Teaching Biochemistry to Medical Students in Singapore – From Organic Chemistry to Problem-based Learning

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Abstract

The medical faculty in the National University of Singapore started in 1905 but the Chair in Biochemistry was only established in 1927. For many years the biochemistry course consisted of the teaching of the organic chemistry of substances of physiological importance, nutrition, metabolism and hormones. In 1961, clinical biochemistry was introduced and in the 1980s, genetics and molecular biology were included. By then, most of the organic chemistry content had been removed as greater emphasis was placed on clinical correlation. Laboratory classes consisted of mock glucose tolerance tests and the measurement of various enzymes. By the 1990s, students were no longer interested in such practical classes, so a bold decision was made around 1995 to remove laboratory classes from the curriculum. Unfortunately, this meant that the medical students who might have been interested in laboratory work could no longer do such work. However, the new curriculum in 1999 gave the department an opportunity to offer a laboratory course as an elective for interested students. This new curriculum adopted an integrated approach with Genetics being taught as part of Paediatrics, and a new module (Structural and Cell Biology) comprising aspects of cell biology and biochemistry was introduced. This module is currently taught by staff from Anatomy, Physiology and Biochemistry. Some biochemistry content is now incorporated into the clinical problem scenarios of problem-based learning such as jaundice, diabetes mellitus, anorexia nervosa, etc. So the evolution of teaching biochemistry to medical students in Singapore has paralleled worldwide trends and moved from the didactic teaching of organic chemistry of biomolecules to problem-based learning using clinical cases.

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Introduction

The medical faculty in the National University of Singapore was started in 1905 and a Chair in Biochemistry established in 1927. Biochemistry was taught only to medical and dental students until 1960, when a degree course in Biochemistry was introduced under the Faculty of Science.

Staffing

Table 1 shows the list of Heads of the Department of Biochemistry. The first holder of the Chair in Biochemistry was Professor JL Rosedale, who was assisted by Dr CJ Oliveiro and Dr Leong Peng Chong (who later became Professor of Biochemistry at the University of Malaya in Kuala Lumpur). Professor Rosedale retired in 1941, just before the Japanese occupation, and Dr Oliveiro took over.

Table 1. Heads of Department of Biochemistry

Year	Name
1927-1941	John Lewis Rosedale
1941-1948	Christopher Joseph Oliveiro
1948-1957	Joseph William Henry Lugg
1957-1966	Theodore Frederic Dixon
1966-1975	E McEvoy-Bowe
1976-1977	Aw Swee Eng
1977-1991	Wong Hee Aik
1992-1996	Kon Oi Lian
1996-2000	Sit Kim Ping
2000-present	Barry Halliwell

Professor Lugg was then appointed in 1948. Professor Dixon took over in 1957 and led the department till 1966, when Professor McEvoy-Bowe became the Head. From

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1977, Singaporeans took leadership and these were Professors Aw Swee Eng, Wong Hee Aik, Kon Oi Lian and Sit Kim Ping. The current Head, who took over in 2000, is Professor Barry Halliwell.

In the early 1950s, the academic staff consisted of Professor JWH Lugg, Dr CJ Oliveiro, Dr JM Bowness, Dr JR Wadsworth and Mr JM Whyte. Subsequently, Drs Bowness, Wadsworth and Whyte left the department, and Mr E McEvoy-Bowe and Dr Frank Vella joined the Department as Assistant Lecturers in February 1954 and April 1956 respectively.[1] Dr Loke Kwong Hung was recruited as Assistant Lecturer in 1958 after he obtained his PhD from the University of Edinburgh. In 1959, two new staff, Drs Wong Hee Aik and JM Bowness, joined the department. Dr Vella resigned and left in January 1960.

In 1965, Dixon[2] reported that it was difficult to recruit medical staff into the preclinical departments (obviously, a problem that has not been solved even till today) as most doctors have few incentives to return to a preclinical teaching appointment. Even though arrangements had been made for medical students to take an extra Honours year in Biochemistry and Physiology, few had availed themselves of that opportunity. So, in order to produce scientifically but not medically qualified biochemists who would be able to teach in the department, the degree course was started. Biochemistry was a popular discipline then, with 400 students taking different courses within the department in the 1964/65 session.

Initially, most of the staff were recruited from overseas, but with the introduction of Biochemistry as a course in the Faculty of Science, more local staff were subsequently recruited. In recent years, the emphasis on international recruitment has reversed the trend and currently accounts for 21 of the 26 current full-time staff being of non-Singaporean origin.

