



**New Sciences of:**

*Systems Thinking; Chaos Theory; and Complexity Science*

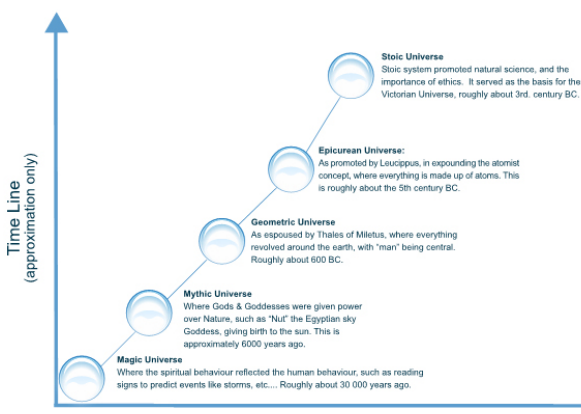


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# The Newtonian Universe

The term Newtonian universe, Cartesian and Mechanistic universe are powerful metaphors that described a universal view of simple “cause-effect”. It is a worldview that we have held dear to hundreds of years, and are still predominantly preached at universities, schools and practically all institutions. It is ingrained into society with many noted scholars citing that it is the fundamental cause of our ill-designed solutions. This notion stems from the mechanistic paradigm that explains all phenomena in terms of a “machine” - if we understand the parts that makes up the machine, we will be able to exactly predict the behaviour of the machine. On a smaller scale, this inference resulted in the scientific belief that if we can control, predict and influence the smallest particles, we will consequently be able to figure out the entire universe, since it is merely a function of many such particles. This notion of determinism has been proven WRONG, yet the mindset still pervades society?

"Each of us live and work with organisations designed upon Newtonian principles, yet science has moved on. As such, we need to ground our work in the science of our times, and indeed stop adopting skewed Seventeenth Century models of reality, and explore what became known to us in the Twentieth Century“ Wheatley



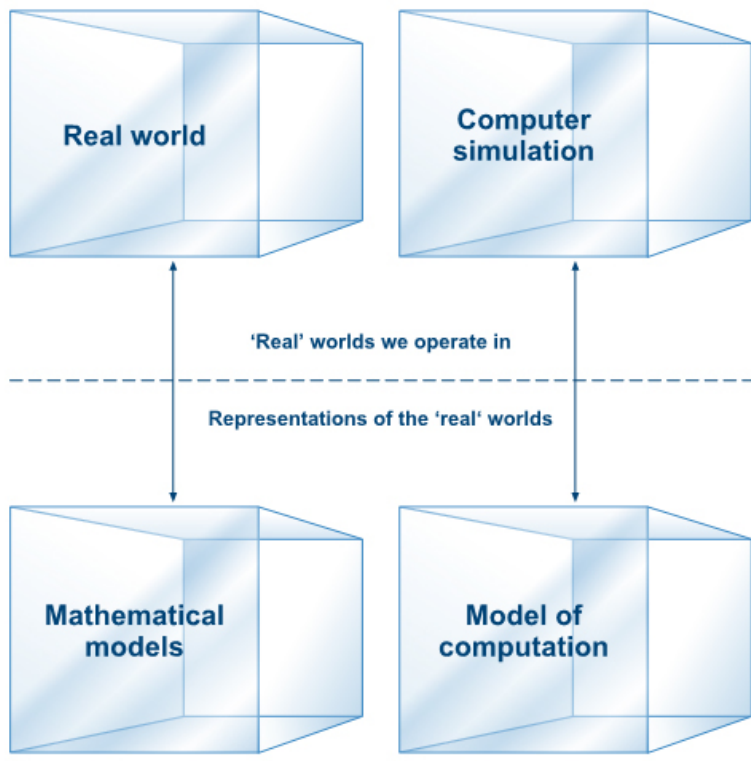
## Models of how we relate to life, things & the universe

This Diagram is a summary of the different models & interpretations of the Universe, we have had, since the beginning of time. We all use this in one way or another to relate to how we fit in; how to make sense of existence, etc. These models are often referred to as masks of the Universe (Edward Harrison - "Masks of the Universe". The implication is that however we perceive the Universe, is mostly of our own making, implying that the Universe is our model of the Universe? It is everything contained in it, including us, trying to make sense of it. This is best summarised by Rene Descartes - "I doubt, therefore I think, I think, therefore I am" - doubting everything, except his doubt.

