

BIOTECHNOLOGY IN DENTISTRY

Yogesh Garg,¹ D.J. Bhaskar,² Chandan Agali R,³ Himanshu Punia,⁴ Vipul Gupta,⁵ Ankita Jain⁶

Post Graduate Student,¹ Professor & Head,² Reader,³ Reader,⁴ Senior Lecturer,⁵ Post Graduate Student⁶

1-6 Department of Public Health Dentistry, Teerthanker Mahaveer Dental College & Research Center, Moradabad.

Abstract

The molecular biology and its application in the study of cancer have significantly advanced the field of human cancer research. It is another change at this time with the help of nanotechnology combined with Nanomaterials, Biotechnology and Nanorobotics. Probiotics are dietary supplements which contain beneficial bacteria or yeasts. Tissue engineering is a novel and exciting field that aims to re-create functional, healthy tissues and organs in order to replace diseased, dying, or dead tissues. Biomimetics is the study of natural structural processes to try to mimic or replicate it artificially in an attempt to restore the same aesthetics or function. Osseointegration is probably the most studied and most investigated area in implantology.

Key Words: Molecular Biology, Nanodentistry, Nanomaterials, Probiotics, Osseointegration.

Introduction

Biomedical science and technology are lead of the medical and dental research in the field. Biomedical science and technologies refers to the application of biologic knowledge and techniques to enhance human health. Evaluation of the genome (genomics), the messenger RNA transcribed from active genes (transcriptomics), the proteins coded for by this mRNA (proteomics) and the metabolites which are the end products of gene expression (metabolomics) all utilize techniques which outcome in great amounts of data.¹

In the general population, oral cancer is the sixth most usual cancer for both gender and the third most usual cancer in developing nations. In India, due to this disease, cancer popularity is determined to be around 2.5 million, with over 8,00,000 new cases and 5,50,000 deaths obtaining each year.²

"The word nano is obtained from Greek word "dwarf". Nanomaterials are the substances with constituent less than 100 nm in at least one dimension, including clusters of atoms, grains less than 100 nm in size, fibres less than 100 nm diameter, films less than 100 nm in thickness, nanoholes and composites that are integration of these.³

The term probiotic, meaning "for life" is obtained from the Greek language. Probiotics was first used by Lilly and Stillwell in 1965. The term prebiotic was initiated by Gibson and Roberfroid. They defined prebiotics as a "non-digestible" food ingredient that beneficially affects the host by selectively stimulating the growth and/or activity of one or a limited number of bacteria in the colon.⁸

Computer-aided design (CAD) and computer-aided manufacturing (CAM) technology systems use computers to accumulate information, design, and manufacture an extensive range of products.¹⁴

A biofilm is an efficient, collaborating community of organisms. Biofilm appear such as formation of conditioning layer, bacterial adhesion, bacterial growth and biofilm expansion.¹⁵

The field of tissue engineering has advanced over the previous decade to re-create functional, healthy tissues and organs in order to replace diseased, dying, or dead tissues. Current procedure used for treatment of lost tissues which

involve the utilization of autogenous grafts, allografts, and synthetic materials (alloplasts).¹⁶

The research on bioactive material and molecules are area of growth of novel bioactive material and molecules which have extensive application in dentistry and biomedical field. There are various types of bioactive materials like osteogenic, osteoconductive, osteoinductive. Biomaterials are native or synthetic polymers that achieve extensive importance in root canal therapy, tooth repair, pulp therapy and dental surgery in the field of dentistry and drug delivery.¹⁷

Mastication is a necessary part of the digestive process. The capability of the masticatory organ to grind and process food is directly associated with the individual purpose and general state of health.¹⁸

Dental plaque is an adherent deposit of bacteria and their products, which forms as a white greenish or even yellow film on all tooth surfaces. Due to many epidemiological, experimental and animal studies that Mutans streptococci (*Streptococcus mutans* and *Streptococcus sobrinus*) are the most major bacteria in the pathogenesis of dental caries.¹⁹

Biomimetics is defined as the study of the formation, structure, or function of biologically produced substances and materials and biological mechanisms and processes especially for the purpose of synthesizing similar products by artificial mechanisms which mimic natural ones.²¹

Nano-biotechnology is examined to be special fusion of biotechnology and nanotechnology by which classical micro-technology can be integrated to a molecular biological approach in real.²²

Collins in 1954 and Southam and Selwyn in 1970, opposed and refused the idea of bone to implant contact without formation of a fibrous layer, since there had been an opinion of development of fibrous layer around implant, reduce integrity with bone. Prof. Per-Ingvar Brånemark and his colleagues in 1950s and 1960s, while considering microcirculation of bone and wound healing that means of vital microscopy accidentally found the process of Osseointegration.²⁴

