Farther observations on the state of the blood after taking food.

FARTHER OBSERVATIONS ON THE STATE OF THE BLOOD AFTER TAKING FOOD.

BY

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Last year I read to the Society a memoir "On the White or Opaque Serum of the Blood;" the object of which was to show, that after a meal consisting of various articles of food in common use the serum of the blood becomes white or otherwise discoloured, and continues in that state for a period, longer or shorter according to circumstances. It could not be determined, from the observations then narrated, whether this discolouration be produced by every sort of food, or follow only certain kinds of it. The present communication is principally intended to supply that deficiency, by giving an account of the effects of various simple alimentary principles, or definite combinations of such simple aliments upon the colour of the blood.

Another object which I have kept in view is to give an account of a white substance different from that which gives the opaque colour to the serum of the blood, but which closely resembles it in appearance, and exists in the serum still more generally and in greater abundance. It first became known to me in the course of these investigations. It exists both in the opaque serum and in that which is transparent, and is precipitated by supersaturating the liquid with common salt, or with sulphate of soda and certain other salts to be hereafter mentioned. It is characterised by being immediately re-dissolved on adding a little more water than sufficient to re-dissolve the excess of salt, while it is again precipitated by adding the salt to supersaturation.

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I intended, farther, to have discussed the question of the existence in the blood of a fermentable principle, yielding carbonic acid gas on being treated with yeast; and had made a great variety of experiments with that object in view: but not having had sufficient time to repeat those experiments, so as to satisfy myself as to the true interpretation of them, I have omitted the subject altogether, except where it is incidentally introduced.

The investigations were conducted, as formerly, by examining the blood drawn from persons, who, after fasting from sixteen to twenty-four hours, had taken a full meal consisting of some simple aliment, or combination of such aliments. I shall narrate the observations nearly in the order in which they were made; and, as nearly as possible, in the words in which they were originally recorded; as there will be less chance of error in this way than if I attempted to arrange and abridge them. I conceive, also, that a detailed account of these observations may not be without use to those who shall hereafter, I hope with better success, engage in similar inquiries: an object which should be kept more especially in view by physiologists, as their observations cannot, like experiments in the physical sciences, be repeated at will, but require opportunities not always to be obtained, and of which, therefore, the most ought to be made. This must also be my excuse for introducing sundry observations on the state of the blood not immediately bearing on the subject of this memoir.

I begin by giving an account of the effects of Gelatin on the blood, with respect to which two series of observations were made.

Gelatin.—On the 2d of April, 1844, two stout men (to distinguish whom I shall employ the letters A. and B., as I shall employ other letters in the same way hereafter,) after fasting sixteen hours, had each for dinner two English pints of strong beef tea, (veal soup was intended, but could not be had,) and half-a-crown's worth of calf-foot jelly, being about the same measure of jelly. Each of them lost a few ounces of blood three hours after the meal, and the same quantity six hours after it.

The serum of the blood first drawn from A. was opaline, but translucent; and exhibited nothing remarkable under the microscope. That of the blood last drawn was very milky, being so opaque that the brightest light could not pass through it; and under the microscope it showed innumerable very minute amorphous particles, almost none of them being spherical. The coagulum of this blood was natural, while that of the former was mottled, but without any translucent crust, the mottling being as if from the intermixture of florid and black blood.

The serum of the other man's blood was much more abundant. That from the first bleeding was opaline, but less so than the corresponding serum of A. That from the second bleeding was more opaline, but still translucent in a good light. The coagulum of the latter was natural, while that of the former had a well-marked crust of transparent fibrin.

Common salt was found to separate a white cream not only from the milky serum, (A. at six hours;) but likewise from the three opaline specimens—of which the explanation will be found below.

These observations are alluded to in the last memoir, having been made immediately after it was submitted to the Society, but before

it was printed. The conclusions to which they appeared to lead, when taken in connexion with the other observations there narrated, were, *first*, that the azotized articles of food, after being digested in the first passages, and absorbed into the blood-vessels, were found there, in the first instance, as the white substance which gives to the serum of the blood its milky colour; *second*, that oily substances appeared to contribute to the formation of the white matter; and, *third*, that most of the other non-azotized articles of food probably existed in the blood in the form of sugar. These conclusions were not, indeed, formally stated, because they were by no means established, and will indeed be shown below to be to a certain extent incorrect; but I mention them here, as they give the clue to the experiments now to be described, which were undertaken with the view either of confirming or overturning the hypotheses just stated.

The object of the first trial was to determine whether Starch—a non-azotized substance—made the serum white, and whether the serum was fermentable. Arrow-root was selected as one of the purest forms of starch; and as the conditions to be fulfilled forbade its being sweetened with sugar in the usual way, it was seasoned with aromatics to correct its insipidity.

