Nanotechnology and Nanoherb

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A **nanoparticle** (or nanopowder or nanocluster or nanocrystal) is a microscopic particle with at least one dimension less than 100 nm. **Nanoparticle** research is currently an area of intense scientific research, due to a wide variety of potential applications in biomedical, optical, and electronic fields.

Size of nanoparticles:

In terms of diameter, fine particles cover a range between 100 and 2500 nanometers, while ultrafine particles are sized between 1 and 100 nanometers. Nanoparticles may or may not exhibit size-related properties that are seen in fine particles. Despite being the size of the ultrafine particles individual molecules are usually not referred to as nanoparticles.

Nanoclusters have at least one dimension between 1 and 10 nanometers and a narrow size distribution. Nano powders on the other hand are agglomerates of ultrafine particles, nanoparticles, or nanoclusters. Nano particle sized crystals are called nanocrystals.

Classification of NPs:

NPs are broadly divided into various categories depending on their morphology, size and chemical properties. Based on physical and chemical characteristics, some of the well-known classes of NPs are given as below:

1- Carbon – Based NPs.

2- Metal NPs.

3- Ceramics NPs.

4- Semiconductor NPs.

5- Polymeric NPs.

6- Lipid – based NPs.

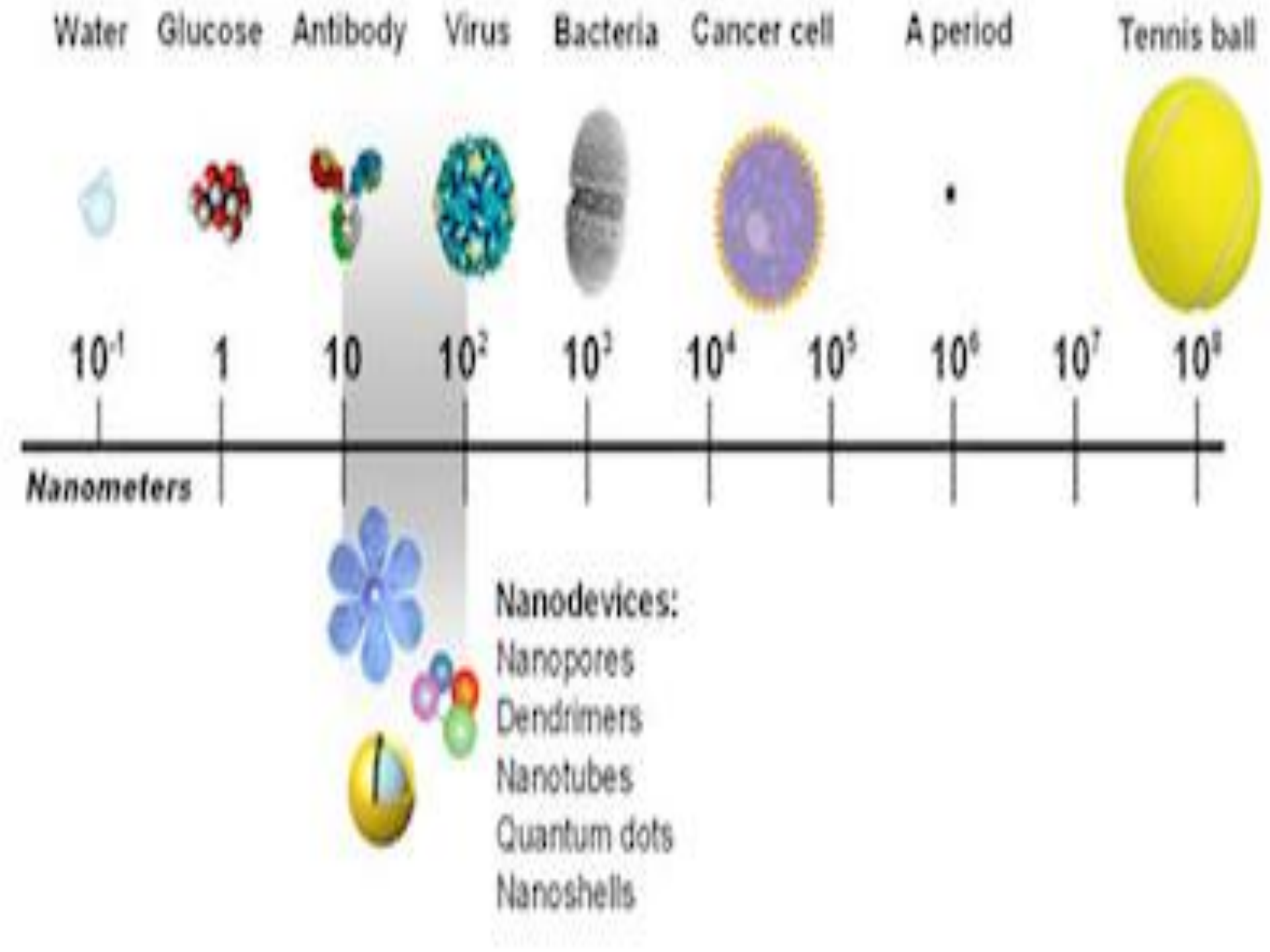
What is Nanotechnology?

