

# THE ROLE OF EXOSOMES IN TREATING CANCER CELLS AS A FUTURISTIC CHEMOTHERAPEUTIC AGENT

## Abstract

The need for novel, safe and efficient drug carriers for cancer treatment has increased over time. The current study shows that exosomes are effective drug carriers due to their immunogenicity, stability, and target ability as well as the generation of an anti-cancer immune response. Exosomes can cross the blood-brain barrier, allowing for the treatment of brain tumors. However, drug delivery systems based on exosomes are still difficult to develop due to their heterogeneous nature, low yield and lack of drug loading efficiency. Blood, cerebrospinal fluid (CSF), urine, saliva, and other body fluids can all include extracellular vesicles known as exosomes. Exosomes perform a wide range of functions, including re-modelling the extracellular matrix (ECM) and serving as a conduit for the exchange of signals and chemicals between cells. The dual properties of exosomes in promoting and inhibiting cancer have been taken into consideration with the research of the many functions exosomes play in the course of cancer. Exosomes are a type of molecule produced by various cells. This article discusses how exosomes can be used as drug carriers for anti-cancer therapy. We also discuss the challenges and opportunities of exosome drug delivery systems for cancer treatment.

**Keywords:** Exosomes, Biomarkers, Cancer Therapeutics, Drug Delivery, Mirna (MicroRNA) Etc.

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## I. INTRODUCTION

Exosomes are tiny vesicles in the extracellular space that are essential for intercellular communication and have been identified as potential targets for drug delivery in cancer therapy. In the twenty-first century, technology in the medical area has advanced incredibly. Significant hurdles still exist in the early diagnosis and full recovery from malignant tumors. Cancer, a global problem, is the main cause for concern right today. To effectively treat cancer, chemotherapy is required. Despite this, most cancer patients do acquire drug resistance after going through a number of treatments, initially with one chemotherapeutic agent and then with others <sup>[1]</sup>. Chemo-resistance is a serious obstacle to effective cancer treatment. Exosomes produced by cancer are thought to contribute to chemo-resistance by giving cancer cells nucleic acids and proteins. Exosomes, which are almost always produced by endothelium and cancer cells, are present in a variety of body fluids, including blood plasma, urine, milk, saliva, amniotic, bronchioalveolar, synovial, and fluid from ascites. 80–90% of the exosomes that circulate in the blood come from immune cells such dendritic cells (DCs), lymphocytes, and platelets. Numerous exosome sources, such as epithelial cells, macrophages, mast cells, reticulocytes, neurons, B-cells, T-cells, oligodendrocytes, Schwann cells, and cancer cells, can be easily investigated. <sup>[2]</sup>.

Most eukaryotic cells secrete exosomes, a subclass of extracellular vesicles (EVs) that are encased in a lipid bilayer membrane. Exosomes were formerly thought to be cellular waste products before they were identified in the late 1980's. Research methodologies and tools have made it possible to discover that exosomes are a special intercellular communication pathway and are involved in a wide range of biological processes in health and disease, including cancer <sup>[3]</sup>.

## II. LIMITATIONS OF TRADITIONAL CHEMOTHERAPY

Traditional chemotherapy has several limitations including toxicity to healthy cells, drug resistance, limited effectiveness against metastatic cancer, and inability to specifically target cancer cells <sup>[4]</sup>.

## III. ROLE OF EXOSOMES IN TARGETED DRUG DELIVERY

Exosomes are tiny vesicles in the extracellular space that can be used as targeted drug delivery systems to deliver specific therapeutic agents to target cells or tissues, improving treatment effectiveness while reducing off-target effects <sup>[5]</sup>.

## IV. ADVANTAGES OF EXOSOMES OVER TRADITIONAL CHEMOTHERAPY <sup>[6,7]</sup>

1. Exosomes are natural nano-particles that can deliver therapeutic agents directly to cancer cells, reducing off-target effects and improving drug efficacy.
2. Exosomes can cross the blood-brain barrier, allowing for the treatment of brain tumors.
3. Exosomes have the potential for targeted drug delivery, minimizing systemic toxicity.
4. Exosomes can be engineered to carry specific therapeutic molecules, enhancing treatment specificity.
5. Exosomes can act as immune-modulators, stimulating the immune system to attack cancer cells.

