THE additions to the Zoological Society's Gardens during the past week include two Great Kangaroos (*Macropus giganteus*), from New South Wales, presented by Mr. A. Nicol; two Common Boas (*Boa constrictor*), two Agoutis (*Dasyprocta?*), from St. Lucia, presented by Mr. Neville Holland; a Virginian Deer (*Cervus virginianus*), from South America, presented by Capt. E. H. Cobbett; a Gazelle (*Gazella dorcas*), from Egypt, presented by Miss Lancaster; a Common Peafowl (*Pavo cristatus*), from India, presented by the Hon. A. S. G. Canning; a Vervet Monkey (*Cercopithecus lalandii*), from South Africa; and a Sun Badger (*Helictis moschata*), from East Asia, new to the collection.

THE "CHALLENGER" EXPEDITION*

DURING our southern cruise the sounding-lead brought up five absolutely distinct kinds of sea-bottom, without taking into account the rock and detritus of shallow soundings in the neighbourhood of land. Our first two soundings in 98 and 150 fathoms on the 17th and 18th of December were in the region of the Agulhas current. These soundings would have been naturally logged "greenish sand," but on examining the sandy particles with the microscope, they were found to consist almost without exception of the casts of foraminifera in one of the complex silicates of alumina, iron, and potash, probably some form of glauconite. The genera principally represented by these casts were Miliola, Biloculina, Uvigerina, Planorbulina, Rotalia, Textularia, Bulimina, and Nummulina; Globigerina, Orbulina, and Pulvinulina were present, but not nearly in so great abundance. There were very few foraminifera on the surface of the sea at the time. This kind of bottom has been met with once or twice before; but it is evidently exceptional, depending upon some peculiar local conditions.

From the Cape, as far south as our station in lat. 46° 16′, we found no depth greater than 1,900 fathoms, and the bottom was in every case "Globigerina ooze;" that is to say, it consisted of little else than the shells of Globigerina, whole, or more or less broken up, with a small proportion of the shells of Pulvinulina and of Orbulina, and the spines and tests of radiolarians and fragments of the spicules of sponges.

Mr. Murray has been paying the closest attention since the time of our departure to the question of the origin of this calcareous formation, which is of so great interest and importance on account of its anomalous character and its enormous extension. Very early in the voyage he formed the opinion that all the organisms entering into its composition at the bottom are dead, and that all of them live abundantly at the surface and at intermediate depths over the Globigerina-ooze area, the ooze being formed by the subsiding of these shells to the bottom after death.

This is by no means a new view. It was advocated by the late Prof. Bailey, of West Point, shortly after the discovery, by means of Lieut. Broke's ingenious sounding instrument, that such a formation had a wide extension in the Atlantic. Johannes Müller, Count Pourtales, Krohn, and Max-Schultze, observed Globigerina and Orbulina living on the surface; and Ernst Haeckel, in his important work upon the Radiolaria, remarks that "we often find upon, and carried along by the floating pieces of seaweed which are so frequently met with in all seas, foraminifera as well as other animal forms which habitually live at the bottom." However, setting aside these accidental instances, certain foraminifera, particularly in their younger stages, occur in some localities so constantly and in such numbers, floating on the surface of the sea, that the suspicion seems justifiable that they possess, at all events at a certain period of their existence, a pelagic mode of life, differing in this respect from most of the remainder of their class. Thus Müller often found in the contents of the surface-net off the coast of France the young of Rotalia, but more particularly Globigerinæ and Orbulinæ, the two latter frequently covered with fine calcareous tubes, prolongations of the borders of the fine pores through which the pseudogradia protrude through the shell. I took similar Globigerinæ and Orbulinæ almost daily in a fine net at Messina, often in great numbers, particularly in February. Often the shell was covered with a whole forest of extremely long and delicate calcareous tubes projecting from all sides, and probably contributing essentially to enable these little animals to float below the surface of the water by increasing their surface greatly, and consequently their friction against the water, and rendering it more difficult for them to sink."* In 1865 and 1866 two papers were read by Major Owen, F.L.S., before the Linnean Society, "On the Surface Fauna of Mid-Ocean." In these communications the author stated that he had taken foraminifera of the genera Globigerina and Pulvinulina, living, in the tow-net on the surface, at many stations in the Indian and Atlantic Oceans. He described the special forms of these genera which were most common, and gave an interesting account of their habits, proposing for a family which should include Globigerina, with Orbulina as a sub-genus, and Pulvinulina, the name Colymbitæ, from the circumstance that, like the Radiolaria, these foraminifera are found on the surface after sunset, "diving" to some depth beneath it during the heat of the day. Our colleague, Mr. Gwyn Jeffreys, chiefly on the strength of Major Owen's papers, maintained that certain foraminifera were surface animals, in opposition to Dr. Carpenter and myself.† I had formed and expressed a very strong opinion on the matter. It seemed to me that the evidence was conclusive that the foraminifera which formed the Globigerina ooze lived on the bottom, and that the occurrence of individuals on the surface was accidental and exceptional; but after going into the thing carefully, and considering the mass of evidence which has been accumulated by Mr. Murray, I now admit that I was in error; and I agree with him that it may be taken as proved that all the materials of such deposits, with the exception, of course, of the remains of animals which we now know to live at the bottom at all depths, which occur in the deposit as foreign bodies, are derived from the surface.

