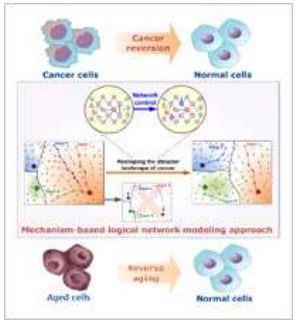
Laboratory for Systems Biology and Bio-Inspired Engineering

Prof. Kwang-Hyun Cho

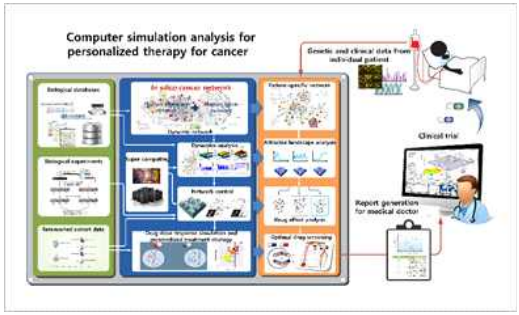
"We decode bio-complexity to unravel/control the hidden logic of life and to further apply it for engineering innovation." The Life Sciences are witnessing a shift of paradigm from traditional characterization of individual molecules towards an understanding of interactive pathways and networks. The role of genes, proteins, metabolites and cells can be understood and defined through their interactions and it is through our focus on intra- and inter-cellular dynamics that we are deeply involved in the emerging area of Systems Biology. Three key characteristics of Systems Biology are dynamic modeling, analysis, and control of complex biological networks. In this context, we focus on developing a systems biological analysis of biological information processing by signaling and gene regulation with particular emphasis towards understanding/controlling cell-fate determination. ***Our research is driven by three long term objectives: (1) understanding and controlling of complex biological phenomena; (2) developing practical biomedical technologies for personalized therapy and systems healthcare; (3) identifying novel drug targets for complex human disease.*** In this way, we are developing innovative theory and useful technologies in systems biology and bio-inspired engineering by combining biology and engineering.

● Reverse Control of Cancer and Aging



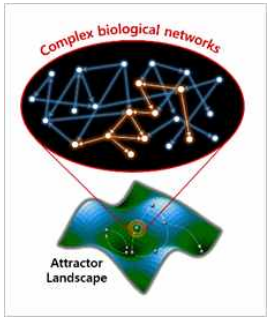
Cancer and aging are generally regarded as irreversible biological phenomena. Might it be possible to reverse these processes? Historically, there have been some reports about such reversion under particular circumstances, indicating the possibility of it, but no systematic analysis or experiment has been attempted so far. We are conducting very creative research on reverse control of cancer and aging through Systems Biology approach to challenge this problem. Through extensive large-scale computer simulation analysis of these models, we try to identify molecular targets that can reverse cancer and aging processes and to further test the resulting changes in dynamic features when those targets are controlled. We also carry out experimental validation of the results through both cell and organoid experiments.

● Computer Simulation Analysis for Personalized Therapy of Cancer



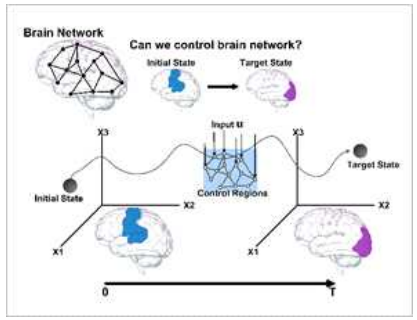
We are developing computer simulation models for primary molecular regulatory networks of cancer on the basis of biological big data. By mapping individual patient's genetic variation to our simulation model, we can use our model to finding out optimal personalized therapy. Individually optimized therapeutic strategies are investigated by analyzing the dynamical features of our personalized computer simulation model through supercomputing-based large-scale simulation analysis. Our study suggests a new paradigm for precision medicine.