Arrow-Root.—On the 12th of April, C., after fasting sixteen hours, had for dinner arrow-root, made with water, and seasoned with mace and nutmeg. He took from half-a-pound to a pound of it. He was bled at three and at six hours after the meal. The serum in both instances was quite transparent, without any white matter. The coagulum at three hours had a thick translucent fibrinous crust, marked with numerous red dots: that at six hours was natural. This man did not feel again hungry so soon as the men fed with gelatin, as if the latter substance were dissolved in the stomach more rapidly than arrow-root.

The serum treated with yeast evolved carbonic acid gas in abundance, as did also the crassamentum liquified by expression through a linen cloth.

It thus appears that pure Starch, taken as food, gives no white colour to the serum of the blood. This conclusion may be considered as established, as it will be seen below that the experiment was repeated three times, and always with the same result.

I now proceeded to test the hypothesis farther in reference to azotized food.

Eggs and Milk.—On the 30th April, 1844, D., after fasting eighteen hours, had at noon a pudding, consisting of six eggs and a pint and a half of milk. He was bled twice, to the extent of eight ounces. The blood first drawn, three hours after the meal, gave but a small quantity of serum, which was opaline, resembling whey. The serum of the blood last drawn, at seven hours after the meal, was much more abundant. It had less whiteness, but still was not clear, being brownish like syrup, an appearance I have since found to depend frequently on the presence of a very minute quantity of the red part of the blood. The crassamentum of the blood first drawn had the translucent fibrinous crust well marked: that of the blood last drawn was natural.

Both specimens of serum showed, under the microscope, a few spherical granules. On adding salt to that marked *D. 3 hours*, a white matter immediately rose to the

surface, and continued there some days without showing any tendency to fall to the bottom. The other specimen marked *D. 7 hours*, gave, on the addition of salt, much more of the white matter than its colour led me to expect, and, as in the former case, the white matter showed no tendency to precipitate. In this respect, as well as in general appearance, the white matter resembled closely a very abundant specimen which I accidentally procured more than four years ago, and which has continued at the top ever since, although the phial has been frequently uncorked. I do not know from what diet it proceeded, but the present and two other trials mentioned below seem to me to render probable that it may have been from eggs.

I was particularly struck with the difference in the quantity of serum procured by these two bleedings, practised upon the same person, with an interval of only three hours; that from the latter being about quadruple that from the former. I at first supposed that a large quantity of liquid must have been taken in the interval, but on inquiry I found the man had taken no drink of any kind. The small quantity of the serum in the first case, therefore, was probably entirely owing to the cup in which the blood was received being very full, and the surface covered with air-bells. These air-bells cause the coagulum to adhere to the rim and sides of the cup, and thus prevent the separation of the serum. I have since more than once observed a similar deficiency from the same purely mechanical cause.

Fibrin.—On the same day, E., after fasting the same length of time as D., had a pound and a half of beaf steak, carefully freed from fat. He was bled at the same periods after the meal. The relative quantities of serum from the two bleedings were here reversed; that from the latter bleeding being considerably less in quantity, and apparently from the same cause. The serum at three hours was of the colour of whey; that at seven hours had the same hue, but less intense: in the former a few globules were seen with the microscope; in the latter numerous irregular particles. On adding as much salt as it could dissolve to the former, it immediately became quite opaque, and showed large flocculent white masses floating through it, which, however, had no tendency to ascend, and at length fell to the bottom. But for this last circumstance, the appearances would have been very much the same as are observed on adding water to an alcoholic solution of Camphor. The other specimen of serum was treated in the same way, with a similar result, only the flocculent precipitate was much less abundant.

The coagulum of the blood first drawn had a fibrinous crust: that of the last drawn none.

Two conclusions may be drawn from these last experiments: first, that the effect of the salt is not merely mechanical, but a true chemical precipitation; and, second, that the white matter proceeding from different kinds of food is probably not always the same, since in some cases it seeks the bottom, and in some the top. Subsequent trials tended to confirm both these conclusions.

As this is the first time I have had occasion to mention the action of salt in causing precipitation from serum, I shall here explain the mode in which the salt requires to be employed: as the process will thus be more readily comprehended, than if I left the knowledge of it to be gleaned in the way I myself learned it, from the experiments to be hereafter mentioned.

In the former memoir I described the action of salt in separating the white matter of milky serum to be purely mechanical, increasing the specific gravity of the liquid, and thus causing the solid particles diffused through it to rise to the surface. This I still believe to be the true mode of action of the salt, whenever it is added in less quantity than the serum is capable of dissolving; but no sooner is the salt added to saturation than it acts in a totally different way, and becomes a true chemical precipitant. This I was led to find out from my having adopted it as a consequence of the mechanical theory above stated, that the heavier the serum was made the more readily would the separation of the white matter take place; and expecting on this principle to obtain at once a maximum effect, I added the salt till a portion of it remained at the bottom undissolved. Operating thus, I was surprised to observe the great increase in the quantity of the white product, which, as stated above, was much greater than could have been anticipated from the whiteness of the serum, and I even found afterwards that it could be obtained in as great abundance from serum which was perfectly limpid. I was thus assured that the salt added to saturation did not act in a mechanical way, but acted as a true chemical precipitant.

