coloured while the vapour will be quite colourless, and will remain so up to the critical point.

Now let the fluid be raised above its critical point, all the internal space will be coloured, showing that (the contents being gaseous) the gas dissolves the solid while the vapour does not. We have here a clear separation of the two kinds of aeriform fluids. The definition which I applied to the gaseous state at the beginning of this paper does not apply to the vaporous state, as we know that any quantity of it will not distribute itself throughout a space, because if we try to force vapour into a space already saturated, we cause a change of state, and a portion of the matter becomes liquid. Thus, instead of only two we have four distinct states of matter: solid, liquid, vaporous, and gaseous.

XVI. "The Relation of the White Blood Corpuscles to the Coagulation of the Blood." By L. C. Wooldridge, B.Sc. Lond., Physiologische Anstalt, Leipzig. Communicated by Dr. Lauder Brunton, F.R.S. Received June 8, 1881.

(Abstract.)

The following is an abstract of some researches which have been carried out by the author in the Physiological Institute of the University of Leipzig.

It has long been known that the white blood corpuscles are concerned in the coagulation of the blood.

Alexander Schmidt, to whom we principally owe our knowledge of this fact, has distinctly formulated the part they play. He considers them as the source of two of the three factors which are, according to his well-known theory, necessary for the formation of fibrin.

The two components which arise from the white blood corpuscles are, according to Schmidt, paraglobulin and fibrin ferment.

The recent researches of Hammarsten have made it very probable that paraglobulin is not directly concerned in the formation of fibrin.

If this be true, and if the views of Schmidt concerning the participation of the white corpuscles be also correct, the latter must necessarily only play a very subordinate part; that is, they must be mere *ferment producers*.

In order to arrive at exact conclusions on this subject, the author has considered it necessary:—1st. To attain some more knowledge than we at present possess concerning the chemical nature of the white blood corpuscles. 2nd. To have exact data for the amount of white blood corpuscles which disappears during coagulation.

The first of these two subjects the author considers here.

For this purpose the leucocytes of lymphatic glands have been used as material.

It can be considered as in the highest degree probable that these are essentially identical with white blood corpuscles.

The leucocytes are obtained by finely dividing the glands (mostly the mesenteric glands of the calf) and gently rubbing the fragments in a mortar with $\frac{1}{2}$ per cent. solution of common salt.

By filtration through a fine cloth, the cells are separated from the other constituents of the glands which remain behind on the filter, the cells passing through.

By means of the centrifugal machine, the leucocytes are well washed out with a $\frac{1}{2}$ per cent. solution of common salt. The cells are perfectly distinguishable under the microscope and are apparently unchanged. After the washing out is completed, the cells are suspended in a little normal salt solution and are subjected to various experiments, the most important of which are as follows:—

1. *The lymph cells are changed by simple chemical reagents into a substance closely resembling fibrin.*

If to one volume of suspended cells an equal volume of 10 per cent. solution of common salt is added, the whole is immediately converted into a peculiar semi-transparent jelly.

If this be poured into water, or into 1 per cent. solution of common salt, it becomes immediately opaque.

It now appears in the form of a white rounded lump, or it forms large membranes, often many inches in extent.

These latter have the greatest resemblance to fibrin membranes such as appear in plasma obtained by various methods. The resemblance of the product to fibrin is made much more apparent if the substance be freed, by means of filtration and expression, as much as possible from water. It then appears as small flocculi, distinctly fibrous in their texture and elastic.

The chemical behaviour of these flocculi are as follows:—

In water they are insoluble.

In solutions of common salt, they gradually swell up.

In 0·2 per cent. hydrochloric acid, they are totally insoluble; if anything, they become firmer and more elastic.

In dilute alkalies, they gradually dissolve.

The microscopical examination shows that the cells, as such, have disappeared. Only nuclei, imbedded in a distinctly fibrous ground substance, are visible.

If the leucocytes are treated with distilled water, or with solutions of sulphate of magnesia, similar results are obtained. The cells are changed into a fibrous mass, with nuclei imbedded therein.

