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A Prescription that Addresses the Decline of Basic Science Education in Medical School

Abstract

Over 30 years ago a cry rang out through the proverbial halls of academia; “The clinician scientist is an endangered species.” These prophetic words have been reverberated in the ears of every specialty and every general medical organization in deafening tones. Why is the role of the clinician scientist or clinician investigator so important that this phrase has been repeated subsequently in medical and educational journals? Simply put, the clinician scientist bridges the ravine between the ever-growing mountain of scientific knowledge and the demanding patient centered clinical care. Here, we describe the current educational model established by the University of Calgary, Leaders in Medicine Program. Our program seeks to train future physicians and clinician scientists by incorporating training in basic science, translational and clinical research with clinical and medical education in a longitudinal program to students of traditional MD/PhD, MD/MSc or MD/MBA stream as well as interested Doctor of Medicine students.

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Over 30 years ago a cry rang out through the proverbial halls of academia; “The clinician scientist is an endangered species.” These prophetic words have been reverberated in the ears of every specialty and every general medical organization in deafening tones. Why is the role of the clinician scientist or clinician investigator so important that this phrase has been repeated subsequently in medical and educational journals? Simply put, the clinician scientist bridges the ravine between the ever-growing mountain of scientific knowledge and the demanding patient centered clinical care.

The role of the clinician scientist becomes more poignantly emphasized in the medical profession as changes in schools of medicine continue to occur. In April 2012, an editorial published by *The Lancet* entitled the “Catastrophic neglect of the basic sciences in medicine” [1] outlined the systematic erosion of basic sciences in medical schools through multiple politically driven policies. The authors felt that neglect and marginalization of the basic medical sciences in medicine will have damaging and far reaching effects on clinical care [1]. To quote the authors parting sentiments;

“The basic science of medicine, and the future of safe and effective patient care, relies on smart people working in laboratories to answer questions about which they are passionate. We seem to have forgotten that lesson. We need to relearn it quickly.”¹[1]

Clearly, as we see further advances in the scientific literature and the absence or dilution of the basic sciences in our medical schools, it becomes imperative that we graduate physicians skilled in both clinical medicine as well as the basic sciences to bridge the widening gap between scientific literature and clinical care. Thus enters the clinician scientist. The clinician scientist, trained with the academic rigor of graduate studies melded with the frontline medical skills of physicians and surgeons, is perfectly poised to facilitate the translation of knowledge from the basic sciences to the clinical practice, while providing the observations of clinical practice that form the basis for further research and innovation. This type of individual fulfills the vision early medical educators must have had of the future of medicine. In the sections that follow, we provide an overview of our approach: (1) to generate such ‘dually-trained’ physicians and (2) to remedy with the decline of the teaching of the basic sciences in our medical schools, not only for our combined program trainees but also for our MD class in general. Our approach is embodied in our Leaders in Medicine program; thus, our overview is focused primarily on our own experience at the University of Calgary Faculty of Medicine, and is not intended to provide a general overview of the MD-PhD program.

The Leaders in Medicine (LIM) program at the University of Calgary was established to facilitate the training of clinician scientists. This joint degree stream allows interested individuals to pursue the doctor of medicine degree while simultaneously obtaining either a PhD, MSc or even an MBA, in an integrated, protected training stream and is the penultimate realization of incorporating scientific and medical education envisioned by Flexner in his report of 1910 [2].

Training research-oriented physicians

The Flexner report, which revolutionized medical education, still has a major impact on the way we select and train our physicians of the future. Flexner was acutely aware of (1) the importance of evidence-based data as an essential component of clinical practice and (2) the key role for research in advancing medical care [2]. What he did not deal with was the critical issue of ensuring the life-blood of the enterprise that is necessary (1) to generate new knowledge that will mitigate the negative impacts of disease; and, (2) to take the disease-altering discoveries (whether derived from ‘test tube’ studies or from patient sources) to bear on the needs of a general patient population. For that process to thrive, our medical faculties must foster all of the three personality types that are necessary for developing the ‘new knowledge’ for improving human health, as described by Goldstein and Brown [3]: (1) the individual involved in curiosity-oriented ‘basic research’; (2) the individual focused on ‘disease-oriented’ research that does not directly involve patient participation (e.g., dealing with cell cultures, tissue samples or clinical-epidemiological data); and, (3) the individual who works directly with patients, either to gain insight into their pathology or to implement and test new therapeutic modalities in the clinic – the illusive clinician scientist. The goal of our LIM program is to develop all three types of individuals who will be ‘bilingual’ in terms of human pathophysiology and in an allied discipline that will generate new approaches for improving human health.

