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THE CELLULAR CHANGES INDUCED IN THE TESTES OF THE ALBINO RAT BY ARTIFICIAL CRYPTORCHIDISM AND X-RADIATION

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ABSTRACT

The gross size of the testes is markedly decreased. The germinal tubules have atrophied to a considerable degree. The germinal epithelium is present in a degenerate condition. The lining cells of the seminiferous tubules become a vacuolated fibrous mass as early as two weeks after artificial cryptorchidism or x-radiation. A single row of cells along the periphery of the tubules is composed of spermatogonial and Sertoli cells. Frequently, in the early stages, large deeply stained cells may be seen undergoing mitotic division in the lumen of the tubule.

The decreased size of the tubules causes the appearance of enlarged intertubular spaces which are filled with granular lymphoid accumulations and prominent cords of interstitial cells. The interstitial tissue appears to be increased in amount. The hypertrophy would be the result of either cell division or growth of the cytoplasmic and nuclear components. Mitotic divisions are not frequently observed, even after subcutaneous injection of colchicine. A progressive growth of the cytoplasmic and nuclear components of interstitial tissue is shown by measurement with an ocular micrometer.

ADRENALINE, INSULIN, POTASSIUM, AND PHOSPHORUS IN CARBOHYDRATE METABOLISM

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During the last ten years there has been an increasing number of observations and experiments which point to an important interrelationship of adrenaline, insulin, potassium, phosphorus and carbohydrate metabolism. In a great many cases there have been reports of simultaneous changes, some of them parallel, and others opposite in effect. Although some of the steps seem to be pretty well understood, on the whole the exact role of each participant in the mechanism needs yet to be clarified.

It has been recognized for some time that one of the outstanding effects of adrenaline, secreted or injected, is to cause the liver to liberate glucose, thus markedly raising the glucose level in the plasma. Since 1932[1] it has been known that in cats the potassium level is also raised. The observation has been confirmed on dogs[2] and rabbits,[3] as well as on cats,[4] by other workers. In all cases the rise is very transitory and is followed in two or three minutes by a fall which is almost as dramatic.

With the human subject, however, Keys[5] found, immediately following intravenous injection of adrenaline, there is a marked *fall* in the concentration of potassium in plasma obtained from the arm veins. Within the last year we have obtained similar results in the dog when the blood samples were taken from the saphenous vein of the hind limb. When they were taken directly from the left heart, a rise followed by the secondary fall was obtained. The decreases of potassium from the initial levels in eight experiments using saphenous vein blood varied from 2.0 to 18.2 per cent, depending upon the time of the sample and the conditions of the experiment. In four experiments in which we took blood samples from the left heart, the average *increase* in potassium in the first minute after the beginning of adrenaline injection was 44.7 per cent, while after the second minute there was an average *decrease* from the initial level of 7.9 per cent.

The rapid disappearance of the potassium from the blood suggests that it must be taken up by some organ or tissue. Data given by Marenzi and Gerschman (1936) indicate that a minute after adrenaline injection in dogs the blood plasma from the femoral vein contains about 20 per cent less potassium than the plasma from the femoral artery. This, of course, indicates that the muscles take up the potassium. We have confirmed this in several similar experiments. It is interesting that where this phenomenon was observed the potassium concentration in the plasma going to the muscle (arterial blood) was abnormally high. In other experiments in which the arterial potassium level was not higher than normal, such as with a perfused gastrocnemius on one hand and a partially isolated hind limb on the other, the arterio-venous difference, while indicating the same trend, was not conclusive.

Whether the adrenaline exerts a direct action on the muscles causing them to take up the potassium or whether the increased concentration of potassium alone is responsible, cannot be determined as yet. Houssay and Marenzi[6] have reported that the rapid disappearance of potassium chloride injected into dogs is due to the uptake by the muscles.

It has been known for some time that in addition to lowering of the glucose level of the blood, insulin causes a decrease in the

[1] Bachromejew, I. R. Pflüger's Arch. 231:427, 1932.
[2] Marenzi, A. D. and R. Gerschman, Rev. Soc. argent. de biol. 12:424, 1936.
[3] Schwarz, H., Arch. f. exper. Path. u. Pharmakol. 177:628, 1935.
[4] D'Silva, J. L., J. Physiol. 82:393, 1934.
[5] Keys, A., Am. J. Physiol. 121:325, 1937.
[6] Houssay, B. A. and A. D. Marenzi, Rev. Soc. argent. de biol. 13:139, 1937.

concentration of inorganic phosphate and the potassium.[7] It has also been concluded that at a critical level of hypoglycemia the adrenal glands are stimulated, and the change in the potassium concentration can be attributed to this secondary adrenaline liberation.[8] It has been pointed out by other investigators that the decrease in phosphate and glucose might well be due to the formation of hexose phosphate in the muscles. The mechanism of the potassium changes under these conditions remains without an adequate explanation.

