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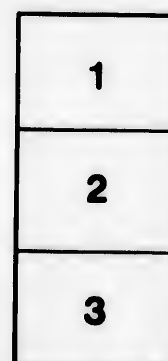
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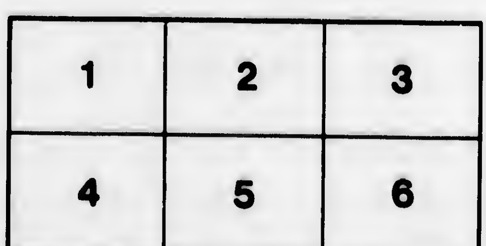
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Observations on Solar Radiation, made at Fort Franklin in the years 1825, 1826, *and* 1827. By John Richardson, M.D., F.R.S., and Inspector of Naval Hospitals. Communicated by the Author.

While residing at Fort Franklin, in North America, in the year 1825–26, I made a series of observations on the heating power of the sun's rays with a black-bulb thermometer, and some of the results were published in the "Appendix to the Narrative of Sir John Franklin's Second Journey." It has been observed by an eminent philosopher, in reference to observations of this kind, that, as measures of solar radiation, they have generally been made on an erroneous principle, "the true indication of the force of the solar rays not being the statical effect upon the thermometer, but their momentary intensity, measured by the velocity with which they communicate heat to an absorbent body."† The actinometer has

* His critique of Kämpf's New Method of curing the most obstinate Diseases of the Bowels (Med. Bibl. vol. ii. No. i.) gave offence to the author, but yet afterwards obtained from him for Blumenbach public thanks (in the second edition of that book, Leipsic, 1786, p. 366).

† Sir John Herschel, quoted in the Report by Professor Forbes on Meteorology; Trans. of the British Association, vol. i.

since been contrived by Sir John Herschel for this purpose; but in the report of the Committee of Meteorology appointed by the Royal Society, it is said, "As the actinometer can only be observed at intervals in perfectly clear weather, additional information with regard to solar radiation, of much interest, *though not of so precise a nature*, may be obtained, by the daily register of the maximum temperature of a register thermometer, with a blackened bulb, exposed to the full action of the sun's rays. It may be placed about an inch above the bare soil, and screened from currents of air. The maximum temperature indicated by such a thermometer, even in cloudy weather, will generally be considerably above that of the air, and the maxima and mean daily maxima of its indications will, after a long series of observations, afford data of the utmost value to the history of climates." As this recommendation will undoubtedly be extensively acted upon by the expedition which has sailed to the antarctic regions, and at the observatories established in connection with it, we may expect to have in a few years a large body of facts recorded concerning solar radiation in various latitudes; and it will obviously facilitate the deduction of general laws therefrom to have the means of comparing observations made in the southern hemisphere with similar ones made in the arctic regions. With this view, I have revised the original records of the Fort Franklin observations, for the purpose of tabulating them more fully than has been done in the appendix above mentioned, so that, in conjunction with the tables there given, the most important of the results may be readily exhibited.

When I first thought of commencing the observations in question, I had no personal experience to guide me in the best mode of conducting them, nor had I read of any example that I could follow, further than the general recommendation to travellers to observe the effect of the sun on a thermometer with the bulb blackened or wrapped round with black wool. My earliest trials were, therefore, of the nature of experiments, and for two or three months were made only at times when the sun shone brightly. In February 1826 I began to observe every hour that the sun was above the horizon, and continued to do so till the end of April, when I found, on summing up the hourly columns of each month, that the curves of temperature were very irregular, the irregularities being evidently caused by the black-bulb thermometer not being properly sheltered from the wind.* I have included these months in the following tables, but they must be considered as very imperfect. In the winter there were many calm days, but as the spring advanced the air was seldom still when the sun shone; and in May, therefore, I completely sheltered the blackened thermometer by enclosing it in a large thin glass bottle. In this month the mean excess of the temperature indicated by the blackened thermometer over one in the shade rises in the morning at each successive hour of observation, attains its maximum at noon, and descends again in the afternoon, as shewn in the accompanying plate (Plate V.) And this I regret to say is the only month for which I possess hourly observations to be depended upon. I left the Fort in June, and though Mr Dease kindly continued the observations every third hour in July and August, yet as he had no watch whereby to measure the time, the results for these months must be somewhat uncertain. It is satisfactory, however, to find that both the mean excess and the maximum excess in these two months are greater the nearer the hours are to noon. From September 1826 to the end of April following (1827), the observations were continued at 8, 10, 11, A.M., and 1, 2, 4, P.M., and after the middle of February at noon also by Sir George Back and Lieutenant Kendall; and though I have not their original registers to refer to, I have extracted from Franklin's appendix as many of the results as the tables there given would furnish.

