slight variations of the chemical composition of the circulation fluid, but also on slight differences of temperature. Thus this simple membrane forms a nice object for quantitative studies on permeability under various physiological conditions.

January 1917. *Physiological Laboratory, Groningen.*

Physiology. — *"Experimental researches on the permeability of the kidneys to glucose"*. By Prof. H. J. HAMBURGER and R. BRINKMAN.

II. THE POTASSIUM REQUIRED IN THE CIRCULATING-FLUID IS REPLACED BY URANIUM AND RADIUM.

(Communicated in the meeting of January 27, 1917)

From our preceding paper it appeared that if a RINGER-fluid containing glucose and composed of NaCl 0.7 %, $NaHCO_3$ 0.02 %, KCl 0.01 %, $CaCl_2$ 0.0075 % was circulated through a frog's kidney, 0.03 % of glucose was retained. Now ZWAARDEMAKER and FEENSTRA availing themselves of the conclusions arrived at by N. R. CAMPBELL that potassium is the only radio-active element found in the body, have discovered that in the RINGER-fluid which maintains the beating of the heart, potassium may be replaced by uranium, radium and thorium and that in equivadioactive doses [1]. It seemed of importance to us to determine whether in the above-mentioned circulating-fluid this substitution may likewise be effected with regard to the kidney. Can here too uranium and radium take the place of potassium and if so in what proportion, *in a molecular or in a radioactive one?*

Hence the KCl in the RINGER-fluid which contained 100 milligrammes of KCl per litre was replaced by the equiradio-active quantity; viz. 15 milligrammes of $U(NO_3)_4$ per litre. And it was indeed found that here too the maximum quantity of glucose was retained. If, however, instead of 15 milligrammes of nitrate of uranium, 25 milligrammes are added, only very little glucose is retained. If the litre of RINGER-fluid without K, contains 35 mGr. of $U(NO_3)_4$, no glucose is retained at all.

Now 100 m.Gr. of KCl are chemically equivalent with 112 m.Gr.

[1]) These Proceedings Vol. XIX p. 99, XX 341 and 633.
Compare also ZWAARDEMAKER, FEENSTRA and BENJAMINS, ibid. Nov. 10 1916.

of the uranium salt, consequently considerably more than 15 m.Gr. which was found by the experiments.

The same substitution could be carried out with bromide of radium solution.

1 capsule of the Allgem. Radiogen Gesellschaft contains $\frac{1}{5} \times 10^{-3}$ milligrammes of $RaBr_2$. It was dissolved by heating in 100 cc. of distilled water, which had been acidified with some HCl. This solution having been neutralized with some NaOH sol. containing no K, $2\frac{1}{2}$ cc. of the fluid obtained was put into 1 litre of RINGER-solution which contained no K. Some glucose having been added, the fluid thus obtained could indeed retain 0.03 % of glucose. The fluid contained 5×10^{-6} mGr. of RBr_2 per litre, the same quantity as that which was found by ZWAARDEMAKER and FEENSTRA to keep up the contractions of the frog's heart.

The use of 7×10^{-6} instead of 5×10^{-6} mGr of $RaBr_2$ per litre, causes the retention of glucose to decrease; this is also the case when $3\frac{1}{2} \times 10^{-6}$ is used.

If the $RaBr_2$ had acted in chemical equivalency the quantity of it being necessary to replace the 100 mGr. of KCl would have been $\frac{168}{149} \times 100 = 259$ mGr. of $RaBr_2$ per Litre instead of 5×10^{-6} mGr.

Hence it follows that potassium, uranium and radium affect the retentive power of the glomerulus membrane for glucose, in equiradioactive doses, and not in chemically equivalent doses.

Further experiments will probably show that the limits can be determined more closely than it has been done here.

These investigations throw a light upon the uranium-glucosuria, which has hitherto not been explained. It is most likely caused by a disturbance in the relative percentages of the metal atoms in the bloqdserum, the potassium of which has been increased by the addition of a metal which is, in a certain sense, related to it (uranium or radium).

The fact that glucosuria is caused by the injection of some nitrate of uranium is not contradicted by the salutary therapeutic effect of uranium in diabetes (HUGHES and WEST) [1]; but then it would have to be assumed that the potassium percentage had decreased. As to this, however, all data are wanting.

Groningen, January 1917. *Physiological Laboratory.*

---

[1]) Quoted from CAMMIDGE. Glucosuria and allied conditions. London, EDWARD ARNOLD 1913, p. 339.