Table 2. Data showing recovery from nickel-induced chlorosis in blueberry plants following treatment with ferrous ethylenediaminetetraacetate.

Description	Dry weight (mg/cm²)	Nitrogen (μg/cm²)			
		Total	80-percent alcohol-soluble	Total amino acids	Arginine
Chlorotic, before treatment	5.1	183	44	32	28
4 days after treatment*	4.7	169	43	31	28
13 days after treatment	6.8	139	14	4	3
26 days after treatment	6.9	107	11	1	0.2

* Approximately 30 ml of ferrous ethylenediaminetetraacetate solution containing 20 ppm of iron was injected into a branch bearing four actively growing shoots. Almost complete regreening had occurred after 26 days.

The dried samples were stored at −18°C. Aliquots were chromatographed quantitatively on Whatman No. 1 paper using procedures similar to those of Levy and Chung (*7*) and Thompson and Steward (*8*). (The data have not been corrected for any losses that may have occurred during the isolation procedure. Controls indicated that the recoveries of amino acids were at least 80 percent.) The content of arginine in the samples was also determined colorimetrically (*9*), using the difference between determinations before and after treatment with arginase. Results are expressed in terms of leaf area. Total nitrogen and 80-percent-alcohol-soluble nitrogen were determined by the micro-Kjeldahl method.

The results (Tables 1 and 2) indicate that an accumulation of free arginine is characteristic of the nitrogen metabolism of plants afflicted with iron-deficiency chlorosis. The disappearance of free arginine during recovery from chlorosis is shown in Table 2. Amino acids, other than arginine, that commonly occur in the leaves studied are (identification by position on the chromatogram) alanine, aspartic acid, asparagine, glutamic acid, and glutamine, with occasional traces of γ-aminobutyric acid, glycine, lysine, proline, serine, threonine, and valine.

Three of the four nitrogen atoms present in arginine (the three nitrogens in the guanidino group) would have been missed by Iljin's analyses and would have been included in his "residual nitrogen" fraction. Therefore, a high free-arginine content, which seems to be characteristic of chlorotic leaves, would account for the "residual nitrogen" described by Iljin.

It is of interest in connection with the findings reported here (*10*) that von Euler and Burström (*11*) found a high free-arginine content in the white borders of leaves of a variegated *Pelargonium* plant. (Leaves from two other variegated plants showed normal arginine content.) It should also be mentioned that Hewitt *et al.* (*12*) have reported that free arginine increases more than other amino acids during manganese deficiency in cauliflower, and these authors suggest that manganese is involved in amino acid metabolism.

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Differential Sensitivity of the Eye to Intermittent White Light

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The eye has often, in the past, been scorned as a temporal analyzer, the ear always seeming to take precedence. Strangely, few data exist that allow a direct, valid comparison between the two modalities. This paper (*1*) reports the results of an experiment that measured the speed of response of the human eye in a new way. The procedure was to measure the difference-limens for intermittent white light at 16 frequencies in the range of 1 to 45 cy/sec.

The intermittent stimulus light was produced by a Sylvania R1131C glow-modulator tube operated independently from two variable-frequency square-wave generators. Glow-modulator tubes follow precisely an electric input, and the square-wave generator was determined to have an accuracy of 0.5 percent in the range of the frequencies studied.

The stimulus spot provided by the tube subtended 1° of visual angle and had a homogeneous luminance of 98 millilamberts. It appeared in the center of a white surround subtending 71° held at a luminance of 44 millilamberts.

Table 1. Difference-limens for intermittent white light. Data from two practiced observers.

