a similar manner the submerged line of growing corals immediately outside the weather-edge of the reef of Keeling Atoll would form a barrier-reef, if it was removed some miles from the shore instead of being only about 100 yards distant. As it is now situated, it lies too close to the edge of the present reef to prevent the obliteration of the channel inside it after it has reached the surface. Its lagoon-channel would be very quickly filled with sand and reef-*débris*, and as a result we should merely have a permanent addition to the present reef-flat, which, when the process was complete, would be 100 yards wider. The process is the same as in the case of a barrier-reef, the difference in the result being due to the submerged line of corals being too close to the edge of the reef for the preservation of the interior channel; and this circumstance is due to the fact of the submarine slope being greater than in the case of a coast fronted by a barrier-reef. These remarks are merely intended to be suggestive. They may, perhaps, direct the attention of of other observers to the examination of the outer slopes of atolls and to their mode of seaward growth. This can only be done during unusually calm weather.

I have discovered many other new features of minor interest in connection with Keeling Atoll, to which I will refer in my full description of these islands. The island of North Keeling, lying fifteen miles to the north, is a small atoll connected with Keeling Atoll by a bank. I hope to describe it at some future time.

In conclusion, I may state that most of my observations in these islands were directed towards estimating the age of Keeling Atoll. These data have yet to be worked up, and I am fairly confident of getting a satisfactory estimate. The lagoon is rapidly filling up with sand and coral, but it is almost impossible to state in precise terms the changes since the visit of the *Beagle*, as the survey then made was little more than a sketch. The present Admiralty chart is of but little service in inquiring into past changes, for in it the original survey of the *Beagle* in 1836 has received several later additions, and there is nothing to distinguish the one from the other. For the purpose of navigation, and for the advantage of science, a complete examination of these islands should be made. The best season for surveying is during the calm weather of the months of January and February, when boats can venture close to the edge of the reef, and a satisfactory examination of the outer shores, as well as the interior of the atoll, can then be made. In collecting information from the residents, it will be necessary to remember that no records are kept in the islands; and in studying past changes the observer will have to receive what may at first sight appear to be very interesting facts with scientific caution. Some corroboration of such facts should always be looked for.

Yours faithfully,

Batavia, November 8. H. B. GUPPY.

SOCIETIES AND ACADEMIES.

LONDON.

Royal Society, December 20, 1888.—"Correlations and their Measurement, chiefly from Anthropometric Data." By Francis Galton, F.R.S.

Two organs are said to be co-related or correlated, when variations in the one are generally accompanied by variations in the other, in the same direction, while the closeness of the relation differs in different pairs of organs. All variations being due to the aggregate effect of many causes, the correlation is a consequence of a part of those causes having a common influence over both of the variables, and the larger the proportion of the common influences the closer will be the correlation. The length of the cubit is correlated with the stature, because a long cubit usually implies a tall man. If the correlation between them were very close, a very long cubit would usually imply a very tall stature, but if it were not very close, a very long cubit would be on the average associated with only a tall stature, and not a very tall one; while, if it were *nil*, a very long cubit would be associated with no especial stature, and therefore, on the average, with mediocrity. The relation between the cubit and the stature will serve as a specimen of other correlations. It is expressed in its simplest form when the relation is not measured between their actual lengths, but between (*a*) the deviation of the length of the cubit from the mean of the lengths of all the cubits under discussion, and (*b*) the deviation of the mean of the corresponding statures from the mean of all the statures under discussion. Moreover these deviations should be expressed on the following method in terms of their respective variabilities. In the case of the cubit, all the measures of the left cubit in the group under discussion, and which were recorded in inches, were marshalled in the order of their magnitude, and those of them were noted that occupied the first, second, and third quarterly divisions of the series. Calling these measures Q_1, M, and Q_3, the deviations were measured from M, in terms of inches divided by $\frac{1}{2}(Q_3 - Q_1)$, which divisor we will call Q. Similarly as regards the statures. [It will be noted that Q is practically the same as the probable error.] This having been done, it was found that, whatever the deviation, y, of the cubit might be, the mean value of the corresponding deviations of stature was $0{\cdot}8y$; and, conversely, whatever the deviation, y', of the stature might be, the mean value of the corresponding deviations of the cubit was also $0{\cdot}8y'$. Therefore this factor of 0·8, which may be expressed by the symbol r, measures the closeness of the correlation, or of the reciprocal relation between the cubit and the stature. The M and Q values of these and other elements were found to be as follow:[1] left cubit, 18·05 and 0·56; stature 67·2 and 1·75; head length, 7·62 and 0·19; head breadth, 6·00 and 0·18; left middle finger, 4·54 and 0·15; height of right knee, 20·50 and 0·80; all the measures being in inches. The values of r in the following pairs of variables were found to be: head length and stature, 0·35; left middle finger and stature, 0·70; head breadth and head length, 0·45; height of knee and stature, 0·9; left cubit and height of right knee, 0·8. The comparison of the observed results with those calculated from the above data showed a very close agreement. The measures were of 350 male adults, containing a large proportion of students barely above twenty-one years of age, made at the laboratory at South Kensington, belonging to the author.

