NIDCR Strategic Plan

FY 2003 –2008

Mission

The mission of the National Institute of Dental and Craniofacial Research is to improve oral, dental and craniofacial health through research, research training, and the dissemination of health information. We accomplish our mission by:

- Performing and supporting basic and clinical research;

- Conducting and funding research training and career development programs to ensure an adequate number of talented, well-prepared and diverse investigators;

- Coordinating and assisting relevant research and research-related activities among all sectors of the research community;

- Promoting the timely transfer of knowledge gained from research and its implications for health to the public, health professionals, researchers, and policy-makers.

Core Values

In our efforts to improve the oral, dental and craniofacial health of the public, we will prioritize scientific opportunities on the basis of their potential impact to improve health, the readiness of the scientific community to accomplish them, and their alignment with the following core values:

SCIENCE Our programs and activities to support research, research training, and information dissemination will be driven by science.

TRUST Our resources and programs will be managed, conducted, and evaluated in a manner that upholds the trust placed in us by the public.

SOCIETY Our programs and actions will aim to improve the oral health of all people and eliminate health disparities.

Vision

We will advance the oral health of all people and support the most rigorous level of science to meet the challenges of a changing society and promote the well-being of the Nation.

Overview

In 1997 the National Institute of Dental and Craniofacial Research (NIDCR) unveiled its Strategic Plan, *Shaping the Future*. The driving forces behind our initial plan and this updated version remain the same – to adopt needed change, to identify and prioritize new opportunities for research, and to respond to the needs of the people we serve. In the same way that we initiated *Shaping the Future*, we embarked on updating the Strategic Plan mindful of the remarkable pace of continuing biological discoveries, and aware that we must do all we can to keep up the momentum, encourage young people in the pursuit of science, transform health professional education, and ensure that oral health research can benefit all people.

Our commitment to respond to the changing needs of the public is evident when we consider how the NIDCR has evolved. Created in 1948 as the third component of the NIH, the NIDCR was first named the National Institute of Dental Research. The driving force that launched the new Institute was concern over the nation's military readiness; far too many otherwise healthy young recruits were rejected for service during War World II because they lacked six opposing teeth. More than 50 years later, tooth loss of this magnitude is rare among young people in the U.S. and remarkably lower overall. Yet much work remains to be done to eliminate oral diseases that keep people from being fully healthy. Today the pressing needs include understanding the complex genetic, environmental, nutritional, and behavioral factors that result in oral diseases and conditions; addressing the persistent disparities in health status; and carrying out the health promotion and outreach efforts needed to improve health.

This Strategic Plan addresses the myriad diseases and conditions that affect the oral cavity and craniofacial structures by outlining a course for the Institute to follow in the areas of research, research training, and communication of research results. Recognizing the need to focus our efforts in areas that offer extraordinary scientific promise, the goals and objectives of this plan are centered on:

- Advances from clinical and population-based research that are identifying risk factors and markers for the progression of disease and are stimulating new preventive, diagnostic, and treatment approaches to oral, dental and craniofacial diseases and disorders;

- New knowledge from the Human Genome Project that is leading to novel ways to prevent, diagnose, and manage oral, dental, and craniofacial diseases and conditions;

- Revolutionary advances in cell and molecular biology and in bioengineering that are enabling the growth, repair and regeneration of tissues damaged by disease, injury or malformations; and

- New knowledge from health communications research that is being used to promote healthy behaviors, improve oral health literacy and enhance the adoption of research into practice.

These and other emerging research advances are changing how oral health research is conducted. More than ever, research is not defined or confined by the boundaries of a single scientific area but is increasingly characterized by an eclectic mix of disciplines. Computer scientists, mathematicians and biologists together have formed the new discipline of *bioinformatics* – the use of mathematics, statistics and computing to model biological processes and ultimately solve biological problems. Biologists, engineers and clinicians are working together to fabricate living parts for the body from cells in the laboratory, creating the new field of *tissue engineering*. Protein biochemists have teamed with engineers to create "labs on a chip," small enough to begin to pursue simultaneous monitoring of multiple substances in real time. The interplay among environmental, behavioral, nutritional, and genetic factors that underlie human health and disease has led to the creation of unique multi- and inter-disciplinary research teams. Recognizing this crucial need to ensure a diverse and adequately trained research workforce, the plan sets forth an aggressive agenda to enhance multidisciplinary career training and development.

As research progress increases, so does our responsibility to ensure that scientific knowledge is communicated clearly and effectively to all who need it. Thus, NIDCR recognizes the need to increase efforts to translate research findings into tangible results that will improve clinical care and to communicate science-based information to health professionals, professional organizations, and the public.

Improving the nation's oral health is an ambitious goal, and NIDCR recognizes the importance of partnerships in achieving that goal. We also recognize the need to bring new partners to the oral health research enterprise from the broader scientific community, academia, the health professions, health voluntary organizations, industry and government. The creation of multidisciplinary research teams will require that we recruit new scientific disciplines to the field. Expanding the opportunities for research training and career development will require that we work closely with medical, graduate, public health and engineering schools as well as dental schools and dental and medical professional organizations. Enhancing our partnerships with both public and private sector organizations is equally important to realize our goal of promoting the timely transfer of knowledge and its implications for health to all audiences.

Our mission has remained the same since the day the Institute was created 55 years ago. We've come a long way, in terms of both scientific advances and improvements in the Nation's oral health. To achieve our ultimate goal, we must take advantage of new scientific knowledge and tools, strengthen and expand partnerships, ensure that research advances are translated into useful technologies, and above all make sure that our scientific efforts benefit people.

Employing Powerful Tools

The completion of the draft of the human genome sequence in 2001 was heralded as one of the most important scientific milestones of all time. Understanding how the 40,000 or so human genes function and how they interact with one another is a major challenge to be overcome to translate genetic knowledge into improved health. Ultimately, it is not only the genes that must be understood, but how they instruct cells to produce proteins, how and where these proteins function normally and interact with one another, and how faulty proteins or protein complexes can lead to disease. To date, the genome sequences of numerous oral microbes are being

deciphered, and major ones implicated in caries and periodontal diseases have been completed. But how is *genomics* -- the analysis of the entire genetic makeup of a species -- adding to our understanding of oral diseases? How is *proteomics*, or the study of the tens of thousands of proteins expressed by a cell type, changing oral health research? And how will the availability of genetic information and powerful technologies to analyze it change the way dentistry is practiced and help to improve the public's oral health?

