

however, has seen a gain of 110 days in average life expectancy (Rowe and Kahn 1998). Life expectancy at birth in the United States has increased from 47 years in 1900 to approximately 76 years today. While the entire population of the United States has tripled since 1900, the absolute number of older persons, currently 33 million, has increased elevenfold (Finch and Pike 1996, Rowe and Kahn 1998, p. 4). The U.S. population is 270 million and will reach 300 million in the next few decades. The Earth's population doubled by 1950, doubled again by 1975, and currently is 6 billion.

### Health Improvement

Measures such as improved sanitation and housing, prenatal care, immunizations, health education and promotion, community water fluoridation, and dental sealants have greatly improved oral health for the majority of the population. Advances in science and technology, health professional education, the science of public health and clinical practice, and the health literacy of the public will continue to improve the health and well-being of Americans in the coming years (Kevles 1997, Schwartz 1998). Ever larger numbers of senior adults expect to retain a full or nearly complete dentition and to live well into their 70s, 80s, and 90s free of pain and discomfort (Slavkin 1997a).

### DIVERSITY OF DISEASES AND PATIENTS

Those seeking care in the decades ahead will present with a wide range of diseases and disorders, unevenly distributed across populations. The very youngest patients include children with complex hereditary or congenital craniofacial defects in need of expert multidisciplinary teams to repair and restore form and function. Early childhood caries, one of the most severe forms of the disease, is especially prevalent among poor children in some racial/ethnic groups in America, such as American Indians and Mexican Americans. Young adults are particularly vulnerable to unintentional and intentional craniofacial injuries. Middle-aged and older generations typically experience chronic diseases affecting the heart or lungs as well as cancers, diabetes, and the various degenerative diseases of joints and bones and the nervous system, all of which may affect or be affected by oral diseases and their treatments.

### TRANSFORMING TREATMENTS

The cultural movements that are changing the human condition will likely transform treatments for many of the complex disorders just described. The instrumentation used to detect subtle genetic variations in each of the 100,000 genes in the human genome will inexorably reveal which gene or genes are defective in hundreds of inherited and acquired craniofacial diseases or syndromes. On the horizon are promotion measures to enhance health and eliminate exposures to teratogens, as well as surgical techniques to correct the defects *in utero*, obviating the need for costly multiple surgeries and rehabilitation programs for affected children.

We are entering the "golden age of molecular oral health" with gene-based diagnostics, therapeutics, and biomaterials. Risk assessment for disease will be based in part on understanding the genetic variations that affect resistance or susceptibility, but also will be determined in part by environmental factors, socioeconomic status, personal behaviors, and lifestyle. The risk for early childhood caries is likely to be determined by a combination of all these factors, as well as cultural beliefs and practices within some populations. Elimination of all infections, whether in the oral cavity or elsewhere, will be seen as a critical part of health promotion.

Prevention of injuries will call for approaches that are both culturally and age sensitive, in addition to the coordinated efforts of policymakers and legislators to mandate protective gear in sports and other safety measures when necessary.

Gene therapy will be applied to treat oral and pharyngeal cancers and also will be used for the oral and systemic delivery of endogenous and synthetic molecules to treat salivary gland disorders, oral infections, and systemic disease. Highly specific drugs will be developed for the management of chronic facial pain such as trigeminal neuralgia and Bell's palsy.

Should additional evidence in the early years of the twenty-first century further indicate that oral infections actually cause some cases of heart disease, pulmonary disease, and stroke, or trigger the birth of premature, low-birth-weight babies, treatment approaches will be radically altered.

### TRANSFORMING HEALTH PROFESSIONAL EDUCATION

The scientific and technological bases of dentistry, medicine, nursing, and pharmacy are expanding rapidly in parallel with the changing demographics of

the nation, the public's expectations for an enhanced quality of life, and changes in the management and financing of health care. Health professional schools, often organized around academic health science centers, are responding to these challenges and opportunities.

Students and clinicians alike need to be prepared to adopt evidence-based health care. Today and tomorrow, students must be well versed in epidemiology, biometry, bioinformatics, molecular biology, bioengineering, and much more. In addition, they must be prepared to adopt and implement new preventive strategies and comprehensive and molecular-based diagnostics and therapeutics; to support cost-effective community-based health programs; and to anticipate all the challenges that promotion of health entails. Clinical science or scientific evidence in the new millennium will continue to evolve in molecular dentistry and medicine with attendant opportunities for addressing the social, legal, and ethical implications. We must prepare clinicians for the nuances and complexities of modern clinical research-based results.

