FORENSIC SCIENCE AND THE ANALYST

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ABSTRACT

Forensic science has been slow to develop as a recognised field of study. Over the past 30 years, analytical and forensic science have developed together; though the application of new analytical techniques in forensic work is retarded by the necessity of having methods of proven reliability. The many techniques now applied in forensic analysis—microscopy, spectroscopy of all types, x-ray analysis, neutron-activation analysis, chromatography, etc.—are surveyed and illustrated by examples. The examination of documents is discussed in some detail. The determination of blood alcohol is mentioned with particular reference to breath-alcohol tests and behavioural comparisons. The similar problems that are encountered by analytical and forensic scientists are discussed.

INTRODUCTION

It is a far cry from the occasion on which Mr. Sherlock Holmes[1], holding in his right hand a slip of litmus paper, said to Dr. Watson, "You come at a crisis, Watson. If this paper remains blue, all is well. If it turns red, it means a man's life". It was even longer ago[2] that Dr. Watson *first* met Mr. Holmes and found him spring to his feet with a cry of pleasure. "'I've found it! I've found it!' he shouted to my companion, running towards us with a test-tube in his hand. 'I have found a reagent which is precipitated by haemoglobin and by nothing else!' " Naïve, perhaps; but the budding forensic scientist can gain much from a careful perusal of Arthur Conan Doyle—a man much before his time—and of that equally prescient writer, R. Austin Freeman[3,4].

There are no, or few, 'black boxes' in the writings of either of these authors—they did their *thinking* long before the days of '*black boxes*'. They present, however, object lessons in thought-processes that are essential for the forensic scientist; and particularly for the forensic scientist who has been brought up with 'black boxes' in his cradle.

In the space available, this account of the various techniques available nowadays to the forensic scientist cannot be comprehensive. The references given will also be selective, being only a preliminary guide to the literature. Various recent and comprehensive reviews[5–11] are available for more detailed information.

THE APPLICATION OF INSTRUMENTAL METHODS

The importance of microscopy

The view that the man in the street has of the present-day forensic scientist is undoubtedly one of a man surrounded by 'black boxes'. It is, of course, not so long ago that the traditional picture of the forensic scientist was that of a man with a lens and bloodhound.

That extension of the human eye, *the lens,* and its further extension, *the microscope,* were first made available to scientists through Hooke and van Leeuwenhoek in the 17th century. The microscope, as a tool of the chemist, probably reached its peak in the late 19th and early 20th century. Gradually, the chemist became much intrigued with the 'black boxes' which began to proliferate from the 1930s, and the microscope took a back seat—possibly because it required rather more effort than just pressing a button in order to use it properly!

Yet it is probably true to say that no forensic laboratory should consider its equipment complete without a considerable range of the low-power and high-power microscopes available—or its staff complete without someone capable of using them.

Since I have always believed that the properly trained analytical chemist should have a reasonable acquaintance with the use of the microscope, I am very pleased to see that recent publications[5, 12] give some account of the wide range of uses to which the microscope can be put.

Indeed, Holden[12] says: "The only reason that I can think of to explain the lack of use of [the microscope] by chemists is that very few of them have been taught microscopy. This is not, however, peculiar to chemists; very few science graduates, even in biology, have been given a proper course in the use of the microscope".

The microscope can take us from the limit of resolution of the eye of about 0·1 mm, down to particles almost at the limit of detection (10^{-12} g) of emission spectrography. It is therefore possible[12] to compare with controls, *optically,* samples which would possibly not be capable of identification by emission spectrography. With a proper training in the use of the petrographic microscope, a surprising range of properties can be determined on small specimens.

Applications of colorimetry and spectrophotometry

Many would regard colorimetry—in its strictest sense of the measurement or comparison of colours–as akin to mediaeval torture! It was, of course, used early in forensic work, as in general analytical chemistry, for the determination of elements by colour reactions. It has survived in forensic work in a somewhat different application: in the identification of paint flakes, particularly from motor vehicles. The paint on a motor car consists of a number of layers, of different colours and often with different plastic constituents. In recent years, in the United Kingdom[13], in the United States[5] and in Canada[7], 'banks' of standard colour plates, supplied by car manufacturers, have been built up. (Some European manufacturers also co-operate with the British 'bank'). These permit the scientist to determine, in many cases, the probable make and model of a car involved in a hit-and-run case. It is true that frequently the actual colour measurements may be combined with a number of the other techniques that will be mentioned later. But this is a common procedure in forensic work.

