biophotonic correlate.** The traditional claims about plant vital force, harvesting timing, and storage degradation map onto measurable properties of biophoton emission — specifically, the coherence operators from the Coherence Engine framework.

2. **The coherence operators formalize qualitative herbalist knowledge.** The Persistence operator $\mathcal{P}$ captures what herbalists call "keeping power"; the Adaptivity operator $\mathcal{A}$ captures "responsiveness to preparation"; the Drift operator $\mathcal{D}$ captures "degradation over time."

3. **A Food Coherence System is experimentally realizable.** Using established biophoton measurement protocols and the DEA analysis pipeline, we can construct a quantitative assessment of plant-derived food and medicine quality that operationalizes traditional potency concepts.

Section 2 surveys the herbalist literature for specific, testable claims. Section 3 reviews the biophoton evidence in detail. Section 4 develops the coherence operator framework for plant biophoton time series. Section 5 applies this framework to food quality assessment. Section 6 presents the experimental design. Section 7 discusses implications and limitations.

2 Herbalist Traditions: Extracting Testable Claims

We survey four distinct herbalist traditions, chosen for their geographic and temporal diversity, and extract claims that are specific enough to test with biophoton measurements. Our goal is not to evaluate these traditions on their own terms — their internal logic is coherent and their pharmacological utility is well-documented [Fabricant and Farnsworth, 2001] — but to identify the subset of claims that make predictions about measurable physical quantities.

2.1 Russian Manuscript Herbals (17th–18th Century)

The *travniki* (herbals) represent one of the oldest continuous manuscript traditions in European folk medicine. Ippolitova's comprehensive study of 17th–18th century Russian manuscript herbals [Ippolitova, 2005] documents a pharmacopoeia that integrates practical botanical knowledge with cosmological and temporal prescriptions. Key claims relevant to biophotonic measurement:

1. **Lunar harvesting timing.** Herbs collected during specific lunar phases possess different therapeutic potency. The *travniki* prescribe waxing moon for "strengthening" herbs and waning moon for "cleansing" herbs. The underlying assumption: the plant's internal state varies with an external periodic signal (lunar cycle).

   Biophotonic prediction: Biophoton emission intensity and/or coherence parameters of the same plant species, measured at the same time of day, will show statistically significant variation across lunar phases.

2. **Time-of-day sensitivity.** Many herbs must be collected "before sunrise" or "at dawn" to preserve their *sila*. The *travniki* distinguish between morning potency and afternoon potency for specific applications.

   Biophotonic prediction: The DEA scaling index η of freshly harvested plant material will differ systematically between dawn-harvested and afternoon-harvested samples.

3. **Drying method affects potency.** Shadow-dried herbs retain more potency than sun-dried herbs, and kiln-dried herbs are least potent. The degradation is described as loss of the plant's "living force."

   Biophotonic prediction: Delayed luminescence (DL) intensity and decay kinetics will differ between shadow-dried, sun-dried, and kiln-dried samples, with shadow-dried showing the longest decay times (highest coherence).

4. **Storage duration limits.** Herbs lose potency over time, with specific lifetimes: roots last longer than leaves, seeds longer than flowers. The *travniki* prescribe one-year maximum for most dried herbs.

   Biophotonic prediction: Biophoton emission coherence parameters (particularly $\mathcal{P}$ and $\mathcal{D}$) will decrease monotonically with storage duration, at rates that differ by plant part (root $>$ seed $>$ leaf $>$ flower).

The Ingvar and Raokriom compilation [Ingvar and Raokriom, 2010] preserves the tradition's emphasis on harvesting timing and confirms that the general rule links gathering to the lunar calendar, with harvesting preferred during waxing moon for roots and seeds, and specific feast days designated for magical (as opposed to purely medicinal) collections.

2.2 Paul Sédir's Occult Botany (1902)

Sédir's *Magie des Plantes* occupies a unique position between Paracelsian alchemy and systematic botany. His concept of the "vegetable Od" — an invisible emanation detected by sensitives — is the closest pre-scientific description of biophoton emission in the Western esoteric literature:

> "Since the work of Reichenbach, it is known that all living things emit a fluid, invisible under ordinary conditions, but visible to sensitives. The color, quantity, and quality of this fluid depend on the vitality and state of the emitting body." [Sédir, 1902, ch. III]

Sédir's framework makes several specific claims:

1. **Planetary signatures.** Each plant is governed by a planetary influence (Mars, Venus, Saturn, etc.) that determines both its therapeutic properties and its "occult" characteristics. Plants collected under the appropriate planetary hour have enhanced potency.

   Biophotonic prediction: While planetary governance is not directly testable, the underlying claim is that external periodic influences (diurnal, seasonal) modulate plant state. This is testable: biophoton emission parameters should show circadian and seasonal periodicity.

2. **The doctrine of signatures.** Plant morphology encodes its therapeutic purpose (e.g., liver-shaped leaves indicate hepatic remedies). Sédir extends this to energetic signatures: plants with similar therapeutic properties should have similar "Od" qualities.

   Biophotonic prediction: Plants traditionally assigned to the same planetary category or therapeutic class will show more similar biophoton coherence profiles than plants from different categories.

3. **Palingenesis.** Sédir describes experiments in which the "astral body" of a burned plant can be made to reappear in a glass vessel containing its calcined ashes — a resurrection of the plant's essential form. While the experiment as described is not reproducible under controlled conditions, the underlying claim is testable: the mineral residue of a plant retains some information about its pre-combustion state.

   Biophotonic prediction: Delayed luminescence of plant ash will differ from that of chemically identical mineral mixtures, if any organized molecular structure survives combustion.

4. **Quintessence extraction.** Sédir, following Paracelsus, describes "quintessence" preparations that concentrate the plant's vital principle through spagyric (alchemical) processes involving fermentation, distillation, and recombination with calcined salts.

   Biophotonic prediction: Spagyric tinctures will show different DL characteristics than standard hydroalcoholic extracts of the same plant material.

2.3 Scott Cunningham's Herbal Pharmacopoeia

Cunningham's *Koldustvo na Travakh* (Herbal Witchcraft) [Cunningham, 1985] provides the most systematic modern herbalist framework, cataloging over 100 plants with specific "magical" properties, associated elements (Water, Fire, Earth, Air), planetary rulers, and preparation instructions. Key testable claims:

1. **Elemental classification predicts energetic quality.** "Fire" plants (ginger, cinnamon, pepper) differ qualitatively from "Water" plants (willow, lotus, chamomile) in their energetic effect. Cunningham describes Fire-element plants as having "hot aura" and Water-element plants as having "cold aura."

