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ORGANIC MATHEMATICS: A SEMANTIC FRAMEWORK FOR ORGANIC SYSTEMS

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ABSTRACT

Organic Mathematics (OM) is designed to model the dynamic, feedback-driven nature of organic systems. OM provides a semantic framework for representing interdependence, contextual variability, and emergence. It departs from linear formulations and input-output computation by introducing a framework tailored to the adaptive and cyclical patterns observed in complex systems. OM enables a structured, yet flexible representation of processes that evolve through mutual influence and shifting context. By offering a concise language for articulating such dynamics, OM transforms the study of organic complexity from descriptive approximation to formal expression—providing researchers with new tools for exploring the logic embedded in living systems.

KEYWORDS: Organic Math, Complex Adaptive Systems, Natural Cycles, Mathematical Modeling.

1. INTRODUCTION

Mathematics has long been viewed as the epitome of logic, order, and precision, capable of describing the motion of celestial bodies or the exact rate of chemical reactions. However, when it comes to explaining the intricate, often messy behaviors inherent in biological organisms, human societies, and complex adaptive systems, it isn't always the best approach, I wondered if there might be something more effective at modeling and communicating these phenomena.

This was the motivation for Organic Mathematics (OM)—an attempt to bridge the gap between rigid semantic structures and the fluid chaos of organic systems. At its core, OM aims to create a universal system of semantics for communicating the logic and patterns inherent in organic systems. As over fixation on computations, can lead us to stumble in our attempts to articulate the behavior of complex adaptive systems such as ecosystems, economies, and human societies, where variables frequently defy neat categorization and are constantly interacting with each other in linear and non-linear ways.

OM introduces variables and concepts that naturally align with the ambiguous nature of organic phenomena. Instead of trying to force nature into linear and static equations even when such an approach may not be effective, OM embraces the messy dynamics of nature, providing a mathematical language flexible enough to communicate different meanings depending on context, reflective of the dynamic reality inherent in organic systems.

In this paper, we explore the conceptual foundations of Organic Mathematics, highlighting its potential to address some of the gaps left by conventional mathematical methods. By examining existing mathematical limitations in modeling biological and complex adaptive systems, I argue that OM not only enriches our understanding but also shifts our engagement with the complexity of the natural world. Rather than being merely theoretical, Organic Mathematics represents a necessary evolution in how we conceptualize and articulate life's inherent ambiguity and intricate dynamics.

2. THE FUNDAMENTAL PRINCIPALS

For a complex organic structure to exist, it must arise from a process—and for that structure to persist through time, the process cannot be linear. A one-way sequence where X leads to Y will simply terminate; it produces Y, then stops. Without feedback, Y becomes static, vulnerable to decay and dissipation.

Organic systems require cyclical processes: X must lead to Y, and Y must in turn influence or regenerate X. This cyclical feedback is what enables persistence, adaptation, and impact over time. It's important to note that the example of X and Y describes an independent cycle—a self-contained loop. The only truly independent cycle we know of is the universe itself. It began with a fixed quantity of matter and energy, which continue to transform from one form to another, creating a closed cycle of perpetual reconfiguration.

Most other cycles are dependent—they rely on external cycles to sustain themselves. A plant, for instance, may appear self-sufficient through its metabolic and photosynthetic cycles. However, without the nuclear fusion in the Sun emitting photons, photosynthesis would cease. Thus, the plant's cycle is not independent, but nested within a larger one. That said, under certain conditions, some cycles can function independently for a time. If the Sun were to vanish, nuclear fusion—and its photons—would cease. Yet for another eight minutes, photosynthesis would continue on Earth, using the light already en route. In that brief moment, the cycle persists autonomously—but only as a consequence of prior dependency.

3. THE ENTROPIC LIMIT OF CYCLE INDEPENDENCE

No organic structure can achieve total independence unless it perfectly recycles all of its energy outputs, the degree to which a cycle approaches independence is inversely proportional to its entropic loss.

