MEDICO-LEGAL BLOOD GROUP TESTS

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THE medico-legal problems in which blood group tests may provide useful evidence fall broadly into two categories. In the first of these, identification of blood groups may give clues as to the origin of stains left on inanimate objects after committed crimes. I have had no personal experience of the special techniques required in this type of problem, so I shall deal only with the second category, i.e. the use of blood group tests in relation to legal problems which hinge on the genetic or so-called blood relationships, or in one word, the kinship of living individuals.

In 1938, as you will know, the Bastardy (Blood Tests) Bill was introduced into the British House of Lords. Its progress through Parliament was interrupted by more pressing problems of the war and post-war periods, and it has not even yet been enacted. Before the Bill was shelved, however, a select committee had been appointed to consider it, who included in their report the following statement:

"The committee are unanimously of the opinion that the qualities of blood underlying blood grouping and the laws of inheritance governing the transmission of these qualities from parents to children are accepted by such a consensus of scientific opinion throughout the world as to render it desirable in the interests of justice for this knowledge to be applicable in affiliation cases."

These words are well-balanced and dignified; I propose as my theme an attempt to demonstrate the significance and justification of their content, by means of a brief description of the relevant features of our knowledge of the existence and method of inheritance of the blood groups, and the principles and criteria which should govern the application of this knowledge

to some of the problems of kinship which could lead to legal action.

Before doing so, I would like to digress a little and introduce to you a few of the many great persons whose contributions to the dramatic story of the human blood groups should be acknowledged. Above all there are two overseas trios of workers, one American, one English, whose names recur throughout this story.

The greatest of them all, and the leader of the American group, is Karl Landsteiner, whose name will be immortal in blood group serology. In 1900, in his native Vienna, he discovered the major blood groups in man, and thereby founded a new branch of biology which now extends with ever widening horizons into the realms of medicine, physical anthropology, and, most important to us to-night, genetics. In 1922 Landsteiner was invited to join the staff of the Rockefeller Institute in New York; in 1943, while at work in his laboratory at that great centre, he died of a heart seizure at the age of 75, after a lifetime spent to its very end in giving to the world vision and inspiration, scientific leadership and a generous sharing of his knowledge.

Two of Landsteiner's pupils, Philip Levine and Alexander Wiener (author of a classic book on "Blood Groups and Transfusion"), complete the American trio.

The present English group, originally inspired by the late Dr. G. L. Taylor of the Galton Laboratory, consists of Professor R. A. Fisher of Cambridge, one of the greatest living mathematicians, and two serologists, Robert Race, Director of the M.R.C. Blood Group Research Unit at the Lister Institute, and Race's assistant, Ruth Sanger, a science graduate of Sydney University, who later gained the London Ph.D. The latter two are co-authors of a recent fine book entitled *Blood Groups in Man.*

It would be unjust to our own country and to my own colleagues if I did not also mention that there are several Australians whose blood group work is of very high calibre. In Melbourne alone, Dr. J. J. Graydon and Mr. R. T. Simmons, of the Commonwealth Serum Laboratories, and Dr. Rachel Jakobowicz, of the Red Cross Blood Transfusion Service, have deserved and won international prestige.

Having effected these "introductions", I will now return to my theme.

During the latter part of the nineteenth century, it was known that if red cells of the blood of one animal species were mixed with the serum (or liquid part) of the blood of a different species, these red cells would usually not remain as separate functionally useful entities, but would become irregularly clumped together, or, as we say, agglutinated. The components in the serum causing this reaction were described as agglutinins or antibodies.

It was generally assumed that such reactions occurred only between the red cells and serum of different species, until in 1900 Landsteiner made his epochal discovery. By the simple device of testing blood samples from a few laboratory colleagues, one against the other, he showed that similar reactions occurred between the blood of individuals of the same species. This first small experiment revealed three varieties of reaction; a fourth was identified a little later in a larger series of two of Landsteiner's pupils working in his laboratory. Landsteiner explained these reactions as being determined by the presence in, or absence from, human red cells of one or other or both of two factors, which he called A and B, and so the four blood groups became AB, A, B and O. It was also demonstrated that the agglutinins which identified these factors were present in human serum, in reciprocal relationship to the factors themselves. The significance, both in genetics and in clinical medicine, of Landsteiner's observations, and the correctness of his interpretation of them, seems to have been largely unrecognized or ignored for several years, since the four blood groups were re-discovered, as it were, independently by Jansky in Europe in 1908, and Moss in U.S.A. in 1910. Both these investigators used numerals to identify the groups, but unfortunately Jansky's group I was called group 4 by Moss, and vice versa. This led to much confusion but, although a recommendation was made in 1927 by the Health Committee of the League of Nations that Landsteiner's original notation should be adopted as the recognized international nomenclature for the blood groups, the numerical notations, particularly that of Moss, were commonly used in medical work for many years, and even yet have not been entirely abandoned. The relationship of the three notations and the reactions between the cells and sera of the four groups are shown in Table I.

