

# Futurodentics-An Introduction

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## ABSTRACT

“The best way to predict future is to create it”. Anonymous

In recent years, there has been an unprecedented growth in research in the field of “Nanotechnology”. The impact of such exciting technology has influence each and every branch of science and dentistry is not an exception.

Nanofillers used in dental composites give superior nanomechanical & optical properties & reduction in polymerization shrinkage.

To understand the nature’s biology is the key in understanding and developing biologically similar material for tooth tissues replacement.

Molecular biomimetics developed a novel nanotechnology through biology, which fabricate materials based on molecular recognition between genetically engineered peptides for inorganics (GEPs) and inorganic crystal which will replace dental hard tissues.

Advancement in dental nanotechnology & nanorobotics, biomimetics shall make the utopian dental dream treatment modalities like biological replacement of tooth, renaturalisation, single visit orthodontic treatment, oral health maintenance by dentifrobots etc described by **Robert A.Freitas** into reality. But the study related to dentistry is scanty.

Therefore author is motivated to coin the term “**Futurodentics**” to describe a branch of dentistry which deals with feasible, possible & predictable future application of current scientific knowledge & research findings to be used for maintenance of comprehensive oral health care.

The main aim of this paper is to conglomerate fields like nanotechnology, nanorobotics, and biomimetics etc.with dentistry & introduce it as **Futurodentics**.

**Key words:** Dental nanotechnology”, “Dental nanorobotics”, “Biomimetics”, “Nanocomposites”

## INTRODUCTION

The concepts of today’s scientific developments were seeded well ahead by scientists, researchers and thinkers of the past.

In recent years, there has been an unprecedented growth in research in the field of “Nanotechnology”.The impact of such exciting technology has influences each and every branch of science and dentistry is not an exception.

**Leonardo da Vinci** could foresee the present helicopter more than five hundred years back which was reflected in his drawings of “Ornithopter”[1].

In 1914, the first seed of “Nanotechnology” was planted by **R.Zsigmondy** by measuring the size of “nanoparticles” [2].

The visionary author **H.G.Wells** emphasized the need for establishment of “Department and Professors of Foresight” in his interview broadcasted by B.B.C. in 1932 [3].

In mid 1940s German professor **Ossip K.Flechtheim** coined the term“**Futurology**” to describe a new branch of knowledge dealing with new science of probability [4].

Noble prize winning physicist **Richard P.Feynman** could foresee the use of nanomachine, nanorobots and nanodevices in1959 [5].

Based on current advances,**Robert A.Freitas** has already foreseen the dentistry of 2030A.D.He envisaged some of the future treatment modalities like biological replacement of whole tooth, renaturalisation, single visit orthodontic treatment, oral health maintenance by dentifrobots, permanent hypersensitivity cure etc[6].

To make the current unprecedented research in the field of nanotechnology, nanorobotics, biomaterials, biomimetics and tissue engineering refocused towards dentistry, it is essential to conglomerate these fields and create a new exciting branch of dentistry. Therefore, author is motivated to coin the term “**Futurodentics**” to describe a branch of dentistry which deals with feasible, possible & predictable future application of current scientific knowledge & research findings to be used for maintenance of comprehensive oral health care.

The author reviewed Wikipedia; MEDLINE for available literature on “Dental nanotechnology”, “Dental nanorobotics”, “Biomimetics”, “Nanocomposites”.The review was not systematic review of literature. In vitro studies as well as comments, reports published in English are included.

The term “Nanotechnology” was first used by Norio Tanguchi [7] in 1974 and later explored and popularized by Dr K.Eric Drexler[8].

There are two main approaches in nanotechnology which is applicable to dentistry also [9].Bottom up, where materials and devices are built from molecular components which assemble themselves chemically by principles of molecular recognition and top down where nano-objects

are constructed from larger entities without atomic level control.

Most of the bottom up approaches related to dentistry does not exist at present. But it is described by **Robert A.Freitas** as future applications.

The technology of creating machines or robots at or close to microscopic scale of a nanometer is known as Nanorobotics. Nanorobots would be ranging in size from 0.1 – 10nm. It is still a hypothetical concept. Future medical and dental nanotechnology has been posited to employ nanorobot injected/dispersed into the patient to perform treatment on a cellular level [10].

Top down approach includes manufacture of nanoparticles (used as nanofillers in composites & siloxane impression materials); nanosolution used as bonding agents, materials used as protective barriers, wound dressing materials etc [11].

## DENTAL NANO & BIO MATERIALS

Development of composite resin has been one of the most significant contributions to dentistry. For manufacturing nanofiller for dental composite, the approach of nanotechnology should be shifted from top-down to bottom up. The resultant composite with nanofiller has superior hardness, flexural strength, modulus of elasticity, handling properties & translucency [12].

