Anti-cancer Drug-delivery Systems via Nanocarriers

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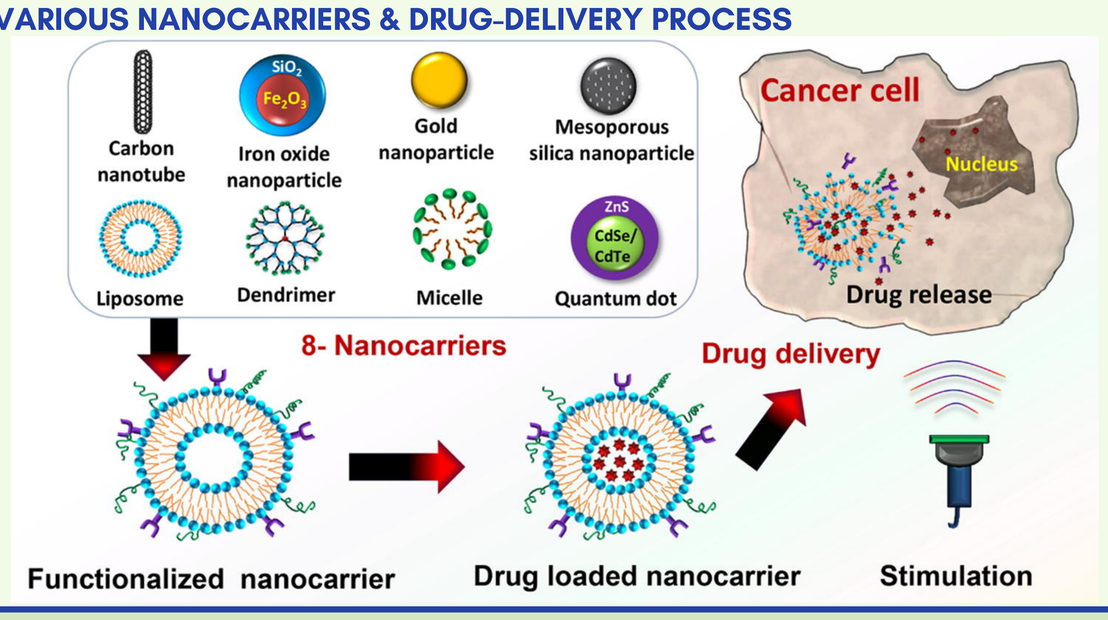
I. Topic Background

- **WHAT**: Nanocarriers, colloidal drug carriers with submicron particle sizes usually under 500 nm, have garnered significant research attention in recent decades due to their promising potential in drug delivery applications (Din et al., 2017).
- **WHERE**: The development of drug delivery via nanocarriers has taken place in research institutions, universities, pharmaceutical companies, and biotechnology firms around the world, especially in the United States, Europe, and Asia from the 1970s to present.
- **WHY**: Unlike chemotherapy which lacks selectivity of the malignant cells, nanocarriers can provide delivery of chemotherapeutic agents at higher drug content levels to the targeted spots, decreasing side effects and increasing efficacy (Edis et al., 2021). According to the National Institutes of Health, "Nanocarriers offer multiple benefits over conventional drug delivery systems like increased plasma half-life, improved biodistribution, and targeted delivery of a drug to tumor microenvironment through endothelial layers (Edis et al., 2021).
- **HOW**: Nanocarriers provide "improved pharmacokinetics and biodistribution, decreased toxicities, improved solubility and stability, controlled release and site-specific delivery of therapeutic agents" (Din et al., 2017).
- **CHALLENGES**: The inconsistency among published studies regarding the documentation of experimental details poses a significant challenge to the advancement of nanotechnology in medicine.Additionally, certain nanomaterials utilized may pose risks to both human health and the environment (Tobechukwu Christian Ezike et al., 2023).
- **VARIOUS NANOCARRIERS & DRUG-DELIVERY PROCESS**



II. Tech Timeline

1970S — EARLY RESEARCH

Researchers such as Robert Langer begin exploring the potential of nanotechnology in drug delivery.