What is a cycle?

A cycle consists of two or more variables, where a change in one variable results in a change in another variable, which results in a change in another etc… ultimately leading to a finite feedback loop. What I mean by a cycle is more closely aligned to what physicist mean when they say "A closed system" the only truly closed system is the universal, anything other than that is a closed system in a very specific way that allows us to only consider what can meaningfully effect our subject in question, it is a useful conceptual tool, instead of having to consider all the thermal dynamics going on in the universe every time i want to measure the efficiency of a diesel engine, I can simplify and only consider the most relevant parts.

This is also true for Organic Mathematics, the universe is one large cycle, we break it down to understand certain segments without having to take on the full complexity of the observable universe. Things emerge as a product of two or more cycles interacting, as a single cycle spinning on its own is limited to itself, and incapable of generating a new phenomenon. But introduce just one more cycle, another rhythm, another pattern, and then you've got complexity, difference, and an open-ended set of possibilities. It's within this dance between multiple variables or cycles where new phenomena don't just pop up—they're practically forced into existence by the endless possibilities created by their interplay.

4. THE ROLE OF ENTROPY

From a purely physical perspective, a system in a state of maximum entropy would be highly homogeneous, devoid of meaningful gradients, and incapable of generating complexity or sustaining organized structures. This principle is well-supported in thermodynamics, where a system at thermal equilibrium reaches a state of maximal disorder, leading to uniform energy distribution with no remaining potential for work (Boltzmann, 1877). This concept also extends to cosmology, where a universe in thermodynamic equilibrium—such as in the theoretical heat death scenario—would lack any free energy sources necessary for complex interactions (Penrose, 2010). Furthermore, in information theory, maximum entropy corresponds to maximum randomness (Shannon, 1948), implying that while a high-entropy system may contain a vast number of possible microstates, none of these are distinguishable or functionally useful for complexity formation (Chaitin, 1975).

Conversely, a system with near-zero entropy lacks the necessary degrees of freedom to allow for meaningful configurations or dynamic processes. A system in a perfectly ordered state exists in a single microstate, meaning that no variability, evolution, or information processing can occur. This is evident in quantum mechanics, where a system at absolute zero temperature (which corresponds to near-zero entropy) exists in its ground state and lacks thermal fluctuations, prohibiting the emergence of complex structures (Heisenberg, 1927). In biological and computational terms, zero entropy is analogous to a system with no redundancy or variation, rendering it incapable of adapting, evolving, or sustaining life (Nicolis & Prigogine, 1977). The early Big Bang universe began in a low-entropy state, but not a zero-entropy one, allowing for non-equilibrium processes that eventually led to galaxies, stars, and life (Hawking, 1988). Similarly, crystals—which exhibit a low-entropy ordered structure—lack the dynamic complexity of biological or computational systems, reinforcing the idea that some level of entropy is necessary for emergent behavior (Lloyd, 2006).

Ultimately, complexity arises in systems that maintain an intermediate entropy state, where order and disorder coexist in a delicate balance. Systems that exist far from equilibrium—such as life on Earth—derive complexity from entropy gradients that allow for energy dissipation and information processing (Schneider & Kay, 1994). This principle suggests that extreme homogeneity (maximal entropy) and extreme order (zero entropy) are inhospitable to complexity, reinforcing the view that structured complexity emerges in a thermodynamically open system operating between these two extremes. I mention this because the existence of one cycle alone cannot in most cases result in the energy gradients necessary to give rise to organic complexity. Even the simplest life form, such as single cells prokaryotic organisms, in order to exist they require more than one cycle to result in their existence, such as a cycle of resource acquisition to sustain their being, and another cycle for them to reproduce.

