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In 1919, Huldschinsky [1] pointed out the value of ultraviolet rays in the healing of rickets. Somewhat later, Hess and Unger [2] and others reported that sunlight possessed the same beneficial action on rickets that ultraviolet light had. According to McCollum,[3] cod liver oil has been used for at least one hundred years for conditions that were probably of a rachitic nature. The ability of medical agencies as well as of hygienic ones to affect favorably the outcome of a rachitic process moved Park, Powers and Guy [4] to remark that "the similarity between the action of cod liver oil and that of radiant energy in rickets is so close that a connection must exist between them."

In 1924, Hess [5] and Steenbock and Nelson,[6] working independently, were able to demonstrate that various foods known to be inadequate in the cure of rickets could be made therapeutically potent by exposing them to the action of ultraviolet radiations. Thus a means that might be difficult to obtain directly was made available in an indirect manner and a partial explanation was provided for the connection existing between cod liver oil and radiant energy aforementioned. Later, these same investigators [7] found that the substance which was thus transformed from an impotent to a potent antirachitic agent seemed to be

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* From the Department of Physiology, University of Oregon School of Medicine.

1. Huldschinsky, K.: Deutsche med. Wchnschr. **45**:712, 1919.

2. Hess, A. F., and Unger, L. J.: Cure of Infantile Rickets by Sunlight, J. A. M. A. **77**:39 (July 2) 1921.

3. McCollum, E. V., and Simmonds, Nina: The Newer Knowledge of Nutrition, Baltimore, Johns Hopkins Press, 1925, p. 365.

4. Park, E. A.; Powers, G. F., and Guy, R. A.: Regulatory Influence of Cod Liver Oil on Calcium and Phosphorus Metabolism, Am. J. Dis. Child. **26**:103 (Aug.) 1923.

5. Hess, A. F.: Experiments on the Action of Light in Relation to Rickets, Am. J. Dis. Child. **28**:517 (Oct.) 1924.

6. Steenbock, Harry, and Nelson, M. T.: Science **60**:224, 1924; J. Biol. Chem. **62**:209 (Nov.) 1924.

7. Hess, A. F., and Weinstock, Mildred: J. Biol. Chem. **63**:25, 1925. Steenbock, Harry; Black, A.; Nelson, M. T., and Hoppert, C. A.: J. Biol. Chem. **63**:25, 1925.

cholesterol. Still later, it was shown by Windaus and Hess [8] and by Rosenheim and Webster [9] that the specific substance undergoing activation was ergosterol and not cholesterol. A full explanation for the aforementioned relationship was provided by Hess and Weinstock [10] when they showed that irradiated human skin would protect rats from the development of rickets. It was assumed that the ergosterol located in the cutaneous tissues became activated by exposing the skin to the influence of ultraviolet radiations and produced a general systemic response because of its ability to circulate in the blood stream. It makes little difference whether this activated material is absorbed from the cutaneous tissues or from the digestive tract, unless, perchance, the ability of the digestive organs to digest fats is impaired. In the latter event, it is obvious that cutaneous irradiation or the parenteral introduction of activated materials would be of more certain value. In some preliminary work it would appear that pups made acholic by biliary fistulas develop rickets notwithstanding the fact that they receive cod liver oil.[11]

The aforementioned researches serve to point out the fact that the ultraviolet rays of sunshine are capable not only of effecting a cure in rickets but also are able to produce such changes in foods that when they are ingested, the rachitic process will be either prevented or corrected. It appears that in the prophylaxis or cure of rickets, recourse must be had either directly or indirectly to the action of sunlight or its substitutes. The only substitute for this activity is the use of certain lamps whose light is rich in those wave lengths found to have specific powers in this respect. Obviously there can be no wholesale application of these artificial substitutes, for the time still lies in the future when artificial sources of ultraviolet radiations will be employed extensively in the raising of foodstuffs; nor, in the light of present knowledge, would this plan be unequivocably advisable. Even the general clinical use of ultraviolet light of nonsolar origin is beset with considerable difficulty, for not only are there technicalities not satisfactorily settled, but to many the economic aspect as well will act as a barrier.

For many years, sunlight has been used as a source of ultraviolet light, but with considerable difficulty since the richness of sunshine in those wave lengths falling within the range of ultraviolet rays varies because of several factors, most of which are beyond control. Hill,[12] for example, presents the situation clearly when he lists the following factors as causes for variation in the amount of the ultraviolet component sunlight: (*a*) the source, whether skyshine or sunshine; (*b*) the time of day; (*c*) the time of year; (*d*) the pollution of the air; (*e*) the geographic location, and (*f*) altitude.

By recording simultaneous readings of ultraviolet rays from both skyshine and sunshine, Hill [13] found "that the total ultraviolet radiation from the sky is far more than from the direct sun." Dorno [14] determined that the ultraviolet rays from skyshine were 15 per cent greater in amount than those from sunshine or, in other words, that the ultraviolet radiation of the sun even when the sun is at its zenith is only about 90 per cent of that of skyshine. Tisdall and Brown [15] showed that for Toronto the ultraviolet radiation of the skyshine during the latter part of April and the first part of May, 1927, averaged 30 per cent more than that contained in sunshine, and that the antirachitic effect of skyshine alone was approximately from one-half to two-thirds as great as that produced by sunshine and skyshine acting together. From the foregoing observations, it is obvious that to get maximal results from heliotherapy one must be assured that direct solar radiations, as well as those that are indirect or diffuse, are being received and that it is not necessary to discard all solarization because direct sunshine is not available.

The diurnal variation in the amount of ultraviolet radiation in the sunlight is due to the differences in the height of the sun as it takes its daily course across the sky. Dorno [14] has shown that sunlight is weak in ultraviolet rays in the early morning and evening and that the greatest intensity occurs between the hours of 10 a. m. and 1 p. m. This is due to the fact that the atmospheric layer is thicker and the absorption of ultraviolet rays greater with the sun low in the heavens than when it is high. As the sun climbs from its position at 5 a. m. to its place at noon, radiations that reach the earth are from 5 to 17 millimicrons shorter.

The seasonal differences in the amount of ultraviolet light contained in the sunshine varies in the same manner and from the same causes as the diurnal variation but are greater in degree. In the winter, diurnal variation in wave lengths fall within 5 millimicrons, in the spring and fall within 12 millimicrons and in the summer within 17 millimicrons.[16] Dorno [14] found that the ultraviolet content of the sun

8. Windaus, A., and Hess, A. F.: Gesellsch. d. Wissensch. z. Gottingen, Math.- Phys. Klasse, 1925, p. 195.

9. Rosenheim, O., and Webster, T. A.: J. Soc. Chem. Indust. **45**:932, 1926.

10. Hess, A. F., and Weinstock, Mildred: Proc. Soc. Exper. Biol. & Med. **22**:319, 1925.

11. Unpublished data from the laboratory of the Department of Physiology.

12. Hill, L.: Proc. Roy. Soc. London **102**:119, 1927-1928.

13. Hill, L.: Nature, London **115**:642, 1925.

14. Dorno, C.: Klimatologie in Dienste der Medizin, Brunswick, Vieweg & Son, 1920.

15. Tisdall, F. F., and Brown, Alan: Antirachitic Effect of Skyshine, Am. J. Dis. Child **34**:737 (Nov.) 1927.

16. Hess, A. F.: The Ultraviolet Rays of the Sun, J. A. M. A. **84**:1033 (April 4) 1925.

at noon in Davos, Switzerland, was 10 per cent as great in January as in July. Sheard,[17] quoting from others, stated that July furnishes the maximal amount of ultraviolet light in the sunlight and that in December and January this value reaches its lowest level, or less than 5 per cent of the July total. Thus it will be seen that in the winter when the zenith distance of the sun is persistently greater than in the summer, the loss in ultraviolet radiation is both quantitative and qualitative. Hess [16] has shown (*a*) that the antirachitic value of sunlight is not dependent on the total or average number of hours of actual sunshine either for the year or for the season; (*b*) that it has no relationship to an equable distribution of sunlight throughout the year and (*c*) that it is due to the quality of sunlight rather than its quantity. He found that rats with experimentally produced rickets obtained little protection when exposed to diffuse daylight for four hours a day during the month of December, and that only incomplete protection was obtained during May. He further stated that the sunlight in New York cannot be relied on for affecting a cure of rickets in the winter although it can be depended on during the summer. Bundesen, Lemon and Coade, working in Chicago, found that in December, 1926, the wave lengths of the ultraviolet end of the spectrum were between 3,030 and 3,150 angstrom units and that in May, 1927, they were between 3,000 and 2,990.

