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Beyond the “omics”:

Translating science into improved health

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If you have knowledge, let others light their candles with it. —Winston Churchill

Scientific progress drives innovation in health care. From digital radiographs to smart dental materials that stimulate tooth repair, new technologies have significantly improved diagnostic quality, patient comfort and efficiency in dental care. Today’s scientific breakthroughs are leading to increasingly powerful and sophisticated tools that promise to improve the lives of millions of Americans. Making it happen will require focused research efforts and a strong link between research and practice.

Dentists have contributed to many important scientific discoveries. Perhaps the most widely known is Frederick McKay, a young dentist who, in the early 1900s, observed that brown stains on his patients’ teeth seemed to be linked to their drinking water supply.¹ His observation eventually led to the discovery that fluoride protects against caries. Although not trained as a researcher, McKay understood the process and value of scientific inquiry. He kept meticulous records, correlated his patients’ dental examination data with their place and length of residence and collaborated with colleagues. He even persuaded G.V. Black, one of the nation’s leading dental researchers, to visit Colorado Springs, Colo., to help decipher the mystery of the “Colorado brown stain.” McKay’s curiosity, insights, discipline and perseverance set in motion the studies that nearly 30 years later transformed dentistry into a prevention-oriented profession.

The link between clinical practice and research is as critical today as it was during McKay’s time. The mapping of the human genome in 2003 triggered the development of powerful research tools such as comparative genomic hybridization, serial analysis of gene expression and DNA arrays. The combination of these analytic tools with dizzyingly fast computers is yielding opportunities to understand complex biological systems from a molecular perspective. Scientists now can extract and integrate vital genomic information to diagnose diseases more precisely at their earliest inception, to direct personalized therapy and to predict and evaluate disease outcomes more accurately. Other “omics”—proteomics and metabolomics—offer even deeper insights into the behavior of cells and their response to genetic and environmental factors and enhance our ability to predict and treat many oral, dental and craniofacial disorders.

Proteomics and metabolomics are valuable spinoffs of the sequencing of the human genome. Proteomics involves the identification and compilation of the complete catalog of proteins

produced by cells in normal and diseased tissues. Metabolomics is a large-scale approach to monitoring and providing a complete score card of all small molecules such as lipids, sugars and amino acids involved in daily cellular function. How does dentistry stand to gain from the characterization of proteins and metabolites? For instance, the National Institute of Dental and Craniofacial Research (NIDCR)—one of the U.S. National Institutes of Health—supports an ambitious effort to catalog all the proteins contained in human oral fluids. The salivary proteome project and additional efforts to map small-molecule metabolites are a key step toward developing saliva-based diagnostic systems capable of rapid, noninvasive and safe identification of molecules and substances that can be detected only through blood tests. The progress being made toward salivary diagnostics is the result of collaboration among engineers, biologists, dental researchers and dental clinicians.

Many oral diseases and disorders, including dental caries, cleft lip/palate and a host of craniofacial syndromes, are complex conditions that arise from the actions of multiple genes and their interactions with one another, the environment and other factors. It will take more than adding up the molecular parts to understand and address such multifactorial disorders. An interdisciplinary approach is needed to integrate the complex web of molecular information with clinical information, particularly for diseases the diagnosis of which is based primarily on clinical findings.

Take, for example, head and neck cancer—a malignancy that kills more than 8,000 Americans each year. Management of head and neck cancer still is based primarily on the evaluation of macroscopic tumor characteristics and extent of disease. But if genomic information could be factored into treatment decisions, it might be possible to predict which patients require aggressive treatment and which do not. Surgeons might be able to distinguish healthy tissue from cancerous tissue more precisely, thus minimizing disfigurement and loss of function.

