by A. BIEDL. In addition to the connection between the function of the cortex and that of the sexual organs, also the possibility of an antitoxic action of the adrenal cortex has been emphasized. In the latest edition of his Manual of Internal Secretion BIEDL still considers it as an open question whether, just as Cobra-poison in vitro, also endogenous poisons can be counter-acted by adrenal-cortex.

It seems to me that the result of adding small quantities of adrenal cortex to the Daphnia cultures — in the case of over-population and of mould infection — indeed points to an inhibitory influence on the action of normal metabolic products. It is notable that this occurs in lower organisms, which, so far as we know, do not possess an organ corresponding to the suprarenal capsule of the vertebrata.

Our deficient knowledge of the normal function of the adrenal cortex justifies a further inquiry of this problem in different directions.

Physiology. — *"The Interchange between Blood-plasm on one hand and Humor aqueus and cerebro-spinal fluid on the other hand, studied from their sugar-percentages and in connection with the problem of combined sugar."* By J. DE HAAN and S. VAN CREVELD. (Communicated by Prof. H. J. HAMBURGER.)

(Communicated at the meeting of March 26, 1921).

Humor aqueus and cerebro-spinal fluid are two very remarkable tissue-liquids. They are so in the first place because they are almost entirely free from colloids and secondly because of the great similarity between their chemical composition and that of the blood. A large part of the present-day investigators are of opinion that these liquids must be regarded as formed by "active secretion" by certain layers of cells, namely the epithelial layer of the corpus ciliare and the chorioid plexus. HALLIBURTON and DIXON [1]) a.o. have accepted this secretion especially for the cerebro-spinal liquid on account of (among other things) the discongruity which would exist between the specific action of certain substances on the secretion of the liquid and the action of those substances on the *pressure* of the blood. It is, however, exceedingly difficult to establish experimentally and without any doubt, an increased formation of the liquid; and equally difficult is the exact determination of the blood-pressure in the vascular system, connected with the formation of the liquid. We here only refer to the recent elaborate publications of BECHT [2]) in which from his own researches this author reaches the conclusion that all the phenomena which at first sight point to secretion, may very well be explained in a mechanical way. For the rest we will leave out of consideration the significance of the blood-pressure, nor will we, in what follows, discuss the value of the argument that the histological gland-structure of the said epithelial cells should furnish a proof for the secretion. Leaving alone the way the liquid is formed and the place where it originates, in other words leaving alone the direction of its movement, we wish to take as starting-point for our researches the chemical composition of these liquids.

And then he who speaks of secretion here, will admit that the

[1]) Journ. of Physiology **47**, p. 215, 1913 and **48**, p. 128, 1914.
[2]) Americ. Journal of Physiology **51**, 1, 1920.

secreting cells "produce" a substance which remarkably resembles the blood-liquid and which therefore those cells hardly alter actively: osmotic pressure, concentration of the various salts and crystalloids and of the H-ions, they all oscillate within narrow limits round values which are practically those always indicated for the blood.[1]) When, however, one states that the secreting membrane actively checks crystalloids (fluorescin for the liquid of the eye-chamber, aceton and other substances in the cerebro-spinal fluid), then the researches, justifying these conclusions, are nearly always open to criticism both on account of the method used and on account of their varying results[2]). The fact that these liquids contain only traces of proteins and that ferments, immune bodies are practically absent from them, does not tell at all for an active, vital stopping. For every well-functioning dialysing-membrane, every ultra-filter will do this too.