5. THE FUNCTION OF CONTEXT

During the development of OM, I encountered many cases where the same variable would emerge in different equations, however it would vary in some minor or major way, and what I initially did is write the same variable but use slightly different notations to differentiate it, for example, if water was a variable, and we use **W** to symbolize it, **W** might appear in two different equations, however in one equation it might be warm water, and in the other it might be cold water, In that case what I used to do is something along the lines of **Wc** (for Cold water) and **Wh** (for hot water) but things got confusing and redundant, the notation started looking overly busy, therefor I decided to take a different approach.

When I looked back at the whole equations, I noticed when looking at the equation as a whole, one can infer what type of water is involved from the context, then it became apparent, that this is the approach I should have chosen from the start, in organic systems, no variable exist in isolation, every variable is simultaneously shaped and get shaped by every other variable, it's something that must be part of Organic Mathematics (the mathematical system that is meant to capture organic systems) it's not only important because it keeps the notations less cluttered, but it's also because it trains the mind to think in wholes, instead of parts as it is the case with mechanical mathematics, it is indeed a bit of a philosophical point, however philosophy is necessary (in moderation) and who says something can't be both functionally valid, and philosophically engaging? how about this as a definition of a cycle: a cycle is a system with two or more parts that are linked together, where a change in one, results in a change in the other, where they generate.

6. THE NOTATION

$$x \rightleftarrows x$$

I refer to this operator as **Influx**, when two variables are **Influx** it means that a change in one, will result in a change in the other, it's like balancing two objects on the opposite ends of a stick, a force acting upon one end, will always influence the other end, somewhat like newton's third law, for every action there's an opposite reaction, equal in strength and opposite in direction. And as such given that a change in one result in a change in the other, not only that makes the process of figuring out which variable is exerting a force on the other, it's impossible to pinpoint, it also means that the distinction is often meaningless, similar to how if one was pushing against a solid wall, the wall is pushing back with the same amount of force, and intervening to ask "But whose pushing who!" is a meaningless question. *because forces come in pairs*.

$$x \rightleftarrows x \rightarrow Y$$

the second operator ($\rightarrow$) signifies a moment of emergence, the emergence of a new cycle from the interactions of two or more existing cycles. Does a moment of emergence in Organic Mathematics represent an actual moment in time? The answer is both yes and no. A moment of emergence is an abstraction, much like Fahrenheit is an abstraction of particle energy. For instance, what does 10°F specifically represent at the atomic or subatomic level? The exact details are irrelevant because Fahrenheit is not designed to capture phenomena at that scale. Similarly, a moment of emergence is not tied to a specific temporal instant but is a conceptual tool for understanding transitions and interactions within the framework of OM. After the moment of emergence, the expression becomes as follows $X_o \rightleftarrows X_o \rightleftarrows Y_o$ which communicates that all 3 variables interact and influence one another regardless of positioning.

$$X_o \rightleftarrows X_o \rightleftarrows Y_o$$

7. SUBSCRIPT (O)

This is one of the fundamental symbols in Organic Mathematics, it simply denotes that the variable in question is in fact a cycle, following the definition of a cycle we have discussed earlier in this paper. There's a possibility that in OM there will be other fundamental units, other than cycles, as of now, all variables in OM are cycles, however some cycles can be further broken down into two smaller cycles, and so on… we will see an example of that later on.

Another fundamental concept in Organic Mathematics is "in the stage of…." As in, two cycles exist on a specific stage, for example all biological processes exist in the stage of earth's biosphere, and the earth exists in the stage of the universe, but then we can specify based on the matter in question, that the equation we are looking at is in the stage of a specific organism.

