CYCLICAL RAINFALL AT SAN FRANCISCO.

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Although I know of no good reason for admitting that the question, whether the moon exerts an influence upon the weather, is still an open one, there is, undoubtedly, considerable uncertainty as to the value of any predictions that may be based upon such influence, liable, as it is, to local, accidental and variable disturbances, partly of a known and partly of an unknown character. On this account, I think it desirable to collect and discuss all accessible records of observations extending over a period of ten or more years, especially in the neighborhood of sea-coasts and large bodies of water, in order to find how the lunar weather-curves are modified by the forms of continental relief, the average hygrometric condition of the air, the changes of wind, and other obvious or more obscure sources of perturbation. I am willing to devote all the time I can spare from

TABLE I.

Different and non-correspondent Rainfalls at San Francisco, in Lunar and Solar periods, from July 1, 1849, *to July* 1, 1872. *R = Total fall ; N = Normal percentage of rain.*

☾ DAY OR ☉ YR. ÷ 30.	LUNAR MONTHLY							SOLAR YEARLY.						
	Nov. Dec.		Jan. Feb.		Mar.-Oct.		Yr.	1849 + 3*n**		1850 + 3*n*		1851 + 3*n*		Av.
	R.	N.	R.	N.	R.	N.	N.	R.	N.	R.	N.	R.	N.	N.
1........	6.67	84	8.16	124	1 26	69	97	22.85	319	16.01	287	12.19	273	297
2........	4.93	83	12.69	128	4 74	81	97	28.41	314	14.94	264	6.12	194	267
3........	5.55	82	6.15	115	5.07	97	94	26.26	260	11 15	242	9.84	155	226
4........	5.61	93	6.81	105	5.88	98	92	5.20	190	14 45	238	3 90	165	198
5........	8 52	109	9.26	99	3.18	90	96	14.98	169	13.67	227	11.97	202	194
6........	7.73	121	5.64	84	4.49	92	104	16.81	163	9.97	200	14.57	220	189
7........	9.74	126	2 79	75	5 65	101	107	7.67	140	9.94	171	4.97	213	169
8........	7.96	125	7.55	86	4 55	111	108	10.08	117	8 50	140	15.32	203	147
9........	9.00	120	7 37	97	6.78	119	107	9 11	97	4.41	108	8 04	158	117
10........	7.03	111	7.16	94	6.51	116	103	4 38	69	5.53	84	2.58	86	78
11........	8.12	104	6 04	79	3.86	111	97	3 25	42	3 29	62	.30	46	49
12........	3.91	115	3.54	67	6.15	117	99	1.46	23	1.56	44	4.07	37	33
13........	13.40	138	4.46	72	7 00	129	110	.83	11	2 72	31	.30	24	20
14........	9.47	148	6.89	91	5 62	148	125	.10	5	.16	16	.08	8	9
15........	9.65	137	7.84	113	9 60	172	138	.17	2	.06	5	.05	1	3
16........	9.41	113	10.79	126	11.10	169	134	.00	1	.14	1	.00	1	1
17........	3.87	86	8 03	128	4.96	133	115	.00	0	.00	1	.21	2	1
18........	4 07	78	9.40	126	3 42	111	105	.05	0	.02	0	.00	1	1
19........	7.92	86	10 06	118	8 15	110	104	.01	1	.02	0	.04	2	1
20........	5.34	86	5.69	101	3.99	97	96	.28	2	.00	1	.00	5	2
21........	5.17	82	6.47	92	3.67	72	85	.11	2	.04	3	.79	9	4
22........	5.61	84	6.96	94	2.26	55	83	.04	3	.58	7	.64	12	6
23........	7.37	80	6.36	100	1.91	57	86	.03	9	.40	8	.03	19	12
24........	2.99	70	9 38	101	3.72	79	88	2.14	25	.61	11	2.17	37	24
25........	4.22	71	4.84	96	6.23	87	89	2.67	52	.24	27	3.03	62	47
26........	7.01	79	8.03	90	3.22	76	86	7.63	91	3.16	69	3.71	84	83
27........	5.25	82	5.17	87	2.16	69	81	10.54	140	6.83	125	6 59	102	125
28........	4.31	89	5.52	93	3.92	76	85	14.88	199	13.22	163	3.75	140	172
29........	9.29	103	9.53	105	5.12	85	93	21.81	260	3 51	203	8.26	233	235
30........	7.09	105	6.94	113	4.43	77	96	26.52	300	20 82	261	25.31	307	290

*1849, '52, '65, '58, '61, '64, '67, '70 ; 1850, '53, '56, etc. . 1851, '54, '57, '60, etc.

daily duties, to such investigations; but the field is so large that I would gladly welcome the co-operation of all who may feel an interest in studies that promise new and satisfactory results as a reward for diligent labor.

The success of the Signal Service Bureau* has demonstrated the importance of careful attention to the most minute indications of possible law, and the influence of the physical geography of our continent upon the weather has been so well ascertained that we may reasonably hope for similar success from a like careful study of astronomical influences. The well-known tendency to weekly meteorological cycles has never been attributed to any more obvious or probable cause than lunar modifications of solar action, and such evidences of cyclical uniformity as have already rewarded my limited researches, encourage me to hope that much of the apparent discordance and supposed accidental irregularity, by which meteorologists are still perplexed, will be finally shown, by broad generali-

TABLE II.

Correspondent Rainfalls at San Francisco, in Lunar and Solar periods.