Various investigators who have measured the amount of ultraviolet light in sunshine under different kinds of atmospheric pollution have found remarkable losses due to such destructive factors as smoke, fog and dust. Hill [12] found that the sunlight was much richer in ultraviolet light in places remote from towns, such as Peppard Common and the top of Hampstead, than in industrial areas such as Kingsway and Hull (chart 1). He said [13] that "smoke pollution robs us of half or more of the ultraviolet rays." The Medical Research Council of England reported [18] that, on the average, two thirds of the ultraviolet light in the sunshine of London was cut out by smoke and dust. Measurements made by the U. S. Public Health Service of the average loss of daylight due to smoke in New York, at the lower end of Manhattan Island,[19] showed that in January, 1927, there was a loss of 42 per cent at 8 a. m. and of 18 per cent at noon. They reported that, as the year progressed, the loss became less so that in June a loss of only 6 per cent was recorded at noon. It was stated also that while these losses occurred on bright, sunny days, on foggy days the drop was

17. Sheard, Charles: Ultraviolet Radiation and Its Transmission by Various Substances, J. A. M. A. **88:**1315 (April 23) 1927.

18. Medical Research Council, Annual Report: Lancet **1:**508, 1927.

19. Loss of Light Through Smoke: General Medical News, J. A. M. A. **89:** 1976 (Dec. 3) 1927.

still greater. Bundesen, Lemon and Coade,[20] in measuring the shortening of the spectrum due to smoke, found a difference of 60 angstrom units. They stated that "the reduction of the spectrum limits by smoke, expressed in intensity, is much greater, however, than the change of 60 angstrom units would imply."

The amount of ultraviolet radiation varies also with geographic location. Hill [12] gave the following figures (acetone-methylene blue method) for December, 1926: Hampstead, England, 0.4 units; Davos, Switzerland, 2.3 units, and Assouan, Egypt, 11.4 units. Hess [16] showed that in Ancon and Colon in the Panama Canal Zone and in San Juan, Porto Rico, rickets is practically nonexistent although these cities have little if any more total sunshine than New York. He concluded from these observations that the sunlight in these places was much richer in ultra-

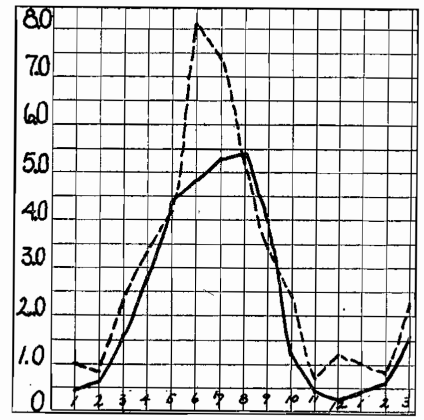

Chart 1.—Comparison between the amount of ultraviolet light in the sunshine of Peppard (broken line), and that of the smoky area of Hampstead (solid line) from January, 1925, to June, 1927. The figures at the left indicate units of ultraviolet light by the acetone-methylene blue scale.

violet rays. Kestner [21] stated that ultraviolet radiation under all meteorologic conditions is stronger in the far North than in central Europe. Elliot [22] stated that the average daily readings of ultraviolet light at Ventnor, Isle of Wight, for November and December, 1926, were 2.35, and that for Edinburgh the readings were nil for the three months between November, 1925, and March, 1926, and that even in March and April the readings only averaged 1.1. Although the manner

20. Bundesen, Herman N.; Lemon, Harvey B., and Coade, E. N.: J. A. M. A. **89:**187 (July 16) 1927.

21. Vitamins of Cod Liver Oil: Berlin Letter, J. A. M. A. **90:**309 (Jan. 8) 1928.

22. Elliot: Lancet **1:**1054, 1928.

of measuring was not given, it is assumed to have been the acetone-methylene blue method.

Dorno [14] showed that the atmospheric absorption of ultraviolet light increased with a decrease in altitude. For example, the loss was found to be four times as great in Kolberg at the level of the Baltic Sea as at Davos in the Alps. Coblentz and others [23] stated that the ultraviolet component of the spectral range lying between 170 and 450 millimicrons was less than 20 per cent in Washington, D. C., which has an elevation of 30 feet, while at Flagstaff, Ariz., with an elevation of 7,000 feet, the value was 30 per cent, an increase of 50 per cent. Hill [13] stated that in the Alps a reading of 41 was obtained in one day, while the highest total reading for one day at Peppard, Oxon, was only 23, by the acetone-methylene blue method.

Consideration of the foregoing facts will at once justify the statement that there is a seasonal as well as a geographic variation in the incidence of rickets. As long ago as 1884, Kassowitz [24] described this aspect of the disease. More recently it was dwelt on by Tisdall and Brown [25] and by Hess.[26] The latter showed that the incidence of rickets bears an inverse relationship to the amount of ultraviolet light in the sunshine and the level of phosphorus in the blood. He spoke of this annual variation in blood phosphorus as the "seasonal tide."

To substantiate the statement that there is a geographic variation in the incidence of rickets, I prepared table 1 from figures given by Williams,[27] Mohr,[28] Hess [16] and Torroella.[29]

While it is undoubtedly true that clinicians vary in their interpretation of a rachitic or nonrachitic condition because of different ideas as to what constitutes adequate criteria for judgment, it need not deter one from a serious consideration of table 1. The differences in incidence show a much greater variation than would probably result from differences in the conception of clinical rickets. All the cities mentioned in the table, except Denver, furnish evidence of the geographic variation in the incidence of rickets. While it is true that Denver, also, can be

23. Coblentz, W. W.; Dorcas, M. J., and Hughes, C. W.: Radiometric Measurements on Carbon Arc and Other Sources Used in Phototherapy, J. A. M. A. **88**:390 (Feb. 5) 1927.

24. Kassowitz, M.: Wien. med. Presse **38**:97, 1897.

25. Tisdall, Frederick F., and Brown, Alan: Seasonal Variation of Antirachitic Effect of Sunshine, Am. J. Dis. Child. **34**:721 (Nov.) 1927.

26. Hess, A. F., and Lundagen, M. A.: A Seasonal Tide of Blood Phosphate in Infants, J. A. M. A. **79**:2210 (Dec. 30) 1922; Seasonal Variation of Rickets, Am. J. Dis. Child. **22**:186 (Aug.) 1921.

27. Williams, C. T.: Infrequency of Severe Rickets in New Orleans and Vicinity, Am. J. Dis. Child. **35**:590 (April) 1928.

28. Mohr, G. J.: Northwest Med. **24**:430, 1925.

29. Torroella: Gac. méd. de México **58**:765 (Dec.) 1927.

included in this category, it would be better still to consider it as exemplifying the variation due to altitude. Because rickets and spasmophila are conditions almost entirely limited to the very young, one should not conceive the idea that the incidence of conditions growing out of a variation in the amount of ultraviolet light or, more indirectly, of vitamin D is limited exclusively to this period of life; in fact, just the contrary is true. On a rachitic status in early life may be superimposed conditions that later result in kyphosis, scoliosis, pes planus, genu valgum, dental caries and, perhaps, other diseases. Thus when a deficiency is once induced and its causes are maintained more or less throughout life, it is necessary to consider those conditions which grow out of a deficiency of ultraviolet light or of vitamin D as being common to all ages.

