Algebraic and geometric understanding of cells, epigenetic inheritance of phenotypes between generations using on-chip single cell cultivation system

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Abstract

We have developed methods and systems of analyzing epigenetic information in cells, as well as that of genetic information, to expand our understanding of how living systems are determined. Because cells are minimum units reflecting epigenetic information, which is considered to map the history of a parallel-processing recurrent network of biochemical reactions, their behaviors cannot be explained by considering only conventional DNA information-processing events. The role of epigenetic information on cells, which complements their genetic information, was inferred by comparing predictions from genetic information with cell behaviour observed under conditions chosen to reveal adaptation processes and community effects. A system of analyzing epigenetic information was developed starting from the twin complementary viewpoints of cell regulation as an 'algebraic' system (emphasis on temporal aspects) and as a 'geometric' system (emphasis on spatial aspects). For example, to understand the meaning of genetic and epigenetic information in a life system from 'tempral' or 'algepraic' viewpoint, we have exploited the single-cell microchambers on a chip to compare two sister Escherichia coli (E. coli) cells' behavior after their born from an isolated single cell division, and found that their behavior was not similar even their genetic information and experience were same. We also have found that the spatially localized cell membrane proteins were inhereted thier localized form even after their cell division, and their tambling tendency was inhereted with their localized conditions on cell memberanes. One of the most important contributions of this study was to be able to reconstruct the concept of a cell regulatory network from the 'local' (molecules expressed at certain times and places) to the 'global' (the cell as a viable, functioning system). Knowledge of epigenetic information, which we can control and change during cell lives, complements the genetic variety, and these two kinds are indispensable for living organisms. This new kind of knowlege has the potential to be the basis of cell-based biological and medical fields like those involving cell-based drug screening and the regeneration of organs from stem cells.

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