The work of Jansky and Moss was, however, mainly in the medical field in relation to transfusion, and did not greatly

influence those primarily interested in the genetic aspects of blood groups, who in general adhered to the fundamentally sound Landsteiner notation. But in this field also evaluation of Landsteiner's work was slow, because it was likewise not until 1908 that the hereditary nature of the blood groups was recognized, and followed, two years later (in 1910), by the suggestion that blood group tests could be of value in medico-legal work.

TABLE I

Relationship of Major Blood Group Notations, Cell Factors (Agglutinogens), and Serum Agglutinins

Landsteiner (League of Nations International)	Jansky	Moss	Factors in cells	Agglutinins in serum
O	I	4	—	anti-A and anti-B
A	II	2	A	anti-B
B	III	3	B	anti-A
AB	IV	1	AB	—

It seems appropriate at this stage to discuss a few genetic conceptions and terms which stem from the work of Mendel, first published in 1866, and their application to the inheritance of the ABO factors, since in principle, but with appropriate variations, they can be similarly applied to all the other blood group factors. I can only do this in elementary fashion, as I cannot claim to be an expert geneticist.

As you are probably aware, those of our physical characters which are hereditary, whether they be external and obvious, such as colour of hair and eyes, or internal and only detectable by laboratory tests, such as blood groups, are determined by the genes we receive from our parents.

Genes are, therefore, spoken of as the units of inheritance and, apart from very rare mutations, pass unchanged from generation to generation. They are sub-microscopic particles, each of which has its special position, or locus, on a strand of cellular nuclear material known as a chromosome. Thus every inherited character is determined by a combination of two genes, one derived from each parent; this combination gives rise to what is called the genotype of any individual in respect of the character concerned.

Genes may exist in simple alternative form, i.e. they may determine the presence, or the absence, of one well-defined

character; but many inherited characters are not quite so simple, and are based on a choice of genes, any one, but only one, of which may occupy the allotted locus on the chromosome. Such multiple genes are known as allelomorphs. These differences between alternative or allelic genes may be illustrated by two of the theories advanced to explain the inheritance of the A, B and O factors. The first theory was that there were two independent pairs of alternative genes, one pair for A or absence of A, another for B or absence of B, and that O was merely a negative quality, indicating absence of A and B. A European mathematician, Bernstein, pointed out, however, that when analysed from the statistical point of view this theory does not conform with the calculated expectancies, and he postulated that inheritance is by means of three allelic genes, A, B and O, any two of which may be present in any person's genotype. This theory is valid statistically, and conforms with many thousands of authentically observed family blood group data; for these reasons it is universally accepted today. In accordance with it, Bernsein formulated his well-known rules which state:

1. The factors A and B cannot appear in the blood of a child, unless present in the blood of one or both parents.
2. A parent belonging to group AB cannot give rise to a group O child, and a group O parent cannot give rise to a group AB child.

A genotype composed of two identical genes is said to be homozygous; if the two genes are different, it is heterozygous. In the latter case, it is not always possible, with the tests ordinarily at our disposal, to identify both genes, and the character revealed is spoken of as a phenotype. Thus, for example, group A is a phenotype which includes the homozygous genotype AA, and the herterozygous genotype AO, in which the O gene cannot be made apparent by the reactions used to identify group A.

Table II illustrates these genetic concepts; it also shows the ten matings which are possible in terms of the ABO blood group factors, and the group which are possible or not possible, according to Bernstein's theory, in the children of these matings.

Table III illustrates how the genetics of the ABO system may exclude paternity, if a man has been falsely accused of being the father of a child.