   Biophotonic prediction: The spectral distribution of biophoton emission will differ systematically between plants classified as Fire vs. Water, potentially showing higher emission intensity or different spectral peaks for Fire-element plants.

2. **Freshness determines magical efficacy.** "Plants lose their magical properties" when stored too long or harvested improperly. Cunningham prescribes specific harvesting rituals that include attention to timing, intention, and environmental conditions.

   Biophotonic prediction: The coherence persistence $\mathcal{P}$ of biophoton emission from freshly harvested material will exceed that of stored material of the same species, measured under identical conditions.

3. **Preparation method transforms properties.** The same plant material produces different effects depending on preparation: infusion, decoction, tincture, incense (combustion), or direct contact. Each method is prescribed for different applications.

   Biophotonic prediction: Different preparation methods applied to the same plant material will yield different DL profiles, reflecting different degrees of molecular organization preservation.

2.4 Plant Wisdom Literature

The contemporary plant magic tradition, represented by works such as *Magiya Rasteniy* (Plant Magic) [Anonymous, 2023], introduces concepts that explicitly parallel biophoton phenomena:

1. **Plant communication.** Plants respond to neighboring plants by modifying their chemical composition — a claim that received experimental support from Rhoades' discovery that Sitka willows (*Salix sitchensis*) change leaf nutrient content in response to herbivore attack

on neighboring trees [Rhoades, 1983]. The tradition extends this to energetic communication: plants "sense" the intentions and emotional state of those who interact with them.

Biophotonic prediction: Biophoton emission from a plant will show measurable changes (in intensity, spectral distribution, or coherence parameters) when a neighboring plant is subjected to stress, consistent with UPE-mediated inter-plant signaling documented by Beloussov et al. in fish embryos [Beloussov et al., 2003].

2. **Lunar phase effects on plant vitality.** The growing moon phase is prescribed for planting and harvesting "strengthening" herbs; the waning moon for "cleansing" herbs. This mirrors the Russian *travniki* tradition with remarkable consistency across independently developed traditions.

3. **Individual plant "personality."** Each plant specimen has distinct energetic qualities that must be assessed individually, not just by species. This implies within-species, within-environment biophotonic variability.

   Biophotonic prediction: The coefficient of variation in biophoton coherence parameters across individual plants of the same species, grown under identical conditions, will be significantly greater than the coefficient of variation across repeated measurements of the same individual.

2.5 Synthesis: The Herbalist Consensus

Across four geographically and temporally distinct traditions, we identify a convergent set of claims (Table 1). The consistency is notable: traditions that developed independently — 17th-century Russian scribes, 19th-century French occultists, 20th-century American Wiccans, and contemporary pan-European plant wisdom authors — agree on the following:

Table 1: Convergent herbalist claims and their biophotonic operationalizations. Sources: T = Russian *travniki*; S = Sédir; C = Cunningham; M = Modern plant magic literature.

Claim	**Sources**	**Traditional description**	**Biophotonic operationalization**
Plants possess vital force beyond chemistry	T,S,C,M	*sila*, Od, magical properties, energy field	UPE coherence parameters (η, μ, $\mathcal{P}$)
Harvesting timing affects potency	T,S,C,M	Lunar phase, time of day, season	Circadian/lunar modulation of η
Drying/storage degrades potency	T,S,C,M	Loss of force, loss of magical properties	Monotonic decrease in $\mathcal{P}$, increase in $\mathcal{D}$
Preparation method transforms properties	T,S,C	Infusion vs. decoction vs. tincture	DL profile differences by preparation
Plant parts differ in potency	T,S,C	Root > seed > leaf > flower	DL decay time ranking by plant part
Individual variation within species	S,M	Plant "personality," individual assessment	Within-species CV($\mathcal{P}$) > 0
Inter-plant communication	M	Plants respond to neighbors' stress	UPE coupling between specimens

3 Biophoton Evidence: From Seeds to Food

3.1 Germination Experiments: The Benfatto–Grigolini Program

The experimental foundation for this paper comes from a series of experiments conducted at INFN Frascati National Laboratories (Laboratori Nazionali di Frascati) by Benfatto, Pace, Curceanu, Scordo, Clozza, and collaborators, with theoretical analysis by Grigolini and coworkers [Benfatto et al., 2019, 2021, 2023, De Paolis et al., 2024].

Experimental setup. Germinating seeds (lentils and beans) are placed in a light-tight chamber. A Hamamatsu H12386-210 photon-counting head serves as the single-photon detector, sensitive across the visible spectrum. A filter wheel with seven positions (empty, spectral filters at different wavelengths, black cap) rotates to provide spectral decomposition. Each wheel position is measured for one minute, completing a full cycle every 443 seconds. Photon counts are recorded as time series for experiments lasting up to 100 hours.

Key results for plant-coherence analysis. *Temporal structure.* The photon time series from germinating seeds shows anomalous scaling: the DEA scaling exponent η departs from the ordinary Brownian value of 0.5 throughout the germination process. Dark counts (no seeds) yield $\eta = 0.5$ exactly, confirming that the anomalous scaling is biological in origin [Benfatto et al., 2021].

Phase transitions. The germination process is characterized by a transition from crucial-event-dominated dynamics (characterized by intermittent bursts with inverse power law waiting time distributions, $\mu \approx 2.5$) to fractional Brownian motion with stationary infinite memory (Figure 1). This transition — from critical to coherent — is the biophotonic signature of a living system organizing itself.

Intensity profile. Photon emission intensity rises from background levels, reaches a peak during maximum germination activity, and subsequently declines. The intensity profile for lentils shows a characteristic multi-peaked structure with identifiable phases (labeled A through E in De Paolis et al. 2024), each associated with distinct biological processes: water absorption, radicle emergence, shoot elongation.

Spectral information. Spectral filtering reveals that the biophoton emission spans the visible range with a broad distribution, consistent with the general finding that UPE spectra are approximately flat from 350–700 nm with slight maxima in the orange–red region [Cifra and Pospíšil, 2014, De Paolis et al., 2024].

