and the conjoint Observatory, will be completely executed at the close of the year 1887. With its unparalleled instrumental equipment, and an unusual endowment for the prosecution of astronomical research; located where the sky is cloudless most of the year, and at such an elevation as to be above the clouds a great part of the remainder; and situate in a region, too, where the steadiness of the air permits astronomical measurement of the highest precision to proceed uninterruptedly throughout the entire night for months at a time,—the Lick Observatory is destined, under prudent management, to take its place at once in the foremost rank; and, although it is the first established mountain observatory, it may well expect to hold its own in the emulation of similar institutions which may subsequently be inaugurated at greater elevations.

## *TWILIGHT*[1]

THIS essay, an extract from a more comprehensive work on the problem of twilight, which the author hopes to conclude in the course of this year, and embodying a lecture recently delivered by him both in Hamburg and Leipzig, describes the phenomena of twilight in general and of the remarkable sky-glows of the winter of 1883 in particular, with clearness, fullness, and exactness, and explains the physical causes of these phenomena from a special and mature study of that universally interesting field of observation, by numerous highly pertinent and illustrative experiments, and altogether in a manner which should bring home, even to the unscientific reader, a new sense and a new intelligence of the painting offered anew every morning and evening to the study and delight of man universally.

After relating and taking measure of the stupendous outburst of Krakatoa and the brilliant glows involving nearly the whole earth for a long period after that event, and comparing these two consecutive phenomena with the analogous phenomena of the outburst of "Graham Island" in 1831, followed by brilliant twilights and peculiar blue and violet sun colours, attracting the admiration, in particular, of Italy, France, and Germany, the book addresses itself to the task of investigating the physical laws concatening these two apparently heterogeneous phenomena, and why all volcanic outbursts are not attended by the same wonderful optic displays. While each particle of dust, smoke, or fog causes a bending or diffraction of the light, a collective effect, comprehending a brilliant development of colours, is produced only when all the particles of matter are of equal size and are distributed uniformly in space—a condition not even most remotely fulfilled in the case of ordinary smoke and fog. Diffraction includes the lateral dispersion of the light, which is all the more efficient the nearer the edges lie to each other, and therefore the smaller the particles are, and also the "interference" of like-coloured rays of light. When a red light falls, for example, on a fine glass thread or a diamond stroke scratched into glass, the shadow will consist not of one thin black line, but of a whole system of parallel stripes alternately dark and brilliant, *i.e.* black and red. When, again, a white light falls on the diamond stroke, the reflection shows a system of parallel stripes glowing in all the colours of the rainbow. In the case of a single line the development of colours is indeed so small as to be scarcely perceptible, but with many thousand lines of exactly the same breadth, and situated at exactly the same distance from one another, the reflex image is such that, taken up on a white screen, it is visible at great distances. Perfectly corresponding is the case with granules of dust. The shadow of a single granule of dust in red light consists of a system of concentric rings, alternately dark and redly luminous, which are all the broader the smaller is the granule. In white light, on the other hand, the shadow of the granule consists of alternately dark and bright rainbow coloured rings. If the dust granules are all of the same size, then will the like-coloured rings pretty nearly coincide, and, in the case of a sufficiently large number of granules, the reflex image will be composed of coloured rings of great luminousness. If, on the other hand, the dust-granules are of different size, then will all the different colours coincide, and, according to a well-known optic law, the image will be colourless. The image of a dust-cloud may, therefore, be rich in colours, poor in colours, or colourless, according as the particles of dust of which it is composed are of the same or of different size.

The experiments of Coulier and Mascart, extended by Aitkin, have demonstrated that in a perfectly moist air, no formation of fog is possible, however much the temperature is lowered, so long as the air is absolutely free of dust; and that the more air, sufficiently moist, is charged with such foreign particles, the more intense is the formation of fog under a sufficient lowering of the temperature or pressure of the air. Let filtered and completely moist air in a glass ball have its pressure diminished, then will only a few particles of fog reveal themselves to the most careful inspection, even under the powerful light of an electric lamp—particles of fog which, moreover, yield not the slightest coloured image. Admit now into this filtered air a few cubic millimetres of ordinary house air, then will a very fine, silvery, transparent fog at once form itself, of such slight density that even in the case of a considerable area of it the transparency of the atmosphere would be but very little affected. At the first moment of its formation let a reflected image of the sun, or the reflected light of an electric lamp, be viewed through it: the image will be seen surrounded by an intensely luminous blue or greenish light, with a broad, reddish ring, the colouring of which may range through all stages from brilliant purple red to the most delicate pale pink.

