THURSDAY, JANUARY 7, 1886

THE RACES OF BRITAIN

The Races of Britain; a Contribution to the Anthropology of Western Europe. By John Beddoe, M.D., F.R.S., &c. (London: Trübner; Bristol: Arrowsmith. 1885.)

BELIEVING that after thirty years of labour his opportunities for observation are not likely to add much to his store of facts, or materially alter their significance in his own eyes, Dr. Beddoe has brought together his numerous contributions to the ethnology of the British Isles, and, with the addition of much new matter, has arrayed them before us in such a manner as to show his own conclusions, and to form "some small part of a solid platform" whereon future anthropologists, with antiquaries and philologists, may ultimately build a more complete and certain structure.

Dr. Beddoe's mode of procedure is to make extensive observations on the physical characters of the present inhabitants of our islands, and on those of the adjoining parts of the Continent which are the reputed cradles of the various elements of our race, and to compare the results with the records of history as far as they are available. The physical characters to which he attaches most importance are colour of hair and eyes, head-form, and stature, and of these he has collected a very large number of observations on a systematic plan, and hence the "numerical method" of studying anthropology which he first inaugurated in 1853, and which has since been largely followed by continental observers. Dr. Beddoe attaches most importance to colour, because he believes that "the colour of the hair is so nearly permanent in races of men as to be fairly trustworthy evidence in matters of ethnical descent; and that nearly as much may be said for the colour of the eyes." With regard to head-form he complains of the great dearth of measurements of modern British skulls, the skulls in our museums being chiefly those of criminals, lunatics, and paupers, and therefore of little value; and he finds from personal experience that the accurate measurements of living heads are alike difficult to make and to obtain. He supplies tables, however, of a considerable number of measurements of heads obtained by himself or his friends in different parts of the country. The statistics of stature and weight collected by Dr. Beddoe have been dealt with in a separate essay, and as they were incorporated with others of a similar kind collected by the Anthropometric Committee of the British Association, and published in their final report for 1883, they are, therefore, not republished in his present volume.

It is to his extensive observations on the colour of the hair and eyes that Dr. Beddoe chiefly trusts for his analysis of the racial distribution of our existing population, and for the purpose of more convenient and definite comparison he adopts a formula which serves as an "index of nigrescence." Having classified the colour of the hair as red (R), fair (F), brown (B), dark (D), and black (N), "the gross index," he says, "is gotten by subtracting the number of red and fair-haired persons from that of the dark-haired, together with twice the black-haired. I double the black, in order to give its proper value to the greater tendency to melanosity shown thereby; while brown (chestnut) is regarded as neuter, though most persons placed in Class B are fair-skinned, and approach more nearly in aspect to the xanthous than the melanous variety:—

$$D + 2N - R - F = \text{index}.$$

From the gross index, the net, or percentage index, is of course easily obtained."

Dr. Beddoe is quite alive to the want of uniformity in the manner of observing, to the different significance of the terms employed for the colours of hair and eyes, and to peculiarities in observers themselves, but as the data he makes use of were collected by himself, the personal equation of the observer and the terms employed are constant. He does not explain the principle on which his classification of colour of hair and eyes, is based, and it would seem to be the result of combinations which his very extensive observations have suggested as the most constant and consistent with each other and with other physical characters, as he claims for it a closer appositeness for defining racial distinctions than other schemes. It differs from the plans of Virchow, Vanderkindere, and Kollmann, and other continental anthropologists, and from that of the Anthropometric Committee, which is based on the simple anatomical arrangement of pigment in and on the surface of the iris, hair colour being deemed of secondary importance both from the difficulty of diagnosis and its greater changeableness with age.

Dr. Beddoe's account, extending over eleven chapters, of the prehistoric races, and the various conquests of the Romans, Anglo-Saxons, Danes, and Normans, and the fresh blood which they introduced into the country, is very fully and impartially rendered. The natives of South Britain at the time of the Roman conquest, according to Dr. Beddoe, "consisted mainly of several strata, unequally distributed, of Celtic-speaking people, who in race and physical type, however, partook more of the tall blond stock of Northern Europe than of the thick-set, broad-headed, dark stock which Broca has called Celts. . . . Some of these layers were Gaelic in speech, some Cymric; they were both superposed on a foundation principally composed of the long-headed dark races of the Mediterranean stock, possibly mingled with fragments of still more ancient races, Mongoliform or Allophylian. This foundation-layer was still very strong and coherent in Ireland and the north of Scotland, where the subsequent deposits were thinner, and in some parts partially or wholly absent . . . no Germans, recognisable as such by speech as well as by person, had as yet entered Britain."

Dr. Beddoe appears to hold a middle place between the writers who believe, on the one hand, in the extermination of the native races by the Anglo-Saxons, and on the other in their extensive survival in all parts of the country; while he attaches more importance to the new blood introduced by the Danes and Normans than is commonly admitted.

The portion of the work devoted to an analysis of the racial elements of the present inhabitants of the British Isles and adjoining countries of Western Europe consists of a very large number of tables showing the distribution of the colour of hair and eyes according to the "index of nigrescence," and to a less extent to the head-forms, from the author's personal observations; and of second series of colour of hair and eyes of military deserters illustrated by maps constructed on the plan of the Anthropometric Committee. There are also tables showing the relation between complexion and disease collected at the Bristol Infirmary; and numerous illustrations are given showing the physiognomy of males and females which the author believes to be typical of the various racial elements at present surviving among us.

Of the conclusions which Dr. Beddoe draws from all these observations it is impossible to give a summary here. He examines the whole country, district by district and county by county, from the Shetlands to Cornwall, and the reader must consult the work itself to see how far the author has succeeded in the task he has set himself, and to what extent he has prepared a solid platform for his successors in the same field of inquiry. It is most probable that Dr. Beddoe's conclusions, based as they are on a minute acquaintance with the history of the conquests and settlements of the country, and on a wide personal survey of the population in most stationary situations, will be accepted by anthropologists as the best results and the nearest approach to the truth which is attainable at the present day. On the other hand it is doubtful whether Dr. Beddoe's confidence in colour as a permanent racial character will bear the test of future inquiry, and whether his method will be accepted as sufficient when the questions of prepotency of stock, relative viability of dark and blond persons, and the influence of sexual selection have been more completely investigated. The Jews of Europe are isolated and preserved as a separate race by the sterility or low fertility of their mixed marriages, and the question of hybridism in the human race has received little attention from anthropologists. The function of reproduction is the most highly specialised and the most easily disturbed, and it is probable that the dying out of races is due more to this cause than to the "vices of civilisation" to which they are commonly attributed. American statistics show that the blond type is more subject to all the diseases, except one (chronic rheumatism), which disqualify men for military service, and this must obviously place blonds at a great disadvantage in the battle of life, while the popular saying, "a pair of black eyes is the delight of a pair of blue ones," shows that sexual selection does not allow them to escape from it. It is more than probable, therefore, from all these considerations, that the darker portion of our population is gaining on the blond, and this surmise is borne out by Dr. Beddoe's remark that the proportion of English and Scotch blood in Ireland is probably not less than a third, and that the Gaelic and Iberian races of the west, mostly dark-haired, are tending to swamp the blond Teutonic of England by a reflex migration—a fact not without significance to others than anthropologists at the present time.

The "Races of Britain" gives a very imperfect idea to those who are unacquainted with such inquiries, of the labour, time, and thought expended on its production, but anthropologists who know how to estimate such work at its full value will welcome it with great satisfaction as the most exhaustive account of the ethnology of our country which has appeared in recent years.

CHARLES ROBERTS

OUR BOOK SHELF

Journal of the Royal Agricultural Society. Vol. 21, Part II., Series II. (London: John Murray, 1885.)

THE second part of the current number of this *Journal* opens with the second instalment of Mr. Fream's report upon Canadian agriculture. The climate, soil, and products of Eastern Canada, comprising the better-known States of Ontario, Quebec, and the maritime provinces, are chiefly dealt with, whereas, in the first report, prairie farming, and the almost untrodden regions of the north-west were particularly dealt with. The principal object of the report is to show the capabilities and rapid progress of Canada, and this is achieved by numerous statistics as to production and exports. In these provinces the first fertility of the soil has been in a great degree exhausted, and as a consequence mixed farming with the maintenance of live stock, and the use of improved processes, is taking the place of consecutive corn-growing. The growth of the dairy industry is a remarkable fact, and in the management of their cows and the manipulation of the products of the dairy, more attention is apparently paid to the teachings of science than is usual in the mother country. The exports of cheese have increased from 6,000,000 pounds per annum in 1870, to 76,000,000 pounds in 1884. The butter trade has long been stationary, owing to the uncertain demand for Canadian butter. The Canadian cattle trade has also increased by leaps and bounds from a gross number of 6940 head in 1877, to 61,843 in 1884. The report is full of details of personal experience gained from many settlers in all parts of Old Canada. Names and addresses of the principal farmers, dairymen, and stock-breeders, are given with great frequency, and confer a special value on the report as a guide to intending settlers.

A large portion of the *Journal* is occupied with official reports of the Preston meeting of the Society (1885), including the report upon the prize farms in Lancashire. These last reports are less interesting than usual to practical men, as the Lancashire farmers are exceptionally placed, and conduct their business upon suburban principles of management. The sale of farm produce directly to the town consumer and the carrying back of town manure is the marked feature. Rents appear to range particularly high for the present depressed state of trade and agriculture, and are generally from fifty to sixty shillings per acre.

The customary reports of the Steward upon live stock and implements, and short memoirs of the late Sir B. T. B. Gibbs and Sir Watkin W. Wynn, close this section. A summary of the Commission's Report on Technical Education, 1884, and a reprint from the Report of the Pennsylvania State Board of Agriculture, 1883, occupy some fifty pages, the latter reviving M. Guénon's curious theory with regard to indications of milking properties in the peculiar distribution of hair on the buttocks, known as the "escutcheon."

Among original articles indicating research, those of Miss E. Ormerod on the ox-warble and the warble maggot, of Prof. Robertson upon rickets in sheep, and of Mr. Clement Stephenson upon abortion in cows may be mentioned. Lastly, the number contains a contribution from Rothamsted upon the valuation of unexhausted manures, in which the results of past experiments are brought to bear upon the claims of outgoing tenants for compensation under recent Acts of Parliament.

From Paris to Pekin over Siberian Snows. By Victor Meignan. Edited, from the French, by William Conn. (London: W. Swan Sonnenschein and Co., 1885.)

THE mode in which this volume has been produced is rather curious. In 1873 M. Meignan, who had already travelled in the regions around the Levant for pleasure, took it into his head that, by way of contrast to these lands of the sun, he would like to see a land where snow and ice were predominant, and accordingly he undertook to travel from France to China through Siberia. He appears to have had no object in the journey but the pleasure of motion and of seeing new and strange objects. It was undertaken in the winter, and the traveller naturally saw, and was interested in, Moscow, Nijni-Novgorod, the Urals, and so travelled through Siberia by Omsk to Irkutsk. After a short stay in the latter place he pursued his journey through Kiachta, Urga, and Kalgan to Pekin. Many travellers have done the journey before and since; it is a long and tedious one, and perhaps that is as much as can be said for it. Mr. Conn talks of crossing "the trackless Desert of Gobi" on the way, but this is an abuse of language. The only part of the Gobi passed is that between Urga and Kalgan, two considerable trading cities, between which caravans, couriers, and travellers go daily along a high road which is a very good one as roads go in Asia. But M. Meignan, having done the journey, and being of a lively and amusing turn, wrote an account of it some time after his arrival in France. This account of a journey in 1873 Mr. Conn has "edited" in 1885; he has, he says, produced a modified version rather than a translation, the modifications consisting in correcting the slipshod style of the original, in producing "a more just co-ordination of parts and subordination of minor details," and also in expanding the original here and there. The volume, notwithstanding this dual authorship, is pleasant reading, much as a tolerably written account of a journey in Wales or Scotland would be pleasant. There are not a few errors, especially as the traveller gets farther east, but these cannot seriously interfere with such enjoyment as may be derived from a perusal of the volume. As Mr. Conn has a taste for this species of literary work—having published another volume, an adaptation or translation of a Japanese tale by a French writer, during the year—we would suggest to him that he should select his originals more carefully. A sterling popular work in French or German might very easily prove a sterling popular work in English; there can be little real use in reproducing trumpery French books in English, except to add to the already enormous mass of similar indigenous literature in England.

LETTERS TO THE EDITOR

[The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts. No notice is taken of anonymous communications.

[The Editor urgently requests correspondents to keep their letters as short as possible. The pressure on his space is so great that it is impossible otherwise to insure the appearance even of communications containing interesting and novel facts.]

Iridescent Clouds

ON December 29 just passed, at 3.40 p.m., or shortly after sunset, and during the late frosty storm, there was a brilliant repetition of the iridescent clouds concerning which I wrote to NATURE about a year ago. The tendency of many of these little clouds, or cloudlets, to rectilinear rhomboidal forms was remarkable; also their confinement in point of colour to blue, violet, rose-pink, and green—eschewing yellow, orange, and vermilion reds: while the sunset sky below them was, on the contrary, a gorgeous panorama of all those yellow-*cum*-red partaking colours.

That so good an example of these iridescent cloudlets is not very frequent may be concluded from the number of letters which this occasion has already produced in the *Scotsman* newspaper here, and of which I send you six.

C. PIAZZI-SMYTH

15, Royal Terrace, Edinburgh, January 1

Peculiar Meteorological Phenomenon.—A somewhat rare phenomenon was observed at Burntisland, Falkirk, Laurencekirk, and many other parts of Scotland yesterday. A large number of miniature rainbows presented themselves in the sky, with the red, orange, yellow, and green colours distinctly discernible. They were not larger than the ordinary sun as it appears to the naked eye, and, after remaining visible for a considerable time, gradually faded away.

Fraserburgh, December 28, 1885

SIR,—To-day, at 3 p.m., a heavy snowstorm from the west-north-west was just clearing off here. Along the horizon, from west to south-west, lay a heavy bank of storm-cloud, hiding the sun. Above this, in same general direction, was a belt of clear sky. Above that, as the rack drifted off to south-east, there was disclosed a belt of light cirro-stratus cloud, in same general direction, about 30° from the sun, and evidently at very great height, for it kept the same general position nearly an hour, though with considerable variation of form. When first visible it was fringed on the side next the sun with bands of the most vivid and delicate prismatic colours—in series, blue end outside and red (prolonged into a splendid band of violet) inside. Detached portions, however, had the bands all round. The appearance continued in its first splendour only a few minutes, but less vividly for some time longer. It would be interesting to know whether the same appearance was seen at other places; and, if so, at what hour, and at what angle from the sun?

W. MACGILL, B.A.

Edinburgh, December 29, 1885

SIR,—I write to ask if any of your readers can give an explanation of a remarkable phenomenon which was visible in the western sky this afternoon. Just after sunset a few thin patches of cirrus clouds not far west of the zenith assumed a rich opal hue, while in others all the colours of the spectrum were beautifully displayed. The appearance of one of these clouds was exactly similar, in fact, to a completed, though, of course, miniature rainbow. This phenomenon continued for some time after the sun had set, and at times the colours could be seen to change rapidly. A cold frosty wind from the north-west was blowing at the time. C. M.

Maxton, December 30, 1885

SIR,—With reference to the two letters on this subject in to-day's *Scotsman*, it may interest you to know that the cloud phenomenon in question was witnessed here twice yesterday. About 8 a.m. the sky was perfectly clear, and the crescent moon was shining in the south-west. As the radiance of the sun, as yet beneath the horizon, began to appear, several detached clouds, of a semi-transparent, filmy nature, suddenly came into view in the south-eastern sky, which had, a moment or two before, been without a single speck to dim it. These clouds, at first of an indefinable colour, quickly heightened in tone, and the prismatic colours became visible with gorgeous distinctness, increasing in intensity as the sun neared the horizon. The top band was of a peculiar blue, obviously different from the sky field. Beneath was a wave of rich rose-pink, next a cloudy-orange, with light streaks or "watermarks," then a rich mass of deep violet, fading lower into white. There were three large clouds, the upper and lower lines of which were quite level and perfectly parallel, though the edges to the east and west were sharp and ruggedly cut. In the case of one of these clouds the denser part was apparently rhomboidal, but on its eastern side, and connected with it, was an opalescent vapour filling up the space between what I may term the base and the hypothenuse of an angle of about 15°. The base of this incomplete triangle was equal in length to the base of the incomplete rhomboid. The lines were most clearly defined. There were a number of minute cloudlets, some the merest specks, but all showing the same colours that I have mentioned. They did not remain very long in this distinct state. As the sun rose above the horizon they became beautifully opalescent, and their forms began to change in a wavy manner, and in a short time vanished as in ether from that part of the sky. The sun was now at a slight altitude, and when I turned round I saw to my astonishment similar clouds, though the colours were less distinct, in the north-west, where a few minutes previously none were to be seen. These did not last long, though during their short appearance their outlines were very distinct, there at the time being a heavy haze of reddish gray, changing to dusky carmine above the northern horizon. At this time a west wind was blowing with considerable force, but these clouds appeared to be high above the wind, as they were certainly not influenced by it. In mid-air there seemed to be a counter current, as light cirrus cloud-streaks drifted slowly across the zenith from the east. About 4 p.m. the same phenomenon occurred in the west and north-west, the clouds, if anything, being more beautiful than in the morning. They remained for a time after the sun had set. At 5 p.m. the thermometer registered 12° of frost. I trust I have succeeded in a partial way to convey some idea of sky effects so inexpressibly beautiful as to baffle description. I was informed last night that the previous Monday afternoon, as a party of noblemen and gentlemen were returning to Tynehead Station from a day's shooting on the Humbie Estate, in East Lothian, and while a terrific storm of wind and sleet prevailed, there was a sudden rift, through which the party saw a number of clouds of a similar nature to those I have attempted to describe. JOHN THOMSON

Maxton, Wednesday Afternoon

At 3 p.m. we have had a steady fall of snow for four hours.
JOHN THOMSON

Wick, December 30, 1885

SIR,—Your correspondent "C. M." in to-day's paper exactly describes the phenomenon as it was seen here. The cirrus clouds were probably floating at a very high elevation in a stratum of air much below the freezing-point, and their structure thus having undergone some change, the sunlight became decomposed, causing the prismatic display. This theory may or may not be correct, but the end of the cirrus band farthest from the sun lost the colours first, and the end nearest the sun was the last on which a vestige remained after the sun had set. NEMO

Sunderland, December 30, 1885

SIR,—I have just read in to-day's *Scotsman* the letters of your correspondents in Fraserburgh and Edinburgh concerning the atmospheric or cloud phenomena of Monday, 28th. The appearance of the heavens here from 3.30 p.m. was most striking. The sun set in a rich water-glow, and the sky in the west being very free from obscuration, we could notice how the glow deepened as it ascended, until from 20° to 50° it presented a dark crimson or purple. Just above Venus—which was like a silver ball—there were seen some cirro-stratus clouds—bright and luminous—just like illuminations on a dark ground. They were stationary, and retained their shape for a very long time. At their western extremities were seen all the prismatic colours, as if they were encircled with rainbows. These colours were very distinct for half an hour, and then gradually disappeared; but still the clouds remained, and were seen at 5.20—almost in their original position—as bright electric clouds. I have observed the heavens for thirty years, but never saw so beautiful a cloud-display. I think the explanation is that the various strata of the atmosphere retain certain rays of light longer than usual when the sun's light falls at the oblique angle it has in December. These clouds evidently rested in a part of the atmosphere not affected by the disturbances nearer the earth.
D. PATTERSON, M.A.

ON going out at 4.12 p.m. to-day, I saw several remarkable clouds in the west part of the sky, somewhat similar to those described by Prof. Piazzi Smyth and several other correspondents in NATURE, vol. xxxi. pp. 148, 192, 264, 315, 338, 360. These clouds were collected in three groups, about south-west, west, and north-west respectively. Some of them were streaked, and the streaks and longer axes of all the clouds were directed approximately towards the spot where the sun had recently set. At the time when I first saw them, only one of these clouds showed prismatic colours, but I am informed by a friend that a little earlier, about 4 p.m., this was the case with several. As the other two sets showed colours and changes exhibited later on by those in the south-west, I propose to describe the latter alone.

