CANCER PREVENTION & RESEARCH INSTITUTE OF TEXAS

Award ID:
R1111

Project Title:
Recruitment of Established Investigators

Award Mechanism:
Recruitment of Established Investigators

Principal Investigator:
Levine, Herbert

Entity:
Rice University

Lay Summary:

Dr. Herbert Levine is a Professor in the Bioengineering and Physics Departments at Rice. He is also co-director of the Center for Theoretical Biological Physics (CTBP), a National Science Foundation Physics Frontier Center devoted to applying concepts and methods from physical science to complex biological and biomedical problems. He is also coordinator of an international research network of researchers in the Physics of Living Systems, under the auspices of the NSF Science Across Virtual Institutes (SAVI) initiative.

Dr. Levine did his undergraduate work at MIT, and received his PhD in Physics from Princeton Univ. in 1979. After a postdoctoral fellowship at Harvard and a position on the research staff of the corporate research lab of Schlumberger inc., he was appointed in 1987 to the faculty at the University of California, San Diego. He rose to the ranks of distinguished professor before leaving in 2012 to accept his new post at Rice. He was elected as a fellow of the American Physical Society in 1989 and as a member of the National Academy of Sciences in 2011.

Dr. Levine has been a long-time leader in the field of non-equilibrium statistical physics. In the earlier parts of his career, he studied non-equilibrium processes in condensed-matter systems, making seminal contributions to topics including patterning during crystal growth, unstable multiphase fluid flow, nonlinear chemical waves, and the dynamics of rapid fracture of brittle materials. This overall body of work has been featured in the NY Times, Scientific American, the Today Show and many other popular science forums. Starting around 1990, Dr. Levine recognized that indeed all biological systems operate far from equilibrium, using free energy derived from metabolism to run all the various processes needed for survival. Thus, progress in the physics of non-equilibrium complex systems is an essential enabling component of advancing our quantitative understanding of biological systems. Thus, Levine (working with Eshel Ben-Jacob at Tel-Aviv Univ.) showed that the conceptual and methodological framework originally developed for crystal growth could be used to explain (and in fact control) stress-induced microorganism colony patterns and indeed to correlate genetically-controlled cellular properties with macroscopic-scale structure. Continuing in this vein, Levine showed how the properties of rotating spiral waves seen in physic-chemical system could be the key for constructing quantitative approaches to non-linear waves in biological systems, ranging from extra-cellular waves that guide Dictyostelium amoebae aggregation to intracellular calcium waves that convey information across the cell. In a different direction, Levine has teamed up with a leading neuroscience group (headed by Terry Sejnowki of the Salk Institute) to create the first ever spatially-extended model of the calcium concentration control of synaptic vesicle release. In the most recent example of how can use non-equilibrium physics to unravel complex biological functions, Levine has over the past decade spear-headed a joint theory-experiment effort into eukaryotic chemotaxis, how cells use chemical gradients to bias their motility. This is at heart another pattern formation problem, as a cell must use external information to set up an internal chemical structure such that different non-equilibrium states exist at the front, back, and sides of the cell; these different states then govern the downstream mechanics, which then actually causes motion.

Being named a CPRIT scholar will enable Dr. Levine and indeed all of the CTBP to shift a significant part of their efforts to the application of non-equilibrium physics to cancer. It has been recognized (for example by the NCI) that collaborative efforts combining cancer biologists, clinical oncologists, and physical scientists will be a necessary component of rapid progress in the decades to come. Efforts on topics such as models of drug resistance evolution, reversible transitions to cancer stem cells, switching of cells to motile phenotypes, and spatiotemporal coordination of primary tumors and their metastatic “seeds” are underway and will hopefully contribute new perspectives as well as new quantitative methods to this most important area of biomedical research.