Mr. Murray has combined with a careful examination of the soundings a constant use of the tow-net, usually at the surface, but also at depths of from ten to one hundred fathoms; and he finds the closest relation to exist between the surface fauna of any particular locality and the deposit which is taking place at the bottom. In all seas, from the equator to the polar ice, the tow-net contains Globigerinæ. They are more abundant and of a larger size in warmer seas; several varieties, attaining a large size and presenting marked varietal characters, are found in the intertropical area of the Atlantic. In the latitude of Kerguelen they are less numerous and smaller, while further south they are still more dwarfed, and only one variety, the typical *Globigerina bulloides*, is represented. The living Globigerinæ from the tow-net are singularly different in appearance from the dead shells we find at the bottom. The shell is clear and transparent, and each of the pores which penetrate it is surrounded by a raised crest, the crest round adjacent pores coalescing into a roughly hexagonal network, so that the pores appears to lie at the bottom of a hexagonal pit. At each angle of this hexagon the crest gives off a delicate flexible calcareous spine, which is sometimes four or five times the diameter of the shell in length. The spines radiate symmetrically from the direction of the centre of each chamber of the shell, and the sheaves of long transparent needles crossing one another in different directions have a very beautiful effect. The smaller inner chambers of the shell are entirely filled with an orange-yellow granular sarcode; and the large terminal chamber usually contains only a small irregular mass, or two or three small masses run together, of the same yellow sarcode stuck against one side, the remainder of the chamber being empty. No definite arrangement and no approach to structure was observed in the sarcode, and no differentiation, with the exception of round bright-yellow oil-globules, very much like those found in some of the radiolarians, which are scattered apparently irregularly in the sarcode. We never have been able to detect in any of the large number of Globigerinæ which we have examined the least trace of pseudopodia, or any extension in any form of the sarcode beyond the shell.

Major Owen (*op. cit.*) has referred the Globigerina with spines to a distinct species, under the name of *G. hirsuta*. I am inclined rather to believe that all Globigerinæ are to a greater or

* "Preliminary Notes on the Nature of the Sea-bottom procured by the Soundings of H.M.S. *Challenger* during her Cruise in the Southern Sea in the early part of the year 1874." By Prof. C. Wyville Thomson, F.R.S., director of the Civilian Scientific Staff on board. Read before the Royal Society, Nov. 26, 1874.

* "Die Radiolarien." Eine Monographie von Dr. Ernst Haeckel. Berlin, 1862, pp. 165, 167.

