Mixing particles with sizes in the sub 100 nm range with polymers results in many unique properties that are not sums of the properties of the constituents. The presence of particles alters polymer dynamics and packing properties while the polymer acts to alter the potential of mean force felt by the particles thus changing their state of aggregation. The result is very useful materials. Engineering the desired properties is, however, somewhat of a mystery. Controlling the degree of particle aggregation and the mechanics of the resulting composites remain materials design challenges. In this seminar I discuss advances in understanding particle and polymer properties that lead to unique nanocomposite properties. As a reference point I start with one of the largest applications of nanocomposites - tires, and discuss how altering the degree of particle dispersion can have profound impact on the fuel consumption of the nation's long haul trucking fleet.