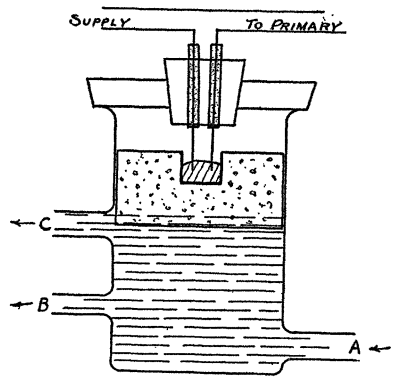

tecting water-cooled X-ray tubes from failures of the water line, the operation of which depends on the outflow from the tube. A device actuated by the water flowing out of the X-ray tube was constructed by the author and used at Cornell University in 1926–1927. Inasmuch as the arrangement used is much simpler in construction than the one described in the journal, and quite efficient, it seemed worth while to give its description here.

A beaker having three tubes sealed to it is placed in the path of the water from the X-ray tube, the water entering the beaker through tube A (see figure). The diameter of tube B is slightly smaller than that of A, and can not carry the outflow. The water in the beaker rises to the level of the large tube C raising a cork plug with a mercury cup in the center. In this position two copper electrodes passing through the cover of the beaker dip into the mercury and close the primary circuit of the transformer. It is, therefore, impossible to operate the tube without turning the water on. In case of failure of the water system the level of the water in the beaker drops and with it the plug with the mercury cup, thereby breaking the primary circuit. Temporary fluctuations of the water pressure will not affect the circuit, as it takes a few seconds for the water level to drop so low as to break the circuit owing to the small diameter of tube B. It is necessary to make the wooden plug waterproof and to prevent its swelling. This is accomplished by keeping the plug in boiling paraffin for about an hour. The copper electrodes are sealed into glass tubes passing through a rubber stopper in the cover. The level of the electrodes is easily adjusted by pushing the glass tubes in or out of the stopper.

A. A. BLESS

UNIVERSITY OF FLORIDA

SPECIAL ARTICLES

VITAMIN B DEFICIENCY IN NURSING YOUNG RATS AND LEARNING ABILITY[1]

INNUMERABLE experimental studies have established the causal relationship between deficient diets and various forms of physical deformities. Howe[2] has produced experimentally in monkeys the most striking cases of tooth and nasal deformities resembling those often seen in human beings simply by placing the young and rapidly growing animals on a diet partially deficient in vitamins.

Similarly, diets deficient in vitamin B experimentally produce polyneuritis in young adult animals and play an important rôle in the etiology of pellagra and beriberi of human beings. These experiments show that the relation also exists between diet and the nervous system. However, thus far there has been practically *no* adequate experimental study on the relation of diet to learning ability.

It was the purpose of our investigation to determine the effect of various deficient diets upon the learning ability of the first, second and succeeding generations of rats of known heritage, and to correlate these findings with the anatomical and chemical changes in their nervous system.

The present report, however, deals only with the number of trials required to learn a standard maze by seventy-one rats of the first generation, some of which were depleted of vitamin B during their nursing period. Other data will be reported in forthcoming articles.

As it was our purpose to deplete the animals during their nursing period, we could succeed only by depleting the nursing mothers. The technique we used in giving the new-born pups a diet at first deficient and later free of vitamin B is that described by Sure,[3] who has demonstrated that the quantity of vitamin B in the milk of the nursing mother rat is proportional to the vitamin B content of the mother's diet.

Forty-three animals were thus depleted on this diet until they were strong enough to wean. The degree of depletion was, of course, subject to variation; some of the pups were depleted to a point so near death that their lives were saved with great difficulty, while others appeared quite normal all the way through except for retardation of the rate of growth. Twenty-eight other animals were used as controls, their

[1] From the Otho S. A. Sprague Memorial Institute and the departments of pathology and psychology, University of Chicago.

[2] Percy Howe, "Percy Howe's Letters," *The Dental Digest.*

[3] Barnett Sure, "Vitamin Requirements for Nursing Young, III," *The Journal of Nutrition,* 1: 139.

mothers being fed on a normal diet during the nursing period.

