other; and that he, *thus judged*, evidently takes his place amongst the members of the suborder *Anthropoidea*.

A list of the principal osteological variations presented by the several groups and genera of the order, before unmentioned, was then given; and the author concluded by stating what he believed to be the degrees of affinity existing between the various forms, as far as could be ascertained from the consideration of the appendicular skeleton exclusively.

January 17, 1867.

WILLIAM SPOTTISWOODE, Esq., Vice-President, in the Chair.

The following communications were read:—

I. "Actinometrical Observations among the Alps, with the Description of a new Actinometer." By the Rev. GEORGE C. HODGKINSON. In a Letter to Professor STOKES, Sec. R.S. Communicated by Professor STOKES. Received December 2, 1866.

SIR,—I have the honour to forward you an account of some actinometrical observations made last summer on the summit of Mont Blanc and at Chamonix, and at the same time to thank the Committee of the Royal Society for the grant which they were so good as to vote me for that object.

I reached Chamonix on the 7th of July, in bad weather, which had been prevailing for some time, but which ushered in a fine week very opportunely for my work. After allowing a few days for the weather to settle and for the snow to consolidate, I left Chamonix in the afternoon of Friday the 13th for the Grands Mulets, having previously arranged for a corresponding series of observations being taken the next morning in the valley. Leaving the Grands Mulets at about $2\frac{1}{2}$ A.M. on the 14th, I reached the summit of Mont Blanc about 8 A.M., and proceeded at once to work.

I had brought with me from England two of Newman's mountain-barometers, a thermobarometer of Casella, six small thermometers graduated on the stem (three for the dry-, and three for the wet-bulb observations), three of the tubes described in Appendix (A), with two of the actinometers in each. I carried besides an aneroid by Cooke, which proved to be of excellent quality. The third set of apparatus was taken in some faint hope that I might be able to arrange for a third set of simultaneous readings at the Grands Mulets. In this I was disappointed. Notwithstanding the greatest care had been taken, one of the barometers was found on the Brevent on the 9th to be deranged, and one of the actinometers to be broken; and on the 12th a second actinometer was broken at Chamonix by an accident. I thought it best to leave the remaining barometer for the valley observations, and to depend upon the thermobarometer, as being more portable and less liable to fracture, for the readings on the summit. I was eventually obliged to rest satisfied with a single observation of this; and the downward range of the small thermometer unfortunately proved too

limited for the wet-bulb readings. Thus the meteorological observations at the upper station are of the scantiest. Neither above nor below were the actinometrical readings so continuous as I had wished to make them. I had no one with me on the summit capable of rendering me the smallest assistance; but it is some consolation to think that, even had this been otherwise, the results could not, under the circumstances, have been materially enhanced.

There either did not exist, or I failed to detect, as the sun's altitude increased, anything like a *uniform progression* of actinic power at either station during the limited time in which the observations were continued.

The results do little more than determine the ratio of the average intensity at the two stations for a portion of the forenoon. This indeed was the main object which I had in view. For looking at the experience of Principal Forbes under easier conditions, when the continuance of the observations, as long as the clearness of the sky might last, presented no difficulty, I did not at all anticipate being able to trace a dependence of the actinic power on the hygrometric state of the atmosphere. He thus remarks (Bakerian Lecture, Phil. Trans. part 2 for 1842, p. 253) of the experiments on the Faulhorn and at Brienz, that "it cannot be affirmed they are sufficient to show the kind of dependence which the opacity has on the dampness, and that the values of the coefficient of extinction do not present any correspondence with the hygrometric variations;" and again, p. 268, "It must be confessed that no evident relation to the hygrometric condition of the air appears in the individual observations."