For these observations, a pair of thermometers corresponding most nearly with each other in their scales was chosen. Up to the end of April 1826, spirit-thermometers were used; in May, July, August, and September, mercurial ones were employed; and from November till the end of April 1827, the spirit ones were resumed. They were all constructed by Newman, and had spherical bulbs half an inch in diameter. The thermometer exposed to the sun was prepared by coating its

* See Franklin's Appendix above quoted, where the days on which the wind affected the black-bulb thermometer are marked by an asterisk.

bulb with a thin film of silk paper, and then blackening it thoroughly with china-ink and indigo. The silk paper was used to overcome effectually the polish of the glass and prevent the reflection of any of the sun's rays. From the commencement of the observations till the end of April 1826, the blackened bulb thermometer was hung on the south side of a rough deal shed used as an observatory; while the corresponding thermometer with a clean bulb was secured on the north, and consequently shady side. The black-bulb thermometer was therefore sheltered from the winds that came from the northern points of the compass only. In May 1826, and all the following months, both the clean and black-bulb thermometers were secured on the top of a slender detached post rising three feet above the sandy soil. A square, thin, clear glass bottle, four inches wide, placed on the top of the post, enclosed the radiation thermometer, and protected it from the wind. Its mouth was left open. The other thermometer was secured on the same post, at the same height, and its bulb, with the lower part of its scale, were enclosed in two concentric brass cylinders, which permitted a free circulation of air, but effectually intercepted the sun's rays. This was ascertained by almost an hourly comparison with two other thermometers, one inside the observatory, which was regularly registered in connection with the magnetical observations, and another hung in the open air on the north side of the observatory. The latter always felt the influence of the sun in May and the summer months, both in the morning and evening (owing to the high latitude), and being also unsheltered from radiation of the sandy soil and of the deal observatory, was scarcely ever lower than the thermometer enclosed in the brass cylinders even at noon. The black-bulb thermometer in the bottle was very sensitive, and has been noticed to fall 10° in the short space of time occupied by a cloud passing over the face of the sun in a moderate breeze. In clear nights it often shewed a lower temperature than any of the thermometers with clean bulbs, the difference in some instances amounting to 4°. During May 1826, a spirit black-bulb thermometer unsheltered by glass was hung against the observatory and shifted from side to side with the course of the sun. A register of its indications is printed in Franklin's appendix, and when contrasted with the register of the one in the bottle, shews the necessity of protecting the radiation thermometer by glass if the observations are to be continued in windy weather.

From Tables IV. V. and VI., the daily curve of the mean effect of the sun in May, July, and August, may be constructed, and the plate on which the curves are exhibited contains also the daily curve of temperature for the twenty-eight days of May on which the observations were made (30° being subtracted from the temperature at each hour). Table VII. is added to shew the effect of the sun in raising the temperature of the atmosphere between sunrise and one or two in the afternoon, the maximum temperature at the two latter hours being recorded.

As the observations are tolerably complete only for one month (May 1826), deductions from them as to the intensity or to the total effect of the sun's rays in the different seasons of the year would carry but little weight. I have, however, in Franklin's appendix, broached an opinion, that in the high northern latitudes of America, the average intensity of the heat of the sun is greater in the spring months than near the summer solstice, the greater clearness of the atmosphere compensating for the smaller altitude of the sun. This opinion is supported by the subjoined tables. In Table I., for instance, the means of the maxima indications of the radiation thermometer for February 1827 are nearly equal to those for May 1826, though the times of observation were so much more numerous in the latter month, and consequently there was more chance of ascertaining the true maximum on each day; they are also considerably above those for the first sixteen days of May 1827, when the observations were more frequent than in February. In March and April 1827, the means exceed those of February and May; and if they do not do so also in April 1826, it is to be attributed to the effect of the frequent winds in that month on the unsheltered radiation thermometer. The column containing the monthly maxima of the black-bulb thermometer also leads strongly to the same conclusion; and here the want of shelter is not so operative, as many of the clearest days were calm, particularly in the winter and early spring months. In this column the maxima increase in amount from December to March or April, and decrease gradually in the succeeding months. The irregularity for July 1826 may be accounted for by only twenty-one days being included; and the smallness of the number of observations in the autumn of 1825 may also be considered as the reason of the small mean for October. Table VII., and what is nearly the same thing, the much greater sharpness and altitude of the mean curves of temperature for March and April, as shewn in Plate I., f. 5, Geograph. Journal, vol. ix., may also be adduced in corroboration of my remark.

I shall not repeat here the attempt I have made elsewhere to explain the cause of the clearness of the atmosphere in the spring of those climates, but shall merely remind the reader, that at Fort Franklin the snow does not disappear till the beginning of May, consequently the soil cannot before that month accumulate heat from day to day; and that when the snow is at the melting point, a powerful sun one day will have little effect in raising the mean heat of the following day.

When the solar rays are projected at low altitudes into the lower dense or cloudy stratum of the air, considerable irregularities and sudden changes of temperature must result, producing partial currents, and mingling of masses of air in different conditions, all increasing the scattering action of the strata on the solar light.* But if, from the natural effect of the climate, the air in the high northern regions of America be peculiarly free from clouds, and clear in the spring, there does not appear to me to be any great difficulty in explaining why the more oblique rays in spring should have a superior effect on the black-bulb thermometer, than the more direct ones passing through a comparatively cloudy atmosphere near the summer solstice. I have no doubt but that future experiments will shew that the sun, at *equal altitudes*, acts more intensely (in spring at least) near the poles, than near the equator, although the increase of the temperature of the atmosphere may be greater in the latter locality through indirect radiation.

