EDITORIAL

Current Intellectual Glance Over Nanoparticles in Cancer and Neurodegenerative Research

Nanoparticles are highly fascinating technologically and are fundamentally important particles due to their large surface area in relation to their volume. They provide numerous advantages in their application to the life- and environmental-sciences consequent to their particle size (1-100 nm), which can be smaller than the size of a virus; thereby allowing them to potentially strongly adhere to surfactant and other biological materials. In this regard, nanoparticles represent promising agents for attaching biological entities to without changing their functions. There are numerous areas across the sciences where these engineered particles could be hugely beneficial; many of them inadequately explored. To aid understand the fuller potential and efficacies of these particles, more research is needed, and the results are brought into the limelight to allow them to be more fully and rapidly applied. Their evaluation in the areas of anticancer, antimicrobial, antiviral, anti-carcinogenic, sensory agents with newer techniques, and environmental applications encouraged.

The recent and continuing implementation of nanoparticles into biomedical research has gained huge and well-deserved importance. One of many highly promising areas is the synthesis of bioactive nanoparticles across various domains. In this regard, metallic nanoparticles are being increasingly utilized across multiple studies focused to mitigate disabling and fatal lifestyle-associated diseases. The eco-friendly (green) synthesis routes for these bio metallic nanoparticles are in high demand to support research to reduce toxicity and augment efficacy, and this can result from enhanced tissue permeation, more effective drug delivery to the disease site, and prolonged circulation time to maintain therapeutic drug levels. Nanoparticles are increasingly playing a critical role in the Veterinary sciences to both mitigate disease and improve animal nutrition. Likewise, a developing area still in its relative infancy, this veterinary research domain should be emphasized, particularly in relation to its agricultural relevance which is of great global importance. This special issue is hopefully fruitful for researchers, academicians (of relevant fields), pharmacists, material scientists, physicists, biologists, and computational scientists in the discipline of Artificial intelligence and deep machine learning. It is envisioned that the issue will explore trends of nanoparticle implementation across a broad spectrum of disciplines, as the knowledge domain naturally coalesces the fields of natural sciences together with physics, chemistry, engineering, material sciences and computational sciences with the biological sciences to provide different unique formulations of nanostructures to support multiple scientific advancements.

Nanotechnology is the process of modulating shape and size at the nanoscale to design and manufacture structures, devices, and systems. Nanotechnology's prospective breakthroughs are incredible, and some cannot even be comprehended right now. The blood-brain barrier, which is a prominent physiological barrier in the brain, limits the adequate elimination of malignant cells by changing the concentration of therapeutic agents in the target tissue. Nanotechnology has sparked interest in recent years as a way to solve these issues and improve drug delivery. Inorganic and organic nanomaterials have been found to be beneficial for bioimaging approaches and controlled drug delivery systems. Brain cancer (BC) and Alzheimer's disease (AD) are two prominent disorders of the brain. Even though the pathophysiology and pathways for both disorders are different, nanotechnology with common features can deliver drugs over the BBB, advancing the treatment of both disorders. This innovative technology could provide a foundation for combining diagnostics, treatments, and delivery of targeted drugs to the tumour site, further supervising the response and designing and delivering materials by employing atomic and molecular elements. There is currently limited treatment for AD, and reversing further progression is difficult. Recently, various nanocarriers have been investigated to improve the bioavailability and efficacy of many AD treatment drugs. Nanotechnology-assisted drugs can penetrate the BBB and reach the target tissue. However, further research is required in this field to ensure the safety and efficacy of drug-loaded nanoparticles. The application of nanotechnology in the diagnosis and treatment of brain tumours and AD is briefly discussed by Unnisa *et al.* [1].

Even though the battle against cancer has advanced remarkably in the last few decades and the survival rate has improved very significantly, an ultimate cure for cancer treatment stills remains an undeterred problem. In such a scenario, nanoinformatics, which is bioinformatics coupled with nanotechnology, endow with many novel research

1875-533X/23

opportunities in the preclinical and clinical development of specially personalized nano-sized drugs and carriers bestowing newer dimensions in anticancer research and therapy. Personalized nanomedicines tend to serve as a promising treatment option for cancer owing to their noninvasiveness and their novel approach. Explicitly, the field of personalized medicine is expected to have an enormous impact on clinical research owing to its diverse advantages and its versatility to adapt a drug to a cohort of patients. Khan *et al.* attempted to explain the implications of nanoinformatic a new emerging field in the field of pharmacogenomics and precision medicine. This review also recapitulates how nanoinformatics could accelerate the development of personalized nanomedicine in anticancer research, which is undoubtedly the need of the hour. The approach and concept of personalized nanomedicine have been facilitated by the impending field of Nanoinformatics. The breakthrough progressions made through nanoinformatics have prominently changed the insight of the future personalized medicinal drug in cancer research. Nanoparticle-based medicine has been developing and has created a center of attention in recent years, with a prime focus on proficient delivery mechanisms for various chemotherapy drugs. Nanoinformatics has allowed the merging of all recent advances from creating nano-sized particles that contain drugs targeting cell surface receptors to other potent molecules designed to kill cancerous cells and its subsequent application to personalize medicine [2].