From the experiments of the 14th of July the actinic ratio between the summit of Mont Blanc and Chamonix, from $9^h\ 31^m$ to $10^h\ 11^m$ apparent time, presents, with a single exception, a gradual decrease from 1·244 to 1·206. The interest of a comparison of these results with those which Principal Forbes obtained between the Faulhorn and Brienz is unfortunately diminished by the fact that his actinometer was not furnished with an internal thermometer for ascertaining the temperature of the liquid employed. This was ammonio-sulphate of copper, which has a coefficient of dilatation varying from 1 at 60° F., to 2·562 at 32° F., and 0·626 at 100° F. His recorded numbers for three hours before and three hours after apparent noon derived from his freehand curve, are as follows:—

Hour.	Ratio.
9	1·141
10	1·214
11	1·345
12	1·219
1	1·078
2	1·207
3	1·217

At 10^h on the Faulhorn the ratio seems to have been rapidly increasing; on Mont Blanc it was slowly diminishing. The actual amount of the ratio at 10^h is almost exactly coincident in the two cases; but at 11^h on the

Faulhorn it was 1·345, a value much higher than any which was obtained at any time on Mont Blanc, or seemed likely to have been obtained at that hour had the observations been continued so long. What share the greater depression of the lower station in the experiments of 1832, the more complete isolation of the upper station in those of 1866, or variable atmospheric conditions in both sets may severally have had in contributing to this effect, remains a matter for future investigation. The respective heights of the stations are as follows:—

	English ft.		English ft.
Faulhorn........	8799	Difference	6853
Brienz..........	1946		
Mont Blanc	15784	Difference	12359
Chamonix	3425		

Professor Forbes gives the numbers—

Faulhorn........	8747	Difference	6844.
Brienz..........	1903		

The sky during the observations was not only cloudless, but, as seen from the summit, remarkably clear.

The observations have all been reduced by means of Tables derived from Gmelin's 'Chemistry,' vol. i. p. 231, to what they would have been had the mean temperature of the liquid during each minute been 32° F.

By a prolonged and careful comparison of actinometers (K) and (A), the factor for reducing the indications of (K) to the standard of (A) was found to be 1·29.

Considerable practice is necessary to acquire expertness in the use of the actinometer employed. It is desirable, as nearly as may be, to work it at such a temperature that the rise in the sun may be equal to the fall in the shade. If the mean of the two mean temperatures of the liquid, in taking the shade observations which precede and follow a given sun, differ much from the mean temperature of the liquid during that sun, a sensible error will be introduced. This, however, is to a great extent eliminated by taking the mean of three, and still more completely by taking the mean of five successive actinic results in column (I).

The difficulty of using the instrument was overcome by the kind cooperation of several friends for the Chamonix observations. To the good offices of my cousin, Mr. G. F. Hodgkinson, were added those of a lady, a worthy sister of one of the foremost mathematicians of his year, and her two nieces. Under her auspices an admirable arrangement of the work was made, by which each of the party was responsible for a precise and definite function, the adjustment and direction of the instrument, with the shading and unshading, the watch, the readings, and the records. To this friendly and efficient help I am greatly indebted for whatever success has been achieved. How small this is, no one can be more sensible than myself; yet I venture to hope that when the difficulty of the undertaking is considered, to those at least who are acquainted with the experience of Principal Forbes in 1832, 1841, and 1842, as given in his Bakerian Lecture,

the results will not appear either disappointing or discouraging. The season was extremely unfavourable for the further prosecution of the work. Looking to the imperfection of the instrument employed by Principal Forbes in his observations in 1832, it would seem to be highly desirable that his experiments on the column of air between the Faulhorn and Brienz should be repeated, and that other pairs of stations, intermediate in character to that and the Chamonix pair, should be essayed. I have selected, in the hope of future opportunities, the following among others:—

	English ft.	English ft.
Becca di Nona	10384	Difference 8415
Aosta	1969	

and should the Piz Stella prove readily accessible,

Piz Stella	11175	Difference 9856
Chianenna	1319	

While simultaneous observations at several adjacent stations of progressive heights are much to be desired, it should not be forgotten how largely the condition of simultaneousness at even only two stations adds to the difficulty of the work. And the question arises, whether detached readings of the actinometer (with the accompanying meteorological facts) taken at various points, as opportunity offers, may not be encouraged with advantage. An accumulation of these, carefully reduced and tabulated, could hardly fail to be valuable; and they may be obtained with comparative facility. It would indeed only be prosecuting these observations as we do those of atmospheric temperature and pressure. In process of time we might hope to obtain the mean actinic power at stations of various heights and circumstance for different altitudes of the sun.