What follows here is the provisional brief communication[3]) of the results of an investigation to find an answer to the question: in how far can the said liquids be regarded as ultra-filtrates or, rather, as dialysates? For the name ultra-filtrate indicates a liquid which is pressed through by means of a super-pressure (in this case the pressure of the blood) and with which a not unimportant speed of circulation is supposed. Now it is very probable, especially for the liquid of the eye-chamber that under physiological conditions the movement of the liquid is very slow. When these liquids follow the fluctuations in the composition of the blood, this will be the consequence of a process, of diffusion for the greater part, and further of direct filtration; consequently in our view a combination of dialysis and ultra-filtration. In how far does the composition of these liquids correspond to what we must expect if the separating layer between the latter and the primary fluctuating liquid (blood) acts as a simple dialysing-membrane? We need not find complete similarity: for the liquid interacts not only with the blood, but also with the remaining surroundings (cerebral tissue, tissues round the eye-chamber). But it will be especially interesting to trace, which changes should be attributed to the last-mentioned factor.

For the present we have limited our investigations to one of the substances which occur normally in the blood, namely: *glucose*.

[1]) See a.o. OSBORNE: Journ. of Physiology, **52**, p. 347, 1918—1919.

[2]) We hope to have an opportunity of returning to this question in further researches.

[3]) A more elaborate publication will appear in the Biochemische Zeitschrift.

Our choice is explained by the fact that one of us[1]) (when he was comparing the sugar-percentage of blood-serum and that of the ultra-filtrate of this serum), made the unexpected discovery that in the process of ultra-filtration a considerable portion of the substance, causing the reduction, remains behind. The above-mentioned difference in the sugar-percentage between serum and its ultra-filtrate[2]) has been described at about the same time by RUSZNYÁK[3]). The problem of combined sugar now again came to the fore. By the researches of v. HESS and MC. GUIGAN[4]), using ABEL'S[5]), method of vivodiffusion, and of MICHAELIS and RONA[6]) it seemed to have been solved in this sense that all the sugar in the blood occurred in a free state. Here we can leave out of consideration (as unsolved) the question whether the reducing substance which remains behind in ultra-filtration, is really combined sugar or whether it must be accounted one of the substances which give the so-called "rest-reduction". We would only observe here that we should have to accept that what does not pass the ultra-filter, is really glucose, if we relied on the investigations of EGE[7]). This author found that of the total reduction of the blood, determined by a slightly modified method BANG (also used by us), only a very small part should be ascribed to this rest-reduction. For convenience sake we shall call the difference which was found, "combined sugar".

When the difference in sugar-percentage between the serum (containing colloids) and the ultra-filtrate (containing no colloids) had been established, this problem presented itself to us: in how for can those liquids of the body, containing like the ultra-filtrate only insignificant quantities of albumen and colloids in general (such as humor aqueus, cerebro-spinal fluid, amnion-liquid) be compared with ultra-filtrates of the blood, also as regards their chemical com-

[1]) S. VAN CREVELD: Communication "Physiologendag" 16 December 1920, Amsterdam. Report to appear in Arch. Néerl. de Physiologie.

[2]) We wish to draw attention to a communication by HAMBURGER and BRINKMAN (Biochem. Zeitschr. **88**, 103, 1918). These authors did not find a difference between the serum and its ultra-filtrate. But their results were based only on provisional investigations, the chief aim of their researches lying in a totally different field. Undoubtedly HAMBURGER and BRINKMAN would by continuing their investigations have found the difference which is mostly present and considerable.

[3]) RUSZNYÁK. Biochem. Zeitschr. **113**, 52, 1921.

[4]) ABEL, ROWNTREE and TURNER, Journ. of Pharmac. and Exp. Ther. **5**, 275 and 611, 1914.

[5]) v. HESS and MC. GUIGAN. Ibid. **6**, 45, 1914.

[6]) MICHäELIS and RONA. Biochem. Zeitschr. **14**, 476, 1908.

