

# Nobel Metallic Nanoparticles with Novel Biomedical Properties

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## Abstract

The strong optical absorption and scattering of noble metal nanoparticles is due to an effect called localized Surface Plasmon Resonance, which enables the development of novel biomedical applications. AuNPs are the most stable metal nanoparticles, and they present fascinating aspects such as their assembly of multiple types involving materials science, the behavior of the individual particles, size-related electronic, magnetic and optical properties [quantum size effect], and their applications to catalysis and biology likewise, AgNPs due to its excellent biocompatibility and antibacterial property raise considerable interest as nanoparticles for biomedical applications. Since the size, shape and composition of silver nanoparticles can have significant effect on their efficacy, extensive research has gone into synthesizing and characterizing silver nanoparticles. This article reviews the various synthetic routes currently used for developing stable silver nanoparticles and their biomedical applications in the areas of microbial resistance, antioxidant activity, anticancerous, drug delivery, antiplatelet, antiangiogenic activity, surface enhanced Raman scattering and metal enhanced fluorescence.

**Keywords:** Silver nanoparticles; Gold nanoparticles; Biomedical applications

## Introduction

Nanotechnology deals with synthesis of nanoparticles of various sizes, shapes, chemical compositions and controlled dispersity and their potential use for human benefits [1]. Generally in nanotechnology a nanoparticle as an object which is in small size is defined  $10^{-9}$  m that behaves a whole unit in terms of its transport and properties [2]. Nanotechnology is applied to various fields such as physical, chemical, biological and engineering sciences where novel techniques are being developed to probe and manipulate single atoms and molecules. Among all nanoparticles the metallic nanoparticles have applications in diverse areas such as electronics, cosmetics, coatings, packaging and biotechnology. Metallic nanoparticles can be attached to single strands of DNA nondestructively. This opens up avenues for medical diagnostic applications [3]. Nanoparticles can traverse through the vasculature and localize any target organ, this leads to novel therapeutic, imaging and biomedical applications [2]. Ag Nanoparticles and Au Nanoparticles are mostly used in application research in nanotechnology. Previously nanoparticles were produced only by physical and chemical methods with various techniques [4]. Biosynthesis methods have started being used later. In biosynthesis method bacterium, fungi and plant parts are used, this biosynthesis method is ecofriendly comparing to physical and chemical methods. Silver nanoparticles have diverse properties like catalysis, magnetic and optical polarizability, electrical conductivity, antimicrobial activity and Surface Plasmon resonance. Similarly Gold [Au] Nanoparticles have optical, electronic, catalytic, biocompatible properties and potentially high surface reactivity.

## Silver nanoparticles and its types

**Silver colloids:** In silver nanoparticles if the product is clear then it is ionic silver, not a true silver colloid. Meso silver is called as purest colloidal silver and silver nanoparticles come to the market in 5 types according to its purpose.

**Nano xact:** Spherical silver formulations are precisely manufactured unaggregated spherical nanoparticles suspended in water.

**Biopure silver:** It is a high concentration formulation that has been extensively purified to remove residual reactants.

**OECD-silver:** This silver was given a Organization for Economic Cooperation and Development guidance. Its formulation has been selected as nanotoxicology standards with PVP and citrate surfaces.

**Custom silver:** This can be produced with custom concentrations, charge, biofunctionalization shells and suspension media.

**Silver nanoparticles:** They have high optical efficiencies and can be tuned to interact with wavelength ranging from 550nm to 950nm. [www.nanocomposix.com](Figure 1).

