Leveraging Omics for the Advancement of Cancer Nanotherapeutics

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In the realm of cancer nanotherapeutics, diverse range of nanomaterials have emerged as promising platforms for drug delivery due to their unique properties such as targeted delivery, prolonged circulation, and stimuli-responsive drug release. These nanotherapeutic agents have showed their potential in cancer treatment by enhancing drug efficacy, minimizing side effects, and improving patient outcomes [1]. However, cancer arises from a complex interplay of genomic aberrations, including mutations, copy number alterations, expression changes, and epigenetic modifications across multiple omic layers [2]. Therefore, in order to design much effective treatment modalities for clinical translation, we need to consider the biology behind these nanosystems. This talk explores how omics technologies—including genomics, transcriptomics, proteomics, metabolomics, and metagenomics—can be harnessed to deepen our understanding of the interactions between nanomaterials, tumor cells, and the tumor microenvironment. By embracing this systems biology approach, we can tailor nanotherapeutics to the specific molecular and cellular context of individual tumors. Our group has applied multi-omics strategies to uncover the mechanisms underlying the biological activity of diverse nanomaterials, including carbon dots, quantum dots, and 2D materials such as MXenes [3-6]. Through these studies, we demonstrate how omics-guided insights can inform the rational design of more effective, personalized cancer nanotherapies. This integrative approach positions omics biology at the forefront of next-generation nanomedicine development, with the potential to transform cancer treatment paradigms.

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