At 4.12 this group consisted of two large clouds and several smaller ones, just above the planet Venus, the centre of the group being at an altitude of about 30°. The uppermost cloud was about 20° in length and 5° in breadth. Its longer axis was directed towards, but slightly above, the point in the horizon where the sun had just set. The west end of the cloud was rounded, almost semicircular, and hazy near the edge. Then followed two or three fringes, also nearly semicircular, showing rather bright prismatic colours, the blue side of each fringe being towards the sun. The coloured fringes occupied about a third of the cloud; the rest of it was bright, with a slightly greenish tinge, as were also the other clouds of this group. The east end was drawn out in striæ parallel to the longer axis of the cloud. Soon after my first seeing them, the prismatic colours began to fade, and by 4.20 were no longer distinguishable, but the clouds themselves were still bright and noticeable. At 4.25 the cloud that had the prismatic fringes became very faint and had now a slight rose-coloured tinge; the others had the same tinge of colour, but remained bright. By this time the striæ at the east end were drawn out in the direction of the length of the cloud, but became gradually fainter, and by 4.27 had disappeared; so that the cloud was now reduced to about half its original length, the remaining part having at the same time become broader, brighter, and of a deeper rose-colour. This colour, however, soon began to fade, and by 4.34 was nearly gone, though there was no apparent diminution of brightness. At 4.41 they were bright and of a grayish-white, almost steel-gray, colour, and continued so for some time. During all the time I watched them (about three-quarters of an hour) this group as a whole was nearly stationary, though the clouds themselves changed considerably in form and slightly in their relative positions. The sky was almost clear, but near the horizon there were some dark, heavy clouds, and at one time (4.25) several of these, driven by a strong wind, passed rapidly below the group above described, partly covering the lowermost. On going out again at 6.20 to watch them, I found that they had all disappeared. I may add that yesterday evening, soon after sunset, the western sky was covered with a rosy flush, reminding one slightly of the wonderful sunsets of two years ago. CHARLES DAVISON

Sunderland, December 28, 1885

YESTERDAY morning (December 29), from about 8.30 to 9 o'clock, a number of very brilliantly-coloured clouds were observed here by myself and others. The weather was cold and frosty, and the sky at the time was clear with the exception of a thick haze round the horizon; a few clouds were thinly distributed over the sky, and these were more or less coloured. The clouds in the south-east had colours rivalling those of the rainbow in intensity. The colours were also distributed in bands, though not in the same order as those of the rainbow. The clouds in the opposite quarter of the sky were smaller, and though unusually bright as regards luminosity the colours were paler than on the other side of the sky. Each cloud also had one uniform tint, a pale green or blue or pink. The more brilliant clouds while fading assumed an appearance similar to these others, some of the bands broadening out, while others disappeared. I saw a beautiful iridescent cloud here at the same hour one morning last December. At that time the phenomenon was generally observed throughout the country, as is evident from the letters which appeared in NATURE (vol. xxxi. pp. 148, 192, 264, &c.). JOHN STEVENSON

Broxburn, December 30, 1885

The Recent Star-Shower

MR. DENNING'S letter of December 12 makes me see that I did not put the point which was in my own mind with sufficient clearness in my letters of December 7 and 8.

It was not to coincidences of star-showers with displays of auroræ as to whose true auroral nature there appeared to be no question, that I wished to draw attention, but to the fact that, among the instances to which I referred, of the coincidence of such showers with *aurora-like phenomena*, there were two occasions, and those two occurrences of the same shower, on which there was a notable absence of any magnetic disturbances. The coincidence of such disturbances with auroral displays is, I suppose, so thoroughly established that the notable absence of them on these occasions may fairly be taken to suggest a possibility that the phenomena were not truly auroral. If so, their coincidence with the star-shower becomes more noteworthy.

Rugby, January 5 J. B. HASLAM

A SPLENDID shower of meteors occurred on the night of November 27, 1885. Seen from Ava, near Mandalay, at 10 p.m. mean time of place, the point of emergence was near the zenith, and the shower radiated to each point of the horizon. The rate at that hour was 450 to 600 per minute, as near as I could judge lying on my back on the steamer's awning. It is probable, however, that I missed a great many. The point of emergence was at one-fifth the distance from γ Andromedæ (Almach) towards β Andromedæ (Mirach). The following night the shower was still plentiful, but I did not count them. The nights have been very clear and beautiful here.

December 1, 1885 ALFRED CARPENTER

Deposits of the Nile Delta

IN the abstract of the Report of the Committee of the Royal Society, on recent borings in the Nile Delta (NATURE, Dec. 10, 1885, p. 142), there is a reference to my "Notes on the Geology of the Nile Valley" (*Geological Magazine*, 1884), which calls for some explanation in the interests of Egyptian geology. When I saw a portion of the borings in Cairo, in the early part of 1884, the work had extended to a depth of only about 40 feet. At a depth of between 30 and 40 feet the boring-rod, after passing through continuous Nile mud, had entered into quicksand, consisting of polished and rounded grains of quartz and other hard rocks (desert sand), and the difficulties incident to this material had for the time arrested the operations. In connection with this and with the insufficiency of the funds on hand for overcoming the difficulties of the work, I wrote a letter at the time to the President of the Royal Society, strongly urging an additi nal grant, in order that greater depths might be reached.

I then believed, and still believe, that the quicksand marks the true base of the modern Delta alluvium, and corresponds with the similar sand which in certain parts of the Delta protrudes itself from beneath the fluviatile deposit. I did not, however, suppose that this sand rests directly on the rocky floor of the valley. On the contrary, as might be inferred from my short statement in the *Geological Magazine* (July 1884, p. 292 and footnote), I anticipated that below the sand would be found the Pleistocene clays, marls, sands, and concretionary limestones of the "Isthmian" formation seen at El Guisr on the Suez Canal, and the equivalents of which rise from under the alluvium in several places on the sides of the Nile Valley. These also constitute the lower strata of the borings reported by Figari Bey; and it appeared to me that in the colour and texture of the sediment mixed with the lower samples of the sand there were indications of the approach to these deposits.

Though I have not seen the borings between 40 and 80 feet, I still think that the question whether these are modern, or belong to the Pleistocene, remains to be disposed of, and will require comparison of the lower samples, if they can be separated from the mud and sand introduced from above, with the overlying deposit. This may have already been attended to, but if so, the fact is not stated in the published abstract. With reference to such comparisons I would ask particular attention to the chemical character and depth of the specimens containing calcareous concretions, which are characteristic of the Isthmian rather than of the Nilotic formation.

Of course I do not affirm that the modern deposit of the Delta is in no place thicker than 40 feet, on the contrary, on my view of the history of the district, there must be old buried channels of the Nile in which it is much thicker, but it should be possible to recognise these by the character of the material filling them.

The softness of the Nile water and the minutely arenaceous character of the Nile mud, as well as the connection of this with its fertility, have been remarked from the most ancient times; and the microscopic details given by Prof. Judd have done much to give precision to our views on these points. With respect however to the causes and geological significance of these phenomena, the conclusions stated in the abstract seem open to serious objections, suggested by the physical features of the area drained by the Nile, and the conditions under which the fluviatile deposits are laid down. As this subject is of some importance both with reference to the geology of Egypt and general geology, I would ask your permission to refer to it in a second short communication. J. WILLIAM DAWSON

McGill College, Montreal, December 24, 1885

The Discovery of the Source of the Mississippi

IT is a matter of little importance or interest in what spot is located the ultimate spring of the longest branch of even the greatest river. Especially is this the case with the Mississippi, where it may easily be an open question which of a dozen branches is the longest, when traced through its innumerable lakes and windings. By common consent, however, a certain branch of the Mississippi has been assumed as the river proper, and its head as Lake Itasca, in northern central Minnesota. The river was explored to this point, and the lake discovered in 1832 by Schoolcraft, who published a map of the lake, and of the river from this point downwards. He spent but one night on the lake, and did not explore its tributaries. Four years later Nicollet led an expedition to the head waters of this stream, reached Lake Itasca, and spent several days in making a thorough exploration of the country about it. In his narrative, published in 1841, he gives a full description of the tributaries to the lake which constituted, according to general acceptation, the extreme head waters of the river. The report is accompanied by a map, on which the geographic features described in the narrative are delineated, and which agrees in general with later and more accurate maps.

During the half century which has passed since the time of these explorers, settlement has crowded upon this region, railroads have been built in close proximity to it, and the country has been explored in every direction in the interest of the lumber industry. Furthermore, in 1876, the surveys of the General Land Office were extended over it. Lines were run at intervals of a mile over the whole region, and every lake and pond of any importance was mapped by traverse survey. In short, the country has long since ceased to be a *terra incognita*.

It is therefore with astonishment, not unmixed with a feeling akin to disgust, that we read in the daily papers, in certain magazines, and finally in the *Journal* of the Royal Geographical Society, an account of the alleged "discovery" of the source of the Mississippi, made by a Capt. Glazier, in the summer of 1881. It appears from his narrative, published in great fulness of detail in the *American Meteorological Journal*, September to December, 1884, that his expedition started at St. Paul and pushed its way manfully by rail and stage to the Leech Lake Indian agency. After obtaining at this place a full complement of men and material (except provisions) for a life in the wilderness, they started westward for Lake Itasca. They fortunately escaped all the perils of the journey, and arrived there on the third day safely. Coasting along the shore of the lake, they found a stream coming in at the head of the south-west arm, up which they journeyed, some two hundred yards, when they entered a second lake, which Capt. Glazier claims to be the ultimate source of the Mississippi, and to which, probably in virtue of his heroic achievement in being paddled to it, he claims the right to give his own name. The failure of provisions prevented him from making any further exploration or discovery, and the expedition returned to settlements.

It appears from the explorer's description and from the extremely incorrect map which accompanies his narrative—made, as he naïvely informs the reader, from information furnished by his Indian guide—that his so-called Glazier Lake is identical with a lake in Township 143 north, Range 36 west, which had been carefully mapped by traverse survey by the General Land Office in 1876, or five years prior to his "discovery." This lake, or pond, has an area of about half a square mile. On the Land Office plat it is called Elk Lake, and its connection with Lake Itasca is plainly indicated. By a mere inspection of this plat Capt. Glazier might have made his discovery, and thus have avoided all the hardships and labours of his perilous journey. Since his claim to the discovery of this lake must be c nsidered as altogether baseless, his desire that his name shall be for ever associated with it as the source of the Mississippi River is preposterous, especially as he cannot be ignorant of the above facts. HENRY GANNETT

Washington, D.C.

Chætoderma

YOUR biological readers will probably be interested to learn that I dredged a specimen of *Chætoderma* last August off the south end of the Isle of Man from a depth of about 20 fathoms. It is about 1·5 cm. in length, and differs somewhat in shape from both *Chætoderma nitidulum*, Lovén, and the new species (*C. militare*, Selenka) found during the *Challenger* Expedition. The calcareous spicules are also different from those of both the previously described species, but they seem to vary considerably in shape. The specimen—along with the other Vermes obtained during the various dredging expeditions carried on last summer by the members of the Liverpool Marine Biology Committee—has been placed in the hands of Mr. R. J. Harvey Gibson, M.A., for detailed examination, and will be described in the First Report upon the Fauna of Liverpool Bay, to be published shortly.

W. A. HERDMAN

University College, Liverpool, December 30, 1885

A Solar Halo

AT about noon on this day a fine halo with its mock suns was well seen at the Radcliffe Observatory. Measurements of the vertical radii of the first circle gave 22° 24′, whilst the angular distance between the true and mock suns was 22° 30′. The radius of the second circle was rather difficult to determine, but the mean of several measures gave 46° 40′. The inverted arcs at the vertices of the two circles were clearly seen. The zenith distance of the sun's centre was nearly 75° at the time of the observation.

E. J. STONE,
Radcliffe Observer

Radcliffe Observatory, Oxford, December 30, 1885

Ventilation

MR. FLETCHER'S letter in your issue of December 17 (p. 153) illustrates the difficulties encountered by people who adopt patent ventilators and so-called systems of ventilation without considering the natural laws ruling the flow of currents of air.

The exit-shafts recommended by the writer of your article on the subject, as he himself confesses, may act as inlets, and generally do, if there is no other free inlet for air. This there seldom is in cold weather when the windows are closed, unless a hot-air grate on the Galton or other model is adopted. There is very little objection to running the exit-tube from the chandelier into the chimney flue, on the same principle as that of the chimney to each ventilator, now so much used.

I think the writer of your article hardly appreciates the difficulties to be encountered in ventilating an English house or assembly-room. Irrespective of the ignorance of the public generally on the subject, we are met by the fact that in most town houses it is very difficult to place a stove, with proper fresh-air inlet, in the entrance, where it may afford a supply of fresh warmed air to the house. As a rule the nearest flue is a very long way off. Again, fire-places being as a rule on inside walls in such houses, the flue to supply a hot-air grate (by far the best method of warming) has to be very long, and there is difficulty in arranging for its due cleansing.

Your correspondent speaks of expense being no object in the erection of public buildings. This is far from my experience. In the cases of churches, schools, and assembly-rooms, the question of ventilation is entirely bound up with that of heating, and in conversation with various makers of heating apparatus I have found their views quite unanimous on the peculiarities of building Committees on this subject. The lowest tender is as a rule accepted, and this never provides for ventilation. They are asked to heat only.

The real objection to ventilation in large rooms is the cost of the necessary heating apparatus. For instance, a large concert-room has recently been erected in this neighbourhood to seat 3800 persons, with a cubical content of 514,800 feet.

Now to warm this in the ordinary manner by hot-water pipes would require about 2600 feet of four-inch piping. But to supply a thousand feet of air per head, heated from 30° to 60° Fahr. would, according to the formula given in Hood's work, require no less than 10,600 feet, or more than four times the amount, while the space occupied by more than two miles of large piping would have to be taken into consideration.

No doubt the heating could be done more economically by steam coils or large stoves if care be taken not to over-heat the air.

Until ventilation is considered as necessary as drainage, and is paid for accordingly, and till failure on the part of architect and builder to secure it is visited with as severe penalties as failure in points of construction or design, I see no chance of improvement on the present state of chaos.

ERNEST H. JACOB

Leeds, December 22, 1885

Travellers' Snake-Stories

TRAVELLERS' "stories" are not expected to be quite matter-of-fact. One of the best of these jokes occurs in an article on "Travellers' Snake-Stories" in the December number of *Good Words*. Among the natural enemies of snakes the mongoose is thus described :—

"The mongoose, a bird known as the kingfisher of Australia, and secretary-bird of Africa, is well known in some of the West Indian Islands almost always to come off victorious in its encounters with the rattlesnake, and it has even been proposed to breed it specially for its extirpation."

From the use of the singular number in the above extract it is clear that only one animal is intended to be described, and that one is a *bird*. Next follows an interesting description in considerable detail (quoted from the *Standard* of January 22, 1883), of fights between the *Indian* mongoose and the Indian cobra in Lucknow, ending with the sentence :—

"He adds that these birds make affectionate pets," &c.

This is the best joke of all. It may be that the Australian kingfisher and African secretary-bird are locally called "mongoose" (this is not within the present writer's experience), but the *Indian* mongoose is a small animal, in shape very like a weasel or a ferret. It is impossible that the writer in the *Standard* (who is stated to have himself arranged the mongoose and cobra duels) could have described the mongoose as a *bird*. What does the man mean?

ALLAN CUNNINGHAM

Blackbird with White Feather

I NOTICE a letter from Mr. Murphy in your issue of December 24, 1885, about a blackbird with a white feather in its tail. Allow me to say that last month I saw a cock blackbird with a pure white tail; the rest of its plumage was natural. I saw it very distinctly, as it was flying away from me at the time, not more than ten yards off when I first noticed it, with its tail extended; I saw it again last week, within a few feet of the same place, this time running under a gate. My wife says she saw a similar bird, at the same spot, about a year ago.

THOMAS J. BUSK

Ford's Grove, Winchmore Hill, January 4

IT may interest your correspondent, Mr. J. J. Murphy, to know that for the last two years we have had a cock blackbird about our garden with a patch of pure white on each side of the head.

E. BROWN

Further Barton, Cirencester, January 3

DURING the frost of January 1880 I frequently noticed a hen blackbird with several white feathers on the head, breast, and back. It was quite tame, and came for food every day.

Hartford, Cheshire, December 30, 1885 E. K.

ON THE METHOD OF RECIPROCANTS AS CONTAINING AN EXHAUSTIVE THEORY OF THE SINGULARITIES OF CURVES[1]

IT is now two years and seven days since a message by the Atlantic cable containing the single word "elected" reached me in Baltimore informing me that I had been appointed Savilian Professor of Geometry in Oxford, so that for three weeks I was in the unique position of filling the post and drawing the pay of Professor of Mathematics in each of two Universities: one, the oldest and most renowned, the other—an infant Hercules—the most active and prolific in the world, and which realises what only existed as a dream in the mind of Bacon—the House of Solomon in the New Atlantis.

To Johns Hopkins, who endowed the latter, and in conjunction with it a great Hospital and Medical School, between which he divided a vast fortune accumulated

[1] Inaugural Lecture of Prof. Sylvester, F.R.S., delivered before the University of Oxford, December 12, 1885.

during a lifetime of integrity and public usefulness, I might address the words familiarly applied to one dear to all Wykehamists:—

> "Qui condis lævâ, qui condis collegia dextrâ,
> Nemo tuarum unam vicit utraque manû."

The chair which I have the honour to occupy in this University is made illustrious by the names and labours of its munificent and enlightened founder, Sir Henry Saville; of Thomas Briggs, the second inventor of logarithms; of Dr. Wallis, who, like Leibnitz, drove three abreast to the temple of fame—being eminent as a theologian, and as a philologer, in addition to being illustrious as the discoverer of the theorem connected with the quadrature of the circle named after him, with which every schoolboy is supposed to be familiar, and as the author of the "Arithmetica Infinitorum," the precursor of Newton's "Fluxions"; of Edmund Halley, the trusted friend and counsellor of Newton, whose work marks an epoch in the history of astronomy, the reviver of the study of Greek geometry and discoverer of the proper motions of the so-called fixed stars; and by one in later times not unworthy to be mentioned in connection with these great names, my immediate predecessor, the mere allusion to whom will, I know, send a sympathetic thrill through the hearts of all here present, to whom he was no less endeared by his lovable nature than an object of admiration for his vast and varied intellectual requirements, whose untimely removal, at the very moment when his fame was beginning to culminate, cannot but be regarded as a loss, not only to his friends and to the University for which he laboured so strenuously, but to science and the whole world of letters.

As I have mentioned, the first to occupy this chair was that remarkable man Thomas Briggs, concerning whose relation to the great Napier of Merchiston, the fertile nursery of heroes of the pen and the sword, an anecdote, taken from the Life of Lilly, the astrologer, has lately fallen under my eyes, which, with your permission, I will venture to repeat:—

"I will acquaint you (says Lilly) with one memorable story related unto me by John Marr, an excellent mathematician and geometrician, whom I conceive you remember. He was servant to King James and Charles the First. At first, when the lord Napier, or Marchiston, made public his logarithms, Mr. Briggs, then reader of the astronomy lectures at Gresham College, in London, was so surprised with admiration of them, that he could have no quietness in himself until he had seen that noble person the lord Marchiston, whose only invention they were: he acquaints John Marr herewith, who went into Scotland before Mr. Briggs, purposely to be there when those two so learned persons should meet. Mr. Briggs appoints a certain day when to meet at Edinburgh; but failing thereof, the lord Napier was doubtful he would not come. It happened one day as John Marr and the lord Napier were speaking of Mr. Briggs: 'Ah John (said Marchiston), Mr. Briggs will not now come.' At the very moment one knocks at the gate; John Marr hastens down, and it proved Mr. Briggs to his great contentment. He brings Mr. Briggs up into my lord's chamber, where almost *one quarter of an hour was spent*, each beholding other almost with admiration *before one word was spoke*. At last Mr. Briggs began: 'My lord, I have undertaken this long journey purposely to see your person, and to know by what engine of wit or ingenuity you came first to think of this most excellent help into astronomy, viz. the logarithms; but, my lord, being by you found out, *I wonder nobody else found it out before*, when now known it is so easy.' He was nobly entertained by the lord Napier; and every summer after that, during the lord's being alive, this venerable man Mr. Briggs went purposely into Scotland to visit him." [1]

Some apology may be needed, and many valid reasons might be assigned, for the departure, in my case, from the usual course, which is that every professor on his appointment should deliver an inaugural lecture before commencing his regular work of teaching in the University. I hope that my remissness, in this respect, may be condoned if it shall eventually be recognised that I have waited, before addressing a public audience, until I felt prompted to do so by the spirit within me craving to find utterance, and by the consciousness of having something of real and more than ordinary weight to impart, so that those who are qualified by a moderate amount of mathematical culture to comprehend the drift of my discourse, may go away with the satisfactory feeling that their mental vision has been extended and their eyes opened, like my own, to the perception of a world of intellectual beauty, of whose existence they were previously unaware.