* *Vide* Astronomy, by Sir J. F. W. Herschel, &c., p. 33.

TABLE I.

Of Mean daily Maximum excess for each month of the Radiation Thermometer over the Temperature in the Shade; and of the Maximum excess for each month.

Months.	No. of Days on which Observ. were made.	No. of Hours at which Observ. were made.	Mean of daily maximum excess of Black-bulb Thermometer.	Mean Temp. in the Shade at the Hours of Observation.	Maximum excess in the month of the Black-bulb Therm.	Temp. in the Shade at the time when the preceding maximum occurred.	Remarks.
1825.							
Oct.	8	53	9.00	+ 19.63	23.5	+ 25.0	
Nov.	19	69	12.31	+ 2.31	35.0	— 5.5	Black bulb thermometer not protected by glass, and only sheltered from northerly winds by Observatory.
Dec.	23	77	11.04	—15.67	28.0	+ 14.5	
1826.							
Jan.	20	49	16.12	—24.61	48.0	—38.5	
Feb.	28	196	25.58	— 8.98	57.9	—15.0	
March,	31	297	34.22	— 5.50	65.0	— 8.4	
April,	30	269	24.99	+ 20.28	51.0	+ 34.9	
18[illegible]							
May	[illegible]8	336	35.62	+ 44.05	49.8	+ 50.2	
July,	23	111	28.02	+ 57.46	38.5	+ 61.5	
August,	31	155	26.12	+ 56.82	41.5	+ 55.5	
Sept.	24	144	25.14	+ 45.70	42.0	+ 31.0	
Nov.	30	120	10.74	+ 3.57	33.5	+ 6.5	Black-bulb thermometer enclosed in a thin glass bottle.
Dec.	31	70	7.05	— 8.89	24.0	+ 2.0	
1827.							
Jan.	31	126	15.29	—22.65	38.3	+ 22.2	
Feb.	28	150	34.58	—19.65	53.2	—17.2	
March,	31	217	45.16	+ 1.01	68.0	+ 17.0	
April,	30	210	53.18	+ 16.15	70.0	— 2.5	

Note.—In October, November, December 1825, and January 1826, the observations were recorded only when the sun shone out favourably; in the following months, up to May inclusive, almost regularly at the stated hours. In July and August 1826, they were made at intervals of three hours; and from September 1826 to May 1827, six, and latterly seven, daily observations were made throughout each month.

The maximum excess of the radiation thermometer in the first sixteen days of May 1827 was 50°.2, and the mean of the maxima for the same time was 33°.85.

TABLE II.

Of the Maximum excess of the Black-bulb Thermometer over one in the Shade at the several hours of Observation.

Hours.	Black-Bulb Thermometer not sheltered.							Ther. sheltered by Glass.		
	1825.			1826.				1826.		
	Oct.	Nov.	Dec.	Jan.	Feb.	March.	April.	May.	July.	Aug.
4 A.M.	...	...	...	...	...	...	...	22.0	...	...
5 ...	...	...	..	...	...	...	...	22.5	..	...
8 ...	...	...	...	...	...	44.5	30.5	38.8	35.5	37.0
9 ...	...	...	...	...	40.1	48.2	48.0	38.5	...	...
10 ...	23.5	19.7	3.5	34.5	53.4	50.0	43.5	42.0	...	...
11 ...	11.5	31.0	18.0	41.0	57.9	57.0	51.0	44.0	38.5	41.5
Noon.	17.8	30.7	28.0	39.8	47.0	65.0	44.8	49.8	...	...
1 P.M.	13.0	24.0	20.0	46.0	42.8	38.9	44.0	49.5	...	...
2 ...	14.0	35.0	12.0	48.0	33.9	46.0	40.5	43.7	34.5	42.0
3 ...	...	...	...	...	30.2	35.4	38.0	40.5	...	...
4 ...	...	...	...	...	...	30.0	32.0	38.4	...	...
5 ...	...	..	...	...	...	17.5	27.5	32.0	30.0	34.5
6 ...	...	...	...	...	...	...	...	46.0	...	...
8 ...	...	...	...	...	...	...	...	...	23.0	23.5

TABLE OF TEMPERATURES IN THE SHADE, WHEN THE ABOVE MAXIMA (TABLE II.) IN THE SUN WERE OBSERVED.

