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RESEARCHES ON THE COMPOSITION OF THE BLOOD IN HEALTH AND IN DISEASE: A MEMOIR PRESENTED TO THE ACADEMIE DES SCIENCES, PARIS, Nov. 18, 1844.

By A. Becquerel, M.D., and A. Rodier, M.D.

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In physiology and pathology, as in every science, the observer and the experimentalizer, after having scrupulously proved and weighed the facts which have been obtained, should endeavour to discover what they have in common with each other, that he may establish therefrom general laws and principles. Such is the object which we have in view, whether in the observations which we have made and collected at the bedside of patients, or in our various analyses of the blood, and which we have prosecuted, without any pre-conceived opinions, and without anticipating in any way the general results at which we have arrived.

These general results are few, and they express certain influences common to a state of health and disease, or peculiar only to the latter.

The first, that is those which are common to the normal and the morbid state, are four in number:—First, sex; second, age; third, constitution; fourth, diet. We ought here to add that of pregnancy, which is merely the development of a physiological function; and we shall first attentively consider the composition of the blood in the normal state, under these five different circumstances.

The influences which are peculiar to disease are more numerous, and may be summed up under eight laws, which, either alone, or variously combined, to the number of two, three, or four together, regulate, to a certain extent, the composition of the blood in all diseases. We shall endeavour to reduce them to a tabular arrangement, based upon exact calculations, and the knowledge thus obtained will in some measure constitute the general pathology of the blood. The special pathology will be afterwards considered in treating of the composition of the blood in the principal varieties of disease.

COMPOSITION OF THE BLOOD IN THE NORMAL STATE.

When it is wished to study the modifications which the blood is capable of undergoing in disease, it becomes necessary to have a fixed and well-determined starting point. This point is the knowledge of its composition in the normal state—a basis which must be established by the researches of the same experimentalist, since otherwise the results cannot be compared with sufficient certainty. This has not hitherto been done, and this it is which, in spite of its great difficulties, we have ourselves undertaken. It is not easy to procure blood from perfectly healthy individuals, nor can we readily find those who will submit to being bled to twelve or fourteen ounces, either for the interests of science or for a pecuniary consideration, which it would be culpable to offer. The plan which we have adopted is as follows:—We have attended for three months, from the first of April to the first of July, 1844, the public consultations of the Hôpital de la Charitè, where may frequently be seen during the period of spring, men and women who come to be bled, having acquired this habit, although in perfect health, under the idea of preventing a disease which exists only in their imagination. Some of these individuals were plethoric; and we have been careful not to consider them as healthy: but in examining the others with the greatest attention, and noting their physical characters, their constitution, &c., we have been able to meet with nineteen perfectly healthy—eleven men and eight women. These individuals have supplied the physiological part of our labour, and upon an analysis of these nineteen bleedings, which have furnished us with very similar results, we proceed to form a basis for ascertaining the composition of the blood in the normal state, in man and woman. This investigation will lead us to establish the four influences which we have above alluded to, as capable of modifying the normal composition of the blood, without any deviation from health. Of these four influences, one,—that of sex, is of the first importance; the three others,—those of constitution, age, and diet, are much less so.

In consequence of the numerous differences in the normal composition of the blood, attributable to sex, we shall separately examine this fluid in the male and female.

NORMAL COMPOSITION OF THE BLOOD IN MAN.