† Mr. Jeffreys desires to record his dissent from this conclusion, since (from his own observations, as well as those of Major Owen and Lieut. Palmer) he believes Globigerina to be exclusively an oceanic foraminifera inhabiting only the superficial stratum of the sea. (Preliminary Report of the Scientific Exploration of the Deep Sea, "Proceedings of the Royal Society," No. 121, page 443.)

less degree spiny when the shell has attained its full development. In specimens taken with the tow-net the spines are very usually absent; but that is probably on account of their extreme tenuity; they are broken off by the slightest touch. In fresh examples from the surface, the dots indicating the origin of the lost spines may almost always be made out with a high power. There are never spines on the Globigerinæ from the bottom, even in the shallowest water. Two or three very marked varieties of Globigerina occur; but I certainly do not think that the characters of any of them can be regarded as of specific value.

There is still a good deal of obscurity about the nature of *Orbulina universa*, an organism which occurs in some places in large proportion in the Globigerina ooze. The shell of Orbulina is spherical, usually about ·5 millimetre in diameter, but it is found of all smaller sizes. The texture of the mature shell resembles closely that of Globigerina, but it differs in some important particulars. The pores are markedly of two different sizes, the larger about four times the area of the smaller. The larger pores are the less numerous; they are scattered over the surface of the shell without any appearance of regularity; the smaller pores occupy the spaces between the larger. The crests between the pores are much less regular in Orbulina than they are in Globigerina; and the spines, which are of great length and extreme tenuity, seem rather to arise abruptly from the top of scattered papillæ than to mark the intersections of the crest. This origin of the spines from the papillæ can be well seen with a moderate power on the periphery of the sphere. The spines are hollow and flexible; they naturally radiate regularly from the direction of the centre of the sphere; but in specimens which have been placed under the microscope with the greatest care they are usually entangled together in twisted bundles. They are so fragile that the weight of the shell itself, rolling about with the motion of the ship, is usually sufficient to break off the whole of the spines and leave the papillæ only projecting from its surface in the course of a few minutes. In some examples, either those in process of development, or a series showing a varietal divergence from the ordinary type, the shell is very thin and almost perfectly smooth, with neither papillæ nor spines, nor any visible structure, except the two classes of pores, which are constant.

The chamber of Orbulina is often almost empty; even in the case of examples from the surface, which appears from the freshness and transparency of the shell to be living, it is never full of sarcode; but it frequently contains a small quantity of yellow sarcode stuck against one side, as in the last chamber of Globigerina. Sometimes, but by no means constantly, within the chamber of Orbulina there is a little chain of three or four small chambers singularly resembling in form, in proportion, and in sculpture, a small Globigerina; and sometimes, but again by no means constantly, spines are developed on the surface of the calcareous walls of these inner chambers, like those on the test of Globigerina. The spines radiate from the position of the centre of the chambers and abut against the insides of the wall of the Orbulina In a few cases the inner chambers have been observed apparently arising within or among the sarcode adhering to the wall of the Orbulina.

Major Owen regards Orbulina as a distinct organism, nearly allied to Globigerina, but differing so far from it as to justify its separation into a special subgenus. He considers the small inner chamber of Orbulina as representing the smaller chamber of Globigerina, and the outer wall as the equivalent of the large outer chamber of Globigerina developed in this form as an investing chamber. Count Pourtales, Max-Schultze, and Krohn, on the other hand, believe, on account of the close resemblance in structure between the two shells, their constant association, and the undoubted fact that an object closely resembling a young Globigerina is often found within Orbulina, that the latter is simply a special reproductive chamber budded from the former, and capable of existing independently. I am rather inclined to the latter view, although I think much careful observation is still required to substantiate it; and some even of our own observations would seem to tell somewhat in the opposite direction. Although Orbulina and Globigerina are very usually associated, in different localities, they are so in different proportions; and in the icy sea to the south of Kerguelen, although Globigerina was constantly taken in the surface-net, not a single Orbulina was detected. Like Globigerina, Orbulina is most fully developed and most abundant in the warmer seas.

