economize your space, I only gave the skeleton of the argument, but I hoped I had said enough to indicate at least the general outline of my logical views. But as this seems not to have been quite the case, may I now explain myself a little more fully?

I may remove a slight misunderstanding at once. I said our knowledge of our own continuous existence *in the present* is to each of us a necessary truth. Dr. Mivart reads this as if I had written "our continued existence in the future"! That we cannot be annihilated while we know that we are existing is, as I shall presently show, *not* a mere consequence of the law of contradiction. If this law is of any use at all in proving the conclusion, it would certainly be useless without a second premiss, viz. that we are existing; and this latter is the premiss which is a necessary truth.

I suppose everyone will acknowledge that a definition is essentially an arbitrary assertion, and that therefore a definition can by itself give no real information. But a well-understood term does not consist of a definition alone. Its definition may be laid down, as a list of items of connotation (or denotation), and the other part of its meaning, which may be called its import, that is its denotation (or connotation) must be discovered by experience; and the knowledge so acquired is real, not only verbal, knowledge. Now it is possible from a number of definitions *alone* to deduce a series of propositions. These, like the definitions from which they were deduced, give by themselves only verbal information—they are all truisms—and before they can be made of any practical use, certain real assertions, assigning real import to the terms, and so expressing real knowledge, must be added to the premisses. Thus, if we wish to determine whether any given proposition is a truism, or conveys real information, we have only to examine the definitions of its terms. If these are found to be inconsistent with each other, the proposition is a contradiction in terms, and must be rejected. If the definitions are not inconsistent, but are independent of each other, the proposition can only be intended to assert the identity of the import of its terms—it therefore conveys real information, which may either be true or false. Lastly, if the definitions can be shown to be dependent on each other, the proposition is equally true whatever import its terms may have, or even if they have no conceivable import at all. It is a truism. If, however, *by the aid of other real propositions* any real import can be given to its terms, it may have objective, or subjective, applications; but the objectivity or subjectivity is introduced by those other propositions, and is not a property of the original truism.

Take, for example, the proposition, "Everything must either 'be' or 'not be'"; or the proposition, "Twice two is four." The truth of either of these propositions depends solely on the definitions of its terms, as I pointed out in my last letter, and this is why I cannot regard them as objective truths. Of course I do not doubt that if I had lost an eye I should not remain in the same condition as I was before. But, although "no man out of Bedlam would suppose a statement of a general law would inform us about a concrete thing," this is precisely what Dr. Mivart does if he regards the above proposition as dependent solely on the law of contradiction. Does he not see that he added the objective element to that law in the phrase, "if he had lost an eye"? "Much virtue in If." The status of the proposition, "Two straight lines cannot inclose a space," similarly depends on the definitions of its terms; but, as I pointed out in my last letter, these terms may be defined in two different ways—either by dependent definitions, so making the proposition a truism, or independently so as to make it a real assertion, in which case it might conceivably be false. Dr. Mivart apparently takes the former set of definitions, and then implies that I deduced the latter result from them, which, if he reads my letter again, he will find not to have been the case.

In reply to Miss Jones, I may point out—

(1) It most certainly *is* merely a verbal convention when Miss Jones says, "A and a 'are not applicable to the same thing.'" She had herself just before laid down the convention in question, in the phrase, "If A signifies the negation of a (whatever A may stand for)."

I do not know why Miss Jones should imagine that I think that "assertions (or denials) of the 'existence' of particular objects are the only real propositions," but perhaps she will understand my view better when she has read this letter.

(2) I certainly hold that "inductions have no logical justification whatever," if by "logic" is to be understood formal, or,

as I prefer to call it, symbolic, reasoning. The essence of induction, in my opinion, is the assumption (at first arbitrarily) of an hypothesis to account for observed facts—that is, ultimately, of directly apprehended sensations. The full significance of the hypothesis is elucidated by symbolic reasoning, and the *enumeratio simplex* is applied to the results of this reasoning, and does not, therefore, appear quite in the simple form exhibited by Miss Jones. But it remains equally true that no induction can ever lead to a necessary truth.

