

TRIBUTE TO BRIAN GOODWIN 1931-2009

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Brian Goodwin, the visionary mathematician, biologist, philosopher and teacher, died on 15th July, at the age of 78. Goodwin was not only a founding member of the editorial board of *Cosmos & History*, he was the patron of the *Joseph Needham Centre for Complex Processes Research* from which *Cosmos & History* emerged. He was highly supportive of the research of this group and the aspirations for *Cosmos & History*, but more importantly, his work itself was an inspiration and a symbol of the bold thinking, transcending all disciplinary boundaries, with a passionate concern to augment life, that both the *Joseph Needham Centre for Complex Processes Research* and *Cosmos & History* have sought to promote. Goodwin's vision was summarized in words recently recorded by an MSc student of Holistic Science at Schumacher College:

Nature and Culture are One, Not Two ... The Great Work, the *Magnum Opus*, in which we are now inexorably engaged, is a cultural transformation that will either carry us into a new age on earth or will result in our disappearance from the planet. The choice is in our hands ... This Gaian Renaissance will lead to what Thomas Berry calls the Ecozoic Age, in which all inhabitants of the planet are governed by principles of Earth Jurisprudence in an Earth Democracy. We can all experience lives of meaning and know that indeed there is no truth beyond the magic of creative participation in the life of the cosmos that embodies the liberation of Chaos, the abundance of Gaia, and the love of Eros.

Goodwin was born in Montreal, Canada on 25th March, 1931. While still a teenager he decided to become a scientist in order to answer the question that fascinated him for the rest of his life: What is life? While studying biology at McGill University he began to wonder whether there might be some powerful principles that could account for the diversity of forms in the living world. While doing his Masters degree in plant physiology at McGill he became deeply dissatisfied with the neo-Darwinist interpretation of evolution for its failure to acknowledge the coherence, self-organising power and creativity of organisms. He was awarded a Rhodes

scholarship to Oxford where for three years from 1954 to 1957 he studied mathematics with the goal of grasping the self-organizing principles of the cosmos manifest in the flows of fluids and the forms of crystals and organisms. From Oxford Goodwin went to Edinburgh University to undertake his Ph.D. with Conrad Waddington, one of the founders of the theoretical biology movement in the 1930s.

Waddington was the leading theoretical biologist at the time. His main work was in the field of embryology, but in this he was advancing the work of the theoretical biology movement, continuing the research program of mathematico-physico-chemical morphology developed by Waddington along with Joseph Needham, J.D. Bernal and others at Cambridge in the 1930s. Inspired by the work of D'Arcy Thompson on growth and form and recent developments in theoretical physics, this was a tradition which continued to oppose the increasingly dominant reductionism of the molecular biologists and the proponents of the 'synthetic' theory of evolution with its claim that living organisms are nothing but survival machines for reproducing strings of DNA. This opposition was more than opposition to a scientific theory, however. Along with Needham and Bernal, Waddington had a strong interest in art, education and politics and the philosophical ideas of Alfred North Whitehead. It was a tradition which went beyond science and sought to unite science with the arts and the humanities in a project to transform culture, to overcome Eurocentricism and to create a more humane and more ecologically sustainable social order, nationally and globally. In the late 1960s and early 1970s Waddington organized four major conferences on theoretical biology which brought together not only most of the world's leading theoretical biologists, but also some of the world's leading mathematicians and physicists. The proceedings of these conferences were later published in four influential volumes as *Towards A Theoretical Biology*. Goodwin participated in all four of these conferences and after Waddington's death, continued to uphold not only the tradition of theoretical biology but also the broader vision of the theoretical biology movement.

Goodwin's Ph.D. with Waddington explored the rhythmic, temporal organization of cells leading to their division and to the generation of form. This was published 1963 as *Temporal Organization in Cells: A Dynamic Theory of Cellular Control Processes*. In 1965, after a three year post-doctoral fellowship at the Massachusetts Institute of Technology, he took up the position of Reader in Biology at the University of Sussex. He continued his research on the temporal organization of cells, publishing *Analytical Physiology of Cells and Developing Organisms* in 1976. Encouraged by his dean, John Maynard Smith, Goodwin explored the applicability of his ideas to the developmental dynamics of organisms such as the clawed toad. In collaboration with Gerry Webster, this opened a new phase in Goodwin's research. This work laid the foundations for the process structuralist movement in biology. Major publications of this movement were the anthology edited by J.W. Pollard, *Evolutionary Theory: Paths into the Future*, published in 1984 and the anthology edited by Mae-Wan Ho and Sidney Fox, *Evolutionary Processes and Metaphors*

