Realigning Biomedical Science Instruction in Predoctoral Curricula: A Proposal for Change


Abstract: Currently in North America, there is an active dialogue going on about the state of predoctoral dental education and the need for curriculum change, innovation, and the adoption of contemporary, competency-based educational models. At the institutional level, curriculum committees struggle with requests from faculty to add new content to an overburdened didactic and clinic schedule. This article will describe potential solutions centering on the role and scope of the biomedical sciences in predoctoral dental education. The authors propose that dental educators and institutions reconsider the current admission prerequisites and curriculum content of the biomedical sciences in predoctoral programs. The proposed changes are intended to eliminate content redundancy between undergraduate and predoctoral dental education by integration of the biomedical sciences—in particular, biochemistry, microbiology, and physiology—into other clinically oriented coursework and learning experiences in the curriculum based on a pathophysiology model that fosters students' comprehension of the etiology of oral and systemic diseases encountered by the general dental practitioner. The authors explore how changes in the biomedical science prerequisites for dental school matriculation and associated modifications in curriculum focus and content would impact admissions testing, composition of national board exams, and strategies for teaching and learning within dental schools.

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Recently in a high profile article published in the New England Journal of Medicine, Cooke et al. called for a fundamental redesign of the educational curriculum taught at United States medical schools. The principal reasons for change include the expanding knowledge base, increasing complexity of delivering medical care, turbulent health care environment, and current subordination of teaching to research at medical education institutions. These authors remarked that curricular reform will not be simple, barriers are numerous, and “turf battles” among faculty, departments, or units are inevitable. Similarly, dental educators are calling for change and innovation in a predoctoral dental curriculum that is perceived nationally as overburdened and poorly integrated.

In 1910, the Flexner report, commissioned by the Carnegie Foundation, offered the first comprehensive critique of medical education in the United States and Canada. Its dental counterpart, written by William Gies and known as the “Gies report,” followed in 1926. This report specifically examined dental education at a time when apprenticeships dominated the educational component of the profession and the majority of dental schools were proprietary in nature. A number of largely critical reports about the process of dental education have followed in the decades since the Gies report. The latest report in this series of dental education critiques was published by the Institute of Medicine in 1995; this report concluded that dental education was particularly vulnerable at the end of the twentieth century because of its isola-
tion from medicine and its parent institutions, budget cuts, shrinking workforce, and tensions between educators and practitioners over issues such as licensure and workforce policy.⁵

Two major stressors to dental schools currently prevent broad curriculum reform. One recognized stressor is the ever-increasing demand for curricular time. Indeed, the science and practice of dentistry have expanded over the last century. The impetus to incorporate new biomedical knowledge and clinical procedures into the curriculum prompted an increase in the number of years and the number of instructional hours at dental schools in the 1930s (when most dental schools expanded their curricula to four years) and then again in the decade after World War II (1945–55), spurred by additional scientific breakthroughs including the discovery of the genetic code and the expansion of pharmacological management of medical disorders. The latest dental school curriculum report by the American Dental Association indicates that U.S. dental schools devote approximately 850 curricular hours to biomedical science (e.g., basic science) instruction.⁶ This is somewhat higher than the average time dedicated to laboratory instruction (704 hours) but less than that allocated to didactic clinical science instruction (1,016 hours).

The other major stressors for dental schools relate to faculty manpower and economics. In his 1926 report, Gies noted that remuneration must be adequate to recruit and retain talented dental faculty who promote the profession through teaching and research. He wrote, “A dental school of the most useful type cannot thrive on an income consisting solely of the fees paid by students and patients. On such limited financial resources, good teachers cannot be given adequate remuneration, and fruitful research is practically impossible.”⁴ Recent surveys consistently paint a dismal picture of the current status of the dental faculty workforce in the United States.⁷⁻¹⁰ Over the last decade, approximately 300 faculty positions have remained continuously vacant around the country. This statistic is compounded by a concomitant rise in the average age of dental faculty and an 18 percent decline in the number of faculty over this same interval.⁷⁻⁸ In addition, the gap in incomes between academic and private practice dentists continues to widen.¹¹ Hence, dental education appears unable to correct the ongoing faculty shortage, which may be exacerbated with the opening of new dental schools.