Hours.	1825.			1826.				1826.		
	Oct.	Nov.	Dec.	Jan.	Feb.	March.	April.	May.	July.	Aug.
4 A.M.	...	...	...	...	...	...	...	+ 44.0	...	...
5 ...	...	...	...	...	...	...	...	+ 38.0	...	..
8 ...	...	...	...	...	...	—30.0	— 9.5	+ 39.2	+ 58.0	+ 61.0
9 ...	...	...	...	...	—25.0	—20.0	+ 29.0	+ 13.0	...	...
10 ...	+ 25.0	—9.2	—34.0	—38.5	—19.8	— 8.8	— 4.5	+ 39.0	...	...
11 ...	+ 30.5	—8.5	—39.8	—41.0	—15.0	—11.5	+ 34.9	+ 40.0	+ 61.5	+ 55.5
Noon.	— 0.8	—8.5	+ 14.5	—39.8	—26.0	— 8.4	— 1.8	+ 50.2	...	...
1 P.M.	+ 32.0	—7.0	+ 15.0	—29.0	— 9.6	— 3.9	— 1.0	+ 44.0	...	...
2 ...	— 5.0	—5.5	+ 14.0	—38.5	—13.0	—10.0	— 0.5	+ 43.8	+ 57.0	+ 58.0
3 ...	...	...	...	...	—14.0	— 0.4	0.0	+ 43.0	...	...
4 ...	...	...	...	...	...	+ 14.0	+ 0.2	+ 34.3	...	...
5 ...	...	...	...	...	...	—23.5	0.0	+ 45.6	+ 56.0	+ 51.5
6 ...	...	...	...	...	...	...	...	+ 44.0	...	...
8 ..	...	...	...	...	...	...	...	+ 48.0	...	+ 51.0

TABLE III.

Of the Monthly Mean excess of the unsheltered Black-bulb Thermometer over one in the Shade, at the several hours of Observation.

Hours.	1825.			1826.			
	October.	November.	December.	January.	February.	March.	April.
8 A. M.	...	...	...	...	4.45	16.04	11.67
9 ...	...	...	. .	...	7.99	22.46	15.41
10 ...	7.05	5.99	2.37	13.50	16.57	25.00	16.38
11 ...	4.50	10.38	7.03	22.57	17.13	24.86	17.63
Noon.	7.88	10.32	11.25	15 13	17.31	23.97	17.72
1 P. M.	7.25	6.02	7.29	16.59	14.45	22.02	17.76
2 ...	5.90	7.07	4.16	26.13	12.43	22.51	18.61
3 ...	...	...	...	...	7.36	18.12	13.76
4 ...	...	...	...	...	4.57	13.97	10.87
5 ...	...	...	...	...	...	10.72	7.77

TABLE OF THE MEAN TEMPERATURE IN THE SHADE AT THE HOURS OF OBSERVATION OF PRECEDING TABLE.

Hours.	October.	November.	December.	January.	February.	March.	April.
8 A. M.	...	...	...	...	...	— 11.11	+ 15.18
9 ...	...	...	...	...	— 13.70	— 6.95	+ 17.72
10 ...	+ 24.20	— 3.28	— 16.12	— 29.30	— 11.14	— 3.38	+ 19.50
11 ...	+ 17.50	+ 1.78	— 17.34	— 33.89	— 9.20	— 1.95	+ 21.07
Noon.	+ 18.92	+ 2.91	— 14.42	— 25.35	— 8.33	— 0.03	+ 21.51
1 P. M.	+ 21.88	+ 1.60	— 13.72	— 25.60	— 7.72	+ 0.84	+ 22.22
2 ...	+ 20.38	+ 2.32	— 15.45	— 29.60	— 8.24	+ 1.71	+ 21.44
3 ...	...	...	...	...	— 9.35	+ 1.47	+ 22.84
4 ...	...	...	...	...	...	— 0.24	+ 22.35
5 ...	...	...	...	...	...	— 2.94	+ 19.64

The observations were recorded only at favourable times in the months previous to February. Thus, in

October at 10 h. there were but 6 obs.; at 11 h., 4 obs.; at noon, 6 obs.; at 1 h., 4 obs.; and at 2 h., 8 obs.

November, at 10 h., 8 obs.; 11 h., 12 obs.; noon, 16 obs.; 1 h., 9 obs.; 2 h., 11 obs.

December, at 10 h., 4 obs.; 11 h., 18 obs.; noon, 22 obs.; 1 h., 20 obs.; 2 h., 13 obs.

January, at 10 h., 7 obs.; 11 h., 8 obs.; noon, 16 obs.; 1 h., 7 obs.; 2 h., 6 obs.

February, only 2 obs. at 8 A.M., but daily at the other hours, except 4, when the observations were necessarily confined to the last 14 days, the sun not being above the horizon before.

March, daily at each hour, except at 11 h., when 29 obs.; 4 h. when 30; and 5 h., 18 obs.

April, at 8 h., 28 obs.; 9 h., 29 obs.; 10 h., 29 obs.; 11 h., 29 obs.; 2 h., 20 obs.; 4 h., 28; 5 h., 21; at the other hours daily.

TABLE IV.