(3) Miss Jones's view of mathematical reasoning is exactly that which I wish to combat. We do not, in mathematics, conclude a universal proposition from a single concrete instance. A mathematical formula does not imply the existence of any instance whatever of its application, any more than a definition implies the reality of the thing defined. The formula is deduced from what may logically be regarded as definitions, and one or any number of applications may indeed be found afterwards, but only by the aid of additional real premisses. It is difficult to exemplify this in the case of geometry, because the accepted geometrical methods are so very imperfect, and geometrical conclusions are not always deduced from definitions alone. As I implied in my former letter, some of them are founded on induction. But it must be evident that the truth of, say, De Moivre's Theorem, does not depend on our having *seen* that it was true in any one instance.

(4) If Miss Jones reads her own paragraph (4) again carefully, I think she will see that it is not I who have contradicted myself. I showed that if the definitions of the terms of a certain proposition were altered, the proposition might no longer be true, and that if they were not altered it would always be true. *Argal*, the truth depends on the definitions, and on nothing else.

I did not maintain that it could ever be to anyone a necessary truth that he was writing with a lead-pencil. That would be an objective proposition, such as I was careful to insist could only be proved by induction. It might, however, be a necessary truth to anyone that he *thought* he was writing with a lead-pencil. As to mathematical truths, so far from believing that "in as far as 'real' they are obtained by induction," I expressed my opinion that they are not "real" at all, but all truisms. Any reality in their applications must be added from outside, by real assertions which are not "mathematical." I object to calling truisms "necessary," not because they are possibly false, but because their truth is only arbitrary. On the other hand, when I call "the apprehension of a present fact" a necessary truth, I mean something more than that it is certain—namely, that its contradictory is unthinkable.

EDWARD T. DIXON.

Trinity College, Cambridge, January 8.

FRESH EVIDENCE CONCERNING THE DISTRIBUTION OF ARCTIC PLANTS DURING THE GLACIAL EPOCH.

LAST summer (1891) I spent some weeks in Western Russia and Northern Germany, in order to ascertain whether the glacial fresh-water deposits of those countries contained any remains of the vegetation which lived there immediately after the inland ice had melted away. The results of my journey being favourable, I have thought it desirable to communicate them to the readers of NATURE; but before doing so it might be convenient to give a brief summary of previous investigations on the same subject.

The first discovery of fossil Arctic plants was made in England by Mr. W. Pengelly, who found in 1860, at Bovey Tracey, in Devonshire, leaves of the dwarf birch (*Betula nana*), together with leaves of some willows, as *Salix myrtilloides*, *S. cinerea*, *S. sp. indet.* The leaves were identified and described by the late Prof. Heer,¹ who pronounced the opinion that the presence of *Betula nana* was conclusive evidence of "a colder climate than Devonshire has at the present day." The significance of this discovery was, however, but little appreciated until the researches mentioned below again

¹ Philosophical Transactions, 1862, p. 1039. In this paper Heer mentions *Salix repens* (?), but this determination was subsequently altered to *S. myrtilloides*.

called attention to the nature of the vegetation which grew round the margin of the great northern inland ice, on the soil which was left bare when it melted away.

During my first visit to Spitzbergen, in 1870, it occurred to my mind that—supposing the glacial theory were true—the remains of those Arctic plants which, in all probability, formerly existed in the area once covered by the great Scandinavian inland ice, would have been buried in the glacial fresh-water deposits, just in the same manner as the leaves of *Salix polaris*, *Dryas octopetala*, *Polygonum viviparum*, &c., are at the present day carried into the small lakes of Spitzbergen,

found the Arctic fossil flora underneath some peat-mosses in the immediate vicinity of Copenhagen. In 1872 I discovered leaves of *Betula nana* in a peat-moss near Oertzenhof, in Mecklenburg, and at Kolbermoor, in Southern Bavaria. In Switzerland I also found an Arctic-Alpine flora in a fresh-water deposit at Schwerzenbach, on the low ground between Zürich and Bodensee. The flora was rich in such species as *Betula nana*, *Salix reticulata*, *S. polaris*, *S. retusa*, *S. myrtilloides*, *Arctostaphylos uva-ursi*, *Polygonum viviparum*, *Azalea procumbens*, &c.

From Switzerland I went to England, and first visited Bovey Tracey (17),¹ where I re-found *Betula nana* in the

SKETCH MAP SHOWING THE LOCALITIES WHERE ARCTIC PLANT-FOSSILS HAVE BEEN FOUND WITHIN THE AREA ONCE COVERED BY THE GREAT NORTHERN ICE-SHEET.