The previous chapters of this report provide the documentation that can be used to assess health professional education. Major progress in health promotion, disease prevention, diagnostics, therapy and therapeutics, and the socioeconomic and behavioral factors that influence oral, dental, and craniofacial health will further contribute to the transformation of health professional education.

### **TRANSFORMING HEALTH CARE**

We are currently witnessing a significant transformation in the financing and management of health care, which is affecting all the health specialties. Care providers are assuming new responsibilities and functions, and changing employment patterns. Traditionally, the management of health care has been centered on the providers of services and hospitals. Recently, the center has enlarged to include additional marketplace stakeholders, the purchasers of health care and health care plans, and increasingly all segments of society. The interactions among all these participants will shape health and health care for the foreseeable future.

Risk assessment models are also being developed and used to design treatment options tailored to communities and to individual patients. Increased use of information technology, greater efforts to conduct community needs assessments, and greater emphasis on enhanced quality of life expectations of

patients, families, and communities are also in evidence (USDHHS 2000).

The responsibility for oral and craniofacial care involves all health professionals, so coordinated care delivery and reimbursement will be critical. Evidence-based systematic assessments and guidelines will contribute to clinical and public health decision making. In addition, the linkage between health care professions and public health and social service activities will need to be strengthened.

These trends are complemented by greater understanding of the psychosocial-behavioral aspects of oral diseases and disorders. These advances will continue to influence the nation's capacity to address the breadth and depth of diseases and conditions affecting oral health across the life span and their relationship to general health and well-being.

Access to the Internet and increased health and science reporting in print and broadcast media have created a more knowledgeable public motivated to understand the value of healthy choices. However, increasing numbers of patients are also questioning traditional practices and seeking alternative and complementary approaches.

### **ORAL HEALTH—NOT YET FOR ALL**

Demographers predict that by 2050 there will be no single racial/ethnic majority in the United States. Rather, we will become an increasingly diverse nation with diverse patterns of disease and levels of health. This is especially evident for African American, Latino, Asian and Pacific Islander, and American Indian communities (Pamuk et al. 1998). Disparities in educational advancement, job opportunities, income and wealth, housing and neighborhood characteristics, health access and status, and involvement in the criminal justice system for various subpopulations will remain unless steps are taken to reverse the trends (Council of Economic Advisers 1998).

The proportion of school-aged children who are caries-free in their permanent teeth has more than doubled during the last 20 years. However, in states such as California, Texas, Louisiana, Alabama, Florida, and Georgia the trends are different; fewer than one third of the children are caries-free in their permanent dentition.

One attempt to come to the aid of poor children is the State Children's Health Insurance Program (SCHIP), federal legislation designed to help individual states meet the health needs of children (Council of Economic Advisers 1998, NRC 1998). As of 1998, more than 11 million children in America—1 in 7

children—are estimated to be uninsured. Most of these children live in families with working parents who have jobs that do not provide health insurance and who are unable to purchase health care insurance (NRC 1998). Nationally, 1 in 6 African American children and 1 in 4 Hispanic children are uninsured, compared with 1 in 10 white children (Council of Economic Advisers 1998, NRC 1998). This limited health care access is particularly significant in relation to oral health.

### HOPE FROM SCIENCE AND TECHNOLOGY

The biological and biotechnology revolutions will accelerate, inspiring theory building and new models of miniaturization and speed that can be applied to improve oral health. The Human Genome Project will be completed no later than 2003. The entire human genetic lexicon will be accessible through the Internet. To date, more than several hundred mutated craniofacial regulatory and structural genes have been found to cause abnormal formation of oral, dental, and craniofacial tissues and structures.

