from the injection of Na^{24} to the centrifugation of the blood samples. The points represent the experimental data. The solid curve has been calculated by assuming that a simple equilibrium exists between corpuscle and plasma sodium, and that the rate at which Na^{24} enters the corpuscle from the plasma is proportional to the difference in their respective concentrations, allowing for the normal difference in sodium content.

The following conclusions may be drawn from these results: first, that the red corpuscles of the dog are permeable to sodium ion; second, that the rate of permeation by sodium ion is nearly the same with blood *in vitro* as *in vivo;* third, that the permeation appears to be of a simple equilibrium nature.

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Blood Sugar in Cats with Diabetes Insipidus Before and After Adrenalectomy.

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Cats with experimental diabetes insipidus produced by interruption of the nervous connections of the posterior pituitary show rather unusual effects after bilateral adrenalectomy.[1, 2, 3] Whereas ordinary adrenalectomized cats show striking diminution in the serum sodium and chloride levels, adrenalectomized d.i. cats have normal serum concentrations of these substances even when *in extremis*. There is a more or less marked elevation of blood potassium, however, similar to that occurring in ordinary animals. The survival time after adrenalectomy is reduced from an average of 8 days for ordinary cats to an average of 3 for d.i. cats. A negative water balance is set up in both cases, the d.i. cats losing water the more rapidly. The total loss of water is not a lethal one; however, it has been suggested that the rapid external loss plus shifts in fluid within

[1] Winter, C. A., Gross, E. G., and Ingram, W. R., *J. Exp. Med.*, 1938, **67**, 251.

[2] Ingram, W. R., Winter, C. A., and Gross, E. G., *Am. J. Physiol.*, 1938, **122**, 143.

[3] Winter, C. A., Ingram, W. R., and Gross, E. G., 1939, in press.

the body may account for the short survival time of the d.i. cats. Another factor must also be considered. In the authors' experience (*cf.* also Ingram and Barris[4]) d.i. cats may show signs of altered carbohydrate metabolism as indicated by increased sensitivity to insulin. In the absence of other apparent causes this change may be provisionally accounted for by some degree of suppression of certain anterior lobe functions. Total hypophysectomy is said to shorten the survival time of adrenalectomized rats.[5] A breakdown in carbohydrate metabolism (diminution in blood sugar and carbohydrate reserves) has been associated with death in adrenal insufficiency by Britton and Silvette;[6] this association is denied by Parkins, Hays and Swingle[7] and others, and Buell, Anderson and Strauss[8] report that such changes in carbohydrate metabolism do not necessarily cause rapid death in rats receiving high salt diets. Corey and Britton[9] observed that adrenalectomy following hypophysectomy resulted in pronounced diminutions in blood sugar and muscle and liver glycogen levels. The participation of the adrenal cortex in certain phases of the metabolism of carbohydrate cannot be denied in view of the work of Long and his coworkers.[10] That loss of this participation is the cause of death in adrenal insufficiency has not, however, been generally accepted. Nevertheless, it seemed necessary to determine if suppression of the anterior lobe as manifest by hypersensitivity to insulin could be associated with the short survival times of d.i. adrenalectomized cats. Attempts to do this are herewith reported along with observations on the terminal blood sugar levels in ordinary and d.i. adrenalectomized cats.

Pre-adrenalectomy insulin sensitivities in a group of 10 d.i. cats were determined by plotting blood sugar curves following intravenous administration of 0.17 unit of insulin per kg.[4] These cats were later adrenalectomized and the blood sugar concentration determined again just before death. Six of these animals were on pitressin treatment during the post-adrenalectomy period.* The results are tabulated in Table I.

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[4] Ingram, W. R., and Barris, R. W., *Am. J. Physiol.*, 1936, **114**, 562.

[5] Samuels, L. T., Schott, H. F., and Ball, H. A., *Am. J. Physiol.*, 1937, **120**, 649.

[6] Britton, S. W., and Silvette, H., *Am. J. Physiol.*, 1932, **100**, 701.

[7] Parkins, W. M., Hays, H. W., and Swingle, W. W., *Am. J. Physiol.*, 1936, **117**, 13.

[8] Buell, M. V., Anderson, I. A., and Strauss, M. B., *Am. J. Physiol.*, 1936, **116**, 274.

[9] Corey, E. L., and Britton, S. W., *Am. J. Physiol.*, 1937, **118**, 15.

