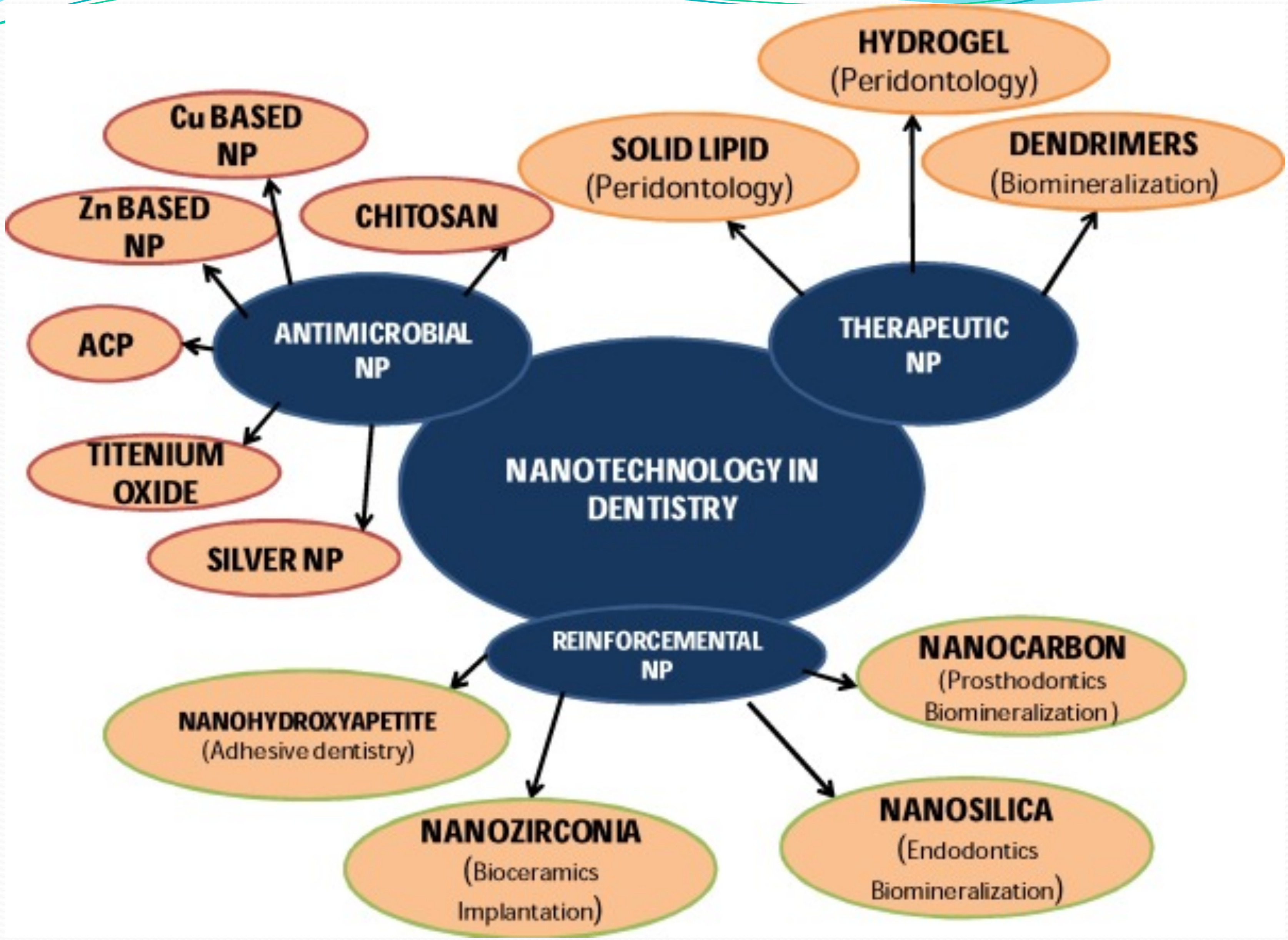
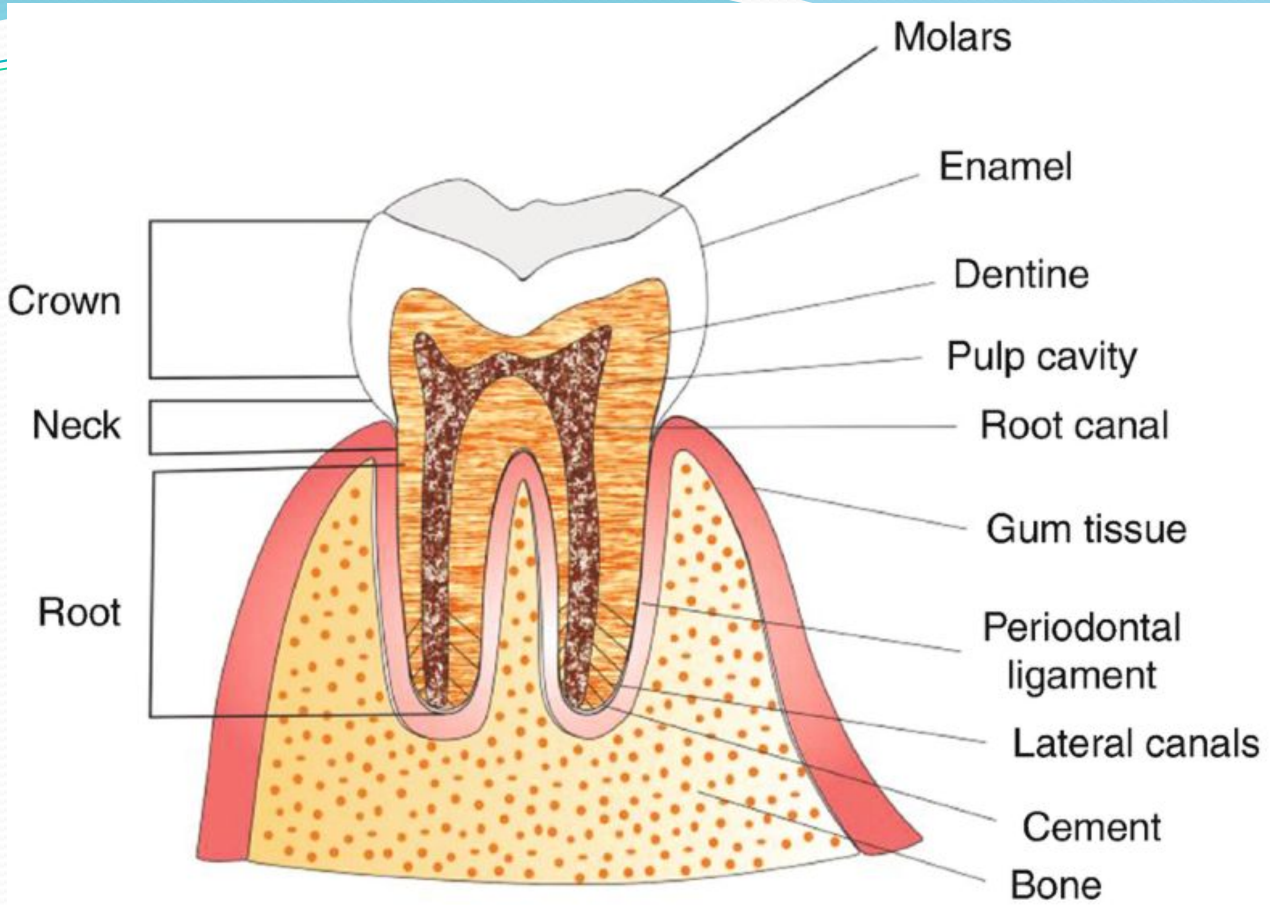