With finite curricular hours, insufficient faculty, and limited resources, curricular rejuvenation appears especially daunting. One potential solution to overcome these obstacles and promote change in dental education is a redefining of the biomedical sciences in admissions prerequisites and curricula at dental schools. The objectives of this article are 1) to assess the feasibility of changing the admissions prerequisites to include introductory coursework in biochemistry, microbiology, and physiology; and 2) to examine the impact of these changes on predoctoral curriculum content, admissions testing, national board exams, student learning and faculty teaching, scholarship, and development.

### Time Delay in Curricular Changes

In their article “ADEA Commission on Change and Innovation in Dental Education,” Kalkwarf et al. remarked that “it’s easier to move a cemetery than to change a curriculum.”⁶ Several obstacles impede curricular change in dental schools including the following: 1) the need to convert clinical education to a general practice-based, comprehensive care model without an adequate number of academic general dentists to accomplish this vision; 2) the desire to eliminate “outdated” clinical approaches only to have faculty defend them; 3) a desire to move active, problem-based learning (PBL) into the curriculum, only to encounter faculty protest because of insufficient training in this format and a perception that PBL is not cost-effective in an era of dwindling faculty resources; and 4) an educational philosophy that is based on the premise that the “facts” tested on national boards are best taught with traditional lectures.²

If we critically examine instructional content, design, and delivery at dental schools, we see that the typical dental school curriculum is primarily structured within departmental silos with little interaction or even coordination among the various disciplinary components of the students’ learning experience. Students perceive that dental school may not be preparing them for contemporary dental practice. For example, exit survey data compiled by the American Dental Education Association (ADEA) indicate that 40–50 percent of graduating students report being inadequately prepared in the field of implant dentistry, 35–40 percent in orthodontics and practice management, and 18 percent in endodontics.¹²⁻¹³ Almost one in five graduating dental students believes
that excessive curricular time is devoted to the basic and behavioral sciences. These outcome data from recent graduates demonstrate perceptions that the curriculum is deficient in certain clinical topics and that the curriculum does not provide students with an understanding of how the biomedical sciences are relevant to patient care.

One approach to decompress the predoctoral dental curriculum would be to reexamine the curricular hours and content dedicated to the biomedical sciences. It is our opinion that there is ample infrastructure at most undergraduate or baccalaureate institutions to provide basic instruction in three of the biomedical sciences—namely, biochemistry, microbiology, and physiology. Making introductory coursework in these three subjects mandatory prerequisites for admission to North American dental schools could release a substantial block of curricular time and allow for the reallocation of institutional and faculty resources. For example, the total mean hours dedicated to instruction in biochemistry (82.6 hours), physiology (102.2 hours), and microbiology (73.9 hours) alone account for almost a third (31.9 percent) of total basic science instructional time at North American dental schools.\(^6\) Shifting a large portion of these three topics from the predoctoral dental curriculum to the students’ undergraduate preparation for dental school could profoundly affect the scope of the curriculum in the first and second years of dental school and create opportunities for educational innovation.

### Effect on Assessment Tools for Dental Admissions and Education

The proposal to remove basic biochemistry, microbiology, and physiology from the current predoctoral dental curriculum and to establish them as prerequisites for admission would require significant changes in both the Dental Admission Test (DAT) and the National Board Dental Examination (NBDE) Part I.

