The Creativity of Cells:

Aneural Irrational Cognition

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On Having No Head: Cognition throughout Biological Systems

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The central nervous system (CNS) underlies memory, perception, decision-making, and behavior in numerous organisms. However, neural networks have no monopoly on the signaling functions that implement these remarkable algorithms. It is often forgotten that neurons optimized cellular signaling modes that existed long before the CNS appeared during evolution, and were used by somatic cellular networks to orchestrate physiology, embryonic development, and behavior. Many of the key dynamics that enable information processing can, in fact, be implemented by different biological hardware. This is widely exploited by organisms throughout the tree of life. Here, we review data on memory, learning, and other aspects of cognition in a range of models, including single celled organisms, plants, and tissues in animal bodies. We discuss current knowledge of the molecular mechanisms at work in these systems, and

Code-Duality and the Semiotics of Nature

by

JESPER HOFFMEYER and CLAUS EMMECHE

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The sphere of Information

Biological information is not a substance

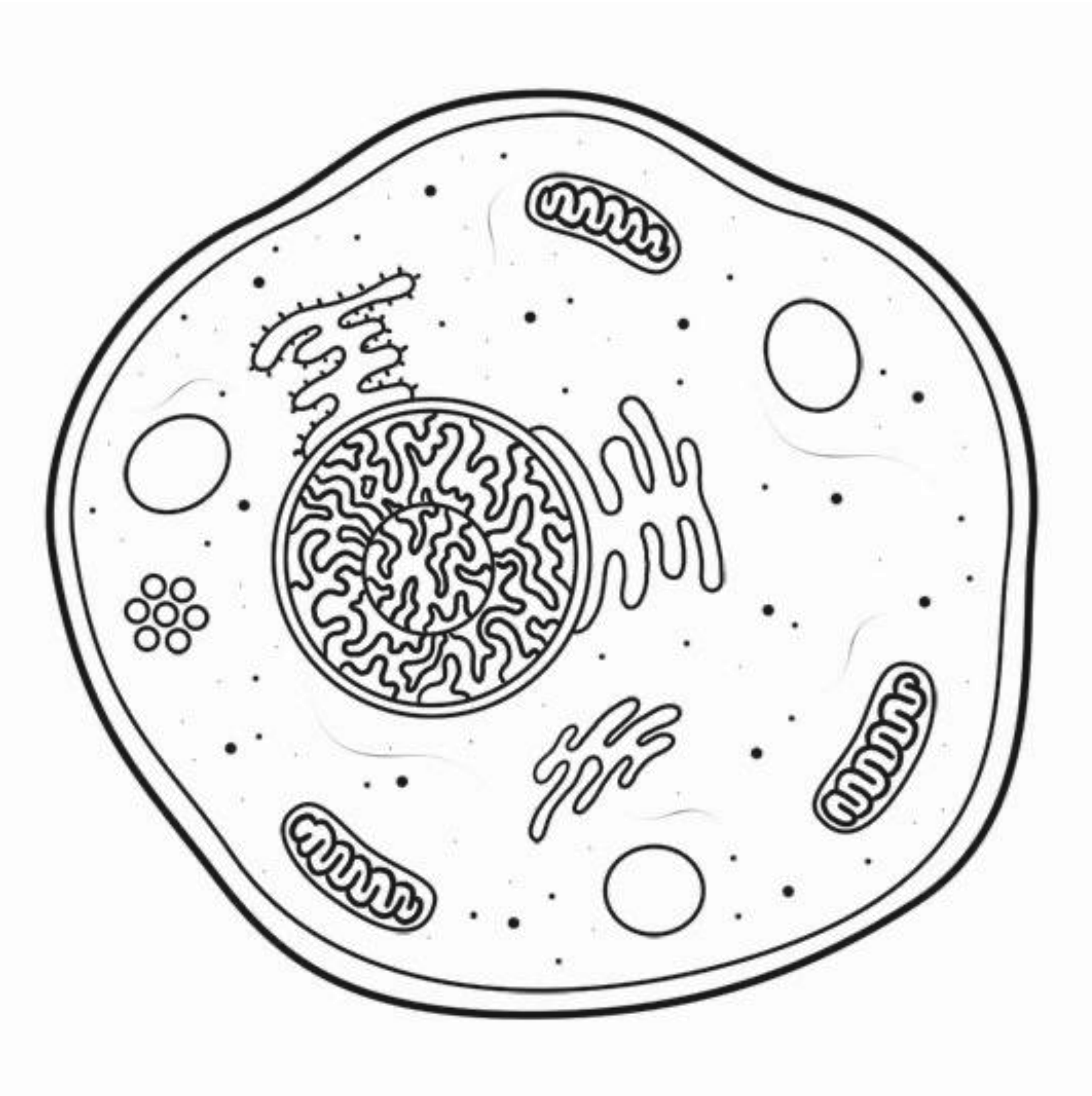
The biological discipline morphology derives its name from the greek word 'morph'. According to the etymological dictionary the romans probably took over this word from the greek, but in a distorted way. Thus, in latin 'morph' became 'form'. From this latin word arose the verb *informare:* To bring something into form. And this again is the root of the now fashionable word *information*.