TABLE II

Blood Groups of Parents and Children

Blood groups of Parents			Blood groups of Children possible*				Blood groups of Children not possible (phenotypes)			
	Phenotype	Genotype								
1	O x O	OO x OO	O					A	B	AB
2	O x A	OO x AA OO x AO	O	**A**O **A**O					B	AB
3	O x B	OO x BB OO x BO	O		**B**O **B**O			A		AB
4	O x AB	OO x AB		**A**O	**B**O		O			AB
5	A x A	AA x AA AA x AO AO x AO	 O	**A**A **A**A, **A**O **A**A, **A**O					B	AB
6	A x B	AA x BB AO x BB AA x BO AO x BO	 O	 **A**O **A**O	**B**O **B**O	AB AB AB AB				
7	A x AB	AA x AB AO x AB		**A**A **A**A, **A**O	**B**O	AB AB	O			
8	B x B	BB x BB BB x BO BO x BO	 O		**B**B **B**B, **B**O **B**B, **B**O				A	AB
9	B x AB	BB x AB BO x AB		**A**O	**B**B **B**O, **B**O	AB AB	O			
10	AB x AB	AB x AB		**A**A	**B**B	AB	O			

*The gene which determines the phenotype of heterozygous genotypes, as revealed by the usual tests, is shown in heavy type.

Although it is now generally well known, it should perhaps be emphasized that not all wrongly accused men can be exonerated by blood group tests, since obviously some of them will happen to have blood group factors compatible with paternity of the child in question. For example, if the child belongs to group A and its mother to group O, a man shown

to belong to group B or group O could not be its father. On the other hand, as far as blood groups are concerned, paternity is possible by any man belonging to group A or group AB, which (in Australia) together comprise about 45% of the population.

If tests for the ABO factors only are used, the average chance of proving non-paternity is about 16%; but, owing to the different frequency for each gene, the chance for any individual man varies according to his group, being approximately 40% for group AB, 23·5% for group O, 15% for group B, and 8% for group A.

TABLE III

Exclusion of Paternity

Blood group of Mother	Blood group of Child	Blood group or groups to which father cannot belong			
O	O				AB
A	O				AB
B	O				AB
O	A	O		B	
B	A	O		B	
O	B	O	A		
A	B	O	A		
A	AB	O	A		
B	AB	O		B	
AB	AB	O			

Bernstein's analysis was published in 1924; it was quickly appreciated, and in the same year ABO blood groups tests were employed with confidence in medico-legal problems. Germany was the pioneer country, and subsequently blood group tests have been introduced in many others, and used, either by court order, where statutory authority has been established, or by arrangements between the litigants.

In 1927 Landsteiner, in association with Levine, identified another set of human hereditary blood factors, which they called M and N. These were found to be inherited quite independently of the ABO factors, and from about 1930 onwards they have also been used in medico-legal blood group tests. The combined use of ABO and MN systems doubled the average chance of exclusion, and each additional blood group system identified further increases the proportion of innocent men who can be exonerated.

In the 1930-40 decade other hereditory factors, such as the P factor of Landsteiner and a property of body fluids known

as the secretor phenomenon, were described and sub-groups of the A factor (originally described in 1911) were studied more intensively from the genetic aspect. Although the method of inheritance of these three factors has been determined convincingly, there are technical difficulties which militate against their general acceptance in medico-legal work.

And so for "Forty years on" there was in several countries a steady and, in retrospect, a seemingly unhurried accumulation of experience, wisdom and progress in the medico-legal use of blood group tests. But in 1940 the calm was rudely shattered. Again the immortal Landsteiner played a leading part, this time in association with Wiener. I refer, of course, to the discovery of the Rh factor. The name Rh is short for Rhesus, because this factor was first identified in experiments with the blood of monkeys of this species; shortly afterwards it was shown to exist also in the blood of human beings. This discovery, and brilliant clinical correlation by Levine and his associates in 1940 and 1941, elucidated and surprisingly linked together hitherto unexplainable transfusion reactions and the baffling condition of haemolytic disease of newborn babes; the rather arresting name "Rh", together with the dramatic and tragic fact that two perfectly healthy normal parents, simply because their genes are different, may sometimes be doomed to produce children affected by this disease, has led to widespread publicity in the lay Press. But although haemolytic disease of the newborn may indeed be serious, it occurs in such a small proportion (less than 5%) of the cases in which the genetic relationships of the parents make it possible that much of this alarmist publicity is unjustified and ill-advised.

