Title of the chapter: **SCIENTIFIC BASIS OF DENTISTRY**

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**Abstract:** Technological and scientific innovations have increased exponentially over the past years in the dentistry profession. In this article, these developments are evaluated both in terms of clinical practice and their place in the educational program. The effect of the biologic and digital revolutions on dental education and daily clinical practice are also reviewed. Biomimetics, personalized dental medicine regenerative dentistry, nanotechnology, high-end simulations providing virtual reality, genomic information, and stem cell studies will gain more importance in the coming years, moving dentistry to a different dimension.

**Keywords:** Science, technology, clinical practice, dental education, biomimetics

**INTRODUCTION**

Dentistry is one of the oldest of medical professions, traceable back to Egyptian times in approximately 2600 BC (American Dental Education Association c2015–2019). Archaeologists have unearthed dental fillings in teeth dating back to ~8000 BC, and references to dental decay can be found in Sumerian texts from 5000 BC (Delta Dental of Michigan). Study of tooth decay has continued since the 1700s until today (ADEA c2015–2019). Although Hippocrates and Aristotle, perhaps the earliest “evidence-based” dental clinicians, wrote about decaying teeth in the 4th century BC, the first book entirely devoted to dentistry—The Little Medicinal Book for All Kinds of Diseases and Infirmities of the Teeth—was not published until 1530 (ADEA c2015–2019). Dentistry as a profession became established in the early 1700s, when the French surgeon Pierre Fauchard published his book titled The Surgeon Dentist, a Treatise on Teeth, introducing key ideas such as the importance of dental hygiene, the proposed use of dental fillings and dental prostheses, and the fact that sugar contributed to tooth decay (Adolfo Patiño 1985). The first dental college, the Baltimore College of Dental Surgery, opened in 1840, nearly 20 y after the American Dental Association (ADA) was formed, and the first university affiliated dental school was founded, the Harvard University Dental School in 1867 (ADEA c2015–2019). Soldiers became the driving force of dentistry following World War II when it became evident that significant improvements needed to be made to dental and oral hygiene, as well as to methods used to repair teeth, to maintain a reliable, functional, and healthy army. This realization spearheaded the establishment of the National Institutes of Health (NIH) in 1931 and the National Institute of Dental Research (NIDR) in 1948, later renamed the National Institute for Dental and Craniofacial Research (NIDCR) in 1988 (Sheridan 1988). Since then, efforts to create new and improved methods for tooth replacement therapies have been pursued.

**HISTORICAL DENTISTRY**

Some dental studies were written before the beginning of the modern Gregorian calender, or before Christ (BC). Hesy-Re, an Egyptian scribe, is accepted as being the first “dentist” (2600 BC). An Egyptian text, the Ebers Papyrus dated 1700-1550 BC, shows teeth and toothache. Between 500 BC and 300 BC, Hippocrates and Aristotle wrote about teeth, eruption, decay, and gum disease. Dentistry was first accepted as a profession in the middle ages. Barbers had undertaken this task before dentistry became a profession. A Guild of Barbers was established in France in 1210, and barber-surgeons performed routine hygienic services including shaving, bleeding, and tooth extraction. In 1530, first dental book for barbers was published by Artzney Buchlein in Germany. It was written for barbers who treated the mouth and contained practical topics including tooth extraction, drilling, and teeth filling. Professional dentistry began to develop in the eighteenth century and there were many advances in dental science in the nineteenth century. The first dental journal, the American Journal of Dental Science, began publication in 1839. The world’s first dental school, the Baltimore College of Dental Surgery, was founded by Horace Hayden and Chapin Harris in 1840, and its graduates were given the “Doctor of Dental Surgery” (DDS) degree. The school joined to Maryland University in 1923. The first professional organization of dentists in the United States of America (USA), the American Dental Association, was formed by 26 dentists in 1859. Harvard University Dental School, the first university-affiliated dental institution, was founded in 1867. The school calls its degree the Dentariae Medicinae Doctorae (DMD). There is continuing controversy with respect to the DDS and DMD. Dr. Robert Tanner Freeman graduated from Harvard University Dental School in 1869 as the first African-American to earn a dental degree, and Ida Gray, the first African-American woman to earn a dental degree, graduated from University of Michigan School of Dentistry in 1890. The first female dental assistant was employed in a dental office in 1885, and the American Dental Assistants Association was founded in 1924 by Juliette Southard and her female colleagues. Although tubed tooth paste started to be manufactured in the 1880s, the widespread use of toothbrushing took place 10 years later. In 1890, Willoughby Miller, an American dentist in Germany, wrote a book entitled “Micro-Organisms of the Human Mouth” and explained the microbial basis of dental decay. From then, regular toothbrushing and flossing began. After the discovery X-rays by the German physicist Wilhelm Roentgen in 1895, New Orleans dentist C. Edmond Kellstook the first dental X-rays of a living person in the USA in 1896. In 1899, Edward Hartley Angle began the first orthodontic studies in dentistry. In twentieth century, many innovations in techniques and technology were achieved. The scientific and technological developments in clinical dentistry increased with turning of the twenty-first century. Developments related to dentistry in the new century are now closely related with medicine