Nanotechnology is science, engineering, and technology conducted at the nanoscale (about 1 to 100 nanometers)

Nano can refer to technologies, materials, particles, objects – we are focusing on **nanomaterials** as these are already being used in workplaces more widely

A sheet of paper is about 100,000 nanometers thick, a human hair is around 80,000- 100,000 nanometers wide

Is already making **today's** products: Lighter ; Stronger ; Faster ; Smaller ; More Durable


Water
Glucose
Antibody
Virus
Bacteria
Cancer cell
A period
Tennis ball
10^{-1}
1
10
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10^{5}
10^{6}
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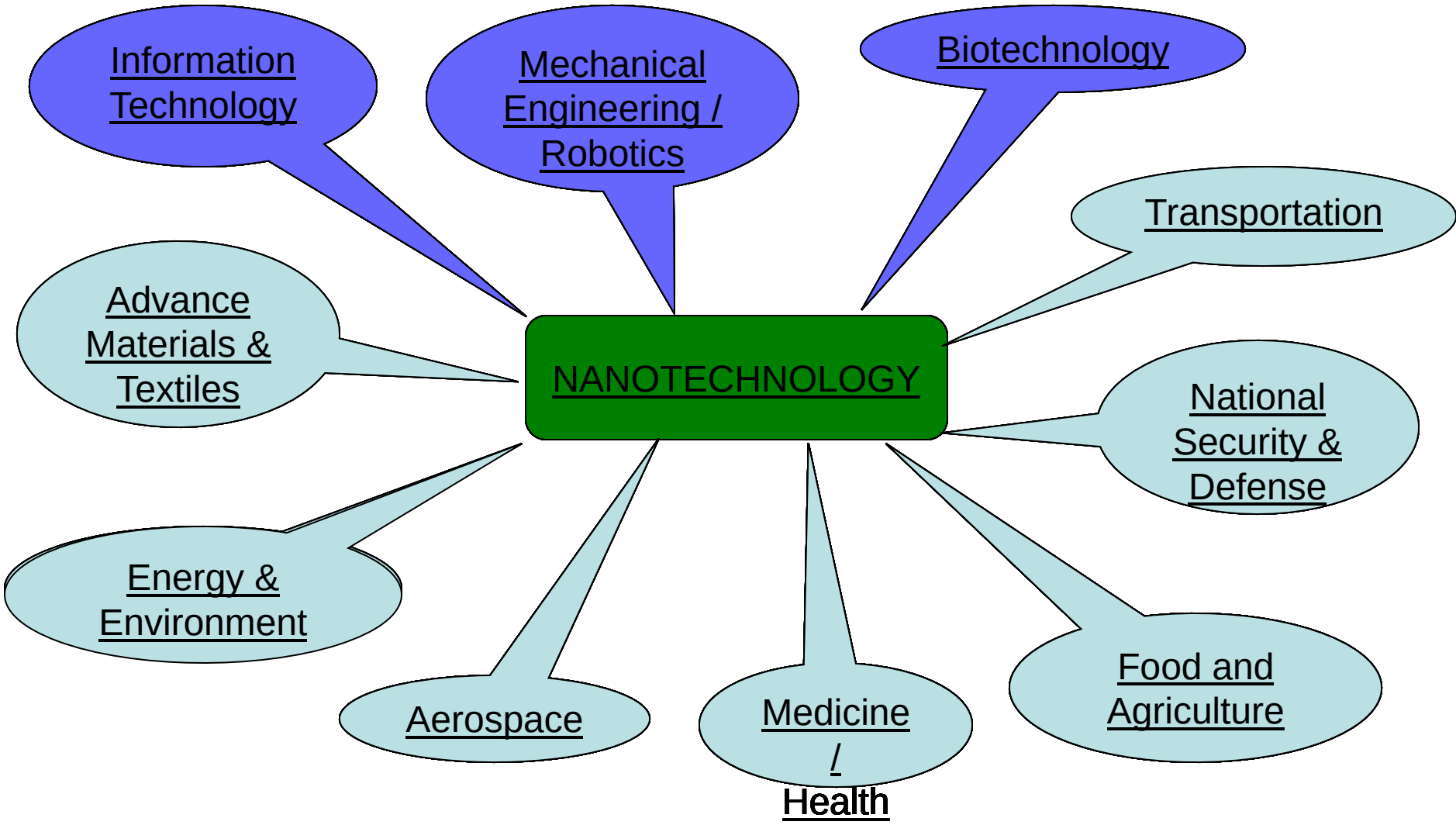
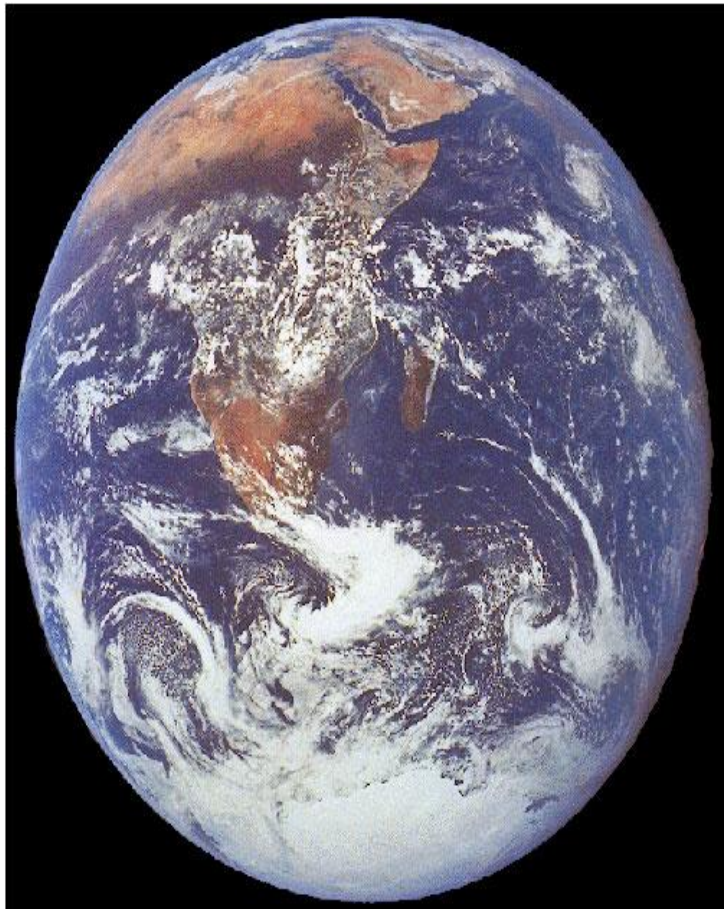
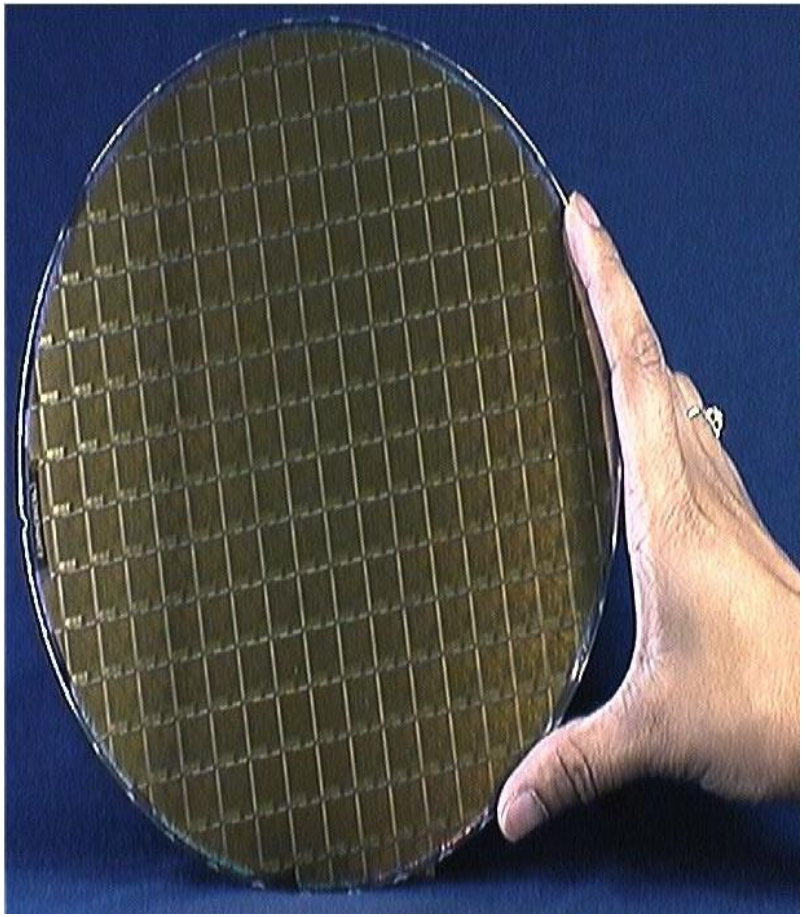
Nanometers
Nanodevices:
Nanopores
Dendrimers
Nanotubes
Quantum dots
Nanoshells

