



EMERGING SCIENTIFIC ADVANCES: HOW DO THEY ENTER DENTAL CURRICULA AND THE PROFESSION?

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ABSTRACT

What is meant by emerging scientific advances? In brief, this terminology is equivalent to new research findings, however, the term "research" is often associated with scientific investigations that have very limited direct clinical relevance. Unfortunately, basic dental research and dental clinical practice have, in many instances, been considered to have nonoverlapping spheres of existence. The existence of mutually exclusive domains is rapidly changing with considerable translational activities between basic research investigation and clinical application developing.

There is a growing emphasis at a national level for the importance of moving basic biomedical research laboratory findings into clinical patient-related applications to realize improvements in health based on the research findings.^{1,2} Ultimately, new approaches to diagnose, treat, and prevent disease will be available and represent the translation of the best scientific evidence into clinical applications. It is critical at this time to prepare our dental graduates to be members of the dental profession who will understand the implications that new scientific advances will have on their approach to patient care. The patterns and practices of oral health care delivery will undergo major changes during the careers of our new dental graduates. They need to be prepared to respond to these changes to the benefit of their patients.

Students graduating from dental school this year will be completing their predicted 40-year careers in 2045, and there is no doubt the profession will be vastly different from the one they entered upon graduation. The likelihood of these dramatic changes can be appreciated when the state-of-the-art of dentistry in 1965 is compared to 2005, a time-frame reflective of a typical dental career. **Table 1** lists some of the products advertised in the *Journal of the American Dental Association* in 1965. Each of these products was important in dental care for patients and included in the dental curricula of the time, yet, during the past 40 years, new advances have replaced each one. Reviewing any current dental journal, it is clear there exists new diagnostic aids, new dental materials, new strategies for prevention, and new therapies that could not have been envisioned by dental curricula or dental practice 40 years ago. During this time, dental practitioners have been required to make informed decisions to change their approach to patient care based on the best scientific evidence. Importantly, each prod-



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uct or technique, both old and new, was developed on a base of scientific investigation that supported their use in oral health care. Basic research and translational clinical research were necessary to validate the technology and introduce it into routine oral health care. Establishing a basis for incorporating new approaches to patient care requires that dental curricula provide the foundation for understanding the implications of scientific advances and interpreting the claims made for new approaches to improve oral health. Continuous review of dental curricula

by faculty and curriculum committees is essential to ensure the curricular content is current and at the cutting edge of evidence-based knowledge. Dental curricula also needs to establish the importance of lifelong learning and the critical-thinking skills required to make the decisions to incorporate a new finding into routine practice following graduation. Thus, dental curricula need to address both specific curricular content areas and individual professional behaviors that will facilitate adaptation to the changes occurring throughout a professional career.

Why Should Dental Curricula Prepare Graduates for a Future of Change?

In 1965, Dr. A.R. Baralt wrote, "There is no question the new dentist is capable of conducting himself professionally and ethically while he sets about establishing a practice, but he does not believe for one minute that he has learned everything he needs to know. He must continue to learn."³ He also quoted Dr. P.E. Blackerby that "With the continual expansion of knowledge brought about by research, the dental practitioner must strive constantly to keep himself and his practice methods fully up to date, in order that his patients may receive the modern dental service to which they are entitled."³ Both of these individuals recognized that changes in dentistry were inevitable and dental professionals needed to continue their learning to provide oral health care at the highest standards. It becomes clear dental curricula must provide the content that will serve as a foundation for understanding the scientific advances that will occur. This can be achieved by continuous curricular review and comparison of the content with the evidence base that has been created through scientific investigation. Similarly the curricula should be continuously reviewed to ensure the behaviors of lifelong learning and critical-thinking skills are included to prepare graduates for the changes that will occur during their careers. Determining the foundation content that should be included in the dental curriculum requires careful attention to the likely growth areas in scientific understanding that would be applicable to oral health care. An important resource for predicting future research findings is to examine the planning completed by federal agencies that have responsibility for public health and federally supported research to improve health. The U.S. surgeon general in 2000 completed a landmark analysis of

Table 1

1965 Advertisements in the *Journal of the American Dental Association*

- Luxene vinyl crown and bridgework
- "Cold" sterilization trays
- Belt-driven dental handpieces
- Achatite – silicate restorative material
- Steele's facings
- Electro-mallet gold foil condenser
- Unacaine anesthetic (metabutethamine HCl)
- Karidium fluoride tablets
- DI-LOK trays for dies
- Zactirin analgesic tablets (ethoheptazine citrate and aspirin)