In order to establish that the eleven individuals bled were in a satisfactory state of health, it is indispensable that we should give a rapid sketch of the condition in which each was placed. They were aged—one 21, one 22, two 23, one 24, one 28, one 33, one 38, one 53, one 55, and one 66 years. They pursued the following avocations:—One locksmith, one cabinet-maker, one domestic, two coachmen, one upholsterer, one water-carrier, one carpenter, one mason, one painter, and one student. Ten stated that they were in comfortable circumstances, and content with their station; one only was in poverty. Of these eleven, eight declared that they were of a strong constitution,

and their physical characters confirmed the statement; three were of ordinary constitution. The colour of the skin and of the hair and eyes, was carefully noticed; it would be useless here to give the result of the two latter. As regards that of the skin, in five cases it was noted to be brown, in three white, and in three intermediate. Two of the subjects were of stout make; three, on the contrary, were spare; and six enjoyed the happy medium. Ten were well nourished, partaking of meat and drinking a little wine daily; one only acknowledged excess in spirituous liquors. The eleventh pretended he was ill-nourished: this was the one most advanced in years. The previous health of all had been variable; but we shall pass over the details which they gave us on this head, as of little interest here.

With regard to the direct cause of each being bled, the following are the facts:—Four were bled on account of habit, (for many past springs, they said they had been accustomed to loose blood;) two for a slight cold, which had lasted for about a month; two for a cutaneous eruption, (one lichen, one acne,) which they attributed to the blood, (it was at their express desire and to anticipete this they were bled;) one for a slight pleurodynia; one for a contusion of the eye; one from having fancied that his expectoration in the morning had been streaked with blood; he doubted it, however, but from excess of precaution wished to be bled. Such is a concise history of these individuals. The following table represents the mean composition of the blood in these eleven cases, as also the maximum and the minimum:—

COMPOSITION OF 1000 GRAMMES OF BLOOD IN HEALTHY MAN.

	Mean.	Max.	Min.
Density of blood deprived of its fibrine	1060.2	1062.	1058.
—— of serum	1028.	1030.	1027.
Water	779.	760.	800.
Globules	141.1	152.	131.
Albumen	69.4	73.	62.
Fibrine	2.2	3.5	1.5
Extractive matters and free salts	6.8	8.	5.
Fatty matters	1.600	3.255	1.000
Seroline	0.020	0.080	
Phosphurated fatty matter	0.488	1.000	0.270
Cholesterine	0.088	0.175	0.030
Soap	1.004	2.000	0.700

IN 1000 GRAMMES OF CALCINED BLOOD.

Chloride of Sodium	3.1	4.2	2.3
Soluble salts	2.5	3.2	2.0
Phosphates	0.334	0.7	0.225
Iron	0.565	0.633	0.508

From the above table we may draw some important conclusions:—

1st. The limits between which the composition of normal blood varies are but of slight extent; the differences observed being probably dependent upon conditions of constitution, age, and alimentation.

2nd. The figures affixed to the globules constitute a greater number than 127, which is generally received as expressing the physiological mean. We shall explain, further on, the cause of this error, which is owing to no distinction having been made between the blood of man and that of woman, and to the fluid submitted to analysis to obtain this mean, not being indubitably drawn from healthy individuals. M. Andral, in his first memoir, read at the Institute, cites three cases which are entirely in favour of our number—141,1.

3rd. The number representing fibrine is below that generally admitted; (3;) and we are very certain that it is exact, from having been obliged to justify it.

As to the remaining numbers, we may admit them without discussing the differences which they present with those, more or less exact, given by other authors.

Let us now endeavour to discover the influence exercised by age, constitution, and alimentation. It is probable that these three important conditions exercise a certain control over the composition of the blood; and although the results which we have obtained from our analyses are so similar, that this proposition may appear somewhat exaggerated, we can easily account for their analogy by considering our choice of subjects, and reflecting that we have only selected individuals of good constitution, in good health, and in the enjoyment, (with one exception,) of wholesome and nourishing food.

1st *Age.*—We do not possess any analysis of the blood prior to the age of twenty, and therefore we shall not attempt to establish any conclusions in regard to this period of life. From twenty to thirty we have endeavoured to discover the mean results; they have appeared to us perfectly similar to those generally received. From thirty to forty, all the numbers are either the same as the usually accepted mean, or are comprised within the limits of the maximum and the minimum. The only regular increase is in the numbers representing cholesterine, which are nearly double. From fifty to sixty-six, which is the most advanced age of those upon whom we have made experiments, we find very little difference; the fibrine, however, is slightly diminished, and its mean, by which it may be represented, does not exceed two. The cholesterine is indicated by a number a little above that of the middle period of life.