☾ DAY OR ⊙ YR. ÷ 30.	LUNAR MONTHLY.							SOLAR YEARLY.						
	1849–57		1857–64		1864–72		Av.	1849–57		1857–64		1864–72		Av.
	R.	N.	R.	N.	R.	N.	N.	R.	N.	R.	N.	R.	N.	N.
1	5.32	88	7.15	103	6.07	99	97	16.98	266	16.77	291	17.40	328	297
2	5.13	89	7.76	103	6.59	98	97	14.01	233	17.71	285	17.75	282	267
3	6.20	94	1.87	82	9.05	101	94	12.98	184	16.63	239	22.64	253	226
4	6.86	94	4.22	81	5.79	98	92	5.03	159	8.43	198	10.09	232	198
5	4.27	89	5.50	102	6.82	98	96	9.87	187	11.60	174	19.15	217	194
6	5.73	91	7.63	119	8.17	103	104	20.62	218	6.76	158	13.97	188	189
7	6.53	97	6.83	118	6.88	109	107	8.63	200	5.20	172	8.75	140	169
8	6.18	98	4.44	114	9.28	113	108	11.28	164	17.47	185	5.15	104	147
9	5.82	94	7.71	123	7.98	108	107	7.55	135	5.62	140	8.39	83	117
10	5.40	92	7.28	129	7.14	93	103	7.64	104	1.54	78	3.31	54	78
11	6.03	94	7.18	119	4.64	83	97	2.95	72	3.62	54	.27	26	49
12	5.79	100	4.81	102	5.13	96	99	3.48	44	2.67	45	.94	16	33
13	7.22	111	4.55	99	11.21	118	110	.62	21	1.41	28	1.82	14	20
14	6.78	129	6.10	116	8.92	129	125	.03	7	.20	11	.11	9	9
15	7.61	147	3.69	139	2.67	128	138	.05	2	.05	·3	.18	3	3
16	10.43	141	10.17	140	11.02	122	134	.12	1	.02	2	—	1	1
17	6.32	118	4.29	116	6.25	111	115	.00	1	.21	2	—	0	1
18	3.49	118	5.84	92	7.27	105	105	.02	0	.05	2	—	0	1
19	13.68	134	3.69	77	9.10	100	104	.01	1	.06	1	—	1	1
20	6.29	126	3.45	69	4.84	90	96	.00	4	.07	1	.21	2	2
21	5.93	101	3.83	70	6.33	82	85	.62	9	.12	1	.20	2	4
22	5.73	84	3.29	81	5.39	84	83	1.14	13	.03	2	.09	3	6
23	3.94	76	7.22	94	6.83	87	86	.09	21	.03	10	.34	5	12
24	4.08	82	3.55	99	6.92	85	88	3.37	35	1.15	28	.40	11	24
25	7.40	95	6.94	98	4.36	78	89	1.49	60	3.10	58	1.35	26	47
26	6.68	94	4.63	90	5.83	75	86	6.33	103	4.60	92	3.57	58	83
27	3.97	80	3.56	83	5.64	81	81	11.26	140	7.52	124	5.18	112	125
28	4.07	74	5.20	80	4.98	98	85	8.32	163	6.97	158	16.56	192	172
29	5.24	82	4.30	77	11.74	115	93	9.59	203	11.03	202	12.96	289	235
30	6.14	88	2.46	84	7.73	112	96	20.09	254	13.35	254	39.21	349	290

* Captain Toynbee's recent discussion, for the British Meteorological Committee, "of the meteorology of the part of the Atlantic lying north of 30° N., for the eleven days ending 8th February, 1870," gives very flattering evidence of the estimation in which this success is held abroad. On page 164, he says: "This paper only deals with eleven days of rather exceptional weather, when a southerly wind prevailed on our coasts. It can only be considered as a first attempt at the style of work which is needed to connect the excellent observations now being taken in America with those in Europe.

zations, to be as completely subject to ascertainable laws as are the motions of the heavenly bodies.

About a year ago, I showed, by my discussions of the Lisbon rainfall (*ante* pp. 178–190), that it is possible, uuder favorable circumstances, to obtain satisfactory evidence of lunar influence upon the weather, even from a comparison of the rainfall in different cycles of less than six years' average duration. My subsequent discussion of the monthly means of Tennent's San Francisco observations (*Journal of the Franklin Institute*, lxiii. 204–6), led me to hazard certain predictions relative to the tidal rains on the opposite shores of continents, and the influence of opposite winds, or of upper and lower tidal currents. Mr. Tennent has generously furnished me a copy of his daily observations on the rainfall, which so fully corroborate the first and third of those predictions, that I hope to obtain from him an equally complete record of the direction of the wind, in order to have the requisite data for similarly testing the other two. Governor Rawson W. Rawson, C. B., has also kindly consented to provide me with a transcript of observations at Barbados, a station within the belt of the trade winds, and, therefore, favorably situated for such comparisons with the San Francisco observations as may serve

TABLE III.

Normals of Rainfall in Synodic years of Jupiter.

	San Francisco.							Lisbon.	
Syn. Yr. ÷ 30.	1849-60.	1860-72.	1855-70.	Nov. Dec.	Jan. Feb.	Mar.-Oct.	1849-72.	Syn. Yr. ÷ 30.	1855-70.
1	80	150	131	132	120	93	118	16	81
2	116	154	141	151	146	98	136	17	88
3	157	111	117	133	144	112	132	18	99
4	166	64	81	97	116	124	111	19	108
5	157	50	68	84	87	142	99	20	110
6	142	58	70	97	62	150	96	21	99
7	110	64	65	101	49	117	85	22	86
8	81	63	57	97	46	70	71	23	84
9	87	68	60	112	51	60	76	24	96
10	119	99	89	127	94	86	108	25	107
11	138	144	128	144	158	113	141	26	112
12	120	159	133	132	170	111	141	27	113
13	81	149	98	122	132	91	118	28	115
14	60	146	75	117	105	82	107	29	120
15	72	131	79	120	95	94	104	30	122
16	83	90	78	90	77	100	87	1	117
17	71	63	64	63	62	82	67	2	103
18	55	70	57	58	64	71	63	3	86
19	55	81	65	61	70	78	69	4	76
20	71	75	78	57	86	79	73	5	76
21	92	68	93	55	100	83	79	6	81
22	103	69	104	63	93	106	84	7	88
23	98	78	107	75	80	121	87	8	93
24	84	97	114	90	81	110	90	9	103
25	77	114	129	102	95	94	98	10	108
26	101	125	157	109	126	107	114	11	113
27	132	127	177	115	148	122	129	12	116
28	124	114	157	109	153	110	119	13	112
29	93	102	120	91	108	96	98	14	98
30	75	117	111	98	101	95	98	15	84

to strengthen the inferences which I have already published, and, perhaps, supply additional data of a novel character.

The accompanying tables and curves are constructed on the same plan as those in my previous meteorological papers. The scale and the degree of smoothing by successive means are uniform; the comparative influence of the sun, moon and Jupiter can, therefore, be readily seen at a glance. The vertical lines (0 to 7) in each set of diagrams indicate the mean hour at which the moon or planet is on the meridian, as follows:

0	12 M.	2	6 P. M.	4	12 P. M.	6	6 A. M.
1	3 P. M.	3	9 P. M.	5	3 A. M.	7	9 A. M.