Using genomic and proteomic approaches, researchers are unraveling the mysteries of how oral bacterial cells attach to a surface and become established in a "biofilm", which oral health researchers and practitioners know as dental plaque. Such knowledge provides a brand new set of tactics for disease prevention. We can envision dental health professionals in the near future using a therapeutic substance to block or weaken the function of cell enzymes that enable caries-causing bacteria to anchor to enamel and form biofilm. Alternatively, they might apply products to render certain oral bacteria harmless by lessening their virulence, or they may give their patients products that short circuit communication among bacteria and host cells. Proteomic discovery of the patterns of salivary expression will lead to early identification of individuals most at risk of oral diseases as well as systemic conditions and diseases. These potential tools would not be possible without the knowledge gained from sequencing of human and oral microbial genomes, and from proteomic studies that reveal how changes in human and microbial protein expression contribute to normal and abnormal function.

In the struggle against oral and pharyngeal cancer, we can foresee a new way of diagnosing and treating disease by using molecular techniques to help identify which lesions are likely to undergo malignant conversion. Earlier detection might be afforded by finding a "signature" pattern of substances in oral fluids – ranging from alterations in salivary proteins to abnormalities detected in the DNA of pre-cancerous cheek cells. Before long, surgeons could be using molecular markers to identify genetically abnormal cells at the margin of a tumor whose removal would reduce the chance of its recurrence. Using molecular information, clinicians may be able to tailor a patient's treatment to deal with the specific molecular defects that caused the malignancy.

A genetic test to predict a person's response to a particular drug – a far-fetched idea less than a decade ago-- is now being used to identify patients who metabolize certain drugs poorly. This emerging field of *pharmacogenetics* offers great promise for improving drug effectiveness, preventing severe adverse drug reactions, and improving patient compliance. Pharmacogenetics will also benefit dental research. Genetic screening may improve drug development and testing by identifying and eliminating the number of participants in clinical trials who will not respond to, or may be harmed by a new drug being tested, thereby making clinical trials smaller, faster and less costly.

Genomics and proteomics are powerful tools that will revolutionize the practice of dentistry and the public's perception of oral health care. We can now anticipate a day when no patient will experience pain, loss of function, or disfigurement from late-stage oral diseases. Instead, they will be treated by oral health professionals who use drugs instead of drills, regenerate damaged oral and craniofacial tissues, identify problems before they manifest clinically, and stop or reverse disease instead of practicing damage control.

Benefiting from Our Investments

The NIDCR is uniquely positioned to remain a key player in genomics, proteomics, and the growing field of tissue engineering. For more than four decades, dental researchers have studied the basic biological, chemical, and molecular structure of bone and have worked to identify proteins that stimulate bone growth and repair. The NIDCR was a pioneer in the study of the chemical properties and molecular structure of collagen, which is an integral part of bones, teeth, and the periodontium -- the connective tissues surrounding the teeth. The Institute's world-class research program in matrix and developmental biology has led to a basic understanding of how cells organize to form the hard and soft tissues of the craniofacial complex. This basic knowledge is pivotal to the new discipline of bioengineering because it provides the key three elements needed for its success: a) the scaffold or matrices on which to grow tissues such as collagen or bone mineral; b) the cells to form cartilage, collagen, or bone; and c) the biologic molecules (e.g. growth factors from bone matrix) that signal the cells to differentiate into specific tissue types.

The orofacial tissues pose particularly interesting challenges to tissue engineering research because of their complex nerve supply, finely-tuned muscle function, unique organs, multiple cell types that must be integrated with one another, and the ubiquitous presence of millions of microorganisms that influence tissue response. Information emerging from the human genome project, advances in our understanding of cell adhesion, and the availability of human adult and embryonic stem cells provide a wealth of potential approaches to designing bioinspired materials that can be used to engineer tissues (*biomimetics)*. Researchers have discovered that third molars, which are often extracted and discarded, contain adult stem cells that when cultured and expanded are capable of producing dentin in animal models. This and other approaches to regenerate dentin and other dental tissues may transform the way endodontic, or root canal therapy is performed.

Tissue engineering research has enormous potential to change clinical practice in other ways too. Someday it may be possible to use biomimetics to repair periodontal tissues, fill in bony defects caused by disease, craniofacial disorders or injuries, and regenerate muscle, nerves and salivary glands. Using remarkable biomimetic approaches, scientists are developing the first artificial salivary gland, a giant scientific leap that would benefit millions of Americans with salivary gland disease or dysfunction.

Contributing to Other Disciplines

Unlike the internal organs of the body, the structures of the mouth are readily visible and accessible. This unique feature has allowed using the oral cavity as a model to understand systems or diseases that occur elsewhere in the body. Only recently have scientists begun to appreciate the potential of the oral cavity to be used as a "real time" laboratory using the tools emerging from molecular and cell biology. Viewed from this perspective, it will be possible in the not-so-distant future to test, observe, measure, and understand complex processes that affect the entire human body by examining the cells, proteins, and molecules from tissues and fluids in the mouth.

Scientists have long recognized that our saliva serves as a "mirror" of the body's health in that it contains the full repertoire of proteins, hormones, antibodies, and other substances that are frequently measured in standard blood tests. The Institute's work currently includes a major research effort to identify and address major cross-cutting biomedical challenges, and will further develop needed technologies and create the first comprehensive baseline catalogue of all proteins found in oral fluids of healthy individuals. The NIDCR envisions that this basic research could one day translate into miniature, hi-tech tests, or so called "labs" on a silicon chip, that rapidly scan oral fluid for the presence or absence of multiple proteins linked to various systemic diseases and conditions. Ultimately, this approach could be used for real-time health surveillance—rapidly identifying persons most at risk at the earliest moments of detectable change in key diagnostic markers.

Oral health researchers have taken advantage of the easy access to oral tissues to make significant contributions to other scientific areas as well, such as immunology, neurobiology, and pain research. The NIDCR's seminal work in microbiology and immunology opened new insights into the nature of the inflammatory process and defined cytokines – hormone-like factors – that participate in the body's inflammatory and immune responses. Institute studies added to the knowledge about many conditions including Sjögren's syndrome, cleft lip and palate, ectodermal dysplasia, cancer, chronic pain and other neurological disorders, and many infectious diseases including candidiasis, herpes, hepatitis, human papillomavirus infection and acquired immune deficiency syndrome (AIDS).

The Institute's research efforts have not only improved the oral health of the nation, but also contributed important knowledge to understand and control systemic diseases. We remain committed to supporting research that has far-reaching implications for improving the health and well-being of people today as well as in the years to come.