In spite of this likely etymological relationship between *morphology* and *information* the two areas occupy nearly antagonistic positions in modern biology: While the study of the anatomical forms of organisms (morphology), is now a rather outmoded discipline, the study of 'biological information' (in

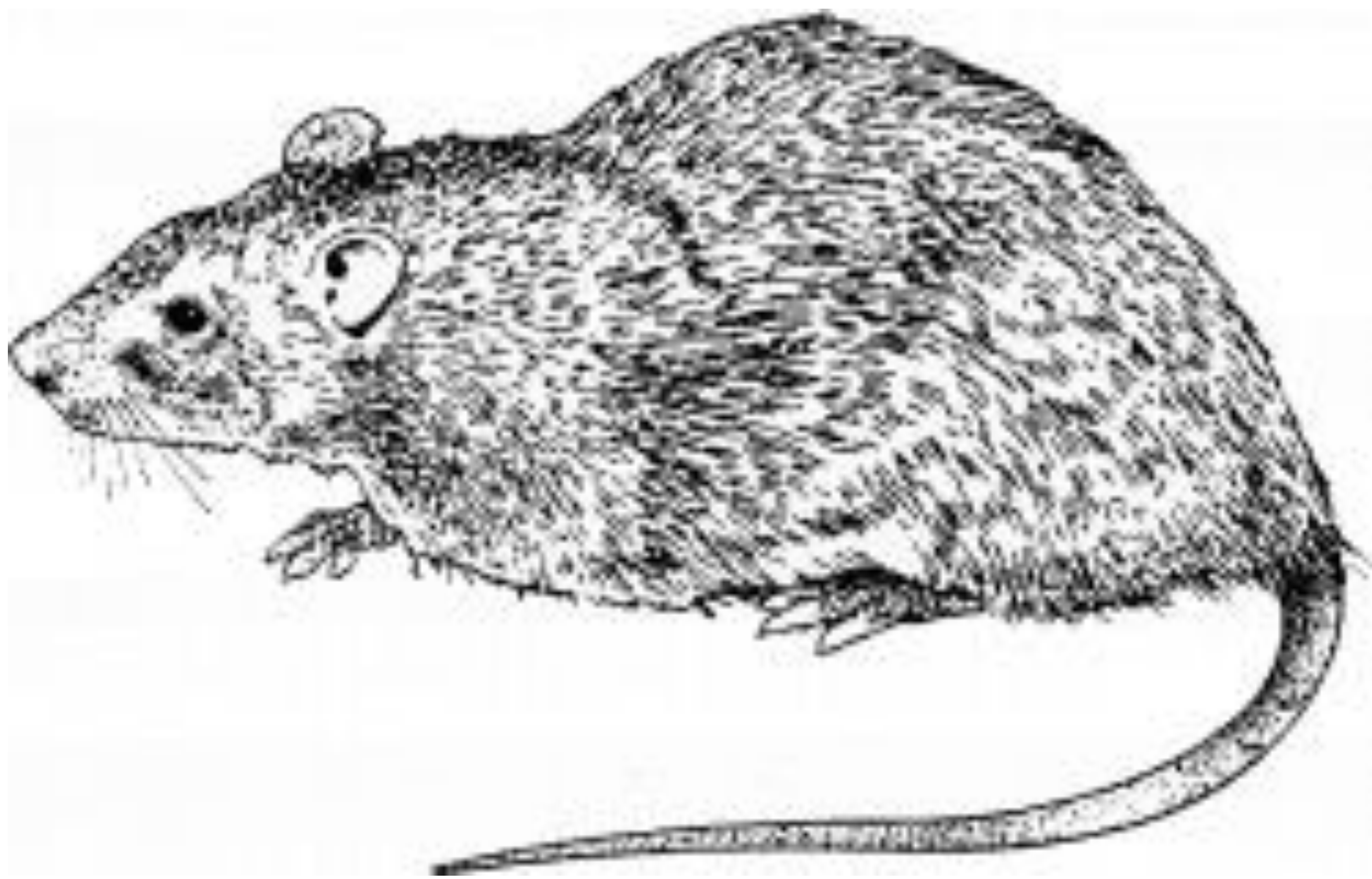
“Evolution is not just gradual change of DNA, but change in the deep structure or logic of the 'programme': Informational reframing.”