[7]) EGE. Biochem. Zeitschr. **107**, 229, 1920.

position? And especially: Is the "combined" sugar kept back here? (We shall have to investigate whether the sugar is combined with protein, or phosphatides or cholesterin). This we have investigated most fully in the case of the liquid of the eye-chamber. The values for the sugar-percentage of this liquid, mentioned in the literature of the subject, did not help us much. We had to rely on our own researches. In the first place one nearly always finds indicated (as e.g. by OSBORNE[1])) that the sugar-percentage of the liquid of the eye-chamber is about equal to that of the blood. Nearly always however it is omitted to investigate blood and eye-chamber liquid simultaneously. This may be called the first requisite, on account of the important fluctuations of the sugar-percentage in the blood which are found even under physiological conditions; and, where this simultaneous investigation was performed, as in the very detailed communication of ASK[2]) of comparatively recent date concerning the eye-liquid, these researches have lost much of their significance in the light of our present state of knowledge. For, the liquid with which the humor aqueus must be compared, is not the total blood, but only the blood-plasm, the sugar-percentages of which are quite different. By investigations of most recent date, a.o. of one of us[3]), it has been established without doubt that in the case of a number of animals (in any case with man and the rabbit) the corpuscles are free from sugar. The value found when determining the sugar-percentage of the total blood, is therefore considerably lower than the actual concentration of sugar in the plasm. And, consequently, if one compares the sugar-percentage of the liquid of the eye-chamber with that of the total blood or with that of a blood-liquid the identity of which with blood-plasma is not entirely without doubt, one arrives at conclusions which are quite wrong. Serum obtained by the coagulation of blood, plasm obtained by blood-coagulating means (hirudin, oxalate) show a lower blood-sugar percentage than the plasm proper, because in these operations in an exceedingly short space of time part of the sugar disappears in the corpuscles, this being due to changed permeability-relations. In this way are to be explained ASK's results (differing from ours) and his conclu-

[1]) OSBORNE, l.c.

[2]) ASK, Biochem. Zeitschr. **59**, 1 and 35, 1914.

[3]) S. VAN CREVELD and R. BRINKMAN: Proceedings of the Royal Acad. of Sciences Section of Dec. 17 1920. Further BRINKMAN and Miss VAN DAM: Arch. Internat. de Phys. XV, p. 105, 1919. In these articles elaborate bibliographies.

sions[1]) based on them, although this investigator, besides examining the total blood, has also tried to investigate bloodplasm.

The bloodplasm required for our purpose was obtained in the way indicated by one of us[2]). Into a small paraffined tube one drops rapidly a small quantity of blood from a punctioned ear-vein of a rabbit, one centrifugates for a few moments and takes away the topmost fluid plasm with a paraffined glass-pipette. The sugar-percentage in this was determined by the latest method of BANG. This method was used by us for all sugar-analyses and gave complete satisfaction. The double-determinations agreed well. We believe that this method, used for a long time already in this laboratory, gives reliable results, provided some precautions are observed. These precautions were that with each experiment the reduction of a 0.1 °/₀ glucose-solution was determined and besides it a blind-determination in duplicate of all reagents used. This was done especially with a view to the varying titre of the thiosulfate-solution.

Using this method with a number of rabbits we have first of all compared the sugar-percentage of the blood-plasm and that of the aqueus humour, which was taken at about the same time (difference in time 10 minutes at most).

The chamber-liquid was obtained very easily (after cocain-anaesthesia) by inserting a glass capillary tube with ground point into the anterior eye-chamber. In general we performed (besides the sugar-determination) also a determination of the refraction of plasm and aqueus humour (refractometer of ABBÉ) to obtain an idea of the albumen-percentage of these liquids.

In Table I the values found for the sugar-percentage in blood-plasm and that in aqueus humour (examined at the same time) are laid down.

In considering this table we must bear in mind the just-mentioned fact that the chamber-liquid flows very slowly under normal conditions, so that we can almost neglect filtration as a factor for establishing the equilibrium in the components of the liquids, but that this equilibrium is a consequence of the slower process of diffusion of the various dissolved components. It follows that (from this point of view) we can expect any change (increase or decrease) in sugar-percentage of blood-plasm to be followed somewhat more slowly by a similar change in the sugar-percentage of the chamber-liquid. Where it is known that important changes in blood-sugar-percentage may take place in a very short time, there may be

[1]) We shall return to these conclusions in detail later on.

