by this amount of carbon would be $\frac{5}{2} \times 0.0835 = 0.2088$ g. Thus, from the oxidation of 55.8 g of iron as ferrous carbonate, there would be formed 106.8 g of ferric hydrate but only 0.209 g of organic cell material. The ratio of the weight of ferric hydrate to the weight of the cell material would thus be about 500 to 1. It is apparent that if these bacteria have efficiency similar to that of other autotrophic bacteria the organic cell material will be only a fraction of the amount of ferric hydrate produced by the oxidation process. Even assuming that the organic cell material contains a greater percentage of water than that of the ferric hydrate and allowing for the higher specific gravity of the ferric hydrate, the volume of the ferric hydrate would be many times as great as that of the organic portion of the bacterial cells.

It can be concluded that, under conditions where iron bacteria grow at the expense of the oxidation of ferrous iron, there will be large quantities of ferric hydrate. It seems unreasonable, therefore, to conclude that an organism is an iron bacterium or that it is developing as an iron bacterium unless there are far greater quantities of ferric hydrate than cell substance in the accumulated materials resulting from bacterial growth. There is reason to conclude that, where most of the products of bacterial development consist of organic filamentous material and slimes, these bacteria have grown upon organic materials instead of ferrous iron.

There are so many reactions whereby iron may be precipitated from iron-bearing waters without the participation of iron bacteria[13, 14] that it is not safe to conclude upon the basis of iron precipitation alone that the product was formed by iron bacteria. Although not all cases of iron precipitation from water are due to iron bacteria, an abundant precipitation of ferric hydrate can be expected whenever the iron bacteria are growing by the oxidation of inorganic ferrous compounds.

There is great need for additional information on the physiology of the iron bacteria, and until more specific information is obtained it seems certain that there will be confusion regarding the identity of iron bacteria, the reactions with which they are concerned and their importance in the precipitation of ferric hydrate in nature.

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13 H. O. Halvorson, *Soil Sci.*, 32: 141–165, 1931.
14 R. L. Starkey and H. O. Halvorson, *Soil Sci.*, 24: 381–402, 1927.

SHORT AND LONG FOOD CHAINS AMONG VEGETABLE CROPS

"LENGTH of food chain" refers to the number of animal organisms that have consumed the original food produced by plants before it is used in human metabolism. The consumption of plants would be considered a "short chain," that of meat and fish a "long chain," since animals must live on organic material produced originally by plants. Our vegetable plants seem to show an analogous relation when one compares the efficiency of those that furnish a vegetative part for food and those that furnish a fruit part. Thus, our fruit crops are those in which fertilization usually occurs before the eatable portion is produced. Vegetative crops are those where the root, stem, leaf and immature flower parts (cauliflower, broccoli and globe artichokes) are consumed.

Cabbage, carrots, potatoes, spinach and similar vegetative crops appear to use food value, land and labor resources more efficiently than fruit crops such as watermelons, sweet corn and cucumbers. In the first group the original vegetative organs are used as food; in the second, the vegetative parts are not eaten directly, but produce an edible fruit. Thus our common foliage, stem, root and immature flower crops could be considered a "short chain"; our vegetable fruit crops a "long chain."

An extreme case of a long food chain has been cited by Kunkel[1] in connection with the food habits of the Eskimo. There are four organisms involved in this chain: the Eskimo lives largely upon seal meat, the seals eat fish, the fish consume snails and other invertebrates, and these in turn feed upon seaweeds. About 625 pounds of seaweed is required originally to produce a gain of 1 pound in the weight of the Eskimo. If the Eskimo would eat fish instead of seal meat, the chain would be shortened, and only 125 pounds of seaweed would be required. In pork production the data are expressed in different terms; but, as Hogan, Weaver, Edinger and Trowbridge[2] have pointed out, only about 40 per cent. of the energy consumed is stored in the animal's tissues. The same workers find that only about 10 per cent. of the protein consumed was stored in the tissues of the swine in this experiment. These values would vary somewhat with the age of the animals and with feeding conditions.

Foods for livestock may be classified into three groups on the basis of the competition between meat-producing animals and human beings. First, there are foods that may be used either by livestock or people, such as wheat and corn. Second, there are livestock feeds which are not usable by people, but which are grown upon land that could have produced human food; an example is alfalfa hay on irrigated

1 B. W. Kunkel, *Scientific Monthly*, 46: 47–58, 1938.
2 A. G. Hogan, L. A. Weaver, A. T. Edinger and E. A. Trowbridge, *Mo. Agr. Expt. Sta. Res. Bul.* 73, 1925.

land. Third, there are ranges, considerable pasture and many by-products that can be utilized only as livestock feed.

