secreting animals die at the surface of the water and their bodies fall to the bottom, the shell is exposed to solution from the action of the sea-water through which it passes, and it may be to that of carbonic acid produced by the decomposition of its own organic matter. If the shell be thin, as in the case of Heteropods and Pteropods, it may be wholly removed before reaching the bottom, but the thicker shelled varieties tend to accumulate even in depths of 2000 fathoms, where they are soon covered up by other shells; and being surrounded by sea-water already saturated with carbonate of lime, are preserved from solution, and form vast beds of calcareous ooze. It is found that the amount of carbonate of lime present in such ooze is greater or less according to the depth of water through which the shells pass from the surface to the bottom, and also to the slow renewal of the water in contact with these great lime deposits. In the red clay area the carbonate of lime is almost entirely absent. The deeper waters which cover such areas are more active in the removal of carbonate of lime, not only because of the larger amount of carbonic acid they contain, but doubtless to the deoxidation of alkaline sulphates by organic matter, which, we have already pointed out, gives rise to sulphuric acid, &c. At the same time account must be taken of the great pressure at such abysmal depths, and the fact that the substance of the shells being less compressible than sea-water, they would fall more slowly, and hence would be longer exposed to the action of the deeper layer of water than those near the surface.

What calcareous remains do reach the ocean floor at such abysmal depths represent the hardest and crystalline varieties of carbonate of lime which resist the solvent action of sea-water to the greatest extent.

In this way we appear to have a perfectly rational explanation of the partial disappearance of carbonate of lime shells from the shallower depths, and their total disappearance from all the greater depths of the ocean. It is to be observed that all those shells in which a considerable quantity of organic tissue is associated with the carbonate of lime disappear in solution more rapidly than the shells of the Foraminifera, which contain little organic matter. (During the whole of the *Challenger* cruise only two bones of fishes, other than the otoliths and the teeth, were dredged from the deposits, and all traces of the cetacean bones were removed, except the dense ear-bones and dense Ziphioid beaks.) The remains of crustacean animals were almost wholly absent from deep-sea deposits, with the exception of Ostracode shells and the hard tips of some claws of crabs.

Turning now to the lagoons and lagoon channels of coral islands, it is believed that large quantities of carbonate of lime are in the same way being dissolved from these shallow basins as well as from the deposits of the deep sea, but under somewhat different circumstances. In the case of a shell falling to the bottom of the sea, it is continually brought in contact with new layers of water, which has the same effect as if a continuous stream of water were passing over the shell. In the case of the lagoons this last is what takes place. The water which flows in and out of the lagoons twice in twenty-four hours passes over great beds of growing coral, and from all the observations we have is largely charged with carbonic acid, owing probably to the large number of living animals on the outer reef over which the water passes on its way to the lagoon. This water passes continually over the dead coral and sand of the lagoon, and takes up and removes large quantities of carbonate of lime in solution (as well as suspension), for in these lagoons the spaces covered by dead coral *débris* always greatly exceed the patches of growing coral. Owing to the fact that the water of the lagoon is continually in motion, and constantly renewed, the layer in contact with the bottom of coral sand can never become saturated or unable to take up more lime, as is apparently the case in the layers of water in contact with the Globigerina ooze and other calcareous deep-water deposits.

From the foregoing discussion and observations it is evident that a very large quantity of carbonate of lime is in a continual state of flux in the ocean; now existing in the form of shells and corals, but after the death of the animals passing slowly into solution, to go again through the same cycle.

On the whole, however, the quantity of carbonate of lime that is secreted by animals must exceed what is re-dissolved by the action of sea-water, and at the present time there is a vast accumulation of carbonate of lime going on in the ocean. It has been the same in the past, for with a few insignificant exceptions all the carbonate of lime in the geological series of rocks has been secreted from sea-water, and owes its origin to organisms in the same way as the carbon of the carboniferous formations; the extent of these deposits appears to have increased from the earliest down to the present geological period.

At the present time most of the carbonate of lime carried to the ocean by rivers has been directly derived from calcareous stratified rocks formed by organic agency in the sea in earlier geological ages, but the calcium in these formations was in the first instance derived from the decomposition of the lime-bearing silicates of the earth's original crust, and this decomposition, which is still going on in the sea and on the land surfaces, is a continuous additional source of carbonate of lime.

In considering the analyses showing the average composition of sea salts, one is struck with the relatively small quantity of those very substances which are extracted so largely from sea-water by plants and animals, viz. carbonate of lime and silica. Siliceous deposits are of vast extent, yet silica occurs merely in traces in sea-water; carbonate of lime deposits are of vastly greater magnitude, yet carbonate of lime makes up only $\frac{1}{790}$th part of the saline constituents of sea-water, and only $\frac{1}{8300}$th part of the whole bulk of sea-water. Sulphate of lime is ten times more abundant than the carbonate in sea-water; on the other hand, the river water that is poured into the ocean contains about ten times as much carbonate as it does of sulphate of lime.[1]