Of the Mean hourly excess shewn by a Black-bulb Mercurial Thermometer sheltered by Glass over a clean Thermometer in the Shade, for the twenty-eight last days of May 1826 *(from fourth to thirty-first day inclusive).*

Hours.	Mean heat in the Shade.	Excess of Black-bulb in the Sun.	
		Mean.	Maximum.
8 A.M.	+38.25	20.42	38.8
9 ...	39.70	23.84	38.5
10 ...	40.51	26.59	42.0
11 ...	42.14	30.10	44.0
Noon.	43.27	30.74	49.8
1 P.M.	43.51	30.16	49.5
2 ...	43.36	26.27	43.7
3 ...	43.42	23.70	40.5
4 ...	43.04	21.14	38.4
5 ...	42.75	18.59	32.0
6 ...	41.39	15.56	46.0

An observation made at 5 A.M. from the 4th to the 17th inclusive, yields a mean excess of the black-bulb of 6.29°, and a maximum of 22.5°; and one at 4 A.M. from the 18th to the end of the month, a mean for the 14 days of 6.36°, and a maximum of 22°. The mean temperature for the whole 28 days at 4 A.M. was +32.35°, and at 5 h., +33.51° F.

TABLE V.

Containing similar Observations for 21 *last days of July* 1826.

Hours.	Mean heat in the Shade.	Excess of Black-bulb in the Sun.	
		Mean.	Maximum.
8 A.M.	+56.45	18.93	35.5
11 ...	59.74	23.90	36.5
2 P.M.	65.38	24.40	34.5
5 ...	56.08	16.75	30.0
6 ...	51.80	3.62	23.0

TABLE. VI.

August 1826.

8 A.M.	51.78	18.17	37.0
11 ...	56.83	23.08	41.5
2 P.M.	56 88	21.68	40.0
5 ...	52.63	13.37	34.5
6 ...	48.89	3.69	23.5

The observations for July and August were made by Mr Dease at intervals of 3 hours, but as he had no watch to regulate his time, the hours could not be very accurately kept. He was accustomed to judge of the time of day by the position of the sun, and a meridian line was traced, by which he could ascertain noon.

TABLE VII.

Exhibiting the Monthly Mean difference of Temperature in the Shade at Sunrise, from the Mean Maximum at 1 or 2 P.M.

Months.	Mean Temp. at Sunrise.	Mean Temp. at 1 or 2 P.M.	Difference of these two.	Mean Temp. of the Month.
1825.				
September,	+42.14	+44.82	2.680	+42.92
October,	+18.32	+23.75	5.430	+20.27
November,	+ 1.77	+ 4.83	3.064	+ 2.79
December,	—14.45	—12.05	2.405	—14.35
1826.				
January,	—24.86	—21.48	3.378	—23.77
February,	—14.79	— 7.72	7.072	—12.70
March,	—15.42	+ 1.71	17.129	— 8.27
April,	+ 7.47	+23.21	15.735	—15.20
May,	+28.27	+41.73	13.462	+36.33

Note.—The mean temperature in the third column is for the most part that at 1 P.M.; but when the temperature at 2 was greater, that is given.

Remarks on the Preceding Paper. By Professor FORBES.

Dr Richardson has, I think, fairly deduced from his observations, confessedly imperfect as they are, that his photometric apparatus was more affected by sunlight in March and April than during the summer months. Whether this be due to the greater intensity of the solar rays in spring, as he supposes, may perhaps be considered as not so fully proved. The principle of measuring the intensity of solar radiation by a blackened thermometer, is due to Lambert, and was ingeniously and elegantly applied by Leslie. Such instruments, *carefully sheltered by glass* (as in Dr Richardson's later experiments), are certainly capable of yielding valuable results, although we have not yet learned to interpret them aright. Their indications are, however, very different from the *sensible* effects of the sun's action on the animal frame for instance, and from the more direct measure of it which is obtained by means of Herschel's Actinometer.* Any measures sufficiently often re-

* It is a curious fact, which has only come lately to my knowledge, that in Sir J. Leslie's earliest paper, read to the Royal Society in 1793, but first published twenty-six years later in Thomson's Annals of Philosophy, vol. xiv., he has laid down with perfect clearness the principle of the actinometer, which he has described as the only true measure, and which yet he wholly overlooked in the final construction of his Photometer, which measures the statical maximum of temperature which a blackened ball is capable of assuming, instead of the momentary increment of heat which it receives. His words are: "The initial change on the thermometer is in

peated, under circumstances nearly the same, have a certain degree of comparability with one another; and Dr Richardson's curve of diurnal radiation is so regular as to confirm the comparable character of his method. The results obtained in different months, (Table I.) are less satisfactory; but by projecting both the mean and extreme numbers, I find a coincidence which seems to indicate a maximum effect about the month of April, and not in June, as we might expect from observations in other climates. Dr Richardson declares that experience has convinced him that the sky is clearer in spring than in summer in the arctic regions, and has assigned reasons for this difference. (Franklin's Second Journey, *Appendix*, p. cx.) But without disputing the fact, we must be allowed to doubt (as contrary to general experience) whether the increased power of the sun's rays, owing to the shorter tract of air traversed, is not far more effective (a few degrees of elevation at low altitudes making a difference of thickness to be traversed quite enormous, varying nearly as the secant of the zenith distance) than any diminution due to slight vapours raised by the solar heat. We must not, however, rest in mere conjecture. Dr Richardson has pointedly alluded in the preceding paper (p. 245, and in Franklin's Appendix (p. cx.,) to the *presence of snow on the ground** as accompanying the peculiar atmospheric condition which he considers so favourable to the solar action. I am disposed to attribute the effect *solely to the mechanical action* of the snow in reflecting the solar light to the instrument. Dr Richardson has alluded to a fact well known to those who have used Leslie's photometer, that the presence of clouds, when dense, white, and luminous, affects most strongly its indications, and that the scattered light even of a blue sky equals sometimes the direct effect of the sun itself. This paradoxical result shews the necessity that there is for cautious deduction from an instrument so curiously sensitive, and as yet so imperfectly studied; but as these facts cannot be doubted, there can be no difficulty in believing, that the reflection from a boundless field of daz-

