The [3N] Model of Life

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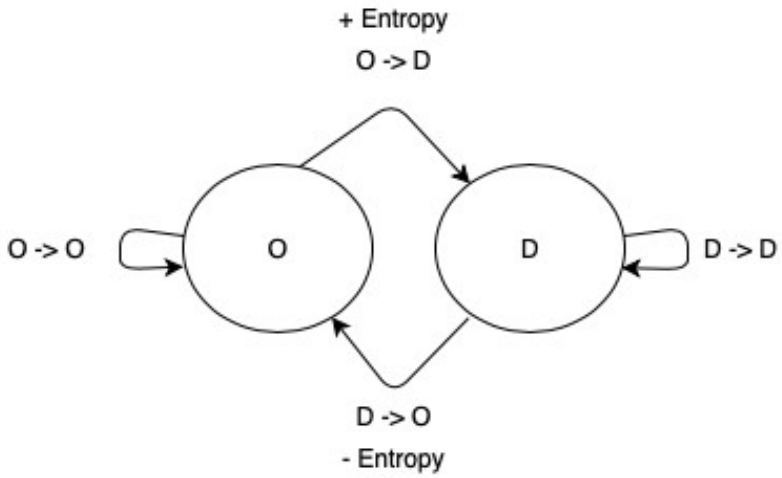
Abstract

Schrödinger's, "What is Life?" asked questions around the functioning of life and how Nature extracted order from disorder relentlessly. This paper illustrates a [3N] model of life which attempts to reconcile the conflict between Quantum and Newtonian states and explains how Nature overcomes the challenges of the second law of thermodynamics using a perpetual motion machine, allowing it to extract order from disorder.

Informational State

A Markov Chain of Order and Disorder

Schrödinger's, 'What is life?' [1] introduces the idea of negative entropy as an action taken by the living entity to maintain itself at a fairly low entropy level hence living in a higher state of orderliness. Building on the simplicity of the solution, one could look at order and disorder as two discrete information states that complement each other. Such an idealized system (in its simplest form) could allow four possibilities associated with a living entity viz. order to order (O-O), order to disorder (O-D), disorder to disorder (D-D), and disorder to order (D-O). The former two links are Newtonian while the latter two are Quantum in character.

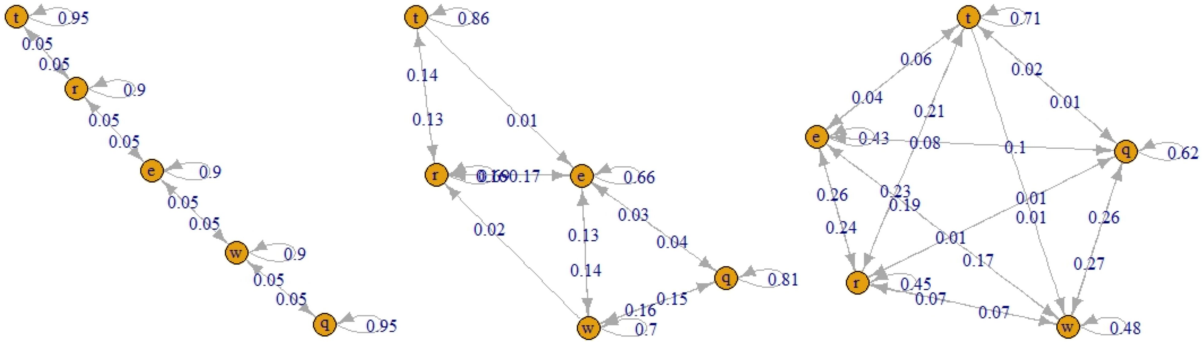


Explaining the functioning of such an 'Informational State' [2] based on laws of thermodynamics could be a model of life addressing quantum indeterminacy, how large scale events could be "controlled" by the dynamical laws of the small-scale events [3], how the non-statistical nature of molecular disorder may be an intrinsic aspect of the statistical nature of Newtonian order, how thinking architecturally may circumvent the need for a super-physical law, how irreversibility and regularity could complement and coexist, how the failure of the second law could be an essential driver for the model to work, how the resulting error could drive the fluctuating engine and create a perpetual motion engine [3], hence allowing living entities to survive, flourish, replicate, all without obviating their natural tendency to increase disorder, a Newtonian-Quantum (NQ) mechanism.