As regards the impact of the Rh factor on medico-legal work, at first it was thought that it was inherited by means of two simple alternative genes, one determining its presence (i.e. the Rh-positive state), and the other its absence (i.e. the Rh-negative state); if this had been so, the observed relative frequency of the Rh-positive and the Rh-negative individuals would have provided very little additional evidence of exclusion in medico-legal tests.

But after a year or so Wiener and other American workers became aware that the Rh factor was genetically far more complex than was thought originally. Subsequent studies have necessitated extensions of the first theory as to its method of inheritance, and these have brought in their train a number

of changes and varieties of descriptive symbols. Wiener now postulates that the Rh factor is determined by a series of eight allelic genes which theoretically make possible 36 different genotypes and 666 matings in respect of the Rh system.

Across the Atlantic, in England, the stage was set, in the tradition of the Galton Laboratory, for further fruitful work on this newly discovered and exciting factor. By the end of 1943, on the data so far amassed, Fisher evolved a theory of the method of inheritance of the Rh factor, which called for prediction of the existence of genetic variants which had not so far been identified; but by 1950 these predictions had all been confirmed.

Fisher's theory differs from that of Wiener, in that it postulates that the Rh factor is inherited by means of three pairs of allelic genes, Cc, Dd and Ee, and also that these genes are so closely linked that one or other of each pair is almost invariably transmitted together from parent to offspring. Each of these six genes determines in the red blood cells a corresponding antigen, i.e. a substance which, if introduced into the blood of a person from whose red cells it is lacking, is capable of stimulating in such a person the production of antibodies which react with the "foreign" antigen. The antibodies reacting with the Rh antigens are referred to in Fisher's terminology as anti-C, anti-c, and so on.

According to Wiener's concept, each of the eight genes contains three antigenic components, which likewise can stimulate the production of their individual antibodies; those corresponding to Fisher's anti-C, anti-D and anti-E are anti-Rh′, anti-Rh_0 and anti-Rh″, and those equivalent to anti-c, anti-d and ante-e are anti-Hr′ anti-Hr_0 and anti-Hr″ respectively.

Wiener's and Fisher's concepts with their corresponding nomenclatures, and the reactions given by each gene, or "gene triplets" with the six antibodies, are shown diagrammatically in Table IV.

It should be noted that the reactions shown in this table are those given by individual genes or gene-complexes (the latter also termed by Fisher the Rh chromosomes). It will be seen that even with all six antisera, it is not possible to distinguish between certain genotypes as found in the red cells (e.g. between CDe/cdE and CDE/cde, each of which contain all six antigens and therefore react with all six antibodies). Such genotypes can only be distinguished if family studies can be made of

TABLE IV

Rh Genes

Wiener (1949)	R^1	r	R^2	R^0	r″	r′	R^z	R^y
Fisher and Race	CDe	cde	cDE	cDe	cdE	Cde	CDE	CdE
	R_1	r	R_2	R_0	R″	R′	R_z	R_y
Testing Sera	Reactions given by each serum with each gene*							
Anti-Rh′(C)	+	−	−	−	−	+	+	+
Anti-Rh_0(D)	+	−	+	+	−	−	+	−
Anti-Rh″(E)	−	−	+	−	+	−	+	+
Anti-Hr′(c)	−	+	+	+	+	−	−	−
Anti-Hr^0(d)	−	+	−	−	+	+	−	+
Anti-Hr″(e)	+	+	−	+	−	+	−	−

*The reactions outside the broken line are those identified since 1943, after Fisher predicted the existence of the genetic variants which give these reactions.

sufficient suitable individuals of two or more generations. It has been shown that the six antigens differ in potency; D is by far the strongest; anti-D antibodies are there fore relatively common; anti-C, anti-c and anti-E come next in frequency; anti-e is rare and anti-d extremely rare. Rh testing can therefore usually be done only with the four sera, anti-D, anti-C, anti-c and anti-E. At this level, instead of the theoretically possible 666 genotype matings, only 78 different phenotypes, some of which include two or more genotypes, can be identified. But neither this limitation nor the theoretical difference between

the concepts of Wiener and of Fisher invalidate the use of Rh tests in medico-legal work, since in common with other blood group tests their value is dependent on the rule that a factor cannot appear in the blood of a child unless it is present in the blood of one or both parents. Moreover, the relative frequency of the several Rh genes and their corresponding antigens is such that Rh tests add considerably to the proportion of exclusions possible.

