THURSDAY, SEPTEMBER 3, 1885

THE ANDAMAN ISLANDERS

On the Aboriginal Inhabitants of the Andaman Islands. By Edward Horace Man, Assistant Superintendent, Andaman and Nicobar Islands, with Report of Researches into the language of the South Andaman Islands, by A. J. Ellis, F.R.S. Reprinted from the *Journal* of the Anthropological Institute of Great Britain and Ireland. (London: Trübner and Co.)

"IN considering the habits, customs, and physical peculiarities of a savage race, it is important to acquire as much information as possible regarding the land they inhabit, and also to ascertain the nature and extent of the influences exercised by, or resulting from, their intercourse with other nationalities."

The author of the work from which the above extract is quoted has proved himself fully qualified to treat of this interesting race of people, among whom he resided for four successive years in his capacity of Assistant Superintendent, from the scientific point of view which he has so well defined in the foregoing passage. The volume before us consists essentially of a series of papers communicated at various times since 1880 to the Anthropological Institute, and now republished, with the sanction of the Institute, in a separate form, with an introduction and fourteen short appendices. The report on the language of the South Andaman Islands concludes the volume, and bears a separate title-page indicating that it has been drawn up by Mr. A. J. Ellis, F.R.S., from the materials furnished by Mr. Man and Lieut. R. C. Temple, of the Bengal Staff Corps.

The Andaman Islands consist of a group situated in the Bay of Bengal between the 10th and 14th parallels of N. latitude, and comprise Great and Little Andaman, the former consisting of North, Middle, and South Andaman, together with the Archipelago, Interview, Rutland, and many other small islets. The entire area of the islands is estimated at about 2508 square miles, of which about 2000 square miles are comprised in Great Andaman. Some pages of the introduction are devoted to a description of the physical features, climate, and scenery, the author calling special attention to the numerous fine harbours which offer safe anchorage during all seasons. With respect to the population, Mr. Man estimates the total number of the aborigines of Great Andaman as probably about 2000, and of those inhabiting Little Andaman 1000 to 1500; the aggregate population of all races is about 15,000, nearly four-fifths of this number being made up of the convicts inhabiting the penal settlement. A succinct history of the settlement is given, from which it appears that the modern history of the Andamans dates from 1857, although a previous attempt to found a penal station had been made by the Honorable East India Company, but this was abandoned in 1796 on account of the high death-rate.

The author recognises eight distinct tribes of aboriginal inhabitants in Great Andaman and one in Little Andaman. The natives with which the officers in charge of the station at first came into contact displayed much hostility and considerably harassed the operations of the working parties; but improvements have gradually been effected in the relationship between the aborigines and the settlers chiefly through the establishment of Government homes, and now, as Mr. Man states in a passage quoted from Dr. Day, "the convicts are left unmolested, the implements of agriculture are not stolen, the fishing stakes are left undisturbed, the gardens are no longer pillaged, runaway convicts have been recaptured, and shipwrecked sailors assisted." The author, who had charge of one of the homes, also states that these "have effected good in bringing together members of the various tribes, between whom the way has thus been paved for intermarriages, which were of course formerly of rare occurrence; tribal feuds have also here been amicably arranged, while, through visits paid to Port Blair and other homes by members of all the Great Andaman tribes, as well as by our visits in the station steamer to the more distant encampments, the knowledge of our power, resources, and kindly intentions has spread throughout their respective territories." The aboriginal inhabitants of Little Andaman are, however, still unreclaimed, and all attempts to civilise them have hitherto failed; their hostility towards strangers is such that any persons unfortuate enough to be cast on their shores would be as ruthlessly slaughtered now as at any period prior to our annexation of the islands.

The effect of the contact with civilisation upon those more friendly tribes who have accepted the advantages offered by the homes is however similar to that which invariably results from all such attempts:—"in proportion as they gain in intelligence and tractability, the more fat and indolent do they become, and, having no incentive towards exertion, frequently lose in great measure their quondam skill in hunting." Still more serious is the moral deterioration which has taken place through contact with the convict population, and Mr. Man is careful to point out that his observations have been confined to those primitive communities which have not yet had time to be affected by the virtues and vices of modern civilisation. One interesting point which has been brought out by an attempt to educate the native children is that up to the age of ten or eleven they are as intelligent and can learn as well as the children of civilised races, but after this age no further progress is possible. This feature in the mental evolution of savage races has, if we remember correctly, been observed in the case of many other uncivilised tribes.

In the succeeding portions of the volume we have an immense amount of detailed information upon all the points which are likely to be of value to the anthropologist. With regard to the vexed question of the origin of the race, Mr. Man considers that the natives are the direct descendants of the prehistoric inhabitants, that they all belong to the same race, and that the tribal differences are the effects of isolation by the natural barriers of the country and the constitutional jealousies and hostilities which formerly prevented the tribes from living on amicable terms with each other. Ethnologically the author regards these people as Negritos, and "racial affinity—if there be any—may possibly some day be found to exist between them and the Semangs of the Malayan Peninsula, or the Aëtas of the Philippine Islands."

Following the section on the ethnology of the Andamanese we have an excellent description of their form and size, forty-eight males and forty-one females having been most carefully weighed and measured, with the result that the average height of the men is 4 feet $10\frac{3}{4}$ inches and of the women 4 feet $7\frac{1}{4}$ inches, and the respective average weights $98\frac{1}{8}$ lbs. and $93\frac{1}{4}$ lbs. To give an idea of the thoroughness with which the author has dealt with his subject, under the heading "Anatomy and Physiology," we have a series of five sets of observations on the temperature and rate per minute of respiration and of the pulse on five subjects ranging in age from seventeen to twenty-two years. Descriptions of the pathology, medicine, physiognomy, physical powers and senses, psychology and morals, magic and witchcraft, of the tribal distribution, topography, arithmetical faculties, and of their habitations, government, laws, crimes, &c., complete the first part.

With respect to diseases it appears that pulmonary consumption and other pectoral complaints are or were the chief causes of mortality among these people; to these have unfortunately now to be added that "terrible scourge" which has spread over the greater part of Great Andaman, and which, as in Australia, unless successfully dealt with, threatens, as Mr. Man informs us, "the early extermination of the race."

The morals of the Andamanese in their primitive state appear to be of a distinctly high standard, as will appear from the following extracts:—

"Much mutual affection is displayed in their social relations, and, in their dealings with strangers, the same characteristic is observable when once a good understanding has been established . . . every care and consideration are paid by all classes to the very young, the weak, the aged, and the helpless, and these, being made special objects of interest and attention, invariably fare better in regard to the comforts and necessaries of daily life than any of the otherwise more fortunate members of the community. Andamanese children are reproved for being impudent and forward . . . they are early taught to be generous and self-denying . . . the duties of showing respect and hospitality to friends and visitors being impressed upon them from their early years," &c. With regard to their modesty Mr. Man states that the esteem in which this virtue is held, "and the self-respect which characterises their intercourse with each other may even be said to compare favourably with that existing in certain ranks among civilised races." It is much to be regretted that the so-called "civilisation" with which these people have been brought into contact should have led to the moral deterioration which the author with scientific candour does not scruple to disclose. It is perhaps hardly necessary to add that the stories concerning the prevalence of cannibalism among these tribes have been completely disproved both with respect to the present time and to former periods of their history.

In the second part of his interesting monograph the author treats of the language, relationships, names, initiatory ceremonies, marriage, death and burial, superstitions, religious beliefs, demonology and mythology. In the third part we have an account of the social relations of the Andamanese, their mode of life, games and amusements, and a description of their weapons, manufactures, &c. Want of space forbids anything more than a mere mention of the ground covered by these sections, but it will suffice to say that they are characterised by the thoroughness which is such a valuable feature of Mr. Man's work. The few slight defects which we have noticed are on matters of quite minor importance, such, for instance, as the statement in the introduction, that "the water in the harbour of Port Blair has been found to be remarkable for its high density, as is evidenced by the rapid oxidation of iron immersed in it;" in its present form this reads rather like a case of *non sequitur*.

It remains only to add that in the fourteen appendices we have a mass of most valuable information on various subjects connected with these islands and their inhabitants: most of these appendices are philological; one is devoted to a list of the native trees, and another to a list of the shells.

The Report on the language of the South Andaman Islanders is reprinted from the *Transactions* of the Philological Society, before which body it was delivered by its author, Mr. A. J. Ellis, F.R.S., as his retiring presidential address in 1882. The volume is illustrated by a good series of typical photographs of the natives and five plates of weapons, ornaments, &c., and a map of the islands forming a frontispiece.

In concluding this notice we must not omit to mention that Mr. Man's mode of treatment is based upon the instructions drawn up by Col. Lane-Fox (now General Pitt-Rivers) on behalf of a Committee of the British Association, and published among the Reports for 1873. This Report was afterwards issued in an expanded form as a Manual of Anthropological Notes and Queries, and the work now under consideration may be regarded as one of the most important practical results of the labours of the Committee referred to. We believe that Mr. Man is at present engaged in a similar study of the inhabitants of the neighbouring Nicobar Islands, one of which—Camorta—was selected as a station by the Eclipse Expedition of 1875. We shall look forward with much interest to the continuation of the author's labours in this new field.

R. M.

COMMERCIAL ORGANIC ANALYSIS

Commercial Organic Analysis. Vol. I. By Alfred H. Allen, F.I.C., F.C.S. (London: J. and A. Churchill, 1885.)

NOTWITHSTANDING the fact that enormous numbers of text-books on chemical subjects have been appearing during recent years, a few comprehensive works on the subject of commercial analysis have been long and greatly needed. When it is considered how every day commerce has been availing itself more and more of the powers of scrutiny and control afforded by chemical analysis, this delay may appear remarkable. But the truth is that to produce such a work very exceptional qualifications and a very unusual degree of experience are necessary. A work on commercial analysis must be thoroughly practical if it is to be useful, and prescribe methods of analysis only which experience has proved to be accurate and serviceable. Analysts as a rule have their specialities—these specialities often being determined by local industries—and long experience frequently leads them to devise or modify processes without any record appearing outside their own laboratories. Almost every analyst has his own manuscript "process-book," according to which he expects his assistants or pupils to work, and so it becomes a matter of extreme difficulty for an author to produce a work that shall be generally acceptable as a laboratory guide. The too frequently occurring discrepancies in commercial analyses may in a measure be attributed to the same cause, and there can be no doubt that a unification in the methods of conducting and recording analyses is greatly to be desired. This end will doubtless be greatly furthered by the production of standard books such as the present one.

A first edition of the work before us appeared in 1879. It has undoubtedly taken already a very high position, and has been welcomed as filling a conspicuous gap in the literature of analytical chemistry. The value of a division between organic and inorganic analysis to the ordinary analyst may not be great, but it is useful to the author in enabling him to keep his work within bounds. The first edition of the book appeared in two volumes; in the new edition a rearrangement and extension is being made, and it will now occupy three volumes. The first volume deals with organic bodies of the fatty series and of vegetable origin, and includes chapters on the alcohols, ethers, and other neutral derivatives of the alcohols, sugars, starch and its isomers, and vegetable acids. The second volume, which is to appear shortly, will be devoted chiefly to coal-tar products and bodies of the aromatic series, to hydrocarbons generally, fixed oils and the products of their saponification, and the tannins. Nitrogenised organic substances, including cyanogen compounds, alkaloids, organic bases, and albumenoids will be treated of in the third and concluding volume. This arrangement of the subject is, we think, a great improvement on the previous one, and makes the book much more convenient for reference.

Mr. Allen treats his subject in as scientific a manner as possible, and this gives quite a peculiar character to his work. It is not, like so many books on analysis, merely a series of receipts or processes of chemical handicraft; but a work assuming the possession of some really scientific knowledge on the part of those using it. It would be easy to go too far in attempting to generalise in such a subject as commercial analysis and in introducing theoretical details; but although the author goes so far, for instance, as to introduce structural formulæ for many of the substances dealt with, it cannot be said that he demands more knowledge than should be forthcoming from those engaging in this difficult and often obscure branch of analysis.

The introduction, extending over thirty-five pages, embraces a description of some general methods, such as the determination of specific gravity, of melting- and boiling-points, optical properties, &c. The rest of the volume is devoted to a consecutive account of substances comprised under the several headings. After the author has described briefly but sufficiently what the substance is or ought to be, he gives the methods for its detection, estimation, or analysis, and intersperses the account with such general information as is likely to be of value to the analyst. We cannot attempt to enumerate the somewhat remarkable collection of products dealt with in the course of the work. Wines, beers, cordials, tinctures, chloroform, sugars, confectionery, starch, vinegar, the commercial acetates, tartrates, and citrates—are examples taken at random, which will serve to give some idea of the variety. They are, however, treated in a connected manner, in illustration of which we may refer with special approval to the division on sugars, and starch and its isomers.

With regard to the methods recorded by Mr. Allen we may say that on the whole they are such as have borne the test of experience, whilst new processes or modifications of old ones are duly referred to and discussed. The author acknowledges assistance from many men of experience, and has, we think, used it to the best purpose. His descriptions are clear and concise, and the book is remarkably free from errors of any kind. We think it really an excellent enterprise, excellently carried out, and congratulate Mr. Allen on having produced a scientific and thoroughly practical book which, we are confident, will find a place in the library of every practical chemist.

RECENT TEXT-BOOKS OF DETERMINANTS

Lecciones de Coordinatoria con las Determinantes y sus principales aplicaciones. Por D. Antonio Suarez y D. Luis G. Gascó. (Valencia, 1882.)

Traité Élémentaire des Déterminants. Par L. Leboulleux. (Genève, 1884.)

Die Determinanten, für den ersten Unterricht in der Algebra bearbeitet. Von Dr. H. Kaiser. (Wiesbaden 1884.)

Lessons Introductory to the Modern Higher Algebra. By George Salmon, D.D. Fourth Edition. (Dublin, 1885.)

THE first of these works is outwardly a very handsome volume, and on examination we find that the authors have also done their part in the most painstaking and methodical way. The main part of the title, "Coordinatoria," is apt at first to mislead, and indeed after a cursory glance at the contents a cosmopolitan reader might be pardoned for thinking that "Coordinatoria" was a misprint for "Combinatoria," for what our grandfathers spoke of as the *Ars Combinatoria* is the subject of the opening chapters. "Coordinatoria" it is, however, and in the preface it is placed as a science side by side but in contrast with the science of Quantity.

There are in all twenty chapters in the book. The first seven (146 pp.) deal with permutations, combinations derangements or inversions of order, substitutions, and difference-products: they form a lengthy and most carefully prepared introduction to the theory which follows. The next ten chapters (242 pp.) deal with determinants, and expound all the more important properties in the most methodical, simple, lucid and ungrudging manner. The learner, for example, is prepared for the evaluation of a determinant whose elements are expressed in figures by—

§ 327. Simplification by addition.
§ 328. Simplification by subtraction.
§ 329. Simplification by addition and subtraction.
§ 330. Simplification by multiplication.

And so on, up to—

§ 335. Simplification by multiplication, addition, and subtraction.

An impatient Briton might be tempted to call this "simplification to the death," but after calmly perusing the whole he might be induced to confess that he had said so in his haste. The last three chapters deal with applications of determinants: one is arithmetical, and is mainly concerned with continuants and magic squares—a rather invidious juxtaposition; one is algebraical, and gives the determinantal solution of a set of simultaneous linear equations; and the last is geometrical. A very valuable feature of the book is a *résumé* in 40 pp. of all the definitions and theorems given in the preceding 410 pp. No one but a most enthusiastic and painstaking teacher would have thought of adding such an admirable abstract.

The next book on our list might have been more accurately described as a *very* elementary treatise: it must have been intended for pupils with exceedingly little algebraical training. The first 18 pp. are occupied with determinants of the second order, and they are followed by 33 pp. treating of those of the third order. It may be safely affirmed that the pupil who requires 18 octavo pages to teach him the theory of such abstruse functions as determinants of the second order would do well to redirect the expenditure of his mental energy. The book is carefully and accurately written, and there is a wealth of simple exercises in it, worked and unworked.

Dr. Kaiser's pamphlet is of the same ultra-elementary character—considerately restricted, however, to 23 pp. On a former occasion (NATURE, vol. xxix. pp. 378, 379) we drew attention to the fact that a new Introduction of this kind appears every year in Germany, and that of late they have not been improving. We merely notify, therefore, that this is the production for 1884.

The preparation of a new edition of Salmon's "Modern Higher Algebra" has been entrusted to Mr. Cathcart. It contains about 40 pp. of new matter, the chief increase arising from the expansion of the chapter on "Applications to Binary Quantics" into *two* chapters, the first with the old title, and the second headed "Applications to Higher Binary Quantics." The changes made on the portion which deals with determinants are slight, and consist chiefly in the insertion here and there of well-chosen examples.

OUR BOOK SHELF

The Three First Years of Childhood. By Bernard Perez. Edited and translated by Alice M. Christie. With an introduction by James Sully, M.A. (London: W. S. Sonnenschein and Co., 1885.)

THE earliest years of infancy are of importance to two classes of inquirers—to the educator who knows how much evil results from the wrong treatment of young children, and to the evolutionist who, rejecting the *tabula rasa* of Locke, looks to infancy as the time freest from any effect of artificial training. In the study of other *men's* minds the observer is as likely as not to be purposely deceived by them, whereas deceit is an accomplishment which few infants have attained to.

Mr. Bernard Perez seems well to combine these characters. He is an educator who has published various works on school matters, and he describes man as an animal which ought to be reasonable, while he is not necessarily so, as criminal scandals and the success of bad novels prove. He notes that the preponderating elements in a child's will are impulsiveness and stubbornness, incapability of fixed attention, qualities most opposed to the temperament of philosophy and discipline. Much of his book is advice to practical educators, whom he urges to study the manifestations of infancy and to endeavour to lead their youngest pupils by example and not check their behaviour by authority; their intellect should be helped, not controlled. He specially points out the danger of deceit before even the youngest of children.

But, on the other hand, there is little of the tone of the pedagogue in his book. Far more is it a book of suggestion than one teaching with authority, and it will encourage the spirits of fruitful doubt and inquiry in the mind of every reader. He enters heartily into the teaching of modern science, even to using the argument that infants have not certain sensations *because* they would be of no use to them at that age; and, thinking it necessary to caution his readers against leaving everything to hereditary dispositions and powers. He urges the importance of comparing early human life with animal life, thus making cats, dogs, birds, and babies more interesting than before. We may enjoy his book without accepting the teaching that human language has grown out of such involuntary signs as laughter, sobs, and screams, afterwards performed voluntarily. No doubt these involuntary sounds are of more use to an infant than more sober utterances, and have therefore become innate and involuntary, while language is an artificial acquirement. We think that few who have watched their vigorous antics will feel sure that a state of equilibrium, a passive state of health, or even that of moderate and appropriate exercise in moving their limbs, is the most enjoyable sensation to infants, though this latter pleasure is sufficient to explain many actions of infants for which our author seeks a deeper reason. On the other hand, we think that the moral sense has become more deeply impressed than he suggests, and is far from entirely the result of approbation and disapprobation.