The tidal influence, therefore, co-operates with the maximum direct solar influence, in the atmosphere as a whole, and especially in the upper currents, at 0 and 4; in the lower atmosphere and with the surface winds, at 2 and 6. The positions of Newton's theoretical high tides (*Principia*, B. I., Prop. 66, Cor. 20) are at 1 and 5; the low tides at 3 and 7. My theoretical low barometer is synchronous with Newton's high tide; high barometer, with low tide.

The moon's influence is most marked in the heavy rains (α); least, in the frequency of rainfall (γ). The principal maximum both in frequency and amount, is near the time of full moon, when the local atmospheric

TABLE IV.

Number of Rainfalls, and amounts of heavy rains (one inch or more), at San Francisco, on Lunar days.

☾ Day.	NUMBER OF RAINFALLS.							AMOUNT OF HEAVY RAINS.						
	1849.57.		1857-64.		1864-72.		Av.	1849-57.		1857-64.		1864-72.		Av.
	No.	N.	No.	N.	No.	N.	N.	A.	N.	A.	N.	A.	N.	N.
1........	8	71	16	108	14	91	89	3.26	118	1.73	84	2.38	75	92
2........	12	76	17	102	16	96	91	2.89	104	4.10	95	.00	66	87
3........	16	88	12	97	20	107	97	2.20	79	.00	66	4.21	81	77
4........	17	96	15	99	21	109	101	1.04	61	.00	67	1.61	92	74
5........	15	98	17	103	17	102	101	1.39	64	3.69	114	2.12	111	97
6........	18	97	14	106	15	99	100	2.08	73	3.29	144	6.29	124	116
7........	14	95	17	111	19	106	104	4.04	103	2.67	143	1.14	113	117
8........	16	95	19	116	22	112	107	1.60	104	2.77	142	3.22	105	115
9........	17	95	16	115	18	109	106	2.87	113	3.50	141	3.49	106	118
10........	14	91	18	110	20	98	99	4.33	120	2.46	122	2.75	91	110
11........	15	89	15	103	11	87	93	2.45	103	2.28	87	1.45	79	90
12........	13	99	13	102	16	85	95	1.85	77	.00	64	1.05	116	88
13........	22	117	18	110	15	93	106	1.21	78	1.80	80	7.76	181	116
14........	23	130	17	121	19	105	118	2.46	123	2.50	123	6.09	207	154
15........	21	131	21	126	20	117	124	4.79	175	1.18	166	.00	190	176
16........	22	125	20	116	25	117	119	6.09	172	5.22	180	6.75	152	166
17........	19	117	11	98	16	104	107	2.30	126	2.46	152	.00	118	131
18........	16	118	14	89	14	98	102	.00	130	2.64	106	4.25	111	117
19........	25	125	13	87	21	101	105	9.30	159	1.07	68	4.54	103	112
20........	20	123	13	87	18	100	104	2.27	129	.00	60	.00	68	87
21........	20	108	13	86	14	95	97	.00	83	2.99	86	1.60	49	72
22........	12	91	13	87	18	97	92	3.63	78	1.06	117	1 62	55	80
23........	13	88	13	89	19	98	92	2.20	72	5.16	121	1.34	66	83
24........	17	99	14	89	15	93	94	.00	59	.00	98	3.08	66	72
25........	20	105	14	81	15	90	93	2.54	67	2.02	90	1.02	48	67
26........	16	101	8	72	17	93	89	2.38	75	2.79	93	.00	31	63
27........	15	91	10	78	16	98	89	1.42	69	1.49	70	1.68	44	60
28........	14	84	16	95	19	103	94	1.38	73	.00	41	.00	94	72
29........	12	81	17	108	19	103	97	2.80	96	1.25	32	8.46	138	94
30........	16	76	17	111	17	96	94	3.41	116	.00	48	1.67	119	98

oscillations from lunar influence are most antagonistic to solar action; the principal minimum, near the time of new moon, when the oscillations tend most strongly to reinforce solar action. These laws have such generality, that, at every station which I have hitherto examined, their influence is distinctly traceable.

Next in importance to the moon's modification of solar meteorologic influence, appears to be its modification of atmospheric pressure. I first called attention to the importance of this perturbation, in the third and seventh inferences of my paper on the "tidal rainfall of Philadelphia" (*ante* vol. x. p. 531), and showed that at Philadelphia it was more important than the direct and simple tidal energy. This modification, like the foregoing, is also traceable in all my previous lunar tables, and its prominence in the San Francisco curves (on lines 1 and 5, 3 and 7, in diagram γ, and on lines 5, 3 and 7, in α, β) is specially noticeable.

The second inference in the paper above quoted, that the tidal rainfall is, "like the ocean tides, more marked in low, than in high latitudes," is illustrated by diagrams β and δ. If further confirmation is desired, it may be found in the tables accompanying my previous discussions of different European, Asiatic and American observations.

My first prediction, that "the tidal rainfall will generally be found more strongly marked on the western shores of the several continents, than in the same latitudes on the eastern shores," is confirmed by the similarity in the amounts of average monthly fluctuation at San Francisco and Lisbon, and the smaller fluctuation at Philadelphia (β, δ). This difference should of course be greatly modified in the regions of the monsoons, and reversed in the trade-wind regions.

My third prediction, that "a certain degree of apparent opposition will be found to exist between the lunar influence upon the upper and lower cloud strata, dependent upon the normal difference of position in the tidal crests of deep and shallow fluid envelopes," is partially verified by the tendency to maxima at quadrature as well as at syzygy (2 and 6, 0 and 4, α, β, γ). The syzygy influence before new moon is manifested by the maximum after high barometer (7), but it is interrupted by the lunar intensification of solar action at new moon. If I succeed in obtaining such a record of the San Francisco winds as is necessary for the complete substantiation of the second, third and fourth predictions, I shall expect to find that the maxima at 2 and 6 are dependent upon the surface winds; those near 0 and 4 upon the upper atmospheric currents.

