was in 1928, when the writer was using the 8-inch Clark refractor of the Maryland Academy of Sciences.

The helioscope used in the observations of present date was one which has the effect of reddening the photosphere but is otherwise neutral. It consists of a thin glass slide, smoked to the proper density and mounted in an adapter which screws directly onto the eyepiece. The writer has found this type of screen very satisfactory, since it intercepts the heat perfectly and gives a beautifully defined, natural-colored image of the sun in which the photosphere appears as light orange. Umbrae normally appear black and penumbrae gray against the orange background. The telescope used is a 3-inch one giving splendid definition with very fine color correction. The objective was ground for the writer some years ago by the American Optical Company and stands up perfectly with respect to color on even such bright objects as Jupiter when seen against a dark sky. It is felt, therefore, that the observations cited above were observations of fact and not mere illusions.

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The Activity of Synthetic Folic Acid in Purified Rations for the Chick[1]

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Previous studies have shown that vitamin B_{10} and B_{11} preparations (*3*), impure folic acid (from University of Texas) (*4*), crystalline isolated third *L. casei* factor (*4, 6*), and pure isolated vitamin B_c (*5*) have activity for growth, feathering, and hemoglobin formation in growing chicks. These earlier studies were necessarily limited by the lack of pure material or sufficient quantities of the compound. Since synthetic folic acid,[2] which has been reported active for growth and hematopoiesis (*1*), has now become available, it is important to study the activity of this compound under our experimental conditions.

Experimental method. Day-old White Leghorn cockerels from a commercial hatchery were maintained in electrically heated cages (32–37°) with raised screen bottoms for three or four days on a basal ration with the following percentage composition: dextrin, 61; casein, 18; gelatin, 10; l-cystine, 0.3; salts V (*2*), 6; soybean oil, 5; α-tocopherol, 0.3 mg.; 2-methyl-1,4-naphthaquinone, 0.05 mg.; thiamin · HCl, 0.3 mg.; riboflavin, 0.6 mg.; Ca pantothenate, 2 mg.; choline, Cl, 150 mg.; nicotinic acid, 5 mg.; pyridoxine · HCl, 0.4 mg.; biotin, 0.02 mg.; and i-inositol, 100 mg. In addition 1,700 U.S.P. units of vitamin A and 170 A.O.A.C. units of vitamin D_3 were administered by dropper. Chicks within a 10-gram weight range were then divided uniformly into groups of six, and supplements were added to the diet as follows: synthetic folic acid at levels of 10–300γ/100 grams of ration, isolated vitamin B_c, and preparations of vitamins B_{10} and B_{11} containing different amounts of "folic acid"[3] which were fed for comparison.

The three experiments were terminated when the chicks were four weeks old. The methods used for determining hemoglobin and measuring feather development were the same as those used previously (*3*). The hematocrit determinations were made following the procedure of O'Dell, *et al.* (*9*).

Results. The addition of 25γ of synthetic folic acid to our basal ration prevents the reduced growth, poor feathering condition, and low hemoglobin and hematocrit values which are consistently obtained when this ration is fed to chicks. Twenty-five micrograms of isolated crystalline vitamin B_c gave a similar effect, although the growth was slightly less than in chicks fed similar levels of synthetic folic acid. When vitamin C or whole liver powder was fed with folic acid, the chicks grew somewhat better than when fed folic acid alone (compare Groups 10 and 11 with 4). The addition to the diet of 50γ of of α-pyracin (2-methyl-3-hydroxy-4-hydroxymethyl-5-carboxypyridine) alone or with 10 or 50γ of synthetic folic acid produced slightly better growth but no improvement in feathering or hemoglobin. When 500γ of α-pyracin were fed with the basal ration alone, no response in growth, hemoglobin, or feathering was noted (Group 14).

Neither *p*-aminobenzoic acid nor a vitamin B_{10} and B_{11} concentrate gave a significant supplementary effect in the presence of an adequate amount of synthetic folic acid. Further comparison of the addition of vitamin B_{10} and B_{11} preparations without added folic acid (Groups 19 and 21) shows clearly the lack of

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[2] Synthetic folic acid was originally called *L. casei* factor.

[3] "Folic acid" (in quotes) is used throughout the paper to designate the microbiological activity of a material when compared to synthetic folic acid on a weight basis (7).

correlation between chick growth and the microbiological activity. Chicks in Group 19, which received in the supplement less than 5γ of "folic acid" (as measured microbiologically after acid hydrolysis, *8*), per 100 grams of ration, grew as well, if not better, than the chicks in Group 20, which received a supplement containing 61γ of "folic acid" per 100 grams of diet.