The CDE notation is the clearest means of indicating graphically which genes are present in any individual's genotype, but it is admittedly clumsy to use in speaking, or in drawing up long lists. Race and his colleagues therefore use also the symbol R in what they call their "shorthand" notation, which, as may be seen from Table IV, differs only slightly from that of Wiener.

This somewhat detailed account of the genetic and antigenic composition of the Rh factor has been given in an attempt to clarify the bewildering differences in nomenclature which may be encountered, according as to whether any authority consulted favours the theory of Wiener or that of Fisher and Race. I hope it has not reduced you to either somnolence or dizziness. The subject is, however, still a rapidly expanding and dynamic one, and hence is not readily compatible with a state of mental equilibrium.

The coincidence in time of this discovery with World War II, in which blood transfusion played so great a part and called for such extensive blood group testing, gave further tremendous impetus to the study of blood group factors; as a result, since 1940 we have learnt not only of the complex Rh factor, but of five additional blood group systems in human blood, named (after individuals in whose blood they were first identified) as Lutheran, Kell, Lewis, Duffy and Kidd, and an additional factor S linked with the MN system.

This brings us up to date, and we may therefore consider more specifically the application of our knowledge, in its present state, to medico-legal problems. Several authorities have defined the criteria to which inherited characters must conform if they are to provide clear evidence of kinship. These criteria have been well summarized by Race and Sanger in *Blood Groups in Man,* as follows:

"A character that is to give unequivocal evidence concerning parentage must be simply inherited, and its mode of inheritance

must be known with certainty; it must be adequately developed at birth or soon after; it must retain its character throughout life, uninfluenced by climate, disease, age, or by any other environmental or genetical agency. If the character is to settle a dispute it must be objective."

Of all genetically determined characters, blood groups are among the most simply inherited, and with occasional exceptions (to some of which I have already referred) can be identified objectively and with certainty by precise laboratory tests. There is also still much to be learnt about the Lewis factor, but apart from these few reservations all the known blood group factors fulfil the criteria laid down by Race and Sanger, and either are, or in the opinion of these authors could be, used in medico-legal work, given adequate technical resources. Under such favourable conditions, the average chances of exclusion in false accusations of paternity are shown in Table V. The extent to which knowledge of blood group relationship can assist in the solution of kinship, other than paternity alone, can also be determined by appropriate calculations.

TABLE V

The Chance of an Englishman of Being Exonerated, by the Blood Groups, of a False Charge of Paternity Brought by an Englishwoman* (after Race and Sanger)

Blood group System	Exclusion by each System	Combined Exclusions		
1. ABO	0·1760	0·1760	or (approx.)	1 in 6
2. MNS	0·2741	0·4019	or (approx.)	1 in 2·5
3. Rh	0·2520	0·5526	or (approx.)	1 in 1·8
4. Kell	0·0421	0·5714	or (approx.)	1 in 1·75
5. Lutheran	0·0333	0·5857	or (approx.)	1 in 1·69
6. Secretion	0·0258	0·5964	or (approx.)	1 in 1·67
7. Duffy	0·0496	0·6164	or (approx.)	1 in 1·61

*English nationality is postulated in this table, as gene frequencies vary in different races.

Now let us consider what is meant by adequate technical resources. The essentials are:

1. The availability of the appropriate antisera on which the tests depend.
2. The existence of expert workers constantly engaged in blood group investigations.