Some recent studies[3, 4, 5] have furnished data for comparing the efficiency of thirty vegetable crops with reference to their food value and to the use of resources such as land and labor. The tables published show the quantity of the nine nutrients per pound as purchased, and also the nutrients produced per acre and per man-hour. These tables were prepared from the following data: (1) chemical composition of the edible portion; (2) relative amount of edible portion in a purchased vegetable; (3) average yield per acre, and (4) hours of work required to produce average yields. Each of the nine essential nutrients (energy sources, protein, calcium, iron, vitamin A, ascorbic acid, thiamin, riboflavin and niacin) was expressed in terms of the recommended dietary allowances of the National Research Council, in which the daily need for each constituent was considered as a unit. The tables on food value per pound as purchased, per acre and per man-hour were first treated by ranking the amounts of each nutrient in all the vegetables. The data were summarized by giving the first rank to the vegetable occurring most often near the first rank and by arranging the others in a descending order. This system gives a superior rating to crops high in most of the nine nutrients rather than a crop that is merely high in one nutrient. Table 1 summarizes this study. This relation among vegetables seems to be largely confirmed by common experience, and the procedure followed was chosen as apparently the most accurate method thus far developed.

According to the results of this procedure (Table 1), the most efficient crops are those in which the vegetative part is eaten, for example, root, stem, leaf or immature flower parts. Group 1 comprises the 7 most efficient crops, 6 of these being vegetative and 1 a fruit crop; group 2 comprises the 6 next most efficient, 5 being vegetative and 1 a fruit crop; group 3, next in line, has 6 vegetative and 4 fruit crops; but in group 4, the least efficient, there is only 1 vegetative crop, whereas 6 are fruit crops. According to this evidence if the vegetative parts are used as food they are produced more efficiently than if a plant needs to produce first a vegetative unit and then a fruit. The vegetative plants are largely cool-season crops, which either are grown entirely in cool weather or must have cool weather at some critical time in their growth. According to an old saying of gardeners, the "cool-season" plants are those desired for their vegetative part (with the exception of peas). The "warm season" plants are those raised for the fruit part (with the exception of sweet potatoes). These two generalizations apply to our common vegetables.

TABLE 1

RELATIVE EFFICIENCY OF VARIOUS VEGETABLES AS FOOD PRODUCERS, BASED ON THEIR RANK IN NUTRIENTS PER POUND, PER ACRE AND PER MAN-HOUR

	Rank in nutrients per			Part of plant eaten			
	Pound	Acre	Man-hour	Vegetative	Fruit	Cool-season crops	Punctual harvesting essential
Crops ranking 1–15 in nutrients per pound, per acre and per man-hour:							
Group 1:							
Broccoli	1	5	7	+		+	
Cabbage	14	6	4	+		+	
Mustard greens	2	1	2	+		+	
Spinach	11	12	8	+		+	
Sweet potatoes	3	13	5	+			
White potatoes	8	2	3	+		+	
Winter squash	15	11	1		+		
Crops ranking 1–15 in two of the following: nutrients per pound, per acre or per man-hour:							
Group 2:							
Beets, bunch	26	4	15	+		+	
Brussels sprouts	4	14	24	+		+	
Carrots, bunch	25	7	13	+		+	
Onions	16½	3	6	+		+	
Tomatoes, market	13	15	17		+		
Turnips, bunch	21	10	12	+		+	
Crops ranking 1–15 in one of the following: nutrients per pound, per acre or per man-hour.							
Group 3:							
Artichokes	12	30	22½	+		+	+
Cauliflower	20	17	9	+		+	+
Casabas and honeydews	27	21	11		+		+
Celery	24	8	22½	+		+	
Green asparagus	7	29	26	+		+	+
Lettuce	22½	18	14	+		+	+
Lima beans	10	22	27		+		+
Peas	6	28	29		+	+	+
Snap beans	5	19	30		+		+
White asparagus	9	31	28	+		+	+
Crops ranking 16–31 in nutrients per pound, per acre and per man-hour.							
Group 4:							
Bell peppers	19	20	19		+		
Cantaloupes	28	24	18		+		+
Cucumbers	29	23	25		+		+
Radish	30	25	31	+		+	+
Summer squash	18	16	20		+		+
Sweet corn	22½	26	16		+		+
Watermelon	31	27	21		+		+

Interpretation: The accuracy of the data do not permit making distinctions between small differences. Vegetables in group 1 are thought to be more efficient than those in groups 3 and 4; group 2 is considered more efficient than group 4.

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[3] John H. MacGillivray, Arthur Shultis, G. C. Hanna and Agnes Fay Morgan, *Calif. Agr. Exp. Sta. Offset Pub.*, September, 1943.

[4] John H. MacGillivray, Arthur Shultis, A. E. Michelbacher, P. A. Minges and L. D. Doneen, *Calif. Agr. Exp. Sta. Offset Pub.*, September, 1943.

[5] John H. MacGillivray, Agnes Fay Morgan, G. C. Hanna and Arthur Shultis, *Calif. Agr. Exp. Sta. Offset Pub.*, December, 1943.

Quality often depends upon harvesting the vegetables at the proper stage of development. All crops that need punctual harvesting fall within groups 3 and 4. During periods of inadequate labor or unfavorable weather, this is a further disadvantage of groups 3 and 4.