## Gold nanoparticles and its types

There are many subtypes of gold nanoparticles based on the size, shape and physical properties. Gold nanospheres: Gold nanospheres although not exactly spherical in a strict sense [also known as gold colloids] of 2 nm to over 100nm in diameter can be synthesized by controlled reduction of an aqueous  $\text{HAuCl}_4$  solution using different reducing agents under varying conditions. Most commonly citrate is used as a reducing agent, which can produce nearly monodisperse gold nanospheres [5]. SERS [Surface-enhanced Raman scattering] is an optical technique that offers many advantages over traditional

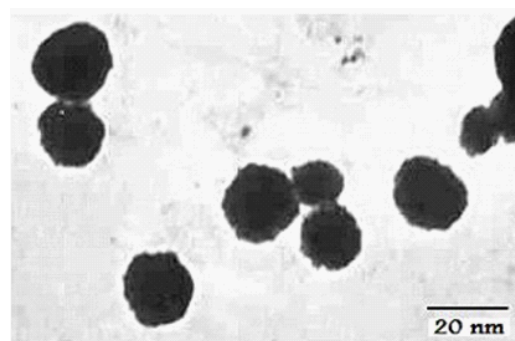


Figure 1: TEM image of Ag nanoparticles.

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technologies, such as fluorescence and chemiluminescence, including better sensitivity, high levels of multiplexing, robustness and superior performance in blood and other biological materials. Gold nanospheres are used as SERS nanoparticles [13 nm in diameter]. Now gold nanospheres are modified with Cy3-labelled, alkylthiol-capped oligonucleotide strands were used as a probe to monitor the presence of specified target DNA strands [6].

### Gold nanorods

The synthesis of gold nanoparticles has been reported using a wide variety of strategies. Gold nanorods are typically synthesized using the template method, based on the electrochemical deposition of gold within the pores of nanoporous polycarbonate or alumina template membranes [7].

### Gold nanoshells

It is used in optical imaging. Gold nanoshells with surface Plasmon resonance [SPR] peaks in the NIR [Near Infrared Region] can be prepared by coating silica or polymer beads with Gold nanoshells of variable thickness [6](Figure 2).

### Physicochemical properties of Au and AgNPs

Properties of nanoparticles depend on structure and composition and can typically be engineered and composition and can typically be engineered or modified by changing the relative influence of interfacial or interphase properties and the macroscopic bulk properties through the characteristic size or dimension of components and domains. The principal parameters of nanoparticles are their shape [including aspect ratios where appropriate], size and the morphological sub-structure of the substrate. Nano particles produce on intense absorption when they excited with an electromagnetic field. That intense absorption attributed to the collective oscillation of electrons on the particle surface termed as a Plasmon resonance. The resonant frequency is highly dependent on particle size. Shape material environment by altering these characteristics the frequency can be shifted over a wide range of wave lengths. Making nano-particles into functional materials for many applications [8]. Silver nanoparticles have diverse properties like catalysis, magnetic and optical polarizability, electrical conductivity,

and microbial activity and enhanced Raman scattering. Silver NPs have unique optical properties because they support surface plasmons. At specific wavelengths of light the surface plasmons are driven into resonance and the AgNPs have a distinct color that is a function of their size, shape and environment [9]. The plasmons resonance of AgNPs is responsible for yellow color in solution. Any visible change to the NPs in solution typically indicates that the aggregation of the nanoparticles has changed [10]. The wavelength of silver nanoparticles is 430nm and is an evidence for the formation of silver nanoparticles.