The total amount of calcium in a cubic mile of sea-water is estimated from analyses to be 1,941,000 tons, and the total amount of calcium in the whole ocean is calculated at 628,340,000,000,000 tons. The total amount of calcium in a cubic mile of river water is estimated at 141,917 tons, and the total amount of this element carried into the ocean from all the rivers of the globe annually is estimated at 925,866,500 tons. At this rate it would take 680,000 years for the river drainage from the land to carry down an amount of calcium equal to that at present existing in solution in the whole ocean. Again, taking the *Challenger* deposits as a guide, the amount of calcium in these deposits, if they be 22 feet thick, is equal to the total amount of calcium in solution in the whole ocean at the present time. It follows from this that if the salinity of the ocean has remained the same as at present during the whole of this period, then it has taken about 680,000 years for the deposits of the above thickness, or containing calcium in amount equal to that at present in solution in the ocean, to have accumulated on the floor of the ocean. From the data here furnished a number of other interesting speculations might be indulged in, relating to the amount of carbonic acid that has been abstracted from the atmosphere and fixed in carbonate of lime deposits; the total amount of disintegration of lime-bearing siliceous rocks measured in terms of the calcium at present existing in solution in water and fixed in calcareous deposits; the relative proportions of substances secreted from the ocean as compared with other materials derived from the direct disintegration of the land-forming deep-sea deposits; and the apparent accumulation of carbonate of lime formations towards the equatorial regions of the globe. These various matters will, however, be discussed in another place.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

Cambridge.—The event of the week has been the achievement of Miss Philippa Garrett Fawcett, of Newnham College, who, in Part I. of the Mathematical Tripos, is declared to be "above the Senior Wrangler," Mr. Bennett, of St. John's.

Mr. Sedley Taylor, the delegate from Cambridge to the Sexcentenary Festival of the Montpellier University, in a letter to the Vice-Chancellor on the subject of his mission, writes:—"We had the great satisfaction of seeing Prof. von Helmholtz, Delegate of the University of Berlin, publicly received with much cordiality, and of learning that, on account of his optical researches, which have given such a beneficent impulse to modern ophthalmology, he was subsequently made the object of a special ovation by the Medical Faculty for which the University of Montpellier has long been famous."

Dr. Butler, Master of Trinity College, was on June 2 again elected to the office of Vice-Chancellor for the ensuing academical year.

The John Lucas Walker Research Studentship in Pathology is vacant by the resignation of Dr. William Hunter, of St. John's College, recently elected to a Research Scholarship in

[1] Murray, "Total Rainfall of the Globe," *Scot. Geogr. Mag.*, 1887.

Sanitary Science by the Grocers' Company. The election will take place about August 26. Candidates are requested to apply to Prof. Roy, 2 Wollaston Road, Cambridge, for information. The Studentship is of the annual value of £200, or of such larger sum, not exceeding £300, as the managers shall from time to time determine; and is tenable for three years. The Student is required to devote himself during the tenure of the Studentship to original pathological research. Dr. Hunter's tenure has been marked by his elaborate and valuable researches on pernicious anæmia.

The Professor of Mineralogy (Prof. Lewis) proposes to give a course of elementary lectures on crystallography in the long vacation, beginning on Tuesday, July 8, at 9 a.m. There will also be a practical course on crystallography given by the Demonstrator, beginning on the same day. Fees for lectures £1 1*s.*; for demonstrations £2 2*s.*

The Special Board for Biology and Geology have nominated Miss L. Ackroyd (Newnham College) to occupy the University table at the Laboratory of the Marine Biological Association for one month during the year 1890.

The Mechanical Workshops Enquiry Syndicate were on Thursday, June 5, empowered by a large majority of the Senate to inquire into the conditions and expense of establishing a definite school of engineering in the University.

The number of persons matriculated during the current academical year was on May 29 brought up to 1027, the largest number on record.

At a meeting of the Council of the Cambridge Philosophical Society on Monday, June 2, it was decided, in accordance with the Reports of the adjudicators, Sir W. Thomson, Lord Rayleigh, and Prof. G. H. Darwin, to award the Hopkins Prize for the period 1883-85 to W. M. Hicks, F.R.S., for his memoir upon the "Theory of Vortex Rings" (Phil. Trans., 1885) and for his earlier memoirs upon related subjects; also to award the Hopkins Prize for the period 1886-88 to Horace Lamb, F.R.S., for his paper on "Ellipsoidal Current Sheets" (Phil. Trans., 1887) and for his numerous other papers on mathematical physics.

Prof. J. J. Thomson announces that a course of demonstrations in practical physics, suitable for students who intend taking the Natural Sciences Tripos after passing Part I. of the Mathematical Tripos, will be given during the Long Vacation in the Cavendish Laboratory on Mondays, Wednesdays, and Fridays, at 10 a.m., commencing July 9. Students wishing to attend the course are requested to send in their names to Prof. Thomson before the end of the term.

The Observatory Syndicate publish in the *Reporter* (June 10, 1890) their record of proceedings for May 27, 1889, to May 26, 1890. The astronomical work of observation and reduction has been steadily carrried out, and the report is not marked by any eventful feature.