I still feel some doubt with regard to the certainty and character of Jupiter's influence upon the weather, but the amount of agreement between the curves for three independent periods of eight, seven and eight years (ζ), the resemblance between the curves at Lisbon and at San Francisco (η), when the origin of the ordinates is taken at opposition in one case and at conjunction in the other, and the character of the contrast between the lunar and Jovian curves at Lisbon (*ante*, p. 181), all tend to impress me with the belief, that at least one of the primary planets is the source of important meteorological perturbations. I shall not be surprised if the Barbados records, when I receive them, furnish data for settling the question definitely in the affirmative. I can think of no more probable reason for the opposition between the Jovian curves at San Francisco and Lisbon, than the opposite directions of the ocean currents near the two coasts.

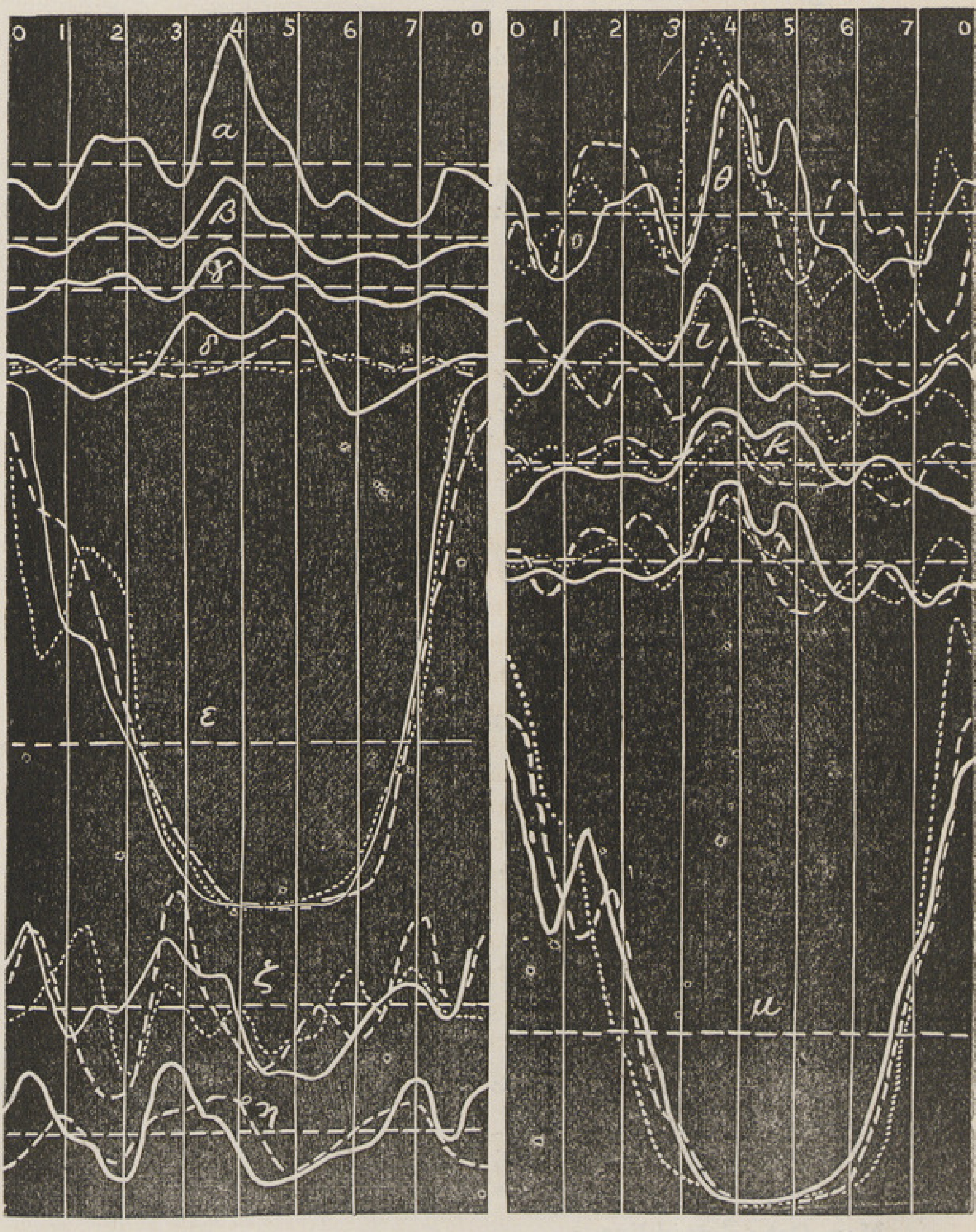
The local disturbances are evidently greater at San Francisco than at Lisbon, but in spite of them all the two sets of lunar curves at the former station, (ι, λ), each set covering three entirely distinct and independent periods, exhibit striking points of similarity, and their differences are no greater than might have reasonably been anticipated, in view of the variations in the solar curves (ε, μ). The same may be said of the monthly curves of heavy rainfall (θ) and of frequency of rain ($\varkappa$) in different periods.

Interesting special resemblances at different stations are shown at Greenwich and Philadelphia, in Fig. 4, *ante*. vol. x., p. 535; at Philadelphia, Lisbon and San Francisco, in all the lunar curves on p. 182 and in the average annual rainfall at Philadelphia on p. 181 (Table IV.) of the present volume, as well as in the accompanying curve which depicts the frequency of rain at San Francisco from 1849 to 1857 ($\varkappa$), continuous line,)* The maxima in my Philadelphia annual curve are somewhat more strongly marked than those in Schott's diagram (Pl. III., *Tables and results of the precipitation &c., in the U. S.*), on account of the different methods employed in computing the ordinates. Schott's were calculated from the monthly means (op. cit. p. 124), mine from means which cover only $\frac{1}{30}$ of a year, and therefore show the characteristic features of the curve more minutely, besides being better suited for comparison with the thirty ordinates of the lunar curve. My anticipations (Jour. of the Franklin Inst., lxiii, 205) that the San Francisco "daily records may probably furnish materials for more minute and detailed profitable investigation," having been thus satisfactorily realized, I now await the arrival of the Barbados records, with the expectation that their discussion will exhibit evidences of lunar, and possibly of planetary action, analogous to those which I have found at other stations, but still more prominent and more decisive than any that have ever hitherto been published. If there are any observations, extending over a long series of years, near the Gulf of Fonseca or on the Southwestern coast of Peru, I think they will furnish indications of the special importance of the lunar action on the barometric pressure, similar to those which I have found at Philadelphia, but that such indications will be more marked on the Peruvian coast, than on either coast of North America.