**DENTISTRY AND RESEARCH**

Research in dentistry must be conducted according to the oral health needs of communities. This is ensured by biotechnological advances. As biomedical techniques evolve, the biomedical knowledge on vaccines, cloning, drugs, DNA, tissues, microorganisms, viruses, and complex proteins are rapidly increasing and contribute to improving human health. One of the most revolutionary techniques regarding nucleic acid analysis is the polymerase chain reaction (PCR), which is used to boost specific DNA fragments in order to detect particular proteins. Measurements can also be made quantitavely using real-time PCR. Gene expression analysis or microarrays can be used to estimate mRNA. PCR has become a standard diagnostic and research tool in dentistry. PCR is used in medicine to detect microorganisms and identify chromosomal disorders and hereditary diseases, for analysis of mutations in oncogenes and tumour suppressor genes, and in the detection and quantification of transcripts of tumour-associated translocations. The applications of PCR in dentistry include the detection of periodontal cariogenic pathogens, microorganisms in endodontic infections, viruses present in host cells, useful markers in the diagnosis and prognosis of some types of oral cancer, and the quantitative estimation of different microorganisms.

Many advances in oral bioscience stem from the “Human Genome Project,” which began in 1990 and was completed in 2003, and in 2007, when the salivary proteome was mapped. Along with the development of bioinformatics and in parallel with biotechnology, research about genomics (structure, function, evolution, and mapping of genomes), transcriptomics (the study of transcriptoms: the complete set of RNA molecules in one cell or a population of cells), proteomics (the study of proteomes: a set of proteins produced in an organism, system, or biological context), and metabolomics (the study of the set of metabolites present within an organism, cell, ortissue) have increased exponentially. Two important diseases that dentists encounter throughout their professional lives are periodontal disease and tooth decay. Bacterial, genetic, and environmental factors play a role in these complex diseases. Understanding these conditions at the molecular level using molecular techniques is necessary for their appropriate treatment. Some salivary tests have been developed to measure genetic susceptibility to periodontal diseases. Although various therapeutic approaches, including the use of recombinant growth factors, complete regeneration of lost periodontium has not yet been achieved.

GENETICS AND DENTISTRY

Important progress in human molecular genetics has been reflected in dental treatments. Advances in oral bioscience from passive immunization for dental caries, induction of new bone and cartilage tissue, and regeneration of periodontal tissues, to the artificial synthesis of saliva for patients with xerostomia also came about courtesy of the Human Genome Project. These remarkable advances provide the basis for gene-based diagnostics and drug developments for the management of condition ranging from chronic facial pain, to osteoarthritis as related with temporomandibular joint disease, and osteoporosis associated with periodontal diseases. Genetic bioengineering will be more impactful on dentistry in the next few decades in ways that encourage the body to repair itself, rather than artificially placing extrinsic materials. Seeding genetically-developed pulpal tissue into the canal to grow and fill the chamber, triggering epithelial cells to form dentin and enamel, thus completing the biologic restoration of teeth will be enabled through genetic engineering techniques in the future.