Attention and vivid perception seem strangely shaken up in his remarks; the latter faculty explains the dislike which children have to hearing a tale repeated with variations. They have indeed got it all "by heart."

Mr. Sully, in his very suggestive introduction, raises the question, Who is best qualified to follow up this delicate business of observing and rightly explaining all the movements and utterances of such young objects? Neither father, mother, nurse, nor doctor is completely qualified for the study. Mr. Sully concludes that the father and mother must conjointly undertake the work, the cooler intellect of the one checking and steadying the close and loving knowledge of the other. Let us suggest that an elder sister is most likely to succeed, and thus indicate a path to intellectual usefulness and even eminence well fitted for a lady's sphere. It will elevate every little labour from drudgery into a scientific study of variations and resemblances of the greatest importance, and add immensely to the interest of nursery life in a large family. On such observations may be based, by herself or by more ambitious philosophers, theories of racial varieties, of biology, and of education. Sir W. Hamilton points out that the study of the human mind requires no scholarship or costly apparatus, and the principal acquirement necessary for success in the study we suggest is a little close knowledge of one's own thoughts and feelings. In recording observations Darwin's golden rule must always be strictly adhered to: Theorise freely—every other observer will help to demolish anything that will not hold water, and whether true or not it may be a suggestive hypothesis. Be most scrupulous as to recording as a fact anything not strictly correct; no one can disprove it, and it may throw back the reception of a useful truth for a generation.

W. ODELL

Un Capitolo di Psicofisiologia. Da Enrico dal Pozzo. Foligno, 1885.)

A GOOD book on abnormal mental phenomena of all sorts was to be expected from Prof. dal Pozzo, one of the very oldest living investigators of this branch of physiology in Europe. The present excellent little treatise comprises the substance of seven lectures delivered during the current year to the medical students at the University of Perugia on "Hypnotism," "Animal Magnetism," "Somnambulism," "Human Radiation," and "Psychism." The whole field is thus covered from the time of Mesmer down to Mr. Crookes's experiments, and the still more recent "Thought Readings" of Mr. Bishop and Mr. Cumberland. As a philosopher of the monist school, the author naturally rejects the spiritualistic conception, accepts the term "psychism" only in Mr. Crookes's sense, and regards all these manifestations as strictly co-related and explicable on physiological grounds. Human radiation he is also disposed to admit as a biological property, hence has no difficulty in believing in such well-attested facts as may be explained by it. But whatever cannot be so explained he regards as unworthy of credence, and treats the terms "spiritual," "transcendental," and the like, as synonymous with ignorance. The power claimed by paid mediums to hold commune with the departed is, of course, emphatically denied, and it is cogently argued that the medium can tell us nothing regarding present or past facts of which the audience may be ignorant. He cannot, for instance, say how many chairs are in the next room if the number is unknown to all present, whereas the somnambulist will often tell it exactly. Hence if these psychic manifestations did not depend on human radiation, but were the work of spirits, it would follow that these spirits are more ignorant than ordinary somnambulists. And to the assertion that psychism produces phenomena absolutely inexplicable by human radiation, the answer is that who cannot do the less can scarcely do the more in matters of this sort.

At the end of the work a chapter is added on Giordano Bruno, and his philosophic system, which, although not directly connected with the subject, will repay perusal.

Die Nutzbaren Pflanzen und Tiere Amerikas und den alten Welt vergleichen in Bezug auf ihren Kultureinfluss. Dr. L. Höck. (Leipzig: E. Engelmann, 1884.)

IN a pamphlet of fifty-eight pages Dr. Höck institutes a comparison between the useful plants and animals employed by man in the two hemispheres. Although the comparison is made in a somewhat rambling manner in the text, the conclusions arrived at are clearly tabulated in the form of an appendix. The influence of useful plants and animals on civilisation seems almost lost sight of, except on p. 10, where guesses at their mode of influence, rather than evidence proving it, are offered. Only those species considered by Dr. Höck to be the most important to mankind are noticed; hence the comparison can only be regarded as approximate to the truth. The author finds that the Old World or eastern hemisphere affords 269 useful plants and 58 animals against 52 plants and 13 animals derived from the New World. In consideration, however, of the larger area of the eastern than of the western hemisphere, which he estimates as being in the proportion of 9 to 4, he concludes that the New World only affords rather more than half so many as the Old.

The tables in the appendix indicate a certain amount of carelessness or confusion, which slightly vitiates the conclusions arrived at. Thus, *Citrullus Colocynthis* and *Momordica Elaterium* are classed under fruits used as food, instead of under medicinal plants; *Rumex Patentia* is indicated as English spinach, and *Haematoxylum campechianum*, which is stated in the text to be a New World plant, is given in the appendix as belonging to the Old World. It is difficult to understand the principle upon which the "more important" plants have been selected, many of them being by no means so extensively used as others which are omitted; this is particularly noticeable in the list of medicinal plants and those used in the arts. But, in justice to the author, it must be admitted that the task he has undertaken is a most difficult one, and cannot be fully treated in so small a space as he has given to it. His claims that the greater proportion of the present work was already completed before De Candolle's "Origin of Cultivated Plants" fell into his hands must also be allowed due weight.

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.*]

Iona

BEFORE the close of the season when there is easy, and indeed luxurious, access to the Island of Iona by steamers from Oban, I would call attention to the high interest which attaches to its geology in connection with the rocks now called "Archæan."

Although the rocks of Iona are lithologically very distinct from the old gneiss of the Hebrides (which is the true "Laurentian" and closely resembles the rocks near Quebec), yet they are equally distinct from the mica slate series of Argyllshire, and I have always regarded them as undoubtedly belonging to the pre-Cambrian horizons. I had never seen, however, until last week, the beautiful sections exhibited in the precipices of the south-west corner of the island. Tourists often visit the little "Bay of the Coracle," where St. Columba is said to have landed, and I had not myself gone farther west. But the very calm sea of last week tempted me to boat round the farther coast to the south-west, and I was much struck by the sections there seen. The rocks are quite free from vegetation, and the exhibition of the strata is very striking. They are intensely hard and highly silicious—beautifully coloured with red, green, and black—and the beds dip at a high angle with remarkable flexures and faults of all kinds.

On the side of the island where the cathedral is, and which tourists visit, the rock is entirely different in its mineral aspect and character—being a dark or black slaty rock, thinly bedded, and with no bright colouring at all. It belongs, however, evidently to the same series, and has generally the same dip and strike as the beds farther west.

I should be very glad if some geologist acquainted with the different horizons of the Archæan series so largely developed in Canada could visit Iona, and determine to which of these horizons its rocks belong. Between them and the mica slates of the mainland of Argyllshire there is interposed the massive granite of the Ross of Mull—which comes up close to the eastern shore of Iona, and on the other side of which, near Bornepan, the mica schists are in the same relative position; while underneath the granite itself, and sometimes interbedded with it, there are some beds of a dark hornblendic gneiss.

The whole neighbourhood is evidently one of great interest in connection with the oldest metamorphic rocks of our island.

S.S. *Columba*, Campbelltown, August 30 ARGYLL

Radiant Light and Heat

THERE are two points in my article of last week which I should like to have the opportunity of discussing at somewhat greater length.

(1) In this article I made use of the following expression, having especial reference to phosphorescent bodies which continue after excitement to emit luminous rays at a comparatively low temperature:—"*There seems to be no reason why molecular energy should not be somehow changed at once into radiant light and heat.*" Let me now explain what I meant by this statement. The concluding quotation from Prof. Tait leads us to see that the definite connexion between the quantity and quality of the heat and light given out by a body and the temperature of that body, which the theory of exchanges asserts, is only statistically true. I can imagine, therefore, a few neighbourin g

molecules of some phosphorescent substance to be in a state of constraint, and to relieve themselves, thus causing vibrations which are communicated to the ether—the whole change taking place so quickly and on so small a scale that the statistical law abovementioned does not apply, and is not therefore broken. Nay, further, I can imagine an enclosure, the walls of which are coated internally with an excited phosphorescent body performing for all practical purposes the part of an enclosure of low temperature under the theory of exchanges, and yet it may be continuing for some time to emit visible rays.

(2) I can, however, imagine the following question to be put: Let there be a phosphorescent substance which is capable of being excited by certain rays coming from a black body at the temperature T, these rays being apparently converted into others of lower refrangibility which continue to be given out for some time by the phosphorescent body. Let us further suppose that the phosphorescent body does not suffer chemical decomposition at the temperature T.

Now imagine a temperature enclosure kept at temperature T, the interior walls of which are lined in part with this phosphorescent substance. What will happen in this enclosure?

I think there can be little doubt that if there be such an enclosure capable of existing permanently and without decomposition of the substances which compose it, then the rays which it gives out must be those required by the theory of exchanges, But if the further question be asked in what way does the phosphorescent body conform to the theory of exchanges, we may, I think, plead ignorance. As far as I am aware we have experimentally little or no knowledge of what the phosphorescent substance will do under these conditions, presuming that it can exist undecomposed. All our knowledge is limited to its behaviour at a low temperature when acted on by high temperature rays, and its peculiar behaviour under these conditions cannot, I think, be viewed as a valid objection to the theory of exchanges.

BALFOUR STEWART

The Eleven-Year Meridional Oscillation of the Auroral Zone

THIS very remarkable law, in favour of which Mr. Tromholt quotes a short series of observations made at Godthaab, which, he says, are supported by a few in other Polar regions, would, it seems to me, if satisfactorily proved, not only advance the science of terrestrial magnetism a stage, but also materially help to elucidate the exceedingly mysterious bond of union between the aurora and weather. As long as we simply knew that the manifestations of the Aurora Polaris increased and diminished *everywhere* with the spotted area of the solar surface, we were obliged to conclude that there was a similar increase and decrease in the electrical energy of terrestrial currents, and meteorological evidence did not favour the idea that the eleven-year variation in terrestrial currents was on such an extensive scale as the amplitude of the auroral oscillation would imply. But now if the law which Tromholt has indicated, really exists, a great deal of the difficulty in correlating the two phenomena disappears, since it is obvious that a comparatively small displacement of the zone would cause the annual average number of auroræ to increase or diminish by their normal amount. Thus from lat. 60° N. to lat. 65° N., a distance of only 350 miles, the annual average number of auroræ diminishes from 80 to 40.

I will not now dwell upon analogous eleven-year oscillations of isobars, such as Blanford's Asiatic seesaw, and the indications of similar secular displacements of the Atlantic isobars noticed by Allan Brown and others, or upon the extraordinary resemblance in form between the auroral zone and the mean storm track of the northern hemisphere charted by Prof. Loomis in his latest contribution to meteorology; but I would merely say that Tromholt's discovery seems likely to become the touchstone which may, in the hands of an intelligent and comprehensive worker, clear up the entire question, and I earnestly hope that no efforts will be spared to corroborate it.

I will conclude by adding my mite. In looking over Fritz's monograph on the connection between solar spots and terrestrial magnetism and meteorology, I have found a series of observations at Godthaab and Jakobshavn (69° 22′ N.) further north, which do not appear to have been utilised by Mr. Tromholt, and which, when combined in the form of percentages, cover a space of ten years, and add strong corroboration to the law indicated by Tromholt.[1]

[1] "Ueber die Beziehungen der Sonnenfleckenperiode zu den magnetischen und meteorologischen Erscheinungen der Erde," p. 48.

TABLE I.—*No. of Auroræ seen annually at Godthaab and Jakobshavn, compared with Wolf's Sunspot Numbers*

Years ...	1840	41	42	43	44	45	46	47	48	49	50
Godthaab ...	—	60	93	84	87	74	32	—	—	—	—
Jacobshavn.	10	15	15	18	12	24	21	17	14	11	21
Sunspots ...	63·2	36·8	24·2	10·7	15·0	40·1	61·5	98·4	124·3	95·9	66·5

TABLE II.—*The above numbers of Auroræ converted into percentages of their means and compared after smoothing with smoothed Sunspot Numbers*[1]

Years ...	1840	41	42	43	44	45	46	47	48	49	50
Godthaab ...	—	84	131	118	122	104	45	—	—	—	—
Jacobshavn.	62	93	93	111	74	148	130	105	86	68	130
Smoothed means of both	70·5	87	106·2	129	109	109·2	101·2	95·7	86·2	88	109
Smoothed sunspots	54·4	40·2	23·9	15·1	20·2	39·1	65·3	95·6	110·7	95·6	76·3

The figures in Table II. speak for themselves.

To corroborate this law by further observation will necessitate a prolonged sojourn in some region *north* of the maximum auroral zone, and Greenland appears to be almost the only region where this could be done in the absence of a regular Polar expedition.

E. DOUGLAS ARCHIBALD

Tunbridge Wells

[1] The figures are smoothed by the formula $\frac{a + 2b + c}{4}$, where b is the figure for the epoch and a and c the preceding and succeeding figures.

On Cases of the Production of "Ohm's (or Langberg's) Ellipses" by Biaxial Crystals

IN examining the macled crystals of potassium chlorate, which are so extremely common in the ordinary crystallised salt, I have found that all those which consist of two hemitrope plates only, nearly equal in thickness, give the above-mentioned secondary interference-curves when placed in homogeneous convergent plane-polarised light.

This result is no more than we should expect if the crystals were uniaxial, as Prof. Langberg showed (*Pogg. Annalen Ergänzungsbd.*, I., 540) many years before the curves were independently discovered by Prof. G. S. Ohm (see NATURE for November 27, 1884, p. 83). But potassium chlorate is a biaxial crystal, the angle included by the optic axes being 28° 30′ (determined in olive oil), and I do not find that the production of the curves in such crystals has been hitherto noticed.

The plane of the optic axes, however, makes so large an angle, viz. 38° 30′ (as determined in olive oil), with the normal to the surfaces of the plates in which potassium chlorate usually crystallises, that the isochromatic curves in the vicinity of this normal belong to a very high order, and do not sensibly differ from portions of circles of large radius. Thus in a macle, in which the crystallographic position of one of the components differs by 180° from that of the other, the planes of the optic axes make equal angles of 38° 30′ with the normal on opposite sides of it, and so the conditions determined by Langberg for the production of the secondary ellipses are fulfilled. I have, in fact, made artificial twins of this kind by cementing together plates of the salt oriented as above indicated; and I find that they show the ellipses precisely as the natural macles do. Of course, in order to see them, the compound plate must be so placed that the plane which includes the normal and the two acute bisectrices makes an angle of 45° with the plane of polarisation of the light. In a good micropolariscope the four optic axes and portions of the lemniscates immediately surrounding them are visible at the edges of the field.

It is possible, but not common, to find crystals of potassium chlorate consisting of three plates nearly equal in thickness, the top and bottom plates being symmetrically disposed, while the intermediate one differs from them in crystallographic position by 180°. In such cases the secondary interference-curves are much more complicated, two sets of ellipses being generally visible, one on each side of the centre of the field (the exact position, of course, depending on the relative thickness of the plates, as Langberg has shown). One macle I have found to consist of five or six distinct plates, and the secondary curves produced by this are too complicated to be easily described.

I do not find any marked difference between the curves produced by the iridescent twins and those given by the ordinary macles. Many of the iridescent crystals show, when the plane of symmetry is either parallel or perpendicular to the plane of polarisation of the light (the analyser being crossed), a few broad, black, curved bands crossing the main black band lying in the plane of symmetry, which are probably portions of the isochromatic curves of a very thin plate. But, on the other hand, some non-iridescent crystals show these bands, and some iridescent crystals do not show them at all. Also the iridescent crystals which reflect D light at moderate incidences show very perfectly the circular band described by Prof. Stokes (NATURE for April 16, 1885, p. 566, par. 9) as sharp black crescents, the horns of which nearly touch each other at the plane of symmetry.

Almost the whole of the ordinary commercial crystallised potassium chlorate seems to consist of macles; so that, in order to get a single individual crystal for examination, I have always had to cut away one component of a twin.

It seemed worth while to try whether other biaxial crystals would, when similarly combined, give similar phenomena. I took a crystal of barite (barium sulphate), the angle included by the optic axes of which is, according to Groth, 63° in air, and cut a plate of it in such a direction that the plane containing the optic axes made an angle of 53° with the normal to the surfaces of the plate. I then cut it in half and cemented one of the portions upon the other in a reversed position. The compound plate thus produced shows the secondary ellipses (which, however, are very nearly circles) in great perfection. I have also made similar compound plates of borax, nitre, and citric acid, and found them to give similar results. H. G. MADAN

Eton College, August 24

The August Meteors

BETWEEN August 4 and 20, 174 shooting stars were recorded here in $16\frac{1}{2}$ hours of observation. These included about 37 Perseids, chiefly seen on August 5, 8, and 13, but the shower was not well observed owing to cloudy weather. The following are the chief radiant points determined from the paths registered:—

No.	Epoch August	Radiant α °	δ °	Notes
1	16–20	5	+12	Meteors bright, max. Aug. 20.
2	13	51	+58	Perseids.
3	4–17	292	+52	Near χ Cygni.
4	5–13	296	±0	On equator near η Aquilæ.
5	5–20	317	+22	Meteors slow and faint.
6	8–17	318	−9	Slow, S.W. of β Aquarii.
7	15–17	328	+27	Slow, faint.
8	11–15	329	+8	Slow, bright, E. of ϵ Pegasi.
9	16–20	345	±0	Rather swift, bright.
10	8–20	345	+53	Very swift, short.
11	16–20	351	+38	Swift, E. of *o* Andromedæ.

Many other shower centres were less distinctly shown. Nos. 4 and 9 fall exactly on the equator, and were sharply defined.

As to the shower of Perseids on August 10, I believe it was more brilliant than usual, though I made no regular observations on that night this year in consequence of overcast sky. Many meteors were, however, noticed in the clear spaces which now and then occurred, and judging from the frequency of the apparitions the display was a fine one. As to the duration of the shower it was still visible, though very feebly, on August 20, for I registered 2 undoubted Perseids during a watch of $3\frac{1}{4}$ hours, when 31 meteors were recorded.

With regard to the minor displays of this epoch they are more remarkable for their number than for individual intensity. The most active of these radiants, as recently observed, was No. 10 at 345°+53°, which supplied about 10 meteors, but the rate was less than one per hour, so that it cannot be ascribed much importance. W. F. DENNING

Bristol, August 25

Disinfection of Sewers

IN the last number of the *Lancet* (August 15, 1885) I have read of the measures taken by the Metropolitan Board of Works for the deodorising and disinfecting of London sewers. Between 30,000 to 40,000 tons of sodium manganate and from 10,000 to 12,000 tons of sulphuric acid are daily poured in the London sewers.