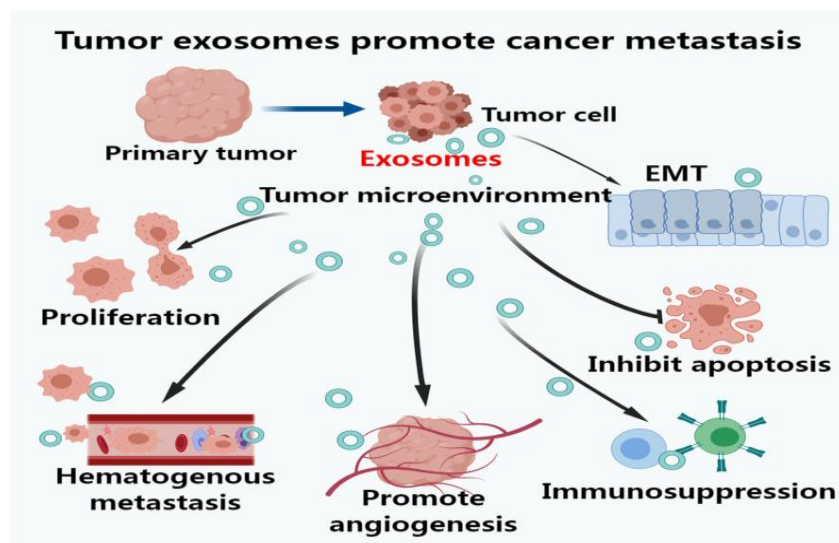
6. Exosomes have the ability to transfer genetic material, allowing for the delivery of RNA-based therapeutics.

## V. DIAGNOSTIC ROLE OF EXOSOMES

Exosomes are tiny vesicles that are released by all cells, but are most commonly released by stem cells. Exosomes are tiny messengers that transport essential signaling proteins and genetic data from one cell to another. As we age, our stem cells become less efficient at repairing tissues. When our cells communicate effectively with each other, they are able to rapidly travel to the injury site and repair it. However, as we age, our cells become less efficient in this process<sup>[8]</sup>. As a result, injuries heal more slowly and degenerative diseases become more common. Age isn't the only factor that can affect the ability of stem cells to repair and reduce inflammation. Environmental factors, genetic defects, chronic diseases such as Lyme disease, autoimmune conditions, and chronic inflammation can disrupt or interfere with the communication between cells, preventing them from repairing and reducing inflammation. The primary function of exosomes is to facilitate communication between cells, whether they are close together or far apart. The information that exosomes carry tells our cells how to activate or inhibit certain functions or how to respond in a certain way<sup>[9]</sup>.

