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A Review Concept on Nanomedicines: Nanotechnology

Sanjanakasturi, Shruti Garad

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ABSTRACT
Nanotechnology is among the most exciting technological developments of the twenty-first century. As a subfield of nanotechnology, nanomedicine deals with highly targeted molecular medical interventions to treat diseases or restore damaged tissues like muscles, nerves, and bones. A group of related technologies on the nanoscale scale, typically 0.1-100 nm, are collectively referred to as nanotechnology. With a standard laboratory microscope, a nanometer is one billionth of a metre, too small to be seen. Within live cells, biological chemicals and structures function at this size scale, which is roughly 100 nanometers or less. Engineering and manufacturing at the molecular level is thus what nanotechnology. The application of nanotechnology to biomedical sciences implies the development of materials and tools with very specialised interactions with the body at subcellular scales. This may have implications for focused therapeutic applications that target particular cells and tissues with the goal of achieving maximum therapeutic results with the fewest possible side effects. Impressive treatments for a number of deadly diseases can be obtained through nanomedicine. Within the next few years, it is anticipated that diseases like cancer, illnesses of the heart, lungs, blood, neurological (particularly neurodegenerative) illnesses, diabetes, inflammatory/infectious illnesses, Parkinson's or Alzheimer's disease, and orthopaedic issues will benefit most from nanotechnology. Nanomedicine is predicted to eradicate almost all major ailments and medical suffering by the first half of the twenty-first century.An overview of several nanotechnology applications in nanomedicine is given in this article.

I. INTRODUCTION

Nanomedicine makes use of tiny instruments to diagnose, treat, and prevent disease as well as to better understand the intricate pathophysiology that underlies all diseases. Enhancing the quality of life is the ultimate objective. The broad definition of nanomedicine is the molecular-level monitoring, repair, and enhancement of all human biological systems through the use of manufactured devices and nanostructures to produce medical benefits. In its broadest sense, nanomedicine refers to the application of molecular tools and molecular understanding of the human body to the diagnosis, treatment, prevention, and pain relief of illness and traumatic injury, as well as to maintain and improve human health. Nanomedicine presents the possibility of effective new instruments. For the application of molecular nanotechnology in the treatment of human diseases and the enhancement of human biological systems. 'Nanotechnology' is the phraseKnown as "the manufacturing technology of the 21st century," nanotechnology will allow for the construction of a wide variety of economically sophisticated molecular devices, including molecular computers. It will enable the creation of computer-controlled molecular instruments that are substantially smaller than human hands.Cell with the precision and accuracy of pharmaceutical compounds. With the use of these instruments, medicine will be able to do sophisticated, regulated cellular and molecular interventions for the first time.A new area known as nanomedicine has emerged as a result of increased interest in the uses of nanotechnology in medicine.They might eradicate cancer cells, clear blockages in the bloodstream, or assume control of subcellular organelles. Similar to how the artificial heart of today has been created. [1]

Nanotechnology has become more and more ingrained in our daily lives in recent years. This ground-breaking technology has been adapted into many different industries. Applications and goods with nanoparticles in them, or at least claims based on nanotechnology, are becoming more and more common. Research on pharmaceuticals also experiences this. Our research currently includes the use of nanotechnology in the creation of new medications, and the European Union (EU) has acknowledged it as a Key Enabling Technology that can provide novel and creative medical solutions to meet unmet medical needs.[2]

Nonetheless, there has been disagreement about what constitutes a nanomaterial among

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international regulatory agencies and different scientific communities. A few attempts have been made to arrive at a consensus definition because, because of their small size, nanomaterials exhibit unique physicochemical features that set them apart from their typical bulk chemical equivalents. These characteristics substantially expand the range of possibilities for medication development; yet, several safety-related worries have surfaced. Concerns regarding the application of nanomaterials include their toxic properties and their persistence in the environment and human body, as well as their physicochemical properties that can alter pharmacokinetics, or the absorption, distribution, elimination, and metabolism. They can also potentially cross biological barriers more easily. [2]

DEFINITION Of NANOMEDICINES

The definition of nanomedicine is the creation of nanoscale (1–100 nm) or nanostructured things, such as skin patches or nanorobots, and their application in medicine for therapeutic and diagnostic reasons based on the unique medicinal effects of their structure. [3] Applications of nanotechnology in medicine are known as nanomedicine. Nanomedicine includes potential future uses of molecular nanotechnology, such as biological machines, as well as the medical application of nanomaterials and biological devices, as well as nanoelectronic biosensors. Comprehension of the toxicity and environmental effects of nanoscale compounds is one of the current challenges in nanomedicine . [4]

NANOMEDICINS IMPACT ON ALL THE TYPES OF MEDICAL

It is believed that nanomedicine will play a major role in enabling personalised, targeted, and regenerative medicine by providing patients and physicians with the newest generation of medications, therapies, and implantable technology, ultimately leading to significant advancements in healthcare. Beyond that, nanomedicine offers significant new tools to address the major issue of an ageing population and is believed to play a key role in better and more economical healthcare, which is a necessary component in ensuring that medications and treatments are accessible and cheap for everyone. [5]

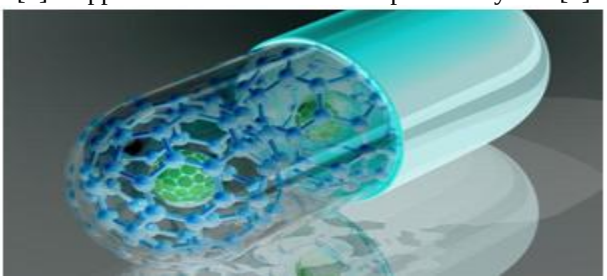

Fig.1Nanomedicine

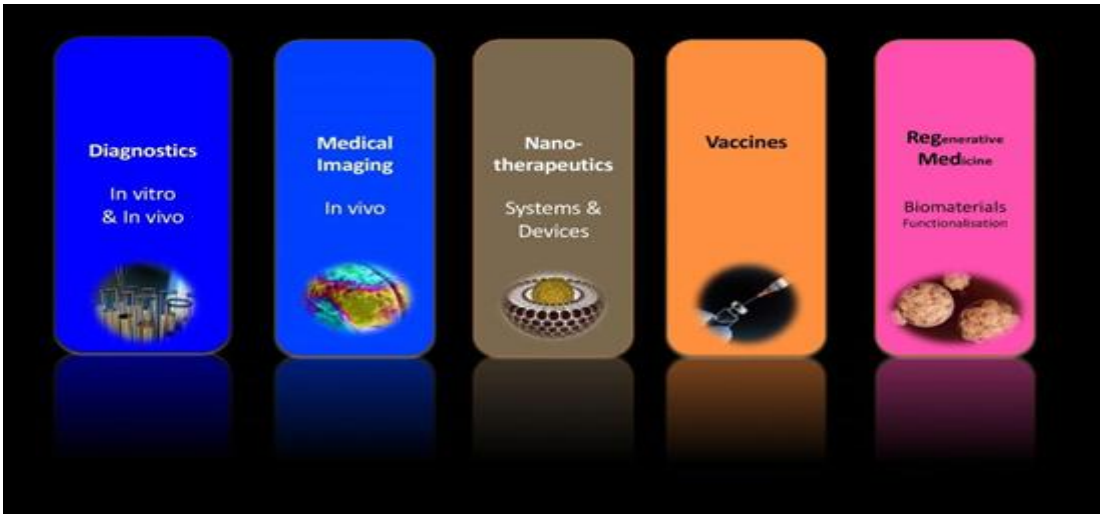

Fig.2 Diagram of Nanomedicine treatment forms.[5]