Genetics and dental anomaly Role of genetics in tooth agenesis Tooth Agenesis is the most common developmental dental anomaly. Agenesis is characterized by congenital absence of one or more teeth. The incidence for permanent tooth agenesis ranges from 1.6% to 9.6% in the general population excluding third molars [3-7]. Various terminologies are used in literature to describe this numeric anomaly. Hypodontia is absence teeth but not more than six (excluding 3rd molars). Oligodontia is used to describe absence of six or more teeth (excluding 3rd molars) in dental arches. Anodontia is an extreme expression of oligodontia denoting complete absence of teeth. Population studies have shown that tooth agenesis can be manifested as an isolated finding or part of a syndrome . Grahnen has proposed that tooth agenesis is typically transmitted as an autosomal dominant trait with incomplete penetrance and variable expressivity. Several genes have been investigated as a candidate for isolated tooth agenesis but mutations occurring in MSX1 and PAX9 are shown to be involved in non-syndromic tooth agenesis. A familial autosomal dominant hypodontia was noted by a point mutation in the MSX1 gene. Vastardis., et al. using a linkage analysis in a family with second premolar and third molar agenesis, demonstrated a locus on the chromosome 4p16 as the site of the MSX1. Arg31-to-pro mutation influences MSX1interactions, which are critical for normal tooth development. On sequence analysis arg31-to-pro missense mutation was demonstrated in the MSX1 homeodomain for all of the affected subjects. Another gene causing tooth agenesis is Pax9 in chromosome 14 (14q21-q13). The frameshift mutation of Pax9 was identified for creating autosomal dominant pattern of oligodontia in a family for four generations. Nieminen., et al. identified an A-to-T transversion of the Pax9 gene in a family with autosomal dominant oligodontia. Mutation of AXIN2 gene is responsible for creating autosomal dominant oligodontia which is also known for creating colon cancer.

Role of genetics in structural anomalies:

The structural anomalies of teeth are caused due to disturbances created during the development of enamel and dentin. Amelogenesis imperfect is a disorder caused by disturbance during enamel formation. Amelogenesis imperfecta is of three types:

1. Hypoplastic: Thin, normally calcified enamel,

2. Hypocalcified: Less mineralized, but normal thickness enamel

3. Hypomaturation: Enamel structure having the same radiodensity of dentin and can be easily separated from dentin. Amelogenesis imperfect exhibits X-linked, autosomal dominant and recessive inheritance caused by mutation of: • AMELX gene: Associated with enamel protein amelogenin. Mutation of AMELX is correlated with hypoplastic and hypomaturation variants. • ENAM gene: Associated with enamel protein enamelin. Mutation of ENAM is correlated with autosomal dominant and recessive patterns of hypoplastic variants. • MMP20: Codes for enamelysin, a proteinase; mutation of this gene is associated with autosomal recessive pattern causing pigmented hypo maturation variant. • KLK4: Is associated with protease kallilerin-4, the mutation of which results in various forms of hypo maturation amelogenesis imperfecta. • DLX3: Codes for various proteins that are critical for craniofacial, tooth, hair, brain and neural development; mutation leading to hypoplastic-hypo maturation variants. Dentinogenetic imperfecta; also known as Capdepont’s teeth dentin is a hereditary developmental disturbance of dentin in absence of any systemic disorder. It is an autosomal dominant condition with three variations: Type I is syndromic form of DGI which is inherited with osteogenesis imperfecta and the genes encoding collagen, type I, alpha 1, COL1A1 and COL1A2. The other two forms are the result from mutations in the gene dentin sialo phosphoprotein (DSPP), encoding dentin phosphoprotein and dentin sialoprotein. Dentinogenesis imperfecta formerly divided into hereditary opalescent dentin and Brandywine isolate, where the later representing unusual pulpal enlargement also known as shell teeth. Current evidences suggest that Brandywine isolation is the variable expressivity of the gene for dentinogenesis imperfecta. Investigators have documented enlarged pulp chambers in the affected individuals whose parents and children represent classic DGI.

