DEVELOPMENT OF A CONSENSUS SYLLABUS FOR BIOCHEMISTRY: The Experience of Cameroonian Universities

Professor Vincent P.K. Titanji, Ph.D.
Dept. of Life Sciences, Faculty of Science
University of Buea

PART ONE

INTRODUCTION AND HISTORICAL DEVELOPMENT OF BIOCHEMISITRY IN CAMEROON

1.1 Pressure is mounting on universities in Cameroon to render university training more professional.

Following the Higher Education reforms of 1993, Cameroonian authorities called on the new universities to adapt their training programs to job-market trends. It was argued that the high rates of graduate unemployment was due to the lack of correlation between job-market needs and the university training which was believed to be too theoretical to be useful to the industries. Gradually the impression was given that the employment statistics would improve as soon as the universities turned towards vocational training instead of the usual liberal education that they believed to be their time-honoured calling.

There are several reasons why this type of thinking is fallacious. First of all, the creation of jobs depends, not only on macroeconomic factors, but also on the state of industrialisation of the country concerned. The Universities can play a role in improving the capacity of graduates to create jobs for themselves, or take on existing ones. But the expansion of the economy and industrialisation of the country is not a traditional task of the Universities.

Secondly, a well-implemented liberal education curriculum yields graduates who are competent, knowledgeable, skilful and above all adaptable. Such graduates are likely to keep up with the rapidly changing requirements of new technologies. They can fit into new job situations, continuously improve their skills through self-education, and provide leadership under a variety of situations. By contrast, graduates whose training is narrowly geared to specific tasks, techniques or operations, without sufficient understanding of the basic principles involved, will soon become obsolescent and certainly fail to cope with the rapidly evolving world of work.

In the following sections I shall trace the development of a core syllabus for Biochemistry in Cameroon during the past two decades. I shall argue that, when a biochemist is well trained in the basic principles and practice of the science, he/she would easily fit into the various professions of the health, agricultural and industrial sectors.

For the sake of clarity we shall briefly survey the development of Biochemical Education in Cameroon, before describing some fundamental principles of University Education and their adaptations for Biochemical training. I have adopted a rather personal approach in the present article to emphasize my experience as I contributed to the development of Biochemical training in Cameroon over the past two decades.

1.2 Biochemical Training in Cameroon started as parts of the Medical and Natural Science curricula

The teaching of Biochemistry in Cameroon probably dates from 1966 when the *Centre Universitaire des Sciences de la Sante* (CUSS) opened its doors as the country's first and only medical school. Biochemistry was taught during the first three years as part of the medical curriculum (table 1). Subsequently the subject was introduced to the Faculty of Science of the University of Yaounde as part of the Chimie/ Biologie/Geologie (CBG) program.

TABLE 1 : 'DOCTORAT EN MEDICINE' (BIOCHEMISTRY COMPONENT)

YEAR	DESCIPLINE	HOURS	
		LECTURES	PRACTICALS
ONE	STRUCTURAL & METABOLIC BIOCHEMISTRY	120	60
TWO	TISSUE ORGAN BIOCHEMISTRY	100	60
THREE	CLINICAL BIOCHEM	60	-

TABLE 2 : LICENCE DES SCIENCES NATURELLES (OPTION BIOCHIMIE)

YEAR	DISCIPLINE	HOURS	
		LECTURES	PRACTICALS
TWO	STRUCTURAL BIOCHEMISTRY	37.5	37.5
THREE	METABOLIC BIOCHEMISTRY	100	50

It was only in 1972 that a biochemistry degree program, designed along the same lines as those in the French Universities, was introduced at the Faculty of Science. The degree course gained immediate success and attracted large numbers of students. Unfortunately the program was short-lived as it was closed down only four years after graduating its first batch of students. Then, it was claimed that Biochemistry graduates cold not find jobs and, consequently, there was no reason to train more of them. We have reasons to believe that the closing down of the biochemistry program was due to its popularity. Some influential professors from the competing biological disciplines were not happy with the manner in which Biochemistry was diverting students away from their own subjects. They consequently championed the campaign against Biochemistry which was finally appended to the Department of Botany and Plant Physiology as a Unit.