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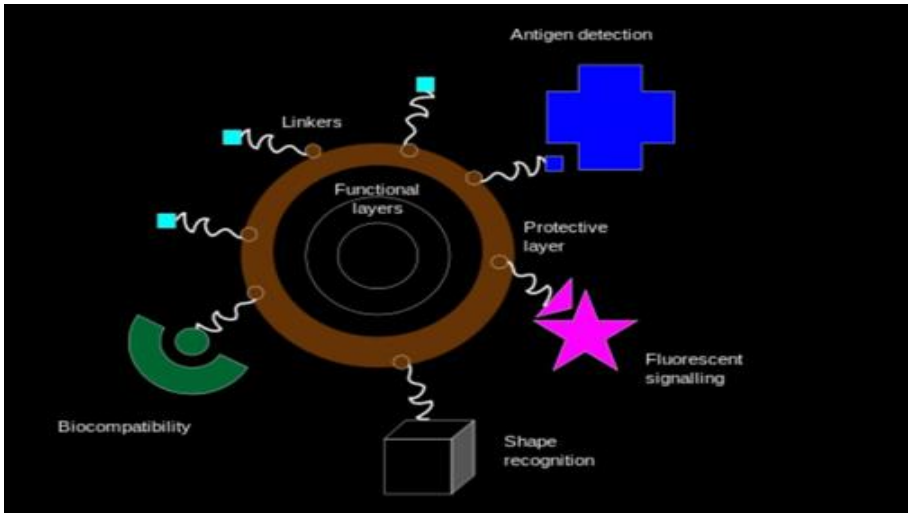
DRUG DELIVERY

Drug delivery to certain cells through the use of nanoparticles has been made possible by nanotechnology. Deploying the active ingredient in the pharmaceutical just in the morbid region and at no more than the necessary amount can greatly reduce total drug consumption and adverse effects. Targeted medication distribution aims to lower pharmacological adverse effects while simultaneously lowering treatment costs and drug intake. Moreover, by limiting unwanted exposure to healthy cells, focused drug delivery lessens the adverse effects that crude medication may cause. Increasing bioavailability at targeted locations in the body as well as over an extended period of time is the main goal of drug delivery. Molecular targeting using nanoengineered devices may be able to accomplish this. Biochemical reaction times are significantly shortened, and smaller, potentially implantable devices are two advantages of adopting nanoscale technology in medicine. These are not your standard medicine delivery systems; they are speedier and more sensitive. The three main factors that determine how effective drug delivery using nanomedicine is: a) effective drug encapsulation; b) drug delivery to the intended area of the body; and c) drug release. By 2019, a number of medications with nano-delivery were available. Lipid or polymer-based nanoparticles can be used as drug delivery vehicles to enhance the medication's pharmacokinetics and biodistribution.

Nonetheless, there considerable patient variability in the pharmacokinetics and pharmacodynamics of nanomedicine. Nanoparticles possess advantageous characteristics that can enhance medication administration when they are engineered to evade the body's defensive systems. The development of sophisticated drug delivery systems includes the ability to carry medications across cell membranes and into the cytoplasm of cells. One method to use pharmacological molecules more effectively is through triggered response. Drugs are injected into the body, and they don't work until they come into contact with a specific signal. To improve solubility, a medication with poor solubility could be substituted with a drug delivery device that has both hydrophilic and hydrophobic environments. Drug delivery systems can also lessen drug clearance rates, control drug release to avoid tissue injury, or decrease the volume of distribution to lessen the impact on non-target tissue. But still, Depending on their size, shape, and composition, nanoparticles can be differently hazardous. These variables also impact potential organ damage and accumulation. Because nanoparticles are designed to survive a long time, they become stuck in organs, particularly the spleen and liver, where they cannot be eliminated or broken down. Mice have shown signs of organ damage and inflammation due to this accumulation of non-biodegradable substances. Tumour growth may be accelerated by magnetically tailored administration of magnetic nanoparticles to the circumvent multidrug resistance (MDR) mechanisms tumour location while magnetic fields are non-uniform. Alternating electromagnetic fields should be employed to avoid the pro-tumorigenic effects.The potential of nanoparticles to reduce antibiotic resistance or for their many antibacterial applications is being investigated. It is also possible to employ nanoparticles. [4]



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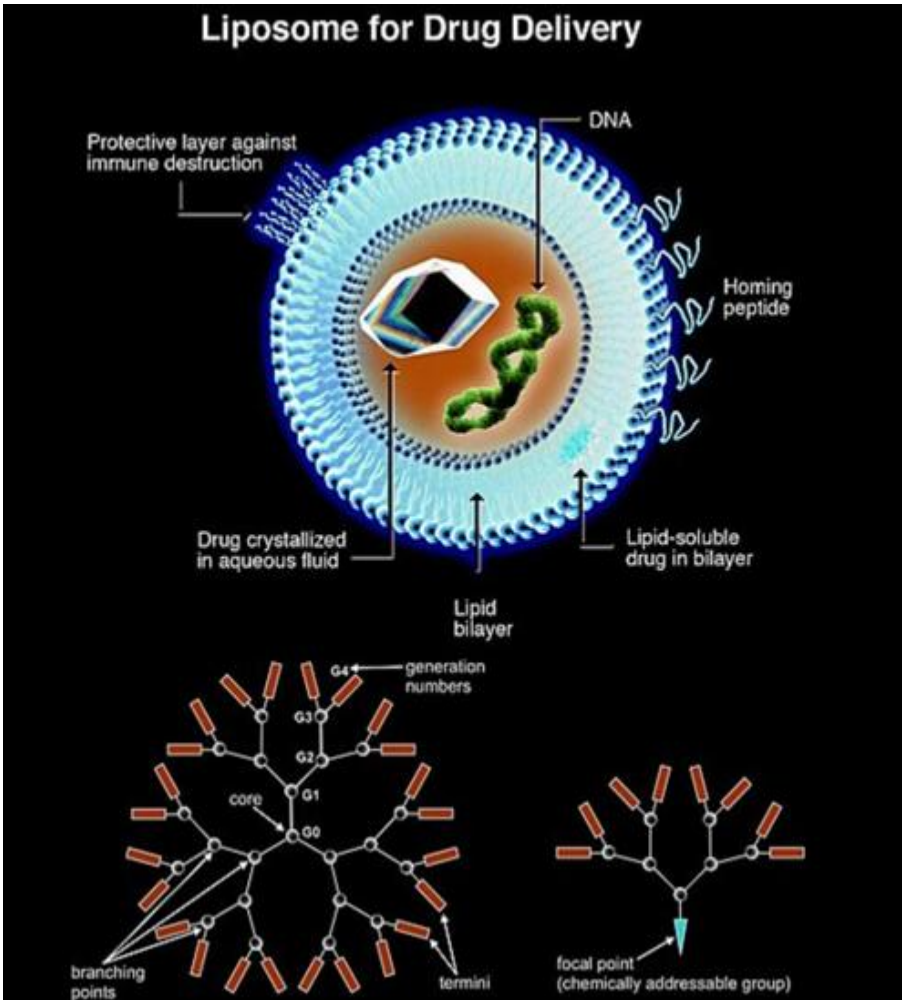

Fig.3

Certain nanomaterials are being studied for use in nanomedicine,including liposomes (middle),Dendrimers (bottom), and nanoparticles (top).(4)

ILLNESSES AND THEIR TREATMENT USING NANOMEDICINS

Impressive achievements have been made in medical science. Antibiotics have significantly decreased the incidence of bacterial illnesses. In industrialised countries nowadays, vitamin and mineral deficiency illnesses are rare. Nevertheless, there are still a lot of illnesses that shorten our lives, and the medications that treat them can only delay the symptoms. There is no way to prolong life indefinitely unless every illness that poses a threat to it is cured.(6)

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Table 1: A Partial Nanomedicine Technologies Taxonomy [5]