This is not the first occasion on which I have appeared before a general mathematical audience, as the messenger of good tidings, to announce some important discovery. In the year 1859 I gave a course of seven or eight lectures at King's College, London, at each of which I was honoured by the attendance of my lamented predecessor, on the subject of "The Partitions of Numbers and the Solution of Simultaneous Equations in Integers," in which it fell to my lot to show how the difficulties might be overcome which had previously baffled the efforts of mathematicians, and especially of one bearing no less venerable a name than that of Leonard Euler, and also laid the basis of a method which has since been carried out to a much greater extent in my "Constructive Theory of Partitions," published in the *American Journal of Mathematics*, in writing which I received much valuable co operation and material contributions from many of my own pupils in the Johns Hopkins University.[1] Several years later, in the same place, I delivered a lecture on the well-known theorem of Newton, which fills a chapter in the "Arithmetica Universalis," where it was stated without proof, and of which many celebrated mathematicians, including again the name of Euler, had sought for a proof in vain. In that lecture I supplied the missing demonstration, and owed my success, I believe, chiefly to merging the theorem to be proved, in one of greater scope and generality. In mathematical research, reversing the axiom of Euclid, and converting the proposition of Hesiod, it is a continual matter of experience, as I have found myself over and over again, that the whole is less than its part. On a later occasion, taking my stand on the wonderful discovery of Peaucellier, in which he had realised that exact parallel motion which James Watt had believed to be impossible, and exhausted himself in contrivances to find an imperfect substitute for, in the steam-engine, I think I may venture to say that I brought into being a new branch of mechanico-geometrical science, which has been, since then, carried to a much higher point by the brilliant inventions of Messrs. Kempe and Hart. I remember that my late lamented friend, the Lord Almoner's Reader of Arabic in this University, subsequently editor of the *Times*, Mr. Chenery, who was present on that occasion in an unofficial capacity, remarked to me after the lecture, which was delivered before a crowded auditory at the Royal Institution, that when they saw two suspended

[1] A very similar story is told of the meeting of Leopardi and Niebuhr in Rome. What Briggs said of logarithms may be said almost in the same words of the subject of this lecture:—"This most excellent help to geometry which, being found out, one wonders nobody else found it out before; when, now known, it is so easy." I quite entered into Brigg's feelings at his interview with Napier when I recently paid a visit to Poincaré in his airy perch in the Rue Gay-Lussac in Paris (will our grandchildren live to see an Alexander Williamson Street in the north-west quarter of London, or an Arthur Cayley Court in Lincoln's Inn, where he once abode?). In the presence of that mighty reservoir of pent-up intellectual force my tongue at first refused its office, my eyes wandered, and it was not until I had taken some time (it may be two or three minutes) to peruse and absorb as it were the idea of his external youthful lineaments that I found myself in a condition to speak.

[1] In one of those lectures, two hundred copies of the notes for which were printed off and distributed among my auditors, I founded and developed to a considerable extent the subject since rediscovered by M. Halphen under the name of the Theory of Aspects.

opposite Peaucellier cells, coupled toe-and-toe together, swing into motion, which would have been impossible had not the two connected moving points each described an accurate straight line, "the house rose at you." [The lecture merely illustrated experimentally two or three simple propositions of Euclid, Book III.].

The matter that I have to bring before your notice this afternoon is one far bigger and greater, and of infinitely more importance to the progress of mathematical science, than any of those to which I have just referred. No subject during the last thirty years has more occupied the minds of mathematicians, or lent itself to a greater variety of applications, than the great theory of Invariants. The theory I am about to expound, or whose birth I am about to announce, stands to this in the relation not of a younger sister, but of a brother, who, though of later birth, on the principle that the masculine is more worthy than the feminine, or at all events, according to the regulations of the Salic law, is entitled to take precedence over his elder sister, and exercise supreme sway over their united realms. Metaphor apart, I do not hesitate to say that this theory, *minor natu potestate major*, infinitely transcends in the extent of its subject-matter, and in the range of its applications, the allied theory to which it stands in so close a relation. The very same letters of the alphabet which may be employed in the two theories, in the one may be compared to the dried seeds in a botanical cabinet, in the other to buds on the living branch ready to burst out into blossom, flower, and fruit, and in their turn supply fresh seed for the maintenance of a continually self-perpetuating cycle of living forms. In order that I may not be considered to have lost myself in the clouds in making such a statement, let me so far anticipate what I shall have to say on the meaning of Reciprocants and their relation to the ordinary Invariantive or Covariantive forms by taking an instance which happens to be common (or at least, by a slight geometrical adjustment, may be made so) to the two theories. I ask you to compare the form

$$a^2d - 3abc + 2b^3$$

as it is read in the light of the one and in that of the other. In the one case the a, b, c, d stand for the coefficients of a so-called Binary Quantic, and its evanescence serves to express some particular relation between three points lying in a right line. In the other case the letters are interpreted to mean the successive differential derivatives of the 2nd, 3rd, 4th, 5th orders of one Cartesian co-ordinate of a curve in respect to the other. The equation expressing this evanescence is capable of being integrated, and this integral will serve to denote a relation between the two co-ordinates which furnishes the necessary and sufficient condition in order that the point of the curve of any or no specified order (for it may be transcendental) to which the co-ordinates may refer, may admit of having, at the point where the condition is satisfied, a contact with a conic of a higher order than the common. In the one case the letters employed are dead and inert atoms; in the other they are germs instinct with motion, life, and energy.

A curious history is attached to the form which I have just cited, one of the simplest in the theory, of which the narrative may not be without interest to many of my hearers, even to those whose mathematical ambition is limited to taking a high place in the schools.

At pp. 19 and 20 of Boole's "Differential Equations" (edition of 1859) the author cites this form as the lefthand side of an equation which he calls the "Differential Equation of lines of the second order," and attributes it to Monge, adding the words, "But here our powers of geometrical interpretation fail, and results such as this can scarcely be otherwise useful than as a registry of integrable forms." In this vaticination, which was quite uncalled for, the eminent author, now unfortunately deceased, proved himself a false prophet, for the form referred to is among the first that attracts notice in crossing the threshold of the subject of Reciprocants, and is but one of a crowd of similar and much more complicated expressions, no less than it, susceptible of geometrical interpretation and of taking their place on the register of integrable forms. A friend, with whom I was in communication on the subject, and whom I see by my side, remarked to me, in reference to this passage:—"I cannot help comparing a certain passage in Boole to Ezekiel's valley of the dry bones: 'The valley was full of bones, and lo, they were very dry.' The answer to the question, 'Can these bones live?' is supplied by the advent of the glorious idea of the Reciprocants; and the grand invocation, 'Come from the four winds, O breath, and breathe upon these slain, that they may live,' may well be used here. That they will 'live and stand up upon their feet an exceeding great army' is what we may expect to happen." This, as you will presently see, is just what actually has happened.

Not knowing where to look in Monge for the implied reference, I wrote to an eminent geometer in Paris to give me the desired information; he replied that the thing could not be in Monge, for that M. Halphen, who had written more than one memoir on the subject of the differential equation of a conic, had made nowhere any allusion to Monge in connection with the subject. Hereupon, as I felt sure that a reference contained in repeated editions of a book in such general use as Boole's "Differential Equations" was not likely to be erroneous, I addressed myself to M. Halphen himself, and received from him a reply, from which I will read an extract:—

"En premier lieu, c'est une chose nouvelle pour moi que l'équation différentielle des coniques se trouve dans Boole, dont je ne connais pas l'ouvrage. Je vais, bien entendu, le consulter avec curiosité. Ce fait a échappé à tout le monde ici, et l'on a cru généralement que j'avais le premier donné cette équation. *Nil sub sole novi!* Il m'est naturellement impossible de vous dire où la même équation est enfouie parmi les œuvres de Monge. Pour moi, c'est dans *Le Journal de Math.* (1876), p. 375, que j'ai eu, je crois, la première occasion de développer cette équation sous la forme même que vous citez; et c'est quand je l'ai employée, l'année suivante, pour le problème *sur les lois de Kepler* (*Comptes rendus*, 1877, t. lxxxiv. p. 939), que M. Bertrand l'a remarquée comme neuve. Ce qui vous intéresse plus, c'est de connaître la forme simplifiée sous laquelle j'ai donné plus tard cette équation dans le *Bulletin* de la Société Mathématique. C'est sous cette dernière forme que M. Jordan la donne dans son cours de l'École Polytechnique" (t. i. p. 53).

All my researches to obtain the passage in Monge referred to by Boole have been in vain.[1]

I will now proceed to endeavour to make clear to you what a Reciprocant means: the above form, which may be called the *Mongian*, would afford an example by which to illustrate the term; but I think it desirable to begin with a much easier one. Consider then the simple case of a single term, the second derivative of one variable, y, in respect to another, x. Every tyro in algebraical geometry knows that this, or rather the fact of its evanescence, serves to characterise one or more points in a curve which possess, so to say, a certain indelible and intrinsic character, or what is technically called a singularity; in this case an inflexion such as exists in a capital S, or Hogarth's line of beauty.

If we invert the two variables, exchanging, that is to say, one with the other, the fact of this indelibility draws with

1 Search has been made in the collected works of Monge and in manuscripts of his own or Prony in the library of the Institute, but without effect. I have also made application to the Universal Information Society, who undertake to answer "every conceivable question," but nothing has so far come of it. Perhaps until the citation from Monge is verified it will be safer in future to refer to the so-called Mongian as the Boole-Mongian. It may be regarded as the starting-point of the Differential Invariant Theory, as the Schwarzian is of the deeper-lying and more comprehensive Reciprocant Theory.

it the consequence that in general these two reciprocal functions must vanish together, and as a fact each is the same as the other multiplied or divided by the third power of the first derivative of the one variable with respect to the other taken negatively. In this case we are dealing with a single derivative and its reciprocal. The question immediately presents itself whether there may not be a combination of derivatives possessing a similar property. We know that no *single* derivative except the second does.

Such a combination actually presents itself in a form which occurs in the solution of Differential Equations of the second order, the form

$$\frac{dy}{dx} \cdot \frac{d^3y}{dx^3} - \frac{3}{2}\left(\frac{d^2y}{dx^2}\right)^2,$$

which, after the name of its discoverer, Schwarz, we may agree to call a Schwarzian (Cayley's "Schwarzian Derivative"[1]). If in this expression the x and y be interchanged, its value, barring a factor consisting of a power of the first derivative, remains unaltered, or, to speak more strictly, merely undergoes a change of algebraical sign. We may now arrive at the generalised conception of an algebraical function of the derivatives of one variable in respect to another, which, if we agree to pay no regard to the algebraical sign, or to any power of the first derivative that may appear as a factor, will remain unaltered when the dependent and independent variables are interchanged one with another; and we may agree to call any such function a Reciprocant.

But here an important distinction arises—there are Reciprocants such as the one I first mentioned, $\frac{d^2y}{dx^2}$, or such as the Mongian to which allusion has been made in the letter from M. Halphen, in which the second and higher differential derivatives alone appear, the first differential derivative not figuring in the expression. These may be termed Pure Reciprocants. Thus I repeat $\frac{d^2y}{dx^2}$, and

$$9\left(\frac{d^2y}{dx^2}\right)^2 \cdot \frac{d^5y}{dx^5} - 45\frac{d^2y}{dx^2} \cdot \frac{d^3y}{dx^3} \cdot \frac{d^4y}{dx^4} + 40\left(\frac{d^3y}{dx^3}\right)^3$$

are pure reciprocants. Those from which the first derivative $\frac{dy}{dx}$ is not excluded may be called Mixed Reciprocants. An example of such kind of Reciprocants is afforded by the Schwarzian above referred to. This distinction is one of great moment, for a little attention will serve to make it clear that every pure reciprocant expressed in terms of x and y marks an intrinsic feature or singularity in the curve, whatever its nature may be, of which x and y are the co-ordinates; for if in place of the variables (x, y) any two linear functions of these variables be substituted, a pure reciprocant, by virtue of its reciprocantive character, must remain unaltered save as to the immaterial fact of its acquiring a factor containing merely the constants of substitution.[2]

The consequence is that every pure reciprocant corresponds to, and indicates, some singularity or characteristic feature of a curve, and *vice versâ* every such singularity of a general nature and of a descriptive (although not necessarily of a projective) kind, points to a pure reciprocant.

Such is not the case with mixed reciprocants. They will not in general remain unaltered when linear substitutions are impressed upon the variables. Is it then necessary, it may be asked, to pay any attention to mixed reciprocants; or may they not be formally excluded at the very threshold of the inquiry? Were I disposed to put the answer to this question on mere personal grounds, I feel that I should be guilty of the blackest ingratitude, that I should be kicking down the ladder by which I have risen to my present commanding point of view, if I were to turn my back on these humble mixed reciprocants, to which I have reason to feel so deeply indebted; for it was the putting together of the two facts of the substantial permanence under linear substitutions impressed upon the variables of the Schwarzian form and the simpler one which marks the inflexions of a curve—it was, if I may so say, the collision in my mind of these two facts—that kindled the spark and fired the train which set my imagination in a blaze by the light of which the whole horizon of Reciprocants is now illumined.

But it is not necessary for me to defend the retention of mixed reciprocants on any such narrow ground of personal predilection. The whole body of Reciprocants, pure and mixed, form one complete system, a single garment without rent or seam, a complex whole in which all the parts are inextricably interwoven with each other. It is a living organism, the action of no part of which can be thoroughly understood if dissevered from connection with the rest.

It was in fact by combining and interweaving mixed reciprocants that I was led to the discovery of the pure binomial reciprocant, which comes immediately after the trivial monomial one,—the earliest with which I became acquainted, and of the existence of compeers to which I was for some time in doubt, and only became convinced of the fact after the discovery of the Partial Differential Equation, the master-key to this portion of the subject, which gives the means of producing them *ad libitum* and ascertaining all that exist of any prescribed type. Of this partial differential equation I shall have occasion hereafter to speak; but this is not all, for, as we shall presently see, mixed reciprocants are well worthy of study on their own account, and lead to conclusions of the highest moment, whether as regards their applications to geometry or to the theory of transcendental functions and of ordinary differential equations.

The singularities of curves, taking the word in its widest acceptation, may be divided into three classes: those which are independent of homographic deformation and which remain unaltered in any perspective picture of the curve; those which, having an express or tacit reference to the line at infinity, are not indelible under perspective projection, but using the word descriptive with some little latitude may, in so far as they only involve a reference to the line at infinity as a line, be said to be of a purely descriptive character; and, lastly, those which are neither projective nor purely descriptive, having relation to the points termed, in ordinary parlance, "circular points at infinity" [for which the proper name is "centres of infinitely distant pencils of rays," *i.e.* pencils, every ray of which is infinitely distant from every point external to it]. Such, for instance, would be the character of points of maximum or minimum curvature, which, as we shall see, indicate, or are indicated by, that particular class of Mixed to which I give the name of "Orthogonal Reciprocants." All purely descriptive singularities alike, whether pro-

[1] More strictly speaking this is Cayley's Schwarzian derivative cleared of fractions—it may well be called the Schwarzian (see my note on it in the *Mathematical Messenger* for September or October past). Prof. Greenhill in regard to the Schwarzian derivative proper writes me as follows:—

"I found the reference in a footnote to p. 74 of Klein's 'Vorlesungen über das Ikosaëder, &c.,' in which Klein thanks Schwarz for sending him the reference to a paper by Lagrange, 'Sur la construction des cartes géographiques' in the *Nouveaux Mémoires de l'Académie de Berlin*, 1779. Compare also Schwarz's paper in Bd. 75 of *Borchardt's Journal*, where further literary notices are collected together. Klein says further that in the 'Sächsischen Gesellschaft von Januar 1883,' he has considered the inner meaning (*innere bedentung*) of the differential equation $\frac{\eta'''}{\eta} - \frac{3}{2}\left(\frac{\eta''}{\eta'}\right)^2 = f(\eta)$, where $\eta' = \frac{d\eta}{d^z}$ . . . ."

There are two papers by Lagrange, one immediately following the other, "Sur la construction des cartes géographiques," but I have not been able to discover the Schwarzian derivative in either of them.

[2] The form as it stands shows that for y a linear function of x and y may be substituted; and the form *reciprocated* (by the interchange of x and y) shows that a similar substitution may be made for x. Hence arbitrary linear substitutions may be simultaneously impressed as x and y without inducing any change of form.

jective or non-projective, are indicated by pure reciprocants, and are subject to the same Partial Differential Equation; just as, in the Theory of Binary Quantics, Invariants, although under one aspect they may be regarded as a self-contained special class, admit of being and are most advantageously studied in connection with, and as forming a part of, the whole family of forms commonly known by the name of "semi-, or subinvariants," but which I find it conduce to much greater clearness of expression and avoidance of ambiguity or periphrasis to designate as Binariants.

The question may here be asked, How, then, are projective and non-projective pure reciprocants to be discriminated by their external characters?

I believe that I know the answer to this question, which is, that the former are subject to satisfy a second partial differential equation of a certain simple and familiar type, but this is a matter upon which it is not necessary for me to enter on the present occasion.[1] It is enough for our present purpose to remark that every projective pure reciprocant must, so to say, be in essence a masked ternary covariant. For instance, if we take the simplest of all such, viz. a, i.e. $\frac{d^2y}{dx^2}$, we have

$$\frac{d^2y}{dx^2}\cdot\left(\frac{d\phi}{dy}\right)^3 = \begin{vmatrix} \frac{d^2\phi}{dx^2} & \frac{d^2\phi}{axdy} & \frac{d\phi}{dx} \\ \frac{d^2\phi}{dxdy} & \frac{d^2\phi}{dy^2} & \frac{d\phi}{dy} \\ \frac{d\phi}{dx} & \frac{d\phi}{dy} & \bullet \end{vmatrix}$$

which, for facility of reference, let me call M. Obviously we might instead of $a = 0$ substitute $M = 0$ to mark an inflexion. And now if we write Φ as the completed form of ϕ, when made homogeneous by the substitution of z for unity; and if we suppose it to be of n dimensions in x, y, z, and call its Hessian H, we shall obtain the syzygy

$$(n-1)^2\left(\frac{d\phi}{dy}\right)^3 . a + H + \left\{\frac{d^2\Phi}{dx^2}\cdot\frac{d^2\Phi}{dy^2} - \left(\frac{d^2\Phi}{dxdy}\right)^2\right\}\Phi = 0.$$

Hence the system $\Phi = 0$, $a = 0$, will be in effect the same as the system $\Phi = 0$, $H = 0$, and in this sense a may be said to carry H as it were in its bosom. And so in general every pure projective reciprocant may, in the language of insect transformation, be regarded as passing, so to say, first from the grub to the pupa or chrysalis, and from this again, divested of all superfluous integuments, to the butterfly or imago state.