Tristimulus colorimetry has also been investigated[7] as a possible method of determining, for example, that two samples of soil have come from the same area, and seems promising, at least as a sorting technique.

It is hardly necessary to mention that *ultraviolet spectrophotometry* became established a long time ago in forensic work, first and foremost for toxicological purposes; naturally it became extensively applied in other fields[7, 11, 14]. Indeed Curry[14] has claimed that when asked whether the forensic scientist should equip himself first with a gas chromatograph, an infrared spectrophotometer or an ultraviolet spectrophotometer (although all three ought to be available and will extend the capabilities of the forensic scientist enormously), he would still put the ultraviolet spectrophotometer as his first choice. In the future, of course, it may not continue to be the main tool of the three.

Infrared spectrophotometry is again a technique, well-tried in general analysis, whose applications become increasingly extensive in forensic work every year[15–20]. Lubricating greases (even contraceptive sheath lubricant in the case of rape), drugs and poisons, paints and plastics, explosives, and petrols are only some of the fields to which straightforward infrared spectrophotometry has been applied.

Two newer uses of the infrared region of the spectrum are of some interest. One is the application of *attenuated total reflectance*[10, 21], particularly for layers of paints films; the other is the utilisation of *infrared luminescence*. Instead of the well-established technique of stimulating visible fluorescence by ultraviolet light, visible light is used to stimulate fluorescence in the infrared[5, 7]. This is then either photographed, or examined by one of the now quite sophisticated image converters. The principal application, so far, of this latter technique seems to have been in the inspection of documents for alterations—this is an application which in a sense follows on from the quite early photography of documents by infrared light[22].

Both *emission spectrography* and *x-ray diffraction* have for long been used in forensic work, both separately and, more recently, in conjunction. My first venture into the forensic field, more than 30 years ago, was in spectrography; on that occasion the aim was to try to establish the identity of paints in a case of breaking and entering. Minerals and paint pigments comprise perhaps the most extensive group of substances to which these two techniques have been applied. An intriguing use has been the identification of a titanium pigment as anatase, not rutile[10]. This was a constituent of a make-up cream used by a girl who had been kicked in the face; the same crystal form was found on the shoe of the suspect. There have been other interesting applications of these techniques in aircraft crashes—both to prove sabotage, and to disprove it[5].

An interesting possible development of emission spectrography is mentioned by Walls[10, 11] in which a laser beam is employed to volatilise the sample. In this way, it may be possible to achieve better sensitivity with a smaller sample than that consumed in the conventional arc or spark methods, and even, by means of spark excitation of the vapour, to render the method quantitative. Indeed, with a little imagination one can see an increasing use of lasers by the forensic scientist, rather than by the criminal!

X-ray photography has, of course, obvious applications in certain aspects of forensic work, involving such things as suspicious parcels or shot wounds. A much more sophisticated use of this technique has a number of interesting overtones[23]. In the early fifties a man died in Scotland, leaving to his widow a large estate, unfortunately entirely in whisky, which was all in bond; the Excise authorities said it could not be released until the duty was paid; and the duty could not be paid till some of the whisky was sold. However, there are large fluctuations in the price of whisky in a bonded store; over four years it went from £150000, to £100000 to £170000. Naturally, when the price (and duty) was high, the excise authorities offered to find ways of releasing the whisky; when it was low, somehow they were unwilling to collaborate with the solicitors to the estate. Stalemate lasted for four years. In the meantime, the various solicitors involved with the estate were, from time to time, advancing sums to the widow. One of the later solicitors became suspicious about a considerable batch of receipts which had been passed on to him—so much so that he asked the police to investigate. Their handwriting experts divided the receipts into two fairly definite groups, one of which they classified as genuine, the other as forgeries (with a few doubtfuls). The widow was of no help, being very vague, with little idea of when she had signed for money, how much she had, or if the signatures were really hers. The Procurator Fiscal was not prepared to proceed on handwriting evidence alone.