Development of novel treatment methods for cancer is needed given the limitations of current treatment methods, including side effects and chemotherapeutic resistance, which may provide new hope to cancer patients. Cancer is the second leading cause of global mortality. Curcumin, the active ingredient of turmeric, has been used since ancient times for various therapeutic purposes. Several studies have identified its activity against cancer. Despite the established anticancer activity of curcumin, its low aqueous solubility and bioavailability are barriers to its effectiveness. In an attempt to solve this problem, many studies have formulated curcumin nanofiber preparations using a variety of methods. Electrospinning is a simple and affordable method for the production of nanofibers. Studies have shown increased curcumin bioavailability in nanofibers resulting from their high surface/volume ratio and porosity. Ataei *et al.* have undertaken a detailed review of studies on the anticancer effects of curcumin nanofibers. Curcumin acts by inhibiting various biological cancer pathways, including NF-κB, mTOR, complex I, cytokines, expression of p-p65, Ki67, and angiogenesis-associated genes. It also induces apoptosis through activation of caspase pathways and ROS production in cancer cells. Curcumin-loaded PLA50/PVP50/Cur15 nanofibers were investigated in breast cancer, one of the most studied cancers, and was shown to have significant effects on the widely used HeLa-cell line. Most of the studies undertaken have been performed in cell lines *in vitro*, while relatively few animal studies have been reported. More preclinical and clinical studies are needed to evaluate the anticancer activity of curcumin nanofibers. Amongst studies undertaken, a variety of curcumin nanofibers of various formulations have been shown to suppress a variety of cancer types. Overall, curcumin nanofibers have been found to be more efficient than free curcumin. Thus, curcumin nanofibers have been observed to improvise cancer treatment, offering great potential for effective cancer management. Further studies, both *in vitro* and *in vivo*, involving curcumin nanofibers have the potential to benefit cancer management [3].

Central nervous system (CNS) disorders account for boundless socioeconomic burdens with devastating effects among the population, especially the elderly. The major symptoms of these disorders are neurodegeneration, neuroinflammation, and cognitive dysfunction caused by inherited genetic mutations or by genetic and epigenetic changes due to injury, environmental factors, and disease-related events. Currently available clinical treatments for CNS diseases, i.e., Alzheimer’s disease, Parkinson’s disease, stroke, and brain tumor, have significant side effects and are largely unable to halt the clinical progression. So gene therapy displays a new paradigm in the treatment of these disorders with some modalities, varying from the suppression of endogenous genes to the expression of exogenous genes. Both viral and non-viral vectors are commonly used for gene therapy. Viral vectors are quite effective but associated with severe side effects, like immunogenicity and carcinogenicity, and poor target cell specificity. Thus, non-viral vectors, mainly nanotherapeutics like nanoparticles (NPs), turn out to be a realistic approach in gene therapy, achieving higher efficacy. NPs demonstrate a new avenue in pharmacotherapy for the delivery of drugs or genes to their selective cells or tissue, thus providing concentrated and constant drug delivery to targeted tissues, minimizing systemic toxicity and side effects. Annu *et al.* emphasized the role of NPs in mediating gene therapy for CNS disorders treatment. Moreover, the challenges and perspectives of NPs in gene therapy are also summarized in it [4].

Triple-negative breast cancer (TNBC) is the most aggressive type of breast cancer with enhanced metastasis and poor survival. Though chemotherapy, radiotherapy, photo-thermal therapy (PTT), photodynamic therapy (PDT), and gene delivery are used to treat TNBC, various side effects limit these therapeutics against TNBC. Akter *et al.* have focused on the mechanism of action of gold nanoparticles (AuNPs) to enhance the efficacy of therapeutics with targeted delivery on TNBC cells. Research data were accumulated from PubMed, Scopus, Web of Science, and Google Scholar using searching criteria "gold nanoparticles and TNBC" and "gold nanoparticles and cancer". Though they reviewed many old papers, most cited papers were from the last ten years. Various studies indicated that AuNPs can enhance bioavailability, site-specific drug delivery, and efficacy of chemotherapy, radiotherapy, PTT, and PDT as well as modulate gene expression. The role of AuNPs in the modulation of TNBC therapeutics through the inhibition of cell proliferation, progression, and metastasis has been proved *in vitro* and *in vivo* studies. As these mechanistic actions of AuNPs are most desirable to develop drugs with enhanced therapeutic efficacy against TNBC, it might be a promising approach to apply AuNPs for TNBC therapeutics. Akter *et al.* reviewed the mechanism of action of AuNPs and their application in the enhancement of therapeutics against TNBC. Much more attention is required for studying the role of AuNPs in developing them either as a single or synergistic anticancer agent against TNBC [5].