Table 2

Major Findings of *Oral Health in America: A Report of the Surgeon General*

- Oral health is more than healthy teeth.
- Oral diseases and disorders in and of themselves affect health and well-being throughout life.
- The mouth reflects general health and well-being.
- Oral diseases and conditions are associated with other health problems.
- Lifestyle behaviors that affect general health such as tobacco use, excessive alcohol use and poor dietary choices affect oral and craniofacial health as well.
- Safe and effective measures exist to prevent the most common dental diseases – dental caries and periodontal diseases.
- There are profound and consequential oral health disparities within the U.S. population.
- More information is needed to improve America's oral health and eliminate health disparities.
- Scientific research is key to further reduction in the burden of diseases and disorders that affect the face, mouth and teeth.

oral health, "Oral Health in America: A Report of the Surgeon General" that contained nine major findings (Table 2).⁴ Importantly, the last two of these findings, "More information is needed to improve America's oral health and eliminate health disparities," and "Scientific research is key to further reduction in the burden of diseases and disorders that affect the face, mouth and teeth," are directly linked to the generation of new scientific evidence that will be applied to oral health problems. In 2003, the surgeon general developed the "National Call to Action to Promote Oral Health" that established a plan to address the oral health needs identified in the 2000 report.⁵

Five action items were identified (Table 3) and the generation of new knowledge through scientific investigation was deemed critical to achieve the goals of the "Call to Action." The U.S. surgeon general has now identified the importance of oral health and the necessity for new scientific advances to improve the oral health of Americans. These observations have been embraced by the National Institutes of Health in the development of their roadmap.^{1,2} As stated, "The NIH roadmap is an integrated vision to deepen our understanding of biology, stimulate interdisciplinary research teams and reshape clinical research to accelerate medical discovery and improve people's health."^{1,2} The NIH roadmap consists of three themes and multiple specific emphases within each theme, which illustrate the commitment of the NIH to translating basic biomedical research findings into clinical therapies (Table 4). Future research funding provided by the NIH will be focused on these roadmap themes, with new scientific advances sure to follow and fundamentally change the ways in which disease is diagnosed, treated, and prevented. The management of dental curricula requires a process to ensure this new knowledge is included. This means there will be a need to incorporate the

Table 3

National Call to Action to Promote Oral Health

- Action 1. Change perceptions of oral health.
- Action 2. Overcome barriers by replicating effective programs and proven efforts.
- Action 3. Build the science base and accelerate science transfer.
- Action 4. Increase oral health work force diversity, capacity and flexibility.
- Action 5. Increase collaborations.

Table 4

NIH Roadmap Themes and Thematic Emphases

- New pathways to discovery
- Building blocks, biology pathways and networks
- Molecular libraries and molecular imaging
- Structural biology
- Bioinformatics and computational biology
- Nanomedicine
- Research teams of the future
- High-risk research
- Interdisciplinary research
- Public-private partnerships
- Re-engineering the clinical research enterprise
- Clinical research networks/NECTAR
- Clinical research policy analysis and coordination
- Clinical research work force training
- Dynamic assessment of patient-reported chronic disease outcomes
- Translational research

appropriate foundation knowledge so that graduates are able to understand the implications of new discoveries, and an emphasis of the development of learning behaviors applicable during a professional career.

What Types of New Scientific Advances in Oral Health Care Will Require Changes in Curricular Content?

It is impossible to completely predict the future, but there is information that allows judgments to be made with respect to likely new advances. Using this information as a guide, the curricular content areas can be identified to assist the students to build a foundation of scientific information suitable for their professional careers.

Faculty on curriculum committees and during the periodic process of dental school accreditation consider the directions of the profession and the impact new knowledge will have on dental education. In this regard, the planning activities of the National Institute of Dental and Craniofacial Research represent an excellent resource to anticipate new developments in research that will lead to new approaches to patient oral health care. The NIDCR works with scientists and clinicians to develop research concepts that will represent the focus for grant funding in the future (Table 5). The 10 concepts generated by the NIDCR in 2004-2005 represent a range of oral health topics related to diagnosis, pathogenesis, therapeutics, and prevention. Many of these new

