

The University of Toronto's Faculty of Dentistry: A Culture of Research

In 1998, the faculty of dentistry at the University of Toronto consolidated its research program into a single department. Activity in some 20 divisions of the faculty was restructured into 6 major research themes. Under the direction of Dr. Johan Heersche, who was associate dean of research at the time, these research areas, the laboratories and their support infrastructure became the Dental Research Institute (DRI), located within the faculty of dentistry, University of Toronto.

Today, DRI has 7 major research themes, an annual research funding base of over \$9 million and a publishing output that exceeded 115 peer-reviewed articles in 2006/07. It is one of North America's leading research institutions oriented toward the study of oral health care delivery and its related sciences.¹ DRI is known throughout the international academic and research community for its innovation and interdisciplinary programs. Its research programs are based on the fundamental sciences, but uniquely structured to translate new knowledge into innovative applications within dental and related health care fields. This transfer of knowledge into practice occurs via DRI's clinical investigation program, which includes dedicated research clinics that are the centre of international training initiatives for dentists from all continents. Novel strategies in epidemiologic investigations provide feedback for the institute's research programs and maintain a forward thinking investigational approach of international calibre. DRI has approximately 70 full-time investiga-

tors and over 100 research trainees bridging fundamental, clinical, health care delivery and population health research topics.

Research Themes

Each theme adopts its own balance of clinical (research that is in the late stage of translation into application to patients), applied (research with a high probability of resulting in a clinical tool or product that will have commercial/industrial applications) and fundamental research (basic biomedical research that seeks answers to fundamental science questions without necessarily leading to clinical or commercial applications).

Biomaterials

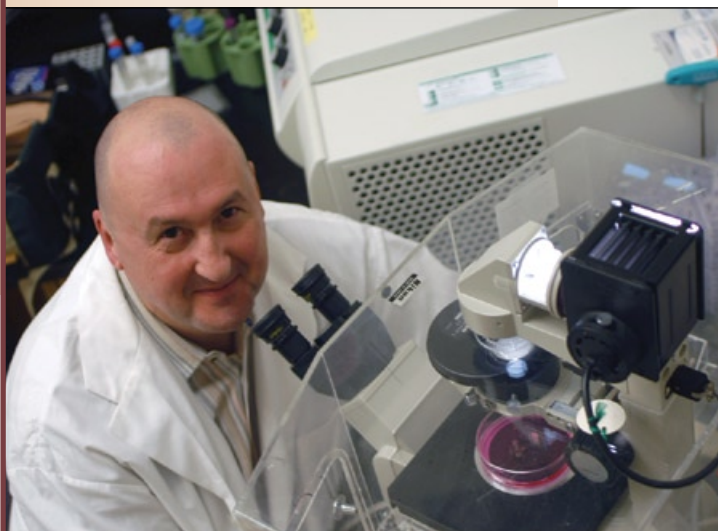
Research into biomaterials focuses on the classical fields of restorative dentistry, prosthodontics, endodontics, periodontics and oral surgery, as well as emerging health care fields of relevance to biofilm research, combination materials (drug-biomaterial), new tissue adhesive technologies, lasers in diagnostics and treatment and tissue regeneration. The 21 investigators collaborate with the University Hospital Network and the Institute for Biomaterials and Biomedical Engineering at the University of Toronto. Their research is 35% clinical, 30% applied commercial and 35% fundamental science.

The success of these researchers in translating scientific knowledge into inventions and clinical products is a key strength and has led to the establishment of several biotechnology start-up companies and an implant device company with multi-million dollar annual gross sales. In 2006/07, this group generated 25 publications with 3 new patent actions and trained 14 PhD and 31 MSc students. The work of researcher Dr. John Davies, an international leader in dental implant and



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Research into human umbilical cord perivascular cell technology was spearheaded by Dr. John Davies, a member of the biomaterials research group.

regenerative therapies and the senior inventor of human umbilical cord perivascular cell technology, has led to the formation of a Canadian life sciences company.²

Diagnostic and Therapeutic Technologies

Research in this area focuses on caries risk testing, fluorine studies, computer-based data management, digital radiography and imaging techniques. Novel research is being undertaken in the area of micro-analysis of saliva as a diagnostic test, volumetrics–telerradiography for diagnosis, image-based dental records and distant health care delivery strategies. Distant diagnostics using telerradiography is a growing area of key interest. The 10 investigators in this area emphasize clinical and applied research (90%) with some activity in basic science (10%). In 2006/07, the group produced 5 publications and trained 3 PhD and 18 MSc students.

This past year, Professor Daniel Haas, associate dean (clinical sciences) and a member of this group, was the first Canadian to receive the American Dental Society of Anesthesiology's highest honour — the Heidbrink Award, given annually to an individual who has made outstanding contributions to anesthesia that have benefited dentistry.