While each academic dental institution maintains a separate set of prerequisites, applicants to North American dental schools are uniformly assessed through the DAT in predefined areas of the basic sciences. Applicants usually take selected undergraduate courses to prepare themselves for the DAT and admission to dental schools. Many applicants to North American dental schools major in biology, physiology, general chemistry, biochemistry, organic chemistry, or physics as part of their baccalaureate education. Once admitted to dental school, students take another set of basic science courses, many of which are repetitive in subject matter, if not in focus, with undergraduate science courses. Of course, it can be (and has been) argued that a biochemistry or physiology course in dental school is (or should be) a uniquely different learning experience from courses with the same titles at an undergraduate campus because of the dental school emphasis on health care problems and the focus on linking biomedical science concepts to normal and abnormal human function. However, from our perspective and experience, the basic science faculty who commonly teach these courses for dental schools are generally not clinicians and often struggle to meaningfully connect basic sciences to the assessment and treatment of dental problems.

The DAT was developed to ensure that students entering dental school had the adequate foundation to successfully navigate the standard dental school curriculum. It was designed to be a national standard for evaluating and comparing students with diverse backgrounds in their undergraduate education. There are four subtests on the DAT: a Survey of Natural Sciences, a Quantitative Reasoning Test, a Reading Comprehension Test, and a Perceptual Ability Test. Accordingly, changing the basic science prerequisites would directly affect the Survey of Natural Sciences portion of the DAT. Presently, this subtest consists of 100 multiple choice questions divided into three sections (basic biology, general chemistry, and organic chemistry).\(^{14,15}\) We recommend that the Natural Sciences subtest be expanded to include questions examining basic knowledge of biochemistry, microbiology, and physiology.

The NBDE is another standard assessment tool, this one documenting student progress at two points during the dental curriculum (Parts I and II). The overall purpose of the NBDE program “is to measure whether a candidate possesses entry-level knowledge adequate for the competent practice of dentistry.”\(^{16}\) Strikingly, 95 percent of academic deans report using NBDE results as a strategy to evaluate the effectiveness of their schools’ curricula.\(^{17}\) Any alteration of the predoctoral dental basic sciences would necessitate extensive reformatting of the NBDE; however, the exam has continuously evolved since its introduction in the 1930s. One recent change occurred in 1992 when a comprehensive case-based
format was added to the Part II examination. In 2007, the Part I examination was also altered. Part I now has more of an integrated format, with questions drawn in an intermixed fashion from four content areas: anatomical sciences (gross anatomy, histology, and oral embryology), biochemistry-physiology, microbiology-pathology, and dental anatomy.18 Previously, Part I clearly separated the four content areas into independent examination sections, so that the student would know that all questions for the time allocated for that section would address the same general topic. Now, students have to demonstrate the capacity to shift gears from discipline to discipline when taking Part I. Additionally, the NBDE Part I now has 20 percent of its questions in a case-based format that requires students to answer questions in the context of information provided in a scenario. In our opinion, based on our collective experience working with dental students, the removal of biochemistry, physiology, and microbiology from the domain of concepts assessed by the NBDE Part I would create additional opportunities to measure the students’ capacity to comprehend the pathophysiological mechanisms involved in commonly encountered oral and systemic diseases—which, after all, is one of the primary reasons for studying the mechanisms of normal and abnormal human function. This new assessment focus would be in contrast to the current NBDE Part I emphasis on testing students’ memory of isolated bits of basic science information, largely out of patient care context and without appropriate emphasis on measuring the students’ comprehension of disease etiology. In other words, the new NBDE Part I could provide a much stronger assessment of students’ readiness for patient care if the focus were on pathophysiology: understanding the causes and mechanisms of health abnormalities.

A majority of dental students already agree that biochemistry (54 percent), microbiology (70 percent), and physiology (58 percent) should be required, not recommended, for admission to dental school.19 Dental students who completed these courses as undergraduates exhibit similar NBDE scores and cumulative grade point averages (GPAs) as compared to their peers who did not have these courses during their baccalaureate years.19 Hence, requiring introductory coursework in physiology, biochemistry, and microbiology for dental school admission would not adversely affect student performances but would “decompress the curriculum and redirect basic science coursework toward disease pathophysiology.”17,20

