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Bio Surveilliance Bacteria in Nanoparticle

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Abstract

The application of nanotechnology to oncology is transforming cancer treatment and diagnosis while also significantly enhancing prognosis. The use of bio- and nanotechnologies, along with the clinical translation of the most recent discoveries in cancer research, is largely to blame for this. The development of more specific targeted therapy for the majority of human malignancies is progressively being influenced by cancer genomes and early diagnoses. A significant advancement in this area has been made during the past ten years thanks to the collection of fundamental information. Through the identification of novel genetic and epigenetic biomarkers, nanooncology has aided in the creation of cutting-edge multifunctionalized nanoparticles for tumour imaging and targeting as well as more sensitive biosensors for early cancer detection. Nanooncology is anticipated to soon make very early tumour diagnosis possible, along with customised cancer treatment. Metal waste and contamination cleanup may be accomplished by the use of microbial metal reduction. In some instances, the bacteria that may decrease metal ions demonstrate the ability to precipitate metals at the nanoscale scale. Bacteria are capable of mobilising and immobilising metals. Around the world, the biosynthesis of nanoparticles (NPs) utilising bacteria has arisen as a quickly growing study field in green nanotechnology, with diverse biological entities constantly being exploited in NPs synthesis as an ecological option to traditional chemical and physical processes. Fast, clean synthesis of NPs with specified morphologies and regulated sizes is possible through process optimization. Consequently, the purpose of this review is to reflect on the situation as it is now, as well as on the potential for the future.

Keywords: Nanooncology; Nanotechnology

Introduction

Cleaning up metal waste and contamination may be done via microbial metal reduction. When metal ions are reduced by bacteria, this bacterium has been shown to have the ability to precipitate metals at the nanoscale level. Metals are both movable and immobile in the presence of bacteria. The biosynthesis of nanoparticles (NPs) using bacteria has emerged as a rapidly expanding research area in green nanotechnology, with a variety of biological entities continually being used in NPs synthesis as an ecological alternative to conventional chemical and physical methods. Process optimization makes it possible to quickly and cleanly synthesise NPs with specific morphologies and controlled sizes [1]. This review's goal is to consider both the current state of affairs and the potential for the future. Not all mutations, nevertheless, outcomes in cancer. EGFR, HER2/ERBB2, KRAS, KIT, FGFR, VEGF-R, ABL, PI3K, mTOR, PDGF-R, and HGFR/MET are examples of growth factor receptors involved in signalling cascades that frequently have somatic mutations in their tyrosine kinase domains. Subgroups of patients with advanced non-small-cell lung cancer who respond to the EGFR tyrosine kinase inhibitors gefitinib or erlotinib have activating mutations of the EGFR, which are representative [2]. The first success in personalised oncology was the HER2 antibody trastuzumab for breast cancer, which was followed by the BCR-ABL1 inhibitor imatinib for chronic myeloid leukaemia, the EGFR-TKIs and the ALK-MET inhibitor crizotinib for NSCLC, and the BRAF inhibitor vemurafenib for melanoma [3].

The particular predictive biomarkers were crucial to the significant advancements in the clinical usage of TKIs for the treatment of cancer. However, CRC with KRAS mutations did not respond to targeted therapy with particular anti-EGFR monoclonal antibodies, even in metastatic colorectal tumours that express EGFR [4]. As a finding of the failure of interleukin-2 (IL-2) and the potentially fatal side effects of adoptive cell-transfer of autologous tumor-infiltrating reactive lymphocytes, current cancer immunotherapy is primarily based on antitumor specific mAbs. Despite this, therapy achieved 40% tumour regression in advanced metastatic melanoma [5]. Due of its potential impact on numerous scientific fields, including energy, medicine, the pharmaceutical industry, electronics, and space industries, nanoscience and nanotechnology have gained a lot of attention in recent years. Small structures and materials with dimensions between a few nanometers and fewer than 100 nanometers are the focus of this technology. Due to their high surface-to-volume ratio, nanoparticles exhibit distinctive and significantly different chemical, physical, and biological properties when compared to bulk materials with the same chemical makeup [6]. NPs have unique features that rely on their size and form and are useful for a variety of applications, including biosensing, catalysts, optics, antimicrobial activity, computer transistors, electrometers, chemical sensors, wireless electronic logic, and memory systems. Many diverse fields, including imaging in medicine, can use these particles [7].