In addition, the genomes of many significant viruses, bacteria, yeast, parasites, plants, and animals are currently being deciphered, and these are revolutionizing how we think about biology and human diseases (Bodmer and McKie 1995, Chambers 1995, Collins et al. 1998). At present, research is under way to decipher the genetic lexicon of 60 microbes, 6 of which are important oral pathogenic bacteria or fungi. The evolution of this knowledge will yield innovations in areas from clinical prevention to drug and biomaterials discovery. Figure 11.1 presents a

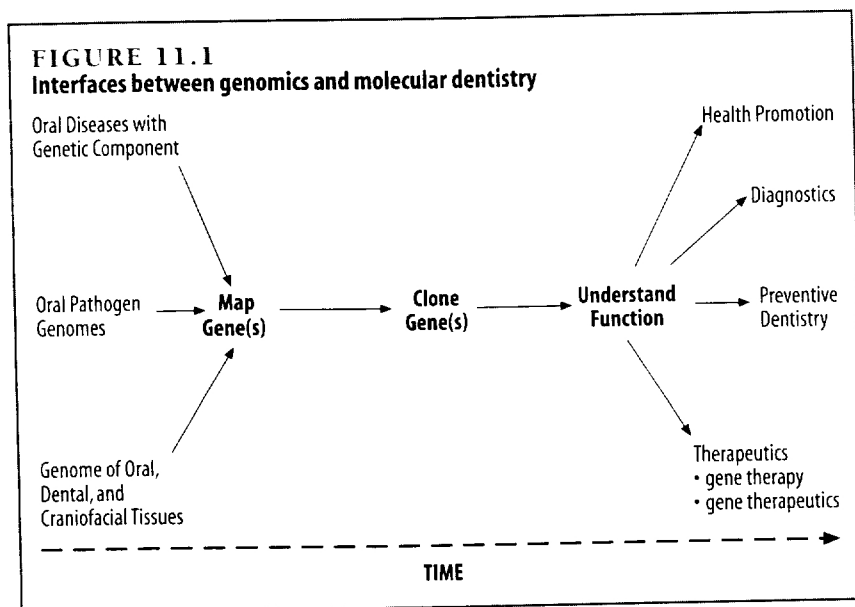
model of the possible interface between genomics and molecular dentistry.

Perhaps with the sole exception of trauma, all human diseases have a genetic component. Genetic dentistry and medicine are based on the paradigm that changes or mutations in individual nucleotides within genes or alleles result in variations or polymorphisms. These mutations are either inherited or acquired after birth. For example, inherited mutations in the amelogenin gene located on the human X (and Y) chromosome can produce X-linked dominant or recessive amelogenesis imperfecta, a painful disease characterized by defective tooth enamel (Backman 1997), and mutations in the fibroblast growth factor receptor 2 gene can produce serious craniofacial birth defects such as Crouzon's disease and other syndromes with premature fusion of cranial bones (craniosynostosis) (Cohen 1997). Mutations in a number of transcription factors that regulate development produce other craniofacial syndromes (Slavkin 1999).

The human genome contains approximately 100,000 genes or alleles. The genome consists of 3 billion nucleotides or bases. Mutations changing one or more bases, in one or more genes, can result in diseases or disorders. Many environmental factors termed mutagens, carcinogens, or teratogens can cause mutations in one or more genes resulting in human disease such as neoplastic diseases. The completion of the Human Genome Project in the next 2 years will afford an unprecedented opportunity to advance our understanding of inherited as well as acquired human diseases and disorders.

Scientific discoveries are rapidly defining single-gene mutations, mapping these individual genes in their precise positions on each of the 46 human chromosomes. These findings are being used to diagnose inherited and acquired clinical phenotypes as well as "at-risk populations" throughout the human life span.

These remarkable advances in human molecular genetics are identifying candidate genes for developing targeted gene-mediated therapeutic approaches to many oral health diseases, ranging 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 suffering from xerostomia.



Gene mutations also define the virulence of microbes (viruses, bacteria, yeasts, and parasites), as well as the fidelity of the human immune system. Microbial as well as human genes are extremely sensitive to environmental stress and can and do mutate, resulting in antibiotic resistance. The genetic variance within microbial genomes such as the genome of the yeast *Candida albicans* may be closely aligned with the host changes associated with immunologically compromised patients. The HIV viral genome is another particularly useful model for considering viral mutation frequency during pathogenesis (Slavkin 1996a). These discoveries provide the foundations for gene-based diagnostics for disease detection; therapeutic drug development; and individual predictors of drug response during the management of chronic facial pain, osteoarthritis as related to temporomandibular joint disease, and osteoporosis associated with periodontal diseases.