8. APPLICATIONS

Now, OM isn't meant to be a purely intellectual exercise, but one that can be used to model and understand Organic Systems, below are a couple of examples of how it can be applied: The phenomena of human social systems is indeed a very complex puzzling one, and perhaps examining it on its own, without putting it in its proper evolutionary context, it might seem like an accident in the story of life, a non-intentional by product, however if we examine it using first principles, we might uncover something rather interesting, that reframes human societies from an evolutionary fluke, to a logical progression.

$$R_o \rightleftarrows E_o \rightarrow S_o$$

The social cycle is "repeated interactions between two or members of a living organism" for there to be two or members of an organism there have to exist a way for an organism to reproduce (which is the reproductive cycle symbolized by (R_o) and in order for them to be sustained long enough to have repeated interactions, they need to acquire energy/matter which is the Economic Cycle symbolized with (E_o). that's why both the economic and reproductive cycle need to exist in order for The Social Cycle to emerge (S_o) This reframes the existence of social interaction, as a byproduct of the Reproductive and Economic cycles being in flux, it's a simple logical succession, The Social Cycle cannot occur if there are no organisms to repeatedly interact with one another, meaning no (R_o) and for multiple members to repeatedly interact, their existence has to persist long enough to allow multiple interactions, meaning they have to acquire the energy necessary to sustain themselves (E_o). I believe this reframing is of vital importance, because it allows us to view organic phenomena through a structured clear lens, not as a random by product of evolutionary processes, but as a series of steps within a logical succession. And of course, once the social cycle emerges, it becomes in flux with the reproductive and economic cycle.

$$R_o \rightleftarrows E_o \rightleftarrows S_o$$

This also reframes the existence of sexual reproduction, as most sexual reproduction requires some form of social interaction, with varying levels of directness, which needed the Social Cycle to emerge, for it to become possible, this also explains why asexual reproduction took precedence in evolutionary history, with sexual reproduction developing much later.

9. THE ECONOMIC CYCLE

OM can be a useful method in communicating fundamental biological processes, such as photosynthesis. At the heart of the economic cycle lies the influx between **resources** (r_o) and the acquisition of those resources (A_o):

$$r_o \rightleftarrows \boldsymbol{A_o} \rightarrow \boldsymbol{E_o}$$

This equation illustrates how the economic cycle (E_o) emerges as an outcome of the feedback loop between the availability of resources $(\boldsymbol{r_o})$ and the acquisition processes $(\boldsymbol{A_o})$**.** Whether it's autotrophs converting sunlight and carbon dioxide into energy or heterotrophs consuming organic matter, this interaction underpins the foundation of life. For example, autotrophic organisms follow this cycle to produce their own biological resources, and that's how the autotrophic economic cycle emerges (ATE_o).

$$Ne_o(Org(Ar_o \leftrightarrows a_o \leftrightarrows C_o \leftrightarrows Br_o)) \rightarrow ATE_o$$

$$Ne_o = Natural\ Envirnoment$$
$$Org_o = An\ Organisim$$
$$Ar_o = Abiotic\ Resources\ (Such\ as\ sunlight, Inorganic\ carbon)$$
$$a_o = Access$$

Because the existence of resources, be it biotic or abiotic is not meaningful, unless there's a passive or active cycle that result in an organism accessing those resources. For instance, sunlight exist in plentiful supply, but unless a plant is positioned at a location where it can access that sunlight, then it's not really useful for the organism. Making a cycle of access an important variable for the economic cycle of any organism.

The above equation tells us the following: within the stage of the Natural environment, and within the organism in said environment, the influx of abiotic resources, with access to those resources, and conversion of those resources, influx with biotic resources, emerge the Heterotrophic economic cycle.

This demonstrates one of the most important utilities of organic mathematics, we started with the broad three fundamental cycles:

$R_o \rightleftarrows E_o \rightleftarrows S_o$ the reproductive, economic, and social cycle

⬇Then if we want to understand the economic cycle in more depth, we zoom in on it.

$r_o \rightleftarrows \boldsymbol{A_o} \rightarrow E_o$ We've identified that the economic cycle is made up of the influx between a cycle of resources and access to those resources

⬇Then wanting to figure how the particular economic cycle for heterotrophs work.

$Ne_o(Org(Ar_o \leftrightarrows a_o \leftrightarrows C_o \leftrightarrows Br_o)) \rightarrow ATE_o$ We've added a cycle of conversion of the abiotic resources into biotic resources, highlighting that stage were those variables are influx, and the resulting overarching cycle, the autotrophic economic cycle.