Table 1.—*Geographic Variation in the Incidence of Rickets*

Locality	Rickets, per Cent
Boston	80
New York	50 to 75
Portland, Ore.*	5 to 75
Seattle	30 to 54
New Orleans	26 to 45
Los Angeles	30
Denver	25
San Juan, P.I.	0
Ancon and Colon, Panama Canal Zone	0
Mexico	0
Far North (Eskimos and Scandinavians)	0 (almost unknown)

* In a personal communication to the author, Dr. L. Howard Smith stated that it is his opinion that in Portland and the surrounding community, 75 per cent of the young childred show a tendency toward rickets, as evidenced by delayed dentition, retarded closure of the fontanels, potbelly or an outward flare of the ribs, while only from 5 to 10 per cent have the florid type of the disease.

The extremely high incidence of rickets in children and of various osteo-porotic conditions among adults; the variable results obtained by the use of cod liver oil and the uniform results obtained with ultraviolet light irradiations or irradiated foodstuffs, together with the wide divergence in the amount of ultraviolet light in the sunshine and the resultant antirachitic activity of foods grown in this light, have made it extremely advisable to attempt to measure the ultraviolet light value of sunshine in various districts over considerable periods of time. A measure of these wave lengths in the sunlight of this district seemed to me of particular value for two reasons; namely, the incidence of rickets here is high and the annual quota of sunshine quite low as compared with most other districts in the United States. So far as is known, no records of this sort have been kept for any place in the United States or Canada, except those of Best and Ridout.[30] In England, considerable data of this kind has already been accumulated.[12]

30. Best, C. H., and Ridout, J. H.: Am. J. Dis. Child. **34**:719 (Nov.) 1927.

EXPERIMENTAL PROCEDURE

In order to get data that would be comparable to results of a similar nature obtained elsewhere, it was decided to use the acetone-methylene blue method described by Hill.[12] Coblentz,[31] of the Bureau of Standards, Washington, D. C., in discussing the various methods for measuring ultraviolet radiations, stated, "the use of a standard methylene blue and acetone solution as a means of measuring the intensity of the ultraviolet seems feasible." He offered criticism as to (*a*) making up identical solutions at different times and (*b*) the effect of temperature on the reduction. The first difficulty was obviated by preparing enough of the standard solution to last through the period of observation. It was placed in a dark glass bottle which was kept in an icebox. In regard to the second criticism, Tisdall and Brown[25] were of the opinion that the temperature coefficient should be more adequately investigated. Hill,[12] however, determined the temperature coefficient between 1.5 and 35 C. and found it to be from 1.15 to 1.2 for 10 C. He found that a difference of 10 C. above or below 20 C. will make a difference of about half a

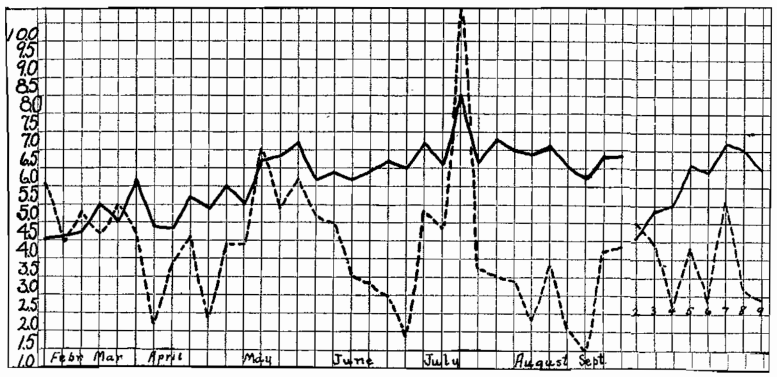

Chart 2.—The weekly average, by the day, of the temperature (solid line) and of the amount of ultraviolet light (broken line) for the period from Feb. 10 to Sept. 28, 1928. The figures in the left hand column, which represent the units of ultraviolet light, can be read as degrees of temperature, by disregarding the decimal point. The curves at the right show the monthly averages by the day.

degree on the scale. As he stated, "such a correction may be required in the tropics or cold climate." In making the records presented in this paper, care was taken to correlate the observations with the temperature curve. Table 2 and chart 2 reveal the fact that there were thirty-three (17 per cent) days having a temperature at noon outside the range of from 50 to 86 (from 10 to 30 C.). If the weekly averages are taken, only five (15 per cent) fall outside the limits and, in the monthly averages, only one (12 per cent). The escape from the limits requiring a correction of five tenths of a point were so few that no attempt was made to institute a correction, especially in view of the fact that the readings were made in favor of the high point on cold days and of the low point on warm days.

The amount of ultraviolet light represented by one unit of the scale may be expressed in two ways: the number of erythema doses, or the power which the light

31. Coblentz, W. W.: Radiology **10**:116, 1928.

TABLE 2.—*The Average Weekly and Monthly Amount of Ultraviolet Light, by the Day, in the Sunlight of Portland, Ore.**

	Daily				Weekly				Monthly			
Date	Sunshine, per Cent	Units Ultraviolet Light	Rainfall	Temperature	Sunshine, per Cent	Units Ultraviolet Light	Rainfall	Temperature	Sunshine, per Cent	Units Ultraviolet Light	Rainfall	Temperature
Feb. 10	100	5.2	0.03	53								
11	92	6.2	0.01	49								
12	70	....	0	39								
13	5	3.0	0.04	46								
14	61	6.0	T†	44								
15	68	7.7	0	42								
16	86	8.5	0	45	69.0	6.1	0.01	45.4				
17	98	6.0	0	54								
18	77	5.0	0	47								
19	44	....	T	41								
20	29	4.0	T	44								
21	0	3.2	0.08	45								
22	0	5.0	0.26	48								
23	2	4.0	T	43	35.7	4.5	0.05	46.0				
24	0	2.0	0.11	40								
25	3	4.0	0.26	47								
26	67	....	0	46								
27	36	5.0	0	49								
28	45	4.0	0	47								
29	7	7.0	0	50					44.5	5.0	0.04	46
March 1	100	10.0	0	53	37.0	5.3	0.05	47.4				
2	100	9.0	0	55								
3	100	2.5	0	59								
4	0	....	0.26	46								
5	15	4.5	0.09	58								
6	11	4.5	0.04	54								
7	18	3.0	0.07	57								
8	1	5.0	0.34	55	35.0	4.7	0.11	55.0				
9	9	4.0	0.43	53								
10	0	1.0	1.16	53								
11	38	....	0.69	52								
12	10	6.0	0	50								
13	1	2.0	0.09	44								
14	63	14.0	0	46								
15	0	6.0	0.18	52	17.0	5.5	0.36	50.0				
16	30	5.0	0	57								
17	97	3.0	0	64								
18	100	....	0	67								
19	82	6.0	0.03	72								
20	0	2.0	0.15	57								
21	5	5.0	0.41	58								
22	29	7.0	0.24	61	49.0	4.7	0.12	62.0				
23	28	3.0	0.39	55								
24	6	....	0.08	46								
25	56	....	0	48								
26	18	3.0	1.08	46								
27	6	2.0	0.29	46								
28	52	2.0	0.05	51								
29	17	1.0	0.06	53	26.0	2.2	0.48	49.0				
30	0	1.0	0.79	52								
31	1	....	0.29	47					32.0	4.46	0.232	53.8
April 1	12	....	0.14	43								
2	11	2.0	0.36	51								
3	52	6.0	0.12	50								
4	3	6.0	0.12	46								
5	50	4.0	0	51	18.4	3.8	0.26	48.6				
6	98	8.0	0	54								
7	100	....	0	59								
8	86	....	0	65								
9	48	5.0	0.04	59								
10	56	4.0	T	54								
11	22	3.0	0.16	55								
12	1	3.0	0.02	54	59.0	4.6	0.03	57.0				
13	30	4.0	0.08	60								
14	39	....	0.05	55								
15	38	....	0.02	61								
16	5	2.0	0.38	57								
17	10	2.0	0.42	50								
18	47	2.0	0.08	50								
19	9	2.0	0.61	42	25.4	2.4	0.23	54.0				

