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To teach or not to teach - Toward the development of a conceptual and technique biased syllabus in palaeontology

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Summary

This paper evaluates some of the criteria essential for the construction of a modern syllabus in palaeontology. It then relates the procedure followed in the preparation of such a syllabus under the auspices of the Council for National Academic Awards in Great Britain and presents a brief summary of the syllabus itself. Some conclusions as to the results achieved during the formative years of the course and of the state of preparedness attained by the resultant graduates are also presented.

Resumen

Este trabajo evalúa algunos de los criterios esenciales para la construcción de un tratado moderno en Paleontología. Se relaciona el procedimiento seguido en la preparación de tal tratado bajo los auspicios del «Council for National Academic Awards» en Gran Bretaña y se presenta un breve resumen del mismo. Se presentan igualmente algunas conclusiones, como son los resultados obtenidos durante los años formativos de la carrera y del grado de preparación alcanzado por los graduados.

Resum

Aquest treball avalua alguns dels criteris essencials per a la construcció d'un tractat modern de Paleontologia. S'explica el procediment seguit en la preparació d'un tractat d'aquesta mena sota els auspicis del «Council for National Academic Awards» a Gran Bretanya i se'n presenta un breu resum. Es donen, així mateix, algunes conclusions, com són els resultats obtinguts durant els anys formatius de la carrera i del grau de preparació assolit pels graduats.

Introduction

During the last two or three decades Geology as a science has been reborn, with multidisciplinary topics such as plate tectonics rekindling interest at all levels. It has also become more quantitative and the qualitative approach has tended to be suppressed in many subdisciplines. In Palaeontology, however, the effect of the quantitative approach is «localised» and many courses still follow the wellworn phylum to phylum trail. As a consequence, it is believed that many potential palaeontologists are lost to supposedly more attractive options such as Sedimentology and Structural Geology. To the school leaver and amateur, Palaeontology is one of the major attractions of the geological sciences and one is compelled to ask why this potential demand is not always realised in tertiary education.

The taxonomic approach to Palaeontology is all too often linked with the rote memorizing of numerous species related to their ultimate use in biostratigraphy. Palaeontology for the student should be much more, however, as the concepts and techniques employed in the studies of palaeoecology, functional morphology, evolution and biometrics represent the «cutting edge» of our science. In educational terms these palaeobiological aspects of Palaeontology are also amongst the most stimulating and should be included in the structuring of any relevant syllabus.

The design of such a syllabus involves the use and development of suitable teaching aids and techniques. Through the inauguration of the Polytechnics and the Council for National Academic Awards in Great Britain many Departments of Geology outside the Universities have been given the opportunity to develop new courses, and many have taken the opportunity to move towards a more conceptual base. The development of one such course is discussed and some of the pitfalls and failings are recalled. The relevance of the syllabus to the needs of the student as an employee are also evaluated in terms of the development of his/her skills and attitudes.

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In his Presidential Address to the Association of Geology Teachers in 1976, Professor D. V. Ager noted, with characteristic frankness that palaeontology «apart from crystallography, was the most unpopular subject» taught under the umbrella of the geological sciences. This pronouncement was based on twenty-five years of teaching experience and direct student contact. Many academic palaeontologists would agree with these findings and share Professor Ager's belief that palaeontology is all too often plagued with too many «dreadful names» and constrained by unimaginative syllabi. Until recently it has also been «starved» of readable, imaginative and reasonably priced textbooks which would in the words of Raup and Stanley (1971), «spark the imaginations of potential palaeontologists and other scientists — to plant the seeds for future harvest».

Palaeontology however, is acknowledged to be an addictive discipline and we are constantly amazed at the aptitude youngsters have for remembering the so-called «dreadful» generic and specific names of long dead dinosaurs and mammals. Amateur geologists are also either palaeontologists or mineralogists, by instinct; the majority driven by a passion to collect, study and understand the nature of minerals and fossils. Both young and mature amateurs show a tremendous capacity to learn, but separately they are selective in terms of theoretical knowledge. They are in contrast, equally excited by field-work and it is from their predictions that we can, as academics, develop syllabi that will literally reap the «future harvest».

No realistic syllabus can in itself be field based, but simulated field techniques and a selective approach on theoretical content, cant be extremely useful in the planning of a degree programme. Most palaeontologists of either an academic or professional leaning would agree that the learning of the subject language is very important and that a given number of skills and attitudes are essential to the young palaeontologist.

It has been said many times that the language of palaeontology is essentially a biological one and thus a plethora of terms results from the direct comparison between fossils and extant taxa. Terminology *sensu strictu* coupled with a host of generic, specific and higher taxonomic names is a formidable diet for the young student and a bludgeoning introduction can easily destroy his or her interest. In this, the phylum to phylum approach is probably the major culprit as it easily lends itself to a restrictive terminological treatment. A knowledge of the major phyla is essential but one questions the value of undergraduates having to memorise the individual characters of hundreds of stony species. Yet even now some degree syllabi still expect students to draw and label innumerable specimens in the traditional manner.

To avoid the tedium of this type of work, where the main objectives are to enhance such skills as the recognition of species, observation and drawing, practicals can be laced with investigative exercises involving literature research, palaeoecology, the interpretation of morphological structures as well as the basic concepts of evolution. This serves to reduce the traditional need to draw numerous specimens and adds information retrieval and interpretation to the skills noted above. Practicals of this mixed or varied nature support, more closely, a modern introduction to our science, in which the basic language is no longer restricted to terms and names but includes reference to the ecology and functional morphology of the various phyla. This approach is of particular relevance in the British Isles where an upsurge in the teaching of geology at O and A levels at secondary achool, has increased the likelihood of an overlap with first year university work (Thompson, 1979).

In the planning of a first year syllabus in palaeontology we should remember that a concentration on morphology and terminology can, and will result in a stifling of intellectual skills. For students under these circumstances will, as indicated by Boulter (1977) and Ager (1979), concentrate on the rote memorization of information. An increased investigative component infers a different teaching strategy and is an attempt to retain the enthusiasm of the young scientist. Personal research however limited, in terms of academic standards, will provide the stimulus for learning and originality. Coupled with the use of seminars and programmes of guided reading it avoids the use of the rigid paradigm noted by Kuhn (1970) and the one way transmission of knowledge (Boulter, 1977).

To combine investigative practicals and seminars with a selective approach to the description of various phyla can result in a useful compromise. It satisfies the traditionalists who rightly recognise the need for a sound training in the identification of fossils yet allows for an early introduction to new concepts, skills and even attitudes.

The basic concepts and principles of palaeontology are centred on taxonomy and evolution, for it is after all a biological discipline within a time perspective. Taxonomy as noted by Clarkson (1978) stands at the heart of palaeontology and a sound knowledge of the procedures of classification and nomenclature are essential to anyone who wishes to undertake further, more detailed studies in the subject. The same is true of the concepts of evolution and all first year students should be introduced to the biological and genetic background of the theory. Together with adequate practice in the skills of fossil description the essentials of taxonomy and evolution and an introduction to well known phyla, should form the core of a first year corriculum. It is through these topics that the basic language of palaeontology will be learnt.

In later years, be it two or three, the palaeontology syllabus should be structured in such a way as to help the student to both appreciate and criticise scientific method. Seminars, reading programmes and mini-projects should supplement lectures. In this way students will, with some tutorship, understand the philosophy behind the science and in the words of Boulter (1976) «learn the value, limitations and significance of scientific method». Such an approach will also help in the developmentof several important attitudes including, the appreciation of the differences between observation and interpretation, an appreciation of the nature of the truth and that of constructive criticism. Three attitudes considered essential by the numerous geologists canvassed by Rondeel (1980).

Lectures, seminars and reading programmes should at second and third year levels deal in depth with the essential concepts and methods of palaeontology. Having acquired the basic language students should be capable of participating more closely in the learning experience. In the second year emphasis can be placed on the theories and concepts concerned with evolution and extinction. Time should also be given to the «species problem» or the species concept in palaeontology, for through this students can be introduced to quantitative methods in the analysis of fossil samples and to the grouping of fossil species into higher categories. Numerical taxonomy and cladistics can also be introduced at this time. Both have interesting methodologies and most students appreciate the challenge that these approaches present to conventional classifications based solely on morphology.

With regard to the theories of evolution, we live in exciting times when the proponents of the punctuational and gradualistic models do battle across the pages of various palaeontological journals. The study of organic evolution in time and space is, as noted by Raup and Stanley (1978), the traditional role of palaeontology. Through a consideration of the trends, rates and patterns of evolution we can breathe life into our science. The challenge to Darwinism can also be conveyed to students at this stage, at the same time as they are introduced to various processes and phenomena e.g. natural selection and neoteny, as well as concepts such as adaptive radiation, convergence and displacement.

The number of topics that can be included in the later years of a palaeontology syllabus are legion. No course would be deemed complete without reference to functional morphology and palaeoecology. Various methods and techniques can be taught through the study of these two topics, with most institutional collections housing a wealth of specimens that can be analysed, measured or described. Clarkson (1966, 1973a and 1973b) and Clarkson and Setti (1975) on trilobite vision, Grant (1966, 1968 and 1972) on brachiopods and Hopson (1975) on hadrosaur dinosaurs, have provided the clues, and most students are enthused by the prospect that they may present an interpretation that is not only logical but unique. Biometrics, computer modelling and even physics can be gainfully employed.

Quantitative methods may also play a major role in the analysis of the structure and distribution of fossil populations and enhance the development of various practical abilities. Strangely however, the use of statistics and computing is still not ranked as important amongst geologists and perhaps palaeontologists in particular (see Rondeel 1980). However students introduced to statistical packages soon appreciate the facilities of computers in the construction and expression of histograms, bivariate plots and orientation diagrams.

Ancillary courses in statistics are organised at most Universities and Polytechnics and these are regarded as important to the developing geologist. They provide the basic language and an understanding of the equations and formulae now handled so competently by machines. Bulk samples and large fossiliferous slabs can be utilised in the practice of palaeoecological techniques and together with simulated field exercises (PLS 1-2) can aid in the appreciation of a biometrical approach.

So far, in this account, little or no reference has been made to the spatial and temporal distribution of fossils in the biostratigraphical sense. This conceals no bias! and I would expect the initial introduction to this study to have been covered in the first year of any palaeontological course. It is just as likely however, that the more advanced concepts and principles will be dealt with in a separate course unit labelled Historical Geology or even Stratigraphy. On the continent of Europe, stratigraphy is still recognised as a viable course unit but in the British Isles it has suffered due to the development of the newer subdisciplines such as structural geology and sedimentology (Ager 1979). In palaeontology, stratigraphy and its more applied aspects can be adequately covered within a course on micropalaeontology and palynology. The value of such a unit has been appreciated in many of the new Polytechnic courses although this too may appear under such headings as Economic Geology, Petroleum Geology or Applied Palaeontology. Stratigraphy in its traditional form has often been regarded as the «great bore» of the Earth Sciences, although recent trends in the construction of depositional models and a genuinely more dynamic approach has resulted in a general revival.

In the structuring of a three year syllabus, the organization of a limited timetable allocation is critical, for apart from the numerous topics and themes noted above, others such as palaeobotany and biogeography can and must be considered. Integrated themes can often encompass many of these, and lecture/seminar/practical programmes on topics like «The development of Tethys in time and space» or «The ecology of the Chalk Seas» can highlight the links between palaeontology and geology as a whole. Selection is critical to the overall structure of the course and to the gradual build up of an adequate conceptual framework. Wilson (1973) has stated that «concepts constructed within the individual became closely associated with language» and argued that the ability to just verbalise a concept is insufficient. In depth experience is needed if the concept, whether it be one as simple as that of a fossil or one such as stratigraphic time, is to be fully understood. This experience is gained through various learning stimuli and the introduction of the relevent concepts at the right time. Discussions, seminars and perhaps written exercises can be used to diagnose areas of conceptual difficulty and adequate steps can be taken so that the students development does not suffer.

In the development of a concept — technique based syllabus we should perhaps experiment more with the construction of teaching models centred around a core topic. From this various lines of investigation and education can be followed and the interaction of past learning experiences and new concepts developed more fully. One such model, albeit with and applied bias, was presented by Dr. R. Cummings (Robertson's Research Laboratories) at the Palaeontology Workshop in 1976 (reported by Wilson 1976). A modified version is illustrated (Fig. 1), it acts as stimulus and is an example of how to approach the construction of a syllabus in a modern realistic manner.

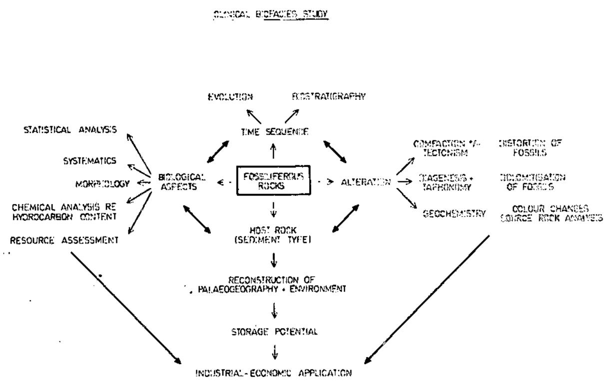


Fig. 1. A conceptual framework for the study of fossiliferous rocks which could act as a core unit during curriculum development. (Based on an idea presented by Dr. R. Cummings, Robertson's Research Laboratories) in 1976.

During the three or four years of their university studies, students should show a considerable development in terms of personality and adaptability. They should also develop an awareness of the complex inter-relationships of palaeontology, as a subdiscipline of geology, and the technical skills that will allow them to work independently and for a potential employer (if they decide to do so). It is the task of the academics involved in the development of a syllabus to provide the opportunities for such developments. In this context no discussion on the preparation of a syllabus, in palaeontology or any other science, would be complete without some reference to the contribution made by active scholarship.

Most palaeontologists and earth scientists recognise that research is one of several important scholarly activities and that together with consultancy, professional practice and discipline-linked creative past-times adds to the knowledge and skills of the teaching staff, thus benefitting the students through the enhancement of effective teaching (Fig. 2). No higher educational institution, even in times of recession, can survive effectively if a significant proportion of its teaching staff themselves rely on «second hand knowledge» or skills. To appreciate the value of scholarship is the first step towards its practice and the genuine satisfaction of knowing that the procedures of finding out have been transferred sincerely. The transfer of skills and attitudes such as four dimensional thinking, report writing and constructive criticism is relevent in the training of a competent, thinking palaeontologist. The type of research conducted is, in itself, largely irrelevent as long as it promotes a lively mind and encourages an air of scholarship, the feedback from which includes the development of given skills and attitudes, and the maintenance of up to date courses and standards. Research projects can and will be generated at all levels and the value of the project in encouraging students to teach themselves is rightly acknowledged in many institutions. Students actually appreciate the things they have taught themselves, and projects encourage them to contact and investigate various agencies both inside and outside their own institution. Their own research and acholarship can therefore encourage the development of new skills in management and methodology which hoperfully will enhance their academic and vocational careers.

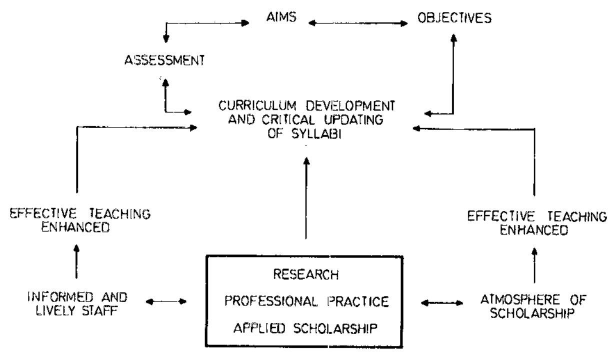


Fig. 2. Flow diagram to show the influence of research on curriculum development within an academic institution.

During the last decade or so the inauguration of the Polytechnics throughout Great Britain has resulted in the development of numerous degree courses in or including geology (Daley 1978). Often these have benn in the hands of a young staff and few retain a conservative structure or content. In some ways the writing and validation of these courses, under the auspices of the Council for National Academic Awards, has resembled the restructuring of geological courses in Holland, France and Spain, in that it has offered similar opportunities for educational advance.

Few of the courses developed in the Polytechnics have a purely applied nature, but a number contain units with an applied bias. This is certainly true of palaeontology as a subdiscipline and micropalaeontology and its applications are invariably included in current syllabi. It might be said that the courses at Polytechnics have effectively aped those of the long established universities and that the opportunity for providing essentially vocational courses has been lost. In part this may be true but one could argue that the advent of the Polytechnics has at least furthered the cause of curriculum development and encouraged the advance of teaching methods. The quality of teaching is held in high esteem at most Polytechnics although the spectre of overteaching can and does raise its head occasionally. Polytechnics have to compete with the universities for students and invariably the two attract students of diferrent academic abilities. As a consequence direct contact between staff and students is often of a high order at most Plytechnics.

At Kingston Polytechnic the present C.N.A.A. degree was developed to replace a commitment to the now discontinued London University (external) degree. Unlike many other Polytechnic degrees, which are modular, the Kingston degree is a single honours course with common first and second year syllabi. Under London University petrology and palaeontology were the major subdisciplines but the rapid development of structural geology and sedimentology during the sixties ensured equal status in the new syllabus. In the third year of the Kingston course petrology, palaeontology, structural geology and sedimentology are offered as options. Of these, students select two and read a common unit termed Advanced General Geology. The latter is thematic with a considerable amount of student research and scholarship. An independent field mapping exercise and research project account for approx. 30 % of the degree assessment.

In offering a choice of two from four options in the third year the staff have literally allowed the students to «vote with their feet». As the traditional subdisciplines, petrology and palaeontology were thus exposed to the challenge of two rapidly developing and perhaps more quantitative options. New time-tabling constraints, over all three years, also came into effect and long established syllabi had to be restructured, streamlined and made more pertinent to present day demands. In the development of the new course the staff, albeit subconsciously, followed the principles set out by Tyler 1950 who posed four questions fundamental to curriculum development (see also Ridky and Stoever 1978). The questions are essentially

1) What educational purposes shall the school be seen to attain (A statement of aims and objectives)?
2) What educational experiences can be provided that are likely to attain these purposes?
3) How can these educational experiences be effectively organised?
4) How can we determine whether these purposes are being attained?

In deciding on the purpose of both the school and the degree, the staff elected to train rounded geologists who were both educated and worthy of employment. The first two years were to provide the basic language as well as a core of essential knowledge, techniques and skills. From the outset the palaeontology staff were against a three year trek through the major phyla and the course was split into three distinct units. If labelled these could be called (1) the language year, (2) a thematic year, (3) an applied year.

During year one students are introduced to the essentials of palaeontology including the processes of fossilization and the nature of the fossil record. Much of the year, however, is devoted to the treatment of the major invertebrate phyla with respect to morphology and function. The number of fossil examples dealt with during this course is restricted and investigative and searching practical exercises (Tab 1) are employed to broaden the students appreciation of the facts nd to test acquired concepts with new, diverse stimuli. Lecture units are also given on the principles of palaeoecology in terms of environments and niche occupation and on trace fossils as evidence of biological activity. The biological aspects of evolution and the methodologies of classification and nomenclature are also discussed and illustrated in practical sessions. The use of the various treatises and monographs is encouraged through set excercises using a series of illustrated «taxonomic» cards.

Related and ancillary courses in Historical Geology, Biological Sciences and Computing and Statistics introduce the students to principles and concepts of biostratigraphy, soft part morphology and statistical packages which support the planned courses in palaeontology and geology in general.

Intensive practical supervision, tutorials and essays are used in the assessment of student progress.

Table 1

The following are examples of investigative topics set during the first two years of the Palaeontology course at Kingston Polytechnic

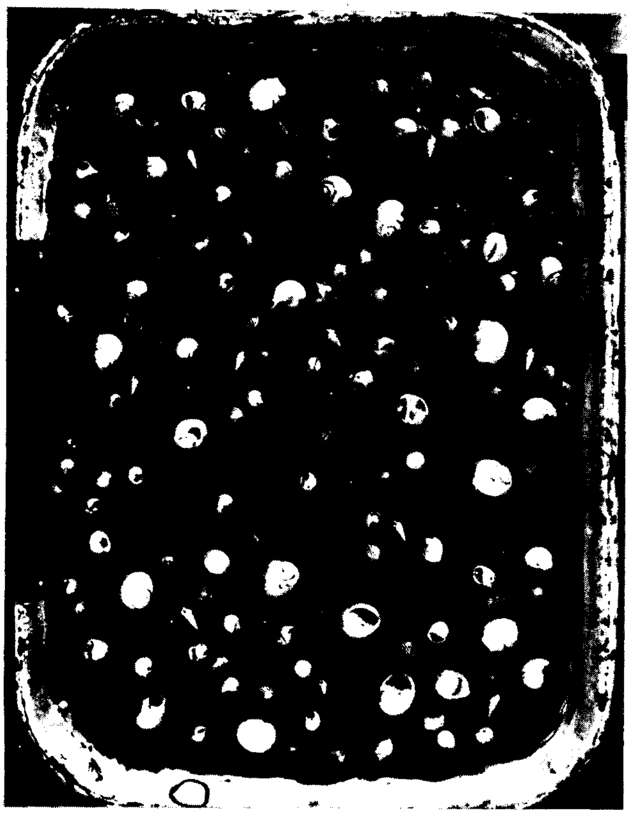
a) Attempt a statistical study of the bivalve shells provided and determine the number of species or varieties present.
b) Attempt to detect any variation in the dentition of the *Glycimeris* specimens. Specimens provided are from the Upper and Lower Eocene, the Pliocene and Recent.
c) Compare and contrast the morphology and modes of preservation of *Endoceras* and *Michelinoceras*. Comment on the functions of the various cameral and siphonal deposits.
d) Examine the series of twelve gasteropods provided. All are labelled as *Cerithium sp.* Do you think this is valid? Explain by means of diagrams and description the reasons for any conclusions you may draw from the study of this series.
e) Examine growth in the specimens of *Rimella* provided.
f) With the aid of the specimens provided discuss the validity of d'Orbigny's reconstruction of the belemnite and the role of the skeleton in both *Belemnites* and *Spirula*.
g) Compare the morphology of trilobite and chelicerate (lobster) appendages.
h) Estimate the size and extent of the visual field of the trilobites provided. From your calculations suggest suitable habitats and life positions for each animal.
i) Reconstruct the serial sections provided and classify the resulting specimen. (Dendroid graptolite).
j) With the aid of diagrams, show the thecal variationof the monograptids provided. Place the forms in stratigraphical order and compare this with their order in the elaboration trend. Give reasons why this trend took place.

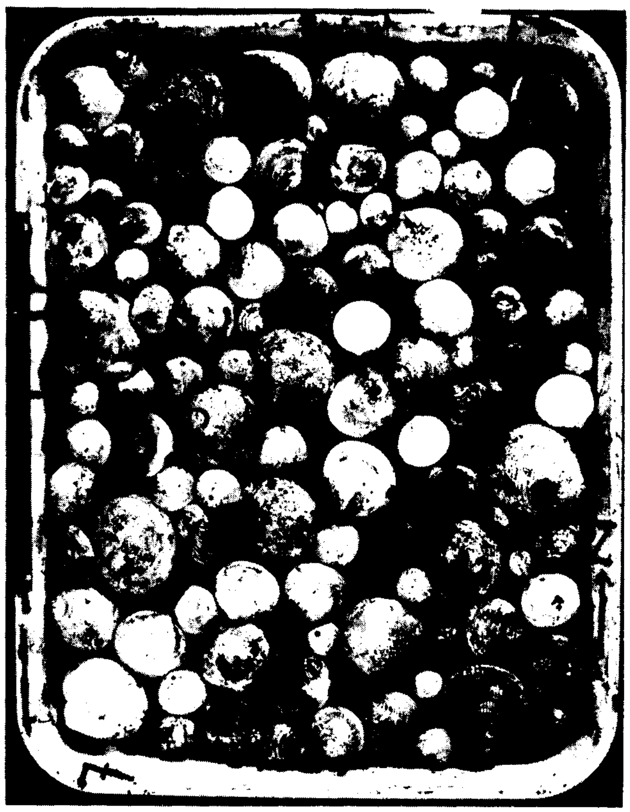
The above topics are normally arranged in schedules with between 10 and 12 allied questions set for each of the major invertebrate phyla.

During the second year of the course the emphasis is changed and a thematic approach is adopted. The concept of a species is dealt with initially and serves as an introduction to the use of biometrics and a quantitative approach to problem solving. Bulk samples are used in practicals and the cooperation of the resident statisticians ensure that the Polytechnic computing facilities are used effectively. The origin of life with particular emphasis laid on the development of early environments, communities and protective and support structures follows. This is a popular unit amongst students and is a useful vehicle by which one can introduce hypotheses related to the origin of life, sexuality, predation, the development of the metazoa; as well as rates of evolution and speciation. The same is true for the third theme the origin of the early vertabrates which reviews the status of possible ancestral stocks, particularly the calcichordates and serves to introduce the cladistic approach to taxonomy. Reading programmes, biometrics practicals, computer usage and museum visits support these course units.

Biometrics is also used in the study of fossil communities and simulated field excercises are used for the evaluation of the orientation and distribution of fossils as environmental indicators (Pls 1-2). One semester of the second year is devoted to functional morphology and the realtionship of the organism to its environment.

At the end of the second semester a techniques training field excursion is organised for all second year students. The techniques taught are those likely to be used during their project research period and are additional to those taught during field mapping training. For palaeontology the techni-





Plates 1 - 2. Bulk samples and simulated distribution models (as illustrated) are useful in the teaching of biometrics and the recording of data related to community and environment analysis.

ques include section measurement and the recording of relevant data on log sheets, correlation of sections across country, the use of quadrats and the collection of data for community environment studies.

Many of the students who opt to read palaeontology in the third year choose sedimentology as their second option. As a result a large percentage of their third year projects have a palaeoecology — environment bias. Projects in micropaleontology, related to the correlation of sections, are also popular and these can be closely linked with the major taught component of the option unit.

The first semester of the third year is devoted entirely to micropalaeontology and palynology with a weekly time commitment of 5 to 6 hours for lectures and laboratory work. This course unit has a high practical component with the emphasis on the techniques and skills of preparation, picking and identification. Early practicals deal essentially with the morphology and stratigraphic distribution of the various groups whilst those that follow are based on the preparation and analysis of field samples. Lectures and seminars deal with the evolution and stratigraphic value of significant taxa.

The final component of the third year option is devoted to the study of ancient communities with staff research topics and collections providing the impetus. At the present time these studies are centred on the Lower Palaeozoics of the Welsh Borderlands, the Cretaceons of Western Europe and North America and the Tertiaries of North Africa. Topics such as community structure, replacement and mass extinction are covered within this unit. Reading programmes, museum visits and lectures from outside experts support both the micropalaeontology and community units of study.

All students of geology maintain contact with palaeontological principles and concepts through the course on Advanced General Geology. Themes such as «The post-hercynian history of the Mediterranean», «Faunal provinces in space and time» and «The evolution of Man» often involve several members of the academic staff and thus present a holistic treatment.

CONCLUSIONS

The development of the three year palaeontology syllabus at Kingston has therefore led to a number of major changes from that of the now redundant London degree. Control of course content has allowed for experimentation and more time has been given to student research and scholarship. A phased and integrated approach to a conceptual framework of increasing complexity has been established and more time has been allocated to the development of the necessary techniques, skills and attitudes.

The introduction of extended reading programmes and more seminars and tutorials, within the new degree syllabus, has resulted in an overall improvement in the ability of students to make a greater contribution to the learning programme. Verbal and written skills have advanced considerably and the researching for project and topic work is often of a very high standard. In palaeontology students have expressed support for open discussion periods related to specific topics and the majority are usually well prepared in their readings. The students have also expressed support for the thematic or topic approach of the second and third years, although a large number continue to believe that palaeontology is still plagued by too many names and terms at the first year level. Over the last seven years palaeontology has attracted approximately 25 % of all students, the actual percentage increasing slightly over the 1978-1981 period. Slight modifications to the format and presentation of the first and second year syllabi may account for this increase. Of the students who have graduated, with palaeontology as a major option, all but two have obtained jobs in geology. Almost ninety per cent of these are in the oil industry and the rest are involved in research. The same figures are also true for the remainder of Kingston graduates and it would appear from employer feedback that the vast majority of these are acknowledged to be well trained, well versed in most areas of geology and above all willing to learn. Naturally most start at the bottom of the ladder in mud-logging but up to date records show that a high percentage seek further training and attend higher degree courses in Petroleum Geology or Mining and Exploration. In educational terms it is believed that the degree and the palaeontology course is a success although like mineralogy and petrology, the latter fails to attract the same number as the sedimentology and structure options. Palaeontology, particularly at the more advanced levels, is justly recognised as an interesting and demanding subject but the questions now posed are «Is it relevant to my career?» or «If I do research will I get a job?»

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