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A pharmacologist's journey in medical education: a personal history

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My journey as an educator in Pharmacology began in 1949, when, after finishing my MA in Biology at Johns Hopkins, I decided that I wanted to be involved in science with more relevance to humans. I had been chasing fireflies around the parks of Baltimore and measuring luminescence in bacteria for my Master's work, but found it not very satisfying. I hoped that Pharmacology would provide a discipline with relevance to human welfare because of its role on study of drug actions and therapeutics and with many possibilities in basic science because of the need to know how drugs act and their availability to define physiology and pathophysiology by intervention in function. In retrospect, this hope has proved correct, at least from my viewpoint and that explains why I am still doing pharmacology teaching and research 54 years on.

My journey began in Salt Lake City in Louis S Goodmans department, with Mark NICKERSON as my supervisor. At that time, Drs GOODMAN and AL GILMAN were the respected authors of the first really comprehensive textbook of Pharmacology and they were in the course of preparing the next edition. Dr GOODMAN had an encyclopediac knowledge of Pharmacology and his office was crammed from floor to ceiling with small file drawers containing notes on all the areas of pharmacology. Furthermore, Dr GOODMAN expected graduate students in his department to acquire a similar range of knowledge. Woe betide the graduate student who gave a seminar that did not display such a detailed grasp of the subject. Dr

NICKERSON, although trained initially as an embryologist, had already acquired a similar range of knowledge of pharmacology. Thus, by the time I got my PhD in 1952, I thought that the correct approach to knowledge of Pharmacology was to know all of it. I was too ignorant to know how much I did not know and too inexperienced in science to realize that knowing all of a developing scientific discipline is impossible.

My original plan to use a NIH postdoctoral fellowship to expand my research in pharmacology was derailed by my political activism, against Senators McCarthy, Representative McCarran, against the Korean War, against the murder of the Rosenbergs, *etc.* My fellowship was withdrawn by the US government, but then an even better opportunity arrived. I was given the opportunity to take up an Assistant Professorship Pharmacology under Dr James FOULKS at the University of British Columbia. UBC had a new Faculty of Medicine, just underway for one year. My move to Canada was the best move in my life and one I have never regretted.

Dr FOULKS and I were the only full time Faculty in Pharmacology at UBC, so I got responsibility very quickly. Besides some lectures, I was responsible for running the student laboratories. With my philosophy derived from Dr GOODMAN's training, I set out to make laboratories demonstrating as many pharmacologic principles as there were laboratory periods. I will not recount the many failures and few successes in that undertaking. Suffice it to say that after a year or two, I ended with experiments on autonomic pharmacology, cardiovascular pharmacology and neuropharmacology, which sometimes worked and which I thought were excellent in educating future physicians

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about drug mechanisms.

Then, I made the mistake of testing my hypothesis: I gave the students who were graduating that year and who had been exposed to my laboratory exercises, a questionnaire asking things like which experiments they liked best or worst and why, as well as which one they thought had provided useful instruction. To my dismay, I discovered that the graduating students could remember neither useful nor useless experiments. After examining the results from my questionnaire and finally accepting them, I began to change my approach. I eliminated several laboratories which did not always work well or which were really exercises in student frustration because the students spent the whole laboratory trying to set up the experiment. I substituted demonstration laboratories in which fewer animals were used and in which Instructors set up the experiment and conducted it before a small group of students. I adopted the principle that any laboratory which failed to work or failed to make a clear demonstration of a point should be eliminated.

In 1959, I had my first sabbatical and took it at London Hospital Medical College located in the East End of London on Turner Street. The Department was chaired by Dr Miles WEATHERALL and had as the junior faculty member, Dr Andrew HERXHEIMER, whose office I shared. I learned a lot in that year, not only about ion fluxes, but also about the philosophy that Medical Education was really an experiment, one that should have hypotheses which were testable and tested. My participation in that activity resulted in my becoming a co-author of my first paper in Medical Education.

Adams BG, Daniel EE, Herxheimer A, Weatherall M. The value of emphasis in eliminating errors. A controlled study in teaching. *Br Med J* 1960; 2: 1007-11.

I adopted that philosophy and acquired a life long friend in Dr HERXHEIMER, now well known for his work as a Clinical Pharmacologist and Member of the Cochrane Collection and, for many years, as Editor of *Which*, a magazine which aids consumers in deciding about the best products.