By what experiments has it been ascertained that the quantities of disinfectants used are sufficient, and how is it proved that the sewers have been properly disinfected?

I need not point out the difference between the deodorising and the disinfecting of sewage. The latter may be perfectly deodorised, and yet be quite adapted to favour the vegetation of bacteria.

The oxidising and deodorising action of sodium manganate cannot be sufficient to prevent bacterial life, unless when the salt is present in large quantities. Considering the enormous volume of London sewage, it is not to be believed that even such a vast amount of manganate as 40,000 tons *per diem* would suffice to destroy bacterial life in the sewers.

The adding of sulphuric acid to the manganate must certainly enhance the disinfecting action of the latter. Only, I do not understand why the quantity of sulphuric acid is relatively so small in comparison with the quantity of manganate. I do not see why manganate should be used at all when sulphuric acid, a more powerful and less costly disinfectant, can be used alone.

It is well known to all who occupy themselves with the cultivation and study of bacteria that these micro-organisms do not grow well in acid media, and that the addition of acids, especially of mineral acids, checks their growth completely.

It can be said that the antiseptic action of acids is of household knowledge, for vinegar is constantly used in the preservation of animal and vegetable products. That mineral acids have a greater disinfecting action than vegetable acids is also well known, unfortunately even by dealers in vinegar, who give durability to this condiment by the addition of a tiny proportion of sulphuric acid.

It is probable that pathogenic bacteria, even more than the bacteria of ordinary fermentations and of putrefaction, are in need of alkaline media, and therefore are more sensitive to the action of acids. In the animal body bacteria invade those fluids and tissues where the alkaline reaction prevails; and it is proved that the germs of disease are easily spread by milk, a liquid generally alkaline. Moreover, it has been proved by experiments on some pathogenic bacteria that gastric juice, although of so slight acidity, easily, and sometimes effectively, checks their development.

Sewage contains all the elements necessary for the nourishment of bacteria, and its alkaline reaction renders it very favourable to their growth and preservation. Disinfection means the destruction of existing bacteria and preventing the development of newly-sown bacterial germs. Therefore I am persuaded that the cheapest and more simple method for effectively disinfecting sewage is to render its reaction *permanently acid* by the addition of a sufficient quantity of mineral acid.

There are of course disinfectants far superior to mineral acids in antibacterial energy. But they are generally costly substances, that cannot be applied to the disinfection of such an enormous quantity of matter as the sewage of a town. As for cheap disinfectants, such as ferrous sulphate, ferric chloride, sodium manganate, their action is inferior to that of mineral acids. Especially of the two former it can be said that their deodorising action is due to their saline constitution, and their disinfecting action to their acid reaction.

The great difficulty in extensive disinfections is to ascertain if the disinfection has been complete—*i.e.* if the substance disinfected has been rendered unfit for the development and preservation of bacteria. Even laboratory experiments, to ascertain the *minimum* of disinfectants necessary for the destroying of bacteria, are not easily conclusive. But, in using acids, the disinfection can be considered complete when a permanent acid reaction is obtained.

I do not believe the quantities of sulphuric acid poured in the London sewers sufficient to give a permanent acid reaction to the sewage. Disinfection must be done completely, or not at all: there are no half measures in disinfection. Therefore I maintain that the London disinfection is useless, and the sewage remains likely to become the culture fluid of infectious germs, unless the sewage is rendered permanently acid. All the sodium manganate added to a sewage that remains alkaline, gets decomposed; the manganese precipitates as sulphide, or is deposited in combination or mixture with the organic sediment. The sewage will thus be cleared and deodorised for a while; but it still contains in solution all the elements necessary for the nourishment of Bacteria, and is still favourable to their growth and preservation. The disinfecting action of sodium manganate would avail only if large quantities of the salt remained dissolved in the sewage, over and above of the quantities decomposed in deodorising and clearing the putrid fluid.

It might be objected that, even if mineral acids stop the development of bacteria—a point that cannot be doubted—they may not kill the spores, thus permitting the germs of disease to escape. There are no experiments (of which I am aware) to answer this objection. But there is reason to believe that pathogenic germs do not resist for a very long time when in unfavourable media; even in sewers, that are not over-filled and stagnant, and that are well ventilated, infection does not easily linger. If inside the sewers disinfection is complete, and bacterial growth checked, and all disease germs rendered inactive, until carried for away from all populous centres, I think we can leave it to air, and to the other natural agents, to ultimately destroy the surviving germs, or completely alternate their pathogenic qualities.

Amongst the mineral acids, hydrochloric would, of course, be the cheapest. But I think sulphuric acid ought to be preferred, nitric acid being too costly and too corrosive. Sulphuric acid does not attack easily calcareous cements; and if the sewers have their walls well plastered, the action of a *slight excess* of sulphuric acid in the sewage would be very slight indeed. Cements, more resisting than plaster, could be prepared. Moreover, if some portions of teh sulphuric sewage get carried in the air, or are dried in the higher parts of the sewers, the germ-laden particles do not rid themselves of the acid by evaporation; on the contrary, the acid becomes more concentrated and active, and finally must disorganise and destroy the noxious germs. This is very important in preventing the effects of sewage air.

Since 1881 Prof. Beilstein of St. Petersburg (NATURE, vol. xxiii. p. 394), experimentally concluded that sulphuric acid is the best disinfectant, although he did not advise its use because of its corrosive action. Strange to say, Beilstein thought that, practically, aluminous sulphate was to be preferred to the free acid.

It is not only during the fear of cholera invasions, but at all times, that I would wish the sewage to be *slightly* acidified with sulphuric acid. Strict supervision should be maintained over all the sewers, to ascertain that the whole mass of flowing sewage is permanently acid. I am persuaded that this simple mode of disinfection would diminish considerably many infectious diseases.

During the cholera epidemic of 1884, in Naples, I did my best, in a series of letters I then published, to persuade the sanitary authorities of this mode of disinfection. But a strange confusion of ideas was then prevalent in Naples. Through the goodwill of Prof. Cantani, Member of the Sanitary Commission, some trials of the method I proposed were done, but not in a complete and systematic manner. Such experiments cannot be done easily in Naples, and the results cannot be conclusive until the system of sewers is in good working order. Indeed, in some parts of the soil of Naples it is difficult to know if there is more sewage inside or outside the sewers. It is no easy problem to disinfect and cleanse such an impure soil, and it is indeed to be wondered that the ravages of cholera were so limited in 1884.

My letters caused sulphuric acid to be used abundantly in the sewers and *pozzi neri* of Portici, Castellamare, Taranto, and, I believe, in other places; but this, like all other disinfections, was done under pressure of approaching cholera, and abandoned as soon as the danger passed, no observation being made to measure the influence of the sanitary method adopted on local infectious diseases. The defective system of sewers and of drainage in many Italian towns renders thorough disinfection scarcely possible, and prevents precision in testing any kind of disinfection.

In English towns sewers are generally well arranged, and often well ventilated; and vital statistics have taken sufficient development to permit the testing of sanitary reforms. When it is proved (and I think the proof can be easily given) that the present systems of sewage disinfection are not sufficient to prevent *entirely* bacterial development in the sewers, these systems cannot be considered good. I venture to hope that beneficial results would soon become evident if the sulphuric acid disinfection of sewage were thoroughly applied in English towns.

Portici, August 20 ITALO GIGLIOLI

Ozone at Sea

THE presence of this element in the atmosphere is alleged to be indicative of its healthiness, and it has been *investigated on land* frequently by observers with varying and uncertain results.

Records of its presence may be seen daily in the *Times*, furnished from the Observatory on Ben Nevis, but as yet little notice has been taken of its *prevalence at sea*, though it has been supposed to be more plentiful there than on land.

During a voyage around the United Kingdom on the s.s. *Ceylon* in August last, we entered into the investigation of its existence at sea, and used Moffatt's papers for the purpose, obtained from Negretti and Zambra. They were exposed in a perforated light wooden box, hung up in the open air on the deck of the ship in the shade, and noted and changed twice a day.

It was found most prevalent in *Cork Harbour* (4), less so in Bantry Bay (2) and Oban Harbour (2), and nearly absent in Kingstown Harbour (1) and Leith Roads (1).

In the open sea it was most shown in the *Irish Channel* (4) and off the Lands End (4); next in the North Seas (3) and in the English Channel (2), and least in the Irish seas (1) and western coasts of Scotland (1).

Ozone was found to be indicated in greater intensity during the prevalence of *westerly winds* in the English and Irish Channels, and Atlantic seas and Dutch seas, and less with *easterly* winds prevailing in the Irish seas, Firth of Forth, and west coasts of Scotland.

The *velocity* of the winds seemed also to create a higher manifestation, as was seen during the gale from the south-west in Cork Harbour and the fresh north-westerly breezes on the south coasts of Ireland and east coasts of England. None, however, of the observations approached those registered in the *Times* from Ben Nevis (8–9), which amounted to double those noticed in the seas around our coasts during the same period (August), supposing that the same papers and scale (Moffatt's) were used for both sets of observations.

Ozone was also found to exist in the *cabin of the ship* both day and night, but at a half intensity to that on the deck, due probably to the great difference in the movement of the air in the two places.

The degrees of manifestation of ozone at sea here shown by no means come up *to expectation* that it prevailed in all its potentiality on the ocean, but of course a whole year's observation would be required to enlighten the subject and furnish a comparison with that on the land.

Again, it may be possible that *altitude* may have something to do with its prevalence, more or less, as it appeared more on the top of Ben Nevis than on the level of the seas of the same coasts near it and at the same period of the year (August).

Should this idea be of any significance it might be as well to search for manifestations of ozone at the base as well as on the top of mountains, and if similar results followed to these here pointed out it would establish the *reputation of high* level sites for great salubrity of atmosphere. W. J. BLACK

August, 1885

THE INTERNATIONAL BOTANICAL AND HORTICULTURAL CONGRESS, ANTWERP, 1885

THE International Botanical and Horticultural Congress met at Antwerp on Sunday, August 2, in the hall of the Artistic, Literary and Scientific Club, the opening meeting being honoured by the presence of a good many ladies. The gathering was a representative one, and included many well-known European botanists and horticulturists. The Burgomaster of Antwerp opened the proceedings with a few appropriate remarks, and Prof. Ed. Morren, of Liége, having been made President of the Congress, took the chair, and a discussion was held on the flora of the Congo. After a short discussion the meeting adjourned to the Exhibition building, where the International Horticultural Show was being held, and which was formally opened at one o'clock. Many of the plants exhibited were of great interest, and the whole of the collections were nicely and artistically arranged. At five o'clock the Congress visited the Plantin Museum, the old printing office of the Plantin Moretus family. The Museum is full of interest, and as the printing office from which the works of Lobel, Dodonaeus, and Clusius issued, doubly interesting to all botanists. Through the kindness of the Burgomaster of Antwerp a sheet had been struck off for the members of the Congress, so that each was presented with a souvenir of the three great herbalists.

In the evening there was a concert in the garden of the Exhibition in honour of the members of the Congress.

During Monday, Tuesday, and Wednesday the two sections of the Congress—the Botanical and Horticultural—met in the Botanic Garden in the upper and lower halls of the Botanical Institute. The different subjects contained in the programme were duly discussed, and a resolution of Congress on the different points raised terminated each discussion. The method adopted at these meetings was one which might well be followed in other assemblies, and is one which reflects great credit on the President of the Organisation Committee, M. Charles de Bosschere. All the subjects to be discussed were treated of in longer or shorter papers, all of which were printed in the four fasciculi of the *Preliminary Reports* issued to the adherents of the Congress. In this way all the members had the subjects before them in a tangible form, and discussion was easy. Might not the British Association take a hint from this? Without giving up the method at present followed, let the British Association add to their work a discussion on one or two subjects of importance, papers by special men to be printed beforehand, so as to be in the possession of those who can discuss the subject at the meeting.

The subjects of discussion—twenty-two in number—were mostly of considerable botanical interest, others being purely horticultural, the question of the Congo being general. Perhaps the most important subjects were the discussions on botanical laboratories, on the amount of instruction in cryptogams to be given in different parts of the botanical course of study and the recent progress of botany in different countries. It is important to notice that the general opinion of the Congress was in favour of two kinds of botanical laboratories, those of instruction and those of research, and there can be no doubt that in every society research should be encouraged in every way and be the highest object of their organisation.

On the evening of August 3 the Burgomaster of Antwerp held a reception at the Hôtel de Ville, which was very largely attended by the members. On the evening of August 4 Dr. Henri Van Heurck, the Director of the Botanic Garden, gave a most interesting series of microscopical demonstrations in the meeting-room of the Botanical Section. The application of the electric light to microscopic work was shown, and nothing could exceed the perfection of the arrangement employed by Dr. Van Heurck. *Surirella gemma*, *Amphipleura pellucida*, and Noberts's 19th band were shown in a manner which left nothing to be desired; and in the case of Amphipleura, not only were the striæ shown as distinctly as one is accustomed to see them in *Navicula rhomboides*, but, by illumination through the object-glass, the striæ were distinctly resolved into beads; by oil-immersion lenses, of which, as of other object-glasses by all the best makers, Dr. Van Heurck possesses a remarkable series. The electric light employed is obtained by a bichromate battery (Trouvé's) and Dr. Helot's photophore. As the photophore works equally well with an accumulator, and where there is no difficulty in getting the accumulators charged, no better illumination can be got, and this I would strongly recommend to all microscopists. Altogether Dr. Van Heurck's demonstration will be remembered as one of the most interesting things connected with the Congress. On the evening of Wednesday there was a grand banquet, when the members spent a very pleasant evening together.

On Thursday morning the Congress left by train for Brussels. On arrival, the members went to the Natural History Museum, and were shown through the building by the Director, who kindly admitted the members of the Congress at an early hour. Next, the party proceeded to the Botanic Garden, where they were received by Prof. Crepin and others. The herbarium, museum, garden, and hot-houses were all inspected, and then the Members of the Congress were entertained in the orangery of the garden to a luncheon given by the Members of the Royal Botanic Society of Belgium. After luncheon the party proceeded by tramway to Laeken, to visit the Winter Garden, which had been opened to them by his Majesty the King of the Belgiums. Mr. Knight, the Inspector of the Royal Gardens, accompanied the party, and pointed out the objects of interest. Friday was to be devoted to an excursion to Ghent, and Saturday to a botanic excursion in the neighbourhood of Herrenthals, Dolen, and Gheel, where the Members of the Congress were to disperse. I left the party at Brussels, spending Friday at Liége with Prof. Morren, who showed me the splendid new laboratory in the pretty little garden under his charge. I afterwards visited Prof. Suringar at Leyden, and saw some of the treasures he has just brought back with him from the Dutch West Indian Islands, where he has been able to make extensive botanic collections of living and dried specimens.

W. R. McNab

August 31

THE FAUNA OF THE SEA-SHORE[1]

THE marine fauna of the globe may conveniently, in the pursuit of certain lines of scientific study, be divided into three groups according to the regions inhabited by it. There is the littoral fauna comprising the animals inhabiting the sea-shore and the shallow waters in its immediate neighbourhood, the deep-sea fauna, and the pelagic fauna, the latter occupying the surface waters of the ocean. Each of these regions presents certain marked peculiarities of conditions of existence, and exhibits, in accordance with these, certain special characteristics in the composition and history of the origin of its fauna. The deep-sea is devoid of sunlight and therefore of plant life. It is dark, cold, and monotonous, being devoid of day and night and periodical or irregular changes of any kind. Its habitation probably dates from no very great antiquity. The ocean surface can support only a peculiar fauna of animals adapted for floating or constant swimming, and affords no shelters nor resting-places.

As Prof. Lovèn writes[2]: "The littoral region comprises the favoured zones of the sea, where light and shade, a genial temperature, currents changeable in power and direction, a rich vegetation spread over extensive areas, abundance of food, of prey to allure, of enemies to withstand or evade, represent an infinitude of agents competent to call into play the tendencies to vary which are embodied in each species and always ready, by modifying its parts, to respond to the influences of external conditions." It is in this littoral zone where the water is more than elsewhere favourable for respiration because of its aëration by the surf and where constant variation of conditions is produced by the alternation of the tides that the ancestors of all the main groups of the animal kingdom came into existence, and all the primary branches of the animal family tree first commenced to grow. It is here, probably, that the first attached and branching plants were developed, thus establishing a supply of food, and rendering possible the colonisation of the region by animals.

The animals inhabiting the littoral region are adapted in most various ways to withstand and endure the special physical conditions which they there encounter—the action of the surf, the retreat of the tides, the numerous enemies. Either they burrow deep in the sand, or cling tight to, or even bore into, the rocks, or develop hard shells or skeletons, or protect themselves by other modifications. Probably all hard shells and skeletons of marine invertebrata have thus originated in the littoral

[1] A Friday evening lecture at the Royal Institution, delivered January 23, 1885, by Prof. H. N. Moseley, F.R.S.

[2] "On Pourtalesia, a genus of Echinoidia," by Sven Lovèn. (Stockholm, 1883, p. 86.)

zone for purposes such as these. It is found that these hard structures tend to degenerate and disappear both in the pelagic and deep-sea regions.

