

Control of Gene Expression at the Single Cell Level

Researchers seek to turn the functions of genes on and off with a burst of light

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2008 laureate

These PUF grantees are developing state-of-the-art techniques from fluorescence spectroscopy, fluorescence microscopy, and biological imaging to single gene activation by light for studying the function of cellular circuits through the control of the activity of an important class of molecules: proteins.

Proteins are life's machines, and have a hand in doing just about anything significant that happens in living organisms. Most proteins are enzymes that catalyze – that is, facilitate – many of life's biochemical reactions. They are thus responsible for the replication of DNA and the replication of cells; they are the engines of metabolic pathways providing organisms with energy; they work as molecular motors shuttling cargo inside the cell; and they participate in signal transfer between and inside cells.

To better understand the cellular networks involving proteins and study how proteins go about their business is one of biology's greatest challenges. Progress requires experts from many disciplines — chemistry, biology, physics, mathematics, computer science, and biochemistry — working in close concert to make sense of the many interactions occurring at this nanoscopic scale.

Within the boundaries of an individual cell is a universe of dynamic processes. At the most fundamental level one finds genes, which encode in the DNA the recipes that make living organisms. The machinery that copies, reads, translates, controls, and executes these recipes is made of – you guessed it – proteins, which are themselves coded in the genes (like the chick is coded in the egg). It is thought that human beings have between 30,000-40,000 genes, the control and execution of which is the task of many proteins.

Genes can be turned on and off at different times and in response to a variety of signals and stimuli inside and outside of the cell. For example, during the development of an embryo, the signals encoded by the genes are translated into proteins that provide spatial and temporal information that is used to control the differentiation of cells into specific organs (heart, brain, muscle, limbs, etc.).

Providing means to activate specific proteins or molecules by light is the focus of the faculty and students working on this PUF project. The approach they develop will provide the research community with the possibility to control the cellular processes at

work during development, regenerations, disease states such as cancer, and learning. Having a detailed understanding of these processes will allow for their control and for the possibility of increased intervention through drug therapy or other means.

The promise and potential empowerment attached to intervention at such preliminary stages of development are staggering. The graduate students presently engaged in this program will represent the next, leading generation of researchers and engineers in France and the U.S. to carry this work forward and develop its applications.

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