History

In 1959, the late Nobel Prize winning physicist Richard P. Feynman introduced a talk entitled ". Feynman suggested that using machine tools to make smaller machine tools, which, in turn, would be used to make still smaller machine tools, and so on all the way down to the molecular level. He proposed that such nanomachines, nanorobots and nanodevices could be used to spread an extensive range of atomically precise microscopic instrumentation and manufacturing tools.³

Elie Metchnikoff was first researcher to suggest that fermented dairy products have beneficial properties. In 1907 the Ukrainian-born biologist and Nobel laureate, working at the Pasteur Institute in Paris, discovered *Lactobacillus bulgaricus*. He developed a theory that lactic acid bacteria (present in Bulgarian yoghurt) in the gastrointestinal tract could be preventing putrefaction and sustain life.¹¹

The term "probiotics" was first initiated in 1965 by Lilly and Stillwell. In 1984 Hull recognized the first probiotic species, the *Lactobacillus acidophilus*. In 1991 Holcomb found *Bifidobacterium bifidum*.¹⁵

The loosening of implants from bone tissues occur that there has been difficulty in reconstructive surgery and joint replacement. The layer of fibrous tissue spread around the implant that reduces the integrity and mechanical stability of the implant/bone interface. Brånemark introduced the term "osseointegration" to describe this modality for stable fixation of titanium to bone tissue.²³

Major Advances in Biomedical Science and Technologies

A timeline of significant achievements in biotechnology:

- 1990** Human Genome Project commenced
- 1995** First complete genome sequence *Haemophilus influenzae*. First use of microarray for gene expression profiling
- 1996** Affymetrix produced the first commercial gene chip. BRC Analysis diagnostic test for breast cancer predisposition to detect *BRCA1* and *BRCA2*
- 1997** Dolly – first cloned mammal (from DNA of adult sheep). Polly–cloned using nuclear transfer technology (sheep DNA with some human genes). IL-1 polymorphism associated with periodontal disease
- 1998** Embryonic stem cells first grown
- 2001** Draft human genome sequence published
- 2002** Genomes of 125 organisms sequenced
- 2003** Human Genome Project completed
- 2007** salivary proteome completed
- Use of Affymetrix chips to detect susceptibility to periodontal disease
- 2017?** Replace missing tooth with cloned tooth¹

Molecular Basis and Biology of Human Oral Cancer

Carcinogenesis is a complex, multi-step process in which genetic events within signal transduction pathways

governing normal cellular physiology are quantitatively or qualitatively altered. There are two mechanisms by which proto-oncogenes can be converted to cellular oncogenes:

Quantitative: Tumour formation influenced by increase in the absolute number of proto-oncogene products or by its production in inappropriate cell types.

Qualitative: Conversion from proto-oncogene to transforming gene involves changes in the nucleotide sequence and obtained of the new properties.²

Nano Tissue Engineering

By utilizing cellular and mineral components occur when we will be able to generate whole new tooth with the principles of genetic engineering, tissue engineering and tissue regeneration at nanoscale. Chen et al by using nanorods like calcium hydroxyapatite crystals which were aligned roughly parallel to each other, were able to create hardest tissue in human body, i.e., dental enamel and pretend the natural bio mineralization process.³

Nanomaterials

Siegel has arranged nanomaterials as zero dimensional, one dimensional, two dimensional and three dimensional nanostructures. Various nanostructures involve: Nanoparticles, Nanopores, Nanotubes, Nanorods, Nanospheres, Nanofibres, Nanoshells, Dendrimers & dendritic copolymers.

Nanodentistry and Its Applications

Nanodentistry will make possible the continuity of comprehensive oral health by utilizing nanomaterials, biotechnology, including tissue engineering, and ultimately, dental nanorobotics. Nanodentistry involves:

- Nanorobotics
- Nanodiagnostics
- Nanomaterials

NANOROBOTICS

Local Anaesthesia

In dental practice, it is the most common method, to make oral anesthesia in which dental professionals will generate a colloidal suspension containing millions of active analgesic micron-sized dental nanorobot 'particles' on the patient's gingivae.

Hypersensitivity Cure

Dentin hypersensitivity may be induced by changes in pressure transmitted hydrodynamically to the pulp teeth.

Dental Biomimetics

The most exciting venue for opinion on the nanorestoration of tooth structures is that of nanotechnology resemble processes that occur in nature (biomimetics), such as the formation of dental enamel.