[2]) S. v. CREVELD, l.c.

TABLE I.

N⁰. of Rabbit	Sugar-percentage Blood-plasm	Sugar-percentage Primary aqueus humour	Difference	Mean Difference
1	0.20	0.19	+ 0.01	
2	0.28	0.19	+ 0.09	
3	0.2	0.15	+ 0.05	
4	0.2	0.19	+ 0.01	
5	0.28	0.16	+ 0.12	
6	0.27	0.21	+ 0.06	
7	0.24	0.22	+ 0.02	
8	0.22	0.19	+ 0.03	$\frac{0.66}{15} = 0.044$
9	0.25	0.17	+ 0.08	
10	0.20	0.19	+ 0.01	
11	0.22	0.19	+ 0.03	
12	0.21	0.19	+ 0.02	
13	0.26	0.24	+ 0.02	
14	0.32	0.25	+ 0.07	
15	0.22	0.18	+ 0.04	

moments that the difference in sugar-percentage between plasm and chamber-liquid does not correspond to what we should expect after the analogy of what was stated with ultra-filtration. With a rapid drop in the sugar-percentage of blood it will therefore be quite possible for the relations to be temporarily reversed, so that the chamber-liquid shows the greater percentage. In this way we can satisfactorily explain the very diverging differences in table I. But when they are compared in a large number of experiments, we may expect the chamber-liquid to show the lower figures in the majority of cases. We may further expect that in the mean values of a large number of figures the same relation between chamber-liquid and plasm will be shown which we should expect if this chamber-liquid was, not a dialysate, but a quickly-flowing ultra-filtrate. And when we find a mean difference of 0.044 °/₀ between blood-plasm of the ear-vein and chamber-liquid, we have a right to conclude: *Provisionally the phenomenon observed in vitro of the combined bloodsugar which behaves as a colloid, is confirmed in vivo: the sugar-percentage of chamber-liquid corresponds to the free plasma-sugar and follows its fluctuations.*

When we look at Table II it becomes still more probable that we have a case of "colloidal sugar" remaining behind. In Table II we have examined not only plasm and primary chamber-liquid, but also the so called "secondary chamber-liquid" which rapidly (in a few minutes) after the punction regenerates. As is known, it has more direct connection with the composition of the blood; it contains e.g. more protein: WESSELY [1]) gives one to two percent; we found (like HAGEN) [2]) much higher values, (on account of refraction-figures), namely from 3 to 5 °/₀. The secondary liquid therefore, as regards albumen-percentage, approaches blood-plasm and the more so, as the primary liquid had been taken away more completely. Now it appeared that this secondary liquid (coagulating rapidly in the case of the rabbit), also "qua" sugar-percentage, must be regarded as a kind of rapidly entering blood plasm, consequently blood of which only the cellular elements are kept back. For the sugar-percentage of this regenerating liquid corresponds strikingly with that of blood plasm, investigated at the same time.

In considering table II we must bear in mind that through "psychic" stimuli (sympathicus-stimulation) during the experiment, the sugar-percentage in the blood of the rabbit mostly increases. As between 1 and 3 (see table II) generally 20 or 30 minutes elapse, the sugar-percentage of 3 (as appears from the table) can no longer be compared with the bloodplasm of 20 minutes before, but with that of 4. Then there appears to be nearly complete correspondence between bloodplasm and secondary chamber-liquid: *the secondary chamber-liquid therefore has obtained the "combined sugar" together with the plasma-colloids.*

To get a further insight into the manner and the rapidity with which fluctuations in the sugar-percentage of bloodplasm are followed by the aqueus humour, we have, in the case of a number of rabbits, traced the sugar percentage of the chamber-liquid at different times during severe hyperglycaemia, caused by subconjunctival injection of 0.75 c.c. of a 1 °/₀₀ adrenalin-solution in both eyes. We shall here mention a few brief results of a long series of experiments. The sugar-percentage of the bloodplasm rises rapidly after the injection, after 45 minutes already it reaches 0.6 to 0.7 °/₀ and remains thus for one to two hours; then it decreases again rather

[1]) Ergebnisse d. Physiologie 4ᴵ, p. 565, 1905.
[2]) Klin. Monatsbl. f. Augenheilkunde **64**, p. 187, 1920.