Since the scale of each actinometer is empirical, in order that observations with different instruments may be comparable, a standard of reference is necessary. If such a standard were kept at Kew, and each instrument employed were marked with a factor of reduction, ascertained by careful comparison, a great encouragement would be afforded to actinometry; nor can any material progress in that department of observation be looked for until some such arrangement is made. The actine-standard of Sir J. Herschel can hardly be said now to have been preserved; to recover it, a careful set of observations under a vertical sun would be necessary; and since an arbitrary standard, which may be assigned without any such trouble will answer every purpose, it seems best at once to resort to this.

I would venture, in conclusion, to couple with my thanks to the Committee for their kind encouragement, an earnest recommendation that measures be taken to provide a standard actinometer accessible for comparison, under such regulations as may seem best to them.

I have the honour to be, Sir,

Your obedient Servant,

George C. Hodgkinson.

November 27, 1866.

Summit of Mont Blanc, July 14, 1866, Actinometer (K).

A. Apparent time of commencing each obs.	B. Sun O, shade ×.	C. Initial reading.	D. Terminal reading.	E. Change in sun, +.	F. Change in shade, −.	G. Solar effect unreduced.	H. Temperature of liquid.	I. Solar effect reduced to 32° F.	K. Actinometer (K) reduced to (A).	L. Averages.
h m										
8 28½	×	1732	1192		540					
8 30	O	1172	1300	128		716	51°	708	913	
8 31½	×	1238	602		636					
8 33	O	600	714	114		738	50	730	942	
8 34½	×	662	50		612					
9 6½	×	2098	1792		306					
9 8	O	1890	2272	382		718	50	711	917	
9 9½	×	2200	1834		366					
9 11	O	1840	2234	394		772	50	764	986	955
9 12½	×	2200	1810		390					
9 14	O	1882	2270	388		753	50	745	961	
9 15½	×	2120	1780		340					
9 19½	×	1460	1198		262					
9 21	O	1300	1800	500		788	48	781	1007	
9 22¾	×	1852	1538		314					
9 24	O	1582	2032	450		775	48	768	991	995
9 25½	×	2026	1690		326					
9 27	O	1754	2178	424		772	49	764	985	994
9 29½	×	1760	1400		360					
9 31	O	1472	1898	426		789	49	781	1007	993
9 32½	×	1906	1540		366					
9 33	O	1568	1974	406		765	49	757	977	996
9 35½	×	1972	1620		352					
9 36	O	1692	2150	458		787	49	779	1003	998
9 38½	×	2146	1840		306					
9 39	O	1880	2358	478		789	49	781	1007	1002
9 41½	×	2290	1974		316					
9 43	O	2068	2514	446		781	50	773	996	
9 44½	×	2454	2100		354					
9 51½	×	1908	1580		328					
9 53	O	1558	1980	422		760	50	752	970	
9 54½	×	1894	1546		348					
9 56	O	1608	2042	434		788	50	780	1006	992
9 57½	×	2022	1662		360					
9 59	O	1680	2094	414		783	50	775	1000	988
10 0½	×	2062	1684		378					
10 2	O	1788	2164	376		758	51	750	967	993
10 3½	×	2126	1740		386					
10 5	O	1820	2220	400		783	51	774	999	994
10 6½	×	2190	1810		380					
10 8	O	1904	2290	386		776	51	768	991	1001
10 9½	×	2426	2026		400					
10 11	O	2060	2440	380		795	52	786	1014	
10 12½	×	2380	1950		430					
10 19½	...	1270	992		278					
10 21	...	1086	1580	494		792	52	783	1010	
10 22½	...	1600	1282		318					
10 24	...	1386	1828	442		778	52	769	992	
10 25½	...	1764	1410		354					

The recorded numbers denote tenths of the scale which is divided to millimetres, the last figure being assigned by estimation.