● Analysis and Control of Biological Networks



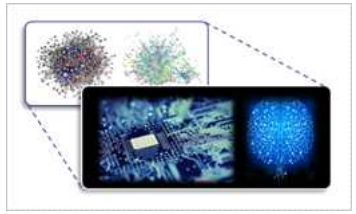
All living-systems are composed of complex networks of their functional subunits and their biological phenomena are determined by dynamic changes of those networks. Therefore, it is indispensable to control those complex networks to regulate the biological phenomena in the way we want. We explore the functions of such biological networks by analyzing both topological as well as dynamical properties. The aim of network systems biology is to investigate the relationship between topological properties and biological function, and to eventually develop practically useful control strategies with which we can regulate the network dynamics.

● Brain Network Control



Our brain comprises complex networks of neurons through synaptic interactions and brain functions are induced by the dynamics of such complex networks. For instance, the selective synchronization is a basis for normal brain functioning, so synchrony disruption can cause functional abnormalities that lead to diverse brain disorder. We investigate the physical and functional regulations in brain and principles of those regulations using large-scale computational models of neuronal networks on the basis of multi-modal brain connectome data. The ultimate goal is to investigate the emergent properties of complex neuronal networks in connection with brain functions and disorders, and to unravel/control the underlying hidden working principles. For this purpose, we are constructing real human brain network models based on the human connectome data and developing brain network control strategies to overcome various brain disorders.

● Bio-inspired Engineering Based on Systems Biology



We are developing a new realm of engineering, named bio-inspired engineering based on Systems Biology, which applies our system-level understanding on biological mechanisms to engineering to find out a novel solution to unsolved engineering problems. For example, we develop self-repairing electrical circuits inspired from biological networks.

Laboratory for Systems Biology and Bio-Inspired Engineering

● **Systems Biology**

A system-level analysis and control of complex biological networks by combining mathematical modeling, computer simulation, and biological experiments to unravel the hidden logic of life and to eventually control the biological phenomena as we want.

- Reverse control of cancer and aging
- Computer simulation analysis for personalized therapy of cancer
- Analysis and control of biological networks
- Brain network control

● **Bio-Inspired Engineering**

Applying the knowledge obtained from the study of biological systems to engineering and pioneering engineering innovation using ideas inspired from systems biology.

- Design and implementation of self-repairing electrical circuits that can function as a living system
- Reconfigurable autonomous systems for dynamic routing and complex tasks

SBiE Members

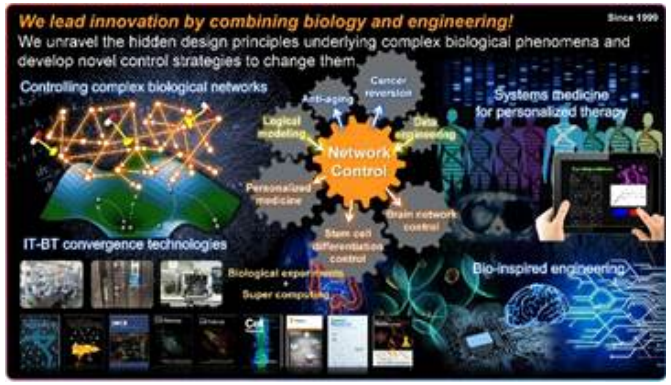
Laboratory for Systems Biology and Bio-Inspired Engineering [SBiE]

Professor Kwang-Hyun Cho, Ph.D.
Department of Bio and Brain Engineering,
Korea Advanced Institute of Science and Technology (KAIST),
291 Daehak-ro, Yuseong-gu, Daejeon 34141, Republic of Korea
Tel.: +82-42-350-4325 (Office), +82-42-350-4396 (Secretary),
+82-42-350-4365/5365 (Lab.)
Fax: +82-42-350-4310
E-mail: ckh@kaist.ac.kr
Website: http://sbie.kaist.ac.kr

Prof. Kwang-Hyun Cho's Laboratory for Systems Biology and Bio-Inspired Engineering

[SBiE]
Since 1999

Department of Bio and Brain Engineering,
Korea Advanced Institute of Science and Technology (KAIST)



http://sbie.kaist.ac.kr

Dept. of Bio and Brain Engineering

KAIST