- Newtonian laws of physics are completely deterministic, i.e., its theoretical base assumption is such that, precise measurements are possible, and that more precise measurement of any condition will yield more precise predictions about past or future conditions.
- This method of scientific reason is often called “Reductionism” - based upon taking a whole, and reducing the whole into parts, and then studying the parts, with the intent of understanding the whole. This model, whilst responsible for most of humanity’s progress, is flawed in a fundamental manner, i.e. it neglects the vital linkages that the parts have between each other, and the whole itself (e.g., we can have all the parts that make a human, but do not possess the ability to create one).



Some views on the various levels of reality, tend to promote the concept that we really only have two "worlds" we live in. This being the real, natural world we experience; Then there is the mathematical world (the attempts at mimicking our natural experience). The diagram below depicts this view, with the bottom blocks being the abstract versions of the 'worlds' we operate within.



## General Systems Theory

The first General Systems Theory (GST), was developed by Ludwig Von Bertalanffy: a system is "a set of units with relationships among them".

- "set" implies that the units or elements contain similar characteristics and that each unit or element is controlled, influenced, or dependent upon the state of other units;
- Open systems exchange matter or information with the environment;
- Closed systems have clear boundaries prohibiting exchange of energy or information - isolated from their environment;
- The essential nature of matter lies not in objects, but in interconnections;
- A system is a set of units that connect to form a whole (e.g. car, eco-system, planets, animals, plants, etc);
- The whole system functions because of interdependence of its parts;
- Systems have input, output, control, and feedback processes;
- Living systems are more complex than mechanical systems;
- Every living organism is essentially an open system. It maintains itself in a continuous inflow and outflow, a building up and breaking down of components;
- This is the essence & fundamental phenomenon of life (metabolism), the chemical processes within living cells;



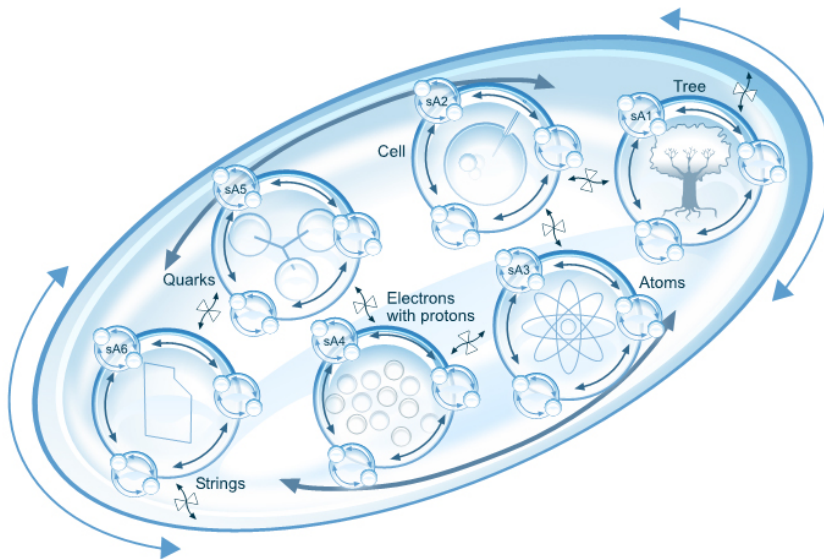
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- It is useful then, to think of people, corporations, organisations, groups, families, interpersonal relationships and computer-based information systems as all being open, living systems;
- A system comprises interrelated components related by flows of energy, material, or information (e.g. Cooling system, Information System, Immune System etc).
- **Hierarchies** (systems within systems)
- **Boundaries** (define system by drawing boundaries)
- **Dynamic** (changing constantly)
- **Emergent** (the whole is greater than the sum of parts)
- **Feedback & Control** (learning, adaptation, homeostasis)
- **Autopoiesis** (self regulating)
- **Equifinality** (same goal achieved via different paths)
- **Entropy** (measure of disorder)

## What is Life”

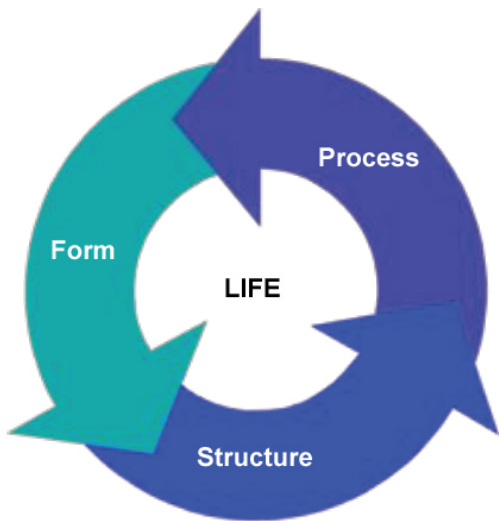
“a property of improbable complexity possessed by an entity that works to keep itself out of equilibrium with its environment” (Dawkins, R., 1986)

Typical de-construction of matter, using a tree as an example.