Associated with these forms, and, like them, living on the surface and dead, and with their shells in various stages of decay at the bottom, there are two very marked species or varieties of Pulvinulina, *P. menardii*, and *P. micheliniana*. The general structure of Pulvinulina resembles that of Globigerina. The shell consists of a congeries of from five to eight chambers arranged in an irregular spiral. As in Globigerina, the last chamber is the largest; the inner smaller chambers are usually filled with yellow sarcode; and as in Globigerina, the last chamber is frequently nearly empty, a small irregular mass of sarcode only occupying a part of the cavity. The walls of the chambers are closely and minutely perforated. The external surface of the wall is nearly smooth, and no trace of a spine has ever been detected. *Pulvinulina menardii* has a large discoidal depressed shell, in diameter consisting of a series of flat chambers overlapping one another, like a number of coins laid down somewhat irregularly, but generally in a spiral: each chamber is bordered by a distinct somewhat thickened solid rim of definite width. On the lower surface of the shell the intervals between the chambers are indicated by deep grooves. The large irregular opening of the final chamber is protected by a crescentic lip, which in some specimens bears a fringe of spine-like papillæ. This form is almost confined to the warmer seas. It is very abundant on the surface, and still more so during the day, at a depth of ten to twenty fathoms in the Mid-Atlantic; and it enters into the composition of the very characteristic Globigerina ooze of the "Dolphine Rise" in almost as large proportions as Globigerina. *Pulvinulina micheliniana* is a smaller variety; the upper surface of the shell is flattened as in *P. menardii*, but the chambers are conical and prolonged downwards, so that the shell is deeper and somewhat turbinate. The two species usually occur together; but *P. micheliniana* has apparently a much wider distribution than *P. menardii*, in which the former was limited to the region of the trade-winds and the equatorial drift-current, and was found rarely, if at all, to the south of the Agulhas current; the latter accompanied us southward as far as Kerguelen Land. Both forms of Pulvinulina, however, are more restricted than Globigerina, for even *P. micheliniana* became scarce after leaving the Cape, and the wonderfully pure calcareous formation in the neighbourhood of Prince Edward Island and the Crozets consists almost solely of *Globigerina bulloides;* and neither species of Pulvinulina occurred to the south of Kerguelen Land.

Over a very large part of the "Globigerina-ooze" area, and especially in those intertropical regions in which the formation is most characteristically developed, although the great bulk of the ooze is made up of entire shells and fragments of shells of the above-described foraminifera, besides these there is frequently a considerable proportion (amounting in some cases to about twenty per cent.) of fine granular matter, which fills the shells and the interstices between them, and forms a kind of matrix or cement. This granular substance is, like the shells, calcareous, disappearing in weak acid to a small insoluble residue: with a low microscopic power it appears amorphous, and it is likely to be regarded at first sight as a paste made up of the ultimate calcareous particles of the disintegrated shells, but under a higher power it is found to consist almost entirely of "coccoliths" and "rhabdoliths." I need scarcely enter here into a detailed description of these singular bodies, which have already been carefully studied by Huxley, Sorby, Gümbel, Carter, Oscar Schmidt, Wallich, and others. I need only state that I believe our observations have placed it beyond a doubt that the "coccoliths" are the separated elements of a peculiar calcareous armature which covers certain spherical bodies (the "coccospheres" of Dr. Wallich.) The rhabdoliths are the like elements of the armature of extremely beautiful little bodies, which have been first observed by Mr. Murray, and naturally called by him "rhabdospheres. Coccospheres and rhabdospheres live abundantly on the surface, especially in warmer seas. If a bucket of water be allowed to stand over night with a few pieces of thread in it, on examining the threads carefully many examples may usually be found attached to them; but Mr. Murray has found an unfailing supply of all forms in the stomachs of Salpæ.