The first utility of this approach is communication, it moves the process from a purely theoretical one into a tangible equation; by distilling complexity into one line, it makes it easier to memorize and communicate.

$$Ne_o(Org(Ar_o \leftrightarrows a_o \leftrightarrows C_o \leftrightarrows Br_o)) \rightarrow ATE_o$$

$$Ne_o(Org(Ar_o \leftrightarrows \boldsymbol{A_o} \leftrightarrows Br_o)) \rightarrow ATE_o$$

I would also like to bring to attention that $a_o \leftrightarrows C_o$ in the equation for ATE, is the Just the Acqusition Cycle (the basic version)

The second utility is that when it's laid bare, with specific variables in question, and within a logical structure, it makes it easy to test, falsify, and refine. For instance, perhaps one would argue that a distinction between the type of access $(\boldsymbol{a_o})$ be it passive or active (relying on sensory) must be made, to highlight that in some instances access to resources, biotic or abiotic, can be passive, relying on external conditions to situate it in a favorable position, or active, relying on the ability to sense its environment to pin point the location of resources. Or that there's a local (non-universal) interaction between some of the variables.

The number of parentheses on the right makes it clear how many stages is the process in question is within. And considering that when examining the economic cycle of any organism, the stage will remain the same, the natural environment then the organism itself, the equation can be simplified to the following:

$$Ar_o \leftrightarrows a_o \leftrightarrows C_o \leftrightarrows Br_o \rightarrow ATE_o$$

Or

$$A_o \leftrightarrows C_o \leftrightarrows Br_o \rightarrow ATE_o$$

I hope this delineate why I believe in the utility of the framework, as I hope it's becoming increasingly clear that it can have interesting and useful applications, speaking of which, let's move on to some of the more ambitious/experimental applications of OM.

10. THE COMPETITIVE EXCLUSION PRINCIPLE

The Competitive Exclusion Principle, states that no two species occupying the same fundamental ecological niche can coexist indefinitely, as one will inevitably outcompete the other, leading to the exclusion or extinction of the less competitive specie.

From that definition, we can extract a couple of main variables:

$Ne_o =$ The natural environment
$Org_o =$ The organism/specie itself

However, how can we communicate that there's more than one specie, and how does that specie effect it's environment, we can't simply write that the influx between the Natural Environment and a given organism leads to the exclusion of other organisms:

$$Ne_o \rightleftarrows Org_o \rightarrow Exc_o$$

This formulization has a few major issues, the first being is that it doesn't really tell us much, there isn't really a story here, there isn't a lot of contextual information, it's simple yes, but what's the point of simplicity if it comes at the cost of capturing reality? The first thing we need to do, is contextualize the relationship between the organism and its natural environment, as the competing organisms will be competing within a specific natural environment/ ecosystem, meaning we end up with something more along the lines of this:

$$Ne_o \rightleftarrows (Org_o) \rightarrow Exc_o$$

This is better, now we understand the contextual relationship between an organism and it's environment, an organism exist in the stage of it's environment, this distinction is important because, Organisms don't exist in a vacuum, the competition between a giraffe and a dolphin will play out very different based on whether the competition is taking place in the Serengeti or the ocean. If it was the Serengeti, the dolphin won't really stand a chance, and vice versa for the ocean. But our Org_o variable is agnostic in some sense, it refers to no one and everyone at the same time, we need to add an additional variable that can accomplish two tasks, a variable that allows us to apply this equation to multiple species, while preserving specificity, additionally the variable need to communicate how the competing species Out Compete one another, what we can communicate with the current formula is limited to saying, that a change in the organism ΔOrg_o can result in some change in the Environment ΔNe_o, which can lead to the exclusion of a another organism Exc_o, few things remain ambiguous, the first as I mentioned, is what differentiates one organism from another, the other is we have yet to communicate how throughout time an organism can outcompete another. What we are missing is a trait variable (T_o).