The proportion of all the other principles is within the limits of the normal state.

2nd. *Constitution.*—The results obtained under this head are almost null, for all the healthy individuals from whom blood was obtained, were, generally speaking, of good constitution. We have, however, drawn up two tables of the mean, the one comprising those of good and very strong, the other those of an equally good but less vigorous, constitution. These two tables differ but little in their results, the mean calculations being the same almost to a fraction. Notwithstanding these data, the numbers obtained in the state of disease establish the fact, that when the constitution is more feeble, the number of the globules slightly diminishes, as also the quantity of albumen, but to a much less degree. In short, the blood is less rich in solid materials.

3rd. *Alimentation.*—Without doubt, diet exercises a very remarkable influence upon the composition of the blood, but on which, nevertheless, we cannot here determine, since all our experiments have been made upon individuals, well nourished, it is true, but fed as common workmen usually are, and all in nearly the same manner. In order to directly ascertain this influence, the blood of a single individual should be examined some time after he has submitted to a particular kind of nourishment; and the same series of experiments must be made in a sufficient number of subjects. Such an under-

taking is almost impossible, from the difficulty of finding persons who will consent to undergo so long a series of physiological operations. The influence of the privation of food on the composition of the blood, may be appreciated, from analogy with what takes place in disease: this analogy compels us to admit that diminution of nourishment has the effect of very evidently lessening the proportion of globules, and slightly also that of its other principles, particularly the albumen. There is only one exception to this rule, the cholesterine, which usually increases under the influence alluded to. We shall have occasion to revert to this remarkable fact when considering the effect of disease.

It has been stated that the quantity of chloride of sodium decreases in a remarkable manner whenever the individual is dieted, or at least undergoes a diminution in the quantity of his food. This is a proposition which we believe to be neither exact nor well founded, for in health, as in disease, we have always found the variation in the quantity of this salt contained in the blood to be extremely small.

COMPOSITION OF THE BLOOD IN THE NORMAL STATE IN WOMAN.

It is desirable that, as we did with the eleven men, we should here also present a correct and concise history of the eight women, from whom we obtained blood to make our experiments.

These women were severally aged: one 22, one 25, one 26, two 33, one 36, one 53, and one 58 years. They pursued the following avocations: one was a washerwoman, one a servant, two were dress-makers, one a milliner, two house-keepers, and one a market-woman. Seven stated that they were in very comfortable circumstances; one only had reason to be dissatisfied with her condition.

With respect to their diet, we may lay it down as a fact, that in women, as in all the working-classes of that sex in Paris, the nourishment is much less substantial than that of the men, and that but few of them partake of wine.

The colour of the skin in four cases was brown, in four, white.

The constitution was noted to be strong in three, in five, good, but a little less vigorous than in the preceding.

Three were of an ordinary *embonpoint*, three were stout, and two were spare.

Of these eight women one was irregular, (the one aged 22,) one had never menstruated, (aged 25,) four were perfectly regular, (aged from 26 to 40,) lastly, two, (aged 53 and 58,) had passed the turn of life.

Some of these women had been previously ill; others had never been so: their history, antecedent to the present period, would here be useless.

They were bled for the following causes: four from habit, and really without there appearing to be the least necessity for it; two for a pain in the head, without any signs of plethora; one for amenorrhœa; and one for a lichenoid eczema of the arm.

The following are the results furnished by analysis.

COMPOSITION OF 1000 GRAMMES OF BLOOD IN HEALTHY WOMAN.

	Mean.	Max.	Min.
Density of blood deprived of its fibrine	1057.5	1060.	1054.
—— of serum	1027.4	1030.	1026.