Statistical properties. Photocount distributions during germination are super-Poissonian (variance exceeds mean), with the variance-to-mean ratio varying across germination stages. The number of thermal modes M ranges from approximately 4 (dark condition) to higher values during active germination, indicating that the emission field is multi-modal and not consistent with a single coherent state [Benfatto et al., 2021, Brouder and Cifra, 2015].

3.2 Delayed Luminescence in Food

Delayed luminescence (DL) — the slow, hyperbolic decay of photon emission following brief illumination — provides a complementary probe of biological organization. Unlike spontaneous UPE, DL intensity is orders of magnitude higher (enabling shorter measurement times) and its decay kinetics encode information about the molecular organization of the emitting tissue.

Popp and colleagues argued that the hyperbolic decay law $I(t) \propto t^{-\alpha}$ (with $\alpha \approx 1$–2) distinguishes DL from exponential fluorescence and indicates a coherent photon field with long-range correlations [Popp, 1992, 2003]. While the interpretation remains debated [Brouder and Cifra, 2015], the empirical phenomenon is robust: DL from biological samples consistently follows power-law rather than exponential decay.

For food quality assessment, DL offers several advantages:

1. **Speed.** A DL measurement requires seconds to minutes, compared to hours for spontaneous UPE characterization during germination.

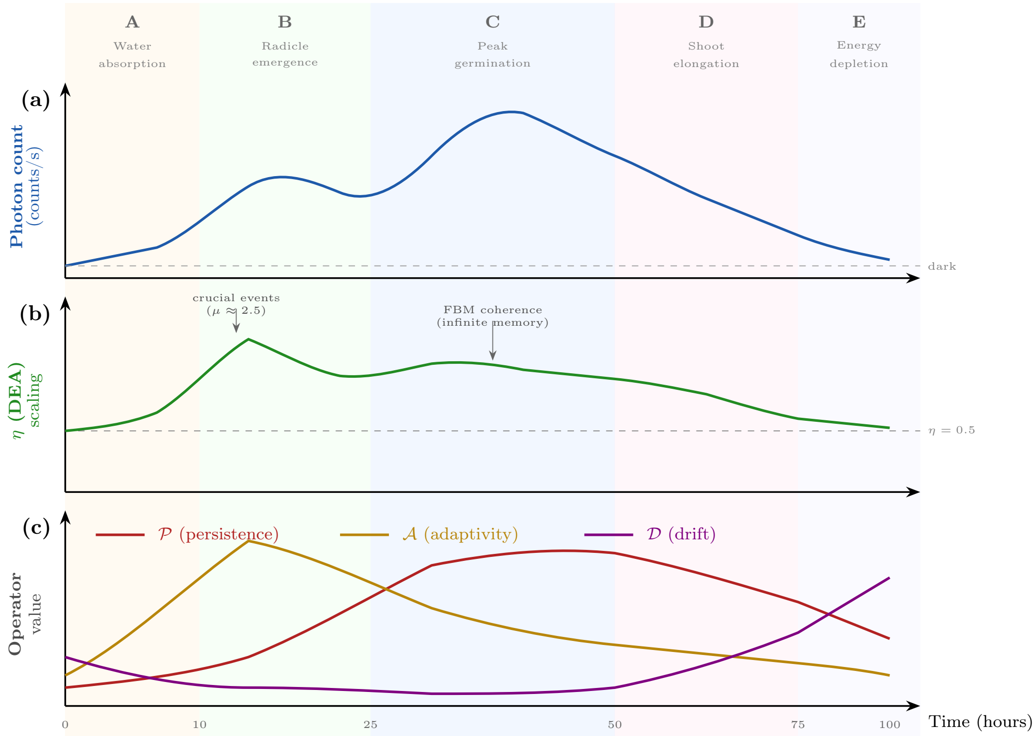

Figure 1: Coherence operator timeline during seed germination, based on Benfatto et al. experimental data. **Top:** Photon count rate (arbitrary units) showing the characteristic multi-peaked intensity profile during lentil germination. **Middle:** DEA scaling exponent $\eta(t)$ computed in sliding windows. $\eta = 0.5$ (dashed line) corresponds to ordinary scaling (no temporal structure). Departure from 0.5 indicates either crucial events ($\eta > 0.5$, driven by $\mu < 3$) or fractional Brownian coherence ($\eta > 0.5$, driven by $H > 0.5$). **Bottom:** Coherence operator values ($\mathcal{P}$, persistence; $\mathcal{A}$, adaptivity; $\mathcal{D}$, drift) computed from the biophoton time series using the Coherence Engine framework. The transition from critical to coherent dynamics is visible as a shift from high $\mathcal{A}$ (adaptive, responsive) to high $\mathcal{P}$ (persistent, stable). $\mathcal{D}$ (drift) increases during the final phase as the seed exhausts its stored energy and coherence degrades.

2. **Sensitivity to freshness.** DL intensity and decay time decrease as food degrades, even when chemical composition has not measurably changed [van Wijk and van Wijk, 2008, Gallep et al., 2004].

3. **Sensitivity to processing.** Ultra-processed foods show different DL profiles than minimally processed equivalents, potentially because processing disrupts molecular organization [Monteiro et al., 2019b].

4. **Non-destructive.** Measurement requires only brief illumination and does not alter the sample.

The connection to herbalist claims is direct: DL provides a physical measurement of the "living force" that herbalists claim degrades with storage and processing.

3.3 Evidence from Adjacent Fields

Several related findings support the biophoton-as-vitality-marker hypothesis:

Alzheimer's biophoton blueshift. Wang et al. [Wang et al., 2023] demonstrated that biophotonic activity in neural tissue is reduced and spectrally blueshifted in Alzheimer's disease and vascular dementia models, establishing that biophoton coherence correlates with biological functional integrity in animal systems.

Meditation effects on UPE. Van Wijk et al. [Van Wijk et al., 2005] showed that meditation practice alters UPE emission from human hands and forehead, demonstrating that biological state modulates biophoton emission in humans.

Fractal analysis of autoluminescence. Dlask, Kukal, and Cifra [Dlask et al., 2019] applied fractional Brownian motion/bridge analysis to mung bean photon time series, finding negative temporal memory (anti-persistent behavior) in short time windows, consistent with a regulatory feedback mechanism.

Quantum photoprotection. Patwa, Babcock, and Kurian [Patwa et al., 2024] demonstrated superradiant enhancement in neuroprotein architectures (microtubules, actin filaments, amyloid fibrils), suggesting that biological macromolecular structures support collective quantum optical phenomena at physiological temperatures.