We are beginning to understand that polymorphisms (variations) in multiple genes confer susceptibility or resistance to chronic and disabling diseases and disorders such as osteoporosis, periodontal diseases, and temporomandibular disorders (Slavkin 1997b). In these examples, multiple genes and multiple gene-environment and gene-gene interactions are associated with the molecular etiology and pathophysiology of the disease process.

The function of most genes must inevitably be studied and understood at the level of their encoded proteins and protein-protein interactions, for these are the biologically active players of life. An enormous number of genes encode protein information that is highly conserved, that is, found in almost identical form in such diverse organisms as fruit flies and humans. Further scrutiny and analysis have determined that specific motifs encoded in larger domains of each protein serve as the "business" portion of the protein, binding to a cell surface, aggregating with other proteins, serving to catalyze a chemical reaction, binding to zinc or calcium ions, or serving other crucial functions in cell biology. The functional motifs are also being characterized in terms of structural biology. The scientific and educational communities are building large databases and then mining this information by using sophisticated information technology.

These genomic databases provide remarkable opportunities for the identification, design, and production of a new generation of biomarkers for diagnostics; innovative biomaterials for repair and regeneration; and the development of highly sensitive and specific drugs and vaccines to improve the health of all people (Baum et al. 1998, Slavkin 1996b,c,

1997a). Genomics has emerged as a major driver to realign academic, industry, and government science and technology to foster health, pharmaceutical, biotechnology, agricultural, food, chemical, environmental, energy, and computer science applications (Kaku 1997, Rifkin 1998). Many of these applications profoundly influence oral health (Slavkin 1996d, 1998a,b).

This epic period will also herald the advent of "biochemistry on a chip," used in connection with body fluids such as saliva, cells, and tissues to diagnose diseases and disorders. The so-called chip technology will enable identification, quantitation, and complex analyses on surfaces no larger than one-centimeter square coupled to laser optical reader systems and computer-assisted informatics. Prototypes are already available to be tested against samples of saliva, cervical fluids, buccal mucosal cells, and blood (Slavkin 1998b). This technology should revolutionize saliva-based diagnostics and prognostics in oral health (Table 11.1). Major progress is also anticipated in bioengineering through nanotechnology, miniaturization, and the innovations of design and fabrication of biomaterials. Anticipated advances include the repair and regeneration of cartilage, bone, muscle, nerve, salivary glands and saliva, and teeth (cementum, dentin, enamel, and periodontal ligament) (Slavkin 1996d, 1998a,b).

Additional scientific progress in the neurosciences will have broad implications for the diagnosis and treatment of diseases and disorders of the craniofacial complex including neuromuscular-related conditions (e.g., facial and dental trauma, bruxism, autism, Mobius syndrome, Bell's palsy, temporomandibular joint disorders, trigeminal neuralgia, Parkinson's disease, and disorders of speech, smell, and taste), the habilitation of craniofacial syndromes, and the management of facial pain.

The field of biomimetics is an example of the translation of human genomics into innovative developments in biotechnology. The idea is to use biological strategies to solve human diseases and disorders, essentially mimicking biological processes in the design and fabrication of new biomaterials to replace body parts or synthesize new drugs or reagents. For example, biological cartilage can now be designed and produced in artificial systems that present three-dimensional forms for nose and ear replacements as required in craniofacial birth defects, head and neck trauma, and oral and pharyngeal cancer patients (Slavkin 1996b, 1998a,b). Another approach is to design and fabricate bioceramics to be used in the replacement of human enamel or dentin on the surfaces of teeth.

### A FRAMEWORK FOR ORAL HEALTH

At the most basic level, local, state, and national health care policies will continue to strive to improve the health status of all Americans. Major reforms will improve public health competency. Enlightened health literacy will continue to influence quality of life expectations. Many social, economic, and political influences will continue to influence local, state, and national priorities for health policies (Isaacs and Knickman 1999). Included in these reforms will be efforts to improve the oral and craniofacial health of the American people.

Oral and craniofacial health issues will continue to be diverse and complex. In this context, two major themes remain: the need and demand for oral and craniofacial health services; and the role, functions, and mix of health professionals (Casamassimo 1996, USDHHS 1998).