Opportunities for Biomedical Science Faculty and Integrated Instruction

Over the past decade, the number of full-time equivalent (FTE) biomedical science faculty available to dental schools to fulfill instructional roles has decreased almost 50 percent, from 1,122 in 1995–96 to 591 in 2004–05.21 Meanwhile, the number of full-time clinical faculty has remained the same at approximately 4,500. Our proposal to redefine biochemistry, microbiology, and physiology as admissions prerequisites does not promote elimination or further reduction in the number of biomedical science faculty. Furthermore, it does not argue for universal reduction in biomedical instruction in the dental curriculum. The proposal does, however, prompt a coordinated realignment of existing educational time, manpower, and resources.22

Currently, biomedical instruction accounts for 16.4 percent of total instructional time (both classroom and clinic) at dental schools and a larger proportion, 35.5 percent, of classroom instructional time.6 Hence, a significant portion of didactic teaching remains dedicated to biomedical sciences. In addition, 86 percent of U.S. dental schools describe their current curricula as primarily discipline-based.17 Despite the adoption of predoctoral dental program accreditation standards requiring competency-based assessment23 and calls for curricular reform to make the biomedical sciences relevant to clinical practice,17,20,21,24,25 most biomedical instruction remains nonintegrated with clinical activities.

Consistent with numerous previous proposals, we recommend that clinically relevant biochemistry, physiology, and microbiology should be integrated throughout the dental school curriculum, with an accompanying shift in focus to emphasize the pathophysiology of oral and systemic diseases, whenever and wherever these topics are addressed. This focus will help our students understand the mechanisms of action that contribute to commonly encountered dental disease and abnormalities and the medical disorders that occur in patients seeking dental care and, in doing so, will help them appreciate the importance of comprehending fundamental biological concepts.22,26-32 This change in emphasis will also facilitate institutional compliance with Council on Dental Accreditation (CODA) accreditation standards for predoctoral dental programs, which stipulate that
biomedical science instruction should be integrated with clinical science instruction, in-depth (Standards 2-9 and 2-12) and broad in scope (Standards 2-12, 2-13, and 2-15). It is our perspective that the intent of these CODA standards is not currently being met in many U.S. dental schools.

We acknowledge a historical separateness of biomedical science and clinical faculty in dental institutions. However, the proposed curricular integration of the three biomedical sciences would open new collaborative opportunities for biomedical science and clinical faculty members. Seventy-five percent of academic deans report curriculum changes related to providing opportunities for dental students to use evidence-based dentistry. In this same survey, the number two reason for considering curricular changes in general was the need to incorporate new scientific findings. The proposed integration of the three biomedical sciences into courses and clinical experiences has the potential to facilitate student-faculty dialogue on the evidence supporting patient care decisions because the focus on pathophysiology of disease more naturally leads to consideration of the evidence for the comparative efficacy of therapeutic options for addressing the underlying root cause of patients’ health problems.

Anticipated Benefits from Realigning the Biomedical Science Content and Curriculum

Survey data collected by Kassebaum et al. demonstrated that the highest rated reason for curriculum change for dental schools is the recognition that resources need to be better utilized. Requiring basic coursework in biochemistry, microbiology, and physiology for admission to dental schools would allow institutions to efficiently redirect faculty, time, and resources for enhanced teaching, learning, scholarship, and institutional effectiveness. We have identified four benefits from realigning the basic science content and curriculum:

1. Empower the biomedical science faculty to redefine new or strengthened existing roles in academics. Under our proposal, new opportunities for biomedical science faculty to contribute to the educational process emerge. These could include updating and deepening existing course content to enhance linkage of biological concepts with oral health problems, developing interdisciplinary courses that focus on pathophysiology, increasing scholarly activity related to exploring the educational outcomes associated with modifying the curriculum in the directions proposed here, and increasing teaching collaborations with members of the clinical faculty.