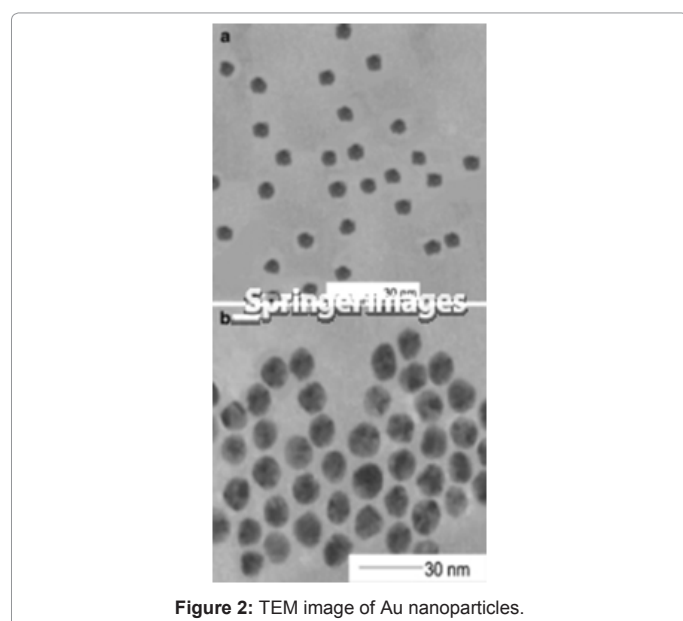
Silver nanoparticles have many toxicological properties. AgNPs interacts and instigates toxicity in mammalian cancer cells. Cytotoxicity was induced by SNPs [AgNPs] and the role that oxidative stress plays in this process were found in hepatoma cells [11]. Ag<sup>+</sup> ions and PVP coated AgNPs induce apoptosis and necrosis in dose dependent manner [12]. Silver nanoparticles are extraordinarily efficient at absorbing and scattering light and, many dyes and pigments, have a colour that depends upon the size and shape of the particle. A unique property of spherical silver nanoparticles is that this SPR peak wavelength can be tuned from 400nm [violet length] to 530nm [green light] by changing the particle size and the local refractive index near the particle surface [13]. When silver nanoparticles are in solution molecules associate with the nanoparticle surface to establish a double layer of charge that stabilizes the particles and prevents aggregation, and silver nanoparticles in catalysis, magnetic, and optical polarizability, electrical conductivity, antimicrobial activity [14].

Gold nanoparticles [GNPs] as a class of nanomaterials with many unique properties such as colorimetric, conductivity, and non linear optical properties, have been explored for potential applications in biomolecular detection [15]. Gold nanoparticles are precious metal and they have high surface area, easy fictionalization, high electric conductivity, high stability and corrosion resistance and their pronounced plasmon resonance band in the visible range as well as sensitivity to aggregation are amongst their most attractive features [16]. Gold nanoparticles have property of converting allowed radiofrequency into high frequency is known as 'Quantum Dot' property and can be used for destroying cancer cells [17]. Gold is known to be a good electrical and thermal conductor and it is relatively easy for these particles to bind with antibodies, carbohydrates and other pharmacological agents [18]. Nano particles produce on intense absorption when they excited with an electromagnetic field. That intense absorption attributed to the collective oscillation of electrons on the particle surface termed as a plasmon resonance [19]. The resonant frequency is highly dependent on particle size. Shape material environment by altering these characteristics the frequency can be shifted over a wide range of wave lengths. Making nanoparticles into functional materials for many applications [20].

### Purpose of Au nanoparticles and Ag nanoparticles

**Delivery:** AuNPs can serve as carriers for drug to and gene delivery. Biologically active molecules absorbed on the surfaces can be guided inside cells and released DNA delivery for instane cells and released DNA delivery the basis for gene therapy [21]. Heating AuNPs have a strong light absorbing property that makes AuNPs suitable as heat mediating objects: the absorbed light energy is dissipated into the particles. Surroundings, generating an elevated temperature in their vicinity. This effect can because to open polymer microcapsules, for eg, for drug delivery purposes [22].

**Hypothermal therapy:** Hypothermal therapy is given to the particle loaded tissue in order ot destruct the malignant cells [23].



**Sensors:** AuNPs can also be used as sensors their optical properties can change upon binding to certain molecules, allowing the detection and quantification of analytes [24]. For labeling certain properties of the are exploited to generate contrast for example in TEM the strong electron absorbing properties of gold nanoparticles make them suitable as a stain for samples with poor contrast such as tissue sample and in immunostaining method they are labeled with antibodies [25]. That shows the small size and the possibility of functionalizing the particles and provides extremely high spatial resolution and specificity in many labeling applications AgNPs. Silver NPs in needed in terms of their interactions with cellular receptors extra – intra cellular proteins, organelles and DNA [26].