First, need and demand will continue to be the two drivers of the health service requirements of our society. Need is an epidemiologically based and clinically derived measure of the amount of disease and adverse conditions that require treatment in order for the population to be healthy. Demand measures a population's health literacy, willingness, and capacity to utilize and finance health services. Public health literacy or competency and proactive

oral health education will increase demand as well as delineate functions of oral health professionals for 2000 and beyond. Often, biomedical research advances in terms of new pharmaceuticals, devices, and procedures popularized in the media influence quality of life expectations, demand for health services, and the economy (Pardes et al. 1999). They can also lead to the creation of new types of health providers. Research also has the potential to reduce the need, demand, and costs for health services (McRae 1994). Thus outpatient surgery obviates the need for hospitalization; immunization or antibiotics control infections; and community water fluoridation, other fluorides, dental sealants, and related oral health policies help prevent dental caries.

Second, the major changes in demography, patterns of disease, and management of health care will continue to shape the roles and functions of health professionals. For example, significant increases in the numbers of senior citizens (65 years and older) with chronic facial pain, osteoarthritis, temporomandibular joint disorders, type 2 diabetes, dementia, osteoporosis, and oral and pharyngeal cancers will challenge health care providers for the next 50 years. These conditions will necessitate interdisciplinary and multidisciplinary approaches to care. Coordination of professional care with that of individuals, caregivers, and the community will be needed to control costs and ensure early diagnosis and prompt treatment.

To ensure that all people have access to health care and can acquire the health literacy necessary to make use of oral and craniofacial health promotion and disease prevention information and activities, a complete assessment of the nation's capacity to achieve access for all is warranted. Federal, state, and local government programs, legislation, and regulation; health professional societies and organizations; professional schools, colleges within universities, and K-12 education; patient groups; the private sector; and the larger society have the responsibility to achieve access to oral health care for all.

**TABLE 11.1**  
**Examples of saliva fluid diagnostics**

<b>Detection of exposure to viruses by measuring antibodies specific for a viral antigen</b>			
Measles	Hepatitis A	HIV-1	
Mumps	Hepatitis B	HIV-2	
Rubella			
<b>Direct antigenic detection of microbes and biomarkers</b>			
Influenza A and B (neuraminidase)			
<i>Streptococcus</i> group A (N-acetylglucosamine)			
Salivary estradiol (pre-term labor indicator)			
CA-15, EGFR, cathepsin-D, and Waf 1 (proposed breast cancer biomarkers)			
Zinc-binding cystic fibrosis antigen (proposed biomarker)			
Glutamic acid decarboxylase autoantibody (proposed predictive biomarker in type-1 diabetes)			
<b>Culture of microbial organisms</b>			
<i>Streptococcus mutans</i> —dental caries			
<i>Lactobacillus acidophilus</i> —dental caries			
<i>Candida albicans</i> —oral candidiasis			
<b>Examples of hormones and drugs identified and measurable in saliva</b>			
aldosterone	progesterone	phenytoin	antipyrine
cortisol	testosterone	theophylline	ethanol
estrogens	carbamazepine	caffeine	marijuana
insulin	lithium	cocaine	opiates
melatonin	methadone	continine	

Sources: Derived from Malamud 1992, AGD 1996, Malamud and Tabak 1993.

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# A Call to Action

The major message of this Surgeon General's report is that oral health is essential to the general health and well-being of all Americans and can be achieved by all Americans. However, *not all* Americans are achieving the same degree of oral health. In spite of the safe and effective means of maintaining oral health that have benefited the majority of Americans over the past half century, many among us still experience needless pain and suffering, complications that can devastate overall health and well-being, and financial and social costs that diminish the quality of life and burden American society.

To maintain the health and well-being of Americans already enjoying good oral health and to address the gaps in oral health status of others require actions at all levels of society, from individuals and neighborhoods to the nation as a whole. A coordinated effort can overcome the educational, environmental, social, health system, and financial barriers that have created vulnerable populations whose oral health is at risk.

## MAJOR FINDINGS

Following are the major findings of the report. They reflect the detailed findings highlighted at the end of each chapter as well as the broad themes presented in Chapter 1.

Oral diseases and disorders in and of themselves affect health and well-being throughout life. The burden of oral problems is extensive and may be particularly severe in vulnerable populations. It includes the common dental diseases and other oral infections such as cold sores and candidiasis that can occur at any stage of life, as well as birth defects in infancy and the chronic facial pain conditions and oral cancers seen in later years. Many of these conditions and their treatments may undermine self-image and self-esteem, discourage normal social

interaction, cause other health problems, and lead to chronic stress and depression as well as incur great financial cost. They may also interfere with vital functions such as breathing, food selection, eating, swallowing, and speaking and with activities of daily living such as work, school, and family interactions.