NANOTECHNOLOGY IN DENTISTRY
ANTIMICROBIAL NP
Cu BASED NP
Zn BASED NP
CHITOSAN
ACP
TITENIUM OXIDE
SILVER NP
THERAPEUTIC NP
SOLID LIPID (Peridontology)
HYDROGEL (Peridontology)
DENDRIMERS (Biomineralization)
REINFORCEMENTAL NP
NANOHYDROXYAPETITE (Adhesive dentistry)
NANOZIRCONIA (Bioceramics Implantation)
NANOSILICA (Endodontics Biomineralization)
NANOCARBON (Prosthodontics Biomineralization)

The tooth is an important part of the body that plays remarkable roles in personality development, digestion, infection and many other physiological activities.

An infectious tooth significantly contributes to poor oral hygiene. Oral health is correlated with many serious complications such as cardiovascular disease, diabetes, neurodegenerative diseases and many more.

To maintain the clean teeth various materials or medicines have developed in the field of dentistry.

Conventional dental materials often cause damage to the tooth properties, such as **tooth whiteness, integrity and promote biofilm formation over the teeth**. Taking the disadvantages of conventional materials into account, various nanomaterials have been developed for the application in the field of dentistry



The tooth is mainly comprised of **four parts**: **enamel, dentin, cementum and dental pulp**. Of which, the hardest part is enamel which is highly mineralized part supported by dentin, which occurs in between the enamel and the pulp chamber, with microscopic channels known as dentinal tubules. Cementum is a specialized bone-like structure that covers the dentin root whose principle role is to serve as a medium for attachment of periodontal ligaments

With the evolution of dentistry, various dental treatment methods and materials such as **temporary dressings, dental restorative materials (such as crowns, bridges and dental fillings), endodontic materials (resin composite and root canal treatment), a coating of the teeth and teeth polishing agents** were developed.