Research

Most of the early research focused on the nutritional properties of local food using chemical analyses and animal feeding experiments. In 1932, a Nutrition Laboratory was opened by the governor, Sir Cecil Clementi. It was funded by a grant of £6000 from the Colonial Development Fund. Out of this work, a complete analysis of the composition of local foods and their nutritive values was compiled.[3] In the 1950s and 1960s, one of the department's members, Dr F Vella, did pioneering work on abnormal haemoglobins, including a study of glucose 6-phosphate dehydrogenase deficiency in the local population.[4] Inter-departmental research was already evident in 1951, when the Biochemistry department collaborated with the Physiology department to study plasma protein concentrations of various races in Singapore. Another interesting study measured the vitamin B content of bread and vitamin B1 content of toddy produced in Singapore.[5]

By the 1960s, research ranged more widely from metabolic investigations to the biochemistry of ketosteroids, sex hormones, mucopolysaccharides, flavonoids, abnormal haemoglobins and glucose absorption by hookworms. Many of these investigations made use of the different ethnic groups in Singapore to make comparative studies.[3] This is, of course, one of the unique features that current biomedical research in Singapore has also capitalised on.

In her 1980 report, Professor Wong Hee Aik[6] revealed that the department was engaged in diverse basic and applied research ranging from human diseases such as diabetes, hepatomas and blood gastrin levels in patients with duodenal ulcers, to the mechanism of insulin action and flavonoid metabolism. Another area of research which later became of economic interest was focused on the growing of mushrooms. A mushroom farm and marketing company, Everbloom, was established by one of the department's lecturers, Dr KK Tan. Funds for research were obtained from external sources such as the Wellcome Trust, the International Foundation for Science, the Turf Club of Singapore, the Zyma Trust of Switzerland and the China Medical Board. A generous university budget enabled the department to purchase new equipment to support research in the fast developing areas of genetic engineering and biotechnology.

By 1996, in line with the great advances in molecular biology, much of the research in the department focused on cell signaling, molecular cloning, neuroscience and biochemical studies on possible therapeutics from venoms and toxins. Some staff also worked on medically related research topics on septic shock, liver cancer and the use of liposomes in drug delivery.[7]

Currently, the Department is well equipped for research and staff members have managed to obtain substantial research funding.[8] The main areas of research include:

- Biochemistry of free radicals and antioxidants;
- Biochemistry and molecular biology of venoms and toxins;
- Biochemistry and biophysics of membranes and lipoproteins;
- Biochemistry of ubiquitination and the proteasome, especially in relation to neurodegenerative disease;
- Detoxification and drug-metabolising enzymes;
- Intracellular protein-trafficking;
- Lipidomics, Proteomics and Transcriptomics;
- Molecular neurobiology;
- Mammalian signal transduction and regulation of apoptosis;
- Molecular biology of bacterial and viral pathogens;

- Sterol metabolism and atherosclerosis;
- Tumour immunology.

Education

When the department first started, the topics taught to medical students in their second year of study included the basics of organic chemistry with compounds that had a bearing upon physiological chemistry in the second term.[9] In the third year, clinical biochemistry and nutrition were taught via both lectures and laboratory work. In 1933, the 2-year course was shortened to 1½ years over 3 terms[10] and lectures on nutrition to fourth-year dental students were started. In the years before the Japanese invasion in late 1941, Professor JL Rosedale and Dr CJ Oliveiro taught the course for medical and dental students.

In 1947, two medical students were appointed as part-time demonstrators.[11] One of them, Wong Hock Boon, later became the Professor of Paediatrics. Research was still mainly on nutrition and an interesting report from a survey of medical students residing in the hostels found the following results. They were of an average age of 26 years, and an average height and weight of 5 ft 6 inches and 126 pounds respectively.[11] I am sure that a survey today would find our average medical student to be younger, taller and heavier.

A report in 1950[12] gave the following details of the Biochemistry course for second-year medical students. The first term had 18 lectures of 2 hours each on general introduction and organic chemistry of substances of physiological importance, with practical classes of 36 hours. In the second term, another 18 lectures covered the physicochemical and functional aspects of digestion, absorption, excretion, elementary metabolism and regulation, with a further 36 hours of practical classes. In the third term, there were 9 lectures on nutrition and 18 hours of practicals. The assessment consisted of both written and practical examinations. In the third year of the medical course, the Biochemistry component had 9 lectures and 18 hours of practicals to cover metabolism and hormones, and a further 9 lectures on clinical Biochemistry in the second term. The third-year assessment was a 3-hour paper and practical with a viva where necessary.

In 1960, a degree course in Biochemistry under the Faculty of Science was introduced.[13] Several graduates of this degree course (Sit Kim Ping, Teo Tian Seng, Tan Chee Hong, Lee Kay Hoon and NP Das) later became academic staff of the department. Other prominent Honours graduates of the department who have contributed to the development of biomedical science research in Singapore are Chua Nam Hai, Louis Lim and Chris YH Tan, who were leaders in the Institute of Molecular and Cell Biology and Institute of Molecular Agrobiology.

