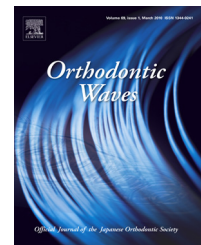


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Review

Lessons learned as a student of craniofacial biology: What this might mean for orthodontic professional education and clinical practice in the 21st century

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ABSTRACT

The National Institute of Dental Research (NIDR) supported the international symposium “Congenital Anomalies of the Face and Associated Structures” led by Professor Sam Pruzansky and members of the first Dental Study Section in 1959. The plan was unique in that it examined the human face as a biological continuum, from conception through postnatal growth and development, to maturity in terms of functions, structures, and behavior. The symposium forged foundations for what we now term “craniofacial biology.” In tandem, the first grant by NIDR was funded in 1957 to Dr. Herbert K. Cooper, orthodontist, for his landmark animal and human studies of cleft lip and cleft palate. What followed were decades of multidisciplinary studies in embryology, anatomy, and physiology coupled with diagnostics, therapeutics, biomaterials, imaging, speech pathology, and studies of human behaviors to promote health and health literacy. In 1998, as Director of the NIDR, I championed a name change for the Institute to become the National Institute of Dental and Craniofacial Research (NIDCR) to better reflect our scientific portfolio. Today I ask how craniofacial biology evolved from teratology to neural crest cell mapping, to experimental embryology, to correlating single gene mutations to phenotype (s), and knowledge of gene functions. Now in the 21st century, craniofacial biology contributes to genomics and epigenetics in animal models and human soft and hard tissue diseases and disorders. For the near future, biomedical scientists and clinical scholars seek to understand how human and microbial genomics impact diseases, how to use gene editing to treat diseases, how to employ precision dentistry and medicine, and how to advance major revisions in professional health education and interprofessional clinical practice. As in the past, orthodontists and many other disciplines will continue to play key roles involving critical thinking and sound clinical acumen to improve the quality and precision of craniofacial-oral-dental healthcare.

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1. Introduction

“The most beautiful discoveries are made not so much by men as by the period. They mature in the course of time, just as fruit falls from the tree at the same time in different gardens.” Goethe

And with this quotation from Goethe, Professor Sam Pruzansky of the University of Illinois and as Chairman for the first Dental Study Section of the NIDR opened a conference “*Congenital Anomalies of the Face and Associated Structures*” held at Mountain View Hotel in Gatlinburg, Tennessee on December 6th 1959 [1]. Pruzansky and his Study Section colleagues Lucien A. Bavetta (University of Southern California and one of my mentors), Gerrit Bevelander (New York University), Gerald J. Cox (University of Pittsburgh), and Robert Hill (Executive Secretary of the Dental Study Section) invited and hosted 125 scientists and clinicians from all parts of the nation, and from abroad, to assess what is known and what were the scientific opportunities in congenital craniofacial diseases and disorders [1]. This conference was a major benchmark for what was soon to follow. That historic period contained teratology and experimental embryology in animals, the “thalidomide epidemic,” radiation induced birth defects, gene-environment interactions, the structure and function of deoxyribonucleic acid (DNA), and major funding from the National Institutes of Health (NIH) and the March of Dimes.

A few years later, *Craniofacial biology* was the term coined by Sam Pruzansky, an orthodontist who served as the Director of Craniofacial Anomalies at the University of Illinois in Chicago [2]. At that time, my postdoctoral mentor Lucien Bavetta sponsored me to attend that fateful evening at the International Association for Dental Research (IADR) being held in March 1968. My postdoctoral studies included developmental biology of teeth, classical biochemistry and immunology related to collagens and enamel proteins. It was for me a thrilling event in San Francisco. Featured speakers at this first meeting of the Craniofacial Biology Interest Group included Sam Pruzansky and Bob Gorland. In turn, Herbert K. Cooper, also an orthodontist, who earlier created the first craniofacial team in Lancaster, Pennsylvania in 1938, inspired Pruzansky and many others to create interprofessional, multidisciplinary craniofacial teams including orthodontists to address diagnosis and treatment of cleft lip and palate and related congenital as well as acquired craniofacial malformations. Both men realized that there was a unique opportunity to organize *craniofacial biology* as a field of study that required elaborate collaboration, communication, and cooperation between anatomists, physical anthropologists, embryologists,

physiologists, biochemists, genetics, pharmacology, microbiology, and immunology, coupled with audiology, dentistry (pediatrics, oral and maxillofacial surgery, orthodontists, and prosthodontics), dental hygiene, medicine (surgery, pediatrics, adolescent pediatrics, primary care), nursing, pharmacy, radiology, speech therapy, and social services—all asking patient-centered questions and advancing investigations of basic, translational, clinical, outcomes, and implementation scientific research of the craniofacial-oral-dental complex. Pruzansky became “the father of craniofacial biology” while many of us served as “midwives” for the birth of *craniofacial biology*. Here was the origin of *craniofacial biology* and “interprofessional patient-centered healthcare” [1-11].

Over the following five plus decades, craniofacial biology became a mature trans-professional, multidisciplinary, and international coalition working to unravel craniofacial developmental biology and clinical problems associated with congenital birth defects, head and neck trauma, and a host of chronic degenerative diseases and disorders, as well as forging the molecular biology foundations for human and microbial genomics and regenerative craniofacial-oral-dental healthcare [5-14]. The progression of craniofacial biology is quite remarkable in breadth and depth (see Fig. 1). The reader is encouraged to explore the author’s latest book “*Birth of a Discipline: Craniofacial Biology*” published in 2012, as well as his earlier text “*Craniofacial Developmental Biology*” published in 1979 with a *Forward* by Dr. Sam Pruzansky [5,6], and several relatively recent reviews of the scientific basis for dentistry in the United States [7-10,12-14]. The genetics, embryology, physiology, cell and molecular biology of craniofacial-oral-dental development has been profoundly advanced in understanding and in many clinical applications for diagnosis, treatment, biomaterials, wound healing and regeneration [5-14].

2. Discoveries by Drs. Cooper, Pruzansky, and Bavetta that inspired and shaped my career

I directly learned from Herb Cooper and Sam Pruzansky in the late 1960s and early 1970s the value of multidisciplinary research as well as for providing health care for patients and their families [1-14]. These men were true clinical scholars with strong convictions and dedication to advancing the field of craniofacial biology. They modeled communication, cooperation, collaboration, and coordination as critical features within craniofacial clinics and laboratories. Further, Lucien Bavetta, biochemist and my mentor, modeled the importance of critical thinking, oral and writing skills, imagination and the scientific method, especially as applied to studies of craniofacial developmental and molecular biology.

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