Biotechnology Contains a lot of Seeds of the ICT Innovation

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Our bodies, made up of 60 trillion cells, each originate from just one fertilized egg, which undergoes repetitive cell division and differentiation to form the body through self-organization. Despite being a system with an enormous number of factors, it is able to function continually in a state of harmony without faltering. The energy required to run the body ranges from a mere several dozen to several hundred watts, and it is able to engage in vigorous activity even at normal temperatures. The body has eyes to sense light, ears to sense sound, a nose and tongue to sense molecules, and a variety of other sensors. It also has muscles that function as actuators, and the materials that make up all of these are organic molecules consisting mainly of elements found everywhere, such as carbon, hydrogen, nitrogen, phosphorus and sulfur. As in this example of the human body, organisms in general have a great capacity for self-organization and autonomy, combined with an enormous number of components, energy-efficient mobility, structures made of organic materials, ability for chemical communication of information, and environmental adaptability, among a variety of other characteristics not found in artificial systems.

Current ICT faces issues of a network that is expanding daily, the necessity to respond to the complexities of the factors making up this network, the necessity to respond urgently to the rapid increase in the energy it is consuming, etc. Furthermore, information communication revolves around people, and people are always found at the receiving end of information communication systems. To create human-friendly ICT such as an interface that is adapted to the needs of human beings as organisms, it is highly important that we deepen our knowledge of biological information processing mechanisms. A biological system has the seeds for spawning technology to address all of these issues.

When one considers a biological system as an object of research, it reveals an enormous number of potential solutions. When one considers it from the perspective of systems, there are extremely extensive fields ranging in scale from the micro to the macro, or ranging from molecules to cells, organs, individuals and society, and the characteristics of organisms are evident throughout each field. The Bio ICT Laboratory has focused on research at a biomolecular level in which molecules retain the characteristics of organisms while complexity is kept to a minimum to enable analysis. We have also focused on research at a cellular level, with cells being the fundamental unit of life.

In accordance with developments in our bio-ICT research, this series of papers will begin with a paper titled "Search for Basic Principle of Life," in Chapter 2. In it, we have compiled the latest scientific knowledge on information processing mechanisms in organisms, and we report on initiatives that will contribute to breakthroughs in scientific technology including future ICT. We will discuss the communication mechanism of chromosomes which function as an information storage system for cells, the energy-saving mechanism of biomolecules, the model of the design of biological systems in which numerous molecules cooperate in movement, research into the mechanism for storing genetic information in organisms, and technology for assessing biological functions for high precision assessment of the functions and structures mentioned above. This will be followed by Chapter 3, titled "Application Technology of Biological Functions." In this chapter we will report on initiatives to build fundamental technology to take advantage of the merits of the functions and raw materials of biological material right before our eyes. We will discuss the development of ICT using cells, technological development for using cells impregnated with foreign substances, technology for creating artificial organelles made of numerous biomolecules, the building of algorithms to carry out multivariate searches for optimal values to imitate biomolecular mechanisms, and technology for creating nano-functional machines using DNA. Then in the final chapter, Chapter 4 titled "System Construction using Biomaterials," we will discuss our initiatives to build sensor systems making use of elemental technology and knowledge in bio-ICT.

We will report on bio-ICT research, based on fundamental research, as a means of contributing to the ICT of the future through development of original and challenging technology. We hope to present our reports through the eyes of on-site researchers in an easy-to-understand way that will allow even non-experts to understand them.

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