These materials possess certain **disadvantages** such as the

- loss of teeth integrity and whiteness,
- formation of bacterial biofilm on dental coatings and
- inability to prevent dental erosion

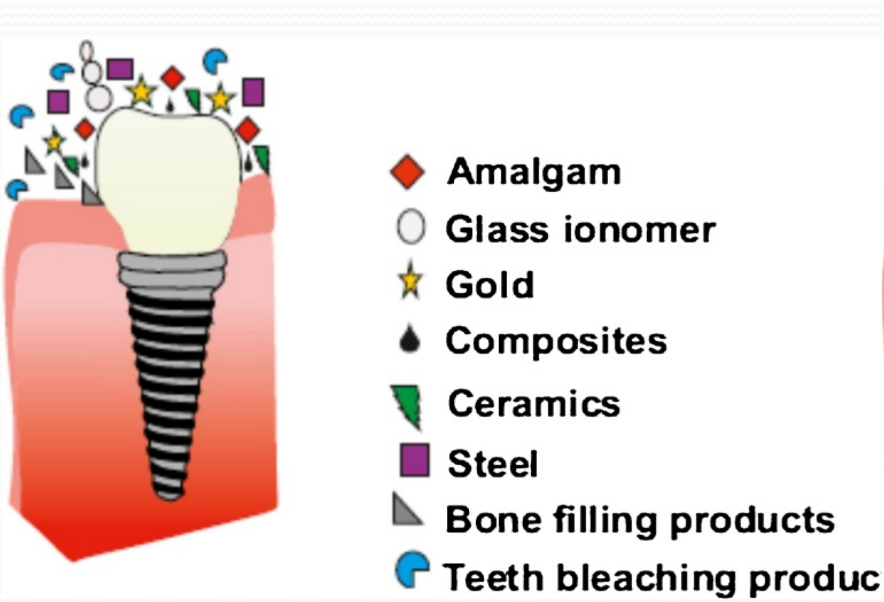
which made people think for the development of better materials to serve the treatment purposes without losing the teeth integrity.

