Steps Towards an Evolutionary Physics

The Sustainable World

Aims and Objectives

Sustainability is a key concept of 21st century planning in that it broadly determines the ability of the current generation to use resources and live a lifestyle without compromising the ability of future generations to do the same. Sustainability affects our environment, economics, security, resources, health, economics, transport and information decisions strategy. It also encompasses decision making, from the highest administrative office, to the basic community level. It is planned that this Book Series will cover many of these aspects across a range of topical fields for the greater appreciation and understanding of all those involved in researching or implementing sustainability projects in their field of work.

Topics

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Data Mining Methodologies
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Waste Management
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PREFACE

by Sven Jørgensen

If we, in a few words, give information about the new world picture that has been presented by modern physics during the 20th century we could apply the following three statements.

(1) Everything is relative (Einstein).
(2) Everything is uncertain (Niels Bohr, Heisenberg and Schrödinger) (alternative formulation "God does play dice").
(3) Everything is irreversible (Prigogine).

All three statements have contributed to a completely new perception of the universe, its development and its underlying processes.

The third statement has received less attention in society than the two others; but it has actually changed our world picture may be even more than statements number (1) and (2). As pointed out by Ilya Prigogine, although quantum mechanics and general relativity are revolutionary, they are still descendants of classical dynamics and carry radical negation of the irreversibility of time. Time, biological development, the evolution of the universe, and history can only continue in one direction and they do play dice. We understand now that irreversibility is an absolute prerequisite for the development of ecosystems, the history and the entire evolution. The world is so dynamic and so complex that the same conditions will never occur again, but new possibilities can emerge from the present conditions due to the irreversibility principle.

Enzo Tiezzi's book "Steps Towards an Evolutionary Physics" considers all the three statements in his description of the new world picture, but with a particular focus on irreversibility. The book builds to a great extent on Prigogine's work; but Enzo Tiezzi "has moved further away from thermodynamic equilibrium" by considering the evolution and the biological core process of "growth". Moreover, he has taken a holistic view: focused on the entire evolutionary process and not on the single steps. He has attempted to see the forest through the trees.

As did Prigogine, Enzo Tiezzi is using entropy as the core thermodynamic variable. Entropy *can* be used to describe systems far from thermodynamic equilibrium, provided that it is applied as a non-state function. *Free energy and entropy are not state functions when applied on living organisms or ecosystems*. At death, the organisms lose momentarily a major part of their free energy (eco-exergy) and produce an enormous amount of entropy (Schrödinger would say that they lose negentropy), because the free energy of the information embodied in the genes are no longer applicable. Death is, however, a very important feature for systems very far from thermodynamic equilibrium, because without death, the important elements will not be recycled and evolution would stop due to lack of carbon, nitrogen, phosphorus, sulphur and so on, the elements that are needed for construction of life. Death is a prerequisite for life!

Evolution has been described many times in the literature by giving details about the present species and their ancestors and their ancestor's ancestors and so on, represented as fossils. The evolutionary literature also contains a presentation of the development of the genomes, the selection processes and the steadily changing life conditions, including changes in climate. Enzo Tiezzi's description is in contrast to this reductionistic description of evolution. Superholistic, he describes the mechanism behind evolution – not the steps or single processes – and the natural laws controlling and governing evolution. The mechanism is that an energy flow through a system inevitably will be utilized to bring the system further away from thermodynamic equilibrium – for instance, to bring the system from chaos to order (see the Fifth Step of the book). An inflow of energy to a system is both necessary and sufficient to move the system further away from thermodynamic equilibrium. Without energy input, the system will inevitably go towards thermodynamic equilibrium, which means that the system will have no life, no gradients and be dull and homogenous. If there is energy input, on the other hand, the system has to move further away from thermodynamic equilibrium, when the energy needed for maintenance is covered. Furthermore, every step forward in evolution towards the very complex organization that characterizes the last emerging class of organisms, the mammals, builds on the previously achieved order and organization. Life is only possible if it does not start from zero for every new generation. A mechanism to store the information gained is needed – the genes. The prerequisites for life and the evolution of life are therefore an energy flow (which is fortunately provided by the sun) and a system that makes it possible to store information – the genes. Approximately 4 billion years have been available for the many many steps that encompass the entire evolution. The

sun has provided the energy needed for each step to move further away from thermodynamic equilibrium.

The application of physical chemistry or thermodynamics helps us to understand

(1) the processes and development of ecosystems,
(2) the driving force behind evolution,
(3) the self-organizing ability of living nature,
(4) how the energy inflow and the genes work together to make up evolution and
(5) the very conditions determining the origin of life.

Combined, the study of these is called *ecodynamics* by Enzo Tiezzi – a very pertinent designation for this new emerging science. It builds on a holistic world view, thermodynamics and *all* the three statements presented above applied on living nature. Ecodynamics can (and should be able to) explain the diversity of life – the biodiversity, which is rooted in the enormous variability of life conditions in time and space – and the beauties of nature – the colour and pattern of butterflies, the spectacular colour symphony of a temperate forest at fall, the songs of birds at dawn, and many more examples or, as expressed by Enzo Tiezzi in the Sixth Step, the songs and shapes of nature. The enormous variability and beauty of the life forms are a result of Monod's combination of necessity and chance: survival is a "must" if the results (information) already achieved should not be lost, but it is also a question of which organisms are fittest under the steadily changing (randomly) conditions.

What is presented here in the preface is in short the challenges and basic ideas of ecodynamics. I am sure that the reader will find ecodynamics as exciting as I do. So, have a good time with this interesting book about a new emerging science.

Copenhagen, 14th November 2005
Sven Erik Jørgensen