TABLE 1

RESULTS OF FEEDING SYNTHETIC FOLIC ACID AND RELATED COMPOUNDS TO CHICKS

No.	Supplement per 100 grams ration	No. chicks	Av. wt. grams 4 wks.	% B_{10}*	Gram % Hb ± 1	Ht %†
1	None	18	150	40	6.6	20
2	10γ synthetic folic acid	17	215	65	8.4	
3	15γ " " "	6	205	85	8.3	
4	25γ " " "	17	250	90	8.4	26
5	50γ " " "	12	235	100	9.0	27
6	100γ " " "	5	250	100	8.9	
7	300γ " " "	6	260	100	8.1	26
8	10γ vitamin B_c	6	180	55	8.6	
9	25γ " "	6	225	90	8.8	
10	25γ synthetic folic acid + 100 mg. vitamin C	6	290	95		
11	25γ synthetic folic acid + 10 grams whole liver powder	6	275	100	8.5	28
12	25γ synthetic folic acid + 5 mg. P.A.B.A.	6	250	90		
13	50γ α-pyracin	6	185	45		
14	500γ α-pyracin	12	155	40	6.6	
15	50γ α-pyracin‡ + 10γ synthetic folic acid	6	235	45	8.7	
16	50γ α-pyracin + 50γ synthetic folic acid	6	260	100	8.7	
17	Vitamin B_{10} and B_{11} prep.§ ≅ 5% liver L (8γ "folic acid")	18	260	90	9.1	
18	Vitamin B_{10} and B_{11} prep. ≅ 5% liver L (8γ "folic acid") + 100γ synthetic folic acid	6	270	100	8.7	30
19	Vitamin B_{11} prep.‖ ≅ ½% yeast extract (4.7γ "folic acid")	6	240	30		
20	Vitamin B_{11} prep. ≅ ½% yeast extract + 10γ synthetic folic acid	6	200	65		
21	Vitamin B_{10} prep.¶ ≅ ½% yeast extract (61γ "folic acid")	6	225	95		

* 0 = very poor; 25 = poor; 50 = fair; 75 = good; 100 = very good.

† See (*8*) for method used to determine hematocrit per cent.

‡ α-pyracin was obtained through the courtesy of Dr. Karl Folkers of Merck and Company, Inc.

§ Prepared following the direction for the superfiltrol eluate from liver fraction L (*3*).

‖ Vitamin B_{11} preparation No. 284–5 was made by autoclaving Difco Yeast Extract in 1 N/KOH for one hour at 15 lb.

¶ Vitamin B_{10} preparation No. 298 was made by treating Difco Yeast Extract with chicken pancreas and incubating at 37° for 70 hours at pH 7.

When sulfasuxidine (succinylsulfathiazole) was included in the basal diet, the chicks receiving no supplement developed a more severe deficiency, and under these conditions 25γ of synthetic folic acid per 100 grams of diet did not give a complete response. Fifty micrograms of synthetic folic acid were not as effective in the ration containing 1 per cent of sulfasuxidine as in the diet containing 0.5 per cent of the sulfa drug. A comparison of the activity of synthetic folic acid with and without the addition of 1 per cent sulfasuxidine in the diet (Fig. 1) indicates that folic acid is about three times as effective without the drug.

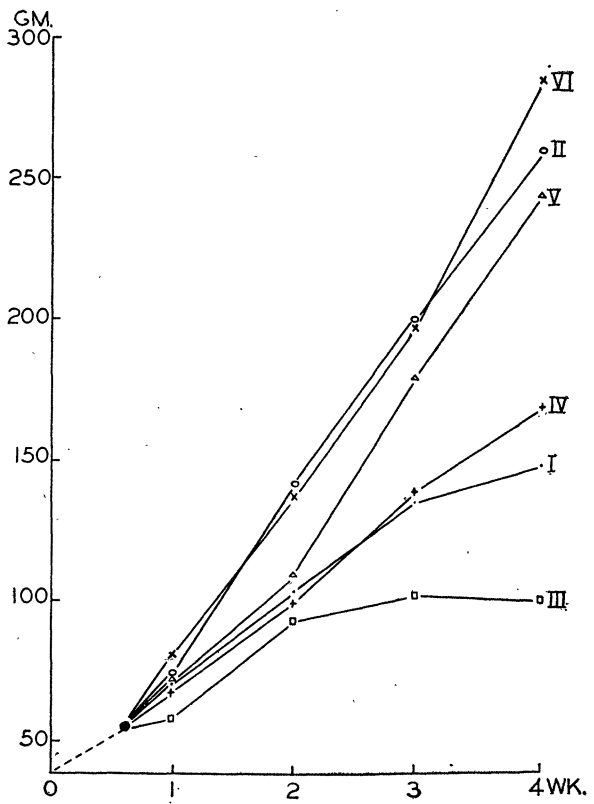

FIG. 1. Activity of synthetic folic acid with and without sulfasuxidine. I = basal ration; II = basal ration + 25γ per cent synthetic folic acid; III = basal ration with 1 per cent sulfasuxidine; IV = III + 25γ per cent synthetic folic acid; V = III + 50γ per cent synthetic folic acid; VI = III + 100γ per cent synthetic folic acid.

