

# Executive Summary

Publication of this first Surgeon General's Report on Oral Health marks a milestone in the history of oral health in America. The report elaborates on the meaning of oral health and explains why oral health is essential to general health and well-being. In the course of the past 50 years, great progress has been made in understanding the common oral diseases—dental caries (tooth decay) and periodontal (gum) diseases—resulting in marked improvements in the nation's oral health. Most middle-aged and younger Americans expect to retain their natural teeth over their lifetime and do not expect to have any serious oral health problems.

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 devastate overall health and well-being, and financial and social costs that diminish the quality of life and burden American society. What amounts to “a silent epidemic” of oral diseases is affecting our most vulnerable citizens—poor children, the elderly, and many members of racial and ethnic minority groups (GAO 2000). (See box entitled “The Burden of Oral Diseases and Disorders.”)

The word *oral* refers to the mouth. The mouth includes not only the teeth and the gums (gingiva) and their supporting tissues, but also the hard and soft palate, the mucosal lining of the mouth and throat, the tongue, the lips, the salivary glands, the chewing muscles, and the upper and lower jaws. Equally important are the branches of the nervous, immune, and vascular systems that animate, protect,

and nourish the oral tissues, as well as provide connections to the brain and the rest of the body. The genetic patterning of development in utero further reveals the intimate relationship of the oral tissues to the developing brain and to the tissues of the face and head that surround the mouth, structures whose location is captured in the word *craniofacial*.

A major theme of this report is that **oral health means much more than healthy teeth**. It means being free of chronic oral-facial pain conditions, oral and pharyngeal (throat) cancers, oral soft tissue lesions, birth defects such as cleft lip and palate, and scores of other diseases and disorders that affect the oral, dental, and craniofacial tissues, collectively known as the *craniofacial complex*. These are tissues whose functions we often take for granted, yet they represent the very essence of our humanity. They allow us to speak and smile; sigh and kiss; smell, taste, touch, chew, and swallow; cry out in pain; and convey a world of feelings and emotions through facial expressions. They also provide protection against microbial infections and environmental insults.

The craniofacial tissues also provide a useful means to understanding organs and systems in less accessible parts of the body. The salivary glands are a model of other exocrine glands, and an analysis of saliva can provide telltale clues of overall health or disease. The jawbones and their joints function like other musculoskeletal parts. The nervous system apparatus underlying facial pain has its counterpart in nerves elsewhere in the body. A thorough oral examination can detect signs of nutritional deficiencies as well as a number of systemic diseases, including microbial infections, immune disorders, injuries, and some cancers. Indeed, the phrase *the mouth is a mirror* has been used to illustrate the wealth of information that can be derived from examining oral tissues.

New research is pointing to associations between chronic oral infections and heart and lung diseases, stroke, and low-birth-weight, premature births. Associations between periodontal disease and diabetes have long been noted. This report assesses these associations and explores mechanisms that might explain the oral-systemic disease connections.

The broadened meaning of *oral health* parallels the broadened meaning of *health*. In 1948 the World Health Organization expanded the definition of health to mean “a complete state of physical, mental, and social well-being, and not just the absence of infirmity.” It follows that oral health must also include well-being. Just as we now understand that nature and nurture are inextricably linked, and mind and body are both expressions of our human biology, so, too, we must recognize that oral health and general health are inseparable. We ignore signs and symptoms of oral disease and dysfunction to our

### **The Burden of Oral Diseases and Disorders**

Oral diseases are progressive and cumulative and become more complex over time. They can affect our ability to eat, the foods we choose, how we look, and the way we communicate. These diseases can affect economic productivity and compromise our ability to work at home, at school, or on the job. Health disparities exist across population groups at all ages. Over one third of the U.S. population (100 million people) has no access to community water fluoridation. Over 108 million children and adults lack dental insurance, which is over 2.5 times the number who lack medical insurance. The following are highlights of oral health data for children, adults, and the elderly. (Refer to the full report for details of these data and their sources.)

#### **Children**

- Cleft lip/palate, one of the most common birth defects, is estimated to affect 1 out of 600 live births for whites and 1 out of 1,850 live births for African Americans.
- Other birth defects such as hereditary ectodermal dysplasias, where all or most teeth are missing or misshapen, cause lifetime problems that can be devastating to children and adults.
- Dental caries (tooth decay) is the single most common chronic childhood disease—5 times more common than asthma and 7 times more common than hay fever.
- Over 50 percent of 5- to 9-year-old children have at least one cavity or filling, and that proportion increases to 78 percent among 17-year-olds. Nevertheless, these figures represent improvements in the oral health of children compared to a generation ago.
- There are striking disparities in dental disease by income. Poor children suffer twice as much dental caries as their more affluent peers, and their disease is more likely to be untreated. These poor-nonpoor

detriment. Consequently, a second theme of the report is that **oral health is integral to general health**. You cannot be healthy without oral health. Oral health and general health should not be interpreted as separate entities. Oral health is a critical component of health and must be included in the provision of health care and the design of community programs.

The wider meanings of *oral* and *health* in no way diminish the relevance and importance of the two leading dental diseases, caries and the periodontal diseases. They remain common and widespread, affecting nearly everyone at some point in the life span. What has changed is what we can do about them.

Researchers in the 1930s discovered that people living in communities with naturally fluoridated water supplies had less dental caries than people drinking unfluoridated water. But not until the end

differences continue into adolescence. One out of four children in America is born into poverty, and children living below the poverty line (annual income of \$17,000 for a family of four) have more severe and untreated decay.

- Unintentional injuries, many of which include head, mouth, and neck injuries, are common in children.
- Intentional injuries commonly affect the craniofacial tissues.
- Tobacco-related oral lesions are prevalent in adolescents who currently use smokeless (spit) tobacco.
- Professional care is necessary for maintaining oral health, yet 25 percent of poor children have not seen a dentist before entering kindergarten.
- Medical insurance is a strong predictor of access to dental care. Uninsured children are 2.5 times less likely than insured children to receive dental care. Children from families without dental insurance are 3 times more likely to have dental needs than children with either public or private insurance. For each child without medical insurance, there are at least 2.6 children without dental insurance.
- Medicaid has not been able to fill the gap in providing dental care to poor children. Fewer than one in five Medicaid-covered children received a single dental visit in a recent year-long study period. Although new programs such as the State Children’s Health Insurance Program (SCHIP) may increase the number of insured children, many will still be left without effective dental coverage.
- The social impact of oral diseases in children is substantial. More than 51 million school hours are lost each year to dental-related illness. Poor children suffer nearly 12 times more restricted-activity days than children from higher-income families. Pain and suffering due to untreated diseases can lead to problems in eating, speaking, and attending to learning.

of World War II were the investigators able to design and implement the community clinical trials that confirmed their observations and launched a better approach to the problem of dental caries: prevention. Soon after, adjusting the fluoride content of community water supplies was pursued as an important public health measure to prevent dental caries.

Although this measure has not been fully implemented, the results have been dramatic. Dental caries began to decline in the 1950s among children who grew up in fluoridated cities, and by the late 1970s, decline in decay was evident for many Americans. The application of science to improve diagnostic, treatment, and prevention strategies has saved billions of dollars per year in the nation's annual health bill. Even more significant, the result is that far fewer people are edentulous (toothless) today than a generation ago.

### Adults

- Most adults show signs of periodontal or gingival diseases. Severe periodontal disease (measured as 6 millimeters of periodontal attachment loss) affects about 14 percent of adults aged 45 to 54.
- Clinical symptoms of viral infections, such as herpes labialis (cold sores), and oral ulcers (canker sores) are common in adulthood, affecting about 19 percent of adults 25 to 44 years of age.
- Chronic disabling diseases such as temporomandibular disorders, Sjögren's syndrome, diabetes, and osteoporosis affect millions of Americans and compromise oral health and functioning.
- Pain is a common symptom of craniofacial disorders and is accompanied by interference with vital functions such as eating, swallowing, and speech. Twenty-two percent of adults reported some form of oral-facial pain in the past 6 months. Pain is a major component of trigeminal neuralgia, facial shingles (post-herpetic neuralgia), temporomandibular disorders, fibromyalgia, and Bell's palsy.
- Population growth as well as diagnostics that are enabling earlier detection of cancer means that more patients than ever before are undergoing cancer treatments. More than 400,000 of these patients will develop oral complications annually.
- Immunocompromised patients, such as those with HIV infection and those undergoing organ transplantation, are at higher risk for oral problems such as candidiasis.
- Employed adults lose more than 164 million hours of work each year due to dental disease or dental visits.
- For every adult 19 years or older without medical insurance, there are three without dental insurance.
- A little less than two thirds of adults report having visited a dentist in the past 12 months. Those with incomes at or above the poverty level are twice as likely to report a dental visit in the past 12 months as those who are below the poverty level.