It is a most remarkable fact that almost all these shore animals in their early development from the egg pass through free-swimming larval stages which are closely alike in form for very widely different zoological groups. As a familiar example may be taken the case of the common oyster. The egg of the oyster develops into a peculiar free-swimming larva known as a Trochosphere. It is globular in form and divided by a transverse band of cilia into a smaller anterior and larger posterior area. The mouth opens just behind the ciliated band. The larva swims actively by means of its cilia. After a time it develops a pair of shells, and becomes metamorphosed into an oyster, and attaches itself immovably by one of its shells to the sea-bottom. Its shells increase in size and thickness, and form a protection against its enemies. This same trochosphere larva is common to a very large number of Mollusca of all varieties and shapes in the adult condition, and an essentially similar trochosphere is common to a large number of annelids. It is most remarkable that there should be so close a resemblance between the larva of two adult forms so widely different in all respects as an oyster and a worm. An old explanation of such facts was that such actively-moving larvæ were contrivances for procuring the wide diffusion of sedentary or less active adult forms, which might thus be conceived as of later origin than the forms themselves. But if this were the case, it is inconceivable that having arisen from so widely different starting points, the larvæ should have attained so closely similar a structure. The only real explanation of the matter is that the common larval form represents a common ancestor, from which the various adult forms, in the existence of which it is now only a phase, diverged. There was thus a common freely-swimming ancestor of the annelids and mollusca, and it seems probable that the entire littoral fauna must have been derived originally in remote antiquity from small primitive and simply organised free-swimming ancestors. All evidence seems further to point to the conclusion that the primitive ancestors of all plants were also free-swimming. The free-swimming ancestral representatives of life no doubt partly inhabited the open sea, leading a pelagic existence, partly swarmed in sheltered bays and pools on the coasts, as the larvæ of the littoral animals do now. The free-swimming plants gradually produced attached descendants, which colonised the shores, and the animals, finding there a supply of food, gradually adapted themselves to the more complicated conditions of shore life. The late Prof. Balfour, in his far-famed work on "Embryology," in discussing the character of larvæ of the kind under consideration, spoke of them as possibly reproducing the characters of some ancestral forms "which may have existed when all marine animals were free swimming."[1]

A peculiar instance in which there can be but little doubt, is that of the common barnacles. These in the adult condition are firmly fixed to supports of various kinds, and withstand the most violent action of the surf. The common acorn barnacles cover the most exposed bare rocks of our coasts, where the waves are heaviest, and nothing else can live. They have developed the stoutest of shells to protect themselves. In the young larval condition, however, they are actively free-swimming larvæ of typical crustacean structure, evidently adapted for pelagic existence, and to be found in swarms at the sea-surface, actively engaged in it. They attach themselves, and become immovably adherent and sedentary, and invested by a shell. There can be no doubt in this case that the locomotive larva represents the ancestral form, for allied crustacea still exist in abundance as adults.

[1] F. M. Balfour, "Comparative Embryology," vol. ii. p. 305.

A most important instance is that of the Echinoderms, the adults of the various groups of which, the sea-urchins starfish, brittle stars, holothurians, and crinoids are most widely different in form, and adapted in most various ways to shore life. Yet these all pass through free swimming larval stages which are most remarkably alike. Supposing the adult forms to have been antecedent, it is quite impossible that a series of larvæ could have been developed independently from starfish, echini, holothurians, and brittle stars, and have attained this remarkable coincidence of structure. This common larval form must represent the ancestral condition, the free-swimming pelagic ancestor from which the echinoderms have sprung.

The fixed and inert sponges are developed from free-swimming ciliated larvæ, and Prof. W. J. Sollas[1] has observed that the young larvæ of the sponge *Oscarella lobularis* are retained longer within the parent in the case of specimens occurring on the coast of Brittany than in that of specimens found in the Mediterranean. He attributes this difference to the influence of the quieter sea and absence of tides in the latter case. The larvæ have come to be longer retained where the risk of their loss by current and tide is greater. By the gradual action of similar influences, no doubt, the loss of larval stages in so many instances has come about. It is probable that there is a special tendency to such loss in the case of deep-sea animals. Hoek[2] has recorded the loss of the nauplius stage as a free-swimming one in the case of a deep-sea scapellum from a depth of 506 fathoms. One of the best examples of the special adaptation by modification of animals sprung from pelagic ancestors for littoral existence is that of the Madreporarian corals, the far-famed builders of reefs. Each coral colony is sprung from a locomotive planula larva, swimming by means of cilia. The larva attaches itself, and developes into a polyp, and acquires a hard skeleton, and by budding produces a large colonial stock. The massive stocks thus formed and strengthened form reefs which are barriers to the waves. They flourish in the water churned by themselves into surf, and thus specially aërated and fitted for their respiration, and between their branches and interstices they sift out the fine pelagic animals on which they feed from the surface water. Probably the advantages thus gained is the cause of their assumption of the colonial form and development of their stout and massive skeletons. Possibly this is the reason why scarcely any colonial Madreporaria occur in deep water, although other colonial animals are abundant in the depths.

The origin of the vertebrata is a complex question, but they are probably sprung from a very simple free-swimming ancestor, as is shown by the survival of a simple ciliated gastrula as an early stage in the developmental history of Amphioxus. An exactly similar developmental stage precedes the trochosphere form in the oyster, and the characteristic larvæ in the case of the echinoderms, and occurs as an early stage in a wide range of other forms. From this ciliated gastrula develops Amphioxus, one of the most interesting components of the fauna of the coasts, one of the most primitive of vertebrates now existing. The Ascidians, which are in the adult condition as inhabitants of the coasts, mere inert sacs, extreme instances of degeneration, are derived from free-swimming larvæ of pelagic habits which show distinct vertebrate structure and have myelonic eyes, which, as Prof. Lankester has pointed out, could only have originated in an animal of pelagic habits. The Ascidians, before reaching their vertebrate larva stage, pass through a gastrula stage like Amphioxus. It is possible, therefore, that their ancestors have twice taken from pelagic to littoral existence, having relinquished the shore for a period after their first experience of it, and returned to it again; whilst some of their close allies, such

[1] W. J. Sollas, *Quart. Journ. Micro. Sci.*, 1884, p. 612.
[2] Report on the Cirripedia. *Challenger* Report, Zoology, vol. viii. p. 75.

as Appendicularia, have never resought the shore, and consequently have never degenerated to qualify for littoral life. The peculiar breathing apparatus adopted by the vertebrata occurs nowhere else in the animal kingdom except in the extraordinary worm-like Balanoglossus. The apparatus, as is well known, consists of a series of slits, opening from the exterior at the sides of the fore part of the body directly into the throat, the anterior part of the digestive tract. The water to be respired is taken in at the mouth and ejected through the gill slits. The late researches of Mr. W. Bateson, of Cambridge, have shown that Balanoglossus, besides breathing by gill slits, shows many other remarkable affinities, both in structure and development, with the vertebrata. Now, Balanoglossus, a shore-inhabiting form which lives buried in the sand, is developed from a most remarkable larva known as Tornaria, which is intermediate in form between a Trochosphere and a star-fish larva. It is quite possible that this extraordinary larva Tornaria may point to the former existence of a primitive pelagic ancestor common to the Annelids, Echinodermata and Vertebrata. Possibly the use of gill slits as a respiratory apparatus first arose in a shore-inhabiting ancestral form, such as Balanoglossus, and hence their presence at the anterior extremity of the body, that nearest to the surface when the animal is concealed in the sand.

It appears not impossible that Amphioxus may once have possessed a larval stage somewhat resembling Tornaria, following on its gastrula stage, and has lost it just as one species of Balanoglossus has lost the Tornaria stage. The developmental history of only one species of Amphioxus is as yet known, and investigation of that of other species may yet reveal something of the kind suggested.

The littoral zone not only became itself stocked with an immense variety of specially adapted inhabitants, but has given off colonists to the three other faunal regions. The entire terrestrial fauna has sprung from colonists contributed by the littoral zone. Every terrestrial vertebrate, every frog, reptile, bird, and mammal, bears in its early stages of development the gill slits still perforating its throat as in its aquatic ancestor. The tadpole still uses them when young for breathing, though they close up completely in the adult frog and in all the higher vertebrates before birth. In some of the tailed Amphibia, like the Axolotl, the breathing is by external gills and also by lungs which are modifications of the air-bladder of fish. In these the gill slits remain open, although they have no longer any respiratory function. It is amusing to watch tame Axolotls when fed in aquariums with large worms. They snap the prey down hurriedly and close their mouths, but usually in a moment or two their throat begins to twitch uncomfortably as if intensely tickled, and one end of the worm appears out of one of the gill slits, and the worm soon wriggles its way out again. Often the Axolotl catches it again by the free end before the other is completely out of the gill slit, and begins another attempt to swallow it, and the process is sometimes repeated several times before actual deglutition is effected. The gill slits are evidently a considerable inconvenience to the Axolotl. The frog is much better off in having them closed, but man himself is not in a position entirely to despise the Axolotl: his lungs are derived from the same source originally, namely, modifications of the air-bladder of a remote aquatic ancestor, an inhabitant of the sea-coast, and they open into the throat just behind the tongue. In man there is a lid to close this opening and a contrivance to pull it under the tongue when swallowing takes place; but every one knows the agony entailed by getting a crumb the wrong way—an accident very much akin to that of the Axolotl, and similarly entailed by the use of a single passage for two different purposes—feeding and respiration. At such moments of suffering the naturalist is inclined to turn traitor and long that he had been produced in accordance with the hypothesis of special creation rather than evolved under the laws of natural selection. The existing arrangement must not be regarded as of inevitable necessity. The vertebrates are the only animals which breathe through their mouths. All other animals have separate passages for respiration and feeding. The common snail has a separate breathing passage completely apart from its mouth, the land crab breathes by openings at the bases of its legs, the scorpion by openings on its abdomen, and the insect by numerous apertures on the sides of its body. All these animals cannot, like man, choke themselves.

Only the pentadactyle vertebrata have adapted themselves completely for terrestrial respiration, but several fish have, by special modification of their gills, become able to remain out of water for almost indefinite periods. Most remarkable amongst these is Periophthalmus, one of the Gobiadæ inhabiting mud flats on the sea-shore in Australia, Ceylon. Fiji, and other eastern tropical regions. It hops along the mud with the greatest agility and so fast that it is most difficult to capture, and even refuses to take to the water when driven to it, skipping along its surface, and resting on projecting stones. It even climbs high up the mangrove trees and sits on the branches. All modes of air-breathing are derived by modification from aquatic breathing apparatus, except, perhaps, in the case of the air-breathing tracheata, the insects and their allies, in the ancestor of which, represented by Peripatus, the respiratory tubes or tracheæ were probably first formed as modifications of skin glands.

Littoral animals of most various kinds have taken from marine to terrestrial life no doubt by gradual adaptation, owing to exposure by the tides. Crustacea seem to have the greatest power of thus adapting themselves to aërial respiration by slight modification of their gill apparatus, so as to permit it to act as a lung. Nothing is more astonishing to the naturalist in tropical countries than to find large crabs amongst the vegetation far inland and high up mountains. But land crabs are not confined to the tropics; in Japan they may be met with walking across the high roads far inland, and 4000 feet above sea-level. One of the most remarkable instances is that of the cocoanut climbing crab, *Birgus latro*, which has developed, as Prof. Semper has shown, a regular pair of lungs out of the walls of its gill cavities. The animal was originally a hermit crab, but got too large for any shell, and thus developed hard plates on the surface of its body for protection instead. Close allies, but of much smaller size, swarm in some Pacific islands. They always bear shells, and carry them with them when they climb the trees and bushes. I have caught hold of the shell of one of them as it clung to the top of a branch, thinking that it was a land-mollusk, and have been astonished by receiving a sharp nip from a pair of claws.

The oldest-known air-breathing animals, so far as geological evidence goes, are scorpions and insects. An ally of the cockroach and two scorpions have lately been obtained from Silurian strata. The close affinities of the scorpions with the king crabs, and thus with the Trilobites, is a most interesting matter, which has lately been urged by Prof. Ray Lankester. He suggests that the lungs, by means of which the scorpions breathe air, are modifications of the gill plates of the king crab, which have become inverted for the purpose. The lung openings of Scorpio correspond with the gill plates of Limulus in position and number. Hence, possibly, the scorpions, and with them the rest of the Arachnida, are sprung from ancestral allies of the king crab and the Eurypterids, having passed from a littoral to a terrestrial existence.

It seems possible that birds were originally developed in connection with the sea-coast, and were fish-feeders. The tooth-bearing birds discovered by Prof. Marsh, such as Hesperornis and Ichthyornis, were marine aquatic birds. Hesperornis lived in a shallow tropical sea surrounding the present Rocky Mountains, then a group of islands. The modern penguins show some remarkable points of affinity to reptiles in the structure of their feet, and probably their embryonic development, when worked out, may throw much light on the past history of birds.

Some of the extinct Dinosauria which show remarkable affinities with birds were at least aquatic in habits.

The fauna of the coast has not only given origin to the terrestrial and freshwater faunas, it has throughout all time since life originated given additions to the pelagic fauna in return for having received from it its starting points. It has also received some of these pelagic forms back again to assume a fresh littoral existence. The terrestrial fauna has returned some forms to the shores, such as certain shore birds, seals, and the Polar bear; and some of these, such as the whales and a small oceanic insect, Halobates, have returned thence to pelagic life.

The deep-sea fauna has probably been formed almost entirely from the littoral, not in most remote antiquity, but only after food derived from the *débris* of the littoral and terrestrial faunas and floras became abundant in deep water. It was in the littoral region that all the primary branches of the zoological family tree were formed; all terrestrial and deep-sea forms have passed through a littoral phase, and amongst the representatives of the littoral fauna the recapitulative history, in the form of series of larval conditions, is most completely retained. It is for this reason that the researches carried on at marine laboratories on the coasts have yielded in the last few years such brilliant results.

BALLOON PHOTOGRAPHY[1]

RECENT experiments in photographic aërostation, carried out by M. Gaston Tissandier, with the assistance of M. Ducom, have been attended with very complete and satisfactory results. The photograph reproduced by heliogravure in Figs. 1 and 2 was taken at an altitude of 605 metres over Paris; others which were taken did not give such perfect results; nevertheless, some of them surpass in distinctness any yet taken by the same method. The ascent took place at Auteuil on June 19, M. Ducom attending specially to the photography, while M. Tissandier looked after the balloon. The photographic apparatus arranged in the car is shown in Fig. 3. The ascent took place at 1.40 p.m. with a south-west wind. Ten minutes after starting a first photograph was taken at 670 metres; soon afterwards another was taken at about the same height, in which a bridge, quay, public

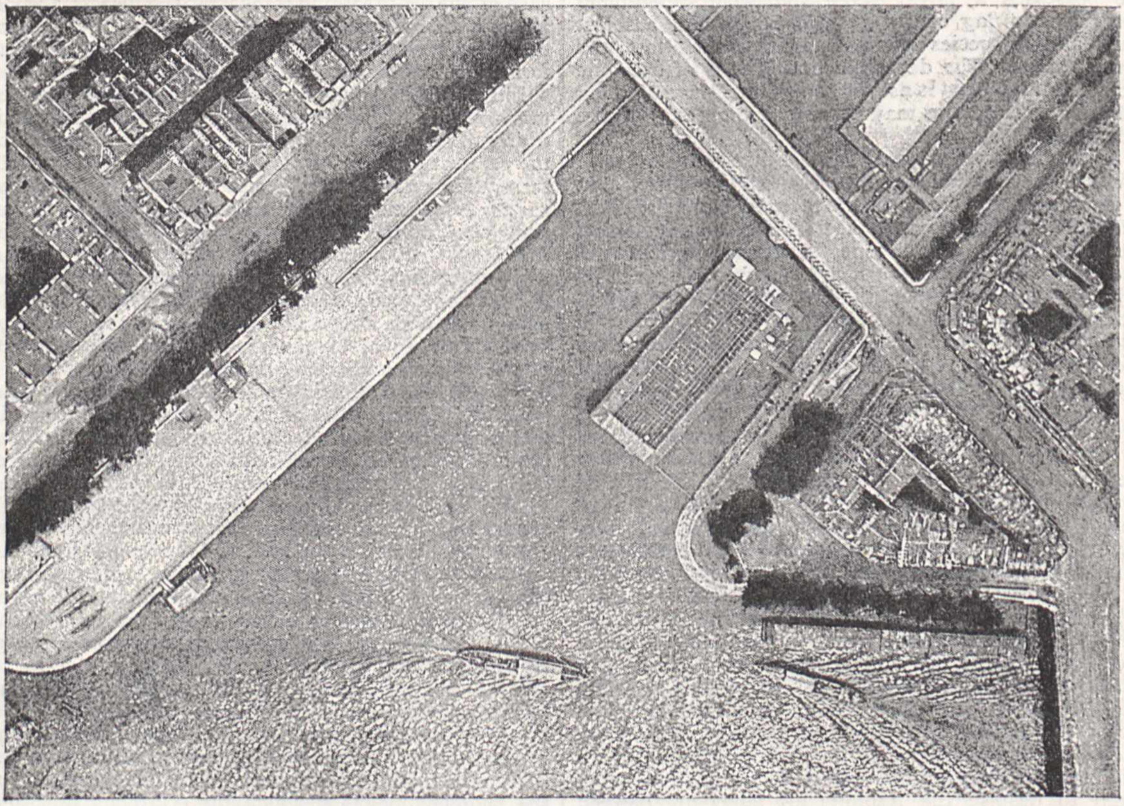

Fig. 1.—Reproduction by heliogravure of a plate taken at a height of 605 metres above Paris, showing the Seine, with two boats, Pont Louis-Philippe, gate of the Hôtel de Ville, &c.

office, fifteen cabs, a tramway, and the people in the streets were clearly reproduced. At 605 metres the photograph here reproduced was obtained, but unfortunately heliogravure does not produce an exact *fac-simile* in the fineness of the details. The smaller plan (No. 2) shows the exact topography of the place. When the photograph itself is examined through a magnifying glass many details are discovered, such as the coils of a rope mooring a boat to the shore, the passers-by, &c. On the photograph, too, the chimneys may be counted forming a number of small black spots on the roofs. A picture of great clearness, but rather greyish, was taken a few minutes later at an altitude of 800 metres above the prison of La Roquette; and another at the moment of leaving Paris at 820 metres. Beyond the city two more

[1] Abstract from *La Nature*.

photographs were taken at greater altitudes—one at 1000, and one at 1100 metres. Hence in crossing Paris, between 1.40 and 2.12, or in twenty-two minutes, five photographs were obtained. It would be easy to have two or three photographic apparatus with an operator in the car for each, and thus to obtain a series of views. By this method a series of topographical documents of incomparable precision might be obtained. Amongst the views taken during this ascent those which are perfect in point of clearness are those taken at the moment when the rays of the sun fell directly on Paris. Good light is absolutely indispensable, and, in spite of the photographs being instantaneous, the car should be kept perfectly free from oscillation at the moment the picture is being taken.

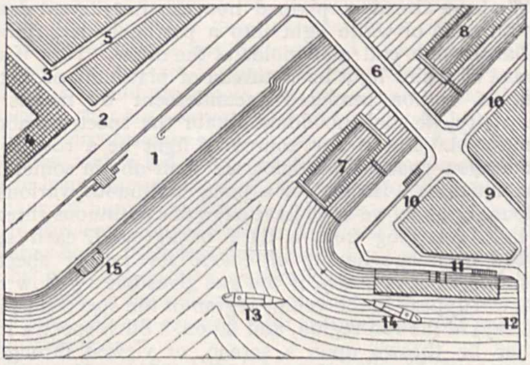

FIG. 2.—Explanatory plan of above:—1. Gate of the Hôtel de Ville. 2. Quay of Hôtel de Ville. 3. Rue de Brosse. 4. Old Lobau Barracks. 5. Rue de l'Hotel de Ville. 6. Louis Philippe Bridge. 7 and 8. Baths. 9. Rue de Bellay. 10. Quai de Bourbon. 11. Quai d'Orleans. 12. Pont St. Louis. 13 and 14. Boats. 15. Pier.

