Electron transfer across large distances (> 10 Å) has been studied extensively in biochemistry, electrochemistry, and materials science. Conduction of electrons in molecules such as DNA, conducting polymers, and conjugated aromatics is important both fundamentally and practically. Of particular interest is the relatively new area of molecular electronics, in which single molecules or collections of molecules act as components in electronics circuits. The principles involved are similar to those in long-range electrochemical charge transfer at modified electrode surfaces. For example, the mechanisms of electron transfer in monolayer films on electrodes are believed to be tunneling, thermally activated hopping, and superexchange, all of which have been proposed for electron transfer in molecular electronic devices. Following a brief review of the field of molecular electronics, a new paradigm based on conjugated, covalent bonding between an organic monolayer and a graphitic carbon substrate will be described. The resistance of carbon based molecular junctions is strongly dependent on molecular structure and length, and junctions in the range of 5-50 Å thickness have been studied so far. A possibly important phenomenon common to several junction types is conductance switching, in which a junction may be repeatedly switched between high and low conductivity states. ON/OFF ratios of 10-100 have been observed so far, and switching is repeatable thousands of times for selected monolayer molecules. The mechanism of conductance switching will be discussed, as will its possible application as a low-power nonvolatile memory element.

References: