The biological bit

physical chemistry and information in living systems

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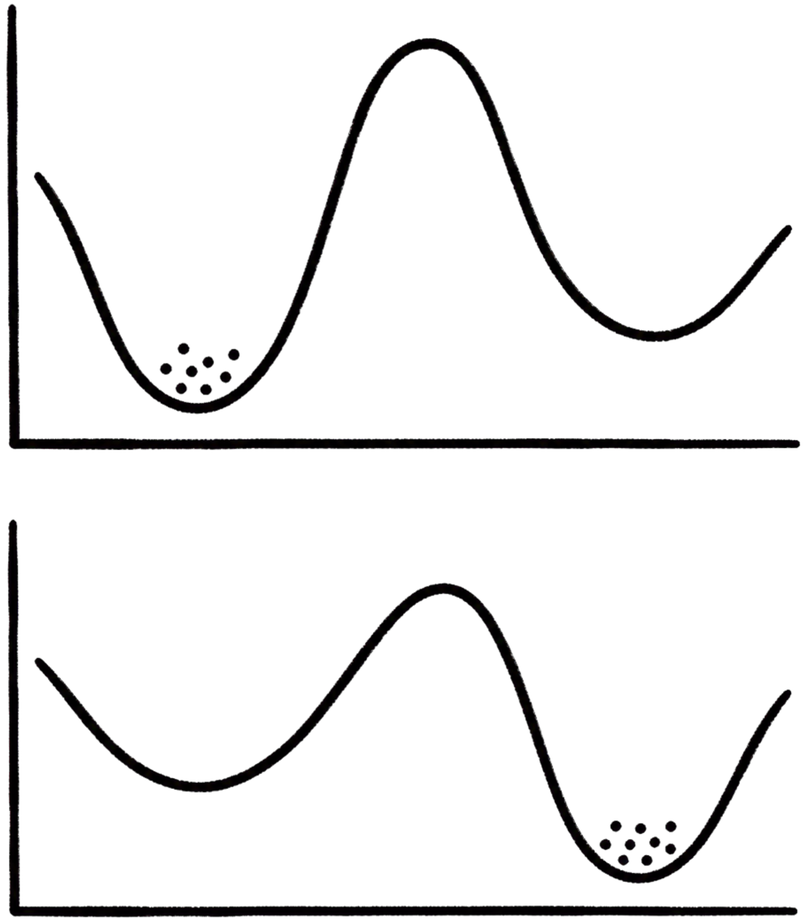


Life is chemistry plus information

"... life cannot be simply viewed as a chemical system governed solely by physical laws; instead, life is composed of both chemical and information systems."