TABLE 2.—*The Average Weekly and Monthly Amount of Ultraviolet Light, by the Day, in the Sunlight of Portland, Ore.**—*Continued*

	Daily				Weekly				Monthly			
Date	Sunshine, per Cent	Units Ultraviolet Light	Rainfall	Temperature	Sunshine, per Cent	Units Ultraviolet Light	Rainfall	Temperature	Sunshine, per Cent	Units Ultraviolet Light	Rainfall	Temperature
April 20	35	2.0	0.02	52								
21	0	....	0.35	53								
22	68	....	0	64								
23	3	1.5	0.65	57								
24	44	3.5	0.02	57								
25	72	8.0	0	62								
26	67	7.0	0.02	70	40.0	4.4	0.15	60.0				
27	44	4.0	0.14	56								
28	65	....	0.10	57								
29	27	....	0.04	54								
30	27	3.0	0.53	50					38.0	2.73	0.15	54.9
May 1	41	6.0	0.32	54								
2	35	4.0	0	53								
3	62	5.0	0	63	43.0	4.4	0.16	55.0				
4	72	6.0	0	65								
5	70	....	0	68								
6	85	....	0	64								
7	71	8.0	0	63								
8	100	8.0	0	68								
9	100	7.0	0	66								
10	100	6.0	0	75	85.4	7.0	0	67.0				
11	55	6.0	0	62								
12	87	....	0	64								
13	87	....	0	76								
14	80	5.0	0	79								
15	100	6.0	0	71								
16	57	3.0	0	61								
17	61	7.0	0	62	75.0	5.4	0	68.0				
18	100	7.0	0	70								
19	100	....	0	75								
20	100	....	0	76								
21	47	4.0	T	66								
22	59	7.0	0	64								
23	86	6.0	0	72								
24	99	7.0	0	79	84.4	6.2	0	72.0				
25	54	6.0	0	69								
26	61	....	0	62								
27	48	....	0.03	62								
28	8	5.0	0.14	58								
29	20	5.0	0.25	50								
30	75	7.0	T	60								
31	91	3.0	0	68	51.0	5.2	0.06	61.4	71.0	4.32	0.024	66.0
June 1	21	5.0	0.01	60								
2	59	....	0.01	66								
3	69	....	0	69								
4	58	6.0	0	67								
5	82	7.0	0	65								
6	62	4.0	0.01	62								
7	26	3.0	0	59	54.0	5.0	0.004	64.0				
8	73	4.0	0	64								
9	57	....	0	63								
10	0	....	0.17	58								
11	4	3.0	0.01	64								
12	32	4.0	0	64								
13	8	3.0	0	64								
14	11	4.0	0.06	60	26.4	3.6	0.034	62.4				
15	6	2.0	T	60								
16	18	....	0.08	58								
17	86	....	0	64								
18	100	4.0	0	69								
19	54	3.0	0.07	69								
20	17	4.0	0	66								
21	6	4.0	0	65	41.0	3.4	0.021	64.4				
22	98	3.0	0	69								
23	100	2.0	0	78								
24	27	3.0	0	64								
25	0	2.0	0	65								
26	20	4.0	0	64								
27	2	3.0	T	64								
28	25	3.0	T	64	39.0	3.0	0	67.0				

TABLE 2.—*The Average Weekly and Monthly Amount of Ultraviolet Light, by the Day, in the Sunlight of Portland, Ore.**—*Continued*

	Daily				Weekly				Monthly			
Date	Sunshine, per Cent	Units Ultraviolet Light	Rainfall	Temperature	Sunshine, per Cent	Units Ultraviolet Light	Rainfall	Temperature	Sunshine, per Cent	Units Ultraviolet Light	Rainfall	Temperature
June 29	13	3.0	0.02	63								
30	0	2.0	0	63					38.0	2.83	0.014	64.4
July 1	0	1.0	0	62								
2	30	1.0	T	68								
3	22	1.0	0.23	68								
4	31	2.0	0.10	66								
5	16	3.0	0.08	65	16.0	1.86	0.061	65.0				
6	60	2.0	0	67								
7	96	6.0	0	71								
8	54	4.0	0	67								
9	71	6.0	0	68								
10	86	6.0	0	76								
11	100	7.0	0	83								
12	78	6.0	0	70	78.0	5.3	0	72.0				
13	100	6.0	0	69								
14	52	7.0	0	62								
15	81	5.0	0	69								
16	72	4.0	0	66								
17	1	3.0	0	63								
18	32	4.0	T	66								
19	63	5.0	0	67	57.3	4.85	0	66.0				
20	70	7.0	0	70								
21	100	8.0	0	84								
22	100	12.0	0	89								
23	100	12.0	0	87								
24	95	14.0	0	88								
25	79	11.0	0	91								
26	100	12.0	0	87	92.0	10.85	0	85.0				
27	79	6.0	0	75								
28	56	6.0	T	65								
29	40	2.0	T	62								
30	64	3.0	0	67								
31	0	3.0	0.01	62					62.0	5.64	0.013	71.7
Aug. 1	24	4.0	T	66								
2	17	2.0	0	67	40.0	3.71	0.001	66.3				
3	46	3.0	0	71								
4	5	3.0	0	66								
5	68	5.0	0	71								
6	62	4.0	0	75								
7	95	3.0	0	78								
8	64	4.0	0	72								
9	77	3.0	0	77	60.0	3.57	0	73.0				
10	49	4.0	0	76								
11	78	5.0	0	73								
12	83	3.0	0	69								
13	58	4.0	0	70								
14	39	3.0	0	63								
15	78	3.0	0	69								
16	84	2.0	0	73	67.0	3.43	0	70.4				
17	82	3.0	0	71								
18	63	2.0	0	67								
19	46	2.0	0	66								
20	83	2.0	0	70								
21	5	3.0	T	62								
22	69	2.0	0	69								
23	81	2.5	0	75	61.4	2.36	0	68.6				
24	52	2.5	0	76								
25	31	2.5	0	66								
26	0	2.0	0	66								
27	43	4.0	T	68								
28	100	4.0	0	75								
29	100	7.0	0	72								
30	99	4.5	0	74	60.7	3.80	0	71.0				
31	72	2.0	0	74					59.0	3.22	0	70.5
Sept. 1	100	2.0	0	69								
2	61	1.5	0	66								
3	55	1.5	0	65								
4	40	2.0	0	62								
5	0	2.5	T	60								
6	0	3.0	0	62	47.0	2.10	0	65.4				

TABLE 2.—*The Average Weekly and Monthly Amount of Ultraviolet Light, by the Day, in the Sunlight of Portland, Ore.*—Continued*

Date	Daily				Weekly				Monthly			
	Sunshine, per Cent	Units Ultraviolet Light	Rainfall	Temperature	Sunshine, per Cent	Units Ultraviolet Light	Rainfall	Temperature	Sunshine, per Cent	Units Ultraviolet Light	Rainfall	Temperature
Sept. 7..........	32	1.5	0	61								
8..........	67	2.0	0	64								
9..........	70	2.0	0	62								
10..........	40	1.5	0	62								
11..........	0	1.0	0.35	55								
12..........	13	1.0	0.23	60								
13..........	21	1.5	0.02	71	34.7	1.50	0.086	62.0				
14..........	15	2.5	T	66								
15..........	71	3.0	0	66								
16..........	86	4.0	0	78								
17..........	100	3.0	0	74								
18..........	42	3.0	0.03	64								
19..........	54	7.0	0	59								
20..........	100	7.0	0	67	67.0	4.20	0.004	68.0				
21..........	95	9.0	0	79								
22..........	93	6.0	0	84								
23..........	100	4.0	0	65								
24..........	50	4.0	0	65								
25..........	0	4.0	0.20	62								
26..........	9	2.0	T	60								
27..........	11	1.5	0	60	51.0	4.36	0.003	68.0				
28..........	6	1.0	T	56								
29..........	25	1.5	0	56								
30..........	5	1.0	0	64					45.0	2.88	0.021	64.8

† Trace.

