HMR–BIO–0 — Introduction to the Biology of Coherence: A ChronoBiological Solution

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Symbol for the body of work: HMR

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Abstract. ChronoBiology extends ChronoChemistry from molecular persistence to living self-maintenance. Life is modeled as an open coherence manifold where structural, metabolic, and informational subsystems exchange awareness-like continuity. The same ledger, $\dot{I} = C - D$, governs biological stability: C = coherence gain (order, repair) and D = dissipation (entropy, decay). This first section develops the structural layer—fascia, cytoskeleton, and tissue architecture—as mechanical coherence fields derived from the unified bond law. If these relations are true, they imply measurable predictions for elasticity, energy distribution, and signaling efficiency in living matter.

Keywords: ChronoBiology, structural coherence, fascia, cytoskeleton, elasticity, ChronoChemistry bridge.

MSC/Classification: 92C10, 74A10, 82C10. **arXiv:** q-bio.BM

1. Introduction

Where ChronoChemistry described how coherence *holds form*, ChronoBiology explains how it *sustains form*. Living systems keep $C > D$ through metabolism, mechanical feedback, and information flow. ChronoBiology therefore studies the geometry of persistence:

$$\nabla_\mu J^\mu_{\mathsf{Coh}} = 0, \qquad J^\mu_{\mathsf{Coh}} = (C - D)u^\mu,$$

but now u^μ represents not only physical motion but collective deformation and biochemical flux inside tissues.

Three coherence layers organize life:

1. **Structural** – fascia, cytoskeleton, membranes: material coherence.
2. **Metabolic** – energy flux and redox networks: chemical coherence.
3. **Informational** – signal transduction and neural timing: phase coherence.

This part elaborates the first.

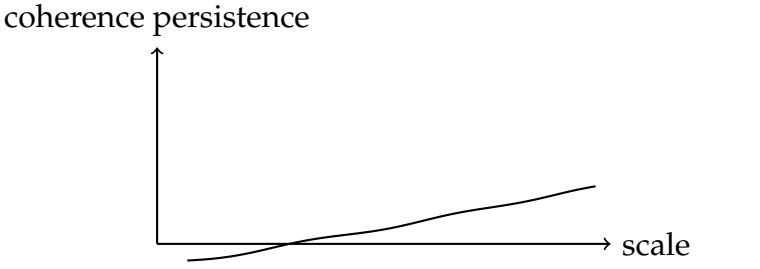

Diagram 1: hierarchy—molecule, cell, tissue, organism

2. Structural Coherence: Fascia and Cytoskeletal Networks

2.1 From molecular coherence to continuum mechanics

In the biological continuum limit, bond-level coherence energy $C - D$ averages into an elastic functional

$$\mathcal{E}_{\mathsf{Coh}} = \int_\Omega \Big(\tfrac{1}{2}\, \sigma : \varepsilon - D_{\text{mech}} \Big) V,$$

where σ is the stress tensor derived from local coherence density and D_{mech} the dissipative term (viscoelastic loss). Stationarity, $\delta \mathcal{E}_{\mathsf{Coh}} = 0$, yields generalized Navier–Cauchy equations for fascia and cytoskeletal filaments.

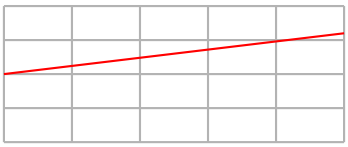

Diagram 2: shear wave through fascial lattice

2.2 Tensorial coherence and fascia continuity

Define a local coherence tensor $C_{ij} = [(\partial_i u)(\partial_j u)]$. Conservation $\nabla_j C_{ij} = 0$ ensures mechanical phase continuity—analogous to Maxwell stress in fields. Fascia functions as a 3-D coherence lattice transmitting deformations as quasi-instantaneous phase signals.

2.3 Energetic interpretation

Stored elastic energy corresponds to positive C; viscous and thermal losses increase D. The fascia's ability to return to shape after stress quantifies C/D. If this is true, then the model predicts measurable frequency-dependent coherence spectra matching viscoelastic relaxation data.