Inorganic organic hybrid materials can be created by means of sol-gel processing of hydrolytically condensable, organically modifies trialkoxysilanes, which can diminish the polymerization shrinkages & improve their wear resistance, optical properties, biocompatibility, increase modular of elasticity. [13]

## BONE REPLACEMENT NANOCOMPOSITE

Bio-polymer based nanocomposites have been replacing synthetic polymer composites with superior nanomechanical, thermal, biocompatibility & have potential application in bone tissue engineering [14].

Dr. John Ricci of NYUCD had developed resorbs more slowly as it is combined with small amount of polymer that traditional  $\text{CaSO}_4$  compound which is resorbed fully within 6-7 weeks. It is resorbed after 16 weeks with significant amount of new bone formation. (Bone Gen – TR™) [15]

In recent years, polymer / hydroxyapatite (HA) nanocomposites have emerged as a new class of biomaterials that can be used as artificial bone. Compared to pure HA or HA based bioceramics & metallic implant, they exhibit good plasticity, improved toughness and good mechanical compatibility with natural bone. [16]

Chitosan, a natural biopolymer originally comes from Chitin from crustacean shells. It is similar with inorganic salt, such as calcium phosphate. Calcium phosphate and Chitosan gel obtained by acetic acid & ascorbic acid treatment are self hardening cement at room

temperature. Their hardness is comparable to spongy bone & above PMMA. It has promising applications in endodontics & restorative dentistry. [17]

In vinylpolysiloxanes nanofillers are integrated to have better flow, improved hydrophilic properties and enhanced precision details.

Nanosolutions are unique and dispensable nanoparticles used in bonding agents which ensures homogeneity & ensures that adhesive is perfectly mixed everytime.

Other dental nano products include- productive clothing & filtration masks using antipathogenic nanoemulsion & nanoparticles, medical appendages for instantaneous healing include biodegradable nanofiber-delivery system, nanocrystalline silver particles for wound dressing.

Scientists at the Research Institute for Cell Engineering at Japan's National Institute of Advanced Industrial Science and Technology (AIST) and Tokyo University of Agriculture and Technology have used nanoneedles attached to an atomic force microscope (AFM) to penetrate the nucleus of living cells [18].

## BIONICS/BIOMIMETICS AND DENTOMIMETICS

Bionics is the application of biological methods & system found in nature to the study & design of engineering & modern technology. The word “Bionic” was coined by Jack E. Steele in 1958 meaning life like. [19]

The term “Biomimetics” was coined by Otto Schmitt in 1950 which means imitating life [20].

The author prefers to use the term “Dentomimetics” to denote the methods of imitating/replacing/creating/regenerating the dental tissues.

Merging of biomimetics & regenerative medicine is termed as “Tissue bionics” [21]

## BIONIC DENTAL PULP

After completion of cleaning & shaping the tooth with pulpitis & periapical disease, it is hypothesized that bionic dental pulp can be filled into the root canals to provide nutrition for teeth like healthy pulp. It will consist of mesenchymal stem cell, platelet rich plasma (in vitro can be made on the core & some biotic absorbable material can be used to wrap the core with nano technology), the frame of extracellular matrix (Collagen) [22]

Biopolymer based novel nanocomposite Chitosan / Mantmorillonite (MMT) / Hydroxyapatite (HAP) was developed with improved mechanical properties, biocompatibility & better cell proliferation can be compared to Chi / HAP composite. It has potential application in bone tissue engineering. [23]

To date restoration repair & replacement of decayed, damaged, missing & lost teeth used metal & plastics and non biological materials. This type of dentistry is referred as “Xenodontics” [24]. Today's focus is on the

use of biologically derived replacement for the same which is called “Biodontics”.

Molecular biomimetics: Biomolecular material interactions accomplished via molecular specificity leads to the formation of controlled structures & functions at all scalar of dimensional hierarchy. Using biology as guide, we can now understand, engineer & control peptide material interaction & exploit these to a variety of practical material system [25].

Recently molecular biomimetics developed a novel nanotechnology through biology, which fabricate materials based on molecular recognition between genetically engineered peptides for inorganics (GEPs) & inorganic crystals. It can be used in the assembly of functional nano structures & analogue of dental hard tissues. [26]

Physicist **Pupa Gilbert** [27] described how the lowly sea urchin transforms calcium carbonate into calcite. “This is nature’s bottom- up nanofabrication.” The sea urchin spicule is a biomineral, composite of organic material and mineral components that the animal synthesizes from scratch. The structure is similar to mollusk shells, zebra fish bone & tooth enamel. This observation may permit researcher to develop new crystal structure based on nanotechnology.

