Chaos and Catastrophe

David Peat

A new optimism

As a young student I was always interested in big ideas and one day was taken to one side by an older and wiser scientist who advised me to find a niche in a small field and publish a series of papers on that niche. "Then when you have established your reputation you can begin to investigate wider ideas". Clearly he felt I should adopt the same attitude as my colleagues and not wander off to think about fundamental questions of physics.

At that time I was part of a research group who were making theoretical investigations of the various properties of metals and other solids. In other words, "solid state physics". The general approach was to investigate, for example, the vibrations of a crystal lattice, by adding together a series of tiny corrections, a method known as perturbation theory. Its origins stretched back to the mechanics of Isaac Newton, who had shown that while it was possible to find an exact solution to a two body problem - the earth's orbit around the sun, for example, it was not possible to do the same for the system of sun, earth and moon. Instead astronomers had to add in corrections for the moon's effect on the earth's orbit around the sun – in other words, its perturbations of the earth's orbit. The same principle applied in many other fields, including solid state physics: solve the basic system and then add a series of corrections.

Most of my colleagues were happy to do this, because it fitted so well into the sociology of science and the advice that had already been given to me – find a field and publish papers in that field, each one being a variant of the one that had gone before. In this way one's publication list grows and becomes the royal road to tenure and promotion. On rare occasions, a voice of caution was raised by one of my colleagues, who pointed out that in principle, the number of corrections could be infinite and while in arithmetic most infinite series converge to a finite answer, on occasions they diverge to infinity. Could the same thing happen in perturbation theory? But this was not the sort of caution people liked to hear and the objection was generally laughed away.

Then, towards the end of the 1960s, disaster struck, as we learned about the work of Rene Thom in Paris and what became known as "catastrophe theory". In other words, while most systems are well behaved, there are some in which a tiny change, a small correction, can blow up into radically different behaviour: what Thom called a catastrophe. From that point on, the face of physics changed rapidly and suddenly chaos theory, with its attendant branches of fractals, complexity theory, self-organization, butterfly effects and strange attractors was upon us. Our world had changed in such a radical way, that it brought a dramatic new meaning to the advice Einstein had once given to the young Heisenberg, "it is the theory which suggests the observables".

Science is a way of seeing the world; it brings some aspects of nature into sharp focus and causes us to ignore others. It could be compared to the green spectacles given to Dorothy when she entered the Emerald City in the land of Oz. Suddenly everything appeared green to Dorothy. Likewise for decades, physicists had been given a set of tools that enabled them to make calculations about systems close to equilibrium, in balance and subject to slow and gentle changes. In turn, experimentalists would also study such systems and confirm a theoretician's prediction, and so a whole community of scientists could get on with their job of publishing papers and writing books. Other systems certainly existed – such as shock waves, violent changes, and systems far from equilibrium, but they tended to be ignored or dismissed.

But then a combination of new mathematical techniques and the development of computers capable of making more advanced calculations suddenly opened up a vast new field. Suddenly self-organization, fractals, order out of chaos and bifurcations were everywhere to be seen. Science had encountered a brave new world. What was of particular importance was that it introduced a new set of principles that could be applied over a wide range of subjects that went far beyond the confines of conventional physics and chemistry: to living systems, social behaviour, ecologies and economic systems. A curious side effect of this new burst of interest is

the way in which in the United States, so many of the top graduates in mathematics and theoretical physics chose not to enter academia, but the stock market, where their skills could be applied to creating mathematical models of stock fluctuations which are now recognized as exhibiting fractal self-similarity. A parody of this situation can be seen in Darren Aronofsky's 1998 film *Pi* in which the protagonist, believing that the entire cosmos is described by numbers, seeks to discover its underlying secrets by studying the fluctuations of the stock market.

I feel that there are two important lessons to be learned from this scientific revolution. One, as we have seen, was first pointed out by Einstein that "the theory suggests the observables". In other words that science does not proceed according to the common assumption that observations are made, data collected and hypotheses made, which are later turned into theories. But instead that a theory, or more generally a paradigm, causes science to look in particular directions in which to gather its data and formulate its theories. Moreover, science itself is not a totally objective exercise, but the result of certain social concerns. Take for example, one of the steps in the development of the second law of thermodynamics. Following the French Revolution, French engineers realised that their nation had fallen behind the British in the development of machines. It fell to people such as Sadi Carnot to attempt to make more efficient engines, but they soon discovered that there was a limit to the efficiency of converting heat into work, since some of this heat is always dissipated. In this way Carnot came to an understanding of the nature of entropy and the limitations inherent in converting heat into work. The Second Law of Thermodynamics therefore arose out of social concerns of the time. To what extent is the direction of some areas of present day science an expression of current social values and norms? Another lesson is that our new understanding of self-correcting and sustainable ecological systems can lead to guidelines for healthy ethical behaviour in social and economic systems.