Growth Development and Regeneration

This theme has attracted the largest group of researchers in the DRI, with 27 investigators working on the molecular biology of bone and soft tissue development and stability as well as

craniofacial function. Strategic areas include new therapies to improve periodontal healing, pain management, reverse engineering of cellular assemblies, developmental biology and genetics in growth development, biopharmaceuticals and drug development related to growth, and the design of drug delivery vehicles for controlling growth of bone tissue. These programs are well known internationally and have been integrated with NASA's program on bone maintenance during space flights. The group's activity is primarily basic science (60%) with 40% devoted to clinical and applied studies. In 2006/07, 67 publications and 2 active patents were generated by this group; 18 PhD students and 63 MSc students were trained.

This year, Dr. Chris McCulloch, Canadian Research Chair in matrix tissue and contact liaison for the theme, was senior author of a review article on controlling inflammation for the clinical management of high-prevalence human diseases, which was published in one of the highest impact journals in the field of medicine.³ The article explored the need for new types of anti-inflammatory drugs and the emergence of novel drug targets based on the clustering of IL-1 receptor molecules into multiprotein aggregates associated with cell adhesions.

Health Status, Clinical Outcome Measures and Health Care Delivery

This area focuses on health care policies and measures of “quality of life” outcomes for various population groups. Studies related to children and elderly populations are of increasing interest to the investigators within this theme. The group maintains an important scientific advisory role for studies on Aboriginal health. Currently, 9 investigators are associated with this theme and about 80% of their work is devoted to clinical/epidemiologic studies, with the remaining 20% focused on the applied area of analytical measurement and protocol development. New areas under development include strategies for the delivery of health care in the home and pain-implant studies in pediatric dentistry.

In 2006/07, these researchers produced 6 publications and trained 5 PhD and 12 MSc students.



Dr. Herenia P. Lawrence, a member of the health status, clinical outcome measures and health care delivery research group, presents Dr. David Mock, dean of the University of Toronto dental faculty, with a lithograph of the logo of the "Oral Health and the Aboriginal Child" forum.

This past year, group member Dr. Herenia Lawrence cohosted "Oral Health and the Aboriginal Child: A Forum for Community Members, Researchers, and Policy-makers," held at the Manitoba Institute of Child Health, Winnipeg, June 7–8, 2007.⁴ One of the goals of the forum was to develop a framework for oral health research carried out with and by Aboriginal people to improve the oral health of Aboriginal children. Forum participants and keynote speakers shared their ideas, perspectives and experiences and identified gaps in oral health research that will be addressed in an upcoming National Oral Health Research Strategy for Young Aboriginals.

Molecular Approaches to the Study of Oral Health and Disease Pathogenesis

Work in this area is at the forefront of molecular biology, looking at the association between disease and cell signalling and protein function. More specifically, it addresses oral secretions, oral bacteria and biofilm formation, quorum sensing and signal transduction systems, bacterial exploitation of host cell cytoskeleton and signalling pathways, osteopontin (bone protein) regulation, macrophage studies and innate immunity. In 2006/07, this group produced 12 publications and trained 9 PhD and 14 MSc students.

A leading research story emerged from the laboratory of biofilm expert, Dr. Dennis Cvitkovitch, an associate professor in the faculty of dentistry

and the Institute of Biomaterials and Biomedical Engineering and a Canadian Research Chair. Dr. Cvitkovitch's group discovered that a signalling pathway activated by a competence stimulating peptide (CSP) is associated with the formation of dental plaque. The group subsequently developed anti-CSP technology, which is now being refined by Kane Biotech, a Winnipeg-based company that plans to bring the plaque-inhibiting power of CSP to the marketplace in the form of toothpaste, chewing gum, bottled water and even dog biscuits.

Pain/Neurosciences

The pain and neurosciences group consists of 13 investigators, 3 of whom are senior Canadian Research Chair awardees. The program includes a range of research activities that extend well beyond craniofacial dentistry and include basic and clinical management of pain, psychophysics and quantitative sensory testing, correlation

of treatment to patient outcomes, neurocognitive studies, genetics and genomics using various models, pain genetics in post-mastectomy patients, clinical investigations of feeding–breathing–swallowing disorders using mastication and ventilation recordings, imaging techniques and the development of novel devices for this work. The theme's investigators are also involved in several pain-management drug studies. The group's research is 35% clinical, 10% applied instrumentation and 55% basic science. Key growth areas are pain genetics, DNA databanks for head and neck patients, translational research from bench to clinic, pain genetics associated with environmental factors, dietary disorders and developing predictors of pain. In 2006/07, this group produced 14 publications and trained 10 PhD and 10 MSc students.

In May 2007, group member and professor Barry Sessle became president of the Canadian Pain Society. He is the first dentist or dental academic to assume leadership of the 750-member society in its 32-year history. During his 2-year term as president, Dr. Sessle will focus on the society's role in enhancing interprofessional education in pain and its management and in raising awareness of the socioeconomic costs of pain.

Education Research in Dental and Related Health Sciences

This is the faculty's newest research theme and it comprises a broad range of topics that



Dr. Barry Sessle (centre), a member of the pain/neurosciences research group, receiving the Institute of Musculoskeletal Health and Arthritis (IMHA) Quality of Life Research Award from Dr. Louise Desjardins, assistant scientific director of IMHA, and Dr. Richard Ellen, professor at the U of T faculty of dentistry and chair of IMHA's Institutional Advisory Committee.

cross health disciplines in a variety of forms: program evaluation, student evaluation, basic science education and the theory and practice of education. Currently, the researchers' goal is to position the faculty of dentistry to take on an international leadership role in this emerging domain of research and to expand a program of research in dental education that will have a positive impact on the faculty's pedagogical curriculum. The group is actively involved with the Wilson Centre for Research in Education, which is affiliated with the faculty of medicine at the University of Toronto.

In addition to these 7 themes, the faculty's research program includes 12 units consisting of investigators from different themes, and in most cases different institutions, who are contributing to collaborative networks in focused areas. The latter include Biomedical Polymers, Bonelab, Burlington Growth Centre for Cranio-Facial Growth, Canadian Institutes of Health Research (CIHR) Group in Matrix Dynamics, Community Dental Health Services Research Unit, Implant Prosthodontics Unit, Molecular Microbiology, Oral Reconstruction Centre, Severe Refractory Periodontal Disease Investigation and Treatment and the Wasser Pain Management Centre. More information about these units can be found on the DRI website.⁵

Major Initiatives in 2006/07

During the past year, the DRI developed a benchmarking measure to assess where the faculty's research programs stood in terms of funding, publication, impact measures, endowed chairs, number of faculty engaged in research and theme areas dedicated to research endeavours within the field of oral health and the broader health sciences in general. Information was tabulated using available online databases and search engines and may have some inconsistencies in actual numbers; however, **Table 1** provides a good indication of relative performance. The faculty's programs are on par with the strongest in North America.

The 2006/07 academic year will be remembered by all those in health sciences as challenging in terms of

research funding, as Canada's central funding body for research in health care, CIHR, saw the greatest drop in success rates for open operating grants in the last decade. The faculty of dentistry weathered this storm with great persistence and resilience. In 2006/07, its research funding increased to just over \$9 million from the previous year's level of about \$7 million. Although CIHR was still the major source of research funding, its contribution was surpassed by the total from other funding agencies. Sources of research funding were: CIHR: 49% of funding; corporations: 18%; National Institutes of Health: 14%; internal: 8%; provincial government: 4%; federal government: 4%; foundation: 1%; education: 1%; miscellaneous (includes associations): 1%. Of particular note, industrial partnerships increased to 18% of funding, compared with 10% in the previous fiscal year. The faculty's drive to expand its translational research program took root with the implementation of DRI's 2006 steering committee recommendations for the development and expansion of Research Institute Clinic operations, now overseen by Dr. Sunjay Suri (an orthodontist in the division of clinical sciences). This initiative is expected to attract research funding partners from outside the traditional CIHR operating grants program and capitalize on new partnering and collaborative opportunities.

The changing landscape of our faculty's research programs is evident in the rate of new

Table 1 Comparison of the University of Toronto's faculty of dentistry with other North American and international dental research centres (2006 except as noted)

Institution	Funding (\$ millions) ^a	Endowed chairs	Total staff	Active investigators ^b	Articles published ^c
UBC	4.0	0	53	44	47
McGill	8.5	1	34	27	47
U of T	9.0	3	125	61	118
Texas	11.0 ^d	2	94 ^d	51 ^d	151 ^d
UNC	12.5	14	n/a	143	160
Forsyth	12.8 ^d	n/a	33	32	67
Michigan	14.8	9	113	60	130
Washington	17.0	4	130	90	111
Manchester	n/a	n/a	40	19	41

Note: n/a = not available, UBC = University of British Columbia, UNC = University of North Carolina, U of T = University of Toronto.

^a Figures are in Canadian dollars.

^b Researchers supported by external grants or contracts and have published as of 2004.

^c Includes only papers published in peer-reviewed journals (electronic publications excluded).

^d Only 2003/04 values available online.

faculty hires over the past 4 years, averaging 4 tenured-track faculty a year. Changes in the Biomaterials Unit have been particularly transformative, with the retirement of its chair, Dr. Phillip Watson, and the hiring of 3 tenure-track professors to develop their independent research programs. Where biomaterials research in the faculty was once dominated by the study of new synthetic materials to replace physical function alone, the program is now heavily oriented toward the conception, development and implementation of material strategies that regenerate biological tissue function, as well as physical function.

The DRI and the faculty are now completing the fourth year of a 6-year academic plan and the progress on DRI's milestone activities are highlighted in its annual research report.⁶ The institute remains committed to supporting a culture of research and lifelong learning for dentistry students, staff and faculty. ➤

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