TABLE II.

N°. of Rabbit	1 Bloodplasm at beginning of experiment		Time passed between 1 and 2	2 Primary aqueus humour		Time passed between 2 and 3	3 Secundary aqueus humour		Time passed between 3 and 4	4 Bloodplasm at end of experiment	
	Sugar-percentage	Refraction		Sugar-percentage	Refraction		Sugar-percentage	Refraction		Sugar-percentage	Refraction
1	0.20	—	—	0.19	1.3345	10 min.	0.24	1.3436	—	—	—
2	0.20	—	10 min.	0.15	1.3333	10 min.	0.20	1.3424	5 min.	0.21	1.3458
3	—	—	—	0.19	1.3339	15 min.	0.20	1.3409	15 min.	0.20	1.3461
4	0.28	1.3449	15 min.	0.16	1.3341	10 min.	0.19	1.3412	10 min.	0.21	—
5	0.27	1.3477	10 min.	0.21	1.3350	10 min.	0.25	1.3444	20 min.	0.29	1.3472
6	0.24	1.3479	7 min.	0.22	1.3340	10 min.	0.27	1.3433	8 min.	0.3	1.3472
7	—	—	—	0.19	1.3341	10 min.	0.21	1.3412	10 min.	0.22	1.3468

quickly to the normal values. The chamber-liquid follows these changes more slowly, here probably abnormally slowly, because, as a second adrenalin-action, the blood-supply to the eyes had decreased very considerably for the time being. Thus, for example, the sugar-percentage in the bloodplasm rose in 30 minutes from 0.25 °/₀ to 0.38 °/₀, in the chamber-liquid (first in the right eye, then the left) it rose in the same time from 0.17 °/₀ to 0.24 °/₀; in another experiment the sugar-percentage in the bloodplasm had increased in 2 hours after the injection from 0.21 to more than 0.6 °/₀, in the chamber-liquid from 0.19 °/₀ to 4 °/₀; the rapidly regenerating secondary chamber-liquid then contained 0.63 °/₀ which corresponds strikingly to the bloodplasm at that moment.

When in the second period the sugar-percentage of the blood-plasm decreases, this decrease is followed more rapidly by the chamber-liquid than the increase which preceded. This is to be expected because in this period the blood-supply to the eyes and consequently the rapidity of diffusion has become greater. Yet we succeeded in establishing a moment when the decrease in blood-sugar-percentage outstripped the chamber-liquid, so that the relations were reversed: 5 hours after the injection the sugar-percentage of the plasm was 0.27°/₀, that of the chamber-liquid was 0.32°/₀.

It might also be possible to explain the great difference (0.6 and 0.4) which was established at the culminating-point of the hyperglycaemia, not by means of retarded diffusion (consequently: equilibrium not yet reached), but by a relative increase also of the combined sugar during the hyperglycaemia. The difference of 0.2°/₀ could then correspond to the quantity of combined sugar and the 0.4°/₀ sugar in the chamber-liquid would indicate the moment of the equilibrium of the diffusion. But this supposition is no longer valid, for during a separate experiment we have, (during the maximum of hyperglycaemia) taken off a slightly larger quantity of blood and we have determined the sugar-percentage of this together with the sugar-percentage of the ultra-filtrate, obtained from it; the same had been done before with the normal blood-plasm. In the beginning the sugar-percentage of the chamber-liquid was 0.24, of the blood-plasm it was 0.26 and of the ultra-filtrate of the plasm it was 0.16; the difference between the last two is therefore 0.09. This difference now remained equal during the adrenalin-hyperglycaemia (0.63°/₀ and 0.54°/₀), while then the sugar-percentage in the chamber-liquid was much lower (0·44°/₀) than that in the plasm. *Hence the quantity of combined sugar does not increase during adrenalin-hyperglycaemia.*