every case the only certain and accurate measure of the communication of heat." (Thomson's Annals, 1819, xiv. p. 7.)

* "It" (the force of the sun's rays) "was much stronger in the spring months, WHEN THE GROUND WAS COVERED WITH SNOW, than in the summer months, when the altitude of the sun was greater."

zling snow must be most energetic indeed, and that the disappearance of the snow in May causes an apparent diminution of solar intensity, because the rays which before were reflected are now chiefly absorbed by the vegetable and earthy surface of the ground.*

I regret very much that a fit opportunity has not offered itself since Dr Richardson's paper came into my hands of verifying my conjecture by direct observation ; but snow and bright sunshine are elements more rarely combined in the latitude of Edinburgh than that of Fort Franklin.

Observations with the actinometer would fairly eliminate the disturbing influence of the snow and all others, and therefore can alone be perfectly relied on in deciding this question.

16th February 1841. James D. Forbes.

Observations on the Progress of the Seasons as affecting Animals and Vegetables at Martin's Falls, Albany River, Hudson's Bay. By George Barnston, Esq. Communicated by Dr Richardson, F. R. S., Inspector of Hospitals, Haslar.

The following Paper was drawn up in consequence of a printed communication from Dr Richardson, handed to me last September. Martin's Falls is a station on Albany river, thirty miles below Gloucester, which is marked in the maps. Having no sextant, I am unable to give the exact latitude.† Our geological position is upon the confines of the great basin of James' Bay, an immense extension of the older calcareous strata. Between the falls and the coast the bed of the river is composed of limestones and clays, both containing extinct genera of shells ; while above, towards the interior, little is to be seen but gneiss and greenstone schist, with a mixture here and there of less fissile granitic rocks. The fossils which I have been able to procure in this neighbourhood are principally spirifers, producta, terebratula, and impressions of trilobites. Although in winter we have the cold of Russia, in the months of July and August we enjoy the climate of Germany and the north of France.

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* Since this explanation occurred to me, I find that M. Arago had adverted to the glare of the snow as a reason of the apparently greater intensity of solar radiation in high latitudes, in his criticism on Mr Daniell's Meteorological Essays.

† About Lat. 51° 30′ N.; Long. 86° 20′ W.

December, January, February,	Our dead winter months.	We are frequently visited by the White Owl or Harfang from the Bay, but the Hawk-owl is our most common bird of prey. Besides our three

indigenous species of grouse (*Tetrao umbellus, Canadensis,* and *Phasianellus*), we have the Willow Grouse, or White Bird as it is called, (*T. saliceti,* Temm. *T. albus,* Auct.) from the northward.

March. Martens pair and soon afterwards rabbits (*Lepus Americanus*).

15. In the middle of the month the snow often melts in the height of the day; and by the 20th a Snow-bird may be seen if the season be early.

20. Tops of the higher grasses appear. A few brown feathers appear on the necks of some Willow-birds (*Tetrao albus*). They now leave us.

April. There is a slight crust on the snow, from the thaw of the day and the frost of the night. When the weather is mild and the sun shines, a few insects appear.

8. Two species of Perla and one of Nemoura come up through the crevices of the ice and the porous snow, and all proceed in direct course for the nearest bank.

10. The cold renders them too weak to fly, though most of them have got rid of their nymph spoil before emerging from the ice.

15. Snow-birds have become plentiful, and are now joined by another Bunting with black head (Emberiza Lapponica?) and the Yellow-breasted Lark (*Alauda alpestris*).

20. The Flesh-fly still scarce. The small Owl (*Scops*) calls in the warm nights. The common Woodpecker (*Picus pileatus*) drums on the hollow trees.

22. The Grey Goose of Canada and Stock Ducks sometimes appear, but are frequently forced to return to the southward by a northerly blast and want of water.

25. A few spots of ground bare.

28. The American Robin (a species of Thrush, with red breast) and the Cattle Blackbird (*Xanthonus,* with yellow eye) are now arriving, and pick up the benumbed grubs and caterpillars. Goshawks arrive.

May. Ground getting barer; snow melting rapidly.