Standard frequency (cy/sec)	Average deviation (cy/sec)	$\Delta f/f$
1	0.010	0.010
2.5	.063	.025
5.0	.157	.031
7.5	.100	.013
10	.151	.015
12.5	.215	.017
15	.238	.016
17.5	.398	.023
20	.614	.031
22.5	.683	.031
25	.516	.021
27.5	.411	.015
30	.328	.011
35	.168	.005
40	.237	.006
45	.358	.008

The observer sat in a room darkened except for the light of the surrounding field. He viewed the standard and comparison frequencies successively on the same tube and selected, by a switch, the frequency he wanted to view. He also controlled the frequency of the comparison stimulus by a linear multirevolution potentiometer. Equality judgments were obtained by the method of adjustment, using ascending and descending matches alternately. The discrepancy between the standard and the comparison frequency was measured with an electronic counter to an accuracy exceeding that of the generating equipment. At least 20 thresholds were obtained from each of two practiced observers for all 16 frequencies.

Since the results from both observers were in agreement, their data have been pooled in Table 1 and Fig. 1. Columns 1 and 2 of the table show the standard frequency and the average deviation or average absolute error, of the comparison frequency from

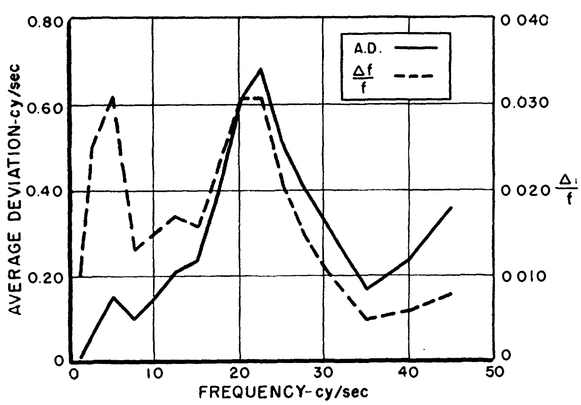

Fig. 1. The difference-limen function for flicker. The average deviations and the relative difference-limens shown on the ordinates are from columns 2 and 3 of Table 1.

each standard. The average deviation is seen never to exceed about 0.6 cy/sec, while for the lower frequencies it is sometimes less than 0.1 cy/sec. Most striking, however, is the sharp rise in the threshold between about 15 and 22.5 cy/sec with a subsequent sharp decline to the region of 30 to 35 cy/sec. The threshold then rises as the fusion point is approached. Fusion for the conditions obtaining here was slightly more than 50 cy/sec for both observers.

Column 3 shows the relative difference-limen, $\Delta f/f$, for each frequency. The range of $\Delta f/f$ values is about 0.005 to 0.030, and 10 of the 16 points fall below 0.02. This is a rather respectable performance for an organ that is thought to have little temporal resolution. Even more impressive is the fact that, at a flicker rate of 35 cy/sec, the average absolute error of the judgments with respect to time is about 130 μsec. That is to say, when the period of the standard differs from that of the comparison by 130 μsec, the eye detects a difference.

Table 2. A comparison of relative difference-limens for auditory flutter and photic flicker.

Standard frequency (cy/sec)	Flutter ($\Delta f/f$) 50 db (sensation level)	Flutter ($\Delta f/f$) 100 db (sensation level)	Flicker ($\Delta f/f$)
20	0.100	0.100	0.031
40	.150	.075	.006
80	.162	.075	
120	.208	.083	
160	.250	.094	
240	.333	.217	
320	.459	.459	

Another facet of this problem concerns the number of just noticeable differences in the stimulus range investigated. This range is limited by the fusion point, but where the other end terminates is purely arbitrary. There is doubt that anything below about 5 cy/sec is really flicker or that the same criterion of judgment can be used as with the higher frequencies (*2*). Be that as it may, the integration of difference-limens by graphic methods yields 280 just noticeable differences for photic flicker between 1 and 45 cy/sec. This is a very creditable number. Indeed, the number of such differences in pitch that can be discriminated is only 6 times as large for a frequency range nearly 450 times as great (*3*).

Only one investigation in audition yields data comparable to those reported here. Miller and Taylor in 1948 studied difference-limens for interrupted white noise, or what they called "flutter" (*4*). It is of interest to relate the differential sensitivity for flutter and flicker despite two serious difficulties in doing so. One is that the frequencies used by Miller and Taylor overlap only two of the data points in the flicker experiment. The other is that a different method of obtaining the difference-limens was used—one that probably resulted in higher thresholds than those obtained here.