Raw nanomaterials	**Cell simulations and cell diagnostics**	**Biological research**
Nanoparticle coatings	Cell chips,	Nanobiology
Nanocrystalline materials	Cell stimulator	Nanoscience in life sciences
Nanostructured materials	**DNA manipulation, sequencing,**	Drug delivery
Cyclic peptides	**diagnostics**	Drug discovery
Dendrimers	Genetic testing	Biopharmaceutics
Detoxification agents	DNA microarrays	Drug encapsulation
Drug encapsulation	Ultrafast DNA sequencing	Smart drugs
Fullerenes	DNA manipulation and control	**Molecular medicine**
Functional drug carriers Smart drugs	**Tools and diagnostics**	Genetic therapy
MRI scanning (nanoparticles)	Bacterial detection systems	Pharmacogenomics
Nanobarcodes	Biochips	**Artificial enzymes and enzyme control**
Molecular medicine	Biomolecular imaging	Enzyme manipulation and control
Nanoemulsions	Biosensors and biodetection	**Nanotherapeutics**
Nanofibers	**Diagnostic and defense applications**	Antibacterial and antiviral nanoparticles
Nanoparticles	Endoscopic robots and microscopes	Fullerene-based pharmaceuticals
Nanoshells	Fullerene-based sensors	Photodynamic therapy
Carbon nanotubes	Imaging (cellular, etc.)	Radiopharmaceuticals
Noncarbon nanotubes	Monitoring	**Synthetic biology and early nanodevices**
Quantum dots	Lab on achip	Dynamic nanoplatform nanosome
Artificial binding sites	Nanosensors	Tecto-dendrimers
Artificial antibodies	Point of care diagnostics	Artificial cells and liposomes
Artificial enzymes	Protein microarrays	Polymeric micelles and polymersomes
Artificial receptors	Scanning probe microscopy	**Biotechnology and biorobotics**
Molecularly imprinted polymers	Intracellular devices	Biologic viral therapy
Control of surfaces		Virus-based hybrids
Artificial surfaces-adhesives	Intracellular biocomputers	Stem cells and cloning
Artificial surfaces—nonadhesive	Intracellular sensors/reporters	Tissue engineering
Artificial surfaces—regulated	Implants inside cells	Artificial organs
Biocompatible surfaces		Nanobiotechnology
Biofilm suppression	BioMEMS	Biorobotics and biobots
Engineered surfaces		
Pattern surfaces (contact guidance)	Implantable materials and devices	Nanorobotics
Thin-film coatings	Implanted bioMEMS, chips, and electrodes	DNA-based devices and nanorobots
	MEMS/Nanomaterials-based prosthetics	Diamond-based nanorobots
Nanopores	Sensory aids (artificial retina, etc.)	Cell repair devices
Immunoisolation	Microarrays	
Molecular sieves and channels	Microcantilever-based sensors	
Nanofiltration membranes	Microfluidics	
Separations	Microneedles	
	Medical MEMS	
	MEMS surgical devices	

Table 1: A Partial Nanomedicine technology Taxonomy [6]

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Table 2: Application of Nanomedicine for the Healthcare [6-11]

Application of nanomedicine	Nanomaterial Name & Type	Pharmacological function	Diseases
Nanomedicines in the clinic	Liposome (30-100 nm)	Targeted drug Delivery	Cancer
	Nano particle (Iron oxide, 5-50 nm)	Contrast agent for magneting resonance imaging	Hepatic (Liver)
Nanomedicines under development	Dendrimer (5-50 nm)	Contrast agent for magneting resonance imaging	Cardiovascular Phase III clinical trial
	Fullerene (Carbon bucky ball 2-20 nm)	Antioxidant	Neurodegenerative, Cardiovascular
	Nanoshells (Goldcoated silica 60 nm)	Hyperthermia	Cancer Preclinical

Table 2: Application of Nanomedicine in healthcare [6]

TYPES OF NANOMEDICINS

According to the type and structure of the carriers, nanomedicines are primarily classified into liposome, antibody–drug conjugate, inorganic nanoparticle, polymer nanoparticle, dendrimer, micelle, polymer–drug conjugate, virus-derived vector, nanocrystal, cell-derived carrier and protein-bound nanoparticle. [9]

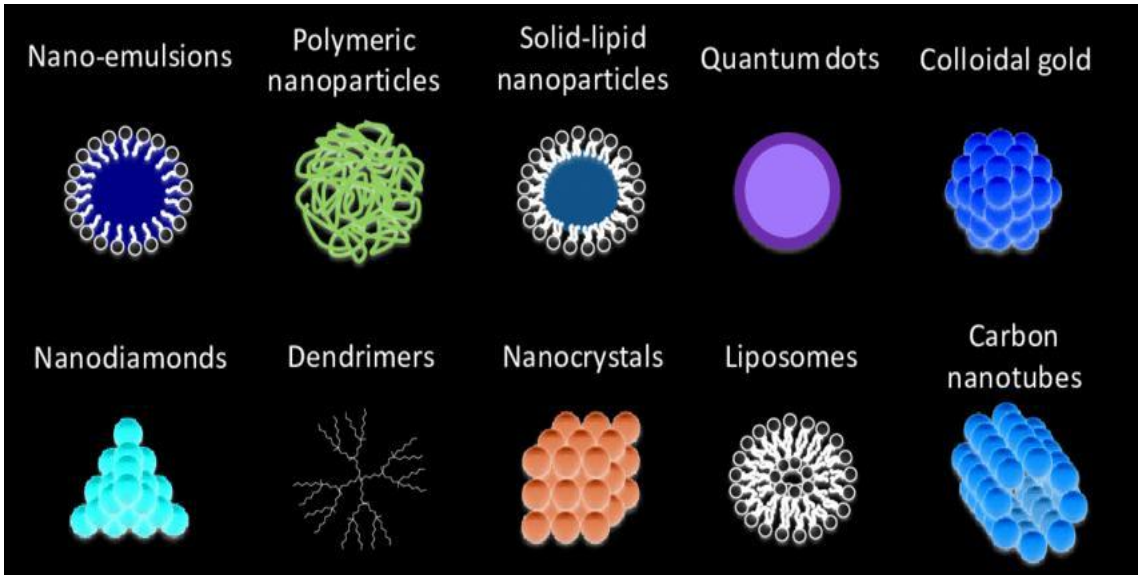

Fig.4 classification [8]

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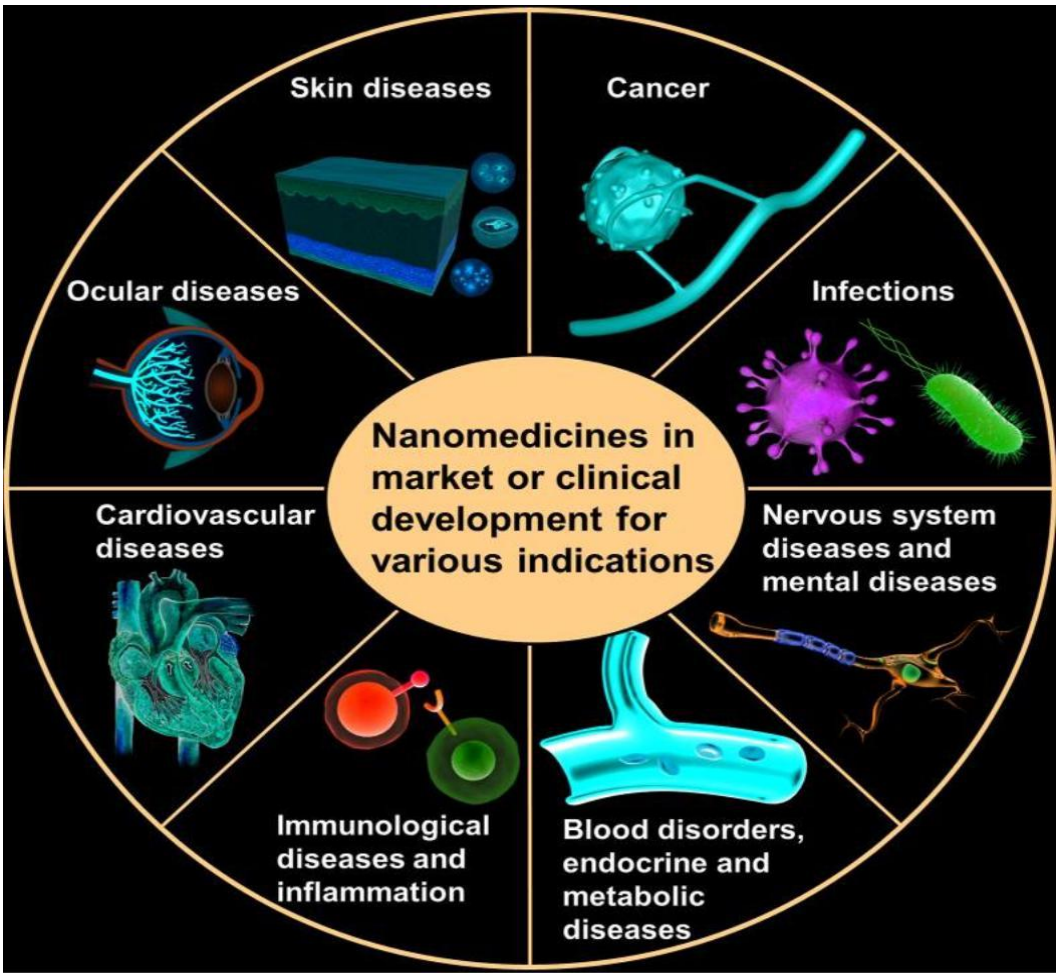

Fig.5 Nanomedicine in clinical development for various indications.(9)

Current clinical translation phases for a wide range of illnesses, as well as available nanomedicines. With permission from Ref. 13, the skin diagram was reproduced. © 2021 American Chemical Society All rights reserved. With approval from Ref. 14, the eye structure was reproduced in accordance with the CC-BY licence. 2020 MDPI, Basel, Switzerland Copyright ©. With approval from Ref. 15, the cardiovascular graphic was duplicated in accordance with the CC-BY licence. 2015 MDPI, Basel, Switzerland. Copyright ©.