The phenomena of colour produced and explained by experiments of the above description are made to serve as the key to the more extensive but essentially identical phenomena composing the total process of twilight, which is distributed, like a spectacular play, into three acts with a prelude, and sometimes, though comparatively seldom, an afterlude—parts which, however, are not strictly distinguished in time, but occur to some extent simultaneously and overlap each other; as also to the comparatively unimportant deviations—apart from the intensity of colouring—from the normal course, which obtained in the remarkable sky-glows that arrested universal attention throughout the fall and winter of 1883.

[1] "Die Dämmerungserscheinungen im Jahre 1883 und ihre physikalische Erklärung." Von J. Kiessling, Professor am Johanneum zu Hamburg. (Hamburg und Leipzig. 1885.)

## *HENRY MILNE-EDWARDS*

HENRY MILNE-EDWARDS was born at Bruges in October, 1800. Having completed his elementary studies in Belgium he attended medical lectures in Paris, where he took his diploma in medicine in 1823. While he retained an interest in medical and surgical pursuits until late in life, and was a member of the Academy of Medicine, Paris, of the Medical Societies of London, Edinburgh, &c., his earliest passion seems to have been for the study of natural history, and he soon abandoned the practice of his profession and devoted himself to scientific researches among the lower forms of animal life.

During the years 1826 and 1828, in company with his friend and fellow-labourer Audouin, the assistant to Lamarck and Latreille, he made a careful study of the various invertebrates to be met with on the coasts at Granville, around the Isles at Chansey, and as far as Cape Frehel. A member of the French Academy was,

during 1828, engaged on some hydrographical work off this coast, and good-naturedly assisted the littoral zone workers, enabling them to use the dredge in somewhat deeper water than they could reach from a row-boat. The results of these investigations were laid before the Academy of Sciences in July and November, 1829, and formed the subject of an elaborate report presented to the Academy in November, 1830, by Cuvier, Dumerit, and Latreille, Baron Cuvier being the writer of the report. In this memoir, for the first time so far as we know, the idea of zones of marine life is promulgated; these were four in number. A considerable portion of the memoir is devoted to the subject of the bristles in Annelids and to a description and classification of the Annelids of the coast of France. The reporters did not hesitate to express their satisfaction with the work the two friends had done, calling the special attention of the Academy to the "efforts heureux par lesquels ces deux habiles naturalistes sont parvenus à enrichir la Faune française d'espèces si nouvelles et si curieuses, et la zoologie en général d'observations si intéressantes." These happy efforts were but the forerunners of others carried on, in the case of Milne-Edwards, throughout a lengthened life.

In 1841 Milne-Edwards was appointed to the Professorship of Natural History in the Collége Royal de Henri IV., and about the same time we find him holding the Chair of Zoology and Comparative Physiology at the Faculty of Sciences, of which Faculty he was afterwards the Dean. On his friend Audouin's death, he was made Professor of Entomology at the Museum, Jardin des Plantes.

A considerable number of original memoirs, the titles of which it is here unnecessary to detail, were published about this period by Milne-Edwards in the *Annales des Sciences Naturelles*. This famous periodical first appeared in 1824, under the editorship of Audouin, Brogniart and Dumas. In 1834 the second series, from which geology and mineralogy were excluded, commenced under the joint editorship, for the zoological portion, of Audouin and Milne-Edwards, so that for now fifty years the zoological department has been under his management.

While labours as important as they were numerous secured for H. Milne-Edwards a high position among men of science, his name was also universally well-known and made popular by his elementary works on zoology. His "Eléments de Zoologie" were published in 1834 and were reissued in 1851 as a "Cours élémentaire de Zoologie." This work had an enormous circulation in France, and has not only been translated into several other languages, but also, until almost the other day, it formed the stock-in-trade, either as to its text or its illustrations, of most of the many small elementary works on natural history published in Europe.