*Indications of a general maximum near full moon, with a diminution at the precise time of solar opposition, are to be found in the majority of the curves which I have computed. They afford, as I think, further confirmation of my third prediction. The surface tidal currents have their greatest Eastward velocity, and the upper atmosphere has its greatest Westward lagging, when the sun is on the upper and the moon on the lower meridian. The blending of currents is therefore peculiarly favorable for the precipitation of moisture, but the intense meridian heat appears to partially counteract the precipitation by re-evaporation.

EXPLANATIONS OF DIAGRAMS.

The average rainfall in each figure is represented by the broken horizontal line. The lunar curves begin and end with the day of new moon; the solar curves with January 1st; the Jupiter curves, at conjunction for



San Francisco, at opposition for Lisbon. The vertical lines divide each cycle into octants. All the curves are for San Francisco, except in diagrams δ and η.

Diagrams of rain in lunar months.

α. Heavy rainfall. Table IV.
β. Average rainfall. Tables I, II.
γ. Frequency of rain. Table IV.
δ. Average rain at Lisbon ; continuous line.
" " Philadelphia ; broken line.
" " Surrey, Eng. ; dotted line.

θ. Heavy rains, Table IV.
" 1849–57 ; continuous line.
" 1857–64 ; broken line.
" 1864–72 ; dotted line.

ι. Average rains. Table I.
Nov.–Dec. ; continuous line.
Jan.–Feb. ; broken line.
Mar.–Oct. ; dotted line.

κ. Frequency of rains. Table IV.
1849–57 ; continuous line.
1857–64 ; broken line.
1864–72 ; dotted line.

λ. Average rains. Table II.
1849–57 ; continuous line.
1857–64 ; broken line.
1864–72 ; dotted line.

Diagrams of annual rain.

ε. Table I.
1849, '52, '55, &c. ; continuous line.
1850, '53, '56, &c. ; broken line.
1851, '54, '57, &c. ; dotted line.

μ. Table II.
1849–57 ; continuous line.
1857–64 ; broken line.
1864–72 ; dotted line.

Rainfall in Synodic years of Jupiter.

ζ. Table III.
Nov.–Dec. ; continuous line.
Jan.–Feb. ; broken line.
Mar.–Oct. ; dotted line.

η. Table III.
At San Francisco ; continuous line.
" Lisbon ; broken line.

SAN FRANCISCO RAINFALL.

July 1st, 1849, to June 30th, 1850.

Day.	July	Aug	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	Total
1							1.01		.06				
2					1.35		.45						
3						.48							
4					.37		.39	.08					
5					1.22					.28			
6					1.12		.05	.13	.88				
7									.55				
8					1.27		1.28		.79	.05			
9				.67									
10				1.27	1.42								
11						.33							
12						1.21							
13					.76	.18	.12						
14						.10	.32						
15									.81				
16					1.15	.31							
17						.06	.16						
18						.13			.67				
19						2.08				.13			
20						.66	.17						
21						.39							
22							.07	.48	.77				
23							.95						
24							.92						
25							.52						
26						.27	.83	.34					
27								.74					
28													
29							1.10						
30				1.20									
31													
Sum				3.14	8.66	6.20	8.34	1.77	4.53	0.46			33.10

July 1st, 1850, to June 30th, 1851.

Day.	July	Aug	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	Total
1													
2						.08				.28			
3										.18			
4							.11			.06			
5							.18	.02					
6							.09	.11					
7							.22						
8										.42			
9										.06			
10													
11						.26							
12			.10										
13						.35							
14			.01										
15			.15										
16										.13			
17						.36				-06			
18								.04	.23		.58		
19					.47				.40	.04	.06		
20								.12	.08		.03		
21			.07		.10			.12	.02				
22					.04				.03				
23					.11								
24					.02			.13	.03				
25									.22				
26							.12						
27									.38				
28					.13				.22				
29					.05				.21				
30									.12				
31													
Sum			0.33		0.92	1.05	0.72	0.54	1.94	1.23	0.67		7.40

SAN FRANCISCO RAIN-FALL.

July 1st, 1851, to June 30th, 1852.

Day.	July	Aug	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	Total
1									.15				
2				.18			.07		.30				
3						.63			.60				
4			.04			.35	.03		.02				
5						.25			.80				
6								.05	1.20				
7			.99	.03					.75				
8					1.47				1.15				
9									.70				
10									.32				
11													
12													
13													
14									.10				
15									.04				
16					.37								
17								.02					
18					.03						.32		
19						.28							
20					.04	.14							
21						.06							
22						2.00				.17			
23						.55							
24						.60							
25						.20				.02			
26						.30							
27						.26			.25	.07			
28						.24	.16	.03					
29					.21	.30	.02	.04					
30						.82	1.30						
31						.12			.30				
Sum			1.03	0.21	2.12	7.10	0.58	0.14	6.68	0.26	0.32		18.44

July 1st, 1852, to June 30th, 1853.

Day.	July	Aug	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	Total
1						.82							
2						.06					.02		
3						.19	.02						
4						.21	.04						
5						.20	.69						
6							.01						
7							1.38						
8							.81		.14				
9					.02								
10							.20				.02		
11					.40		.33			.81	.25		
12											.03		
13					.30					.36			
14					.80	.52	.18		.76				
15					.25	.03			.02				
16						.20				1.85			
17					.20	3.00				1.74			
18					.62	1.40							
19						.05				.07			
20										.11	.02		
21					1.10	.21							
22						.07		.29					
23					.12	.76		.15					
24						.11		.37			.03		
25						2.54		.34					
26								.27					
27							.25		2.85		.01		
28				.80	.30	.31	.01		.62	.08			
29					1.16	1.72			.47	.35			
30					.04	.75							
31						.05							
Sum				0.80	5.31	13.20	3.92	1.42	4.86	5.37	0.38		35.26

SAN FRANCISCO RAIN-FALL.

July 1st, 1853, to June 30th, 1854.