These results are identical in form with those already arrived at by the author in his memoir on hereditary stature (Proc. Roy. Soc., vol. xl. p. 42, 1886), when discussing the general law of kinship. In that memoir, and in the appendix to it by Mr. J. D. Hamilton Dickson, their *rationale* is fully discussed. In fact, the family resemblance of kinsmen is nothing more than a special case of correlation.

The general result of the inquiry was that, when two variables that are severally conformable to the law of frequency of error, are correlated together, the conditions and measure of their closeness of correlation admits of being easily expressed. Let x_1, x_2, x_3, &c., be the deviations in inches, or other absolute measure, of the several "relatives" of a large number of "subjects," each of whom has a deviation, y, and let X be the mean of the values of x_1, x_2, x_3, &c. Then (1) $y = rX$, whatever may be the value of y. (2) If the deviations are measured, not in inches or other absolute standard, but in units, each equal to the Q (that is, to the probable error) of their respective systems, then r will be the same, whichever of the two correlated variables is taken for the subject. In other words, the relation between them becomes reciprocal; it is strictly a correlation. (3) r is always less than 1. (4) r (which, in the memoir on hereditary stature, was called the ratio of regression) is a measure of the closeness of correlation. Other points were dwelt upon in the memoir, that are not mentioned here: among these was as follows: (5) The probable error, or Q, of the distribution of x_1, x_2, x_3, &c., about X, is the same for all values of y, and is equal to $\sqrt{(1 - r^2)}$ when the conditions specified in (2) are observed.

It should be noted that the use of the Q unit enables the variations of the most diverse qualities to be compared with as much precision as those of the same quality. Thus, variations in lung-capacity which are measured in volume can be compared with those of strength measured by weight lifted, or of swiftness measured in time and distance. It places all variables on a common footing.

"Preliminary Account of the Morphology of the Sporophyte of *Splachnum luteum*." By J. R. Vaizey, M.A., of Peterhouse, Cambridge. Communicated by Francis Darwin, F.R.S.

[1] The head length is here the maximum length measured from the notch below the brow. The cubit is measured with the hand prone, from the flexed elbow to the tip of the middle finger. The height of knee is taken from a stool, on which the foot rests with the knee flexed at right angles; from this the measured thickness of the heel of the boot is subtracted. All measures had to be made in the ordinary clothing. The smallness of the number of measures, viz. 350, is of little importance, as the results run with fair smoothness. Neither does the fact of most of the persons measured being hardly full grown affect the main results. It somewhat diminishes the values of M, and very slightly increases that of Q, but it cannot be expected to have any sensible influence on the value of r.