Chamonix, July 14, 1866, Actinometer (A).

A. Apparent time of commencing each observation.	B. Sun O.; shade ×.	C. Initial reading.	D. Terminal reading.	E. Change in sun, +.	F. Change in shade, —.	G. Solar effect unreduced.	H. Temperature of liquid.	I. Solar effect reduced to 32° F.	L. Averages.
h m									
8 22½	×	1230	780		450				
8 24	O	1160	1560	400		837	85°	811	
8 25½	×	1514	1090		424				
8 27	O	1140	1554	414		818	85	793	812
8 28½	×	1484	1100		384				
8 30	O	1180	1640	460		857	85	831	799
8 31½	×	1504	1094		410				
8 33	O	1204	1614	410		830	85	804	794
8 34½	×	1330	900		430				
8 36	O	950	1304	354		779	84	755	805
8 37½	×	1214	794		420				
8 39	O	890	1280	390		814	84	789	803
8 40½	×	1230	802		428				
8 42	O	842	1310	468		872	84	846	800
8 43½	×	8112	802		380				
8 45	O	812	1280	468		848	84	822	803
8 46½	×	1202	822		380				
8 48	O	940	1380	440		814	84	789	802
8 49½	×	1280	912		368				
8 51	O	1040	1460	420		795	85	770	791
8 52½	×	1312	930		382				
8 54	O	1032	1462	430		806	85	781	797
8 55½	×	1350	980		370				
8 57	O	1092	1542	450		820	85	795	795
8 58½	×	1452	1080		370				
9 0	O	1182	1660	478		878	85	851	807
9 1½	×	1744	1330		414				
9 3	O	1394	1780	386		801	86	776	
9 4½	×	1620	1204		416				
9 6½	×	1204	800		404				
9 8	O	890	1324	434		841	84	816	
9 9½	×	1230	820		410				
9 11	O	950	1394	444		844	85	818	821
9 12½	×	1264	874		390				
9 14	O	1014	1480	466		856	85	830	807
9 15½	×	1420	1030		390				
9 17	O	1124	1554	430		808	85	783	800
9 18¼	×	1420	1054		366				
9 20	O	1220	1670	450		813	85	788	
9 21½	×	1560	1180		360				
9 23	O	1310	1790	480					
9 27½	×	1554	1294		260				
9 29	O	1414	1914	500		820	86	794	
9 30½	×	1774	1394		380				
9 32	O	1560	2000	440		820	86	794	798
9 33½	×	1870	1490		380				
9 35	O	1614	2100	486		831	86	805	811
9 36½	×	2024	1710		310				
9 38	O	1664	2210	546		876	86	849	809

TABLE (*continued*).

A. Apparent time of commencing each observation.	B. Sun O, shade ×.	C. Initial reading.	D. Terminal reading.	E. Change in sun, +.	F. Change in shade, −.	G. Solar effect unreduced.	H. Temperature of liquid.	I. Solar effect reduced to 32° F.	L. Averages.
h m									
9 39½	×	2070	1720		350				
9 41	O	1590	2084	494		837	86°	811	822
9 42½	×	1990	1654		336				
9 44	O	1590	2082	492		813	86	787	835
9 45½	×	1940	1634		306				
9 47	O	1500	2064	564		885	86	857	838
9 48½	×	2040	1704		336				
9 50	O	1854	2454	600		896	87	869	
9 51½	×	2036	1780		256				
10 4½	×	1190	830		360				
10 6	O	1094	1584	490		857	89	828	
10 7½	×	1494	1120		374				
10 9	O	1334	1820	486		846	89	818	826
10 10½	×	1690	1344		346				
10 12	O	1374	1880	506		862	90	833	841
10 13½	×	1750	1384		366				
10 15	O	1490	2050	560		888	90	858	853
10 16½	×	1960	1670		290				
10 18	O	1810	1404	594		899	91	869	
10 19½	×	2270	1950		320				
10 27½	×	1540	1234		306				
10 29	O	1424	1934	510		821	93	792	
10 30½	×	1820	1504		316				
10 32	O	1688	2224	536		849	94	818	814
10 33½	×	2130	1820		310				
10 35	O	1740	2300	560		865	95	833	
10 36½	×	2182	1882		300				

