Smart Drugs Using Nanomaterials by David Scheinberg, M.D., Ph.D.

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The field of nanotechnology is now 50 years old and has begun to reach increasingly into the world of cancer diagnosis and therapy. Nanotechnology is the science of manipulating materials at the nanometer scale-- That is 1 billionth of a meter. This is the scale at which the important enzymes, proteins and other biologic substances like DNA interact with each other within normal cells and cancer cells. While nanomaterials have long been valued in the electronics industry in an effort to make ever smaller computer circuits, recognition that these novel materials might also be useful in the development of drugs has been more recent. In general, the nanomaterials, which may be composed of inorganic or organic materials such as metals, carbon or complex polymers, or which may be constructed from biologic materials such as lipids (fats), proteins or DNA, have been used as carriers of cancer diagnostic agents or therapeutic agents to confer new properties upon the agents. The new properties typically change where the drugs go inside a patient, thereby reducing toxicity. There are already several FDA-approved anti-cancer agents that incorporate nano-materials. One example is Abraxane, for the treatment of breast cancer. Another is Doxil, for the treatment of ovarian cancer, myeloma and Karposi's sarcoma. Because of the complexity of these new materials, some of them have new intrinsic properties which can be useful medically. For example, carbon nanotubes, which are long, thin, pure carbon rods, heat up when exposed to radiofrequencies and thus can

be used to heat and kill tumors in this manner. Quantum dots, on the other hand, which are small spheres made of metal complexes, can be made to fluoresce with various different colors after exposure to light waves. In this way, these "Q-dots" can be used to diagnose different types of cancer cells in a pathology lab. Metallic nano-particles have been constructed to enhance MRI scans of tumors. Still other materials are being constructed in various shapes and sizes to be used as cancer vaccines or to deliver gene therapies to cancer cells. One recent report used a polymeric nano-material that contained a protein that directed the nano-particle to the cancer cell and carry it inside, as well as a short stretch of RNA designed to shut down important genes within the cancer cell. This latter example illustrates another feature of these new nanomaterial drugs: They are not simply small molecules that blindly distribute throughout the body killing both normal and cancer cells, but instead have multiple functions such as the ability to target the tumors, the ability to kill the tumors, and in some cases, simultaneously, the ability to report back via an imaging modality where the drug has gone (such as through a PET Scan or MRI scan). The National Cancer Institute has recently awarded a large amount of funding to develop this generation of smart drugs based on nanomaterials and we expect over the next several years to see more of these agents enter human clinical trials. The Cancer Research & Treatment Fund has awarded Dr. Scheinberg a grant to continue this vital research.