COMPOSITION OF 1000 GRAMMES OF BLOOD IN HEALTHY WOMAN.

Water	791.1	773.	813.
Globules	127.2	137.5	113.
Albumen	70.5	75.5	65.
Fibrine	2.2	2.5	1.8
Extractive matter and free salts	7.4	8.5	6.2
Fatty matters	1.620	2.860	1.
Seroline	0.020	0.060	
Phosphorated fatty matter	0.464	0.800	0.250
Cholesterine	0.090	0.200	0.025
Soap	1.046	1.800	0.725

IN 1000 GRAMMES OF CALCINED BLOOD.

Chloride of Sodium	3.9	4.0	3.5
Soluble salts	2.9	3.0	2.5
Phosphates	0.354	0.650	0.250
Iron	0.541	0.575	0.486

These numbers, compared with those supplied by the analysis of normal blood in man, lead to some important conclusions. We first observe that the figures resulting from these eight analyses resemble each other somewhat less than those obtained from the male, and that the limits comprised between the maxima and minima are more extended. It is difficult to assign any cause for these individual differences; we are content with establishing the fact, which is incontrovertible, and which we see also to happen in disease.

The mean density of the blood, deprived of its fibrine, is less than that of man; the blood also of woman, in general, contains more water, and is less rich in solid materials.

The mean density of the serum is the same in the two sexes.

The proportion of globules is less in the female than in the male, and in this diminution, especially, consists the fundamental difference between the two species of blood. In the former, the mean number to indicate the globules is 127, the maximum 137, the minimum 113; in the latter, mean 141, maximum 151, minimum 131.

The proportion of fibrine is almost the same in man and woman.

The quantity of albumen is the same in both sexes.

The seroline presents the same character of irregularity.

The phosphorated fatty matter, (cerebrine,) exists in almost the same quantity; so also the cholesterine and saponaceous fats.

In woman, as in man, the quantity of cholesterine increases with advancing years.

The chloride of sodium and the various soluble salts are almost in the same proportion in both sexes.

The weight of the iron is always in proportion to that of the globules.

The influence of menstruation on the composition of the normal blood in the female is very considerable, and is especially exercised upon the globules. The following is the result of a minute analysis of the facts of which we are in possession. Prior to the establishment of menstruation, the proportion of the globules is below the mean, 127; if it is not well established, or is incomplete and irregular, the number remains below the mean; from the time that this function is perfected it ascends, and then varies between 127 and 137; when the critical period arrives and menstruation ceases, the number again decreases; thus at one time we see it at 113, at another at 121, even though

the health may be always unimpaired: it was thus in the cases which we have collected. The influence of age, so to speak, is pourtrayed in the female by that of menstruation.

Constitution and alimentation very probably exercise some influence over the composition of the blood, and here, doubtless, the reason of the numerous individual differences to which we have alluded must be sought for; but the facts which we possess are not sufficient to enable us to treat of these questions or to determine the positive value of this influence.

OF THE BLOOD DURING THE PERIOD OF PREGNANCY.

Pregnancy exercises a very remarkable influence on the composition of the blood, which may be thus expressed:—a diminution in the globules; a diminution of the albumen; a slight increase in the fibrine and phosphorated fatty matter; an increase in the water.

In order to determine this influence with precision, we have analysed the blood in nine cases of advanced pregnancy, free from complications. The following is a short summary of their history:—

Of these individuals; two were aged 20, two 22, one 25, one 27, one 29, one 34, and one 41 years.

Five of them were strong and robust, two were of ordinary, and two of feeble constitution, having a lymphatic appearance.

The skin of two was brown; in two, also, it was white and delicate; and in five it partook of both characters.

Of these nine women, three were stout, two spare, and four mediocre.

Six were in comfortable circumstances, being well nourished, and living in healthy localities; one was in less easy circumstances; and two were unfortunate.

