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Genetics and the Law

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GENETICS AND THE LAW*

IN the ST. JOHN'S LAW REVIEW for May, 1933, appeared an article on *Genetics and the Law.* Unfortunately, the author of this article reaches the erroneous conclusion that there is still no reliable method for proving paternity or non-paternity, and that to apply blood grouping for this purpose would be "to anticipate scientific facts." This fallacious conclusion was reached primarily because of misinterpretation and misquotation of statements made by authorities in the field. Such errors are to be expected when a lawyer attempts to review one of the medical sciences, particularly a branch as technical as blood grouping and genetics. In order to correct these errors and to emphasize the value of blood grouping in medico-legal cases in which the parentage of children is disputed, this article is written. When the method is properly applied, and its limitations clearly recognized, conclusions based on blood grouping tests are entirely reliable.

In order to be able to explain more clearly the errors in interpretation and quotation made, it will be necessary first to briefly review the scientific basis for the application of blood grouping in paternity cases:

The blood is made up of two main fractions, the red blood cells, from which the color of the blood is derived, and the plasma (or serum [1]), which is the fluid portion of the blood. In the red blood cells are two substances called agglutinogens A and B. If an individual possesses both these agglutinogens in his blood cells, he is said to belong to group AB; if he possesses neither, he belongs to group O; if he possesses only A, he belongs to group A; and if he possesses only B, he belongs to group B. In the serum are two substances called agglutinins, α (or anti-A) and β (or anti-B). If serum containing agglutinin α is mixed with red blood cells containing agglutinogen A (group A or group AB),

* In the last issue of this publication, there appeared an article bearing the same title as the one above. The present author objects to some of the conclusions drawn by our previous contributor. The ST. JOHN'S LAW REVIEW presents this second paper without assuming any responsibility for the correctness of either view. It is interesting to note, however, that the writer of the article which follows is a medical man, while the former is a lawyer.—Editor's note.

[1] The fluid remaining after coagulation of the plasma is the serum.

these cells will be clumped (or agglutinated) or may be destroyed. On the other hand, such a serum would not affect red blood cells not containing A (of group O or group B). Similar reasoning holds for agglutinin β. Naturally, an individual of group A cannot have agglutinin α in his serum (or he would die); and, similarly, a group B individual does not possess agglutinin β. The actual composition of the four blood groups is as follows:

Group	Red Blood Cells (*Agglutinogen*)	Serum (*Agglutinin*)
O	—	α and β
A	A	β
B	B	α
AB	A and B	—

The group of any individual can be determined by testing his blood cells with two kinds of sera, one containing agglutinin α (group B) and the other agglutinin β (group A). If his cells are agglutinated by both sera, he belongs to group AB; if by neither, to group O; if only by the group B serum, to group A; and if only by the group A serum, to group B.

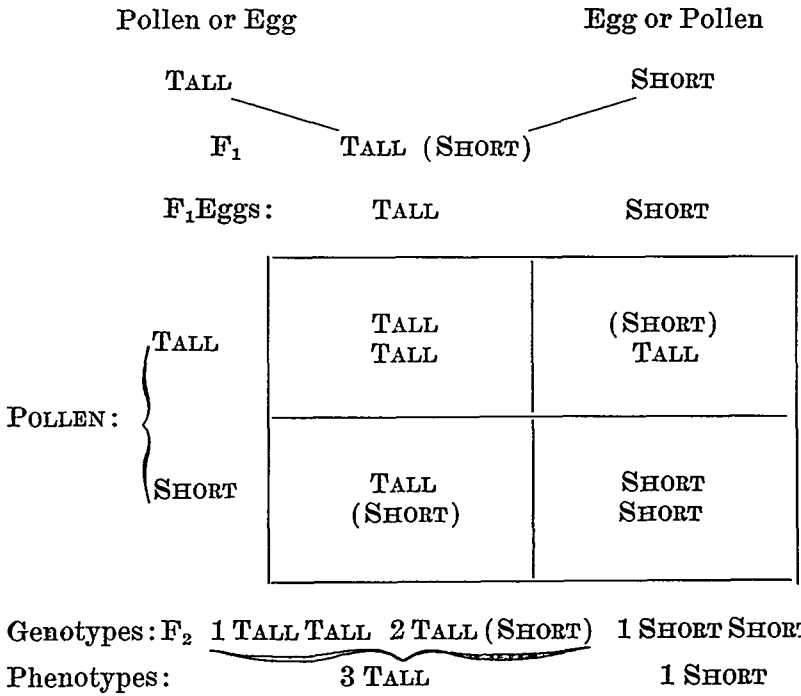
The discovery of the existence of blood groups and their use for blood transfusion by Dr. Karl Landsteiner was of the utmost importance to medicine, since blood transfusions can now be safely performed by selecting a donor belonging to the same group as the recipient. Before 1900, when this discovery was made, fatal reactions were frequent after blood transfusion. At present, 10,000 transfusions are performed every year in New York City alone, so that Landsteiner's discovery is responsible for the saving of many thousands of lives.