## Characteristics of Life

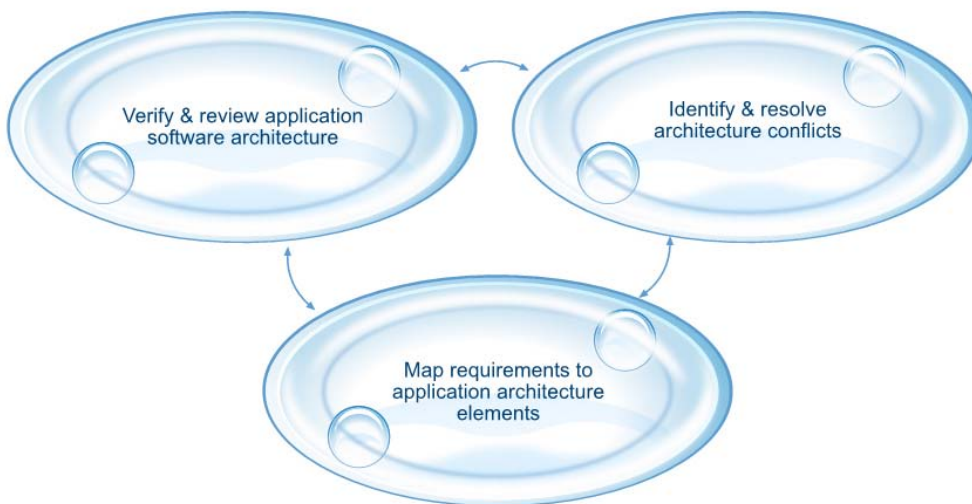
- All living things:
  - are organised;
  - work together to create increasingly higher levels of complexity;
  - Metabolize;
  - maintain internal environment;
  - In short thus, living things:
    - grow
    - respond
    - reproduce
    - evolve



- Living systems learn constantly (they adapt in order to survive);
- Living systems are self-organising (require no external agency);
- Life is systems-thinking (interconnected, interlinked nature of the universe);
- Living systems have feedback loops (reciprocal, learning and adaptive);
- Living systems are interconnected (great deal of interdependencies between and within systems);
- Living systems are self-referential and autopoietic (self regulating).

#### Application architecture definition

This diagram illustrates the road map in defining the application architecture. This is best executed in an interactive model.



## Laws of Thermodynamics

### First Law of thermodynamics:

Total energy in the universe is constant (i.e., energy can neither be created nor destroyed), implying that we can't win:, but perhaps we can break even.

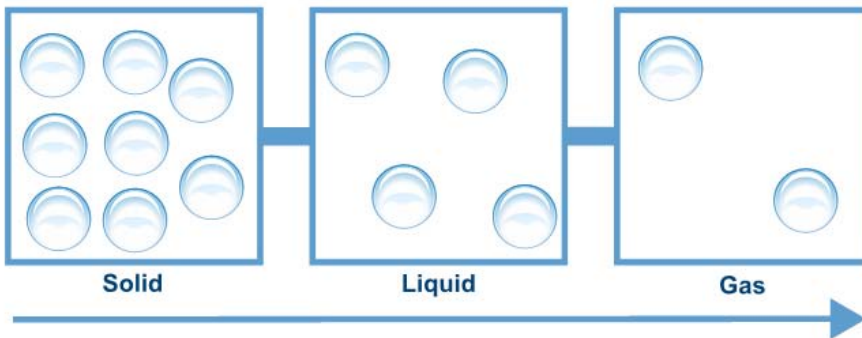
### Second Law of Thermodynamics:

Total entropy (randomness) in the universe is increasing, implying that we can't even, break even.



## Entropy

The 2nd law of Thermodynamics, refers to entropy, with particular reference to the sub-atomic level, which relates to the broad concept that all change is the collapse of energy and matter into disorder. Such tendency of matter to move inexorably toward increased entropy, is illustrated below.