Royal Meteorological Society, December 19.—Dr. W. Marcet, F.R.S., President, in the chair.—The following papers were read:—On the prolonged spell of cold weather from September 1887 to October 1888, by Mr. C. Harding. During the fifty-nine weeks ending the third week in October, there were but four warm weeks in the north-west of England, and only five warm weeks in the south-west of England, whilst in the latter district there was not a single warm week between March 12 and October 22. The mean temperature for the whole period was dealt with for the twelve districts into which the Meteorological Office divides the whole area of the United Kingdom, and with the single exception of the north of Scotland the weather for the period ending in October this year was the coldest of any during the past ten years. At Greenwich the temperature during the fourteen months was below the average on 312 days out of 427, or 73 per cent., and in July there was not a single warm day, the temperature being continuously below the average from June 27 to August 6. The means for July 11 and 12 were colder by several degrees than those for March 9 and 10.—Report on the phenological observations for 1888, by the Rev. T. A. Preston. Vegetation was generally backward throughout the season. In the south west of England and south of Ireland plants were earlier than usual, but not elsewhere. In February they were from one to four weeks later, and gradually gained ground till June. In the south of Ireland they were slightly in advance of the average in June and July; in the south-west of England they just reached the average in July; whilst in Guernsey they were a fortnight later. Fruits generally were a failure; very few really ripened, and from want of sun were deficient in flavour. Haymaking was unusually late (as much as five weeks); it began in July or August, and was not entirely finished till late in September; much of it was spoilt or secured in bad condition. Straw was plentiful, and though the corn was not an average crop, the fine October enabled farmers to secure a better one than could have been expected. Roots were often a failure, and potatoes were much diseased.—A winter's weather in Massowah, by Captain D. Wilson-Barker. This paper gives the results of four-hourly observations during December 1887 to February 1888. The highest shade temperature was 95°, and the lowest 68°.

Zoological Society, December 18, 1888.—Mr. Howard Saunders in the chair.—The Secretary read a report on the additions that had been made to the Society's Menagerie during the month of November 1888, and called attention to a specimen of the Small-clawed Otter (*Lutra leptonyx*), presented by Mr. W. L. Sclater, Deputy Superintendent, Indian Museum, Calcutta, new to the Society's Collection, and to a Monkey of the genus *Cercopithecus*, from South Africa, apparently referable to the Samango Monkey (*Cercopithecus samango*), also new to the Society's Collection.—Mr. G. B. Sowerby read descriptions of fourteen new species of Shells from China, Japan, and the Andaman Islands, chiefly collected by Deputy Surgeon-General R. Hungerford.—A communication was read from Mr. Herbert Druce, in which he gave an account of the Lepidoptera-Heterocera collected by Mr. C. M. Woodford in Guadalcanar Island, Solomon Islands. The collection was stated to contain examples of 53 species, 18 of which were described as new to science.—Mr. J. H. Leech read the second portion of a paper on the Lepidoptera of Japan and Corea, comprising an account of the Sphingidæ, Bombycidæ, Notodontidæ, and Cymatophoridæ, in all 352 species. Of these, 38 species were now described as new to science.—Dr. Hans Gadow read a paper on the numbers and on the phylogenetic development of the remiges of Birds. The author showed that the number of primaries is of very limited taxonomic value, as was proved by the numerous exceptions mentioned in the lists contained in the paper. A comparison of the remiges of the Penguins with those of other Carinatæ seemed to indicate an extremely low stage in the Penguins, which, however, was not borne out by other anatomical features. The Ratitæ were most probably descendants of birds which formerly possessed the power of flight and had lost it. This view was strengthened by an examination of the structure of the wings and of the feathers of their nestlings. The paper concluded with general remarks upon the probable gradual development of the organism of flight in birds.

PARIS.