The value of blood grouping in medico-legal cases depends upon the hereditary nature of the blood groups. For an understanding of the heredity of the blood groups, it is necessary to be familiar with Mendel's first law of heredity (the law of segregation). The manner of operation of this law is best illustrated by considering an actual experiment performed by him:

Mendel crossed a tall variety of edible pea with a short variety and obtained in the first generation (F_1) hybrid plants, all of which were tall. When the hybrid tall plants were allowed to self-fertilize, three quarters of the offspring were tall and one quarter were short. Mendel explained these observations by postulating that tall plants had something (now known as gene) in the germ cells which in the offspring

determines the character "tall," and, similarly, the short plants had something in the germ cells determining the character "short."

DIAGRAM ILLUSTRATING THE LAW OF SEGREGATION
(*After Morgan*).



All cells other than the germ cells contain a double set of genes, one derived from the maternal, and the other from the paternal parent. Thus, the hybrids receiving one gene from each parent will possess a gene (T) for tall and a gene (t) for short. Since the hybrids are all tall, tall is said to be "dominant" over short, and short to be "recessive" to tall. In the second (F_2) generation, ova and pollen bearing the genes T and t will be produced in equal numbers. On fertilization, one-fourth of the individuals will have the constitution (genotype) TT, one half Tt, and one quarter tt, as

shown in the above figure, so that three quarters of these individuals will be tall and one quarter short.

The essential features of the law of segregation, therefore, are the following: A factor (or gene) carried in the germ cells of one parent and a contrasting factor carried by the germ cells of the other parent come together and coexist for one generation in the cells of the hybrid offspring *without blending or losing their identity.* When such a hybrid individual produces its own germ cells, the two factors are again separated, or *segregated* from one another, each of the germ cells being entirely pure, containing either one factor or the other, but never both.

Pairs of genes like T and t (governing contrasting characteristics) are termed "allelomorphic" genes.

It is clear that a trait which is inherited as a simple mendelian dominant (like the character tall of edible pea), cannot arise unless one or both parents possess the trait. Thus, in order to be tall, a plant must possess at least one gene T, so that one of the parents, at least, must possess the gene T, and therefore must be tall. On the other hand, a trait which is inherited as a recessive may appear in an individual even though neither parent exhibits the trait. Thus, short plants (tt) may arise from tall plants, provided that these tall plants are hybrid (Tt), as explained above, because the recessive gene t can be transmitted by individuals who are tall because of the simultaneous presence of gene T.

With reference to the blood groups, it was shown by von Dungern and Hirszfeld in 1910 that the agglutinogens A and B are inherited as simple dominants. As was proved by Bernstein in 1925, the blood groups are inherited by means of three allelomorphic genes, A, B, and R, where the genes A and B determine the presence of agglutinogens A and B, respectively, and gene R, which is recessive to genes A and B, determines neither agglutinogen. The three genes form six pairs which correspond to the four blood groups as follows:

GROUP	GENOTYPES
O	RR
A	AA and AR
B	BB and BR
AB	AB

It is a simple matter now to determine what the groups of the children must be, when the groups of the parents are known. For example, if the parents belong to group AB and group O, respectively, the former parent, of genotype AB, will produce equal numbers of germ cells bearing gene A and gene B, whereas the latter, belonging to genotype RR, will only produce germ cells bearing gene R. Half of the children

will therefore belong to group A and half to group B (corresponding to genotypes AR and BR, respectively). For practical purposes, Bernstein's theory of heredity of the blood groups may be summarized in two laws:

> (1) A child cannot possess agglutinogen A or B unless the agglutinogen is present in the blood of one or both parents.
>
> (2) A parent of group AB cannot have a child belonging to group O, and a group O parent cannot have a group AB child.[2]

The significance of these two laws is summarized in the following table:

GROUPS OF PARENTS	GROUPS OF CHILDREN POSSIBLE	GROUPS OF CHILDREN IMPOSSIBLE
O x O	O	A, B, and AB
O x A	O, A	B, AB
O x B	O, B	A, AB
A x A	O, A	B, AB
A x B	O, A, B, AB	——
B x B	O, B	A, AB

How this knowledge can be applied is best illustrated by citing an actual case. In a recent case tried in the Court of Common Pleas of New Haven County, a woman falsely accused a man of the paternity of her child. The bloods were sent to the present writer for examination, and it was found that the man belonged to group A, the woman to group O, and the child to group B. Since the child possessed an agglutinogen B not present in its mother's blood, the true father must belong to group B or group AB. Confronted with this evidence, the woman withdrew her charge and the man was acquitted. Suppose, however, that it had been found that the accused man belonged to group B or group AB. This would not prove that he was the true father any more than any other man belonging to either of these groups. In such an event, the blood group testimony would be worthless. Blood

[2] Since the cases in which one or both parents belong to group AB are still the subject of some discussion, the exclusions which fall under this heading will be omitted in the present paper. However, on account of the rarity of group AB, these cases play but a minor part.

grouping can therefore be used only *to exclude* paternity, and not *to prove* paternity.

That the agglutinogens A and B are inherited as simple mendelian dominants has been confirmed by studies by many authors on many thousands of families. The present writer has examined the bloods of more than 5,000 individuals without finding a single exception to Bernstein's theory. Blood grouping has been used in affiliation cases in Europe since 1924, and in 1929, Schiff estimated that it had already been applied in more than 5,000 such cases. Since 1929, the number of cases in which the method has been used has been more than doubled. Countries in which blood grouping is being used for the exclusion of paternity are Austria, Germany, Switzerland, Denmark, Danzig, Norway, Sweden, Russia, Japan, France, Italy and Belgium.

As has already been pointed out, not in every case where a man is falsely accused of paternity, will blood grouping prove his innocence. Thus, if the falsely accused man and the true father belong to the same blood group, no definite statement will be possible. In one sixth of the cases where false accusations are made, however, blood grouping will establish the man's innocence. Until recently nothing could be done about the remainder of the cases. In 1927, however, Landsteiner and Levine discovered two additional agglutinogens, M and N, in human red blood cells, by means of agglutinins in the serums of rabbits which had been injected with human blood. These agglutinogens are entirely independent of the agglutinogens A and B, and define three types of human blood, the so called M/N types, as follows:

Type M or M+N— (blood possessing only agglutinogen M)
Type N or M—N+ (blood possessing only agglutinogen N)
Type MN or M+N+ (blood possessing both agglutinogens M and N)

No individuals have been found whose blood lacks both agglutinogens M and N.

In 1928, Landsteiner and Levine showed that the agglutinogens M and N are inherited as simple mendelian dominants, so that these agglutinogens could also be used in

medico-legal cases for proving non-paternity. The number of cases which can be solved has been doubled by this discovery, so that now one-third of all falsely accused men can be exonerated.

We are now in a better position to demonstrate how the author of the article *Genetics and the Law* reached his fallacious conclusions. On page 283, he writes:

> "It should be noticed that the writer has tried to refrain from commenting upon either the scientific or legal data collated in the preceding pages. The data are there, various conclusions can be obtained from a close analysis. The writer's conclusion is that the New York Courts, at least, have refused to fall into the errors that the European courts have, and that is, *to anticipate scientific facts.*
>
> "In 1927 the Landegericht II was convinced of the infallibility of the blood test to prove the impossibility of paternity; yet in the following year the two scientists who had performed most of the research work, and one of whom later was awarded the Nobel Prize for this research, frankly admitted that more studies must be made before the test in question could be used as a matter of routine."