Genetics and periodontal disease

Periodontal disease is multifactorial in which both genetic and environmental factors play an important role, whereas microbiota is responsible for the progression of disease. A range of host genetic factors can influence individual susceptibility to periodontal Genetics and dental anomaly Role of genetics in tooth agenesis Tooth Agenesis is the most common developmental dental anomaly. Agenesis is characterized by congenital absence of one or more teeth. The incidence for permanent tooth agenesis ranges from 1.6% to 9.6% in the general population excluding third molars. Various terminologies are used in literature to describe this numeric anomaly. Hypodontia is absence teeth but not more than six (excluding 3rd molars). Oligodontia is used to describe absence of six or more teeth (excluding 3rd molars) in dental arches. Anodontia is an extreme expression of oligodontia denoting complete absence of teeth. Population studies have shown that tooth agenesis can be manifested as an isolated finding or part of a syndrome. Grahnen has proposed that tooth agenesis is typically transmitted as an autosomal dominant trait with incomplete penetrance and variable expressivity. Several genes have been investigated as a candidate for isolated tooth agenesis but mutations occurring in MSX1 and PAX9 are shown to be involved in non-syndromic tooth agenesis. A familial autosomal dominant hypodontia was noted by a point mutation in the MSX1 gene. Vastardis., et al. using a linkage analysis in a family with second premolar and third molar agenesis, demonstrated a locus on the chromosome 4p16 as the site of the MSX1. Arg31-to-pro mutation influences MSX1interactions, which are critical for normal tooth development. On sequence analysis arg31-to-pro missense mutation was demonstrated in the MSX1 homeodomain for all of the affected subjects. Another gene causing tooth agenesis is Pax9 in chromosome 14 (14q21-q13). The frameshift mutation of Pax9 was identified for creating autosomal dominant pattern of oligodontia in a family for four generations. Nieminen., et al. identified an A-to-T transversion of the Pax9 gene in a family with autosomal dominant oligodontia. Mutation of AXIN2 gene is responsible for creating autosomal dominant oligodontia which is also known for creating colon cancer.

Role of genetics in oral cancer:

Oral cancer is one of the leading causes of death in developing countries; the disease being more prevalent in heavy smokers, tobacco and alcohol addicts. It is likely that more than one factor is needed to produce cancer. Extrinsic factors include tobacco smoke, alcohol, syphilis, sunlight, radiation etc. Intrinsic factors general malnutrition or iron deficiency anemia, gene mutation. Oncogenes and tumor suppressing genes are chromosomal components capable of being affected by variety of causative agents. Normal genes or proto-oncogenes are transformed into activated oncogenes through three mechanisms (I) Point mutations in a proto-oncogenes that result in a constitutively acting protein product, (ii) localized reduplication (gene amplification) of a DNA segment that includes a proto-oncogenes leading to overexpression of the encoded protein, (iii) chromosomal translocation that brings a growth-regulatory gene under the control of a different promoter and that causes inappropriate expression of the gene [26]. Once activated, they may stimulate the production of excessive amount of new genetic material through amplification of involved gene. It has been supposed that oncogenes are involved in initiation and progression of wide range of neoplasms whereas tumor suppressor genes allow the tumor production indirectly when they become inactive or mutated. Commonly identified genetic deviance in oral squamous cell carcinoma include abnormality of ras, myc and EGFR oncogenes and p53, pRb, p16 and E-cadherin tumor suppressor genes. According to researcher’s accumulation of several genetic aberrations is necessary before the affected cell expresses malignant phenotype. Carcinogenesis is a complex, multi-process in which genetic events within signal transduction pathways governing normal cellular physiology are quantitatively altered. Cancer is the result of accumulation of changes in the excitatory and inhibitory cellular pathways, which may occur at any level of a given pathway. It has been estimated that from three to six somatic mutations are needed transform a normal cell into its malignant counterpart. For human oral cancer more than 63 karyotypes have been described. Among them loss of chromosome 9, 13, 18 and Y deletions are more commonly reported than others. Approximately two-third of all head and neck cancer cells contain a deleted region located in chromosome 9p21-22, which appears in dysplastic and carcinomain-situ lesions. Smoking and tobacco use have been associated with the mutation of the p53 gene in squamous cell carcinoma of the head and neck. By immunohistochemistry p53 expression has been shown in oral tumors from patients who were heavy smokers and drinkers. Dental genetic test With available knowledge and techniques, dental genetic tests are possible by taking saliva or cheek swab. In certain test blood samples are also taken. The purpose of genetic test is to:

* Identify increased risks of health problems.
* Choose treatments.
* Assess responses to treatments.
* The available types of genetic test are:
* Diagnostic: To identify the disease gene. Predictive: To identify gene that increases the chance of developing disease.
* Carrier testing: To find a person having a gene responsible for a disease.
* Pharmacogenomic: To get information how certain medicines are processed by individual’s body.
* Prenatal: Done during pregnancy to find if the fetus has certain disease.
* Newborn screening. From dental genetic test one can confirm the disease, identify genes that are responsible for a disease and genes that could be passed on to offspring, determine severity of disease, guide in deciding the course of treatment and best medicine for certain individual and screen newborns for avoidable and treatable conditions.

DENTAL STEM CELLS

The dental pulp cells {DPSCs} develops from both cranial neural crest-derived mesenchymal stem cells (MSCs) and oral-derived epithelial stem cells in the early stages of embryogenesis. The first dental pulp-related stem cells were isolated from the third molar dental pulp by Gronthos et al. in 2000, it is also said that DPSCs could also be isolated from other dental pulps including human exfoliated deciduous teeth and supernumerary teeth. Human DPSCs have a higher reprogramming efficiency than human dermal fibroblasts because they have a rapid proliferation rate and endogenously express high levels of the reprogramming factors c-MYC and Klf4. DPSCs are potentially an important patient-specific cell source of iPSCs for clinical applications in regenerative medicine.

Properties of DPSCS

* Multipotency
* High proliferation activity
* Self renewal capacity
* Colony-forming unit-fibroblasts forming ability
* Immunomodulation
1. Dentin/Pulp Regeneration

Autologous transplantation of DPSCs is clinically tried to regenerate the dentin-pulp complex. Tubular dentin formation was observed when human pulp stem cells with scaffold (HA/tricalcium phosphate) were implanted in immunocompromised mice. Reparative dentin formation on amputated pulp was found when stem cells were combined with recombinant human bone morphogenetic protein 2 in experimental studies on animal models.

1. PDL Regeneration

Marei et al. in their experiment on goat was able to regenerate periodontal tissues around titanium implant using autologous bone marrow stem cells with the scaffold. Transplantation of PDL derived cells into animal models was shown to regenerate periodontal tissue.

1. Bone Regeneration

Positioning of a biocomplex of collagen sponge filled with DPSCs in the extracted site of mandibular third molar resulted in a higher rate of mineralization and cortical levels leading to complete regeneration. The samples also showed a well-organized and vascularized bone with a lamellar architecture surrounding the Haversian canal was observed. They also prove to be a useful tool for the treatment of degenerative diseases involving the maxilla and mandible.

1. Root Regeneration

SCAP has remarkable cell migration activity; which is considered to involve root growth in tooth development. when a root formed carrier containing SCAPs covered with PDLSC- immersed absorbable gelatin sponge is implanted into a socket of the mandibular bone of a swine, the rootform carrier is reconstructed with newly formed dentin/pulpcomplex and is surrounded by regenerated PDL on de novo cementum.

1. CNS

DPSCs will lead to both regeneration of new neural precursor cells and their enhanced neuronal and glial differentiation. They will also lead to survival and maintenance of existing neural cells through secretion of trophic factors.

1. Stroke

Some in vivo studies have shown that transplantation of DPSCs into the ischemic areas of middle cerebral artery occlusion in Sprague-Dawley rats promoted locomotor functional recovery and decreased infarct areas by their differentiation into dopaminergic (DA) neurons and secretion of neurotrophic factors.

1. Parkinson

Intrathecal transplantation of DPSCs into the 1-methyl-4- phenyl-1,2,3,6-tetrahydropyridine (MPTP) induced old-aged mouse model of PD, promoted recovery of behavioral deficits, restored DA functions, and attenuated MPTPinduced damage by reducing the secretion of proinflammatory factors such as IL-1α, IL-1β, IL6, IL8, and tumor necrosis factor (TNF)-α and by upregulating the expression levels of anti- inflammatory factors such as IL2, IL4, and TNF-β.