The theme of prevention gained momentum as pioneering investigators and practitioners in the 1950s and 1960s showed that not only dental caries but also periodontal diseases are bacterial infections. The researchers demonstrated that the infections could be prevented by increasing host resistance to disease and reducing or eliminating the suspected microbial pathogens in the oral cavity. The applications of research discoveries have resulted in continuing improvements in the oral health of Americans, new approaches to the prevention and treatment of dental diseases, and the growth of the science.

The significant role that scientists, dentists, dental hygienists, and other health professionals have played in the prevention of oral disease and disability leads to a third theme of this report: **safe and effective disease prevention measures exist that everyone can adopt to improve oral health and prevent disease.** These measures include daily oral hygiene

### Older Adults

- Twenty-three percent of 65- to 74-year-olds have severe periodontal disease (measured as 6 millimeters of periodontal attachment loss). (Also, at all ages men are more likely than women to have more severe disease, and at all ages people at the lowest socioeconomic levels have more severe periodontal disease.)
- About 30 percent of adults 65 years and older are edentulous, compared to 46 percent 20 years ago. These figures are higher for those living in poverty.
- Oral and pharyngeal cancers are diagnosed in about 30,000 Americans annually; 8,000 die from these diseases each year. These cancers are primarily diagnosed in the elderly. Prognosis is poor. The 5-year survival rate for white patients is 56 percent; for blacks, it is only 34 percent.
- Most older Americans take both prescription and over-the-counter drugs. In all probability, at least one of the medications used will have an oral side effect—usually dry mouth. The inhibition of salivary flow increases the risk for oral disease because saliva contains antimicrobial components as well as minerals that can help rebuild tooth enamel after attack by acid-producing, decay-causing bacteria. Individuals in long-term care facilities are prescribed an average of eight drugs.
- At any given time, 5 percent of Americans aged 65 and older (currently some 1.65 million people) are living in a long-term care facility where dental care is problematic.
- Many elderly individuals lose their dental insurance when they retire. The situation may be worse for older women, who generally have lower incomes and may never have had dental insurance. Medicaid funds dental care for the low-income and disabled elderly in some states, but reimbursements are low. Medicare is not designed to reimburse for routine dental care.

procedures and other lifestyle behaviors, community programs such as community water fluoridation and tobacco cessation programs, and provider-based interventions such as the placement of dental sealants and examinations for common oral and pharyngeal cancers. It is hoped that this Surgeon General's report will facilitate the maturing of the broad field of craniofacial research so that gains in the prevention of craniofacial diseases and disorders can be realized that are as impressive as those achieved for common dental diseases.

At the same time, more needs to be done to ensure that messages of health promotion and disease prevention are brought home to all Americans. In this regard, a fourth theme of the report is that **general health risk factors, such as tobacco use and poor dietary practices, also affect oral and craniofacial health.** The evidence for an association between tobacco use and oral diseases has been clearly delineated in almost every Surgeon General's report on tobacco since 1964, and the oral effects of nutrition and diet are presented in the Surgeon General's report on nutrition (1988). All the health professions can play a role in reducing the burden of disease in America by calling attention to these and other risk factors and suggesting appropriate actions.

Clearly, promoting health and preventing diseases are concepts the American people have taken to heart. For the third decade the nation has developed a plan for the prevention of disease and the promotion of health, embodied in the U.S. Department of Health and Human Services (2000) document, *Healthy People 2010*. As a nation, we hope to eliminate disparities in health and prevent oral diseases, cancer, birth defects, AIDS and other devastating infections, mental illness and suicide, and the chronic diseases of aging. To live well into old age free of pain and infirmity, and with a high quality of life, is the American dream.

Scientists today take that dream seriously in researching the intricacies of the craniofacial complex. They are using an ever-growing array of sophisticated analytic tools and imaging systems to study normal function and diagnose disease. They are completing the mapping and sequencing of human, animal, microbial, and plant genomes, the better to understand the complexities of human development, aging, and pathological processes. They are growing cell lines, synthesizing molecules, and using a new generation of biomaterials to revolutionize tissue repair and regeneration. More than ever before, they are working in multidisciplinary teams to bring new knowledge and expertise to the goal of understanding complex human diseases and disorders.

## **THE CHALLENGE**

This Surgeon General's report has much to say about the inequities and disparities that affect those least able to muster the resources to achieve optimal oral health. The barriers to oral health include lack of access to care, whether because of limited income or lack of insurance, transportation, or the flexibility to take time off from work to attend to personal or family needs for care. Individuals with disabilities and those with complex health problems may face additional barriers to care. Sometimes, too, the public, policymakers, and providers may consider oral health and the need for care to be less important than other health needs, pointing to the need to raise awareness and improve health literacy.

Even more costly to the individual and to society are the expenses associated with oral health problems that go beyond dental diseases. The nation's yearly dental bill is expected to exceed \$60 billion in 2000 (Health Care Financing Administration 2000). However, add to that expense the tens of billions of dollars in direct medical care and indirect costs of chronic craniofacial pain conditions such as temporomandibular disorders, trigeminal neuralgia, shingles, or burning mouth syndrome; the \$100,000 minimum individual lifetime costs of treating craniofacial birth defects such as cleft lip and palate; the costs of oral and pharyngeal cancers; the costs of autoimmune diseases; and the costs associated with the unintentional and intentional injuries that so often affect the head and face. Then add the social and psychological consequences and costs. Damage to the craniofacial complex, whether from disease, disorder, or injury, strikes at our very identity. We see ourselves, and others see us, in terms of the face we present to the world. Diminish that image in any way and we risk the loss of self-esteem and well-being.

Many unanswered questions remain for scientists, practitioners, educators, policymakers, and the public. This report highlights the research challenges as well as pointing to emerging technologies that may facilitate finding solutions. Along with the quest for answers comes the challenge of applying what is already known in a society where there are social, political, economic, behavioral, and environmental barriers to health and well-being.

## **THE CHARGE**

The realization that oral health can have a significant impact on the overall health and well-being of the nation's population led the Office of the Surgeon General, with the approval of the Secretary of Health and Human Services, to commission this report.

Recognizing the gains that have been made in disease prevention while acknowledging that there are populations that suffer disproportionately from oral health problems, the Secretary asked that the report “define, describe, and evaluate the interaction between oral health and health and well-being [quality of life], through the life span in the context of changes in society.” Key elements to be addressed were the determinants of health and disease, with a primary focus on prevention and “producing health” rather than “restoring health”; a description of the burden of oral diseases and disorders in the nation; and the evidence for actions to improve oral health to be taken across the life span. The report also was to feature an orientation to the future, highlighting leading-edge technologies and research findings that can be brought to bear in improving the oral health of individuals and communities.

### **THE SCIENCE BASE FOR THE REPORT**

This report is based on a review of the published scientific literature. Standards established to determine the quality of the evidence, based on the study design and its rigor, were used where appropriate. In addition, the strength of the recommendations, where they are made, is based on evidence of effectiveness for the population of interest. The scope of the review encompassed the international English literature. Recent systematic reviews of the literature are referenced, as are selected review articles. A few referenced articles are in press, and there are occasional references to recent abstracts and personal communications.

The science base in oral health has been evolving over the past half century. Initial research in this area was primarily in the basic sciences, investigating mechanisms of normal development and pathology in relation to dental caries and periodontal diseases. Prevention research has included controlled clinical studies, with and without randomization, as well as community trials and demonstration research. More recent research has broadened the science base to include studies of the range of craniofacial diseases and disorders and is moving from basic science to translational, clinical, and health services research.