To the white substance thus obtained I gave, provisionally, the name of *Pabulin;* on the supposition that it proceeds from the alimentary matter or pabulum, which has just undergone digestion in the first passages. This name will accordingly be employed below to designate the white substance obtained from the blood by the process just described, or by analogous processes to be hereafter mentioned. This however is only done for convenience, and without prejudging the questions as to the origin of the matter so designated, and its relations to the white matter which gives the milkiness to the blood.

Eggs.—On the 20th of May, F. had for dinner six eggs, which were eaten without any other accompaniment than a little salt. He was bled at two and at four hours after the meal. The serum was small in quantity in both cups, which were very full, and with the coagulum adhering, by means of froth, to the edges, so that the whole serum lay on the surface of the coagulum. It was deeply tinged red.

The serum from the blood first drawn was kept two days, that the red matter of the blood might subside from it. During that time it threw up a cream spontaneously. On filtering it, the white matter and a little oil were left on the filtering paper: the latter being shown, as formerly, by drying the paper. The filtered liquid was quite transparent, but on adding salt to supersaturation, a greyish sublimate separated, showing that the salt acted as a precipitant, if indeed that name may be applied to an agent separating a matter which swims on the surface.

The serum from the blood last drawn threw up no cream, although kept the same time as the other specimen. On adding salt in the usual way, a sublimate separated so abundant as to be equal to about one-fourth of the whole liquid in volume. It was loose and flocculent; greyish, like chewed meat; or more strikingly still—(although the physician only can appreciate the comparison)—like the characteristic discharge from the bowels in dysentery. It continued several days at the top, with no tendency to subside. It was then skimmed off, and a part of it left behind

subsided probably from the agitation. The sediment thus produced was completely redissolved on adding water, the solution being then quite transparent, but on again saturating with salt becoming turbid.

The coagulum was, in both cups, natural.

Casein.—On the 29th of May, G. having taken no breakfast, had at 11 A.M. a Scotch pint of curds, (two English quarts nearly.) He was bled at two, and at four hours after the meal. The serum in both cups was very abundant, being after thirty hours about equal in volume to three-fourths of the whole blood drawn. That in the first cup was the most abundant, and the corresponding coagulum had a thick buffy coat. The other coagulum had only a trace of a paler fibrinous crust.

The serum in both instances was turbid; but that was owing to a minute quantity of red colouring matter, which, subsiding in six hours, left both liquids beautifully transparent, that from the blood first drawn having a greenish, while the other inclined to a yellow tint. Salt added to supersaturation gave an abundant precipitate, which partly rose to the surface, buoyed up by minute air-bells, but was chiefly diffused through the liquid in voluminous flocks, and at length the whole subsided to the bottom.

The transparent liquid placed under the microscope was observed to contain some minute entozoa (vibriones), although it was quite fresh. This was forty-six hours after the blood had been drawn, the weather being coldish at the time. I once before saw the same animalcules in blood taken from a man after a fast of sixteen hours. They were elongated, and of very rapid movement, and not accompanied by any of the globular and elliptical infusoria which commonly show themselves first in organic liquids undergoing decomposition.

Thinking that other salts naturally contained in the serum, and therefore not likely to interfere with its chemical equilibrium, might cause a precipitate like common salt, I tried phosphate of soda, but on adding it to supersaturation it did not at all affect the limpidity of the serum; and on afterwards adding common salt, the usual effect was produced. I tried also bicarbonate of soda, but with no better success; and my stock of serum being exhausted, I abandoned the inquiry, but, as will be seen below, without losing sight of it.

White-Fish.—On the 2d of June, H., after fasting the usual time, had four pounds of white-fish, of which he took a large proportion, with no other accompaniment than a little salt. He was bled at two, and at four hours after the meal. The serum on both occasions was scanty, obviously owing to air-bells on the coagulum, which had caused it to adhere to the edge of the cup almost all round. The coagulum was red on the surface, and very loose in texture from retained serum. The serum in both cups was quite transparent, and on being supersaturated with salt, gave a voluminous precipitate like that from milk already described.

These two last experiments fully satisfied me, that partaking freely of a highly azotized diet does not necessarily occasion any milkiness in the serum of the blood. It appeared to me, however, probable, that the white matter which in these instances was precipitated by the salt, was the very same that in other circumstances causes the serum to be milky, the only difference being, that in the former instances the white matter is completely dissolved, and in the latter only imperfectly. Now, in the experiment made on the 12th of April, a man fed on arrow-root was found to have the serum of his blood transparent, or

without whiteness, and no farther examination of its qualities was made except ascertaining that it was fermentable on the addition of yeast. But it was desirable to know whether a diet of Starch, although it did not render the serum of the blood milky, might not, as in the cases just detailed, introduce with it a white matter precipitable by salt.