It will strike that in vitro in this experiment we find a quantity of combined sugar of 0.09 °/₀ whereas the mean difference between eye-chamber liquid and bloodplasm amounted to only 0.044 °/₀. This figure is really low; for as an average in eight experiments we found a quantity of combined sugar of 0.075 °/₀ in ultra-filtrates (in vitro) of serum of our test-rabbits.

Now this difference between the processes in vitro and in vivo is not yet such that on the strength of this we should no longer regard the chamber-liquid as a kind of ultra-filtrate, but moreover we are inclined to think that this difference is not essential. For in comparing the eye-chamber liquid and the plasm of the blood from an ear-vein we found an average difference of 0.044 °/₀. But the blood which interacts with the eye-chamber liquid, will in no case be venous blood, but it will agree more with the composition of arterial blood. Now, as a consequence of the sugar-consumption of the various organs, the sugar-percentage of venous-blood will be lower than that of arterial blood; the magnitude of this difference will depend on the intensity of the sugar-metabolism of the particular organ. We may take for granted that this metabolism will be very slight in the case of the tissues (cornea, crystalline-lens) etc., which surround the eye-chamber, and also that the venous blood flowing from it, would differ very little from arterial blood, supposing we could investigate the former separately. This difference exists very distinctly when we compare blood taken simultaneously from the a. carotis and from the v. facialis posterior, the latter of which practically corresponds to the blood from an ear-vein. In three experiments we found here differences of 0.09, 0.03 and 0.02, on the average therefore over 0.04 °/₀. If, therefore, we increase the sugar-percentage of the plasm from the ear-vein with this amount, the sugar-percentage of the chamber-liquid will correspond very well to what we should expect of an ultra-filtrate.

As regards the second liquid investigated by us, the *cerebro-spinal fluid*, we can dispose only of a much smaller number of experiments. The statements in the literature of the subject made it probable that here also we should find a sugar-percentage, lower and even considerably lower than that in the blood-plasm. Thus for example FINE and MYERS [1]) state that with a number of patients the sugar-percentage of the cerebro-spinal liquid amounted to only 57 °/₀ of that of the total blood. A similar statement we find in WESTON [2]).

For the reasons given before, this difference would become more

[1]) Proceedings Soc. Exp. Biol. **13**, p. 126, 1916.
[2]) Journ. of Med. Research. **35**, p. 199.

striking still, when compared with bloodplasm instead of the total blood.

As regards the technique to obtain cerebro-spinal liquid from rabbits, we obtained it by puncturing (with a glass capillary tube); the ligament connecting occiput and atlas after this had first been exposed by cutting the skin and preparing the muscles of the neck under local anaesthesia (without adrenalin); consequently obtaining the liquid of the fourth ventricle. The animals can bear this quite well.

We have embodied the results in tables III and IV.

In examining these tables we must bear in mind that a comparison of cerebro-spinal liquid and bloodplasm under physiological conditions is much more troublesome than in the case of chamber-liquid; the operation generally lasts half an hour, and, when the liquid can be obtained, distinct hyperglycaemia has occurred in the blood in the mean time (this appears from the tables). Hence in the values found for cerebro-spinal liquid, which in themselves are not abnormally low (average 0.18 °/₀ in table III) there is already a certain amount owing to the increase of the quantity of blood-sugar. The value of this quantity cannot be given however, as we do not know the rapidity of diffusion here. The physiological difference with the bloodsugar-percentage is, therefore, fairly certainly smaller than that which we find if we compare with the plasm, taken simultaneously (column 3). But it is most certainly larger than would appear from a comparison with the plasm at the beginning of the experiment (column 1). By means of a larger number of experiments and by causing the operation to last as short as possible we may probably obtain more accurate data here. We shall, besides, obtain an insight into the rapidity of diffusion from an investigation of the speed with which adrenalin-hyperglycaemia manifests itself in the cerebro-spinal liquid and also of the degree of this manifestation. Our next experiments will lie in that direction [1]).