The clinical literature includes the full range of studies, from randomized controlled studies to case studies. Most of the literature includes cross-sectional and cohort studies, with some case-control studies. General reviews of the literature have been used for Chapters 2 through 10. Chapter 4 includes both published and new analyses of national and state databases that have been carefully designed and for which

quality assurance has been maintained by the Centers for Disease Control and Prevention. Studies of smaller populations are also included where relevant. In Chapter 5, tables present information on the association of oral infections and systemic conditions, and in Chapter 7, tables exhibit oral disease prevention and health promotion measures. The published literature related to the development of new technologies, their potential impact, and the need for further research are described in the course of addressing the requested futures orientation.

The report was generated with the advice and support of a Federal Coordinating Committee composed of representatives of agencies with oral health components and interests. The chapters were based on papers submitted by experts working under the guidance of a coordinating author for each chapter. Independent peer review was conducted for all sections of the report at various stages in the process, and the full manuscript was reviewed by a number of senior reviewers as well as the relevant federal agencies. All who contributed are listed in the Acknowledgments section of the full report.

### **ORGANIZATION OF THE REPORT**

The report centers on five major questions, which have been used to structure the report into five parts.

#### **Part One: What Is Oral Health?**

The meaning of oral health is explored in Chapter 1, and the interdependence of oral health with general health and well-being is a recurrent theme throughout the volume.

Chapter 2 provides an overview of the craniofacial complex in development and aging, how the tissues and organs function in essential life processes, and their role in determining our uniquely human abilities. Our craniofacial complex has evolved to have remarkable functions and abilities to adapt, enabling us to meet the challenges of an ever-changing environment. An examination of the various tissues reveals elaborate designs that serve complex needs and functions, including the uniquely human function of speech. The rich distribution of nerves, muscles, and blood vessels in the region as well as extensive endocrine and immune system connections are indicators of the vital role of the craniofacial complex in adaptation and survival over a long life span. In particular, the following findings are noted:

- Genes controlling the basic patterning and segmental organization of human development, and specifically the craniofacial complex, are highly

conserved in nature. Mutated genes affecting human development have counterparts in many simpler organisms.

- There is considerable reserve capacity or redundancy in the cells and tissues of the craniofacial complex, so that if they are properly cared for, the structures should function well over a lifetime.

- The salivary glands and saliva subserve tasting and digestive functions and also participate in the mucosal immune system, a main line of defense against pathogens, irritants, and toxins.

- Salivary components protect and maintain oral tissues through antimicrobial components, buffering agents, and a process by which dental enamel can be remineralized.

### **Part Two: What Is the Status of Oral Health in America?**

Chapter 3 is a primer describing the major diseases and disorders that affect the craniofacial complex. The findings include:

- Microbial infections, including those caused by bacteria, viruses, and fungi, are the primary cause of the most prevalent oral diseases. Examples include dental caries, periodontal diseases, herpes labialis, and candidiasis.

- The etiology and pathogenesis of diseases and disorders affecting the craniofacial structures are multifactorial and complex, involving an interplay among genetic, environmental, and behavioral factors.

- Many inherited and congenital conditions affect the craniofacial complex, often resulting in disfigurement and impairments that may involve many body organs and systems and affect millions of children worldwide.

- Tobacco use, excessive alcohol use, and inappropriate dietary practices contribute to many diseases and disorders. In particular, tobacco use is a risk factor for oral cavity and pharyngeal cancers, periodontal diseases, candidiasis, and dental caries, among other diseases.

- Some chronic diseases, such as Sjögren's syndrome, present with primary oral symptoms.

- Oral-facial pain conditions are common and often have complex etiologies.

Chapter 4 constitutes an oral health status report card for the United States, describing the magnitude of the problem. Where data permit, the chapter also describes the oral health of selected population

groups, as well as their dental visit behavior. The findings include:

- Over the past five decades, major improvements in oral health have been seen nationally for most Americans.

- Despite improvements in oral health status, profound disparities remain in some population groups as classified by sex, income, age, and race/ethnicity. For some diseases and conditions, the magnitude of the differences in oral health status among population groups is striking.

- Oral diseases and conditions affect people throughout their life span. Nearly every American has experienced the most common oral disease, dental caries.

- Conditions that severely affect the face and facial expression, such as birth defects, craniofacial injuries, and neoplastic diseases, are more common in the very young and in the elderly.

- Oral-facial pain can greatly reduce quality of life and restrict major functions. Pain is a common symptom for many of the conditions affecting oral-facial structures.

- National and state data for many oral and craniofacial diseases and conditions and for population groups are limited or nonexistent. Available state data reveal variations within and among states in patterns of health and disease among population groups.

- Research is needed to develop better measures of disease and health, to explain the differences among population groups, and to develop interventions targeted at eliminating disparities.

### **Part Three: What Is the Relationship Between Oral Health and General Health and Well-being?**

Chapters 5 and 6 address key issues in the report's charge—the relationship of oral health to general health and well-being. Chapter 5 explores the theme of the mouth as reflecting general health or disease status. Examples are given of how oral tissues may signal the presence of disease, disease progression, or exposure to risk factors, and how oral cells and fluids are increasingly being used as diagnostic tools. This is followed by a discussion of the mouth as a portal of entry for infections that can affect local tissues and may spread to other parts of the body. The final sections review the literature regarding emerging associations between oral diseases and diabetes, heart disease and stroke, and adverse pregnancy outcomes.

The findings include:

- Many systemic diseases and conditions have oral manifestations. These manifestations may be the initial sign of clinical disease and as such serve to inform clinicians and individuals of the need for further assessment.

- The oral cavity is a portal of entry as well as the site of disease for microbial infections that affect general health status.

- The oral cavity and its functions can be adversely affected by many pharmaceuticals and other therapies commonly used in treating systemic conditions. The oral complications of these therapies can compromise patient compliance with treatment.

- Individuals such as immunocompromised and hospitalized patients are at greater risk for general morbidity due to oral infections.

- Individuals with diabetes are at greater risk for periodontal diseases.

- Animal and population-based studies have demonstrated an association between periodontal diseases and diabetes, cardiovascular disease, stroke, and adverse pregnancy outcomes. Further research is needed to determine the extent to which these associations are causal or coincidental.

Chapter 6 demonstrates the relationship between oral health and quality of life, presenting data on the consequences of poor oral health and altered appearance on speech, eating, and other functions, as well as on self-esteem, social interaction, education, career achievement, and emotional state. The chapter introduces anthropological and ethnographic literature to underscore the cultural values and symbolism attached to facial appearance and teeth. An examination of efforts to characterize the functional and social implications of oral and craniofacial diseases reveals the following findings:

- Oral health is related to well-being and quality of life as measured along functional, psychosocial, and economic dimensions. Diet, nutrition, sleep, psychological status, social interaction, school, and work are affected by impaired oral and craniofacial health.

- Cultural values influence oral and craniofacial health and well-being and can play an important role in care utilization practices and in perpetuating acceptable oral health and facial norms.

- Oral and craniofacial diseases and their treatment place a burden on society in the form of lost days and years of productive work. Acute dental conditions contribute to a range of problems for employed adults, including restricted activity, bed days, and work loss, and school loss for children. In addition, conditions such as oral and pharyngeal

cancers contribute to premature death and can be measured by years of life lost.

- Oral and craniofacial diseases and conditions contribute to compromised ability to bite, chew, and swallow foods; limitations in food selection; and poor nutrition. These conditions include tooth loss, diminished salivary functions, oral-facial pain conditions such as temporomandibular disorders, alterations in taste, and functional limitations of prosthetic replacements.

- Oral-facial pain, as a symptom of untreated dental and oral problems and as a condition in and of itself, is a major source of diminished quality of life. It is associated with sleep deprivation, depression, and multiple adverse psychosocial outcomes.

- Self-reported impacts of oral conditions on social function include limitations in verbal and non-verbal communication, social interaction, and intimacy. Individuals with facial disfigurements due to craniofacial diseases and conditions and their treatments may experience loss of self-image and self-esteem, anxiety, depression, and social stigma; these in turn may limit educational, career, and marital opportunities and affect other social relations.

- Reduced oral-health-related quality of life is associated with poor clinical status and reduced access to care.