Silver nanoparticles of only [1-10 nm] undergo a size dependent interaction with HIV-1 Ag compounds have also been in the medical field to treat the burns and a variety of infections [27]. Salts of silver and their derivatives are commercially employed as antimicrobial agents. Nanoparticles of silver have thus been studied as medium for antibiotic delivery. Metallic nanoparticles exhibit size and shape-dependent properties that are of interest for applications ranging from catalysts and sensing to optics, antibacterial activity and data storage. Nanoparticles of silver have thus been studied as a medium for antibiotic delivery and to synthesize composites for use as disinfecting filters and coating materials [28].

### Synthesis of Au/Ag NPs

Previously nanoparticles were produced only by physical and chemical methods some of the commonly used physical and chemical methods are ion sputtering solvothermal synthesis, reduction and sol gel technique. Basically there are two approaches for nanoparticle synthesis. They are bottom up approach and the top down approach. In the top down approach scientist try to formulate nanoparticles using larger ones to direct their assembly [29]. But in the bottom up approach is a process that builds towards larger and more complex systems by starting at the molecular level maintaining precise control of molecular structure [30]. The bottom up approach promises a better change to obtain nanostructures with less defects. The nanoparticle will have more homogenous chemical composition and better short and long range ordering, because this approach is mainly driven by the reduction of Gibb's free energy. Some of the commonly used physical and chemical methods are

1. **Chemical reduction:** This is carried out by the reduction of an ionic salt in an appropriate medium in the presence of surfactant using reducing agents such as sodium citrate [31].
2. **Solvothermal synthesis:** This is a versatile low temperature route in which polar solvents under pressure and at temperatures above their building points are used. Under solvothermal conditions, the solubility of reactants increases significantly, enabling reaction to take place at lower temperature [32].
3. **Sol gel technique:** It is a wet chemical technique used for the fabrication of metal oxides from a chemical solution which acts for integrated network (gel) of discrete particles or polymers. The precursor sol can be either deposited on the substrate to form a film, caste into a suitable container with desired shape or used to synthesize powders [33].
4. **Laser ablation:** This is the process of removing materials from a solid surface by irradiating with a laser beam. Thus they produce nanoparticles [34].
5. **Biosynthesis:** Biosynthesis of nanoparticles is a kind of bottom

up approach where the main reaction occurring is reduction/oxidation. Micro organisms and plant extracts are used in general. The advantages of this summarize are 1) Eco friendly 2) They reduces agents employed 3) capping agent in the reaction in synthesis by Bacteria many bacteria species had been used when these species were exposed to silver nitrate ( $\text{AgNO}_3$ ). It produced AgNPs of microbial synthesis of gold nanoparticles was achieved by [35] using mesophilic bacterium shewanella algae with  $\text{H}_2$  as the electron donor by using fungi AgNPs were synthesized by bioreduction of  $\text{AgNO}_3$  followed by stabilization and / or encapsulation of the same by a capping agent. Ag and Au nanoparticles were synthesized by the reduction of  $\text{Ag}^+$  and  $\text{AuCl}_4^-$  ions using extract from (*Emblia officinalis*). Here the metal ions reduction was motivated by the possibility of inducing shape control of nanoparticles due to the presence of polyphenols in the fruit extract naturally [36](Table 1).

### Characterization

#### UV visible spectrophotometer

A beam of light from a visible or UV light or NIR source is separated into its component wavelengths by a prism or diffraction grating. Each monochromatic (Single wave length) beam in turn is split into two equal intensity beams by a half – mirrored device. One is sample beam that passes through the solution and the other beam is a reference beam that passes through the identical cuvet contains solvent and intensities of these light beams are then measured by electronic detectors and compared.

#### Scanning electron microscopy (SEM)

Scanning electron microscopy is the microscope that uses electrons instead of light to form an image the resolution of SEM can approach a few mm and it can operate at magnifications that are easily adjusted from about  $10 \times - 300,000 \times$ s. SEM uses electro magnets rather than lenses; the researcher has more control in the degree of magnification.

#### X-ray diffraction (XRD)

It involves the monitoring of the diffraction patterns of x-rays after they interact with the sample. It is used to identify crystal structure.