4 The Coherence Framework for Plant Biophoton Analysis

We now apply the five coherence operators from the Coherence Engine framework [Thorarinson et al., 2026b] to plant biophoton time series. The Coherence Engine was developed for engineering systems (turbofan degradation, industrial process monitoring) but its mathematical structure is domain-independent: it operates on any time series where the question is "how organized is this system's behavior over time?"

4.1 Operator Definitions Applied to Biophoton Data

Let $\{n_t\}_{t=1}^{T}$ be a biophoton photon-count time series recorded from a plant sample, and let $\eta(t)$ be the DEA scaling exponent computed in a sliding window centered at time t.

Definition 1 (Persistence $\mathcal{P}$)**.** *The persistence operator measures how long the system maintains a given coherence state. For biophoton data:*

$$\mathcal{P} = \frac{1}{T-w} \sum_{t=1}^{T-w} \nVdash [|\eta(t+1) - \eta(t)| < \epsilon] \tag{1}$$

where w is the DEA window size and ϵ is the stability threshold. High $\mathcal{P}$ indicates that the plant maintains a stable coherence level; low $\mathcal{P}$ indicates fluctuating coherence.

Herbalist interpretation: $\mathcal{P}$ corresponds to "keeping power" — a plant with high persistence maintains its vital force over time.

Definition 2 (Adaptivity $\mathcal{A}$)**.** *The adaptivity operator measures the system's response to perturbation. For biophoton data:*

$$\mathcal{A} = \frac{Var[\eta(t) \mid perturbation\ at\ t_0]}{Var[\eta(t) \mid no\ perturbation]} \tag{2}$$

where perturbations include brief light exposure (inducing DL), temperature changes, or introduction of chemical stimuli. High $\mathcal{A}$ indicates the plant's biophoton coherence responds strongly to perturbation; low $\mathcal{A}$ indicates insensitivity.

Herbalist interpretation: $\mathcal{A}$ corresponds to "responsiveness" — the quality that herbalists assess when they claim certain plants "react to" human intention or environmental change.

Definition 3 (Repeatability $\mathcal{R}$)**.** *The repeatability operator measures the consistency of the system's coherence response across repeated perturbation cycles:*

$$\mathcal{R} = 1 - \frac{Var[\Delta\eta_i]}{\mathbb{E}[\Delta\eta_i]^2} \tag{3}$$

where $\Delta\eta_i$ is the change in scaling exponent during the i-th perturbation-recovery cycle. High $\mathcal{R}$ indicates that the plant responds to the same perturbation in the same way each time.

Herbalist interpretation: $\mathcal{R}$ corresponds to "reliability" — a plant material that produces consistent therapeutic effects.

Definition 4 (Drift $\mathcal{D}$)**.** *The drift operator measures the rate of long-term change in coherence:*

$$\mathcal{D} = \left| \frac{d}{dt} \langle \eta(t) \rangle_{moving\ avg} \right| \tag{4}$$

where the moving average is computed over windows large enough to remove circadian oscillations. Low $\mathcal{D}$ indicates stable vitality; high $\mathcal{D}$ indicates degradation (or enhancement).

Herbalist interpretation: $\mathcal{D}$ corresponds to "degradation" — the loss of potency over storage time that every herbalist tradition describes.

Definition 5 (Noise structure $\mathcal{N}$)**.** *The noise structure operator characterizes the statistical nature of fluctuations around the coherent signal:*

$$\mathcal{N} = \frac{\sigma_n^2}{\langle n \rangle} - 1 \tag{5}$$

where σ_n^2 is the variance and $\langle n \rangle$ is the mean of the photocount distribution. $\mathcal{N} = 0$ for Poisson (coherent state), $\mathcal{N} > 0$ for super-Poissonian (thermal or multi-mode), and $\mathcal{N} < 0$ for sub-Poissonian (quantum squeezed state).

Herbalist interpretation: $\mathcal{N}$ distinguishes between "living" plant material ($\mathcal{N}$ varies dynamically and is typically super-Poissonian) and "dead" or "depleted" material ($\mathcal{N} \to 0$, approaching Poissonian noise).

4.2 The Coherence Profile as a Fingerprint

The five-dimensional coherence vector $\mathbf{C} = (\mathcal{P}, \mathcal{A}, \mathcal{R}, \mathcal{D}, \mathcal{N})$ provides a fingerprint of a plant sample's biophotonic state. We propose that this fingerprint encodes what herbalists call "potency" and that it evolves predictably under the conditions herbalists describe (Table 2).

Table 2: Predicted coherence operator values under herbalist-described conditions.

Condition	$\mathcal{P}$	$\mathcal{A}$	$\mathcal{R}$	$\mathcal{D}$	$\mathcal{N}$
Freshly harvested, optimal timing	High	High	High	Low	Super-Poisson
Freshly harvested, suboptimal timing	Med	Med	Med	Low	Super-Poisson
Stored 1 month, shadow-dried	High	Med	High	Low	Super-Poisson
Stored 1 month, sun-dried	Med	Low	Med	Med	Near-Poisson
Stored 6 months	Med	Low	Low	Med	Near-Poisson
Stored 12+ months	Low	Low	Low	High	Poisson
Commercially processed	Low	Low	Low	High	Poisson

5 Food Quality as Coherence

5.1 The Ultra-Processed Food Problem

The global food system increasingly depends on ultra-processed foods (UPFs) — industrial formulations composed primarily of substances extracted from foods or synthesized, with little if any intact food [Monteiro et al., 2019b]. The NOVA classification system [Monteiro et al., 2019a] categorizes foods on a processing spectrum from unprocessed (Group 1) to ultra-processed (Group 4). Epidemiological evidence links high UPF consumption to increased risk of cardiovascular disease, metabolic syndrome, depression, cancer, and all-cause mortality [Monteiro et al., 2019b, Hall et al., 2019].

The mechanistic explanation remains incomplete. UPFs contain known harmful additives (emulsifiers, colorants, TiO_2 nanoparticles [Nam et al., 2025]) and lack fiber, micronutrients, and phytochemicals. But this chemical account may be insufficient: the same nutrients delivered in whole food versus UPF form produce different health outcomes even when matched for macronutrient composition [Hall et al., 2019].

We propose that the missing variable is *molecular organization* — the spatial and temporal coherence of the food matrix's molecular architecture. Ultra-processing destroys this organization. The biophotonic signature of this destruction is measurable.