An overview of the present clinical translation of several nanomedicines was provided by this graph, which compiled the nanomedicines that have been approved for commercialization or have progressed into the clinical phases. Cancer, bacterial, fungal, viral, and parasite infections, blood disorders, endocrine and metabolic disorders, cardiovascular disorders, immune system disorders, nervous system disorders, mental disorders, ophthalmic disorders, skin disorders, and other indications are among the topics covered by examples of the applications. Lastly, we offered some insights into clinical failure, the future directions, and various viewpoints on nanomedicines during the clinical translation and commercialization processes.[9]

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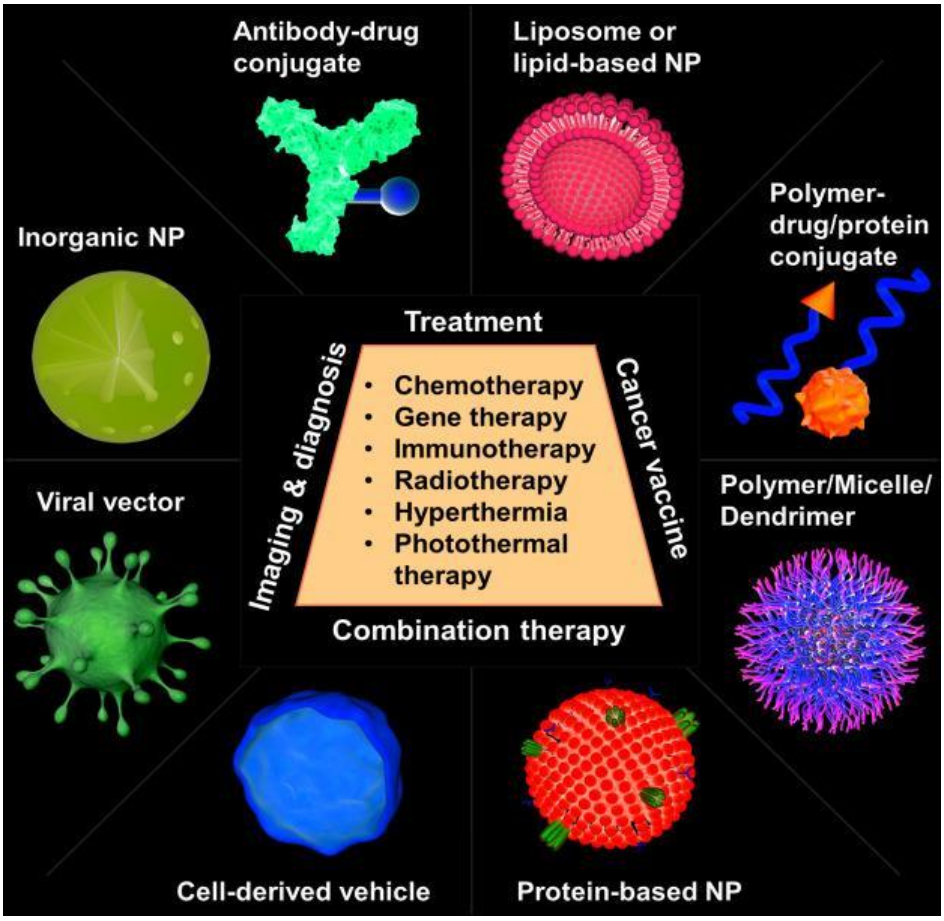

Fig.6 clinical translations or market snapshots of nanomedicines[19]

Nanomedicines that are either being developed or are undergoing clinical trials, exhibiting a variety of carrier types, applicable indications, and modes of action. This article provides an overview of the uses of nanomedicines in the prevention, diagnosis, and treatment of a variety of diseases, including cancer, infections, blood disorders, cardiovascular diseases, immuno-associated diseases, diseases of the nervous system, and more, from the standpoint of indications. In order to aid in the development of nanomedicines and their clinical application, the review also offers some viewpoints and concerns for research and development.[19]

The Cortellis Drug Discovery Intelligence (CDDI) database was used to obtain nanomedicines that have undergone clinical trials or been licenced for use in the market. In June 2021, information was searched and filtered. Microsoft Excel was used to combine, remove duplicates, and order the search results. The relationship between the obtained outcomes and nanomedicines was also verified through manual inspection of the CDDI database fields pertaining to drug "chemical name/description," "product summary," and "product category," as well as literature searches on PubMed.gov [9]

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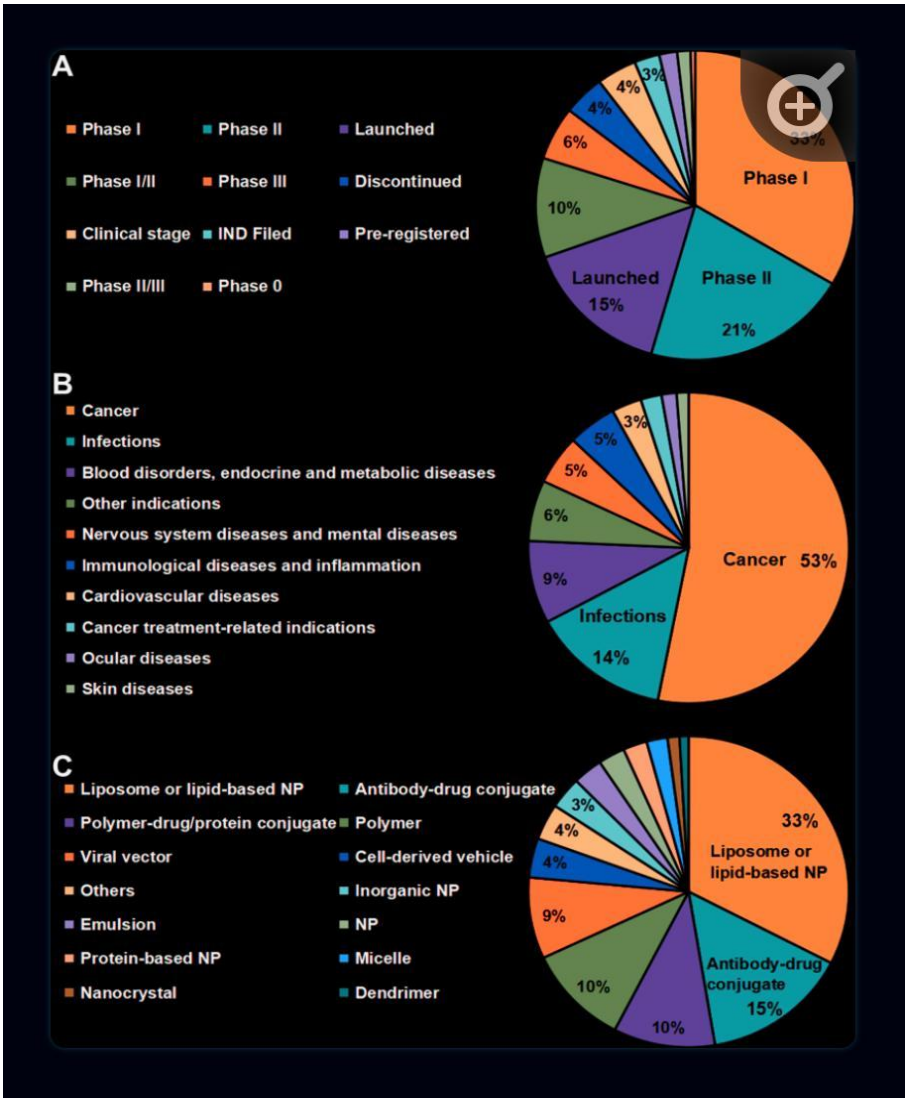