Sustaining our Uniqueness

To achieve our vision of advancing the oral health of all people, we must strike a fine balance between attracting researchers from other related disciplines, and maintaining a critical number of investigators with intimate knowledge of the uniqueness of the orofacial structures and the diseases that affect them. The NIDCR has a rich tradition of working across diverse fields of basic science. These inter-disciplinary collaborations have resulted not only in generating new knowledge, but also in improving clinical care. Further improvements in the oral health of individuals and communities will require a strengthened link among basic, translational and clinical research[1.] Clinical research has been described as "the 'neck of the scientific bottle' through which all scientific developments in biomedicine must flow before they can be of real-world benefit to the public."[2] Thus, enhancing the clinical research infrastructure, expanding the capacity and skills of future clinical researchers, and maintaining their link with basic

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1 Clinical research is defined in this document consistent with the NIH "Nathan Report" to include patient-oriented research, epidemiological and behavioral studies, and outcomes research and health services research. See http://www.nih.gov/news/crp/97report/

2 Association of American Medical Colleges; American Medical Association. Breaking the scientific bottleneck: report of the Graylyn consensus development conference. Washington, DC: AAMC, 1990.

researchers are critical to sustain and exceed the achievements of more than 50-years of public investment in oral health research.

Findings from oral health research have led to the development of many successful approaches to prevent, diagnose, and manage oral, dental and craniofacial diseases. Indeed, NIDCR-supported research has led to the widespread adoption of water fluoridation and other measures to prevent tooth decay. These preventive efforts are estimated to have saved nearly $40 billion from 1979 to 1989, and continue to save money and improve the quality of life for millions of Americans[3]. Combining the tools of molecular and cellular biology, bioimaging, genetics, genomics, proteomics, engineering, epidemiology, social, behavioral science and clinical research will bring immense benefit to the millions of people affected by oral, dental and craniofacial diseases.

Facing the Challenges

Addressing Multiple Complex Diseases

The mouth is a complex and unique environment. It contains exquisitely sensitive tissues that are used for taste, chewing, swallowing, speech, facial expression and fighting off diseases. It has one of the highest concentrations of sensory and motor nerves in the body, four different types of calcified tissue, and contains nearly 500 species of microbes (only about half of which have been cultivated thus far) that maintain a delicate balance between health and disease. Not surprisingly, there are a multitude of diseases and conditions that affect the oral cavity and related dental and craniofacial structures, including the teeth, soft tissues, salivary glands, the temporomandibular joint, jaws, and facial bones, muscles and nerves. Our challenges extend from the continued struggle against two of the most common infectious diseases –dental caries and periodontal diseases – to eliminating life-threatening oral and pharyngeal malignancies, craniofacial birth defects and developmental disorders, acute and chronic orofacial pain and other conditions that compromise oral health. We must not only understand the factors that increase the risk for and contribute to oral diseases, but also find the causes of oral diseases, seek new ways to improve quality of life for persons who suffer from them, and at the same time be prepared to face the unforeseen challenges that lie ahead.

Attracting Researchers with Required Competencies

With the remarkable advances in science and technology have come increased responsibilities to assure an adequate and diverse supply of highly competent investigators in the years to come. A variety of flexible and innovative research training and career development programs are needed to recruit and retain researchers with the right mix of skills. Specifically, future researchers will need to be familiar with a broad range of scientific areas, manage complex studies, and learn to create and work successfully in teams and with individuals from new disciplines. Specific competencies that will be required include knowledge of cellular and molecular biology, human genetics, human nutrition, structural biology, molecular epidemiology, bioengineering,

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3 Brown LJ et al. Public Health Reports, 1994, Vol 109 No 2 195-203.

computational biology, behavioral and social sciences, and informatics among others. In addition, there is a critical need for researchers who are rigorously trained in the design and conduct of clinical trials and clinical research. Research aimed at eliminating oral health disparities will require investigators who can integrate knowledge from diverse fields and perspectives including biology, behavioral research, psychology, sociology, health economics, and health services research. The 1997 *NIDCR Blue Ribbon Panel on Research Training and Career Development* (http://www.nidcr.nih.gov/research/blueribbon/summary.pdf) emphasized the need to diversify the NIDCR research and training portfolio, expand the mix of disciplines in oral, dental and craniofacial research and adopt new strategies to promote diversity in the scientific workforce. Many challenges remain ahead to realize the full potential of the scientific opportunities that are unfolding before us today.

Adopting and Applying New Technologies

Against the backdrop of the extraordinary developments in biomedical science, there is a pressing need to ensure that tools emanating from new technologies are adopted and used. This is no easy task. It has been estimated that on average, it takes approximately 20 years for a new technology to be fully adopted and implemented into the health care system. Efforts will have to be devoted to increasing the awareness of NIDCR research results among providers, policy makers and the public and to enhance the Institute's capacity to translate research results into practice. Promoting technology transfer as well as the integration of oral health-related research findings into both the undergraduate and postgraduate curricula in academic health science centers will be important to ensure that the clinicians, researchers and educators of the future can fully apply science to benefit the public.

Closing the Knowledge Gap

Many oral diseases and conditions can be prevented and controlled; yet significant gaps exist in the public's oral health knowledge, attitudes and behaviors. For instance, only 62 percent of U.S. adults recognize that the primary purpose of water fluoridation is to prevent dental caries; fewer than one-quarter of U.S. adults know that dental sealants prevent dental decay. Overall, U.S. adults are ill informed about signs and symptoms and risk factors for oral cancers – only 25 percent of adults can identify even one sign of this disease. The dental knowledge gap, while greater among individuals with lower educational attainment, also exists among racial and ethnic groups and is as prevalent among persons who make frequent dental/medical visits as it is among those who do not. Ensuring that target audiences become informed, make appropriate decisions about their health, and adopt behaviors that will improve their oral health, requires further advancement of our tools to communicate with audiences effectively. We also must enhance the public's access to and use of the most current science-based health information.

The Burden of Oral Diseases

Oral diseases affect the most basic human needs: the ability to eat and drink, swallow, maintain proper nutrition, smile, and communicate. Oral health and overall health and well-being are inextricably connected. Many systemic conditions such as human immunodeficiency virus (HIV)/AIDS, diabetes, Sjögren's syndrome, and osteoporosis have important oral symptoms, manifestations or complications. The lips, tongue, gingivae (gums), oral mucosa and salivary glands can all signal clinical disease elsewhere in the body. Long considered to be localized infections only, periodontal or gum diseases are now being investigated as potential risk factors for the development of systemic disease. For instance, accumulating evidence now points to a possible link between periodontal diseases and the incidence of premature, low-birth weight babies, cardiovascular disease, and pulmonary disease. Oral diseases affect not only the health of the oral cavity and associated craniofacial structures, but can be detrimental to the overall health and well-being of individuals.

In the section that follows, we highlight selected oral diseases, disorders, birth defects and conditions that are uniquely within NIDCR's mission to improve the oral health of the nation.