After the nursing period, all pups were placed on exactly the same diet and cared for in exactly the same way. The animals were frequently handled, while their body weights were taken and recorded at regular intervals.

The depleted animals at seventy days were stunted and smaller than the control animals so that it was decided to test part of them at ninety days, while the rest of them and the control animals were started on preliminary training at seventy days. This was done with a view to ascertain whether there was a permanent damage done to the nervous system or just a mere retardation in learning ability.

NUMBER OF TRIALS REQUIRED FOR MAZE LEARNING

Group	Control	Depleted	Depleted
Dietary condition	Vitamin B rich while nursing	Vitamin B depleted while nursing	Vitamin B depleted while nursing
Age on maze	70 days	70 days	90 days
Individual records	6	29	25
	7	31	25
	11	39	28
	12	40	31
	18	48	33
	19	49	34
	19	53	38
	19	69	48
	20	68	57
	24	69	73
	24	70	76
	25	70	85
	26	86	85
	27	92	92
	29	96	106
	29	99	109
	30	99	111
	31	112	113
	31	112	132
	33	124	142
	34	275	151
	34	283	
	35		
	41		
	64		
	67		
	67		
	84		
Total	866	2,013	1,594
Average	30.9	91.5	75.9
Median	28	70	76

After one week of preliminary training in the food box, the animals ran the maze once daily during the first three days, after which two trials were given a day until the problem was learned. The criterion of mastery was eight correct out of ten consecutive trials.

The incentive used was a vitamin concentrate (Wheatamin) which is rich in vitamin B. Sure's B-free food plus a certain percentage of yeast, available with water, was always in the living cage of each animal after the nursing period. Both groups were anxious to get the needed additional vitamin B. Preliminary work showed that this represented the best procedure in getting the two groups to the nearest approximation in relative strength of incentive.

The results thus obtained are presented in the table.

The average number of trials for the depleted animals tested at seventy and ninety days old are ninety-two and seventy-six respectively, as compared with thirty-one for the normal animals tested at seventy days. In other words, normal rats of seventy days old learn on the average three times better than vitamin B deficient rats of the same age, and two and one half times better than vitamin B deficient rats of ninety days old. None of the depleted animals (except three of the ninety days old) ever reach the attainment of the median of the normal group in learning, while the worst animal in the control group learns better than 47 per cent. of the depleted animals. Such large differences are statistically reliable.

The significance of our result becomes striking when compared with the findings of Anderson and Smith.[4] According to these investigators, rats fed on diets which contained incomplete protein or insufficient calories, are, on the contrary, superior to normal rats in maze learning. Evidently their stunting produced little or no harmful effect, but rather increased the incentive of the stunted animal.

This may be due to their inadequate control of incentive, to the particular kind of diet chosen and to the late stage of life at which stunting was introduced.

Hoefer and Hardy[5] correlated the intelligence quotients of public-school children with the method of feeding during their early life, and found that those children who had been breast fed from six to nine months ranked highest, the artificially fed next and the entirely breast fed for the first eighteen months lowest in their test scores. The results are only suggestive, as adequate control of diet, environment and heritage is lacking.

[4] John E. Anderson and Arthur H. Smith, "The Effect of Quantitative and Qualitative Stunting upon Maze Learning in the White Rat," *Jour. Comp. Psychology*, Vol. VI, No. 5, 1926.

[5] Carolyn Hoefer and Mattie Compton Hardy, "The Physical and Mental Growth of Breast-fed and Artificially Fed Infants," *J. A. M. A.*, 92: 615. 1929.

To recapitulate, our data show conclusively that normal rats are far superior in maze learning to rats which have been depleted of vitamin B during their nursing period. In so far as deficiency of vitamin B is etiologically associated with changes in the nervous system, our investigation has opened a new avenue in attacking the problem of the relation between nervous system and learning ability.