Fig.7 is the summary of nanomedicines that are available for purchase or use in clinical settings. (A) Current state of development; (B) indications; and (C) formulations. NP standsfor Nanoparticles. [9]

There are currently 663 nanomedicines in total—100 on the market and 563 in clinical trials or other stages. The majority of these nanomedicines (Fig. 5A) are primarily focused on treating infections (14%) and cancers (53%) and are in clinical phases I (33%) and II (21%). Additionally, diseases of the neurological system, the brain, blood disorders, endocrine and metabolic disorders, immunological disorders, inflammation, cardiovascular disorders, ophthalmic disorders, skin disorders, and other indications have all been treated with nanomedicines (Fig. 5B). Nanomedicines are also utilised in the creation of vaccines and imaging diagnosis. Liposomes, or lipid-based nanoparticles, are the most common type of nanomedicine available on the market or in various stages of clinical translation (33%). This is followed by antibody-drug conjugates (15%), polymer-drug/protein conjugates (10%), and polymer (10 percent). Viral vectors (8%), cell-derived vehicles (4%), inorganic nanoparticles (3%), emulsions, protein-based nanoparticles, micelles, nanocrystals, dendrimers, and so forth are examples of additional nanomedicine forms (Fig. 5C). [9]

Key Advantages of Nanomedicins [10]

1. **Medication distribution at targeted part-** Targeting particular bodily cells is one of the primary benefits of using nanomedicines. Conventional non-targeted medications spread throughout the body and may have serious

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adverse effects. Most often, nanomedicines are made up of drug-carrying nanoparticles. Treatments can be made more potent and less hazardous by engineering these nanoparticles to improve drug distribution to the target cells.[10]

2. **Extended half-life**- The time it takes for the body to get rid of half of a substance is known as its half-life. Since small molecule medications usually have short half-lives, frequent administration is necessary to keep the body's levels of the drug at the optimal levels. Since nanomedicines can be made to have longer half-lives, they can be used less frequently.[10]
3. I**ncreased solubility**- Certain medications may not dissolve as well in water, which can lessen their effectiveness. These medications can be made more soluble and effective by using nanoparticles. [10]

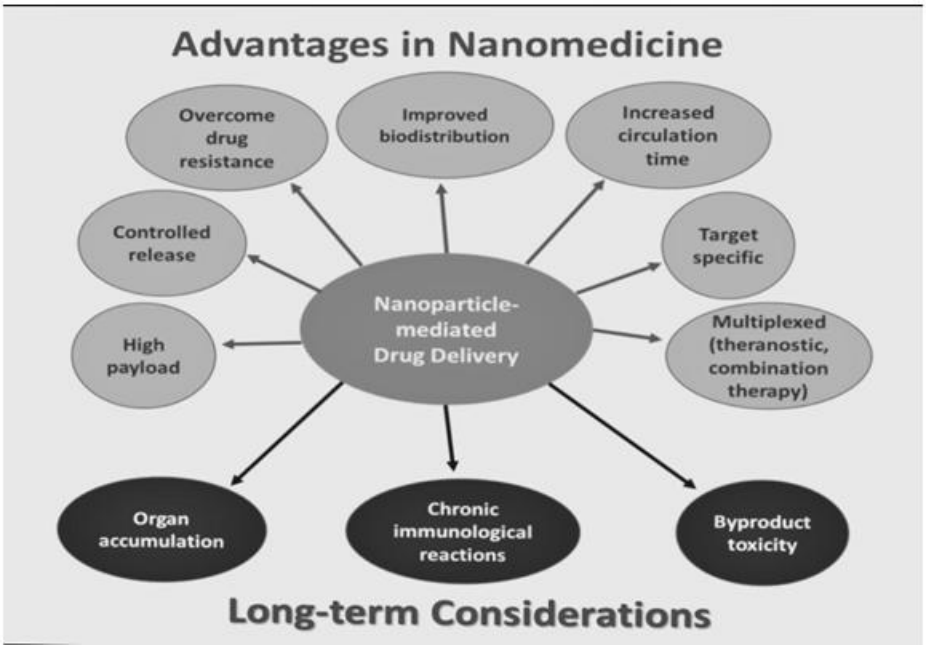

Fig.8 Advantages of Nanoparticles mediated Drug delivery.[11]

MOST USED NANOPARTICLES IN MEDICINES ARE

1. **Lipid nanoparticles-** Liposomes are the most often utilised lipid nanoparticles. A liposome is a spherical structure consisting of cholesterol and phospholipids, among other lipidic substances. Drugs that are hydrophilic or hydrophobic can be loaded into liposomes; hydrophilic molecules can be placed inside the aqueous space, and hydrophobic compounds can be placed inside the lipid bilayer. By adding ligands like peptides, proteins, carbohydrates, aptamers, antibodies, and polymers, one can alter the liposome surface. Surface alterations enable liposome-based nanomedicines to be delivered more precisely and to be more effective. [10]
2. **Polymeric nanoparticles-** Therapeutic substances, which can be contained in the polymeric core or directly conjugated to the polymer, and biocompatible/biodegradable polymers make up polymeric nanomedicines. Natural polymers including chitosan, starch, and dextran, as well as synthetic ones like polyethylene glycol (PEG), polylactic acid (PLA), polyglycolide (PGA), and poly(lactic-co-glycolic acid) (PLGA) can be found among the polymers. Small compounds, proteins, antibodies, and nucleic acid aptamers can all be used as medicinal agents. But the medicinal substance itself, like glatiramer acetate, can also be a polymer. Drugs conjugated to or encapsulated in polymers have better regulated release and increased bioavailability as benefits. [10]

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3. **Albumin-based nanoparticles-** The production of novel nanomedicines has found a strong platform in the serum protein albumin. In fact, medications coated with albumin become more stable and extend their bloodstream circulation. This is because the medicine is "invisible" to the immune system due to the albumin coating, which slows down its rate of elimination. Additionally, as mentioned below under "Nab-paclitaxel," the albumin coating enables targeted drug administration in a number of cancer types. Diagnostic applications are also possible using albumin-based nanoparticles. Indeed, to improve the visualisation of particular organs in imaging modalities, albumin-coated contrast agents are often utilised in diagnostic contexts.[10]

4. **Inorganic nanoparticles-** Nanoscale materials include silica and many inorganic materials like metals. Among them, iron, gold, and silver nanoparticles are the subjects of extensive research to create novel nanomedicines. For instance, tissue regeneration and wound healing are enhanced by the use of nanosized gold and silver. Moreover, gold nanoparticles are helpful for imaging and diagnostic applications due to their special optical characteristics. Iron oxide nanoparticles can be used in a variety of diagnostic contexts. Moreover, they can be applied to cancer therapy involving hyperthermia. For the treatment of iron deficient anaemia, iron-carbohydrate nanocomplexes are frequently utilised as iron replacement therapy. [10]