Health Disparities

The substantial gains in the oral health of the nation over the past generation have not benefited all Americans equally. The burden of oral and dental disease, particularly untreated disease, falls heaviest on individuals from lower socioeconomic groups, which include disproportionately large numbers of racial and ethnic minorities. Individuals in lower socioeconomic status groups also have higher incidences of HIV infection and diabetes, diseases that increase the risk for serious oral, viral, bacterial and fungal infections. Children in low-income families are particularly vulnerable to oral health problems. Their nutrition may be poor, their oral hygiene inadequate, and their access to oral health care lacking. A partial remedy for addressing health disparities lies in improving access to effective and appropriate health promotion, preventive, diagnostic, and treatment services. The research challenges to reducing health disparities include elucidating risk factors, identifying and eliminating barriers to health care, designing better means of care delivery, and designing educational strategies to reduce risk and enhance health promotion that are appropriate to the social and cultural frameworks of the groups in question.

Dental Caries

Dental caries – also known as tooth decay -- is not extinct. Despite tremendous declines in the past three decades, tooth decay, the end result of a bacterial infection, remains the single most common chronic disease of childhood in the U.S. A troubling trend that partly explains the continued prevalence of caries is the increasing polarization of oral health in the U.S. – while most children enjoy excellent oral health, about 25 percent of children 5-17 years of age experience 80 percent of all dental caries in their permanent teeth. Dental caries begins early in life: 18 percent of preschoolers in the U.S. have already experienced tooth decay and by age 6-8, more than half have experienced this disease - making it 5-8 times more common than asthma. By age 17, more than 80 percent of the adolescent population is affected by caries. Dental caries

is also a problem among adults; recurrent caries and root caries are prevalent among adults and the elderly. The subset of the general population most prone to caries is also the most vulnerable: the poor, the very young and the elderly, and those with compromising medical conditions or disabilities. Continued research to identify the most effective health education messages for the prevention of caries, particularly among underserved populations, is needed. New approaches to diagnose, manage and prevent caries throughout the lifespan may come from further research to understand the molecular consequences of the interaction between host and microbes, and from deciphering the genomic makeup of bacteria implicated in dental caries.

Periodontal Diseases

Periodontal diseases are a result of infections caused by bacteria in the biofilm that forms on the teeth in the *cul de sac* between the tooth and gum (gingiva). They include a range of clinical variants -- from mild forms such as gingivitis to severe disease that can destroy the periodontal ligament and surrounding bone, in some cases leading to the loss of teeth. Almost half of U.S. adults ages 35 to 44 have gingivitis, a reversible inflammation of the gingivae, and about one-fourth have the more severe condition of periodontitis. Severe periodontal disease affects 14 percent of adults ages 45 to 54, and 23 percent of 65- to 74-year olds. Tobacco use is a major risk factor for the development and progression of periodontal diseases. There also is considerable evidence that diabetes, particularly if poorly controlled, increases the risk for periodontal disease. At present, treatment of periodontal diseases includes surgical as well as non-surgical approaches. Substantial advances in our understanding of how cells adhere to one another, and increased knowledge about the molecules that support and regulate nearly all cells are giving clinicians potential new options to manage periodontal diseases through the regeneration of tissues.

Tooth Retention and Edentulism

Vast improvements in tooth retention have taken place in the U.S. over the past three decades. Total tooth loss or total edentulism, once a relatively common condition among middle age adults is now most prevalent in older persons, affecting approximately one-third of adults 65 years and older. There is evidence that people with impaired dentitions due to missing teeth must choose foods that do not provide optimal nutrition; in the elderly, total edentulism and poor oral health can lead to significant weight loss that can affect overall health. The presence of 21 or more natural teeth has been used worldwide as an indicator of functional ability. Yet in the U.S. 58 percent of people 50 years or older and over one-quarter of the population over 19 years of age do not have 21 or more natural teeth. Low-income individuals, and in particular low-income white adults, are most likely to be totally edentulous. The standard treatment for tooth loss involves prosthetic devices such as full or partial dentures. Although these devices initially restore some of the ability to chew, as people age and lose underlying bone, the fit and aesthetics of dental prostheses are often compromised. Replacement of teeth with dental implants provides more natural and stable function than do dentures, but not every patient is an ideal candidate for implants. While continuing efforts to prevent tooth loss, there is a need to evaluate the appropriate replacement of tooth function, and to pursue evolving technologies that are enabling the development of biologic materials to repair and eventually regenerate teeth.

Oral and Pharyngeal Cancer

Oral and pharyngeal cancer is the sixth most common cancer in the developed world. Each year, an estimated 28,900 Americans are diagnosed with this disease and more than 7,400 die each year from it [4]. The most disturbing aspect about oral and pharyngeal cancer is the survival rate. In the U.S. the 5-year survival rate is approximately 50 percent, a statistic that has not improved over the past twenty years. African American men suffer the highest incidence of these cancers and have a much poorer five-year survival rate than do white men regardless of diagnostic stage. Despite the devastating consequences of oral cancer, which include impaired ability to chew, swallow, and speak, and often disfigurement from extensive surgery to remove parts of the face and oral structures, only 14 percent of U.S. adults report receiving oral cancer exams that can detect early disease. Reconstruction and management of the oral cancer survivor come at a high price both economically and socially. Not only are more efforts needed to increase public and professional knowledge about oral cancer and its prevention, there also is a critical need to develop biomarkers and diagnostic tests that can be used to improve cancer diagnosis and more accurately predict the course of the disease. There also is a pressing need to develop more effective, individualized treatments that spare healthy tissues and improve quality of life.

Pain and Chronic/ Disabling Conditions

International epidemiologic studies indicate that orofacial pain occurs in approximately 10 percent of the adult population. Orofacial pain, by itself or as a symptom of an untreated oral problem, is often a major cause of poor quality of life. Toothaches alone are associated with significant morbidity and high economic cost. Sources of orofacial pain include caries, periodontal diseases, and neuropathic and musculoskeletal conditions. Orofacial pain also is a major symptom of temporomandibular muscle and joint disorders (TMJD) that are estimated to affect 10 million people in the United States. Orofacial pain may also be caused by conditions involving the dental pulp (the innermost part of a tooth that contains blood vessels and nerves) and the area around the root, leading to symptoms that can range from sensitivity to thermal changes to severe pain and/or abscesses. Today, pain researchers know that chronic pain can become a disease in itself, causing long-term detrimental changes in the nervous system. These changes may affect resistance to other diseases, as well as effectively destroy quality of life. There is considerable need for research that integrates knowledge gained from cell biology, genetics, molecular biology, imaging technologies, neuroscience, behavioral sciences and epidemiology to better understand the mechanisms underlying the causes and progression of orofacial pain and dysfunction associated with TMJDs and other pain conditions.

