petroleum ether saturated with aqueous ammonia (sp gr, 0.90) the solvent being allowed to ascend for about 30 min. The strips are finally dried and sprayed with the permanganate and benzidine reagents as above. Under these conditions, the allyl cinerolone barely moves from the point of application. The cis- or trans-chrysanthemum monocarboxylic acids remain at the final position of the acid solvent front as the ammonium salts, and the unchanged esters move with the ammoniacal solvent front. The application of these methods to the study of the metabolic fate of the C^{14}-labeled insecticides will be the subject of a later report.

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Algae (*Chlorella*) as a Source of Nutrients for the Chick[1]

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Following the work of Spoehr and Milner (*1*) on the effect of environmental conditions on the chemical composition of *Chlorella pyrenoidosa,* interest has been shown concerning the possibility of using mass cultures of this green unicellular plant for the production of food. Myers *et al.* (*2*) studied the design of a growth chamber necessary for maximum growth rates of Chlorella. These papers have recently been reviewed (*3*). Nevertheless, little or no experimental work has been done involving the use of *C. pyrenoidosa* in animal feeding trials. Consequently, the value of dried Chlorella as a nutrient source has been tested with chicks.

Uniform groups of 16 day-old New Hampshire chicks of both sexes were maintained in electrically heated battery brooders with raised wire floors throughout a 4-week experimental period. Feed and water were supplied *ad lib.* Mortality, feed consumption, and body weights were recorded. The basal diet used in this study consisted of ground yellow corn, 61.7%; soybean oil meal (solvent), 34%; ground limestone, 1%; steamed bone meal, 3%; iodized salt, 0.3%; manganese sulfate, 0.025%; D-activated animal sterols, 0.05%; and 0.2 mg 2-methyl-1,4-naphthoquinone/lb. This ration is considered suboptimal in its content of riboflavin, vitamin B_{12}, and vitamin A activity for supporting rapid early growth of chicks. The Chlorella[3] had been dried *in vacuo* at a temperature of 70° F. When Chlorella was fed, it was substituted in the diet for an equal weight of soybean oil meal.

An amino acid assay of the dried Chlorella used in these feeding trials is given in Table 1, and a vitamin assay is given in Table 2. The sample had been grown under pilot plant conditions. It is reasonably similar in nutritive value to samples grown elsewhere under laboratory conditions, assays of which are also given in Tables 1 and 2. Aside from the low level of methionine, Chlorella protein compares favorably with soybean oil meal protein. The vitamin levels are relatively high as compared with many other important foods and feedstuffs.

TABLE 1
AMINO ACID ASSAY OF DRIED CHLORELLA

Nutrient	Pilot plant* sample (%)	Laboratory† sample (%)
Crude protein	44.0	40.0
Arginine	2.06	2.39
Histidine	0.62	0.65
Isoleucine	1.75	1.69
Leucine	3.79	1.99
Lysine	2.06	2.43
Methionine	0.36	0.57
Phenylalanine	1.81	2.14
Threonine	2.12	1.91
Tryptophane	0.80	0.41
Valine	2.47	2.67
Glycine	—	2.20

* Microbiological assay by Food Research Laboratories, Inc., reported to Carnegie Institution of Washington by Kenneth Morganridge, chief chemist, March 27, 1952.
† Mean values of two samples grown by Spoehr and Milner (*1*); microbiological assay by Merck & Co., 1949.

The various supplements added to the basal diet, together with the results obtained, are shown in Table 3. The inclusion of 10% Chlorella to the basal diet in place of an equal amount of soybean meal resulted in a very marked increase in growth and improvement in feed efficiency. This improvement is attributed primarily to the high riboflavin and carotene content of the Chlorella, although important quantities of several other B-complex vitamins are also supplied by this level of Chlorella. The addition of 0.1% DL-methionine (group 3) to the Chlorella-containing diet resulted in some improvement. However, the further addition of vitamin A, vitamin B_{12}, riboflavin, niacin, pantothenic

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[3] The dried *Chlorella pyrenoidosa* (Emerson strain) was supplied by A. W. Fisher, Jr., of Arthur D. Little, Inc., Cambridge, Mass. It had been grown in their Chlorella pilot plant for the Carnegie Institution of Washington. The conditions of growth are described in *The Large-scale Culture of Algae,* a monograph edited by John S. Burlew, Carnegie Institution of Washington, Pub. No. 598 (1952).