After returning to UBC, I began some new practices in the laboratory. These included use of Autonomic Unknowns, in which the students received a clear solution of an autonomic agent and had several possible *in vitro* or *in vivo* preparations in which to identify it and its concentration. I also began to utilize drug ad-

vertisements as problems in which students had to go to the literature to identify the accuracy of claims. These laboratories were successful in the sense that students participated with interest. I have never had the opportunity to test how well students incorporated the knowledge and the sceptical attitude from these problems in their future approach to medical practice.

In 1961, I had the opportunity to become chair of a new department of Pharmacology at the University of Alberta. The challenge and the joy of making a new department of excellence was accompanied by the ability to incorporate my ideas into the course and its associated laboratory. We carried out Autonomic Unknowns and Critical Evaluations of Drug Advertisements as part of the laboratory experiences. Dr Bill MAHON, our Clinical Pharmacologist, and I used our experiences with the evaluation of drug advertisements to do a study, which became my second paper in the field of education.

Mahon WA, Daniel EE. A method for the assessment of reports of drug trials. *Can Med Assoc J* 1964; 90: 565-9.

As time went on, I became dissatisfied with the didactic nature of pharmacology lectures and their disconnection with medical therapeutics. I tried introducing a segment of Therapeutic Topics which focussed on a given area in which drug therapy was prominent, such as Thyroid Disease or Depression. The students received handouts which outlined what was known about the physiology and pathophysiology of the disease states, the rationale for drug therapy and evidence of efficacy and safety. These were then discussed in a lecture/seminar session. These had limited success, probably because the students received them and acted on the issues passively.

In 1972 after 10 years as Chair, I realized that I had to make a decision about my future: should it be research or administration? I easily decided that it would be research and resigned as Chair. Within two years, I realized that it is very difficult for many reasons for a former Chair to exist in the Department he/she previously Chaired. This, along with a desire to experiment in pharmacology education, led to my move to McMaster in 1975, after a Sabbatical in Australia with Drs Molly HOLMAN and David HIRST. This sabbatical solidified my interest, ongoing to the present, in control of gastrointestinal motility.

McMaster in 1975 had no Department of Pharmacology or Physiology and all Canadian pharmacologists

had eschewed joining it faculty. It did have a Department of Neuroscience, chaired with Dr Jack DIAMOND so that is where I was placed. I suspect that he regarded me, interested in research on smooth muscle functions, as a weird person using up his limited resources. It took some time to get fully established there because there was almost no one else interested in gastrointestinal and cardiovascular smooth muscle pharmacology and physiology. The only research space available to me was in the Pharmacology Research Program, a strange anomaly since its members had almost no common research interests. Moreover, very little research was going on there and within a year the Program Director returned in frustration to the UK. This vacuum enabled me to start research on smooth muscle functions and to use multiple approaches to their study.

I was lucky in my early colleagues: Dr Sushil SARNA had been a PhD. Student under my co-supervision in Electrical Engineering at the University of Alberta studying electrical control of gastrointestinal function. He joined McMaster as an Assistant Professor in Surgery, the only Department with an interest in gastrointestinal function. Then I acquired some excellent post-doctoral fellows, who later became Faculty at McMaster or elsewhere: Dr MA MATLIB, who moved later to the University of Cincinnati, and Dr CY KWAN and later Dr AK GROVER, both still at McMaster. After a short time I was able to bring in Dr RE GARFIELD, another former PhD student, who has since become a world leader in reproductive physiology, now at the University of Texas Medical Branch in Galveston. As these colleagues became independent, studying various aspects of smooth muscle function, they also became the nucleus of the first Smooth Muscle Research Program in Canada and maybe anywhere. It became clear to me that scientists of diverse backgrounds, working together, could provide a deeper approach to solve scientific problems than any individual. Of course, there are many problems when individuals with great intellect, ego and different personalities have to co-exist in a small space, share resources and collaborate, but the rewards are also great.

Immediately after I arrived in McMaster, I got involved in problem based learning as a tutor of medical students. It was an exhilarating experience. My first tutorial groups of five had one B Sc graduate, two former nurses, a former social worker and a former computer programmer. It was amazing how the ex social worker and the ex computer programmer excelled in problem

solving even though each began with lesser background knowledge. I was soon convinced that this was the ideal educational experience. I was also convinced that programmatic approaches to research were the most fruitful and saved resources by sharing them. However, education in Pharmacology at McMaster had serious problems, which have not been solved to this day.