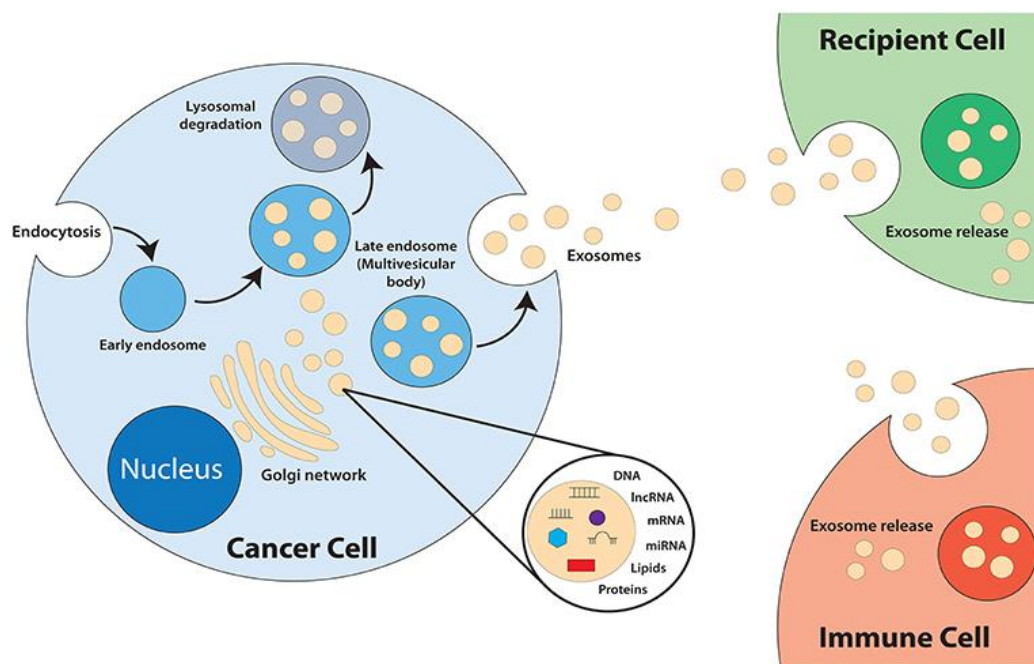
## VI. MECHANISM OF EXOSOMES

Exosomes are biologically active because they may transport bioactive substances including lipids, metabolites, proteins, and nucleic acids to the target cells. Exosomes have been shown to be able to deliver various bio-molecules to recipient cells throughout the body and demonstrate a new method of cell-to-cell communication. Using this as a foundation, researchers have also been successful in engineering the exosome's contents to realise the system's potential as a natural drug delivery mechanism<sup>[10]</sup>. The exosome research community has recently begun to explore many of the described biological sources for the isolation of exosomes and their development as drug delivery vehicles<sup>[11]</sup>.



**Figure 1:** Tumor-Derived Exosomes Promote Cancer Metastasis

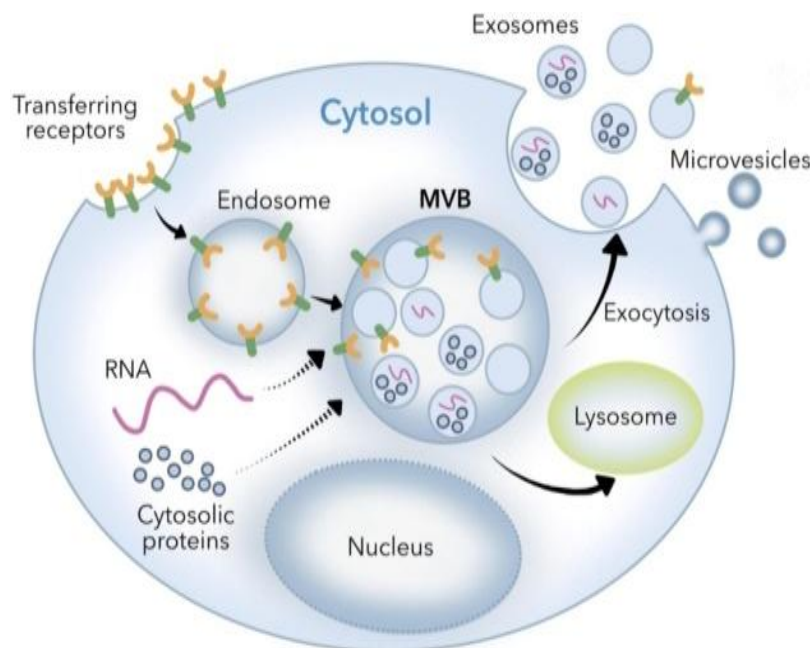
Exosomes are biologically active because they may transport bioactive substances including lipids, metabolites, proteins, and nucleic acids to the target cells [12]. Exosomes have the ability to transmit and convey various bio-molecules to recipient cells all over the body, indicating a new method of intercellular communication. In order to realize the promise of exosomes as a natural medication delivery mechanism, scientists have effectively altered the exosome contents. Several biological sources that have been reported for exosome separation are only now being used in the development of medicines and drug delivery systems [13].



