Table 1. Starch content and packing volume of chloroplasts isolated from *Digitaria decumbens* treated at 10°C and 30°C. Sample was 8.5 g (fresh weight) for each treatment.

Night temperature	Starch content (mg/g)	Packing volume (cm/g)
Continuous 30°C	0.61	0.09
Continuous 30°C + 1 night of 10°C	4.11	0.12
Continuous 30°C + 2 nights of 10°C	6.01	
Continuous 30°C + 2 nights of 10°C + 1 night of 30°C	1.62	

tion. The larger size of chloroplasts after low night temperatures, as indicated by a larger packing volume, gives evidence of lowered photosynthetic potential. Thus, the severe reduction of growth in *Digitaria decumbens* by low night temperatures may be the result of the failure of translocation of products of photosynthesis from the mesophyll chloroplasts and consequent interference with photosynthesis.

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References and Notes

1. W. G. Blue, N. Gammon, Jr., H. W. Lundy, *Soil Crop Sci. Soc. Fla. Proc.* **21**, 56 (1961); D. E. McCloud, O. C. Ruelke, J. M. Creel, Jr., *Fla. Agr. Exp. Sta. Res. Rep.* **2** (1), 8 (1957).
2. C. R. Slack, M. D. Hatch, D. J. Goodchild, *Biochem. J.* **114**, 489 (1969).
3. P. A. Siegenthaler and L. Packer, *Plant Physiol.* **40**, 785 (1965).
4. T. Bisalputra, W. J. S. Downton, E. B. Tregunna, *Can. J. Bot.* **47**, 15 (1969).
5. E. Madsen, *Physiol. Plant.* **21**, 168 (1968).
6. Supported in part by an NDEA fellowship grant. We thank Dr. H. C. Aldrich and staff, Biological Ultrastructure Laboratory, University of Florida, for assistance and facilities. Florida Agricultural Experiment Station Journal Series No. 3496.

22 December 1969

Obesity: Absence of Satiety Aversion to Sucrose

Abstract. *In obese subjects, ingestion of glucose did not cause the transformation of the gustative sucrose sensation from pleasant to unpleasant as in normal subjects. This result is consistent with the theory of a decreased sensitivity to internal signals in the control of food intake of obese people.*

Food intake is controlled by a system receiving multiple inputs, which can be grouped according to their origin as (i) internal signals, such as humoral modifications, gastric contraction or distention, and internal temperature changes and (ii) external stimuli, such as the taste, smell, or sight of food.

The response of obese humans has been compared with the behavior of hypothalamic hyperphagic rats, and the differences between internal and external signals were noted (*1*). These observations led to the theory that obese people are highly sensitive to external stimuli but are relatively insensitive to internal signals.

Two components can be distinguished in sensation. (i) The discriminatory component analyzes the nature and the intensity of the stimulus and (ii) the affective component analyzes whether the sensation is pleasant or unpleasant. For example, the taste of a sweet solution is pleasant to fasting subjects but turns unpleasant after a load of glucose in the stomach (*2*). Because the pleasantness or unpleasantness of sweet sensation is controlled in part by a gastric internal signal, it is relevant, according to the above theory, to look at the affective response of obese people to gustative stimulation. The obese subjects were patients entering the hospital for a cure of obesity or detection of potential diabetes, ten women averaging 151.6 cm in height, and 83.5 kg in body weight and five men averaging 173.2 cm and 93.2 kg were used. None of the subjects used in this experiment was diabetic. The subjects, not yet under a controlled caloric food intake, wished to decrease their body weights. Control subjects were six females, averaging 160 cm in height and 50.5 kg in body weight, and four males, averaging 176 cm and 69.9 kg, respectively.

After the subjects were fasted for 12 hours, they were given a taste test with a series of sucrose solutions (2.5, 5, 10, 20, and 40 percent). Taste samples (25 ml each) were presented in random order, with suitable precautions. Each sample was taken in the mouth but not swallowed. After 15 seconds, the subject expectorated the sample and then graded the solution just tasted on an affective scale as follows: + 2, very pleasant; + 1, pleasant; 0, neutral; − 1, unpleasant; − 2, very unpleasant.