## **REGENERATIVE MEDICINE & DENTAL TISSUE ENGINEERING**

It is an emerging multidisciplinary field to look for the reparation, improvement, and maintenance of cells, tissues, and organs by applying cell therapy and tissue engineering methods. With the help of nanotechnology it is possible to interact with cell components, to manipulate the cell proliferation and differentiation, and the production and organization of extra cellular matrices[28].

Biomaterial science is in the midst of largest transition in its history in term of refocusing and embracing new and exciting technology. There is a shift in biomaterial from the materials engineering side (Materials) toward the biological engineering side [29]. The biological material fabrication is purely based upon tissue engineering, nanoengineering and self assembling system. It may be possible to demonstrate the production of biologically new tooth using stem cell pathways but its routine clinical application is still long way. True biological biomaterials are ones that lead to natural tissue restoration. These can be sub grouped into: tissue engineered System, biological & non biologic self assembling system & nanotechnique & technologies.

Nakashiwa and Reddi had summarized the opportunities for tissue engineering to develop, scaffolds, cells and signals to create substitute or replacement of dental tissues in future [30] Potential application include, fracture replacement, alveolar ridge augmentation, TMJ reconstruction, dentine and periodontal ligament replacement, proosseointegration of dental plants[30].

Any biocompatible substance once it is introduced into living tissues is regarded as extracellular matrix (ECM) by cells there. The term “Biomaterial” is better referred to as “Artificial ECM” [31]. Any regenerative treatment requires three key elements: an extra cellular matrix scaffold (which can be synthetic, Progenitor / Stem Cells and inductive morphogenetic signals.

Ease of access and observation is being the special advantage of oral cavity over other parts for tissue engineering. Successful bioengineering has demonstrated that mature tooth stands from single cell suspension of four day post natal cultured rat tooth bud cells on polyactic acid scaffolds grown as implants in omenta of adult rat hosts over twelve weeks. [32]

The transplantation of dental pulp stem cells may be used some day to repair bone or regenerate teeth using patient’s own stem cells to avoid issues from of histocompatibility.

Self assembling Systems can be biological (tissues, cells etc) or nonbiological owns (e.g. Crystals). The domain can be at nano, micro milli and macro scales. It can be made from metals, ceramics, polymers or complex construction of several materials. At the moment the most intriguing system are nanoscale objects involved organic or composite or ceramic constructions. Production of assemblies occurs in orchestrated stages of initiation, propagation and termination. Control system for initiation and or propagation may be templates (template polymerization of proteins) or they might depend simply on natural rules corresponds to energetically favorable, physical, chemical mechanical and or biological events e.g. (nucleation of crystallization etc.)[33].

Presently Tissue engineering relies heavily on system outside the body to create scaffolds, provide cells, and create signaling system. It is conceivable that the same event, could be managed on a nanoscale within the body and with the proper self-assembling nanoscaffolds, this process could be highly targeted.

Research tools for new biomaterials have been changed due to nanotechniques or technology. Dr. Sally Marshall et al [34] investigated dentine with nanoscopic tools. They used X-ray Scanning tomography (XTM) to profile in three dimensional microarchitechture of 1 x 1 x 1 1µm cube of normal and carious dentine. They have built fully functioning Atomic Forced Microscopy (AFM) to explore properties of tooth structures in nanodomain [35].

## **FEW FUTURE CLINICAL APPLICATIONS**

Local anesthesia: Dental professionals will instill a colloidal suspension containing millions of active analgesic or anesthetic micron-sized dental nanorobot particles on the patient’s gingivae. After contacting the surface of the crown or mucosa, the ambulating nanorobots reach the dentin by migrating into the gingival sulcus and passing painlessly through the lamina propria or the 1.3-micron thick layer of loose tissue at the cementodentinal junction.

On reaching dentin, the nanorobots enter dentinal tubules and proceed toward the pulp. As it reaches pulp the dentist can take over the nerve traffic with the help of onboard nanocomputer controlled.

Dentifrobots (Mouth wash/dentifrices containing nanorobots) delivered by mouthwash or toothpaste could patrol all supragingival and subgingival surfaces at least once a day metabolizing trapped organic matter into harmless and odorless vapors and performing continuous calculus debridement.

By using native biological materials guided by dental nanorobots open dentinal tubules causing dentin hypersensitivity could selectively and precisely occlude specific tubules within minutes, offering patients a quick and permanent cure.

## CONCLUSION

Advancement in the field of nanotechnology, nanorobotics, and biomimetics is helping to foresee the future of dentistry. But the study related to dentistry is scanty & widely scattered.

It is convincing to conglomerate different emerging fields like nanotechnology, nanorobotics & biomimetics etc. with dentistry to introduce futurodentics to describe a branch of dentistry which deals with feasible, possible & predictable future application of current scientific knowledge & research findings to be used for maintenance of comprehensive oral health care.

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