Nanotechnology spans many Areas



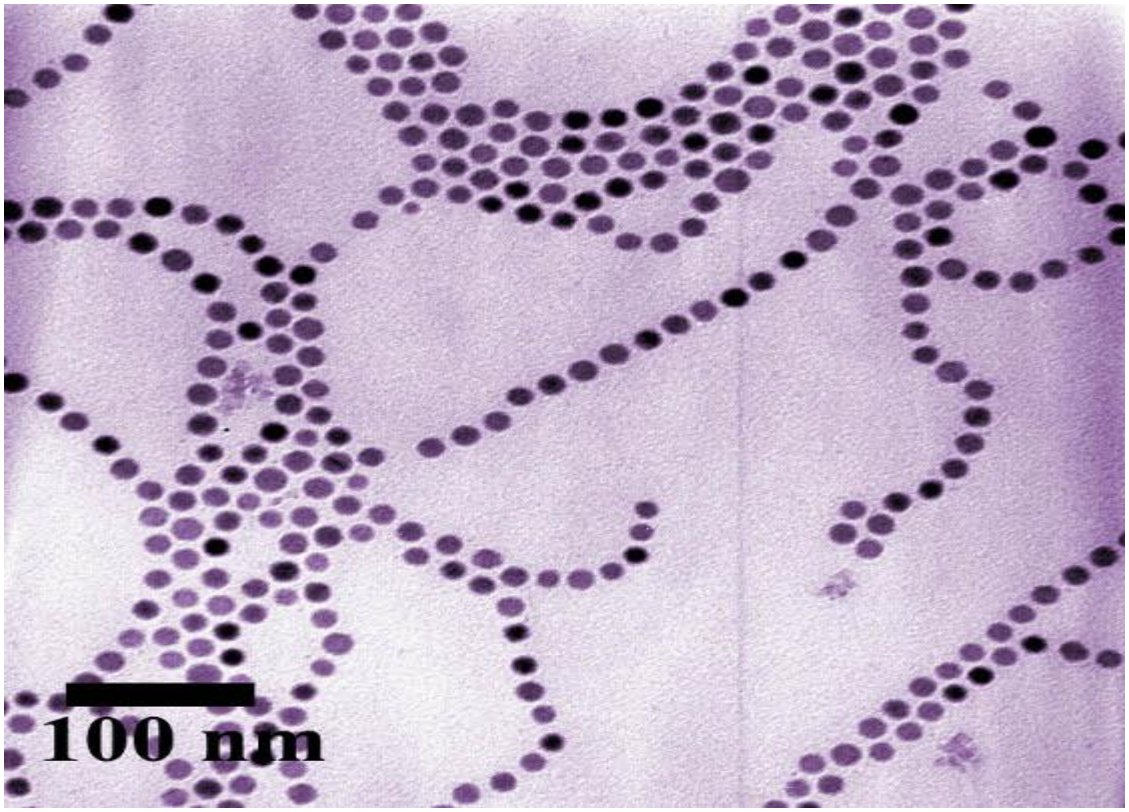


6 billion people
8000 mile diameter



10 billion components
8 inch diameter

The use of nanotechnology in medicine and more specifically drug delivery is set to spread rapidly. Currently many substances are under investigation for drug delivery and more specifically for cancer therapy. Interestingly pharmaceutical sciences are using **nanoparticles** to reduce toxicity and side effects of drugs.



Colorized transmission electron micrograph showing chains of cobalt nanoparticles.

Nanotechnology Benefits for Treatment and Clinical Outcomes

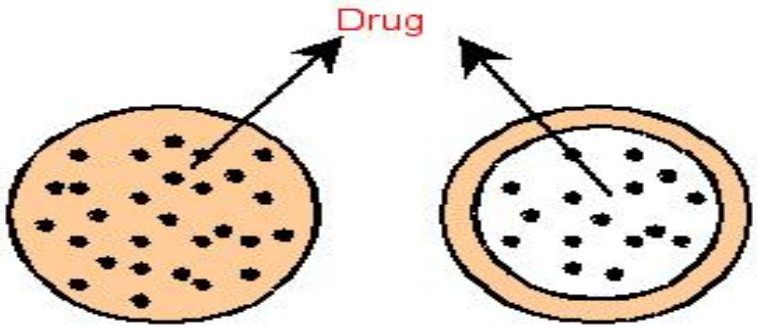
* Cancer therapies are currently limited to surgery, radiation, and chemotherapy. All three methods risk damage to normal tissues or incomplete eradication of the cancer.

* Nanotechnology offers the means to aim therapies directly and selectively at cancerous cells.

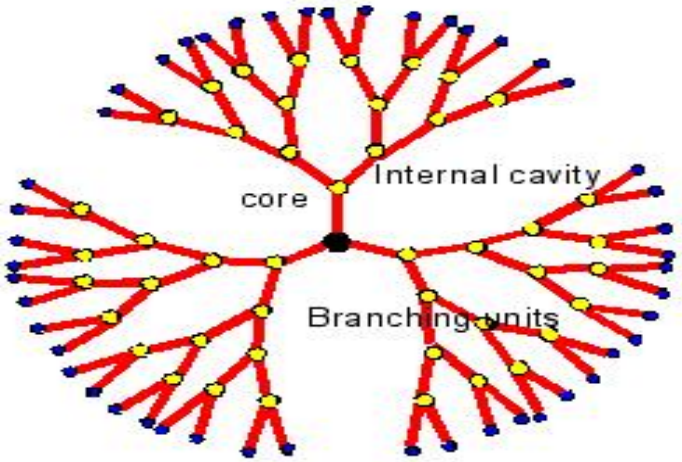
- **Nanocarriers**
- **Passive Targeting**
- **Active Targeting**
- **Destruction from Within**

* Synthetic techniques can be useful to control the specific morphology, size and magnetic properties of NPs. Though NPs are useful for many applications, but still there are some health hazard concerns due to their uncontrollable use and discharge to natural environment, which should be consider for make the use of NPs more convenient and environmental friendly**.**