5. Wild-geese and Ducks passing to the northward. Hawks still arriving.

10. Every fine day brings an accession to the small bush birds,—Muscicapæ, Motacillæ, &c. Food for these is still scarce, and they approach the houses in quest of the Dipteræ which rise from the manure and rich earth around the place. Snow-birds have left us. Ermines and Rabbits become altogether brown. The ice is now shingly and dangerous. Strong currents and rapids

open everywhere. Wavies, as they are called (Snow Geese), and Barnacles passing in large flocks for the bay. No weather now stops them.

May. 12. The Northern Diver or large Loon and black Ducks (*nigra, fusca, perspicillata*) are still scarce, but are sometimes seen. The buds of Poplar, Aspen, and of various Willows, swell. On the latter may be found a few of the earliest Tenthredines. The tender bud is the nursery of their larvæ. Two species of Butterfly (*Vanessa* and *Argynnis*) sport over the ice and snow, when these are not gone.

15. The larger rivers break up. Fish ascend the small streams. The Jack fish and Perch (*Lucioperca*) spawn. The Suckers or Carp soon follow. Trout take the bait greedily. The Cliff-Swallow is seen. Swamps and stagnant pools are thawed. A frog may be heard attempting to croak: A Musquito (*Culex*) felt to bite.

20. Shells (*Limnæi*) begin to move in the pools along the river. Snails (*Limax, Helix, Bulimus,* &c.) remove from under stones and fallen timber. The end of the month discloses some species of Moths (*Noctualites*).

25. Our only Goatsucker (the white patched wing) and the Ground Woodpecker (*Picus auratus*), the last of our spring birds, arrive. Beavers, Otters, and Musks, have their young. In late seasons, the lakes to the northward break up.

28. The Poplar and Aspen leaves expand. The Rein-Deer, or Grey Deer of Hudson's Bay, has young.

June. Sturgeon begin to frequent the Falls and Rapids, and to spawn.

5. Insects on warm days are busy, the Tenthredenitæ on the bushes, the Sphingides, Andrenetæ, and Pangoniæ, on the ground, all attended by a great variety of parasite ichneumons. The first flowers blow, and those of the Willow are surrounded by Sylphides and Flower Flies (*Anthomoyæ.*)

10. A night of frost will still sometimes intervene, and in the woods the ground is still solidly frozen at a foot from the surface. Vegetation nevertheless still goes forward. Gnats become a torment, the swamps and puddles swarm with their larvæ. Small Tadpoles abound in the pools.

12. The country is now covered with verdure. Birds are nestling, Geese and Ducks hatching. Indians generally occupied with the Sturgeon fishery.

15. The latest shrubs have leaves, and the majority of Moths and Butterflies are disclosing themselves. The large species of Ephemera, Perlæ, and Phryganeæ issue from the water.

20. Trout take the fly-hook. White fish rise to the surface. Cattle seek the houses to get rid of their tormentors the Tabani. In

dry seasons the creeks become low, although the large rivers retain their strength.

July. Our warmest month. The river usually gets low. Sturgeon fishing continues. Cattle are lean, feeding only at night, tormented by flies during the day.

10. Many genera of Coleoptera appear, some of them peculiar (if I may say so) to warmer climes. We have Cicindelæ, Necrophori, many Buprestes, and a species allied to Lucanus.

20. Of those whose larvæ live on wood, the Serropalpus, a very fine Dorcacerus, Cerambyx, Callidium, Lamia, and numerous species of Lepturetæ. Neuroptera are abundant on the banks of the river—Libellulæ, Agrion, &c., and on the leaves, Hemerobius, Panorpes, Sialis;—in the other orders there are also many genera to keep up the character of the month. It ends with bringing us strawberries, which have been hitherto scarce, and in sending off the Sturgeon, which return to the depths.

Aug. The Raspberry begins to ripen. Young Ducks are well feathered. We have sultry weather for a few days, and then thunder storms with chilly nights.

10. Pigeons are numerous. Young Geese can fly. Gnats decrease, but Sandflies (*Similium*) supply their place.

15. The Raspberry and red and black Currants ripen. Grasshoppers are full grown. Trout move about, ascending the river. Sturgeon are very scarce. Grass becomes brown in dry situations.

20. The noisy Yellow Leg (*Totanus*) appears, and if we have much rain we are visited by a species of Snipe. The Golden and Ring Plovers are not uncommon.

Sept. The air generally is cooler, the winds stronger, and frosty nights may be expected.

10. Trout spawn. Insectivorous birds of many kinds leave us. The Migratory Pigeon, so frequently seen during August, disappears. Hawks and the large Yellow Horned Owl (*Strix Virginiana*) are common. Frosts frequent at night.

15. Tops of potatoes always blackened. Caterpillars nearly all cased. Trout refuse the fly-hook, but still take the bait. They are now poor fish. Grey Geese begin to pass to the southward. Ducks abound in the grassy lakes. Leaves turning rapidly yellow.

20. Pleasant weather in the middle of the day, but cold at night. The Fall Moth (*Phalæna autumnalis*) is now to be seen. Sandflies bite only in the height of the warmer days. The Musquito is utterly defunct. Diving Ducks common, the others gone.

Oct. Pools and swamps crusted with ice. White fish begin to spawn.