Synthesis of nanometer-sized particles with various morphologies, diameters, and monodispersities is a crucial topic of nanoscience research. In this context, there is a rising need to create dependable, nontoxic, clean, eco-friendly, and green experimental techniques for the synthesis of NPs. Utilizing natural mechanisms for the production of NPs, such as those involving enzymes, microbial enzymes, vitamins, polysaccharides, biodegradable polymers, microorganisms, and biological systems, is one way to accomplish this goal [8]. One strategy has tremendous potential and is based on employing microorganisms for the production of NPs. Recent research aims to create a regulated and up-scalable approach for the manufacture of monodispersed and extremely stableNPs. In order to investigate alternate techniques for

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the production of NPs, a large variety of bacterial species have been employed in green nanotechnology [9]. For the purpose of creating NPs, researchers have begun to employ the biomass or cell extracts of bacteria. Bacteria are viewed as a possible biofactory for the synthesis of NPs such as gold, silver, platinum, palladium, titanium, titanium dioxide, magnetite, cadmium sulphide, and others. Magnetotactic bacteria and S layer bacteria are two well-known types of bacteria that may synthesise inorganic compounds. The bioreduction of ions or the creation of water insoluble complexes is a defence mechanism established by the bacteria to overcome such toxicity as the majority of metal ions are harmful to them [10].

Molecular Diagnostics for Personalized Oncology

Due to their ability to trigger malignant transformation, mutations in the TK genomic domains of a variety of growth factor receptors were given the moniker "driver" mutations. Targeted therapy may not be successful in all patients, despite early finding, particularly in cancers harbouring driver mutations. A minority of tumour cell subclones may exhibit genetic heterogeneity, the emergence of drug resistance due to secondary mutations, and tumour relapse, which outcomes in drug sensitivity and tumour progression [11]. These events can happen either early on in the tumour formation process or later on. New therapeutic strategies can now be developed thanks to the growing clarity of the metabolic and signalling pathways that are involved in the majority of resistance mechanisms that are encountered. A multidrug resistant cancer type is exemplified by advanced melanoma, which is extremely resistant to chemotherapy and spreads quickly. In more than 60% of melanoma cases, BRAF-V600E mutations have been identified. Despite being initially sensitive to particular inhibitors, resistance quickly arises in the form of amplified genes with mutations. The MAPK pathway, which transmits proliferative signals from cell membrane receptors via the cytoplasm to the nucleus, includes BRAF as one of its components [12].

Advanced Genomics Identifies Genetic Oncomarkers in Tumor and Metastasis

The primary method of therapeutic targeting in solid tumours is the discovery of cancer-specific gene alterations. Successful treatment of NSCLC exhibiting EGFR mutations or carrying the EGFR-amplified gene was achieved with targeted delivery of medicines selectively tailored to particular tumour cells. Small-cell lung cancer patients did not react to gefitinib treatment; however NSCLC patients demonstrated a significant increase in survival. The application of personalised medicine, which both provides a predictive response to treatments and indicates the possibility of adverse events, emerged from the integration of novel proteomics assays for finding biomarkers with statistical analysis for standardising clinical data. Genomic mutations in HER2, BRAF, ALK, and KRAS are frequently expressed in NSCLC [13]. Depending on the type of tumour and its genetic makeup, different TKIs have different effects.

In order to disclose transcription profiling and perform large-scale single-nucleotide polymorphism experiments to find DNA deletions or amplifications, molecular diagnostics now uses next-generation DNA sequencing, or oligonucleotide arrays. The most recent tests for sequencing a person's entire genome and nanopores are specially tailored to the clinical needs that are unique to a particular cancer. Through the use of cutting-edge methods for genome resequencing and genetic variation, certain DNAs or RNAs, cDNAs, miRNAs, and short RNAs are picked. Using target-capture hybridization, the full exome of a genome may be sequenced, revealing both common and unusual variants as well as infrequent mutations that increase the risk of developing cancer [14]. The analysis of sequence changes in chromosomal regions from various individuals as well as the detection of single-nucleotide polymorphisms using chip-based techniques have both been made possible by genome-wide association studies.