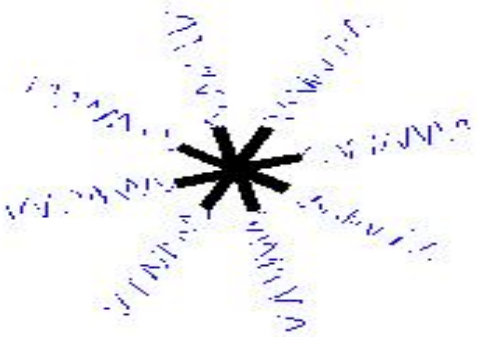
Nanotechnology Based Drug Delivery Systems for Cancer Therapy



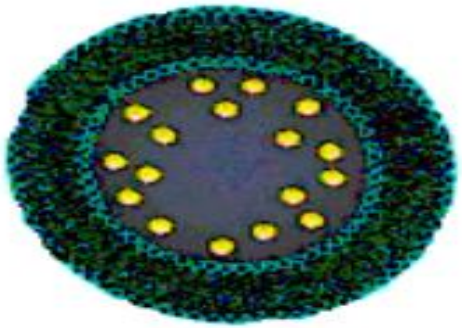
Nanosphere Nanocapsule



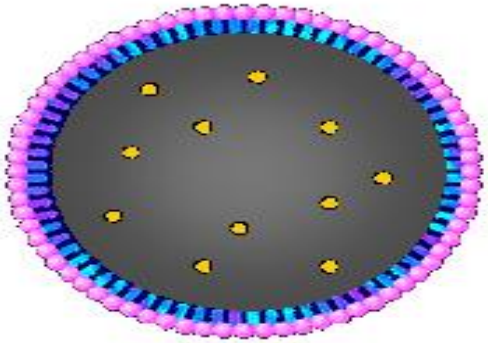
Dendrimer



Polymeric micelles



Liposome



SLN

Nanotechnology Based Drug Delivery Systems for Cancer Therapy

Nanoparticle	Description	**Recent applications**	**Reference**
Nanocapsules	Vesicular systems in which the drug is surrounded by a polymeric membrane	Stability of the cisplatin nanocapsules has been optimized by varying the lipid composition of the bilayer coat	Velinova, 2004
Nanospheres	Matrix systems in which the drug is physically and uniformly dispersed	Bovine serum albumin nanospheres containing 5-fluorouracil show higher tumour inhibition than the free drug	Santhi, 2002
Micelles	Amphiphilic block copolymers that can self-associate in aqueous solution	Micelle delivery of doxorubicin increases cytotoxicity to prostate carcinoma cells	McNaealy, 2004
Ceramic nanoparticles	Nanoparticles fabricated using inorganic compounds including silica, titania…	Ultra fine silica based nanoparticles releasing water insoluble anticancer drug	Roy, 2003
Liposomes	Artificial spherical vesicles produced from natural phospholipids and cholesterol	Radiation-guided drug delivery of liposomal cisplatin to tumor blood vessels results in improved tumour growth delay	Geng, 2004
Dendrimers	Macromolecular compound that comprise a series of branches around an inner core	Targeted delivery within dendrimers improved the cytotoxic response of the cells to methotrexate 100-fold over free drug	Quintana, 2002
SLN particles	Nanoparticles made from solid lipids	SLN powder formulation of all-trans retinoic acid may have potential in cancer chemoprevention and therapeutics.	Soo-Jeong, 2004

Uses and advantages of nanoparticles in medicine:

Some of the uses of nanoparticles in biology and medicine include:

1- Creating fluorescent biological labels for important biological markers and molecules in research and diagnosis of diseases

2- Drug delivery systems

3- Gene delivery systems in gene therapy

4-For biological detection of disease causing organisms and diagnosis

5- Detection of proteins

6- Isolation and purification of biological molecules and cells in research

7-Probing of DNA structure

8- Genetic and tissue engineering

9- Destruction of tumours with drugs or heat

10- In MRI studies

11- In pharmacokinetic studies.

Nanoparticles are being increasingly used in drug delivery systems. The advantages of using nanoparticles as a drug delivery system include:

1- The size and surface characteristics of nanoparticles can be easily manipulated. This could be used for both passive and active drug targeting

2- Nanoparticles can be made to control and sustain release of the drug during the transportation as well as the location of the release. Since distribution and subsequent clearance of the drug from the body can be altered, an increase in drug therapeutic efficacy and reduction in side effects can be achieved.

