THE

AMERICAN LAW REGISTER.

MAY 1877.

MICROSCOPICAL EXAMINATION OF BLOOD IN ITS RELATION TO CRIMINAL TRIALS.

[Second Article. For the first see 15 Am. Law Reg. N. S. 561.]

Professor Schuman, in his work on Physiological Chemistry, quoting from Carl Schmidt's "Die Diagnostic verdächtiger Fleche in Criminfallen, says: "C. Schmidt has shown by accurate microscopical measurements of the blood corpuscles of many of the mammalia that they can be individually detected and distinguished from that of man," and further, that "by numerous measurements carefully made he *has proved* that the corpuscles of the different *species* of the mammalia present *constant* differences in size."

Of course in a question of such grave importance as the one under consideration it cannot be conceived for a single moment that any individual whatsoever could desire to establish anything but the absolute truth in the case. It was to this end that I began this investigation, having had my attention called to it first by accident while engaged in some other medico-legal cases.

It may not perhaps be improper for me to state that certain spots on a bank check were examined by me which I was able to determine were blood spots; and since this I have made tables from this check showing to what *species* of animal the blood belonged. The paper on which this check was written is so highly sized that I should not now find the task a very difficult one.

In the beginning of my investigation I was met with a difficulty,

which Professor Schuman notices as follows: "the ordinary methods of measuring these minute bodies ('blood globules') by the micrometer are by no means sufficient;" and I therefore adopted for the purpose the plan I have before described.

The task of measuring and recording the measurement of each separate corpuscle of a sufficiently large number to warrant a reliable verdict would be almost appalling to most observers, and this could not well be done if, as in my tables, the globules were taken without selection as they occur on the slide, and further if, as seems to me necessary to any right conclusion in the matter, they were to be measured in *two* directions.

Let any one with the best of instruments try to get the aggregate measurement of one of my tables, by measuring each separate corpuscle in two directions, and he will find it quite a difficult task; how much greater must this difficulty become when this measurement must be made of objects a million times smaller than these under all the impediments of thin and thick glass covers, collar adjustment, &c., &c.!

Dr. Woodward quotes Gulliver as saying, in regard to the reliability of measurements with the micrometer: "In the absolute accuracy of any micrometer applied to objects so extremely small, it is difficult to place implicit reliance in the result," and he only claims "relative exactness." In order to give some idea of the difficulties alluded to above, I quote still further from Dr. W. Speaking of Mr. Gulliver's measurements, he says: "The objectives used were an eighth by Ross, and a tenth by Powell. It is not stated whether these objectives were provided with the screw-collar adjustment for thickness of cover, but *they probably were*, and if so, *doubtless all the measurements* were somewhat vitiated, like others of the same date, by the failure to allow for the variations in magnifying power produced by turning the screw-collar."

I have quoted this author, from the fact that it has been claimed by some that he has *settled* the question. I have italicised the words above as an example—shall I call it?—of *accurate guessing* as to the methods of this *eminent* authority (Gulliver), remarking in this place what I show still farther on, that it is a strange kind of manipulation which makes human blood corpuscles considerably too small, while it makes dogs' twice as much too large.

As my method of comparison of the blood corpuscles of man and other animals differs so entirely from that of all others, I

should not have mentioned this objection, only as it has been quoted as authority, as I have before noticed. Whether my *scale* of measurement was *right* or *wrong*, it of course would not, in the slightest degree, vitiate the relation of my tables. All of these, as I have before described, have been drawn from blood dried on glass slides, with the same object-glass, in all cases without collar-adjustment, or any variation of distance, or of any other circumstance whatever connected with the working of the instrument.

It certainly seems to me, however, no mean testimony to the accuracy of the old observers, that the thousands of measurements I have made, by my method, so closely coincide with theirs.

Prof. Beal says: "We should be slow in coming to a negative conclusion in opposition to the received authorities. The conclusions which have been arrived at are probably the result of very long and patient investigations."

I had thought I had finished this part of my subject in my first paper, but other matter has come up in the interval which seems relevant to it and is therefore necessary to its full elimination.