Source Used	Nanoparticles synthesized
<i>Bacillus subtilis</i> [Bacterium]	Gold [37]
<i>Shewanella algae</i> [Algae]	Gold [38]
<i>Pseudomonas stutzeri</i> [Bacterium]	Silver [39]
<i>Lactobacillus</i> [Bacterium]	Gold, silver, Au–Ag alloy [40]
<i>Thermomonospora sp.</i> [Bacterium]	Gold [41]
<i>Rhodococcus</i> [Bacterium]	Gold [42]
<i>Chlorella vulgaris</i> [Algae]	Gold [43]
MKY3 [Yeast]	Silver [44]
<i>Verticillium</i> [Fungi]	Gold, silver [45]
<i>Fusarium oxysporum</i> [Fungi]	Gold, silver, Au–Ag alloy, cadmium, sulfide, zirconia [46]
<i>Colletotrichum sp.</i> [Fungi]	Gold [47]
<i>Aloe vera</i> [Plant]	Silver and gold [48]
<i>Emblia officinalis</i> [Plant]	Silver, gold [36]
<i>Azadirachta indica</i> [Plant]	Silver, gold and Ag Core Au – shell [49]

**Table 1:** Biological synthesis of gold and silver nanoparticles.



## Applications

### Antimicrobial activity of AgNPs

Silver nanoparticles have antimicrobial activity. It is used as a antimicrobial agent. Colloidal silver is a proven killer of bacteria. It is far more efficient antibiotic than any allopathic pharmaceutical. Colloidal silver is effective in Killing 650 bacteria in less than five minutes, at most in concentrations of five to six parts per million (ppm)

The ASAP nanosilver product has proven effective at eliminating malaria from the blood stream in 4 different preliminary studies, in an overage of just 3.34 days by internal human ingestion. The produced (ASAP nanosilver) was proven in an animal model study at a U.S government NIH lab, to be able to increase the survival rate of mice by 100% against the dead by H5N1 bird flu virus when using the product orally on a daily basis (relation in peer review journal). The product has been proven to be able to increase the t-lymphocyte count in 7 human AIDS patients by an average of almost 40% in four months of oral usage at just 2 ounces daily. The product technology is patented to be able to kill TB, MRSA, Hepatitis b, HIV, yeast and too many other pathogens to list here. The point is that it is very broad spectrum antimicrobial agent, which also has been tested found to be completely non-toxic to humans and animals at any level tested. Silver nanoparticles undergo a size dependent interaction with HIV-1. NPs ranging in size from 1 to 10 nm readily interact with the HIV-1 via preferential binding to gp 120 glycoprotein knobs. This interaction of AgNP, inhibits the virus from binding host cells. Thus they control HIV infection. Colloidal silver is also an anti-parasitic it works by attacking bacteria when they are in their egg-producing stages. Colloidal silver NPs bind with the cell walls of single – cell organisms and inhibit their respiration. Colloidal SNPs a powerful antiviral colloidal silver kills a broad spectrum if viruses. It kills even most eared and dead by viruses, which are not able to be killed by allopathic antiviral and other treatments. It kills HIV, strains of Hepatitis and even emerging strains of flu-viruses. Health Benefits of Colloidal Silver (Angela Kaelin, eHow Contributor, eHow.com).

AgNPs also find application in topical ointment and creams used to prevent infection in burns and open wounds anticancer particles with paclitaxel inhibits the growth of hep G2 cell more effectively AgNPs was found as nontoxic on live cells, induced apoptosis on cancerous HT29 [50]. It infers mitochondrial membrane damage during cell apoptosis and fragmentation of BrdU labeled cellular DNA was quantifies by ELISA [51]. DNA breakage was found when cells were treated with AgNPs by using comet assay. Cell cycle arrest raise with AgNPs and mitochondrial dysfunction. Induction of ROS where found these is all the evidences that AgNPs has cytotoxicity and genotoxicity on cells [52]. Gold nanoparticles have been sued in treating B-chronic lymphocytic leukemia (CLL). CLL is an incurable disease predominating characterized by Apoptosis resistance anti VEGF ab has been used previously to treat CLL, however treatment was found more effective when VCGF Ab was attach with A<sub>u</sub>NPs (1-) chromosomal breakage has been found when cells are treated with AgNPs using cytokines – blocked micronucleus Assay (CBMN) [53].