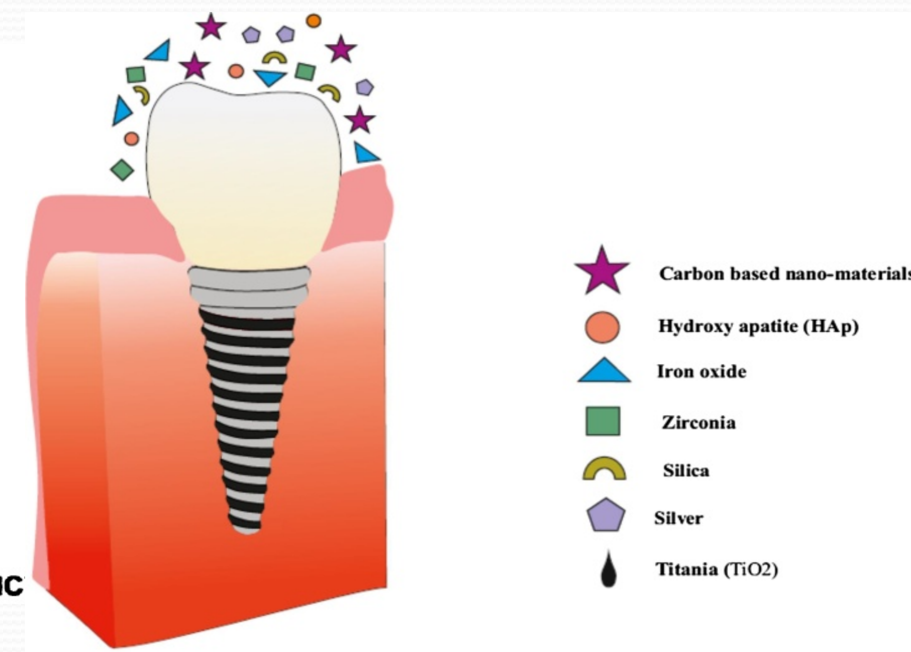
Preventive nanodentistry

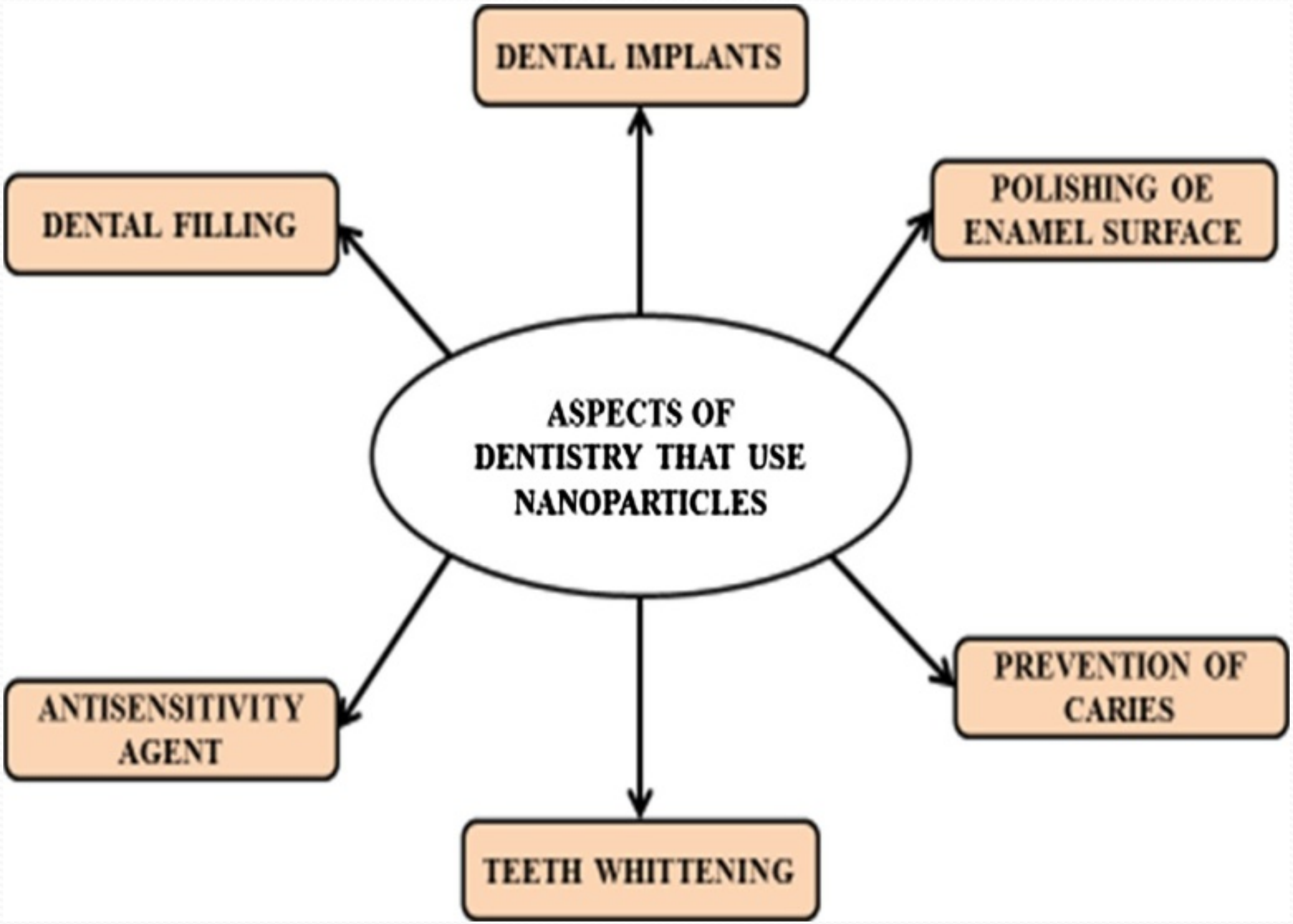
Nanoparticles used in Various Fields of Dentistry

Nanodentistry' was born in the year 2000 and applied in diagnostics, therapy and prevention of dental abnormalities and improvement of dental health.

It is used for root canal irrigation, adhesives, implants, antibacterial medicine formulations, resin composite adhesives, mouthwash, cement and bleaching agents. They are way more effective than conventional practices.






DENTAL IMPLANTS
DENTAL FILLING
POLISHING OE ENAMEL SURFACE
ASPECTS OF DENTISTRY THAT USE NANOPARTICLES
ANTISENSITIVITY AGENT
PREVENTION OF CARIES
TEETH WHITTENING

Antibacterial nanotherapy

Several nanoparticles **(eg, zinc oxide,,silver,and polyethylenimine** have been incorporated into dental composites or dental adhesives to inhibit the bacterial growth through **several mechanisms**.

These mechanisms include disruption of the bacterial cell membrane, inhibition of the active transport as well as the metabolism of sugars, generation of reactive oxygen species, displacement of magnesium ions required for the enzymatic activity of oral biofilms, disturbance of the electron transportation across the bacterial membrane,and prevention of DNA replication.

These nanoparticles were effective in reducing the S. mutans and Lactobacillus acidophilus biofilms in an in vitro model.