Non-projective pure reciprocants undergo only one such change. There is no possibility of their ever emerging into the imago—their development being finally arrested at the chrysalis stage.

It would, I think, be an interesting and instructive task to obtain the imago or Hessianised transformation of the Mongian, but I am not aware that any one has yet done, or thought of doing, this.[2] It seems to me that by substituting Reciprocants in lieu of Ternary Covariants we are as it were stealing a dimension from space, inasmuch as Reciprocants, *i.e.* Ternary Covariants in their undeveloped state, are closely allied to, and march *pari passu* with, the familiar forms which appertain to merely binary quantics.

I will now proceed to bring before your notice the general partial differential equation which supplies the necessary and sufficient condition to which all pure reciprocants are subject.

It is highly convenient to denote the successive derivatives

$$\frac{dy}{dx^2}, \frac{dy}{dx^3}, \frac{dy}{dx^4}, \ldots$$

by the simple letters $a, b, c, \ldots$

The first derivative $\frac{dy}{dx}$ plays so peculiar a part in this theory that it is necessary to denote it by a letter standing aloof from the rest, and I call it τ. This last letter, I need not say, does not make its appearance in any pure reciprocant. This being premised, I invite your attention to the equation in question, in which you will perceive the symbols of operation are separated from the object to be operated upon.

Writing $V = 3a^2\delta + 10ab\delta_c + (15ac + 10b^2)\delta_d + \ldots$ and calling any pure reciprocant R,

$$VR = 0$$

is the equation referred to.

I cannot undertake, within the brief limits of time allotted to this lecture, to explain how this operation, or, as it may be termed, this annihilator V is arrived at. The table of binomial coefficients, or rather half-series of binomial coefficients, shown in Chart 4, will enable you to see what is the law of the numerical coefficients of its several terms. Let the words *weight*, *degree*, *extent* (extent, you will remember, means the number of places by which the most remote letter in the form is separated from the first letter in the alphabet) of a pure reciprocant signify the same things as they would do if the letters $a, b, c, \ldots$ referred, according to the ordinary notation, to Binariants instead of to Reciprocants. The number of binariants linearly independent of each other whose weight, extent, and order are w, i, j is given by the partition formula $(w; i, j) - (w - 1; i, j)$ where in general $(w; i, j)$ means the number of ways of partitioning w into i or fewer parts none greater than j. It follows immediately from the mere form of V that the corresponding formula in the case of Reciprocants of a given type $w.i.j$ will be $(w; i, j) - (w - 1; i + 1, j)$ the augmentation of i in the second term of the formula being due to the fact that, whereas in the partial differential equation for Binariants it is the letters themselves which appear as coefficients, it is quadratic functions of these in the case of Reciprocants. From the form of V we may also deduce a rigorous demonstration of the existence of Reciprocants strictly analogous to those with which you are familiar in the Binarian Theory, which are pictured in Chart 2, and are now usually designated as Protomorphs, as being the forms by the interweaving of which with one another (or rather by a sort of combined process of mixture and precipitation), all others, even the irreducible ones, are capable of being produced. The corresponding forms for Reciprocants you will see exhibited in the same table. Each series of Protomorphs may of course be indefinitely extended as more and more letters are introduced. In the table I have not thought it necessary to go beyond the letter g You also know that besides Protomorphs there are other irreducible forms, the organic radicals, so to say, into which every compound form may be resolved, always limited in number, whatever the number of letters or primal elements we may be dealing with. The same thing happens to Reciprocants as you will notice in the comparative table in Chart 2. Without going into particulars, I will ask you to take from me upon faith the assurance that there is no single feature in the old familiar theory, whether it relates to Protomorphs, to Groundforms, to Perpetuants, to Factorial constitution, to Generating Functions, or whatever else sets its stamp upon the one, which is not counterfeited by and reproduced in the parallel theory.

[1] In Paris, from which I correct the proofs, I have succeeded in reducing this conjecture to a certainty and in establishing the marvellous fact that every Projective Reciprocant, or, which is the same thing, every Differential Invariant, is, at the same time, an Ordinary Subinvariant. Thus a differential invariant (or projective reciprocant) may be regarded as *a single personality clothed with two distinct natures*—that of a reciprocant and that of a subinvariant.

[2] M. Halphen informs me that this has been done by Cayley in the *Phil. Trans.* for 1865, and subsequently in a somewhat simplified form by Painvin, *Comptes rendus*, 1874. But neither of these authors seems to have had the Boole-Mongian objectively before them, so that a slight supplemental computation is wanting to establish the equation between it and the function which either of them finds to vanish at a *sextactic* point

So much—for time will not admit of more—concerning pure reciprocants.

Let me now say a few words *en passant* on Mixed Reciprocants.

Pure Reciprocants, we have seen, are the analogues of Invariants, or else of the leading terms [for that is what are Semi- or Subinvariants] of Covariantive expansions; each is subject to its own proper linear partial differential equation. Mixed Reciprocants are the exact analogues of the coefficients in such expansions other than those of the leading terms. Starting from the leading terms as the unit point, the coefficients of rank ω are subject to a partial differential equation of order ω; and just so, mixed reciprocants, if involving τ up to the power ω, are subject to a partial differential equation of that same order.

I have alluded to a peculiar class of mixed under the name of "Orthogonal Reciprocants." They are distinguished, as I have proved, by the beautiful property that, if differentiated with respect to τ, the result must be itself a Reciprocant. In Chart 1 you will see this illustrated in the case of a mixed reciprocant $(1+\tau^2)b-3\tau a^2$, which serves to indicate the existence of points of maximum and minimum curvature. Its differential coefficient with respect to t is the oft-alluded-to Schwarzian, transliterated into the simpler notation. Proceeding in the inverse order—of Integration instead of Differentiation—I call your attention to a mixed reciprocant, of a very simple character, one which presents itself at the very outset of the theory, viz.—

$$\tau c - 5ab,$$

which, integrated in respect to t between proper limits, yields the elegant orthogonal reciprocant—

$$(\tau^2+1)c-10ab\tau+15a^3.$$

Expressed in the ordinary notation, this, equated to zero, takes the form—

$$\left\{\left(\frac{dy}{dx}\right)^2+1\right\}\frac{d^4y}{dx^4}-10\frac{dy}{dx}\cdot\frac{d^2y}{dx^2}\cdot\frac{d^3y}{dx^3}+15\left(\frac{d^2y}{dx^2}\right)^3=0.$$

Mr. Hammond has integrated this, treated as an ordinary differential equation, and has obtained the complete primitive expressed through the medium of two related Hyper-Elliptic Functions connecting the variables x and y (see Chart 3). It may possibly turn out to be the case that every mixed reciprocant is either itself an Orthogonal Reciprocant, or by integration, in respect to τ, leads to one.

It will of course be understood that, in interpreting equations obtained by equating to zero an Orthogonal Reciprocant, the variables must be regarded as representing not general but rectangular Cartesian co-ordinates.

Here seems to me to be the proper place for pointing out to what extent I have been anticipated by M. Halphen in the discovery of this new world of Algebraical Forms. When the subject first dawned upon my mind, about the end of October or the beginning of November last, I was not aware that it had been approached on any side by any one before me, and believed that I was digging into absolutely virgin soil. It was only when I received M. Halphen's letter, dated November 25, in relation to the Mongian business already referred to, accompanied by a presentation of his memoirs on Differential Invariants, that I became aware of there existing any link of connection between his work and my own. A Differential Invariant, in the sense in which the term is used by M. Halphen, is not what at first blush I supposed it to be, and as in my haste to repair what seemed to me an omission to be without loss of time supplied, I wrote to M. Hermite it was, in a letter which has been or is about to be inserted in the *Comptes rendus* of the Institute of France; it is not, I say, identical with what I have termed a general pure reciprocant, but only with that peculiar species of Pure Reciprocants to which I have in a preceding part of this lecture referred as corresponding and pointing to Projective Singularities. In his splendid labours in this field Halphen has had no occasion to construct or concern himself with that new universe of forms viewed as a whole, whether of Pure or Mixed Reciprocants, which it has been the avowed and principal object of this lecture to bring under your notice.

I anticipate deriving much valuable assistance in the vast explorations remaining to be made in my own subject from the new and luminous views of M. Halphen, and possibly he may derive some advantage in his turn from the larger outlook brought within the field of vision by my allied investigations.

Let me return for a moment to that simplest class of pure reciprocants which I have called protomorphs. Each of these will be found (as may be shown either by a direct process of elimination, or by integrating the equations obtained by equating them severally to zero, regarded as ordinary differential equations between x and y) each of these, I say, will be found to represent some simple kind of singularity at the point (x, y) of the curve to which these co-ordinates are supposed to refer. Thus, for instance, No. 1 marks a single point of inflexion; No. 2, points of closest contact with a common parabola; No. 3, what our Cayley has called sextactic points, referring to a general conic; No. 4, points of closest contact with a common cubical parabola; and so on. The first and third, it will be noticed, represent projective singularities, and as such, in M. Halphen's language, would take the name of Differential Invariants. The second and fourth, having reference to the line at infinity in the plane of the curve, are of a non-projective character, and as such would not appear in M. Halphen's system of Differential Invariants. It is an interesting fact that every simple parabola, meaning one whose equation can be brought under the form $y = x^{\frac{m}{n}}$, corresponds to a linear function of a square of the third, and the cube of the second protomorph, and consequently will in general be of the sixth degree. In the particular case of the cubical parabola, the numerical parameter of this equation is such that the highest powers of b cancel each other so that the form sinks one degree, and becomes represented by the *Quasi-Discriminant*, No. 4.

This simple instance will serve to illustrate the intimate connection which exists between the projective and non-projective reciprocants, and the advantage, not to say necessity, of regarding them as parts of one organic whole.

It would take me too far to do more than make the most cursory allusion to an extension of this theory similar to that which happens when in the ordinary theory of invariants we pass from the consideration of a single Quantic to that of two or more. There is no difficulty in finding the partial differential equation to double reciprocants which, as far as I have as yet pursued the investigation, appear to be functions of $a, b, c, \ldots$; $a', b', c', \ldots$; and of $(\tau-\tau')$.

The theory of double reciprocants will then include as a particular case the question of determining the singularities of paired points of two curves at which their tangents are parallel, and consequently the theory of common tangents to two curves and of bi-tangents to a single one.

I think I may venture to say that a general pure multiple reciprocant which marks off relative singularities, whether projective or non-projective, of a group of curves, is a function of the second and higher differential derivatives appertaining to the several curves of the group, and of the differences of the first derivatives, whereas in a mixed multiple reciprocant these last-named differences are replaced by the first derivatives themselves. As a particular case, when the group dwindles to an individual and there is only one τ, this letter disappears altogether from the form, for there are no differences of a single quantity.

In the chart (marked No. 2) you will see the table of Protomorphs carried on as far as the letter g inclusive, and will not fail to notice what may be termed the higher organisation of Reciprocantive as compared with ordinary Invariantive Protomorphs; the degrees of the latter oscillate or librate between the numbers 2 and 3, whereas in the former the degree is variable according to a certain transcendental law dependent on the solution of a problem in the Partition of Numbers. Another interesting difference between general Invariants and general Pure Reciprocants consists in the fact that, whilst the number of the former ultimately (*i.e.* when the extent is indefinitely increased) becomes indefinitely great, that of the latter is determinate for any given degree even for an infinite number of letters.

In carrying on the table of protomorphs up to the letter h (see Chart 6) a new phenomenon presents itself, to which, however, there is a perfect parallel in the allied theory. An arbitrary constant enters into the form, its general value being a linear function of U and W (for which see Chart 6). But this is not all. If you examine the terms in both U and W (there are in all twelve such) you will find that these twelve do not comprise all of the same type to which they belong. There is a Thirteenth (a banished Judas), equally *a priori* entitled to admission to the group, but which does not make its appearance among them, viz. b^4d. I rather believe that a similar phenomenon of one or more terms, whose presence might be expected, but which do not appear, presents itself in the allied invariantive theory, but cannot speak with certainty as to this point, as the circumstance has not received, and possibly does not merit, any very particular attention.

Still, in the case before us, this unexpected absence of a member of the family, whose appearance might have been looked for, made an impression on my mind, and even went to the extent of acting on my emotions. I began to think of it as a sort of lost Pleiad in an Algebraical Constellation, and in the end, brooding over the subject, my feelings found vent, or sought relief, in a rhymed effusion, a *jeu de sottise*, which, not without some apprehension of appearing singular or extravagant, I will venture to rehearse. It will at least serve as an interlude, and give some relief to the strain upon your attention before I proceed to make my final remarks on the general theory.

TO A MISSING MEMBER

Of a Family Group of Terms in an Algebraical Formula

Lone and discarded one! divorced by fate,
Far from thy wished-for fellows—whither art flown?
Where lingerest thou in thy bereaved estate,
Like some lost star, or buried meteor stone?
Thou mindst me much of that presumptuous one
Who loth, aught less than greatest, to be great,
From Heaven's immensity fell headlong down
To live forlorn, self-centred, desolate:
Or who, new Heraklid, hard exile bore,
Now buoyed by hope, now stretched on rack of fear,
Till throned Astræa, wafting to his ear
Words of dim portent through the Atlantic roar,
Bade him "the sanctuary of the Muse revere
And strew with flame the dust of Isis' shore."

Having now refreshed ourselves and bathed the tips of our fingers in the Pierian spring, let us turn back for a few brief moments to a light banquet of the reason, and entertain ourselves as a sort of after-course with some general reflections arising naturally out of the previous matter of my discourse. It seems to me that the discovery of reciprocants must awaken a feeling of surprise akin to that which was felt when the galvanic current astonished the world previously accustomed only to the phenomena of machine or frictional electricity. The new theory is a ganglionic one: it stands in immediate and central relation to almost every branch of pure mathematics—to Invariants, to Differential Equations, ordinary and partial, to Elliptic and Transcendental Functions, to Partitions of Numbers, to the Calculus of Variations, and above all to Geometry (alike of figures and of complexes), upon whose inmost recesses it throws a new and wholly unexpected light. The geometrical singularities which the present portion of the theory professes to discuss are in fact the distinguishing *features* of curves; their *technical* name, if applied to the human countenance, would lead us to call a man's eyes, ears, nose, lips, and chin his singularities; but these singularities make up the character and expression, and serve to distinguish one individual from another. And so it is with the so-called singularities of curves.

Comparing the system of ground-forms which it supplies with those of the allied theory, it seems to me clear that some common method, some yet undiscovered, deep-lying, Algebraical principle remains to be discovered, which shall in each case alike serve to demonstrate the finite number of these forms (these organic radicals) for any specified number of letters. The road to it, I believe, lies in the Algebraical Deduction of ground-forms from the Protomorphs.[1] Gordan's method of demonstration, so difficult and so complicated, requiring the devotion of a whole University semester to master, is inapplicable to reciprocants, which, as far as we can at present see, do not lend themselves to symbolic treatment.

How greatly must we feel indebted to our Cayley, who while he was, to say at least, the joint founder of the symbolic method, set the first, and out of England little if at all followed, example of using as an engine that mightiest instrument of research ever yet invented by the mind of man—a Partial Differential Equation, to define and generate invariantive forms.

With the growth of our knowledge, and higher views now taken of invariantive forms, the old nomenclature has not altogether kept pace, and is in one or two points in need of a reform not difficult to indicate. I think that we ought to give a general name—I propose that of Binariants—to every rational integral form which is nullified by the general operator

$$\lambda a d_b + \mu b d_c + \nu c d_d + \ldots .$$

where $\lambda, \mu, \nu, \ldots$ are arbitrary numbers.

This operator, I think, having regard to the way in which its segments link on to one another, may be called the Vermicular.

Binariants corresponding to unit values of $\lambda, \mu, \nu, \ldots$ may be termed standard binariants. Those for which these numbers are the terms of the natural arithmetical series $1, 2, 3, \ldots$ Invariantive binariants, which may be either complete or incomplete invariants; these latter are what are usually termed semi- or sub-invariants. I may presently have to speak of a third class of binariants for which the arbitrary multipliers are the numbers $3, 8, 15, 24 \ldots$ (the squares of the natural numbers each diminished by unity) which, if the theorem I have in view is supported by the event, will have to be termed Reciprocantive Binariants. But first let me call attention to what seems a breach of the asserted parallelism between the Invariantive and the Reciprocantive theories. In the former we have complete and incomplete invariants, but we have drawn no such distinction between one set of pure reciprocants and another. A parallel distinction does however exist.

If we use w, i, j to signify the weight, extent, and degree of an invariantive form, w is never less than the half product of ij; when equal to it the form is complete. In the case of reciprocants certain observed facts seem to indicate that there exists an analogous but less simple

[1] See the section on the Algebraical Deduction of the Ground-forms of the Quintic in my memoir on Subinvariants in the *American Journal of Mathematics*.

inequality. If this conjecture is verified it is not merely $\frac{ij}{2} - w$, but $\frac{ij}{2} - (j - 2) - w$, which is never negative: and when this is zero, the form may be said to be complete.[1] There would then be thus complete forms in each of the two theories; in the earlier one they take a special name: this is the only difference.

We have spoken of Pure Reciprocants as being either projective or non-projective, but so far have abstained from particularising the external characters by which the former may be distinguished from the latter. I have good reason to suspect that the former are distinguished from the latter by being Binariants; that, in addition to being subject to annihilation by the operator V, they are also subject to annihilation by the Vermicular operator when made special by the use of the numerical multipliers 3, 8, 15 . . . above alluded to, or in other words (as previously mentioned incidentally) are subject to satisfy two simultaneous partial differential equations instead of only one.[2] Projective Reciprocants we have seen are disguised or masked Ternary Covariants—Covariants in the grub, the first undeveloped state. Now ternary covariants are capable, it may or may not be generally known, of satisfying 6 reducible to 2 simultaneous Partial Differential Equations, and at first sight it might be surmised that nothing would be gained by the substitution of the two new for the two old simultaneous partial differential equations. But the fact is not so, for the old partial differential equations are perfectly unmanageable, or at least have never, as far as I know, been handled by any one, for they have to do with a *triangular heap*, whereas the new ones are solely concerned with a *linear series* of co-efficients.

I have alluded to there being a particular form common to the two theories. In the one theory it is the Mongian alluded to in the correspondence, which has been read, with M. Halphen. In the other it is the source of the skew covariant to the cubic. If the latter be subjected to a sort of MacMahonic numerical adjustment, it becomes absolutely identical with the former. Let us imagine that before the invention of Reciprocants an Algebraist happened to have had both forms present to his mind, and had thought of some contrivance for lowering the coefficients of the Mongian written out with the larger coefficients, and had thus stumbled upon this striking fact. It could not have failed to vehemently arouse his curiosity, and he would have set to work to discover, if possible, the cause of this coincidence. He would in all probability have addressed himself to the form which precedes the source alluded to in the natural order of genesis, and have applied a similar adjustment to the much simpler form, $ac - b^2$: having done so he would have tried to discover to what singularity it pointed—but his efforts to do so we know must have been fruitless, and he would have felt disposed to throw down his work in despair, for the intermediate ideas necessary to make out the parallelism would not have been present to his mind. So long as we confine ourselves to Differential Invariants, *i.e.* to projective pure reciprocants, we are like men walking on those elevated ridges, those more than Alpine summits, such as I am told[1] exist in Thibet, where it may be the labour of days for two men who can see and speak to each other to come together. Reciprocants supply the bridge to span the yawning ravine and to bring allied forms into direct proximity.

I have spoken of mixed reciprocants as being subject to satisfy not a linear partial differential equation, but one of a higher order dependent on the intensity, so to say, of its mixedness—the highest power, that is to say, of the first differential derivative which it contains, and it might therefore be supposed that these forms are much more difficult to be obtained than pure reciprocants. But the fact is just the reverse, for as I discovered in the very infancy of the inquiry, and have put on record in the September or October number of the *Mathematical Messenger*, mixed reciprocants may be evolved in unlimited profusion by the application of simple and explicit processes of multiplication and differentiation. From any reciprocant whatever, be it mixed or pure, new mixed ones may be educed infinitely infinite in number, inasmuch as at each stage of the process, arbitrary functions of the first differential derivative may be introduced.