* The first column represents the percentage of sunshine estimated from the number of hours of possible sunshine; the third column is the precipitation in inches from midnight to midnight, and the fourth column is the local temperature at noon. The table also gives the weekly averages by the day and the monthly averages by the day.

has to kill infusoria placed in a quartz cell. According to Hill,[12] "one unit of fading on the scale is equal to twice the infusoria-killing dose, and from two to four times the erythema dose, the sensitivity of the skin varying in individuals. The skin of the inner surface of the arm was used for the erythema dose." With the quartz tube containing the acetone-methylene blue solution placed 12 inches (30.5 cm.) from the mercury arc of a Burdick lamp (operated at 8 amperes and 75 volts), it took an exposure of ten minutes to reduce the standard solution 4 points. This means that at 12 inches, an erythema dose could be produced in from 37.5 to 75 seconds. At 24 inches, the same dose would require from two and one-half to five minutes and at 36 inches, from about five and one-half to eleven minutes. An erythema dose can be considered slightly in excess of a therapeutic dose, according to the data of Tisdall and Brown.[13]

By irradiating the standard solution in the quartz tube through a sheet of vitaglass, 2 mm. in thickness, it was found necessary to give an exposure of twenty minutes to get a reduction of 1.5 points. This means that the vitaglass cut out 81.25 per cent of the ultraviolet light. Similar measurements with helioglass showed that it took thirty minutes to get a reduction of 4.5 points. In this instance, 62.5 per cent of the ultraviolet light was cut out. Therefore, in order to get the same reduction with vitaglass as without it, about five times as much time must be allowed, and with helioglass about three times as much. These results were confirmed by finding that the time necessary to produce an erythema of the skin of the inner surface of the forearm corresponded to the foregoing results.

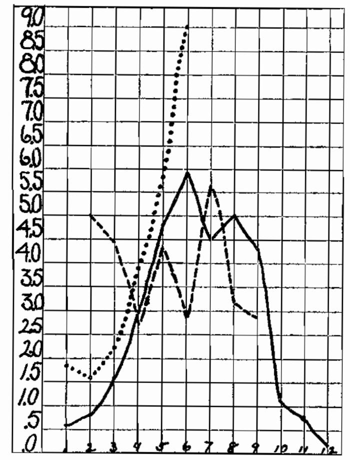

Chart 3.—The monthly average, by the day, of ultraviolet light in the sunshine of Portland, Ore. (broken line), Toronto, Ont. (dotted line), and London (solid line). The figures in the left hand column indicate units of ultraviolet light, according to the acetone-methylene blue scale. The figures at the bottom are for months of the year.

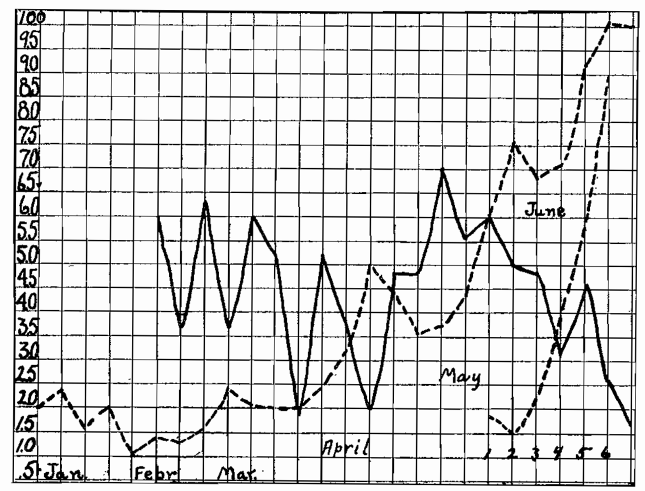

Chart 4.—The weekly average, by the day, of the amount of ultraviolet light in the sunshine of Toronto (solid line) and Portland, Ore. (dotted line), from January to July, 1927. It will be noted that for Toronto, the curve starts low, and for Portland, high, and that in April this relationship is reversed and thus maintained for the rest of the period. The amount for Toronto is shown by the solid line; the amount for Portland is indicated by the broken line, that at the left representing the daily average for the week, and that at the right, the daily average for the month.

Fleming [32] found that with a continuous exposure, the winter sunshine of Washington, D. C., provided enough ultraviolet light to promote normal calcification even when filtered through vitaglass. Tisdall and Brown [33] working in Toronto with exposures limited to two hours (from 11 a. m. to 1 p. m.) found that winter sunlight possessed a slight but definite antirachitic effect; that skyshine had one-half to two-thirds the effect of the sunshine (sunshine plus skyshine), and that through vitaglass there was no appreciable effect until March. A comparison of the curves for ultraviolet light in Toronto and in Portland for the same months, shown in charts 3 and 4, indicates that better results could be obtained here in the winter months than in Toronto and that poorer results would follow after the first of March.

From data so far collected, I believe that not less than half of the total ultraviolet light for one day is received between the hours of 10 a. m. and 1 p. m. Measurements for this period were undertaken with the belief that, all points being considered, it represented the best time of the day for solarization. If subsequent data should confirm the foregoing impression, it would be possible to work out a table as follows:

Table 3.—*Dosage of Ultraviolet Light, Based on the Total Amount for the Day*

Total Units Ultraviolet Light for Day	Units Received from 10 a.m. to 1 p.m.	Time Necessary for 1 Erythema Dose, Minutes		
		Sunshine*	Through Vitaglass	Through Helioglass
2	1.0	45 - 90	225 - 450	135 - 270
3	1.5	30 - 60	150 - 300	90 - 18C
4	2.0	22.5- 45	112.5- 225	67.5- 135
5	2.5	18 - 36	90 - 180	54 - 108
6	3.0	15 - 30	75 - 150	45 - 90

* Sunshine plus skyshine.

From table 3 it will be seen that all those days in which there was a total of 2 or more units of ultraviolet light would be capable of furnishing a therapeutic dose if the irradiation were direct. When the light is filtered through helioglass, as it would be in a solarium glazed with this material, only those days having 3 or more units would be potent, while with a vitaglass filter the daily amount would need to be 5 or more units. It is assumed that the glass is kept scrupulously clean and is changed sufficiently often to insure its primary transmissibility.

32. Fleming, W. D.: Mil. Surgeon **62**:592, 1928.

33. Tisdall, Frederick F., and Brown, Alan: Antirachitic Value of Sun's Rays Through Various Special Window Glasses, Am. J. Dis. Child **34**:742 (Nov.) 1927; footnotes 15 and 25.

Table 4 has been prepared by arranging the thirty-three weeks recorded in table 2 according to the frequency of their daily averages:

Table 4.—*Frequency of the Daily Averages for Weeks Reported in Table 2*

Units Ultraviolet Light, Daily Average	Weeks	Months	Units Ultraviolet Light, Daily Average	Weeks	Months
2—	2	0	6+	4	0
2+	31	8	7+	2	0
3+	27	5	8+	1	0
4+	19	4	9+	1	0
5+	10	2	10+	0	0

Thus it will be seen that during most of the time of observation, definite therapeutic results could be expected from direct solarization for periods of exposure well within the three hours which were chosen as the ideal time of the day for irradiation. In solariums glazed with helioglass, solarization would be of value 80 per cent of the time, and in those using vitaglass benefit would be obtained only 30 per cent of the time.