Xerostomia

Saliva is a remarkable fluid essential for oral health: it guards against infections by favoring the accumulation of "beneficial" bacteria and helping to eliminate other microorganisms, lubricates the soft tissues of the mouth, buffers acids produced by cariogenic bacteria, aids digestion, and

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4 Ries LAG, Eisner MP, Kosary CL, Hankey BF, Miller BA, Clegg L, Edwards BK (eds). SEER Cancer Statistics Review, 1973-1999, National Cancer Institute. Bethesda, MD, http://seer.cancer.gov/csr/1973_1999/, 2002.

facilitates speech and swallowing. Salivary gland hypofunction or obstruction can result in xerostomia or dry mouth. Xerostomia is a significant health problem, particularly among the elderly, owing to the some 400 over-the-counter and prescription drugs, including tricyclic antidepressants, antihistamines, and diuretics that have xerostomic side effects. The most common disorder involving the salivary glands is Sjögren's syndrome, an autoimmune condition that affects between 1 and 4 million Americans, mostly middle age women. Over 30,000 individuals who have cystic fibrosis are also at higher risk for salivary gland dysfunction. In addition, each year an estimated 40,000 people lose salivary gland function as a result of radiation treatment for head and neck cancer. Whether salivary glands are irreparably damaged by disease or by radiation for head and neck cancer, the resulting loss of saliva flow markedly impairs quality of life. Without adequate saliva, people may experience difficulty speaking, chewing and swallowing. They may also experience rampant tooth decay, mucosal infections such as candidiasis, loss of taste, and considerable oral discomfort. Currently, there is no effective treatment for this condition. New treatments such as the potential use of adult and embryonic stem cells for regeneration of salivary gland tissue and function, and gene transfer technology may offer new hope for patients with salivary gland damage or disorders.

Craniofacial Birth Defects or Syndromes

Craniofacial defects are among the most common of all birth defects. Birth defects and developmental disorders can be isolated or may be part of complex hereditary diseases or syndromes. Cleft lip and cleft palate are among the more common birth defects in the U.S., occurring in about 1 to 2 of 1,000 births. Numerous other disorders with oral and craniofacial manifestations such as ectodermal dysplasias, Treacher Collins syndrome, Apert's syndrome, and Waardenburg syndrome, while considerably more rare than cleft lip/cleft palate, also have serious lifetime functional, esthetic and social consequences. These disorders are often devastating to parents and children alike. Surgery, dental care, psychological counseling, and rehabilitation may help ameliorate the problems, but often at a great cost and over many years. In fact, the lifetime cost of treating the children born each year with cleft lip or cleft palate is estimated to be $697 million.[5] Exciting advances in genetic studies are shedding light on genes that are important in forming the head and face, how these genes function and how they interact with environmental, nutritional and behavioral factors. Such information may ultimately provide the information necessary for prenatal diagnosis, the development of methods to prevent craniofacial birth defects, and the basis for developing better treatments. The development of biocompatible naturally derived materials and biodegradable scaffolds offer new hope for the treatment of defects resulting from craniofacial birth defects or syndromes.

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5 CDC. Economic costs of birth defects and cerebral palsy – United States, 1992. MMWR 1992;44(no . 37). http://www.cdc.gov/mmwr/preview/mmwrhtml/00038946.htm

Infrastructure Needs

Research and Professional Workforce

Adequately trained professionals are the lifeblood of dental education, practice and research. Oral health researchers, educators, and practitioners should reflect the diversity of America and have the broad mix of skills needed to address complex oral, dental and craniofacial diseases and conditions. However, the research and professional dental workforce does not adequately represent the composition of the U.S. population.   Data show that underrepresented minority dentists play a large role in increasing access to underserved and minority populations, can influence other health professionals to be more culturally sensitive, and serve as powerful role models to other minorities and to would-be educators or researchers. The challenges here include addressing the inadequate number of underrepresented minorities in all aspects of dentistry, addressing the critical shortage of clinical researchers, and developing researchers who will be familiar with knowledge and methods from a variety of disciplines. In terms of diversity, the magnitude of the challenge is perhaps best expressed by looking at the "pipeline," or the number of underrepresented minority dentists and students in U.S. dental schools. African Americans account for 12.9 percent of the general population but only 2.2 percent of active dentists and less than 5 percent of students enrolled in dental schools. Hispanics comprise 12.5 percent of the population but only 2.8 percent of active dentists and 5.3 percent of enrolled dental students in 1999-2000. Most troubling perhaps is the 15 percent decline in the number of underrepresented minority first-year students in dental schools since 1990[6]. While enrollment of women in dental schools is increasing, they are underrepresented in academics and research. Sustained efforts, new partnerships, and innovative and flexible programs are needed to ensure a competent, diverse and robust oral health research workforce. These critical national needs are identified in the Surgeon General's report on oral health (http://www.nidcr.nih.gov/sgr/oralhealth.asp) and in the National Oral Health Call to Action http://www.nidcr.nih.gov/sgr/nationalcalltoaction.htm

Developing and Enhancing Key Research Infrastructure

Strong research-oriented academic environments are needed to develop the intellectual talent for research, and to enable existing investigators to acquire and expand their skills in new areas of science. Oral health research can be carried out in a number of settings including dental schools, different components of academic health centers, hospitals and independent research institutions. The capacity of dental schools to conduct research and to serve as training grounds for future investigators is key to the future of clinical and applied oral health research. However, major barriers must be overcome. These include a critical shortage of faculty, a lack of integration between the basic and clinical sciences in pre-doctoral programs, inadequate incorporation of research into the dental curriculum, and financial shortfalls. Research, while exceptionally strong in some dental schools, is almost non-existent in others. Between 50 to 60 percent of NIDCR research support is concentrated in ten of the 55 U.S. dental schools. Substantial

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6 Valachovic RW, Weaver RG, Sinkford JC, Haden NK. Trends in dentistry and dental education. Journal of Dental Education: June 2001; 65(6):539-561.

investments will be needed to bolster U.S. dental schools' research infrastructure and to ensure a workforce that is adequate both in numbers and in its ability to address the changing scientific needs.

Further advancements in science will require continued developments in technology, computer power, and analytic methods. New large databases and mathematical methods will be required to catalogue, organize and understand vast amounts of information generated from the sequence of genes or proteins. The *NIDCR Scientific Expert Panel on Genomics and Proteomics* (http://www.nidcr.nih.gov/research/genomics82002.asp) highlighted the need for significant development in bioinformatics, and for creating "new algorithms to analyze and interpret the data and ways to visualize and present genomic information to researchers." The panel also suggested a number of strategies that NIDCR could pursue to make resources available to researchers and share the cost of expensive technology development.

Strategic Initiatives

In the section that follows, the Strategic Plan identifies three major areas to achieve the NIDCR mission: 1) research opportunities, 2) research capacity, and 3) communications. Two crosscutting areas -- health disparities and data acquisition and analysis-- are also identified. The initiatives, goals, and objectives described are interrelated and in some cases inextricably linked. However, they are presented under discrete categories for ease of planning and developing the action steps needed to implement them, and for tracking and evaluating our success in achieving them.