a) Transparency and Openness

Self-organized systems survive because of their feedback loops. Positive feedback allows the market to foster innovation; negative feedback protects that which has been established. It is therefore vital that information and meaning should flow through the system and not become blocked. This means transparent accounting, open declarations of intent and action, and coherence between a corporation's public image and ethical statement and its internal culture of trust and respect for others. What is more, each individual corporation has an obligation to foster the health of the system as a whole.

b) Respect for Competition

Natural systems flourish because of their inherent diversity. If any one species begins to dominate then the flexibility of the environment declines. Likewise in a business environment, competition is necessary to keep the entire ecosystem flexible, so that goods, money and information can flow through the system's feedback loops.

c) **The Role of Redundancy**

Natural systems achieve their ends in a number of different ways, which at face value does not appear particularly efficient. However when situations change, or damage occurs to part of a system, redundancy means that it can continue to function. Likewise it is important to accept a level of redundancy in a corporation, for maximizing efficiency could make that business over-rigid and incapable of making quick adjustments when the market changes.

d) Accepting Uncertainty

Uncertainty and limits to control are facts of life that must be accepted within any non-linear system. There will always be a degree of "missing information" which at times may make us uncomfortable. Likewise we may not always be able to control what occurs around us. It is important for us to decide if we are going to view this in terms of insecurity and lack of control, or as doorways into new possibilities and relationships.

The Pari Center for New Learning

In 1996 ***David Peat*** and Maureen Doolan moved from Canada to the medieval hilltop village of Pari, some 25 km south of Siena, Tuscany. The village and surrounding area was particularly beautiful and the people welcoming, so Pari seemed an ideal place from which to write and think. On the other hand, the village was uncertain of its future. When once it had a population of one thousand, during the 1950s and 60s people began to leave to find work in cities and now there were fewer than two hundred people in the village and the Palazzo, the public building at the top of the village, had been abandoned.
I (David Peat) have always enjoyed discussions with artists in the UK and North America and in 1999 the Arts Council of England invited me to host a weekend encounter between artists and scientists. The meeting was a great success with new works such as Antony Gormley's "Quantum Cloud" emerging out of the discussions. Word began to circulate and I was asked to run a similar meeting on the role of universities. At first I assumed that this should take place in London or New York, but after the ground floor of the Palazzo had been refurbished, I approached the president of the Pari village association and asked if the meeting could be held in Pari.

While conclusions about the present role of the universities was rather bleak, the participants did comment on how much better it felt to meet in a small village than in an anonymous hotel in a large city. They also experienced the great warmth of being fed in the village hall with food cooked by the local women. While they agreed that the universities were certainly here to stay, they saw a need for alternative academies and suggested that Pari was an ideal location for such an academy. Feedback also came from the local people who said how much they had enjoyed seeing new faces. They asked us to organize other meetings, and so the Pari Center for New Learning was born. Over the years we have held conferences on such topics as Business and Ethics, the future of knowledge in the world of the Internet, the dialogue between religion and science, and the life and work of David Bohm. Thanks to support from the Metanexus Institute we also ran a series of talks in Italian for people from Pari and the surrounding villages, on the relationship between religion and science. We were three time winners of the Metanexus Prize for excellence of programming.

In addition to our conferences, we offer three residential courses a year on "New Paradigms, New Science", "Synchronicity: the Bridge between Matter and Mind" and "Art, Science and the Sacred". We also have a visitors program where people come to study, work on a book, engage in an art project or compose music. The Center's website contains a series of "Basic Books in Science and Mathematics" which are free to download and which provide a complete education in science up to university entry level for students living in the Third World. The Center is also bringing out a series of "Pari Dialogues" through Pari Publishing. Volume 1 looks at Science, Religion, Society and the Arts. Volume 2 will explore the relationships between "Traditional Knowledge and Western Scientific Knowledge".

The Center and the village are very much engaged in a win-win situation. Visitors and participants can rent empty furnished houses owned by people in the village, buy provisions in the local shop, have a coffee in the bar and eat at the local restaurants. In return the Center has the use of the Palazzo where its conference room, coffee room, library and office are located.***www.paricenter.com*** . A discussion of David Peat's notion of Gentle Action can be found at ***www.gentleaction.org***

In September 2009, the Center ran a conference/workshop whose theme was ostensibly to explore what the world may look like in 50 or 100 years and how businesses could contribute to a sustainable future. However by the second day the discussion had become much more general and participants, mainly from the world of business, noted that the Center provided a safe container, almost an alchemical vessel, in which new ideas were being generated. The notion of Pari Dialogues was proposed – that the Center should invite an organization or business that faced particular issues to send representatives to Pari where they would meet with Pari Dialoguers to explore new and creative pathways and solutions. We would invite any organization that would like to participate in a Pari Dialogue to write to ***info@paricenter.com***