On the strength of table IV we may accept as certain that the sugar-percentage in cerebro-spinal liquid is considerably lower than it is in the chamber-liquid which was investigated simultaneously (cf. columns 3 and 4).

So we see here two "ultra-filtrates" with diverging sugar-percentages. Are we to think here of an "active" stopping of glucose by the plexus chorioideus? It seems to us that we need not call in the aid of a similar force, but that the cause should rather be

[1]) The results of these have been mentioned in the more detailed publication in the "Biochemische Zeitschrift". **123**. 190. 1921.

TABLE III.

Number of Rabbit	1 Blood-plasm		Time passed between 1 and 2	2 Cerebro-spin. liquid		Time passed between 2 and 3	3 Blood-plasm	
	Sugar-percentage	Refraction		Sugar-percentage	Refraction		Sugar-percentage	Refraction
1	—	—	—	0.14	1.3341	15 min.	0.40	1.3451
2	—	—	—	0.18	1.3341	8 min.	0.48	1.3441
3	0.23	1.314	20 min.	0.20	1.3341	50 min.	0.40	1.3456
4	0.30	—	35 min.	0.20	1.3341	15 min.	0.36	1.3451

TABLE IV.

Number of Rabbit	1 Blood-plasm		Time between 1 and 2	2 Prim. aqueus humour right eye		Time between 2 and 3	3 Cerebro-spin. liquid		Time between 3 and 4	4 Prim. aqueus humour left eye		Time between 4 and 5	5 Blood-plasm	
	Sugar-percentage	Refraction		Sugar-percentage	Refraction		Sugar-percentage	Refraction		Sugar-percentage	Refraction		Sugar-percentage	Refraction
5	0.30	—	10 m.	0.24	1.3336	25 m.	0.20	1.3341	10 m.	0.28	1.3341	—	0.36	1.3451

looked for in the action of the entire surrounding tissues, which, in the case of the eye-chamber, will fairly certainly show a smaller metabolism than the cerebral tissues with which the cerebro-spinal liquid is as much in interaction as it is with the blood.

A somewhat rapid sugar-consumption in the cerebral-tissues will necessarily cause a continuous diffusion of glucose from the cerebro-spinal liquid to this place of lower sugar-concentration. The quantity of sugar in the cerebro-spinal liquid therefore remains constantly lower than its value would be if it had interacted only with the blood; lower also than is found in the chamber-liquid. Thus we may expect for the same reasons that the blood itself will yield more sugar in the brain than round the eye-chamber and that, therefore the blood in a cerebral vein will show a greater decrease in sugar-percentage than the blood flowing from the eye-chamber and its surroundings.

A comparison of the ultra-filtrates of the blood from the a. carotis and the v. facialis posterior taught us that the difference in sugar-percentage between arterial and venous blood is almost completely due to the free sugar, while the quantity of "combined sugar" suffers hardly any modification in passing the capillary tubes.

It looks tempting to suppose that the combined sugar plays a part in the consumption of the sugar in the tissues: here the sugar would continually be combined (adsorbed?) and be combusted in that condition; this would continually cause the fixing of fresh "free" sugar from the neighbourhood; this would cause the decrease of concentration of free sugar on that spot, followed by diffusion from the blood, etc. A correct opinion about this supposition can only be pronounced when it is settled that the reducing substance, which cannot be ultra-filtrated, is sugar and when it is further settled of what kind the substance is to which this sugar is "combined".