Table 2 compares the two sets of data at the points where a comparison is possible. The wide discrepancy that exists for interruption rates of 20 and 40 cy/sec is in favor of the eye. It is hard to believe that the eye can beat the ear at its own game. Since the differences in method might explain this discrepancy, it is hoped to put the matter to the test soon.

References and Notes

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Communications

Explanation of the Effect of Feeding Desiccated Thyroid on the Incidence of Dental Caries in the Rat

Muhler and Shafer (*1*) have recently produced convincing experimental evidence that the feeding of desiccated thyroid has a marked anticariogenic effect in the rat. It is, in fact, as effective as the administration of sodium fluoride. They have also shown that there is an increased incidence of dental caries in rats when the level of thyroid hormone in the blood is lowered by "blocking" the thyroid with thiouracil. Their work leaves no doubt that thyroid activity is related in some manner to the incidence of dental caries in the adult rat.

We would like to suggest a possible explanation for this relationship. It has recently been postulated that the submaxillary and parotid salivary glands in the rat function to control the level of thyroid hormone in the blood stream by degrading it to iodide ion (*2–5*). The iodide ion is then recycled to the thyroid gland via the saliva and the gastrointestinal tract. This explains the long-known ability of the salivary glands to concentrate iodide and means that the concentration of iodide in the saliva will depend on the rate of thyroxine degradation if the dietary iodide does not vary.

A convenient explanation of the results of Muhler and Shafer would be that it is the increased concentration of iodide ion in the saliva and/or the increased saliva flow resulting from the stimulation of the degradative processes in the salivary glands that accounts for the effect of feeding desiccated thyroid. The increase in the incidence of dental caries noted when thiouracil was fed, may well have been caused by a decrease in the level of iodide in the saliva and a decrease in the rate of saliva flow associated with a diminished rate of degradation of the thyroid hormone. It is well established that a diminution in the rate of salivary flow has a marked effect on the incidence of dental caries in experimental animals (*6*) and it is possible that iodide ion, like a variety of other substances, has an anticariogenic action when it is in solution in the saliva.

There are many reports in the literature which indicate that hyperfunction of the salivary glands is associated with hyperthyroidism. Thus Moehlig, in a review (*7*), states that obvious swelling of the salivary glands is often associated with hyperthyroidism, and he quotes references to other workers who have observed the same phenomenon. Moehlig also states that hypersalivation is often a troublesome symptom in hyperthyroidism and quotes other workers who have also observed this. Hammerli (*8*) observed, in a study of 197 autopsies on goiter patients, a hypertrophy of the submaxillary salivary glands. The extent of hypertrophy was related to the size of the goiter. Albright, Larson, and Deiss have recently reported (*9*) transient swelling of the parotid and submaxillary salivary glands in a myxedematous patient after the administration of triiodothyronine.

In the rat, both thyroidectomy and the administration of thiouracil or thiourea result in marked atrophy of the submaxillary salivary gland (*10–12*). This atrophy, both in the case of thyroidectomized and thiouracil-fed rats, can be prevented by the administration of thyroid hormone (*10–12*). In view of the recent direct experimental demonstration that the salivary glands in the rat are concerned with the extrathyroidal metabolism of organically bound iodine (*4*), this atrophy is very probably the result of the cessation of the degradative function in the submaxillary gland. It would appear reasonable to assume that this would result in a diminution in the concentration of iodide ion in the saliva, along with a decreased saliva flow. The feeding of desiccated thyroid has been shown to result in an increase in the weight of the submaxillary gland of the rat (*12*). This is very probably caused by the increased degradation of the excess thyroid hormone, which would result in an increased concentration of iodide ion in the saliva and, perhaps, to an increased flow of saliva.

In summary, there is evidence both from the clinical literature and from work on experimental animals that there is hyperfunction of the salivary glands in hyperthyroidism and hypofunction of the salivary glands in hypothyroidism. We feel that the anticariogenic action of desiccated thyroid may well result