The facilities and collection of the Indiana University Chemistry Library will be used as a training center for recipients of the Indiana University Chemistry Department Training Scholarship in Chemical Literature. The study program is intended to familiarize the student with chemical literature past, present, and future and with the administration of a special library. In addition to special assignments, the student will work closely with the Chemistry Librarian, more or less as his special assistant. Thus he will have every opportunity to master the necessary techniques and acquire the background that will enable him, or her, after completing the necessary formal degree requirements, to become a qualified Chemistry Librarian.

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On the Job Training for Literature Chemists*

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In the days of Louis Pasteur, or even Paul Erlich, it was possible for the individual scientist to read all of the literature in his field (and even in several related fields), to know everything that was known of his scientific discipline, and to be in touch with all of the people in the world who might be working in his field. Thus the scientists of that day often carried on voluminous exchanges of ideas by mail or in person. I have the impression that a great deal more information was retailed in advance of publication at the end of the nineteenth century than is revealed in conversations today. In any case the growth of scientific disciplines, in both volume of detail and in complexity, has tended to steer scientists into ever narrower areas of specialization: and this at the very time that most progress seems to be made as a result of interdisciplinary approaches to problem solving. All of the above factors have tended to promote the team approach to research that is so popular today.

One might conclude from these remarks that the role of the individual creative scientist in the world today is becoming less important in research. Far from it. Many scientists pick certain aspects of research and devote their lives to it, and only this diligent application of outstanding brains could hope to see any progress in may fundamental and very difficult fields, and even in many interdisciplinary fields. In many ways fundamental research is more readily attacked by the individual scientist than by the research team, inasmuch as the type of speculation required in fundamental research often will not survive the scrutiny of a collection of scientists, however brilliant they may be. Perhaps one of the weaknesses of our system of supporting research through government or institutional grants to researchers based on concrete grant applications is that all of the really wild, potentially brilliant, ideas tend to get screened out by the panel system of evaluation of potential research projects. These remarks are not intended to be critical of the panel system of handling research grant requests, inasmuch as this is probably the only system that could deal equitably with such a machinery of research support. We can, however, quarrel with the emphasis on the project-orientated nature of research support, and we should all press in the direction of longer range support for investigators—even lifetime support of qualified people in order not to stifle the tender shoots of creativity.

How do all of these remarks relate to the education of the literature scientists? In order to discuss this subject from a common starting point we need some definitions here. First of all we should make clear that there are at least two, and possibly more, distinct types of information specialists. The first we might call the Documentation Specialists and these could be defined as the people who operate between the data processing machine, or other device, and the information specialist who readies data for machine processing. The Documentation Specialist, of course, does many other things as well, but his primary orientation is in the area of data processing rather than in one of the classical scientific disciplines. The chemical information scientist is generally another breed. He is usually an alumnus of the laboratory who had the same

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rigorous scientific training as his laboratory colleagues. He goes into information by choice in order to broaden the scope of his work, in order to go more readily into interdisciplinary research, or for a variety of other reasons.

Now as to the place of the information scientist in the creative process which I discussed earlier, we can only say that the success of the information scientist is measured directly by how effectively he assists the research group, or the individual researchers, in bringing to bear all pertinent published information on the solution of the problem at hand. The concept of the information scientist has thus evolved in order to assist research personnel in both the scanning of current literature to make certain that pertinent published information is not missed, and in the searching of past information to determine the novelty of any new research suggestion.

Having dealt in the generalities during the above discussion, it is now worthwhile to look into the roles of certain of our specific information scientists to see what their duties are, what their training was for their duties and how effective they seem to be in carrying out their assigned roles. The first of the information scientists I would like to speak about is a specialist in the natural products area. This organic chemist was trained in the U. S. and did post-doctorate training in Switzerland at both the Polytechnic Institute in Zurich and the University of Basel. After more than ten years in industrial research laboratories as a medicinal chemist he elected to go into information work in the natural products field. His responsibilities here are mainly twofold, although he has a great many secondary responsibilities. First our national products information representative is responsible for collecting and correlating all of the information on alkaloids from the current literature. This means scanning all of the current chemical or botanical journals which are likely to report the existence of new alkaloids and to record this information suitably for later retrieval. That this is no mean feat may be seen from the fact that of the some two thousand known alkaloids more than eight hundred have been isolated in the last ten years. This is an indication of the rapid rate of growth of research in the plant alkaloid field. In this group also resides the responsibility for picking up the biological activity of any plants that may be reported in the literature.

The files in the national products group consist of, in addition to the name file of alkaloids, a genus and species file of plants which contain alkaloids. Any publication about a plant alkaloid in the literature is noted on the alkaloid card for the name of that particular alkaloid and on the genus species card for that particular plant, filed under the plant family. As new data accumulate on the alkaloid, for example as the structure is elucidated and/or the synthesis is published, this information and the reference to it is appropriately filed.

After about five years' work this group ended up with one of the best alkaloid files in the world. This file can be entered from either the alkaloid name or from the plant genus and family. It was then felt desirable to be able to retrieve information from this file from other parameters as well, and from the standpoint of multiple parameters simultaneously. Accordingly this file was converted to a punched card system in which the structure of the compound, the plant family, the biological activity of the alkaloid and the genus and species are entered on punched cards. With the imminent completion of this project it thus will become possible to ask questions like "what are all the indole alkaloids from the Apocynaceae family which are hypotensive in activity."

Obviously the alkaloid chemist working off by himself in his laboratory can no longer pick alkaloids at random to work on with any assurance that he would not be repeating the work that other investigators may already have published. Thus for a highly active natural products group it becomes essential that all new submissions be screened through a literature facility in order to start out with a background of all the work that has been done on this alkaloid, on this plant species, in this plant family, and in related alkaloids and plants. All this information is now readily at hand thanks to the efforts of our natural products literature scientist and his group.

A second and equally important function of this natural product information scientist is his liaison and field activity, using his chemical, and by now botanical, background. He is the ideal person to travel about and cooperate in the collection of plants for the operation of this program. It may be of some interest to look at the travels that our natural products information specialist has undertaken in the past few years and Fig. 1 shows that there are not many areas of the free world that have not been at least touched on. In the course of his information career our natural products scientist also takes tours of duty back into the laboratory to refresh himself on new techniques, to improve on spot-tests for alkaloids, and to elaborate them to the point where they can be used in the field. Such field testing greatly increases the efficiency of our collecting operation by avoiding the sending of samples back and forth from the field collectors to the nearest laboratory station. Our information scientist also participates in improving on chromatographic separation,

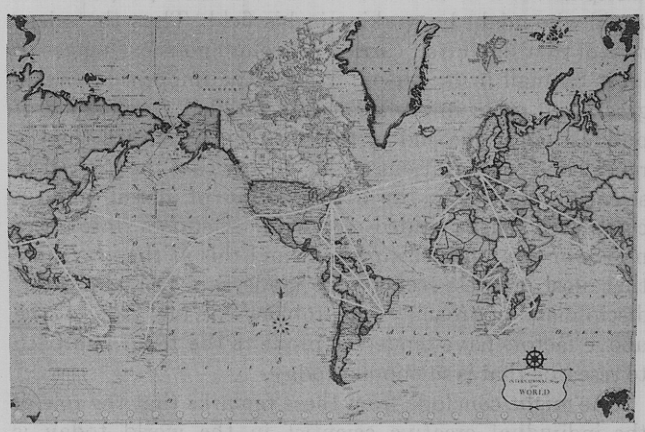

Fig. 1.

countercurrent distribution, and thin layer chromatographic procedures, as well as many of the other modern isolation and purification techniques which are involved in prosecution of the alkaloid art.

Another of our senior information scientists is a specialist on medicinal chemical developments on the European scene. He heads up the Foreign Information Services Group (FISG), and he brings to this job a high degree of pharmaceutical and linguistic skill. (It is of interest,

parenthetically, that in our Section we have people who are fluent in German, French, Italian, Spanish, Hungarian, Schwyzer-Deutsch, and some of our people even know some Russian and a little Japanese.) Our FISG representative is an expert on literature searching and he directs state of art searches for patent purposes. He has traveled widely in Europe over the past five years, and Fig. 2 gives some idea of the areas he has covered.

One of our most verstile information specialists, the man in charge of the Structure-Activity Correlation Group (SAC), bears much the same relationship to published information on synthetic medicinal compounds as our natural products representative has to alkaloids or medicinal plants. Our SAC expert doesn't do as much traveling, but he directs a laboratory group in addition to his information functions, so there is no question of his keeping up his level of synthetic competence.

Other scientists in our section construct indexes to material not yet covered by published reports, compile indexes to organic reactions, and carry out a variety of other functions designed to permit the creative use of scientific information by both the laboratory scientist and the information specialist.

We may summarize by saying that the training necessary to produce an effective chemical information scientist, in our experience, is identical with that required to produce a really topflight laboratory research man. If we throw in the added seasoning of ten years of laboratory experience, plus the added spice of linguistic ability and foreign

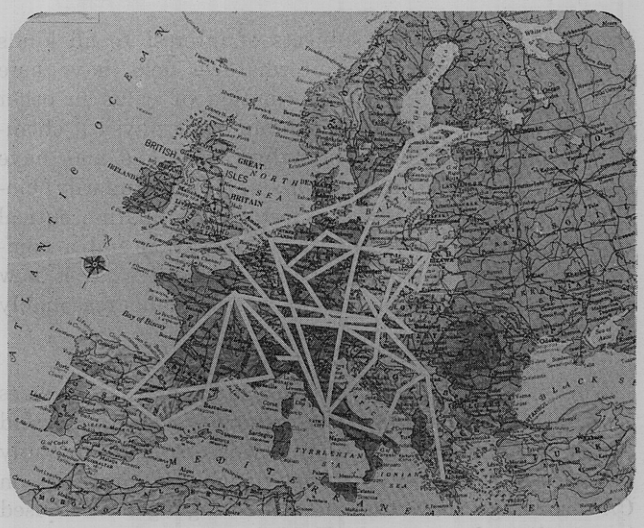

Fig. 2

travel, we will get a man who might meet our specifications. We would then have to determine whether he can write well, express himself clearly and, most of all, get along with his laboratory colleagues. If he does all of these things well he should be a credit to any research organization, if a competitor or the State Department does not snap him up first. He will then, if he is creative, go on to become a co-inventor on patents and a co-author on scientific papers, and he will find his scientific career richly diverse and satisfying.

On-the-Job Training at Chemical Abstracts Service*

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In general, producers of literature or information aids need the same kinds of training as do effective users of these aids. This mutual need varies in degree according to operations and to specific situations. The writing of this paper on the training of Chemical Abstracts Service (CAS) workers will proceed on the assumption that these differences in degree need not be pointed out.

In chemical-literature work, all need to know much chemistry, a good deal about languages, and considerable about information sources and documentation methods and tools. Primarily, CAS workers must learn about abstracting and indexing.

Many of the CAS workers acquire a *wide* knowledge of chemistry because, from the nature of the CAS work, the progress of chemistry continuously marches like a parade through the CAS office. This parade is marshalled and it must be closely observed by a considerable portion of the CAS workers. This kind of training occurs every day. Some of these workers must do a good deal of specializing in training and work because it is most efficient for biochemists to deal primarily with biochemistry, for organic chemists to work mostly with organic abstract editing and indexing, and so on, but all learn chemistry continuously.

For most of the CAS chemical work, as indexing, for example, college training to the M.S. and often to the Ph.D. stage is desirable as a beginning qualification. The opportunities for learning in the CAS work are so great as to make it possible for workers with lesser college training to acquire proficiency in it and to move up to highly responsible jobs.

The requirement for a broad knowledge of chemistry in addition to a degree of specialization cannot be overemphasized. The assigners of papers and patents for abstracting must be able to recognize chemical interest in the papers and patents examined (many are borderline), and to select the suitable abstractor in each case. The editors of abstracts must properly classify these as to subject matter and they must recognize the needs for cross references. These editors must learn also to recognize and correct all kinds of mistakes. The indexer, no matter what his field of specialization in chemistry may be, must

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