In 1838 Milne-Edwards was elected a member of the Academy of Sciences in the section of anatomy and zoology. He was made an officer of the Legion of Honour in 1847, and a commander of this Order in 1861. In 1862 he succeeded Isidore Geoffroy Saint-Hilaire as Professor of Zoology at the Jardin des Plantes, and in a year or two afterwards was made assistant director of the museum.

Of his more important works as distinct from his memoirs may be mentioned his "Histoire naturelle des Crustacés," 1834-40. In this he was assisted by his friend Audouin, and it long remained as a standard authority on this group.

The "Histoire naturelle des Coralliares," 1857-60, was commenced after Milne-Edwards's return, in 1834, from a collectingtour on the coast of Algeria; but in 1847, in order to satisfy the calls of his publishers, he associated Jules Haime, so well known for his memoirs on the Polyps in the Palæontographical Society of London and in the *Annales des Sciences Naturelles*, with him in this work; but the death of Haime in 1856 compelled Milne-Edwards to complete the work himself. It is in a few tender words dedicated to the memory of Jules Haime.

"Leçons sur la Physiologie et l'Anatomie comparée de l'Homme et des Animaux" were published between 1857 and 1881, in fourteen volumes. The series is dedicated to his friend, M. J. Dumas, to whom he had dedicated the first work of his early pen. These lectures will always possess an importance to the student, from the immense mass of details, accompanied with copious references to the labours of others, that are brought within a limited compass.

"Recherches anatomiques et zoologiques faites pendant un Voyage sur les Côtes de la Sicile, &c.," forms a splendid quarto volume of over 850 pages, which are illustrated with nearly 100 coloured plates. This work is, for the most part, a corrected report of a series of memoirs contributed to the *Annales des Sciences Naturelles* by Milne-Edwards, A. de Quatrefages, and Emile Blanchard.

There can be little question that the name of H. Milne-Edwards will always rank high among the naturalists of the first half of the nineteenth century, and for years he was incontestibly one of the leaders of zoology. He was among the first who, not content with the study of the dead forms of animal life, made prolonged visits to the sea-coasts to study the living forms and to investigate their habits. These were days before biological stations were thought of and when the details of geographical distribution were little known. That Milne-Edwards's study of the geographical distribution of the lower forms of Invertebrates led him to the theory of there being centres of creation was what, from a purely zoological point of view, might have been expected; and when larger and truer views burst upon the world through the genius of Darwin, Milne-Edwards's mind, already preoccupied, was never altogether able to take them in. By the student of biology Milne-Edwards will be remembered by his theory of the division of physiological labour, one which threw an interesting light on many an intricate problem.

H. Milne-Edwards was an excellent linguist. English he spoke like a native. In manner courteous, he was kindly and affable to all. His house at the Jardin des Plantes was for years the focus of attraction for all the men of science in or visiting Paris. He was the possessor of a splendid library, the treasures of which were most freely at the services of students. He was a member of most of the learned Academies of Europe and America, and the possessor of several orders of State. Full of years and service, he died in Paris on July 29 last. As Geoffroy Saint-Hilaire was on his death succeeded by his son Isidore, so, happily for zoology, Henry Milne-Edwards has, in his son Alphonse, handed down his name and place to one every way worthy of both.

## *RADIANT LIGHT AND HEAT*

### *Preliminary Notions*

IT has been known from time immemorial that a sufficiently hot body when left to itself gives out light and heat, and likewise grows cold. It has also been known that a body not sufficiently hot to give out light may yet be capable of giving out heat, cooling as it does so.

If the above facts be studied scientifically they at once give rise to a series of important issues, all of which we are now in a position to reply to. These may be put in the form of the following questions:

(1) Is radiant light a substance or, if not, what is it?
(2) With what velocity does it move through space?
(3) Is radiant heat physically similar to radiant light?
(4) What is meant by a hot body?
(5) In what manner is the issue of radiant light and heat related to the cooling of the body?

Of these five questions the second was the first to