## Organisms vs. Machines

<b>Systemic</b>	<b>Mechanical</b>
Non-linear	Linear
Organic	Mechanistic
Interrelationships	Objects
Chaos	Clock
Open	Closed
Dynamic	Static
Fluid	Rigid
Adaptive	Bounded
Complex	Simple
Quantum	Newtonian

**Question:** How can you hold a hundred tons of water in the air with no visible means of support?

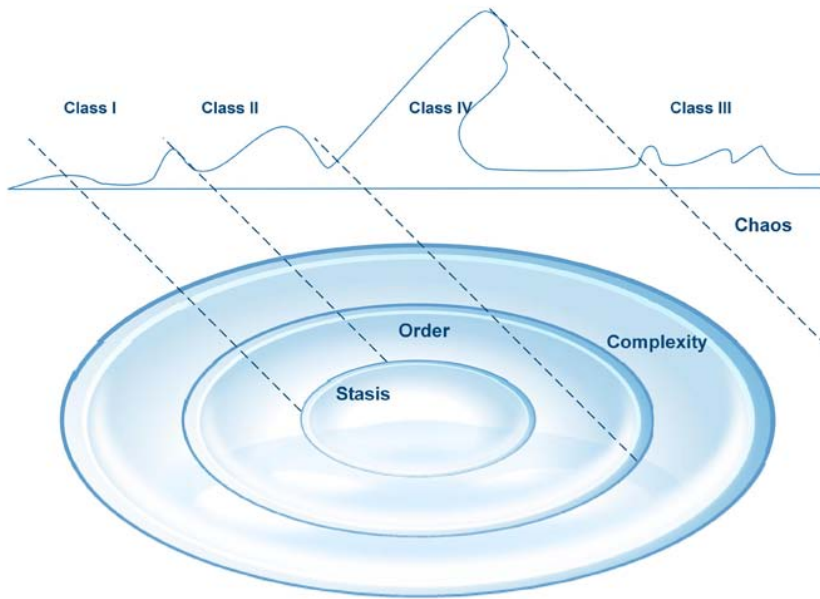
**Answer:** By building a cloud

## Chaos Theory

- The scientific study of various attempts to uncover the statistical regularity hidden in processes that otherwise appear random, (e.g., turbulence in liquid flow; weather patterns; predator-prey cycles; spread of disease; onset of war).
- Systems described as "chaotic" are extremely susceptible to changes in initial conditions, i.e., small uncertainties in measurement are magnified over time (small changes can have large effects), making chaotic systems predictable in principle but unpredictable in practice, thus the "butterfly effect".
- Chaos refers to an apparent lack of order in a system that nevertheless obeys particular laws or rules.

- Systems - no matter how complex - rely upon an underlying order

The example below, using a wave as an example, helps to put into perspective, the different classes of complex adaptive systems. The fourth class, as brought to light by Chris Langton, being that of a complex system. Key to note is that the 4th class lies between the 2nd and 3rd classes of the systems categorisation (between order and chaos). This is often referred to as the Edge of Chaos (EOC), where learning and qualities of adaptation are the greatest.



## Chaos & Complexity

- Human, society, our social structures and organisations operate from some of the following core beliefs:
  - The universe is living, creative, and continually experimenting. Life’s natural tendency is to organise. Life is self-organising. Life is always an act of creating an identity. People are intelligent, creative, adaptive, self-organizing, and meaning-seeking. Organisations are living systems, with these same attributes.
- Chaos & Complexity seeks to:
  - Emphasise the interconnectedness of everything;
  - Connectedness generates order from disorder;

**Complexity and Ecosystem parallels**  
(adapted from the work by Arthur Battram, "Navigating complexity")

The Concept	The Traditional View	Ecosystem View
Boundries	Boundries are everywhere and considered a given both externally and internally	Boundries are variable, a matter of choice and perspective (sub-system under review)
Primary Unit	Reference to the industry, market or segmant	Connectedness and interrelatedness of the business ecosystem
Economic performance	Internal management and the average profitability of the industry	How well and robust are the relationships and alliances in the system
Central concern and primary objective	Individual and company specific growth	Continuous development and positioning in the economic network
Cooperation	Mostly limited to direct suppliers and VIP customers	All stakeholders in the system are important (butterfly effect)
Competition	Cut throat competitions between companies and products	Leadership within and between ecosystems