#### **Part Four: How Is Oral Health Promoted and Maintained and How Are Oral Diseases Prevented?**

The next three chapters review how individuals, health care practitioners, communities, and the nation as a whole contribute to oral health. Chapter 7 reviews the evidence for the efficacy and effectiveness of health promotion and disease prevention measures with a focus on community efforts in preventing oral disease. It continues with a discussion of the knowledge and practices of the public and health care providers and indicates opportunities for broad-based and targeted health promotion. The findings include:

- Community water fluoridation, an effective, safe, and ideal public health measure, benefits individuals of all ages and socioeconomic strata. Unfortunately, over one third of the U.S. population (100 million people) are without this critical public health measure.

- Effective disease prevention measures exist for use by individuals, practitioners, and communities. Most of these focus on dental caries prevention, such as fluorides and dental sealants, where a combination of services is required to

achieve optimal disease prevention. Daily oral hygiene practices such as brushing and flossing can prevent gingivitis.

- Community-based approaches for the prevention of other oral diseases and conditions, such as oral and pharyngeal cancers and oral-facial trauma, require intensified developmental efforts.

- Community-based preventive programs are unavailable to substantial portions of the underserved population.

- There is a gap between research findings and the oral disease prevention and health promotion practices and knowledge of the public and the health professions.

- Disease prevention and health promotion approaches, such as tobacco control, appropriate use of fluorides for caries prevention, and folate supplementation for neural tube defect prevention, highlight opportunities for partnerships between community-based programs and practitioners, as well as collaborations among health professionals.

- Many community-based programs require a combined effort among social service, health care, and education services at the local or state level.

Chapter 8 explores the role of the individual and the health care provider in promoting and maintaining oral health and well-being. For the individual, this means exercising appropriate self-care and adopting healthy behaviors. For the provider, it means incorporating the knowledge emerging from the science base in a timely manner for prevention and diagnosis, risk assessment and risk management, and treatment of oral diseases and disorders. The chapter focuses largely on the oral health care provider. The management of oral and craniofacial health and disease necessitates collaborations among a team of care providers to achieve optimal oral and general health. The findings include:

- Achieving and maintaining oral health require individual action, complemented by professional care as well as community-based activities.

- Individuals can take actions, for themselves and for persons under their care, to prevent disease and maintain health. Primary prevention of many oral, dental, and craniofacial diseases and conditions is possible with appropriate diet, nutrition, oral hygiene, and health-promoting behaviors, including the appropriate use of professional services. Individuals should use a fluoride dentifrice daily to help prevent dental caries and should brush and floss daily to prevent gingivitis.

- All primary care providers can contribute to improved oral and craniofacial health. Inter-

disciplinary care is needed to manage the oral health–general health interface. Dentists, as primary care providers, are uniquely positioned to play an expanded role in the detection, early recognition, and management of a wide range of complex oral and general diseases and conditions.

- Nonsurgical interventions are available to reverse disease progression and to manage oral diseases as infections.

- New knowledge and the development of molecular and genetically based tests will facilitate risk assessment and management and improve the ability of health care providers to customize treatment.

- Health care providers can successfully deliver tobacco cessation and other health promotion programs in their offices, contributing to both overall health and oral health.

- Biocompatible rehabilitative materials and biologically engineered tissues are being developed and will greatly enhance the treatment options available to providers and their patients.

Chapter 9 describes the roles of dental practitioners and their teams, the medical community, and public health agencies at local, state, and national levels in administering care or reimbursing for the costs of care. These activities are viewed against the changing organization of U.S. health care and trends regarding the workforce in research, education, and practice.

- Dental, medical, and public health delivery systems each provide services that affect oral and craniofacial health in the U.S. population. Clinical oral health care is predominantly provided by a private practice dental workforce.

- Expenditures for dental services alone made up 4.7 percent of the nation's health expenditures in 1998—\$53.8 billion out of \$1.1 trillion. These expenditures underestimate the true costs to the nation, however, because data are unavailable to determine the extent of expenditures and services provided for craniofacial health care by other health providers and institutions.

- The public health infrastructure for oral health is insufficient to address the needs of disadvantaged groups, and the integration of oral and general health programs is lacking.

- Expansion of community-based disease prevention and lowering of barriers to personal oral health care are needed to meet the needs of the population.

- Insurance coverage for dental care is increasing but still lags behind medical insurance.



For every child under 18 years old without medical insurance, there are at least two children without dental insurance; for every adult 18 years or older without medical insurance, there are three without dental insurance.

- Eligibility for Medicaid does not ensure enrollment, and enrollment does not ensure that individuals obtain needed care. Barriers include patient and caregiver understanding of the value and importance of oral health to general health, low reimbursement rates, and administrative burdens for both patient and provider.

- A narrow definition of “medically necessary dental care” currently limits oral health services for many insured persons, particularly the elderly.

- The dentist-to-population ratio is declining, creating concern as to the capability of the dental workforce to meet the emerging demands of society and provide required services efficiently.

- An estimated 25 million individuals reside in areas lacking adequate dental care services, as defined by Health Professional Shortage Area (HPSA) criteria.

- Educational debt has increased, affecting both career choices and practice location.

- Disparities exist in the oral health profession workforce and career paths. The number of under-represented minorities in the oral health professions is disproportionate to their distribution in the population at large.

- Current and projected demand for dental school faculty positions and research scientists is not being met. A crisis in the number of faculty and researchers threatens the quality of dental education; oral, dental, and craniofacial research; and, ultimately, the health of the public.

- Reliable and valid measures of oral health outcomes do not exist and need to be developed, validated, and incorporated into practice and programs.

## **Part Five: What Are the Needs and Opportunities to Enhance Oral Health?**

Chapter 10 looks at determinants of oral health in the context of society and across various life stages. Although theorists have proposed a variety of models of health determinants, there is general consensus that individual biology, the physical and socioeconomic environment, personal behaviors and lifestyle, and the organization of health care are key factors whose interplay determines the level of oral health achieved by an individual. The chapter provides examples of these factors with an emphasis

on barriers and ways to raise the level of oral health for children and older Americans. The findings include:

- The major factors that determine oral and general health and well-being are individual biology and genetics; the environment, including its physical and socioeconomic aspects; personal behaviors and lifestyle; access to care; and the organization of health care. These factors interact over the life span and determine the health of individuals, population groups, and communities—from neighborhoods to nations.

- The burden of oral diseases and conditions is disproportionately borne by individuals with low socioeconomic status at each life stage and by those who are vulnerable because of poor general health.

- Access to care makes a difference. A complex set of factors underlies access to care and includes the need to have an informed public and policymakers, integrated and culturally competent programs, and resources to pay and reimburse for the care. Among other factors, the availability of insurance increases access to care.

- Preventive interventions, such as protective head and mouth gear and dental sealants, exist but are not uniformly used or reinforced.

- Nursing homes and other long-term care institutions have limited capacity to deliver needed oral health services to their residents, most of whom are at increased risk for oral diseases.

- Anticipatory guidance and risk assessment and management facilitate care for children and for the elderly.

- Federal and state assistance programs for selected oral health services exist; however, the scope of services is severely limited, and their reimbursement level for oral health services is low compared to the usual fee for care.

Chapter 11 spells out in greater detail the promise of the life sciences in improving oral health in the coming years in the context of changes in American—and global—society. The critical role of genetics and molecular biology is emphasized.

Chapter 12, the final chapter, iterates the themes of the report and groups the findings from the earlier chapters into eight major categories. These findings, as well as a suggested framework for action to guide the next steps in enhancing the oral health of the nation, are presented below.

## **MAJOR FINDINGS**

**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.

## REFERENCES

- Health Care Financing Administration (HCFA). National Health Expenditures projections: 1998-2008. Office of the Actuary. <http://www.hcfa.gov/stats/NHE-Proj/>. 2000 Apr 25.
- U.S. Department of Health and Human Services (USDHHS). Healthy People 2010 (Conference Edition, in two volumes). Washington; 2000 Jan.
- U.S. General Accounting Office (GAO). Oral health in low-income populations. GAO/HEHS-00-72. 2000 Apr.