The subject was allowed to give any rational number between − 2 and + 2. Immediately after this series of tests, he ingested 50 g of glucose in 200 ml of aqueous solution. This amount is routinely used for blood insulin and glucose responses and gives comparable results regardless of body weight and size in nondiabetic subjects.

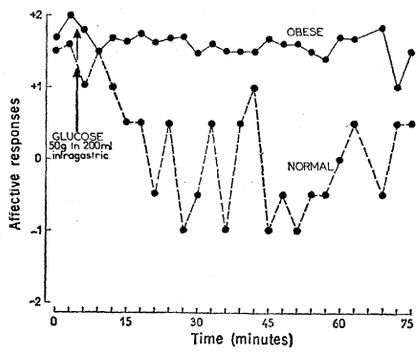

Fig. 1. Development of the affective responses given by one obese and one control subject to gustative stimuli of 25 ml of 20 percent sucose solution. Duration of each stimulus, 15 seconds.

To test the development of the sensation, each subject was given 5 g of sucrose in 25 ml of aqueous solution every 3 minutes after glucose ingestion. One hour after the glucose gastric load, the subject was offered the same range of sucrose solutions as previously and in the same order of presentation.

Blood glucose and insulin were measured 10 minutes before, and 30, 60, and 120 minutes after glucose ingestion. Only two obese subjects had hyperglycemic responses; insulin responses were quite variable. No correlation was found between gustative response and these parameters.

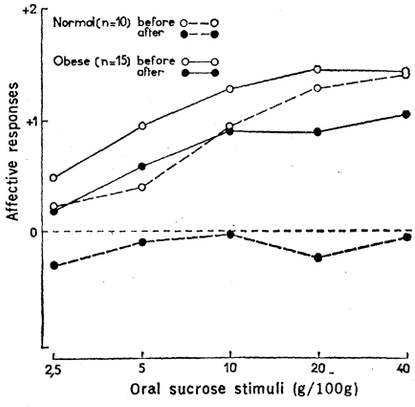

Fig. 2. Affective responses given by ten control and 15 obese subjects after tasting, for 15 seconds, 25 ml of sucrose aqueous solutions at increasing concentrations before and 45 to 70 minutes after ingestion of 200 ml of 25 percent glucose solution. Presentation of solutions was in random sequence and was different for each subject, but the same sequence was used for each subject before and after stomach load. Note that the coordinates are semilogarithmic.

Initially sucrose was pleasant at all concentrations to fasting normal subjects (*3*). After glucose ingestion, the sweet sensation became unpleasant, developing with time and varying from subject to subject (*2*) (Fig. 1). When sucrose at the concentration of 20 g per 100 ml of solution became unpleasant, all other concentrations tasted also were unpleasant in most cases (Fig. 2). The difference between affective response for sucrose before and after glucose ingestion is statistically significant ($.05 > P > .02$) (*4*).

In obese patients, the gastric glucose load also changed the affective preference for sucrose (Figs. 1 and 2), but to a much smaller extent, and the sucrose stimulus after glucose did not become unpleasant at any of the concentrations offered. The difference in responses before and after glucose load in obese subjects was not statistically significant ($P > .05$) (*4*).

Obese patients, unlike the nonobese controls, seemed to feel very little difference between the pleasantness of the taste of sweet solutions before and after glucose loads. These data lend support to the theory that obese people are generally unaware of internal signals for control of food intake. It is not known whether this phenomenon is a cause or a result of obesity (*5*).

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References and Notes

1. R. E. Nisbett, *Science* **159**, 1254 (1968); S. Schachter, *ibid.* **161**, 751 (1968); A. S. Stunkard, *Fed. Proc.* **27**(6), 1367 (1968).
2. M. Cabanac, Y. Minaire, E. Adair, *Commun. Behav. Biol. Part A* **1**, 77 (1968).
3. C. Pfaffman, *Psych. Rev.* **67**, 253 (1960).
4. Series of "χ^{2}" tests [L. Lison, Ed., *Statistique appliquée à la biologie expérimentale* (Gauthier-Villars, Paris, 1958)].
5. The averages after glucose load given in Fig. 2, as well as the statistical analyses, include: of the ten control subjects, one gave a typical "obese" response; and of the 15 obese, two subjects gave normal responses. We suggest that these "exceptions" may not be atypical for their groups if their past or future case histories are studied. Indeed, such "anomalous" results may prove to have predictive value.
6. We thank M. Plauchu and R. Mornex (as well as the subjects themselves) for permitting the observation of obese patients, and C. Bizollon for the quantitative analyses of the blood samples for glucose and insulin.

