J Forensic Sci, Apr. 1974, Vol. 19, No. 2

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Research at the Home Office Central Research Establishment

The subject of this paper is the research work at the British Home Office Central Research Establishment (CRE). One might expect a report on the technical aspects of current toxicology as my colleagues and I see them; however, I do not think it appropriate to discuss the minutiae of a particular technique or such exotic topics as new concepts of cellular biology; instead I would like to discuss research work in our area generally, and to survey its objectives, initiation, control, organization, achievements, and hopes.

In our work job fulfillment is furthered by knowing the object of what one is doing. I would define the prime objective of our research as an increase in the efficiency of operational laboratories. This is strictly a practical exercise with no concession to the academic pursuit of knowledge for its own sake. This is not to say we do not tread that pathway occasionally, but we cannot allow ourselves to sail the boat wherever the wind blows. Sometimes the captain has to start the engine and direct the crew to head once again for the attractive harbor of achievement of the main objective. What I am talking about, therefore, is *applied* research.

It is easy to define one's objective as I have done, but the disposition of forces to achieve it requires the skill of an army commander who must organize his attacks, staff, logistics, and communications to support a broad front. The commander also has to be directed on a strategic basis and high command may itself be subject to social and political influences. I intend to confine my comments to the battle, not to the war which is against crime itself.

I would like to begin by discussing the concepts involved in the organization of research. These vary tremendously from country to country and I have found the system which has developed in England and Wales to be unique in that it is very largely nationally controlled. That is to say, the scientific content of all the research programs covering forensic science, forensic toxicology, and the use of scientific methods and equipment by police forces are the responsibility of the Chief Scientist and Director General of Research at the Home Office, Mr. C. J. Stephens; he also looks after the professional well-being of the several hundred scientists involved.

Two factors have enabled this system for research to develop over the years. One is the existence of a forensic science service having a number of regional forensic science laboratories staffed by government scientists who are not directly responsible to any police authority or police forces, and the other is the fact that police forces depend for fifty percent of their funds on the Central Government (the other fifty percent is raised by local authorities). Central authority can thus insist that an inspection system examine efficiency, and is also able to provide a national system of common police services (for

Presented at the Joint Session, The International Association of Forensic Toxicologists and the Toxicology Section, American Academy of Forensic Sciences, Las Vegas, Nev., 21 Feb. 1973. Received for publication 23 Feb. 1973; accepted for publication 10 Sept. 1973.

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example, the Police College and training schools, a national police radio system, and a Police National Records Computer, as well as the forensic science service). Research investments in these areas have been logical developments. The whole system is, therefore, reasonably coherent with clearly defined areas of responsibility and funding. I should mention that New Scotland Yard, while to some extent independent, is tied into the national system by virtue of the fact that the Home Secretary is its Police Authority.

My first comment on the organization of research is that management structure must be established first. My second comment is that once the policy and level of funding has been decided, the organization and extension of the research itself should be left in the hands of scientists, who clearly must be both good researchers and good managers.

I would next like to turn to the processes whereby research is initiated and controlled. Prior to 1966, in the U.K., this was entirely *ad hoc* with scientists in the regional laboratories solving their urgent operational requirements on a short-term basis. It was then that the Home Office Central Research Establishment was formed, with a staff of about 30 and an annual funding of about $250,000. Capital costs for equipment for setting up the Establishment were about $250,000. The staff is now 44, amounting to about a 10 percent investment in research and development in staff in relation to the whole forensic science area. Another feature of our growth has been the initiation of contracts with university departments, other government agencies, industrial firms, and research associations to do work for us. The funding for this activity now almost equals the cost of work done "in house."

As previously stated, I would like to consider some of the features involved in the initiation of research. I found that in the early years of the laboratory, initiation was relatively easy—forensic science and toxicology had many vulnerable areas because, I think, there had been so much emphasis on *ad hoc* problems that fundamental work had not been done. For example, the frequency of random occurrence of glass on clothing was not known, nor was the incidence of fragments of paint, and little work had been done on detailed analysis in such obvious areas; quantitative analyses of serological factors were a closed book; and in toxicology the collection of analytical parameters for thousands of drugs and poisons and their presentation in a form suitable for computer output had not begun. Even today our studies into correlations between thin-layer and gas chromatographic parameters reveal a widespread lack of realization of what constitutes analytical proof.

At the Home Office Central Research Establishment I decided to divide our interests into four main areas concerned with Information Science, Fundamental Chemistry, Biology, and Toxicology, with Divisional Heads appointed from a cadre of experienced forensic scientists. In this paper I wish to concentrate on the development of information science and on research into toxicology.

In initiating research into information science, it is interesting to note that this was the "top of the pops" as far as regional laboratory directors were concerned. All recognized that the days of each scientist keeping his own card index file were a feature of the past and not of the future. In the last six years the Information Division has amassed over 12,000 reprints of published scientific articles which have been distributed to the regional laboratories on microfilm, and a computer based retrieval system has been introduced. In this system each reprint is "key worded" and given a linear accession number; any subsequent interrogation of the computer is by means of relevant key words and the output is obtained as one or more numbers referring to relevant papers on file. The introduction of this system involved a tremendous amount of work. The first requirement was the production of a dictionary of forensic science words and then came the development of an efficient key wording system, which involved considerable research exercises,

followed by staff training and the development of parallel computer programs. I cannot stress too heavily the value of such a system. Operational problems can be rapidly solved or, if there is a nil output, at least one can be sure that no one has met the problem before. In research areas a rapid selective search of relevant literature can be made and this is invaluable in directing the researcher into potentially profitable areas and helps to prevent duplication of previous work. We have favored the use of a specific forensic science vocabulary rather than the wider "English Dictionary" approach recommended by some computer firms. This is because all the users will themselves be specialists.

It may be of interest to note that all senior scientists in the Establishment are involved in the searching procedures and that the follow-up occupies the time of five other staff members as well as the incorporation of the work from external contracts.

The extension of this work to the formation of data banks in such areas as the cataloging of ultraviolet, infrared, mass spectrometry, thin-layer chromatography, and gas chromatography data is being progressively accomplished by way of in-house analytical studies using our own computer. This is clearly an area of great interest to The International Association of Forensic Toxicologists (TIAFT) and Leo Kazyak's [*1*] visit to us for a year was the first step on a long road in this direction.

I said that so far the initiation of research has been no real problem in this area. Questions have been obvious and numerous and limitations have been set by staff availability. Clearly, though, in the future we shall wish to do more than be a selective quick-response library. As I see it, control must be increasingly exercised by the specialists themselves. They know the operational scientists' problems and provide a shield against the publication explosion. I see the linear accession system as being of paramount value in this context. Here the number of the paper gives a date to it and selective weeding will have to be introduced in the next five years. This means that a scientific appraisal of value will be necessary, which is not easily accomplished automatically.

I will return to the topic of the initiation and control of research shortly, but implicit in the drawing up of a research program is the allocation of priorities. This is an intensely difficult problem once the most obvious requirements have been met, and especially when big capital expenditure has already been involved. In the U.K., this difficulty can be minimized by transferring apparatus to the casework laboratories for operational use, but the intermediate "operational trials" field is a clear one and it too may require as much high quality effort as the original research program. There is a clear difference between use of large equipment in the research laboratory and its day-to-day use in cases. We find that every operational laboratory firmly believes that it can modify received techniques to be more applicable to its own interest. The dialogue at this stage involves "communication" and I will refer to this later. It suffices to say now that it is absolutely essential that this need for dialogue be recognized and that positive steps be taken to tackle it. I think that, in itself, this is a research area.

In drawing up priorities one has to keep very much in mind the main objective of a research establishment such as the Home Office Central Research Establishment. What our users need are practical, positive results. Users are not primarily interested in the long-term projects, however elegant these may be, but it is necessary that their value not be minimized. I happen to believe that the biochemical lesion in toxicology is a vital aspect. To show the mere presence of a drug, albeit in high concentration, does not necessarily account for death, and to find out more about this we are putting effort into what must be a long-term, partially academic study. Hence, we are working on "cyclic AMP" in relation to drug deaths, and the basic biochemical interactions involving the catecholamines and their metabolites. I do not know of other work in this area specifically related to forensic toxicological problems.

I am equally well aware that this is highly speculative and I acknowledge the freedom I am allowed to exercise in deciding these few, but most important, long-term projects. Similarly, I believe that the localization of drugs and poisons in a cellular locus has high significance—hence our interest in fluoroscence microscopy and enzymatic reactions.

It is nevertheless true to say that the operational scientist now demands such services as digoxin and insulin estimations, which have required the development of new radio-immunoassay techniques applied to postmortem samples, and it is indeed satisfying to researchers to see such an immediate practical outcome to their work. Similarly, research into the bases likely to be encountered in putrefaction and into methods for the detection of quaternary ammonium compounds such as tubocurarine and succinyl choline, has had a positive and immediate application.

Sometimes one can be wrong in one's vision of the future, and consequently in assigning priorities. Only time can really assess this feature. Indeed, it is a matter of degree. A few years ago I thought the problem of drug addiction and the consequential demand for analyses of vast numbers of urine samples for drugs of addiction would be soon required. About two man-years were put into solving this problem and I believe a highly successful outcome was achieved with implications for the whole area of drug analyses and metabolic studies that have not yet been fully realized. It is, however, true that the expected problem has not materialized in the UK, but the spin-off has been immense in the acquisition of expertise, and invaluable in solving related problems associated with automation, particularly the difficult and pressing problem of how best to deploy high-grade scientific manpower in performing accurate analyses for alcohol in blood. In 1967 a mandatory legal maximum level of 80 mg/100 ml of alcohol in blood was introduced and the number of cases submitted to regional laboratories have been rising spectacularly. Automated gas chromatographic methods are being investigated and to some extent introduced into certain regional laboratories. An automated alcohol dehydrogenase (ADH) method analyzing 60 samples per hour is also being operationally tested. Great effort on this problem continues at the Home Office Central Research Establishment.

The area of alcohol in blood research is a good example of how priorities require constant reappraisal and how necessary it is to have annual "re-thinks" that must take account of further requirements, staff availability, availability of external agencies, and forward financial planning. I believe that the allocation of priorities is an area in which the director of a research establishment must be given considerable freedom. He alone receives feedback from his "users" and he can view this feedback in the light of policy directives from those that fight the war and not the battle. He must be able to assess the relative merits of enthusiastic researchers, manufacturers who think they have discovered perpetual motion, and shy young scientists who really have a good idea. I cannot give a formula for this, but two factors are overriding. Firstly, create a situation wherein financial resources are adequate, and secondly, take good scientific advice. The Home Office has acted very positively in ensuring that we have the best possible professional advice. I refer to the Home Office Scientific Advisory Council, which in turn has formed a Forensic Science Committee. On this Committee some of the nation's foremost experts from universities, industry, and government freely give advice, and in addition to scientific meetings at regular intervals, our whole research program is examined in detail by the Committee annually. Such meetings are invaluable both to the progress of current research and to the formulation of future policy.

I said that the early decisions were relatively easy and that the Home Office Scientific Advisory Council Forensic Science Committee had helped tremendously, but I also believe that a systems analysis look at operational needs is a necessity. It is salutary to

realize that it took six years of work for us to come to grips with this. What do toxicologists want? What do they really want in contradistinction to what they *think* they want? What are the priorities? How much will it cost in manpower? How much will it cost in money?

I, therefore, see the recommendation of priorities as an intensely personal job; one can be given broad guidelines, but the selection of short-term projects is best left to the director. Long-term looks must be speculative and a five- to ten-year look is hazardous with no guarantee of positive success. Naturally I am prejudiced, but I am also hopeful, because my Director General has not asked me to strike this paragraph out of my paper! At least the present system, as we currently practice forensic science in England and Wales, has yet to be shown to be ineffective.

I have referred above to the various stages of evolution in which basic work gives way to an operational trial stage followed by full-scale application to casework. Sometimes certain areas can be short-circuited and this is accomplished by the encouragement of "local" research. This is typified by the scanning electron microscopy work at our West Midlands Laboratory, and by the extensive research programs at the Metropolitan Police Laboratory. We find it of great value for operational scientists to have some involvement in research, and a small financial allocation is made to the regional laboratories for such projects.