In 1978, several staff members of the department, together with the Department of Pathology, began to teach Clinical Biochemistry to fourth-year medical students. Later, however, these Biochemistry department staff became part of the Department of Pathology. Professor Wong reported in 1980 that the department had been able to attract 2 medically qualified lecturers and were in the process of attracting 2 more.[6]

By the early 1990s, as the rest of the world revised their medical curricula so as to allow the courses to be more integrated and clinically relevant, as well as to reduce the content and information overload, the Faculty of Medicine also responded by revising its curriculum.[14] It was decided that our school "was not ready for the fully integrated problem-based approach," and so only a "more coordinated programme" was introduced. In July 1993, Biochemistry became part of a "Human Biology Block" in the first year to provide the foundations for the study of clinical topics. Since this resulted in a significant increase in content taught in Year 1, a decision was made to reduce and to move some content to the second year. Practical classes for medical students were also removed entirely.

In 1998, a new team in the Dean's Office realised that there was a need to follow the advice of *Tomorrow's Doctors* (1993), published by the General Medical Council (GMC), UK, for a more integrated, student-centred curriculum. The NUS medical curriculum used to be a traditional one based on 2 years of preclinical disciplines – Anatomy, Biochemistry, Physiology, Microbiology, Pathology and Pharmacology, followed by 3 years of clinical subjects. In the first 2 years, teaching was mainly based on lectures and some tutorials. The students did not see any patients until they started their third year. Although some attempts were made to integrate the curriculum in the late 1980s and early 1990s, resistance by older teachers and continued control of the curriculum by departments meant that very little change was made. The new Dean established a curriculum committee chaired by a Vice-Dean, which put the control of the curriculum in the Dean's Office. This culminated in a revised curriculum in 1999, integrated both horizontally and vertically. For various reasons, lectures, dissection classes, tutorials were all retained. At the same time, other instructional methods that would allow greater self-directed learning opportunities were introduced. These included problem-based learning (PBL) sessions, special studies modules (SSM), physician development programmes (introduction of students to patient care in the first year), clinical skills labs and more electives. The department offered a SSM in molecular biology techniques for medical students who were interested in laboratory work.

More specifically, in the Year 1 curriculum, teaching of

the core objectives was integrated on a system-based approach with clinicians providing clinical overviews and summations. PBL had about 20% of curriculum time devoted to it. It is a method of self-directed learning that uses a patient problem as a trigger and context for students to learn problem-solving skills and to acquire the ability to search for relevant basic science and clinical knowledge independently.[15] Academic staff in the department have been actively involved as tutors in the PBL sessions. They have also been case writers for clinical cases on topics ranging from diabetes mellitus, jaundice, myocardial infarct, anorexia nervosa to human-powered flight.

In this new integrated curriculum, the department of Biochemistry becomes the anchor department for the Structural and Cell Biology (CB) Track of the core medical year 1 curriculum. The CB Track, which extends over the 2 semesters of the first year, emphasises the current thinking on the biochemical and molecular basis of human disease as well as the relevance of biochemical investigations in the clinical setting. Active and independent learning by the use of recommended texts as a supplement to lectures and small-group teaching is actively encouraged. Major topics of the CB Track include the structure and function of biological molecules, intermediary metabolism and its regulation, bioenergetics, the biochemical basis of cellular processes, detoxification, molecular biology, biochemical genetics and molecular medicine. These aspects are integrated with the teaching in the other 2 tracks (Systems Biology and Human Structure & Development) whereas in the former, the Biochemistry department also contributes to the teaching of topics such as nutrition, heme metabolism and signaling.

In the year 2 medical curriculum, the department contributes to the teaching of cancer, medical genetics and neuroscience. The department staff also contribute significantly to the Special Study Modules and Medical Faculty Research Opportunities Programmes.

Apart from medical students, the department also contributes to teaching in the Faculty of Dentistry and the new Life Sciences curriculum in the Faculty of Science.

With the publication of the revised *Tomorrow's Doctors* (2002) by the GMC to modernise medical education and the move to competency-based rather than experience-based learning outcomes, the Faculty of Medicine will be re-examining and revising the curriculum that was introduced in 1999. The Department of Biochemistry will be part of this revision.

Conclusion

In recent years, many departments of biochemistry have ceased to exist as they were absorbed into larger schools of life sciences or became departments of biochemistry and/or molecular biology. This is probably due to the overwhelming success of biochemistry because biochemical concepts and techniques are now integral parts of research in areas as diverse as genetics, pharmacology, microbiology, endocrinology, immunology, nutrition, pathology and other clinical disciplines. Since integration is occurring naturally in research, it is logical that the teaching of biochemistry should increasingly be done in an integrated manner.

In this centennial year of the Faculty of Medicine, National University of Singapore, it can be seen that the Department of Biochemistry has made amazing progress from the days of teaching organic chemistry and researching the chemical analyses of local food products to using the latest teaching methodologies in medical education and research areas in molecular medicine. It has become a department with many strong collaborative projects with the clinical departments, national and international research institutes and its teaching programmes have become more integrated into the medical, dental and science curricula.

In a century, teaching in the department has evolved from the didactic teaching of organic chemistry to emphasising the student-centred learning of biological processes, using a PBL approach to demonstrate clinical relevance. On the other hand, the recruitment process has come full circle and a large pool of foreign talent is again contributing to teaching and research in biochemistry.

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