The argument that the lack of employment for biochemist justified its removal from the university syllabus was as faulty then as it was today. The, the University of Yaounde was training thousands of lawyers although a majority of them could not find jobs. The problem of graduate unemployment depends on whether or not our economy is expanding rapidly enough to be able to absorb the graduates at the rates they are being produced.

We believe that the Cameroon government has made a wise political choice to expand higher education. We should not let ourselves to be caught in the vicious circle where it would be claimed that we do not have qualified personnel for industrial growth and yet we would not train people because there are no industries to work in. We believe that well-trained persons are ignorant ones. It was this conviction that spurred us forward in our pursuit of an adequate biochemical syllabus for the University of Yaounde and the county.

When I returned to this country in 1979 after qualifying as the first Cameroonian to earn a Ph.D. degree in Biochemistry, the subject was at its lowest ebb. The expatriate biochemists who had been teaching the subject had retuned to their respective countries.

Dr. Felicite Mbiapo (now a professor), who had meanwhile taken up a job in 1974 as an Assistant Lecturer in Biochemistry at the Faculty in the Faculty of Science, was at the University of Ibadan completing her Ph.D. training. (It should be noted that I was employed in 1973 as an Assistant Lecturer in Biochemistry at the Faculty of Science, but could not take up the appointment as I was already enrolled for the Ph.D. degree at Uppsala University in Sweden). There was no department of Biochemistry, and the subject was then associated with Medical Physiology (at CUSS) and Botany (at the Faculty of Science). Rather surprisingly, I was not immediately accepted at the Faculty of Science under the pretext that there was no opening for biochemists there.

It took four good years for me to battle my way into the Faculty of Science of the University of Yaounde, strongly supported by Professors Victor Anomah Ngu and B.L. Sondengam, who saw in the solid training I had received from Swedesh and Russian universities, an asset that could be used for Biochemical Training at the University.

Meanwhile, whilst waiting for an employment opportunity at the Faculty of Science, I got a temporary position as a part-time lecturer and researcher at the CUSS, where between 1978-1982, I helped to re-instate practical laboratory training which had

TABLE 3: LICENCE DES SCIENCES NATURELLES (OPTION BIOCHIMIE)

2ND YEAR	Structural	37.5H	37.5H
3rd YEAR	Structural Biochem	26H	6.5H
	Enzymology & Bioerosgetics	50H	37.5H
	Tissue & Organ Biochem metabolic Biochem	100	50 H
	Tissue Biochem	13H	6.5H
	Biochemical Methods And subsidiaries	13H	6.5

Note the absence of molecular Biology (Information Transfer) and the low weighting of Biochemical Methods.

been abandoned in 1978 after the departure of Professor Aquaron (the former head of Medical Biochemistry at CUSS). During this period I also helped to up-date the Medical Biochemistry syllabus as well as start research on metabolic regulation and lipid chemistry (1,2).

Within this period (1979-1982), I began to apply biochemical methods in the laboratory of Professor Jacob Ngu to the characterization of the antigens of *Onchocerca volvulus,* the parasite that causes river blindness 93). With a research base created, it was easier to set up a research group from which biochemical techniques could be demonstrated, rather than taught theoretically as has hither-to-for been the case. These developments, however, were to take place at the Faculty of Science, University of Yaounde where I started to work in 1982 (4).

1.3 Biochemistry emerges as an independent Discipline with significant infrastructure for research and training

Cameroonian Biochemistry made significant strides in the 1980's. Not only did it gain its autonomy by being recognized as an independent discipline, the Biochemistry Unit was elevated to the status of an academic department with the capability to offer degree programs at all levels including the doctorate. But this was a gradual process that faced a lot of the obstacles and prejudices created by the closure of the Biochemistry degree program at the end of the 1970's.

When I moved to the Faculty of Science of the University of Yaounde in 1982, the Biochemistry Unit was still administered as part of the Botany Department. The subject itself was taught as part of the Bachelor's degree in the natural Sciences (Licence des Sciences naturelles). The number of lecture hours allocated to Biochemistry was very limited (table 2).

