Heylighen, Francis and Joslyn, Cliff: (1995) "Towards a Theory of Meta-System Transitions: Introduction to the Special Issue", World Futures, v. 45:1-4, pp. 1-4, https://doi.org/10.1080/02604027.1995.9972552

Towards a Theory of Metasystem Transitions: Introduction to the SpecialIssue

The Principia Cybernetica Project (PCP) was conceived by Valentin Turchin, and formally founded by him and Cliff Joslyn, in 1989. In 1990, they were joined by Francis Heylighen, to form its present Editorial Board. The project's aim is the collaborative, computer-supported development of a complete cybernetic and evolutionary philosophy (Heylighen, Joslyn & Turchin, 1991;Joslyn, Heylighen & Turchin, 1993; Heylighen & Joslyn, 1993). Its approach is deliberately "meta-cybernetical": applying the tools and methods of cybernetics(in particular, distributed hypertext and active semantic networks) to develop the foundations of cybernetics itself, while integrating cybernetics and systems theory. The resulting philosophical system (Turchin, 1991, 1993) is intended to be a clearly thought out and well-formulated, global "world view", integrating different domains of knowledge. It should provide answers to the basic questions: "Who am I? Where do I come from? Where am I going to?".

This philosophical framework is based on a core idea: the Metasystem Transition (MST). This concept was proposed by Turchin (1977) to describe the process whereby, through variation and natural selection, a new control level emerges, integrating a set of subsystems at the level below. A metasystem transition functions as a "quantum of evolution", a discrete jump to a higher level of complexity. It thus provides a general principle to explain evolutionary "progress" or development.

The major steps in evolution, such as the origin of life, multicellularity, or the origin of thought, can be viewed as large scale metasystem transitions. Thus, the history of life and the universe can be conceptualized as a (branching) sequence of MST's, leading to ever more complex, adaptive, and intelligent systems: from atoms and molecules, to dissipative structures, cells, multicellular organisms, organisms capable of movement or learning, and finally to human culture (as the provisionally highest level). MST Theory (MSTT) can also be used to make predictions about the future, thereby helping us to anticipate the next level of organization to which we are evolving.

The theory of metasystem transitions was first developed in Turchin's book "The Phenomenon of Science: A Cybernetic Approach to Human Evolution" (1977). Some of its applications to social systems were discussed in "The Inertia of Fear and the Scientific Worldview"(1979). The role of the metasystem transition in the foundations of mathematics was outlined in a paper entitled "Constructive Interpretation of the Full Set Theory"(Turchin, 1987). The concept of the metasystem transition has also been applied by Turchin and his colleagues in a

research project on computer program transformation, which is centered around the concepts of the "supercompiler" (Turchin, 1986) and "metacomputation" (see the paper by Glueck and Klimov in this issue).

The first statement of what would become Metasystem Transition Theory in the context of the Principia Cybernetica Project was "The Cybernetic Manifesto" by Turchin and Joslyn (1990). The involvement of Heylighen, together with project activities such as the organization of workshops (Heylighen, 1991b) and symposia, accelerated the theoretical development, resulting in the publication of further papers (Heylighen, 1991a, 1992; Turchin, 1991, 1993a,b). Finally, the project began to take its full form with the development of the theory through electronic collaboration over the Internet, the results of which are maintained on the project's World-Wide Webserver (`http://pespmc1.vub.ac.be/`) (Heylighen & Joslyn, 1993;Heylighen & Bollen, 1995).

We felt it appropriate at this time to bring together the latest ideas about MSTT developed within the Principia Cybernetica Project and a number of related ideas by other researchers. Therefore, we decided to edit a major collection of papers on the theory, with contributions from ourselves as well as from invited authors. *World Futures*, which "is dedicated to the study of general patterns of change and development, in nature as well as society, and to evolutionary processes, with special attention to multidisciplinary approaches", seemed the perfect venue for the publication of a collection on such a wide-ranging subject with essential implications for our evolutionary future.

Although the MST concept has shown its explanatory and unifying ability in many domains, several basic questions about MST Theory remain to be addressed. Furthermore, in parallel with Turchin, other researchers have developed similar schemes for analysing evolutionary levels (without focusing on the process of the emergence of anew level). For example, William Powers (1973) has proposed a hierarchy of control levels, and Donald T. Campbell (1974) has introduced a nested hierarchy of vicarious selectors. Our intention was to start a dialogue among these different approaches, and to move towards resolution of the remaining incompleteness and inconsistencies.

This required the clarification of the basic concepts and principles needed to understand levels of organization (e.g., system, control, constraint, variety, hierarchy, model) and the evolutionary transitions between them (e.g., self-organization, emergence, blind variation, selective retention, and the MST itself). Moreover, we wanted to show some of the applications of MST Theory, such as supercompilation in computer science, and the evolution towards future "cybernetic immortality". Although there is as yet no consensus on many of these

topics, we hope that this collection of papers provides a least a clear overview of the main issues and the different approaches to this fascinating new domain.

The collection starts (appropriately enough) with a paper by Turchin, the originator of the theory. In the form of a dialogue between himself and an imaginary discussant, he outlines the theory, expounds the main philosophical assumptions underlying it, and answers some common objections. The two subsequent papers, by the other editors of this collection, attempt a more formal and systematic analysis of some of the fundamental concepts. Heylighen develops a classification and definition of supersystem, metasystem and metasystem transition (which is in some respects different from Turchin's), and uses it to analyse the most important MST's in the history of evolution. Joslyn then develops some fundamental ideas logically prior to the MST, including the concepts of "system" and "control", the essential role of semantics in control, and the various roles played by "distinction", "constraint", "variety", and other systems theoretical concepts.

Powers opens the series of invited papers by applying ideas from his own Perceptual Control Theory (Powers, 1973) to conceive of a possible, feedback-based scenario for the origin of life, which is also the origin of control systems, and thus a primary MST. Jon Umerez and Alvaro Moreno give an overview of developments in theoretical biology and systems theory parallel to MST Theory, and discuss some difficult philosophical questions about interlevel relations, similarly focusing on the origin of life. Charles François proposes a number of concepts developed outside MST Theory which may help to better understand the MST concept, and discusses the on-going MST in human society as a possible application. Elan Moritz similarly applies MST Theory, in conjunction with memetics (the theory of memes), to discuss the possible evolution of cybernetically immortal "beings". Heylighen and Campbell survey the evolution of social control mechanisms, with the aim of better understanding the patterns of cooperation and competition between selfish individuals, and the MSTs shaping present society. Finally, Robert Glueck and Andrei Klimov review the applications of MST Theory in computer science and mathematics, which are based on the technique of metacomputation: the manipulation of programs (linguistic models) by other (or the same) programs.

The development of this issue has been a long and sometimes tortured process. We would like to extend our sincere thanks to all of the authors, and especially to Vilmos Csanyi of *World Futures*, for their long-suffering patience and endurance: here it is at last, Vilmos! We would also like to thank Johan Bollen for his able and willing assistance in the final production.

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March 1995
Brussels

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