Academy of Sciences, December 17, 1888.—M. Janssen in the chair.—On the analytical theory of heat, by M. H. Poincaré. In a previous note (*Comptus rendus*, civ. p. 1754) the author studied the problem connected with the cooling of a homogeneous and isotropous solid body; here a more satisfactory demonstration is given of the theorem growing out of that problem.—On the abruptly and slowly contracting muscles of the hare, by M. L. Ranvier. A recent experiment is described, which has been carried out for the purpose of studying in the hare the two species of muscles, which in the rabbit differ in colour, structure, and functions, but which in the hare are all alike red.—On M. Zédé's submarine boat, the *Gymnote*, by Admiral Paris. An account is given of the first trial of this boat, recently launched at Toulon, and constructed for the purpose of realizing the suggestions made by M. Dupuy de Lôme on the subject of submarine electric navigation. As this is an engine of warfare, the details of its mechanism are suppressed; but it is stated that the trial more than realized the expectations of its inventor. It works by electricity, with perfect ease, on, and at any desired depth below, the surface, obeys the helm in all positions, fully attains the hoped-for velocity, and its ventilation and lighting are all that can be expected down to a certain depth. By introducing sundry obvious modifications, boats of this description may be turned to the best account for the purpose of scientific marine exploration.—Eocene Echinidæ in the province of Alicante, Spain, by M. Cotteau. The recent explorations of the Eocene formations in this region have yielded as many as 76 species of fossil Echinidæ, grouped in 36 genera, and representing nearly all existing groups of this family. Of the species, 50 are new to science, and some of these are specially interesting, as they belong to extremely rare genera, well deserving the attention of palæontologists, and four of which are quite new. A striking feature of this Eocene Echinidian fauna is the enormous preponderance of irregular over regular forms, the former comprising as many as 67 out of the 76 species here described.—On the nutriment of castaways at sea, by Prince Albert of Monaco. The researches made during the *Hirondelle's* last expedition in the North Atlantic tend to show that the crew of a vessel short of provisions might support life indefinitely if supplied with the proper appliances for capturing the small marine fauna which is found to exist in great abundance in the Atlantic, and probably in all temperate and warm marine waters.—On the diurnal variation of the barometer, by M. Alfred Angot. It is shown that diurnal barometric variation results from the interference of two distinct waves. One of these is exclusively due to the diurnal variation of temperature in the given region, and subject like it to local influences. The other, of semi-diurnal periodicity, is produced by a general cause independent of all local influence; its phase is constant, approximating to 63°, and its amplitude for all regions and all seasons is determined by an equation, whose terms show a certain analogy with those corresponding to the theory of the tides.—On certain new properties and on the analysis of the fluoride of ethyl, by M. H. Moissan. In a previous communication the author showed that ethylfluorhydric ether (ethyl fluoride) was a gaseous body capable of being obtained in a very pure state, and causing ethyl iodide to react on the anhydrous fluoride of silver. Here he describes several other properties of the same substance. Heated to a dull red for several hours in a glass ball, the fluoride of ethyl yields a complex mixture of carburets containing traces only of the fluoride of silicium. Under the action of a weak induction spark the volume increases greatly, yielding hydrofluoric acid, a small quantity of acetylene, and especially ethylene, without depositing carbon. In the presence of a powerful spark, carbon is deposited with formation of acetylene, ethylene, propylene, &c.—On the employment of oxygenated water for the quantitative analysis of the metals of the iron group (continued), by M. Ad. Carnot. Here the author deals more especially with chromium and manganese.—On the reproduction of zircon, by MM. P. Hautefeuille and A. Perrey. Zircon, obtained at a very high temperature by Sainte-Claire Deville and Caron, by making the fluoride of zirconium to act on silica or on silicium fluoride, is here reproduced at a temperature not exceeding 700° C. by the action of the bimolybdate of lithin on a mixture of zircon and silica. This is the same process by means of which these chemists have obtained the emerald and phenacite.—Papers are contributed by M. Raoul Varet, on the action of the cyanide of mercury on the salts of copper; by M. Albert Colson, on a diquinolic base; by M. W. Louguinine, on the heats of combustion of the camphors and borneols; by M. Louis Crié, on the affinities of the Jurassic and Triassic floras of Australia and New Zealand; and by M. Michel Hardy, on the discovery of a Quaternary burial-place at Raymonden, in the commune of Chancelade, Dordogne.