1980S — LIPOSOMES & MICROSPHERES

Liposomes and microspheres emerge as early nanocarriers for drug delivery, offering controlled release properties and improved bioavailability.

1990S — NANOPARTICLE ADVANCEMENTS

More sophisticated nanocarriers are developed, including polymeric nanoparticles and dendrimers, offering improved drug encapsulation and controlled release properties.

- Lead developers: Patrick Couvreur, Kazunori Kataoka

2000S — CLINICAL APPLICATION

Researchers started translating nanocarrier-based drug delivery systems into clinical applications, like cancer therapy.

- Lead developers: Omid Farokhzad, Mauro Ferrari
- 2000: U.S. government launches the National Nanotechnology Initiative (Park et al., 2021)

2010S — COMMERCIALIZAITON

This decade marks a period of commercialization and expansion.

- 2014: NNI publishes their Strategic Plan relating to research, development, training, and infrastructure.

2020S — ONGOING EVOLUTION

2020s: Researchers continue to make advancements in nanocarrier design.

- 2020: development of lipid nanoparticle formulations for COVID-19 vaccine delivery (Park et al., 2021).

III. Biotech Innovators & Economic Impact

Abraxane, a nanoparticle albumin-bound paclitaxel, has been used to treat over 600,000 metastatic breast cancer patients around the world and is considered the standard of care in some places. It was developed by Dr. Neil Desai and Dr. Patrick Soon-Shiong and has been approved for the treatment of breast cancer, non-small cell lung cancer, pancreatic cancer, and metastatic melanoma in the U.S., Europe, Canada, Australia, and other countries. It has been proven to be less toxic and improve drug efficacy in tumors through enhanced permeability and retention effect (Zhao et al., 2015).

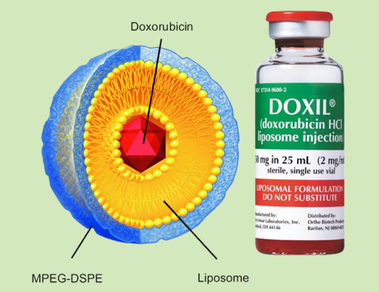
Doxil, also known as liposomal doxorubicin, is primarily used in the treatment of various cancers, including ovarian cancer, multiple myeloma, and Kaposi's sarcoma. It is often prescribed when conventional chemotherapy has failed or when patients cannot tolerate standard chemotherapy regimens. The development of Doxil involved researchers from the Southern Research Institute in Birmingham, Alabama, in collaboration with scientists at the Albert Einstein College of Medicine in New York. The liposomal formulation of doxorubicin, which forms the basis of Doxil, was pioneered by Dr. Alberto Gabizon and his team at the Shaare Zedek Medical Center in Jerusalem, Israel. Sequus Pharmaceuticals played a significant role in commercialization (Barenholz, 2012).

On February 13, 2024, the FDA approved **Onivyde**, irinotecan liposome, with oxaliplatin, fluorouracil, and leucovorin, for the first-line treatment of metastatic pancreatic adenocarcinoma. While Merrimack Pharmaceuticals led the development of Onivyde, Ipsen Biopharmaceuticals holds the commercialization rights for Onivyde in the United States and some other territories outside of Europe (Ipsen's Onivyde® Regimen, a Potential New Standard-of-Care First-Line Therapy in Metastatic Pancreatic Adenocarcinoma, Approved by FDA, 2024).

While these biotech products may not have the same broad market as some medications for more common conditions, they can be considered drugs with a moderate-sized market due to the prevalence of the cancers it treats and the need for alternative treatment options in certain cases.

IV. Ethical, Legal & Social Issues

- Unintended consequences resulting from the nanoscale size of these particles may include harmful interactions with biological systems and the environment with the potential to generate toxicity (Ebbesen & Jensen, 2006).
- Some of the public speculate that nanoparticles used in drug delivery may get "out of control" in the absence of feedback mechanisms to control their function (Ebbesen & Jensen, 2006).



V. References

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