A, margin of the great northern inland ice at the climax of glaciation; B, margin of the Uralo-Timan glacier (according to Nikitin); C, margin of the glaciers of the Alps.

(1) Several localities (more than thirty) in Scania; (2) Rangilstorp, near Vadstena; (3) Fröjel, in the isle of Gotland; (4) several localities in Jemtland; (5) Leine, in Norway; (6) several localities in Seeland; (6') Möen; (6'') Northern Jutland; (6''') Bornholm; (7) Kunda, in Esthonia; (8) Samhof and Kinzli, in Livonia; (9) Pingo and Wieratz in Livonia; (10) two localities at Rjeshiza, Government of Vitebsk; (11) Kuhrische Nehrung; (12) Schroop, in Western Prussia; (13) Krampkewitz, in Pomerania; (14) Neetzka and Oertzenhof, in Mecklenburg; (15) Nantrow, in Mecklenburg; (16) Projensdorf, north of Kiel; (17) Bovey Tracey, in Devonshire; (18) Hoxne, in Suffolk; (19) several localities at and near Cromer, Norfolk; (20) Holmpton, Yorkshire; (21) Brudlington, Yorkshire; (22) localities near Edinburgh.

and buried at their bottoms. On my return from that expedition, I at once examined some glacial fresh-water deposits at Alnarp, in Scania, and was glad to find in them the leaves of *Salix polaris*, *S. herbacea*, *S. reticulata*, *Dryas octopetala*, *Betula nana*, &c.; thus proving that a true Arctic flora had once lived in the southernmost part of Sweden. The next year, after having discovered the same flora in a great many other localities of the same province, I was invited by Prof. Japetus Steenstrup to extend my researches into Denmark; and our joint investigations were soon crowned with success, for we

original locality, and also in another little basin close by, together with leaves of *Arctostaphylos uva-ursi* and *Betula alba*. Then I went to the coast of Norfolk, where I was so fortunate as to find *Salix polaris* and *Hypnum turgescens* in the pre-glacial deposits between the boulder-clay and the forest-bed in the vicinity of Cromer (19). This plant-bearing bed has since then been noticed by Mr. Clement Reid, of the Geological Survey, who has named it the "Arctic fresh-water bed," and he has traced

¹ The figures within parentheses refer to those on the accompanying sketch map

it in some other places on the coast of Norfolk. Besides *Salix polaris*, Mr. Reid has also found in it leaves of *Betula nana* and seeds of some other plants. At Hoxne, in Suffolk (18), Messrs. Reid and Ridley have discovered *Salix polaris*, *S. myrsinites*, and *Betula nana*, together with many other species in a glacial fresh-water deposit of a precisely similar character to those in Southern Sweden. Again, in 1879, I found leaves of *Betula nana* in a peat-moss at Bridlington (21), and the same plant has been found by Mr. Reid at Holmpton (20). According to a statement of Mr. Reid, *Salix herbacea* was found some years ago by Mr. Bennie in an inter-glacial deposit at Hailes, about three miles from Edinburgh. Finally, during this present year (1891), Mr. Reid has himself discovered a rich Arctic flora, yielding *Salix polaris*, *S. herbacea*, *S. reticulata*, *Azalea procumbens*, and *Betula nana*, in lacustrine deposits immediately above the boulder-clay near Edinburgh (22).¹

Returning to Sweden, a great many new localities yielding Arctic plants have also been found in Scania since 1871, partly by myself, partly by Dr. Gunnar Andersson and others, so that the number of localities in Scania (1) now exceeds thirty. In Ostrogothia, leaves of *Betula nana* and *Dryas octopetala*, &c., were found in 1886 in a calcareous tufa near Vadstena at Lake Vetter (2); and in the isle of Gotland (3), Mr. R. Sernander, in 1890, discovered leaves of the same species in a fresh-water deposit overlain by the curious gravel-bed containing *Ancylus*. In Jemtland, Mr. A. F. Carlson, in 1885 and 1886, discovered leaves of *Dryas* and *Salix reticulata* in calcareous tufa in several localities (4) far removed from the regions where these species now exist. In Norway nothing whatever was known of the ancient Arctic flora until last summer (1891), when, according to Prof. A. Blytt, leaves of *Dryas octopetala* were found in calcareous tufa at Leine (5). In Denmark the continued researches of Prof. Steenstrup have added many new localities (6) to the original ones mentioned above, not only in Seeland, but also (from a private communication made to the author) on the isle of Möen (6'), in Northern Jutland (6''), and on Bornholm (6'''). Turning to Switzerland, Prof. C. Schröter, of Zürich, has discovered three new localities for the glacial flora, and in 1880 I myself found leaves of *Salix herbacea*, *Dryas octopetala*, and *Betula nana* in a fresh-water deposit near Hedingen (Canton Zürich), and leaves of the last-mentioned species underneath a peat-moss at Wauwyl (Canton Luzern), and in peat at Le Chaux de Fonds.