Practical training was limited to simple clorimetric assays for biomolecules, with no attempts being made to conduct more sophisticated experiments involving the extraction and purification of biomolecules. Separation techniques such as electrophoresis and column chromatography were not taught although they were central to biochemical practice of the day. The use of radio isotopic methods was out of the question although these formed the core of analytical biochemistry. Research on the dynamic aspects of Biochemistry was neglected, and although molecular biology was taught in the 4th year (at the *maitrise* level), it was not practiced; even the isolation of nucleic acids was not taught to the students. Whatever research went under the name of biochemistry could easily be classified as nutrition or food technology. There was then an up-hill task first of all to increase the quota of hours allocated to Biochemistry within the Natural Science program, and secondly to institute Practical Biochemistry as it was then taught in universities abroad.

It is pertinent to note that more time was allocated to the teaching of Biochemistry in the medical curriculum than it was in the Science degree program (tables 2 & 3). Given the stiff opposition of the authorities of the Faculty of Science to up-grade Biochemistry into an independent degree program, we decided to push for an increase in the quota of hours devoted to Biochemistry at the B.Sc level, and to introduce a postgraduate diploma (or maitrise) program in which we could catch up with the teaching of Biochemistry. (Table 3)

Simultaneously, I began to set up a research laboratory in which at least the most fundamental techniques of biochemistry could be practiced. In 1984 I approached the General Delegation for Scientific and Technical Research (DGRST) for assistance to set up a laboratory for Recombinant DNA and Hybridoma technologies, two domains which were rapidly expanding at that time. My request was

turned down on the pretext that genetic diseases cannot be cured, and in any case the targeted technologies were too advanced for Cameroon.

I did not relent, and by 1986 I had persuaded the University of Yaounde, the Uppsala University and the International Science Programs (Uppsala), to provide funds and equipment for the creation of a Biotechnology Centre (4, 5). This was done, and for the first time in Cameroon well equipped laboratories for Biochemical research were organized which opened the way for the training of advanced students in cutting-edge technologies.

Meanwhile, a new syllabus in Biochemistry was introduced towards the late 1980's together with the up grading of the Biocemistry Unit into a Department. Unfortunately this new program, came in too late, and at a time when the University of Yaounde was disintegrating as a result of political agitation, overcrowding and inadequate infra-structure. The new biochemistry syllabus could not be fully implemented and its impact remains largely negligible.

In 1993 the Government dissolved the University of Yaounde, and in its place, created six new universities. The old syllabuses were scrapped, and new ones, meant to be more responsive to market needs were instituted. Many of the research groups that had been painfully constituted over the years and were beginning to gain international recognition were disbanded and its members scattered all over the country at the new Universities that were now established at distant provinces away from Yaounde.

I happened to be transferred to Buea during this exodus, and had the challenge of fashioning syllabuses not only for Biochemistry, but also for supervising the curriculum development process for other science subjects. Although the dissolution of the University of Yaounde had its negative effects, the opportunity to reorganize the teaching programs from the scratch was unique. Convinced that university has the sacred duty to train the whole person for civilised living, I developed a set of principles which guided our efforts at curriculum development. The second part of the present article will articulate some of these principles and then illustrate our attempts to apply them to the Biochemistry syllabus.

PART TWO

Profiles of a university graduate and the biochemistry syllabus

2.1 University education has certain inalienable attributes that transcend the mechanical acquisition of job skills

The traditional mission of the university is to train the whole human being into a highly competent, knowledgeable and responsible citizen with specialised skills (table 4). University education that narrows down to the acquisition of skills with little understanding of the governing principles is of a mundane and unsatisfactory type. As well a university graduate, who is not a master of any particular discipline, has failed in his/her task of acquiring higher education. Stated differently the university provides the opportunities for the acquisition of specialised knowledge and skills within the context of evolving cultural, economic and technological values. Some of the outcomes listed in table 4 can be acquired in the classroom; others informally through the university community, and others discovered through personal research. Whatever the discipline that is studied, these values are expected to be inculcated. However, each subject has additional specific attributes. Our task will be to consider the factors that set Biochemical training apart.