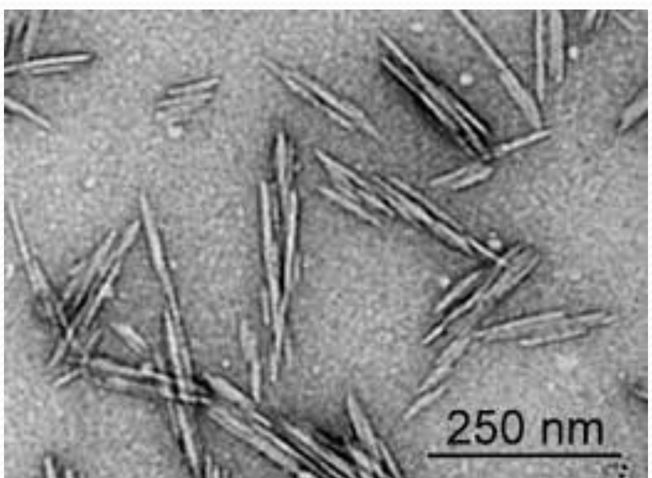
Coating tooth surfaces with antibacterial nanocoating was found to be effective in killing bacteria as well as inhibiting bacterial adhesion and maintaining its integrity in the presence of biological fluids (saliva).The antibacterial action of these nanoparticles was shown to be size dependent.

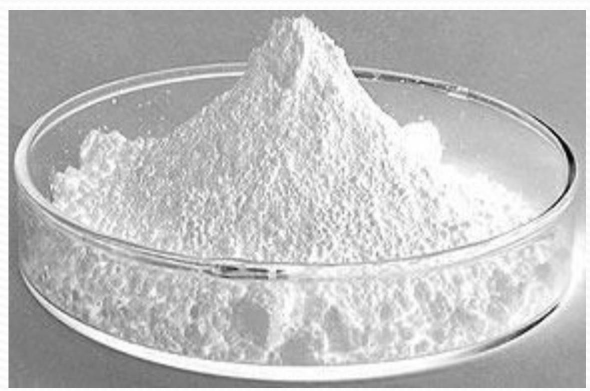
Biomimetic remineralization

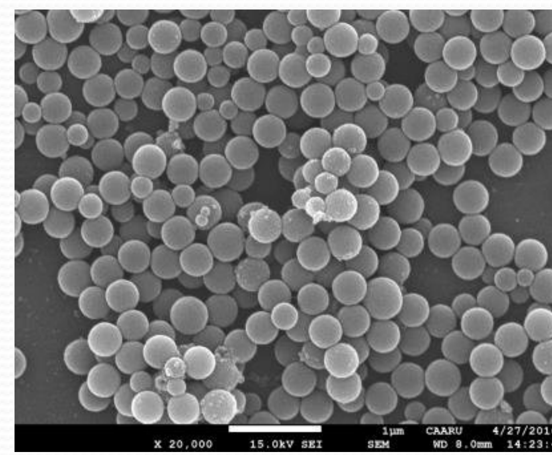
Different forms of nanocalcium phosphates were used as Ca^{2+} - and PO_4^{3-} -releasing fillers, eg, dicalcium phosphate anhydrous, tetracalcium phosphate, monocalcium phosphate monohydrate, and carbonate hydroxyapatite.

The release of Ca and PO_4 is dependent on degradability and volume fraction of CaP form.

Regardless of Ca and PO_4 release, these nanocomposites could be still used for high-stress bearing applications since these nanoparticles are used in combination with other fillers, eg, whiskers fused with nanosized silica. The Ca^{2+} and PO_4^{3-} can also be released on demand







WHISKERS

NANO SILICA

Dental Implants

With the development of nanodentistry, the implant surface was modified mimicking nature
.

Implant surface which imitates bone-like structures, properties and compositions at nanoscale level was made.

Proper modification of the surface from macro to nanoscale may improve the process of implant healing.

Implant with bioactive coatings with **micro hydroxyapatite (HAp) or micro β-tricalcium phosphate (β-TCP) surfaces appeared clinically undesirable**.

The poor attachment of particles to the implant surface, which in turn resulted in their mechanical peel off due to shear forces, initiates an inflammatory response and in consequence removal of the implant.

The **problem with conventional ceramics was replaced with nano counterparts with gradient micro nanosurfaces on the implant, which can guide tissue regeneration**.