One night, one of the investigating officers noticed his daughter sticking stamps in her stamp album, and observed that she had stuck in two twopenny Queen Elizabeth stamps. He asked why.
colour had been changed from dark brown to light brown. This was right in the middle of the period of the questioned receipts. The officer thought that this might be worth following up, and found that in addition to the change in colour there had been two changes in watermark. This, in fact, gave three earliest possible dates for the twopenny stamps using the colour and—if one could determine it—the watermark. But how to determine the watermark of a stamp that was stuck on paper and could not be removed (otherwise, legally, of course, the document was destroyed)?

Ultimately the police found two workers in a hospital x-ray laboratory who were prepared to carry out some experiments. By means of soft x-rays, photography of the watermarks was eminently successful[24]. It was, in fact, possible to show that the police division of the receipts into genuine and false had been quite correct.

An investigation of whether the ^{14}C-impregnated paper now available from Amersham[25] might be used for the same purpose, could be profitable.

The advantages of neutron-activation analysis

Because of certain advantages which are characteristic of *neutron-activation analysis* (e.g. the irrelevance of contamination after irradiation, and the high sensitivity for a wide range of elements), this technique has been an obvious one for forensic investigations. However, the high sensitivity and the novelty of the technique emphasise one important aspect of the work of the forensic scientist. He must always lag behind the pure scientist since he must always be certain that his methods are valid and above reproach. Always, in his work he must remember the life or liberty of the subject.

This is undoubtedly why the first presentation of results by this method in a British Court[26] did not, apparently, take place until 1967.

The case was one of breaking and entering, where £15000 worth of silver was stolen. A piece of glass in the sole of the shoe of the suspect was compared with the glass in a broken window at the scene of the crime. Five points of comparison weighed heavily to suggest that the two types of glass were rather unusual in composition and were of common origin. When this (and other) evidence was presented for the prosecution, the suspect pleaded guilty.

With a thermal neutron flux of $1 \cdot 8 \times 10^{12}$ n. cm^{-2}. sec^{-1}, the sensitivity for 69 elements examined lies between 0·00005 μg (for some rare earth elements) and 0·01 μg for 38 elements; and between 0·01 and 0·1 μg for another 17 elements[27]. This makes it the most sensitive method so far devised for more than half of the elements in the periodic system.

The technique is being increasingly applied to the examination of poisons, firearm residues, hair, glass, rubber, plastics, greases, soils and metals[5, 7, 11, 27, 28]. One of its its more curious applications is cited by Lucas[7]; it was possible to show, 20 years after a suspected murder had been committed, that a hole in a skull was probably a bullet hole, because of the high antimony content.

Probably the greatest publicity for the technique came from the examination of Napoleon's hair for evidence of arsenic poisoning. The method is certainly capable of the precision required, but it seems clear from more recent work[29, 30] that there was insufficient appreciation of external contamination. Thus it would be necessary to establish that cosmetics and other preparations for hair treatment in Napoleon's time did not contain a high arsenic content. Morgan[29] cites the high iodine content in many specimens of hair nowadays because of the use of iodinated detergent shampoos. He warns us, very aptly, that we should 'stress the importance of not being impressed by the elegance of technique. Just as in general, we are not interested in the tool which a carpenter uses to drill a hole, but only in the result, so here. It is not particularly important to catalogue methods; the relevance of the result is the important factor'. How appropriately that applies to all forensic investigations.

Some investigations of the arsenic content of hair[31] indicate how the pattern of arsenic uptake can be determined much more precisely by neutron activation than by chemical methods, where 1-cm lengths are examined. Neutron-activation analysis permits the determination of arsenic by 1-mm stages along a single hair. Since the daily growth of hair is approximately 0·5 mm per day, it is possible to plot arsenic uptake over intervals of 1–2 days.

Over-enthusiastic claims have been made, in their first days, for many techniques, and neutron-activation analysis is no exception. The premature claims that a hair could probably be tied as closely to a head as a finger-print to a finger are now discounted. Like the reports of Mark Twain's death[32], they were somewhat exaggerated. But it is now clear that there *are* significant differences between hairs, and that after further work, the results, when properly assessed statistically, will be of considerable value[9].