The assimilation or the injection of carbohydrate into the body results in regular decreases in the concentrations of phosphate and of potassium in the blood.[9, 10] In addition, Fenn[11] has recently reported that the gain in glycogen of the livers of four carbohydrate fed rats as compared with four starved controls, is accompanied by proportionate gains in potassium and phosphate. This indicates that in the injection or assimilation of glucose the plasma potassium and phosphate enter the liver along with the glucose, and the losses of these substances from the plasma are accounted for. The function of phosphate and potassium in this case is probably similar to that in the mobilization of glucose by the liver in response to adrenaline.

Muscular activity liberates large amounts of potassium from the muscle cells both in the isolated muscle and in the intact organism[12]; it should be recalled that the adrenal glands are stimulated by muscular activity. Fenn[11] has recently found that 38 per cent of the potassium lost from the muscles of the hind legs in the rat after thirty minutes stimulation could be accounted for in the liver. It is possible that this movement of potassium accompanied lactic acid which would probably be produced in abnormally large quantities as a result of the stimulation. In the intact organism the cessation of muscular activity is followed by a rapid rise in the blood glucose[13] at the time potassium is returning to the tissues.

The interrelationship indicated from all this evidence is undoubtedly complex but that an interrelationship exists cannot be doubted. The role of the liver is important; depending on the circumstances, it gives up or stores potassium, glucose (as glycogen) and phosphorus and these substances tend to move together. There are indications that the muscles may act in a similar but opposite manner. A hormonal control of these movements between the blood and, respectively, the muscles and the liver, seems to be exerted by adrenaline and insulin. The hormone of the adrenal cortex ("cor-

[7] Briggs, A. P., I. Koechig, E. A. Doisy, and C. J. Weber, J. Biol. Chem. 58:721, 1923–24.

[8] Keys, A., Amer. J. Physiol. 123:608, 1938.

[9] Harrop, G. A. and E. M. Benedict, J. Biol. Chem. 59:683, 1924.

[10] Flock, E., J. L. Bollman, F. C. Mann and E. C. Kendall, J. Biol. Chem. 125:57, 1938.

[11] Fenn, W. O., Proc. Amer. Physiol. Soc., 51st Meeting, April, 1939.

[12] Fenn, W. O., Physiol. Rev. 16:450, 1936.

[13] Christensen, E. H., Arbeitsphysiol. 4:128, 1931.

tin") seems to exert a rather similar control over the same group of substances but the action is much slower than seen with insulin or adrenaline. Muscular exercise calls the hormonal controls into action and, apart from this, sets up diffusion gradients involving these substances by burning glucose, by releasing potassium from the inside of the cells and by breaking down the important fuel complex phosphocreatine.

A NEW SPECIES OF TREMATODE FROM THE BLADDER OF THE SPOTTED SALAMANDER

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See Some Monogenetic Trematodes from the Galapagos Islands and the Neighboring Pacific.
Allan Hancock Pacific Expeditions. Vol. 2, No. 5. Univ. of Southern California Press. 1938.

A CONTRIBUTION TO THE KNOWLEDGE OF THE MINNESOTA FLORA[1]

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During the period from June until late September field studies were made with the definite purpose of obtaining more information on the occurrence and distribution especially of higher plants in Minnesota.

Two extended field excursions were made. One was into St. Louis County, where plants were collected in the region of the Mesabi Iron Range, thence along the northern border from International Falls to Warroad on Lake of the Woods with stops at intervals for the purpose of collecting plant specimens. The second was through the western part of the state from Breckenridge, in Wilkin County, south to Luverne, in Rock County, and east through the southernmost counties to Fillmore. Several shorter excursions were made north, east, and south from the Twin City area.

A total of 415 collections was secured with an aggregate total

[1] The report which is here presented is the outcome of field work during the past summer and fall, (1938), under the auspices of the Minnesota Academy of Science and the American Association for the Advancement of Science.