The wonderful fertility of this method of generation excited warm interest on the part of one of the greatest of living mathematicians, the expression of which acted as a powerful incentive to me to continue the inquiry. They may be compared with the shower of December meteors shooting out in all directions and covering the heavens with their brilliant trains, all diverging from one or more fixed radiant-points, the radiant-point in the theory before us being the particular form selected to be operated upon.

The new doctrine which I have endeavoured thus imperfectly to adumbrate has taken its local rise in this University, where it has already attracted some votaries to its side, and will, I hope, eventually obtain the co-operation of many more. I have ventured with this view to announce it as the subject of a course of lectures during the ensuing term.

When I lately had the pleasure of attending the new Slade Professor's inaugural discourse, I heard him promise to make his pupils participators in his work by painting pictures in the presence of his class. I aspire to do more than this—not only to paint before the members of my class, but to induce them to take the palette and brush and contribute with their own hands to the work to be done upon the canvas. Such was the plan I followed at the Johns Hopkins University, during my connection with which I may have published scores of Mathematical articles and memoirs in the journals of America, England, France, and Germany, of which probably there was scarcely one which did not originate in the business of the class-room; in the composition of many or most of them I derived inestimable advantage from the suggestions or contributions of my auditors. It was frequently a chase, in which I started the fox, in which

1 If this should turn out to be true, the "crude generating fraction" for reciprocants would be almost identical with that of in- and co-variants of the same extent j. The denominators would be absolutely identical; as regards the numerators, while that for invariantive forms is $1 - a^{-1}x^{-2}$ the numerator for reciprocants would be $1 - a^{-2}x^{-2j}$. As I write abroad and from memory there is just a chance that the index of a here given may be erroneous.

2 As already stated in a previous footnote this conjecture is fully confirmed, my own proof having been corroborated (if it needed corroboration) by another entirely different one invented by M. Halphen, who fully shares my own astonishment at the fact of there being forms (half-horse, half alligator) at once reciprocants and sub-invariants, and as such satisfying two simultaneous partial differential equations.

If instead of denoting the successive differential derivatives (starting from the second $a, b, c, \ldots$ we call them $\frac{a}{1.2}, \frac{b}{1.2.3}, \frac{c}{1.2.3.4}, \ldots$ the two Annihilators will be

$$a\delta_b + 2b\delta_c + 3c\delta_d + 4d\delta_e + \ldots \text{ and}$$

$$4\frac{a^2}{2}\delta_b + 5ac\delta_c + 6(ad + bc)\delta_d + 7\left(ae + bd + \frac{c^2}{2}\right)\delta_e + \ldots$$

the latter being my new operator, the Reciprocator V, accommodated to the above-stated change of notation for the successive differential derivatives.

Hardly necessary is it for me to point out in explanation of the semi-sums $\frac{a^2}{2} \frac{c^2}{2}, \ldots$ that we may write the MacMahonised V under the form

$$4a^2\delta_b + 5(ac + ca)\delta_c + 6(ac + bc)\delta_d + 7(ac + bd + c^2 + db + ea)\delta_e + \ldots$$

It is to be presumed that in addition to mixed reciprocants (the ocean into which flows the sea of pure reciprocants, as into that again empties itself the river of projective reciprocants) there may exist a theory of forms in which y as well as $\frac{dy}{dx}$ will appear, or, so to say, doubly mixed reciprocants, the most general of all, in which case we must speak of the content of these as the ocean and of the others as sea, river, and brook. Curious is it to reflect that in the theory which as it exists comprises Invariantives, Reciprocants, and Invariantive Reciprocants or Reciprocant Invariantives, the order of discovery was (1) Invariantives (Eisenstein, Boole, &c.); (2) Invariantive Reciprocants (Monge and Halphen); (3) Reciprocants (Schwarz, the author of this lecture).

1 I think my informant was my friend Dr. Inglis, of the Athenæum Club, who some time ago undertook a journey in the Himalayas in the hopes of coming upon the traces of a lost religion which he thought he had reason to believe existed among mankind in the pre-Glacial period of the earth's history.

we all took a common interest, and in which it was a matter of eager emulation between my hearers and myself to try which could be first in at the death.

During the past period of my professorship here, imperfectly acquainted with the usages and needs of the University, I do not think that my labours have been directed so profitably as they might have been either as regards the prosecution of my own work or the good of my hearers: my attention has been distracted between theories waiting to be ushered into existence and providing for the daily bread of class-teaching. I hope that in future I may be able to bring these two objects into closer harmony and correlation, and think I shall best discharge my duty to the University by selecting for the material of my work in the class-room any subject on which my thoughts may, for the time being, happen to be concentrated, not too alien to, or remote from, that which I am appointed to teach; and thus, by example, give lessons in the difficult art of mathematical thinking and reasoning—how to follow out familiar suggestions of analogy till they broaden and deepen into a fertilising stream of thought—how to discover errors and to repair them, guided by faith in the existence and unity of that intellectual world which exists within us, and is at least as real as that with which we are environed.

The *American Mathematical Journal*, conducted under the auspices of the Johns Hopkins University, which has gained and retains a leading position among the most important of its class, whether measured by the value of its contents or the estimation in which it is held by the Mathematical world, bears as its motto—

πραγμάτων ἔλεγχος οὐ βλεπομένων.

I have the pleasure of seeing among my audience this day the most distinguished geometer of Holland, Prof. Schoute, who has done me the signal honour of coming over to England to be present at this lecture, who hospitably entertained me at Groningen (in a vacation visit which I recently paid to his country, the classic soil which has given birth to an Erasmus, a Grotius, a Boerhaave, a Spinoza, a Huyghens, and a Rembrandt), and who was kind enough, in proposing my health at a party where many of his colleagues were present, to say that he felt sure "that I should return to England cheered and invigorated, and would, ere long, light on some discovery which would excite the wonder of the Mathematical world."

I do not venture to affirm, nor to think, that this vaticination has been fulfilled in the terms in which it was uttered, but can most truly say that the discovery, which it has been my good fortune to be made the medium of revealing, has excited my own deepest feelings of ever-increasing wonder rising almost to awe, such as must have come over the revellers who saw the handwriting start out more and more plainly on the wall, or the *scienziati* crowding round the blurred palimpsest as they began to be able to decipher characters and piece together the sentences of the long lost and supposed irrecoverable *De Republicâ*.

When I was at Utrecht, on my way to Groningen, Mr. Grinwis, the Professor of Mathematics at that University, showed me an English book on "Differential Equations," which had just appeared, of which he spoke in high terms of praise, and said it contained over 800 examples. I wrote at once for the book to England, and on seeing it on my arrival, forgetting that it had been ordered, mistook it for a present from the author or publisher, and, what is unusual with me, read regularly into it, until I came to the section on Hyper-geometrical series, where the Schwarzian Derivative (so named by Cayley after Prof. Schwarz) is spoken of.

Perhaps I ought to blush to own that it was new to me, and my attention was riveted by the property it possesses, in common with the more simple form which points to inflexions on curves, of remaining substantially unaltered, of persisting as a factor at least of its altered self, when the variables which enter it are interchanged. Following out this indication, I at once asked myself the question, "ought there not to exist combinations of derivatives of *all* orders possessing this property of reciprocation?" That question was soon answered, and the universe of mixed reciprocants stood revealed before me. These mixed reciprocants, by simple processes of combination, led me to the discovery of the first pure reciprocant, $3b^2 - 5ac$: whereupon I again put the question to myself, "are there, or are there not, others of this form, and if so, what are they?"

In an unexpected manner the question was answered, and my curiosity gratified to the utmost by the discovery of the partial differential equation which is the central point of the theory, and at once discloses the parallelism between it and the familiar doctrine of Invariants. Two principal exponents of that doctrine, who have infused new blood into it, and given it a fresh point of departure—Capt. MacMahon and Mr. Hammond—I have the pleasure of seeing before me. Mr. Kempe, who is also present, has lately entered into and signally distinguished himself in the same field, availing himself in so doing of his profound insight into the subject of linkages, his interest in which I believe I may say received its first impulse from the lecture which he heard me deliver upon it at the Royal Institution in January 1874, on the very night when the Prime Minister for the time being sent round letters to his supporters announcing his intention to dissolve Parliament. Of the two events I have ever regarded the lecture as by far the more important to the permanent interests of society. He has lately applied ideas founded upon linkages to produce a most original and remarkable scheme for explaining the nature of the whole pure body of Mathematical truth, under whatever different forms it may be clothed, in a memoir which has been recommended to be printed in the *Transactions* of the Royal Society, and which, I think, cannot fail when published to excite the deepest interest alike in the Mathematical and the Philosophical worlds.[1]

I also feel greatly honoured by the presence of Prof. Greenhill, who will be known to many in this room from his remarkable contributions to the theory of Hydrodynamics and Vortex Motion, and who has sufficient candour and largeness of mind to be able to appreciate researches of a different character from those in which he has himself gained distinction.

I should not do justice to my feelings if I did not acknowledge my deep obligations to Mr. Hammond for the assistance which he has rendered me, not only in preparing this lecture which you have listened to with such exemplary patience, but in developing the theory; I am indebted to him for many valuable suggestions tending to enlarge its bounds, and believe have been saved, by my conversations with him, from falling into some serious errors of omission or oversight. Saving only our Cayley (who, though younger than myself, is my spiritual progenitor—who first opened my eyes and purged them of dross so that they could see and accept the higher mysteries of our common Mathematical faith), there is no one I can think of with whom I ever have conversed, from my intercourse with whom I have derived more benefit. It would be an immense gain to Science, and to the best interests of the University, if something could be done to bring such men as Mr. Hammond (and, let me add, Mr. Buckheim, who ought never to have been allowed to leave it) to come and live among us. I am sure that with their endeavours added to my own and those of that most able body of teachers and researchers with whom I have the good fortune to be associated—my brother Professors and the Tutorial Staff of the University—we

[1] In his memoir for the *Phil. Trans.* Mr. Kempe contends that any what ever mathematical proposition or research is capable of being represented by some sort of simple or compound linkage. One would like to know by what sort of linkage he would represent the substance of the memoir itself.

could create such a School of Mathematics as might go some way at least to revive the old scientific renown of Oxford, and to light such a candle in England as, with God's grace, should never be put out.[1]

TABLES OF SINGULARITIES AND FORMULÆ REFERRED TO IN THE PRECEDING LECTURE

CHART 1.

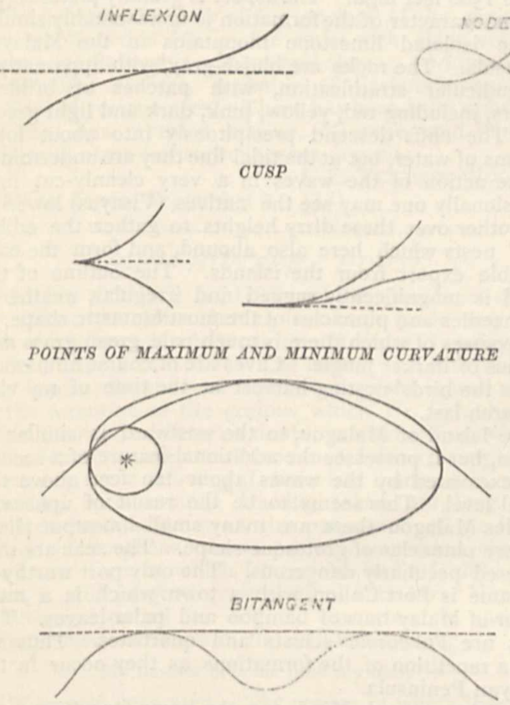

CHART 2.—PROTOMORPHS

Binariants	*Reciprocants*
a	a
$ac - b^2$	$3ac - 5b^2$
$a^2d - 3abc + 2b^3$	$9a^2d - 45abc + 40b^3$
$ae - 4bd + 3c^2$	$5a^2e - 35abd + 7ac^2 + 35b^2c$
$a^2f + 5abe + 2acd + 8b^2d - 6bc^2$	$45a^3f - 420a^2be - 42a^2cd + 1120ab^2d - 315abc^2 - 1120b^3c$
$ag - 6bf + 15ce - 10d^2$	$a^2g - 12abf - 450ace + 792b^2e + 588ade^2 - 2772bcd + 1925c^3$

CHART 3.

No. 1. a
No. 2. $3ae - 5b^2$
No. 3. $9a^2d - 45abc + 40b^3$
No. 4. $45a^3d^2 - 450a^2bc + 192a^2c^3 + 400ab^3d + 165ab^2c^2 - 400b^4c$

$$x = \int \frac{dt}{\sqrt{\kappa(1 - 15t^2 + 15t^4 - t^6) + \lambda(3t - 10t^3 + 3t^5)}} + \mu$$

$$y = \int \frac{tdt}{\sqrt{\kappa(1 - 15t^2 + 15t^4 - t^6) + \lambda(3t - 10t^3 + 3t^5)}} + \nu$$

$$V = 3a^2\delta_b + 10ab\delta_c + (15ac + 10b^2)\delta_d + (21ad + 35bc)\delta_e + (28ae + 56bd + 35c^2)\delta_f + \ldots$$

1 I have purposely confined myself in my lecture to reciprocants, indicatives of properties of plane curves, but had in view to extend the theory to the case of higher dimensions in space leading to reciprocants involving the differential derivatives of any number of variables $y, z, \ldots$ M. Halphen, with whom I have had the great advantage of being in communication during my stay in Paris, has anticipated me in this part of my plan, and has found that the same method which I have used to obtain the Annihilator V applied to a system of variables leads to an Annihilator of very similar form to V, and at my request will publish his results in a forthcoming number of the *Comptes rendus*. Thus the dominion of reciprocants is already extended over the whole range of forms unlimited in their own number as well as in that of the variables which they contain

CHART 4.—COEFFICIENTS OF ANNIHILATOR V

1	4	3			
1	5	10			
1	6	15	10		
1	7	21	35		
1	8	28	56	35	
1	9	36	84	126	
1	10	45	120	210	126

CHART 5.—RECIPROCANT TRANSFORMATIONS

Grub	*Chrysalis*			*Imago*		
$\frac{d^2y}{dx^2}$	$\frac{d^2\phi}{dx^2}$	$\frac{d^2\phi}{dxdy}$	$\frac{d\phi}{dx}$	$\frac{d^2\Phi}{dx^2}$	$\frac{d^2\Phi}{dxdy}$	$\frac{d^2\Phi}{dxdz}$
	$\frac{d^2\phi}{dxdy}$	$\frac{d^2\phi}{dy^2}$	$\frac{d\phi}{dy}$	$\frac{d^2\Phi}{dxdy}$	$\frac{d^2\Phi}{dy^2}$	$\frac{d^2\Phi}{dydz}$
	$\frac{d\phi}{dx}$	$\frac{d\phi}{dy}$	●	$\frac{d^2\Phi}{dxdz}$	$\frac{d^2\Phi}{dydz}$	$\frac{d^2\Phi}{dz^2}$
(*a*)		(*M*)			(*H*)	

$$(n-1)^2\left(\frac{d\phi}{dy}\right)^3 a + H + \left\{\frac{d^2\Phi}{dx^2}\cdot\frac{d^2\Phi}{dy^2} - \left(\frac{d^2\Phi}{dxdy}\right)^2\right\}\Phi = 0.$$

$\frac{dy}{dx}\frac{d^3y}{dx^3} - \frac{3}{2}\left(\frac{d^2y}{dx^2}\right)^2$ is the Schwarzian, otherwise written $tb - \frac{3a^2}{2}$.

CHART 6.—THE *H* RECIPROCANTIVE PROTOMORPH

U	*W*
$65a^4h$	$120a^3cf$
$-975a^3bg$	$-200a^2b^2f$
$-990a^3cf$	$-195a^2de$
$+6200a^2b^2f$	$-145a^2bce$
$+4690a^2bce$	$+1000ab^3e$
$-1540ab^3e$	$+1365a^2bd^2$
$-2730a^2bd^2$	$-777a^2c^2d$
$+7161a^2c^2d$	$-22260ab^2cd$
$+3080ab^2cd$	$+2485abc^3$
$-24255abc^3$	$+105b^3c^2$
$+25410b^3c^2$	

$$H + \Lambda U + MW$$

Λ and M are arbitrary numbers.

The Vermicular Operator

$$\lambda a\delta_b + \mu b\delta_c + \nu c\delta^d + \pi d\delta_e + \ldots$$

Examples

$$a\delta_b + b\delta_c + c\delta_d + d\delta_e + \ldots$$
$$a\delta_b + 2b\delta_c + 3c\delta_d + 4d\delta_e + \ldots$$
$$3a\delta_b + 8b\delta_c + 15c\delta_d + 24d\delta_e + \ldots$$

☞ b^4d does not appear in either U or W.

New College, Oxford, January 6

THE GEOLOGY OF MALAYSIA, SOUTHERN CHINA, &c.

THERE is a remarkable uniformity in the geology of a very large portion of Southern Asia and its dependent islands, especially from the Malay peninsula, as far east as the Philippines, and as far north as the Chinese continent. In the Malayan peninsula we have an elevated granitic axis. At the base of this there are Palæozoic schists and slates. Above these in a few places there are limestones in detached weathered masses. This limestone is often crystalline, white, blue, and black. In a few cases there are traces of stratification, but no fossils.

In a recent journey through Pahang I found precisely the same formations on the eastern side of the peninsula, with only this addition, that there is a belt of trachytic rocks of modern origin forming detached hills between the main range and the sea.

In Sumatra I learn that there are the same formations from the granite upwards. I cannot confirm this from personal observation, as I have travelled very little in the island. The mountain axis is far from the Straits of Malacca, and difficult of access. As far as I can judge from the geology of such large islands as Bilitou, Bintang, and Banca, the mountains are probably granitic and stanniferous.

Proceeding eastward and northerly, detached granite islands are met with. They are thickly strewn through the intermediate ocean. Those I have seen, such as the north and south Natunas, and other similar outliers, on voyages between Java, Singapore, Borneo, China, Cochin

China, and Siam, are all granitic, with a few Palæozoic slates and schists. To the eastward of the Malay peninsula a few limestone islands are seen, and they are similar in character to the calcareous rocks of the mainland.

It is perhaps needless to draw attention to the extraordinary number of these outliers. They do not show well on a map, as most of them are so very small, but those who travel in these regions can well understand why the early Arabian voyagers called this "the sea of the twelve thousand islands." Granite is the prevailing rock, but I have little doubt that modern trap-rocks form some of the islands. But there is no active volcano amongst them. The nearest point for such phenomena is said to be Formosa, but I think this doubtful. Yet, proceeding north from this large island, along the chain which connects it in an almost unbroken series through the Meiaco group, Liu Kiu and Linschoten Islands, to Japan, we find two active volcanoes (Naka Sima and Sawa Sima, the latter 3400 feet high), which seem to point to a line of disturbance, of which Formosa is a portion.

When we come to Borneo we find the first extensive development of stratified rocks. Though outliers of granite are met occasionally, it is evident that there is a great change in the geology of the coast. I shall confine my observations to what I saw. From Brunei northwards we meet with carbonaceous rocks, brown and yellow sandstones and shales with intercalated grits and conglomerates. The dip varies: sometimes slight, or nearly horizontal, showing but trifling disturbance in this part of the world. It seemed to me as if these carbonaceous rocks were of different ages. Those which line the Brunei River are much older-looking than those of Labuan. At Gaya, and again at Kudat, at the north extremity of Borneo, I saw brownish-yellow sandstones with shales and small seams of coal. The appearance of these beds reminded me much of the Mesozoic carbonaceous rocks of Queensland and New South Wales. At Sandakan or Elopura (North-East Borneo) the present capital of the North Borneo Settlement, there are high cliffs of red and yellow sandstone, which look older than anything I saw on the north or north-eastern coast. Over 600 feet are exposed in one cliff, with no signs of any carboniferous strata.