Arrow-Root.—Accordingly on the 15th of June, M., after fasting the usual time, had a meal of arrow-root, prepared with water, and seasoned with spice. He took it readily, but not so much of it as was taken on the last occasion. He was bled at two, and four hours after the meal.

The serum on both occasions was transparent, and with a greenish tinge. That from the blood last drawn gave a precipitate with salt, but not so abundnnt as in several former cases. The other specimen gave a much more abundant precipitate, in part rising to the surface. This last also, on being filtered, left oily stains upon the filtering paper, as I have since found the serum of the blood very frequently do. I found the white precipitate from salt to be completely resoluble on adding as much water as brings the solution somewhat under the point of saturation. On again saturating with salt, the precipitate falls, and on again adding water, it is redissolved, and so for several times in succession.

Does, then, Starch give a white precipitate with salt like the azotized principles? Before drawing this conclusion there are some causes of fallacy to be guarded against. The white matter may have proceeded from food taken before the fast, and the more abundant precipitate in the blood first drawn seemed to countenance this conjecture. The fast may not have been strictly observed. Both these sources of error will be precluded by drawing a little blood before the meal, and testing the serum with salt. Lastly, arrow-root contains a certain proportion of azotized matter, which, in some specimens examined by him, Dr. R. D. Thomson found to be about three per cent. This experiment appearing to me to be an important one, I repeated it twice, as will be seen below; and on one of these occasions a fast of upwards of twenty-four hours was rigidly observed before the meal, so as to remove entirely the second objection mentioned above, and diminish the first as much as I believe practicable.

Arrow-Root—Starch and Suet.—On the 5th of July, O. and P., after a fast of sixteen hours, which I had no reason to suspect was not faithfully observed, had, the former a mess of spiced arrow-root prepared with water, and the latter a pudding composed of two parts common starch and one of suet. They were both bled immediately before the meal, and again at two, and at four hours after it.

The serum from the blood of O. was, the whole three times, quite transparent. On testing it with salt, the serum of the blood drawn before the meal gave a precipitate nearly as abundant as that from the blood drawn after the meal. The blood taken from P. before the meal gave a serum which was quite limpid, while the blood taken after the meal gave on both occasions a very white serum: that from the first bleeding after the meal threw up spontaneously a white cream, which on the third day was as abundant as I had ever seen it; that again from the second bleeding, although equally white, yielded no cream. On filtering the creamy serum, the filtering paper after being dried was found stained with oil, which it was natural to think was occasioned by the suet; but on filtering the corresponding limpid serum

of O., who had taken only arrow-root, the oily stain was found not less deep. The serum of P. gave a precipitate with salt as well before as after the meal, and that from the serum after the meal was far more abundant than could possibly have proceeded merely from the matter in suspension. The serum of P. before the meal was kept many days in a phial only in part filled, and yet continued quite free of any unpleasant smell, both then and when afterwards poured into an open glass, and allowed to remain till the water had all evaporated. I have met with several other instances of serum resisting putrefaction, but can offer no probable conjecture as to the cause of so remarkable a property.

This experiment shows clearly the effect of an oily diet in giving milkiness to the serum, since the milkiness was as great from the diet of starch and suet just mentioned, as from the more highly azotized diet of flour and suet mentioned in the last memoir. To illustrate the mode in which the milkiness is occasioned, I added a few drops of oil to the limpid serum of the man who had dined on the arrow-root alone, and on shaking them together I found the liquid become turbid and throw up a kind of cream. This effect, which I had often before observed, I have been in the habit of ascribing to the action of the free alkali of the serum upon the oil forming with it a kind of emulsion. There are indeed good reasons for thinking that the white matter of milky serum is not a mere emulsion of this kind, but an azotized substance, yet it seems probable that the introduction of an oil into the blood is one, and probably the most frequent cause of the white colour of the serum. It is also worthy of remark, that the effect seems to be only occasioned by oil recently introduced with the food, since, as in the case just mentioned, we often find serum abounding with oil, and yet quite limpid, which must be owing to the oil, whether absorbed from within or from without, having been so adjusted by the processes of the vital economy to the other ingredients of the blood, as no longer to disturb their chemical equilibrium.

Reflections not less important are suggested by the fact brought out by both the two last experiments, that the serum of the blood after a fast of sixteen hours gave a precipitate with salt added to supersaturation. Was the fast not strictly observed by men who might naturally be supposed to care little for the result of the experiment, and more for their breakfast of which they were deprived? Was the white matter from the supper of the previous night? or, lastly, does all serum give a white precipitate with salt? To this last query, which I had both put to myself, and which had been put to me by others, I had hitherto answered in the negative, relying upon a specimen of beautifully limpid serum which has been in my possession since 1840, and was shown to the Society last spring, and which I believed to have been saturated with salt, when most probably no more had been dissolved in it than was necessary to keep it from decomposing. Now, however, that the inquiry was again forced upon me, I examined a great many specimens of the serum of blood; and I found all of them, without exception, to give a precipitate with salt, although in very

different degrees of abundance. I next examined the liquid of the serous cavities, thinking that possibly it might not be effused till the secondary digestion was completed. In this, however, I was mistaken, as all the specimens of hydrocelic fluid which I examined gave a white precipitate with salt.