The operator and occupants of the car must at that moment remain perfectly still. The movement of the balloon has no injurious effect on the clearness of the proofs obtained; in the present instance the current of air was somewhat rapid, for the balloon traversed Paris at its greatest width, 11 kilometres, in thirty-two minutes. The rapidity of the wind increased subsequently to much more than this. After taking photographs of the earth below, the apparatus was turned upwards to obtain views

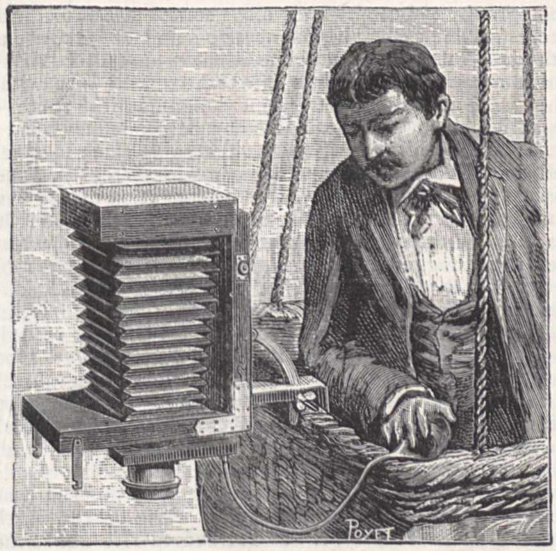

FIG. 3.—Arrangement of photographic apparatus in the balloon.

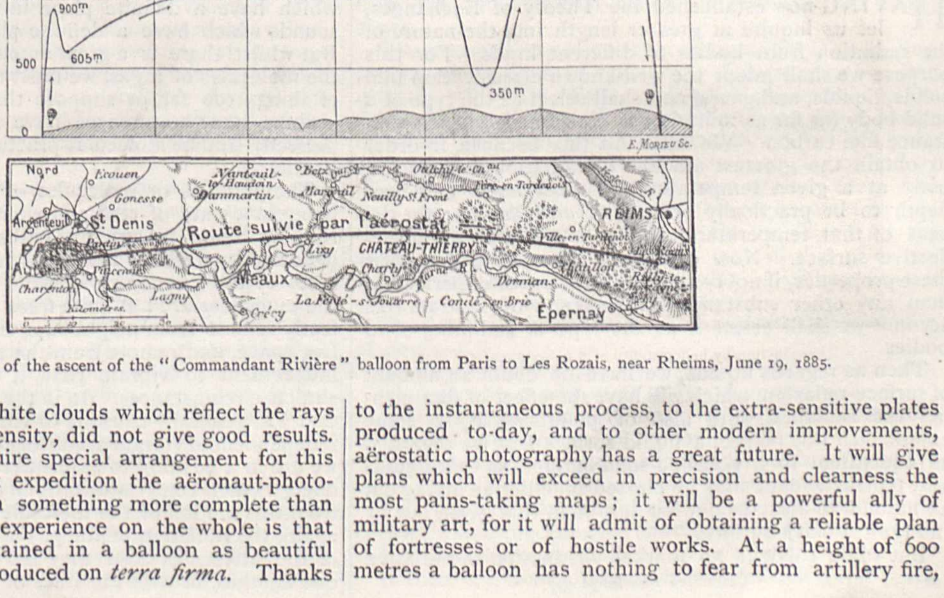

FIG. 4.—Diagram of the ascent of the "Commandant Rivière" balloon from Paris to Les Rozais, near Rheims, June 19, 1885.

of the clouds; but the white clouds which reflect the rays of the sun with great intensity, did not give good results. The apparatus will require special arrangement for this work, and in their next expedition the aëronaut-photographers hope to obtain something more complete than they have done. Their experience on the whole is that photographs may be obtained in a balloon as beautiful and clear as the best produced on *terra firma*. Thanks to the instantaneous process, to the extra-sensitive plates produced to-day, and to other modern improvements, aërostatic photography has a great future. It will give plans which will exceed in precision and clearness the most pains-taking maps; it will be a powerful ally of military art, for it will admit of obtaining a reliable plan of fortresses or of hostile works. At a height of 600 metres a balloon has nothing to fear from artillery fire, and the photographer can operate as safely in his car as in his studio. It will also add to the resources of photography, for there are no places on the earth's surface inaccessible to a balloon.

The ascent here described had for its main purpose photography; but it had also some meteorological interest. The ascent began at 1.20; and at 3.20, at an altitude of 1100 metres above Meaux, another balloon, which ascended some time after them, was met with. They were actually in a frequented aëronautical route—an aërian river. At Meaux Nadar descended in 1863; M. Tissandier himself landed at the same place in 1872, and several other descents were made there. A little farther, at Château-Thierry, on a prolongation of the line from Paris to Meaux, M. Tissandier and M. de Fonvielle made an extraordinary descent in a storm in 1869, when they were dragged along the ground four kilometres in five minutes. They travelled from Paris to Château-Thierry, a distance of 80 kilometres as the crow flies, in 35 minutes—the most rapid balloon voyage on record. On the present ascent, at an altitude of 1000 to 1400 metres, an aërial current of considerable speed prevailed; it was estimated at about 40 kilometres an hour. At 1400 metres a mass of white translucid clouds stretched across the sky and floated in the upper part of the aërial current. Above this, again, the air was calm; small white clouds remained immovable at 2000 metres, and the sun was very hot. After having descended close to the earth above Château-Thierry, it was decided to rise above the clouds amongst which the aëronauts had just been. At 6 o'clock, at a height of 1900 metres, they observed the shadow of the balloon projected on a white ground of clouds; the latter formed a small greyish circle, surrounded by an aureole of the seven colours of the rainbow. When they approached the clouds, it was only the shadow of the car and of the lower part of the balloon of which the projection could be distinguished, and the aureole assumed a larger diameter. This remarkable and beautiful phenomenon resembles that of the spectre of the Brocken. At 6.10 the descent commenced; the balloon crossed the bank of clouds, and the surface of the earth, when it came in sight, looked grey and dull compared with the magnificent regions of the upper atmosphere.

RADIANT LIGHT AND HEAT [1]

III.

Radiation and Absorption—Terrestrial Applications.

HAVING now established the Theory of Exchanges, let us inquire at greater length into the nature of the radiation from bodies of different kinds. For this purpose we shall adopt the well-known classification into solids, liquids, and gases, and shall select as the type of a solid body (as far as radiation is concerned) a black substance like carbon. We must do this because, in order to obtain the greatest amount of radiation from such a body at a given temperature, it must be of sufficient depth to be practically opaque, or *athermanous*, for the heat of that temperature, and it must have a non-reflective surface. Now carbon or lamp-black possesses these properties, if not completely, yet to greater perfection than any other substance that we know of; and on this account we shall select it as the type of radiating solid bodies.

Then as regards liquids, we have no doubt an amount of surface-reflexion, which will have the effect of diminishing the radiation, and also of polarising it, to some extent. In this respect a liquid surface may be regarded as equivalent to a polished solid surface, so that liquids and polished solids may be classed together as giving out an amount of heat somewhat less than that given out by the typical black surface.

But while there is no marked distinction in radiation between solids and liquids, if only the depth of substance be sufficiently great, the radiation of gases is essentially different. This difference consists in the fact that while solids and liquids radiate all kinds of heat possible to the temperature, gases radiate only a few. We shall best perceive this distinction if we confine ourselves to rays which affect the eye, and view these by means of the spectroscope.

We have already explained how this instrument draws out a thread of white light into a parti-coloured ribbon, red at the one end and violet at the other. Now if our thread of white light be a thread of platinum, or, better still, of carbon rendered incandescent by means of electricity, we shall no doubt obtain the spectrum above mentioned. But if our source of light be a row of incandescent gaseous particles, we shall obtain something very different. Instead of a long, continuous, variously-coloured ribbon, we shall have a few discontinuous threads of light emerging from a dark background, each such thread or image having of course its proper spectral position; that is to say, if the gas gives out a yellow ray, this will appear in the yellow region of the spectrum; if a red ray, in the red region, and so on. Such spectra may either be thrown upon a screen, or viewed through a telescope—sometimes it is possible to throw them upon a screen and render them visible to a large audience, but sometimes this is not possible. In all cases, however, they may be thrown into a telescope and viewed by the individual observer.

We are thus in a position to formulate the distinguishing characteristic between the spectra of solids and liquids, and those of gases, the former giving out a continuous spectrum, consisting of all the rays of light possible to the temperature, while the latter give a discontinuous spectrum, consisting of a few bright lines on a dark background.

We can, in an imperfect manner, assign a reason for this behaviour. In a solid, or even a liquid, the various molecules are near together, so that no individual is free from the trammels of its neighbour in its vibrations. On the other hand, it is not so in a gas, or at least in a gas of which the molecules are very far from one another.

Here one individual is for the most part of its existence free from the trammels of its neighbours, and is able to vibrate after its own fashion and in a way to suit itself, just as freely as a bell, or the string of a musical instrument. It thus gives out, as it were, its own peculiar note, or series of notes, these notes being here, however, rays which have a definite place in the spectrum, instead of sounds which have a definite place in the musical scale. But whilst there is a great amount of freedom amongst the molecules of a gas, we must not carry this conception of things too far, or suppose that in a compound gas at ordinary temperatures we have nothing but a series of perfectly similar molecules practically independent of one another.

The particles or molecules of such a gas are far from being in a state of rest, and we may imagine them to be running about in straight paths, except when they are deflected by dashing against a neighbour, or against the sides of the containing vessel. It will thus be seen that the molecules are not quite free. In fact, a molecule perfectly remote from neighbours, travelling, for instance, in free space, and remote from the sun, would have no more inducement to vibrate than a bell would have under similar circumstances. It is the collision with its fellows that will generally cause it to vibrate, but it is sufficiently independent to vibrate according to its own laws. Indeed, we are in a position to assert that a great portion of that energy which constitutes ordinary heat in a gas is derived from this motion of the molecules in straight lines, while, again, the radiation of the gas is caused by the vibrations of the molecules after they have been in collision with one another, or with the sides of the containing vessel.

[1] Continued from page 399.

Now in a compound gas these collisions sometimes cause dissociation of the compound molecule into more elementary constituents, which constituents will probably afterwards combine again, so that we may imagine that in such a gas (see "Heat," by Prof. Tait, page 203) equilibrium is maintained by a constant amount of dissociation, accompanied by an equal amount of recombination. It is thus apparent that we have not here perfect simplicity and uniformity of molecular structure, and without discussing the question whether a simple molecule might or might not be expected to vibrate in only one way, we can readily imagine that the spectrum of such a gas should present us with more than one mode of vibration; that is to say, more than one spectral line.

Again, circumstances which conduce to proximity of molecules, and to the action of molecules upon each other, tend to bring about a state of things similar to that which we have in liquids and solids; that is to say, they will favour the emission of various kinds of rays, while on the other hand, the characteristics of a gaseous spectrum will be best shown by a perfect gas, that is to say, by a gas which is far removed from any tendency to condensation. A rare gas at a high temperature will possess these properties.

Having now defined the characteristics of the spectra of solids, liquids, and gases, let me say a few words about the methods by which we obtain gaseous particles heated to a high temperature. These are obtained in two ways. First, by means of flames, such as that of a Bunsen's burner, into which the particles are introduced. In such flames we may imagine that we have before us a certain number of the particles of a certain gas all, or nearly all, heated to a temperature somewhat approaching that of the flame. The substance will probably have been introduced into the flame in a different chemical state from that in which it appears in giving out the light; for instance, we may introduce into a spirit-lamp a little chloride of sodium, or into a Bunsen's burner a little bicarbonate of soda. The flame becomes immediately of a yellow nature, giving us the double line D, or the yellow line of incandescent sodium vapour, and this affords us evidence that dissociation has taken place. In like manner the red line produced by salts of Lithium, the green line produced by those of Thallium, and so on, are indications that the compound saline molecules have become dissociated in the flame.

The second way of producing gaseous spectra is by an application of electricity, as when a high tension spark is sent through a tube containing a small quantity of a given gas, or a vacuum tube, as this is sometimes called. We have then a momentary flash, consisting of the rays which characterise the spectrum of the gas through which the discharge has passed. It is probable that in this case only a portion of the particles filling the tube have been brought to the high temperature which is denoted by the discharge.

Before proceeding further, it may be well to mention that while from the title of our subject we must necessarily consider the spectrum to some extent, yet this is not to be regarded as a treatise on the spectroscope and its applications, which formed the subject of a previous set of essays in the NATURE Series by Mr. Lockyer. We shall discuss the subject in a somewhat different manner, and also give more especial attention to those branches which had not yet been developed when Mr. Lockyer wrote his work. With these preliminary remarks, we shall divide the subject before us into two sections.

(1) Radiation and its consequences.

(2) Absorption and its consequences.

In the first we shall discuss radiant spectra to a considerable extent, but shall not entirely confine our remarks to these phenomena; while in the second we shall discuss absorption spectra to a considerable extent, but shall not entirely confine ourselves to spectral absorption.

There is likewise another convenient way of dividing our subject, namely, in its application to terrestrial and celestial phenomena.

Combining, therefore, these two principles of subdivision, we shall, in the first place, treat of terrestrial applications of the laws of radiation and absorption, and in the next place of their celestial applications; and, finally, we shall discuss the light which both of these branches together appear to throw upon the ultimate constitution of matter.

With regard to our own Earth, it is abundantly evident that the great bulk of the heat which it receives is from the radiation of the sun, while, on the other hand, the great bulk of the heat which it loses is through radiation into space.

There is a sort of balance kept up between the gain on the one hand and the loss on the other, in virtue of which we are placed under conditions in which life is endurable, and for the most part pleasant. The variations in these conditions in temperate latitudes may sometimes cause distress to the weak, but they are not less the source of enjoyment and vigour to the strong; and, as a matter of fact, the most energetic races of mankind are they which dwell in those favoured regions that are neither too cold nor too hot.

Inasmuch as the regions near the equator are hotter than those near the poles, it follows that there is greater radiation into space from the former of these than from the latter. If, therefore, we could imagine an observer to be placed many thousand miles above the earth, having an eye capable of distinguishing dark rays, and to regard that portion of the earth unilluminated by the sun, his eye would receive more rays from the equatorial than from the polar regions.

On the other hand, the polar regions being manifestly colder than those of the equator, we have convection currents of hot air passing in the upper atmospheric regions from the equator to the poles, and currents of cold air passing in the lower atmospheric regions from the poles to the equator. These latter are known as the Trade Winds, and the former as the Anti-Trades. In like manner we have in all probability currents of hot water passing in the upper oceanic regions from the equator to the poles, and currents of cold water passing in the lower oceanic regions from the poles to the equator. It is not, however, our object to dwell on these phenomena here; suffice it to say, that our well-being depends on the balance between the radiant heat which we receive from the sun and that which we give out into empty space.

The phenomena of dew form an exceedingly good illustration of the laws of radiation. This subject was first investigated by Dr. Wells, an English physician. When the sun has sunk beneath the horizon of any place, bodies of small mass and great radiating power for dark heat, such as the leaves of plants, become quickly cooled by their uncompensated radiation into space. They thus cool the air around them, until this air becomes so cold that it can no longer retain in the viewless state the aqueous vapour which it holds; part of this is consequently deposited in the form of dew, or of hoar-frost, if the temperature be sufficiently low.

The following are the laws which regulate the deposition of dew:—

(1) Dew is most copiously deposited under a clear sky.

(2) And with a calm state of the atmosphere.

(3) It is most copiously deposited on those substances which have a clear view of the sky.

(4) And which are good radiators and of small mass.

(5) And which are placed close to the earth.

The first of these conditions is essential, because the cooling which precedes the deposition of dew is owing to radiation into free space.

If there are clouds, these will radiate back to the body, and thus prevent it from cooling fast enough. We see, likewise, the necessity for a calm atmosphere, when we reflect that dew can only be deposited by means of the body cooling the air around it; now if this air is constantly renewed, it cannot cool this large body of air to any great extent, and hence dew cannot be formed.

It is very manifest why the body must have a clear view of the sky, and why it must be a good radiator in order to promote the deposition of dew. Also why it must not be of a great mass, for, if it were, the heat from the interior might be conducted to the surface, and thus keep up the temperature.

Finally, the substance must be near the earth, for, if not, the cooled air will fall down, giving place to warmer air. The body will thus have a larger mass of air to cool, and it will less easily succeed in bringing this mass below the dew point. I shall return to this subject at a later stage, when the part played by the aqueous vapour of the air is taken into account. Let me here state that there are regions in the earth where dew forms an important factor in agricultural operations.

The artificial warming of our rooms is at present accomplished very much by radiation. An ordinary fire of coal or wood acts by this process. The heated carbonic acid gas which is the product of the combustion is carried up the chimney and out into the air, so that all that remains to heat the room is the light and heat given out by the glowing fire.

It is by no means an economical use of heat, but there are other considerations besides those derived from economy, and an open fire will always be cherished by those nations whose social life is greatly within doors.

The burning of gas in order to obtain illumination has nothing to recommend it. As it is used at present, it gives out a great deal of heat compared to its light, as well as a quantity of carbonic acid, and other products still more deleterious.

It ought to be replaced by some kind of electric light, such as that proposed by Swan, where a thread of carbon is kept at a high temperature in a glass vacuum by means of an electric current. There the luminous effect is very large in comparison with the heat produced, besides which there is no foul air or other hurtful product.

If we regard radiation as a means of increasing our knowledge, apart altogether from its primary and indispensable action in rendering us acquainted by means of vision with the objects around us, we cannot have a better instance than that which is given us in spectrum analysis. Here, in the first place, a little reflection will convince us that we can gain hardly any knowlege by this means of the nature of a luminous solid or liquid body, for all such bodies at the same temperature will give out all the various rays which are possible to that temperature. There is, therefore, no means afforded us by their spectra of distinguishing one from another, so that spectrum analysis is here impossible.

It is very different, however, when we come to gases which give out spectra consisting of bright lines in a dark background. Here there are various laws which combine not only to make spectrum analysis possible, but to constitute it an extremely delicate instrument of research. *In the first place*, we have the law that the lines given out by any one elementary vapour are different in spectral position from those given out by any other. *Secondly*, as a rule such bright lines remain in their places throughout a great temperature range. *Thirdly*, an exceedingly small amount of the element in question is generally sufficient to produce the lines.

It is stated that by means of the spectroscope the presence of less than one two-hundred-millionth part $\left(\frac{1}{200,000,000}\right)$ of a grain of sodium may be detected. Indeed, the difficulty is to get rid of the sodium line in an insular climate like ours, surrounded by sea-water which contains chloride of sodium.