Nanostructured ceramics increase contact with surrounding tissues, comparing to their bulk forms, and do not cause any inflammatory response

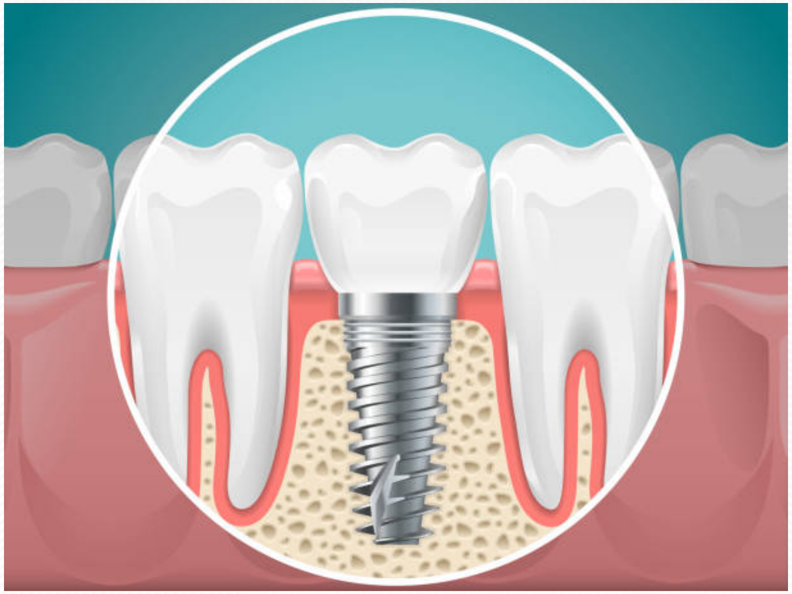
Nanoparticles used in dentistry can be classified mainly into three classes

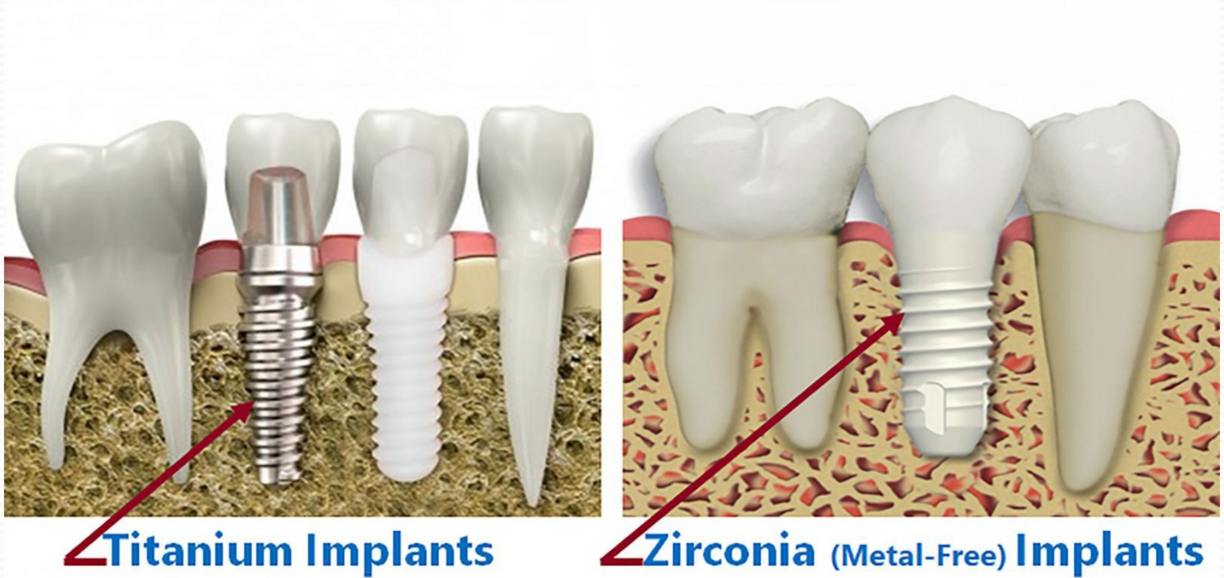
(1)*Polymeric nanomaterial*: chitosan, dendrimers, nanogels, polyethylene glycol and solid lipids

(2)*Metallic nanoparticles*: silver, gold and copper

(3)*Inorganic nanoparticles*: silica, zirconia, titanium dioxide, hydroxyapatite, zinc oxide and carbon nanotubes.

Nanocoatings on endosseous implants such as nanocrystalline diamond, carbon nanotubes, bioactive glass, poly (lactide-co-glycolide), hydroxyapatite nanocomposite or zinc-substituted n-HAp are the biomaterials of the future implant





ZIRCONIA dental implants

Hydroxyapatite NPs

This is the main composition of mineralized tissues of the human body ($Ca_{10}(PO_4)_6 \cdot 2(OH)$). It is a natural calcium phosphate ceramic, predominant in 97% enamel.

Teeth are acellular in nature, thus it cannot be logically repaired like a bone. Thus regenerating the enamel surface is a significant challenge.