I was thus fully satisfied that in all ordinary circumstances serum contains a white matter precipitable by salt. This, however, is by no means inconsistent with the opinion, that the white matter in question is the nutritious part of the food absorbed from the digestive passages, but, on the contrary, renders that opinion the more probable. Iodine taken so as to saturate the system, is found in the blood, in the liquid of the serous cavities, and in the synovia of the joints; and it may be detected in the excretions not only as long as the medicine continues to be taken, but for four days thereafter.* If then a substance taken once or twice daily, to the extent of a few grains, continues so long within the body, it is surely not surprising that we should find there as uniformly traces of our food, which we take three or four times a-day or oftener, to the extent of several pounds.

It was, however, desirable to determine with greater accurary, whether the white matter precipitated by salt from the serum of the blood was really derived from the recently taken food. To accomplish this object, three methods of proceeding suggested themselves, viz.:— to compare the quantity of precipitable matter found after taking food—1st, with that found in the serum of a person who had fasted, *bona fide*, for twenty-four hours—2d, with that obtained from a person labouring under some disease for which he had been put upon an antiphlogistic regimen—and lastly, with that obtained from an animal kept long without food.

The first method being that most readily put in practice, was tried first. As a twenty-hour hour's fast is attended at least with eight hours of uneasy sensation, it could not be expected, unless enforced, to be rigidly performed but by a person interested in the success of the experiment. It was also desirable that the person experimented upon should not be under confinement, but take as much exercise as possible to promote the assimilative actions of the system. I therefore tried this experiment upon myself.

Arrow-Root.—I dined lightly between four and five o'clock in the afternoon of the 25th of July; in the evening I took exercise on horseback, and next day went about my usual avocations with a good deal of walking, till between five and six in the afternoon, having taken nothing in the interval but a draught of water before going to bed. I now had blood drawn from the arm by a medical friend, and thinking the opportunity a favourable one for trying the effect of starch, I dined upon arrow-root, prepared with water and sweetened with sugar, of which I took a large bowlful—in appearance a mess for a ploughman, but which in reality contained no more than three ounces of dry arrow-root powder. I also drank freely of water sweetened with sugar, and was bled again three hours after the meal.

* London Med. Gaz., 1836.

The serum from both bleedings was quite limpid, and of a deep amber yellow. That from the first bleeding had the deepest tinge; on supersaturating it with salt it became slightly troubled, but without losing its transparency, and at length showed pale flocks, which became whiter in colour as they subsided to the bottom. The serum from the second bleeding gave a precipitate, which was likewise flocculent, of a more decidedly white colour, and more abundant, although very insignificant in point of quantity when compared with the precipitates obtained after a full azotized meal.

This experiment shows, that abstinence from food for twenty-four hours, by a person in good health, taking active exercise in the open air, reduces to a minimum, but does not altogether remove the precipitable matter of the blood. The two other experiments suggested above, lead to the same conclusion; and the last further shows, that a very prolonged fast introduces a new complication into the question by occasioning an incipient decomposition of the blood.

In the beginning of August I got from a medical friend some serum from the blood of a man bled for a pleurisy, of which he died soon afterwards. It gave a scanty precipitate on being saturated with salt.

On the 16th of August, a dog, which had been kept fifty-one hours without food, and had drunk little although allowed a free supply of water, was bled from the saphena, to the extent of about two ounces. The blood trickled slowly down the leg, and was coagulated in part before the whole had been received in the cup. Whether owing to this circumstance, or to the long fast, the serum was tinged deeply red, apparently from the colouring matter being dissolved, for it was quite transparent, and did not lose the colour by standing at rest. Salt gave a precipitate, although little abundant.

We may infer then from these experiments, that it is not possible, without carrying fasting to a greater length than prudence or humanity permit, to deprive the blood altogether of its white precipitate. This conclusion is quite conformable to what our experience of the persistance of Iodine in the body would lead us to expect. It has, however, been ascertained that the white precipitate obtained from the serum of the blood by supersaturation with salt, is most abundant after a meal; that it is less abundant as the period of taking food has been more remote; and that, after a fast of twenty-four hours, it is very insignificant in quantity. Still farther, after certain kinds of food, such as eggs, casein, and white-fish, a much larger quantity of white matter is found in the serum than after certain other kinds of food, such as starch. Last of all, the characters of the precipitate vary, so that it may either be made to swim on the surface, or sink to the bottom, according to the kind of food. It appears, therefore, not unreasonable to conclude, that this white precipitate proceeds from the food, being the newly digested nutritious matter introduced by certain aliments into the blood.