“… Neodarwinism has no need for interpretation. … In our opinion, Neodarwinism gravely underestimates the autonomy and inventiveness inherent to semiotic systems exhibiting code-duality.“

How do cells learn?



Irrational Semiosis



Mehmet Yasar, et al. (2016). Effects of propolis in an experimental rat model of allergic rhinitis, American Journal of Otolaryngology, (37),4, 287-293,

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Living systems are smarter bots: Slime mold semiosis versus AI symbol manipulation

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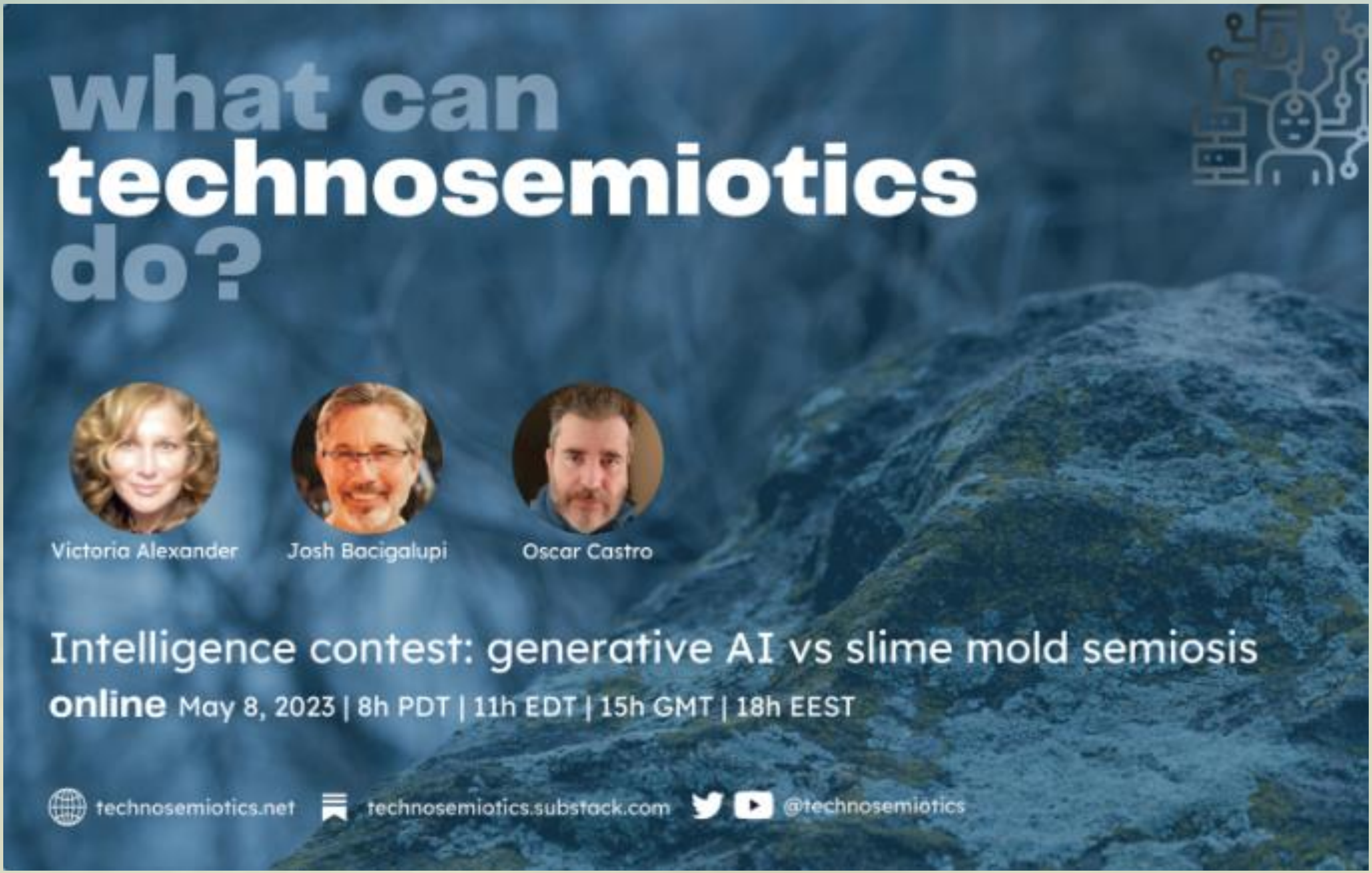
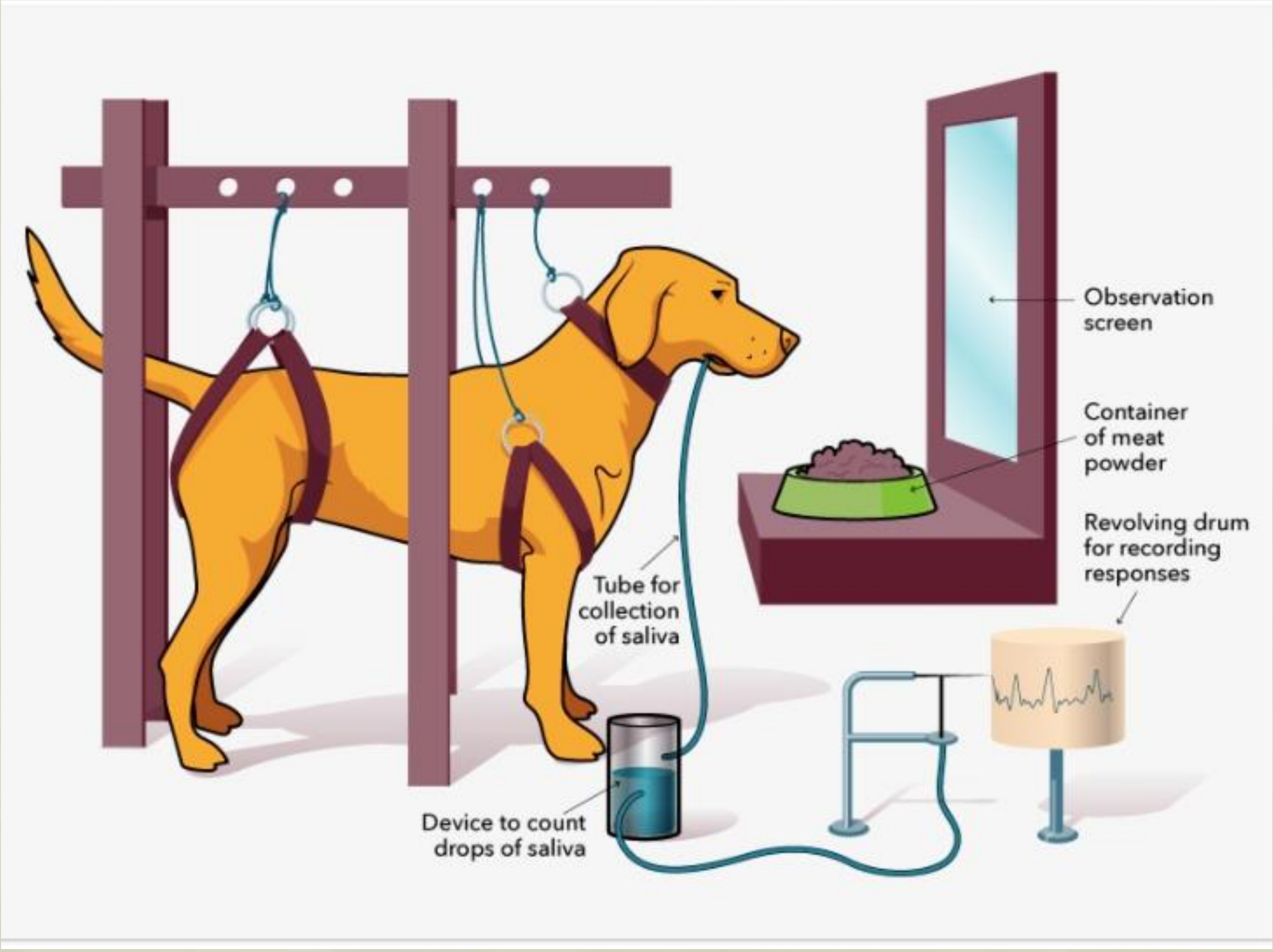
ABSTRACT