Anti EGFR antibody – conjugated nonorods binds specifically to the surface of the malignant type cells with a much higher affinity due to over expressed AgNPs EGFR on the cytoplasmic membrane ant cancer of the malignant cells and kills the effect malignant cells with its laser energy. Thus both efficient cancer cell diagnostics and selective photothermal therapy are realized at the same time [54].

### Cell imaging

Aptamer based silver nanoparticles are used in intracellular protein imaging and single nanoparticle spectral analysis, Here AgNPs acts as an illumiophore and the aptamer as a biomolecule specific recognition unit respectively [55]. Gold nanoparticle has strong electric fields at the surface. The absorption and scattering of electro magnetic radiation by noble metal nanoparticles are strongly enhanced. These unique properties provide the potential of designing novel optically active reagents for simultaneous molecular imaging and photothermal cancer therapy. In *in vitro* studies the gold nanorods are novel contrast agents for both molecular imaging and photo thermal cancer therapy [54]. The versatile optical imaging of cells and phantoms with a wide variety of contrast mechanisms. Functional cellular imaging around single molecules has been reported. Functional cellular imaging around single molecules has been reported, tuning advantage of the enhanced second harmonic signal by antibody – conjugated gold nanospheres [56]. Two photon luminescence imaging of cancer ells in a 3D tissue phantom down to the 75 mm depth has been achieved using gold nanorods. Gold nanorods have been reported for cell imaging using techniques such as dark field light SPR scattering. The use of NIR absorbing gold nanoparticles can significantly enhance the image contrast due to the more substantial differences in optical absorption [hence stronger photo acoustic wave generation] than the endogenous tissue chromophore. Gold NPs are used also in vivo imaging many paramagnetic nanoparticles have been used for preclinically and clinically [57]. Au3Cl1 nanoshells are used to enhance the contrast of blood vessels in vivo, which suggested their potential us in MR angiography as blood – Pool agents.

### Biosensors

Prostate specific Antigen (PSA) has been used to confirm the presence of semen and absence of sperm in sexual assault cases the use of PSA is forensic analysis has a different set of requirements such as lack of sample or need to extract. Nanoparticles and nanostructures are used to enable the analytic detection, gold NPs probes are attached to Antibodies that are labeled with Raman dyes. This assay has been regarded robust for PSA detection due to being label free and in expensive in this method PSA detection is done by enhancement Raman Scattering [58].

### Cancer therapy (anticancer)

Conventional strategies for cancer intervention include surgery, chemotherapy, and radiation therapy.

Taking advantage of their unique properties, most studies of gold nanoparticle – based cancer therapy have used photothermal therapy for the destruction of cancer cells or tumor tissue, which may be potentially useful in the clinical setting. Gold nanoshells are sufficiently large (about 100-300 nm in diameter) to have SPR peaks in the WIR region. In one pioneering study, human beast carcinoma cells incubated with gold nanoshells were found to undergo photothermally induced morbidity upon exposure to NIR light. In one study 93% of tumor necrosis and regression. Was observed in a high dose nanoshell (8.5 ml/g) treated group [59].

### Diagnosis

Gold nanoparticles (GNPs) as a class of nanomaterials with many unique properties such as colorimetric conductivity, and nonlinear optical properties, have been explored for potential applications in biomolecular detection. GNPs can be used to quantitatively detect

nucleic acids and proteins in clinical samples. For example, a DNA based method for rationally assembling gold nanoparticles into macroscopic materials has been reported by mirkin and coworkers. For protein detection, an aggregation – based immunoassay for anti-protein A using gold nanoparticles has been developed [60]. The hyper-Rayleigh scattering signals of aggregated gold nanoparticles labeled with immunoglobulin G could be used to quantify antibody / Antigen in aqueous solution, [15]. These two methods could only detect proteins at the microgram level, which limits their applications in immunoassay especially in early cancer diagnosis.