Discussion. The results presented here clearly demonstrate that chicks given our basal ration show significant responses in growth, feathering, and hemoglobin formation when 25γ of synthetic folic acid are given. It is still important to decide whether the compound functions directly to produce all these responses or whether the activity may be indirect to some extent. In fact, the increased requirement with the sulfasuxidine suggests some degree of indirect activity. The reason the third *L. casei* factor and the Texas folic acid preparation appeared to be inactive in our earlier studies (*4*) may now be explained on the basis of the increased requirement of folic acid in the presence of sulfasuxidine.

The existence of microbiologically inactive compounds which produce feathering (vitamin B_{10}) and growth (vitamin B_{11}), of highly active synthetic folic

acid, and of preparations with high bacterial potency but relatively little chick activity makes it necessary to determine which or how many of these compounds are used directly and the possible interrelationships between these compounds.

Summary. The addition of 25γ of synthetic folic acid per 100 grams of our basal ration prevents the reduced growth, poor feathering condition, and low hemoglobin and hematocrit values consistently obtained when the basal ration is fed to chicks. More than 25γ are needed when the diet contains sulfasuxidine. Evidence for the possible indirect action of folic acid is summarized.

Vitamin C or whole liver powder gives a slight response in the presence of adequate amounts of synthetic folic acid.

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Fluctuations in Abundance of Marine Animals

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The starfish (*Asterias forbesi* Desor) is at times a source of serious injury to the mollusk fisheries of southern New England. The precise extent of the damage done by this pest is extremely difficult to assess, but the cost of efforts at control provides some indication of the magnitude of the problem. The oyster growers of Connecticut alone are conservatively estimated to spend an average of $100,000 per year in combating starfish on their private beds; and approximately $75,000, independent of Federal grants, was paid out for the removal of starfish from public bottoms by the authorities of Massachusetts and Rhode Island during the decade from 1932 to 1942.

It has long been recognized by oyster growers that the amount of trouble caused by starfish is not constant but rises from time to time to the proportions of a plague. Until the present, however, no attention has been given to the pattern of these fluctuations. Evidence here presented in part (Fig. 1) seems to demonstrate that troughs and peaks of abundance of starfish have alternated at seven-year intervals, since 1852 at least, in synchrony throughout the region from New York to Cape Cod. The regularity of these changes during the past hundred years suggests that potential damage from starfish may be expected to decline to a minimum around 1950 and to increase thereafter to a peak during the years around 1957. It is believed that ability to foretell in a general way the times of danger from starfish may effect considerable direct and indirect savings to the New England oyster industry, by permitting a more efficient planning of the use of vessels, oyster stock, and oyster grounds.

Adequate statistical information upon starfish is not available. Definition of periods of scarcity and of abundance of starfish upon the oyster beds has, nevertheless, been found possible by the systematic employment of semiquantitative data, the value of which for such purposes has not heretofore been generally appreciated. These nonnumerical data are derived from statements concerning relative amounts of trouble with starfish at various points in southern New England, contained in reports of public commissions, trade journals, newspapers, periodicals, private memoranda, etc. As examples of such statements, the *Norwalk Gazette* for 3 July 1858 reports that "the star-fish are eating up the oysters in the beds of New York harbor . . . [and in consequence the] proprietors have petitioned the state to remit the usual taxes . . ."; and the Reports of the Rhode Island Commissioners of Shellfish for 1859 and for 1861 state that "during the past year [1859] a very large quantity of the oysters planted upon the private oyster beds [of Narragansett Bay] have been destroyed by the star fish . . . [so that] the past two years have been . . . years of want . . . ," and that "for some time prior to . . . 1860 the increase of the star-fish had been very rapid, until, in that year, they became so numerous and so destructive as to render an entire abandonment of the ground necessary."

One hundred and eighty-five such statements have been collected, tabulated chronologically, compared, and evaluated in terms of "Many," "Few," etc. Although these evaluations are necessarily subjective, the indications upon which they are based are in general quite unequivocal; and although the reliability of individual indications might be questioned, there is in general a close agreement between independent statements from the same as well as from different parts of New England during the same period. A