Although machines may be good at mimicking, they are not currently able, as organisms are, to act creatively. We offer an understanding of the emergent qualities of biological sign processing in terms of generalization, association, and encryption. We use slime mold as a model of minimal cognition and compare it to deep-learning video game bots, which some claim have evolved beyond their merely quantitative algorithms. We find that these discrete Turing machine bots are not able to make productive, yet unanticipated, "errors"—necessary for biological learning—which, based on the physicality of signs, their relatively similar shapes, and relative physical positions spatially and temporally, lead to emergent effects and make learning and evolution possible. In organisms, *stochastic resonance* at the local level can be leveraged for self-organization at the global level. We contrast all this to the symbolic processing of today's machine learning, whereby each logic node and memory state is discrete. Computer codes are produced by external operators, whereas biological symbols are evolved through an internal encryption process.



Alexander, V.N., J. Augustus Bacigalupi, and Òscar Castro Garcia. 2021. “Living Systems Are Smarter Bots: Slime Mold Semiosis versus AI Symbol Manipulation.” Biosystems 206

Index Sign


Observation screen
Container of meat powder
Revolving drum for recording responses
Tube for collection of saliva
Device to count drops of saliva

Mind Palace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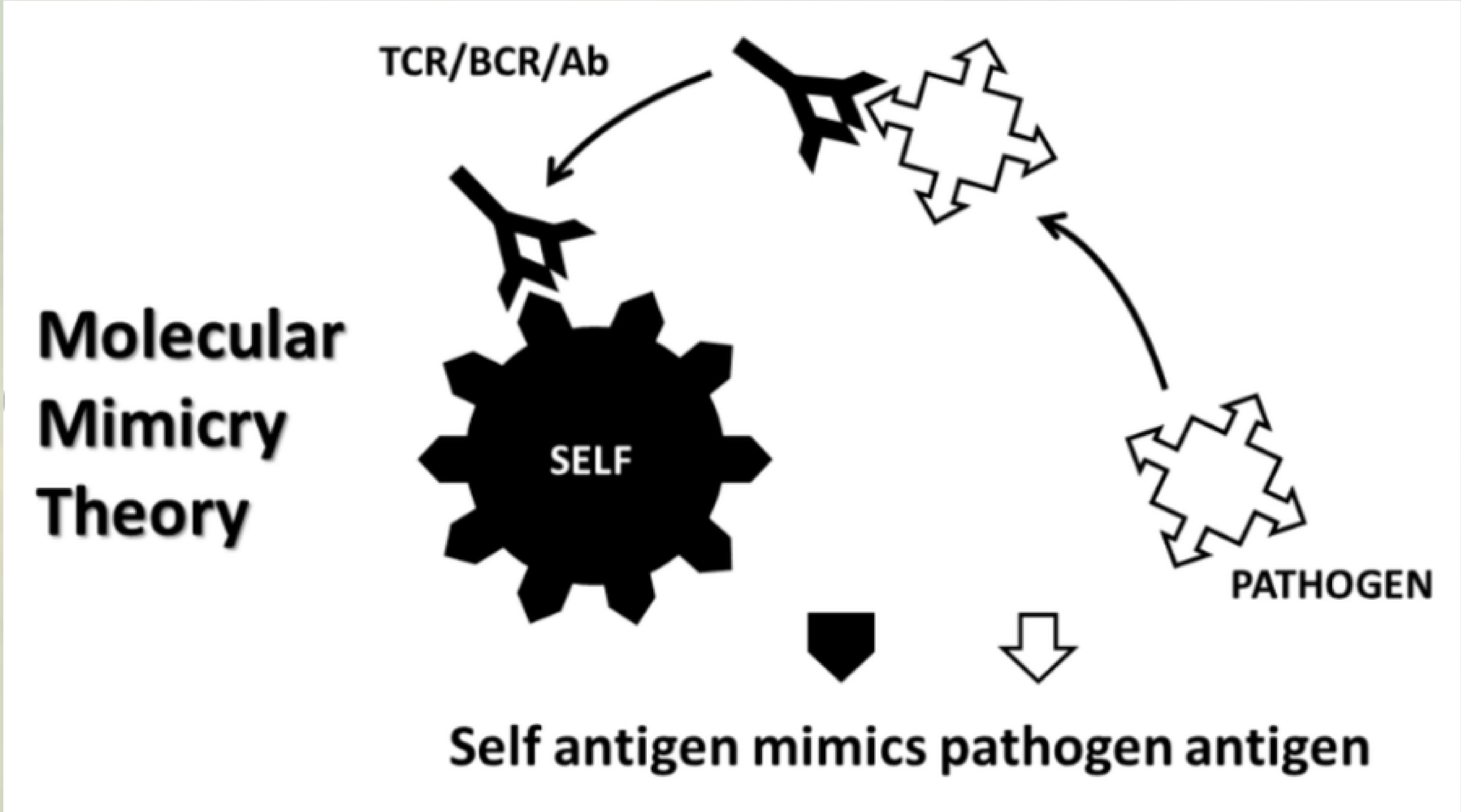
Poetic Learning and Memory