The only other view that can be taken of the nature of this precipitate, is, that it is occasioned by the salt re-acting upon the albumen dissolved in the serous liquid. This view does not seem to me reconcileable with the great variations in the quantity of the precipitate,

without any corresponding difference in the quantity of the albumen. Thus in a specimen of hydrocelic serum, of which the specific gravity was 1·038,* the precipitate was so scanty as merely to render the liquid a little turbid; and in another specimen of the same kind of serum, of which the specific gravity was only 1·025, the precipitate was in great abundance. The following considerations and experiments may serve to elucidate this question.

After finding that hydrocelic serum gave a precipitate with salt, I took the opportunity afforded by my getting a plentiful supply of that liquid, to resume the inquiry mentioned above, as to whether any other saline substances acted in the same way upon serum as common salt. I first tried the sulphate of soda, which I found to produce the same effect as the common salt, only I thought the precipitate for the most part more abundant. I found also that this precipitate was immediately redissolved on the addition of water, and was again thrown down on supersaturating with the sulphate. On afterwards trying this salt with the serum of the blood, I found that the precipitate obtained sometimes floated, and sometimes fell to the bottom, and that in this respect there was not always a correspondence in the action of the two salts on the same liquid.

I found sulphate of magnesia to act in the very same way, so that I have since been in the habit of employing commonly these three salts as precipitants.

I found that neither the sulphate of soda nor the common salt threw down the whole precipitable matter contained in the serum. To show this, I saturated some serum with each of these salts separately. I then removed the precipitates by the filter, so as to get the liquids again quite clear. I now saturated each solution with the salt not before dissolved in it, when I obtained a fresh precipitate in each about as abundant as at first. Still farther, on filtering the liquids again, and saturating with sulphate of magnesia, I obtained an additional precipitate, but much less abundant than I obtained with that salt used in the first instance.

I now tried various other salts, the mode of action of which will be best seen from the following Table, from which are excluded all saline substances, such as the acetate of lead, chloride of mercury, and sulphate of alumina and potass, which, in whatever quantity added, produce a precipitate in serous liquids. It comprehends only those substances, which may be added in any quantity under the point of saturation, without troubling the serum. These may be divided into three classes. Some of them like common salt, produce a precipitate resoluble on the addition of water; some, like the carbonate of potass, and muriate of lime, cause a precipitate not resoluble by water, and some, like the phosphate of soda, cause no precipitate.

I.

Chloride of Sodium,	Abundant Precipitate,	Resoluble.
Sulphate of Soda,	Do.	Do.
Carbonate of Soda,	Considerable,	Do.
Sulphate of Magnesia,	Abundant,	Do.
Tartrate of Potass,	Do.	Do.
Tartrate of Soda and Potass,	Considerable,	Do.

* This specific gravity is, I believe, the highest upon record of any serous liquid. The serum was taken from one of the strongest men in this city, who has laboured under hydrocele for about ten years, and from whom I have regularly removed it at intervals of from six to ten months. The specific gravity mentioned above was determined by the hydrometer, but to remove all doubt, I had it again determined with great accuracy by the balance, when it was found to be 1·0377.

II.

Carbonate of Potass,	Abundant,	Not Resoluble.
Bicarbonate of Potass,	Slight,	Do.
Muriate of Lime,	Abundant,	Do.

III.

Phosphate of Soda,	No Precipitate.
Borate of Soda,	Do.
Bicarbonate of Soda,	Liquid slightly turbid.
Sulphate of Potass,	Do.
Nitrate of Potass,	No Precipitate.
Chlorate of Potass,	Do.
Hydriodate of Potass,	Do.
Triple Prussiate,	Do.
Sulphate of Iron,	Do.
Carbonate of Ammonia,	Do.
Muriate of Ammonia,	Do.

A solution of the albumen ovi gives a precipitate on being saturated with salt, but it is not resoluble on the addition of water.

I may now relate a few additional experiments and observations, some of which were made before those last mentioned, but the account of them was deferred, not to interfere with the preceding argument.

Chyle and Serum.—Having obtained a little chyle from the thoracic duct of a dog fed a few hours previously with oatmeal porridge and milk, I mixed it with some serum which I had brought with me for the purpose. It rendered the serum turbid, and very like in appearance to that which separates from blood after taking food. A very delicate voluminous coagulum soon formed in the liquid.

Serum of Diabetic Blood.—Towards the end of July, I obtained from a medical friend some very opaque serum from the blood of a woman labouring under diabetes, for which she had been bled three times, the blood each time exhibiting the same characters. The discolouration was occasioned by a flocculent brownish white matter, which, in the course of two days, collected in the upper half of the vessel, leaving the liquid below quite clear. This matter exactly resembled in appearance that separated by salt, and this strengthened the opinion which I had begun to entertain, that the substance separating spontaneously and that separable by salt, were mere modifications of the same substance. On drawing off the clear liquid, and saturating it with salt, it gave a precipitate not less abundant than that which had previously separated spontaneously. As I had never before seen serum so loaded with alimentary matter, I inquired as to the diet of this woman, and found it to consist daily of beef 24 oz., bread 12 oz., milk 12 oz., cabbage 6 oz., and 11 lbs. of drink including the milk. She took besides 3 gr. of opium daily The urine amounted to 26½ lbs. on an average in the twenty-four hours, and was highly saccharine.