published in 1988. In contributions to these anthologies Goodwin exposed the lacunae in the reigning orthodoxy in biology and argued that evolutionary theory should be subsumed under a generative paradigm focused on developing a general theory of form generation. In 1987 Goodwin along with Peter Saunders, organized the first Waddington memorial conference on theoretical biology, again in the spirit of Waddington's conferences, bringing together an interdisciplinary group of scientists and mathematicians. The proceedings of this were published as *Theoretical Biology: Epigenetic and Evolutionary Order from Complex Systems* in 1989. Goodwin and Webster published *Form and Transformation: Generative and Relational Principles in Biology* published in 1996, a work which drew attention to the continuity of their work with the work of Goethe. Subsequently, Goodwin wrote a number of pieces praising the open, exploratory and rigorously phenomenological approach to science of Goethe and defended Goethe's contribution to the theory of light.

At the invitation of Steven Rose, in 1984 Goodwin took up a professorship with the Open University where he worked until 1996, working with Rose and also Mae-Wan Ho whose book *The Rainbow and the Worm: The Physics of Organisms* (recently republished in its third edition) was written at the instigation of Goodwin. Goodwin said to Ho: 'Why don't you write a book on what is life?' and Ho thought 'why not?' Goodwin continued his research into the principles of organization which could account for the forms of life. With L.E.H. Trainor and C. Brière he developed a highly influential model that elegantly simulated the whorl formation in *Acetabularia*, showing the influence of calcium ions on the properties of the cell. This justified his claim that the most important features of life can be accounted for through the dynamics generating form rather than through natural selection of variants. Goodwin's work with *Acetabularia* also revealed the irreducibility of form generation to DNA. Working with Ricard Solé and Octavio Miramontes, Goodwin developed another mathematical model showing how rhythmical activity emerges in a model ant colony when individually chaotic ants interact with each other at a specific density.

During this period Goodwin also began a close association with the Santa Fe Institute and its research into complex systems. Goodwin's own work had influenced Stuart Kauffman, with whom he formed a life-long friendship. Now he was enthralled with the notion developed by Chris Langton and Kauffman that organisms live at the edge of chaos where, in the words of his colleague Mae-Wan Ho, there is 'maximum freedom to the individual with maximum coherence to the whole.' At the Santa Fe Institute, Goodwin argued that complexity theory leads beyond disciplinary science. 'We all grow up in particular disciplines' Goodwin averred, 'But really, what complexity is moving towards is a nondisciplinary, integrated science which actually goes beyond science. It goes right into the so-called social sciences, and now I think that it goes into the arts as well.' The results of his work in this area were published in two books, *How the Leopard Changed Its Spots: The Evolution of Complexity*, published in 1994, and with Ricard Solé, *Signs of Life: How Complexity Pervades Biology*, published in 2004.

In 1996 Goodwin moved to Schumacher College. In 1998, together with Stephen Harding, he began the world's first M.Sc. in Holistic Science, accredited by the University of Plymouth. At Schumacher Goodwin, along with his colleagues, developed a science of qualities in order to help shift the emphasis in culture from control towards participation with nature and attempted to overcome the split between facts and values, quantities and qualities. With the mathematician Philip Franses, Goodwin developed a model of the genome as a text riddled with ambiguity that can be read in a variety of ways by the rest of the cell, conceived as an active subject. While at Schumacher College Goodwin became increasingly concerned with efforts to overcome the looming ecological crisis, embracing the call of his friend Vandana Shiva to create an Earth democracy. The ideas he was working on in his later years at Schumacher were published in Goodwin's last book, *Nature's Due: Healing Our Fragmented Culture*, published in 2007. In the concluding section of this book, he wrote 'The Great Work, the *Magnum Opus* in which we are now inexorably engaged, is a cultural transformation that will either carry us into a new age on earth or will result in our disappearance from the planet. The choice is in our hands. I am optimistic that we can go through the transition as an expression of the continually creative emergence of organic form that is the essence of the living process in which we participate.'

This, essentially, is the project that we must all embrace.