Afterword: Anatomy of Bio-ICT

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If ICT were simply to be considered as any kind of technology for communicating information, one could say that it has existed in human society since prehistoric times. Putting aside any debate on whether language or writing can be considered ICT, ways of communicating such as the use of signal fires and flags, which are perhaps more like signals than a means of full communication, have probably existed since ancient times. Perhaps it is more appropriate to call such technology, retro-ICT. By comparison, modern technology known as electro-ICT only came into practical use in the 19th century, and it took 200 years for it to develop into the massive Internet-based society of today. Although the technologies differ greatly in appearance, they are both "ways of communicating information," and as it is mentioned in the NICT Charter, ICT forms the foundation on which the intellectual and economic activities of humankind are based. It can be said that ICT was sought after whenever and wherever humankind tried to achieve something as a group or as individuals.

Let us consider what constitutes "ICT" when the word "humankind" is replaced with the word "organisms" or "cells" in the underlined portion of the sentence above. When an organism (cell) tries to achieve something as a group, or as an individual, "mechanisms for communicating information" are inevitably sought after. This is what is known as bio-ICT. Retro-ICT and electro-ICT mentioned above would not have existed without humankind, but bio-ICT has existed for 3 billion years; since the birth of life, well before the birth of humankind. It is a technology that has been passed down and cultivated through the generations.

Looking at the details of this series of papers reveals that bio-ICT research is undertaken with a soft (biological control) and a hard (biomaterials) approach, and the ultimate goal of today's research is nothing less than to merge bio-ICT with electro-ICT, with the aim of overcoming various issues faced by electro-ICT.

The characteristics of bio-ICT often mentioned are that they are plastic yet durable, or they are minute, efficient, autonomous, etc. These are the various properties for which great expectations are held for them to overcome the various issues faced by electro-ICT. As mentioned above, these outstanding characteristics of organisms were created over a period of more than 3 billion years since the birth of life. But if we were to summarize what organisms have achieved during this time in a single word, it would perhaps be "equilibrium." If we were to examine whether everything an organism does has a purpose or a meaning, we would no doubt discover many inefficiencies. Organisms that are forced to survive on limited resources undoubtedly do their utmost to cut waste, but too many cutting of corners, and too much reduction and downsizing immediately result in loss of plasticity and durability. Plasticity was no doubt required of organisms to survive in an environment that changes drastically. Efficiency and durability are ambivalent properties, but close examination reveals that the epitome of organisms probably lies in struggle to maintain an equilibrium between these over 3 billion years. Too much of this means not enough of that, and vice versa, and a balance has to be achieved at some point. It is the way organisms achieve this equilibrium that testifies to their being, and the characteristic that epitomizes organisms is the extreme plasticity of this point of balance itself. The issue at hand is to ascertain what physical force or system is involved in maintaining this characteristic which epitomizes organisms. Trying to understand this is where bio-ICT research begins.

In the case of fission yeast, which has relatively few genes as a non-parasitic eukaryote, one cell has approximately 5,000 genes, and actively growing cells are believed to have around 100 thousand or more messenger RNAs and around 100 million proteins. This rise and fall in the amount of messenger RNAs and proteins are considered to be the workings of life for the cell from a molecular biological point of view. This indicates that whenever a cell tries to do something, the act is inevitably associated with a rise and fall in the amount of RNAs and proteins, and in that sense, bio-ICT (at least from a molecular and cellular biological perspective) is ultimately this rise and fall and interaction between the RNAs and proteins. Current advances in measuring technology have enabled comprehensive measurements to be made of RNAs and proteins. The interactions between proteins and the distribution of messenger RNAs are often likened to the topology of the Internet or the WWW. These similarities are the reasons why there are high expectations for the possibility of some kind of cross-talk between bio-ICT and electro-ICT. If one aspect of the characteristics of life can be attributed to the rise and fall of RNAs and proteins and their interactions, perhaps we will discover the wonder of balance from the accumulated data, as the epitome of life. But to aim for the true merging of bio-ICT with electro-ICT, actually developing and applying bio-ICT to electro-ICT are important in addition to identification of the superficial similarities between the two and their special characteristics (including the wonder of balance). In fact that is the main point of bio-ICT research. We hope that the budding of such endeavors are recognized in the various results of research reported in this special issue.

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