There were no lectures in Pharmacology or in Physiology. All learning was supposed to come from the pharmacological issues which existed in the various problems. This was fine in theory, but there were always multiple issues in any problem, inadequate time to tackle them all and the ones that were focussed on depended on the students choosing them or the tutor raising questions about them. Since most tutors were physicians and not pharmacologists and most students entered knowing little about it, these issues usually never were raised and discussed adequately in the formal tutorial sessions. Since Pharmacology rarely had any administrative power base, appeals or suggestions to improve the situation over the 26 years I taught at McMaster never produced significant changes.

Eventually, the medical students in their second or third years, as they approached or were in clerkships realized that had serious deficiencies in Pharmacology and Therapeutics. McMaster has always provided time and incentive for students to take electives to make up the deficiencies they perceive. Soon students began to come to me, since I was listed as resource person in pharmacology, for Electives in Pharmacology. In responding to their requests, I developed a series of therapeutic problems which focussed on pharmacological solutions. Of course, I included all the issues of physiology and path-physiology as well, but I set the problems up so that the rationales, and choices regarding applications of drugs to clinical problems were the foci. These electives became widely known and used by the students and other pharmacologists at McMaster also began to take on electives for students who realized their deficiencies.

During my time at McMaster, I also spent 13 years going twice a year for two weeks to St George's University, Kingstown Medical College in Kingstown, St Vincent and the Grenadines to run the Therapeutics course with Dr Diana GAZIS, head of Pharmacology. We both developed additional problems and adapted them to the fact that we had to take at least 10 students per tutorial groups and the reality that the students had little time and almost no access to the relevant literature.

They had little time because other didactic courses continued during this period and they were also approaching final examinations. They also had an inadequate library for looking up both the underlying pathophysiology, pharmacologic mechanisms or relevant clinical trials. This necessitated that we supply the students with the minimum literature required for problem solving. Since they had little time, we had to divide responsibilities for dealing with the several issues among the students fairly arbitrarily. There were also not enough tutors, so we had to begin each problem by training local physicians about the relevant issues so they could function as tutors. Despite the difficulties, the students enjoyed this different approach to medical education as did the tutors. I was unable to test their effectiveness in teaching problem solving in Pharmacology and Therapeutics. I am attaching one of my problems, on Hypertension, to illustrate the approach.

At McMaster the Medical Faculty was until recently constrained by its charter from teaching undergraduate courses in any discipline. The first breakthrough was a Cooperative Honours Course in Biology-Pharmacology. Along with other interested pharmacologists scattered in various departments in the Faculty of Health Sciences, I began planning for such a course in 1994

The Chair of Biology, Dr Steve THRELKELD, was supportive and we worked out a curriculum which involved PBL courses in Pharmacology to be taught by faculty in Health Sciences as well as other courses in Biology. We developed Laboratory exercises which included muscle bath pharmacology, pharmacokinetics, electrophysiology, ligand binding and study of platelet aggregation. We realized that we had to prepare the students to have both theoretical and practical knowledge and problem solving ability in the laboratory in order for the students to function in the workplace. The hardest part initially was finding enough work sites for our students but as their performance was observed and found to be excellent, we had less difficulty. When I stepped down as Director in 1997, my place was taken by Dr PK RANGACHARI, an outstanding teacher and enthusiast for PBL. This Honours Course has proved highly successful and was the first of several now operating in the Faculty of Science.

I retired from getting paid at McMaster in 1997, but continued as Professor Emeritus until 2001. At that time, I moved back to the University of Alberta. There were multiple reasons, among them the bad effects of

the air pollution in Southern Ontario and in Hamilton in particular on my severe asthma and the political situation at McMaster. Also my family is all in Western Canada.

