Carbon nanotubes, like inorganic nanowires, are materials were electrons are confined to a single physical dimensional, resulting in new and unusual properties. Our laboratory has been focused on understanding their chemistry and engineering 1D materials in general for applications in biodetection and energy. In the former, nanoscale sensing elements offer promise for single-molecule analyte detection in physically or biologically constrained environments for the first time. Single-walled carbon nanotubes (SWNT), as optical sensors, offer unique advantages such as photostable near-infrared (n-IR) emission for prolonged detection through biological media, single-molecule sensitivity, as we have recently documented, nearly orthogonal optical modes for signal transduction that can be used to identify distinct classes of analytes. Selective binding to the SWNT surface is difficult to engineer, but we have shown that even a pair of single-walled carbon nanotubes provides at least four optical modes that can be modulated to uniquely fingerprint chemical agents by the degree to which they alter either the emission band intensity or wavelength. We validate this identification method in vitro by demonstrating detection of six genotoxic analytes and their chemical kinetics in NIH-3T3 cells, including chemotherapeutic drugs and reactive oxygen species (ROS), which are spectroscopically differentiated into four distinct classes. We also demonstrate single-molecule sensitivity in detecting hydrogen peroxide, one of the most common genotoxins. An array of such sensors has allowed us to study a new signaling pathway of the Epidermal Growth Factor Receptor (EGFR) involving biocatalyzed H2O2 production on the membrane protein receptor itself in response to ligand binding. We show the detection of single molecule H2O2 at the membrane surface for the first time, and map the kinetics of the receptor in the bound and unbound state while on the live cell surface. The platform is promising for extending single molecule kinetic analysis to traditionally difficult biological systems. For the latter application, we address a longstanding problem of providing high power density for miniaturized circuits and devices. Phonon confinement in one dimensional nanotube and nanowire systems results in thermal conductivities that often exceed those of conventional materials by orders of magnitude. We show theoretically that a chemical reaction represented as a non-linear source term in Fourier’s law decomposes to a directed reaction wave of amplified velocity confined almost exclusively to an annular region around a nanotube thermal waveguide. The reaction creates a concomitant thermopower wave with interesting properties that will be discussed. Lastly, we experimentally release such waves and show that they can be used as novel power sources at the nanoscale.