Cancer stem cell targets

CSC is a persistent cell population whose origin is still hotly contested. They are defined by their in vitro and in vivo self-renewal, which maintains a steady reservoir. CSC interacts with the tumour microenvironment and make sure that their own alterations create the best environment for long-term preservation and continuity. Despite being few in number in tumours, CSC exhibit heterogeneity even within the same tumour, depending on the stage, degree, and level of differentiation. CSC functions as tumor-initiating cells and plays a role in metastasis, tumour development, and recurrence. In order to isolate and characterise CSC showing various characteristics in various types of malignancies, a number of markers have been established.

Cancer Diagnostics Using Nanotechnology

The specificity and sensitivity of routine tests are lacking. Multifunctional nanoplatforms for monitoring cancer therapy have been made possible by the development of nanoparticles that particularly target cancer cells and that combine diagnostic imaging with pharmacological and physical anticancer agents. Using novel nanodevices, electromagnetic signals can be transmitted or amplified depending on information about interactions between molecules and subcellular structures that are based on mutations and changes to the pathways that cause cells to become malignant [15]. Due to their lower toxicity and exclusive focus on altered cells, they can also be used in conjunction with therapeutic approaches that are more effective.

Nanoparticle Synthesis Using Bacteria

Bacteria are one of the greatest possibilities for synthesising nanoparticles because of their exceptional capacity to decrease heavy metal ions. To combat pressures like the toxicity of heavy metal ions or metals, for example, some bacterial species have evolved the capacity to use particular defence mechanisms. It was found that some of them were able to develop and thrive in environments with high metal ion concentrations. As an added bonus, when growing on elemental sulphur as an energy source, the Thiobacillus ferrooxidans, T. thiooxidans, and Sulfolobus acidocaldarius were able to convert ferric ion to the ferrous state. Ferric iron could be reduced aerobically by T. thiooxidans in low pH media. T. thiooxidans could only bioreduce ferric iron since the ferrous iron produced was stable to autoxidation and could not be oxidised. The silver-resistant bacterium strain Pseudomonas stutzeri AG259, which was discovered in silver mine, collected silver NPs and small amounts of silver sulphide inside its cells. When P. stutzeri AG259 was exposed to high concentrations of silver ions while being cultured, larger particles were produced, outcoming in the intracellular synthesis of silver NPs with sizes ranging from a few nm to 200 nm. With a variety of crystal typologies, including hexagons and equilateral triangles, as well as three different types of particles: elemental crystalline silver, monoclinic silver sulphide acanthite (Ag2S), and a fourth unidentified structure, AG259 detoxified silver through its precipitation in the periplasmic space and its bioreduction to elemental silver. The periplasmic region constrained the crystals' thickness but not their width.

Automatistic Elements

The ability of bacteria to survive and thrive under stressful conditions may be attributed to particular mechanisms of resistance,

such as efflux pumps, metal efflux systems, inactivation and complexation of metals, impermeability to metals, a lack of specific metal transport systems, alteration of solubility and toxicity by changes in the redox state of the metal ions, extracellular precipitation of metals, and volatilization of toxic metals by enzymatic reactions. The ability to create silver nanoparticles has been demonstrated, for instance, in Pseudomonas stutzeri AG 259 isolated from silver mines. The biotechnological domains of biomineralization, bioremediation, bioleaching, and microbially influenced corrosion processes are just a few examples of how microbes and metals interact and are crucial to these applications. Understanding of MIC processes as localised changes in surface chemistry caused by microbes. The ex situ and in situ cleanup of metal wastes and contaminations may both benefit from microbial metal reduction. Researchers have studied the mechanisms of nanoparticle synthesis and bioreduction and have concentrated their attention on reducing agents in bacteria and biochemical pathways leading to metal ion reduction in order to determine the relevance of metal reduction, biorecovery of heavy metals, and bioremediation of toxic ones. The importance of these agents prompted more research into the function and use of naturally occurring and genetically modified bacterial strains and other microorganisms in the bioremediation of radionuclide- and toxic metal-contaminated terrestrial environments. These microorganisms were capable of mobilising and immobilising metals, and in some cases, the bacteria that could reduce metal ion.