Unifying Postulates

Newtonian Discreteness

Ernst Ising illustrated how social systems can exhibit phase change [4]. Newtonian discreteness (ND) means looking at structures as a discrete state is a probabilistic way to look at Newtonian systems which exhibit thresholds, excitability, memory and form structures which would be assumed to be an aspect of the quantum realm. ND systems like 'Information States' can exhibit stable and probabilistic structures. A Markov chain of five threshold stock market system over 20, 100, and 500 days evolves from a linear to a geometrical structure, as components between various thresholds interact [5] and jump from one threshold to another in a chaotic way.

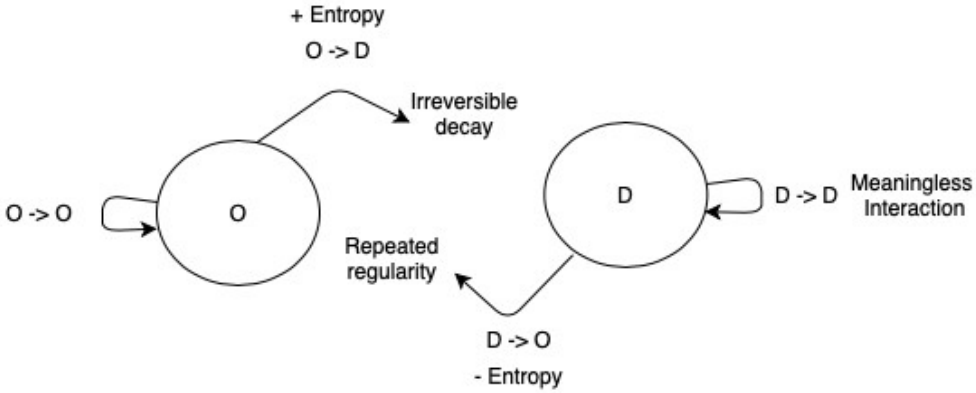


Necessity for Disorder

Mutations assist in the evolution and natural selection. Model of life needs an error generation mechanism, which leads to dynamism, hence transmission of the message (information) from one component to another, or from one generation to the next while retaining integrity and stability of the mechanism. A group hence becomes more relevant in error enhancement, obscuring the message at the individual level, but still aware of the order it is designed to achieve at a group level; the whole is greater than the sum of its parts.

Regularity from Meaningless Interaction

The meaningless interaction which is driven by irreversibility, cull out a meaningful order repeatedly, like patterns of diffusion. The disorder seems intentional and purposeful.



Seminal Ideas

A model of life is built on the interacting seminal ideas in Physics, Chemistry, Mathematics, Biology, and other Sciences. Together they become coherent and alive.

The 1713 Jacob Bernoulli, Ars Conjectandi [6] expressed the stochastic nature of probability, a metastatement [7] which like many phenomena experienced convergence and was the real “opprobrium of mathematics” [8]. This would mean that the Newtonian order could never be considered completely certain.

1738 de Moivre has been credited for the bell-shaped curve [9] and the birth of normality (N), followed later by the work of Carl Friedrich Gauss (1809) [10], Pierre Simon Laplace (1810), [11] and James Clerk Maxwell who demonstrated [12] occurrence of N in natural phenomena in 1860.

1824 Carnot’s Heat Engine[13] laid down the basis for the second law of Thermodynamics and hence its conflict with Nature’s perpetual motion machine.

1838 P. F. Verhulst formulated the logistic growth models [14] where he combined dual equilibrium to produce a stable cycle explaining population and growth. This was early work in dynamical systems.

1828 G.T Fechner’s original ideas [15] were later developed by Boris Belousov 1951 [16] and Anatol Zhabotinsky 1961 [17] to give birth to the phenomenon of non - linear chemical dynamics.

“The philosopher always claimed that the atomist did not go far enough in his analysis of matter, that he did not try to answer ultimate questions. What he fails to see, however, is that the physicist does not attempt to answer such questions; he is only trying to explain the data given in experience. The dynamicist perhaps understood that matter did ultimately consist in forces of attraction and repulsion” - Fechner

Belousov–Zhabotinsky reaction is one of a class of reactions that serve as a classical example of non-equilibrium thermodynamics, resulting in the establishment of a non-linear chemical oscillator, which is symmetry breaking, temporally independent, require interference of vibrations to produce oscillations, have a small scale to long scale forecasting potential. Laws of thermodynamic forbid chemical oscillation just as they prevent the operation of perpetual motion machines, however, controlled signals, like in neurons, generate oscillators at all scales, simple to complex to simple again.

Biochemical pathways or structures are a set of linked oscillators, structured hierarchically, running at the same rate mean equilibrium, but maintained far from equilibrium. A feedback mechanism with bistability, tristability, creating hysterisis i.e. state of the system depends on its past history. The feedback causes the system to jump periodically from one branch of the steady states to another.