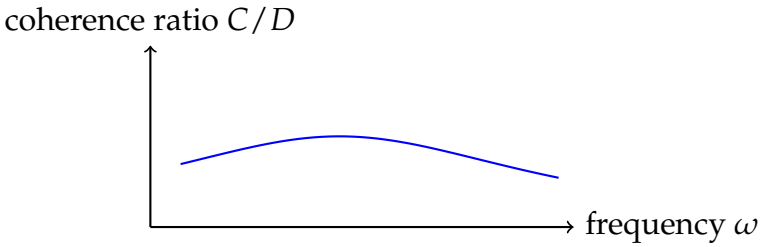

Diagram 3: predicted fascia coherence spectrum

2.4 Cytoskeletal coherence

At cellular scale, actin and microtubule networks obey the same ledger but with active (ATP-driven) C sources. Active-gel theory modifies the stress tensor:

$$\sigma = \sigma_{\text{passive}} + \zeta\, Q,$$

where ζ is activity and Q is filament alignment. ChronoBiology interprets $\zeta\, Q$ as local injection of coherence; when active gain equals dissipative loss, pulsation or wave propagation occurs—basis of contractility and transport.

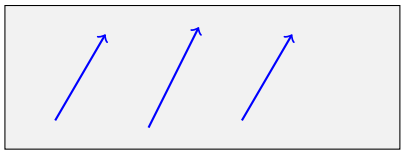

Diagram 4: active filament coherence flux

2.5 Mechanical-chemical coupling

The fascia and cytoskeleton couple to metabolism through mechanotransduction. Stress alters local reaction rates $k(\sigma) \approx k_0 e^{\alpha\sigma/k_B T}$, linking mechanical coherence to chemical coherence. If this correlation holds, then mechanical feedback loops can stabilize metabolism by keeping $C > D$ across deformed regions.

3. Metabolic Coherence: Energy Flow and Minimum-Action Cycling

3.1 Flux balance and coherence free energy

Let $x \in \mathbb{R}^m_{\geq 0}$ be concentrations, $S \in \mathbb{R}^{m\times r}$ stoichiometry, and $J(x)$ reaction fluxes. Steady states satisfy $S\,J(x^*) = 0$ (flux balance). Define the *coherence free energy*

$$\mathcal{F}(x) = \Phi_D(x) - \Phi_C(x),$$

where Φ_C projects bond/resonance storage from ChronoChemistry and Φ_D collects thermal and entropic losses.

3.2 Minimum-action metabolic cycles

For slow coordinates s, the Onsager–Machlup functional

$$S[s] = \int_0^\tau \frac{(\dot{s} + \mu_s\,\partial_s\mathcal{F})^2}{4D_s}\,t$$

selects observed cycles; traversal rate $k \simeq Ae^{-S^*/\hbar_{\text{eff}}}$.

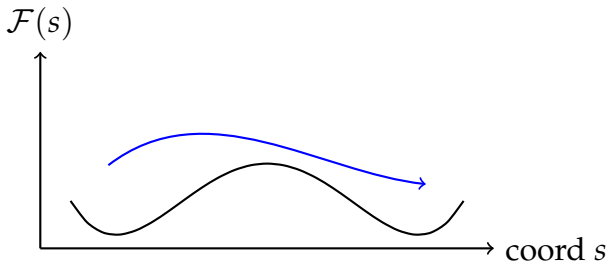

Diagram 5: minimum-action metabolic circulation

3.3 Redox chains and proton gradients

Let J_{ET} be electron-transport flux and ΔG_{H^+} the proton-motive free energy.

$$\dot{I} = C_{ET} + C_{H^+} - (D_{\text{ohmic}} + D_{\text{leak}}), \qquad C_{ET} \approx J_{ET}\Delta E,\ C_{H^+} \approx J_{H^+}\Delta G_{H^+}.$$

If this ledger is correct, reducing D_{leak} increases ATP yield and narrows redox-noise spectra.

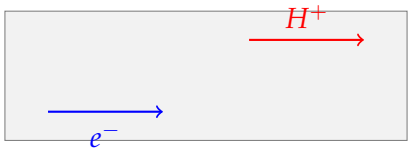

Diagram 6: redox + proton-gradient segment

3.4 Elastic–metabolic coupling

Stress σ modulates reaction rates $k(\sigma) \approx k_0 e^{\alpha\sigma/k_B T}$. Define an *elastic-coherence gain* $\Delta C_{\text{mech}} \propto \int \sigma\, \varepsilon\, V$. If this coupling holds, metabolic fluxes align with stress fields, predicting anisotropic energy maps in tissues.

4. Informational Coherence: Signaling and Phase Coupling

4.1 Signaling as coherence transport

Let $y_i(t)$ denote node activities.

$$\dot{y}_i = f_i(y) - \gamma_i y_i + \sum_j K_{ij}\, g_{ij}(y_j - y_i).$$

Linearization gives graph-Laplacian flows; nonlinearities produce waves and pulses.