While at Sandakan I met the Governor's private secretary (Mr. D. D. Daly), who had just returned from a journey of exploration on the Kinebetungen River. He brought down many samples of good coal, besides tin and gold. Amongst the collection were some limestones very like the rocks I had seen in the Malay peninsula. These also form detached mountains. There are fine caves, I am informed, over 600 feet high, and in them are found some of the best kinds of edible birds' nests. Amid the fragments of limestone I recognised a Fenestella and a Stenopora. If this rock is of the same formation as the limestone outliers of the whole of Malaysia, then its age may be for the present considered as Palæozoic, and probably between Devonian and Carboniferous.

After visiting some islands of the Sooloo Archipelago (all volcanic) I went to the Philippines. At Luzon, Mindoro, and some of the larger members of the group, the rocks are principally volcanic. But it would be an error to regard them as exclusively so. There are some areas of stratified rocks with coral and other marine fossils, which are of probably Miocene and Pliocene age. In Mindanao there is gold. I obtained a few fossils from the Miocene beds of the latter island. They were all Foraminifera in a loose friable limestone, including *Orbulina universa*, D'Orb., *Globigerina biloba*, *triloba*, and *bulloides*, D'Orb., *Cristellaria italica*, D'Orb., *Pulvinulina Haueri*, D'Orb., *Rotlaia simplex*, D'Orb., and some others belonging to about twenty different genera. The same species are found in Luzon, and the beds are considered Eocene by Kusrer (see *Boletin de la Carta Geol. del. España*, vol. vii.).

One of the most interesting portions of the Philippines is the Calamianes group, a small cluster of islands a short distance south and west of Mindoro. Here we find repeated the main geological features of the Malayan peninsula, with the addition of recent volcanic emanations. To the east of Busuanga (the largest of the group) is the Island of Coron, which presents to the sea a magnificent rampart of limestone cliffs and pinnacles from 600 to 1500 feet high. The aspect is grandly picturesque, but the character of the formation is unmistakably similar to the isolated limestone mountains in the Malayan Peninsula. The rocks are bluish-gray, with apparently a perpendicular stratification, with patches of brilliant colours, including red, yellow, pink, dark and light green, &c. The cliffs descend precipitously into about forty fathoms of water, but at the tidal line they are undermined by the action of the waves in a very cleanly-cut line. Occasionally one may see the natives (Visayas) lowering each other over these dizzy heights to gather the edible birds' nests which here also abound, and form the only valuable export from the islands. The outline of the island is magnificently rugged and irregular, weathered into needles and pinnacles of the most fantastic shape, in the recesses of which there is much pale green grass and patches of darker jungle. Caves are of course numerous. It was the birds'-nesting harvest at the time of my visit in March last.

The Island of Malagou, to the westward is similar to Culion, but it possesses the additional feature of a second line excavated by the waves about ten feet above the actual level. This seems to be the result of upheaval. Besides Malagou there are many small limestone islets, or mere pinnacles of grotesque shape. The seas are thus rendered peculiarly dangerous. The only port worthy of the name is Port Culion, with a town which is a mere cluster of Malay huts of bamboo and palm-leaves. The rocks are Palæozoic schists and quartzites. Thus we have a repetition of the formations as they occur in the Malayan Peninsula.

At Palawan and Mindanao the same formations are stated to occur. Of Mindanao there can be no doubt, but of Palawan little is known, and I have only seen the coast at a distance.

There is a continuance of the same geological features in South China, at least from those portions of the coast which I have seen between Macao and Swatow. At Hong Kong we have granite, ancient trap-rocks, felsites, and detached outliers of limestone exactly like the Palæozoic deposits all through the Eastern Archipelago. From the Canton River the same rocks have been seen by me together with well-marked Palæozoic fossils of carboniferous type (*Spirifer* especially).

I have never succeeded in getting away from the alluvial deposits of the great rivers of Cochin China. Just now the time could not be more unfavourable for any kind of exploration, but I believe the French are not neglecting the geology of the country.

Coal is extensively distributed in all the northern portions of the countries I have been describing. It is found in South China abundantly, Formosa, Tonquin, the Philippines, Japan, and Borneo, and I believe I have seen indications of a carbonaceous deposit in the Malay Peninsula.

Of the coals in South China little more is known than that they are abundant and of good quality. From the fossils I have seen they are probably of Palæozoic age. The Formosa coals are so bad that they have ceased to be worked or at least offered in the Hong Kong market. I know nothing of their age nor of the quality and age of the coals of Tonquin. The coals of the Philippines belong most probably to the Borneo older series. They are found on the south of Luzon and south of Zebu since 1827. More recently they have been found in the province of Albay (south-east of Manilla) and in Panay.

Samples from the latter mines were tried by the P. and O. Company with good results. The Japan coals are certainly Tertiary and most probably Miocene. Though brittle, they make such good steam coals that they are preferred to every other except Cardiff coal. Borneo is a mass of coal, and, as I believe, of very different ages. Those of Labuan were said to be Tertiary; those of Brunei look much older. But I question the Tertiary age of the Labuan beds.

The general character of the geology of the regions I have mentioned is (1) Granite rocks with older volcanic dykes; (2) Palæozoic schists and slates; (3) Limestones in detached outliers, probably of Carboniferous age; (4) Coal of various ages. There has been little upheaval, and that has revealed marine, Miocene, and Pliocene beds, with some few carbonaceous deposits.

J. E. TENISON-WOODS

Osaka, Japan, September 24, 1885

JOHN HUNTER'S HOUSE

EARL'S COURT HOUSE, once the residence of the illustrious John Hunter, has been made very properly the subject of a letter in the *Times* of Tuesday last, by Dr. Farquharson, M.P. The house, with which I have been familiar for the past twenty-two years, is well worth all the attention of the curious which Dr. Farquharson claims for it. It differs, no doubt, somewhat from what it was in Hunter's time, but not so much, I think, as my friend supposes; for a drawing I have had made of it, when compared with another drawing taken not long after Hunter's death, and now in the possession of the Royal College of Surgeons, shows no very important change. The Lions' Den, of which I have also had a faithful copy taken, is still in good preservation, and Mrs. Hunter's boudoir retains all its original character, as she, the accomplished authoress of the well-known song,—

"My mother bids me bind my hair,"—

had it herself decorated. The copper in which the Irish giant was boiled down is in good order, and stands in an outhouse in the same place in which it stood when the giant, in piecemeal, found his way into it. In 1850 the late distinguished scholar, Dr. Robert Willis, of Barnes, took me to Kensington to see a man who remembered John Hunter. He was the son of Hunter's gardener, and was ten years of age at the time of Hunter's death in 1793. This man related some curious anecdotes of the great anatomist. One of these had reference to his presence of mind. One day as Hunter was entering his garden by the field at the back, still a field, one of the lions had got loose from its den. From the house the people called out to Hunter to get out of the way into a place of safety. Instead of this he took his handkerchief from his pocket, and marching boldly up to the lion, flipped it back into the den, and securely shut it in.

That Hunter conducted dissections in this place is clear from the remains that have been dug up in the garden. I examined a number of bones that were thus unearthed by the late occupier during some improvements which were going on about fifteen years ago. The bones showed some sections and re-sections of so curious and skilful a kind, that I asked and obtained permission to retain a few of them.

Upon the death of John Hunter, Earl's Court, held for a time by Mrs. Hunter, and by more than one future occupier, was turned into an asylum for ladies under restraint for lunacy, was held for many years as that by the Misses Bonney, and got the general name of "Miss Bonney's House" or Asylum. In 1864 it passed, still as an asylum, into the possession of my late friend Dr. Gardner Hill, who played so great a part as the practical pioneer of the system of the treatment of the insane without restraint. Dr. Hill continued to reside in the house till his death, by apoplexy, a few years ago, and his family have held it since his death up to the close of the past year, when they left it on the expiration of their lease. The fate of the house will almost certainly be its absorption, with its grounds, into a square or a series of streets, so that nothing will remain of it beyond the views which I and others who are given to antiquarian research may have taken of it, and at my instance Mr. Gardner has added several views to his magnificent collection of London. The memory of the place is thus secured for the future at least. But I agree with my learned brother Farquharson that the copper ought to go to the Hunterian Museum, to join the giant who is already so conspicuous and famous there.

BENJAMIN WARD RICHARDSON

NOTES

AN American Pasteur Institute has been incorporated in New York, its declared objects being the study and treatment of rabies and diseases susceptible of inoculation.

THE Rev. Thomas John Main, formerly Fellow of St. John's College, Cambridge, and a chaplain in the Royal Navy, died on the 28th ult. Mr. Main took his Bachelor's degree at St. John's College in 1838, as Senior Wrangler and first Smith's Prizeman, and proceeded M.A. in due course. He was for a period of thirty-four years Professor of Mathematics at the Royal Naval College at Portsmouth. Mr. Main was the author of various works on the marine steam-engine.

THE death is announced from St. Petersburg of Prof. Zakharow, of the University there, an eminent Orientalist. Nearly thirty years ago he went to China as a Russian missionary, and after General Ignatieff's Treaty of Pekin in 1860, he was employed, on account of his knowledge of Chinese and Manchu, in the work of delimiting the frontier created by that treaty. He then prepared a large map of this region, of which only one copy has been made, which is at present in the Russian Topographical Department. He also compiled a Manchu-Russian dictionary, published in 1875, and a Chinese-Manchu-Russian dictionary was almost completed at the time of his death. On his return to Europe he was appointed Professor of Manchu in the University of St. Petersburg, and in addition to his dictionaries compiled also a grammar of that language, which is now dying out in China, as the Manchus are a mere handful in the midst of the Chinese Empire, and are gradually losing their special tongue. Manchu is, however, still used at Chinese Court ceremonials, and in officially addressing the Emperor of China in person. M. Zakharow's great works have therefore a special value.

THE Association for the Improvement of Geometrical Teaching will hold its annual general meeting on Friday, January 15, at 11.30 a.m., at University College, Gower Street. At the afternoon meeting (2 p.m.) the President (R. B. Hayward, F.R.S.) will give an address on the Correlation of the Different Branches of Elementary Mathematics. A discussion will follow the reading of the address. Persons interested in the objects of the Association or in the subject of the address are cordially invited to attend.

THE Prince of Wales having expressed his desire that specimens of Australian fish might be exhibited in the Aquarium which will be opened in connection with the forthcoming Indian and Colonial Exhibition, the Trustees of the Melbourne Exhibition Building have given the matter their consideration, with a view of determining if specimens of therarer varieties could be sent from the Melbourne Aquarium. It has, however, been found that very great cost would be incurred in sending anything like an adequate supply of fish, and the project has therefore been abandoned. It has been decided instead to forward for exhibition in the Victorian Court upwards of 100 water-colour drawings of the fishes of the colony, which have been executed to the order of the Trustees by a competent artist, and which, it is hoped, will be of interest to ichthyologists and others. It is also the intention of the Trustees to request the Government to assist them in the production of a descriptive work on Victorian fishes, the illustrations of which will be taken from these drawings. Prof. M'Coy has promised his assistance, and Mr. J. E. Sharrard, the Secretary to the Trustees, is already engaged in collecting materials for the work.

It is announced that the seventh Congress of Orientalists will be held at Vienna in September next. The sittings will take place in the lecture-hall of the new University. It is hoped that the Archduke Rénier will act as honorary president.

Among the additional lectures announced at the Society of Arts are:—"The Experiments with Lighthouse Illuminants at the South Foreland," by E. Price Edwards; "Magnetism of Ships and the Mariner's Compass," by Mr. W. Bottomley, jun.; "Photography and the Spectroscope in their Application to Chemical Analysis," by Prof. W. N. Hartley; "The Scientific Development of the Coal-Tar Industry," by Prof. R. Meldola.

Reports reached London on Tuesday that a severe shock of earthquake was felt on Monday morning at 10.20, all along the route between Dartmouth and Kingsbridge, Devonshire, as well as at other places lying more inland. Just after leaving Dartmouth the driver of an omnibus which runs daily to and from Kingsbridge experienced an oscillation of the ground, which lasted some seconds. On arriving at Stoke Fleming a number of persons stated that they felt the shock. A house at Stokepenny is stated to have "rocked." In the "Green Dragon" public-house the shock caused a quantity of plaster to fall down from the ceilings. At Street the oscillation was similarly felt. At Blackawton the shock is reported to have been very conspicuously felt. It appears, however, to have been most severe at Torcross. The occupants of the "Fisherman's Arms" public-house, which stands on the beach, were so frightened that they rushed out of the place, thinking, as they said, that the building was going to fall. Mr. T. R. Vickary, of the Torcross Hotel, gives several particulars of the severity of the shock. It appears to have been felt by almost every one in the village. At Stoneham, Chillington, and Frogmore the oscillation was also experienced.

A slight shock of earthquake, lasting seven seconds, was felt in Venice at 11 o'clock on the night of the 29th ult. No damage was done.

The volcano of Colima, on the Pacific coast of Mexico, exhibited a violent eruption on the 27th ult., which caused great alarm. The streams of lava completely covered the sides of the mountain. At the date of the last report flames were still darting from the crater, and clouds of smoke overhung the summit.

Mr. Blanford's theory of the winter rains of Northern India, based on a study of the meteorological registers, is as follows:—We have, he says, in the first instance, steady evaporation over an extensive moderately humid tract, at a comparatively low temperature, it is true, but in an atmosphere the stillness of which allows of the steady diffusion of the vapour to high levels, and the consequent formation of cloud. The slight disturbance of the baric equilibrium which follows (since the vertical decrease of temperature in a cloud-laden atmosphere is slower than in a clear atmosphere) is succeeded by a gentle indraught of warmer and more humid air from the south; for the Himalaya bars access to northerly winds. A vortex is then rapidly formed, accompanied with an increased cloud-formation, and speedily followed by precipitation, which takes the form of snow on the hills, and of rain over the river plains. The rainfall is invariably followed by a cool wind, and a wave of high barometric pressure from the west, which Mr. Blanford attributes to a drainage of cool heavy air from the valleys of the hills surrounding the Punjaub and the high lands of Beloochistan and Afghanistan—air cooled by precipitation on the mountains. If this theory be correct, the stillness of the atmosphere, combined with the presence of a moderate evaporation, must be accepted as the condition which primarily determines the formation of barometric minima and the winter rains of Northern India. As this stillness is due to the presence of lofty mountain-ranges in the north, it follows that, if the Himalayan chain were absent, these rains would probably cease, for any local evaporation in the Punjaub and the valley of the Ganges would be swept away by strong dry north-east winds blowing from the seat of high pressure, which in the winter months lies in Central Asia.

The electric lighting of the French Opera House is almost complete. The number of incandescent lights is 3000.

M. Joubert, the director of the Trocadéro popular Observatory, has made arrangements with the several telegraphic stations in Paris, so that the public may be warned when the sky is deemed sufficiently clear for conducting observations and demonstrations.

Messrs. Swan Sonnenschein and Co. announce for early publication a Pocket Handbook to the Flora of the Alps, specially adapted for botanical tourists, and edited by Mr. A. W. Bennett.

According to the Report for the past year of the Superintendent of the Royal Botanic Garden at Calcutta, further attempts to introduce into Bengal the kind of plantain (*Musa textilis*) from which Manilla hemp is derived have proved failures, owing to the low temperature of the cold weather; but the plant (*Sanseviera Zeylanica*) from which bow-string hemp is obtained grows very well. The Japan paper-mulberry, which has lately been introduced, has also been a success. Efforts are being made to introduce other plants of economic value, the principal being the coca plant, from which the important alkaloid cocaine is derived. The additions to the herbarium during the year appear to have been unusually large and comprehensive. As an example of the public utility of the Garden, it may be mentioned that 23,433 living plants were distributed to public institutions in India, while those sent abroad were proportionally numerous. In the same way 2,979 packets of seeds were sent out. The Report of the Lloyd Botanic Garden in Darjeeling is also included in the paper, which concludes with the usual statistical returns. We are glad to notice at the end a copy of a resolution conveying the thanks of the Lieutenant-Governor of Bengal to those concerned in administering the Gardens.

We have received the numbers of the *Journal* of the Asiatic Society of Bengal (Science Section) for 1885, so far as they have been published. They contain in all eleven papers, some being continuations of papers previously published. Mr. Lionel de Nicéville contributes a fourth list of butterflies taken at Sikkim in October 1884, with notes. The number of species already recorded was 284, which is now raised to 313, or about twice the number of species found throughout the year in Calcutta; but even this number does not exhaust the region, for some valleys and the higher elevations were not explored. The same writer describes some new Indian *Rhopalocera*, and also a list of the butterflies of Calcutta and its neighbourhood, with notes on their habits, food-plants, &c. Mr. Atkinson publishes the second and third instalment of his notes on Indian

Rhynchota. Dr. Giles, the Surgeon-Naturalist to the Indian Marine Survey, writes on the structure and habits of *Cyrtophium calamicola*, a new tubicolous amphipod from the Bay of Bengal, a description of a new species of the amphipod genus *Melita* from the same place, and notes on Prothallus of *Padina pavonia*. These three form part of the Natural History Notes of the Indian Marine Survey steamer *Investigator.* Commander Alfred Carpenter, of the same steamer, under the title "The Swatch of no Ground," explains the presence in the deltaic banks ("the-Swatch") off the mouths of the Ganges and the Brahmaputra of channels of great depth. Mr. Hill, the Meteorological Reporter to the North-Western Provinces and Oudh, contributes observations on the solar thermometer at Lucknow, while last of all comes a paper from Japan. Dr. O. F. von Möllendorff (not to be confounded with his brother of recent Corean fame) writes on Japanese land- and freshwater-mollusks, a series of notes based chiefly on a collection made by Dr. John Anderson during the year 1884, and sent to the writer for classification.

We are glad to learn that Prof. Morse, Director of the Peabody Academy of Science, has in the press a work entitled "Japanese Homes and their Surroundings." Prof. Morse, it may be remembered, was Professor of Zoology in the University of Tokio, and his prehistoric discoveries in Japan formed one of the earliest of the publications of that institution. The publishers of the work, which will contain numerous illustrations by the author, are Messrs. Ticknor and Co. of Boston.

At a meeting of the Seismological Society of Tokio held on November 18, 1885, in the University there, Prof. Shida described an instrument which he had designed to give an automatic record of earth-currents. The chief feature in it is an ingenious method of obtaining a record of the position of the coil or needle which indicated the current which might be passing through the instrument. This was accomplished by the needle, as it turned, making a series of almost frictionless electrical contacts between a series of metallic points and a film of liquid. The instrument has been practically worked, and is said to have yielded satisfactory records. A second paper by the same writer gave a history of all the facts with which we are acquainted respecting the phenomena of earth-currents. A considerable portion of the material embodied in the paper was derived from Prof. Shida's own observations on the lines and cables of this country. He made numerous references to instances where earth-currents of unusual magnitude had accompanied or preceded earthquakes. Many theories have been advanced to account for these phenomena, and it has been demonstrated by several investigations that they have a connection with the occurrence of sunspots. In the discussion which followed, Prof. Knott referred to the possibility of these disturbances being due to the inductive action of electrified bodies of air, while Prof. Milne added to the instances adduced by Prof. Shida of the simultaneous occurrence of earthquakes and earth-currents. Earthquakes occurring in America have, by the currents which had accompanied them, recorded themselves in Europe.

The Japanese do not appear to have lost any of their faith in the efficacy of vaccination for the small-pox. They have just enacted a very stringent law on the subject, for, besides ordinary vaccination in the first year of infancy, it provides for at least two subsequent re-vaccinations at intervals of from five to seven years, so that by the time a child has reached its fifteenth year it will have been vaccinated three times. Besides, during epidemics of small-pox, local authorities have power, when they deem it necessary, to order the vaccination of all the inhabitants of their districts, irrespective of the vaccinations required by the law.

We are informed that it is not the case that Dr. Sklarek has arranged to edit a new scientific journal to be published in Brunswick.