1867 Maxwell’s Demon [18] was a thought experiment to explain how Nature overcame the second law of Thermodynamics.

The thought experiment where a demon caught the fast molecule and allows the slow one to pass was Nature’s way of extracting order from the state of disorder.

Fluctuations which temporarily reduce the entropy without compensation and, therefore, violate the laws of thermodynamics [is an impossibility] - Einstein [19].

One who is continuously and exactly informed of the existing state of nature and who is able to start or interrupt the macroscopic course of nature at any moment without expenditure of work. A system in which such measurement occurs shows a sort of memory - Leo Szilard [20].

1886 Francis Galton (Regression to Mediocrity) [21]

The frequentists revolution flourished from 1886 England with the publication of Francis Galton, where he laid the foundation of statistics with the law of mean reversion using data of heights of parents and their children. He illustrated the functioning of nature, which maintains balances as taller parents don't give birth to taller children and vice versa.

Galton's considered reversion as extremely regular, leading to a state of constancy. Regularity meant that reversion and dispersion followed a cyclical process. He talked about an alternation between the two. The time durations Galton considered were generational and hence were more discrete rather than continuous in their expression. Galton observed or focused on a complete cycle from one generation to the next, from dispersion and reversion rather than a multiplicity of cycles. This is why his conclusion regarding unchanged states, a kind of completion, which was necessary for him to showcase the phenomenon of reversion, and the constancy in it.

1894 Paris, Guillaume Ferraro [22] discovered the principle of least effort which illustrates human nature to want the greatest outcome at the least amount of work. Not so strangely, further 10 years, in 1906, another frequentist, an Italian working in Paris, Vilfredo Pareto [23], observed 80% of Italian wealth in the hands of 20% Italians. Paris was fecund ground for the frequentists. From 1925 England, Uduny Yule [24], wrote about similar behavior in species, based on the work of Botanist J.C Willis [25]. In 1916, Paris, J. B. Estoup [26], a stenographer observed a proportional dependency between word usage in texts. In 1949, Kingsley Zipf [27] confirmed and popularized the idea by studying children's frequency of word usage to establish the principle of least effort which he believed governed our entire individual and collective behavior of all sorts, including the behavior of our language and preconceptions. This was NonNormality (NN) also loosely referred to as Pareto curve, Zipf's law, preferential attachment, etc.

Zipf argued that language development was about a vocabulary balance that was driven by two opposing forces, the forces of reversion (order) and diversion (disorder). The force of reversion tended to reduce the vocabulary and corresponds to a principle of least effort made by the speaker while the force of diversion had the opposite effect and was linked with the listener (auditor). Zipf did not transform these ideas into a mathematical model, his basic consideration was that conversation (knowledge) was as a two-person game, a speaker, and a listener. Galton had a similar lapse as he focused on the phenomenon of the reversion without considering the model of nature which generated reversion. Both Zipf and Galton considered a child-parent relationship, one came up with the idea of reversion using a group of children heights, while the other confirmed the idea of a hyperbolic behavior in a group of words used by children.

1925 Ernest Ising

The Ising model is being successfully used to explain the properties of living organisms on all scales. Though NN in character some Ising experiments expressed[28] simultaneous expressions of N and NN in different expressions of the same measure. In its paramagnetic phase, the Ising model has a magnetization that fluctuates around zero. Suppose we measure the magnetization 'm' at uniform intervals and calculate the fractional change '$\delta = (\Delta m)/m$' between each successive pair of measurements. The change 'Δm' is roughly normally distributed and has a typical size set by the width of

that normal distribution. The 1/m, on the other hand, produces a power-law tail when small values of m coincide with large values of ∆m.

1944 Erwin Schrödinger's, What is life? illustrates how there was an N and NN conflict in entropy. How could Nature extract order from increasing NN disorder, a reversion, a normalising mechanism. 1962 Herbert Simon's Architecture of Complexity [29] was intrinsically simple and hierarchal. The structure was more important than the content. There was a commonality across various types of natural systems including market systems. The group behavior persisted over its components, suggesting complexity generated by a definable structure. One of the key ideas of Simon was to understand how Pareto worked, how did the rich get richer!

Unique Elements

The history of scientific research illustrates a set of unique elements, which could complete the puzzle. The table below summarizes the chronology of work across the respective elements.

