DISPUTED PATERNITY

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Illegitimacy in New Zealand occurs very frequently and it is not unusual for men accused of fathering a baby to deny responsibility. It frequently occurs to the parties involved that perhaps the matter could be resolved by a blood test on mother, baby and putative father. A common misapprehension by all parties and often, too, by their legal advisers is that paternity might be *proved* by such testing. Occasionally all parties have agreed to blood testing but have asked that the results should not be disclosed to the other side. In this event the tests are useless as it is necessary for all the results to be compared simultaneously in order for an assessment of the situation to be made. The purpose of this paper is to explain in simple terms the mechanism of heredity and how results of tests in affiliation cases are evaluated.

TESTS USED

The most informative tests are those for simply inherited common genetic characters. The majority of these involve the blood groups but there are also genetic characters demonstrable in the blood serum proteins and these are now being increasingly used. Certain properties of saliva have a genetic basis and a saliva test could be included in the test battery where it was desired to maximise the chances of an exclusion.

In some countries certain anthropological characters such as the shape of the head, the hands and characteristics of the ears are also included but no definite exclusion of paternity can be established with such characters, although it can be rendered very unlikely if the baby shows some configuration not found in the mother and not present in the alleged father. Certain quantitative properties of the hand and finger-prints may also be used in the same way as the resemblances between relatives are well documented. Again, however, no positive exclusion of paternity can be demonstrated using these characters.

In this discussion we will confine ourselves to characters such as the blood and serum protein groups in which the genetic mechanisms are clear cut.

METHODS OF INHERITANCE

At the moment of conception we receive from our parents a series of "instructions" which determine our individuality. No two persons (with the exception of identical twins) receive the same set of "instructions". It is apparent that some variation in these "instructions" or genes must occur in the population otherwise we would all be identical. As we have two parents we receive for each genetic character two genes, one from each parent. The two genes received may be the

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same or they may be different. For most characters there will be more than two different genes available in the population but any one person can only have two genes from the set available.

In order that variation may occur there must be at least two alternative forms of gene for a given character. These alternative forms are called *alleles*. A simple two allele genetic system is the MN blood group system where the alleles are M and N. Only three kinds of blood group can exist in this system viz:— MM, MN, and NN. A person of type MM can only pass an M gene to his children and NN persons can only pass an N gene. However, the MN person may pass either M or N (see Table I) with equal frequency.

Parental Genotype	MM	MN	NN
Passed to child	always M	*either* M *or* N 50% chance for each)	always N

<p align="center">TABLE I. Genes passed to children.</p>

The child, of course, receives a second M or N gene from the other parent.

CHANCES OF EXCLUSION

It is now possible to see how there may be exclusion of paternity when we consider the various combinations of mother, child and putative father (Table II). Note that two mother/child combinations are impossible (mother MM/child NN and mother NN/child MM) so that they do not appear in the table.

Mother	Child	"Fathers" excluded	"Fathers" not excluded		
MM	MM MN	NN MM	MM	MN MN	NN
MN	MM MN NN	NN — MM	MM MM	MN MN MN	NN NN NN
NN	MN NN	NN MM	MM	MN MN	NN

TABLE II. In the column headed "child" the gene received from the mother is underlined. In one case (mother and child both MN) this cannot be done and no exclusion of paternity is possible.

The frequency with which a wrongly accused man will be excluded depends of course on the frequency of the alleles and so of the different blood group types in the population. If a man is wrongly accused of paternity there is no guarantee that he will necessarily be excluded as he may have blood groups compatible with his being the father even though he is not. For this system the maximum chance of exclusion for a wrongly accused man occurs when the alleles M and N are equally frequent in the population, and is equal to 18.75%. The alleles M and N are about equally frequent in New Zealand but more refined methods of testing recognise additional alleles so that in practice the

chances of exclusion are closer to 24%. Only one other system (the Rh blood groups) gives a better chance of exclusion, but here it is only slightly greater than 25%.

It is important therefore that as many systems as possible should be tested in order to increase the chances of exclusion if a charge of paternity is wrongly brought. Table III sets out the chances of exclusion for four commonly used genetic systems.

Systems	Prob. of exclusion	Cumulative prob. of exclusion
1 ABO blood groups	18%	18%
2 Rh blood groups	25%	38.50%
3 MN blood groups	24%	53.25%
4 Hp (haptoglobin) serum groups	18%	61.67%

TABLE III. The cumulative probability of exclusion gives the combined chances of exclusion when the tests are applied successively in the given order.

The addition of a further six blood group tests to those listed in Table III will increase the cumulative chances of exclusion by at least one of the tests to the region of 70%. Unfortunately some of these tests are not particularly useful as one allele tends to far exceed the other in frequency so that the chances of getting an exclusion are very small.

A further complication, not mentioned so far, is that in some systems the presence of one allele may obscure the other if it is present. If, for example the MN system behaved in this way so that persons who were actually MN appeared to be indistinguishable from those who were MM we could only classify individuals into those who were M positive (M+) (i.e. carried the M gene) and those who were M negative (M—) who did not. The latter would be type NN. Thus the only situation which would exclude the alleged father would be the second to last line of Table II which corresponds to an M— mother with an M+ baby. The M gene in the baby must have come from the real father, and if the alleged father is M— he is excluded. If the MN system behaved in this way with M dominant to N the chances of exclusion on this system would be reduced to about 3%.

Unfortunately a number of the blood group systems have this property as well as that of having one allele much more frequent than the other. It is this combination of facts which leads to the relatively small increase in the chances of exclusion when these systems are added to those listed in Table III. It is also clear that not infrequently a wrongly accused male may fail to be excluded and we must now consider our interpretation of the results when exclusion has failed.