## PROJECT TEAM

- Caswell A. Evans DDS, MPH  
Project Director and Executive Editor  
Assistant Director, Los Angeles County Department of Health Services
- Dushanka V. Kleinman DDS, MScD  
Co-Executive Editor  
Deputy Director, National Institute of Dental and Craniofacial Research, National Institutes of Health
- William R. Maas DDS, MPH, MS  
Chief Dental Officer, U.S. Public Health Service  
Director, Division of Oral Health,  
Centers for Disease Control and Prevention
- Harold C. Slavkin DDS  
Director, National Institute of Dental and Craniofacial Research, National Institutes of Health
- Joan S. Wilentz MA  
Science Writer and Editor
- Roseanne Price ELS  
Editor
- Marla Fogelman  
Editor

July 2000

## What Is Oral Health?

The two chapters that follow explore the answer to this question, an answer that continues to evolve throughout the report. Oral health means more than healthy teeth and the absence of disease. It involves the ability of individuals to carry out essential functions such as eating and speaking as well as to contribute fully to society. Chapter 1, the introduction, explains how the meaning of oral health has developed in tandem with progress in understanding the two chief dental diseases—dental caries and periodontal diseases—which historically have been the major preoccupation of patients, providers, and research investigators alike. There is a marvelous success story here regarding the role of fluoride in preventing dental caries and the research that proved that dental caries and periodontal diseases are infections and can be prevented. These investigations were complemented by studies of the tissues of the mouth and adjacent areas—the craniofacial complex. Chapter 2 describes the tissues and organs of the craniofacial complex, providing a primer and guide to their essential features that emphasizes the ways they contribute to the richness of human experience, and at the same time protect and nurture the human body.

# The Meaning of Oral Health

The intent of this first-ever Surgeon General's report on oral health is to alert Americans to the full meaning of oral health and its importance in relation to general health and well-being. Great progress has been made in reducing the extent and severity of common oral diseases, and recent history has seen marked improvements in the nation's oral and dental health, thanks to successful prevention measures adopted by communities, individuals, and oral health professionals. However, not everyone is experiencing the same degree of improvement. What amounts to a "a silent epidemic" of dental and oral diseases is affecting some population groups—a burden of disease that restricts activities in school, work, and home, and often significantly diminishes the quality of life.

The word *oral*, both in its Latin root and in common usage, refers to the mouth. The mouth includes not only the teeth and the gums (gingiva) and their supporting connective tissues, ligaments, and bone, but also the hard and soft palate, the soft mucosal tissue lining of the mouth and throat, the tongue, the lips, the salivary glands, the chewing muscles, and the upper and lower jaws, which are connected to the skull by the temporomandibular joints. Equally important are the branches of the nervous, immune, and vascular systems that animate, protect, and nourish the oral tissues, as well as provide the connections to the brain and the rest of the body. The genetic patterning of development in utero further reveals the intimate relationship of the oral tissues to the developing brain and to the tissues of the face and head that surround the mouth, structures whose location is captured in the word *craniofacial*.

A major theme of this report is that **oral health means much more than healthy teeth**. It means being free of chronic oral-facial pain conditions, oral and pharyngeal (throat) cancers, oral soft tissue lesions, birth defects such as cleft lip and palate, and

scores of other diseases and disorders that affect the oral, dental, and craniofacial tissues, collectively known as the *craniofacial complex*. These are tissues whose functions we often take for granted, yet they represent the very essence of our humanity. They allow us to speak and smile; sigh and kiss; smell, taste, touch, chew, and swallow; cry out in pain; and convey a world of feelings and emotions through facial expressions. They also provide protection against microbial infections and environmental insults.

The craniofacial tissues also provide a useful means to understanding organs and systems in less accessible parts of the body. The salivary glands are a model of other exocrine glands, and an analysis of saliva can provide telltale clues of overall health or disease. The jawbones are examples of other skeletal parts. The nervous system apparatus underlying facial pain has its counterpart in nerves elsewhere in the body.

A thorough oral examination can detect signs of nutritional deficiencies as well as a number of systemic diseases, including microbial infections, immune disorders, injuries, and some cancers. Indeed, the phrase *the mouth is a mirror* has been used to illustrate the wealth of information that can be derived from examining oral tissues.

New research is pointing to associations between chronic oral infections and heart and lung diseases, stroke, and low-birth-weight, premature births. Associations between periodontal disease and diabetes have long been noted. This report assesses these associations and explores mechanisms that might explain these oral-systemic disease connections.

In parallel with the broadened meaning of *oral health*, the meaning of *health* has evolved. The standard definition of health, "freedom from disease, defect, or pain," defines what health is not, rather

than what it is. A more positive definition, one that the World Health Organization established in 1948, states that health is a complete state of physical, mental, and social well-being, and not just the absence of infirmity.

The broadened meaning of *oral health* parallels the broadened meaning of *health*. In 1948 the World Health Organization expanded the definition of health to mean "a complete state of physical, mental, and social well-being, and not just the absence of infirmity." It follows that oral health must also include well-being. Just as we now understand that nature and nurture are inextricably linked, and mind and body are both expressions of our human biology, so, too, we must recognize that oral health and general health are inseparable. We ignore signs and symptoms of oral disease and dysfunction to our detriment. Consequently, a second theme of the report is that **oral health is integral to general health**. You cannot be healthy without oral health. Oral health and general health should not be interpreted as separate entities. Oral health is a critical component of health and must be included in the provision of health care and the design of community programs.

The wider meanings of *oral* and *health* in no way diminish the relevance and importance of the two leading dental diseases, caries (tooth decay) and the periodontal diseases. They remain common and widespread, affecting nearly everyone at some point in the life span. What has changed is what we can do about them.

At the start of the twentieth century, most Americans expected to be toothless by age 45, and most were. Expectations have changed, and most people now assume that they will maintain their teeth over their lifetime, and take active measures to do so. Researchers in the 1930s discovered that people living in communities with naturally fluoridated water supplies had less dental caries than people drinking unfluoridated water. But not until the end of World War II were the investigators able to design and implement the community clinical trials that confirmed their observations and launched a better approach to the problem of dental caries: prevention. Soon after, adjusting the fluoride content of community water supplies was pursued as an important public health measure to prevent dental caries.

Although this measure has not been fully implemented, the results have been dramatic. Dental caries began to decline in the 1950s among children who grew up in fluoridated cities, and by the late 1970s, declines in decay were evident for many Americans. The application of oral science to improved diagnos-

tic, treatment, and prevention strategies has saved billions of dollars per year in the nation's annual health bill. Even more significant, the result is that far fewer people are edentulous (toothless) today than a generation ago.

The theme of prevention gained momentum as pioneering investigators and practitioners in the 1950s and 1960s showed that not only dental caries but also periodontal diseases are bacterial infections. The researchers demonstrated that the infections could be prevented by increasing host resistance to disease and reducing or eliminating the suspected microbial pathogens in the oral cavity. The applications of research discoveries have resulted in continuing improvements in the oral health of Americans, new approaches to the prevention and treatment of dental diseases, and the growth of the science.

The significant role that scientists, dentists, dental hygienists, and other health professionals have played in the prevention of oral disease and disability leads to a third theme of this report: **safe and effective disease prevention measures exist that everyone can adopt to improve oral health and prevent disease**. These measures include daily oral hygiene procedures and other lifestyle behaviors, community programs such as community water fluoridation and tobacco cessation programs, and provider-based interventions such as the placement of dental sealants and examinations for common oral and pharyngeal cancers. It is hoped that this Surgeon General's report will facilitate the maturing of the broad field of craniofacial research so that gains in the prevention of craniofacial diseases and disorders can be realized that are as impressive as those achieved for common dental diseases.

At the same time, more needs to be done to ensure that messages of health promotion and disease prevention are brought home to all Americans. In this regard, a fourth theme of the report is that **general health risk factors, such as tobacco use and poor dietary practices, also affect oral and craniofacial health**. The evidence for an association between tobacco use and oral diseases has been clearly delineated in almost every Surgeon General's report on tobacco since 1964, and the oral effects of nutrition and diet are presented in the Surgeon General's report on nutrition (1988). All the health professions can play a role in reducing the burden of disease in America by calling attention to these and other risk factors and suggesting appropriate actions.

Clearly, promoting health and preventing disease are concepts the American people have taken to heart. For the third decade the nation has developed a plan for the prevention of disease and the promo-



tion of health, embodied in the U.S. Department of Health and Human Services (2000) document, Healthy People 2010. As a nation, we hope to eliminate disparities in health and prevent oral diseases, cancer, birth defects, AIDS and other devastating infections, mental illness and suicide, and the chronic diseases of aging. To live well into old age free of pain and infirmity, and with a high quality of life, is the American dream.