Clearly, these goals and objectives do not encompass the entire range of NIDCR-supported research that collectively contributes to our overall mission. Nonetheless they capture the areas that offer the most significant scientific promise in the near-term.

RESEARCH OPPORTUNITIES

Goal 1. Advance the understanding of the normal and abnormal processes underlying oral, dental and craniofacial diseases and disorders through the development and application of new technology and research tools.

Genetics, Structure and Function of Oral Tissues and Cells

Subgoal A: Support studies that address the genome, the transcriptome and the proteome of dental, oral and craniofacial diseases and disorders.

> Objective 1: Identify genes, genetic and protein variations and molecular pathways associated with susceptibility to craniofacial disorders, malignancies and oral infectious diseases.

> Objective 2: Further the understanding of gene and protein networks and signaling mechanisms associated with oral, dental and craniofacial diseases and disorders.

> Objective 3: Identify human genetic variations for possible genetic contributions to complex disease in populations experiencing oral health disparities.

Communication Between and Within Cells

Subgoal B: Support research to understand the molecular mechanisms of oral cell cycle regulation related to the development and progression of oral, dental and craniofacial diseases and disorders.

> Objective 4: Use biochemical, genomic and proteomic approaches to study cell signaling systems and pathways in the oral cells, tissues and organs of the developing and growing craniofacial complex.

Objective 5: Use biochemical, genomic and proteomic approaches to study prokaryotic-eukaryotic cell signaling systems and pathways, as well as prokaryotic-prokaryotic signaling within maturing microbial biofilms (dental plaque).

Objective 6: Examine the molecular alterations responsible for head and neck cancer development, including alteration of genes and proteins involved in cell cycle regulation, and regulatory networks controlling cell cycle progression and cell survival or death.

Microbial Pathogenesis and Immunology

Subgoal C: Support research on the structural and functional properties of biofilms and biofilm-mediated diseases.

Objective 7: Support research to further understand the normal microbial ecology of biofilms in the oral environment, including biochemistry, physiology and taxonomy of oral bacteria.

Objective 8: Identify and characterize microbial products involved in virulence and disease pathogenesis and interactions in mixed microbial infections.

Objective 9: Encourage research on the immunobiology of oral infectious diseases, cancer, autoimmunity, inflammation and microbial commensalism.

Gene and Environment Interactions

Subgoal D: Support research to understand gene-disease associations, genes and gene products in normal craniofacial development, and gene-environment interactions in oral, dental and craniofacial diseases and disorders and birth defects.

Objective 10: Investigate complex multifactorial disorders of the oral and craniofacial structures that arise from the interaction of several genes and environmental components.

Objective 11: Identify genetic, nutritional, and environmental risk factors that influence susceptibility, severity or progression of oral, dental and craniofacial diseases and disorders and that affect the response to treatment.

Objective 12: Foster studies to identify environmental triggers that precipitate diseases with a specific genetic context.

Pharmacogenetics

Subgoal E: Understand individual variability of responses to drugs that are used for the treatment of dental, oral, and craniofacial diseases and disorders to develop highly effective, low-toxicity drugs or agents.

Objective 13: Establish gene expression profiles that control or regulate drug metabolism and response in different populations to predict and optimize efficacy of agents used in the treatment of oral and craniofacial diseases and disorders.

Objective 14: Identify biomarkers for both phenotype and genotype of different subgroups of the population that have various drug responses.

Objective 15: Use biomarkers to monitor and direct clinical treatment including predicting drug response, optimizing efficacy, and preventing or reducing side effects and toxicity.

Biocompatible Materials

Subgoal F: Support and encourage research for the design and development of "living" materials for the repair and regeneration of orofacial tissues and organs based on advances made in biological systems research.

Objective 16: Elucidate the mechanism leading to the formation of mineralized structures through the support of biomimetic studies.

Objective 17: Encourage the use of human adult and embryonic stem cells and tissue engineering approaches for the repair and replacement of orofacial tissues and organs.

Objective 18: Enhance research on the interface between materials and tissues, including the development of methods to access biocompatibility and prevent rejection.

Goal 2. Develop new or improved approaches and methods for preventing, diagnosing, treating and eventually eliminating oral, dental and craniofacial diseases and disorders.

Development and Validation of Biomarkers

Subgoal A: Develop and validate biochemical, cellular, physiologic, or genetic biomarkers that can be used to predict risk, aid in early diagnosis, and assess disease progression and response to treatment of chronic and disabling oral diseases and disorders.

Objective 1: Utilize genomic and proteomic approaches to screen for novel biochemical, cellular or genetic markers associated with disease susceptibility, disease progression or treatment efficacy.

Objective 2: Conduct early clinical and epidemiologic studies to evaluate the predictive accuracy, sensitivity and specificity of known and newly identified potential biomarkers.

Clinical Research and Clinical Trials

Subgoal B: Expand and enhance the Institute's clinical research and clinical trials program to identify effective preventive, diagnostic and treatment approaches for oral, dental and craniofacial diseases and disorders.

> Objective 3: Identify and validate novel and existing methods for early diagnosis and the identification of risk factors for diseases such as dental caries, periodontal diseases, oral cancer, and conditions such as chronic orofacial pain

> Objective 4: Identify and evaluate the efficacy of novel and existing strategies for the prevention, management and treatment of oral infectious diseases such as dental caries and periodontal diseases, and oral and pharyngeal cancer, particularly in populations that are at high-risk.

> Objective 5: Define the relationship between oral infectious diseases and systemic diseases and conditions such as cardiovascular disease, preterm birth, diabetes, and pulmonary disease.

> Objective 6: Identify and evaluate the efficacy of existing and new prevention, management and treatment strategies for chronic conditions including orofacial pain resulting from temporomandibular muscle and joint disorders.

> Objective 7: Identify and evaluate the efficacy of novel and existing methods for preventing, managing and treating mucosal infections such as oral candidiasis, herpes simplex, and conditions such as mucositis and aphthous ulcers, especially in patients with AIDS or immune dysfunction secondary to cancer therapy.

> Objective 8: Develop and evaluate new technologies including gene transfer therapy, drugs and biologics for treating or alleviating the oral symptoms of xerostomia and Sjögren's syndrome.

> Objective 9: Determine the relative safety, efficacy and effectiveness of new and commonly used dental restorative materials.

Population-Based, Genetics, Social and Behavioral Research

Subgoal C: Support studies that expand and enhance the integration of population-based, genetic, social, and behavioral research.

> Objective 10: Further the understanding of how genetic, biologic, social, behavioral and environmental factors interact to contribute to disease susceptibility or resistance in diseases such as head and neck cancer, caries, periodontal diseases, and conditions such as craniofacial defects or syndromes, birth defects, and chronic and disabling pain.