The development of individuals in the first two categories listed above (basic and disease-oriented research) appears secure; however, those in the third category, research-trained physicians who work directly with patients, are perceived as an ‘endangered species’ [4]. Much has been written about the challenges of fostering clinical investigators who do patient-oriented research [3, 5, 6] and we believe that part of the answer to addressing this issue is to capture the imagination of our trainees early on to develop the passion for research that is one of the ‘Ps’ (Passion, Patients and Patience) that Goldstein and Brown suggest are the essential traits for a successful clinician scientist involved in patient-oriented research [3]. In our

LIM program, our goal is to develop that passion in those who will fit into all three research categories outlined above, including the patient-oriented 'clinician scientist'.

To generate that passion for furthering the future of biomedical research, we involve our students in several programs: (1) research-in-progress sessions, in which each trainee presents their research work or new ideas; (2) translational research rounds, which emphasize patient-oriented research and converting new basic science into enhanced patient care; and, (3) a visiting speaker series, developed by the trainees to host research-oriented physicians who present the latest in important areas of current biomedical research and who interact directly with them in an informal setting as clinician-scientist role models. Finally, our trainees organize an annual 'Research Day' that highlights work done not only by our LIM students but also by those in our MD class at large who are also engaged in research activities during the academic year. These student-led programs have had a substantial impact on all of the MD trainees in our faculty: (1) amplifying the basic science component of their education; and, (2) raising the profile and impact of clinically-oriented research in general. We believe that this prescription for capturing the imagination of our LIM students is not only creating a passionate 'ownership' in our LIM trainees for furthering the future of biomedical research, but is also responsible for a positive 'bystander effect' that is furthering the commitment to research endeavors in all of the other MD trainees in our student population.

The LIM Program, supported by the Graduate Science Education Department within the Faculty of Medicine at the University of Calgary is run largely by the students. The program has grown to 90-125 students per year (Fig 1). At present there are 63 active joint degree students (MD/MSc or MD/PhD) and 58 Affiliate (medical degree only) students. The program has evolved continuously over the years, based on student input, and directly addresses the "catastrophic neglect of the basic sciences in medicine". To enter the joint degree program a student must be accepted into both the medical school and a graduate program at the University of Calgary. Students can apply to the medical program any time before or during graduate school. The Affiliate Program was initiated at the request of the medical student body. The Affiliate Program was initiated at the request of the medical student body and welcomes all students, including those that have already completed graduate degrees, to attend and participate in all LIM activities. On average, 20% of students that enter into medical school in Canada have a graduate degree [7], including our students in the LIM Program (via the Affiliate Program), and this increases the depth and diversity of our LIM student body. The Affiliate

Program has allowed students with interests in basic science or other pillars of science to continue, or to enhance, their interests by interacting with like-minded students and staff. A number of our Affiliate students who do not yet have a graduate degree take advantage of our LIM program to step away from their MD curriculum to pursue a joint MD/MSc or MD/PhD and then later re-enter the medical school stream.

The unique aspect to the University of Calgary Medical School is that it accepts applicants who are currently in graduate school. Many medical schools in Canada do not allow this and require students to complete their graduate degree before entering into medical school. We feel it is restrictive to bar students from applying to medical school during graduate work, since most students that gain entry to medical school apply more than once: on average, a student who gains entry into medical school in Canada has applied 3 times [8]. At other universities, a student keen to pursue an MD and PhD, for example, will do 4 years of undergraduate work then 4-6 years of graduate studies (PhD) before even being eligible to apply to medical school. If all goes well, with no delays, the 18 year old high school student will be 26-28 years old before they can possibly get into medical school, and if they have average success at getting in then they will be 29-31 years old making them older than the average medical student at most universities in Canada [7, 8]. If they do not get into medical school on their first attempt, then these students can be left in limbo. Some go back and redo undergraduate courses to raise their marks, some are underemployed and some commit themselves to a post-doctoral program. Another possible constraint in the training of clinician scientists is the rigid format of joint degree completion, usually consisting of a 4-year window for graduate studies flanked at the beginning by 2 years of pre-clerkship medical studies and at the end by 2 years of clerkship. The average completion for a conventional PhD in North America is well above 4 years, and therefore this strict timeline might persuade students to defend their theses before their thesis can be as thoroughly explored as their supervisors would wish.