In the past, the importance of root, stem and leafy crops from a dietetic standpoint has been pointed out largely on the basis of individual crops. As Table 1 shows, high food value and efficient use of labor and land areas is a general characteristic of this group of vegetables. An average diet contains 739 pounds of plants out of a total consumption of 1,420 pounds of food. About a third of our plant food is vegetative portions of vegetables; the remainder is vegetable, grain and tree fruits. Unfortunately, data are available to test this hypothesis only in our vegetable plants. Vegetables, despite their low energy and protein content, have praiseworthy qualities for improving our diet, whether they are produced commercially or in a home garden. The high efficiency of these plant parts as food calls attention to the fact that only in the case of vegetables do the American people consume a vegetative part of the plant.

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THE DESTRUCTION OF PYROGENS BY HYDROGEN PEROXIDE

PYROGENS are toxic, non-dialyzable substances formed by various micro-organisms. They are relatively stable in boiling water and cause prompt temperature rises in animals when injected in microgram doses. In man, Co Tui[1] estimates that an intravenous dose of 0.02 micrograms of typhoid pyrogen per kilogram of body weight will provoke a rise in body temperature of 0.5–0.6° C.

The necessity for the complete absence of pyrogens from solutions intended for parenteral administration is well recognized,[2] but many substances injected parenterally, especially in investigative work, are not available in pyrogen-free form. Practicable methods for removing pyrogens are therefore of utility, and several such methods have been described. For example, Co Tui and Wright[2] have recommended adsorptive filtration with Seitz filters, although Francke and Rees[3] found preliminary treatment with powdered charcoal before Seitz filtration to be required for complete removal of pyrogens from solutions of inulin. Seitz filtration was also found unsatisfactory for removing pyrogens from enzymatic hydrolysates of protein by Zittle *et al.*,[4] who resorted to heating with acid to destroy the pyrogens.

Since no satisfactory general method for removing pyrogens from all solutions appears to have been found, our observation that pyrogens can be destroyed by heating with dilute hydrogen peroxide may prove

TABLE 1

EFFECT OF HYDROGEN PEROXIDE TREATMENT UPON PYROGEN ACTIVITY

Pyrogen preparation	Source	Concentration of H_2O_2	Heating: Time (min.)	Heating: Temp. (°C.)	pH: Before heating	pH: After heating	Rectal temp. rises (°C.)	Average rise (°C.)[4]
A[1]	*Pseudo-*	0	30	100	6.58	6.66	1.25, 1.25, 1.60	1.37
	monas	0.001 M	30	100	...	...	1.50, 1.55, 2.25	1.77
	aerugi-	0.01 M	30	100	6.82	6.75	0.80, 1.05, 1.10	0.98
	nosa	0.1 M	60	100	6.21	6.64	0.00, 0.20, 0.40	0.20
B[2]	*Pseudo-*	0	20	100	7.26	6.88	0.95, 1.40, 2.25	1.53
	monas	0	120	100	7.28	7.02	0.70, 1.05, 1.40	1.05
	aerugi-	0.01 M	120	100	7.27	6.99	−0.10, −0.10, 0.15	0.05
	nosa	0.1 M	120	100	7.33	6.88	−0.15, −0.05, 0.35	0.12
		0	120	100	7.20	7.19	0.95, 1.10, 1.10	1.05
C[3]	Gelatin	0.1 M	120	100	7.03	6.51	0.25, 0.60, 0.80	0.55
		0.1 M	120	100	7.16	5.12	−0.25, −0.10, 0.00	0.00
D[3]	Gelatin	0	20	116	...	...	0.60, 0.75, 0.85	0.73
		0.04 M	20	116	...	...	0.00, 0.15, 0.20	0.12

[1] Pyrogen solution prepared by U. S. Food and Drug Administration for First Collaborative Assay (H. Welch, H. O. Calvery, W. T. and McClosky and C. W. Price, *Jour. Am. Pharm. Assoc.*, 32: 65, 1943), diluted 1:10 with 0.9 per cent. NaCl solution.

[2] Dried concentrated pyrogen from *Pseudomonas aeruginosa*, kindly supplied by Dr. Henry Welch, U. S. Food and Drug Administration dissolved in 1:100,000 dilution in 0.9 per cent. NaCl solution buffered with sodium phosphate.

[3] Commercial gelatin, in approximately 5 per cent. solution in distilled water.

[4] Negative values considered as zero temperature rise, in calculating averages.

[1] Co Tui, D. Hope, M. H. Schrift and J. Powers, *Jour. Lab. Clin. Med.*, 29: 58, 1944.

[2] Co Tui and A. M. Wright, *Ann. Surg.*, 116: 412, 1942.

[3] D. E. Franke and V. L. Rees, *Jour. Am. Pharm. Assoc.* (Pract. Pharm. Ed.), 4: 158, 1943.

[4] C. A. Zittle, H. B. Devlin, G. Rodney and M. Welcke, *Jour. Lab. Clin. Med.*, 30: 75, 1945.