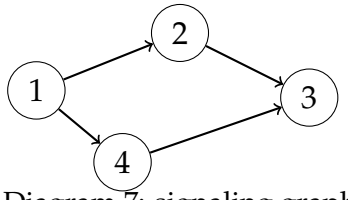

Diagram 7: signaling graph

4.2 Phase synchronization across cells

For oscillatory nodes with phases θ_i,

$$\dot{\theta}_i = \omega_i + \sum_j K_{ij} \sin(\theta_j - \theta_i) + \xi_i(t), \quad Re^{i\Psi} = \tfrac{1}{N} \sum_j e^{i\theta_j}.$$

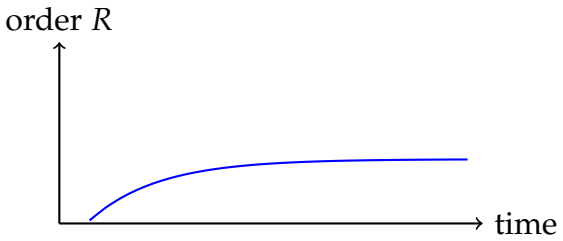

Diagram 8: rise of phase order under coupling

4.3 Information–coherence link

Mutual information $I \propto \log(1 + \mathrm{SNR})$ rises with phase alignment; thus coherence predicts information throughput until over-synchronization reduces capacity.

5. Neural Phase Integration: Macroscopic Informational Coherence

5.1 Network field equations

At neural scale, $\theta(\mathbf{r}, t)$ obeys

$$\partial_t \theta(\mathbf{r}, t) = \omega(\mathbf{r}) + \int W(\mathbf{r} - \mathbf{r}') \sin[\theta(\mathbf{r}', t) - \theta(\mathbf{r}, t)]\, \mathbf{r}' + \eta.$$

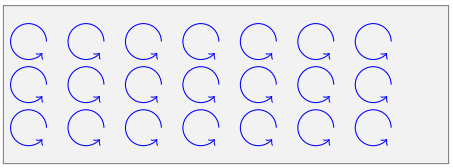
Diagram 9: distributed neural phase elements

5.2 Coherence spectra and rhythms

Define spectral density $S_{C/D}(\omega)$ of C/D fluctuations; peaks correspond to efficient phase transport (theta–gamma bands).

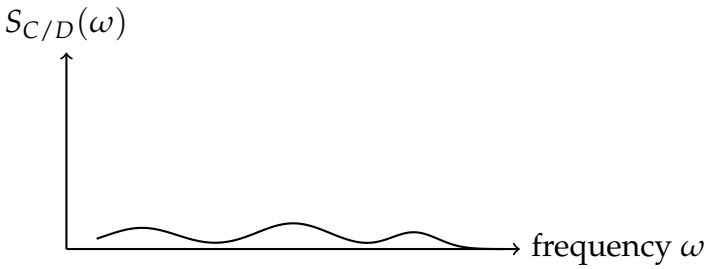

Diagram 10: exemplar coherence spectrum

6. Synthesis and If–Then Implications

Across all scales the ledger equations persist:

$$\nabla_\mu J^\mu_{\mathsf{Coh}} = 0, \quad J^\mu_{\mathsf{Coh}} = (C - D)u^\mu; \qquad S^* = \int \frac{(\dot{s} + \mu_s \partial_s \mathcal{F})^2}{4D_s}\, t; \qquad k = Ae^{-S^*/\hbar_{\mathrm{eff}}}.$$

If these hold, then:

1. Structural coherence spectra $\rightarrow$ measurable viscoelastic signatures.
2. Metabolic flux efficiency $\rightarrow$ minimized action S^*.
3. Informational phase order $\rightarrow$ maximal mutual information.

Testable extremes include transient $C > D$ microdomains at low temperature, anisotropic coherence propagation, and trade-offs between synchrony and information.

7. Conclusion and Bridge to ChronoPsychology

ChronoBiology views living matter as layered coherence networks—material, metabolic, and informational—each obeying the same ledger law. If the framework is true, quantifying C/D spectra, minimum-action fluxes, and phase order will reveal objective coherence landscapes of biological systems. The next series, **HMR–PSYCH**, will extend this to cognition: informational coherence under feedback and awareness.

END OF HMR–BIO–0

Transition to: **HMR–PSYCH — The Psychology of Coherence**

"Biology is coherence learning to sustain itself.
Psychology is coherence learning to understand itself."

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