The method is, in fact a valuable 'future' method, still on trial, and is likely for some time to continue to be applied, with proper discrimination, only non-routinely[10].

The use of chromatographic methods

All the varieties of *chromatographic techniques* were applied early in forensic work, and increasing use has been made of them[10, 33-35]: paper and thin-layer chromatography for inks, fats, oils, greases, and waxes, drugs and poisons, insecticides, tars, dyes, explosives, and metals (as the organic derivatives); vapour-phase chromatography, with its rapidly extending applications[10, 35, 36] for petrols, volatile drugs, paint and other resins (after pyrolysis); and, of course, the determination of blood-alcohol (see p. 522) Walls, indeed, claims[10] that vapour-phase chromatography may be perhaps the most versatile technique in forensic science.

The applications of other techniques and combined methods

Scanning electron-probe analysis is likely to be increasingly important as apparatus becomes more readily available[10, 11, 37]. By this technique, characteristic x-rays of the elements down to boron can be excited in particles as small as a few microns in diameter, and the method is capable of quantitative and qualitative applications. As Walls[10] says, it is another of the 'future' techniques.

Carbon-14 dating has had preliminary trials for determining the age of natural fibres (wool, cotton) and for investigating time of death from tissues or from bones[38]; it is pointed out that in the present era strontium-90 may be another significant radioactive element.

Differential thermal analysis and *mass spectrometry*[10] are both techniques likely to be of future significance. Curiously, *atomic absorption spectroscopy* appears up to the moment to have given little other than 'hypothetical' uses[39].

After all this catalogue of highly sophisticated techniques, it is almost a relief to turn to an account of a straightforward *chemical* reaction for restoring erased serial numbers on aluminium, using a variant of the old 'whisker' production by a mercury salt[40]; and to learn that 'real' chemistry is still useful. Even the *plastic arts* may be useful, for example in an identification from a bite-mark in cheese[41]! The use of *combined techniques* rather than a single technique to produce an answer has already been mentioned. This will, of course, be an increasing trend. A typical instance, quite common at present, is the identification of drugs[42] by a combination of extraction, vapour-phase chromatography, thin-layer chromatography and ultraviolet spectrophotometry (probably also infrared spectrophotometry). Again, for paints a combination of chromatography, infrared spectroscopy, nuclear magnetic resonance and mass spectrography has been proposed[43].

This sort of thing brings in its train many complications, and Walls has adverted to it at some length in his Presidential Address to the British Academy of Forensic Sciences[9]. He explains that earlier forensic workers were probably talented scientists, or doctors with a scientific bent, who as a sideline, liked to get mixed up with the police, and who enjoyed the sort of problems this association brought them. 'They could still, in those days, without being geniuses, cope with all the science the job demanded. Now, most people realise that this is not true',

No one, he points out, can nowadays either be expert in all the necessary fields, or indeed (partly because of the well-known desire of the expert to advance his own expertise, regardless of its relevance) can have a broad enough view to make a proper use of the skills available. He admits that he may perhaps be exaggerating slightly when he continues 'It may not be too fantastic to look forward one day to computerised laboratory programming, with which the man in charge feeds into the computer, suitably coded, both all the questions asked, and details such as sensitivity and specificity of the possible techniques, and the times needed to get an answer by them; the computer would then tell the optimum procedure to yield the greatest amount of information with the minimum consumption of time and material'.

However, there, are still many areas of forensic work, where, on the whole, the sophisticated techniques mentioned above are not always necessary and indeed, in many cases, are inapplicable.

The first of these is the examination of *glass*. It is clear from publications on this subject[5, 44–47] that the principal scientific techniques employed are basically observation, deduction, and physical measurements of properties such as specific gravity, refractive index and dispersion.

Out of eight points which Nelson[45] suggests as offering useful evidence from glass, four are in the nature of a very complex jig-saw puzzle and one is essentially inspection to determine, if possible, the type of object from which the glass came. The remainder largely consist of simple physical measurements; actual determination of the chemical constitution cannot be expected to be of much help, except in unusual cases such as that mentioned earlier[26] (p. 517). Variations are only likely in the trace elements; one would find little help from the normal silicate analysis. And even the spectrograph may not be sensitive enough to show the type of variation to be expected.