**Figure 2:** Biogenesis of Exosomes

## VII. MILK-DERIVED EXOSOMES

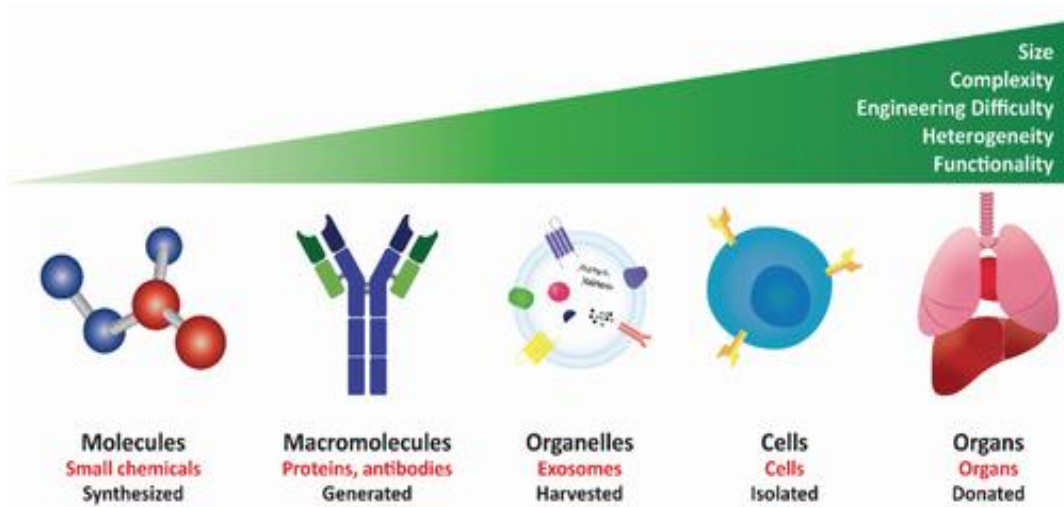
Milk is an important part of a healthy diet because it is a rich source of several important minerals such as calcium, vitamin D, and protein. Exosomes were first successfully removed from breast milk in 2007 after extensive research. Exosomes have been found, for example, in the milk of cows, pigs, kangaroos, camels, rats, horses, pantos, yaks, sheep, and goats. Because they are readily available, produce large amounts of exosomes, and are less cytotoxic than exosomes from other sources, milk-derived exosomes are a promising natural source for exosome production [14].



**Figure 3:** Biogenic Mechanism of Exosomes

## VIII. BENEFITS OF EXOSOMES IN CANCER TREATMENT

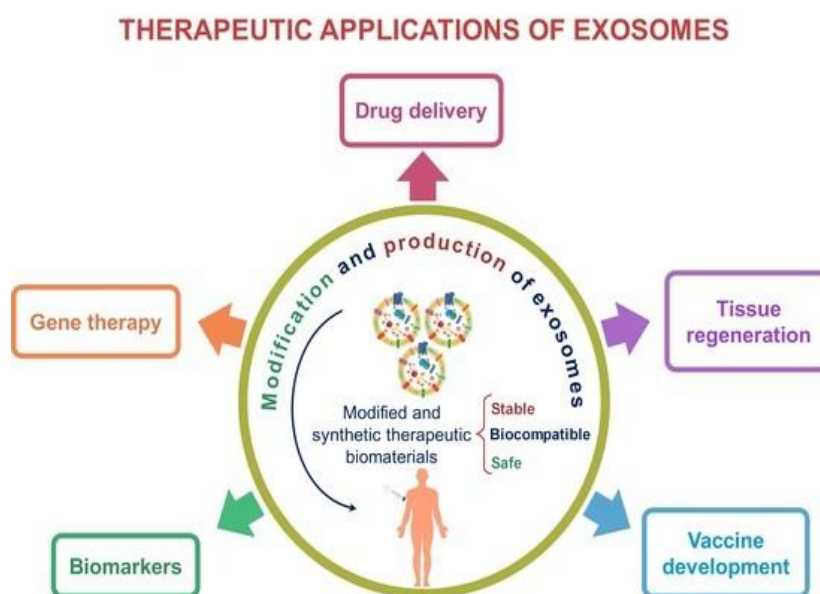
Treatments for cancer can be divided into small molecules (small chemicals), macromolecules (proteins and antibodies), cells, or organs. Cancer treatments have been researched for decades in these categories, which include size and complexity, engineering difficulty, diversity, and function. Research has concentrated on these areas, ranging from tiny compounds that inhibit signaling pathways through organ transplants. While current research is focused on protein antibody drugs, more advanced therapeutic modalities need to be developed. Exosomes are organelles that can be classified as being in between a macromolecule and a cell. Exosomes have become increasingly popular as diagnostic markers as well as therapeutic agents<sup>[15]</sup>. Unlike a single protein or a small molecule, an exosome contains heterogeneous functions but lacks the complexity of a cell or an organ. As a result, it is considered appropriate to treat various diseases such as cancer. Exosomes also have many advantages in terms of bio-compatibility and immunogenicity as well as stability and pharmacokinetics as well as bio-distribution as well as cellular uptake mechanism. These advantages can increase the therapeutic index for exosome based cancer therapies by targeting tumor cells in a way that minimizes unwanted side effects<sup>[16]</sup>.