TABLE 2

VITAMIN ASSAY OF DRIED CHLORELLA

Vitamin	Pilot plant* sample	Laboratory† sample
Carotene, mg/lb	—	218.0
Thiamin, mg/lb	11.0	4.5
Riboflavin, mg/lb	26.2	16.3
Niacin, mg/lb	54.0	109.0
Pyridoxine, mg/lb	—	10.4
Pantothenic acid, mg/lb	3.6	9.1
Choline, mg/lb	—	1370.0
Biotin, μg/lb	—	67.0
Vitamin B_{12}, μg/lb	45.0	10.0
Lipoic acid, acetate u/mg	1.5	—

* Microbiological assay by J. J. Mayernik and David Hendlin, of Merck & Co., Jan. 1952.

† Grown by Stanford Research Institute in continuous dilution culture apparatus; assay by Curtis and Tompkins, San Francisco. Data taken from unpublished report from Stanford Research Institute to the Research Corporation of New York, March 22, 1950, by permission.

acid, and choline chloride (group 4) did not improve the results. Chicks fed the same diet without Chlorella (group 5) attained slightly heavier weights. The last group of chicks (group 6) was fed the complete broiler mash, which not only contained adequate levels of all nutrients, but also an antibiotic, thus accounting for the additional growth improvement obtained.

The apparent growth-depressing action resulting from the inclusion of 10% dried Chlorella to the adequate supplemental diet is believed to be due to the hygroscopic nature of the Chlorella. Chicks fed this level of dried Chlorella exhibited an impacted beak condition. This mechanical impediment interfered with feed consumption and, consequently, resulted in a slightly lower total weight at 4 weeks of age. Three other groups of chicks not shown in the table were also included in this study. These groups received 2½, 5, and 20% Chlorella, respectively. Impacted beaks also were noted in the chicks that received 2½ and 5% algae. The chicks that received the 20% level developed impacted beaks and beak deformities, so

TABLE 3

EFFECT OF DRIED CHLORELLA ON BODY WEIGHT AND FEED EFFICIENCY OF CHICKS

Group No.	Treatment	Av wt at 4 wks (g)	G feed required/ g gain
1	Basal ration	135 (13)	3.1
2	As 1 + 10% chlorella	262 (16)	2.4
3	As 1 + 10% chlorella + 0.1% DL-methionine	298 (16)	2.3
4	As 1 + 10% chlorella + 0.1% DL-methionine + vitamin mixture*	292 (16)	2.3
5	As 1 + 0.1% DL-methionine + vitamin mixture†	316 (16)	2.2
6	Complete broiler mash	342 (16)	2.2

* Numbers in parentheses refer to surviving chicks.

† Vitamin mixture supplied the following per lb of diet: 6 μg vitamin B_{12}, 2 mg riboflavin, 10 mg niacin, 2 mg calcium pantothenate, 150 mg choline chloride, and 2500 IU vitamin A.

that their feed consumption and growth rate were greatly lowered. The hygroscopic nature of the Chlorella used in this trial is not considered a serious handicap for its use in feeds since it is expected that suitable processing methods can readily be developed which will eliminate this problem. No other harmful effects were observed in the chicks fed Chlorella. The consistency and appearance of the chick droppings were normal.

Although a mechanical difficulty was observed in the use of the vacuum-dried algae, the results demonstrate clearly that dried Chlorella may serve as a source of certain dietary nutrients for the chick. From the nutritional analysis of this material and the growth data obtained, dried Chlorella seems to supply important quantities of carotene and certain B-complex vitamins. Additional work is required to establish further its nutritional value. This information, combined with a determination of the cost of producing Chlorella on a large scale, will help decide to what extent Chlorella may be considered a new food source. Even the present limited study indicates that it may well be considered as a potential food source in areas of limited agricultural resources.

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Concerning the Ability of Homing Pigeons to Discriminate Patterns of Polarized Light

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The search for the sensory basis of bird navigation is apparently far from ended, despite the large number of investigations devoted to this problem (*1–3*). The demonstration by von Frisch (*4*) that honeybees can discriminate among patterns of polarized sky light, and that they apparently utilize such patterns as cues in their homing flights, suggests the possibility that migratory and homing birds possess a similar ability.[2] The present paper reports an experimental test of this possibility. If homing pigeons do utilize polarization patterns of sky light as cues in their flights, they should be able to discriminate readily between two visual stimulus patterns, one of which consists of light polarized in one plane and the other of light polarized in a plane orthogonal to the first.

The subjects were three homing pigeons, 1–2 years

[1] The senior author is now at Yale University; the junior, at Harvard University.

[2] This possibility was mentioned by Donald R. Griffin in a talk attended by one of the writers about two years ago. The writers wish to express their appreciation to Dr. Griffin for his interest and cooperation in the present study.