The University of Calgary LIM program encourages students to complete both components of their joint degrees in whatever format is best suited for the student and supervisor, provided that the total program is completed within 8 years, starting from the time they gain entrance into medical school. It is our opinion that students get most out of their program by completing each part in whole blocks, while participating in LIM events during both parts (MD and graduate training). This sequence of study keeps the student informed of what their colleagues in different stages of the program are doing and the program enhances both their science and medical

FIGURE 1. Student enrollment in the Leaders in Medicine Program
The Affiliate program was started in 2010 at the request of the medical school student body.

knowledge base. In some situations, we feel a student may benefit from having flexible timelines as research is often unpredictable. By enforcing a strict timeline, there is the potential liability that combined MD/PhD program students might generate lower calibre graduate projects since they would be expected to complete a PhD in a shorter time than other doctoral trainees. More importantly, students and supervisors should be given some flexibility to explore a curiosity-driven side project or follow-up on an unprecedented result, giving rise to future avenues of research interests. Again, this option may be limited in a strict four year format for a PhD flanked by MD training.

Structure

The University of Calgary Medical School is a three year program and the LIM program had been developed at the University of Calgary over the last 25 years. Initial students were given the authorization to complete their graduate work as they attended medical school. Over the past 18 years, we have developed a formal joint degree program with the hallmarks of flexibility and acceptance. This flexibility applies both to the

acceptance of students into the MD program and to the sequence of studies (graduate plus MD) selected by each trainee. The program has grown markedly since 2000 (see Fig. 1), where there were 13 students in the program pursuing joint degrees, to 2013, where there were 22 new admissions to the joint degree program, with a total of 63 pursuing joint degrees and 53 Affiliate members for a total enrollment of 116 students. Of these 116 students, some will be pursuing their graduate training while others will be participating in the MD courses. Each year approximately 50% of joint degree students are in MD/PhD and 50% in the MD/MSc stream. To date, we have also had three MD/MBA students. See Fig. 2 for details on program structure.

Translational Journal Club

Translational research has become an important area of investigation, and funding agencies have increasingly supported this research in hopes of enhancing patient-relevant discoveries. The definition of translational research remains nebulous and the specifics of how to perform this research are unclear. The key principle of this research relates to understanding how to

FIGURE 2. Overview of the University of Calgary Leaders in Medicine and Leaders in Medicine Affiliate program and comparison of traditional MD/PhD training programs

convert, or translate, scientific discovery into medical patient utility. Clearly, clinician scientists are well positioned to accept the challenge of translational research. At the University of Calgary, we have developed a highly focused translational journal club that differs from traditional discipline-based journal clubs. Following careful article selection from any of the research disciplines, key questions are posed to the trainees. These questions reflect previously well-developed strategies for conceptualizing translation research [9]. A clinician scientist trainee presents the article during the first half of the seminar, followed by small group discussion of the posed questions, ending with a full group discussion. Major questions addressed include the following:

- Can a medical need be clearly defined?
- How good is the scientific evidence supporting the article's discovery?
- What intellectual property issues exist that impact financial investment?
- What regulatory and bioethical challenges exist in performing human investigations based on the article findings?

- Can a definitive efficacy phase III clinical trial be conceived to justify continued investment in the discovery?

To better prepare the trainees to evaluate translational research, a longitudinal didactic lecture series runs concurrently. Here, experts are invited to lecture on patent law, intellectual property, health regulatory requirements, clinical trial design and product development. This directed approach to evaluating translational research is essential to building the skills necessary for future clinician scientists.

Research in Progress/brief presentation "TED Talks style"

The LIM program at the University of Calgary, in addition to the variety of other activities, runs a monthly Research in Progress (RIP) session. These RIP sessions allow several students to present (1) their own research, (2) interesting research observed in any area relevant to clinical medicine and (3) clinical case studies/presentations, or other topics. The presentations of these RIP sessions are done in a brief presentation in a "TED talk" style. The benefit of such a format is, firstly, that multiple students in each session are able to present, allowing diverse

topics to be showcased. Secondly, the dissemination of research in this format allows ample opportunity for obtaining feedback from both peers and faculty as well as for building connections for future projects. The plethora of topics that have been presented at these sessions include radiology profiles, medical business models, the use of mass media in clinical research, the use of literacy in mental illness, as well as more traditional basic science presentations. The RIP sessions are open to all those interested including LIM students, MD students and faculty; thus, this forum facilitates a dynamic conversation following presentations. The ability to convey research and scientific literacy is the backbone of successful clinician scientists. With the LIM program's dedication and commitment to building these skills in the context of the activities described above, students will be poised to have this understanding into residency and further on with their careers.