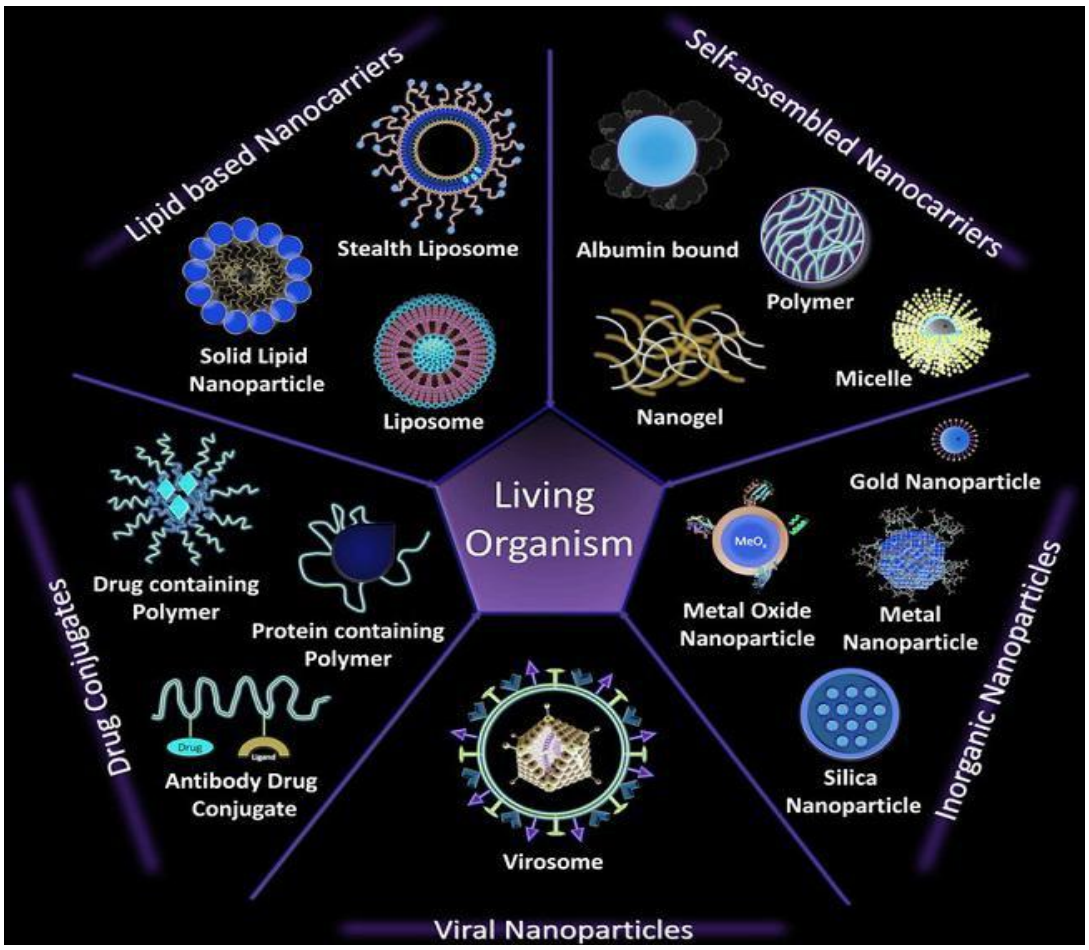

Fig.9 showing the many nano-drug and delivery methods that are developed and used in clinical cancer care. [12]

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NANOMEDICINS ARE USED To TREAT DISEASE AND INFECTIONS

A number of nanomedicines are being developed and licenced to treat a range of illnesses. A few instances of nanomedicines being used in clinical settings to treat infectious diseases and cancer are shown below.

A] CANCER

Nanotechnology has become increasingly used in several therapeutic sectors in recent years, particularly oncology. The most popular anticancer medications become much safer and more effective when nanoparticles are used in oncology. The primary benefits of nanomedicine and delivery systems based on nanotechnology include lower systemic toxicity, effective targeting, delayed release, and prolonged half-lives. The use of nanotechnology has greatly enhanced drug delivery to the target as compared to the conventional techniques of delivering these medications. [12]Since the FDA authorised the first nanomedicine (Doxil) for use in treating cancer in 1995, an increasing number of nanomedicines have been given global approval for sale. Vascular permeability and retention (EPR effect) is the primary mechanism of action for lipid nanoparticle formulations, which are the most commonly employed among them. Preclinical and clinical research, as well as development, are now underway for a multitude of liposomal nanomedicines. According to García-Pinel et al., for instance, over 60 nanomedicines are undergoing various phases of clinical testing. For clinical usage, only a limited number of formulations based on lipid nanoparticles are permmitted. The current list of licenced nanomedicines for cancer therapy is provided in the following table (Note: Drugs for other indications are not included in this table; nanomedicines are only listed for cancer treatment).[12]

List of Clinically Approved Nanomedicines for Cancer Treatment				
Name	**Description of Carrier**	**Indication(s)**	**Approval Year**	**Company**
Untargeted delivery				
Doxil(Caelyx)	Liposomal Doxorubicin (PEGylated)	AIDS-related Kaposi's sarcoma, breast cancer, ovarian cancer	FDA (1995) EMA (1996)	Janssen
DaunoXome	Liposomal daunorubicin (non-PEGylated)	HIV-associated Kaposi's sarcoma (primary)	FDA (1996)	Galen
Marqibo	Liposomal vincristine (non-PEGylated)	Philadelphia chromosome-negative acute lymphoblastic leukemia (tertiary)	FDA (2012)	Acrotech
Onivyde(Merrimack)	Liposomal irinotecan (PEGylated)	Metastatic pancreatic cancer (secondary)	FDA (2015)	IPSEN
Myocet	Liposomal doxorubicin (non-PEGylated)	Metastatic breast cancer (primary)	EMA (2000)	Teva UK
MEPACT	Liposomal mifamurtide	Osteosarcoma (primary following surgery)	EMA (2009)	Takeda
SMANCS	Poly(styrene-co-maleic acid)-conjugated neocarzinostatin	Hepatoma	Japan (1997)	Astellas
Genexol-PM	Polymeric NP micelle formulation of paclitaxel	Breast cancer and NSCLC	South Korea (2007)	Samyang
Lipusu	Liposomal paclitaxel	NSCLC, ovarian cancer, and breast cancer	China (2006)	Luye Pharma
DepoCyt	Liposomal cytarabine	Lymphomatous meningitis	FDA (1999)	PACIRA Pharma
Abraxane	Albumin-particle bound paclitaxel	Advanced NSCLC (surgery or radiation is not an option) Metastatic breast cancer (secondary) Metastatic pancreatic cancer (primary)	FDA (2005) EMA (2008)	ABRAXIS Bioscience
Oncaspar	PEGylated asparaginase	Acute lymphoblastic leukemia	FDA (1994) EMA (2016)	Sigma Tau
Eligard(Tolmar)	Leuprolide acetate	Advanced prostate cancer	FDA (2002)	Tolmar Therap
Targeted delivery				
Ontak	Engineered protein combining interleukin-2 and diphtheria toxin	Cutaneous T-cell lymphoma	FDA (1999)	Eisai
Combinatorial delivery				
Vyxeos	Liposomal formulation of cytarabine:daunorubicin	Acute myeloid leukemia	FDA (2017) EMA (2018)	Celator Pharms
Hyperthermia				
Nano-therm	Iron oxide nanoparticles	Recurrent glioblastoma, Prostate Cancer	EMA (2010) FDA (2018)	MagForce

Table.3 show list of clinically approved Nanomedicine for cancer treatment [12]

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A new approach to cancer treatment called "nano-oncology" uses therapeutic materials with nanoscale dimensions as anticancer agents. Research and clinical trials using this approach have shown encouraging outcomes. With the advent of innovative methods for cancer treatment, detection, and prevention during the past 20 years, this profession has experienced enormous growth.The great potential and treatment efficacy of nanotechnology in treating different types of cancer has made it a new approach to treating a wide range of ailments. With its focus on targeted delivery, improved delivery, imaging, and viral nanoparticles, cancer nanomedicineoffers a broad range of applications in successful tumour therapy.