Dental Durability and Cosmetics

Artificial materials such as sapphire or diamond are used to raise the durability and appearance of tooth which have 20 to 100 times the hardness and failure strength of natural enamel or contemporary ceramic veneers, as well as good biocompatibility.

Renaturalization Procedures

Through esthetic dentistry, the dentition renaturalization approach may become a popular addition to the future dental practice. This can be mostly used in patients who determine old dental amalgams excavated and their teeth remanufactured with native biological materials.

NANODIAGNOSTICS

Nanoscale Cantilevers

These are flexible beams similar a row of diving boards that can be arranged to bind to molecules related with cancer.

Nanopores

These are minute holes that enable DNA to pass through one strand at a time. They will make DNA sequencing better organized.

Nanotubes

These are carbon rods that half the diameter of a molecule of DNA and not only can identify the manifestation of altered genes but may also help researchers the exact location of those changes.

Quantum Dots

These are nanomaterials that glow very brightly when enhanced by ultraviolet light. Quantum dots are attaching themselves to proteins special to cancer cells and show tumours to light.

Nano Electromechanical Systems (NEMS)

Nanotechnology based NEMS biosensors that demonstrate perfect sensitivity and specificity for analyte detection and down to single molecule level are being developed.

NANOMATERIALS IN DENTISTRY

Nanocomposites

Non agglomerated distinct nanoparticles are homogeneously spread in resins or coatings to produce nanocomposites. The nanofiller involve an aluminosilicate powder having a mean particle size of 80 nm and a 1:4 M ratio of alumina to silica and a refractive index of 1.508.

Nanosolution

Nanosolutions produce individual and dispersible nanoparticles, which can be added to various solvents, paints & polymers in which they are dispersed homogeneously.

Nano-optimised Mouldable Ceramics

- Nanofillers

- Nanopigments
- Nanomodifiers

Nanoneedles

Suture needles integrating nano-sized stainless steel crystals have been developed.

Implants

Nanotechnologies are used for surface variation of dental implants as surfaces properties such as chemistry and roughness play a determinant role in attaining and sustaining their long-term stability in bone tissue.⁴

Nanomedicine

It is the science and technology of diagnosing, treating and preventing disease and traumatic injury, of relieving pain, and improving human health, using nanoscale structured materials, biotechnology and genetic engineering and ultimately complex machine systems and nanorobots.⁷

Tiny machines, known as nano assemblers, could be managed by computer through dentists to perform specialized jobs. Nanocomputers would suppose the major task of activation, controlling and deactivating such nano-mechanical devices.⁵

Future prospects of nanobiotechnology

It could show indication of a choice of various new materials and devices that is useful in the field of medicine, electronics, biomaterials and energy production. It may show to alter by playing a major role in various biomedical applications ranging from drug delivery and gene therapy to molecular imaging, biomarkers and biosensors.²²

Ozone therapy

Studies have shown that 99% of all the bacteria causing tooth decay have been obliterated after 10 s of ozone exposure and even 99.9% bacteria after 20 s exposure. Ozone can now be organized in several treatments like bleaching of discoloured teeth, root canal treatment, desensitization and treatment of some soft tissue infections.⁶

Genomics

In 1990, the ambitious Human Genome Project (HGP) commenced. A draft of the human genome was published in 2001 and the project was completed in 2003, with 99% decoded. Mapping the genome was only the first step.

Proteomics

Proteomics is the study of the products of the 2% or less of the human genome which is transcribed - that is, protein coding. These proteins experience significant post-translational modification (proteolysis, glycosylation etc.) resulting in a number of different products from a single gene; 30000 human genes code for 400000 or more proteins.

Biomaterials

Biomaterials research is changing from testing of “synthetic biomaterials” to evolving and testing “biological biomaterials”. In this context, two research directions will decide future education and clinical procedures.

- (i) Characterization of the structure-property events within synthetic and biological restorative materials, and
- (ii) The interactions at their interfaces with oral tissues and vice versa.¹

Genetic damage in oral cancer cells can be divided into two categories:-

1. Dominant changes: Those occur in proto-oncogenes and certain tumour suppressor genes (TSGs) developing in gain of function.
2. Recessive changes- Those occur in growth inhibitory pathway genes or commonly in tumour suppressor genes causing loss of function.²

Biomimetics in Restorative Dentistry: The physiological performance of intact teeth is the result of intimate and balanced relationships between mechanical, biological, functional and esthetic parameters.