1. Peripheral Nerve

Injury Studies suggest that DPSC-embedded biomaterial nerve conduits such as polylactic glycolic acid tubes have the ability to promote regeneration of injured facial nerve and to improve functional recovery comparable to that of autografts. Collagen conduits loaded with Schwann-like cells induced from DPSCs in vitro have facilitated repair and regeneration of 15 mm sciatic nerve defect. 9) Bone Diseases Systemic transplantation of mesenchymal stem cells could ameliorate bone loss and autoimmune disorders in a MRL/lpr mouse SLE mode by suppression of Interleukin-17 and maintaining a regular positive bone metabolism.

1. Liver Diseases

DPSCs prevented the progression of liver fibrosis in the liver of CCl4-treated rats and contributed to the restoration of liver function. Engraftment of DPSCs and SHED morphologically and functionally ameliorate acute and chronic injury of livers in CCl4-treated rats.

1. Muscular

 DPSCs can differentiate into dystrophin-producing multinucleated muscle cells and can be utilized in disorders such as muscular dystrophy, wherein, the body is unable to produce dystrophin. Utilization of myogenic progenitor cells derived from dental pulp produced more dystrophin as compared to the heterogeneously present stem cells proving to be a potential alternative for stem cell therapy in muscular dystrophy patients.

1. Diabetes

 Diabetes is a chronic degenerative disease. One of the treatments for diabetes includes transplantation of pancreatic islet cells. Chen et al. demonstrated that insulin-producing cells can be derived from monoclonal and polyclonal DPSCs. Govindasamy et al. demonstrated that DPSCs have the capacity to differentiate into islet-like aggregates.

1. Corneal Stoma Transplantation

DPSCs are a potential alternative to cadaveric tissue grafts. Autologous stem cells that are capable of remodeling the corneal tissue into the proper structure (without scarring) could bypass the limitation of current treatments Study findings demonstrated that DPSCs have the capacity to create engineered corneal stromal-like constructs with an organized matrix similar to that of native corneal tissue. Also, data showed that human DPSCs have the ability to maintain their keratocyte phenotype after in vivo implantation into mouse corneas, indicating that the DPSCs secreted the appropriate matrix in the in vivo corneal stromal microenvironment without triggering rejection. All of these properties indicate that human DPSCs have potential use in regenerative corneal therapies.

## Biochemical developments in dental research

Recently, biochemical studies have become an area of increasing importance in dental research, from dental pulp stem cells to synovial fluid analyses, in order to understand the etiology and pathology of temporomandibular joint disorders. Saliva is now an important biofluid for the early detection of diseases; rapid and sensitive analyses of saliva and crevicular fluid are used as important diagnostic tools In fact, the recent development of saliva as a diagnostic tool has placed dentistry at the forefront of monitoring systemic health and disease. The use of gingival crevicular fluid is an important biochemical tool in the diagnosis of diabetes and other inflammatory conditions. Advances in the science and technology of miniaturization (nanotechnology) now enables a biochemistry laboratory on a miniature chip and these types of microfluidic chips have been widely used to analyze small-volume fluids. This “lab-on-a-chip” technology allows oral fluids to be used for diagnostic and prognostic purposes

## Biomimetics in dentistry

Biomimetics is a field in which some chemical, biologic, and engineering principles are applied to the synthesis of materials that mimic biochemical processes. Some biomimetic products can be used in regenerative dentistry such as shallow dentin defects, bone substitutes, remineralization of the tooth surface, and biofilm destruction. In contrast to traditional treatment principles, biomimetics align with the biology, function, and mechanics of natural teeth.Biomimetic dentistry is an emphasis of modern dental education.

**According to the Academy of Biomimetic Dentistry, the biomimetic approach is less invasive than the traditional approach.** There’s less drilling involved — in fact, biomimetic dentists avoid using dental drills whenever possible and use other methods to sanitize teeth and treat decay.