Day.	July	Aug	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	Total
1													
2									.02				
3									.20				
4						.05		.22	.07				
5						.01		.51					
6								.16					
7													
8										.01			
9					.11	.20		.70		.01			
10				.10	.02	1.35		.52		.03			
11								.12		.20		.03	
12					.02	.11	.59	1.06	.07				
13					.08	.02	1.22		2.25				
14					.35		.27		.50				
15			.11		.20		.29		.20				
16					.22		.32						
17			.10	.02					.03			.05	
18					.14		.15						
19					.02	.10		.01	.13	.05	.02		
20						.33		.05		.43			
21								.91		.25			
22						.01	.01	1.10					
23						.02	.42	.25	.02				
24			.02				.55			.42			
25					.68		.06	.56					
26					.40			.48					
27					.04			1.26					
28						.12		.13		1.72			
29									.02				
30		.04											
31													
Sum		0.04	0.23	0.12	2.28	2.32	3.88	8.04	3.51	3.12	0.02	0.08	23.64

July 1st, 1854, to June 30th, 1855.

Day.	July	Aug	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	Total
1							1.26	.09	.54	.10			
2		.01				.02	.32		.34		.03		
3			.04			.04	.80		.16				
4				.18			.15						
5							.03		.56				
6							.08		.10				
7							.32	.05	.23				
8							.29	.24	.03				
9				.22			.17						
10			.06	.21				.22		.81			
11										.38	.05		
12									.20	.17			
13				.20					.04	.50	.30		
14									.03	1.65	1.15		
15			.05							1.05			
16										.19			
17										.10			
18					.32								
19											.10		
20											.25		
21													
22				.10	.02			.15					
23				.31				.11					
24				.65									
25				.22				.25					
26				.32				1.29					
27								.52		.05			
28								1.85					
29													
30							.19		1.21				
31						.75	.06		1.20				
Sum		0.01	0.15	2.41	0.34	0.81	3.67	4.77	4.64	5.00	1.88		23.68

SAN FRANCISCO RAINFALL.

July 1st, 1855, to June 30th, 1856.

Day.	July	Aug	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	May.	June.	Total
1												.03	
2										.32			
3						.10							
4						.07		.03					
5						.17							
6						.30							
7						1.15							
8							.38						
9							1.05			.21			
10					.02	'.23	1.04			.58			
11							.72			1.04			
12										.17			
13					.05	.22							
14						.05	.67		1.02				
15						.20	.32						
16													
17													
18													
19						.24		.12			.28		
20						.38	.55	.33					
21					.10	.75	.10				.08		
22					.21	.10	1.14				.40		
23					.13		.47						
24													
25													
26						.80							
27						1.00							
28					.08		1.22	.02	.05				
29							1.08		.10				
30					.08		.66		.20	.62			
31									.23				
Sum					0.67	5.76	9.40	0.50	1.60	2.94	0.76	0.03	21.66

July 1st, 1856, to June 30th, 1857.

Day.	July	Aug	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	May.	June.	Total
1									.13				
2							.15						
3							.44						
4							.21	.37					
5							.12	.43					
6											.01		
7				.31		.15							
8									.03				
9													
10			.02					.07			.02		
11			.05			.28		.05					
12						.21		.31					
13								.53					
14				.01		.04		1.27					
15					.16	.03		1.30					
16				.02	.06		.24	.84					
17				.03	.20	.45	1.19						
18							.10	.04					
19								.04					
20					.90								
21					.17				.18				
22					.70				.03				
23						.20							
24				.08	.22	.24		.87	.29				
25								1.17					
26	.02							.85					
27						.20		.45	.36				
28					.06				.47				
29					.32	.08						.12	
30						.48					.02		
31						1.39			.13		.05		
Sum	0.02		0.07	0.45	2.79	3.75	2.45	8.59	1.62		0.10	0.12	19.96

SAN FRANCISCO RAINFALL.

July 1st, 1857, to June 30th, 1858.

Day.	July	Aug	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	Total
1										.42			
2					.10								
3					.35								
4					.88	.15				.27			
5					.31	.20							
6				.17		.26							
7				.44			.03	.03		.72			
8				.32						.14			
9						.22							
10		.03				.43	.25						
11						1.68	.37						
12						.22	.40		.52				
13							.51	.05					
14								.30					
15								.44					
16								.41	.17				
17								.25	.04				
18												.05	
19								.20			.23		
20							.83	.15			.06		
21							.55				.05		
22							1.42						
23													
24					.15	.98			.40				
25					.49								
26					.14				.37				
27					.17				1.80				
28		.02			.04				.60				
29					.33				1.65				
30					.05								
31													
Sum		0.05		0.93	3.01	4.14	4.36	1.83	5.55	1.55	0.34	0.05	21.81

July 1st, 1858, to June 30th, 1859.

Day.	July	Aug	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	Total
1								.24			.38		
2											1.07		
3									.21				
4						.07			.29				
5						.27							
6								.16					
7								.08	.20				
8								.54	.20	.13			
9								.11					
10						1.80		.12		.03			
11						1.02		.62		.02			
12						.08		.78					
13								.14					
14		.04				.17							
15								.34					
16								.14					
17						.06		1.04					
18													
19					.27								
20				.30	.20				.15				
21				2.06	.14	.05			1.07				
22					.04				.73		.06		
23				.12		.42		.13			.04		
24				.26		.64		.34					
25								.12					
26		.12			.04	.28		.08	.03				
27	.02					1.04	.05	1.11	.04				
28	.03					.20	.21	.23					
29									.03				
30							.17		.07				
31						.04	.85			.09			
Sum	0.05	0.16		2.74	0.69	6.14	1.28	6.32	3.02	0.27	1.55		22.22

SAN FRANCISCO RAINFALL.

July 1st, 1859, to June 30th, 1860.

Day.	July	Aug	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	May.	June.	Total
1							.08		.40	.49	.12		
2					.06		.07				.62		
3		.02			.36		.24			.05	.43		
4					.90	.04				1.32	.12		
5					.84		.21		.37	.65			
6							.56		.03	.06		.07	
7							.22	.60		.04			
8							.23			.44			
9					.92								
10					.80				.13				
11					.13						.17		
12								.10	.03				
13								.43					
14													
15			.03						.10				
16								.04	.17				
17					.07			.17					
18								.14			.39		
19										.09			
20													
21					.14								
22					.23		.03		.39		.35		
23				.05	.25	.21			.11		.28		
24					.31	.63					.04		
25					1.73	.38					.28		
26					.51	.21					.06		
27						.10			.05				
28									.90			.02	
29								.12	.62				
30													
31					.03				.69				
Sum		0.02	0.03	0.05	7.28	1.57	1.64	1.60	3.99	3.14	2.86	0.09	22.27

July 1st, 1860, to June 30th, 1861.