Objective 11: Elucidate the mechanisms involved in the regulation of gene expression by other variables such as other genes, lifestyle, nutrition and the environment.

Objective 12: Assess and bridge gaps in the knowledge, opinions and practices of the public, educators and health care professionals about oral diseases and their prevention.

RESEARCH CAPACITY

Goal 3. Ensure an adequate and well-trained research workforce that reflects the current and emerging needs of science and includes sufficient numbers of investigators from diverse disciplines and from underrepresented groups.

Objective 1: Increase and diversify the number of individuals engaged in oral, dental, and craniofacial research through innovative and flexible research training and career development programs at all stages of career development.

Objective 2: Increase the number of investigators from groups that are underrepresented in oral, dental and craniofacial research, including individuals from racial and ethnic minorities or from disadvantaged backgrounds.

Objective 3: Increase the number of researchers from disciplines such as bioengineering, chemistry, computer science, informatics, imaging, biostatistics, genomics, neuroscience, behavioral sciences and epidemiology working in areas that are relevant to the NIDCR mission.

Objective 4: Increase the number of investigators having specialized skills and knowledge in the design, conduct, and evaluation of clinical research and clinical trials in areas that are relevant to the NIDCR mission.

Objective 5: Increase the number of oral health professionals working in oral health research and interdisciplinary research relevant to the NIDCR mission.

Goal 4. Support research infrastructure and enhance the development of new approaches for conducting inter- and cross-disciplinary research.

Objective 1: Expand NIDCR's collaborations with public and private research organizations, academia and industry to maximize resources and develop needed technology both nationally and internationally.

Objective 2: Enhance the research capacity of U.S. academic dental institutions and their ability to address changing scientific needs through improvements in the research infrastructure, including research personnel and equipment.

COMMUNICATION

As defined in Healthy People 2010, health communication "encompasses the study and use of communication strategies to inform and influence individual and community decisions to enhance health." [7] Consistent with that definition, NIDCR's communication efforts are meant to ensure that target audiences become informed, change behavior, and make decisions in a manner that will improve clinical care and health outcomes. Target audiences are broadly defined to include health care providers, consumers, the research community, and other groups such as educators, policymakers, industry, and the media. One of the main challenges of our health communication efforts is to find the most effective ways to communicate and disseminate health information, clinical information, and research findings to target audiences.

Goal 5. Enhance the translation of research results into clinical practice and communicate science-based health information to ensure that NIDCR-supported research leads to improved health.

Objective 1: Communicate information to dentists, dental hygienists, educators and researchers that could be used to improve the prevention, diagnosis, management, and treatment of craniofacial, oral and dental diseases.

Objective 2: Communicate information to health care providers and researchers in other disciplines that could be used to improve the prevention, diagnosis, management and treatment of craniofacial, oral and dental diseases.

Objective 3: Increase the general public's knowledge of research findings with implications for improving oral health, in particular among parents, and high-risk, special needs and underserved populations.

Objective 4: Ensure that science-based information is integrated into health communication and education programs for high-risk and underserved populations as well as the general public.

Objective 5: Expand outreach efforts to populations with limited oral health literacy and disseminate information that is in plain language and is culturally sensitive, including languages other than English.

Objective 6: Support communications research to identify optimal strategies and tools for reaching various audiences and for disseminating research findings so they can be adopted widely by all who need it.

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7 http://www.healthypeople.gov/Document/HTML/Volume1/11HealthCom.htm

CROSSCUTTING AREAS

Most NIDCR research areas and programs are complementary, interdependent and cut across programmatic and organizational boundaries. Indeed, it would be difficult to identify many scientific areas within NIDCR's mission that are not interrelated in some fashion. We have singled out health disparities and data acquisition and analysis as major crosscutting areas because of their far-reaching implications and contribution to NIDCR's mission:

HEALTH DISPARITIES

To address the persistent inequalities in oral health status among U.S. population subgroups, NIDCR has developed a *Plan to Eliminate Oral, Dental and Craniofacial Health Disparities* (http://www.nidcr.nih.gov/research/healthdisp/hdplan.pdf). The objectives related to health disparities in this Strategic Plan, stated below, provide the foundation for the initiatives and detailed implementation strategies to address the persistent inequalities in the oral health of the Nation within the NIDCR Health Disparities Plan.

We are interpreting health disparities to refer to the diminished oral health status of population subgroups defined by demographic factors such as age and socioeconomic status, geography, disability status, behavioral lifestyles, gender, racial or ethnic identity. There are at least four interdependent and interacting variables that are key determinants of health, namely, the unique biology of an individual, behavioral lifestyles, environment, and the organization and financing of health care. Accordingly, addressing health disparities requires more than an understanding of the biology and lifestyle of an individual. We also must take into account the environment where the individual lives, works, and plays as well as the larger social and cultural environment. Critical to the development of effective interventions to reduce health disparities across the lifespan is the inclusion of individuals from all racial/ethnic, gender, and age groups in clinical trials. In addition, using evidence-based approaches for translating science into practice is key to ensure that NIDCR research benefits the people with the greatest needs.

Goal 6. Eliminate health disparities in oral, dental and craniofacial diseases and conditions among underserved populations and groups.

Objective 1: Encourage interdisciplinary research to understand and address the multiple factors underlying oral health disparities among U.S. subgroups.

Objective 2: Increase the enrollment and retention of women, children, racial and ethnic minorities and other underrepresented groups in studies conducted at NIDCR and in NIDCR-funded clinical research.

Objective 3: Ensure the integration of science-based oral health information into health communication and education programs for populations with high needs (racial/ethnic minorities, individuals with disabilities, and other susceptible populations.

DATA ACQUISITION AND ANALYSIS

Documenting the full extent and magnitude of the many oral, dental and craniofacial diseases and conditions is critically important. Given the wide implications and significant impact of the many oral and craniofacial conditions and diseases, we must continue to determine their prevalence, incidence, and co-morbidity and their effect on physical health, quality of life, and social and economic impact. However, reliable measures and data are lacking for common diseases in selected populations and for many less widespread conditions in the U.S. population in general. Baseline and trend data are needed for demonstrating progress in improving the nation's oral health and to provide a key foundation for research efforts to improve oral health.

The changing U.S. demographic profile brings additional responsibility to collect information on the oral health of many more and increasingly diverse population subgroups. Adequate and reliable national data are lacking for common conditions for many racial and ethnic minority groups and other vulnerable populations, and for less prevalent oral, dental and craniofacial conditions in the U.S. population. At the same time, there is a need for continued assessment and revision of survey methods and designs, enhancing the capacity for longitudinal follow-up of participants while maintaining privacy, and increasing the inter-relationship among surveys. Data acquisition and analysis, particularly among unique population subgroups, will benefit from collaborations with other Federal agencies as well as with patient and community groups, state and local-based organizations, foundations, industry and others in the private sector.