ABSENCE OF EXCLUSION

Previously we have seen that a failure to exclude does not necessarily prove paternity but it does allow us to make a probability statement about the observed results. Consider the case when the mother and child are both MM and we have two men as possible fathers. One man is also MM and the other MN. The child must have received an M gene from the real father and as the MM male has only M genes available it is 100% certain (probability 1.0) that all his children will

304

be MM if the mother is MM. On the other hand the second male has both M and N genes available and the chance that he passed an M gene to the baby is a half. Thus the first man has probability 1.0 of passing on an M gene while the second man has probability 0.5 or, in terms of odds the first man is twice as likely (1.0/0.5) to pass on an M gene as the second.

In practice we usually have only one putative father (the first man) and we calculate the probability that this man could have passed the appropriate gene to the baby. If this is zero (i.e. he does not have the gene) then he is excluded, but if, as in this example, he is group MM then the probability that he would pass an M gene is 1.0. Now we ask the following question: "If this man is not the father, what is the probability that the baby would have received an M gene from some other unspecified male?" This depends on the frequency of the gene in the population from which the fathers could be drawn, i.e., the total population. The frequency of the M gene in the population happens to be close to 0.5 so that the odds in favour of *this* man rather than some unspecified man is again 1.0/0.5 = 2. In betting parlance the odds are 2 to 1 in favour of the alleged father being the true father. The advantage of expressing the situation in this way is that we can now calculate the odds for a second system and combine the results by simple multiplication in the same way as the odds are compounded when betting on "doubles" or "trebles" in horse racing.

If the accused male should possess some rare alleles also possessed by the baby and not by the mother than the combined odds in favour of him being the father can become very high. On the other hand common alleles possessed by all parties tested leave the odds low and so the possibility of some other male being responsible is still likely.

Examples

An example of the method applied to actual data is given in Table IV.

Test System	Mother	Baby	Alleged Father	Prob.	Gene Freq.	Odds
ABO	OO	A_2O	A_2O	0.5	.07	7.14/1
Rh	R_1, r	R_1w, R_1	R_1w, r	0.5	.01	50.00/1
MN	MM	MM	MM	1.0	.50	2.00/1
Haptoglobins	Hp1, Hp1	Hp1, Hp1	Hp1, Hp1	1.0	.40	2.50/1
		Cumulative odds 1785/1				

TABLE IV. The baby's entries have the allele received from the father underlined. The explanation of the last three columns is given in the text.

Here the alleged father possesses one rare gene (A_2) and one very rare Rh gene (R_1w). Both of these genes are present in the baby and the alleged father's chance of passing the A_2 or R_1w genes is 0.5 in each case. For the MN and Hp systems the probability is 1.0 is each case as the alleged father has only one type of allele available. These figures are given in column 5. Column 6 contains the frequencies in the general population of the various alleles received by the baby from its father. If the true father was not the one accused then these frequencies give the probabilities that an unspecified male might have contributed the required genes. The ratio of the figure in column 5 to that in column 6 gives the odds in favour of the accused man being the father rather

than some other male from the population. These odds are given in column 7. When the four figures given are multiplied together we have the cumulative odds of 1785/1 in favour of the accused man being the father. This figure makes it virtually certain that he is the man and there remains only a small (1/1786) chance that we are mistaken.

Table V is another example where no rare genes are involved and a similar calculation shows that it is actually a little more likely to be another man than the accused.

Test System	Mother	Baby	Alleged Father	Prob.	Gene Freq.	Odds
ABO	OO	$\underline{O}$O	A_1O	0.5	.66	0.76
Rh	R_1R_1	$\underline{R_1}R_1$	R_1r	0.5	.41	1.22
MN	MM	M$\underline{N}$	MN	0.5	.50	1.00
Haptoglobin	Hp1, Hp1	$\underline{Hp2}$, Hp1	Hp2, Hp1	0.5	.60	0.83
					Cumulative odds	0.77/1.00

TABLE V. The alleged father has common blood groups so that the cumulative odds are more in favour of some other man being the father. The baby's allele received from the father is underlined.

In practice the calculations are often more involved than those presented in the examples given here. In the ABO blood group system there are four common alleles A_1, A_2, B and O so that there are ten possible genotypes complicated by dominance relationships. As an example of this, genotypes A_1A_1, A_1A_2 and A_1O all type as group A_1 and the real genotype can only be inferred by studying other relatives, or probabilities can be assigned which are functions of the gene frequencies in the population. A further complication in New Zealand is the existence of two intermingled populations, Maori and Pakeha. Certain genes are relatively infrequent in Maoris so that under some circumstances it may be necessary to specify the racial origins of any alleged father. The probability ratios with respect to a particular putative father may well be quite different if we compare his chances of paternity with that of some unspecified Maori rather than an unspecified European.

CONCLUSION

The decision to embark upon blood testing is one that rests with the parties involved and it is difficult to know how to advise them.

If the accused male is actually innocent of the charge brought, then he has everything to gain by being tested as his chances of an exclusion on one of the four systems mentioned here is better than 60%. On the other hand, if he is guilty he may find that the odds suggesting that he is indeed the father reach a considerable figure. There is no chance at all of an exclusion, unless of course, there is a mistake in typing, but the chances of this are very small. If the man accused is the actual father and knows that he possesses some rare blood group he would be ill advised to agree to testing. On the other hand a mother whose baby has an unusual blood group not shared by her should press for blood tests provided she is sure of the father's identity. These considerations mean that a refusal to agree to testing may well prevent a correct

decision being reached. There is probably a case for making blood tests compulsory whenever these cases reach the courts.

Finally we should note that if the odds are large suggesting that a particular man is indeed the father of the baby then it is essential that his brothers and other close male relatives should have alibis or not be involved with the mother. Rare genes present in the man accused may also be shared with his relations.