



Science for Survival and Sustainable Development



Study Week 12-16 March 1999 – "Men and Women have at their disposal an array of resources for generating greater knowledge of truth so that their lives may be even more human" (*Fides et Ratio*, 'Know Yourself', § 5). In this spirit the Pontifical Academy of Sciences organised a study-week on the subject of *Science for survival and sustainable development* from 12-16 March of this year. In addressing itself to how to use the many resources of modern knowledge, the Academy paid especial attention to those rooted in non-linear dynamics - the science of chaos and self-organisation. This branch of learning now finds itself on the very frontiers of basic research. It is a discipline which studies chaotic systems of interacting elements (entities) which overcome their own complexity and organise themselves into strange, counter-intuitive but clearly recognisable behaviour patterns, much like those to be found in the fascinating configurations made by a waterfall or a log fire. These patterns sometimes culminate in abrupt overall changes which may be termed "critical phenomena".

The science of chaos and self-organisation originated about a hundred years ago. Like other forms of basic research, it was driven forward in the first instance by the human thirst for pure knowledge. However, sharing the common destiny of basic research, this branch of science eventually acquired a paramount practical importance. This is because a critical phenomenon in some chaotic systems may unleash the fury of the elements and industrial and socio-economic disasters.

Without always being aware of the fact, it can be said that we are surrounded by chaotic systems: the earth's crust with its millions of billions of billions of grains of rock which self-organise from time to time into a devastating earthquake; a megalopolis on its way to self-destruction; a socio-economic system prone to an outburst of mass violence or economic collapse, etc. Our world becomes more and more vulnerable to such disasters which are always on the horizon and still take us by surprise. They may take place at any moment, even while you are reading this article: causing up to a million casualties, rendering a large part of our world uninhabitable, triggering global economic depression, or sparking off a war in a "hot" region. As threats to the survival of our civilisation, such disasters are commonly placed on the same level as nuclear war.

Of equal importance is the question of the sustainability of our world over the next decades. Our planet is threatened by a multitude of interacting processes - the depletion of natural resources; climatic changes; population growth (from 2.5 billion people to over 6 billion over the last 50 years); a rapidly growing disparity in the quality of life; the destabilisation of the ecological economy; and the disruption of social order. In addition, each country has become vulnerable to the developments which take place in other parts of the global village, which are, of course, outside its own individual control.

Human society is increasingly recognising these threats. Throughout the world huge resources, indeed hundreds of billions of U.S. dollars, are being spent annually to counteract them. While these efforts are to be praised because they prevent a part of the potential damage, it is nonetheless the case that on the whole these initiatives have reached a kind of stalemate - the destabilising factors now prevail and the scale of possible catastrophes is increasing rapidly.

The study-week focused on the question: how can we use our knowledge of chaos and self-organisation to understand, predict and control such developments? To this end, the Academy brought together experts from the fields of mathematics and theoretical physics who study the general properties of chaotic systems, in addition to experts on a wide range of specific kinds of crises and disasters. The synergy of these fields of expertise has been highly successful in the past and the study-week explored further applications of such a joint-approach. Discussion took place on the moral, ethical and spiritual dimensions of proposed scientific initiatives and their implementation at the level of public policy. Altogether thirty-five world famous experts were brought together, representing the natural sciences, the social sciences, epistemology, and public policy. They came from the countries of the West and the East, and from the North and the South of the globe. Probably never before had such a variety of expertise been brought together for the purposes of a professional brainstorming discussion which was unconstrained by formal limitations. It focused on what can be done rather than simply drawing attention to the growing threats with which we are now faced.

In examining the problems of sustainability over the next decades, the study-week discussed such subjects as the shortfalls in global food supply; the deterioration of bio-diversity; the possible lack of response of the global village to the inevitable changes in the environment; the inefficient use of water resources; climatic changes; the economic burden of nuclear armament; and the threats and opportunities generated by the globalisation of the economy.

The study-week discussed a range of "instant" critical phenomena and addressed itself in particular to geological and geotechnical disasters and to the globally co-ordinated prediction of major earthquakes; socio-economic collapse in urban areas; political and economic crises, and their prediction; the outbreak of nuclear war; the use of electromagnetic terrorism and its threat to modern systems of communication and control; the self-organisation of clusters of neurons and how this may help us to construct a rather general new approach to the control of critical phenomena; and the dangerous deficiencies in decision-making caused by greed and ignorance. In the search for a potential contribution by non-linear science to these problems, the meeting discussed scenarios of transition to a critical phenomenon. Such scenarios emerge when a chaotic process is examined at a not too detailed level (in the way that an oil painting cannot be understood through a microscope). They happen to be partly 'universal' and this is something which is shared by somewhat differing processes. The mathematical modelling of such scenarios opens up the possibility of predicting critical phenomena and may even supply the key to how to control them.