There are three chief points for consideration in the study of gaseous spectra:—

(1) The effect produced by increasing the pressure of the gas.

(2) The effect produced by giving the gas a motion to or from the observer.

(3) The effect produced by increasing the temperature of the gas.

The effect produced by increase of pressure consists in a widening of the bright lines. This subject was first studied by Frankland and Lockyer, who found that all lines are not affected by pressure to nearly the same extent. The F line produced by incandescent hydrogen was found by them to be peculiarly subject to an increase of pressure, widening out in certain cases to a really remarkable extent.

Lockyer, who has since greatly studied this subject, is of opinion that it is not *pressure per se* that is influential in thickening the lines, but rather *the frequency of encounters of precisely similar molecules*. An important application of this law of pressure has been made by Lockyer, who has for this purpose used the electric arc, placing the slit of his spectroscope so as to embrace a section of this arc mid-way between its terminals and at right angles to its length. Now in the heart or central axis of this arc the gaseous particles which give out the light may be supposed to be somewhat near together, whereas at the border or circumference they are comparatively far apart. When the spectrum of such a transverse section is taken, this is found to consist of a number of bright lines, some long and some short. The long lines are those which remain visible even when the particles are far apart, while the short lines are those which require a greater nearness of particles to come out, and are therefore confined to the central regions of the arc.

Suppose now that we take the spectrum of such an arc, from terminals composed of absolutely pure iron, and that by this means we obtain a number of long and short lines, characterising the spectrum of this metal in the state of vapour.

Suppose next that we obtain the spectrum of some other metal, such as copper, which is not chemically pure, but which, we suspect, contains a little iron. We shall obtain, of course, the copper lines well defined and intense, *plus* an indication of the iron lines; but inasmuch as the iron particles are here few and far between, the iron lines which make their appearance will be those which do not require great nearness of particles in order to come out—in other words, they will be the long iron lines, and not the short ones. In searching spectroscopically for an impurity it is thus only necessary to direct our attention to the long lines of the various metals which we suspect to be present. Thus the whole process of comparison is made much simpler, and we are enabled likewise to obtain with comparative ease the true spectra of the various elements.

Let me now say a few words about the effect produced by a motion of the radiating gas to or from the observer. Suppose that a tram car starts from a station every five minutes in a certain direction, and that we are walking briskly *towards* this station, we shall meet the cars oftener than every five minutes. On the other hand, if we are walking briskly *from* the station, they will overtake us less frequently than every five minutes. Suppose, again, that the whistle of a locomotive engine strikes the air 1,000 times every second, then if the locomotive be at rest, we know from the theory of sound that the one blow will have advanced about 13 inches before the next is delivered to the air.

If, however, the locomotive engine be itself travelling in this direction, it is evident that the interval between the blows will be less, for the engine may have itself advanced one inch during the time that the last blow has advanced 13 inches, and thus the distance between the two blows will be 12 inches, or one foot. If, therefore, an observer be standing on a railway platform and a railway engine be advancing at full speed whistling as it comes, the interval between the blows will be less than usual, or the note will be shriller than if the engine were at rest. On the other hand, when it has passed the station and is rapidly receding from the observer, the interval will be greater than usual, and the note less shrill.

It is precisely the same with regard to light. If a luminous body emitting rays of definite wave length be moving towards the observer, the wave length will be lessened and the ray pushed forwards to the more refrangible side of the spectrum. If, on the other hand, it be moving from the observer, the wave length will be increased, and the ray pushed backwards to the less refrangible side of the spectrum.

The only difference between light and sound is that the former moves so fast, that in order to get an appreciable alteration in wave length we must have a luminous body moving from or towards us with velocities much greater than we can produce experimentally, whereas in the case of sound we can make the experiment.

Nevertheless if we go to the surface of the sun, or to the fixed stars, we shall find luminous objects moving from or towards us with velocities sufficiently great to suit our purpose.

Let me now say a few words on the effect produced on some gaseous spectra by increasing the temperature of the gas. It is quite certain that at comparatively low temperatures such spectra are more complicated than they are when the temperature is high. In the former case they frequently present a fluted appearance, while in the latter we have spectra composed of a few bright lines on a dark background.

In some cases an increase of temperature entirely changes the character of the spectrum, so that certain so-called elementary substances may be said to have two or more spectra. In general, however, we have, notwithstanding these remarks, the great feature already mentioned of a persistence of the more permanent spectral lines, more especially in the case of metals, throughout a large temperature range.

By means of spectrum analysis we have discovered the existence of several new elementary metals, all of which are very sparingly distributed.

Bunsen was the first to detect two new elementary metals, cœsium and rubidium. Shortly afterwards Crookes discovered thallium, Messrs. Reich and Richter indium, and other elementary metals have since been discovered by the same means.

It is now time that something should be said about the phenomena of absorption. Since gases have small radiating powers, they may naturally be supposed to have small powers of absorption. We know, for instance, how feeble is the absorption of pure air for luminous rays, or even for ordinary heat rays. Tyndall has studied the absorptive power of gases for low temperature heat, and has come to some very interesting conclusions. The following table embodies the results of his experiments:—

Comparative absorption of various gases, each of the pressure of 1 *inch.*

Air	1	Nitric oxide	1590
Oxygen	1	Nitrous oxide	1860
Nitrogen	1	Sulphide of hydrogen	2100
Hydrogen	1	Ammonia	7260
Chlorine	60	Olefiant gas	7950
Bromine	160	Sulphurous acid ...	8800
Hydrobromic acid ...	1005		
Carbonic oxide	750		

By this we learn that the absorptive power of the three permanent simple gases for dark heat is very small, while that of compound gases is very considerable. Tyndall imagines that the molecule of a compound gas may be more inert and less nimble in its vibrations than that of a simple gas. That is to say, the compound molecule will vibrate more slowly than the simple one, and will thus give rise to rays of great wave length; and inasmuch as its absorption and radiation are connected together, it will be peculiarly liable to absorb rays of great wave length.

Its absorption for dark heat may therefore be very great, even although it may appear perfectly transparent for ordinary light rays.

Tyndall has found, as the result of his inquiries, that aqueous vapour absorbs many more dark rays than dry air, and justly concludes that the aqueous vapour present in the atmosphere plays a very important part in terrestrial economy. Being transparent for rays of high temperature it stops but a small proportion of those which come to us from the sun; on the other hand, being comparatively opaque for rays of low temperature, it stops the radiation into space from the surface of the earth. To speak more accurately, it does not absolutely prevent this radiation, but absorbs it and returns as much or nearly as much again. Its action, in fine, is virtually the same as that of a cloud in preventing the refrigeration which accompanies dew. Tyndall remarks that in those regions where the air is very dry the nights are often intolerably cold, owing to this uncompensated radiation into space.

Such regions are those in Central Asia and the great African desert, in the latter of which water can readily be frozen after the sun has sunk. The glass of a greenhouse acts in the same way as the aqueous vapour of the air. It allows the sun's rays freely to penetrate and to heat the air within; but it stops the dark heat of the plants and of the soil from being radiated outwards into free space. Even a loose frame of glass may save the tender blossoms of the peach, and other wall fruit, from being destroyed by nocturnal refrigeration.

BALFOUR STEWART

(*To be continued.*)

NOTES

ON Monday Prof. Michel Eugene Chevreul entered upon his 100th year. Apart from the fact that among men whose lives have been devoted to active scientific research no one has before attained such an age, M. Chevreul stands conspicuous for the vast amount of work he has done and for the great practical effect his work has had on the industries of the world. When Dumas in 1852 addressed M. Chevreul on the occasion of handing to him the *prix* of 12,000 francs accorded to him by the Société d'Encouragement pour l'Industrie Nationale, he said:—"Le prix consacre l'opinion de l'Europe sur des travaux servent de modèle à tous les chimistes; c'est par centaines des millions qu'il faudrait nombrer les produits qu'on doit à vos découvertes." More recently, in 1873, when the award of the Albert medal was made by our Society of Arts, the terms in which the Council expressed the grounds of the award were:—"For his chemical researches, especially in reference to saponification, dyeing, agriculture, and natural history, which for more than half a century have exercised a wide influence on the industrial arts of the world." His scientific work, apart from its commercial outcome, was in this country recognised by the Royal Society as far back as 1826, when he was elected a foreign associate. In 1857 the Copley medal was awarded to him. Other countries have also paid him honour, while the distinctions of his native land have showered upon him. Born in Angers in 1786 (on August 31), where his father was a physician of note, he was but seventeen when he went to Paris to be "manipulateur" in the laboratory of the celebrated Vanquelin. At the age of twenty he published his first chemical paper, and in the next half dozen years he had published more than a score on different subjects. Then began that series of papers (commencing in 1813), "Recherches chimiques sur plusieurs corps gras, et particulierment sur leurs combinasions avec les alcalis," which extended for many years and were compiled and rearranged in the volume "Les corps gras," issued in 1823 with the dedication "à Nicolas-Louis Vanquelin, mon maître." In 1824 he was appointed Professor of Chemistry at the famed factory of Gobelins, and the energy and untiring industry which was one characteristic of his work soon accumulated stores of knowledge based on experiment. To exact experiment he attached the highest importance. He wrote in 1823 "experiment is not chemistry, facts alone do not constitute that science, but we cannot have discoveries without exact experiment." His "Recherches sur la Teinture" is an elaborate work, and his "Moyen de définer et nommer les couleurs" occupies the whole of vol. xxxiii. of the *Memoirs* of the Institut. It has often been remarked that it is difficult to believe that the Chevreul of "Corps gras" fame and the Chevreul who wrote on colours are one and the same man.

We regret to have to announce the death, on August 27, of Lieut. L. Brault, of the French navy, who had charge of the Meteorological Service at the Depôt des Cartes et Plans, Paris. M. Brault was the author of several important meteorological works, among which may be specially mentioned one on the circulation of the atmosphere in the North Atlantic and a treatise on astronomy and nautical meteorology. But the great work to which he devoted the larger part of his energy was the preparation and publication of wind charts for the Atlantic, Indian, and Pacific Oceans, a work begun in 1869 and finished in 1880. It consisted of sixteen large charts giving for each *quarter*, and for squares of 5°, the probable direction and force of wind over those oceans. At the time of his death he was employed in the extraction and tabulation of observations from ships' logs, with the view of publishing *monthly* charts of various elements as soon as he had collected sufficient data. It is sad to see so able a man cut off in the midst of such useful work.

Mr. George Frederick Armstrong, M.A., F.G.S., C.E., some time Professor of Engineering in the M'Gill University, Montreal, and in the Yorkshire College, Leeds, has been appointed to the Regius Professorship of Engineering in the University of Edinburgh, vacant by the death of Mr. Fleeming Jenkin, LL.D., F.R.S.

The Queen has been graciously pleased to confer the distinction of Knight Commander of St. Michael and St. George on Mr. John Fowler, C.E.

We regret to learn that Mr. Trelawney Saunders has retired from the post of geographical assistant to the India Office, a position which he has held with credit to himself and advantage to the public service for the period of seventeen years.

Prof. Calladon, of Geneva, writes a correspondent to the *Times*, has communicated to the local press a description of a remarkable atmospheric phenomenon which was noticed on August 6. Until after five o'clock p.m. the sky had been calm and serene over all the valley of the Leman, but at half-past five, albeit the atmosphere above the lake and neighbouring mountain remained remarkably still, vapours were seen at a great height (evidently produced by a strong and warm south-west wind in the upper air) advancing rapidly towards the north-east, and taking the undulatory forms which characterise clouds strongly charged with electricity. At half-past eight the aspect of the sky had become decidedly stormy. The thick cloud-masses were oscillated wildly, albeit their general movement was still from south-west to north-east. After nine o'clock these clouds, drawing away, rendered visible the sheet of cirrus which stretched above them. The cirrus was phosphorescent, and looked as if lighted up by a bright moon. On the north-western horizon the sky along all the chain of the Jura was obscured by thick clouds that from time to time were illuminated by flashes of lightning. It was the same over Mont Galène, above which the lightning played every few minutes. A long black cloud stretching from the Dôle to the Galène presented on each side a broad phosphorescent border, and about a quarter past nine there became suddenly visible in that part of the cloud nearest the Jura a luminous centre whence escaped two or three phosphorescent rays pointing towards the south-west. This phenomenon lasted some twenty minutes, and was sufficiently striking to be remarked by many observers. From a quarter past nine to eleven o'clock, moreover, the south-western extremity of Mont Galène was illuminated by a phosphorescent light so intense that its rays were visible from every part of the horizon. The general appearance of this south-west section of the Galène resembled that which is presented by the city of Geneva in thick weather when the mists of evening are lighted up by the gas of the streets. Some rare instances are on record of forests of resinous trees becoming phosphorescent in stormy weather, but the distance from Geneva was too great to enable observers to determine whether the light resulted from the phosphorescence of the fir trees which cover the sides of the Galène or from that of other parts of the mountain. The Central Meteorological Bureau publishes, about eight o'clock every morning daily, accounts of the general condition of the atmosphere throughout Europe, and special reports from twelve stations in Switzerland at eight o'clock a.m. and one o'clock p.m. These reports are received at Geneva on the following day, and those of August 5 and 6 show that on the dates in question there took place a complete change in the atmospheric equilibrium of western Europe, and that the high pressures which for several weeks previously had prevailed over England and the Channel suddenly ceased and gave place to warm, vapour-charged winds from the south-west.

If original scientific work has been poured forth principally from the old settled countries of Western Europe, it is not a small labour which America seems to be undertaking to thoroughly collect and arrange in available order, not indeed the knowledge, but even the confused heaps of publications from which such knowledge may be painfully extracted. Another valuable catalogue compiled by Dr. H. C. Bolton appears as one of the valuable publications of the Smithsonian Institution. With the unexplained exception of medical science, it contains a list of all the scientific and technical periodicals published in Europe or America since the rise of this literature. It does not include the *Proceedings* and *Transactions* of Societies already indexed in Mr. S. H. Scudder's Catalogue of Scientific Serials, published in 1879. As this latter did not contain the titles of technical journals, the two publications are complementary, and together make up a most valuable list to any seeking information; a large proportion of papers, however, neither technical nor Societies' Proceedings, being, of course, found in both. The many large libraries open to the public which form such an item in the wealth of the United States have much assisted in this work, and a list most useful to a student is appended, showing in which of more than 120 of them each publication is to be found. A table, in chronological order, commencing with 1728, is also given, showing during which years each of 500 publications was carried on, and this is provided also with an index by which the place of each in the list may be found. Another index of subjects referring the reader to the principal publications in which each is treated adds greatly to the practical value of the whole work.

Dr. Josiah Parsons Cooke has just published a volume entitled "Scientific Culture and other Essays." *Science*, in referring to the volume, says that the most important statements which are made in these essays are quite independent of the subject-title. They should be printed after the manner of certain biblical texts, and displayed on the walls of every collegiate hall in the land. We append a few of these paragraphs:—"There is no nobler service than the life of a true teacher; but the mere taskmaster has no right to the teacher's name, and can never attain the teacher's reward" (p. 85). "The teaching which a professorship implies, instead of being a hindrance, ought to be a great stimulus to scientific investigation. Of course this influence is greatly impaired, if, as in many of our colleges, the available energies of the teacher are exhausted by the daily routine of instruction, or by outside work required to supplement his meagre salary; but if the teaching is only moderate in amount, and in the direction of the professor's own work, there is no stimulus so great as that which the association with a class of earnest students supplies" (p. 280). "Men of affairs should resign the endowments intended for the maintenance of scholars to those whose zeal is sufficient to induce them to make gladly the sacrifices which the advancement of knowledge usually entails" (p. 277).

MR. EDWARD SAUNDERS writes as follows to the September number of the *Entomologist's Monthly Magazine*, under date August 6, on the subject of "Dead Humble-bees under Lime Trees." Dead humble bees, more or less mutilated, have often been observed in large numbers under lime trees, and various suggestions have been offered to account for their presence in such a position. Some observations which I was able to make the other day suggest the probable reason for the death and evisceration of such bees, and, therefore, may be worth recording. While walking on Hayes Common, Kent, on the 3rd of this month, I noticed, under a large spreading lime tree, in full flower, that the ground was strewn with bodies of humble-bees of several species; I and one of my children picked up a number of them, and found several still moving their legs, and evidently only quite recently mutilated, nearly every specimen appearing to have been killed in the same manner, having a large hole in the upper surface of the thorax, and another at the apex of the abdomen, the apical segments being removed; thinking that it would be a good opportunity to try and find out who or what was the cause of their death, I sat down close to the tree and watched. The tree was covered with bloom, and hive-bees and humble-bees abounded, but I could not see any wasps, so I at once abandoned the idea that they were the culprits, as some have thought probable; everything seemed peaceable, and for some time I could see no possible enemy to suspect. At last, I saw among the higher branches a bird, and from the exact spot where it was fidgeting about down dropped a carcase of a bee. I at once picked it up, and found the legs still twitching convulsively; although I did not actually see the bird drop the bee, I think there can be little doubt that it did. I went back again, and sat down to try and discover what bird it was, and after a little time a bird, which was in all probability the same, although I had lost sight of it while examining the bee, came out into a less leafy part of the tree, and I was able to identify it as a great tom-tit; and although I have no positive evidence whereby to convict *Parus major*, I think the probabilities of his being the culprit are so strong, that it is hardly necessary to seek further for the murderer of these humble innocents.

ADVICES received by the last mail from Iceland state that the weather in the island during the summer has, in common with everywhere else in North Europe, been very cold and stormy. Even in the middle of July night-frosts occurred frequently in the higher-lying districts, and sometimes also by the coast. The grazings have suffered greatly in consequence of the weather, being in many places in a miserable state. During June and July severe storms devastated the island, killing the sheep in many places, notably in the Westfjord. The fishing has been fairly good in some places where the herring have been plentiful this summer. The fish was fat and in excellent condition.

ON the west coast of Norway, too, very unusual weather has been experienced this summer, snow having fallen in several places, whilst night-frosts have injured the crops. Tourists from the interior state that they never have experienced so backward a season in that part. The cold weather is being ascribed to the enormous ice-masses which have descended from the Polar regions into the Gulf Stream in the spring, and the large quantity of drift ice in motion to the north and north-east of Norway.

INTELLIGENCE received from North and Central Sweden states that the migratory birds are already leaving in large numbers. Between August 16 and 18 thousands of wildfowl were seen passing over Stockholm, their progress lasting for hours at the time. During the night, too, their calls were heard. That the birds have previously left their summer haunts so early is unknown.