Day.	July	Aug	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	May.	June.	Total
1						.02	.21						
2										.16			
3				.01						.15	.10		
4				.12			1.03			.03			
5				.08			.49					.04	
6				.01		.04	.23						
7						.13		.06					
8													
9								.12					
10	.21					.02		.14					
11					.21	.13		2.02					
12					.35	.07						.04	
13													
14						.37							
15						.23	.03						
16						.78							
17				.04		.04							
18						.26							
19				.17		.27	.14						
20				.08		.21	.22				.65		
21						.15		.21			.25		
22						.58							
23						1.03	.12	.08	.79				
24				.12		.77		.10	.07	.17			
25						.63		·99	.04				
26						.13			2.53				
27				.03		.07			.40				
28				.11	.02				.04				
29				.04					.18				
30				.10					.03				
31						.23							
Sum	0.21			0.91	0.58	6.16	2.47	3.72	4.08	0.51	1.00	0.08	19.72

SAN FRANCISCO RAIN-FALL.

July 1st, 1861, to June 30th, 1862.

Day.	July	Aug	Sept	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	May.	June.	Total
1						.05				.11	.02		
2			.02					.79		.13	.56		
3						.07				.07			
4													
5							2.67	.04		.01			
6						1.02	1.49						
7						.29			.02				
8						1.65	1.35			.09			
9						.18	3.50		.01	.17			
10					.27		2.46		.47				
11							1.25		.57	.01	.03	.05	
12					.74				.18		.11		
13					.29		0.22			.02			
14					.05				.25	.12			
15					.08		.49		.11				
16					.39	.01	2.46		.12				
17					.22		2.64						
18							.52				.02		
19					.56		.72	.44					
20							1.69						
21							.55	2.09					
22						.03	1.00	.80					
23						1.06		.84					
24						.56		.33					
25								1.49					
26					.48	2.02		.38					
27					.60	.23	.04	.33					
28						.17			.07				
29					.08	.70	.76		.20				
30					.34	1.25	.55		.20				
31						.25							
Sum			0.02		4.10	9.54	24.36	7.53	2.20	0.73	0.74	0.05	49.27

Jnly 1st, 1862, to June 30th, 1863.

Day.	July	Aug	Sept	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	May.	June.	Total
1							.27						
2													
3							.12						
4							.71						
5							.46	.44					
6					.11			.16					
7					.02				.05				
8								.11		.19			
9						.19							
10					.02								
11							.15	.16					
12								.71					
13										.12			
14								.11		.10			
15										.38			
16								.40		.32			
17								.58	.16				
18						.12		.47	.19		.14		
19						.05	.74		.11		.09		
20						.32	.36		.56	.24			
21						1.01		.05		.10			
22						.17	.76						
23						.14	.06						
24									.04				
25									.07				
26									.88	.12			
27										.04			
28													
29				.02									
30				.38		.22							
31						.13							
Sum				0.40	0.15	2.35	3.63	3.19	2.06	1.61	0.23		13.62

SAN FRANCISCO RAIN-FALL.

July 1st, 1863, to June 30th, 1864.

Day.	July	Aug	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	May.	June.	Total
1										.91			
2						.33	.12						
3										.35			
4										.23			
5							.39						
6													
7													
8													
9						.15							
10						.05					.01		
11					.05	.02					.10		
12					.07								
13						.27					.01		
14					.87						.11		
15					.92		.14		.03				
16					.64								
17									.04		.55		
18									.89				
19													
20			.03						.02				
21						.37							
22													
23						.52							
24						.09							
25													
26										.08			
27									.06				
28									.14				
29							.37		.09				
30									.07				
31							.81		.18				
Sum			0.03		2,55	1,80	1.83		1.52	1.57	0.78		10.08

July 1st, 1864, to June 30th 1865.

Day.	July	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	May.	June.	Total
1							.51						
2						.33							
3						.13			.21				
4						.03			.38				
5						.04							
6						.92	.08			.21			
7			.01							.62			
8													
9										.11			
10						.01							
11						1.05							
12						2.56			.07				
13						.99		.30					
14								.10					
15					.14	.04		.08					
16						.27		.12					
17													
18							.07	.40			.45		
19								.24	.08		.18		
20													
21													
22		.11											
23		.03			.05	.38							
24		.07		.02			.07						
25					.48	.47	.88						
26				.05	3.98	.81	.38						
27				.06	.42		.74	.05					
28					.44	.02	.91	.05					
29					.50	.04							
30					.67	.30							
31						.52	1.50						
Sum		0.21	0.01	0.13	6.68	8.91	5.14	1.34	0.74	0.94	0.63		24.73

SAN FRANCISCO RAINFALL.

July 1st, 1865, to June 30th, 1866.

Day.	July	Aug	Sept	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	Total
1						.01		.36					
2						.01		.16					
3								.43					
4								.19					
5							.30	.22	.02				
6							.19		.21				
7				.03			.41						
8				.07		.04	1.51		.66			.04	
9								.16	.30				
10							.40						
11							.46						
12							.60	.06					
13					.18	.06	.60						
14					.37								
15													
16					.07		.23						
17					1.03		2.17		.02				
18					.27				.21				
19					.06		.11		.41				
20					.06		2·22		.23				
21					.63		1.14				.06		
22					1.12	.04	.15				.22		
23						.15	.08						
24			.06			.25	.31						
25				.01					.36		1.05		
26			.18			.02					.01		
27								.07			.05		
28								.47			.07		
29									.02	.12			
30				.15	.40				.11				
31									.49				
Sum			0.24	0.26	4.19	0.58	10.88	2.12	3.04	0.12	1.46	0.04	22.93

July 1st, 1866 to June 30th, 1867.

