# Nanobiotechnology: Nanoscale Chemical Reactions and Separations

Laurie Locascio (839), Wyatt Vreeland (839), Ksenia Brazhnik (800), Rani Kishore (842), Simone Kulin (842), Kristian Helmerson (842)

This project focuses on the development of nanoscale structures to facilitate the performance of ultra-small volume chemical reactions and separations. The work is associated with the Single Molecule Manipulation and Measurement competence program whose purpose is to study the behavior of biomolecules one molecule at a time to elucidate the differences that make them uniquely beneficial or detrimental. The nanoscale structures that we are designing are composed most often of phospholipid molecules and are self-assembled spherical or tubular structures with diameters ranging from tens to hundreds of nanometers. We have demonstrated the use of these nanometer structures for controlled chemical reactions using picoliters of reagents.

Due to their amphiphilic nature, when phospholipid molecules are dispersed in water they self-assemble into bilayer membranes to form structures called liposomes that are often spherical and encapsulate an aqueous internal volume. Liposomes range in size from 50 nm to 10's of micrometers encapsulating volumes that are measured in attoliters to picoliters. Water-soluble molecules, including DNA, RNA, proteins and small ionic molecules, can be readily incorporated into the liposomes upon formation. In this work, we use liposomes to sequester very small amounts of reagents in discrete packages to control their reaction. The liposomes are trapped and manipulated in a microenvironment using optical tweezers. Liposomes containing two different reagents that are brought into contact using the optical tweezers do not bind or fuse, therefore their contents cannot react. However, if the liposome membrane is exposed to a short UV laser pulse while in contact with another liposome, the membrane destabilizes and the two liposomes fuse together to form a single liposome structure as shown in Figure 1. During fusion, the contents of the two liposomes react immediately. The time scale of liposome fusion events varies in length from milliseconds to seconds and is most likely dependent on the lamellarity of the liposome membrane.

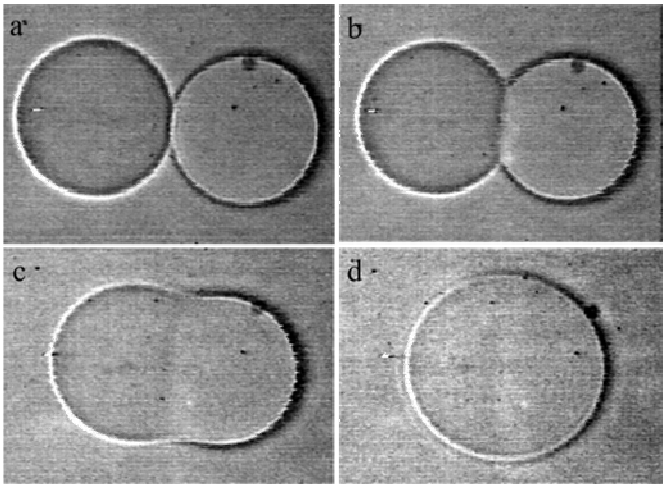


**Figure 1.** A. Two liposomes brought into contact using optical tweezers. B. A UV laser pulse at the interface initiates fusion of the two membranes. C, D. Fusion is completed in the next 2 successive video frames.