The essential basis of all blood group tests is the agglutination of red cells when mixed on a slide or in a test tube with a serum containing antibodies which react with these red cells. Such a serum is conveniently referred to as an antiserum, or testing serum. The antisera which are used in blood group tests are broadly of three different kinds:

1. *Those in which the antibodies occur as normal physiological characters,* and which may, therefore, be readily obtained from appropriate normal individuals. The only blood groups for which such antisera exist in human beings are those in the ABO system, to which I have already referred. Why this reciprocal relationship is a constant physiological characteristic in the ABO system, and is lacking in all other systems, is an intriguing problem not as yet fully elucidated.
2. *Antisera produced by deliberate immunization of animals* by injection into them of human red cells. The procedures involved are technically not easy, and considerable skill and experience are needed both to carry out the immunization of the animals (usually rabbits) and to use the resultant testing sera correctly. At present, this method is only used for obtaining anti-M and anti-N sera.
3. *Immunization of human individuals.* This can be brought about in several ways:
   (a) *By heterospecific pregnancy.* If a woman becomes pregnant with a foetus which has inherited from its father a blood group factor which is absent from her own blood, she may (though by no means always does) produce antibodies in her serum against this factor. This phenomenon is theoretically possible in respect of all the known blood groups, and has been encountered in most of them; but because of its medical importance in connection with "Rh babies", is has been most commonly looked for and met with in the Rh system. Such antibodies in the mothers blood sometimes disappear soon after the birth of the baby, but may persist for months or even years. Women who develop these antibodies are the main source of our supply of Rh testing sera.
   (b) *Transfusion of incompatible blood.* Before the existence of the Rh factor was known, it had been observed with concern that unfavourable reactions occasionally

followed transfusions even after every known precaution had been taken to ensure that the patient and donor were completely compatible in respect of their ABO groups. Most of the hitherto baffling reactions of this kind were found to be due to Rh incompatibility, and their incidence has been greatly reduced by selection of donors of the appropriate Rh group. But even with this precaution, such reactions have not been entirely eliminated, particularly in patients who have received numerous transfusions. Reactions of this kind have in fact been the means of discovery of the Lutheran and Duffy factors. As our knowledge and experience grows, it is obvious that supplies of such antisera resulting from unwitting transfusions of incompatible blood will progressively diminish.

(c) *Deliberate immunization of human volunteers.* This means of producing antibodies has been used by some workers to obtain supplies of anti-Rh testing serum, when insufficient could be obtained from women immunized by pregnancy.

It can therefore be appreciated that apart from the ABO and MN systems, we cannot command at will at all times a certain supply of testing sera. Samples of the rarer antisera are more likely to be encountered in countries with large populations, but even in such countries supplies can only be maintained by well organized co-operation by clinicians and their patients with serologists who are sufficiently experienced and skilled, and who have adequate facilities, to identify any unusual antibody sent to them. In addition to their specificity for the various blood group factors, antisera must be suitably potent, if they are to be used for the clear-cut results required in medico-legal tests. Sera also deteriorate if bacterially contaminated through unskilful use, and eventually through passage of time.

All those who regard themselves as experts are in agreement that medico-legal blood group tests should only be done by experts. This is not quite such self-interest or complacency as it might seem at face value, because it is only through constant work in any field, perhaps especially when it is a biological one, that one comes to appreciate the possible pitfalls, and I think even the brief survey I have attempted tonight will suggest to the wise layman also that blood group testing is a complex

process and becoming more so. Among these pitfalls is the known existence of sub-groups and variants within most of the blood group systems. If blood group tests are undertaken by the unwary or inexperienced, these sub-groups and variants, though rare, could lead to errors, which might unjustifiably discredit the general validity of blood group evidence.

Experienced and competent workers are, however, aware of the possible though rare existence of such variants, and are technically equipped to identify them where this is possible, and to assess their significance, if any, in any given set of circumstances.

Since availability of some of the testing sera is so largely a matter of chance, it is obviously right that they should be conserved for those (i.e. the experts) who are best fitted to use them safely and economically, and with full knowledge of their potentialities and limitations.

It is, of course, necessary also to have ready access to panels of persons previously classified in respect of all the known blood group systems, whose red cells may serve as controls to check the potency and reactions of the testing sera.

These various facilities are likely to be available only in laboratories where blood group testing is a major rather than an intermittent or occasional pre-occupation.