The move has been very good for my health and my research has not suffered too much. Moreover, the Faculty of Medicine and Dentistry at the University of Alberta is gradually moving into PBL, not full blown PBL but a kind of hybrid which involves lectures on background matters being considered in the problems and a final written examination. Now I tutor in the PBL course which first year medical students receive. My impression is that medical students at the University of Alberta enjoy PBL but never get the full flavour of taking personal responsibility for their own learning. In addition, I have started a PBL course in Therapeutics in our Department for Honours or for Graduate students. It began with four students two years ago and this year will have 30 students. PBL is fun for tutors and tutored. I hope to continue for several years ahead.

In summary, the lessons I have learned on my long educational path are first, encyclopediac knowledge of any scientific subject is impossible to attain. It is also undesirable to attempt because it imprisons the seeker in the intellectual past. Second, PBL properly executed, is fun for all participants in the educational experience. Third, skill at PBL does not depend on the student having extensive background, but it does require that those who make problems utilize extensive, regularly-updated background information to continually improve problems. This allows students to achieve the most correct and relevant information and reminds them that Medical Sciences are continually evolving. Fourth, it is desirable to test ones hypotheses, assumptions and prejudices about medical education whenever possible. You may learn a lot. Finally, educational experiences in PBL provoke an attitude of continual inquiry, and promote interaction and teamwork. PBL is the most useful learning experience in my biased opinion.

The following is an example of the PBL problem, in which the multiplicity of antihypertensive drugs may represent a good example to illustrate the power of PBL in exploring and perhaps solving problem of such a complexity:

TREATMENT OF HYPERTENSION

You are a family physician working as part of a team in a community health centre. A new family has come to join the patient roster and you are providing

the initial history and physical examination. The family consists of a father (age 45), mother (age 46), three children (18 year old, 16 year old, and a 12 year old) and an elderly (aged 78) grandmother, who is the mother of the father.

The histories are not revealing except that the grandmother's husband died at age 52 from a massive hemorrhagic stroke. There have been common illnesses, but no hospitalizations, fractures or chronic illnesses. All appear in good health, but when you take the blood pressures, you find that the father has a BP of 160/95 and the grandmother 155/85. She has osteoporosis, she says, based on a bone scan done several years ago, but has never had a fracture.

Are these levels a concern? How will you follow up to ensure accuracy? Do you think there is a connection between the grandfather's death and the father's high blood pressure.

You persuade the family to get an electronic blood pressure recorder and you provide them with an ambulatory monitor for a week. You ask the father and grandmother to wear the ambulatory monitors for 2 or 3 days and take note of their pressures under different circumstances and return in a week.

Why are you doing this?

On their return, they report that their blood pressures varied with activity levels and stress levels, sometimes reaching 180/110 under stress and falling to 145/90 while reading for the father and reaching 175/90 when climbing stairs and falling to 140/65 while watching her favourite game show for the grandmother.

What is going on? What is the significance of these findings? Do you need to make further observations and take an action to change these values?

The father is a smoker, but he is not overweight (he works at the steel mill in a job requiring considerable physical activity) and he has no evidence of diabetes. There is some left ventricular hypertrophy. The grandmother never smoked but has become less active and

weighs 69 kg for a height of 154 cm. Her fasting blood sugar levels are elevated, but there is no protein in her urine.

How would you find these things out? What is their significance? What actions will you recommend to the father and the grandmother? Will you treat the grandmother with drugs since at rest her BP is within normal range? What about the father, who is not cooperative about your suggestions? Please outline your long term strategy for managing the blood pressures in these patients and justify your decisions. How will you monitor that these things are done?

The following are some learning issues for further exploration. The tutors must realize that understanding of the therapeutic principles and pharmacological actions of the drugs also goes hand-in-hand with their anatomical, physiological and biochemical counterparts.

1. Determinants of systolic, diastolic and pulse pressures. Is each an independent risk factor?
2. Other risk factors?
3. White coat hypertension? Is it a pharmacological issue?
4. Specific agents for some cases?
5. How do diuretics/beta blockers/ACE inhibitors cause chronic lowering of BP? Their mechanisms of action?
6. Cardiovascular remodelling, hypertension and ACE inhibitors?
7. ACE inhibitors vs AT₁ receptor antagonists as therapeutic agents?

This problem can be explored in stages over more than one tutorial, paragraph by paragraph or several paragraphs at a time. Dealing with the entire problem in one tutorial may be too overwhelming for students and may result in superficial learning. The questions given in italics are sample questions for the tutors to challenge the students with. Use them if and when necessary. Let the students brain-storm first.