2. Facilitate an integrated and more practical application of the biomedical sciences. As the connection between oral and systemic health becomes more broadly accepted, the timing for a more integrated teaching of the biomedical sciences couldn’t be more opportune. Establishing matriculation prerequisites for these three subject areas would encourage biomedical science and clinical faculty to join and redesign a biomedical science curriculum that is clinically relevant and that fosters lifelong learning. For example, the collagen biochemist would collaborate with the pediatric dentist or orthodontist and teach the molecular bases for dental agenesis or tooth movement. These interactions among biomedical science faculty, clinical faculty, and students would begin in year 1 and continue through year 4, so students can encounter the basic biological sciences throughout the curriculum and not see these essential foundations for patient care as isolated, out of context topics to “finish and forget” as soon as the final multiple choice examination is completed.

3. Decompress the curriculum and promote innovation. A principal benefit of our proposal would be decompression of the current overburdened curriculum. This would allow institutions to identify and gain new curriculum time for independent study, novel course offerings, early patient experiences (in years one or two), or community-based service opportunities. We estimate that approximately 200 curriculum hours may become available for alternative learning experiences for our students if biochemistry, microbiology, and physiology are integrated into other components of the curriculum as described here. Indeed, this gained time could be used to address deficient curricular areas identified by our recent graduates such as implant dentistry, orthodontics, practice management, and endodontics.

4. Increase student exposure to research. Curricular integration of the biomedical sciences may also provide time for students to engage in the process of research directly with biomedical and/or clinical research mentors. Mentoring of students in the process of scientific inquiry has the potential to strengthen students’ appreciation for the processes of critical appraisal and systematic problem
exploration and also promote academic dentistry as a career path.

Summary and Conclusions

Designating biochemistry, microbiology, and physiology as prerequisites for dental school applicants has the potential to prompt changes across the spectrum of dental education including admissions standards and testing, focus and content of the NBDE Part I, and altered curricular emphasis. This modification has the potential to exert a trickle-down influence on teaching/learning strategies, scholarship to assess outcomes of altered curricula, interaction among basic science and clinical faculty, and professional development to help faculty acquire the skills needed to teach a newly integrated curriculum in which the biological sciences play a more prominent role throughout the overall educational process.

While some critics may suggest our proposal is another attempt at institutional outsourcing, we argue that this change would actually reinvigorate and deepen the dialogue between the teacher and dental student. Students’ knowledge of biochemistry, microbiology, and physiology would not be limited to superficial rote-learning levels. Indeed, with these modified admissions standards, curricula could be redesigned to focus on pathophysiology, which would allow teachers to engage dental students more effectively in critical analysis and synthesis of these topics in the practice of general dentistry and, most importantly, emphasize the basic science underpinnings for oral and systemic diseases that students encounter among their patients in the dental school clinic. Some readers may wonder why we do not include human gross anatomy, histology, or pharmacology as part of our prerequisite proposal. It is our observation that most undergraduate institutions do not provide adequate basic instruction in these areas. Indeed, some small, private colleges may not offer courses in biochemistry or mammalian physiology. This may require prospective students to choose their undergraduate colleges more carefully or anticipate cross-registering at other institutions.

We acknowledge that these changes may introduce new expectations for faculty and lead to modifications in traditional patterns of teaching as well as changes in the way that faculty from different disciplines interact with each other. Institutions must anticipate the need for faculty development and mentoring to enhance the capacity of the faculty to design curricula and teach in ways that promote students’ comprehension of pathophysiology. We do not propose that dental schools eliminate instructors in microbiology, biochemistry, or physiology. Rather, we challenge institutions to more efficiently utilize these faculty members and their expertise as important resources.

While several daunting issues continue to plague North American dental schools, redefining the basic science curriculum by restructuring the curricular hours in biochemistry, physiology, and microbiology in North American dental schools would create several exciting opportunities. Simply changing the prerequisites has the potential to catalyze other sweeping educational changes such as new accreditation standards requiring evidence of curricular integration or a new national board format. Furthermore, dental schools could have the flexibility to create time for emerging topics and the ever-increasing knowledge base in dentistry and medicine.

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REFERENCES