Safe and effective measures exist to prevent the most common dental diseases—dental caries and periodontal diseases. Community water fluoridation is safe and effective in preventing dental caries in both children and adults. Water fluoridation benefits all residents served by community water supplies regardless of their social or economic status. Professional and individual measures, including the use of fluoride mouthrinses, gels, dentifrices, and dietary supplements and the application of dental sealants, are additional means of preventing dental caries. Gingivitis can be prevented by good personal oral hygiene practices, including brushing and flossing.

Lifestyle behaviors that affect general health such as tobacco use, excessive alcohol use, and poor dietary choices affect oral and craniofacial health as well. These individual behaviors are associated with increased risk for craniofacial birth defects, oral and pharyngeal cancers, periodontal disease, dental caries, and candidiasis, among other oral health problems. Opportunities exist to expand the oral disease prevention and health promotion knowledge and practices of the public through community programs and in health care settings. All health care providers can play a role in promoting healthy lifestyles by incorporating tobacco cessation programs, nutritional counseling, and other health promotion efforts into their practices.

There are profound and consequential oral health disparities within the U.S. population. Disparities for various oral conditions may relate to income, age, sex, race or ethnicity, or medical status.

Although common dental diseases are preventable, not all members of society are informed about or able to avail themselves of appropriate oral-health-promoting measures. Similarly, not all health providers may be aware of the services needed to improve oral health. In addition, oral health care is not fully integrated into many care programs. Social, economic, and cultural factors and changing population demographics affect how health services are delivered and used, and how people care for themselves. Reducing disparities requires wide-ranging approaches that target populations at highest risk for specific oral diseases and involves improving access to existing care. One approach includes making dental insurance more available to Americans. Public coverage for dental care is minimal for adults, and programs for children have not reached the many eligible beneficiaries.

**More information is needed to improve America's oral health and eliminate health disparities.** We do not have adequate data on health, disease, and health practices and care use for the U.S. population as a whole and its diverse segments, including racial and ethnic minorities, rural populations, individuals with disabilities, the homeless, immigrants, migrant workers, the very young, and the frail elderly. Nor are there sufficient data that explore health issues in relation to sex or sexual orientation. Data on state and local populations, essential for program planning and evaluation, are rare or unavailable and reflect the limited capacity of the U.S. health infrastructure for oral health. Health services research, which could provide much needed information on the cost, cost-effectiveness, and outcomes of treatment, is also sorely lacking. Finally, measurement of disease and health outcomes is needed. Although progress has been made in measuring oral-health-related quality of life, more needs to be done, and measures of oral health per se do not exist.

**The mouth reflects general health and well-being.** The mouth is a readily accessible and visible part of the body and provides health care providers and individuals with a window on their general health status. As the gateway of the body, the mouth senses and responds to the external world and at the same time reflects what is happening deep inside the body. The mouth may show signs of nutritional deficiencies and serve as an early warning system for diseases such as HIV infection and other immune system problems. The mouth can also show signs of general infection and stress. As the number of substances that can be reliably measured in saliva increases, it may well become the diagnostic fluid of choice, enabling the diagnosis of specific disease as

well as the measurement of the concentration of a variety of drugs, hormones, and other molecules of interest. Cells and fluids in the mouth may also be used for genetic analysis to help uncover risks for disease and predict outcomes of medical treatments.

**Oral diseases and conditions are associated with other health problems.** Oral infections can be the source of systemic infections in people with weakened immune systems, and oral signs and symptoms often are part of a general health condition. Associations between chronic oral infections and other health problems, including diabetes, heart disease, and adverse pregnancy outcomes, have also been reported. Ongoing research may uncover mechanisms that strengthen the current findings and explain these relationships.