Scientists today take that dream seriously in pursuing the intricacies of the craniofacial complex. They are using an ever-growing array of sophisticated analytic tools and imaging systems to study normal function and diagnose disease. They are completing the mapping and sequencing of human, animal, microbial, and plant genomes, the better to understand the complexities of human development, aging, and pathological processes. They are growing cell lines, synthesizing molecules, and using a new generation of biomaterials to revolutionize tissue repair and regeneration. More than ever before, they are working in multidisciplinary teams to bring new knowledge and expertise to the goal of understanding complex human diseases and disorders.

### **THE CHALLENGE**

This Surgeon General's report has much to say about the inequities and disparities that affect those least able to muster the resources to achieve optimal oral health. The barriers to oral health include lack of access to care, whether because of limited income or lack of insurance, transportation, or the flexibility to take time off from work to attend to personal or family needs for care. Individuals with disabilities and those with complex health problems may face additional barriers to care. Sometimes, too, the public, policymakers, and providers may consider oral health and the need for care to be less important than other health needs, pointing to the need to raise awareness and improve health literacy.

Even more costly to the individual and to society are the expenses associated with oral health problems that go beyond dental diseases. The nation's yearly dental bill is expected to exceed \$60 billion in 2000 (Health Care Financing Administration 2000). However, add to that expense the tens of billions of dollars in direct medical care and indirect costs of chronic craniofacial pain conditions such as temporomandibular disorders, trigeminal neuralgia, shingles, or burning mouth syndrome; the \$100,000 minimum individual lifetime costs of treating craniofacial birth defects such as cleft lip and palate; the costs of oral and pharyngeal cancers; the costs of

autoimmune diseases; and the costs associated with the unintentional and intentional injuries that so often affect the head and face. Then add the social and psychological consequences and costs. Damage to the craniofacial complex, whether from disease, disorder, or injury, strikes at our very identity. We see ourselves, and others see us, in terms of the face we present to the world. Diminish that image in any way and we risk the loss of self-esteem and well-being.

Many unanswered questions remain for scientists, practitioners, educators, policymakers, and the public. This report highlights the research challenges as well as pointing to emerging technologies that may facilitate finding solutions. Along with the quest for answers comes the challenge of applying what is already known in a society where there are social, political, economic, behavioral, and environmental barriers to health and well-being.

### **THE CHARGE**

The realization that oral health can have a significant impact on the overall health and well-being of the nation's population led the Office of the Surgeon General, with the approval of the Secretary of Health and Human Services, to commission this report. Recognizing the gains that have been made in disease prevention while acknowledging that there are populations that suffer disproportionately from oral health problems, the Secretary asked that the report "define, describe, and evaluate the interaction between oral health and health and well-being [quality of life], through the life span in the context of changes in society." Key elements to be addressed were the determinants of health and disease, with a primary focus on prevention and "producing health" rather than "restoring health"; a description of the burden of oral diseases and disorders in the nation; and the evidence for actions to improve oral health to be taken across the life span. The report also was to feature an orientation to the future, highlighting leading-edge technologies and research findings that can be brought to bear in improving the oral health of individuals and communities.

### **THE SCIENCE BASE FOR THE REPORT**

This report is based on a review of the published scientific literature. Where appropriate, standards established to determine the quality of the evidence, based on the study design and its rigor, were used. In addition, the strength of the recommendations, where they are made, is based on evidence of effectiveness for the population of interest. The scope

of the review encompassed the international English literature. Recent systematic reviews of the literature are referenced, as are selected review articles. A few referenced articles are in press, and there are occasional references to recent abstracts and personal communications.

The science base in oral health has been evolving over the past half century. Initial research in this area was primarily in the basic sciences, investigating mechanisms of normal development and pathology in relation to dental caries and periodontal diseases. Prevention research has included controlled clinical studies, with and without randomization, as well as community trials and demonstration research. More recent research has broadened the science base to include studies of the range of craniofacial diseases and disorders and is moving from basic science to translational, clinical, and health services research.

The clinical literature in the oral health sciences includes the full range of studies, from randomized controlled studies to case studies. Most of the literature includes cross-sectional and cohort studies, with some case-control studies. General reviews of the literature have been used for Chapters 2 through 10. Chapter 4 includes both published and new analyses of national and state databases that have been carefully designed and for which quality assurance has been maintained by the Centers for Disease Control and Prevention. Studies of smaller populations are also included where relevant. In Chapters 5 and 7, evidence tables are presented for the discussion of the association of oral infections and systemic conditions and for oral disease prevention and health promotion measures, respectively. Experts in the respective fields contributed to the report, and independent expert peer review was conducted for all sections of the report. The published literature related to the development of new technologies, their potential impact, and the need for further research are described in the course of addressing the requested futures orientation.

### **ORGANIZATION OF THE REPORT**

The report centers on five major questions, which have been used to structure the report into five parts.

#### **What Is Oral Health?**

The meaning of oral health is discussed in the opening pages of this chapter, and the interdependence of oral health with general health and well-being is, as noted, a recurrent theme throughout the volume. Chapter 2 provides an overview of the craniofacial

complex in development and aging, how the tissues and organs function in essential life processes, and their role in determining our uniquely human abilities. The later chapters elaborate further on the meaning of oral health. Of particular importance is the discussion of oral health in relation to well-being and quality of life described in Chapter 6.

#### **What Is the Status of Oral Health in America?**

Chapter 3 is a primer describing the major diseases and disorders that affect the craniofacial complex. Chapter 4 constitutes an oral health status report card on the noninstitutionalized civilian population of the United States, describing the magnitude of the problem. It is based on the most recent national and state data available for a range of craniofacial diseases, disorders, and conditions. In general, the national data provide information categorized by sex, age, income (poor versus nonpoor), and broad racial and ethnic categories. In addition, the chapter includes a profile of the oral and general health of selected population groups. These include racial and ethnic groups such as African Americans, Hispanics, Asians, Native Hawaiians and Other Pacific Islanders, and American Indians/Alaska Natives. The health status of women and individuals with disabilities is highlighted. Although it is clearly desirable to describe the health status of additional populations, data are insufficient or lacking for groups defined by sexual orientation or rural residency or categorized as homeless, migrant workers, or incarcerated. As an initial step toward understanding the burden of disease in relation to the provision of care, available data on the number of dental visits are provided.

#### **What Is the Relationship Between Oral Health and General Health and Well-being?**

Chapters 5 and 6 address key issues in the charge—the relationship of oral health to general health and well-being. Chapter 5 explores the theme of the mouth as a mirror that in some measure can reflect general health or disease status. Examples are given of how oral tissues may signal the presence of disease, disease progression, or risk factor exposure levels, and how oral cells and fluids are increasingly being used as diagnostic tools. This is followed by a discussion of the mouth as a portal of entry for infections that can affect local tissues and may spread to other parts of the body. The next section reviews the

literature regarding emerging associations between oral diseases and disorders and diabetes, heart disease and stroke, and adverse pregnancy outcomes.

Chapter 6 demonstrates the relationship between oral health and quality of life, presenting data on the consequences of poor oral health and altered appearance on speech, eating, and other functions, as well as on self-esteem, social interaction, education, career achievement, and emotional state. Anthropological and ethnographic literature is introduced to underscore the cultural values and symbolism attached to facial appearance and teeth.

### **How Is Oral Health Promoted and Maintained and How Are Oral Diseases Prevented?**

The next three chapters review how individuals, health care practitioners, communities, and the nation as a whole contribute to oral health. Chapter 7 reviews the evidence for the efficacy and effectiveness of oral health promotion and disease prevention measures with a focus on community efforts in preventing dental disease. It continues with a discussion of the need to expand efforts in such areas as oral cancer prevention.

Chapter 8 explores the role of the individual and the health care provider in promoting and maintaining oral health and well-being. For the individual, this means exercising appropriate self-care and adopting healthy behaviors. For the provider, it means incorporating the knowledge emerging from the science base in a timely manner for prevention and diagnosis, risk assessment and risk management, and treatment of oral diseases and disorders. The chapter focuses largely on the oral health care provider. The management of oral and craniofacial health and disease necessitates collaborations among a team of care providers to achieve optimal oral and general health.

Chapter 9 describes the roles of dental practitioners and their teams, the medical community, and public health agencies at local, state, and national levels in administering oral health care or reimbursing for the costs of care. These activities are viewed against the changing organization of U.S. health care

and trends regarding the workforce in research, education, and practice.