The nano sized HAp particles can easily integrate into the dental tubules.

HAp helps to reduce dental hypersensitivity.

HAp NPs can bind strongly with proteins as well as with bacterial and plaque fragments.

Their high biological activity and reactivity enable them to bind to the dentin apatite and tooth enamel.

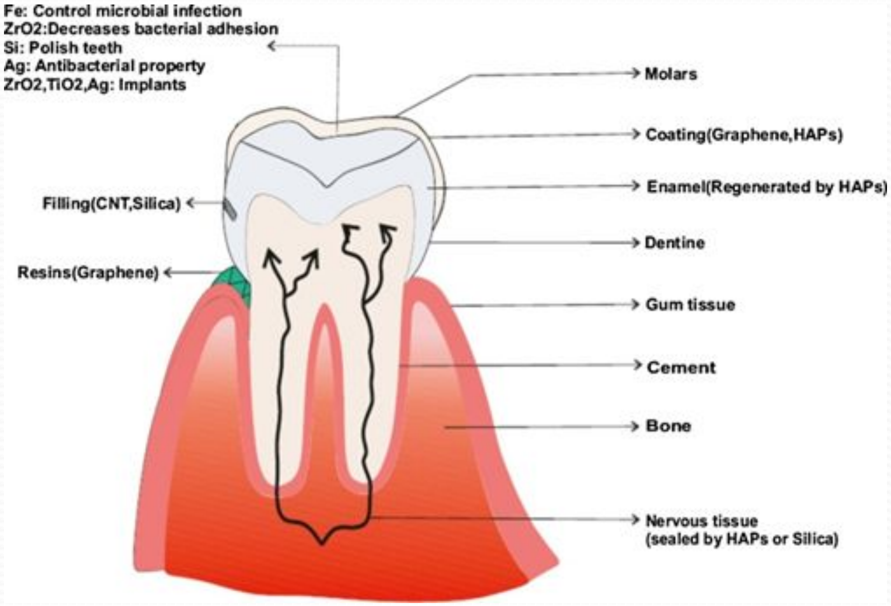
Hydroxyl apatite nanoparticles can fit well with the very small cavities present in the enamel originated by acidic erosion.

The HAp NPs are adsorbed robustly to the enamel of the teeth and thus retard auxiliary erosive demineralization.

Various toothpaste, mouth-rinsing solutions integrate these nanocrystals to repair the enamel surfaces.

The biomimetic function of hydroxyapatite is to protect the teeth by **making a film of artificial enamel around the tooth.**

The granular hydroxyapatite is employed in dental clinical rehearsal to reform periodontal shortcomings.



Zirconia NPs

The use Zirconia (Zirconium dioxide, ZrO_2) has considerable significance in dental science.

It has similar metallic properties and color like tooth. Zirconia is a chemical oxide which is insoluble in water. Thus, it reduces the bacterial adhesion and has low cytotoxicity.

Zirconia implants encompass glorious resistance against corrosion and carry, as well as sensible biocompatibility.

Moreover, high fracture resistance can be acquired by ZrO_2 because of energy retention property throughout the conversion of polygonally shaped molecules into monoclinic ones.

Zirconia NPs is a bio inert material, the encapsulation by animal tissue is weak and also the unleash of remains virtually unnoticeable.

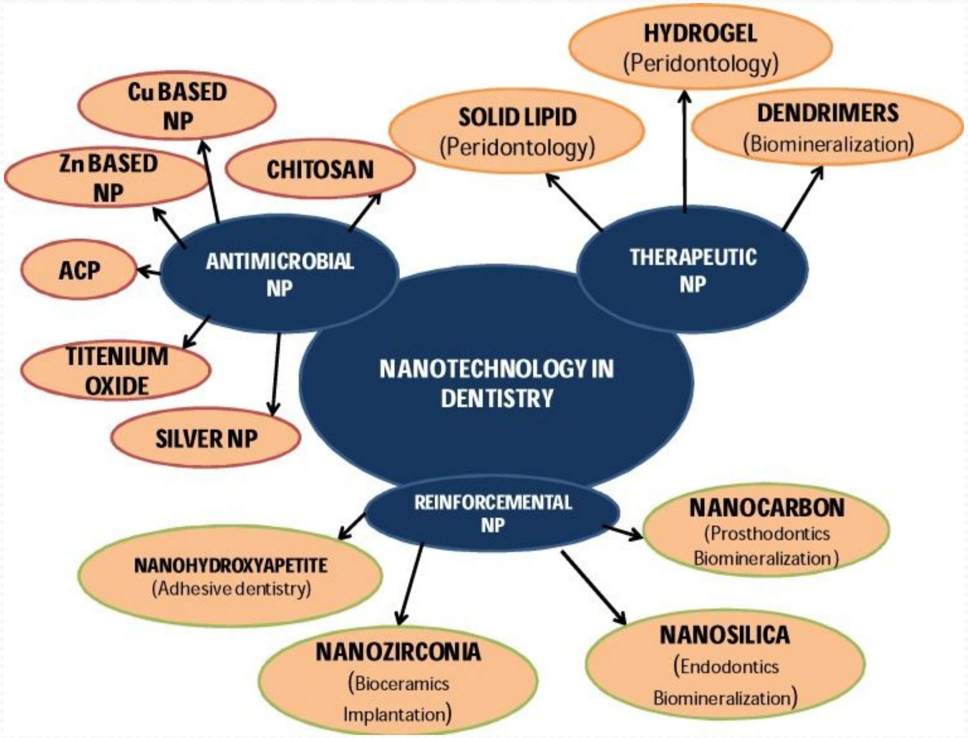
Additionally, Zirconia is osseo conductive, thereby it facilitates bone formation.