Dr. D. MacAlister and Prof. Roy have been appointed to represent the University at the Tenth International Medical Congress at Berlin.

The General Board of Studies, with a view to recruiting the finances of the University, especially in the scientific departments, propose to raise the examination and other fees payable by students. As a commencement they propose that the aggregate fees to be paid for the six M.B. examinations be raised from eight guineas to twelve.

SOCIETIES AND ACADEMIES.

LONDON.

Royal Society, June 5.—"Account of Recent Pendulum Operations for determining the Relative Force of Gravity at the Kew and Greenwich Observatories." By General Walker, C.B., F.R.S., LL.D.

It is well known that a series of pendulum observations was carried on in India, during the years 1865 to 1873, with two invariable pendulums, the property of the Royal Society. The Observatory of the Royal Society at Kew was chosen as the base station of the operations, and the pendulums were swung there before being sent out to India, and again on their return from India. With a view to connecting the observations with those which had already been taken with other pendulums in other parts of the world, it was intended, on the return of the pendulums from India, to swing them at the Royal Observatory at Greenwich, which was a well-established pendulum station, observed at by General Sir Edward Sabine, the Russian Admiral Lütke, and others. But when the time arrived for making the observations at the Greenwich Observatory, such extensive preparations were being made there for the equipment of expeditions for the observation of the approaching transit of Venus that no room was available for the pendulum operations. It was, therefore, decided to make the connection with Kew by swinging at Kew Kater's convertible pendulum, for determining the absolute length of the seconds' pendulum, which had been swung 40 years previously at Greenwich by General Sabine. This being done, the length of the seconds' pendulum at Kew was found to be 0·0027 of an inch greater than the length which had been previously determined at Greenwich, and consequently that the daily vibration number was three vibrations greater at Kew than at Greenwich. The difference, however, was far too large to be admissible, as the Observatories are nearly in the same latitude, and differ very slightly in height.

In 1881, Colonel Herschel, R.E., was deputed by the Secretary of State for India to take pendulum observations at the two Observatories, and at the old pendulum station in London, and also at some stations in America, with a view to improving and strengthening the connection between the observations in India and those in other parts of the world. On completing his work in America, he handed over the three pendulums which he had employed to officers of the United States Coast and Geodetic Survey, by whom they were taken round the world, and swung at Auckland, Sydney, Singapore, Tokio, San Francisco, and finally at Colonel Herschel's terminal station at Washington.

But when the observations came to be finally reduced, it was found that the difference between Colonel Herschel's results at Kew and Greenwich, as shown independently by the three pendulums, had an extreme range of about seven vibrations in the daily vibration number. The cause of these differences was mysterious and inexplicable, and there was no alternative but to swing the pendulums a second time at the two Observatories.

The revisionary work was undertaken by the Observatory staff at each place, in such intervals of leisure as they could obtain from their regular operations. The final results, by the three pendulums, make the vibration number at Kew in excess of that at Greenwich by 1·56, 1·50, and 0·59, giving an average excess of 1·22.

The correction to this quantity for the excess of height of the Greenwich over the Kew Observatory is − 0·58. Thus, the revisionary operations, reduced to the mean sea-level, make the excess of Kew over Greenwich = 0·64 of a vibration, which may be accepted as very fairly probable.

Royal Microscopical Society, May 21.—Mr. James Glaisher, F.R.S., Vice-President, in the chair.—Mr. Mayall referred to the donation, by the Messrs. Trainini Bros., opticians of Brescia, of an early form of achromatic microscope objective, constructed by the late Bernardini Marzoli, Curator of the Physical Laboratory of the Lyceum of Brescia. The objective was a cemented combination, and was described and figured in the "Commentari della Accademia di Scienze" of Brescia in 1808. This and other works and documents in proof of its authenticity were exhibited.—Mr. Mayall exhibited on behalf of Mr. P. Vallance an eye-piece similar to that shown at the previous meeting by Mr. Goodwin. It was one of two constructed by Mr. Murrell nearly forty years ago, and was provided with a screw which enabled the compound eye lens to be adjusted with reference to the field lens through a space of nearly ½ inch.—Mr. E. M. Nelson read a paper on micrometers, in the course of which he described a new micrometer made for him by Messrs. Powell and Lealand. The subject was illustrated by a drawing upon the board, and the micrometer attached to a microscope and lamp was handed round.—Mr. Thomas Comber's paper on a simple form of heliostat, and its application to photomicrography, was read. Apart from the question of the extreme simplicity of the heliostat, which was mainly due to limiting the reflection of the mirror to the polar direction and deflecting the pencil in the horizontal direction in the axis of the microscope, by means of a fixed mirror placed at half the angle of the latitude above the heliostat mirror, Mr. Comber had rendered important service to photomicrography by showing how the heliostat might be placed close to the microscope so that the error due to slight inaccuracy of the adjustment of the heliostat might escape the optical leverage which took place when the reflected beam was made to travel through a considerable space.

PARIS.

Academy of Sciences, June 2.—M. Hermite in the chair.—On the application of a double plane mirror to the precise