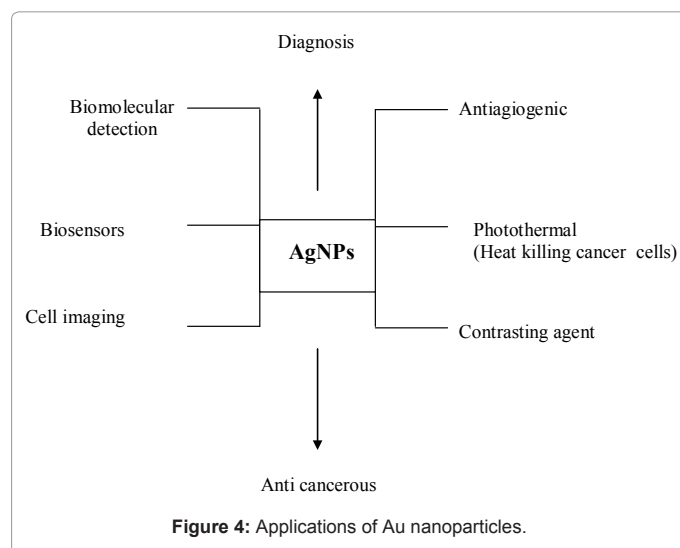
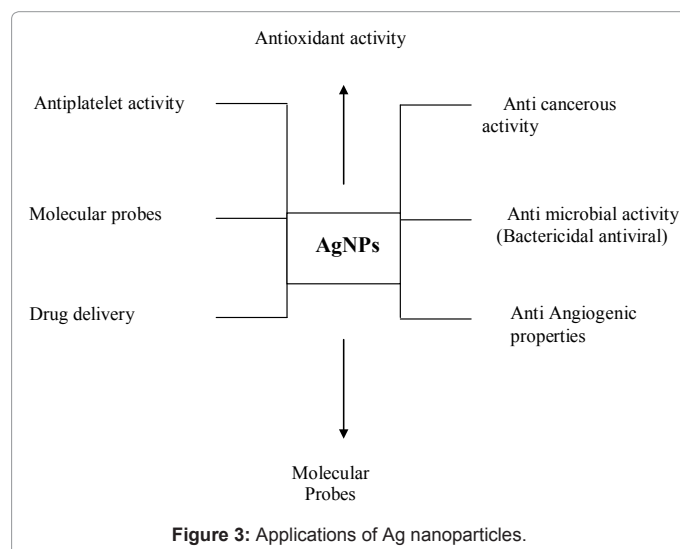
### Antioxidant properties

Previously it was reported that AgNPs reduce mitochondrial function and increase membrane leakage in mammalian germline stemcells and increase reaction oxygen species (ROS) generation, deplete antioxidant GSH content, and reduce mitochondrial function in BRL 3A rat liver cells [61]. In addition to the well known specific effects of peroxide, superoxide and hydroxyl radicals, ROS in general also cause DNA damage, including a multitude of oxidized base lesions, abasic sites, single and double-strand breaks; all of these can be cytotoxic and/or mutagenic [62,63]. Excessive ROS generation is also known to induce apoptosis/cell death in various cell culture models. Excessive production of ROS in the cell is known to induce apoptosis. ROS generation has been shown to play an important role in apoptosis induced by treatment with AgNPs [64]. It has been studied that AgNPs increase the production of intracellular ROS and decrease reduced glutathione levels, leading to apoptosis [65]. Showed that AgNPs decreased GSH levels through the inhibition of GSH synthesizing enzymes (GCLS and GSS), leading to the generation of ROS. However, GSH is not the only intracellular antioxidant defence, therefore it remains to be determined if the other intracellular antioxidant systems (e.g. superoxide dismutase, catalase) are also impaired by AgNPs.