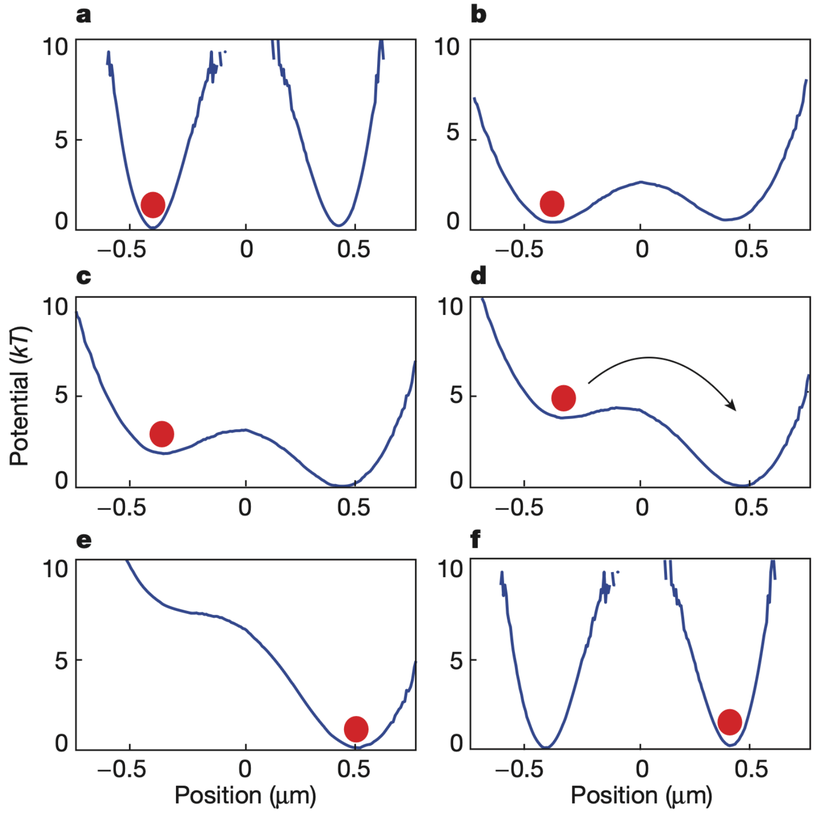
—Wang, 2025

What is biological information here?

The organism is its own apparatus

"For this, we use a custom-built vertical optical tweezer that traps a silica bead (2 μm in diameter) at the focus of a laser beam."

—Bérut et al., 2012



Bérut et al., 2012

Biological information is constrained by physical chemistry

STABILITY

$$\tau_{life} \approx 1/k_{loss}$$

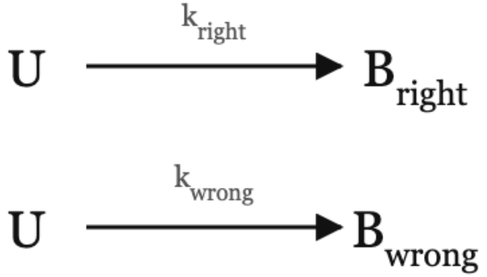
$$= A^{-1} \exp(E_a/k_B T)$$

barriers set how long a distinction persists

τ_{life} mean lifetime · k_{loss} first-order loss rate · A effective prefactor

E_a effective activation energy · k_B Boltzmann constant · T absolute temperature

SPECIFICITY



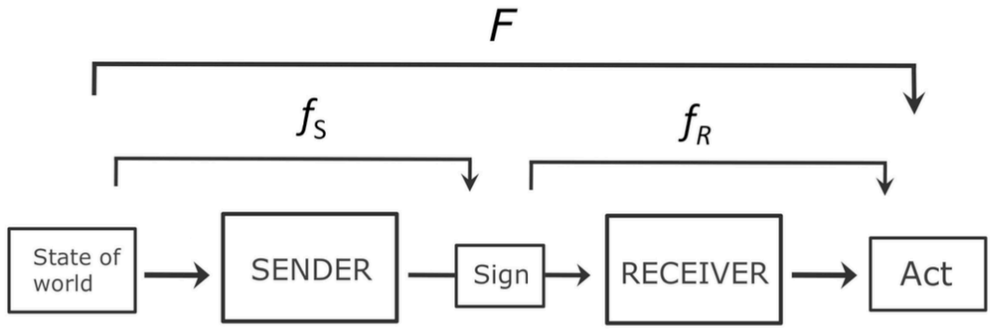
$$\eta_o = \frac{k_{wrong}}{k_{right} + k_{wrong}}$$

relative rates set which distinction is made

Molecules become messages through sender-receiver systems

"The strategies of sender and receiver evolve over time, driven by the payoffs, according to some adaptive dynamics."

—Skyrms, 2010



f_S : sender's rule, maps states of the world to signs.

f_R : receiver's rule, maps signs to acts.

F : the resulting mapping from states to acts.