2. *Behaviour of Leucocytes towards Plasma.*

The only animals at the author's disposal were dogs. The most convenient way of obtaining plasma from dog's blood is to inject a solution of peptone into the blood of the living animal. If the animal be bled five or ten minutes after the injection of the peptone, the blood does not coagulate. (This fact was discovered by Dr. Adolf Schmidt, Mulheim.)

By means of the centrifugal machine the blood corpuscles can be separated from the plasma. With this plasma I have experimented, and I shall call it peptone plasma.

A general account of the action of peptone on the blood has been published by my friend, Dr. Fano. His researches were also carried out at Leipzig, and his observations have supplied me with many necessary details. My observations have led me to the conclusion that peptone plasma behaves towards the cells in a manner which is essentially similar to that in which solutions of common salt, of sulphate of magnesia, and distilled water behave. As I have already stated, by these latter reagents the protoplasm of the lymph cells becomes converted into a fibrous mass resembling fibrin.

When peptone plasma is the destroying agent, the substance produced is undoubtedly fibrin, and it owes its origin to a simple transformation of the protoplasm of the leucocytes into fibrin. It is perfectly independent of the presence of a fibrinogenic substance in the plasma.

The grounds on which I base this statement are clearly brought forward in the following experiments, which I shall adduce as examples.

A dog was injected with peptone; five minutes afterwards it was bled. The corpuscles were separated from the plasma by the centrifugal machine, and the plasma allowed to stand overnight in ice. During the night, incomplete coagulation of the plasma occurred.

This is a perfectly normal occurrence in peptone plasma, and it can be immediately brought about by dilution of the plasma with water, or by passing a stream of carbonic acid through it.

The plasma in question, after the coagula had been separated by filtration, presented the following characters :—

It was totally uncoagulable—

1. On dilution with water.
2. On passing a current of CO_2 through it.
3. On addition of Schmidt's fibrin ferment.
4. On addition of paraglobulin.
5. On addition of normal serum.
6. On standing till it was foul.

In short, by no means could the presence of a coagulable substance—fibrinogen—in the plasma be demonstrated.

It behaved as follows towards cells :—

To 20 cub. centims. plasma a very small quantity of lymph cells were added. Two minutes afterwards it coagulated, but only imperfectly. The coagulum contracted rapidly. The serum which exuded was divided into two portions, to one a large quantity of lymph cells were added; very complete coagulation occurred in two or three minutes. The other portion showed not the slightest sign of coagulation for the twenty-four hours it was under observation.

This process was repeated four times; ultimately, the plasma lost the property of changing the cells into fibrin.

Now, I say the plasma changes the cells into fibrin, and I base this statement on the following facts, in addition to those already mentioned :—

1. The weight of the coagulum found is identical, that is, as nearly so as can be in such determinations, with the weight of cells which have been added.

2. The percentage of albumens in peptone plasma before coagulation with cells is identical with the percentage after coagulation with cells.

3. The protoplasm of the cells has completely disappeared and has been converted into a partly fibrous, partly granular, ground substance the nuclei remain.

4. If to a very large quantity of suspended cells, say 50 cub. centims., a very small quantity (1 cub. centim.) peptone plasma be added, the whole clots firmly. The microscope shows that the cell-body has disappeared.

These facts suffice to show that the plasma converts the cells into fibrin, and that this conversion is independent of the presence of a coagulable substance (fibrinogen) in the plasma.

But this is not all. I have already referred to the fact that a spontaneous coagulation occurs in peptone plasma on standing, and that this can be accelerated by dilution with water, or by passing a current of carbonic acid through it. Solutions of the fibrin ferment also bring it about, but not very much more rapidly than mere dilution.

In some cases, the coagulation which can be induced by these means is very complete, in others it is very scanty. The case I have described at length was one of the latter.

In other cases, the coagulation is very complete, a firm dense clot is formed by the means adopted. Now, on adding cells to such a plasma, not only are they converted into fibrin, but they induce the coagulation of the existing fibrinogen in the plasma.

I may here remark, that I have failed to find any ground whatever for the assumption that paraglobulin arises from lymph corpuscles.

In the destruction of the lymph cells by salt solutions the only pro-

duct is the fibrinous body mentioned, not the slightest trace of a globulin can be detected.