5.2 Delayed Luminescence as Food Quality Metric

A DL-based food quality assessment protocol operates as follows:

1. **Illumination.** The food sample is briefly illuminated with broadband white light (100 ms pulse, standardized intensity).
2. **Detection.** Photon emission is recorded by a single-photon counting module in a light-tight chamber for 60–300 seconds following illumination cutoff.
3. **Fit.** The DL decay curve is fitted to a multi-component power law:

$$I(t) = \sum_{i=1}^{k} A_i \, t^{-\alpha_i} \tag{6}$$

where A_i is the amplitude and α_i is the decay exponent of the i-th component.

4. **Coherence extraction.** The five coherence operators are computed from the DL time series and the multi-component fit parameters:
   - $\mathcal{P}$: stability of the DL profile across repeated illumination cycles
   - $\mathcal{A}$: sensitivity of DL to illumination wavelength or intensity changes
   - $\mathcal{R}$: reproducibility of DL profile across samples from the same food item
   - $\mathcal{D}$: change in DL parameters over the food's storage lifetime
   - $\mathcal{N}$: photocount statistics of the DL signal (Poisson vs. super-Poisson)

5.3 The Food Coherence Index

We define a scalar Food Coherence Index (FCI) as a weighted combination of the coherence operators:

$$\text{FCI} = w_P\,\mathcal{P} + w_A\,\mathcal{A} + w_R\,\mathcal{R} - w_D\,\mathcal{D} + w_N\,f(\mathcal{N}) \tag{7}$$

where $f(\mathcal{N})$ maps the Fano factor excess $\mathcal{N}$ to $[0, 1]$ (with super-Poissonian emission scoring higher than Poissonian) and the weights w_P, w_A, w_R, w_D, w_N are determined empirically by calibrating against known freshness benchmarks.

Predicted FCI ordering: fresh whole food > minimally processed > processed > ultra-processed.

This ordering operationalizes what every herbalist tradition asserts: fresh, minimally handled plant material possesses a quality that processing destroys, and this quality is not fully captured by chemical analysis.

5.4 Connection to Koplik's Research Program

This work is part of a broader research program on coherence-based biological assessment initiated by Koplik, which encompasses biophoton physics [Benfatto et al., 2021, De Paolis et al., 2024], exclusion zone water phenomena, and biofield measurement. The Food Coherence System proposed here extends this program into food science, where the same coherence operators that measure germination dynamics and biological recovery signatures [Thorarinson et al., 2026a] can assess food quality through biophotonic measurement.

6 Experimental Design

We propose a staged experimental program to test the herbalist-derived predictions using biophoton measurement.

6.1 Stage 1: Freshness Gradient (Validation)

Objective. Confirm that biophoton coherence parameters decrease monotonically with storage time for common herbs.

Protocol.

1. Select 5 herb species with well-established traditional potency claims: *Mentha piperita* (peppermint), *Matricaria chamomilla* (chamomile), *Rosmarinus officinalis* (rosemary), *Salvia officinalis* (sage), *Urtica dioica* (nettle).

2. Harvest 100 g of each species from a single garden plot at the same time of day.

3. Divide each harvest into 10 equal portions.

4. Store portions at room temperature in paper bags (traditional shadow-drying).
5. Measure biophoton emission (spontaneous UPE + DL) of one portion per species at intervals: fresh (day 0), 1 day, 3 days, 7 days, 14 days, 30 days, 60 days, 90 days, 180 days, 365 days.
6. For each measurement: record 4-hour spontaneous UPE time series + three DL cycles (100 ms illumination, 300 s decay recording).
7. Compute coherence operators $(\mathcal{P}, \mathcal{A}, \mathcal{R}, \mathcal{D}, \mathcal{N})$ for each measurement.

Prediction. $\mathcal{P}$ and $\mathcal{A}$ decrease, $\mathcal{D}$ increases monotonically with storage time. The rate of decrease depends on plant part (consistent with herbalist claim that roots preserve potency longer than leaves).

Equipment. Hamamatsu H12386-210 photon counting module; light-tight enclosure; broadband LED for DL illumination; temperature/humidity logger; filter wheel (optional for spectral decomposition).

6.2 Stage 2: Harvesting Timing (Herbalist Prediction)

Objective. Test the herbalist claim that harvesting timing affects biophoton coherence.

Protocol.

1. Select 3 herb species. For each species, harvest equal portions at 6 time points within a single 24-hour period: 05:00 (pre-dawn), 08:00 (morning), 12:00 (noon), 16:00 (afternoon), 20:00 (evening), 00:00 (midnight).
2. Measure DL immediately after harvest (within 30 minutes).
3. Repeat on three consecutive days spanning different lunar phases (new moon, first quarter, full moon — requires scheduling harvests across a lunar cycle).
4. Compute coherence operators for each measurement.

Prediction. Pre-dawn harvested samples show highest $\mathcal{P}$ and $\mathcal{A}$ (consistent with *travniki* prescriptions). Lunar phase effect on coherence parameters is tested but predicted to be smaller than circadian effect.

6.3 Stage 3: Processing Comparison (Food Coherence)

Objective. Test whether biophoton coherence distinguishes fresh from processed plant foods.

Protocol.

1. Select 5 plant foods available in both fresh and ultra-processed forms: tomato (fresh vs. canned sauce vs. ketchup), apple (fresh vs. juice vs. fruit snack), wheat (whole grain vs. white flour vs. bread), basil (fresh vs. dried vs. pesto), ginger (fresh root vs. dried powder vs. candied).
2. For each form: measure DL in triplicate.
3. Compute FCI (Equation 7) for each sample.
4. Compare FCI ordering with NOVA classification.

Prediction. FCI decreases monotonically with NOVA processing level: fresh (Group 1) > culinary ingredients/processed (Groups 2–3) > ultra-processed (Group 4).

6.4 Stage 4: Preparation Method Comparison

Objective. Test whether different preparation methods preserve or transform biophoton coherence differentially.

Protocol.

1. Select *Chamomilla recutita* (chamomile) as a test case.
2. From a single harvest, prepare: cold infusion (4 hours), hot infusion (5 minutes at 95°C), decoction (15 minutes boiling), tincture (50% ethanol, 2-week maceration), spagyric tincture (fermentation + distillation + calcination + recombination).
3. Measure DL of each preparation and of the unprepared dried herb.
4. Compute coherence operators.