If 4.34 units are considered the general weekly average (by the day), it will be found that the weeks with a lower average occur with equal frequency throughout the entire period under observation. The astonishing thing is that in over one half of the days of the summer period (June 21 to September 21) the rate falls below this average. Fortunately at this time of the year compensation is easily obtained by increasing the time of exposure. It should be kept in mind, however, that outside of the three hour limit, the time of exposure must be increased as rapidly as the amount of ultraviolet light decreases. In August, for example, when there were few days when the rate was more than 4 units (the average for the month being 3.22), the maximum time necessary to produce a therapeutic result was about one hour. At this period of the year, the time of the exposure could easily be trebled if necessary, but in a solarium glazed with vitaglass where the maximum time is already five hours, a threefold increase would be impossible.

The amount of ultraviolet light in the sunshine of Portland, Ore., as recorded for 1928, by the method here employed, does not mean that this is the total light available for biologic reactions. Low as the record is, it would be lower still if the readings were made in the city proper. At is was, the readings were made on top of the medical school building which is located on the summit of a small hill southwest of the city. The difference in elevation is about 300 feet but is sufficient to rise above much of the low lying fog and smoke. The readings thus obtained are undoubtedly greater than what would be obtained in the city proper. A further analysis would seem to make necessary another reduction in the amount of ultraviolet light here recorded. Hill, in the article to which reference has already been made,[12] stated that "there is a minimal value below which no biologic reaction results, (*a*) for time, (*b*) for intensity of the source. While interrupted excitations, each below the threshold value, may be summated and provoke a reaction, with sufficient intervals such interrupted excitations become ineffectual." That such interruptions do occur is seen in the data of the U. S. Public Health Service.[19] They stated that on a clear day when small clouds pass over the sun, the illumination will fall in one minute's time from 9,000 or more foot candles to 3,000 or less and return as rapidly during the succeeding minute. An acetone-methylene blue may show fading during a period of twenty-four hours' exposure to weak and interrupted excitations that would not be capable of producing any biologic result such as antirachitic activation of foodstuffs or elevation of blood phosphorus.[34] It is thus seen that while the readings for ultraviolet light in the sunshine of the area studied are very low, they probably will have to be reduced still further before they can be thought of in terms of biologic units.

Chart 5.—The dotted areas are those reporting an amount of sunlight as low as or lower than that of Portland, Ore.

A study of the quantity of sunshine recorded by the various stations of the Weather Bureau will show that the sunshine of Portland, Ore., as representative of the Northwest, is consistently exceeded in amount by all the stations except those found in Michigan, New York, Vermont,

34. With the Burdick lamp, summation results with two minute intervals of excitation.

Maine and the Ohio valley. Just how low Portland falls in this respect can be seen from the following table:

Table 5.—*Relation Between Amount of Sunshine Reported for Portland, Ore., and That for Other Stations*

Year	Number of Stations	Portland Among the Lowest	Per Cent
1926	163	36	22
1925	164	24	15
1924	165	22	14
1923	165	28	17
1922	165	23	14
1921	165	24	15
1920	165	37	23
1919	165	32	20
1918	162	22	14
1917	155	7	5
1916	153	6	4
1915	152	4	3
1914	148	5	4
1913	148	5	4
1912	136	3	3
1911	138	5	4
1910	138	4	3
1909	125	18	15
1908	137	11	8
1907	125	31	25

During the same period of time, that is, from 1907 to 1926 inclusive, the number of times that stations by states were reported as low as, or lower than, Portland, Ore., are as follows:

Table 6.—*Frequency with Which Stations Reported as Low Amounts of Ultraviolet Light as That for Portland, from 1907 to 1926*

State	Frequency	State	Frequency
Michigan	68	Iowa	5
Washington	59	Rhode Island	4
New York	45	Montana	4
Pennsylvania	21	Tennessee	3
Oregon	21	Texas (Del Rio)	2
Vermont	21	South Dakota	2
West Virginia	17	Wyoming	2
Ohio	14	Virginia	1
California (northern half)	11	Wisconsin	1
Juneau, Alaska	9	Massachusetts	1
Kentucky	8	North Carolina	1
Maine	7	Alabama	1
Indiana	6	Louisiana	1
Connecticut	5	Minnesota	1

In table 6, all the states as far down the list as Connecticut can be grouped as already outlined, with the exception of Juneau, Alaska. The remainder can be considered as appearing in the list only because of occasional low records. A map of the United States, stippled in such a way as to represent the data contained in the foregoing tabulation, graphically portrays the division already mentioned (chart 5).

For further comparison, Cincinnati, O., may be considered a representative station for the Ohio Valley; Atlanta, Ga., for the South; Portland, Me., for the New England states; Bismarck, N. D., for the North Central states; Yuma, Ariz., for the Southwest, and Portland, Ore., for the Northwest. A graphic representation of the monthly and annual averages for sunshine in these areas is found in chart 6. It also furnishes the material for the following summary:

TABLE 7.—*Periods of More than the Average Amount of Sunshine for Six Representative Stations*

Station	Annual Average, per Cent	Months Above the Average, Inclusive	Months Above the Average, Inclusive
Yuma, Ariz.	90	March to November	December to February
Altanta, Ga.	59	April to November	December to March
Bismarck, N.D.	59	April to October	November to March
Portland, Me.	58	May to October	November to April
Cincinnati.....................	55	May to October	November to April
Portland, Ore.	50	April to September	October to March

It might be contended that the amount of sunshine reported for Portland, Ore., for 1928 does not represent an average year's total amount of sunshine. Chart 7 seems to bear out this contention, for there it will be observed that the average amount of sunshine for a period of thirty-five years for the months under consideration is 54 per cent, while that for 1928 is only 48 per cent, a decrease of 11.1 per cent. If one considers the average deviation from the mean (9.4 per cent), however, it will be found that the average for the year 1928 departs from this by only 1.7 per cent. At the same time, the maximum deviation was found to occur during the year 1917 (22 per cent) and the minimum during 1908 (0.9 per cent). The year 1928, therefore, is far from being an extreme year and varies from the average for thirty-five years by less than 2 per cent.

Charts 2, 8 and 10 will show that the ultraviolet light of sunshine is directly correlated to the amount of sunshine and that, in general, there is a reciprocal relationship between it and rainfall. There seems to be no correlation between the temperature and the amount of ultraviolet light. As a rule the curve for ultraviolet light parallels that for the amount of sunshine. However, it must be noted that for February and March the relative amount of ultraviolet light is greater than the amount of sunshine. In April this relationship is reversed; from then on, this relationship is maintained except for variations in the width of the zone between the two curves. An explanation of these two variations will be of interest. The greater relative amount of ultraviolet light in February and March than in the other months here reported is probably due to the ultraviolet value of skyshine. During that time of the year in this district the air is comparatively free from fog and smoke so that, although the sky is frequently overcast with clouds, much of the ultraviolet radiation of the sun is capable of reaching the earth's surface. After April, the amount of smoke in the air increases. Farmers, homesteaders and others select this time of the year, as well

as the fall after the first rains, to burn their slashings. During the summer months the amount of smoke in the air steadily increases and is due for the most part to forest fires. The width of the zone in May and August can be explained as being due to the absorption of ultraviolet rays by the smoke. The narrowness of the zone in the latter

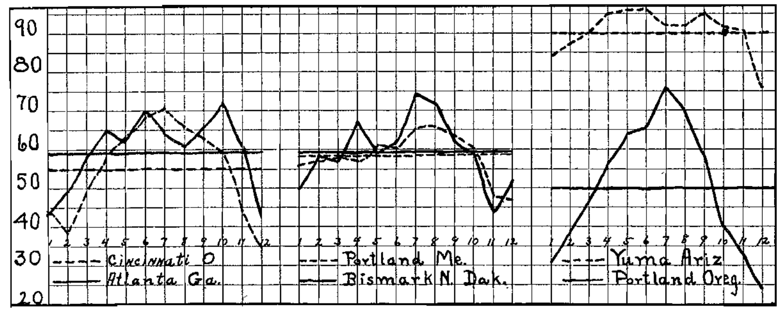

Chart 6.—The monthly and annual average of sunshine, by the day, in six cities, representing the Ohio valley, the South, New England, the north central, southwest and northwest areas of the United States, for the years 1920 to 1926, inclusive. The horizontal lines show the annual averages for the respective areas.