Goal 7. Ensure the adequacy of systems to document and monitor the extent and impact of oral, dental and craniofacial diseases, disorders and conditions.

Objective 1: Identify and validate new methods to measure and document oral, dental and craniofacial diseases, disorders, conditions, risk factors and markers in population-based studies.

Objective 2: Assess the social, educational and economic impact of oral, dental and craniofacial diseases, disorders, conditions, and birth defects.

Objective 3: Assess and monitor changes in disease status, access to care, and the utilization of professional, community and self-care oral health services.

NIDCR Planning and Priority Setting

The areas NIDCR chooses to emphasize in its solicited extramural and intramural research are selected through long-term and short-term science planning. Planning activities develop and use information from a number of different sources and consult a broad range of key external stakeholders. These individuals and organizations include:

- The extramural scientific community, including both individual researchers and professional societies;
- Patient organizations and voluntary health associations that may deal with the NIDCR directly or indirectly through Congress and the public media;
- The Congress and the Administration;
- The National Advisory Dental and Craniofacial Research Council and the NIDCR Board of Scientific Counselors;
- Other NIH Institutes, program offices, and other federal agencies;
- Industry, and;
- Ad hoc advisory groups.

In addition, the Institute relies on input gleaned through a variety of conferences and workshops. These include collaborative, trans-NIH scientific conferences and workshops that constitute reviews of emerging scientific opportunities, public health concerns, or state-of-the-science assessments, many of which outline specific areas of research that should be the target of future initiatives or activities. Consensus development conferences also may be held. Finally, NIDCR's planning and priority setting occurs in a larger context, including areas of emphasis determined by Congress, the Department of Health and Human Services, and NIH; a highly refined peer review process; the annual congressional appropriation; and other factors.

Evaluation research is an important tool to assist NIDCR with planning, management, and accountability. At the Institute, evaluation is defined as objective, systematic research that uses scientific criteria and analytical techniques to measure the effectiveness of program implementation and/or the impact of program results. Comprehensive evaluation projects are conducted for key disease-based and crosscutting areas of NIDCR's portfolio of research and activities. Areas are selected for evaluation on the basis of several criteria, including the prevalence and impact of related diseases or conditions, NIDCR resources, the current state of the science in that area, and the recommendations of Council and other advisory groups.

Acknowledgments

This plan is a collaborative effort that included input from many individuals and organizations – the Institute's senior staff and National Advisory Dental and Craniofacial Research Council (NADCRC), NIDCR staff, researchers, academics, professional organizations, public health communities, patient groups, Federal committees and the public. We are grateful to all who contributed to the development of the plan, and to the many outside organizations and individuals who provided comments on the draft document. In addition to the public comments that were invited through the NIDCR website, we convened a meeting of outside constituents to receive their input. This stakeholders meeting included representatives of professional dental organizations, including research, education, organized dentistry, dental specialties, patient advocates and industry. A special session was also held during the May meeting of the NIDCR Patient Advocates Forum to invite their input and comments, and presentations were made to the Associate Deans for Research during the 2003 Annual Session of the American Association for Dental Research and to the US Public Health Service Oral Health Coordinating Committee.

Special thanks to Dr. Isabel Garcia who led this effort, to Dr. Frank Macrina, the National Advisory Council representative for the project and who chaired the stakeholders meeting, to the individuals who assisted during that meeting -- the breakout group facilitators Dr. Skip Collins, Dr. Rick Valachovic, and Mrs. Kathy Hammitt, and the recorders Dr. Rob Selwitz, Dr. Kevin Hardwick, Ms. Karina Boehm, Ms. Ellie Murcia, Drs. Kathy Hayes and Wande Morgan. Our thanks to Ms. Jody Dove, Ms. Susan Johnson, and Dr. Mike Barnett, for their helpful suggestions and editorial comments.

In 2001, the Institute established an internal study group with representatives from all of its Divisions to identify broad areas of importance to NIDCR's long-range scientific agenda. This group identified three main areas of interest: genomics and proteomics; repair and regeneration of oral, dental and craniofacial tissues; and clinical research. Expert panels were then convened during the summer and fall of 2002 on each of these three topics to assist the Institute in identifying areas of scientific opportunity, and to catalogue, in general terms, the resources required to successfully address them. An additional expert panel on research training and career development was held to build upon the previous work carried out by the 1999 *NIDCR Blue Ribbon Panel on Research Training and Career Development* http://www.nidcr.nih.gov/research/blueribbon/summary.pdf The reports of these expert panels along with other resources were used to develop specific research objectives for the updated plan. The objectives and activities set within the plan go hand in hand with the overall Institute's planning, budget, and evaluation activities and address research needs identified in *Oral Health in America: A Report of the Surgeon General,* the oral health objectives of *Healthy People 2010,* and the *National Oral Health Call to Action*.

I. NIDCR and Public Health Service

National Advisory Dental and Craniofacial Research Council

NIDCR Board of Scientific Counselors

NIDCR Patient Advocates Forum

US Public Health Service Oral Health Coordinating Committee

II. Outside Organizations Represented at Stakeholders Meeting

American Academy of Pediatric Dentistry

American Academy of Periodontology

American Association for Dental Research

American Association of Endodontics

American Association of Public Health Dentistry

American College of Prosthodontics

American Dental Association

American Dental Education Association

American Dental Hygienists' Association

American Dental Trade Association

Colgate Palmolive Company

Dental Manufacturers of America

Friends of the National Institute of Dental and Craniofacial Research

Hispanic Dental Association

National Dental Association

National Foundation for Ectodermal Dysplasias

Oral Microbiology and Immunology

Sjögren's Syndrome Foundation

The Paget Foundation

The Procter and Gamble Company

III.   Organizations Represented at NIDCR Patient Advocates Forum

About Face USA

Cleft Advocate, Inc

Cleft Palate Foundation

FACES: The National Craniofacial Association

Jaw Joints & Allied Musculo-Skeletal Disorders Foundation, Inc.

Juvenile Diabetes Research Foundation

National Foundation for Ectodermal Dysplasias

National Healthy Mothers, Healthy Babies Coalition

National Marfan Foundation

Osteogenesis Imperfecta Foundation

Scleroderma Foundation

Sjogren's Syndrome Foundation

Special Olympics University

The Paget Foundatoin

The TMJ Association

Trigemial Neuralgia Association

Wide Smiles

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NIDCR Expert Panel on Scientific Opportunities. Panel on the Repair and Regeneration of Oral, Dental and Craniofacial Tissues. http://www.nidcr.nih.gov/research/panelReportTissues.asp

NIDCR Expert Panel on Scientific Opportunities: Training Expert Panel http://www.nidcr.nih.gov/funding/training_expert_panel82002.asp

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