Biomimetics Endodontics: By application of tissue engineering, biomimetic approach to restore tooth structure is established on regenerative endodontic procedures.²¹

Prebiotics and Symbiotic

Prebiotics are dietary substances that take care of a selected group of microorganisms living in the gut.⁸

Mechanisms of Probiotic in Oral Cavity

- (a) Normalization of intestinal micro biota
- (b) Modulation of immune response
- (c) Metabolic effects

In oral cavity, probiotics act as a preventive lining for oral tissues against oral diseases by producing a biofilm. Such a biofilm keeps bacterial pathogens off oral tissues by lining a space pathogens would perfuse in the absence of the biofilm and engaging with cariogenic bacteria and periodontal pathogens growth.¹⁰

Role of probiotics in dental caries

Dental caries is a disease where bacterial process effect damage to the hard structure of tooth, characterized by acid demineralization of the tooth enamel. When changes occur in the micro flora in oral cavity resulting in an overgrowth of several bacteria involving *Streptococcus sorbinus*, *Streptococcus mutans* and *Porphyromonas gingivalis* which are identified as the primary cause of the dental caries.

Role of Probiotics in Halitosis

Halitosis is caused by a number of volatiles and most of its etiologic factors are present in the oropharynx (gingivitis, periodontitis, tongue coating and tonsillitis). *F. nucleatum*, *P. intermedia*, *P. gingivalis*, and *T. denticola* are produce

“Volatile Sulphur Compounds” (VSC"s) are responsible for halitosis.

Probiotics in infections and oral diseases

When a test group of older people consumed cheese containing *Propionibacterium freudenreichii*, *Shermanii*, *JS* and *L. rhamnosus* strains GG and LC705 for 16 weeks, the number of high oral yeast counts decreased but no changes were observed in mucosal lesions.⁸

Probiotic delivery

Probiotic bacteria are normal commensals of the intestines. Probiotics can be given in the form of lozenges, sucking tablets and chewing gums in replacement therapy.

Probiotics can be provided in food by four basic ways:

1. Beverages
2. Prebiotic fibers
3. Dietary supplements
4. Milk and milk products

RECENT TRENDS IN PROBIOTICS: PATHO-BIOTECHNOLOGY

Patho-biotechnology techniques are being used to manufacture new modified probiotics which is a major biological goal for probiotic which have raised stress profile tolerance and ability to overcome the physiochemical defence of the host. Lactic acid bacteria (LAB) have been altered to produce new varieties by traditional and genetic engineering methods.⁹

SAFETY ASPECTS OF PROBIOTICS

When probiotics are applied orally can communicate with a patient"s systemic health and at least a part of them will be ingested. When ingested orally, probiotics are generally safe and well allowed with bloating and flatulence occurring normally.¹²

FUTURE PERSPECTIVES

The following future applications of probiotics may be identified:

1. Genetic engineering of already identified probiotics.
2. Biotherapy using antibiotic-sensitive bacteria to displace resistant strains.
3. Microbiota removal
4. Passive immunization
5. Interference with signalling mechanisms involving Competence Stimulating Peptide (CSP) as the signalling molecule.¹³

Probiotics can be used as passive local immunization against dental caries. Primarily probiotic *Lactobacillus* and *Bifido-bacterium* strains have been used along with few more strains.²⁰

APPLICATIONS OF BIOACTIVE MATERIALS AND MOLECULES DENTISTRY

Root Canal Therapy

Portland cement or Mineral trioxide aggregate (MTA) is a bioactive material used for preserving pulp and periodontal

tissue vitality as part of pulp capping and perforation repair procedures.

Tooth Repair and Regeneration

Growth factors which can develop tooth healing and pulp regeneration by dentin extracellular matrix proteins (ECMPs). ECMPs can stimulate dental pulp stem cell proliferation, differentiation and migration to sites of injury.

Coating of Implants

When metals have good physical and mechanical properties such as low density and mechanical resistance then they can be used in dental and medical devices. Dental implants are made from titanium alloys and have a coating of hydroxyapatite to help in osteogenesis and bone healing.²²

Conclusion

Currently, molecular biosciences and technologies are appearing fields in dentistry. Nanodentistry still faces many important challenges in recognizing its enormous potential. Probiotics play a major role in preventing issues with overuse of antibiotics and antimicrobial resistance. CAD/CAM systems have raised dentistry by providing high-quality restorations. Genetic engineering, nanotechnology and ozone therapy will change dentistry, healthcare, and human life more extremely than other developments of the past. Osseointegration is a very complex method then there are many micro and macro molecular aspects of bone-implant interface that need to be understood and illuminated.

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Corresponding Address:

Dr. D.J. Bhaskar
Professor & Head
Department of Public Health Dentistry
Teerthanker Mahaveer Dental College & Research
Centre, Moradabad, Uttar Pradesh