Six were in the enjoyment of excellent health, if we except the symptoms of plethora, for which they were bled; two were not quite so free from all ailments; one came to the hospital for wandering pains in the abdomen, and a cough which she had had for some little time, but which was of no importance.

They had reached the following periods of uterine gestation: one, four months; four, five months; one, five months and a half; one, six months; two, seven months.

All were bled, merely beause they felt the want of it, and on account of actual plethora, positively indicating the propriety of bleeding.

In three only could a *bruit de souffle* be heard in the carotids; one being five, the two others six months advanced.

COMPOSITION OF HEALTHY BLOOD DURING THE PERIOD OF PREGNANCY.

	Mean.	Max.	Min.
Density of blood deprived of its fibrine	1051.5	1055.1	1046.2
—— of serum	1025.5	1026.8	1023.6
Water	801.6		
Globules	111.8	127.1	87.7
Albumen	66.1	68.8	62.4
Fibrine	3.5	4.	2.5
Extractive matter and free salts	6.6	8.7	4.7
Fatty matters	1.922	2.519	1.158
Seroline	Variable	0.108	0.018
Phosphorated fatty matter	0.646	0.863	0.381
Cholesterine	0.061	0.225	0.030
Soap	1.195	1.323	0.737

IN 1000 GRAMMES OF CALCINED BLOOD.

Chloride of sodium	3.2	3.9	2.3
Soluble salts	2.4	2.8	1.8
Phosphates	0.425	0.690	0.282
Iron	0.449	0.490	0.370

From this table we may draw the following conclusions:—In a certain number of cases of pregnancy, when it is not very far advanced, and has not as yet exercised any very appreciable influence upon the living organism, the composition of the blood is not altered; in proportion as utero-gestation approaches its full period, the circulating fluid generally becomes modified.

It undergoes the following alterations:—Diminution of density, when deprived of its fibrine, and a diminution in the density of the serum; increase in the proportion of water; very remarkable diminution of the globules; (mean, 112.6;) slight augmentation of fibrine; diminution of albumen in the serum; increase of phosphorated fatty matter, which we generally see to be more abundant when the blood is impoverished. The normal proportion of cholesterine was preserved, or there was a very slight diminution. No change in the calcareous salts.

The mean of the three cases in which the *bruit de souffle* was noticed, was not sensibly different from the general mean: the proportion of the globules was alone a little under, (105, instead of 112,) and that of the phosphorated matter slightly increased. (0,724, instead of 0,632.)

Before concluding, it should be observed, that all these pregnant women, although the blood was notably modified and impoverished, were not on that account the less plethoric: all complained of cephalalgia, vertigo, and tinnitus aurium; in some there was somnolence and general sluggishness, and all were greatly relieved by the blood-letting. Lastly, these modifications of the circulating fluid, more marked towards the close of the period of uterine gestation than at the commencement, should be taken into consideration, to explain certain phenomena of the puerperal state.

(*To be continued.*)

OBSERVATIONS ON PORRIGO, WITH REFERENCE TO SOME RECENT STATEMENTS MADE BY DR. CORRIGAN.

By PHILIP HENRY WILLIAMS, M.D., Worcester.

In a lecture by Dr. Corrigan, of Dublin, published in the *Medical Times* of the 7th instant, are some singular statements in reference to the cutaneous diseases, Impetigo and Porrigo, to a few of which statements I beg to draw the attention of your readers.

"All the writers," says Dr. Corrigan, "on diseases of the skin, from Willan to Bateman, and Bateman to Biett, have erred in their description of porrigo; in fact, they seem to know nothing whatever about it, for under the head of porrigo they have described various diseases differing from it in every particular. Under the name of porrigo they have described various forms of impetigo, as it attacks the scalp and other parts of the body, while they have not given a history of porrigo as it really presents itself. Bateman, in his clever work on skin diseases, has made no less than five varieties of porrigo, namely, porrigo larvalis, p. favosa, p. scutulata, p. decalvans, and p. lupinosa."