The two scientists referred to are Dr. Karl Landsteiner and Dr. Philip Levine, and the conclusion on which the above statement was based is given on page 264 of the article *Genetics and the Law:*

> "*Landsteiner* and *Levine* (1928) 48 JOUR. EXP. MED. 731, 748.
>
> "that the agglutinogens A and B are inherited as mendelian dominants * * *."
>
> "The heredity of two agglutinable structures demonstrable by immune agglutinins was studied in 166 families. From the data collected it is evident that one deals with a case of mendelian inheritance. * * * Irrespective of the ultimate theory it seems probable that the properties M and N do not appear in the offspring when they are absent in both parents—a conclusion substantiated by the examination of ten families with 46 children. These findings offer the prospect of forensic application in cases of disputed paternity, and, in our opinion, a correct opinion could already be given, at least with great probability, provided the reagents are available and the method properly applied. *Of course, further work is needed before the test can be adopted as a routine procedure."* (Italics by author of the article *Genetics and the Law.*)

The above statement is taken from a study by Landsteiner and Levine in 1928 on the heredity of the agglutinogens M and N. As has already been pointed out, these agglutinogens had only been discovered by Landsteiner and Levine the year before, and this was the *first study* on the heredity. For that reason, the authors advised further stud-

ies before recommending the procedure, which is somewhat involved, as a routine procedure. *Their statement did not refer to the four blood groups O, A, B, and AB, however, which were discovered in 1901, and have been applied in medico-legal cases in European countries since 1924.*

With reference to the three M/N types, it must be remembered that the statement cited above was made by Landsteiner and Levine in 1928, *after making the first study on the heredity of those agglutinogens,* which explains their cautious attitude. Since 1928, five years have elapsed, and, during this interval, studies have been made by other authors (including the present writer) on a total of more than 20,000 individuals, and all the data compiled has confirmed the theory of heredity proposed by Landsteiner and Levine. For this reason the M/N types have been applied in European countries for the past two years in cases involving the establishment of non-paternity. Today, Dr. Landsteiner and Dr. Levine also approve of the application of the M/N types together with the four blood groups in affiliation cases. (Verbal communication.)

According to Landsteiner and Levine, the heredity of the M/N types is determined by a pair of allelomorphic genes M and N. Three genotypes are possible, corresponding to the three M/N types as follows:

Types	Genotypes
M	MM
N	NN
MN	MN

The theory, therefore, explains the non-existence of individuals lacking both agglutinogens M and N. It is a simple matter to determine what the types of the children must be if the types of the parents are known. For example, if the parents belong to type M and type MN, respectively, their respective genotypes are MM and MN. The former parent produces germ cells only bearing gene M, and the latter produces equal numbers of germ cells bearing gene M and gene N. Half of the children must, therefore, belong to type M and half to type MN. The other matings may be worked out in a similar manner:

Types of Parents	Types of Children Possible	Types of Children Impossible
M x M	M	N, MN
N x N	N	M, MN
M x N	MN	M, N
M x MN	M, MN	N
N x MN	N, MN	M
MN x MN	M, N, MN	——

As an argument against the application of blood grouping in medico-legal cases, a second citation from Landsteiner and Levine is also given in the article *Genetics and the Law* (see p. 264). In this citation neither the four classic blood groups nor the three M/N types are referred to, however, *but an entirely different agglutinogen independent of the agglutinogens A, B, M, and N.* To be sure, this newer agglutinogen has not yet been sufficiently studied, and the technique has not been sufficiently perfected for medico-legal work, *but this statement does not apply to the agglutinogens A, B, M, and N.* Therefore, the main arguments against blood grouping based upon the literature are due to a misunderstanding. However, the author of the article *Genetics and the Law* also writes:

> "As previously indicated, the European courts have accepted as infallible the blood test which indicates the impossibility of paternity. Members of the legal profession in this state are attempting to use the decisions of the European courts as a reason why the New York courts should recognize such blood tests. Surely, when as eminent a scientist as Dr. Alec Hrdlicka, Anthropologist of the United States National Museum, emphatically states that such blood tests cannot as yet be regarded as anything but experimental, and that no definite conclusions can be based on such tests, together with the premature decisions of the European courts, as a matter of law, the courts of the State of New York will be justified in refusing to allow testimony relative to such blood tests."

