

## Complexity science

Complexity science is a new approach or method to science that has arisen over the past few decades to present an alternative paradigm to our standard method of scientific enquiry. To give it context let's start by talking a bit about our traditional approach to scientific research.

We can loosely define science as a type of enquiry into the world around us, as opposed to other areas such as art or religion that are based upon aesthetics or revelation, the scientific method of enquiry claims to be based upon empirical data, otherwise known as facts.

The beginning of the modern era, a proximately 500 hundred years ago, saw the development of a systematic and coherent framework for conducting this scientific process. This framework became clearly formulated with the work of Sir Isaac Newton, and thus Newtonian physics became an example or paradigm of how modern science should be conducted.

The Newtonian paradigm is a whole way of seeing the world that describing phenomena as the product of linear cause and effect interactions between isolated objects that are determined by mathematical laws, this vision of the things results in a very mechanical world sometimes called the clock world universe.

This new paradigm in turn gave rise to a new method of enquiry called reductionism. Reductionism is the process of breaking down complex phenomena into simple components that can be modeled using linear equations. by then reassemble these individual components we can understand the whole system as simply the sum of its individual parts.

Having been phenomenally successful within physics this framework for modern science has gone on over the century to be applied to almost all areas of enquiry from biology to engineering and business management, placing it at the heart of our modern understanding of the world.

It is only during the 20<sup>th</sup> century that this approach to science began to be called into question as the revolutions of quantum physics and relativity showed some of its most basic assumption about time, space and causality to be flawed. Whilst later in the century chaos theory began to open up a new world of non-linear systems.

Outside of science the world has also become very different from the one Newton lived in as globalization, information technology and sustainability present us with the new challenges of understanding, designing and managing systems that are highly interconnected, interdependent and non-linear, that we can now call complex systems.

This is where complexity science comes in to provide us with an alternative scientific method better suited to researching these complex system, supported by a paradigm that sees the world as a set of interconnected elements whose interaction give rise to the patterns and phenomena that we observe in the world around us.

As opposed to traditional science that tries to eliminate complexity by studying the individual component of a system within an isolated environment. Complexity science places a greater emphasis upon open system that is understand systems within the complex of relations that give it context.

Where as traditional reductionist science primarily uses linear mathematical models and equations as its theoretical foundation, complexity science uses the concepts of complexity theory, such as self organization, network theory, adaptive and evolution.

This new theoretical framework is combined with new methods such as agent based modeling. As opposed to describing the phenomena we observe in terms of the laws of nature encode in equations, agent based modeling takes a more bottom up approach describe them as the emergent phenomena of local level interaction of agents governed by simple rules.

Complexity science studies the complex systems in our world that have previously fallen between the gaps of modern science, such as financial networks, cities, ecosystems and social networks, studying these large complex systems typically requires significant amounts of data.

Thus what the microscope, telescope and laboratory were for modern science, computation and data are to complexity science, which relies heavily on computer simulations and analysis of the mass of rich and diverse data that information technology, has provided us with.

In a time when science has become highly specialized and focused upon extreme scales from the big bang to little strings, complexity science is providing a fresh perspective for refocusing on the every day world in front of us and helping to bridge the traditional divides between sciences.

In so doing it is helping us expand our scientific body of knowledge to make it richer more inclusive and proving particularly relevant as a new methods for providing the knowledge needed to tackle some of the core challenges we face at the turn of the 21<sup>st</sup> century