The Ras superfamily of GTPases is a significant target for cancer therapeutics as oncogenic mutations are found in 20-30% of human cancers. Cysteine residues near the Ras C-terminus must undergo several post-translational lipid modifications, including farnesylation by farnesyltransferase (PFTase) and palmitoylation by palmitoyl acyltransferases (PAT), followed by consequent intracellular translocation and plasma membrane anchorage to propagate its cell signaling. As a result, PFTase inhibitors (FTIs) were designed to intercept this initial farnesylation process. Although FTIs have been largely unsuccessful in advanced clinical trials, post-prenylation Ras trafficking and interactions with effector and chaperone proteins are rapidly becoming the most important current therapeutic targets. To better understand these critical processes, this research intends to incorporate photoactivatable cysteines into whole-Ras proteins using wavelength-selective two-photon photoremovable protecting groups (PPGs) and selectively activate farnesylation and palmitoylation of these proteins in cells to study both of these modifications independently. The superior spatial and tissue-penetration capabilities of two-photon activated uncaging of nitrodibenzofuran (NDBF)-protected thiols was probed by demonstrating localized, targeted drug delivery of NDBF-FTI in 2-D and 3-D cell culture. A dimethylamine-derivatized NDBF (aNDBF) with a significantly red-shifted absorption profile was synthesized, and the thiol-uncaging kinetics of aNDBF will be directly compared with NDBF after 700, 800, and 900 nm two-photon irradiation. The ability of these PPGs to be selectively photoactivated will be investigated by incorporating aNDBF- and NDBF-caged cysteines into Ras peptides. After initial in vitro characterization of selective cysteine uncaging, photoactivated farnesylation, palmitoylation, and intracellular translocation processes of a fluorophore-tagged caged Ras peptide will be observed in live cell microscopy experiments. Finally, in future works, modified caged peptides will be incorporated directly into Ras proteins using sortase-A mediated protein semi-synthesis techniques with a developed truncated GFP-N-Ras mutant. The two-photon-induced farnesylation-palmitoylation modification and trafficking kinetics of this engineered whole-Ras protein will be determined and compared with those found in Ras peptides. Furthermore, intermediate partially processed Ras forms are accessible for study by introducing additional structural features into the C-terminus peptide such as a nonhydrolyzable CaaX box and irreversible palmitoyl modification. The modularity of the developed GFP-N-Ras mutant peptide would allow for the incorporation of many different investigative components into the C-terminus of N-Ras and provides access to a broad selection of experiments that would not be possible using current methodologies. These studies will help direct current and future therapeutics development for Ras-derived cancers.