Visiting Speakers Series

An important aspect of the LIM program is the active promotion of mentoring opportunities for its students. Often, research-oriented institutions have a sizable fraction of faculty involved in clinical research; however, a constant challenge in training the next generation of clinician scientists is to provide suitable role-models and to enable and nurture mentoring connections that can develop over the course of the training program. Furthermore, obvious time limitations (on both the part of the student and faculty) can limit these opportunities to the detriment for those interested in pursuing a clinical investigator career path; thus, the program has made it a priority to provide these opportunities through monthly seminars with local clinician scientists. Specifically, faculty members are asked to discuss training and career paths as well as their current research with a group of trainees in a regularly planned series of 'Visiting Medical Educator' sessions. This seminar series has dedicated LIM funding to bring individuals from either local or off-campus institutions to meet with our trainees. The invitees are selected by our students. This format is highly engaging, as students are encouraged to openly ask questions that normally would not come up outside of these sessions. Questions include: What were their greatest challenges? and What is the most rewarding part of their job or their most difficult career decision. Often, feedback from faculty members is as positive as it is from students and, furthermore, students are exposed to branches of medicine that they may not have previously considered.

We feel these sessions provide a unique opportunity (1) to broaden the students' understanding of the career of a clinician scientist and (2) to introduce the students to role model indi-

viduals who may possibly become mentors for them in the future. This kind of impact between role models, potential mentors and students is difficult to achieve through traditional didactic seminars presented by visiting speakers.

LIM Research Symposium and Related Conferences

The University of Calgary LIM Program has presented an annual research symposium for the past five years. This half-day symposium is student-organized and features oral and poster presentations by students along with a keynote address by an invited clinician scientist. This well-attended event fulfills several key objectives for our program. (1) To showcase the impressive variety of projects undertaken by students in the LIM Program as well as U of C medical students. All types of research projects (e.g., clinical, basic and case reports) are accepted into the symposium and students in the medical class are encouraged to participate in addition to our students. All accepted abstracts are published in a symposium abstract booklet and awards are given out to highlight particularly remarkable work. (2) To encourage medical student participation in research and special projects. The symposium is an enjoyable event that provides students with an opportunity to present research that may not be published or presented elsewhere. The poster session is highly interactive and allows students with similar research interests to forge connections. (3) To inform students and faculty about the diversity of opportunities available for research and special projects during medical school and beyond.

We strive to involve university faculty in the symposium to showcase student research and provide students with opportunities for networking. Approximately two dozen faculty members participate as judges in the poster session, with representation from a wide range of departments and specialties. In recent years, individuals from the Clinician Investigator Program have also been invited to judge. The keynote speaker serves as an inspirational model of a successful clinician scientist, with past keynote speakers including NASA Flight Surgeon Dr. Douglas Hamilton and former Canadian Medical Association president Dr. Hugh Scully. LIM students are given the opportunity to attend career development sessions prior to the symposium where they can ask the keynote speaker about career management, life-work balance and other issues crucial to aspiring clinician scientists. Upon conclusion of the symposium, students are asked to provide formal feedback to help with the growth of this symposium. Future directions for the symposium include: separate award categories for medical students, a "three-minute thesis" competition, and further strategies to expand faculty involvement.

In addition to hosting our own symposium, the LIM program routinely sends delegates to two annual, national conferences: the joint Canadian Society of Clinical Investigation (CSCI)- Clinical Investigator Trainee Association of Canada (CITAC) Young Investigators Day Symposium and the Canadian Medical Students Research Symposium (CNMSRS). Both conferences have national prominence and showcase research by active clinician scientists in Canada. Moreover, these conferences provide excellent networking and mentoring opportunities at a national level that would otherwise be limited at individual institutions. Importantly, students are exposed to the challenges faced by new investigators in simultaneously managing both scientific and clinical careers. Often, these directed, small group sessions have much greater impact than engaging a larger audience. We therefore encourage and finance students to join CITAC and attend the annual CSCI-CITAC meeting where they meet like-minded students and staff from across Canada. The joint CSCI-CITAC meeting has specific workshops on career development (industry, clinical and research), mentorship and career planning, including specific session on “finding your first faculty position”, “signing your first contract” and “how to protect time for research”. Thus, it is and will be a continued priority for the LIM program to have strong representation at these gatherings.