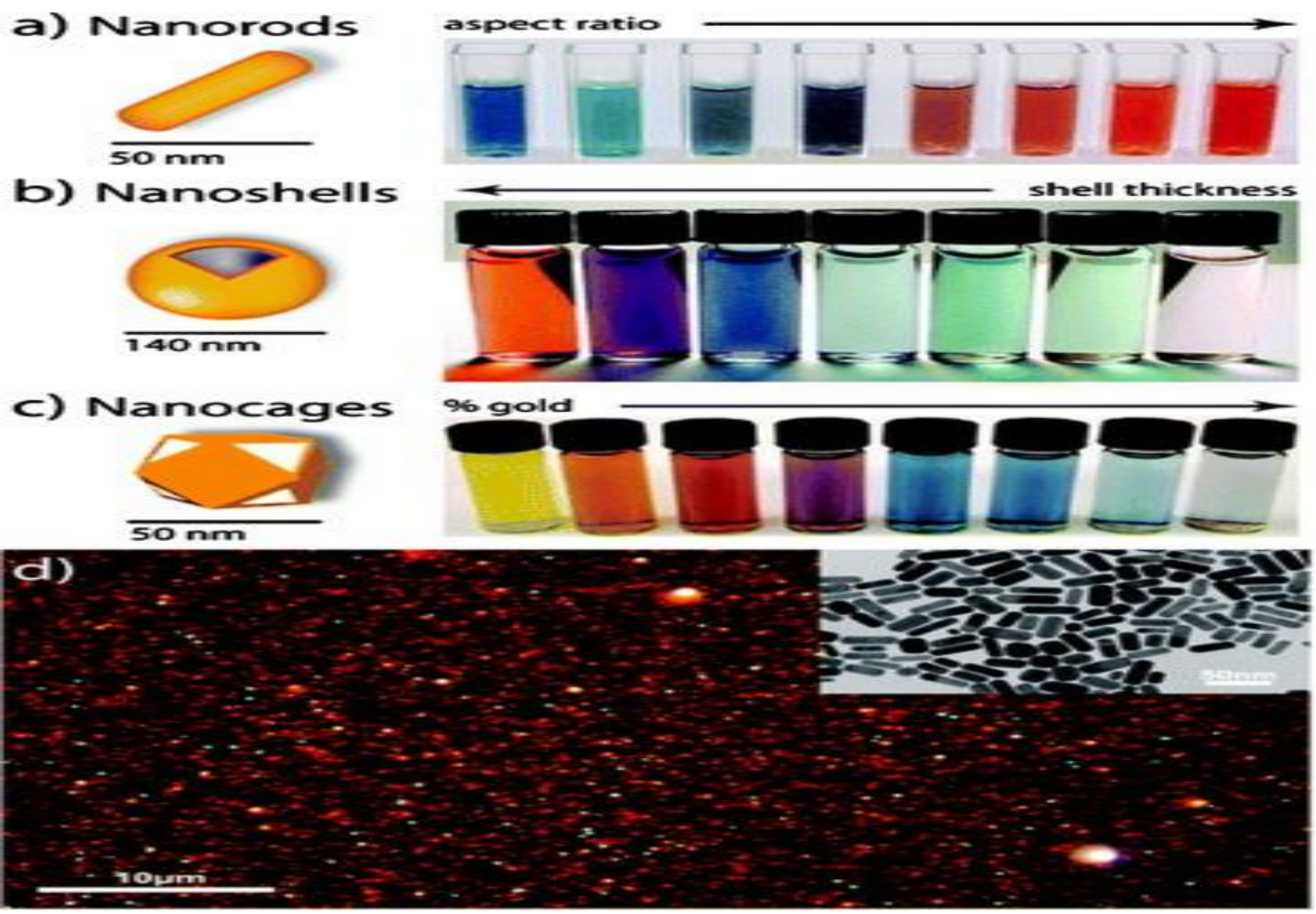
3- Choosing an appropriate matrix also helps in increasing the efficacy and reducing side effects

4- Targeted drugs may be developed

5- Various routes of administration including oral, nasal, injection, intra-ocular (within the eyes) etc. can be used.

The importance of these materials realized when researchers found that size can influence the physiochemical properties of a substance e.g. the optical properties. A 20-nm gold (Au), platinum (Pt), silver (Ag), and palladium (Pd) NPs have characteristic wine red color, yellowish gray, black and dark black colors, respectively. Next figure (a) shows an example of this illustration, in which Au NPs synthesized with different sizes. These NPs showed characteristic colors and properties with the variation of size and shape, which can be utilized in bioimaging applications. As next Figure (b) indicates, the color of the solution changes due to variation in aspect ratio, nanoshell thickness and % gold concentration. The alteration of any of the above discussed factor influences the absorption properties of the NPs and hence different absorption colors are observed.

NPs are not simple molecules itself and therefore composed of three layers i.e. (a) The surface layer, which may be functionalized with a variety of small molecules, metal ions, surfactants and polymers. (b) The shell layer, which is chemically different material from the core in all aspects, and (c) The core, which is essentially the central portion of the NP and usually refers the NP itself



Color_dependence of Au NPs on size and shape

Nanoparticles characterization methods:

1- FESEM, field emission scanning electron microscopy

2- TEM, transmittance electron microscopy

3- XPS, X-ray photon spectroscopy

4- XRD, X-ray diffraction

5- DRS , Diffuse reflectance spectroscopy

6- FT-IR,Fourier transform infrared

7- SERS, surface enhanced raman spectroscopy

8- UV.

9- Particle size analysis.