Potential Futures

The time-consuming purifying processes and lack of knowledge of the mechanisms involved in the production of NPs utilising bacteria are major limitations. Controlling the particle size and shape as well as achieving monodispersity in the solution phase are significant difficulties that typically arise during the biosynthesis of NPs. Before this green bio-based technology will be a viable and competitive alternative for the industrial synthesis of NPs, it appears that a number of significant technological difficulties must be addressed. Scaling up for processing at the production level is a significant obstacle. Furthermore, little is known about the mechanistic aspects, and knowledge in this area is required for the economical and logical growth of nanoparticle biosynthesis.

Discussion

A tremendous amount of work has been put into designing and creating nanometer-sized targeted probes for cancer diagnosis and therapy over the past 20 years. These probes combine a variety of features and diverse functions, including stability in the circulation, accumulation to particular areas, responsiveness to local cues, effective intracellular drug delivery, and multimodality of action. The morphological characteristics of the tumour are provided by magnetic iron oxide (ION) nanoparticles employed as an MRI contrast agent in cancer imaging, and the therapy response is continuously tracked. Highly lymphotropic superparamagnetic iron oxide nanoparticles (SPIONs), which simultaneously combine high-resolution MRI with optical imaging, have been utilised successfully for micrometastasis screening in patients with prostate cancer who have undergone surgical lymph node resection or biopsy. Studies are being conducted to address these issues and determine the optimum methods for the extraction and purification of the metal NPs produced by bacteria (either through intercellular or extracellular synthesis) for subsequent applications. Additional processing steps are needed, such as ultrasonic treatment or a reaction with the appropriate detergents, to release the NPs created intracellularly. The recovery of valuable metals from mine wastes and metal leachates can take advantage of this. Metal NPs embedded in biomatrix could be employed as catalysts in a variety of chemical processes. This will aid in keeping the NPs in place for ongoing use in bioreactors. The generated NPs can be removed from the cells using physicochemical techniques as freeze-thawing, heating procedures, and osmotic shock.

Conclusion

Cancer diagnosis is frequently made in the latter stages, when conventional cancer therapy is limited by side effects and disadvantages. Fresh molecular biomarkers give rise to new optimism; for instance, miRNAs enable very early, accurate, and cutting-edge cancer diagnosis and therapy and enhance prognosis. Personalized anticancer therapies began with particular antitumor mAbs and TKIs, but mAbs are typically useless as second-line therapy and TKIs quickly cause resistance. A molecular anticancer strategy that is specifically targeted at a single cancer cell is needed for personalised oncology to be effective. The molecular signature of the tumour that needs to be treated must therefore be thoroughly diagnosed. Orthotopic tumour models using patient-derived xenograft in immune-deficient mice enable drug response prediction and personalised anticancer treatment. The evaluation of second-generation polymeric nanoparticles has already been approved. The binding to several cell ligands is made easier by the modification of NPs, which also improves their physicochemical properties for drug targeting, release, and clearance. Cancer theranostics is a newly emerging field. There are many different cancer types that could benefit from the use of recently produced nanoparticles, including malignancies that exhibit a stem-cell characteristic. These nanoparticles were functionalized to give multifunctional nanoplatforms in melanoma. Theranostics, which is molecularly focused, can monitor very successful targeted therapy while simultaneously enabling tumour detection at the level of a single cell and combining it with tumour diagnostic imaging. Real-time detection of nanovectors localised at the target areas and immediate visual evaluation of therapeutic effect on tumour cells are made possible by a dual diagnostic and therapeutic method combined with selective targeting.

The stability and aggregation of the biosynthesized NPs, control of crystal growth, form, size, and size distribution are the most significant challenges now encountered with bio-based techniques, which are still in the development stages. Additionally, biologically produced NPs are more polydisperse than those made chemically. The control of NP characteristics can be achieved by optimising crucial factors that affect cellular activities, enzymatic reactions, and organisms' growth conditions.

Mechanistic issues have not been thoroughly and precisely articulated or explored. Therefore, more thorough research is required to understand the precise mechanisms of reaction and pinpoint the proteins and enzymes involved in nanoparticle manufacturing. The employment of bacteria in the large-scale synthesis of NPs is intriguing because it eliminates the need for risky, pricey, and poisonous chemical ingredients in the synthesis and stabilisation procedures. These natural nanofactories appear to be capable of producing stable NPs with well-defined sizes, morphologies, and compositions by tuning the reaction conditions and choosing the right bacteria.

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Conflicts of Interest

The author has no known conflicts of interested associated with this paper.

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