It ought also to be mentioned that Prof. M. Staub, of Buda-Pest, has lately described a fossil glacial flora from the Southern Carpathians, which, besides seeds of *Pinus Pumilio* and *Pinus Cembra*, also contains leaves of *Dryas octopetala*, *Betula nana*, and *Salix myrtilloides*, together with fruits of *Tofieldia borealis*, thus proving the existence of a somewhat colder climate than the present one.

In 1880, I discovered a locality at Neetzka, in Mecklenburg, not far distant from Oertzenhof where I had found *Betula nana* in 1872. The new locality (14) yielded *Dryas octopetala*, *Salix reticulata*, *Betula nana*, *B. odorata*, and *B. verrucosa*, together with leaves of *Myriophyllum*, some other *Salices* and mosses, such as *Hypnum scorpioides* and *H. fluitans*. According to the manner in which the samples of clay were gathered, it is very possible that the species mentioned belong to different horizons.

Neetzka and Oertzenhof being the sole localities in

Northern Germany which until then had yielded fossil Arctic plants, while nothing whatever was known of the existence of Arctic plant-fossils in Russia, Prof. O. Drude, of Dresden, in 1889 expressed the opinion¹ that the margin of the great northern inland ice might have been surrounded, not by an Arctic flora, but by a forest growth; and further, that such a growth may even have existed on the surface moraines of the inland ice itself.

I have² lately tried to show, however, that this hypothesis is erroneous; but with the conviction that facts would prove the best arguments, I resolved to visit those portions of Western Russia and Northern Germany which I had not previously examined, and, thanks to the liberality of the Swedish Society for Geography and Anthropology, who gave me the balance of the *Vega* fund, I have been enabled to carry out my project, with the results communicated below. As my collections are, however, only partially worked out as yet, the present notice must be considered as only preliminary.

The circumstances under which the Arctic plant-fossils occur are pretty uniform, and it may therefore be convenient to state them at once, instead of giving a description for every locality. In those parts of Western Russia and Northern Germany which I visited, the ground almost everywhere consists of a true *moraine profonde* (till) which has never been covered by the sea. Though marine glacial deposits are consequently absent in this area, fresh-water deposits, which have been formed in ancient lakes or ponds, are very abundant. These deposits consist generally in their lower part of a bluish clay or sandy clay, sometimes distinctly laminated, while the colour of the clay in the upper part is generally somewhat yellowish. This fresh-water clay is often covered by white shell marl, principally derived from the shells of fresh-water Mollusca; sometimes, however, by mud containing the remains of microscopical Algæ, fragments and excrements of insects and other minute fresh-water animals. Then comes the peat, terminating the deposit above—sometimes developed as a true peat-moss; at others, only as a peaty mould 1 to 2 feet thick. In places the peat is totally absent, *i.e.* the fresh-water lake has been entirely filled up by the alluvial clay before the formation of peat had begun.

The Arctic plant-fossils are found principally in the clay, sometimes also in the white marl or mud, whilst only *Betula nana* ascends into the peat. Some fresh-water Mollusca are found together with the Arctic plants—namely, some species of *Pisidium*, *Limnaea ovata*, *Anodonta* or *Unio*, sometimes also *Cyclas cornea*. By studying the distribution of the Mollusca in the different horizons, the order of immigration of the different species can be ascertained, and we know now very well the manner in which this has taken place in Southern Sweden. Besides Mollusca, the Arctic plants are often accompanied by remains of beetles and by Ostracoda, such as *Cytheridea torosa* and others; and in one locality in Scania I have also found abundant remains of *Apus glacialis*. Finally, it is in this horizon that the remains of the reindeer are principally found in Southern Sweden, Denmark, and Northern Germany.