A QUICK change of temperature arrived on the U.S. Atlantic coast on the afternoon of August 25, the mercury falling 40°. A hurricane along the Florida and Caroline coasts accompanied it, causing serious damage. Charleston, South Carolina, had one fourth of its houses unroofed; church steeples were blown down and the wharves were overflowed and damaged, the wind blowing at the rate of seventy miles per hour. The hotels and summer-houses on Sullivan's Island were partly destroyed. The damage is reported to amount to $1,000,000. Savannah reports serious losses from the overflow and the wind. Jacksonville and and Fernandina, Florida, report heavy losses with wrecked vessels. The storm, which extended northward with less severity, was general along the Atlantic coast.

AT the last meeting of the Asiatic Society of Japan (reported in the *Japan Mail*) a paper by Mr. H. Pryer was read on the relation between the Lepidoptera of Great Britain and Japan. From the statistics given it appears that about 16 per cent. of the British species are found in Japan. At first sight there does not seem to be any strong resemblance between the Japanese and British specimens of certain species; but the differences are demonstrably due simply to the effect of temperature. In Japan the temperature forms are very numerous, because of the fluctuations in temperature which are so peculiar to the country. When the great distance separating the countries and the striking climatic differences are considered, the identity of such a large percentage of species is a fact of the highest interest to the entomologist.

THE syllabus of the day and evening classes of the Mason Science College, Birmingham, for the session 1885-86 has been published.

THE Asiatic Society of Bengal has just issued a centenary review of the work accomplished by it. The first meeting of the Society took place during the Governor-Generalship of Warren Hastings, in the year 1784.

IT is stated that various lines of telegraphs are to be constructed in Corea under the superintendence of Chinese officials. The preliminary surveys have already been commenced between Gensan and Seoul, and at various points on the Chino-Corean frontier. The length of the lines actually undertaken is over 400 miles.

THE recent earthquakes in Java appear to have extended all over the Eastern Archipelago. The official journal of Batavia contains a report from the Government resident at Amboyna stating that on April 30 violent shocks were felt at Amboyna, in

Banda, and Kayeli, and on the following day at Kairatu. Villages on the beach were overwhelmed by the sea. At intervals of about twenty minutes the sea receded to a distance of 300 yards from low water mark, and then returned to overflow to a depth of 34 feet the broad plain near the beach, fifteen miles west of Kayeli. This phenomenon does not appear to have been general, but to have confined itself to the locality mentioned.

EARTHQUAKE shocks were felt on August 26 in the valley of the little river Mürz, in Styria. They caused no damage beyond loosening the foundations of a few cottages. Several shocks were felt in the same district last May.

THE *Nacion* of Guayaquil gives details of the eruption of the volcano of Cotopaxi early on the morning of July 23. It states that about one o'clock in the morning people were awakened by a sound as of heavy artillery fire, apparently from guns of the heaviest calibre. The explosions followed one another with wonderful rapidity, sometimes causing a continuous roar, shaking the earth and causing the windows and the doors of the houses to rattle. At Chimbo, which is situated almost at the foot of the volcano, there was what the residents along the river Yana-Yacu call an "aluvion." The phenomenon so-called is really the stream of lava which descends the mountain sides, melting the snow with which it is covered, and pouring down a tremendous mass of lava, mud, stones, and all obstacles encountered in its progress. Investigations during the day showed that the shocks produced by the explosions during the night were exceedingly heavy. The smoke hung like a pall over the face of the country, and the steady fall of ashes thrown constantly out of the terrible crater intensified the darkness. Accounts from Latacunga state that the eruption began with a terrible storm. The damage done was considerable, but the number of victims is not known A similar catastrophe occurred in June 1877.

THE "Bureau Scientifique Central Néerlandais," established in 1871 at Haarlem, after the death of its first Director, the lamented Prof. E. H. von Baumhauer, has been taken in hand by Dr. P. P. C. Hoek, at Leiden. The Bureau is in relation with the Smithsonian Institution, Washington, the "Ministère de l'Instruction publique en France," the "Commission des Echanges Internationaux à Bruxelles," with bureaus in Christiania, Stockholm, Copenhagen, &c. Packages sent as *donations* or *exchanges*, and destined for Dutch learned societies or scientists, henceforth are to be sent to the new Director at Leiden or to be delivered to the agent of the Bureau at London *free of expense*. The agents of the Bureau are Messrs. Williams and Norgate, 14, Henrietta Street, Covent Garden, London.

THE additions to the Zoological Society's Gardens during the past week include a Macaque Monkey (*Macacus cynomolgus* ♀) from India, presented by Mr. H. J. Thimbleby; a Binturong (*Arctictis binturong* ♂) from Malacca, presented by Mr. T. H. Haynes; a Great Kangaroo (*Macropus giganteus*) from New South Wales, presented by Mr. A. McIlwraith; two Golden-crowned Conures (*Conurus aureus*) from South-East Brazil, presented by Mr. Cuthbert D. Middleton; a Common Cuckoo (*Cuculus canorus*), British, presented by Mr. R. B. Spalding; two Javan Sparrows (*Padda oryzivora*) from Java, presented by Miss Coleman; a Black-headed Gull (*Larus rubicundus*), European, presented by Mr. Humphries; a Horned Lizard (*Phrynosoma cornutum*) from Texas, presented by Miss Simpson; a Common Chameleon (*Chamæleon vulgaris*) from North Africa, presented by Master Cecil Guy Dart; a Robben Island Snake (*Coronella phocarum*) from Robben Island, South Africa, presented by the Rev. G. H. R. Fisk, C.M.Z.S.; a Macaque Monkey (*Macacus cynomolgus*) from India, a Siamese Blue Pie (*Urocissa magnirostris*) from Siam, an American Black Snake (*Coluber guttatus*) from North America, a Smooth-headed Capuchin (*Cebus monachus*), a Squirrel Monkey (*Chrysothrix sciurea*) from South America, deposited; two Axolotls (*Siredon mexicanus*) from Mexico, purchased; fourteen Striped Snakes (*Tropidonotus sirtalis*), born in the Menagerie.

ASTRONOMICAL PHENOMENA FOR THE WEEK, 1885, *SEPTEMBER* 6–12

(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 September 6

Sun rises, 5h. 22m.; souths, 11h. 58m. 8·3s.; sets, 18h. 34m.; decl. on meridian, 6° 18′ N.: Sidereal Time at Sunset, 17h. 38m.

Moon (New on September 8) rises, 2h. 11m.; souths, 9h. 44m.; sets, 17h. 6m.; decl. on meridian, 14° 3′ N.

Planet	Rises h. m.	Souths h. m.	Sets h. m.	Decl. on meridian ° ′
Mercury	4 53	11 28	18 3	6 14 N.
Venus	8 29	14 0	19 31	6 23 S.
Mars	0 32	8 40	16 46	22 14 N.
Jupiter	5 30	12 6	18 43	6 31 N.
Saturn	23 18*	7 27	15 35	22 23 N.

* Indicates that the rising is that of the preceding day.

Sept.	h.	
8	4	Mercury in conjunction with and 0° 27′ south of the Moon.
8	—	Total eclipse of Sun, visible only in regions near the south pole.
8	22	Jupiter in conjunction with Sun; also in conjunction with and 1° 57′ north of the Moon.
11	9	Mercury stationary.
11	10	Venus in conjunction with and 2° 27′ south of the Moon.

GEOGRAPHICAL NOTES

MR. GARDNER, British Consul at Newchwang, publishes with his annual trade report this year (China, No. 6, 1885) a most interesting account of his consular district, which embraces the whole of Manchuria. It contains an area of about 300,000 square miles and a population estimated by the Roman Catholic missionaries at 15,000,000. Its boundaries are, on the north, the Amour, separating it from Eastern Siberia, on the east the Ussuri River and Sihoti Mountains separating it from the Russian province of Primorsk, on the south the Tiumen and Yalvo Rivers separating it from Corea, the Yellow Sea and the Gulf of Liao-tung, on the west China, Mongolia, and Russian Siberia. The first part of the report deals with the ordinary trade and productions of Manchuria, and gives a summary of the statistics of foreign trade since the port of Newchwang was opened to trade in 1861. The second part is devoted to geographical notes on Manchuria, its three provinces, Heh-lung-Kiang (or Sagalien), Kirin and Fêngtien being taken separately. The history, government, military force, and divisions in towns are the heads under which these provinces are described. Various appendices contain an account of a journey from Moukden to San-sing, an essay on Christian missions in Manchuria, and a sketch of the botany of South Manchuria by Dr. Morrison. The latter is, from a scientific point of view, the most important part of the report. The lists given are defective, as the greater part of Dr. Morrison's collections remain unidentified, there having been no opportunity of visiting herbaria or consulting published accounts of Northern Chinese plants.

THE report of the Resident in the State of Selangore in the Malay peninsula for the past year contains some curious information with regard to "aboriginal tribes" called the Sakeis, who number between 700 and 800. They are in nine divisions, under head-men called Batins, and they live mainly by collecting gutta, rattans, and other jungle produce. As far as is known they have no form of religious worship, but they are very superstitious, believing in good and bad omens, the sacred character of certain birds, and they always desert a village as unlucky on the death of any member of the tribe. They tattoo figures on their arms, but apparently only for the sake of ornament, and do not use any specially significant figures, peculiar to each tribe, analogous to the totems of the North American Indians. They consider no kind of edible food unclean, but eat even monkeys, snakes, and scorpions, which they kill by means of a blow-pipe, throwing a dart poisoned with the juice of the Ipoh or Upas tree. For large game they use a kind of cross-bow, consisting of a sharpened bamboo spear placed horizontally on a grooved log, and a bent sapling fastened back by a rattan cord. This cord is stretched across a path in the jungle, and, on being touched, releases the sapling with sufficient force to drive it completely through a deer's body. The Sakeis live in small huts built of bamboo and thatched with leaves of the Bertam palm, raised eight feet or more above the ground. They are shy and easily frightened, but are quite harmless, and are gradually becoming accustomed to Europeans, by whom they are employed to track game and to cut paths through the jungle. They are smaller in stature, but are otherwise very similar in appearance to the Malays, from whom they differ, however, in usually having wavy instead of straight-growing hair. A few Malays are attached to every Sakei community to act as go-betweens in the sale of their produce, and the officials have received special instructions to protect these aboriginal tribes.

THE last issue (Bd. xxviii. Nos. 7 and 8) of the Vienna Geographical Society contains a paper by Dr. B. Jirus describing several visits made by him to the Scoglios, or small reefs off the Dalmatian coasts.—Dr. Polek writes on the colonies of Lipporwans, or Ras Kolniks, Russian schismatics who fled in the middle of the seventeenth century into Bessarabia and Moldavia, which they subsequently left for Bukowina in a romantic way. The writer discusses the history of their flight, and describes their manners and mode of life. The charm of mystery hangs around this small sect of the Greek Oriental Church.—Mr. H. Polakowsky discusses the historical value of the Spanish heroic poem "Araucana," recording the struggles the Spaniards for the possession of the central part of the present Republic of Chili. The object of the author of the paper is to draw attention to this poem, and its translation into German, and by a complete critical examination to separate the historical and actual from the poetical and imaginative.—Herr Baumann describes the projected geodetic work of Dr. Lenz's Congo expedition, and also writes from the vessel taking out the expedition on the present position of the question it is going out to solve.

THE Geographical Society of Hamburg has published a memorandum showing the territorial extent of the recent German annexations in the Pacific Ocean. Reduced to English measurements the German estimates are as follows:—Kaiser Wilhelm's Land (German New Guinea), 34,508 square miles; New Ireland, 3,398·8 square miles; New Britain, 9,348·8 square miles; the Bismarck Archipelago, 15,261·6 square miles: in all about 65,512 English geographical square miles. The same authority estimates the area of New Guinea taken under British protection as 65,517·76 square miles, or about the same as the total of the German annexations in the Pacific, and in each case the area acquired is rather more than twice that of Ireland.

THE *Indépendance Belge* announces that the two Portuguese explorers, Capt. Capello and Commander Ivens, who started last year upon an expedition across Africa, have reached the Cape after a most adventurous journey. Leaving Mossamedes in March, 1884, with an escort of 120 men recruited along the coast between that place and St. Paul de Loanda, they reached Quillimane, upon the eastern coast, to the south of Mozambique, in May, 1885, after having discovered the watershed whence the rivers of Central Africa flow north and east towards the sea. They travelled over 4500 miles of territory, and they are said to have discovered the sources of the Lualaba. They also came upon a region which is extraordinarily rich in copper, this being the district of Yaranganga, situated between the Lualaba and the Luapala. The chief of the country, however, was so hostile that they could not visit it in detail, but they think that as this was the first visit of white men his hostility may be appeased by judicious presents. Messrs. Capello and Ivens found that the tsetse fly was very abundant. The *Indépendance Belge* adds that the two explorers started again at the beginning of last month for Mossamedes, with the intention of returning to Europe by way of the Congo.

THE Calcutta correspondent of the *Times* states that the Government of India has conferred the title of Raj Bahadoor and a grant in perpetuity of a rent-free village in Oude on Pundit Kishen Singh Milwal, an *employé* of the Survey Department, who is well known to all geographers for his explorations in Thibet, which have been published under the initials "A. K."

ON August 10 Col. Lockhart was at Hargil, near Gilghit, and is now probably marching to Chilval. His mission is expected to largely increase our knowledge of the country towards the upper waters of the Oxus.

THE IRON AND STEEL INSTITUTE

THE autumn meeting of the Iron and Steel Institute is being held in Glasgow this week, under the presidency of Dr. Percy, F.R.S.

On Tuesday, after the President had acknowledged the welcome given to the Institute by the Corporation of Glasgow and referred to the depression of trade, due, in his opinion, to over-production, and to be remedied only by a diminution of production or increased consumption, the three following papers were read, of which abstracts are given below.

On the Iron Trade of Scotland, by Mr. F. J. Rowan.—The author separates the history of iron-making into two periods—the *empirical*, characterised by rude and imperfect appliances; and the *scientific*, in which exact methods of working are employed, the introduction of the hot-blast in 1830 closing one and opening the other period. At this period there were in Scotland 27 blast-furnaces making 37,5000 tons; at present there are 92 in blast, with an average production of 200 tons per week each, and 269 puddling-furnaces at work, each producing annually 732 tons. There has been a steady increase in the production per furnace, and reduction in the amount of coal used to produce a ton of pig iron, the latter result being due to the introduction of closed tops, higher furnaces, and higher temperatures of blast. About two-thirds of the coal raised have been from the coal-measures, and one-third from the carboniferous limestone series. It is remarkable that the increased production of coal that has recently taken place has been accompanied by a reduction in the proportionate number of persons employed due to mechanical haulage and other improvements both below and above the surface. The increased manufacture of open-hearth steel, which employs a large quantity of Spanish and African ore, has caused a diminution in the output of ironstone, and has also had an influence on the pig-iron trade; this, however, has been compensated for by the malleable iron tube manufacture, the manufacture of boiler tubes having increased ten times in the last twenty-five years. The author claims for Scotland a good record of advancement and improvement in connection with the iron trade—the first cylinder-blowing engine, the first use of raw coal in the blast-furnace, the discovery of blackband ironstone by David Mushet, the invention of the hot blast by Neilson, and the collection and utilisation of the gases from the tunnel-head. The spirit of enterprise is still potent among Scottish ironmasters, and it is hoped more prosperous times will soon reward and further stimulate the energy and ability which are to be found in all branches of the iron trade in Scotland.

The Rise and Progress of the Scotch Steel Trade, by James Riley.—The author first makes a short reference to the manufacture of cast steel in crucibles, which is carried on only to a very small extent.

As regards the Bessemer process, the first trial, which proved unsuccessful, was made in 1857, at the Coats Iron Works, by Mr. T. Jackson, the apparatus being fitted up from the drawings and letterpress in the *Illustrated London News*.

Other attempts on a small scale were afterwards made to introduce the manufacture, but since the application of the basic lining to the Bessemer converter, by which the pig-iron of the district will become available, the process has again received attention, and a large production is anticipated.

The history of the Scotch steel trade really commences with the formation, in 1871, of the Steel Company of Scotland, which manufactured open-hearth steel by the processes of the late Sir William Siemens, their output being principally boiler and ship plates, angles, bars, castings, and forgings. The extension of manufacture in these directions has been dne to the fact that the Admiralty in 1875 declared for steel, "giving Siemens's steel a preference," and that in 1879 concessions were made to steel by Lloyds' and the Board of Trade, which has caused a great demand for shipbuilding and for the purposes of the civil engineer, who has recognised that by the use of steel, difficulties in constructive engineering can be overcome which would otherwise have been most formidable.

Mr. William Jones read a paper on processes for the recovery of tar and ammonia from blast-furnaces fed with raw coal. The coal generally employed is what is known as Scotch splint coal; it contains on an average 40 per cent. of volatile matter and 50 to 55 per cent. of fixed carbon. The average amount of nitrogen in the coal is 1·35 per cent.; if all this nitrogen was evolved as ammonia and this again converted into sulphate, it would amount to 142½ lbs. of pure sulphate, equal to 152·8 lbs. of commercial sulphate containing 24 per cent. of real ammonia; in blast-furnace practice only 17 to 20 per cent. of the theoretical quantity, or 25 to 28 lbs. per ton, is recovered, whilst in gas-works 14½ per cent. is evolved. Two methods are mainly employed: the one depending on the condensation or cooling of the gas from the blast-furnace, and the other on the treatment of the hot gas with either dilute sulphuric acid or sulphurous acid, which absorbs the ammonia in the gas; towers or scrubbers have to be used for washing the gas in both methods of treatment. The paper contains a detailed description of the various processes employed in carrying out these two methods for the recovery of by-products. The make of sulphate of ammonia from blast furnaces in Scotland has been greatly exaggerated. Even a year hence, when the whole plant being laid down will be available, the make will not exceed 4000 tons per annum. If the gases of the whole of the blast-furnaces in Scotland at present in blast were being treated for ammonia, the turn-out of sulphate of ammonia would be some 18,000 tons per annum, equal to about 22 per cent. of the present British production.

With the discussion of this paper proceedings on Wednesday began; after which Mr. J. Riley read a paper descriptive of an experimental cupola-furnace, which it is proposed to employ in connection with the open-hearth process, with the object of shortening the time employed. Many years ago Mr. Hackney tried at Landore the experiment of pre-melting the pig-iron in a cupola, whence the fluid charge was quickly and readily transferred to the melting-furnace. Instead, however, of saving three or four hours by charging fluid metal, it was found, on repeating the experiment at Hallside, that there was only a saving of about a quarter of an hour in time, obtained at the expense of the coke and labour expended at the cupola. This is due to the circumstance that during the melting of a charge in the open-hearth furnace a large proportion of the silicon and carbon is removed, leaving little more than half the carbon to be eliminated in subsequent operations. Now in the case of the fluid charges, which had been pre-melted with coke in the cupola, these changes have not taken place, and the time required to remove the impurities from the fluid metal, after being charged on the open-hearth furnace, is almost as long as that required to melt and purify the solid charge. The idea occurred to the author to substitute gaseous for solid fuel in the cupola. The gas generator has a closed grate and is dependent upon forced blast, and the air for supporting combustion in the body of the furnace is also obtained from the blower, and is heated.