I do not wish to gloss over problems associated with the transfer of fundamental research into operational practice. There are two aspects which require close consideration. First is the realization that implementation of research needs an intermediate operational trials phase. So many forensic techniques require what Irving Sunshine has always called "the minutiae," and in transferring them to operational use one uncovers defects associated with transferring a system constantly in use in the research stage into one which may be only occasionally used when awaiting cases. This is not the only area where transfer problems occur. In a "gray" area fall techniques which require high-cost sophisticated instrumentation or highly specially trained manpower or both, which precludes them being easily available on a regional basis. In the U.K. we try to provide these on a national basis with techniques, for example, such as neutron activation analysis, inorganic and organic mass spectrometry, and radioimmunoassay. I must draw attention to the fact that sometimes one finds oneself in the very situation that the creation of the CRE was meant to overcome: too much casework, too little research. It is a very difficult moral decision to decline to help in cases simply because research is being disrupted, but sometimes a line must be drawn. Inevitably, successful research and its publication lead to consumer demand, and this leads to implementation perhaps on the only available instrument. It is, therefore, imperative that forward planning in research take into account early the consequences of its success.

In this context it is perhaps timely to quote some examples to illustrate the points I wish to make. In 1966 the collation of data about the analytical parameters of poisons and drugs seemed under control, but there has been a revolution. Not only do we have greatly increased numbers of compounds to deal with, but the introduction of new techniques like mass spectrometry (where computer searching is the only practical solution) and, in addition, a great increase in available sensitivity, have created heavy user demand for this research instrument. It has also been a feature of the last six to seven years that toxicologists now require more than the demonstration of the presence of a drug. The massive intakes of drugs by addicts emphasizes that much more than analytical expertise and superb pathological skill is required to provide the true cause of death in a case of drug poisoning. The entry of biochemists and cellular biologists into forensic toxicology can now be confidently forecast.

At the Home Office Central Research Establishment the collection of analytical data has been a major effort and what I have so far said indicates that this is more than can be accomplished by the card index mentality. Equally, I believe that while commercial organizations can do a credible job, I am certain that the specialist toxioclogist has to be intimately concerned if a really efficient information system is to be produced. I hope that international thinking will be directed along these lines.

I previously stated that I would not delve into the minutiae of toxicology or cellular biology but I have already mentioned them. It has become inevitable, however, if toxicologists are to discuss the present and the future of this science.

I want to emphasize this last point, for by using the word "discuss" I have now entered the area of communication. I have heard a tremendous lot talked about this in toxicology. In 1966 TIAFT formed a Committee to look at the idea of an International Institute and in 1972 in Edinburgh, Leo Kazyak discussed his project at the Home Office Central Research Establishment designed to provide compatible computer facilities for the benefit of all toxicologists. However, all communication is at least a two-way dialogue and needs hard work to achieve it successfully. We all know of examples of failures in communication; even within one laboratory it is a common feature. Between researcher and operational scientist it becomes a little more difficult. Internationally it tends to soften, since heads of laboratories agencies, universities, or establishments have sufficient wisdom to know that "the days are long until you reach September" and have consequently arrived at a stage where practicalities count.

I do not pretend to know the answer—I have presented a worldwide problem and I have tried to show some of the pitfalls. I think I know the road leading to some of the answers, especially that international cooperation is essential. I would, however, urge that cooperation within each country is the first step and I am sure that in the U.K. we have now achieved this cooperation to a very high degree. I see in Interpol a means of overcoming language and other organizational problems, but it is clearly a very difficult area on an international scale. The importance of TIAFT's role as a co-ordinator cannot be overemphasized. I urge support for organizations such as the American Academy of Forensic Sciences and TIAFT; their function is to help, to coordinate, and to define problems which researchers are expected to solve.

Summary

The organization of a research program in forensic science and toxicology in particular is discussed. The system in England and Wales, where national funding is available for research for activities within government and by means of external contracts in universities and industry, is probably unique in the world. Consideration of the allocation of priorities both in long- and short-term research, the initiation of computerized information services, and the provision of expert advice, is followed by the practical problems of translating research into the operational phase, and then into day-to-day routine. The role of the International Association of Forensic Toxicologists and other international agencies is reviewed, with the need for the sharing of research programs emphasized.

Reference

[1] Kazyak, Leo, "Information Exchange and Computerized Data Retrieval for Toxicology," *Journal of Forensic Sciences*, JFSCA, Jan. 1974, pp. 147–154.

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