The recorded numbers denote tenths of the scale which is divided to millimetres, the last figure being assigned by estimation. The numbers in column L are the means of the five nearest numbers in the preceding column when not less than two observations precede and follow the one against which the average number is placed, otherwise the mean of the three nearest numbers.

Comparison of Results, Summit of Mont Blanc and Chamonix.

Apparent time.	M. Blanc. Actinometer (K) reduced to actinometer (A).	Chamonix. actinometer (A).	Ratio of actinometers, Mont Blanc and Chamonix.	Apparent time.	Actinometer (K) reduced to actinometer (A).	Chamonix actinometer (A).	Ratio of actinometers, Mont Blanc and Chamonix.
h m				h m			
8 27		812		9 34	996		
8 30		799		9 35	......	811	1·228
8 33		794		9 37	998		
8 36		805		9 38	......	809	1·234
8 39		803		9 40	1002		
8 42		800		9 41	......	822	1·219
8 45		803		9 44	......	835	
8 48		802		9 47	......	838	
8 51		791		9 56	992		
8 54		797		9 59	988		
8 57		795		10 2	993		
9 0		807		10 5	994		
9 11	955	821	1·163	10 8	1001		
9 14		807		10 9	......	826	1·212
9 17		800		10 11	1014		
9 24	995			10 12	......	841	1·206
9 27	994			10 15	......	853	
9 31	993			10 21	1010		
9 32		798	1·244	10 24	992		
				10 32	......	814	

Meteorological Observations on summit of Mont Blanc and at Chamonix, July 14, 1866.

Mean time.	Apparent time.	Mont Blanc.			Chamonix.		
		Thermo-barometer.	Thermometer (dry).	Thermometer (wet).	Barometer corrected and reduced to 32° F.	Thermometer (dry).	Thermometer (wet).
h m	h m						
8 30	8 25				26·90	69° F.	57° F.
8 40	8 35	16·86	22° F.	Below 20°			
9 30	9 25	Boiling-point = 184°·5 F.			......	72 F.	59 F.
9 45	9 40		22·5 F.	Below 20			
10 45	10 40				......	75 F.	58 F.
11 0	10 55	......	24 F.				
2 5	2 0				......	82 F.	63 F.

Appendix (A).

Description of the Actinometer.

The actinometer employed consists of a thermometer with a spherical bulb one inch in diameter, and a tube, of which an inch and a half next the bulb is, for a reason which will presently be apparent, left unscaled. The succeeding ten inches is made to represent, as nearly as may be, the range

from 40° F. to 45° F. At eleven inches and a half from the bulb the tube is widened, so that the following inch and a half may represent the range from 45° F. to 115° F. The tube then finishes in a spheroidal chamber, of which the diameters are about an inch and half an inch. The widened portion of the tube may be dispensed with, as the correction which it serves to ascertain may be otherwise found by means of a Table experimentally constructed for each instrument. In that case the spheroidal chamber, in which the tube will then terminate at eleven and a half inches from the bulb, should be made somewhat larger. The fluid employed is alcohol coloured with a drop of pure aniline-blue. A considerable quantity of air is left in the chamber. As a running column has to be read at a particular instant, great plainness is the first requisite for the scale. On this account graduation on the tube has not been adopted; but at an inch and a half from the bulb is attached an ivory scale, nine-tenths of an inch broad and eleven and a half inches long (or somewhat less if the widened tube be dispensed with), its other extremity coinciding with the commencement of the spheroidal chamber. This scale is graduated throughout in millimetres. The number of millimetres corresponding to each degree Fahr. on the tube of narrow bore, and to every fifth degree from 45° to 115° on the widened tube, should be noted on the back of the scale.