It is also worthy of remark with respect to this serum, that after it had been a day in my possession I found it to have a most distinct acid reaction. This fact can scarcely be explained, but on the supposition that the serum contained sugar, which had been converted into lactic acid.

Herrings.—On the 2d of August, after a fast of eighteen hours, R. took a full meal of fresh herrings, with no other accompaniment than salt. He was bled immediately before the meal, and at two, and four hours after it.

The serum from the first bleeding was quite limpid, that from the second was highly opaline, and that from the third was quite opaque. All of them gave a

precipitate with common salt, but in none of them was it very abundant, and in the first it was little less in quantity than in the two last. On the other hand the two last gave a very abundant precipitate with sulphate of soda, while the first gave only a scanty one.

In all probability a much larger precipitate would have been obtained from the blood of this man, had the bleeding been deferred to six or eight hours after the meal, for it may well be supposed that the digestion of such a heavy meal would be laborious, and, therefore, probably the alimentary matter would be late of entering the blood-vessels.

Potatoes—Whisky.—On the 9th of August T., a stout healthy man, after fasting eighteen hours, dined abundantly upon potatoes and salt. He was bled at four hours after the meal. He had then three glasses of Glenlivet whisky with hot water and sugar, and half-an-hour thereafter he was again bled.

The serum from the first bleeding was rather scanty: that from the last very abundant. Both were quite limpid, and of a yellowish-green tinge, less deep in the latter. Both gave a scanty precipitate with common salt and sulphate of soda: but it was remarkable that while the latter gave the most abundant precipitate with common salt, the former gave the most abundant with sulphate of soda; and that while the precipates with the salt were truly such falling to the bottom, the matter separated by the sulphate of soda was in both cases more properly a *sublimate* rising to the surface.

There was a most striking difference between the clots obtained from these bleedings. That from the first was quite natural, being red on the surface, and without contraction; while that from the second was cupped and buffy. The buff, when seen under the serum, was like that of inflammation; but when viewed attentively, after pouring off the serum, it was found to consist of transparent fibrin, with very opaque filamentous and granular particles imbedded in it.

The only conclusion that can be drawn from the last part of this experiment is, that alcohol has no effect in rendering the serum of the blood white; but it would require to be repeated several times to enable us to judge, whether the appearances of the clot were really due to the action of the alcohol, or were owing to some accidental circumstance.

Eggs.—On the 16th of October, U., after fasting sixteen hours, had six eggs for dinner, which were eaten, as before, with a little salt and nothing else but water for drink. He was bled immediately before the meal, and again four hours after it. The serum from the first bleeding was limpid, and, on supersaturating it with salt, gave a true precipitate falling altogether to the bottom. The serum from the second bleeding was whitish, and, on being treated in the same way, it gave only a scanty precipitate, but a very abundant sublimate, which remained swimming at the surface for many days thereafter. The coagulum of the blood first drawn had a plentiful fibrinous crust, very transparent; the other coagulum was natural.

This result corresponds with those obtained on two former occasions mentioned above, when eggs had been eaten. The experiment was repeated, for the purpose of confirming an argument which has been employed above as to the source of the white matter of the serum. It

is obvious, that the meal of eggs either introduced into the blood a sublimable substance not before present, or that it altered the quality of some substance previously existent; which last is a less probable supposition. The small quantity of the serum first obtained, prevented any comparison of the relative quantities of the precipitates.

The following conclusions may be deduced from the observations and reasonings contained in this and the former memoir.

1. The serum of the blood of a healthy man fasting, is perfectly transparent, and of a yellowish or slightly greenish tint.

2. A heterogeneous meal, such as that usually set on the tables of the rich, renders the serum white.

3. The whiteness may commence as early as half-an-hour after eating, and may continue ten or twelve, and sometimes as long as eighteen hours, according to the kind and quality of the food, and the state of the functions of primary and secondary digestion.

4. *Starch*, and *Sugar*, and probably all vegetable substances destitute of oil, give no whiteness to the serum of the blood.

5. *Fibrin*, *Albumen*, and *Casein*, and probably *Protein-compounds* in all their forms if destitute of oil, give no whiteness.

6. Oils combined, whether naturally or artificially, with protein-compounds or with starch, render the serum of the blood white; probably, therefore, oils produce that effect in whatever way taken.

7. Gelatin seems to render the serum of the blood white; this, however, cannot be considered as certainly established, as there may have been some fat in the beef-tea which was taken along with the calf-foot jelly in both experiments on which the above conclusion rests.