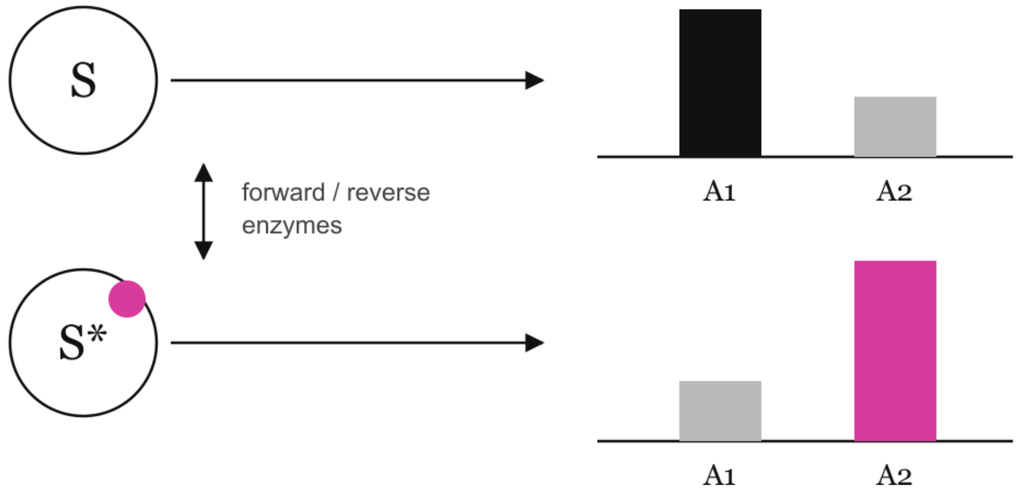
F^*: the mapping from states to acts preferred by both agents.

Godfrey-Smith, 2012

Biochemical signals modify conditional dispositions

"What has been affected ... is not necessarily what you do ... but rather what you would be ready to do if given (relevant) circumstances arose."

—MacKay, 1969

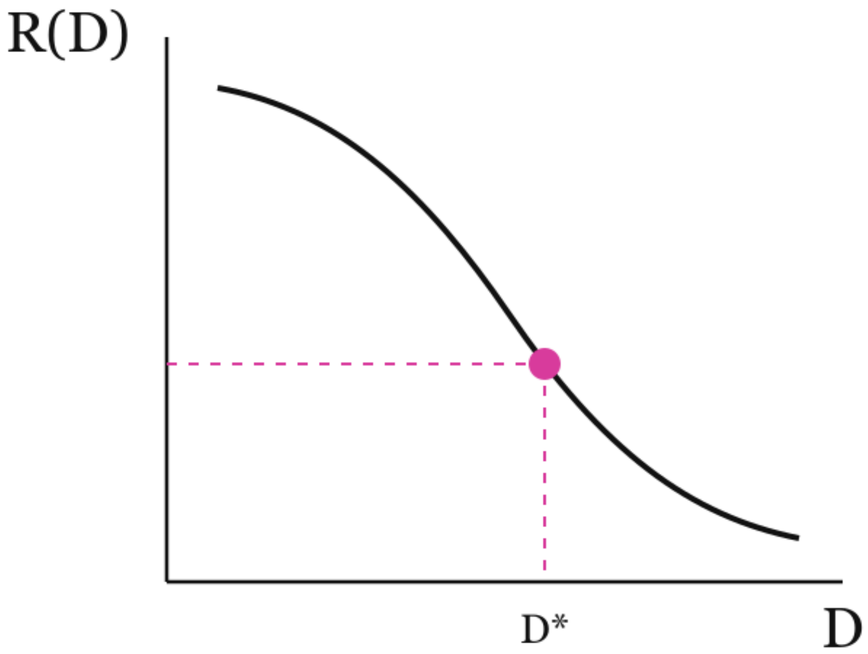


Living systems recruit and tune molecular distinctions

Skyrms provides for the emergence of coordination where common interest intersects with selective feedback.

