Chapter 2
Intracellular Behavior of Nanoparticles Based on their Physicochemical Properties

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ABSTRACT

This chapter addresses physicochemical properties that affect Nanoparticle (NP) intracellular behavior using Gold NPs (GNPs) as a model system. The main objective is to outline what is known about the effect of GNP size, shape, and surface properties on cellular uptake and intracellular pathway. The authors propose that the entry of GNPs into cells is related to its effectiveness in applications that favor intracellular localization of such GNPs. The authors also discuss how such properties are used to optimize GNP designs for medical applications. Finally, the authors discuss how GNPs may improve disease diagnosis and treatment. Furthermore, how they may be incorporated or used as alternatives to current treatment options is defined.

INTRODUCTION

Recent advances in engineering and technology have led to the development of many new nanoscale biomedical platforms, including quantum dots, nanoshells, gold nanoparticles, paramagnetic NPs, carbon nanotubes, and improvements in traditional, lipid-based nanoscale platforms. In particular, gold nanoparticles have been explored as a model platform for biomedical research due to their favorable physical and chemical properties (Bergen, van Recum, Goodman, Massey, & Pun, 2006). In this book chapter, spherical colloidal gold nanoparticles are referred to as GNPs while rod-shaped gold nanoparticles are referred to as GNRs. Recent progress in GNP-based research work and understanding how physicochemical properties of gold nanoparticles affect intracellular fate will be discussed. Figure 1A is a schematic diagram that highlights some of the important cellular processes involving GNPs that will be discussed in this review. As illustrated, NPs are first internalized by cells through RME and are trapped in organelle called 'endosomes' (Chithrani & Chan, 2007). These endosomes then fuse with lysosomes for processing before being transported

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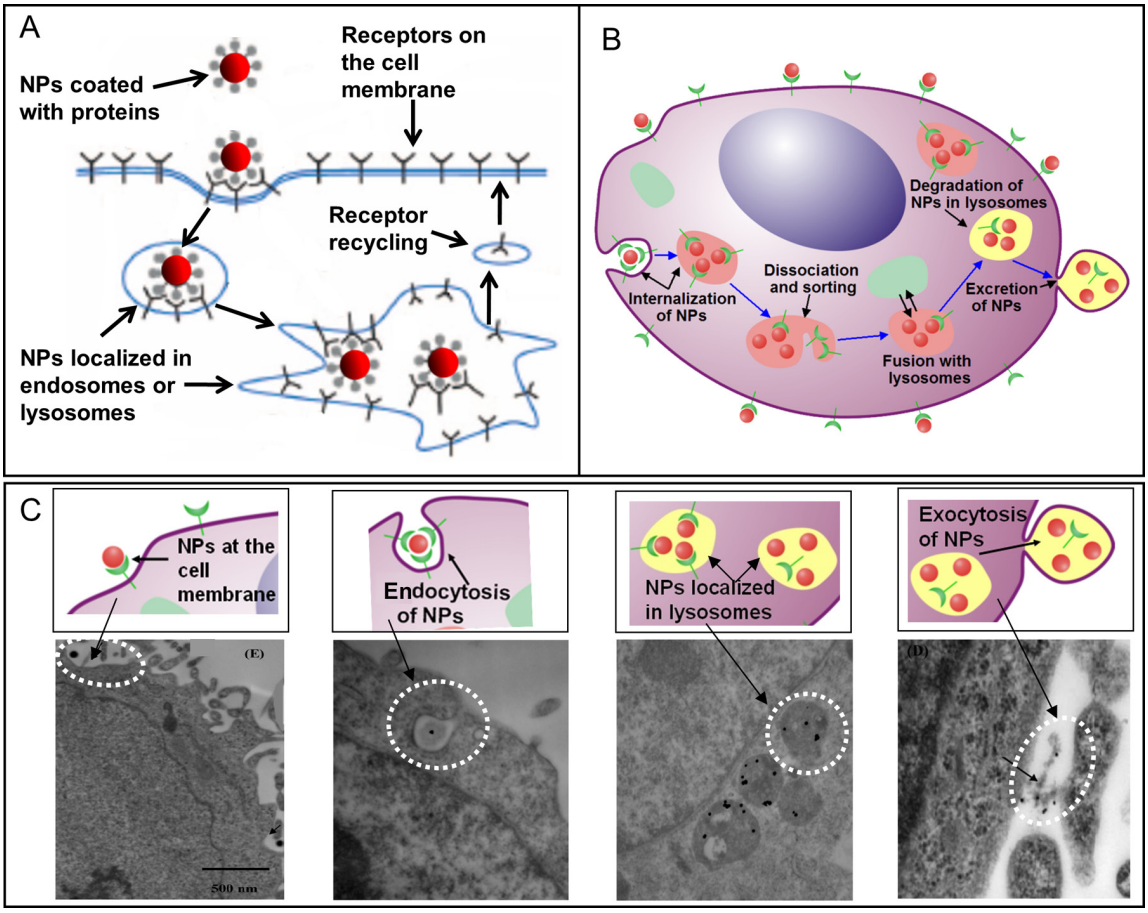
Figure 1. Intracellular uptake, transport, processing, and excretion of NPs. (a) Schematic describing the receptor mediated endocytosis process. (b) Schematic describing endo-lysosomal pathway of NPs inside the cell. NPs are internalized by receptor-mediated endocytosis and trapped in endosomes. These endosomes fuse with acidic organelles, lysosomes, for processing. Finally they are transported to the cell periphery for excretion. (c) TEM images capturing different stages of NP transport through the cell. (Reproduced with permission from Chithrani & Chan, 2007; Chithrani et al., 2006; Jin, Heller, Strano, Sharma, & Strano, 2009).



to the cell periphery for excretion. These different stages of NP transport through the cell captured by TEM are illustrated in Figure 1B. In the first part of the chapter, current knowledge about physicochemical properties effect on cellular uptake of NPs is discussed. Current understanding of transport properties, organelle distribution, and exocytosis of NPs are also discussed, followed by GNP nuclear targeting and their applications. Finally, the feasibility of incorporating gold nanoparticle into future generations of cancer therapy and imaging applicable NPs, or as multifunctional NPs, will be discussed.

BACKGROUND

GNPs have been receiving significant attention for use in cancer diagnosis and treatment (Brown et al., 2010; Chithrani et al., 2010; El-Sayed,