In peptone plasma, paraglobulin is present in large quantities, and yet it is quite certain, as I shall mention later, that no breaking up of white blood corpuscles has taken place.

3. The generally received view, as to the course of events in the normal coagulation of the blood, is as follows:—

Very soon after leaving the body the white corpuscles die; as a consequence of this they break up, and thereby give rise to the ferment and paraglobulin.

The fibrinogen is pre-existent in the plasma.

According to this view, then, the essential element in coagulation is the death of the white blood corpuscles.

The results of my experiments are totally opposed to this view.

They are shortly stated as follows:—

The injection of a large quantity of dead lymph cells into the blood of a living dog, both in its normal state and when it has been injected with peptone, has no marked influence on the functions of the animal. No sign whatever of emboli can be detected after the animal is dead.

I give one example:—

A dog was peptonised; five minutes later a small quantity of blood was removed and divided into two portions, to the one lymph cells were added, it coagulated immediately, exactly like normal coagulation. The other portion remained uncoagulated for hours.

After the removal of this small test quantity of blood, a very large quantity of dead lymph cells, suspended in $\frac{1}{2}$ per cent. solution of common salt, were injected into the animal. The latter was apparently quite unaffected by this. It was in the narcotic state always produced by peptone, but it was able, in the course of three-quarters of an hour, to walk about. No coagula were found on post-mortem examination.

These facts are of great importance, for they show that coagulation is the result of a change in the plasma, and has nothing to do with the vital properties of the cells; and they further fully confirm what I have endeavoured clearly to bring out, that the conversion of the white cells into fibrin is quite independent of the presence of any "fibrinogen" substance. Fibrinogen is present in "living" plasma, yet the dead cells produce no coagulation. Fibrinogen was absent from the peptone plasma, which still gave practically unlimited quantities of fibrin with lymph cells.

Now, Alexander Schmidt has shown most distinctly that white blood cells do unquestionably disappear as such during the normal coagulation of the blood; and, in another communication I shall confirm this in a most decided manner. I feel, therefore, justified, although I have, at present, only fully worked out peptone plasma, in saying that

there are two essential processes in the coagulation of the blood, one of which has been hitherto entirely wrongly appreciated or overlooked. This latter process is that the "dead" plasma converts the white corpuscles directly into fibrin. At the same time, however, that this occurs, a substance is liberated from the cells which converts the fibrinogen also into fibrin. This is the other process. The substance which is liberated from the cells is fibrin ferment.

XVII. "A New Line of Research bearing on the Physiology of Sugar in the Animal System." By F. W. Pavy, M.D., F.R.S. Received June 8, 1881.

Twenty-three years ago I presented a communication to the Royal Society, entitled "On the alleged Sugar-forming Function of the Liver."

Four years previously, viz., in 1854, whilst conducting experiments directed towards determining the manner in which the sugar presumed, under the glycogenic doctrine, to escape from the liver was destroyed (as it was then believed to be) in the lungs, I discovered that what had been taken as representing the natural condition of the liver, and of the blood escaping from it in relation to sugar, was founded upon a fallacious inference. By those who have only been acquainted with what, in recent times, has been recognised as constituting the state existing, the original position in which the matter stood will hardly be fully comprehended. The strongly saccharine state in which the liver and the blood of the hepatic veins are found shortly after death was looked upon, without any question being raised about it, as representing the state existing during life. Without the slightest prior conception that such was likely to be the case, I found first that the blood between the liver and the lungs was not during life in the condition that had been supposed, and next that what I discovered for the blood applied also to the liver. The evidence which presented itself led me, as is known, to dispute the validity of the glycogenic theory, and the additional information which I have since from time to time obtained has materially strengthened the position I took. To my own mind, the conditions that we have to deal with looked at in their entirety, are totally irreconcilable with the glycogenic theory; but I know that the difficulty which has existed in accounting for the disposal of the glycogenic matter of Bernard encountered in the liver has stood in the way of a general adoption of my views. This subject, however, I am now prepared to approach and consider.

When the glycogenic matter was discovered, it was described as undergoing transformation into sugar immediately it was brought into