Icon Sign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Mimicry
Theory
SELF
PATHOGEN
Self antigen mimics pathogen antigen

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Learning by Association in Plants

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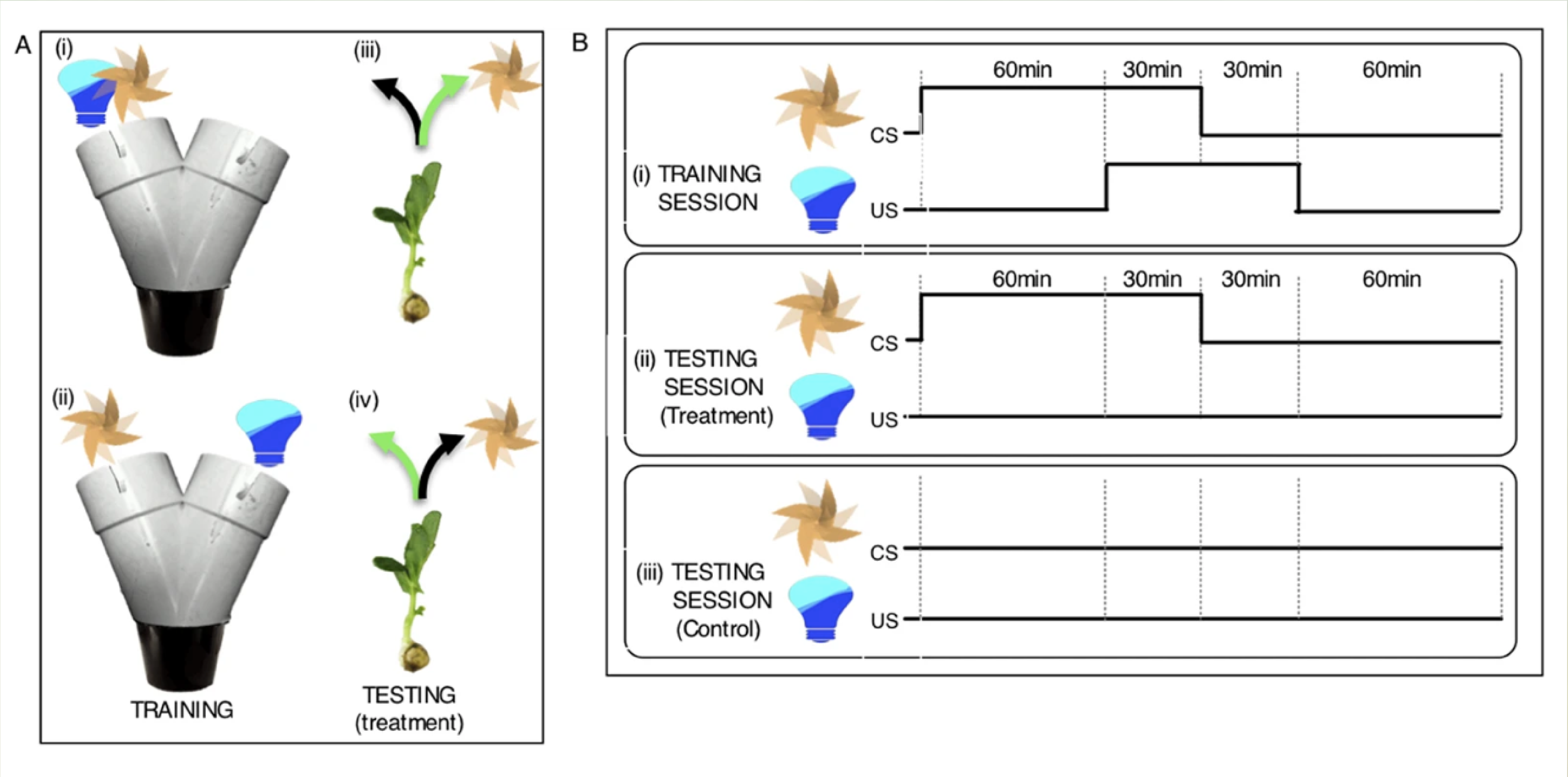
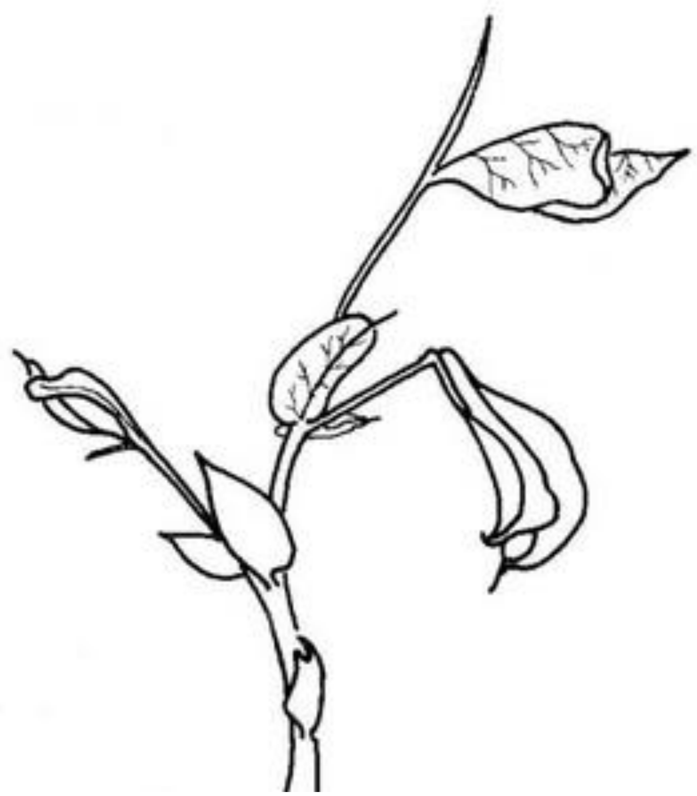
In complex and ever-changing environments, resources such as food are often scarce and unevenly distributed in space and time. Therefore, utilizing external cues to locate and remember high-quality sources allows more efficient foraging, thus increasing chances for survival. Associations between environmental cues and food are readily formed because of the tangible benefits they confer. While examples of the key role they play in shaping foraging behaviours are widespread in the animal world, the possibility that plants are also able to acquire learned associations to guide their foraging behaviour has never been demonstrated. Here we show that this type of learning occurs in the garden pea, *Pisum sativum*. By using a Y-maze task, we show that the position of a neutral cue, predicting the location of a light source, affected the direction of plant growth. This learned behaviour prevailed over innate phototropism. Notably, learning was successful only when it occurred during the subjective day, suggesting that behavioural performance is regulated by metabolic demands. Our results show that associative learning is an essential component of plant behaviour. We conclude that associative learning represents a universal adaptive mechanism shared by both animals and plants.

The ability to choose among different and often conflicting options, and predict outcomes, is a fundamental aspect of life[1–4]. One form of choice behaviour is based on establishing an association between an occurrence of external events and the opportunity to satisfy internal homeostatic needs, such as hunger, thirst or sleep. The notion that choices are driven by the expectation of their rewarding outcome goes back to Aristotle[5] and has been observed extensively across the animal kingdom[6–9]. However, it remains unknown whether this is also true for plants.