$$Ne_o \rightleftarrows (Org_o \rightleftarrows T_o) \rightarrow Exc_o$$

When a trait within an organism change, it alters the organism as a whole. However, that holistic change can, in turn, influence how the original trait manifests, since no trait exists in isolation. Each trait interacts with the organism's broader system—its other traits, behaviors, and internal dynamics. Moreover, changes at the organism level inevitably ripple outward, affecting the surrounding environment. For instance, a new trait might enable the organism to exploit an ecological niche more efficiently, reducing available resources for competing species and potentially triggering a cycle of competitive exclusion.

If the influx between an organism and its traits results in a negative delta in the environment/ ecological niche $-\Delta Ne_o$ then that niche becomes less available for other organisms to exploit, and that organism is on its way toward excluding the competitors, if instead an organism experiences a change in one of its traits ΔT_o, which will inevitably change the organism it's influx with, meaning $\Delta Org_o \rightleftarrows \Delta T_o$ and if the influx between an organism's traits and it's whole leads to a positive change in the environment $+\Delta Ne_o$ which means the trait impairs the ability of the organism to extract resources from the environment, it will result in a surplus that other organisms which are adequately fit, can exploit.

The exclusionary organism, will have the following equation:

$$+\Delta Ne_o \rightleftarrows (\Delta Org_o \rightleftarrows \Delta T_o) \rightarrow Exc_o$$

While the excluded Organism will have the following equation:

$$-\Delta Ne_o \rightleftarrows (\Delta Org_o \rightleftarrows \Delta T_o) \rightarrow Exc_o$$

Of course, an organism could experience a change in it's traits/whole that has a neutral impact on its ecological fitness. However this formulation reveals things that as far as I'm aware, haven't been explicitly articulated in the Competitive Exclusion Principle, which is that even if competition is happening between two organisms with overlapping niches, the competition will not only shape the evolutionary trajectories of the competing organisms, but also the trajectory of the whole ecosystem and all its inhabitants, for instance, Near deep sea hydrothermal vents where primary productivity is made possible via the process of chemosynthesis, some organisms will be competing for the same food source, that being the chemosynthetic microorganisms. The competition for the same ecological niche, in the cases where it doesn't lead to the extinction of one of the competing organisms, can lead to a phenomena called resource partitioning, where the competing organisms develop different adaptations to exploit the same niche in different ways reducing direct competition. Those different ways of exploiting the same niche, can result in a multitude of different niches for other organisms, and that will continue to ripple through trophic levels.

Going back to deep sea hydrothermal vents, Tube Worms and Yetti Crabs both compete for the same food source, however their methods vary greatly, Tube Worms enter an endosymbiotic relationship with the chemosynthetic microorganisms, while Yetti Crabs have filament like hairs which the microbes stick to, each method of attainment generates opportunities for other organisms.

For instance, the external cultivation strategy of Yeti Crabs creates a surplus of microbial biomass that isn't entirely consumed, leaving organic detritus and microbial mats available to smaller scavengers such as amphipods and polychaete worms. These organisms benefit from proximity to crabs without directly competing with them, carving out a secondary trophic role based on leftover material. In contrast, Tube Worms—by hosting bacteria internally—produce distinct chemical gradients in their immediate surroundings, particularly via their respiratory plumes which release waste products and modulate local sulfide and oxygen levels. These gradients support niche-specialist organisms like vent copepods and certain bivalves that have adapted to thrive in transitional chemical zones. As a result, the divergent strategies of Tube Worms and Yeti Crabs not only alleviate direct competition but actively shape the surrounding ecological architecture, enabling a cascade of secondary interactions and niche formations across the hydrothermal community.