Prediction. Cold infusion preserves highest coherence (consistent with herbalist prescriptions for "delicate" herbs). Spagyric preparation shows different coherence profile than standard tincture (testing Sédir's quintessence claim).

7 Discussion

7.1 What Herbalists Were Measuring

The convergence of herbalist traditions on claims about plant vitality is remarkable precisely because these traditions developed independently and employ different explanatory frameworks (Christian prayer in the Russian *travniki*; Paracelsian alchemy in Sédir; Wiccan elemental theory in Cunningham; pan-spiritual ecology in modern plant magic). The consistency of their practical prescriptions — despite radically different theories — suggests that they are all detecting the same underlying phenomenon through different cultural lenses.

We propose that this phenomenon is biophotonic coherence. The human perceptual system, while unable to consciously detect single visible-range photons, may respond to the statistical properties of UPE through mechanisms not yet understood. Alternatively, biophotonic coherence may correlate with other measurable properties (scent intensity, visual appearance, tactile quality) that herbalists learned to use as proxy indicators over centuries of empirical observation.

The key insight is that herbalist knowledge systems function as compressed empirical databases: they encode the results of centuries of observation into prescriptions that, while couched in vitalist or magical language, make specific predictions about measurable quantities. Our framework provides the decoder ring.

7.2 Limitations and Honest Uncertainties

We must be explicit about what this paper does and does not establish:

1. **We have not performed the experiments.** This is a theoretical framework and experimental design paper. The predictions in Table 2 are falsifiable, but they have not been tested.

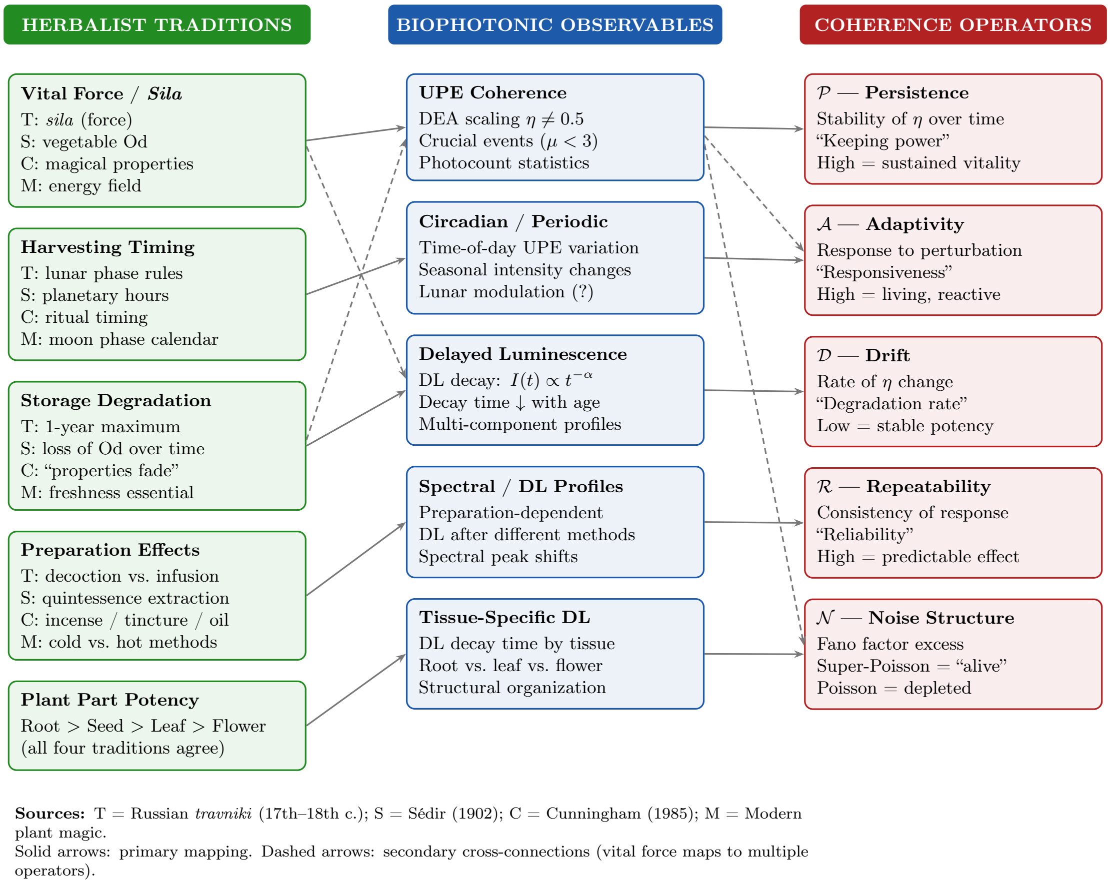

Figure 2: Mapping from herbalist traditions to biophotonic measurements. **Left column:** Traditional herbalist concepts (vital force, harvesting timing, storage degradation, preparation effects) from four independent traditions. **Center column:** The biophotonic observables that operationalize each concept (UPE coherence parameters, DL decay profiles, spectral distributions, photocount statistics). **Right column:** The coherence operators ($\mathcal{P}, \mathcal{A}, \mathcal{R}, \mathcal{D}, \mathcal{N}$) that formalize the measurement. Arrows indicate the correspondence between traditional qualitative descriptions and quantitative measurements. The mapping is not one-to-one: "vital force" corresponds to a combination of $\mathcal{P}$, $\mathcal{A}$, and $\mathcal{N}$; "degradation" corresponds primarily to $\mathcal{D}$ but also to decreasing $\mathcal{P}$.

2. **The coherence–potency link is a hypothesis.** That biophoton coherence correlates with therapeutic efficacy is plausible given the evidence, but not established. The DL measurements may show the predicted patterns without this implying that "high-coherence" plants are more therapeutically effective.

3. **The herbalist traditions contain much that is not testable.** We have selectively extracted claims that make predictions about physical observables. Many herbalist claims (planetary influences, spiritual entities, sympathetic magic) are not addressed by our framework.

4. **The biophoton field remains contentious.** The coherent-field interpretation of biophotons (Popp's theory) is not universally accepted. Brouder and Cifra's comprehensive review [Brouder and Cifra, 2015] shows that many claims of coherent UPE have not survived careful statistical scrutiny. Our framework is designed to work regardless of whether biophotons reflect coherent quantum fields or complex stochastic processes: the coherence operators measure temporal structure in the time series, not the quantum state of the light.