It's not a far-fetched scenario. Emerging evidence from geneticists studying breast and prostate cancer suggests that treatment of those malignancies could be optimized by taking into account genetic information.²⁻⁴ Using genomic approaches, scientists now can determine the expression patterns of thousands of genes simultaneously in a tumor sample. This kind of information could prove extremely valuable for predicting which tumors are likely to recur or metastasize. Metabolomics methodologies are evolving, but they hold tremendous promise for improved disease screening, diagnosis and prognosis. For example, metabolic profiling has been used to identify biomarkers of myocardial ischemia—a critical step toward more accurate diagnosis of coronary heart disease and for selecting and evaluating the response to therapy.⁵ Incorporating these genomic approaches into the clinical setting will require close collaboration among researchers, cancer geneticists and clinicians.

Innovations in health care likely also will come from genomewide association studies, which look at variations across the human genome to identify genetic associations with observable traits or the presence or absence of a disease or condition. NIDCR is supporting two genomewide association studies that focus on dental caries and oral clefting. The studies offer real potential for understanding the molecular basis of these conditions and eventually improving our ability to predict and manage them. But to be useful, the data from genomewide association studies must be combined with clinical information and physical findings. Here, too, dentists and other clinicians can bring their knowledge and unique perspectives to the table and work in partnership with geneticists, epidemiologists and informaticians.

In the aforementioned examples, clinicians play the role of research collaborators and facilitators. Dentists also can play a more central role in research by participating as investigators in the NIDCR-funded dental practice-based research networks. Three regional networks are in operation, one in the east (administered by the New York University College of Dentistry, New York City), one in the south (administered by the University of Alabama at Birmingham School of Dentistry in collaboration with the University of Florida College of Dentistry in Gainesville) and one in the west (administered by the University of Washington School of Dentistry, Seattle, in collaboration with the Oregon Health and Science University, Portland, School of Dentistry). The networks conduct short-term clinical studies to compare the benefits of different dental procedures, materials and prevention strategies for a range of patient and clinical conditions. They also collect data regarding disease prevalence and treatment trends. The practice-based research networks provide a unique opportunity for dentists to propose research ideas and generate high-quality data that can help guide them in making the treatment decisions they face in everyday practice. They also provide a much-needed clinical infrastructure to investigate emerging health issues. Last year, as reports of jaw osteonecrosis associated with bisphosphonates began to surface, NIDCR mobilized the networks to study the prevalence and risk factors of this debilitating drug side effect. Bisphosphonates are a commonly used class of drugs that inhibit bone remodeling.

Scientific knowledge leads to improved health only when it is translated into practical applications. The translation process is a two-way street, with researchers providing tools to improve clinical practice and clinicians offering observations and insights needed to generate and refine research ideas. A century ago, Frederick McKay keenly understood the symbiotic relationship between practice and research, and his willingness engage in research helped to define a new preventive era for dentistry. It will take a similar symbiosis between researchers and clinicians to ensure the knowledge and tools emanating from the “omics” ultimately translate into better oral health and quality of life.

References

1. National Institutes of Health, National Institute of Dental and Craniofacial Research. [Accessed Jan. 31, 2008] The story of fluoridation. www.nidcr.nih.gov/HealthInformation/DiseasesAndConditions/Fluoride/StoryFluoride.htm
2. Liu R, Wang X, Chen GY, et al. The prognostic role of a gene signature from tumorigenic breast-cancer cells. *N Engl J Med.* 2007; 356(3):217–226. [PubMed: 17229949]
3. Fan C, Oh DS, Wessels L, et al. Concordance among gene-expression-based predictors for breast cancer. *N Engl J Med.* 2006; 355(6):560–569. [PubMed: 16899776]
4. Wang X, Yu J, Sreekumar A, et al. Auto-antibody signatures in prostate cancer. *N Engl J Med.* 2005; 353(12):1224–1235. [PubMed: 16177248]
5. Sabatine MS, Liu E, Morrow DA, et al. Metabolomic identification of novel biomarkers of myocardial ischemia. *Circulation.* 2005; 112(25):3868–3875. [PubMed: 16344383]