Abstract: The Physics and Biology of Macromolecular Crowding

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The typical notion of “concentration” within the interior of a cell is drastically altered due to the crowding of macromolecules. There exists a complicated network of interactions among biological macromolecules in vivo (in fact some proteins are only found in a bound state with no “free floating” within the cell). About one fourth to one half of the volume of the cell cytoplasm is composed entirely of macromolecules while the rest of the cell consists of an electrolyte network. The sheer volume available for interaction among macromolecules is consequently much less than expected. This may allow for significantly lower copy numbers of certain proteins within a cell than one would expect. It is also interesting to note that in such a crowded and charged environment, electrostatic interactions among the many charged residues and nucleic acids must play an even more important role. By introducing the concept of “effective” or “local” concentrations, it should be possible to determine the effect of cellular crowding on the kinetics and dynamics of proteins and nucleic acids.