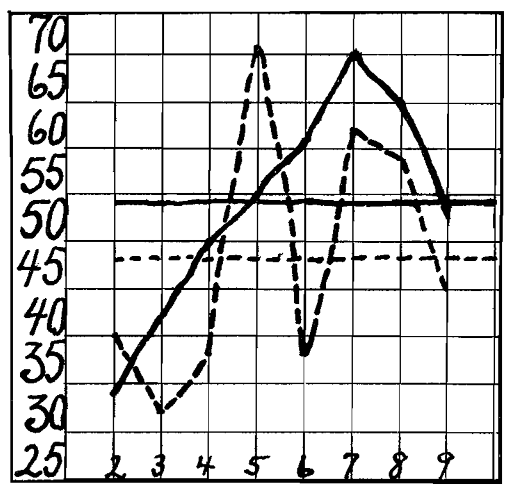

Chart 7.—The amount of sunshine received in Portland, Ore., during a period of thirty-five years (solid line), as compared with the amount received in 1928 only (broken line). February to September, inclusive, are the months reported. The monthly average by the day, and the total average by the day are contrasted.

part of March and April is undoubtedly due to the effect of the rainfall in clearing the atmosphere of smoke.

In chart 9, the weeks having a daily average over 4.34 units of ultraviolet light are numbered above the line and those below this

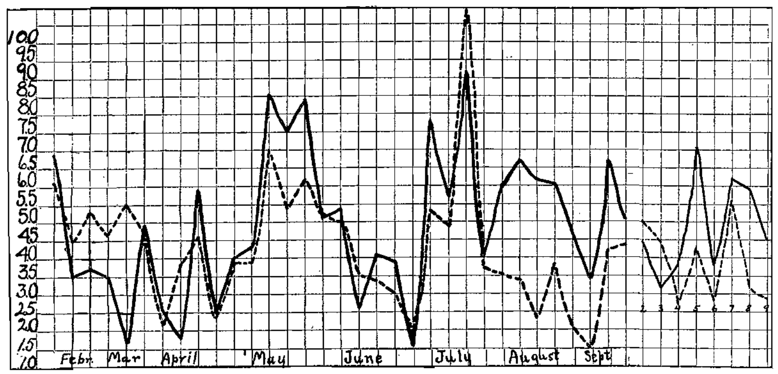

Chart 8.—The weekly average, by the day, of the sunshine (solid line) and of the amount of ultraviolet light (broken line) for the period from Feb. 10 to Sept. 28, 1928. The figures in the left hand column, representing the units of ultraviolet light, can be read as percentage of sunshine by disregarding the decimal point. The curves at the right show the monthly averages by the day.

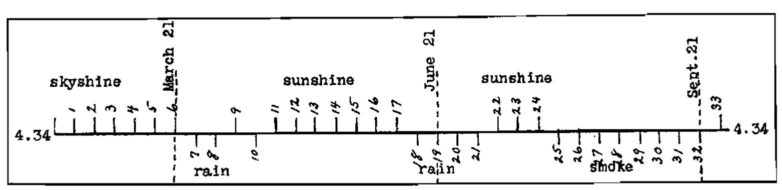

Chart 9.—The relative number of weeks having more or less than a daily average of 4.34 units of ultraviolet light. The figures above the line represent the weeks with more than the average amount; those below, the weeks with less.

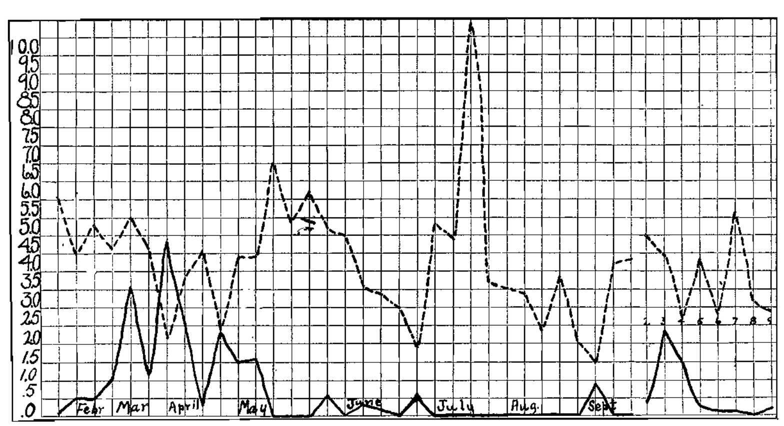

Chart 10.—The weekly average, by the day, of the rainfall (solid line) and of the amount of ultraviolet light (broken line) for the period from Feb. 10 to Sept. 28, 1928. The figures in the left hand column, which represent units of ultraviolet light, should be read as hundredths of an inch, disregarding the decimal point. The curves at the right show the monthly averages by the day.

average are numbered below the line. In the entire period of thirty-three weeks there are eighteen weeks averaging over 4.34 units, and fifteen weeks averaging less than this. If the totals are taken for the spring and summer quarters, it will be found that during the spring there were eight weeks above the average and five below, and for the summer, three above and ten below. The marked contrast between the steady and pronounced increase of ultraviolet light in the sunshine of London and of Toronto (charts 3 and 4) as midsummer approaches, as compared to the inconstant, low and fluctuating values for this district, emphasizes the degree to which the sunshine of this area has been devitalized by smoke. With an annual average of sunshine of only 50 per cent and with this markedly reduced in its ultraviolet content during those months of the year when there should be a natural increase, one can realize to some extent the necessity for more accurate quantitative data as well as information concerning the methods available for compensating for this deficiency.

TABLE 8.—*Incidence of Forest Fires in Oregon and Washington for 1927 and 1928*

Year	Total Number of Fires	Caused by Man	Not Caused by Man
1927	1,536	424	1,112
1928	1,350	772	578
Total	2,886	1,196	1,690

The United Forest Service reports [35] that for 1927 and 1928, the number of forest fires in the National Forest Reserves of Oregon and Washington were as shown in table 8.

The curve obtained by plotting the number of fires reported for ten day periods throughout the 1928 season can be seen by referring to chart 11. There it will be observed that the curve has the same general conformation as the one for sunshine so that if it were superimposed on chart 8 the reason for the wide zone occurring in August between the curve for sunshine and that for ultraviolet light would become apparent. The amount of smoke present in the Northwest because of 1,350 or 1,536 forest fires becomes still more impressive when it is realized that these figures do not include those from forest areas under private protection, smoke from burning slashings, saw-mill dumps and industrial areas. The Forest Service feels so strongly about the subject that a vigorous educational program is being undertaken calculated to arouse sufficient interest that measures will be instituted to bring about an abatement in the nuisance. Their propaganda is based on five points, namely: (*a*) inability of forest patrol observers to make accurate observations because of the smoke screen; (*b*) curtailment

35. Personal communication.

in the effectiveness of aeroplane fire patrol; (*c*) danger to commercial aviation; (*d*) ineffectiveness of tourist propaganda when the scenic beauties pointed out are obscured by smoke and (*e*) failure of crops to properly mature because of lack of sunlight. (Wenatchee apple orchardists, for example, stated that they lost thousands of dollars this season because of the failure of the apples to develop their proper color.) Another important point can be added: namely, that a naturally low