When travelling in Esthonia and Livonia I had the advantage of being accompanied by the well-known geologist, Akademiker Fr. Schmidt, of St. Petersburg, and the success of our investigations was largely due to his advice. The Arctic plant-fossils were first discovered at Kunda in Esthonia (7), where the fresh-water marl and clay are used in the preparation of cement. The upper part of this deposit has yielded a great many bone implements of Neolithic age, which were described some years ago by the late Prof. Grewingk, of Dorpat, and antlers of reindeer are likewise present. The Arctic plants were obtained at a depth of 17½ feet below the

¹ It is curious that *Dryas octopetala* has not yet been reported from the glacial plant-fossils of Great Britain, although it abounds in the glacial fresh water deposits of Sweden, Denmark, Germany, and Russia; and although the plant still lives in the mountains of Scotland, Yorkshire, and Wales. May not, however, the leaf from Crofthead which Mr. Mahony has identified with *Scutellaria galericulata* (Geol. Mag., vol. vi. p. 392) in reality have been a leaf of *Dryas*? The leaves of *Scutellaria* can hardly be preserved in the fossil state.

² Petermann's Mittheilungen, 1889, pp. 282-290.

³ Engler's Botan. Jahrbücher, Bd. xiii., 1891, Beiblatt Nr. 29.

surface, *Salix polaris* being the most common form. Of other species found, the following have, up to the present, been recognized: *Salix herbacea*, *Dryas octopetala*, *Betula nana*, *Polygonum viviparum*, *Saxifraga cæspitosa* or an allied species, mosses, &c.

From Kunda we went to Hellenorm in Livonia (8), where we were welcomed by the old Siberian traveller, A. Th. van Middendorff, who took a great interest in my researches. On the day of our arrival Prof. Schmidt found a leaf of *Salix reticulata* in a bed of clay at Samhof. In another clay-bed in the vicinity, at Kinzli, I found *Dryas octopetala*, *Betula nana*, *Salix* sp., mosses, &c.

Then we went to Fellin (9), where I found the Arctic plants at two different localities, Pingo and Wieratz. The species obtained were *Dryas octopetala*, *Betula nana*, *Salix reticulata*, *Potamogeton* sp., &c. I then parted from Prof. Schmidt, and went to Rjeshiza (10), in the Government of Vitebsk, accompanied by Dr. J. Klinge, of Dorpat. In Rjeshiza we were welcomed by Dr. E. Lehmann, a skilful botanist; and on the very day of our arrival we discovered the following Arctic plant-fossils, *Dryas octopetala*, *Betula nana*, *Polygonum viviparum*, &c., in two different localities in the vicinity of the town. My ignorance of the Russian language made it impossible for me to continue my researches further eastwards into the interior of the country, and I consequently turned westwards to Königsberg, in Eastern Prussia. There Prof. A. Jentsch reminded me of the discovery of *Hyphnum turgescens*, in an alluvial deposit at Kuhrische Nehrung, made by Berendt many years ago. As this is a mountain species, it is possible that it may have been found in a glacial fresh-water deposit, and this locality has consequently been indicated on the sketch map (11).

Accompanied by Prof. A. Jentsch, of Königsberg, and by Prof. H. Conwentz, of Danzig, I now went to Marienburg, in Western Prussia, and at Schroop (12), about 10 kilometres south-east of this town, a locality yielding Arctic plant-fossils was discovered. They occur here under precisely the same conditions as in Scania or at Kunda, in Esthland; *Salix polaris* and *Dryas octopetala* being found in the lower strata, whilst *Betula nana* occurs somewhat higher. The next locality discovered was at Krampkewitz (13), near Lauenburg, in Pomerania, whither I had gone with Prof. Conwentz. The plant-fossils found were *Dryas octopetala*, *Betula nana*, and some others.