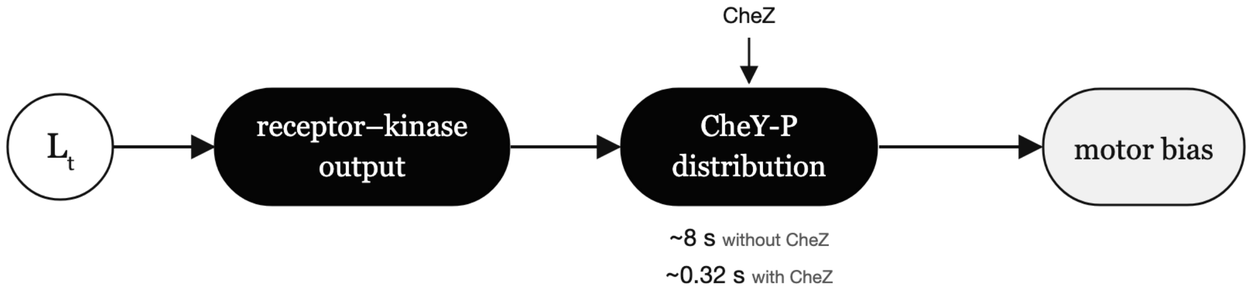
Rate-distortion tells us which distinctions need to survive, with what fidelity; physical chemistry tells us how those distinctions can survive for the required time.

The distortion function thus reflects how selection will recruit and tune information carriers for particular signalling roles.

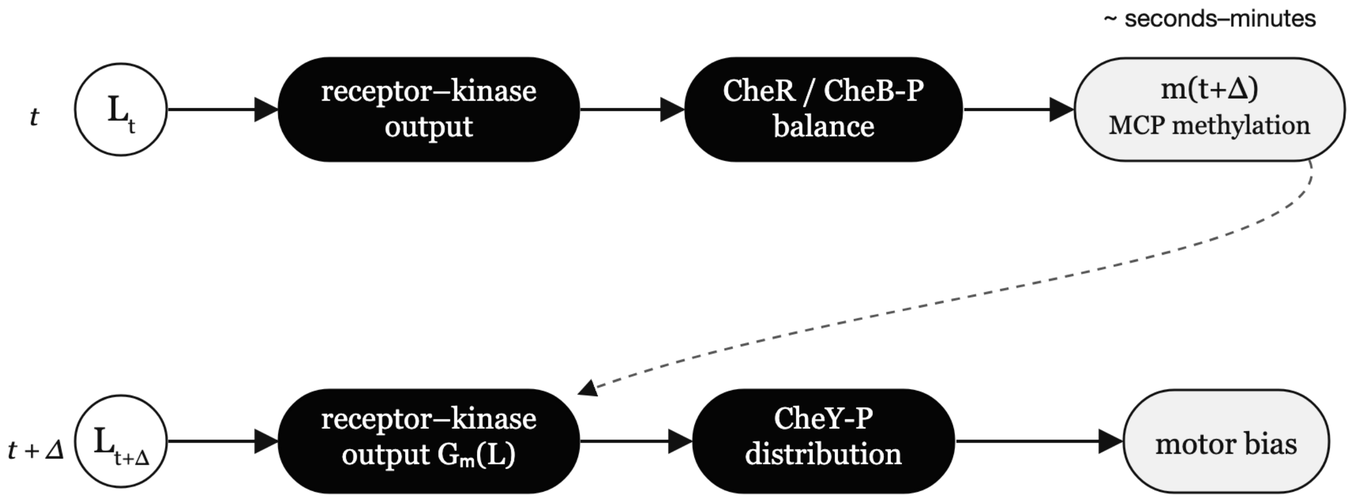


Bacterial chemotaxis as a concrete example

CheY-P carries receptor–kinase output across the cell to the flagellar motor.



MCP methylation carries prior receptor activity forward in time, changing how later input is transformed into receptor–kinase output.



Biological information is constituted through chemistry

Biological information involves the organisation of molecular distinctions in signalling systems.

These distinctions are constrained by the physical chemistry of their constituents.

The properties that make a distinction useable are also evolved components of this informational organisation.

Living systems tune persistence through reshaping the passive escape landscape and regulating access to reset pathways.