SIEGFRIED MAURER
LOH SENG TSAI
UNIVERSITY OF CHICAGO

SAVING TIME AND STORAGE IN BREEDING SUGAR-BEETS[1]

RECENT trials at the Utah Experiment Station have established the feasibility of producing in that region, in one year instead of two, successive seed generations of sugar-beets for breeding purposes.

In New Mexico, Overpeck[2] has reported that early seeding makes it possible to produce seed the succeeding summer without moving the beets. In Utah, fall or winter seeding can not be practiced, as the beets freeze in the ground. In attempts to breed sugar-beets, or to produce seed without breeding, two years have been required for each seed generation. Winter storage has proved to be a major problem, at least when attempted on a large scale.

In the spring of 1926, about seventy sugar-beet roots were set out to produce inbred and normal seed, which practically all of them did. Under the conditions prevailing at Logan, Utah, small amounts of selfed seed[3] were produced by bagging branches. Some of the selfed seeds from twelve plants were sown in the greenhouse during November, and the rows thinned to ten plants in the row. After the tops had made enough growth to begin to cover the ground, the plants were exposed to electric light from twilight to about 11 P. M.

The roots from one half of each row were harvested early and put in an ordinary potato cellar for a month. The other half continued to grow in the greenhouse until transplanting time. Water was withheld until the leaves were well wilted down. At this time, all the roots were set out in the field—the ones from the greenhouse first. All save two grew after being transplanted to the field. Most of them produced seedstalks and successfully matured seed. A summary of the data is given in Table I.

Out of twelve strains involving 114 beets, twenty failed to set seed—six in the half transplanted directly from the greenhouse and fourteen in the half given a storage period of one month.

TABLE I

NUMBER OF SUGAR-BEET ROOTS SET OUT IN FIELD DIRECTLY FROM GREENHOUSE, NUMBER STORED IN CELLAR ONE MONTH BEFORE BEING SET OUT, NUMBER AND PERCENTAGE PRODUCING SEEDSTALKS FROM EACH TREATMENT. ALL SEEDED IN GREENHOUSE IN NOVEMBER AND SET OUT IN FIELD IN LATE APRIL. GROWN WITH THE ASSISTANCE OF ELECTRIC LIGHT DURING THE WINTER OF 1926–27 AT LOGAN, UTAH

Pedigree No.	Roots set out		No. plants seeding		Percentage seeders	
	Directly from greenhouse	Stored in cellar one month	Directly from greenhouse	Stored in cellar one month	Directly from greenhouse	Stored in cellar one month
14	5	5	5	4	100	80
23	5	5	4	4	80	80
24	5	5	5	3	100	60
36	4	4	2	1	50	23
37	5	5	4	5	80	100
59	5	5	5	1	100	25
69	3	4	3	4	100	100
101	5	5	4	4	80	80
105	5	5	5	5	100	100
106	5	5	4	4	80	80
158	3	5	5	4	100	80
160	4	5	4	5	100	100

About four hundred beets were grown in the greenhouse, in 1928, and transplanted directly to the fields. Some of the beets were started in the greenhouse in early December and others in late January. All the early-seeded plants set seed successfully in 1928, but of the late-seeded group only a few set seed. This indicates that probably a minimum size or age or light exposure is required before the plants will seed normally.

CONCLUSIONS

(1) By seeding sugar-beets in the greenhouse in early December or sooner, by exposing the growing beets to electric light for a few hours in the evening and by transplanting the roots into the field in spring, a seed generation may be produced every year.

(2) The beets must have reached a minimum stage of maturity at transplanting time, otherwise many may fail to produce seed.

(3) Storage for one month in a cellar before transplanting failed to give any observable benefit.

GEORGE STEWART
UTAH AGRICULTURAL EXPERIMENT STATION

[1] Publication authorized by the director, May 1, 1929.

[2] J. C. Overpeck, "Sugar-beet Investigations," *New Mex. Agr. Exp. Sta. Bul.*, 162: 3–16. 1927.

[3] G. Stewart and D. C. Tingey, "A Method for Controlling Pollination of Sugar-beets," *Jour. Amer. Soc. Agron.*, 19: 126–128. 1927.