SUMMARY AND CONCLUSIONS.

We can sum up the results of our investigations as follows:

1. In the case of rabbits *the sugar-percentage of tissue-liquids containing practically no colloids* (*aqueus humour, cerebro-spinal fluid*) is as a rule *smaller than that of blood-plasm, investigated at the same time*. This phenomenon is in agreement with the lower value for the sugar-percentage which ultra-filtrates of serum in vitro show when compared with this serum.

2. As regards *the liquid of the eye-chamber*, this *difference of sugar-percentage*, compared with *plasm* of arterial blood, is *the same* as the

quantity of *"combined sugar"* in bloodserum which does not ultra-filtrate.

3. As to *cerebro-spinal fluid*, the results do not yet give sufficient certainty concerning the exact proportions of its sugar-percentage and that of blood-plasm; *to all appearance it is considerably lower than it is in the liquid of the eye-chamber*. We wish to indicate the possibility of accounting for this difference by assuming a larger glucose-consumption in the cerebral tissues than occurs in the tissues lining the eye-chamber.

4. From the fluctuations in the sugar-percentage of eye-chamber liquid under normal conditions and with *hyperglycaemia after adrenalin-injection* we must conclude that *the equilibrium with the blood is here chiefly caused by diffusion* and hardly by the circulation of liquid; such corresponds to what is accepted about the speed of circulation of the eye-chamber liquid. On the other hand, the so-called *secondary liquid of the eye-chamber is, as regards its sugar-percentage, perfectly equal to blood plasm at the same moment*. This is accounted for as follows: what has entered is practically *blood-plasm with a high percentage of colloids and a corresponding quantity of combined sugar*.

5. In comparing *arterial* blood from the a. carotis and *venous* blood from the v. facialis posterior it appeared that the *difference of sugar-percentage* between these two is to be ascribed to the *free sugar* which is therefore yielded to the tissues.

6. The hyperglycaemia caused by adrenalin-injection depends entirely on an increase of the free sugar.

Physiological Laboratory.

Groningen, March **1921**.

Physiology. — *"Experiments on the Quick component Phase of Vestibular Nystagmus in the Rabbit"*. By A. DE KLEYN. (Communicated by Prof. R. MAGNUS).

(Communicated at the meeting of March 26, 1921).

When cold water is allowed to run into the right external auditory canal, a nystagmus will appear whose immediate effect is a slow deviation of both eyes towards the syringed, ergo the right side.

This deviation is succeeded by a quick movement of the two eyes towards the non-syringed, i. e. the left side. Then again follows the slow deviation to the right. These alternations of slow-, and quick eye-movements will recur while the syringing continues, and for some time after.

With every vestibular nystagmus the primary deflection is such a slow deviation, the so-called slow component phase of the nystagmus; the rapid movement, the so-called quick component phase is secondary.

It would be reasonable therefore to determine the direction of a nystagmus by the direction of the slow component phase. However, the quick eye-movements strike the observer more particularly, so that what in the clinical and in the physiological literature is called a nystagmus to the right is almost exclusively a nystagmus in which the quick component phase moves to the right; whereas by a nystagmus to the left a nystagmus is meant in which the quick component phase moves to the left. Although in strictness this does not square with the theory, from a practical point of view it will be well to adhere to this conception.

All researchers agree that the slow component phase arises from a direct reflex from the labyrinth via the nucleus of the N. vestibularis to the nuclei of the eye-muscle and the eye-muscles. As regards the origin of the quick component phase, opinions differ widely. Hardly any experiments have been made, so that we possess only a large number of more or less probable theoretical speculations and are still left much in the dark.

We have no intention to discuss these several theories. Only one of them, viz. BARTELS' theory, we will test experimentally. BARTELS assumes that the source of the reflex that gives rise to the quick