The additions to the Zoological Society's Gardens during the past week include a Macaque Monkey (*Macacus cynomolgus* ♀) from India, presented by Mr. T. W. Hall; a Sooty Mangabey (*Cercocebus fuliginosus* ♀) from West Africa, presented by Mr. T. Riseby Griffith; a Common Badger (*Meles taxus*), British, presented by Mr. Charles E. Russell; a Siamese Blue Pie (*Urocissa magnirostris*) from Siam, a Chinese Jay Thrush (*Garrulus chinensis*) from China, a Brazilian Hangnest (*Icterus jamaicai*) from Brazil, presented by Mr. Charles Clifton, F.Z.S.; an Alexandrine Parrakeet (*Palæornis alexandri*) from India, presented by Mr. C. Kerry Nicholls, F.Z.S.; a Ring-necked Parrakeet (*Palæornis torquatus*) from India, presented by Miss Shackthwaite; a Larger Hill-Mynah (*Gracula intermedia*) from India, presented by Miss G. Lampard; a Greater Spotted Woodpecker (*Dendrocopus major*), British, presented by Mr. A. S. Hutchinson; a Scops Owl (*Scops giu*), British, presented by Mr. J. H. Leech, F.Z.S.; a Caracal (*Felis caracal*), a Puff Adder (*Vipera arietans*), three Horned Vipers (*Vipera cornuta*), an African Cobra (*Naia haje*), a Hyghian Snake (*Elaps hygiæ*), a Smooth-bellied Snake (*Homolosoma lutrix*), two Rhomb-marked Snakes (*Psammophylax rhombeatus*) from South Africa, presented by the Rev. G. H. R. Fisk, C.M.Z.S.; twelve Quails (*Coturnix communis*) from South Africa, presented by Capt. M. P. Webster; a Leopard (*Felis pardus*) from India, five Mauge's Dasyures (*Dasyurus maugæi*), a White-backed Piping Crow (*Gymnorhina leuconota*) from Australia, deposited; a Virginian Opossum (*Didelphys virginiana*) from North America, purchased; a Collared Fruit Bat (*Cynonycteris collaris*), born in the Gardens.

OUR ASTRONOMICAL COLUMN

Discovery of a New Nebula by Photography.—MM. Paul and Prosper Henry have recently announced the discovery by means of photography of a new nebula in the Pleiades. It was first photographed on November 16 last, and, though it was again photographed on December 8 and 9, MM. Henry have as yet been unable to detect it by direct telescopic observation. The nebula is about 3′ in extent, and "très-intense." It presents a well-marked spiral form, and seems just to escape Maia. Its position is as follows:—R.A. 3h. 38m. 57s., Decl. 24° 1′ N.

Gore's Nova Orionis.—M. C. Wolf, who has examined the spectrum of this star, finds that the impression of the presence of bright lines which a first glance produces is not confirmed when the spectrum is more carefully examined under a high dispersion. The spectrum is simply that of the well-known third type, viz. a continuous spectrum crossed by a succession of bands, which terminate towards the violet in a very dark and sharp edge, and which gradually shade away towards the red. M. Wolf further believes that he was able, in the moments of best definition, to resolve the dark bands into lines. The Nova therefore does not appear to resemble the so-called "temporary" stars, but to be simply a variable of the same class as Mira Ceti. Prof. Millosevich gives its exact position for 1885·0 as follows:—R.A. 5h. 48m. 59·59s., Decl. 20° 9′ 13″·2 N.; or 1m. 25·21s. *f* and 5′ 59″·14 *s* of χ' Cygni. It is almost precisely due north of α Orionis, and distant from it 12° 46′ 20″.

The Astronomical Prizes of the Paris Academy of Sciences.—The Lalande Prize of the Académie des Sciences has been decreed to M. Thollon for his great map of the solar spectrum. This map, which has so far demanded four years of uninterrupted work, extends from *A* to *b*, and contains 3200 lines, 900 of which M. Thollon has been able to identify as of telluric origin. The Damoiseau Prize is reserved, no memoir having been offered for it. The subject proposed is the same as in former years: a revision of the theory of the satellites of Jupiter; a discussion of observations with special reference to the direct determination of the velocity of light; and lastly, the construction of particular tables for each satellite. The Valz Prize has been awarded to Dr. Spörer for his researches on sunspots,—his discovery of the striking relationship between the distribution of the spots in latitude and the epochs of their maxima and minima receiving especial notice.

FABRY'S COMET.—The following ephemeris from elements he has recently computed is given by Dr. S. Oppenheim in the *Astr. Nach.*, No. 2702:—

Ephemeris for Berlin Midnight

1886	App. R.A. h. m. s.	App. Decl. ° ′ ″	Log. Δ	Log. r	Brightness.
Jan. 9 ...	23 36 33 ...	21 12 51 ...	0·2478 ...	0·2523 ...	1·40
11 ...	35 0 ...	20 38			
13 ...	33 35 ...	29 19 ...	0·2514 ...	0·2382 ...	1·47
15 ...	32 16 ...	38 54			
17 ...	31 4 ...	49 23 ...	0·2543 ...	0·2236 ...	1·55

BARNARD'S COMET.—Dr. J. von Hepperger has computed the following parabolic and elliptic elements for this comet:—

	Parabola		Ellipse
T	1886 May 6·2586	...	1886 May 4·5165
	° ′ ″		° ′ ″
ω	118 57 9·9	...	121 41 24·9
☊	67 42 52·2	...	68 37 19·7
i	87 24 30·0	...	82 51 6·2
log q	9·695574	...	9·665966
log a		...	1·336444
log e		...	9·990625

Error of the middle place (O − C).

$$d\lambda = -2''\cdot4 \qquad d\lambda = +4''\cdot8$$
$$d\beta = -3''\cdot9 \qquad d\beta = +1''\cdot9$$

The following ephemeris is by Dr. A. Krueger:—

Ephemeris for Berlin Midnight

1886	App. R.A. h. m. s.	App. Decl. ° ′	Log Δ	Log r
Jan. 9 ...	2 53 7 ...	+ 9 41·1 ...	0·3497 ...	0·2112
11 ...	49 7 ...	10 2·7		
13 ...	45 16 ...	10 24·8 ...	0·3383 ..	0·2131
15 ...	41 34 ...	10 47·3		
17 ...	38 2 ...	11 10·2 ...	0·3265 ...	0·2155

ASTRONOMICAL PHENOMENA FOR THE WEEK 1886 *JANUARY* 10-16

(FOR the reckoning of time the civil day, commencing at Greenwich mean midnight, counting the hours on to 24, is here employed.)

At Greenwich on January 10

Sun rises, 8h. 5m.; souths, 12h. 7m. 51·1s.; sets, 16h. 11m.; decl. on meridian, 21° 55′ S.: Sidereal Time at Sunset, 23h. 31m.

Moon (at First Quarter on Jan. 13) rises, 10h. 17m.; souths, 15h. 56m.; sets, 21h. 45m.; decl. on meridian, 4° 41′ S.

Planet	Rises h. m.	Souths h. m.	Sets h. m.	Decl. on meridian ° ′
Mercury ...	6 25 ...	10 27 ...	14 29 ...	22 0 S.
Venus ...	9 41 ...	14 55 ...	20 9 ...	9 43 S.
Mars ...	21 53* ...	4 24 ...	10 55 ...	5 21 N.
Jupiter ...	23 7* ...	5 5 ...	11 3 ...	1 5 S.
Saturn ...	14 44 ...	22 54 ...	7 4* ...	22 35 N.

* Indicates that the rising is that of the preceding evening and the setting that of the following morning.

Occultations of Stars by the Moon

Jan.	Star	Mag.	Disap. h. m.	Reap. h. m.	Corresponding angles from vertex to right for inverted image ° °
14 ...	B.A.C. 830	... 6	... 19 9	.. 20 11	... 75 343
16 ...	θ^1 Tauri ...	... 4½	... 15 56	... 16 58	... 66 244
16 ...	θ^2 Tauri ...	... 4½	... 15 58	... 16 56	... 45 264
16 ...	75 Tauri ...	... 6	... 16 33	near approach	155 —
16 ...	B.A.C. 1391	... 5	... 16 58	... 17 57	... 93 224
16 ...	80 Tauri ...	... 6	... 17 5	near approach	337 —
16 ...	81 Tauri ...	... 5½	... 17 20	near approach	338 —
16 ...	85 Tauri ...	... 6	... 17 55	near approach	340 —
16 ...	Aldebaran	... 1	... 19 48	... 20 49	... 122 248

Phenomena of Jupiter's Satellites

Jan.	h. m.		Jan.	h. m.	
11 ...	4 4	II. ecl. disap.	14 ...	23 53	I. ecl. disap.
13 ...	1 29	II. tr. ing.	15 ...	3 16	I. occ. reap.
13 ...	4 15	II. tr. egr.	16 ...	0 25	I. tr. egr.
13 ...	5 24	I. ecl. disap.	16 ...	4 59	III. tr. ing.
14 ...	3 42	I. tr. ing.	16 ...	7 45	III. tr. egr.
14 ...	5 57	I. tr. egr.			

The Occultations of Stars and Phenomena of Jupiter's Satellites are such as are visible at Greenwich. Attention may be drawn to the Occultations occurring on the evening of January 16, and especially to that of Aldebaran.

Jan.	h.	
10 ...	12 ...	Saturn in conjunction with μ Geminorum and less than 1′ north of that star.
13 ...	— ...	Venus at her point of greatest evening brilliancy.

Variable-Stars

Star	R.A. h. m.	Decl. ° ′		h. m.
U Cephei	0 52·2 ...	81 16 N. ...	Jan. 13,	0 24 *m*
Algol	3 0·8 ...	40 31 N. ...	,, 14,	2 22 *m*
			,, 16,	23 11 *m*
T Monocerotis ...	6 19·1 ...	7 9 N. ...	,, 15,	17 0 *m*
ζ Geminorum ...	6 57·4 ...	20 44 N. ...	,, 13,	2 30 *M*
U Monocerotis ...	7 25·4 ...	9 32 S. ...	,, 10,	*m*
δ Libræ	14 54·9 ...	8 4 S. ...	,, 12,	17 47 *m*
			,, 15,	1 38 *m*
U Coronæ	15 13·6 ...	32 4 N. ...	,, 13,	1 24 *m*
U Ophiuchi... ...	17 10·8 ...	1 20 N. ...	,, 11,	1 39 *m*
			,, 11,	21 47 *m*
		and at intervals of		20 8
R Lyræ	18 51·9 ...	43 48 N. ...	Jan. 10,	*M*
η Aquilæ	19 46·7 ...	0 43 N. ...	,, 12,	5 0 *M*
δ Cephei	22 24·9 ...	57 50 N. ...	,, 12,	2 30 *m*
			,, 13,	17 0 *M*

M signifies maximum; *m* minimum.

Meteor Showers

The cloudy weather generally prevailing at this season of the year greatly interferes with meteor-observation, but a number of fairly active radiants have been observed, the following amongst others:—From the constellation of the Lynx, R.A. 104°, Decl. 53° N.; from Coma Beren, R.A. 181°, Decl. 35° N.; from near χ Cygni, R.A. 295°, Decl. 53° N. Large meteors should be looked for on January 15, 16, and 17.

STANDARDS OF WHITE LIGHT[1]

THE experimental work of the Committee during the past year has not been extensive, as they had no funds at their disposal for experimental research, and they have been chiefly occupied with reviewing what has been done in the past and laying plans for future operations.

Lord Rayleigh has constructed an instrument which he calls a monochromatic telescope, by means of which the illuminated screens of a photometer may be examined, allowing light only of one definite colour to pass. It was hoped by Lord Rayleigh that experiment might show that, with some suitably-chosen colour, this instrument, used with any ordinary photometer, would, in comparing lights of different intensities and temperatures, give to each a candle-power which would be sufficiently accurate to represent for commercial purposes the intensity of the light. The Secretary has made some experiments at the Society of Arts, where he was kindly permitted to use the secondary batteries and glow-lamps; but the results so far are not definite enough to justify their publication.

Mr. Vernon Harcourt has been engaged on an investigation on the barometrical correction to his pentane standard, and on another concerning the possibility of using lamp-shades as a protection from air-currents. His researches are communicated independently to the meeting.

Capt. Abney and Col. Festing have continued their observations on the intensity of radiations of different wave-lengths from incandescent carbon and platinum filaments at different

[1] Report of the Committee, consisting of Prof. G. Forbes, Capt. Abney, Dr. J. Hopkinson, Prof. W. G. Adams, Prof. G. C. Foster, Lord Rayleigh, Mr. Preece, Prof. Schuster, Prof. Dewar, Mr. A. Vernon Harcourt, and Prof. Ayrton, appointed for the purpose of reporting on Standards of White Light. Drawn up by Prof. G. Forbes (Secretary).

temperatures, which will go far to assist the Committee in their work.

Other isolated experiments have been made by members of the Committee, which will be published in due course.

Most of the members have examined the experiments of the Trinity Board at the South Foreland.

Existing Standards.—A consideration of existing standards convinces the Committee that the standard candle, as defined by Act of Parliament, is not in any sense of the word a standard. The French "bec Carcel" is also liable to variations; and with regard to the molten platinum standard of Violle, it seems that the difficulty of applying it is so great as to render its general adoption almost impossible.

With regard to the so-called standard candle, the spermaceti employed is not a definite chemical substance, and is mixed with other materials, and the constitution of the wick is not sufficiently well defined. Hence it is notorious that interested parties may prepare candles conforming to the definitions of the Act which shall favour either the producer or consumer to a serious extent. In view of these defects of the standard candle, it is a matter of great importance that a standard of light should be chosen which is more certain in its indications.

The Committee have looked into the merits of different proposed standards, and the majority feel satisfied that, for all the present commercial requirements, the pentane standard of Mr. Vernon Harcourt—since it has no wick and consumes a material of definite chemical composition—when properly defined, is an accurate and convenient standard, and gives more accurately than the so-called standard candle an illumination equal to that which was intended when the Act was framed.

Yet the Committee, while desiring to impress the Board of Trade and the public with these views, do not feel inclined at present to recommend the adoption of any standard for universal adoption until, further information on radiation having been obtained from experiment, they may learn whether or not it may be possible to propose an absolute standard, founded, like electrical and other standards, on fundamental units of measurement —a standard which, for these reasons, would be acceptable to all civilised nations. They are, however, inclined to look upon the pentane lamp as an accurate means of obtaining an illumination to replace the so-called standard candle.

Proposed Experimental Researches.—Radiation is measured as a rate of doing work, and consequently radiation might be measured in watts. The illumination (or luminous effect of radiation) depends partly upon the eye, and is a certain function of the total radiation. This function depends upon the wave-length of the radiation, or on the different wave-lengths of which the radiation, if it be compound, is composed. This function of the radiation perceived by the eye is partly subjective, and varies with radiations of different wave-lengths and with different eyes. Thus the illumination cannot, like the radiation, be expressed directly in absolute measurement. But the connection between the illumination and the radiation can be determined from a large number of experiments with a large number of eyes, so as to get the value of the function for the normal human eye. This function, however, is constant only for one source of light, or, it may be, for sources of light of the same temperature. It appears, then, that, in the first instance at least, a standard should be defined as being made of a definite material at a special temperature.

The energy required to produce a certain radiation in the case of a thin filament of carbon or platinum-iridium heated by the passage of an electric current can be easily measured by the ordinary electric methods, and the radiation may be measured by a thermopile or a bolometer, which itself can be standardised by measuring the radiation from a definite surface at 100° C., compared with the same at 0° C. The electric method measures the absorption of energy; the thermopile measures the total radiation. These two are identical if no energy is wasted in convection within the glass bulb of the lamp, by reflection and absorption of the glass, and by conduction from the terminals of the filament. Capt. Abney and Col. Festing have come to the conclusion that there is no sensible loss from these causes. The Committee propose to investigate this further. This constitutes a first research.

No research is necessary to prove that with a constant temperature of a given filament the luminosity is proportional to the radiation, because each of these depends only upon the amount of surface of the radiating filament. It will be necessary, however, to examine whether with different filaments it be possible to maintain them at such temperatures as shall make the illumination of each proportional to the radiation. This will be the case if spectrum curves, giving the intensity o radiation in terms of the wave-length when made out for the different sources of light, are of the same form. Thus a second research must be undertaken to discover whether the infinite number of spectrum radiation curves, which can be obtained from a carbon filament by varying the current, are identical in form when the filament is changed, but the material remains so far as possible of constant composition.

It will be an object for a later research to determine whether, when the radiation spectrum curve of any source of light has been mapped, a similar curve can be found among the infinite number of curves which can be obtained from a single filament.

The next step proposed is to examine a large number of carbon or of platinum-iridium filaments, and to find whether the radiation spectrum curve of different specimens of the same material is identical when the resistance is changed in all to x times the resistance at 0° C. If this law be true, a measurement of the resistance of the filament would be a convenient statement of the nature of the radiation curve. If, then, a number of filaments were thus tested to give the same radiation spectrum curve, their luminosities would in all cases be proportional to their radiations, or (if there be no loss in convection, conduction, absorption, and reflection) proportional to the electrical energies consumed.

Thus it might be hoped to establish a standard of white light, and to define it somewhat in the following manner:—*A unit of light is obtained from a straight carbon filament, in the direction at right angles to the middle of the filament, when the resistance of the filament is one-half of its resistance at 0° C., and when it consumes 10^9 C.G.S. units of electrical energy per second.*

Since Mr. Swan has taught us how to make carbon filaments of constant section by passing the material of which they are composed through a die, it is conceivable that another absolute standard should be possible—viz., a carbon filament of circular section, with a surface, say, 1-100th sq. cm., and consuming, say, 10^9 C.G.S. units of energy per second.

Whether such standards are possible or not depends upon the experiments of the Committee. The probability of success is sufficient to render these experiments desirable.

Proposed Later Experimental Researches.—Should these hopes be realised, and an absolute standard of white light thus obtained of a character which would commend it to the civilised world, it would then become an object of the Committee to find the ratio of luminosity when the radiation spectrum curve of the standard filament is varied by varying the current, and consequently the resistance of the filament.

Thus, by a large number of subjective experiments on human eyes, a multiplier would be found to express the illumination from the standard lamp, with each degree of resistance of the filament.

A research, previously hinted at, would then be undertaken—viz., to find whether the radiation spectrum curves of all sources of illumination agree with one or other of the curves of the standard filament. It is not improbable that this should be the case except for the high temperature of the electric arc.

Should this be found to be true, then photometry would be very accurate, and the process would be as follows:—*Adjust the standard filament until its radiation spectrum curve is similar to that of the light to be compared.* (This would probably be best done by observing the wave-length of the maximum radiation, or by observing equal altitudes on either side of the maximum, the instruments used being a spectroscope and a line thermopile or a bolometer.) The total radiation of each is then measured at equal distances by the thermopile. The resistance of the filament is measured, and its intensity in terms of the unit of white light obtained therefrom by the previous research. The luminosity of the compared source of light is then obtained directly.

The Committee desire to be reappointed, and to enable them to carry out the researches indicated they ask for a grant of 30*l.*

PHYSICS AT JOHNS HOPKINS[1]

THE large and well appointed laboratories recently erected by the Trustees of the Johns Hopkins University for the Chemical and Biological Departments have by contrast made

[1] From *Science* of December 18, 1885.

the more evident the needs of the Physical Department, which has been obliged to occupy temporarily parts of four different buildings. The Trustees, recognising this need, are now erecting a building for a physical laboratory. The new laboratory is to be a handsome building of red brick, trimmed with brown sandstone, and will occupy a fine site about a block from the other University buildings, on the corner of a quiet little street midway between the more important streets, which carry the bulk of the traffic of that region. It will therefore be as free from disturbance from the earth-vibrations as could be expected in a city.

The building will be 115 feet long by 70 feet broad, and will have four stories besides the basement. In the centre of the building, and below the basement, are several vaults for instruments requiring to be used at constant temperature, also a fire-proof vault for storage. In these vaults will be placed Prof. Rowland's dividing-engine, by which the diffraction-gratings are ruled, and the Rogers-Bond comparator, which has recently become the property of the University. In the basement will be rooms for the mechanical workshop, for furnaces, and for piers for instruments requiring great stability. The first floor will include the main lecture-room, which will accommodate 150 persons, and rooms for investigations by advanced students in heat and electricity. The second floor will contain mathematical lecture-rooms, studies for instructors, and a room for the mathematical and physical library of the University.