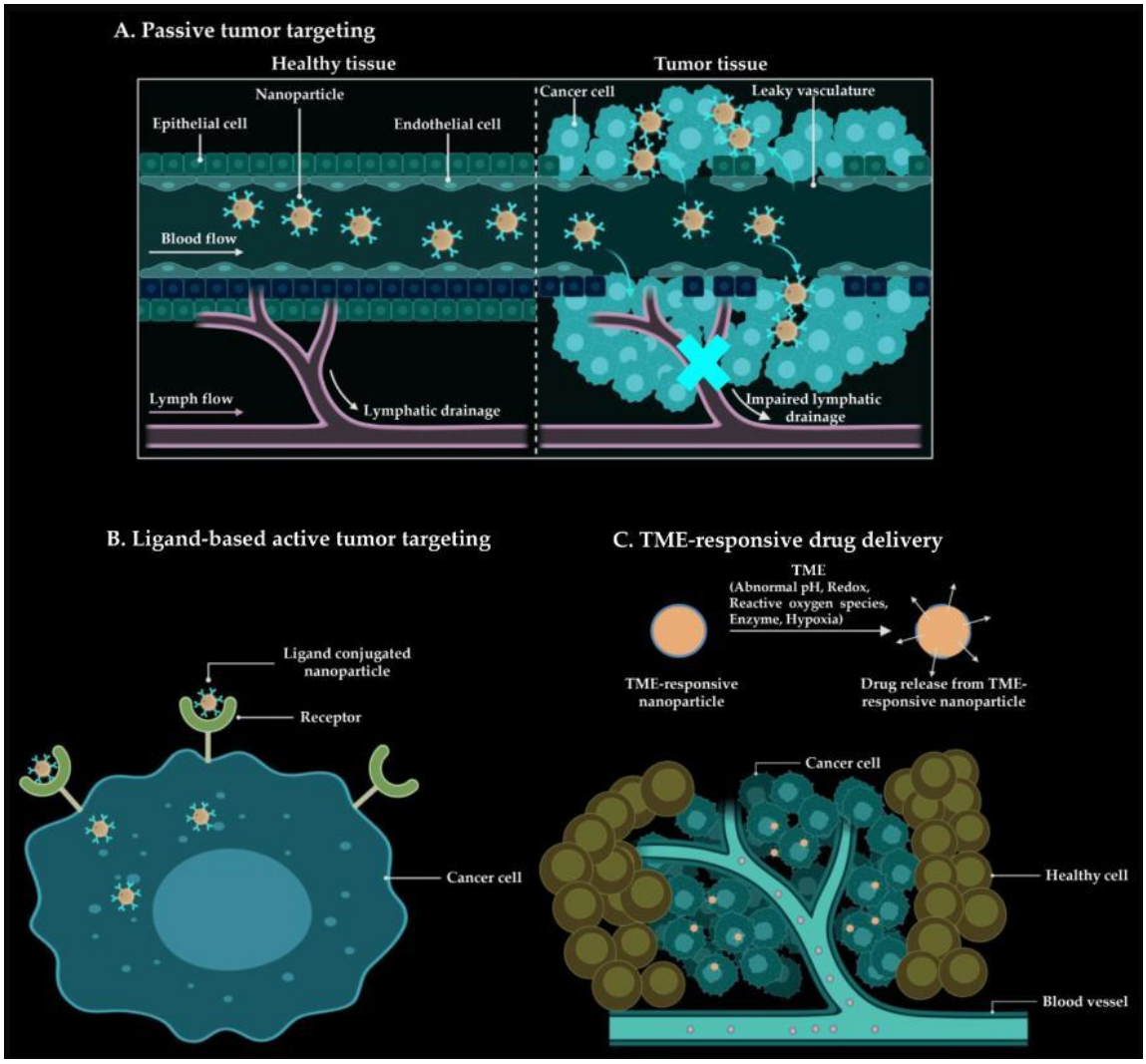

Fig.10Tumour targeting with nanocarrier technology. (A) TME-responsive drug delivery; (B) ligand-based active tumour targeting; and (C) passive tumour targeting.[15]

Treatment of various forms of cancer is arguably the most well-known use of nanomedicines. Chemotherapy medications can be delivered to cancer cells via nanoparticles with minimal harm to healthy cells that are multiplying. Liposomes, albumin- and polymer-based nanoparticles, and other nanoparticles are commonly employed in cancer treatment.[10]

PEGylated liposomal doxorubicin

Doxorubicin that is PEGylated A version of the chemotherapeutic medication doxorubicin known as PEGylated liposomal doxorubicin contains the molecule enclosed in a liposome that has an exterior layer coated in polyethylene glycol (PEG). Ovarian cancer, multiple myeloma, and

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HIV-related Kaposi's sarcoma are all treated with PEGylated liposomal doxorubicin. Although the liposomes are too small to access normal tissues, their size allows them to collect preferentially in the tumour microenvironment. They are about 100 nm in size." To further extend the drug's half-life, the PEG coating shields the medication against immune system deterioration and clearance.[10]

Nab-paclitaxel

Paclitaxel is a chemotherapeutic medication that is available in a nanoformulation called nanoparticle albumin-bound (Nab)-paclitaxel. It is used to treat non-small cell lung cancer as well as cancers of the breast, lung, pancreas, and other organs. Nab-paclitaxel is made up of an albumin shell and a hydrophobic core that contains paclitaxel. The bulk nanomedicine separates into individual nanoparticles once it is in the blood. Following their binding to the albumin receptor gp60 on the endothelial cells of tumour blood arteries, the single albumin-paclitaxel nanoparticles pierce the tumour tissue. When compared to traditional paclitaxel, naproxenochalcone (Nab-paclitaxel) exhibits better accumulation at the target tissue and does not require harmful solvents, enhancing the ratio of effectiveness to toxicity. Additionally, the albumin coating enhances the medication's stability and circulation in theboby. [10]

Vincristine liposomal

When patients' Philadelphia chromosome-negative acute lymphoblastic leukaemia (Ph-ALL) worsens or when they have had at least two unsuccessful prior cancer treatments, liposomal vincristine is utilised to treat them. This nanoformulation results in better medication efficacy by improving drug distribution to the target tissues and minimising neurotoxicity by lowering the amount of free drug in the plasma.[10]

Irinotecan PEGylated Liposomal

PEGylated liposomal irinotecan is a nanoformulation of the chemotherapeutic agent irinotecan, a member of the "topoisomerase inhibitors" class of medications. Irinotecan hinders DNA duplication, which is a necessary step in the division of cells. When combined with other medications, PEGylated liposomal irinotecan is used to treat pancreatic cancer.[10]

Liposomal cyclorubicin/daunorubicin

Liposome-encapsulated fixed combinations of the anthracycline topoisomerase inhibitor daunorubicin and the nucleoside metabolic inhibitor cytarabine are known as liposomal daunorubicin/cytarabine. Several nations have approved the use of this nanomedicine to treat therapy-related acute myeloid leukaemia (tAML) and AML with alterations associated with myelodysplasia (MRC). [10]

Cytarabine liposomes

The meninges can develop lymphomatous meningitis, a kind of lymphoma that can be treated with liposomal cytarabine. The goal of the formulation of liposomal cytarabine is to provide a prolonged release of the chemotherapeutic drug cytarabine.[10]

B] NANOMEDICINS USED IN INFECTIONS

Infections continue to be a major public health issue with substantial financial consequences. A class of illnesses with significant morbidity and fatality rates worldwide is bacterial pneumonia, which serves as our example for this review. In the US, it ranks among the top 10 causes of death annually. This corresponds to an approximate annual expense above $17 billion within the United States. Pneumonia is the most common infectious cause of paediatric mortality worldwide, making over 15% of all paediatric deaths in 2017. Antibiotics are widely used, but these facts still hold true. Three issues with the pharmacokinetics and biodistribution of antibiotics contribute to these depressing results. First off, a lot of antibiotics are small molecule medications with undesirable pharmacokinetics that necessitate frequent dosage. Second, in certain infections, like those of the central nervous system and abscesses (infectious pockets that are walled off by the body's reaction to high quantities of bacteria), many antibiotics are unable to reach the anatomic source of germs. Lastly, unfavourable effects on organ systems other than the target might result in toxicities that limit the dosage or be so bad that an antibiotic cannot be utilised in a therapeutic setting.[16]