5. Suckers and Trout desert the small streams. Foliage is yellow, and falls. Rutting season of Deer. Instead of rain we have

snow, which, however, generally melts, the earth being warmer on the surface than the atmosphere.

Oct. 10. A single blast of northerly wind will suffice to bare the trees, strip the shrubs, and send all water-fowl to the south. The last of these are the weak or lingering flocks of Snow-Geese or Wai-wai-duck, which may frequently be observed passing. They seldom alight except when met by adverse winds.

20. The small lakes and rivers sometimes fast, that is, frozen. Tullibee (*Coregonus*) spawns. Animals get well furred. The Willow Grouse arrives from the north. There is usually a little snow on the ground, and the American Hare, as also the Ermine, are changing colour.

Nov. The ground covered with snow, which in mild weather is often blackened by a species of Podura, like a grain of gunpowder.

10. I have also frequently observed crawling about at this time and later, a species of Tipula. It is wingless, and I have named it *Chionea hiemalis*. Can it be this insect which gives rise to the idea of Spider rains?

20. Large rivers, as well as the lakes, are often solidly frozen, strong rapids filling up, and setting fast. Rabbits and Ermines are entirely white, the swamps are passable, and winter may be deemed to have set fairly in.

Geo. Barnston.

Martin's Falls, 10th June 1840.

Appendix to Dr Richardson's Observations on Solar Radiation.

Professor Forbes having referred to Leslie's Photometer in the remarks which he has had the kindness to make on my observations, I have, with the view of rendering the paper more complete, added two tables containing abstracts of a register of that instrument kept at the same time with that of the radiation thermometers. In the spring months the action of the sun on the photometer was so powerful as to drive the coloured liquid beyond the limits of the scale attached to the instrument, and in twelve different instances, in March 1826, entirely into the clear bulb. To remedy the shortness of the scale, I divided the two limbs of the photometer, including the bend at the bottom, into 35°, each degree being as nearly as possible equal to one of the scale attached to the descending limb by the maker. As results such as I have mentioned did not seem to be contemplated by the inventor of the instrument, and as I conjectured that the very low mean temperature of the air in February, March, and April, might affect the indications of the instrument by greatly contracting the coloured fluid, I did not print the register in Franklin's Appendix. The abstracts now given, however, serve to corroborate the deductions made from the observations on the radiation thermometer as to the greater effects of the sun-light in spring in high latitudes, whether it be owing to reflection from the snow or some other cause. Table VIII. contains an abstract of the register for three months in which the observations were most regularly made. Table IX. includes the months in which the observations were made only on favourable or convenient days. From the crust which forms on the snow in March, the radiation from it affects the eyes more severely in March and April than at other times.

TABLE VIII.

Results of a Register of the Indications of Leslie's Photometer kept at Fort Franklin in 1826.

Hour.	February, whole Month.		March, whole Month.		May, 26 last Days.	
	Mean Height of Photometer.	No. of Obs.	Mean Height of Photometer.	No. of Obs.	Mean Height of Photometer.	No. of Obs.
A.M.						
8	...	...	13.24	17	6.09	22
9	5.53	28	16.19	27	7.09	25
10	11.31	28	22.47	29	7.74	22
11	14.41	28	20.26	29	8.67	23
Noon.	14.20	28	22.08	30	9.70	24
1	11.37	28	20.41	31	9.45	22
2	10.12	28	19.28	29	8.42	24
3	7.05	16	15.84	29	7.28	20
4	3.05	11	12.39	29	6.16	22
5	...	...	9.12	18	6.95	14

TABLE IX.

Results of a Register of the Indications of Leslie's Photometer kept at Fort Franklin in 1825–26.

Hour.	October. 1825 (Observations spread through the whole Month.)		November. 1825 (Observations spread through the whole Month.)		December. 1825 (Observations spread through the whole Month.)		January. 1826 (Observations spread through the whole Month.)		April. 1826. First 7* Days only.	
	Mean Height of Photometer.	No. of Obs.	Mean Height of Photometer.	No. of Obs.	Mean Height of Photometer.	No. of Obs.	Mean Height of Photometer.	No. of Obs.	Mean Height of Photometer.	No. of Obs.
A. M.										
8	1.63	7	...	...	...	...	...	...	11.99	22
9	2.45	14	0.69	7	...	...	...	...	14.00	25
10	5.00	15	4.12	13	0.55	2	8.33	3	17.30	22
11	7.83	11	5.68	18	2.99	15	16.00	4	22.76	23
Noon.	5.43	19	6.96	23	5.16	18	12.30	8	21.70	24
1	3.60	16	7.24	15	2.68	17	16.17	3	20.12	22
2	5.69	15	5.84	14	0.71	9	9.73	6	17.79	24
3	4.99	9	2.81	8	...	...	2.70	2	18.00	20
4	2.15	4	...	...	...	...	...	...	13.97	22
5	...	...	...	...	...	...	...	...	7.20	14

* Note.—The observations on the Photometer were interrupted by my absence from the Fort from the 8th of April to the 6th of May; but up to the end of April the register of the radiation thermometer was kept by the other officers when I was absent.