Nanoherbs

The advancement of green syntheses over chemical and physical methods is: environment friendly, cost effective and easily scaled up for large scale syntheses of nanoparticles, furthermore there is no need to use high temperature, pressure, energy and toxic chemicals.

The use of plant extracts for this purpose is potentially advantageous over microorganisms due to the ease of improvement, the less biohazard and elaborate process of maintaining cell cultures. It is the best platform for syntheses of nanoparticles; being free from toxic chemicals as well as providing natural capping agents for the stabilization of silver nanoparticles. Moreover, use of plant extracts also reduces the cost of micro-organisms isolation and their culture media which enhance the cost competitive feasibility over nanoparticles synthesis by microorganisms. Hence, a review is compiled describing the bio-inspired syntheses of silver nanoparticles that provide advancement over physical and chemical methods which are eco-friendly, cost effective and more effective in a variety of applications especially in bactericidal activities.

Green syntheses of silver nanoparticles using plant extracts:

The use of plants as the production assembly of silver nanoparticles has drawn attention, because of its rapid, eco-friendly, non-pathogenic, economical protocol and providing a single step technique for the biosynthetic processes. The reduction and stabilization of silver ions by combination of biomolecules such as proteins, amino acids, enzymes, polysaccharides, alkaloids, tannins, phenolics, saponins, terpinoids and vitamins which are already established in the plant extracts having medicinal values and are environmental benign, yet chemically complex structures. The protocol for the nanoparticle syntheses involves: the collection of the part of plant of interest from the available sites was done and then it was washed thoroughly twice/thrice with tap water to remove both epiphytes and necrotic plants; followed with sterile distilled water to remove associated debris if any. These; clean and fresh sources are shade-dried for 10–15 days and then powdered using domestic blender. For the plant broth preparation, around 10 g of the dried powder is boiled with 100 mL of deionized distilled water (hot percolation method). The resulting infusion is then filtered thoroughly until no insoluble material appeared in the broth. To 10^{-3} M $AgNO_3$solution, on addition of few mL of plant extract follow the reduction of pure Ag(I) ions to Ag(0) which can be monitored by measuring the UV–visible spectra of the solution at regular intervals.

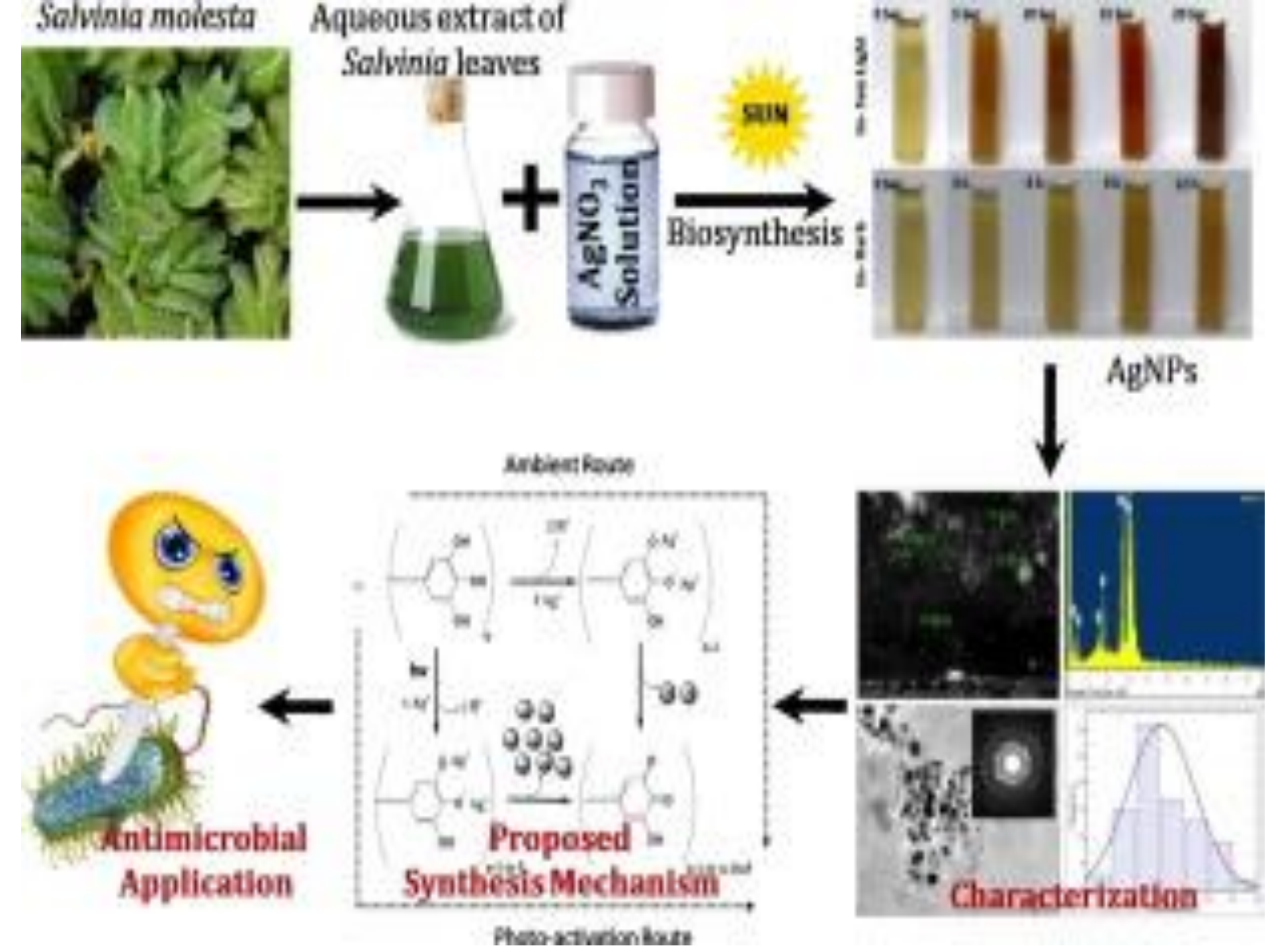
Nanotechnology for Herbal Drugs and Plant Research