### Other applications

Gold nanoparticles have received great attention as an anti-angiogenic agent with the evidence nanoparticles block VEGF-induced retinal vascular permeability *in vivo* [66]. Ag-NPs to be a potent anti-angiogenic molecule that inhibits angiogenesis in VEGF (Vascular endothelial growth factor) -induced BRECs (bovine retinal endothelial cells) through the inhibition of the PI3K/Akt cell-survival signal in a similar pattern of PEDF (Pigment epithelium-derived factor – also known as serpin F1 (SERPINF1), is a multifunctional secreted protein that has anti-angiogenic functions) This in turn alters the downstream signaling and subsequent cellular responses. These findings provide strong evidence that nanostructures cannot only passively interact with cells, but also actively engage and mediate the molecular processes that are essential for regulating cell functions. The particles of 50 nm have been used. Further studies involve a size-dependent study involving Ag-NPs as anti-angiogenic molecule that can elucidate the potency, efficacy and efficiency compared to PEDF. This study provides a mechanism to account for the inhibition of Ag-NPs on VEGF-mediated angiogenesis and also suggest that Ag-NPs could be the targeted therapeutic molecule for the treatment of diabetic retinopathy and other eye-related neovascular diseases [67]. Gold nanoparticles have found application in analytical methods such as colorimetric techniques for the determination of heavy metal ions in aqueous solutions gold nanoparticles also used in the field of sensor [68]. Nanosilver has an innate antiplatelet property and effectively prevents integrin-mediated platelet responses both *in vivo* and *in vitro* in a concentration

dependent manner. It is useful to treat thrombotic disorders. It regulates and maintains platelets in an inactive state treatment by anticoagulant and Thrombotic therapies are usually associated with serious bleeding complication [69]. Förster Resonance energy transfers have served as a molecular ruler that reports conformational changes and intramolecular distances of single biomolecules. This molecular ruler are rigid oligoproline cross linking reagent of defined length such reagents are useful in probing the structures of biological macromolecules in solution, but they suffer from low fluctuating signal intensities and limited observations. It has been demonstrated that plasmon coupling can be used to monitor distances between single pairs of gold and silver nanoparticles dimmers in real time and studied the kinetics of single DNA hybridization events these are known as plasmon rulers [70]. The toxicity of Ag nanoparticles is investigated using a panel of recombinant bioluminescent bacteria. The presence of the nanoparticles leads to the production of a superoxide radical. Furthermore, the Ag nanoparticles damage the cellular membranes, causing a disruption in the ion efflux system. Thus, the cells cannot effectively extrude the Ag ions and, hence, Ag nanoparticles cause more damage than do Ag ions [71] (Figure 3, Figure 4).



## Conclusion

In this review, we have focused on the current applications of AuNPs and AgNPs in biomedical science. In addition, the biocompatibility and photo-optical distinctiveness of AuNPs are now proven to be powerful in diagnostic and biosensing applications. With the “right” combination of delivery agents and particle size, AuNPs-based therapeutics could effectively kill the diseased cells while eliminating the horrendous side effects of the conventional chemotherapeutic agents. Ag nanoparticles shows toxicity to cancerous cells and also on normal cells, but target delivery helps to achieve good results. And it has been proven that AgNPs have antiplatelet activity and anti angiogenic activity. These two properties of AgNPs will be helpful in therapeutics. Physical, Chemical and biological methods are used to synthesize Au and Ag nanoparticles. Plants are used to synthesize these metallic nanoparticles and in this plant mediated synthesis, plants are used as a stabilizing agent and capping agent. Plants reduce the ions of these metals and help to produce nanoparticles. This enhances the activity of the Au and Ag Nanoparticles. Au nanoparticles plays a major role in molecular diagnosis. As the nanoparticle is less than 1 $\mu$ m in diameter, it is useful in diagnosis.

Taken together gold and silver nanoparticles are useful in almost all medical fields in It reaches sensitivities of a few molecules, perhaps even a single molecule, per nanoparticle sensor element. Gold and silver nanoparticles were employed as Glucose sensing platforms through the modification of their surfaces with dextran and boronic acid groups, respectively. This concludes that gold and silver nanoparticles have novelty as biosensors in molecular level. Photo thermal therapy is the unique property of gold nanoparticles and silver nanoparticles are known for antimicrobial activity.

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