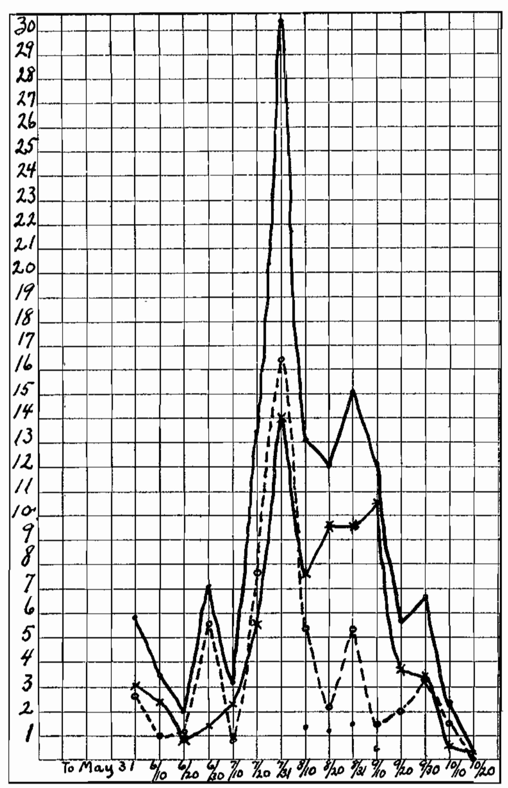

Chart 11.—The number of forest fires in Oregon and Washington reported at ten day intervals during 1928. This does not include data from forested areas privately owned and protected, which probably should not affect the record of seasonal incidence. The curve traced by the solid line shows the total number of fires; by the solid line and crosses, the number which man caused, and by the broken line, the number which were not caused by man.

amount of ultraviolet light, with its benevolent influence on animal and plant life, is reduced still further in quantity.

Granted, then, that the amount of the ultraviolet component of sunshine in the Northwest is naturally low and that it is still further reduced by the excessive pollution of the air by smoke, fog and dust, the ques-

tion arises as to the methods available for effectively combating or compensating for this deficiency. Without a too detailed discussion of this aspect of the situation, let it be said that there are several lines along which considerable work can be accomplished.

From the figures given for the number of forest fires during the last two years, it is obvious that if the Forest Service is given adequate support, measures can be initiated that will reduce the smoke menace from forest fires by nearly 50 per cent. It is also possible to control the smoke in industrial areas.

The relative mildness of the climate in the Northwest should permit of greater freedom in the style of dress. Man has not yet compensated for the deficiency of ultraviolet light in the sunshine of the temperate zone; in order to prevent undue losses of heat he has clothed himself in such a manner that a poor condition is made worse. However much has been said against the modern styles in women's dress, it must be admitted that they allow much more exposure of the skin to the beneficial action of the sun and air than is permitted by the prevailing modes for men. It has been shown that certain fabrics possess the power of greater transmissibility to ultraviolet radiations than others.[36] It would therefore seem that a more intelligent adjustment to styles and choice of fabrics would have considerable influence in alleviating the condition of shortage of ultraviolet light.

While a more determined effort to benefit by outdoor irradiation either by actual exposure or exposure permitted by modified dress can do much good, the benefit to be derived from irradiated foods should not be overlooked. In this connection, it would be wise to keep in mind a strict supervision of the selection of foods. Preference should be given to fieldgrown crops unless greenhouses install mercury vapor lamps or other sources of ultraviolet light or glaze their buildings with glass that is permeable to these rays; to foods shipped in from the districts that are not so limited in sunshine rich in the shorter wave lengths, and to foods deliberately irradiated by ultraviolet light.

Too much confidence must not be placed in the efficacy of various window glasses to transmit the shorter wave lengths found in the spectrum of the sun. Fleming[32] has shown that when vitaglass, one of the best of these materials, is exposed to the weather in Washington, D. C., from Dec. 12, 1927, to March 26, 1928, its original transmissibility of 47 per cent is decreased to 34 per cent, in the case of clean glass, and 21 per cent for dirty glass. The Bureau of Standards found that the complete degeneration of vitaglass by the mercury arc reduced its transmissibility to 25 per cent and that further exposures to either sun-

36. Dozier, C. C., and Morgan, H.: Am. J. Physiol. **84**:603, 1928. Morgan, H.: Am. J. Physiol. **86**:32, 1928.

light or the mercury arc caused no further decrease. It is therefore evident that unless window glass substitutes are cleaned frequently and replaced every two or three months, their ability to transmit ultraviolet light will shrink from less than one half to one fourth or even more.

As far as calcium and phosphorus metabolism are concerned, vitamin D seems to be the ultimate form in which ultraviolet light is utilized by the body. There appears to be a certain limit in the ability of the irradiation of the skin to alter the level of blood calcium or phosphorus because of the development of a pigment characteristic of tanning. This pigment production is Nature's method of protecting the human organism against excessive amounts of ultraviolet irradiation. On the other hand, also, Nature seems to have set an upper limit to the ingestion of vitamin D by making it quite scarce in natural foods. The general shortage of vitamin D in foods is adequately compensated for in the tropics by the abundance of the shorter wave lengths in the sunlight. Furthermore, as already mentioned, there is no danger of overcompensation and, because of the adequacy of sunlight, there is no call for an increased ingestion of foodstuffs rich in vitamin D. This is not true for those areas in which both the food and sunlight are deficient. Thus, when the dark skinned races are transplanted from their natural habitat to regions where there is less sunshine they immediately become more susceptible to a deficiency in ultraviolet light than the white-skinned races.[37] Increases can be brought about in irradiation, both natural and artificial, with no more danger of overstimulation than existed in the aforementioned conditions. In the tropics, irradiation is obtained without any effort or expense. This is not true in the areas of deficiency. The resulting condition is that an increase in the ingestion of substances containing vitamin D offers as good an alternative as seeking or obtaining more ultraviolet irradiation. Now that it is possible to produce vitamin D and ultraviolet light at will, it has become exceedingly easy to exceed those limits beyond which Nature has never gone. While it is not superficially apparent that much harm can arise from the prolonged use of ultraviolet irradiations by normal people, there are some pathologic conditions in which it is definitely contraindicated. Too much emphasis, therefore, cannot be placed on the undesirability of allowing the promiscuous use of ultraviolet lamps or the uncontrolled dispensing of such highly potent preparations of vitamin D as activated ergosterol. Nor can the warning be made too forcible that definite contraindications exist to the excessive use of these therapeutic modalities.

In the irradiation of foods, the following facts should be kept in mind: (*a*) vitamin A may be destroyed; (*b*) vitamin D may be inactivated and, hence, cannot be reactivated; (*c*) it may be possible to eliminate objectionable features such as the bad taste developed in irradiated milk, by irradiation in an atmosphere of carbon dioxide.[38]

37. Hess, A. F.: Am. J. Pub. Health. **12**:104, 1922.

These measurements are being continued so that a period of twelve months will be included. Furthermore, readings are made at 10 a. m. and 1 p. m. so that data will be available to show what part of the daily total will fall within this period. This material will form the substance of a future report.

CONCLUSIONS

1. Portland, Ore., as a representative locality of the Northwest, has the lowest annual average of sunshine of all areas in the United States. Michigan, Main, Vermont, New York and the Ohio Valley receive almost as low a percentage.

2. Plotting the curve for ultraviolet light against that of temperature, rainfall and sunshine shows that the closest correlation exists between ultraviolet light and sunshine, the least between it and temperature and that a possible inverse relationship exists between ultraviolet light and rainfall.

3. The readings for 1928 cannot be vitiated by the fact that it appears to be a year usually low in sunshine, for two reasons: (1) the deviation of the average for 1928 from the average for the preceding thirty-five years is well within the maximum and minimum deviation (22 per cent and 0.9 per cent); and (2) the average for 1928 deviates from the mean of the preceding thirty-five years by only 1.7 per cent, the average deviation being 9.4 per cent.

4. Instead of the amount of ultraviolet light gradually increasing as the months progress, as occurs in London and Toronto and as one would expect from the gradual increase in the amount of sunshine, there is an extreme fluctuation, so that only one month (July) shows a higher average than February.

5. The pall of smoke hanging over the Northwest during the late spring, summer and early fall is considered more of a menace than a nuisance.

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38. Scheer, K.: München. med. Wchnschr. **75**:642, 1928.

535 North Dearborn Street
CHICAGO