Nanotechnology is the new emerging technology in the drug discovery and it has the property of self targeting in the sense that without the attachment of a specific ligand, the nanoparticles can be used for targeting, due to their distinctively small size, at the infected pathological areas. Drug delivery system fetched a novel drug delivery system, a novel approach to overcome the drawbacks of the traditional drug delivery systems. Treatment of chronic diseases like cancer using targeted drug delivery nanoparticles is the latest achievement. By analyzing the relationship between nanotechnology and biological medicine, the application of nanotechnological methods for bioavailability enhancement of herbal drugs can be brought about. „Bhasma", a natural product, is a metallo-medicine in powder form of nano to submicron size. At present, several nano drugs are under investigation for drug delivery and more specifically for cancer therapy. Interestingly, pharmaceutical sciences are using nanoparticles to reduce toxicity and side effects of drugs

Nanotechnology is an advanced scientific technique in the 21st century. By analyzing the relationship between nanotechnology and biological medicine, the application of nanotechnological methods for bioavailability enhancement of herbal drugs can be brought about. It is indicated that nanotechnology is one of the fastest developmental, the most potential and the far-reaching high and new technology in the present era, and it greatly promotes the development of biological medicine and bioavailability enhancement of herbal drugs. With the application of nanotechnology of nanomization of herbal drugs, it will make the development of nanoherbal drugs possessing high bioavaibility, which consequently will open the new era of herbal drug discovery . The breakthrough in this regard will be achieved from the research of the nanomization of herbal drugs against cancer and various other diseases.

An example of synthesis nanoherb is „Ayurveda‟ is the ancient Indian medical science based on herbs and herbo-mineral preparations. In Ayurveda, seven metals used therapeutically are: gold (Au), silver (Ag), copper (Cu), iron (Fe), lead (Pb), tin (Sn) and zinc (Zn). These are passed through many processes and finally transformed into therapeutic form. „Bhasma‟ is the metal based medicine prepared from metals after many systematic processes to raw metal into therapeutic form. „Swarna bhasma‟ (gold ash) is a therapeutic form of gold metal of nanosized particles when evaluated through various tools and techniques. The size of particle was found to be about 56 nm. Swarna bhasma was also analyzed qualitatively and found that the final product is almost pure gold (Au). „Bhasma‟ is a metallo-medicine in powder form of nano to submicron size. The raw metal is converted into therapeutic form through classical process by repeated incineration and grinding with some herbal juices and other specified matters. Specialty of preparation process is that the whole process is not a chemical based, rather it is fully a mechanical process and chemical properties much differ to nanoparticles prepared through chemical process

Use of nanotechnology in medicine and more specifically drug delivery is set to spread rapidly. Presently, many substances are under investigation for drug delivery and more specifically for cancer therapy. Interestingly, pharmaceutical sciences are using nanoparticles to reduce toxicity and side effects of drugs. From a positive view point, especially the potential to cross the blood brain barrier may open new ways for drug delivery into the brain. In addition, the nanosize also allows for access into the cell and various cellular compartments, including the nucleus. A multitude of substances are currently under investigation for the preparation of nanoparticles for drug delivery, varying from biological substances like albumin, gelatin and phospholipids for liposomes, and more substances of a chemical nature like various polymers and solid metal containing nanoparticles . Herbal drugs have now occupied lead positions in the pharmacopoeia, and the improvement in this concern through nanoformulations using nanotechnology have been done. Known effects and no side effects have made natural products/herbal drugs a powerful therapeutic solution to the organisms. But the delivery of plant/herbal therapeutic molecules as drugs is problematic due to poor solubility, poor permeability, low bioavailability, instability in biological milieu and extensive first pass metabolism. These limitations of herbal drugs can be overcome by attaching or encapsulating them with suitable nanomaterials. The nanomaterials can significantly enhance the pharmacokinetics and therapeutic index of plant drugs. Targeted delivery and combination therapy can drastically improve the performance of herbal drugs.


Salvinia molesta
Aqueous extract of
Salvinia leaves
AgNO3 Solution
SUN
Biosynthesis
AgNPs
Characterization
Proposed
Synthesis Mechanism
Antimicrobial
Application