27 October 1969; revised 12 January 1970

Summer Hibernation Induced by Cryogenically Preserved Blood "Trigger"

Abstract. *Summer hibernation induced by transfusions of blood (serum, cells, or whole blood) from hibernating ground squirrels and woodchucks demonstrates that (i) this "trigger effect" can be preserved cryogenically in vitro for at least 5 months, (ii) it cross-reacts between these species of hibernators, and (iii) its effectiveness relates to the donor's previous hibernation history.*

In January of 1969 an experiment was reported (*1*) in which the blood of hibernating ground squirrels (*Citellus tridecemlineatus*), transfused into active ground squirrels, produced hibernation serially in summer months. That experiment had been performed in 1968. We report now on our 1969 efforts to reconfirm and extend this observation.

Our experimental approach was threefold. In the first instance, we endeavored to discover how a pattern of hibernation in both the donor and the recipient may affect the phenomenon we had observed. Second, we wished to know whether or not the "trigger" for hibernation, which exists in hibernating blood, can be preserved intact cryogenically. Third, an answer was sought to the question of whether hibernating woodchuck (*Marmota monax*) blood would trigger hibernation in the ground squirrel. A series of experiments was carried out addressed to these problems. This report divides into two subsections: (i) blood directly transfused, experiment involving cold- and warm-adapted animals, and (ii) blood cryogenically preserved, stored blood transfusion experiment.

Blood directly transfused. On 26 March 1969, in each of seven cases, approximately 1 ml of blood taken from a hibernating ground squirrel [following a procedure identical to that described previously (*1*)] was transfused into the saphenous vein of an active ground squirrel which was then placed in the cold room (7°C). Four of these animals had been kept in the warm room (about 20°C) throughout the previous winter and had not hibernated. The other three had lived in the cold room throughout the previous winter and also had not hibernated. It should be noted that these three were aberrant cold-adapted animals (in contrast to most of our animals in the cold room which had hibernated at one time or another), since they were cold-adapted, nonhibernating hibernators. The results of this experiment are describable quite simply: the four transfused warm-room animals went into hibernation within the next 22 days, whereas the three transfused cold-room animals did not enter hibernation for at least 100 days thereafter. One of the warm-room animals that hibernated died 24 days after the transfusion (having entered hibernation 10 days after transfusion).

Inspection and treatment of data on the four transfused animals that hibernated gave three relations of interest. These are shown in Figs. 1 and 2. Briefly, the data indicate: (i) The number of days in which the donor animal was in hibernation at the time of exsanguination was inversely and logarithmically related to the length of time in days required for the recipient warm-room animal to enter hibernation (Fig. 1). (ii) Cold-adapted recipients did not hibernate following transfusion, whereas warm-adapted animals did hibernate (Fig. 2). (iii) The percentage of time that an animal spent hibernating in the 60-day period following transfusion was directly related to the percentage of time in hibernation shown by the donor animal during the 60-day period prior to its exsanguination (Fig. 2).

Blood cryogenically preserved. Basically, this experiment consisted of withdrawing bloods on 20 January, separating cells and serum in some cases, and freezing all samples in liquid nitrogen (*2*). The same procedure was followed on 21 February. These blood

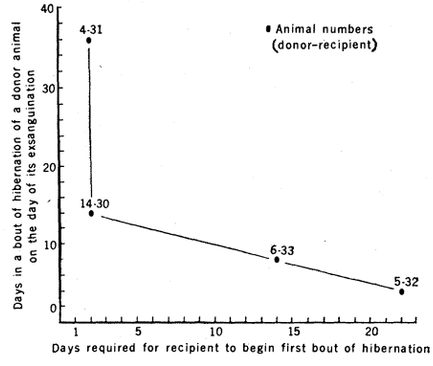

Fig. 1. This figure shows how soon the recipient began hibernation following direct transfusion on 26 March 1969.