8. The coagulum of the blood very frequently exhibits, after taking food, a crust of pellucid fibrin, or of pellucid fibrin dotted with more opaque particles, and with little of the contraction technically named "cupping."

9. The appearances of the coagulum just mentioned are much more common after azotized than after non-azotized food.

These conclusions relating to the visible characters of the blood may be considered, with the single exception above mentioned, as well established. The conclusions which follow relate chiefly to the chemical properties of the blood, and are not worthy of the same reliance; but the evidence on which they rest has been laid before the reader, and he must judge of them for himself.

1. The substance defined above under the name of Pabulin, is most abundant in the blood a few hours after taking food, sooner or later according to the rapidity of digestion.

2. It is less abundant as the time when food has been taken is more remote, and is small in quantity after a fast of twenty-four hours.

3. It is much more abundant after azotized, than after non-azotized food.

4. It varies in quality, floating or subsiding, according to the kind of food taken.

5. It is probably analogous in nature to the white substance which gives colour to the serum of the blood.

6. The difference between these two forms of this substance probably is, that it is sometimes combined with an alkaline, or earthy salt (choride of sodium, sulphate of soda, &c.), and sometimes with an oily body (stearate of glycerine, &c). In the former case, it seems to dissolve completely in the blood, while in the latter it is only partially dissolved, and renders the serum opaque.

7. The azotized principles of the food are probably made to combine, in the digestive tube, with the alkaline, earthy, and oily salts mentioned above; and thus become capable of being absorbed into the blood.

8. The alkaline and earthy compounds are probably absorbed directly by the blood-vessels, while it seems to be well ascertained that the oily compounds are absorbed through the lacteals.

The subjoined table exhibits, at one view, the results of the observations contained both in this and the preceding memoir, so far as they relate to the visible characters of the blood.

	Diet.	Time of Bleeding after Meal, or before it.	Serum	Coagulum.
1.	Beef Steak, Bread, Soup, Porter,	½ hour,	Whitish,	Natural.
		1 hour 40 minutes,	White,	Do.
		18 hours,	Limpid,	Pellucid Fibrinous Crust.
2.	Beef Steak, Bread, Soup,	Before,	Do.	Natural.
		3 hours 15 minutes,	White,	Pellucid Crust.
		3 hours 15 minutes,	Do.	Do.
		18 hours,	Limpid,	Do.
3.	Beef Steak, Bread, Potatoes, Soup, Porter,	Before,	Do.	Natural.
		2 hours 10 minutes,	Whitish,	Do.
		8 hours,	Gruel-like,	Pellucid Crust.
		18 hours,	Whitish,	Do.
4.	Wheaten Flour Suet,	Before,	Limpid,	Natural.
		3 hours,	Whitish,	Do.
		6 hours,	Milk-white,	Do.
5.	Calf Foot Jelly, Beef Tea,	3 hours,	Opaline,	Mottled.
		6 hours,	Quite Opaque,	Natural.
6.	Calf Foot Jelly, Beef Tea,	3 hours,	Opaline,	Pellucid Crust.
		6 hours,	Very Opaline,	Natural.
7.	Arrow-Root, Spiced,	3 hours,	Limpid,	Pellucid Crust.
		6 hours,	Do.	Natural.
8.	Eggs, Milk,	3 hours,	White,	Pellucid Crust.
		7 hours,	Whitish,	Natural.

	Diet.	Time of Bleeding after Meal, or before it.	Serum.	Coagulum.
9.	Beef Steak, Without Fat,	3 hours,	White,	Pellucid Crust.
		7 hours,	Whitish,	Natural.
10.	Eggs,	2 hours,	Do.	Do.
		4 hours,	Do.	Do.
11.	Curds & Whey,	2 hours,	Limpid,	Buffy Crust.
		4 hours,	Do.	Slight Pellucid Crust.
12.	White-Fish,	2 hours,	Do.	Natural.
		4 hours,	Do.	Do.
13.	Arrow-Root, Spiced,	2 hours,	Do.	Do.
		4 hours,	Do.	Do.
14.	Arrow-Root, Spiced,	2 hours,	Do.	Do.
		4 hours,	Do.	Do.
15.	Starch, Suet,	2 hours,	White,	Do.
		4 hours,	Do.	Do.
16.	Arrow-Root, Sugar,	Before,	Limpid,	Do.
		3 hours,	Do.	Do.
17.	Beef Steak, Bread, Cabbage, Milk,		Thick from diffuse grey flocks.	
18.	Herrings,	Before,	Limpid,	Do.
		2 hours,	Opaline,	Glistening.
		4 hours,	Quite Opaque,	Do.
19.	Potatoes,	4 hours,	Limpid,	Natural.
20.	Alcohol,	½ hour,	Do.	Buffy.
21.	Eggs,	Before,	Do.	Fibrinous Crust.
		4 hours,	White,	Natural.

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