Originators	Body of Work			p	2	D	RD	f	O	DE	P	A	N	NN	[3N]
Jacob Bernoulli (1713)				√											
de Moivre (1738)	Gauss	Laplace	Maxwell										√		
Carnot (1824)	Boltzmann				√										
Fechner (1828)	B. Belousov (1951)	A. Zhabotinsky (1961)					√		√						
Verhulst (1838)						√									
Maxwell (1867)											√				
Galton (1886)							√						√		
Pareto (1898)	Estoup (1912)	Zipf (1902)	Willis and Yule (1922)				√							√	
Ernst Ising (1925)													√	√	
Schrodinger (1944)					√								√	√	√
Herbert Simon (1962)												√		√	

Stochastic probability (p); 2nd Law of Thermodynamics (2); Dynamic Systems (D); Reversion and Diversion (RD); fluctuation (f), Oscillation (O); Disequilbrium (DE) Perpetual Motion Machine (P); Normality (N); Non - Normality (NN); Normal-Non Normal (3N)

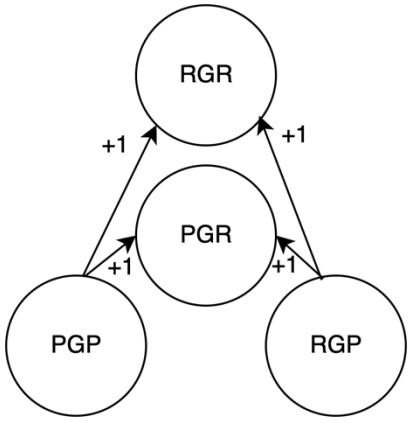
Stochastic Probability (p): NQ system assumes a stochastic nature in probability.
Second Law of Thermodynamics (2): How does Nature overcome the problem of increasing Entropy.
Dynamic Systems (D): Nature is a dynamic system.
Reversion and Diversion (RD): Attraction-repulsion, reversion-diversion, excitement - inhibition are broad forces of Nature.
Fluctuations (f): Fluctuations lead to oscillations.
Oscillations (O): Oscillations lead to patterns and behaviors.
Disequilibrium (DE): For life to function, Nature has to avoid equilibrium and slow down decay.
Perpetual Motion Machine (P): Nature is a perpetual motion machine, extracting order from disorder.
Architecture (A): Architecture could circumvent the need for a super-physical law.
Normality (N): Normality is a statistical law.
Non-Normality (NN): Non-Normality is a statistical law.
Normal-Non-Normal (3N): The combination of the two laws is Architecture.

Model of Life

Preferential attachment (PA) the mathematical reasoning behind the rich get richer (RGR) phenomenon fails to explain why sometimes the second mover usurps the first mover. The N and NN are in conflict.

PA = RGR

PA does not naturally occur in Nature because for every new link that RGR attracts, there are probabilistic states like poor get poorer (PGP), or rich get poorer (RGP) that detach from their existing links and there is a poor get richer (PGR) state that competes for a link with the RGR.



PA = U [RGR, PGR]
PA is a combination of RGR and PGP as the respective states accumulate new links (+1).

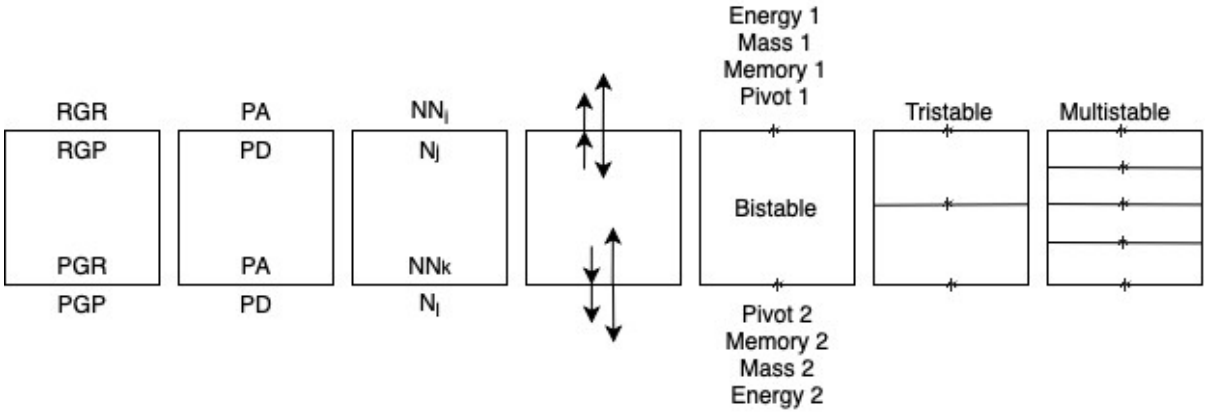
Preferential detachment (PD) is a combination of PGP and RGP as the respective states that shed their links (weights).
PD = U [PGP, RGP]

Together PA and PD make up an idealized mechanism with four states.
PA + PD = U [RGR, PGP, PGR, RGP]

RGR and PGP behave normally while RGP and PGR behave non-normally. The combination of PA and PD system creates an N
NN system, or the [3N] model.
PA + PD = U [NN, N] = [3N]

The [3N] Model

The set of four conditions, placed around two boundaries for interaction, two pivots, a bi-stable system which polarize N and NN behavior into four unique vibration generators. The states operate with a different memory, different speeds of accumulation of mass and energy. In a more complex mechanism, the system could be tri-stable or multi-stable. The missing [PA+PD] architecture and the dynamics around the four probabilistic states, create non-linearity and hence the excitability and inhibition needed for a system to retain memory and oscillate perpetually.