The experiments made with this cupola prove that not only is there a saving in time and fuel, but that the percentage of silicon and carbon in the pig-iron and steel scraps are very much reduced, so that it is anticipated that when the fluid metal can be charged direct into the open-hearth furnace, the time for its conversion into mild steel will be greatly shortened.

This paper caused a very lively discussion, with which the proceedings on Wednesday terminated.

On Thursday amongst other papers was one descriptive of the Forth Bridge by Mr. Baker, which we print below *in extenso*.

In the afternoon of each day the members visited various steel and iron works in the neighbourhood.

THE FORTH BRIDGE[1]

As the members of the Iron and Steel Institute purpose paying a visit to the Forth Bridge works, I have been requested by the Secretary to prepare a short paper on the subject for the information of the members, and do so with pleasure.

The North British Railway Company for many years have striven hard to obtain a physical connection of their lines north and south of the Forth by means of a bridge. Twenty years ago they were authorised by Act of Parliament to build a bridge across the Forth at a point five miles above the site of that now under construction, but borings 120 feet in depth showed nothing but soft silt and mud, and the bridge, which was to have been two miles in length, inclusive of four spans of 500 feet each, was luckily abandoned, as the difficulties with the foundations would have proved practically insuperable. In 1873 another Act was passed for a bridge across a narrower and deeper part of the Forth at Queensferry. At low water the width of the channel there is about 4000 feet; and the island of Inchgarvie affording a foundation for a central pier, it was possible to cross the 200 feet deep portion of the sea-way by a couple of spans from 1600 feet to 1700 feet each in the clear. Sir Thomas Bouch prepared a design for this bridge on the suspension principle, with towers 665 feet in height from base to summit, and the contract for its construction was let to Mr. Arrol. Owing to the subsequent fall of the Tay Bridge, public confidence in Sir Thomas Bouch's design was shaken, and in session 1881 a bill for the abandonment of the Forth Bridge was proceeded with. Whilst in Committee, the different companies interested, namely, the North British, Great Northern, North-Eastern, and Midland Railway Companies, ordered a final reference of the whole question to their respective consulting engineers, with the result that the abandonment bill was dropped, and the design for a cantilever or continuous girder bridge prepared by Mr. Fowler and myself, in consultation with Mr. Harrison and Mr. Barlow, was substituted for the original suspension bridge. In 1882 the necessary Parliamentary powers were obtained, and in January 1883 the works were commenced by Messrs. Tancred, Arrol, and Co., the contractors.

The total length of viaduct included in the contract sum of 1,600,000*l*. is about 1½ miles, and there are—

2	spans of	1710	feet each.
2	,,	675	,,
15	,,	168	,,
5	,,	25	,,

Including piers, there is thus one mile of main spans, and half a mile of viaduct approach. The clear headway is 150 feet above high water, and the tops of the great cantilevers are more than 200 feet higher still. There will be about 45,000 tons of steel in the superstructure of the bridge, and 120,000 cubic yards of masonry in the piers.

Piers.—The *South Queensferry* main pier consists of a group of four cylindrical piers of masonry and concrete, founded by means of pneumatic caissons on the strong boulder clay constituting the bed of the Forth at this point. Owing to the slope of the clay, the caissons required to be sunk to depths varying from about 70 feet to 90 feet below high water. The diameter ranges from 70 feet at the base to 60 feet at low-water level, above which the iron skin of the caisson is replaced by a facing of Aberdeen granite. At the base of the caissons is a working chamber 7 feet in height supplied with compressed air, and electrically lighted, for the men excavating the material. This chamber was kept clear of water by a pressure of air considerably less, as a rule, than that due to the head of water outside. For example, at 90 feet below high water, when the north-east caisson had been sunk through a considerable thickness of silt, the air-pressure required to be maintained at 18 lbs. per square inch only, although at the reduced depth of 57 feet it was found convenient to work at 30 lbs. air-pressure. Three shafts and air-locks were provided for each caisson, two for the excavated material, and one for the men. The former had two horizontal sliding doors actuated by small hydraulic rams, and the skip containing the clay and boulders was hoisted up the 90-feet shaft by a steam-engine mounted on the side of the air-lock. As a rule, from 200 to 300 skips of excavated material were raised per day of 24 hours by a force of from 20 to 30 men. The maximum number of skip-loads was 363, and of men 33. The size of the skips was 3 feet diameter by 4 feet 3 inches high. Owing to the extreme hardness of the clay it was necessary to provide a certain number of spades having hydraulic rams in the handles, which, abutting against the roof of the working chamber, sliced the clay readily.

At the present time three of the South Queensferry caissons have been sunk successfully to the full depth, and the fourth and last would also have been completed but for an unfortunate accident which happened to it at the beginning of the year. By some means the caisson, which had been floated into position for some weeks, accidentally filled with water, and sank and slid forward on the mud. It is now being carefully cased in timber to admit of the water being pumped out and the caisson floated again into position.

[1] Paper read at the Glasgow meeting of the Iron and Steel Institute by Mr. Benjamin Baker, M.Inst.C.E.

At *Inchgarvie* similar pneumatic caissons are used for two out of the four cylindrical piers, and the work on both is in full progress. Owing to the slope of the rock bottom, it is necessary to cut away as much as 18 feet in thickness of whinstone rock to form a level bench for the pier at 70 feet below high water, and the most convenient way of doing this was to convert the base of the pier practically into a great diving-bell 70 feet in diameter. In this case, there being no silt over the rock, the pressure of air necessarily is that due to the depth of water outside, and somewhat sensational "blows" occur with a falling tide. Rock drills are provided, and blasting goes on in the compressed-air chamber without necessitating the withdrawal of the men.

At *North Queensferry*, the four main piers were built either on dry land or within timber and clay cofferdams. Above low water the whole of the main piers are built of Arbroath masonry in cement faced with Aberdeen granite, and hooped occasionally with 18 inches wrought-iron bands. The cantilever end piers, and the viaduct piers, are built of rubble, concrete, and granite in cement.

Superstructure.—Although the piers of the Forth Bridge present many points of interest, it is the enormous span and novel design of the superstructure that has attracted the attention of the engineers of the world to the work now in progress at Queensferry. The chief desiderata in the biggest railway bridge ever proposed to be constructed are durability, strength, and rigidity under express trains and hurricane pressures; facility and security of erection, high quality of material and workmanship, and economy in first cost and maintenance. These, we considered, would be best met by a steel "cantilever" or "continuous girder" bridge. Since the commencement of the Forth Bridge, American engineers, ever bold and ready, have built three cantilever bridges of considerable spans, and practical experience has confirmed our anticipations as to the advantages of the system; the Niagara Bridge, over 900 feet in length, which was manufactured and erected across the rapids in the short time of ten months, having stood all the tests of actual working in the most satisfactory manner.

In the Forth Bridge, each span of 1710 feet is made up of two cantilevers, projecting 680 feet, and a central girder connecting the same, 350 feet in length. The cantilevers are 343 feet deep over the piers, and 40 feet at the ends. The bottom members consist of a pair of tubes tapering in diameter from 12 feet to 5 feet, and spaced 120 feet apart, centre to centre, at the piers, and 31 feet 6 inches apart at the ends.

The top members consist of a pair of box lattice girders, tapering in depth from 12 feet to 5 feet, and spaced 33 feet apart at the piers, and 22 feet 3 inches at the ends. Each tube has a maximum gross sectional area of 830 square inches, and each girder a maximum net sectional area of 506 square inches. Upon each cylindrical masonry pier is bolted a bed-plate carrying a "skewback," from which spring vertical and diagonal columns and struts. The former are 12 feet in diameter, and from 368 to 468 square inches sectional area; the latter are flattened tubes. Horizontal wind-bracing of lattice girders connect the tubes forming the bottom member of the cantilevers, and similar vertical wind-bracing connects the vertical and diagonal tubes, so that the whole structure is a network of bracing capable of resisting stresses in any direction and of any attainable severity.

The rolling load provided for is (1) trains of unlimited length on each line of rails weighing 1 ton per foot run; (2) trains on each line made up of two engines and tenders, weighing in all 142 tons, at the head of a train of 60 short coal-trucks of 15 tons each. The wind provided for is a pressure of 56 lbs. per square foot, striking the whole, or any part of the bridge, at any angle with the horizon, the total amount on the main spans being estimated at no less than 7900 tons. In practice only two trains, weighing 800 tons in all, would be on this length of bridge at the same time, so the wind pressure (if such a hurricane as 56 lbs. per square foot could ever occur) would be ten times as great as the train load. Under the combined stresses resulting from the test load in the worst position, and the heaviest hurricane, the maximum stress on the steel will not exceed $7\frac{1}{2}$ tons per square inch on any portion of the structure, and on members subject to great variation in the intensity and character of stress, the maximum will not exceed 4 tons per square inch. For tubular columns and struts 34 to 37 ton steel, with an elongation of 17 per cent. in 8 inches, is specified, and for tension members 30 to 33 ton steel, with 20 per cent. of elongation. We have now about 15,000 tons of steel delivered and worked up, and are satisfied that the quality as supplied to us by the Steel Company of Scotland and the Landore Company is admirably adapted for bridge construction. In making the tubes the plates are heated in a gas furnace and bent hot between dies in a powerful hydraulic press. A slight distortion takes place in cooling, which is corrected by pressing the plates again when cold. After bending, all four edges are planed and the plates built up into a tube. Travelling annular drill frames surrounding the tube, fitted each with ten traversing drills, bore the holes at once through plates, covers, and stiffeners, so that when again fitted in place for erection every piece comes into exact juxtaposition. Similar travelling drill frames deal with the lattice box-girders, every hole being drilled as the machine advances. Generally the plant designed by Mr. Arrol for drilling the innumerable holes in the 42,000 tons of steel-work for the main spans is of signal merit and efficiency, and well worthy the attention of practical engineers.

At the present time, although, as already stated, about 15,000 tons of steel-work is on the ground, only the approach viaduct girders and some of the bed-plates of the main spans are erected and rivetted up. In a few weeks, however, the erection of the portion of the main spans over the North Queensferry piers will be proceeded with. The "skewbacks" and connecting tube will first be rivetted up, and then a platform of temporary girders and planking will be constructed, and raised gradually by hydraulic rams in the four vertical 12-foot diameter columns as the work of erection and rivetting-up progresses. This platform will carry cranes and other appliances, and the men will be thoroughly protected, so that work may be carried on with as much confidence at a height of 350 feet as at sea-level. When the portion of steel-work over the piers is erected, the first bay of cantilever on each side of the same will be added, the work forming its own staging. This will be followed by succeeding bays until the cantilevers are complete, and the central girders will then be erected, probably on the same plan.

It will be observed that for certain parts of the Forth Bridge we use steel of a higher tensile strength than is at present considered admissible either for ships or boilers. This has not been done without full and mature consideration of the whole question. Our experiments showed that steel, having a tensile strength of from 34 to 37 tons per square inch, offered a decided advantage over very mild steel, when compressive stresses and the flexure of long columns were concerned. Indeed, an inferior quality of steel, such as would be used for rails, will stand compression far better than the best boiler steel or Lowmoor iron. Thus, I found a column twenty diameters in length of common Bessemer steel carry 27 tons per square inch, where one of mild boiler steel has stood but 17 tons. It would be inexpedient, however, to use inferior steel, even for the compressive members of a bridge, and therefore a high quality and high tensile resistance were indicated. Although this steel takes a temper and becomes brittle if cooled in certain ways, it will stand the ordinary Admiralty temper tests, bending to a radius of double the thickness, after being made red-hot and cooled in the usual way. In a boiler the steel plates are subject to great changes of temperature and consequent stresses from expansion and contraction. In a ship almost every plate in the hull is subject to alternate tensile and compressive stresses when amongst waves; and, further, a vessel is liable to severe alternating stresses and shocks on taking ground, dry docking, and under other circumstances. In the compression members of the Forth Bridge the steel is subject only to a steady pressure of varying intensity, and a quality of steel was adopted which combined perfect facility in working with a high resistance to compression. Although an increased tensile strength is accompanied by a decidedly increased resistance to flexure in columns and struts, the latter is not proportional to the former. If the thing were practicable, what I should choose as the material for the compression members of a bridge would be 34- to 37-ton steel, which had been previously squeezed endwise in the direction of the stress to a pressure of about 45 tons per square inch—the steel plates being held in suitable frames to prevent distortion.

My experiments have proved that 37-ton steel so treated will carry as a column as much load as 70-ton steel in the state in which it leaves the rolls, that is to say, not previously pressed endwise. It would be a matter of much practical moment to ascertain if some convenient treatment could be devised which would endow steel with this greatly increased power of resistance to compression without injuring its resistance to tension, or its ductility, which remained unaffected by previous compression in my experiments. At least one-half of the 42,000 tons of steel in the Forth Bridge is in compression, and the same proportion holds good in most bridges, so the importance of gaining an increased resistance of 60 per cent. without any sacrifice in the facility of working, and safety belonging to a highly ductile material, can hardly be exaggerated.

Our experience has led us to the conclusion that sheared edges are a more fruitful source of fracture than partial tempering or other contingencies. All of our bent plates are made red-hot, and the effect of the shearing is thus eliminated even before planing. Those plates which are not heated have the edges carefully planed so as to leave no trace of the shearing, and we find that, whether we are dealing with 30-ton or 37-ton steel, the plates so treated stand all the desired tests. Experiments which I have made, and am still making, on the resisting power of different classes of iron and steel to repeated bendings, such as the shaft of a marine engine undergoes if the bearings get out of line, indicate that the superiority of low-tension steel is considerably greater than the increased ductility would indicate.

In conclusion I may state that the approximate value of the plant now at the Forth Bridge is 250,000*l.*, and of the work executed 600,000*l.*

SOCIETIES AND ACADEMIES

Sydney

Royal Society of New South Wales, June 3.—Prof. Liversidge, F.R.S., President, in the chair.—A paper was read by Mr. G. H. Knibbs on a system of accurate measurement by means of long steel ribands. The chief feature of the method of measurement is the application of such tensions to the riband as eliminate the effects of its suspension when it becomes necessary.—Mr. Law. Hargrave read a paper, notes on flying-machines, which consisted of deductions drawn from close observation of the behaviour of about fifty self-supporting flying-machines of various weights, from three-quarters of an ounce to four ounces. Sixteen models were exhibited. Mr. Hargrave stated that, although he believed the trochoided plane to be the true mechanical power used by birds in flight, he though its rejection as a scientific truth of very trifling importance compared with the judicious variation and adjustment of the details of the models, so that rules could be laid down for work on a larger scale

July 1.—Prof. Liversidge, F.R.S., President, in the chair. —A paper was read by Mr. H. C. Russell, B.A., on local variations and vibrations of the earth's surface.

Paris

Academy of Sciences, August 24.—M. Bouley, President, in the chair.—Note on human locomotion; mechanism of the jump, jointly communicated by MM. Marey and G. Demeny. This first communication on the subject of human locomotion begins with the action of springing or jumping, because, although not the most usual, it is regarded by the authors as by far the simplest, and much less intricate than walking or running, in which the body executes complicate movements in the direction of the three dimensions of space. The paper is illustrated by a *chromo-photograph* showing the successive positions of legs, arms, and shoulders in a man taking a standing leap (*saut de pied ferme*); also by diagrams of two high jumps executed on the dynamograph.—Observations on the prevalence and development of pestilence and cholera in Persia, where quarantine preventive measures have never been adopted, by M. J. D. Tholozan. The author, who has had twenty-eight years' experience of the action of these epidemics in Persia, is inclined to think that the quarantine system would have proved of little or no avail in arresting their progress. The paper was followed by a few remarks by M. Larrey, also pointing at the general inefficacy of quarantine measures.—Note on M. Hirn's paper on the crepuscular lights inserted in the *Bulletin* of the Colmar Natural History Society, by M. Faye. From his observatory at Colmar the author noticed this phenomenon at an altitude far higher than that of the terrestrial atmosphere. Without deciding on the merits of the different theories advanced to explain its origin, he considers that electricity alone would be capable of retaining at such an altitude the particles of matter causing the afterglows, whether these particles were derived from the Krakatoa eruption or from the interstellar spaces.—Observations of the new planet, 249 (discovered by M. Peters on August 16 at Clinton, New York), made at the Paris Observatory (equatorial of the West Tower), by M. G. Bigourdan.—Observations of Barnard's comet made at the Observatory of Bordeaux with the 14-inch equatorial, by M. G. Rayet.—On the theory of revolving mirrors as a means of measuring the velocity of light, by M. Gouy.—Experiments on double refraction (four illustrations), by M. D. S. Stroumbo. By a simple contrivance the author renders visible to a large audience the course of two rays, ordinary and extraordinary, in a birefringent crystal: (1) when the two facets are artificial and perpendicular to the axis; (2) when they are artificial and parallel to the axis; (3) when they are the natural facets of the crystal parallel to each other.—Note on the alcoholic derivatives of pilocarpine, by M. Chastaign.—On the transmission of pathogenetic microbes from the mother to the fœtus and in the milk, by M. Koubassoff. From experiments made on the guinea-pig the author infers that the charbon virus, the bacilli of tubercular affections, and other germs of disease pass into the milk and remain there during the term of lactation, or till the death of the mother; also that the fœtus nourished on such milk do not catch the respective diseases, but survive even the death of the mother; lastly, that the transmission of microbes from mother to fœtus depends probably on the existence in the placenta of direct communications between the vessels of mother and fœtus.—On an alkaloid substance extracted from the liquid in which Koch's microbe was cultivated, by M. A. Gabriel Pouchet. An analysis of this liquid revealed traces of the presence of an alkaloid liquid presenting outward characteristics, such as small and toxic properties, apparently identical with those detected in the dejecta of cholera patients. Should these results be definitely established, they would furnish an indirect proof that Koch's microbe is really the pathogenetic agent in cholera.—Influence of the sun on the vegetation of the spores of *Bacillus anthracis*, by M. S. Arloing.—Action of the antiseptics on the higher organisms: iodine, nitrate of silver; fourth communication, by MM. Mairet, Pilatte, and Combemale. —A note was received from M. Sacc of Cochabamba, on an extremely rich deposit of alunite lately discovered in the Peruvian Andes.

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