5. **Cultural bias in source selection.** Our herbalist survey emphasizes European and Russian traditions. Chinese, Ayurvedic, African, and indigenous American herbalist traditions make analogous claims but are not surveyed here.

7.3 Implications for Food Science

If the Food Coherence Index proves empirically valid, it would provide the first non-chemical quality metric for plant-derived foods — one that measures *organizational integrity* rather than *compositional adequacy*. This has implications for:

- **Food regulation.** Current food quality standards are chemical (nutrient content, contaminant levels, microbial counts). An FCI threshold could distinguish between nutritionally equivalent foods that differ in biological quality.

- **Agricultural practice.** Harvesting timing, drying methods, and storage conditions could be optimized for FCI rather than yield or shelf appearance.

- **Traditional medicine validation.** Herbalist preparation methods could be compared quantitatively, potentially identifying which traditional practices preserve biological quality and which are ritual without physical effect.

- **Ultra-processed food assessment.** The FCI provides a physical basis for the NOVA classification's distinction between processed and ultra-processed foods, grounding an epidemiological taxonomy in measurable physics.

8 Conclusion

We have constructed a bridge between three literatures: ethnobotanical knowledge systems that describe plant vitality in qualitative terms; biophoton physics that measures ultra-weak photon emission with statistical rigor; and coherence operator formalism that provides the mathematical framework to connect them.

The bridge rests on a simple observation: herbalist traditions claim plants possess a quality beyond chemistry that degrades predictably, and biophoton experiments demonstrate that plants emit photons with temporal structure that varies with biological state. The coherence operators $(\mathcal{P}, \mathcal{A}, \mathcal{R}, \mathcal{D}, \mathcal{N})$ provide the formal language to translate between these domains.

The experimental program proposed here is designed to test whether this bridge bears weight. If fresh plant material shows higher persistence ($\mathcal{P}$) and adaptivity ($\mathcal{A}$) than stored material; if dawn-harvested herbs show different coherence profiles than afternoon-harvested; if minimally processed foods show higher Food Coherence Index than ultra-processed equivalents — then the herbalists were detecting something real, and biophoton physics provides the measurement instrument their traditions lacked.

If the experiments fail — if coherence operators show no systematic variation with the conditions herbalists describe — then either the herbalist claims are wrong about the physical mechanism, or biophoton emission is not the right observable. Either outcome advances understanding.

The deeper contribution is methodological: demonstrating that traditional knowledge systems, when treated not as superstition to be debunked but as compressed empirical databases to be decoded, can generate precise experimental predictions that modern physics is equipped to test. The herbalists had centuries of data. We have the photon counters. It is time to compare notes.

References

Anonymous. *Magiya Rasteniy: Otkroyte dlya Sebya Magiyu, Svyashchennyy Yazyk i Mudrost' [Plant Magic: Discover the Magic, Sacred Language and Wisdom]*. 2023. Contemporary plant magic; 200 herbs described with magical and medicinal properties; plant communication, lunar harvesting.

L. Beloussov, A. Burlakov, and N. Louchinskaia. Biophotonic patterns of optical interactions between fish eggs and embryos. *Indian Journal of Experimental Biology*, 41:424–430, 2003.

Maurizio Benfatto, Elisabetta Pace, Catalina Curceanu, Alessandro Scordo, Alberto Clozza, Ivan Davoli, Massimiliano Lucci, Roberto Francini, Paolo Grigolini, and Rohisha Aladhar. Biophotons: Low signal/noise ratio reveals crucial events. *bioRxiv*, 2019. doi: 10.1101/555391. First demonstration of crucial events in biophoton time series from germinating seeds.

Maurizio Benfatto, Elisabetta Pace, Catalina Curceanu, Alessandro Scordo, Alberto Clozza, Ivan Davoli, Massimiliano Lucci, Roberto Francini, Fabio De Matteis, Luca De Paolis, and Paolo Grigolini. Biophotons and emergence of quantum coherence — a diffusion entropy analysis. *Entropy*, 23(5):554, 2021. doi: 10.3390/e23050554. DEA on lentil seed germination biophotons: anomalous scaling $\eta > 0.5$, transition from crucial events to FBM with infinite memory.

Maurizio Benfatto, Elisabetta Pace, Ivan Davoli, Roberto Francini, Fabio De Matteis, Alessandro Scordo, Alberto Clozza, Luca De Paolis, Catalina Curceanu, and Paolo Grigolini. Biophotons: New experimental data and analysis. *Entropy*, 25(1):47, 2023. doi: 10.3390/e25010047. Extended experiments: lentil vs bean germination, spectral filtering, multi-component intensity profile.

Christian Brouder and Michal Cifra. Coherence and statistical properties of ultra-weak photon emission. In Daniel Fels, Michal Cifra, and Felix Scholkmann, editors, *Fields of the Cell*, pages 163–188. Research Signpost, Trivandrum, India, 2015. ISBN 978-81-308-0544-3. Definitive review of UPE statistical properties: quantum vs classical coherence, photocount analysis, fractal properties.

Michal Cifra and Pavel Pospíšil. Ultra-weak photon emission from biological samples: Definition, mechanisms, properties, detection and applications. *Journal of Photochemistry and Photobiology B: Biology*, 139:2–10, 2014. doi: 10.1016/j.jphotobiol.2014.02.009.

Garland Culbreth, Bruce J. West, and Paolo Grigolini. Caputo fractional derivative versus quantum coherence. *Entropy*, 23(2):211, 2021. doi: 10.3390/e23020211. Theoretical framework connecting FBM dominance in biophoton time series to quantum coherence.

Scott Cunningham. *Cunningham's Encyclopedia of Magical Herbs*. Llewellyn Publications, St. Paul, MN, 2nd edition, 1985. Russian translation consulted: *Koldovstvo na Travakh*. 100+ plants with magical properties, elemental classifications, preparation methods.

Luca De Paolis, Roberto Francini, Ivan Davoli, Fabio De Matteis, Alessandro Scordo, Alberto Clozza, Marco Grandi, Elisabetta Pace, Catalina Curceanu, Paolo Grigolini, and Maurizio Benfatto. Biophotons: A hard problem. *Applied Sciences*, 14(12):5496, 2024. doi: 10.3390/app14125496. Review: imperfection vs coherence theory, experimental setup, DEA method summary.