TABLE 4: OUTCOMES OF HIGHER EDUCATION

GENERAL
CURIOSITY
LOGICAL THINKING, EXPRESSION & ACTION
OBJECTIVITY
SPECIALIST KNOWLEDGE
SPECIALIST KNOW – HOW (DEXTERITY)
NUMERATE/QUANTITATIVE THINKING)
TOLERANCE
FLEXIBILITY (ADAPTABILITY)
FOR THE BIOCHEMIST (INADDITION)
PATIENCE
GOOD MEMORY
METICULOUSNESS
OBSERVANCE

2.1 A deep understanding of biochemistry provides tools for enhancing the quality of life.

What do we train biochemists for?
What do we expect of them, that sets them apart from other graduates, after 3-5 years of University training? Certain cardinal objectives should be met by all biochemical training. At the end of the training the biochemist should be able to:

1. Identify, detect and quantify biomolecules for structural and functional studies

2. Isolate and purify biomolecules from tissues and organs

3. Understand how the structures of important biomolecules are elucidated.

4. Understand, interpret and explain biochemical data that account for the complexity, diversity and similarity of life forms.

5. Assess dynamic processes involving the transformation of matter and energy within the living cells.

6. Understand the principles that govern heredity, genetic information transfer, expression and regulation.

7. Apply the knowledge gained in (1-6) to improve human and animal health, enhance agricultural production, improve environmental management and create goods and services.

8. Develop a capability for self-education

All of the above are to be acquired within he greater context of a liberal university education as described above.

2.3 Biochemical Training proceeds in stages.

Biochemistry derives from a variety of fundamental scientific disciplines. As such, it is best introduced after students have acquired a sound foundation in allied disciplines. The first phase of Biochemical training is therefore devoted to foundation courses in Cell Biology, Physics, Chemistry and Mathematics. The last three subjects should be carefully designed to emphasize notions that will be required in understanding subsequent biochemical processes. The subject of Cell Biology should provide a bird's – eye-view of major biochemical concepts including a description of biomolecules, metabolism, energetics and the genetic apparatus.

In stage two an in-depth description of cellular components is given. A strictly chemical approach is recommended, whilst the relationship between structure and function is emphasized. This prepares the way for the dynamic aspects of biochemistry, which includes disciplines such as enzymology, bioenergitics and metabolisms. A careful balance between the quantitative and descriptive treatments of enzymology and energitics is encouraged, whereas an understanding of the delicate balance between metabolic pathways is to be preferred to the simple learning of metabolic sequences by rote.

Stage three is devoted to information transfer (or molecular biology), metabolic regulation and molecular physiology which includes biochemistry of the organs. By the end of stages 4-5 the student is ready for specialization through the analyses of primary literature and independent research.

TABLE 5: MINIMAL SYLLABUS FOR BIOCHEMICAL TRAINING TIME FRAME 3-5 YEARS

STATE 1	STAGE 2	STAGE 3	STAGE 4	STAGE 5
FOUNDATIONS	STRUCTURAL	DYNAMIC	INFORMATION TRANSFER/TRANSDUCTION	SPECIALISATION
CELL BIOLOGY	BIOMOLECULES	ENZYMOLOGY	GENE TECHNOLGOY	CORE DISCIPLINES RESEARCH
CHEMISTRY	WATER	BIOENERGETICS	METABOLIC REGULATION	
PHYSICS	HYDROGEN BUFFERS	METABOLISM	MOLECULAR PHYSIOLOGY	
TECHNIQUES				
MICROTECHNIQUES	ANALYTICAL METHODS	SEPARATION SCIENCE	GENE TECHNOLOGY	PRIMARY LITERATURE RESEARCH
COMPUTATIONAL METHODS	COMPUTER LITERACY	KINETICS	APPLIED BIOCHEMISTRTY	MANAGEMENT MARKETING

2.4 Biochemistry is a practical subject, which must necessarily be taught in the laboratory.

Many of the concepts in biochemistry cannot be fully grasped unless they are demonstrated in the laboratory and performed by the learners themselves. As such at all stages laboratory techniques must be integrated with the theoretical training to enable the students learn the skills they will need in their future practice as biochemists. A minimal portfolio of laboratory skills should cover the analytical biochemistry, separation methoda, kinetics, gene technology and applications.

The exact types of techniques will depend on the sophistication of the laboratory. But the general principle should be to proceed from simple exercises requiring just one method to more complex ones requiring several procedures. For example, at the beginning, students may be required to quantity biomolecules in various situations; subsequently, isolation and characterisation of such molecules may be required.

Throughout, the practical training, dexterity, observational skills, patience, objectivity, a questioning and quantitative approach should be encouraged. Problem solving rather than rote learning should be stimulated as well.

2.5 The Minimal biochemical curriculum can be completed in 3-5 years

Depending upon the infrastructure available, the minimal syllabus can be completed in three years, after which students may proceed to do research or obtain gainful employment. But quite often, it is drawn out to 5 years, particularly if it is intended that the student should take other accessory subjects, for example chemistry or other biological subjects.

In some situations industrial training is required; but this is only possible where such industries exist. The stages listed in table 5 could follow as given or could be rearranged to overlap depending upon the facilities and organizational structure of the school concerned.

2.6 Course Description of major biochemical disciplines

Structural Biochemistry covers the structures and functions of the main constituents of the living cell e.g. proteins, peptides, amino acids, enzymes, nucleic acids, sugars or carbohydrates, lipids, vitamins, trace elements, water and hydrogen buffers.

Dynamic Biochemistry. This covers the major metabolic pathways in the cell and their regulation. This includes uptake and digestion, followed by synthesis and catabolism of the various constituents listed under structural biochemistry. Noteworthy are pathways of carbohydrate catabolism: glycolysis, krebs cycle, oxidative phosphorylation, the hexose monophosphate shunt, glyoxalate pathway; glyuconeogenesis, a biosynthetic pathway. Lipid biosynthesis and catabolism through beta oxidation; biosynthesis and degradation of cholesterol. Metabolism of amino acids, purines and pyrimidines. Protein synthesis is normally covered under molecular biology.

Molecular Biology. This covers the chemical basis of heredity. The structures and functions of DNA and RNA, the genetic code, along with processes such as replication, transcription, translation are described. The chemical basis of mutations and genetic diseases are covered. Finally the main steps in gene manipulation are examined. The various concepts are applied to explain genetic diseases and prospects for their control.

Enzymology describes catalytically active proteins. The structural aspects covers the nature of the active centre; classification of enzymes. The dynamic aspects covers the kinetics of mono and bisubstrate reactions, introducing the theories of Briggs-Haldane, Michaelis-Menten and the formalism of Cleland. The basis for the efficacy of enzymes are described along with mechanisms for their regulation. Allosterism and cooperativity are introduced, but the various mathematical models are considered only at the M.Sc. levels. The mechanisms of enzyme regulation including the effects of pH, temperature, substrate and co-factor availability, covalent modifications are a described. The applications of enzymes in clinical diagnosis and manufacturing are presented.

Bioenergetics deals with the accumulation, transformation (transduction) and dissipation of metabolic energy, emphasizing the role of ATP. Thermodynamic laws are applied to biochemical processes. Processes such as oxidative phosphorylation and photosynthesis are described at the molecular level.

Biophysical Chemistry (Physico-chemical methods.
The physical properties of macromolecules are examined, along with methods for their isolation analyses. Principal separation techniques covered are elec-

trophoresis, chromatography and centrifugation which are described with respect to proteins and nucleic acids. Analytical procedures include spectrophotometry, fluorimetry, nephalometry, and radioisotopic methods.

2.7 Computer Science, Management and Marketing are imposing themselves on all subjects including Biochemistry.

Computer literacy is mandatory for success nowadays and should be acquired as early as possible. As graduates are being called upon to establish on their own, the rudiments of management and marketing could be incorporated in the syllabus. With the rapid accumulation of biochemical data, the use of increasingly sophisticated computer analyses is becoming more and more routine. Similarly, managerial competence is required of all those who dream to manage research groups or biochemical industries.

2.8.1 Conclusions

The emphasis in this paper has been to train a biochemist who can survive change and adapt to it. Whilst a certain core of techniques which one does not fully understand. However, it is absolutely necessary for laboratory skills to be mastered through first-hand experience by the learners. Understanding biochemistry from the literature is only a beginning. The real excitement comes in conducting experiments by oneself and learning from one's own results.

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