THE EXAMINATION OF DOCUMENTS

It is probably in the field of *document examining* that procedures entirely different from those discussed above are most often essential. It is true that the document examiner, as has been mentioned in a number of cases already in passing, makes use of instrumental tecnniques and sophisticated separation processes for the examination of inks and of documents on which they are applied.

The extent to which the examination of documents may form part of the work of the forensic laboratory is perhaps not generally realised. According to Conrad[5] documentary evidence accounts for more than half of all the items received in the F.B.I. Laboratories for examination. And this is by no means the whole story since it is stated[48] that 'most of the work of a document examiner ... consists of the examination and comparison of handwritings'; indeed, this is my own experience.

The identification of handwriting is probably the most controversial part of a document examiner's work. The ability to recognise the important characteristics in a sample of handwriting appears to be partly innate. This view is supported by a well-known test piece[49] consisting of a random arrangement of 64 specimens of a single work written by 32 writers. The speed with which inexperienced test individuals sort the specimens into the appropriate pairs varies very widely. Some people can do this quite rapidly; others appear to suffer from what is often called 'form-blindness' and are either very slow in the test or are unable to complete it.

However, given that the innate ability is there, the person who would then become a 'handwriting expert' must collect and study as extensive a range of specimens of handwriting as possible. The general nature of the writing is, of course, important; but the study must extend to the details of the writing—some authorities list well over a hundred so-called 'minor characteristics' which may be of evidential value and which should therefore be studied. Examples of this type of characteristic are the way in which the letter '*o*' is closed—whether it is closed directly on top, or to the right or left of the top, or left open, or looped, and the size and shape of the loop; the method of forming and placing the stroke of the '*t*'—short or long, curved or tilted up or down, before, through or after the vertical stroke; the relation of the arches of the letter '*m*' to each other—and if the letter falls at the end of a word, the direction and nature of the final stroke; and many more points of this kind.

By long study it is possible to learn to recognise the relative importance of various characteristics, based on their relative frequency in the writings of a large number of people. In this way it is possible to decide that some types of formation are relatively frequent and have low evidential value whereas others are relatively rare and carry more weight as indications of identity. Since an increase in the number of identical formations in two pieces of writing involves a multiplication of probabilities, the existence of, say twenty similarities, even of common occurrence will give a remarkably high probability that the writings are by the same person; and if even a few of the similarities are uncommon formations the probabilities can very easily run into ratios of millions to one. If these values are not offset by any significant differences then a sound case can be made for identity.

It must, of course, always be borne in mind that there are always minor variations in handwriting. Indeed, if one found two signatures which were absolutely identical one would immediately suspect forgery by some copying process. Yet these minor variations produce the strongest argument used against the handwriting expert. It is always argued that the writing of most people varies markedly from day to day, even sometimes from hour to hour. In spite of this, it is indubitable that the basic characteristics are still there, permitting identification; just as an individual can be recognised by basic facial or other characteristics, although the general appearance may change markedly through such causes as age or illness.

Many tests have been carried out, particularly in the United States, which show conclusively that specialised training produces people capable of reaching the right conclusions about the identity or non-identity of handwriting in tests where untrained people, or even people with a different sort of training in handwriting, e.g. bank clerks, cannot achieve this.

Possibly the most spectacular example of the identification of handwriting that has ever occurred is quoted by Conrad[5] in the case of the Weinberger kidnapping of 1956. A ransom note was used as the basis of comparison. It was stated to be a 'non-normal' type of handwriting (though even experts with over 20 years of experience, might hesitate to try to define 'normal' and 'abnormal' handwriting). A team of 90 specially trained special agents was then briefed by the experts in the F.B.I. Laboratories, and an examination was begun of all handwriting specimens in the various local public records. Any records that looked promising were pulled out and examined further by the experts. Approximately 2000000 handwriting samples were examined over a period of about 6 weeks, and a single file was then turned in to the experts;

this they were able to identify as being in the same handwriting as the ransom note. It is interesting to note that this file, a probation office file, was actually out of the office when the specimens were first examined. But the team went back specifically for the purpose of examining any files not available on their first examination. La Marca, the person to whom the file pertained, admitted the kidnapping.