11. TRACING THE ORIGINS OF LIFE WITH ORGANIC MATHEMATICS

The emergence of life from non-living matter—**abiogenesis**—remains one of the most profound and enigmatic questions in science. While traditional frameworks have explored the biochemical pathways and environmental conditions that might have fostered life, they often fail to capture the interplay of cycles and feedback loops that likely drove this transition. Organic Mathematics (OM), rooted in the principles of emergence and interdependence, offers a new lens for exploring abiogenesis.

Thermodynamics, particularly the second law, provides a compelling foundation for understanding the conditions under which life might emerge. As entropy increases, systems far from equilibrium—such as the early Earth—develop gradients and energy flows that create opportunities for complexity to arise. OM formalizes this complexity by mapping how cycles of energy exchange, molecular replication, and resource partitioning interact to create the precursors of life.

Here's my preliminary attempts at describing abiogenesis using Organic Mathematics (this is for demonstration purposes only):

$$\mathrm{Br}_o \rightleftarrows a_o \rightleftarrows \boldsymbol{sp_o} \rightleftarrows C_o \rightleftarrows Br_o \rightarrow Pr_o$$

Consider the interplay of these foundational cycles:

1. Br_o: Refers to **resources** in the environment, which given that early life was believed to be heterotrophic, they didn't have the ability to produce their own energy, thus they relied on available biological resources in the environment, which means there was an ongoing process of generating biological resources that early life could capitalize upon.
2. a_o: Early life needed to have **access** (being in proximity) to the biological resources to benefit from them, as biological resources or organic matter that couldn't be accessed, couldn't have played a role in the sustenance of those early organisms.
3. sp_o: **a separation process**, for life to exist in any way shape or form, it needs limitation, it needs a method of distinguishing the outside from the inside, if there isn't, if life had no boundary, then the energy required to sustain a boundless organism would be infinite. And I'm afraid there are many laws of physics that don't allow that, some studies suggest that there were naturally occurring lipids on the surface of the primordial soup, which formed early bilipid layers that created the separation needed for protocellular structures. Research has demonstrated that prebiotic phospholipids could self-assemble into bilayers under primitive Earth conditions, contributing to early compartmentalization. Similarly, simulated experiments have shown that lipids can form stable bilipid layers, resembling modern membranes. This aligns with the idea that bilipid layers played a crucial role in prebiological compartmentalization, as proposed in various theoretical and experimental models (Monnard & Walde, 2015). Prior literature further emphasizes the importance of lipid self-assembly in the context of prebiotic systems chemistry. Additionally, the process of self-assembly and bilipid layer formation is discussed extensively in studies on prebiotic evolution and compartmentalization (Sillerud, 2024).
4. C_o : There had to be additional metabolic pathways to convert the biological resources (organic molecules) into energy or other forms.
5. Br_o: The last step involves the output of the conversion process, usually being ATP.

Besides potentially offering insights into the origins of life on Earth, OM could also inform the search for life beyond our planet. By identifying the key cycles necessary for abiogenesis, researchers could use OM to pinpoint environments—such as subsurface oceans on Europa or hydrothermal vents on Enceladus—where life might emerge under similar conditions.

This approach transforms the study of abiogenesis from a descriptive endeavor to one grounded in predictive and mathematical rigor. By bridging thermodynamics, chemistry, and biology, OM not only deepens our understanding of life's origins but also provides a roadmap for exploring its emergence across the universe.

A Summary of all Symbols:

Symbol	Meaning	Description / Usage
X_o	**Cycle**	The fundamental unit of Organic Mathematics represents a self-referential process or loop of interaction. Subscript $_o$ distinguishes individual or nested cycles.
⇄	**Influx**	Denotes the inward flow of energy, matter, or information *into* a cycle; represents the sustaining input or initiation of a process.
→	**Emergence**	Symbol for the generation of new structures, patterns, or higher-order cycles arising from the interaction of existing ones.
()	**Parentheses**	Used to denote *within* or *in the stage of* — e.g., the interaction between an organism and its environment.

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