**Scientific research is key to further reduction in the burden of diseases and disorders that affect the face, mouth, and teeth.** The science base for dental diseases is broad and provides a strong foundation for further improvements in prevention; for other craniofacial and oral health conditions the base has not yet reached the same level of maturity. Scientific research has led to a variety of approaches to improve oral health through prevention, early diagnosis, and treatment. We are well positioned to take these prevention measures further by investigating how to develop more targeted and effective interventions and devising ways to enhance their appropriate adoption by the public and the health professions. The application of powerful new tools and techniques is important. Their employment in research in genetics and genomics, neuroscience, and cancer has allowed rapid progress in these fields. An intensified effort to understand the relationships between oral infections and their management, and other illnesses and conditions is warranted, along with the development of oral-based diagnostics. These developments hold great promise for the health of the American people.

## **A FRAMEWORK FOR ACTION**

All Americans can benefit from the development of a National Oral Health Plan to improve quality of life and eliminate health disparities by facilitating collaborations among individuals, health care providers, communities, and policymakers at all levels of society and by taking advantage of existing initiatives. Everyone has a role in improving and promoting oral health. Together we can work to broaden public understanding of the importance of oral health and its relevance to general health and well-being, and to ensure that existing and future preventive, diagnostic, and treatment measures for



oral diseases and disorders are made available to all Americans. The following are the principal components of the plan:

**Change perceptions regarding oral health and disease so that oral health becomes an accepted component of general health.**

- *Change public perceptions.* Many people consider oral signs and symptoms to be less important than indications of general illness. As a result, they may avoid or postpone needed care, thus exacerbating the problem. If we are to increase the nation's capacity to improve oral health and reduce health disparities, we need to enhance the public's understanding of the meaning of oral health and the relationship of the mouth to the rest of the body. These messages should take into account the multiple languages and cultural traditions that characterize America's diversity.

- *Change policymakers' perceptions.* Informed policymakers at the local, state, and federal levels are critical in ensuring the inclusion of oral health services in health promotion and disease prevention programs, care delivery systems, and reimbursement schedules. Raising awareness of oral health among legislators and public officials at all levels of government is essential to creating effective public policy to improve America's oral health. Every conceivable avenue should be used to inform policymakers—informally through their organizations and affiliations and formally through their governmental offices—if rational oral health policy is to be formulated and effective programs implemented.

- *Change health providers' perceptions.* Too little time is devoted to oral health and disease topics in the education of nondental health professionals. Yet all care providers can and should contribute to enhancing oral health. This can be accomplished in several ways, such as including an oral examination as part of a general medical examination, advising patients in matters of tobacco cessation and diet, and referring patients to oral health practitioners for care prior to medical or surgical treatments that can damage oral tissues, such as cancer chemotherapy or radiation to the head and neck. Health care providers should be ready, willing, and able to work in collaboration to provide optimal health care for their patients. Having informed health care professionals will ensure that the public using the health care system will benefit from interdisciplinary services and comprehensive care. To prepare providers for such a role will involve, among other factors, curriculum changes and multidisciplinary training.

**Accelerate the building of the science and evidence base and apply science effectively to improve oral health.** Basic behavioral and biomedical research, clinical trials, and population-based research have been at the heart of scientific advances over the past decades. The nation's continued investment in research is critical for the provision of new knowledge about oral and general health and disease for years to come and needs to be accelerated if further improvements are to be made. Equally important is the effective transfer of research findings to the public and health professions. However, the next steps are more complicated. The challenge is to understand complex diseases caused by the interaction of multiple genes with environmental and behavioral variables—a description that applies to most oral diseases and disorders—and translate research findings into health care practice and healthy lifestyles.

This report highlights many areas of research opportunities and needs in each chapter. At present, there is an overall need for behavioral and clinical research, clinical trials, health services research, and community-based demonstration research. Also, development of risk assessment procedures for individuals and communities and of diagnostic markers to indicate whether an individual is more or less susceptible to a given disease can provide the basis for formulating risk profiles and tailoring treatment and program options accordingly.

Vital to progress in this area is a better understanding of the etiology and distribution of disease. But as this report makes clear, epidemiologic and surveillance databases for oral health and disease, health services, utilization of care, and expenditures are limited or lacking at the national, state, and local levels. Such data are essential in conducting health services research, generating research hypotheses, planning and evaluating programs, and identifying emerging public health problems. Future data collection must address differences among the subpopulations making up racial and ethnic groups. More attention must also be paid to demographic variables such as age, sex, sexual orientation, and socioeconomic factors in determining health status. Clearly, the more detailed information that is available, the better can program planners establish priorities and targeted interventions.