[10] Long, C. N. H., and White, A., *Ergebn. d. Physiol.*, 1938, **40**, 164.

* Thanks are due Dr. Oliver Kamm of Parke, Davis & Co. for generous supplies of Pitressin.

TABLE I.
Effect of Adrenalectomy on Blood Sugar of Normal Cats and Cats with Diabetes Insipidus.

Cat	Pre-adrect. Urine Vol. cc	Initial Blood Sugar mg%	Terminal Blood Sugar mg%	Days Survived	Insulin Sensitivity
		Cats with Polyuria—Adrenalectomy.			
32	416	82	82	2*	N
39	206	70	70	7	N
49	202	71	46	4	H+++
54	328	77	88	2	H+
26	423	85	24	2*	?
23	232	92	44	4*	?
	Cats with	Polyuria—Adrenalectomy,	Pitressin	Treatment.	
47	490	77	67	6	N
51	536	61	96	7	N
59	396	66	84	4	N
40	557	98	86	5	H+
55	715	80	61	4	H++
58	567	69	55	2	H+++
57	687	—	94	7	?
		Cats without Polyuria.			
31	119	65	25	6	
29	112	65	54	9	
43	121	79	66	5	
60	142	—	88	5 Pitressin	
Na5	101	75	59	5 "	
Na7	117	—	62	6 "	

* After discontinuing cortin treatment.
Normal sensitivity to insulin indicated by N.
Hypersensitivity to insulin indicated by H.

It will be noted that 5 of 10 d.i. cats showed hypersensitivity to insulin in varying degrees. Cat 32, of normal pre-adrenalectomy sensitivity, had as short a survival time as the hypersensitive cats (49 and 54). On pitressin treatment the survival times of the normally sensitive cats were slightly greater than those of the hypersensitive animals. Two d.i. cats (32 and 39) of previously normal sensitivity showed terminal blood sugars of 70 and 82 mg %. Two d.i. cats (49 and 54) hypersensitive to insulin had terminal blood sugars of 46 and 88 mg %, and in the latter instance (Cat 54) the survival time was the shortest. D.i. cats on pitressin treatment show but slightly higher terminal blood sugars. In general, of 13 d.i. adrenalectomized cats, only 3 showed terminal blood sugars below 50 mg %, only one of which (cat 26, of unknown insulin sensitivity) was at a convulsive level. Of 6 non-polyuric adrenalectomized cats only one showed a strikingly low blood sugar.

These data advance no evidence that the short survival times of d.i. adrenalectomized cats are primarily associated with anterior lobe suppression as indicated by insulin sensitivity. Furthermore, there seems to be no justification for suggesting that death in these or in

ordinary adrenalectomized cats is necessarily related to low levels of blood sugar. In the authors' experience blood sugar levels of 50-70 mg % in cats are not incompatible with life, while the convulsive level lies between 20 and 28 mg %. No statement as to the carbohydrate reserves of these animals can be made. It is not unreasonable to presume that these are reduced, especially in view of the period of anorexia preceding death from adrenal insufficiency and the defect in conversion of protein to carbohydrate which follows loss of the adrenal cortex.[10] With the exception of the 2 cases mentioned, however, the blood sugars were not at a lethal level. It has recently been observed, moreover, that d.i. adrenalectomized cats may be maintained for considerable periods of time on high intakes of sodium and chloride, with maintenance of relatively dilute blood, in the absence of cortin (Ingram, Winter and Gross[11]). This would lend further weight to the suggestion that the short survival periods and death of d.i. adrenalectomized cats are in general not associated with suppression of the anterior lobe nor with decline in the blood sugar level due to anterior lobe involvement or loss of the adrenal cortex. The cause of the early demise of these animals may more likely be connected with shifts of fluid shown to take place within the body by other workers, together with rapid loss of water from the body in the absence of the fluid-conserving influence of the normally innervated posterior lobe.

Summary. Cats with posterior pituitary inactivation may die in adrenal insufficiency with blood sugars in the normal range, even if these animals have previously been found to be hypersensitive to small doses of insulin. This is true whether or not the animals are under treatment with pitressin. There is no evidence that the short survival period of untreated diabetes insipidus cats after adrenalectomy is associated with the blood sugar level or partial anterior lobe suppression.

[11] Ingram, W. R., Winter, C. A., and Gross, E. G., *Proc. Am. Physiol. Soc.*, 1939, p. 128.