Nano zirconia-alumina materials combine the physical and chemical properties of ceramic material.

In these NPs, low percentage of tetragonal ZrO2 particles is in an aluminum oxide matrix. Thus, the toughness and longevity which are the principal interest in the dentistry are retained.

Alumina/zirconia nano composites are new implant materials which show better efficacy as compared to the ceramic materials.

Zirconia oxide nanoparticles are found to have anti-biofilm activity against certain bacteria and therefore they can be effectively used as a polishing agent in dental practices.



Silica

In the field of dentistry silica NPs used as dental filler. various dental filler products developed to improve their mechanical properties.

Tooth polishing is a conventional practice, which uses silica particles. Silica particles are used in polishing for their biocompatibility and low cost

Polishing of teeth surfaces is often done to protect the enamel surfaces.

Thus, polishing prevents dental caries, which acts as a primary defense mechanism against the cariogenic bacteria.

Modified silica nanoparticles are used to treat dental hypersensitivity. Enamel loss exposes dentinal tubules, thereby increasing the risk of dental hypersensitivity.

Over the years, a number of desensitizing agents are commercially available that aim at occluding dentinal tubules.

Unfortunately, the products can penetrate only up to a small depth into the dentinal tubules which may not combat the daily adverse conditions.

mesoporous silicas have been widely researched over the past two decades.

Silver NPs

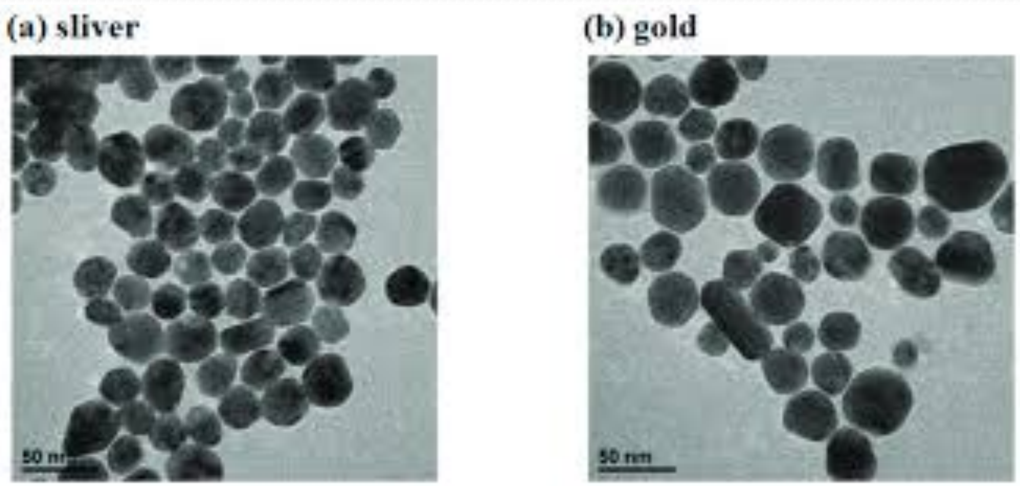
AgNPs have also been studied for use in several areas of dentistry which includes endodontics, dental restorative material, dental prosthetics, dental implants.

Incorporation of AgNPs decreases microbial colonization over dental parts and increases oral health.

As the nanoparticles possess small size having the larger surface area, they show the antimicrobial effect at very low level.

Because of its minute size, AgNPs can able to penetrate easily the bacterial cell membrane resulting in rapid bactericidal activity.

Silver can interfere with DNA and proteins by interacting with —SH groups, and also alters the base pairing, DNA unwinding, cell wall synthesis and respiratory processes, resulting in bacterial death


(a) sliver
(b) gold
50 nm

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