The reason for measuring the blood corpuscles in *two* different directions will be sufficiently obvious to any one who will undertake this sort of investigation. Blood corpuscles are so often irregular in form on the slide that sometimes it would be impossible to select a table of fifty, which would be anywhere near perfect in form, among many thousands of specimens.

Thus it happens in some of my tables, that the aggregate measurement in one direction will exceed the other by nearly an inch, which, of course, if taken as the true aggregate, would materially affect the final statement.

If there were no source of error in *adjustment* of the micrometer, &c., it seems to me that there would be great liability to such error in selecting "*perfectly formed*" corpuscles as they are brought in view by the movement of the stage of the instrument. This is well illustrated by the table of deformed corpuscles appended to my first paper. From this very group I have made a table of one hundred, moving the paper so as to bring the forms into line as nearly as possible, the points of contact of course causing great irregularity in the lines, and yet, notwithstanding this irregularity, this table gives precisely "the classical" $\frac{1}{3200}$ of an inch, as the average measurement of a single corpuscle. Since this, I have made several tables of these deformed corpuscles of

other animals than man, and have found them thus far as near the received average as those which chance to be less deformed, as they are seen on the glass slide. I may say that I have the drawings of all of these tables made in a permanent manner, so as to be preserved for future reference. I may quote with propriety here what Prof. Beal says upon the subject of making drawings of objects under microscopic examination. I do this especially, as in a recent case in court, involving this very question, in which the writer was called as a witness, the judge was asked by counsel to rule out this testimony on this very question of accuracy. It was admitted, however, as competent.

"In delineating an object, magnified by the microscope," says Beal, "it is important to copy it correctly, both as regards the relative position of the several parts to one another, and also with respect to size; this may be done by means of the Camera Lucida, with great accuracy."

As a further illustration of the necessity, where there is the least doubt in an inquiry of this nature of making a great number of examinations, I mention one case, where in a table of fifty-six corpuscles of dog's blood, I got an average measurement of $\frac{1}{3400}$ of an inch. From the same slide upon making two more tables I have an average of $\frac{1}{3575}$ of an inch, which is very near the received average. Had I come to a conclusion from this one table, I should have decided that the "authorities must, of course, be in the wrong." In comparing any other *organized* forms taken at random, such as coffee, beans, &c., placed in rows, occasionally one row will greatly exceed in length any other row of a large group. One author, in speaking of the subject, in a legal point of view, remarks: "We should not be too hasty in coming to a conclusion in regard to the average size of the blood corpuscles in specimens submitted for examination. We must remember that, like other organized forms, they differ in size, and that, therefore, in some cases we may chance to select a field where a preponderance of large globules may, from some cause, have grouped themselves, from which fact, if we should decide the case, we should, of course, fall into serious error; whereas, if we pursue the investigation by measuring a large number of forms, we could not fail to arrive at a correct conclusion." It is this habit of hasty generalization which has done much to throw discredit upon scientific truth. Thus in a recent trial of a case of poisoning, in one of our courts, doubt was

thrown upon a well-known and admitted scientific fact, for the reason that the chemist failed to find starch in the paper under examination, which starch was contained in the size with which the paper had been coated.

The same fact in regard to the variation of organic forms may be stated in respect to the smaller blood corpuscles, which sometimes from some inexplicable cause are seen to congregate in groups, excluding almost entirely the larger forms, so that in a few cases, during the course of my examinations, I could have selected such *groups* which, taken continuously, would materially affect any one of my tables.

A group of this kind occurs on the same slide from whence the large-sized table alluded to above was taken. From this group I have made a table of fifty-six corpuscles, the average measurement of which is $\frac{1}{3828}$ of an inch. This added to the table which exhibits the large average $\frac{1}{3400}$ of an inch gives $\frac{1}{3514}$ of an inch as the mean, which is within a very small fraction of the standard authorities.

I give here a table for reference of the measurement of the red-blood corpuscles of some few of the mammalia from Gulliver and Schmidt, and also my own, drawn and measured, as I have before described, after first settling the magnifying power of the object glass.