December 24.—M. Janssen in the chair.—After the usua annual allocution pronounced by the President, M. Janssen, the names were announced of the successful competitors in the prize essays proposed for the year 1888. These were as under:—*Geometry:* Grand Prize of the Mathematical Sciences, M. Emile Picard; Prix Bordin, Madame Sophie de Kowalewsky; Prix Francœur, M. Emile Barbier; Prix Poncelet, M. E. Collignon. *Mechanics:* Extraordinary Prize of 6000 francs, MM. Banaré, Hauser, and Reynaud, 2000 francs each; Prix Montyon, M. H. Bazin; Prix Plumey, Madame Benjamin Normand and family; Prix Dalmont, M. Jean Resal. *Astronomy:* Prix Lalande, M. Joseph Bossert; Prix Valz, Mr. E. C. Pickering; Prix Janssen, Dr. William Huggins; Prix Damoiseau, not awarded. *Statistics:* Prix Montyon, M. Félix Faure, M. J. Teissier, and MM. Lallemand and Petitdidier. *Chemistry:* Prix Jecker, M. Maquenne and M. Cazeneuve. *Geology:* Prix Cuvier, M. Joseph Leidy. *Botany:* Prix Desmazières, M. V. Fayod; Prix Montagne, M. Gaston Bonnier. *Agriculture:* Prix Vaillant, not awarded. *Anatomy and Zoology:* Prix Savigny, not awarded; Prix Thore, Dr. Carlet; Prix da Gama Machado, not awarded. *Medicine and Surgery:* Prix Montyon, Dr. Hardy, Dr. Albert Hénocque, and MM. Follin and Duplay; Prix Bréant, Dr. Hauser; Prix Barbier, MM. Leroy, Raphael Dubois, and Dr. Ehrmann; Prix Godard, Dr. Maurice Hache; Prix Lallemand, MM. François-Franck and Paul Blocq. *Physiology:* Prix Montyon, Dr. Augustus D. Waller (London) and M. Léon Fredericq. *Geography:* Prix Gay, M. Simart. *General Prizes:* Prix Montyon (Unhealthy Industries), Dr. Paquelin and M. Fumat; Prix Trémont, M. Fénon; Prix Gegner, M. Valson; Prix Delalande-Guérineau, Père Roblet; Prix Jérome Ponti, M. Kœnigs; Prix Laplace, M. Paul-Louis Weiss.—The programme of prizes proposed for the year 1889 comprises the following:—*Geometry:* Prix Francœur (1000 fr.), discoveries or works useful to the progress of pure or applied mathematical sciences; Prix Poncelet (2000 fr.), same subject. *Mechanics:* Extraordinary Prize of 6000 francs for any invention tending to increase the efficacy of the French naval forces; Prix Montyon (700 fr.), invention or improvement of instruments useful to the progress of agriculture, the mechanical arts or sciences; Prix Plumey (2500 fr.), any invention or improvement tending most to the progress of steam navigation; Prix Fourneyron (500 fr.), theoretical and practical essay on the progress of aërial navigation since 1880. *Astronomy:* Prix Lalande (540 fr.), any essay or observation most useful to the progress of astronomy; Prix Valz (460 fr.), the most interesting astronomical observation during the year; Prix Janssen (gold medal), any discovery or work tending to the progress of physical astronomy. *Physics:* Prix L. La Caze (three of 10,000 fr. each), the best work on physics, chemistry, and Physiology. *Statistics:* Prix Montyon (500 fr.), the best work on the statistics of France. *Chemistry:* Prix Jecker (10,000 fr.), any work tending most to the progress of organic chemistry. *Geology:* Prix Delesse (1400 fr.), best work on geology or mineralogy. *Botany:* Prix Barbier (2000 fr.), most useful discovery in medicine, surgery, pharmacy, or botany; Prix Desmazières (1600 fr.), the most useful work on all or any section of Cryptogamy; Prix Montagne (1000 and 500 fr.), useful works on the anatomy, physiology, development, or description of the lower Cryptogamous plants; Prix de la Fons Mélicocq (900 fr.), best work on the botany of North France. *Agriculture:* Prix Vaillant (4000 fr.), best work on the diseases of cereals in general. *Anatomy and Zoology:* Grand Prix des Sciences Physiques (3000 fr.), the complete study of the embryology and development of any animal; Prix Bordin (3000 fr.), a comparative study of the auditory apparatus in mammals and birds; Prix Savigny (975 fr.), in aid of young zoologists studying the invertebrates of Egypt and Syria. *Medicine and Surgery:* Prix Montyon (one or more prizes not otherwise specified), for the best work on the healing art; Prix Bréant (100,000 fr.), for a specific against cholera; Prix Godard (1000 fr.), anatomy, physiology, and pathology of the genito-urinary organs; Prix Lallemand (1800 fr.), researches on the nervous system in the widest sense of the term; Prix Ballion (1400 fr.), any work most useful to the health and improvement of the human race; Prix Mège (10,000 fr.), to continue and complete the essay of Dr. Mège on the causes that have retarded or advanced the progress of medicine. *Physiology:* Prix Montyon (750 fr.), for the promotion of experimental physiology; Prix Pourat (1800 fr.), experimental researches on muscular contraction; Prix Martin-Damourette (1400 fr.), therapeutic physiology. *Physical Geography:* Prix Gay (2500 fr.), comparative study of the floras and faunas and relations existing between the Polynesian Islands and surrounding lands. *General Prizes:* Prix Montyon, one or more prizes for the best means of rendering unhealthy industries less dangerous; Prix Trémont (1100 fr.), for any work tending in any way to promote the interests of France; Prix Gegner (4000 fr.), to promote the positive sciences; Prix Petit d'Ormoy (10,000 fr.), researches in pure and applied mathematical sciences and the natural sciences; Prix Laplace (a complete collection of the works of Laplace), the first student leaving the Ecole Polytechnique.