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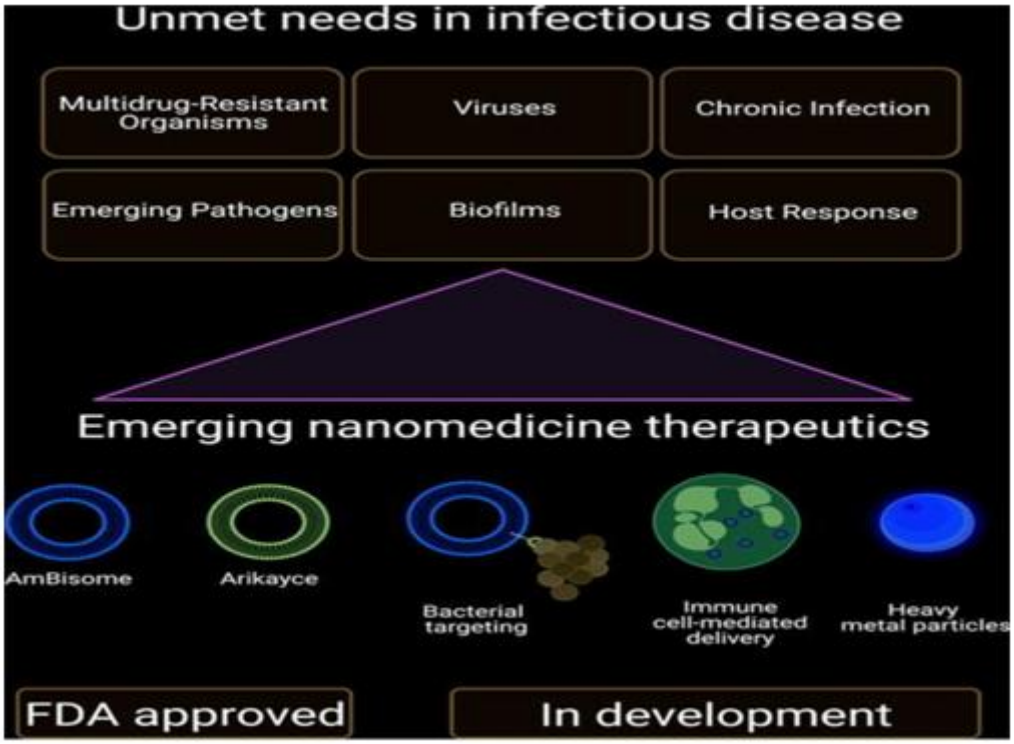

Fig.11 Action of Nanomedicins to fight infections [16]

The potential of nanoparticles to cure bacterial, fungal, and viral infections is being studied. These are a few instances of clinically used nanoparticles for the treatment of infectious diseases.[10]

Application of Nano-technology in Diagnosis of Infectious Diseases

To stop the transmission of infectious diseases, scientists and medical professionals need precise instruments to identify pathogens (Abed et al., 2023; Abderrahmane et al., 2023; Younis et al., 2022; Smaisim et al., 2022a; Wang et al., 2022). The last fifty years have seen minimal changes in the techniques used to diagnose infectious diseases, despite the critical nature of accurately identifying microorganisms. The common methods used to diagnose infectious diseases are PCR, ELISA, tissue culture, and microscopy. These methods are slow, expensive, and have a low threshold for detection. They can't even distinguish between various infections (Xiao and Smaisim, 2022; Mourad et al., 2022; Cheng et al., 2022; Smaisim et al., 2022b; Abderrahmane et al., 2022; Tan et al., 2022; Mir et al., 2022; Ruhani et al., 2022). Currently, the focus of molecular illness diagnostics is on current developments in nanotechnology. Since drug resistance can be overcome and microbiological agents can be quickly, sensitively, and effectively detected thanks to the special electrical, magnetic, luminescent, and catalytic capabilities of nanoparticles (Bhale et al., 2020; Muluk et al., 2020; Giorgadze et al., 2020). [17]

Three different methods can be used with nanoparticles to create biosensors for the diagnosis of infectious diseases:[17]

1.Immunochromatographic testing with lateral flow (Hauck et al., 2010).

2. Assays for the aggregation of nanoparticles (Hauck et al., 2010).

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3. Whole pathogen labelling with nanoparticles (Hauck et al., 2010).

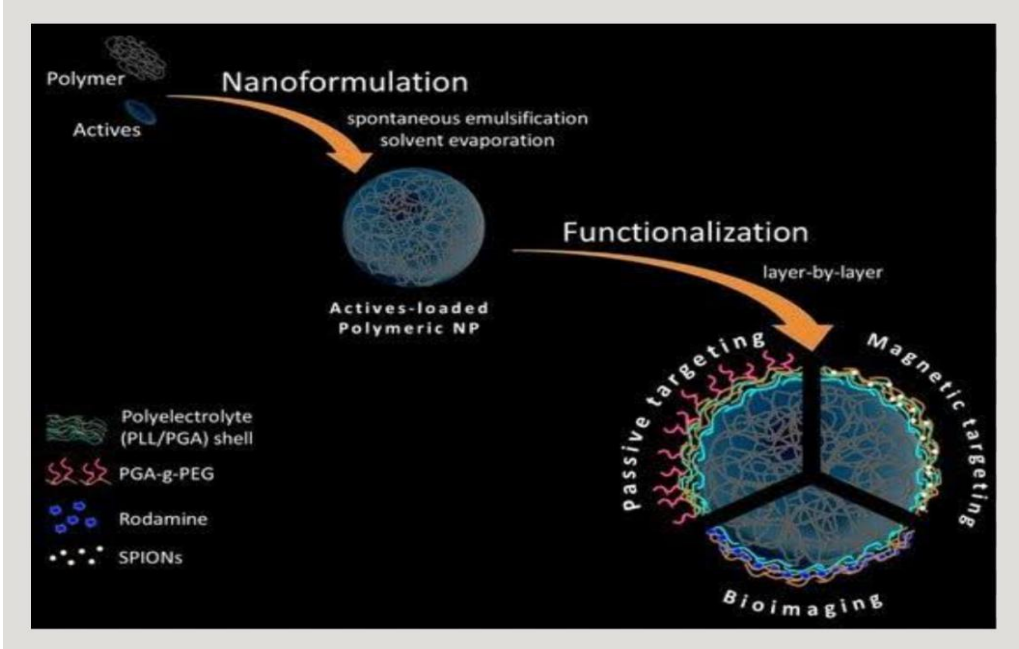

Fig.12Application of Nanomedicine in infections [17]

The amphotericin B liposome

Amphotericin B is a general-purpose antifungal drug that works against moulds, yeasts, and Leishmania species. However, scientists working in the pharmaceutical industry have been forced to create new, less lethal formulations because to the severe dose-limiting toxicity of Amphotericin B. A special lipid nanoformulation of amphotericin B called liposomal amphotericin B has been used for more than 20 years to treat leishmaniosis and systemic fungal infections. It has been demonstrated that this liposomal formulation is less nephrotoxic than free Amphotericin B.Amphotericin B is, in fact, encapsulated in the liposome in the lipid nanoformulation and is not available for interaction with the renal distal tubules. The medication cannot be filtered by the glomerulofiltration system due to the liposomes' enormous size, which may account for the lower renal toxicity.[10]

Extended-release cabotegravir/rilpivirinenano-suspension

This is an injectable long-acting (LA) antiretroviral preparation for the treatment of HIV-1 that contains rilpivirine nanocrystals and capetecavir. With respect to traditional oral antiviral treatments, this LA formulation provides improved distribution to lymphatic tissues, increased stability, and a delayed release into the bloodstream.[10,18]

Lipid-mRNA nanoparticles COVID-19 immunisations

A portion of the virus's genetic code activates the immune system in mRNA-based vaccines. Once within our cells, the genetic message is "scanned" by certain cell machinery, which then converts the code into a viral product (viral antigen). The new antigen is recognised by our immune system as a foreign substance, and it triggers a strong defence that results in the creation of antibodies [44]. Sadly, the effectiveness of the initial mRNA-based vaccinations was quite low. Indeed, "naked" mRNA preparations were fragile and extracellular enzymes quickly destroyed them. Lipid nanoparticle creation was the breakthrough that significantly improved the efficacy of mRNA vaccines. In fact, once the mRNA is inside the lipid nanoparticle's aqueous core, it is shielded from breakdown and can reach its target cells without risk. The COVID-19 pandemic provided mRNA-lipid nanoparticles with an opportunity to demonstrate their efficacy. In response to the crisis, mRNA-lipid nanoparticle COVID-19 vaccinations were created quickly, and since they were approved in December 2020, they have significantly lessened the pandemic's negative effects on daily living. [10]

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