What these coccospheres and rhabdospheres are we are not yet in a position to say with certainty; but our strong impression is that they are either algæ of a peculiar form, or the reproductive gemmules, or the sporangia of some minute organism, probably an alga, in which latter case the coccoliths and rhabdoliths might be regarded as representing in position and function the "amphidisci" on the surface of the gemmules of Spongilla, or the spiny facets on the zygospores of many of the Desmideæ. There are many forms of coccoliths and rhabdoliths, and many of these are

so distinct that they evidently indicate diffe rent species. Mr. Murray believes, however, that only one form is met with on one sphere; and that in order to produce the num erous forms figured by Hæckel and Oscar Schmidt, all of which, and many additional varieties, he has observed, the spheres must vary in age and development, or in kind. Their constant presence in the surface-net, in surface-water drawn in a bucket, and in the stomachs of surface animals, sufficiently prove that, like the ooze-forming foraminifcres, the coccoliths and rhabdoliths, which enter so largely into the composition of the recent deep-sea calcareous formations, live on the surface and at intermediate depths, and sink to the bottom after death. Coccospheres and rhabdospheres have a very wide but not an unlimited distribution. From the Cape of Good Hope they rapidly decreased in number on the surface, and at the bottom as we progressed southwards. The proportion of their remains in the Globigerina ooze near the Crozets and Prince Edward Island was comparatively small; and to this circumstance the extreme clearness and the unusual appearance of being composed of Globigerinæ alone was probably mainly due. We found the same kind of ooze nearly free from coccoliths and rhabdoliths in what may be considered about a corresponding latitude in the north, to the west of Faröe.

Before leaving the subject of the modern chalk, it may be convenient to pass on to stations 158, 159, and 160, on March 7th, 10th, and 13th, on our return voyage from the ice. The first two of these, at depths of 1,800 and 2,150 fathoms respectively, are marked on the chart "Globigerina ooze;" and it will be observed that these soundings nearly correspond in latitude with the like belt which we crossed going southwards; the third sounding at a depth of 2,600 fathoms is marked "red clay."

According to our present experience the deposit of Globigerina ooze is limited to water of a certain depth, the extreme limit of the pure characteristic formation being placed at a depth of somewhere about 2,250 fathoms. Crossing from these shallower regions occupied by the ooze into deeper soundings, we find universally that the calcareous formation gradually passes into and is finally replaced by an extremely fine pure clay, which occupies, speaking generally, all depths below 2,500 fathoms, and consists almost entirely of a silicate of the red oxide of iron and alumina. The transition is very slow, and extends over several hundred fathoms of increasing depth; the shells gradually lose their sharpness of outline and assume a kind of "rotten" look and a brownish colour, and become more and more mixed with a fine amorphous red-brown powder, which increases steadily in proportion until the lime has almost entirely disappeared. This brown matter is in the finest possible state of subdivision, so fine that when, after sifting it to separate any organisms it might contain, we put it into jars to settle, it remained for days in suspension, giving the water very much the appearance and colour of chocolate.

In indicating the nature of the bottom on the charts, we came, from experience and without any theoretical consideration, to use three terms for soundings in deep water. Two of these, Gl. oz. and r. cl., were very definite, and indicated strongly marked formations, with apparently but few characters in common; but we frequently got soundings which we could not exactly call either "Globigerina ooze" or "red clay;" and before we were fully aware of the nature of these we were in the habit of indicating them as "grey ooze" (gr. oz.) We now recognise the "grey ooze" as an intermediate stage between the Globigerina ooze and the red clay; we find that on one side as it were of an ideal line, the red clay contains more and more of the material of the calcareous ooze, while on the other the ooze is mixed with an increasing proportion of "red clay."

Although we have met with the same phenomenon so frequently that we were at length able to predict the nature of the bottom from the depth of the sounds with absolute certainty for the Atlantic and the Southern Sea, we had perhaps the best opportunity of observing it in our first section across the Atlantic, between Teneriffe and St. Thomas. The first four stations on this section, at depths from 1,525 to 2,220 fathoms, show Globigerina ooze. From the last of these, which is about 300 miles from Teneriffe, the depth gradually increases to 2,740 fathoms at 500, and 2,950 fathoms at 750 miles from Teneriffe. The bottom in these two soundings might have been called "grey ooze;" for although its nature has altered entirely from the Globigerina ooze, the red clay into which it is rapidly passing still contains a considerable admixture of carbonate of lime.