Biomimetic dentistry focuses on rebuilding teeth, simulating the natural dentition as much as possible. Cavities and other lesions to the tooth are carefully repaired using advanced materials and adhesives so the tooth retains its inherent natural properties.

Traditional dentistry is much more invasive dentistry. Tooth tissues are commonly removed in traditional dentistry, and many of the restorative materials traditional dentists use to repair teeth are harder than natural teeth, which can result in shrinkage and cracked or damaged teeth.

## Personalized dental medicine

The concept of “personalized medicine” (PM) necessarily emerged because an individual’s response to treatment of disease depends on their genetic factors and individual behavior. PM facilitates the selection of optimal therapy with the highest safety margin, thereby reducing trial-and-error prescribing and increased adherence to treatment by patients. Genomic information plays an important role in PM and can be used in the practice of dentistry by taking into account ethical and legal obligations. Genome-derived information of a patient can help physicians understand the disease etiology and permit earlier diagnosis. Applying preventive dentistry rather than treating disease is made possible by using genomic tests. Also in orthodontics treatment, genetic and environmental (including treatment) factors (nature and nurture together) should be considered to ensure better results. “Regenerative dentistry” has progressed through the innovations in new diagnostics. In the future, analyzing “personal genetics” may determine the most effective treatment options in dental practice; for example, filling materials may be able to regenerate decayed teeth.

## The effects of scientific developments on dental education

History of dental education: Changes and innovations parallel to technological developments have occurred in dental education. After the second half of the 16th century and at the beginning the 17th century, there were many advances in dental education. The publication of the first textbook on dentistry in Leipzig (1530), and identification of microorganisms in material scraped from teeth by van Leeuwenhoek (1683) both occurred during this period. Later, the first American dental school was founded in Baltimore by four physicians (1840), and institutional dental education began in the USA after the medical department of the University of Maryland refused a request to include dental education in its curriculum. After Harvard started the first university-based dental department in close association with medical department in 1867, much research was performed related with dentistry. Data were published indicating the infectious basis of tooth decay (1891). In 1926, the tenth in the series of Carnegie reports on dental education was written and published by William Gies, a Columbia University biochemistry professor with a particular interest in dental research. It was the first comprehensive report for dental education that took five years to research and write, and consisted of 250 pages of text plus more than 400 pages of appendixes. Gies, forcefully supported a strong basic science education and almost certainly encouraged dental schools to strengthen this aspect of their curriculum. It was proposed in Gies’s report that dentistry should be an independent part of health services in universities, and it should receive the same quality of consideration and support as medicine. Additionally, Gies supported hospital internships and a broad array of graduate specialty programs. The suggestion of Gies that predoctoral education should emphasize general practice and early specialization still maintains its validity today. Twenty-five years after Gies’s report, recognized specialties in dentistry included dental public health (1950), endodontics (1963), oral and maxillofacial surgery (1947), oral pathology (1949), orthodontics (1947), pediatric dentistry (1947), periodontics (1947), and prosthodontics (1947). Dental school accreditation standards were published by the American Dental Asociation (ADA) council in 1941. In 1980, the Kellogg report on advanced dental education was published. The Dentist Scientist Award, founded in 1984, sponsored individuals in a five-year dental education and research training program that went on to doctoral degrees in basic sciences. In Turkey, developments in dental education closely followed those in the world. The first dental manuscript book in Turkey was published by Dr. Musa Bin Hamun (1490-1554) before the first American book on dentistry (1801). The first Turkish dental school was founded in Istanbul in 1908, later becoming Istanbul University, Faculty of Dentistry. In Europe, the origins of formal dental education were more diverse. Dental schools were founded as separate schools, especially in northern Europe, whereas in southern Europe they were a discipline in medical schools.

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## Conclusion

As a result, it can be stated that world scale innovations in educational models have caused systemic changes contributing to the advancement of dental education. Since characteristics of scientific and technological developments, as well as their repercussions on dental education, will always be of utmost importance in modern dentistry, rapid integration of innovations into the dental curriculum plays a key role in reaching higher standards in patient treatment and disease prevention.

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