Multiscale Approach to BioNano Interactions: From Water to Protein Corona

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The recent exploitation of nanoparticles in commercial and medical applications has increased the possibility that people could enter in direct contact with these materials. Thousands of products in the market, such as fabrics, cleaning products and cosmetics, include nanocomponents. Nanomaterials are already used in medical treatments, electronics or as food additives, generating millions of dollars in sales. Human exposure to nanomaterials, smaller than a thousandth the diameter of a hair, raises important issues about if the interactions between nanomaterials and biological systems can have adverse health effects. Therefore, it is fundamental to study the BioNano Interactions and to understand how we can control them. This is relevant both for the technological applications and for the social impact. In fact, a distorted knowledge or a superficial control of the nanoparticle effect for the health could generate a social concern. For example, in the past years these issues have generated a strong reaction to the OGM food, limiting the research and its possible benefits. The starting hypothesis of our research is that water dominates the structure and the organization of the biosystems at the molecular level. Water properties are paramount in BioNano Interactions. The presence of water in living organisms is responsible for much of the structural and physicochemical properties of biomolecules because of the unique water ability to form hydrogen bonds. In this report we will present our recent results in describing the formation of the "protein corona" around the nanoparticles when these are in aqueous solutions with biomolecules. With great simplification, chemical molecules interact directly with the biological elements, while nanoparticles are coated with proteins and lipids. These macromolecules adhere so strongly to the nanoparticle surface that the exchange times with the solution are extremely long. As a consequence, the biological identity of the particles depends largely of the protein corona, instead of the nanoparticle material.

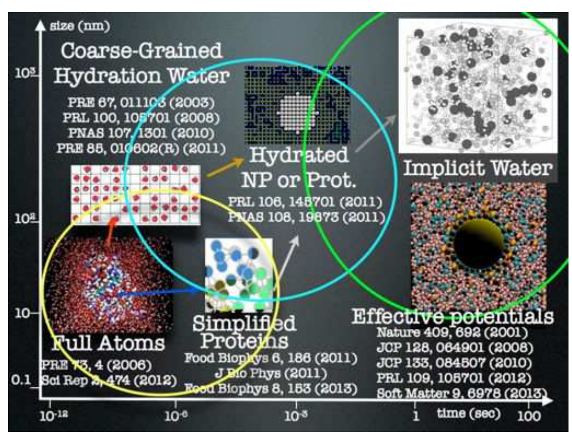

FIG. 1. Schematic representation of our multiscale approach. The horizontal axis represents the time scale and covers fourteen orders of magnitude. The vertical axis shows the length scales and covers five orders of magnitude. The circles mark the different scales that are considered here. The citations and insets refer to the works that we published in relation to each scale.

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