The depth goes on increasing to a distance of 1,150 miles from Teneriffe, when it reaches 3,150 fathoms; there the clay is pure and smooth, and contains scarcely a trace of lime. From this great depth the bottom gradually rises, and with decreasing depth the grey colour and the calcareous composition of the ooze return. Three soundings in 2,050, 1,900, and 1,950 fathoms on the "Dolphin Rise," gave highly characteristic examples of the Globigerina formation. Passing from the middle plateau of the Atlantic into the western trough with depths a little over 3,000 fathoms, the red clay returned in all its purity: and our last sounding in 1,420 fathoms before reaching Sombrero, restored the Globigerina ooze with its peculiar associated fauna.

This section shows also the wide extension and the vast geological importance of the red clay formation. The total distance from Teneriffe to Sombrero is about 2,700 miles. Proceeding from east to west, we have

About 80 miles of volcanic mud and sand,
" 350 " Globigerina ooze,
" 1,050 " red clay,
" 330 " Globigerina ooze,
" 850 " red clay,
" 40 " Globigerina ooze;

giving a total of 1,900 miles of red clay to 720 miles of Globigerina ooze."

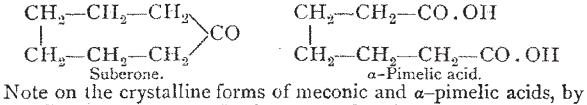
(*To be continued.*)

SCIENTIFIC SERIALS

THE *Journal of the Chemical Society* for October commences with a paper, by Prof. Roscoe, On a new chloride of uranium. The new compound is the pentachloride UCl_5, obtained by passing chlorine over a heated mixture of any oxide of uranium and charcoal. If the current of chlorine is slow, the substance forms dark needle-shaped crystals with a green metallic lustre and ruby red by transmitted light. When the chlorine is passed rapidly, UCl_5 is formed as a brown powder. The compound decomposes on heating into the tetrachloride and free chlorine.—The next paper is on suberone, by C. Schorlemmer and R. S. Dale. This body is formed by distilling suberic acid with lime according to the equation—

$$2C_8H_{14}O_4 = 2CO_2 + 2H_2O + C_{14}H_{24}O_2.$$

Hexane is produced at the same time, and can be separated by fractional distillation. Pure suberone is a mobile liquid, boiling at 179° to 181°. The molecular formula is $C_7H_{12}O$, and it is oxidised by nitric acid into an acid of the formula $C_7H_{12}O_4$. The authors have examined the barium, calcium, and silver salts of this acid. The new acid has the same composition as the pimelic acid obtained by Hlasiwetz and Grabowsky from camphoric acid, but its properties are quite different, and it has been provisionally named α-pimelic acid. The authors assign the following constitutional formulæ to suberone and α-pimelic acid:—



Suberone. α-Pimelic acid.

Note on the crystalline forms of meconic and α-pimelic acids, by Dr. C. A. Burghardt.—On the action of earth on organic nitrogen, by E. C. C. Stanford. The experiments were made on mixtures of lean meat with ordinary loam-earth, and the author deduces therefrom the following conclusions:—1. Earth mixed with organic nitrogenous matter is an indifferent dryer, and, except in considerable quantity, a poor deodoriser. 2. That the mixtures continuously lose nitrogen to about the extent of 73 per cent. in five months. 3. That the loss is perhaps wholly due to decay, the nitrogen being probably evolved as ammonia. 4. That in such mixtures the earth does not act as an oxidiser, no nitrification taking place.—The remainder of the journal is devoted to abstracts from foreign periodicals, many of which have been already noticed in these columns.

Gazzetta Chimica Italiana, fascicolo vi., vii., and viii., October.—This part begins with a long and valuable paper by W. Koerner, entitled "Studies of the Isomerism of the bodies known as Aromatic Substances with six Carbon Atoms." This research has led the author to study the action of nitric acid on acetanilide giving rise to the formation of nitro-acetanilide, which is converted by potassium hydrate into a mixture of ortho- and