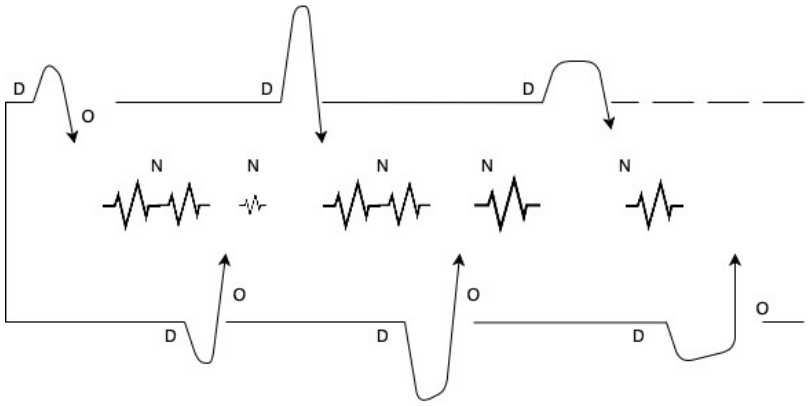


Quantum Determinacy

Why did Schrödinger call imperceptibility, quantum indeterminacy? When he sensed that there was an order coming out of the indeterminacy, he could have referred to it as quantum determinacy, hence solving the conflict for Science by using a strong philosophical pivot despite its perceived illusion. Nature rewards purposeful disorder by giving it a quantum balance. The excitability - Inhibition (E/I) signals in the neurons [30], the attraction-repulsion in nature, the reversion-diversion in our statistical laws, are Nature's design. Quantum determinacy is Nature's machine to extract order from disorder. Life is not about the conscious, it is the balance and imbalance between the subconscious and conscious. There may be a lot of disorder when it comes to reading the mind, the map is jumbled but together, it makes sense, derives meaning and intelligence. The purposeful disorder as Aristotle put it, is the hidden, the imperceptible, the error that balances life despite its imbalance.

Perpetual Motion Machine

The interacting system is vibrating at different scales of time and space. As a component breaches a threshold say RGR, its memory allows it to accumulate faster, hence amplifying the signal, leading to excitement that could breach the boundary (membrane) and move to another state. The failure to do so eventually weighs on the vibration which loses energy and falls back from an extreme state of disorder back into order. A similar process happens on the way down, where the threshold leads to decay, detachment, distribution, as the component loses energy, mass (size) and falls through the boundary (membrane), eventually either ready to leave its current state and move into another state, or make an eventual recovery, back into the cycle of order by accumulating enough energy to jump. This repetitive excitement on boundaries generates the proverbial neuronal firing (the Maxwell demon) that keeps the system in a perpetual oscillation, moving from disorder (D) to noise (N) to order (O), repeating relentlessly like a perpetual motion machine. Nature after all may not need a new brain than what we currently support above our shoulders, however, it may operate a bit differently than we have imagined till now.



The simplest bistable system operates with two membranes (boundaries) that consume (attach) the most links (RGR) and reduce (detach) the most links (PGP). There different memories (probability of stickiness) leading to different behaviors at the two boundaries and hence a feedforward and feedback perpetual mechanism which though simple as an engine to generate oscillation, owing to its perpetual behavior could be driving Nature's strange attractors. The system is permeable, open to exogenous influences acting like a Natural Neural Network, learning and adapting on the go while retaining both short and long term memory, not losing any vibration that was created in the history of its working, fulfilling its group purpose despite the meaninglessness of individual interactions. Nature it seems has a clear intention and purpose for the disorder, to extract energy from noise. The [3N] model oscillates as to moves between the N and NN states, creating disorder from order and generating order from disorder, consuming and generating energy, being irreversible and regular at the same time, a perpetual machine at all scales of time, which has no NQ conflict as it relies on the failure of the second law of thermodynamics to produce disorder. The intelligent machine is conscious because it is aware of itself, its boundaries, its limitations, and the limitations it can overcome.

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