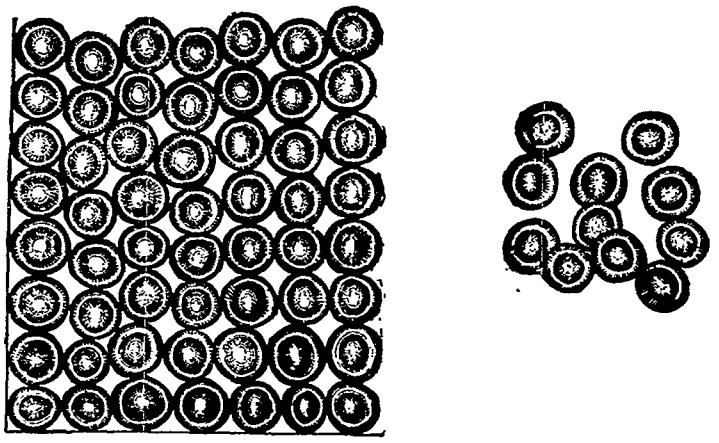
TABLE OF MEASUREMENT OF BLOOD CORPUSCLES.

	Observers.		
Blood.	Gulliver.	Schmidt.	Piper.
Human	1/3200 of inch .007940 Mill.	1/3269 of inch .007776 mm.	1/3265 of inch .007774 mm.
Dog	1/3542 " " .007160 "	1/3625 " " .0070 "	1/3525 " " .007147 "
Ox	1/4267 "		1/1433 " "
Horse	1/4600 "		1/4604 " "
Sheep	1/5300 "		1/5314 " "
Ourang Ou.	1/3300 "		
Whale	1/3099 "		
Fox	1/4117 "		
Cat	1/4404 "		
Elephant	1/2745 "		
Seal	1/3281 "		
Wolf	1/3600 "		

My measurement of dog's blood in this table is the average measurement from 3499 corpuscles from fifty-five different dogs.

Since writing my first paper I have drawn several additional tables of human blood, and also of dog's blood, which I have arranged in tables of *fifty-six* corpuscles; even these have been obtained from dogs of almost every variety. I have also made tables containing eleven hundred corpuscles of ox blood, one

hundred and fifty of horse's blood and two hundred and fifty of sheep's blood, besides quite a number of corpuscles from other animals. The amount of labor bestowed upon the subject by one of those who are called authorities (Gulliver) may be inferred when we consider the fact that he gives us as the result of his own labor the measurement of the blood corpuscles of six hundred species of animals.



I give here a plate showing the manner in which my tables are formed. This is drawn on a somewhat reduced scale. The small group shows precisely how the corpuscles are arranged on the glass slide on which the fresh blood was put and allowed to dry. In arranging the tables the paper is moved so as to bring the reflected images in lines as they are shown in the table.

Among animals having round blood disks, the elephant's are the largest. The sloth has them next in size. The whale has them somewhat larger than man.

Those of the common mouse are larger than those of the ox or horse.

The blood corpuscles of the frog, which are oval in form, are several times larger than those of man, and so are those of the humming bird, in the long diameter.

In addition to the drawings of corpuscles which make up my average tables, I have made tables of extreme large sizes selected from all these tables and directly from slides.

Dalton, in his Human Physiology, published A. D. 1875, says: "The largest size of human blood corpuscle observed measures

.009300 of a millimeter," $\frac{1}{2730}$ of an inch. The average measurement from my table of selected large-sized corpuscles, forty-nine in number, ninety-eight measurements, is .009342 of a millimeter, $\frac{1}{2716}$ of an inch.

This, as will be seen, is about the average size of the blood discs of the elephant. The largest sized corpuscle of dog's blood according to Gulliver measures .008863 millimeter, $\frac{1}{2900}$ of an inch. Dr. Woodward quotes Welker as recording the maximum measurement of human blood corpuscles as .0097 mm., $\frac{1}{2592}$ of an inch.

It will be seen by the tables that there is but little chance of the blood of any of the mammalia, if we except that of the dog, being called in question in legal cases, which could not be readily distinguished from that of man.

