Chapter 7
The Biotic Logic of Quantum Processes and Quantum Computation[1]

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ABSTRACT

This chapter explores how the logic of physical and biological processes may be employed in the design and programing of computers. Quantum processes do not follow Boolean logic; the development of quantum computers requires the formulation of an appropriate logic. While in Boolean logic, entities are static, opposites exclude each other, and change is not creative, natural processes involve action, opposition, and creativity. Creativity is detected by changes in pattern, diversification, and novelty. Causally-generated creative patterns (Bios) are found in numerous processes at all levels of organization: recordings of presumed gravitational waves, the distribution of galaxies and quasars, population dynamics, cardiac rhythms, economic data, and music. Quantum processes show biotic patterns. Bios is generated by mathematical equations that involve action, bipolar opposition, and continuous transformation. These features are present in physical and human processes. They are abstracted by lattice, algebras, and topology, the three mother structures of mathematics, which may then be considered as dynamic logic. Quantum processes as described by the Schrödinger's equation involve action, coexisting and interacting opposites, and the causal creation of novelty, diversity, complexity and low entropy. In addition to 'economic' (not entropy producing) reversible gates (the current goal in the design of quantum gates), irreversible, entropy generating, gates may contribute to quantum computation, because quantum measurements, as well as creation and decay, are irreversible processes.

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INTRODUCTION

Quantum gates and circuits may provide an opportunity to incorporate the pattern of quantum processes into the logical structure of the computer, and thereby employ rules for reasoning that take into account the pattern of quantum processes as well as that of many other natural processes.

This article explores the possibility for a logical design of computers that matches the logic inherent in natural processes. There are natural creative processes that are evident in biological organisms and also found in physical processes, including quantum ones. These biotic processes could become the basis for the working of a machine. We speculate on the possibility of harnessing these biotic processes for computation. Such logic would be natural and empirically based. In most mathematical systems, the axioms that we take are carefully abstracted from a certain aspect of experience. Quantum processes do not follow Boolean logic (Birkhoff and von Neumann, 1936), and therefore the development of quantum computation involves the development of quantum logic.

Adapting our humanly-conceived computer hardware and software to the actual logic of nature, one would hope to model mathematical, natural, and mental processes more directly and accurately. Of course we do not know what the "actual logic of nature" is, but we have a proposal based on physical and biological considerations. The founders of science and philosophy regarded biological processes as useful models for the cosmos; Aristotle noted that "*the heavens are high and far off and of celestial things the knowledge that our senses give is scanty and dim*" while "*living creatures are at our door and we may gain ample and certain knowledge of each and all*" (quoted by Prigogine, 1980). Cybernetics, Chaos and Complexity were largely inspired by biology, and Bios was found in human physiology before it was demonstrated in physics. The objective of this chapter is to sketch the general principles of a system of logic that incorporates the biotic complexity of quantum processes, hoping that it will be useful in quantum computation.

We focus on quantum processes because they are particularly relevant to the development of quantum computers. This will allow the full use of quantum processes for computation. Employing quantum processes directly could be extremely helpful to understanding them. Processing, transmitting and storing information encoded in systems with quantum properties will provide practical advantages as illustrated by the factoring of large numbers (Shor, 1997).2 A number of physical systems for quantum computation hardware (Ladd et al, 2010), and software (Nielsen & Chuang, 2000) are being developed.

Here we address a complementary task, to formulate the logic of quantum processes. A key new element that we bring into physics, logic and computation is the existence of causal creativity at all levels of organization including fundamental physical and biological processes (Sabelli, 2005). As a result, quantum processes as well as cosmological ones display life-like (biotic) patterns (Sabelli and Kovacevic, 2003, 2006; Thomas et al. 2006; Sabelli et al, forthcoming) as illustrated in Figure 1 for the wave function of an electron confined to a well. The same pattern is observed for purported gravitational waves presumably originating in the Big bang, and at processes at multiple levels of organization (see later). The Schrödinger equation originally was intended to portray the movement of electrons; it was later on interpreted by Born as the probability of finding the electron in a given place, but such 'probability' changes in time, hence the Schrödinger equation portrays a process, the temporal change of the distribution of the electron.3

We speculate on the possibility of harnessing biotic processes at the quantum level in quantum computers. This speculation is worth exploring because there are creative recursive processes that are not hard to specify. Causal creative processes can be generated by simple mathematical recur-