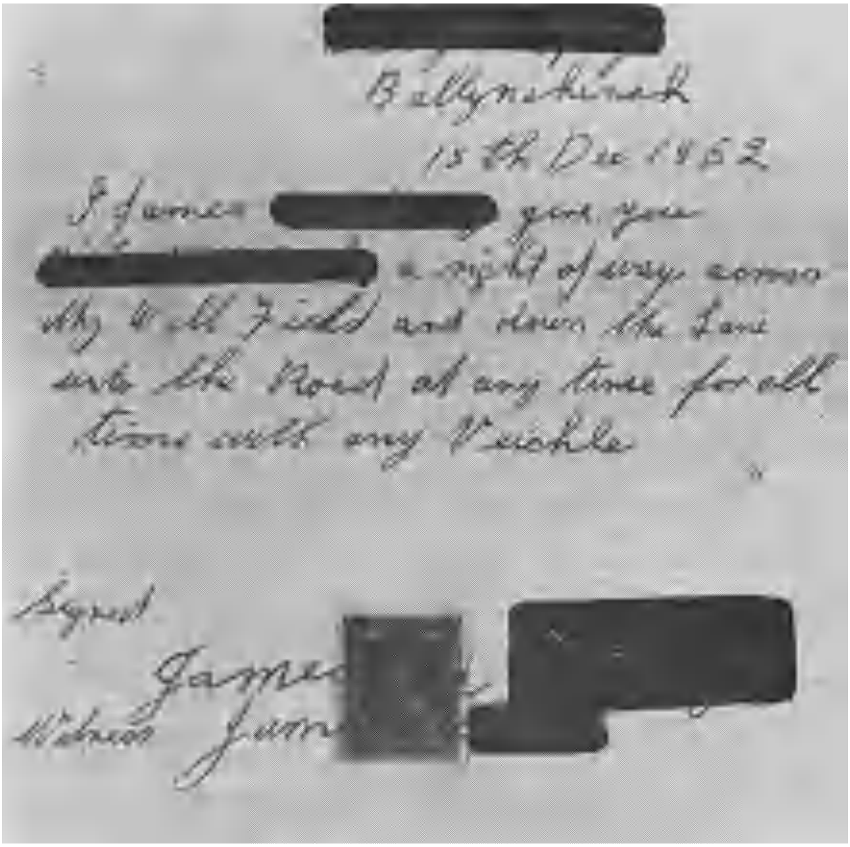
In a rather similar case, by no means so spectacular but nevertheless, in its way difficult, since it involved some 300 schoolboys, who usually have much more 'unformed' handwriting than adults, the writer of a malicious letter was identified, and confessed.

In the United Kingdom, expert evidence on handwriting was first allowed in Court in a civil action in 1856 and in a criminal action in 1865, but it is only relatively lately that it has been generally accepted that handwriting experts are not necessarily witch-doctors. A jury is relatively easy to convince about the expert evidence of a chemist or physicist, since he is talking of things which they hardly comprehend. But because they can (usually) write they are very ready to assume that they know as much about writing as the expert.

In many cases writing which is otherwise undistinguished may have very characteristic capital letters. Although this may have a use in identification, such unusual formations must be examined with considerable care. The very nature of the capitals lends itself to attempted simulation and many instances are on record where the capitals have been carefully copied or traced, and little or no attention has been paid to the apparently less revealing small letters. Such copying is often quite apparent when the writing is examined under an appreciable magnification. The care with which the 'drawing' has been done produces in the line a character readily distinguishable from a freely written line. Indeed, on occasions it is possible to observe under magnification the remains of a pencilled or carbon line, insufficiently erased (or even an indentation made by a dry point) and to see clearly that the inked line subsequently added has not been able to follow the guide line exactly, although no irregularity can be seen with the naked eye.

Finally, any document requires a careful and complete examination for any anomalies whatsoever, apart from the actual content as outlined above. This might be termed the application of scientific observation and logical deduction (or commonsense). In this region every case is different from every other.