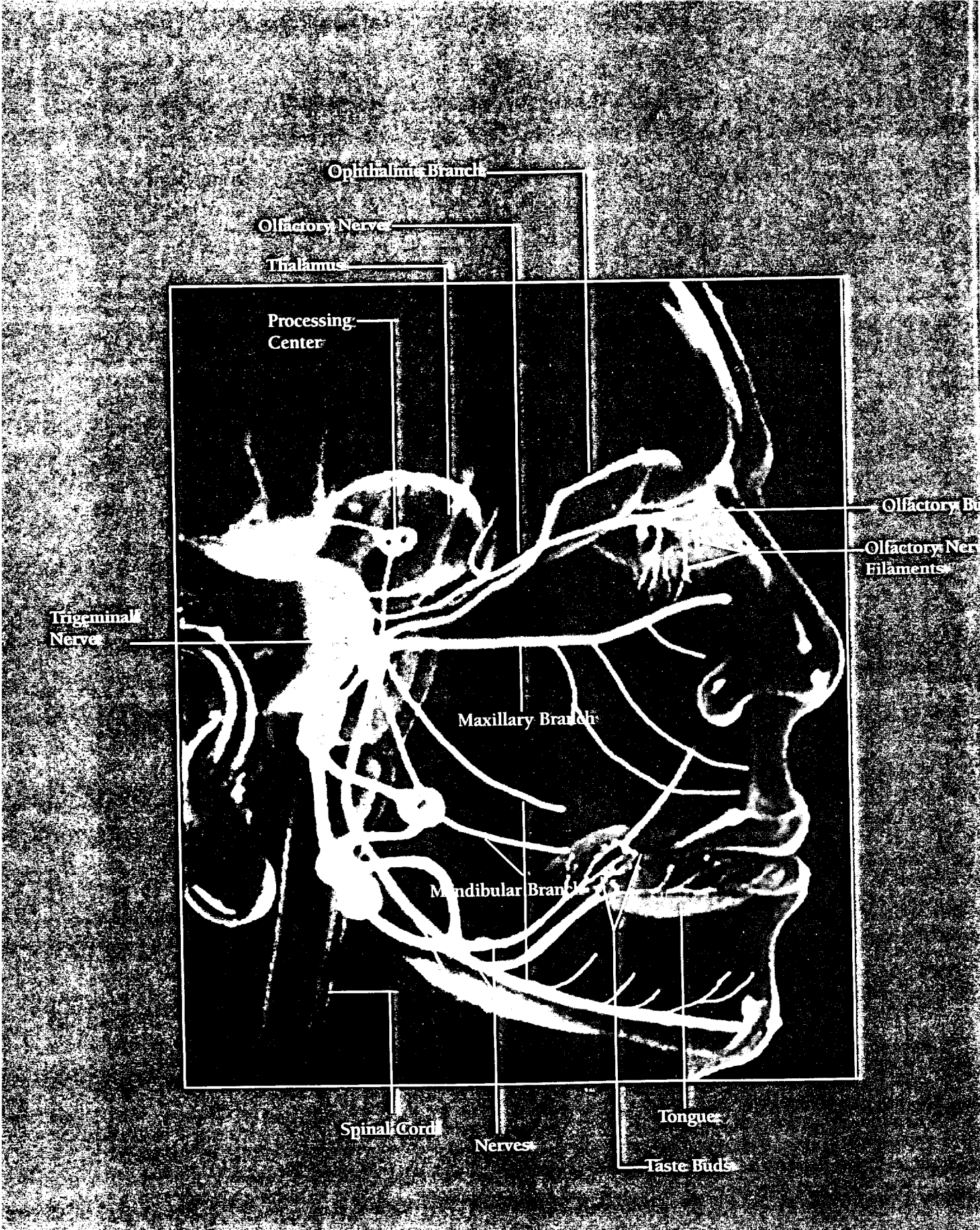
### **What Are the Needs and Opportunities to Enhance Oral Health?**

Chapter 10 looks at determinants of oral health in the context of society and across various life stages. Although theorists have proposed a variety of models of health determinants, there is general consensus that individual biology, the physical and socioeconomic environment, personal behaviors and lifestyle, and the organization of health care are key factors whose interplay determines the level of oral health achieved by an individual. The chapter provides examples of these factors and, in the latter half, illustrates their varying effects at different stages of the life span, with an emphasis on children and older Americans. Barriers and ways to raise the level of oral health that can be achieved at each life stage are presented.

Chapter 11 spells out in greater detail the promise of the life sciences in improving oral health in the coming years in the context of changes in American—and global—society. The critical role of genetics and molecular biology is emphasized.

### **A Call to Action**

Chapter 12, the final chapter, summarizes the major findings of the report and suggests actions to guide the next steps in enhancing the oral health of the nation. The need for partnerships between public and private sectors in carrying out a proposed National Oral Health Plan is emphasized. To ensure progress, these partnerships need to include individual patients and the general public and to reflect all population groups in the nation. All the health care disciplines need to be involved, along with industry, academia, and government, as well as health care organizations, health professional associations, health insurers, and patient groups. United by the evidence that oral health is essential to general health and well-being, the combined forces and collective wisdom of all interested parties and stakeholders can make optimal oral health a reality for all people.



Ophthalmic Branch

Olfactory Nerve

Thalamus

Processing Center

Trigeminal Nerve

Maxillary Branch

Mandibular Branch

Spinal Cord

Nerves

Tongue

Taste Buds

Olfactory Bulb

Olfactory Nerve Filaments

# The Craniofacial Complex

The first line a child draws on a face is usually the mouth. The mouth is the center of communication and contact. Along with the eyes, ears, and nose, it is positioned near the brain, ensuring close integration and coordination. We use the craniofacial complex—the oral, dental, and the other craniofacial tissues that house the organs of taste, vision, hearing, and smell—to experience and interact with the world around us. These sense organs have evolved to serve as superb information processors and aids to survival. At the most elemental level, they enable us to sense our environment—from alerting us to predators or poisons to recognizing family, friends, or prospective mates.

Our ability to act on the nerve signals from these organs results from the abundant supply of paired cranial nerves that innervate the craniofacial tissues. No place in the body is as rich in both the number of sensory nerves and the ratio of motor nerves to muscle fibers as the face, and, within it, the mouth and teeth. The nerve circuits not only trigger protective reflexes to make us blink, gape, and start in surprise, but also enable us to perform countless functions we take for granted. We speak and taste and chew and swallow. We express our feelings through smiles and scowls; we grimace and cry out in pain; we murmur endearments and kiss our loved ones.

Beyond the special senses of vision, hearing, taste, and smell, the craniofacial complex includes nerve endings sensitive to the body's position in space and to touch, pressure, temperature, and pain. In sum, if the brain is the command-and-control center of the body, evolution has ensured that the staff reporting from the field and carrying out orders are stationed a strategic few inches away, in the craniofacial complex.

## CONTACT AND COMMUNICATION

### Taste and Smell

The developmental process by which vital nerve centers came to be concentrated in the head, mouth, and teeth began early in evolution. Even paramecia have mouths, as do worms, bugs, and all more complex organisms. The mouth appears in the human embryo during the third week of development. By the thirteenth or fourteenth week, the fetal mouth can open in response to stimulation of the lower lip. During the next 2 months, the fetus will practice protruding and then pursing the lips, eventually achieving the ability to suck vigorously at 29 weeks. In the meantime, inspiratory gasps, tongue movements, lip curling, and swallowing responses will have been established (Wilentz 1968).

At birth, the taste buds are found on the roof of the mouth and in the throat, as well as on the tip, sides, and back of the tongue. Taste buds, such as those on the tip of the tongue, are particularly subject to wear and tear, and may be replaced every 2 weeks. The total number of buds diminishes over time, but there appears to be considerable reserve capacity, so there is normally little loss in the sense of taste as we age.

It has been said that taste is 90 percent smell, and to some extent that is true. The taste cells that line the buds respond to only five known qualities: sweet, sour, salty, bitter, and glutamate. The experience of taste is a complex mixture of smell, temperature, taste, and texture.