Astronomical Society, November 7.—M. Moussette in the chair.—Colonel Laussedat read a paper on national time, in which he urged the adoption of Paris time throughout France.—M. Gunziger observed Barnard's comet on November 4. It was about the size of the nebula in Andromeda, with scarcely any tail, but a bright nucleus of about the sixth magnitude.—Rev. S. J. Perry, of Stonyhurst College, was elected an honorary member.—The Royal Astronomical Society and the Liverpool Astronomical Society were elected Corresponding Societies.

December 5.—M. Flammarion, President, in the chair.—The President announced that important gifts had been offered for the Society's proposed Observatory: M. Bardou offered a 4-inch equatorial, M. Secretan a transit instrument, M. Lütz spectroscopic and photographic apparatus, M. Lévy a set of binocular glasses. Thanks were voted to the above donors.—M. Flammarion read a paper on the changes observed in Mars, specially referring to Dawes's forked bay and Lake Mœris.—M. Gérigny read a paper on the aberration of light, showing the influence of the sun's motion upon that phenomenon by Yvon Villarceau's method.

BOOKS, PAMPHLETS, and SERIALS RECEIVED.

Boilers: their Construction and Strength: T. W. Traill (Griffin).—Our Fishery Rights in the North Atlantic: J. I. Doran (Philadelphia).—Methods of Analysis of Commercial Fertilizers, Cattle Foods, &c. (Washington).—The Probable Cause of the Displacement of Beach Lines: A. Blytt (Christiania).—Bulletin of the New York State Museum of Natural History, Nos. 4, 5, 6 (Albany).

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