As an example, one case concerned a document (*Figure 1*) brought forward to show claim to a right of way. This document dated 15th December, 1952, turned up after both the alleged writer and the alleged witness were dead. The official Examiner was suspicious of the handwriting, and in particular of the similarity between the alleged writing of the witness and that in the remainder of the document; after a time he turned his attention to the Queen Elizabeth one-shilling stamp. Queen elizabeth came to the throne in February 1952, and New Reign Stamps, particularly the less used values, tend to be delayed in their date of issue. A quick check with a stamp catalogue showed that in fact, the shilling stamp was issued on 6th July 1953. In a sense, that finished the case, but since a stamp catalogue might not be regarded as the best evidence by the Courts, an enquiry was made to the G.P.O. in London. Some six weeks later (possibly the time taken to consult a stamp catalogue), their Philately Department wrote to confirm that the first date of issue was, in fact, 6th July 1953!


[redacted]
Ballynahinch
15th Dec 1862
I James [redacted] give you
[redacted] a right of way across
thy well field and down the Lane
into the Road at any time for all
time with any Veichle

Signed
James [redacted]
Witness James [redacted]

Figure 1. Forged claim to a right of way

It should be emphasised that no document examiner can give a positive answer in every case submitted to him. Indeed, he is lucky if he can do this in 30 per cent of his cases. Many forgeries may (indeed, undoubtedly do) go undetected because no question has been raised about them. If, however, a document is queried it soon becomes clear that the forger requires a great deal of intelligence, knowledge, and luck, if his handiwork is to go undetected.

THE DETERMINATION OF BLOOD-ALCOHOL

The *determination of blood-alcohol* has been the subject of much controversy. It is perhaps worth noting the slightly disturbing fact[50] that apparently the action of bacteria frequently present at a post-mortem, can convert compounds such as glucose, sucrose and lactose into ethyl alcohol in significant amounts.

It has been shown, in a sample of more than 200 drunk-in-charge cases, that it is undesirable to calculate blood-alcohol from the figure for a random specimen of urine, and indeed if this is done it may be prejudicial to the defendant[51]. Indeed, why a urine test should ever have been considered as an alternative to a blood test is something of mystery, since apparently the taking of a blood sample by the police costs one-third less than that of a urine sample!

The permissible maximum content of alcohol in the blood in Great Britain is 80 mg/100 ml. (In the North of Ireland, since the 1968 Act, 80 mg/100 ml constitutes a minor limit with, if no other complications exist, a minor penalty. There is then a major limit at 125 mg/100 ml, at which point one is considered to be completely incapable of driving). The Alcotest, or 'Breathalyser' is, of course, merely a screening test, and is not really evidence. The blood-alcohol *analysis,* on the other hand, is above suspicion. In the United Kingdom, split samples (or two simultaneous samples) are run on two separate gas-chromatographs with different packings and with independent operators. One cannot attempt to quarrel with the figure.

But in fact, the major controversies in this connection have been in respect of what these figures mean in terms of human behaviour—over a range of age, sex, drinking habits, etc. A number of laboratories have tried to relate blood-alcohol with such matters as coherence and muscular and mental control. In this connection it is of interest to quote a series of experiments designed to go some way into this question[52].

The objects of the study were (a) to establish what blood level might be expected from consumption of different alcoholic beverages when consumed with or without food; (b) to attempt to correlate the amount of alcohol in the blood with the reading of the Alcotest using the breath, and (c) to attempt to correlate the amount of alcohol in the blood with the behavioural pattern of the individual at the same time. Two experiments were carried out, the first being a preliminary 'screening' one.

In the preliminary experiment six subjects were used in order to establish what happened at an 'ordinary business lunch'. One hour was allowed for pre-lunch drinking, there was then a four-course lunch which, if requested, could be accompanied by a half-bottle of wine, and this was followed by brandy or

Table 1. Correlation of Alcotest and blood-alcohol test[52]

No.	*Sex*	*Total consumption*	*Alcotest*	*Blood-alcohol* (mg/100 ml)
1	♂	5 double whiskies	—	24
2	♀	2 double whiskies ½ bott. claret 1 brandy	±	40
3	♀	3 sherries ½ bott. champagne 1 Benedictine 1 brandy	+	53
4	♂	3 double whiskies ½ bott. burgundy 2 brandies	+	64
5	♂	1 double sherry 2 double whiskies ½ bott. burgundy	+	122
6	♂	5 double whiskies	+	69

liqueurs. The total drinking time was $2\frac{1}{2}$–3 hours; the participants were, of course, asked to restrict themselves to so-called 'normal' drinking. The consumption and the results are shown in *Table 1*.