If we agree that it is desirable that medico-legal tests should be done only by those constantly engaged in blood group work, it is also necessary to recognize that these experts may be called to give evidence. The timing of appearances in court is relatively inflexible; they may be protracted and, especially if medico-legal testing is by law restricted to a few approved laboratories, frequently repeated. They could therefore represent a claim on the expert's time of no small order. This might often conflict with the performance of laboratory investigations for sick persons, sometimes needed as an urgent measure; which is after all the primary function of a medical clinical pathologist. But many of the existing statutes enabling these tests to be ordered by the courts provide that they shall only be done by qualified medical practitioners. This provision was probably made (and justified) in the days when blood group tests were so predominantly performed as a means of ensuring safe transfusion that medically qualified serologists were the only ones of suitable status and experience likely to be available. But at the present time, with growing recognition of the importance

of blood group serology as a tool in the study of genetics, restriction of legal tests to medical practitioners would exclude their performance by a number of workers of world-wide reputation in the field of genetics. I do not imply that medically qualified laboratory workers should be debarred, if their inclination and aptitude has led them to specialize in such work (Landsteiner was a medical graduate, and so are Wiener, Levine and Race, among my sextet alone), but rather that experience and competence in this special field are the important qualifications. As I have indicated, team work between serologists and mathematician is also necessary, particularly on the more complicated cases, which may involve multiple relationships.

The collection of the blood samples may pose both technical and psychological problems of a type for which medical experience is desirable, but to ensure compliance with the legal requirements for identification of the persons and their blood samples the advice of a solicitor may be needed.

Though not always essential, the performance of at least one series of tests on all parties to the case, by the same serologist, at the same time and with the same set of testing sera and controls, usually makes the most satisfactory experiment. This may not be possible unless the court is empowered to order the tests.

So far, my emphasis has been mainly on disputed paternity of illegitimate children. This problem does, of course, call for such emphasis, since it embraces the large majority of the legal actions in which blood group tests may be of value, but there are various others also in which these tests may provide a solution. These include:

1. Cases brought by men who suspect their wives of adultery.
2. Exclusion of maternity. This is probably a rare situation, but a case has been described by Wiener in which a woman obtained a child from an orphanage and exhibited it as his offspring to a man whom she sought, and acquired, as her seventh husband. The man later sought annulment of the marriage on the grounds of fraud. Blood group tests showed subsequently that the woman could not be the mother of the child in question. Deception of a similar kind is also conceivable from distorted psychological motives, or because a fortune or other presumed advantage is contingent on the

appearance of an heir. I do not know of any such case on record in which blood group tests have been involved.

3. Deliberate substitution of babies. One recalls stories of bygone days, such as that of a foster-mother who, thinking to give her own child a better chance in life, substituted him for a young lordling entrusted to her custody; and of the attempt said to have been made to smuggle in a warming pan a changeling into a royal birth chamber. It may seem unlikely that cases of this kind would occur in our day, but if you will forgive the use of clichés, it is said that "Human nature never changes", "History repeats itself", "Truth is stranger than fiction", so it is possible that some such happening could occur in modern trappings, though with little chance of success if a competent blood group serologist could deal with the miscreants.
4. Accidental interchange of babies in maternity hospitals. Of this sad possibility we have only too recent a memory in this State, in the case of Morrison and Another v. Jenkins and Another.
5. Kidnapping. A case is reported by Race and Sanger in which a baby was stolen from its pram. The police found a baby, but blood group tests showed that this baby could not belong to the distressed mother.
6. Children in occupied countries. Blood group tests have been used in connection with attempts after the lapse of several years to restore to their rightful parents children separated during babyhood as a result of war. Under favourable conditions these tests might, by exclusion, narrow the fields in which other evidence need be sought.

These examples are all variants of the same essential problem of blood relationships, and until about twenty-five years ago, in those which were legally tested, the decisions of the courts had usually to be based on the evidence of verbal testimony and the subjective evaluation of external physical resemblance, with all their acknowledged limitations. To the serologist, at least, these seem frail and uncertain weapons compared with the evidence provided by blood group tests, which can justly be claimed to be forged of the tempered steel of proven knowledge.

As I see it, medico-legal blood group testing is, or should be, a carefully planned and skilfully executed scientific contri-

bution, and as such, completely objective and impartial. This status is unlikely to be achieved unless there is provision in our law for the tests to be performed and reported, by order of and with the dignity conferred by the protection of the court. Only in this way will the co-operation of those best qualified to make this contribution be readily obtained and, again in words from the British Select Committee's Report, the fine ideal of "bringing new knowledge to the service of justice in all its relations" be fully realized.

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