In making up my *last* tables of dog's blood, thirty in number, from twenty-five different dogs, the tables were *all* drawn as described, before *one* was measured. And, as will be seen, the largest average corpuscle of any one of the tables, made *without selecting*, is $\frac{1}{3515}$ of an inch, .7220 mm., which is considerably below the smallest average human corpuscle .007583 mm., $\frac{1}{3349}$ inch. I have now in my possession sixty tables of dogs' blood in all, drawn from fifty different dogs, and thirty tables of human blood, from twenty different individuals. The magnifying power used in all cases, as I have several times stated before, was 1275 diameters, and there is not a table of human blood among these which could not be distinguished at *a glance* from the *largest* table of dogs' blood of all the sixty.

In Dr. Woodward's tables of human blood from five different individuals, the *highest* measurement, $\frac{1}{3289}$ of an inch, .00772 mm., falls below the *average* given by Gulliver, $\frac{1}{3200}$ of an inch .007926 mm., while the *average* of all the other measurements, *twelve* in *number*, shows a still lower result, $\frac{1}{3378}$ of an inch .00751 mm., while his smallest average gives $\frac{1}{3472}$ of an inch .00731 mm.

On the other hand, from the same number of dogs the highest measurement is twice as much above the received authorities as the other is below, *e. g.*, $\frac{1}{3349}$ of an inch .00759 mm.—Gulliver giving $\frac{1}{3543}$ of an inch .007167 mm., the average of the other measurements being $\frac{1}{3467}$ of an inch, .00733 mm.

This statement of the average measurement of the human blood corpuscles being so much *below* the authorities, and of dogs so *much above*, is certainly not borne out of my tables.

Thus far I have shown, as I think, by methods which can be made evident to the eyes of every intelligent person, that in any given case of alleged homicide, where blood is put in evidence, and the average size of the blood discs of the same rounded form could be clearly seen to be above the largest average of dog's blood discs, we should be justified in coming to the conclusion that it was human blood, unless it could be proved to belong to those few species of animals, such as the seal or whale or some species of the monkey tribe whose blood discs are quite near in size to those of the human species.

Another method to the same end suggests itself which has not to my knowledge been proposed before; that is, when practicable to institute a comparison, between the extreme large sizes of human blood corpuscles and those of the animals whose blood should be put in question. As I have said before, I have found in some, if not in all of my examinations of human blood discs, some measuring as high as the average of those of the elephant and in a few cases somewhat larger. The *highest* quoted by Dr. Woodward, as I have before said, measured .0095 mm.; I have some in my tables which are a trifle above this. The largest blood disc of the dog mentioned by the same authority measured .0085 mm. The largest from my tables measures .00857 mm.

Here the difference between the *largest* human blood discs and those of the dog is greater than the difference between the average tables. Whether these large discs exist in every individual in sufficient numbers to determine the case, remains, so far as I am concerned, for further inquiry.

I have already found them in a number of instances, as I have before stated, and this induces me to pursue the subject still further. In regard to the shrinkage of blood corpuscles upon various substances and under different circumstances of drying, &c., this does not enter into the legal question at all. Of course if the professional man cannot find corpuscles large enough in a given case, this determines the question so far as his testimony is concerned, and merely shows his incapacity or the want of proper material with which to make his investigations. I have made three *full-sized tables* of one hundred and forty-seven corpuscles taken from one side of the blade of a knife, while on the other side they had shrunk to one-half the natural size, owing I think to that side being rusty and the loose particles of rust allowing the blood

plasma to slide, as it were, in drying. In another case, after working all day in examining blood spots on an unglazed card without success, all the corpuscles seeming to have shrunk to one-fourth the natural size, I found one spot of some forty *full-sized discs*, of which I made drawings.