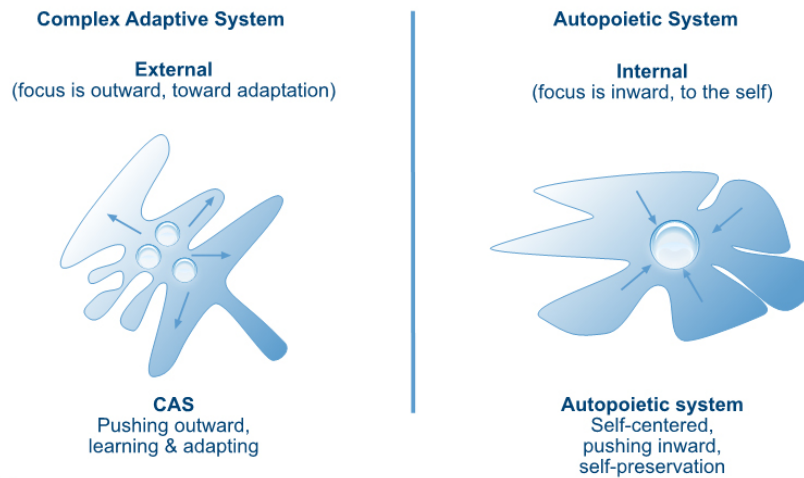


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# Quantum Mechanics

## CAS vs. Autopoietic system

These two diagrams highlight the essential difference between a complex adaptive system and that of an autopoietic system. The CAS being orientated toward learning and adaptation, whereas the autopoietic system tends to have an inward focus, i.e. self-preservation.



- Quantum theory suggests that our make-up is of a more connected nature;
- There are fields of energy flooding the entire universe, and are responsible for "action-at-a-distance" (Wheatly). Scientists now believe that these fields of energy contain all the information that has ever existed, exists now, or will ever exist in the future;
- This data is available and influences our lives daily (i.e., we are "always online" to God, nature, and the universe);
- At the sub-atomic level of the universe, and thus our core make-up, the physical nature of the universe is a dance of energy (String theory, M-theory, etc);
- We are made up of the same light and energy as the electro-magnetic fields that permeate space and all of creation. Therefore, as a part of this celestial dance, we can have access to nature's wealth of information, and we can be influenced by it;
- If we can be influenced by this vast database of energy and knowledge, can we tap into this cosmic database and perhaps even influence it as well? The implication for our social structures & Leadership
- The implications are vast, yet most of us ask, What does nature, the cosmos and the untapped capabilities of people mean to both the individual, and the organisation? Our desire for equilibrium or balance is one of our key contradictions - i.e. we continuously seek to have some form of balance, and equilibrium as it provides us with a sense of "certainty"
- Yet, both of these aspects (equilibrium & certainty) is a contradiction to the most cutting edge scientific findings.
- Complex systems operate at their best in a band called the "edge of chaos" (EOC), this is where there is neither total anarchy, nor equilibrium. It represents systems at their most robust, agile and adaptive behaviour. Complex systems are best managed from the bottom up. However, today we still have top-down command and control management styles, which are complicated, inefficient, & problematic.

- We must appreciate the tremendous individual human potential in the workplace. There must be a place at the corporate table for all employees, regardless of physical characteristics or role or position in the corporate hierarchy.

Characteristics of:

<b>Successful Organisations</b>	<b>Learning Organisations</b>
Self-organising or self-renewing	Respond to environmental changes
Adaptive	Tolerate stress
Flexible to internal and external change	Compete effectively
Feedback loops (reflection, awareness)	Exploit new ideas & innovate
Globally stable with local fluctuations	Embrace change
Open system	Develop symbiotic relationships
Self-referential	Evolve

## Organisations = Self

- Portfolio of skills as opposed to portfolio of business units
- Many levels of autonomy as opposed to control-centric hierarchies
- Need strong competency, identity, and vision
- Strong frame of reference (Self-referent)
- Capacity to innovate based upon lessons and learning from environment
- Strong relationship to environment - as matures, more efficient, more adaptive
- Controlled chaotic forces organisation to seek new points of view
- Organisations and their environments are evolving simultaneously toward better fitness for each other.

System in focus (in complex adaptive systems), can be explained by this diagram. Each aspect or component, being a system on its own - the "system-in-focus". Each of these systems, may however fit into a higher level system. The example uses a city at the higher level of recursion, with the buildings forming a sub-system to the city system. In turn, the building has groups of people as a sub-system of its architecture. In turn, the groups of people are constituted of individuals (sub-system of group). We can take the sub-systems to lower levels still (cellular level of individuals). Alternatively, we could go to a higher level systems, say from a city, to a province, a region, a country, a trade bloc, a continent, the planet, the solar system, the galaxy, etc...