If Dr. Hrdlicka has actually made such a statement, which is in contradiction to the opinions of all workers in the field, it cannot be used without knowing upon which facts he bases his conviction.

The value of blood grouping is best emphasized by comparing it with *the ancient and notoriously unreliable method* (the purpose of italics here is to point out a misquotation of a statement made by the present writer, and which appears on page 262 of the article *Genetics and the Law*) of demonstrating similarity of features of putative father and child.

(1) The blood group (and M/N type) of an individual can be determined at birth, or, at the latest, during the first few months after birth, and remains unchanged regardless of disease, age, drugs, etc. On the other hand, an individual's features are not fully formed until puberty, and even after

that time are continually changing, and may be completely altered by disease (such as smallpox, acne, etc.) or accident (burns, cuts, etc.).

(2) Blood grouping is purely objective. Thus, if one competent observer finds that a given individual belongs to group A, all other observers making independent examinations of that individual's blood obtain the same result. On the other hand, the determination of facial resemblance is largely subjective. Thus, many people have told me that they would have known who I was at the very first meeting, because of my resemblance to my brother, whereas, just as many other people remark how entirely different my brother and I appear.

(3) The blood groups (and the M/N types) are inherited by means of a simple mechanism. On the other hand, the facial features are inherited by means of many factors, since the features have many components (the chin, the nose, the brow, etc.), each probably with an independent heredity. Not uncommonly the child does not resemble either parent; and, on the other hand, two totally unrelated individuals may closely resemble one another.

Despite these facts, many courts permit the exhibition of the child to the jury to demonstrate resemblance to the putative father. In some cases, the infants were only a few months old, and the features were not fully formed. In such cases, of course, imagination plays an important role. By using blood grouping, it will be possible in many cases to render decisions based upon *scientific facts,* instead of upon the emotions and imagination of the jury.

It is of interest to note that the cases cited in the article *Genetics and the Law,* in which resemblance between child and putative father was used as proof of paternity, date back in some cases almost one hundred years. In fact, the use of this method is mentioned even by the ancients. It is only during the past thirty years, however, that the science of genetics has been developed. Opinions rendered before 1900, therefore, have little or no scientific basis. It is important to emphasize that although the science of genetics has advanced tremendously in the past thirty years, there has been little or no change in the methods used in the courts of this country for determining blood relationship. Occasionally, superstitious beliefs, such as the belief in "maternal impressions," take the place of scientific knowledge even today. Thus, Thomsen, in Den-

mark, reported a case in which the illegitimate child of a servant girl possessed an unusual deformity of the fingers that corresponded exactly to that of the mother's employer. The claim for maintenance for the child was refused by the court, however, since it was held that the continual observation by the mother of her master's deformity fully accounted for the appearance of the deformity in her child.

The reader may find ample references for the above statements by consulting the following books and reviews on blood grouping:

SCHIFF, F.: DIE BLUTGRUPPEN UND IHRE ANWENDUNGSGEBIETE. Julius Springer. 267 pp. Berlin (1933).

WIENER, A. S.: BLOOD GROUPS AND BLOOD TRANSFUSION. Charles C. Thomas Co. (in press).

HERZOG, A. W.: MEDICAL JURISPRUDENCE. Bobbs-Merrill Co. Indianapolis (1932).

Levine, P.: *The Application of Blood Groups in Forensic Medicine* (1932) 3 AMER. JOUR. POLICE SCIENCE 157-168.

LATTES, L.: INDIVIDUALITY OF THE BLOOD. Oxford Medical Publications. 413 pp. London (1932).

STEFFAN'S HANDBUCH DER BLUTGRUPPENFORSCHUNG. J. F. Lehmann. Munich (1932).

SNYDER, L. H.: BLOOD GROUPING IN RELATION TO LEGAL AND CLINICAL MEDICINE. Williams and Wilkins. Baltimore (1929).

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