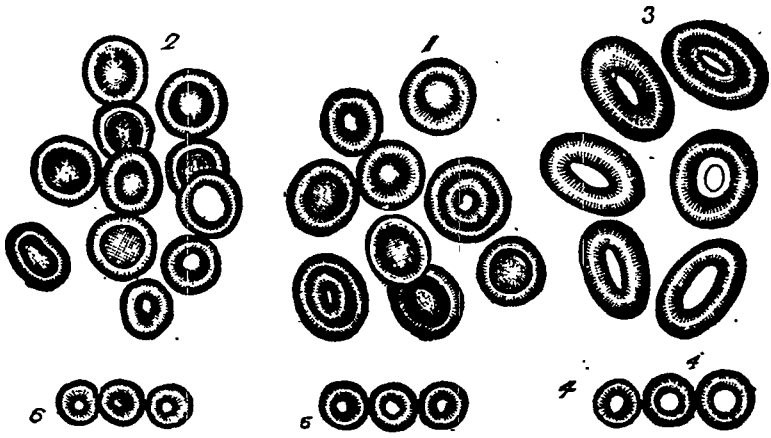
As I have said before, each individual case, so far as the legal question is concerned, must rest upon the exhibition or non-exhibition of full-sized corpuscles. And this again rests upon the fact whether the blood spot can by any means be shown to be that of the animal involved in the question.

To show the minute quantity of blood required under favorable circumstances in order to arrive at a certain conclusion, I quote from Dr. J. G. Richardson, as follows: "Upon a square of waxed paper determined by Mr. Eckfeldt on the accurate balance used for the national assays to weigh exactly 48 milligrammes, I made twenty drops of fresh blood from my finger, which, when dry, added .4 of a milligramme to the original weight, and consequently were each on an average equivalent to about .02 of a milligramme or $\frac{1}{3200}$ of a Troy grain nearly. The fourth part of one of these spots, weighing of course in round numbers $\frac{1}{12000}$ of a grain, was detached with the point of a cataract needle, and when moistened under the $\frac{1}{25}$ object glass, showed *many hundred* well-defined red-blood corpuscles. Ten *circular* ones amongst these, measured with the micrometer, averaged $\frac{1}{3472}$ of an inch in diameter, and could therefore by this criterion of superior size alone be diagnosticated from the corpuscles of an ox, sheep or pig with the same feeling of certainty with which any surgeon could testify that a perforation of the skull only half an inch across could not possibly have been made by a bullet measuring an inch in diameter."

And I think I may feel warranted to add to this, as the result of my own investigations, that the blood corpuscles of man may be distinguished from those of the *dog* with a like degree of certainty.

I add to this groups of corpuscles of some of the animals mentioned above. The first three groups are drawn precisely as they appear on the slide magnified 1275 diameters. No. 1. Human blood; No. 2. Dog's blood; No. 3. Hen's blood.

It does not seem as if it would be very difficult to distinguish the group of human blood in this case from either of the others. No. 4. Ox's blood; No. 5. Horse's blood; No. 6. Sheep's. These



are drawn very near to the *average* size. They are magnified the same number of diameters as the other three. Since writing this paper, I have, through the kindness of Professor Freer, of Rush Medical College, had the opportunity to examine the blood of a boy of thirteen whose foot was crushed by a rail car. Of this blood I have made two tables of 135 corpuscles each, drawn as in all cases from continuous groups on the glass slide. It is curious to notice in what manner these corpuscles sometimes group themselves. The average measurement deduced from both tables, consisting of 270 corpuscles, is the $\frac{1}{3353}$ of an inch. While some groups of six or seven average $\frac{1}{2814}$ of an inch, .0097 mm. in diameter, others of like number measure but $\frac{1}{3985}$ of an inch, .006345 mm. These it will be remembered are *continuous* groups, the corpuscles nearly or quite touching one another on the glass slide. In these two tables may be found at least twenty corpuscles which measure far above the highest *claimed* for the dog, and would of course, if this should be the fact, settle the case.

I ought perhaps to remark here that I have not spoken of the *white* corpuscles of the blood. These exist in varying proportions under differing conditions of the system; ordinarily one to three or four hundred of the red corpuscles it is believed. They are larger than the red-blood globules, and in the dried state have been mistaken for them. Indeed I have one slide of this character in which this mistake was made. This is of *dog's blood* and in some fields on the slide the white corpuscles are more numerous than the red ones; I have made a table of this case, and, as will be seen, it would not be difficult to make out a *high average* from this