Day.	July	Aug	Sept	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	Total
1						.53			.17	.32			
2					.68		.03		.16	.15			
3					.25	.13							
4					.14		.18						
5					.31		.65			.40			
6			.07				.51			.15			
7													
8					.07				.40				
9										.02			
10										.67			
11						.53	.11			.50			
12						.01	.75			·15			
13													
14							.05						
15			.04			.63							
16					.26	·43							
17									.16				
18						.95		.49					
19					.02	4.28	.23	.15					
20						3.62	.18	2.12					
21						.64	.58	2.22	.34				
22						.31	.17	.30					
23							.40						
24					.38	.06	.35						
25					.29	.71		.08					
26					.28	.56	·78	.14					
27						.32		1.02					
28						.63		.68					
29					.14	.40							
80					.53	.42	.19		.05				
31									.30				
Sum			0.11		3.35	15.16	5.16	7.20	1.58	2.36			34.92

SAN FRANCISCO RAINFALL.

July 1st, 1867, to June 30th, 1868.

Day.	July	Aug	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	May.	June.	Total
1						·02	.93		.56			.01	
2						.18	.33		.20				
3							.12		1.55	.10			
4							.15		.55				
5				.20	.62								
6					.75								
7						.15		.06		.20			
8						.55	.66						
9						.24				.38			
10						.33				.30			
11							.12		.19	.70			
12							.87			.47	.01	.05	
13							.43		.56	.06			
14			.04						.44	.04			
15									.14				
16						.04							
17						1.62	.12						
18						.69	.41				.02		
19					.79		.43						
20						.48	.64		.16				
21					.75	.84		.64	1.05				
22						1.68	1.08	.54	.90			.08	
23						.72	.99	.14				.09	
24					.44	.08	.84	.86					
25					.06	1 35	.36	.69					
26							1.02	1.61					
27								1.02					
28								.37					
29						.06		.20					
30						.21				.06			
31						1.45							
Sum			0.04	0.20	3.41	10.69	9.50	6.13	6.30	2.31	0.03	0.23	38 84

July 1st, 1868, to June 30th, 1869.

Day.	July	Aug	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	May.	June.	Total
1				.06			1.28						
2				.08			.53	.44					
3								.30					
4				.01	05	.01							
5													
6													
7							.10	.20		.28			
8								.82					
9								.32					
10							.01	1.67					
11							.07	.15					
12									.05				
13									.08				
14							.08		.10			.02	
15									·14				
16									.63	.45			
17						.05			.55	.69			
18					.30	.55			.18	.68			
19					.64				.48	.09	.06		
20									.67				
21						.07							
22						.18	.15				.02		
23						1.20	1 45						
24						.29	.19		.01				
25					.08	.47	.25						
26						.92	.20		.10				
27							.15						
28							.54						
29					.11	.18	1.10		.15				
30						.32	.25						
31						.10							
Sum				0.15	1.18	4.34	6.35	3.90	3.14	2.19	0.08	0.02	21.35

SAN FRANCISCO RAINFALL.

July 1st, 1869 to June 30th, 1870.

Day.	July	Aug	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	Total
1			.12										
2										.48			
3										.21	.02		
4										.09			
5													
6					.14								
7						.41							
8						1.10				.01			
9								.41					
10					.65	.13	.09	.02	.02				
11					.20	.14	.11		.14	.16			
12					.05		.14	.14	.18	.58			
13					.05		.35						
14							.53	.11					
15							.31	.34					
16									.22				
17									1.05				
18				.02			.76						
19				.17			1.03	.08			.18		
20				.36			.27	.86					
21				.74				.25					
22						.22	.30	.90					
23						.46		1.57	.27				
24						.51		.10					
25						1.34							
26													
27					.04								
28					.06								
29													
30									.01				
31													
Sum			0.12	1.29	1.19	4.31	3.89	4.78	2.00	1.53	0.20		19.31

July 1st, 1870, to June 30th, 1871.

Day.	July	Aug	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	Total
1						.59							
2						.57							
3										.06			
4					.01			.37					
5						1.42				1.47			
6					.02	.12		.12	.26				
7					.22	.32							
8								.02					
9							.42						
10							.32						
11													
12									.01				
13						.09		.14					
14						.27		.13					
15								.67			.04		
16									.08	.29			
17							.21		.08	.11			
18							.78						
19									.36				
20								.72					
21								1.02					
22							.28	.28	.13				
23							.62	.29	.37				
24													
25													
26											.01		
27													
28							.44				.16		
29					.18								
30			.03										
31													
Sum			0.03		0.43	3.38	3.07	3.76	1.29	1.93	0.21		14.10

SAN FRANCISCO RAINFALL.

July 1st, 1871, to June 30th, 1872.

Day.	July	Aug	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	May.	June.	Total
1								.02	.14				
2						.16		.06					
3					.19		.86	.14					
4								.01	.17			.01	
5							.17		.50				
6							.10						
7							.18	.33					
8							2.35	.89	.11				
9					.03		.34	.82	.06				
10								.21					
11							.11	.28	.33				
12							.02		.13	.05			
13					.02		.02						
14					.18			.10					
15					.22			.24		.35			
16								.29		.43			
17			.01			.63		.28		.08			
18						3.22		.02					
19						3.49				.01			
20						.62							
21						.93		.61					
22						.32		.44	.02				
23						3.48		.76					
24				.02	.35			.41			.03		
25								.16					
26					1.67	.15				.16			
27			.02	.09	.13	.74		.90	.04	.02			
28					.93	.23							
29						1.04							
30						.13					.02		
31						1.60	.07		.14		.11		
Sum			0.03	0.11	3.72	16.74	4.22	6.97	1.64	1.10	0.16	0.01	34.70

ON THE DENTITION OF METALOPHODON.

By Edward D. Cope.

(*Read before the American Philosophical Society, September* 20, 1872.)

This discovery of a second species allied to *Bathmodon*, Cope, represented by more complete remains of dentition than that on which that genus was originally established (*B. radians*), renders it possible to enlarge our knowledge of its characters.

It may be premised that the new species may belong to the group *Loxolophodon*, and, as its characters differ from those of the large species *Eobasileus cornutus*, *furcatus* and *pressicornis*, I must retain the last named genus with characters ascribed in my last paper to the former, and withdraw the species from the former, to which I at that time referred them. It appears that this name, used first for a section of *Bathmodon*, was, perhaps, based on mandibular teeth alone, which in *Metalophodon*, differ remarkably from the maxillaries. The cranium of the new species to be described was so decayed as to be irrecoverable, but the teeth obtained were in place, and in close proximity, so that there can be no reasonable doubt that they belong to the same animal.

The species differ considerably from the *B. radians*. The most prominent are: first, the failure of the lateral or straight limbs of the