They were then asked to write 100 words on 'Drinking and Driving'. No. 5, who was over the limit, in *his* '100 words' wrote a coherent account asking for this type of test to be carried over to a major test; he used an ingenious device 'to complete the required 100 words' which then came to a total of 45! No. 6 said that after two more double whiskies he would probably have called a taxi! But it would appear that *he* was not *quite* sober.

The second experiment was designed to test 'week-end luncheon drinking'—interpreted as being, in Great Britain, drinks and *perhaps* snacks, simulating a pub or a club and starting about 11.30 a.m. Drink was unlimited but restricted to the legal drinking hours, and the amount was noted by bar chits. Sixty-two males and seventeen females, a total of seventy-nine, with drinking habits reported as ranging from occasional drinkers to heavy regular drinkers 'competed'. The results are summarised in *Table 2*. A remarkable figure of 220 was achieved by a 'spirits drinker only, who did not eat'.

Table 2.

Number of individuals	*Alcotest*	*Blood-alcohol*
21	–	<70
21	±	<80
1	±	>80
16	+	<80
20	+	>80

The conclusions drawn by Camps and Robinson[52] are that 'for those participating in this trial, the blood alcohol level did not exceed 80 mg/100 ml after consuming either five measures ($\frac{5}{6}$ fluid oz; $\frac{1}{6}$ gill, i.e. the English measure) of spirit *or* six half pints of bitter beer *or* seven drinks (one drink = 1 measure of whisky or half a pint of bitter), some of spirits and some of beer. This confirms that although half a pint of beer contains the same amount of alcohol as one measure of spirits, the blood alcohol figure resulting from consumption of each is not necessarily the same.'

CONCLUSION

Over the past 30 years or so, analytical chemistry and forensic science have developed very extensively, but in the application of new techniques, the forensic scientist must lag behind, since, where the life or liberty of the individual may be at stake, the methods used must be of proven reliability in the general field. In much of the work of the forensic scientist, a proper knowledge and appreciation of analytical techniques is essential, but these must be supported, always, by precise observation, logical deduction, and the ability to use 'every branch of knowledge that could prove useful', even including, as two of the above examples have shown, pastimes such as philately and the plastic arts. The intricacies of the analytical techniques involved and the breadth of knowledge required over many disciplines are indeed formidable.

The forensic scientist, faced by a battery of lawyers, is presented with another formidable task. There is a well-known legal story[52] which has some bearing on this. Lord Birkenhead, then Mr. F. E. Smith, was dealing with a 'difficult' judge, and offered an explanation in a longish speech.

"Mr. Smith, I have listened to you patiently, but I am no wiser".

"No, my Lord, merely better informed".

Few expert witnesses would have the temerity to make that reply to the learned Judge; but the truth inherent in it is very obvious. In conjunction with that story I would like to refer to Nicholls[45] who says. "I must . . . express my strong disapproval of the use of the word 'evidence' associated with the work of the forensic scientist. It is the job of the scientist to produce information—specialised information—and to give this information, together with an assessment of the scientific value of the information, to the appropriate authorities".

For years, because of what, to the mild fury of my legal friends, I call the intriguing difference between 'scientific' and 'legal' truth, I have maintained that the expert, or a board of experts, should act as assessor to the Court. Nothing can be more harmful to the reputation of the expert witness than to have two of them disagree because, as is so often the case, neither has the whole story. Each is then presented in Court with the other half of the evidence, and is regarded as something of a charlatan if he cannot do a week's—or a month's—work in five minutes.

This problem has been referred to by others than myself[54], and it would appear that there is some hope[55] that what is now at least suggested by the 1966 Winn Committee for medical experts, where 'the true facts can be determined impartially', might be extended to the evidence of the expert forensic scientist.

Until this happens, we can only hope that no one will revive[56] Trial by Ordeal, Trial by Combat, or Compurgation.

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