Table 5**NIDCR Research Concepts Generated in 2004 and 2005**

Drug delivery systems for treatment of orofacial disease
Protein profiles of the oral mucosal tissues in the context of HIV/AIDS
Sjögren's Syndrome: A model complex disease
Development of technologies for saliva/oral fluid-based diagnostics
Building a tooth: Bridging biology and materials science
Role of neuronal/glia cell interactions in orofacial pain disorders
Validation of new technologies for clinical assessment of tooth surface demineralization
Clinical research on osseointegrated dental implants
Oral complications of cancer treatment
Novel approaches to study polymicrobial diseases

research initiatives will investigate the specific problem areas using molecular genetic techniques and, in some cases, examine the problem using embryonic stem cells. The availability of the DNA sequence of the human genome represents a remarkable achievement that has provided a wide range of new opportunities to advance oral health care.^{6,7} Evaluation of genetic etiologies and genetic risks in patients will ultimately allow patient care to be planned that is unique for each individual and based on both the specific genetic background of the patient and the molecular pathogenesis of the disease. Already it has been shown that saliva is a valuable diagnostic medium and that genetically induced changes in the constituents of saliva can alter the risk for dental caries.⁸ Genetically based diagnostics, such as tests of saliva will be available soon. The use of any specific future test is difficult to incorporate into a current dental curriculum. However, since the genetics represents the foundation many types of tests that will be developed in the future, it becomes ever more important that foundation knowledge in genetics be integrated throughout dental curricula. The development of new diagnostic tests will be valuable for diagnosis, treatment, and prognosis, however, the NIDCR has therapies based on scientific advances. One remarkable example is

a new research initiative launched by the NIDCR with the goal to regenerate a tooth, an interdisciplinary program of research that will include molecular biologists, biomedical engineers, materials scientists, and clinical investigators. The potential results from this initiative include the production of a vital tooth that could be used to restore edentulous areas and the development of biomimetic restorative materials consisting of dental enamel. Additionally, California has created a remarkable opportunity with the stem cell research initiative to use these unique cells to create cells, tissues, and organs that could lead to dramatic new approaches to patient treatment.⁹ These diagnostic and therapeutic advances are made possible by the availability of the human genome and represent only the initial steps to tap this remarkable resource. The future use of the human genome to address the health needs of patients requires that dental curricula include a foundation in human genetics, and cell and molecular biology sufficient to understand the basic principles for new diagnostic and therapeutic modalities. It will also require that students develop expertise in finding recent, relevant literature and interpreting the outcomes to make the critical decisions to incorporate new approaches into routine practice.

Which Behavioral Skill Sets Will a Dental Graduate Need for the Future to Evaluate Scientific Advances?

There has been an explosion in new knowledge in the past decade, and the growth in information technology ensures an ever-more rapid dissemination of scientific advances. As information sources have progressed from books to journals, and now Internet-based materials, the ease of posting findings has created another problem, critically evaluating the material. While the availability of information has never been greater, the quality of the information is not always either consistent or reliable. This requires students and professionals to conduct careful reviews of the information and make informed judgments, yet these skills may not necessarily have been developed in current curricula. The linkage between scientific evidence and clinical care was a point of concern identified in the IOM report of 1995, "The basic and clinical sciences do not adequately relate the scientific basis of oral health to clinical practice."¹⁰ Finding and critically evaluating information becomes a professional behavior to be included in the curriculum and skills that will be necessary throughout a professional career. Developing curricular elements that require students to review literature as an integral component of the pedagogy becomes a key consideration as curricula are updated. The National Academy of Sciences has completed an evidence-based analysis of learning, "How People Learn: Brain, Mind, Experience and School" that provides considerable insight into the development of effective learning skills.¹¹ The power of learning through inquiry has been shown to be an effective strategy to help students learn to ask the appropriate questions and identify the best sources to answer these questions. Often, students rely principally on textbooks during the course of study, however, even the very best textbooks may be two

or more years out of date due to the publishing lag time. It will become increasingly important for students to develop learning behaviors that move away from the static nature of textbooks to the much more dynamic environment of journals and online resources.

Curricular revisions to include the dynamic aspects of information will be critical to developing the appropri-

ate behaviors for a professional career. Patients have access to this information and will be searching for information and answers, which requires the oral health professional to be prepared to respond to the patient's queries. Structuring a curriculum using real-life patient problems as the stimulus for inquiry and the foundation for learning begins to build the skills necessary for a career.¹² One approach to utilize potential future clinical encounters as the prompt for inquiry-based learning is through the use of a problem-based learning pedagogy.¹³⁻¹⁶ PBL requires the students to learn to ask relevant questions about a clinical situation they have never previously encountered, identify the resources to answer the question, and apply the new information to better understand the patient's signs and symptoms. Decisions about the patient case being analyzed are based on the best available evidence and it becomes clear that the state of knowledge is dynamic. Learning curricular content in a manner that best approximates the future use and application of the knowledge has

been shown to be a very powerful method.¹¹ The professional behaviors necessary to adapt to the future changes in the profession can be developed simultaneously with the growth in basic content foundation knowledge. The graduates would then understand the limits of current knowledge and have the skills to continue to identify the most current scientific advances.

can be predicted. It is essential dental students develop the foundation content and the professional behaviors that allow them to provide the finest quality oral health care to their patients during their career. **CDA**

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