Owing to heavy rains, a visit to Breslau proved fruitless, and for the same reason the fresh-water deposits near Waren and Rostock were inaccessible, but acting on the advice of Prof. E. Geinitz, of Rostock, I examined a small peat-moss at Nantrow (15), north-east of Wismar, where I found *Betula nana* and some *Salices* in mud and sand underneath the peat. The following day I examined the sections at the great North Sea-Baltic Canal at Holtenau, north of Kiel (16), under the guidance of Prof. R. v. Fisher-Benzoni, of Kiel. We succeeded in finding two fresh-water basins yielding plant-fossils. The first basin, of which only a small portion now remained, contained fruits of *Betula nana*, together with some other species, not yet determined, but probably indicating a sub-Arctic climate. In the other basin, which was also cut through by the canal, the glacial fresh-water strata underneath the peat were laid bare, yielding abundant leaves of *Salix polaris*, sometimes intermingled with those of *Dryas octopetala*, mosses, &c.

In view of these facts, thus briefly communicated, I think it may be accepted as proved that the Arctic flora flourished on the plains south and east of the Baltic round the margin of the ice-sheet, and some time after the inland ice had melted away (see the accompanying sketch map). There can also be hardly any doubt that this same flora may have lived round the margin of the great northern inland ice at the climax of the glaciation. For otherwise it is difficult to understand how it could

have obtained so great an extension as from Suffolk to Kunda, in Esthonia, or why it should have flourished during so long a time after the amelioration of the climate, which caused the melting of the ice, had commenced. The fresh-water deposits with Arctic plants are sometimes so thick that they probably indicate an interval of several thousand years, during which the Arctic flora prevailed. If the margin of the ice-sheet at the climax of glaciation had been surrounded by a forest growth, this ought still more to have existed round the margin of the retreating ice. But as we have shown that this is not the case, we are entitled to conclude that the Arctic flora formerly flourished, not only round the margin of the great northern inland ice, but probably also over a part at least of the area between this ice and the glaciers of the Alps. In connection with this, it ought not to be overlooked that the Arctic tundra-fauna, which Prof. Nehring discovered at Thiede, underneath the steppe-fauna, perfectly harmonizes with this view, as this locality is situated relatively near to the outermost margin of the great northern ice-sheet. The existence of *Salix polaris* in Suffolk and Norfolk may also be considered as a strong argument for the same hypothesis. Thus the theory advanced by E. Forbes so far back as 1846—that the Alpine flora of Europe, so far as it is identical with the flora of the Arctic and sub-Arctic zones of the Old World, is a fragment of a flora which was diffused from the north, and that the termination of the glacial epoch in Europe was marked by a recession of an Arctic fauna and flora northwards—may now be regarded as definitively proved.

A. G. NATHORST.

CYCLONES IN THE ARABIAN SEA.¹

THIS discussion was undertaken primarily by the Meteorological Office with the object of throwing some light on the very exceptional storm which was experienced at Aden in the summer of 1885, but advantage was taken of this opportunity to produce synchronous weather charts of the Arabian Sea for a limited period, since it was felt that such charts would be of especial interest, dealing as they do with a part of the ocean which is subject to the regular change of monsoon winds. The charts also exhibit the occurrence of a second cyclone which had originated over the eastern portion of the Arabian Sea before the full effect of the first disturbance had passed away. The Gulf of Aden and the northern portion of the North Indian Ocean are rarely visited by cyclones or typhoons, and consequently the occurrence in these waters, in the summer of 1885, of a violent cyclone, causing the loss of several vessels, among them the German corvette *Augusta*, and the French despatch-boat *Renard*, attracted considerable attention. The number of ships' logs which have been collected and utilized in the preparation of the charts is 239, and the information has been obtained from all available sources, including our own Navy and mercantile marine, and those of many foreign countries. For the first few days of the period discussed, the normal conditions were apparently prevailing over the Arabian Sea, the wind was north-westerly near the Indian Peninsula, but the south-west monsoon was blowing steadily near the African coast and for some distance over the sea on the western side of the district. Until about May 20, the weather in the neighbourhood of Ceylon seems to have been quiet, and the wind fairly steady from the south-westward. On the 20th, Her Majesty's ships *Briton* and *Woodlark* experienced somewhat disturbed weather at Trincomalee, the squalls attained the force

¹ "Daily Weather Charts for the Period of Six Weeks ending June 25, 1885, to illustrate the Tracks of Two Cyclones in the Arabian Sea." (London: Published by the authority of the Meteorological Council, 1891.)