The principle of the instrument is the same as that of Sir J. Herschel's; and it is to be worked according to the directions given by him in 'The Manual of Scientific Enquiry.' It was devised for mountain use, where the weight of the Herschel and the fragility of its internal thermometer are elements of difficulty. It has also the advantage of being less costly. The air-chamber is made to serve the purpose of the screw in the Herschel, viz. that of altering at will, according to circumstances, the range of the thermometer. This is effected by throwing off into the chamber a greater or less quantity of fluid, retaining it there by holding the instrument with the chamber end somewhat lower than the bulb, and working with the remaining column. As alcohol expands unequally between its freezing- and boiling-points, a small correction is necessary, depending on the temperature of the alcohol at the time of working, This temperature is ascertained by noting the point in the widened tube, at which the column stands, when the fluid is thrown off into the chamber. The excess of this temperature above 45° F., the point from which the fluid is thrown off, has to be added to the temperature between 40° and 45° shown by the head of the working column, in order to have the true temperature. From the openness of the scale, and consequent small range of the instrument *for any one adjustment*, it is necessary to select for working a temperature not much removed from that at which the rise in the sun is equal to the fall in the shade. This temperature, which may be called the temperature of equilibrium, will vary practically, according to the solar intensity, from some 5° F. to 20° F. above the temperature of the surroundiug influences. By driving the fluid into the chamber until the temperature of equilibrium is represented at a point

near the middle of the tube, the readings will go on for a considerable time without altering the quantity of fluid in the chamber, and ten inches of graduation are found to be ample under all circumstances. By thus taking all the readings, so to speak, on the balance, a uniformity of proceeding is secured, which is not without its value. The instrument, constructed according to the dimensions here given, will denote the intensity of the noonday sun at the summer solstice near the sea-level in England by about 100 divisions of the scale.

Owing to the difficulty of shading satisfactorily, and anomalies found to occur in observing among the snow-fields on the high crests of the Alps, the following contrivance has been adopted :—

A plain telescope-tube of bright metal, 18 inches long and $2\frac{1}{2}$ inches in diameter, open at both ends, is pierced in its central section with a circular hole $1\frac{1}{4}$ to $1\frac{1}{3}$ inch in diameter, from which springs a flanged shoulder projecting about $\frac{1}{3}$ inch to receive a perforated split bung, which clasps the thermometer-stem and holds the bulb firmly in the centre of the axis of the tube. Two caps, fitted at the ends with clean plate-glass, are made to slide off and on at the two ends to admit of the glasses being readily wiped. By protecting these with a little wadding, the tube serves as a case for two actinometers. In the central section of the tube, made by a plane perpendicular to its axis, and nearly 90° from the centre of the circular hole, is a screw to attach the tube to an altitude and azimuth motion, by means of which it may be kept constantly directed towards the sun. Below the joint is provided means of attachment to an alpenstock or ice-axe. The shading is effected by means of a loose-fitting cap, bottomed by a chamber with air-holes. The shadow of the large thermometer-bulb on the lower glass, or on a plane held beneath it, is a guide to a perfect adjustment in the working of the instrument.

II. "An Eighth Memoir on Quantics." By Professor A. Cayley, F.R.S. Received January 8, 1867.

(Abstract.)

The present memoir relates mainly to the binary quintic, continuing the investigations in relation to this form contained in my Second, Third, and Fifth Memoirs on Quantics ; the investigations which it contains in relation to a quantic of any order are given with a view to their application to the quintic. All the invariants of a binary quintic (viz. those of the degrees 4, 8, 12, and 18) are given in the memoirs above referred to, and also the covariants up to the degree 5 ; it was interesting to proceed one step further, viz. to the covariants of the degree 6 ; in fact, while for the degree 5 we obtain three covariants and a single syzygy, for the degree 6 we obtain only two covariants, but as many as seven syzygies. One of these is, however, the syzygy of the degree 5 multiplied into the quintic itself, so that, excluding this derived syzygy, there remain (7—1=) six syzygies