The day-old newborn responds to sweet stimuli. Suckling, the first oral function following the cry, is enhanced by the presence of lactose, the sugar in breast milk. Liquids sweetened with sugar or honey have been used widely after birth to stimulate appetite, and later to wean children from breast-

feeding. The ability to recognize a sweet taste clearly has survival value, enabling the recognition and selection of carbohydrates—a vital source of energy.

The other taste modalities are also physiologically important. A sour taste, for example, can signal an unripe fruit. However, sour substances may be involved in more subtle biochemistry, such as maintaining the body's ion balance. They also satisfy thirst and promote digestion by stimulating the secretion of saliva. A bitter taste is sufficiently unpleasant to evoke aversion, a useful response given that many bitter-tasting plant alkaloids are toxic. A salty taste indicates the presence of sodium, which is essential to maintaining the fluid balance between cells and the extracellular compartment.

Humans probably began as herbivores before the advent of hunting and gathering and retained taste-discriminating ability as an evolutionary advantage. The combination of taste and smell remains important not only for the maintenance of an optimal diet (Young 1977), but also clearly for the pleasures of eating.

Unlike taste cells, olfactory cells can respond to many thousands of odorants, including ones that have been newly synthesized. Millions of olfactory receptors line a postage-stamp-sized area in the upper part of the nose, the olfactory epithelium. Although some smells may be judged universally as unpleasant or foul, others are subject to learning and cultural conditioning. For example, a ripe Roquefort cheese may delight some people, but repel others.

The primary receptor cells of the olfactory system are neurons with fine hairs at one end that project into the olfactory epithelium to pick up the olfactory stimulus. The cells translate the stimulus to nerve impulses transmitted to the brain along the two olfactory nerves—one from each nostril. Olfactory neurons have the unusual ability to regenerate (although recent studies suggest that neurons in other parts of the adult brain may also have this ability (Johansson et al. 1999)). Olfactory pathways are widely distributed in the brain, relaying to emotional and cognitive centers in the cortex. These connections undoubtedly account for the ability of odors to stir old memories as well as stimulate a range of feelings, from fear to sexual arousal.

### **Touch, Temperature, and Pain**

The mouth also contains large numbers of nerve endings, similar to those found elsewhere in the body, that are sensitive to touch (mechanoreceptors), hot and cold temperatures (thermoreceptors), and pain (nociceptors). The dense concentration of these

receptors in the facial skin, joints, muscle, and oral soft tissues, relayed to an image of the body mapped onto the sensory cortex of the brain, accounts for the finesse with which we can discriminate the qualities and precise location of these sensations. In particular, the periodontal ligament, which anchors the teeth in the jaws, is a tactilely sensitive tissue providing important feedback with regard to mastication (chewing) and dental occlusion (bite). As a test of this sensibility, a human hair placed between the tips of the fingers will rarely be sufficient to stimulate the nerve endings, but the same hair placed between the lips or incisors will instantly be felt.

Pain and thermal sensitivity in the teeth are transmitted through nerve endings in the pulp. Because the pulp is in a narrow canal composed of connective tissue, blood vessels, and nerves and surrounded by hard tissue, any infection or inflammation that would normally cause tissue to swell creates pressure on the pulpal nerves. That pressure, along with bacterial or immune system products that stimulate the nerve endings, produces the severe pain of pulpal infections.

Neuroscientists have long studied oral-facial pain, not only because of its importance in oral disease, but also because it provides an accessible model of pain elsewhere in the body. These investigations have greatly enriched our understanding of the basic mechanisms of pain perception and modulation. They have helped delineate the complex pathways and multiple transmitters that convey pain signals to the brain and spinal cord, as well as the mechanisms and molecules that can modulate and inhibit nociceptive input. These studies have also exploited new brain-imaging techniques to confirm the wide distribution of pain pathways and relay centers in the cerebral hemispheres and cerebellum.

This research has generated new approaches to the control of acute and chronic pain. These approaches include the use of nonsteroidal, anti-inflammatory drugs and long-acting local anesthetics for acute oral and dental pain, and the use of more potent drugs, drug combinations, and other kinds of therapies to treat chronic pain. Researchers have emphasized the importance of adequate pain control in patients with chronic pain conditions. Otherwise, the constant barrage of signals can effect long-term changes in the brain that actually worsen the pain (producing hyperalgesia) and cause normally non-painful stimuli to be perceived as painful (a condition called allodynia). Unrelieved chronic pain may also suppress the immune system.

Recently, investigators discovered a link between certain taste sensations, pain, and temperature. Their

findings indicate that capsaicin, the ingredient that makes hot peppers taste hot, binds to a receptor on the surface of nociceptors that also responds to noxious heat. The researchers have cloned the gene for the capsaicin receptor (called vanilloid receptor 1); they believe it is involved in several chronic pain conditions, especially those where inflammation plays a role, such as viral and diabetic neuropathy, rheumatoid arthritis, and oral mucositis pain caused by cancer chemotherapy or radiation (Caterina et al. 1997).

There is evidence that the prevalence of a number of pain conditions varies by gender and that men and women respond differently to different analgesic drugs. These findings have prompted studies aimed at determining whether there are sex differences in pain anatomy and neurochemistry and whether (and how) nociception is affected by sex hormones.

## Speech

Human speech and language are the faculties that most distinguish us from other higher primates; they are also the links that bind people together in diverse social groups and cultures.

Central to speech are laryngeal mechanisms involving the vocal cords. Equally critical are the respiratory system, the pharynx, and the nasal and oral cavities. The tongue is the most important structure of the peripheral speech mechanisms, working in conjunction with the lips, teeth, and palate to produce a rich repertoire of sounds. Abnormalities in oral structures, from missing or malformed teeth and malocclusion to cleft lip and palate, can seriously affect articulation. The movements of speech are orchestrated by brain centers that coordinate the muscles of mastication, facial expression, and jaw movements.

Hearing impairments can also affect speech. To learn to speak, children must be able to hear others and monitor the feedback from their own voices. Congenital deafness and the serious hearing defects associated with some craniofacial syndromes (see Chapter 3) can severely compromise speech acquisition.

## THE ORAL CAVITY

The mouth is the gateway to the body, performing dozens of functions that place high demands on its unique hard and soft tissues. The point of entry is the lips, which open into the oral cavity. The cheeks form the sides of the cavity, and the roof is formed by the palate, which separates the mouth from the nose above and the pharynx (throat) behind. The anterior

palate is hard, formed by underlying bone, and serves as a shield against trauma to the face and head. The posterior palate is soft, composed of muscles and connective tissue that blend into the walls of the pharynx. Hanging from the rear of the soft palate is the uvula, a mass of muscle and connective tissue. Under the tongue is the floor of the mouth, composed primarily of muscle and salivary glands. The paired tonsils and adenoids, important components of the immune system, lie at the sides of the palate and within the nasopharynx, respectively.

The pharynx opens into channels leading either to the lungs for respiration or the esophagus for further digestion and passage to the stomach. This is a point of vulnerability: should food or some other obstruction lodge in the airway, it could lead to death by asphyxiation.

Externally, the oral cavity is bounded by the maxilla (the upper jaw bone), attached to the cranium, and the mandible (the lower jaw), attached to the temporal bone of the skull by the temporomandibular joint.

## The Oral Mucosa

Except for the teeth, the oral tissues are covered by a mucous membrane called the oral mucosa, which varies in color from pink to brownish purple, depending on an individual's skin color. Like skin, the oral mucosa acts as a major barrier against chemical irritants and mechanical forces; it can even withstand temperatures that would be painful to the skin. In areas subject to chewing forces and food movements, the surface layer is relatively hard, composed of epithelial cells filled with insoluble keratin, the fibrous protein found in skin, nails, hair, and animal horn. Elsewhere—in the mucosal lining of the cheeks, for example—the surface layers are softer and more flexible, enabling the mobility we need to speak, chew, and make facial expressions. To aid in their barrier function, surface mucosal cells are square-shaped and closely juxtaposed, with specialized organelles and cell products that promote cell-cell adherence. The cells can also secrete sticky molecules to plug gaps between them and further impede penetration by damaging chemicals or microorganisms. Still another type of oral mucosa forms the pebbly surface of the back and sides of the tongue. Lining the depths of these surface "papillae" are the taste buds.

Interestingly, the epithelium that lines the gingival surface completely lacks a keratin layer, yet this "naked" epithelium lies next to one of the most dense concentrations of bacteria to be found in the body.