Assistant Professor Charles Schroeder has won a 2011 Packard Fellowship to advance his research on developing a new class of fluorescent probes for super-resolution microscopy. These fluorescent probes will facilitate higher resolution imaging and will enable the study of bacterial cells, live mammalian cells and intracellular molecular events that cannot be addressed with existing methods.

For centuries, optical microscopy has been the standard workhorse to study cellular events. However, light microscopy is limited to a lateral spatial resolution of approximately 250 nanometers due to the diffraction of light. Over the last few years, advances in super-resolution microscopy have broken the diffraction barrier for optical imaging. Current technology for super-resolution has enabled imaging at a resolution of 20 to 25 nanometers for biological systems. Schroeder and his team hope that their discoveries will allow imaging at molecular scale resolution, approximately 1 to 5 nanometers. A nanometer is one-billionth of a meter, and a human hair is about 40,000 to 60,000 nanometers wide.

Schroeder will use the $875,000 grant, distributed over five years, to study the relationship between molecular organization in chromosome structure and gene expression in bacteria, which plays a major role in cell decision-making but has been poorly understood. In addition, Schroeder will study the process of retroviral budding and interactions between viral machinery and host cellular factors during viral assembly. Retroviral budding and assembly are key steps in the life cycle of human retroviruses.

The new set of fluorescent probes is based on photoswitchable dendritic nanoconjugates, which are macromolecules in which the fluorescence emission can be “turned on” and “turned off” by exciting the molecules with distinct emission wavelengths using laser excitation. Moreover, these fluorescent probes are brighter and more stable than existing ones, which enhances imaging resolution.

“We plan to apply these tools to study regulation of anaerobic metabolism with exquisite resolution in single bacterial cells,” Schroeder said. These types of research studies are helpful because large-scale fermentation reactions, which are used to synthesize alcohols, fuels and some high-value small molecule pharmaceuticals, are performed in anaerobic conditions.

These fluorescent probes also appear to be cell permeable under many conditions for mammalian cells, which enables straightforward delivery to study how live cells behave, a major advantage.

Schroeder is thrilled to receive the Packard Fellowship, in part because it offers a large amount of freedom and flexibility to conduct research. The Foundation has few paperwork requirements, and Fellows may use their funds at their discretion for ways that would best advance their research.

“If we stumble onto something that is exciting and promising, then this gives us the freedom to explore new directions in research,” Schroeder said.

Department Head Paul Kenis is enthusiastic about the implications of Schroeder’s research.

“The Packard award will enable his research group to do high-risk, high-return research that will advance the field of optical microscopy to reach the level of molecular-scale resolution, thereby enabling unprecedented studies of processes of living and non-living systems,” Kenis said.

Each year, the David and Lucile Packard Foundation invites the presidents of 50 universities to nominate two early-career professors each from their institutions. A panel of distinguished scientists and engineers selected 16 Fellows out of the 100 final applicants.

The Packard Foundation established the Fellowships for Science and Engineering in 1988 to allow the nation’s most promising professors to pursue science and engineering research early in their careers. The awards are given to untenured assistant professors in the first three years of their appointments.

Schroeder is the first University of Illinois professor in Chemical & Biomolecular Engineering to earn the fellowship. In 2010, University of Illinois Physics Professor Benjamin Lev won the fellowship to study unexplored exotic quantum phases, which combine properties of every day matter, solids, liquids and liquid crystals with superfluidity.

Packard Fellows must be faculty members who are eligible to serve as principal investigators engaged in research in the natural and physical sciences or engineering. They are encouraged to think big and look at complex issues with a fresh perspective. Packard Fellows have gone on to receive additional awards and honors, including the Nobel Prize in Physics, the Fields Medal, and MacArthur, Sloan, Searle and Guggenheim Fellowships.