Lung cancer is one of the commonest cancers with a significant mortality rate for both genders, particularly in men. Lung cancer is recognized as one of the leading causes of death worldwide, which threatens the lives of over 1.6 million people every day. Although cancer is the leading cause of death in industrialized countries, conventional anticancer medications are unlikely to increase patients' life expectancy and quality of life significantly. In recent years, there are significant advances in the development and applications of nanotechnology in cancer treatment. The superiority of nanostructured approaches is that they act more selectively than traditional agents. This progress led to the development of a novel field of cancer treatment known as nanomedicine. Various formulations based on nanocarriers, including lipids, polymers, liposomes, nanoparticles and dendrimers have opened new horizons in lung cancer therapy. The application and expansion of nano-agents lead to an exciting and challenging research era in pharmaceutical science, especially for the delivery of emerging anti-cancer agents. The objective of the review by Gholami *et al.* discussed the recent advances in three types of nanoparticle formulations for lung cancer treatments modalities, including liposomes, polymeric micelles, and dendrimers for efficient drug delivery [6]. Afterward, they have summarized the promising clinical data on nanomaterials based therapeutic approaches in ongoing clinical studies.

Even though the promising therapies against cancer are rapidly improved, the oncology patient population has seen exponential growth, placing cancer in fifth place among the ten deadliest diseases. Efficient drug delivery systems must overcome multiple barriers and maximize drug delivery to the target tumors, limiting the side effects simultaneously. Since the first observation of the quantum tunneling phenomenon, many multidisciplinary studies have offered quantum-inspired solutions to optimized tumor mapping and efficient nano-drug design. The property of a wave function to propagate through a potential barrier offer the capability of obtaining 3D surface profiles using imaging of individual atoms on the surface of a material. The application of quantum tunneling on a scanning tunneling microscope offers an exact surface roughness mapping of tumors and pharmaceutical particles. Critical elements to cancer nanotherapeutics apply the fractal theory and calculate the fractal dimension for efficient tumor surface imaging at the atomic level. Alexiou *et al.* presented the latest biological approaches to cancer management based on fractal geometry [7]. We, the Guest-Editors, would like to express our gratitude to the many authors who contributed to this special issue and to reviewers for sparing their precious time in providing constructive feedback for the improvement of the articles.

REFERENCES

[1] Unnisa, A.; Greig, N.H.; Kamal, M.A. Nanotechnology: A promising targeted drug delivery system for brain tumours and Alzheimer's disease. *Curr. Med. Chem.,* **2023**, *30*(3), 255-270.

[2] Khan, F.; Akhtar, S.; Kamal, M.A. Nanoinformatics and personalized medicine: an advanced cumulative approach for cancer management. *Curr. Med. Chem.,* **2023**, *30*(3), 271-285.

[3] Ataei, M.; Roufogalis, B.D.; Majeed, M.; Shah, M.A.; Sahebkar, A. Curcumin nanofibers: A novel approach to enhance the anticancer potential and bioavailability of curcuminoids. *Curr. Med. Chem.,* **2023**, *30*(3), 286-303.

[4] Annu; Rehman, S.; Nabi, B.; Sartaj, A.; Md, S.; Sahoo, P.K.; Baboota, S.; Ali, J. Nanoparticle mediated gene therapy: a trailblazer armament to fight CNS disorders. *Curr. Med. Chem.,* **2023**, *30*(3), 304-315.

[5] Akter, Z.; Khan, F.Z.; Khan, M.A. Gold nanoparticles in triple-negative breast cancer therapeutics. *Curr. Med. Chem.,* **2023**, *30*(3), 316-334.
[6] Gholami, L.; Ivari, J.R.; Nasab, N.K.; Oskuee, R.K.; Sathyapalan, T.; Sahebkar, A. Recent advances in lung cancer therapy based on nanomaterials: a review. *Curr. Med. Chem.,* **2023**, *30*(3), 335-355.
[7] Alexiou, A.; Tsagkaris, C.; Chatzichronis, S.; Koulouris, A.; Haranas, I.; Gkigkitzis, I.; Zouganelis, G.; Mukerjee, N.; Maitra, S.; Jha, N.K.; Batiha, G.E.S.; Kamal, M.A.; Nikolaou, M.; Ashraf, G.M. The fractal viewpoint of tumors and nanoparticles. *Curr. Med. Chem.,* **2023**, *30*(3), 356-370.

Tanima Bhattacharya
(Guest Editor)
College of Chemistry and Chemical Engineering
Hubei University
P.R. China

Bairong Shen
(Guest Editor)
Institutes for Systems Genetics
West China Hospital
Sichuan University
Chengdu 610041
P.R. China

Nigel H. Greig
(Guest Editor)
Translational Gerontology Branch
National Institute on Aging
National Institutes of Health
Baltimore
USA

Mohammad Amjad Kamal
(Guest Editor)
Institutes for Systems Genetics
Frontiers Science Center for Disease-related
Molecular Network
West China Hospital
Sichuan University
P.R. China

King Fahd Medical Research Center
King Abdulaziz University
Jeddah 21589
Saudi Arabia

Department of Pharmacy
Faculty of Allied Health Sciences
Daffodil International University
Bangladesh

Enzymoics, 7 Peterlee place
Hebersham, NSW 2770
Novel Global Community Educational Foundation
Australia