The work in this field requires high level professionals and the question of the education and training of experts is thus of crucial importance. For this reason the meeting discussed the very successful achievements in such training which has been obtained by the Abdus Salam International Centre for Theoretical Physics in Trieste.

On the positive side, the study-week may be seen as an attempt to reduce the Babel fragmentation which has taken place in the study of critical phenomena, more commonly known as disasters, catastrophes and crises. It outlined the common features of different critical phenomena and discussed commentary on each of them. It was also observed that in some cases it is possible to identify the future possible scale of a catastrophe as it approaches. In the case of many critical phenomena the work of the study-week amounted to a continuation of existing debate because a great deal of synergy in this field already exists. However, the meeting also identified the areas where the resources offered by non-linear dynamics have not as yet been exploited and stressed that certain groups of experts and scholars have not yet entered into dialogue. This may include the study of scenarios of transition to unsustainability and of specific ways of responding to it. Such a study may help to overcome a lack of interest in this question, something which was criticised by several speakers.

The step from many kinds of actual experience to a physical model is not easy, and the transition from a metaphor to an algorithm is always very difficult. The synergy between observations on specific disasters and their general theory is neither a panacea nor an easy task. And the transition from a physical model which describes actual phenomena to knowledge which in a certain way is able to foresee or even predict them is even more difficult, and this is especially the case when one is dealing with human matters. Still, these new co-ordinated approaches provide hope that we may find as yet unexplored possibilities by which to overcome the present stalemate which exists in relation to how to face up to the many threats to our civilisation. This synergy probably reflects the paradigm formulated in *Fides et Ratio*: "human reason a capacity which seems almost to surpass its natural limitations. Not only is it not restricted to sensory knowledge, from the moment that it can reflect critically upon the data of the senses, but, by discoursing on the data provided by the senses, reason can reach the cause which lies at the origin of all perceptible reality" (§22).

In this way the human being becomes the vicar of God on earth within the advance of the creation in relation to the beings of nature from which he derives - and always with new methods - the means for survival and the achievement of growth and development, and this even in situations which are critical or apparently no longer sustainable. The immense range of the celestial bodies which pierce the firmaments - the sun, the moon, the stars, the galaxies, the comets - and the universal cosmic forces to be found on the earth, all have their laws

which man must not change but which he must try to explore with his mind and employ for the purposes of his own survival and the attainment of growth and development. Therefore we should engage neither in the Cassandra-like announcement of future catastrophes nor in an irresponsible optimism. Today, in the face of the global complexity of our contemporary context, the human being, more than ever before, is called upon to find that right kind of rationality (orthòs logos) which will achieve survival and sustainability through the application of new and well deployed practical criteria. For this reason, however limited the action of man within the cosmos may actually be, he is nonetheless a real participant in the power of God and must be able to build his own world, or rather an environment suited to his person integrated into his own space and his own special time.

V.I. Keilis Borok

M. Sánchez Sorondo

Participants

Prof. Werner Arber

Dr. Wallace S. Broecker

Prof. Luis A. Caffarelli

Prof. Nicola Cabibbo

Prof. Bernardo M. Colombo

Prof. Partha S. Dasgupta

Prof. Jeff Dozier

H.E. Msgr. Agostino Ferrari-Toniolo

Prof. Vladimir E. Fortov

Dr. Uriel Frisch

Prof. Michael Ghil

Dr. Peter H. Gleick

Prof. José Luis Gotor

Prof. Raymond Hide

Dr. Calestous Juma

Prof. Vladimir I. Keilis-Borok

Prof. Joel L. Lebowitz

H.E. Msgr. James T. McHugh

Prof. Benoit B. Mandelbrot

Sir Robert M. May

Dr. Rajul Pandya-Lorch

Prof. Wolfgang K.H. Panofsky

Prof. M. Elisabeth Paté-Cornell

Prof. Crodowaldo Pavan

Prof. Luciano Pietronero

Msgr. Tullio Poli

Prof. Alberto Quadrio Curzio

Prof. Mikhail I. Rabinovich

Dr. Peter H. Raven

Dr. Andrew W. Reynolds

Prof. Andrea Rinaldo

Prof. Giorgio Salvini

Msgr. Prof. Marcelo Sánchez Sorondo

Dr. Yukio Sato

Prof. Gaston G.S. Schaber