**Figure 4:** Biological Levels of Living Organisms, Ranging from the Simplest to the Most Complex, Including Molecules, Macromolecules, Organelles, Cells, Organs, and Organisms

## IX. THERAPEUTIC ROLE OF EXOSOMES

The utilisation of exosomes as a biomarker, cell-free therapeutic agents, drug delivery mechanisms, basic research on exosome dynamics, and cancer vaccination are among their main clinical applications. Exosomes of different human or plant origins are used in a variety of therapeutic studies. Exosomes capacity to move intracellularly gives them a greater therapeutic potential for a range of diseases <sup>[17]</sup>. Exosomal pathogenicity in a variety of disorders can now be studied thanks to technical advances in nanomedicine. The continuous release of exosomes is a key component of the targeted drug delivery technique used in nanomedicine, which enables biological activity to be exerted at the desired area. Exosomes act as initiators or vectors for biological processes <sup>[18]</sup>.



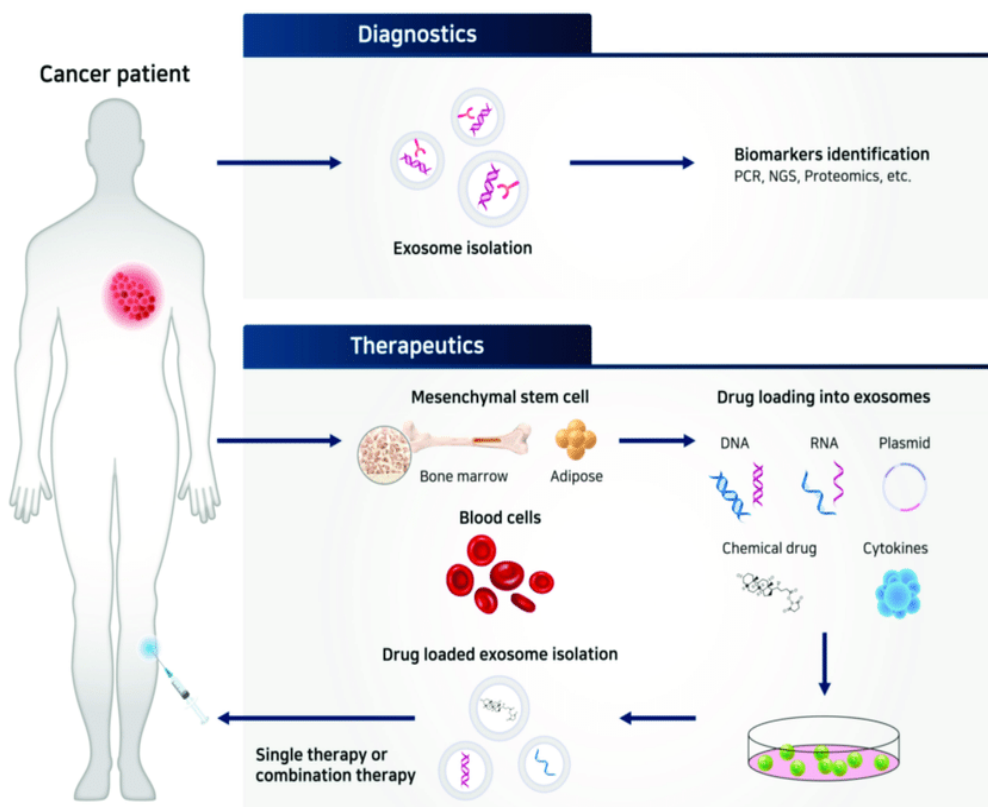
**Figure 5:** Therapeutic Applications of Exosomes