Progress in elucidating the relationships between chronic oral inflammatory infections, such as periodontitis, and diabetes and glycemic control as well as other systemic conditions will require a similar intensified commitment to research. Rapid progress

can also occur with efforts in the area of the natural repair and regeneration of oral tissues and organs. Improvements in oral health depend on multidisciplinary and interdisciplinary approaches to biomedical and behavioral research, including partnerships among researchers in the life and physical sciences, and on the ability of practitioners and the public to apply research findings effectively.

**Build an effective health infrastructure that meets the oral health needs of all Americans and integrates oral health effectively into overall health.** The public health capacity for addressing oral health is dilute and not integrated with other public health programs. Although the Healthy People 2010 objectives provide a blueprint for outcome measures, a national public health plan for oral health does not exist. Furthermore, local, state, and federal resources are limited in the personnel, equipment, and facilities available to support oral health programs. There is also a lack of available trained public health practitioners knowledgeable about oral health. As a result, existing disease prevention programs are not being implemented in many communities, creating gaps in prevention and care that affect the nation's neediest populations. Indeed, cutbacks in many state budgets have reduced staffing of state and territorial dental programs and curtailed oral health promotion and disease prevention efforts. An enhanced public health infrastructure would facilitate the development of strengthened partnerships with private practitioners, other public programs, and voluntary groups.

There is a lack of racial and ethnic diversity in the oral health workforce. Efforts to recruit members of minority groups to positions in health education, research, and practice in numbers that at least match their representation in the general population not only would enrich the talent pool, but also might result in a more equitable geographic distribution of care providers. The effect of that change could well enhance access and utilization of oral health care by racial and ethnic minorities.

A closer look at trends in the workforce discloses a worrisome shortfall in the numbers of men and women choosing careers in oral health education and research. Government and private sector leaders are aware of the problem and are discussing ways to increase and diversify the talent pool, including easing the financial burden of professional education, but additional incentives may be necessary.

**Remove known barriers between people and oral health services.** This report presents data on access, utilization, financing, and reimbursement of oral health care; provides additional data on the extent of the barriers; and points to the need for public-private partnerships in seeking solutions. The data indicate that lack of dental insurance, private or public, is one of several impediments to obtaining oral health care and accounts in part for the generally poorer oral health of those who live at or near the poverty line, lack health insurance, or lose their insurance upon retirement. The level of reimbursement for services also has been reported to be a problem and a disincentive to the participation of providers in certain public programs. Professional organizations and government agencies are cognizant of these problems and are exploring solutions that merit evaluation. Particular concern has been expressed about the nation's children, and initiatives such as the State Children's Health Insurance Program, while not mandating coverage for oral health services, are a positive step. In addition, individuals whose health is physically, mentally, and emotionally compromised need comprehensive integrated care.

**Use public-private partnerships to improve the oral health of those who still suffer disproportionately from oral diseases.** The collective and complementary talents of public health agencies, private industry, social services organizations, educators, health care providers, researchers, the media, community leaders, voluntary health organizations and consumer groups, and concerned citizens are vital if America is not just to reduce, but to eliminate, health disparities. This report highlights variations in oral and general health within and across all population groups. Increased public-private partnerships are needed to educate the public, to educate health professionals, to conduct research, and to provide health care services and programs. These partnerships can build and strengthen cross-disciplinary, culturally competent, community-based, and community-wide efforts and demonstration programs to expand initiatives for health promotion and disease prevention. Examples of such efforts include programs to prevent tobacco use, promote better dietary choices, and encourage the use of protective gear to prevent sports injuries. In this way, partnerships uniting sports organizations, schools, the faith community, and other groups and leaders, working in concert with the health community, can contribute to improved oral and general health.

## **CONCLUSION**

The past half century has seen the meaning of oral health evolve from a narrow focus on teeth and gingiva to the recognition that the mouth is the center of vital tissues and functions that are critical to total health and well-being across the life span. The mouth as a mirror of health or disease, as a sentinel or early warning system, as an accessible model for the study of other tissues and organs, and as a potential source

of pathology affecting other systems and organs has been described in earlier chapters and provides the impetus for extensive future research. Past discoveries have enabled Americans today to enjoy far better oral health than their forebears a century ago. But the evidence that not all Americans have achieved the same level of oral health and well-being stands as a major challenge, one that demands the best efforts of public and private agencies and individuals.