Martin Dlask, Jaromír Kukal, Michaela Poplová, Pavel Sovka, and Michal Cifra. Short-time fractal analysis of biological autoluminescence. *bioRxiv*, 2019. doi: 10.1101/578286. Hurst exponent via fractional Brownian bridge on mung bean biophoton time series.

Valeriy Erofeev. *Okkul'tnaya Sila Rasteniy: Taynaya Praktika Istseleniya i Ochishcheniya [Occult Power of Plants: Secret Practice of Healing and Cleansing]*. Moscow, 2005. Contemporary Russian occult herbalism; energy fields of plants, specific preparation rituals.

Daniel S. Fabricant and Norman R. Farnsworth. The value of plants used in traditional medicine for drug discovery. *Environmental Health Perspectives*, 109(Suppl. 1):69–75, 2001.

Cristiano M. Gallep, Ettore Conforti, Masako T. Braghini, Mirian P. Maluf, Yan Yan, and Fritz-Albert Popp. Ultra-weak delayed luminescence in coffee seeds. In *IEEE MTT-S International Microwave and Optoelectronics Conference*, pages 241–244, Salvador, Brazil, 2004.

Alexander G. Gurwitsch. Die natur des spezifischen erregers der zellteilung. *Archiv für Entwicklungsmechanik der Organismen*, 100:11–40, 1923.

Kevin D. Hall, Alexis Ayuketah, Robert Brychta, Hongyi Cai, Tom Cassimatis, Kong Y. Chen, Stephanie T. Chung, Elise Costa, Amber Courville, Valerie Darcey, et al. Ultra-processed diets cause excess calorie intake and weight gain: An inpatient randomized controlled trial of ad libitum food intake. *Cell Metabolism*, 30(1):67–77, 2019. doi: 10.1016/j.cmet.2019.05.008.

Ingvar and Raokriom. *Sekrety Tselitel'stva i Magiya Trav [Secrets of Healing and Herbal Magic]*. Akademiya Universal'noy Magii, Kiev, 2010. Compilation of folk healing recipes; harvesting timing linked to lunar calendar.

A. B. Ippolitova. *Russkie Rukopisnye Travniki XVII–XVIII Vekov: Issledovanie Fol'klora i Etnobotaniki [Russian Manuscript Herbals of the 17th–18th Centuries]*. Indrik, Moscow, 2005. Comprehensive study of 450+ Russian manuscript herbals; harvesting timing, lunar prescriptions, plant *sila* (force).

Carlos Augusto Monteiro, Geoffrey Cannon, Mark Lawrence, Maria Laura da Costa Louzada, and Priscila Pereira Machado. The NOVA food classification system. *World Nutrition*, 10(1):33–48, 2019a.

Carlos Augusto Monteiro, Geoffrey Cannon, Renata Bertazzi Levy, Jean-Claude Moubarac, Maria Laura C. Louzada, Fernanda Rauber, Neha Khandpur, Gustavo Cediel, Daniela Neri, Eurydice Martinez-Steele, et al. Ultra-processed foods: What they are and how to identify them. *Public Health Nutrition*, 22(5):936–941, 2019b. doi: 10.1017/S1368980018003762.

H.-N. Nam, S.-M. Jeong, S.-B. Kim, and S.-J. Choi. Comprehensive evaluation of the genotoxic potential of food additive titanium dioxide in human intestinal cell systems. *Nanomaterials*, 2025. Genotoxicity of food-grade TiO_2 in intestinal barrier models.

Hamza Patwa, Nathan S. Babcock, and Philip Kurian. Quantum-enhanced photoprotection in neuroprotein architectures emerges from collective light–matter interactions. *Frontiers in Physics*, 12:1387271, 2024. doi: 10.3389/fphy.2024.1387271. Superradiance in microtubules, actin filaments, and amyloid fibrils; tryptophan UV photoprotection.

Fritz-Albert Popp. Coherent emission and absorption of photons by biosystems. *Cell Biophysics*, 21:1–38, 1992.

Fritz-Albert Popp. Properties of biophotons and their theoretical implications. *Indian Journal of Experimental Biology*, 41:391–402, 2003.

Fritz-Albert Popp, K. H. Li, W. P. Mei, M. Galle, and R. Neurohr. Biophoton emission: Multi-author review. *Experientia*, 44(7):543–600, 1988. doi: 10.1007/BF01953300.

David F. Rhoades. Responses of alder and willow to attack by tent caterpillars and webworms: Evidence for pheromonal sensitivity of willows. *ACS Symposium Series*, 208:55–68, 1983. First evidence of inter-tree chemical communication in response to herbivory.

Paul Sédir. *Les Plantes Magiques: Botanique Occulte [Magic of Plants: Occult Botany]*. Chamuel, Paris, 1902. Russian translation consulted: *Magiya Rasteniy: Okkul'tnaya Botanika*. Key concept: vegetable Od as invisible plant emanation.

Joel Thorarinson, Allison Hensgen, and Iulia Koplik. Recovery is not return to baseline: Coherence operators for measuring biological recovery signatures. In preparation, 2026a.

Joel Thorarinson, Allison Hensgen, and Iulia Koplik. The coherence engine: Measuring system organization through time series operators. In preparation, 2026b.

Eduard P. A. Van Wijk, John Ackerman, and Roeland Van Wijk. Effect of meditation on ultraweak photon emission from hands and forehead. *Forschende Komplementärmedizin*, 12 (2):107–112, 2005.

Roeland van Wijk and Eduard P. A. van Wijk. Delayed luminescence. *Journal of Photochemistry and Photobiology B: Biology*, 139:2–10, 2008. Delayed luminescence as probe of biological molecular organization.

Hildebert Wagner and Gudrun Ulrich-Merzenich. Synergy research: Approaching a new generation of phytopharmaceuticals. *Phytomedicine*, 16(2–3):97–110, 2009. doi: 10.1016/j.phymed.2008.12.018.

Zhuo Wang et al. Reduced biophotonic activities and spectral blueshift in Alzheimer's disease and vascular dementia models with cognitive impairment. *Frontiers in Aging Neuroscience*, 15: 1208274, 2023. doi: 10.3389/fnagi.2023.1208274. Biophoton activity reduced and blue-shifted in AD/VaD models.

Elizabeth M. Williamson. Synergy and other interactions in phytomedicines. *Phytomedicine*, 8 (5):401–409, 2001. doi: 10.1078/0944-7113-00060.