## X. EXOSOMES AS DRUG CARRIERS: PROSPECTS AND CHALLENGES

Exosomes have been proposed as a viable drug delivery method in cancer therapy in numerous papers in recent years. The fact that exosomes are extremely biocompatible, immunocompetent, swiftly traverses biological barriers, and do not accumulate in the body makes them an advantageous treatment option for cancer. Therefore, the development of an exosome-based drug delivery system has great scientific value and potential to be used in therapeutic settings<sup>[19]</sup>. However, as a drug carrier, exosomes face certain challenges in the therapeutic environment. For example, in addition to the heterogeneity of cell-derived exosomes, their size, composition, and functional properties can also vary, raising concerns about their safety. Therefore, to avoid anticancer effects, it is necessary to remove the normal content of exosomes before proceeding with clinical work. The modified exosomes are then loaded with anticancer drugs or can be modified with targeting moieties to form an engineered exosome<sup>[20]</sup>.

## XI. FUTURE DIRECTIONS AND POTENTIAL APPLICATION

Exosomes have shown promising results in cancer treatment with their ability to effectively deliver targeted drugs while minimizing side effects, making them a potential futuristic chemotherapeutic agent. In the future, exosomes have the potential to revolutionize cancer treatment by enabling targeted drug delivery, early detection of cancer, monitoring of treatment response, and development of personalized medicine<sup>[21]</sup>.



**Figure 6:** Potential Therapeutic Applications of Exosomes in Cancer

Exosomes are interesting and potentially useful biological nanoparticles. With increasing acceptance and promising results, exosome therapy could theoretically easily replace current cellular therapies. Exosomes are still in the early stages of research and clinical trials for their use in therapeutic drug delivery; more information and systematic characterization techniques are needed [22]. The main disadvantages of using exosomes as a drug delivery mechanism are related to the lack of consistent extraction and loading techniques and the risk of carrying unwanted exosome-related cargo components. The lack of a standardized exosome isolation process results in low purity and batch-to-batch variability. Large-scale isolation of exosomes remains difficult and clinical trials are expensive. Therefore, the main disadvantages of using exosomes as cargo vehicles are their low loading efficiency and the lack of a defined drug loading method. There is a lack of information on proteomics and the nature of exosomes in disease situations. According to the research, exosomes may cause biological damage that result in horizontal miRNA translocation, which would make cancer cells more resistant to treatment. [23].

## XII. CONCLUSION

Although the term "organic exosome" is still in its infancy, it is an exciting area of research for the development of products suitable for clinical applications. Clinical studies have shown that exosomes can be effective in the treatment of many diseases. However, more research is needed on these small bubbles. Our understanding of the mechanisms that drive the various identified exosomal roles is still very limited. Further studies are needed to fully understand the molecular mechanisms that drive exosome formation and exocytosis and their biological function in tumor progression. Only then will the promise of exosomes in diagnosis and treatment be realized in clinical practice. With continued research, we expect that exosomes as natural carriers will be fully utilized and their limitations overcome in the near future. For many cancer patients, significant advancements have been made in the development of exosomal cancer therapy.

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