The elementary laboratory will be on the third floor, which will also have rooms for more advanced work. The fourth floor will contain rooms for special work in light.

There will be a tower on the south-east corner of the building, which will have two rooms above the fourth floor. The upper of these will be provided with telescope and dome, and will be a convenient observatory when great steadiness in the instruments is not required. There will be power in the building for driving the machinery in the workshop and for running the dynamo-machines. A large section of the building is to be made entirely free from iron. The sash-weights will be of lead, and the gas-pipes of brass. Brackets will be attached to the walls, on which galvanometers and cathetometers may be placed. In order to avoid the inconvenience of having piers go up through the lower rooms, and yet to secure steadiness, beams have been introduced into the floors, which reach from one wall to the other between the regular floor-beams, and do not touch the floor at any point. If, now, a table is made to rest on two of these beams, by making holes in the floor over them to admit the legs of the table, it is entirely undisturbed by any one walking over the floor, except by such motion as is transmitted to the walls. There will also be a small vertical shaft in the wall of the tower, running from top to bottom, in which a mercurial manometer may be set up.

The vaults for constant temperature have been built with double walls, so that a current of air may be drawn between them whenever desirable to prevent dampness. It is expected that the laboratory will be ready by October next.

The photographic map of the spectrum upon which Prof. Rowland has expended so much hard work during the past three years, is nearly ready for publication. The map is issued in a series of seven plates, covering the region from wave-length 3100 to 5790. Each plate is 3 feet long and 1 foot wide, and contains two strips of the spectrum, except Plate No. 2, which contains three. Most of the plates are on a scale three times that of Angström's map, and in definition are more than equal to any map yet published, at least to wave-length 5325. The 1474 line is widely double, as also are b_3 and b_4, while E may be recognised as double by the expert. In the region of the H line these photographs show even more than Lockyer's map of that region. Negatives have also been prepared down to and including the B group, and they may be made ready for publication, one of which shows eleven lines between the D lines. A scale of wave-lengths is printed on each plate, and in no case does the error due to displacement of the scale amount to one part in 50,000. The wave-lengths of over 200 lines have been determined to within one part in 500,000, and these serve as reference lines to correct any small error in the adjustment of the scale. The great value of such a map lies not only in the fact that it gives greater detail and is more exact than any other map in existence, but that it actually represents the real appearance of the spectrum in giving the relative intensities and shading of groups of lines, so that they are readily recognisable. The photographs were taken with a concave grating 6 inches in diameter, and having a radius of curvature of 21½ feet, and the photographs were taken when the plate was placed directly opposite the grating; both the sensitive plate and grating being perpendicular to a line joining their centres, and placed at a distance apart equal to the radius of curvature of the grating, the slit being on the circumference of the circle, whose diameter is the distance between the grating and plate. With this arrangement, the spectrum is photographed normal for wave-lengths without the intervention of any telescopes or lens systems; and a suitable scale of equal parts applied to such a photograph at once gives relative wave-lengths.

Few persons have any idea of the perseverance and patience required to bring such a task to a successful issue. More than a year was devoted to preliminary experiments designed to discover the best mode of preparing the plates for the particular regions to be photographed. Hundreds of preparations were tested to find their influence on the sensitised plate, and the whole literature of photography was ransacked, and every method tested to the utmost, before the work of taking the negatives could begin.

The Rogers-Bond comparator, which has been already referred to as having been purchased by the University lately, is one of two instruments that were constructed in 1881 by Pratt and Whitney of Hartford, Conn. The general plan and requirements were made out by Prof. W. A. Rogers of Cambridge, and the drawings and details were worked out by Mr. George M. Bond, then a student at Stevens Institute. The comparator was designed for making exact comparisons of standards of length. The other similar comparator is owned by the Pratt and Whitney Manufacturing Company, and is used by them in testing and constructing their standard gauges.

The instrument consists essentially of two microscope-carriages, which slide on two parallel cylindrical steel ways between stops, which may be clamped at any point. A carriage entirely independent of the ways on which the microscopes slide supports the two bars to be compared, and is provided with means of accurate and rapid adjustment, by which the bars may be successively brought into position under the microscopes, and the lengths compared by the micrometers attached to the microscopes; or one microscope only need be used, and slid first against the stop at one end, and then against that at the other end. The instrument also affords great facility in determining fractions of a given length with any desired degree of precision. The instrument is one requiring the utmost skill in its construction, and it cost several thousand dollars to make it. A full account of this remarkable instrument is given in the *Proceedings* of the American Academy of Arts and Sciences for 1882–83. K.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE

THE Chancellor of St. Andrew's University (His Grace the Duke of Argyll) has given his sanction to a recent enactment of the University Court empowering the Senatus to admit to the Science Degrees of the University, students who may have received their education at University College, Dundee.

SOCIETIES AND ACADEMIES

LONDON

Royal Society, December 17, 1885.—"A Preliminary Account of a Research into the Nature of the Venom of the Indian Cobra (*Naja tripudians*)." By R. Norris Wolfenden, M.D., Cantab. (from the Physiological Laboratory, University Coll., London). Communicated by E. A. Schäfer, F.R.S.

In this account the author refers only to cobra venom, the venom of *Naja tripudians*. The dried venom dissolved in water and filtered from accidental particles yields a solution, clear, and usually slightly acid. This solution contains a large amount of proteïd. Boiling produces a copious coagulum, and after removal of all coagulum by frequent filtration there is still much proteïd in the solution. A fresh solution of the venom is at once precipitated by neutral salts such as $MgSo_4$, NaCl, &c., and also by absolute alcohol.

The previous valuable labours of Sir Joseph Fayrer (*Proc. Roy. Soc.*, 1873, 1874, 1875, 1878), and Dr. Lauder Brunton and others, have dealt chiefly with the physiological side of the question, but have left the chemical nature of these snake venoms still undetermined.

Weir Mitchell and Reichert (*Med. News*, April 28, 1883; *Lancet*, July 21, 1883), working with the venoms of American snakes, have indicated in these venoms certain poisonous proteïds, the nature of which, however, is not fully elucidated. Wall's ("Indian Snake Poisons," Allen and Co., 1883) experiments and conclusions lead to the same view. Blyth (*The Analyst*, vol. i.) attributed the venom to an acid ("cobric acid") of deadly power. Gautier asserted that he had separated two ptomaïnes from Trigonocephalus and Naja venom. The author undertook this research with the object of determining whether the active venomous properties reside in the proteïd constituents or some other non-proteïd body or bodies. His work falls under the following heads:—

(1) The possibility of cobra-poisoning being due to "germs" or living organisms in the secretion.
(2) Its possible dependence upon an alkaloidal body.
(3) Its dependence upon some acid (cobric acid).
(4) Its dependence upon the proteïds contained in it.
(5) The mode of action of these proteïds.

With regard to the first proposition, the author finds nothing in cobra poison which will grow under cultivation methods favourable for such organisms. The symptoms of the poisoning are entirely unlike bacillary infection, and resemble more the effect of some rapidly-acting chemical poison. With regard to the presence of "alkaloids" in cobra venom, the author made three examinations of the dried venom by the Stass Otto method, but failed to find any trace of an alkaloid. He thus confirms the results of Prof. Wolcott Gibbs, who examined cobra poison for Dr. Weir Mitchell, in search of "ptomaïnes," but stated that he could find no trace of such bodies. In reference to the "cobric acid" said to have been obtained by Blyth from cobra venom, the author remarks that as it is said to be crystalline, it will presumably readily dialyse. Searching the dialysates for such a body, the author has failed to meet with it. Dialysates that retain any toxic power do so by virtue of the proteïd which they contain, since cobra venom, or the dialysate of cobra venom, loses its poisonous properties with the removal of its proteïds.

The fourth proposition—viz. that the toxic power of the venom is resident in the proteïds, is the author's chief point, and on this subject he remarks as follows:—

The coagulum obtained by boiling the venom is harmless when injected into rats. The filtrate from the coagulum is toxic, though in less degree than the original solution. The author thinks this toxic power to be due to syntonin remaining in the solution. That it is due to proteïd is shown by the fact that, with the removal of this proteïd by acetate of lead, it is rendered harmless.

The dialysates of cobra venom which are toxic contain proteïd, but lose their poisonous properties when this proteïd is removed by boiling with ferric acetate.

The variable degree of toxic power of the dialysates is dependent on the length of time the dialysis has lasted, and thus upon the amount of proteïd that has passed through the dialyser.

From what has been said as to the non-existence of any poisonous acid or alkaloid in cobra venom, and also the diminution of toxicity on boiling solutions of the venom, and complete removal of poisonous properties on completely freeing the boiled venom from such proteïd as has escaped coagulation by heat, and, further, as to the dependence of the toxicity of the dialysates upon the proteïd therein, there can be no further doubt that the toxic power of the venom is entirely due to its proteïds, and that it completely loses all poisonous power on the removal of these bodies.

The formerly reputed power of permanganate of potash as an antidote is explained by the action of this body upon albumens, which it converts into oxyprotosulphonic and other allied acids (according to Brücke and Maly) and it fails as an antidote within the body because it oxidises all albumens indifferently, without any selective power for the cobra proteïds.

The proteïds contained in cobra venom are—

(1) Globulin, which is obtained by saturation and shaking with $MgSo_4$, and which is coagulated in its solutions at 75° C. It is extremely toxic, and kills by involving the respiratory system, producing speedy asphyxia.

(2) Serum albumen, present in the filtrate from the $MgSo_4$ precipitate, and which is brought down on further saturation and shaking with Na_2So_4. It coagulates between 70° and 80° C. There is very little of it present, and it probably acts in a poisonous manner by producing a general and ascending paralysis.

(3) Syntonin, which is left in the filtrate after boiling the venom, and is also partially precipitated by $MgSo_4$, along with the globulin, and also appears in the dialysates, from which it is entirely removed by boiling with ferric acetate, or lead acetate. It possesses poisonous properties, chiefly like the globulin.

It is possible that some specimens of cobra venom contain a little peptone, though it can only be in faint traces. The bodies which Weir Mitchell and Reichert have described as peptone in Crotalus and Mocassin venoms are probably albumoses. That they are precipitated by dilute acetic acid, NaCl, and liquor potassa indicates this character. The "globulin," which they have described as dissolved by heating instead of coagulating, is also possibly a body of this nature. The complete removal of all proteïds from cobra poison by boiling with ferric acetate, except in some specimens the very faintest trace (as indicated by metatungstic acid), shows that when peptone is present it is only in the smallest traces, and it is not constantly found in cobra venom.

In conclusion, the author desires to express his thanks to the Indian executive for readily acceding to the request of Mr. Vincent Richards, a member of the last Snake Commission, to supply him with the dried venom. The amounts received have, however, been small, making the research not only slow, but very difficult.

Victoria (Philosophical) Institute, January 4.—A paper by Mr. Boscawen, on the Abramic Migration, and the light thrown thereon by recently discovered Assyrian Inscriptions was read.

PARIS

Academy of Sciences, December 28, 1885.—M. Jurien de la Gravière, Vice-President, in the chair.—Obituary notice of the late M. L. R. Tulasne and his botanical work, by M. P. Duchartre.—Note on the new star in Orion recently discovered at Lord Crawford's Observatory, Dun Echt, by M. C. Wolf. From a study of its spectrum, which belongs to Class III., section *a* of Vogel, this would appear to be, not a temporary star like τ Coronæ discovered in 1866, but a true star hitherto undetected.—On the movement of the molecules of the "solitary wave," by M. de Saint-Venant.—Researches on the functions of Wrisberg's nerve—complementary note, by M. Vulpian.—Researches on the real origin of the secreting nerves of Nuck's salivary gland, and of the labial salivary glands of the dog, by M. Vulpian.—Observations on the structure of the vascular system in the genus Davallia, and particularly in *Davallia repens*, by M. A. Trécul.—On the respiration of plants outside the living organisms, in connection with M. Regnard's recent communication, by M. Ad. Chatin.—On a new theory of algebraic forms (continued), by Prof. Sylvester.—Report on M. Mestre's claim of priority of discovery in connection with MM. Napoli and Abdank-Abakanowicz's integraph, by the Commissioners, MM. Bertrand and Jordan. To a certain extent M. Mestre's claim is allowed; he appears entitled to the credit of the general idea of the apparatus, all the details of which must, however, be accredited to M. Napoli.—Letter on the proposed appointment of a special Commission to study the subsidence of the land along the coasts of the English Channel, by the Minister of Public Instruction.—On the relative frequency of the spots on the two hemispheres of the sun, by M. Spörer. Between the years 1880-82 the spots occurred most frequently in the northern hemisphere (56 per cent.), but from 1882-85 they were most frequent in the southern, being last year in the proportion of 69 to 30 per cent.—On a unique method of determining the constants of the altazimuth, and of M. Lœwy's recently-invented meridian lunette "à grand champ," by M. Gruey.—Observations of Barnard's comet made at the Observatory of Bordeaux, by MM. G. Rayet, Doublet, and Flamme.—Observations of Fabry's comet made at the Observatory of Bordeaux, by MM. G. Rayet and Flamme.—Elements of Fabry's comet, by M. Gonnessiat.—Note on the secular diminution of the obliquity of the ecliptic, by M. F. Folie.—On the potential energy of two ellipsoids mutually attracting each other, by M. O. Callandreau.—On the doubly periodical functions of the third species, by M. Appell.—Note on the effects of the rheostatic machine of quantity (two illustrations), by M. Gaston Planté.—A new application of the principle determining the transmission of power to a distance by means of electricity, by M. Manceron.—Application of the numerical laws of the chemical equilibria to the dissociation of the hydrate of chloride, by M. H. Le Chatelier. The principles here developed are directly applicable to all the hydrates of gaseous bodies, and to a large number of other compounds, such as the alkaline bi-carbonates, with which the author is at present occupied.—Action of some deoxidising agents on vanadic acids, by M. A. Ditté. It is shown that, when subjected at a high temperature to the action of hydrogen, sulphur, arsenic, phosphorus, and some other reducing agents, vanadic acid may, according to the circumstances, lose a greater or less quantity of oxygen.—Note on the preparation and physical properties of the pentafluoride of phosphorus, by M. H. Moissan. —Note on the combinations of the trichloride of gold with the tetrachlorides of sulphur and selenium, by M. L. Lindet.—Thermic researches on glyoxylic acid ($C_4H_4O_8$), by M. de Forcrand.—On the oxidation of sebacic acid, by M. H. Carette. —On a new means of testing the purity of volatile substances, by M. E. Duclaux.—On the normal character of the morbid process developed by tuberculous inoculations, by M. G. Colin. —Remarks on the character of the glycogen observed in the ciliated Infusoria, showing that it is in every respect analogous to that developed in the liver of higher organisms, by M. E. Maupas.—A physiological study of acetiphenone, by MM. A. Mairet and Combemale.—On the dialytic properties of the membrane of the cyst in *Vorticella nebulifera* and other Infusoria, by M. F. Fabre.—Note on the polychete Annelidæ found on the French coast, district of Dinard, by M. de Saint-Joseph.—On the traces left by the Quaternary glaciers in the cave of Lombrives, Ariège Valley, by M. E. Trutat.—Remarks on the first sheets of the new geological map of France, prepared to a scale of 1 : 500,000, by MM. G. Vasseur and L. Carez. This work, which is to be completed during the course of the year 1886, will comprise altogether forty-eight sheets, of which fifteen have already been issued. These include the south coast of England, the greater part of Belgium, Luxemburg, the Rhine to Bonn and Frankfort, Alsace-Lorraine, the eastern and central parts of the Paris Basin, and the neighbourhood of Bordeaux.—Chief results of the systematic researches made in Sweden since the year 1873 on the upper atmospheric currents, by M. H. Hildebrandsson.—Note on the northern limit of the south-west monsoon in the Indian Ocean, by M. Venukoff. It appears from M. Prjevalsky's recent voyage to Northern Thibet that the limit of the south-western monsoon coincides approximately with the 37th parallel of latitude, and stretches west and east from about the head-waters of the Oxus and Tarim Rivers to the meridian of Lang-chew, capital of the province of Kan-su, in West China.—A reply to M. Bourquelot's recent note on interverted sugar, by M. E. Maumené.—Note on the guano of Alcatras, by MM. A. Herbelin and A. Andouard.—Reply to M. Cartailhac's objections on the human remains and pottery recently found in the cave of Nabrigas, by MM. Martel and de Launay. The authors deny the possibility of a post-Quaternary disturbance of the cave, and consequently maintain the conclusions already formulated on the significance of these discoveries.—The death was announced of M. Tulasne, Member of the Botanical Section, who died at Hyères on December 22, 1885.

Vienna

Imperial Academy of Sciences, October 8, 1885.—On the establishment of a homogeneous magnetic field on the tangent galvanometer for measuring stronger currents, by G. A. Schilling.—On the blood-circulation of the ganglion-cell, by A. Adamkiewicz.—Determination of the orbit of the planet Ida (243), by N. Herz.—On the energy of the yeast-cell, by G. Czeczetka.—On a new method for the determination of phosphorus in pig-iron and steel, by W. Kalmann. —On Brooks's comet of September 2, 1885, by E. Weiss.—Astronomical researches on the eclipses noted by Hebrew writers: i. the Biblical eclipses, by E. Mahler.

October 15.—Contributions to our knowledge of sulphohydantoïns, by R. Andreasch.—On the disposition of karyokinetic figures in the central nervous system and in the retina of adder-embryos, by L. Merk.—Researches on strychnine, by F. Loebisch and P. Schoop.

October 22.—On some applications of the principle of apolarity, by B. Igel.—Studies on quercetin and its derivatives, ii., by J. Herzig.—On some derivatives of phloroglucin, by the same.—On rhamnin and rhamnetin, by the same—Results of an embracing computation of the elements of all central and partial eclipses of the sun—8000—which have occurred in the period −1207 November 10 (Jul.) till +2161 November 17 (Greg.), and of all total eclipses of the moon—5200—in the period from −1206 April 21 (Jul.) till +2163 April 12 (Greg.), by Th. von Oppolzer.—On prophetic eclipses, by E. Mahler.

November 5.—On the fat of cochineal, by E. Raimann.—On *Tosoraphinia texta*, Rœm. sp., and on *Scytalia pertusa*, Reuss. sp., from the environs of Raudnitz (Bohemia), by J. Fahalka.—On Crocodilida from the Miocene of Styria, by A. Hofmann.—On the application of the gravity of a rolling body as a motive power, by J. Burgaritzki.—On a new mechanical principle of the force hitherto called gravitation, by W. Bosse.—A preliminary note on the zodiacal light, by T. Unterweger.—Sketch of a theory of the moon, by Th. von Oppolzer.

Stockholm

Academy of Sciences, December 9.—Remarques concernant un cas special du problème des trois corps, éclaircies par une première approximation pour les mouvements de la planète Hécube (108) sous l'influence du soleil et de Jupiter, by Dr. Paul Harzer.—On Schefferite from Långbau and Pajsberg, by Dr. G. Flink.—Observations on the meteoric showers, November 27, 1885, by Prof. H. Hildebrand.—Sur la théorie des ensembles, by Prof. G. Cantor.—Remarks on this paper, by Dr. G. Enström. —New and imperfectly-known Isopoda, by Dr. C. Bovallius.—Systematic list of the family Asellida, by the same.—The laws of the atomic weights, by Dr. Y. R. Rydberg.—On double oxalates of platinum, by Herr H. G. Söderbaum.—On rocks composed of pyroxene and amphibole in Central and Eastern Småland: (1) classification and description of the rocks, by Dr. F. Eichstädt; (2) Myrmecological studies, by Herr G. Adlerz. —On pyramidal stones (Dreikanter) from the Cambrian formaion of Sweden, by Prof. A. G. Nathorst.

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