Mentorship

Mentorship is a critical aspect of the LIM program. The directors (Dr. Beck and Dr. Hollenberg), associate director (Dr. Yipp) as well as our program administrator (Ms. Selman) frequently meet with students on a one on one basis. We have developed a program where clinical clerks from the LIM Program return and talk to the 1st and 2nd year medical students to give them advice on clerkship and research. We have also started a program where LIM graduates (some residents and some in junior staff positions) lead sessions to discuss career development, balancing research career with residency/clinical work and family. We have now set up a “mentorship flow” process involving our own graduates, where we help to identify mentors for the students to guide them through their graduate program, medical school, clerkship, residency and, ideally, into their first faculty position. We have identified LIM graduates and/or others at universities across Canada and many in the United States who can mentor our students. A list of willing high level mentors is posted on the LIM website and is given to students on a yearly basis. Developing this list of mentors from across North America has been crucial in aiding students when they start a new position or at a new university. The assigned mentors enable our trainees to get involved in research groups

and to develop strong local, discipline-specific guidance. Many LIM students who have graduated still contact our program directors for advice, mentorship and career planning.

Funding

Financial issues can dramatically affect one's ability to pursue a career as a clinician-scientist; thus, minimizing debt-load due to the long training time frame of a clinician scientist is an important goal of our LIM program. Early in the history of the LIM Program we received an anonymous donation and the Faculty of Medicine matched this donation, allowing us to provide some financial support for students throughout their program. At present, tuition awards are available to all joint MD/PhD students and funds are available for all LIM students (and Affiliates) to attend conferences. We have recently added a competition where MD/MSc students can also apply for tuition support. The program is also supported by Canadian Institutes of Health Research (CIHR) from whom we receive one or two MD/PhD stipend awards annually (each award provides six years of funding). Alberta Innovates Health Solutions (AIHS) also has a MD/PhD program that supports many of our students. We also award two AIMs (Achievers in Medical Science) awards to graduating MD/PhD students, which we hope will reduce their financial burden allowing them to further pursue their goal of becoming clinician-scientists as they enter their residencies.

Success

Success of a program such as LIM can be measured according to several outcomes; however, our outcomes data are limited since our program is relatively new, with many of our students still involved in their residency training, some in the process of returning to academic positions and a few already established as very successful career clinician-scientists. We are just now seeing evidence of success of the program: the contributions of our students to medicine and science can already be seen in terms of their roles as authors of peer-reviewed manuscripts, teachers, expert physicians as well as administrators. One of our first graduates, Dr. Douglas Hamilton, has served as the NASA flight surgeon for many years - overseeing many space missions as well as developing several associated programs within NASA on space travel-related medical issues. Dr. Hamilton has recently returned to our Faculty, where he is contributing to our LIM program. We look forward to comparable contributions by our other graduates, who will have expertise in many areas, including those who have completed joint MD/

MBA degrees. We look forward to their successes in medicine, research, administration and health care delivery.

In our most recent in-depth assessment, which was completed for 2011-12, our 54 full LIM students (joint MD/PhD, MD/MSc) and 33 Affiliates were extremely successful. (1) Matching to training programs: most of our LIM students do extremely well in the residency matching competition, with approximately 90% landing their first choice of program and location. (2) Peer-reviewed publications: In 2011-2012, our LIM students published 59 papers (many in very high impact journals) and 21 more were in-submission and in-review. (3) Book chapter and abstract publications associated with meeting presentations: They also published six book chapters and 100 abstracts, and were responsible for 118 presentations at local (69) at national/international meetings (49). These students won 95 awards, many that were at the provincial and national level and some at the international level! We have set up a database to track our students and measure success. (4) Program completion rate and job placement: Unfortunately, there are limited data on the outcomes of our other graduate education programs for comparison with our LIM trainees. For the LIM program, we have a dropout/noncompletion rate of less than 5%. In contrast, non-LIM trainees in our faculty MSc/PhD programmes have a dropout/non-completion rate of from 20-25%. The best index of success for clinician-scientist training in Canada has come from the Canadian Child Health Clinician Scientist Program at the Hospital for Sick Children at University of Toronto, where they reported that all but 1 of 18 graduates went on to seek a junior faculty position as a clinician scientist [10]. This is a much smaller and more intensive and specialized program than the LIM but it is clearly remarkably successful. Although we do not have data for Canadian post-doctoral programme trainees, in the United States it is estimated that only about 20% of post-doctoral fellows advance to a tenure-track academic, research position [11]. Although it is too early for us to document, we project a much

higher success rate of our graduates in terms of playing key roles in academic leadership and in furthering medical practice.

In summary, the LIM Program at the University of Calgary is committed to enhancing science education in medical school and committed to training clinician scientists and MD/MBA students. We have developed a unique program that not only trains clinician scientists but also aims to enhance basic science education and research in the undergraduate medical school curriculum.

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