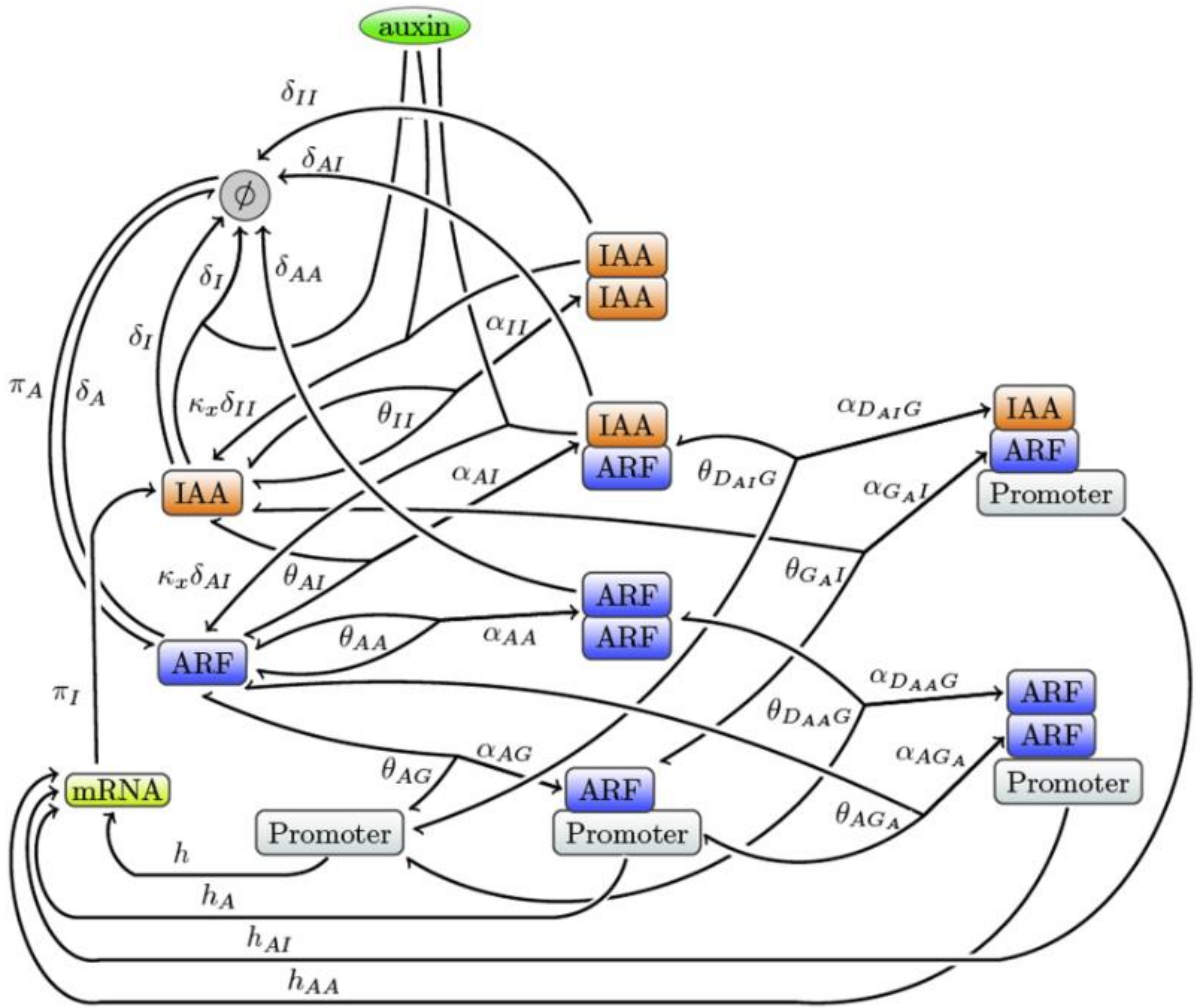
Gagliano et al. 2016



Pavlov's Peas



A Modular Analysis of the Auxin Signalling Network Etienne Farcot et al 2015



level the distinction between life and not-life is dependent on this ability: the response to differences. In the world of nonliving matter which is described by the laws of physics and chemistry the ability to respond to differences plays no part."

– Hoffmeyer & Emmeche, 1991