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No. 3. — *A Letter concerning Deep-Sea Dredgings, addressed to PROFESSOR BENJAMIN PEIRCE, Superintendent United States Coast Survey, by LOUIS AGASSIZ.*

CAMBRIDGE, MASS., December 2, 1871.

MY DEAR FRIEND, —

On the point of starting for the Deep-Sea Dredging expedition, for which you have so fully provided, and which I trust may prove to be one of the best rewards for your devotion to the interests of the Coast Survey, I am desirous to leave in your hands a document which may be very compromising for me, but which I nevertheless am determined to write in the hope of showing within what limits Natural History has advanced toward that point of maturity when science may anticipate the discovery of facts.

If there is, as I believe to be the case, a plan according to which the affinities among animals and the order of their succession in time were determined from the beginning, and if that plan is reflected in the mode of growth, and in the geographical distribution of all living beings; or, in other words, if this world of ours is the work of intelligence, and not merely the product of force and matter, the human mind, as a part of the whole, should so chime with it, that, from what is known, it may reach the unknown; and if this be so, the amount of information thus far gathered should, within the limits of errors which the imperfection of our knowledge renders unavoidable, be sufficient to foretell what we are likely to find in the deepest abysses of the sea, from which thus far nothing has been secured.

I will not undertake to lay down the line of argument upon which I base my statement, beyond what is suggested in the few words preceding, namely, that there is a correlation between the gradation of animals in the complication of their structure, their order of succession in geological times, their mode of development from the egg, and their geographical distribution upon the surface of the globe. If that be so, and if the animal world designed from the beginning has been the motive for the physical changes which our globe has undergone, and if, as I also believe to be the case, these changes have not been the cause of the diversity now observed among organized beings, then we may

expect from the greater depth of the ocean representatives resembling those types of animals which were prominent in earlier geological periods, or bear a closer resemblance to younger stages of the higher members of the same types, or to the lower forms which take their place nowadays. And to leave no doubt that I have a distinct perception of what I may anticipate, I make the following specific statement.

It lies in the very nature of these animals that, among vertebrates neither Mammalia nor Birds can exist in deep waters, and if any Reptiles exist there, it could only be such as are related to the extinct types of the Jurassic periods, the Ichthyosauri, Plesiosauri, and Pterodactyles; but even of these there is very little probability that any of their representatives are still alive. Among the fishes, however, I expect to discover some marine representatives of the order of Ganoids of both the principal types known from the secondary zoölogical period, such as Lepidoids, Sauroids, Pycnodonts, Cœlacanthes, Amioids, and Glyptolepis-like species may even be looked for. Among Selachians some new representatives of Cestraciontes or Hybodontes may be forthcoming, connecting the latter more closely to Odontaspis. I also look forward to finding species allied to *Corax*, or connecting this genus with *Notidanus*, perhaps also Jurassic-like forms. Among Chimæroids we may expect some new genera more closely related to the extinct types of that family than those now living. Among ordinary fishes I take it for granted that *Beryx* genera may be added to our list, approaching perhaps *Acanus*, or rather *Sphenocephalus*; also types allied to *Istieus*, to *Anenchelum*, and to *Osmeroides*, *Elops*, and *Argentina*. *Dercetis* and *Blochius* may also come up. Species of all classes of the animal kingdom which have been very rarely met with by fishermen and naturalists are likely to be found in the deepest waters, in which neither hooks nor nets are generally lowered. Nothing is known concerning the greatest depth at which fishes may live. Upon this point I hope to obtain positive data.

The Mollusks will, no doubt, afford a rich harvest of novelties, among which some may be of the deepest zoölogical interest. It stands to reason that a variety of Nautiloid Cephalopods may be discovered when *Nautilus* proper and *Spirula* are so rarely found alive, and among new forms there may be those combining characters of Argonauts with features of *Nautilus*; some may even be coiled up like *Turritiles*. Belemnitic Squids would appear natural. Among Gasteropods

we may look for high spired *Natica*-like types, for representatives of *Acteonella*, *Avellana*, and the like; for small *Volutoids* of the tertiary and cretaceous types, for *Rostellarias*, even for *Nerineas*, and more particularly for forms intermediate between *Firula* and *Cyprea*. Among *Acephala* I would expect a variety of *Myacea* approaching those described in my monographs of that family from the Jurassic and cretaceous formations, such as *Ceromya*, *Corimya*, *Circomya*, *Goniomya*, *Myopsis*, etc., with *Panorpa* and *Pholadomya*, and others recalling perhaps also *Cardinia*, *Gresslya*, or *Cardiacea* more closely related to *Conocardium* than the living species, perhaps leading to *Opis*, or *Trigonia* of extinct types akin to *Myophoria*, with *Pachymya*, *Diceras* *Grammisia*, *Inoceramus*, *Pterinea*, *Monotis*, and *Posidonia*. *Rudistes* should take the place of oysters, and the harvest of *Brachiopods* should be large.

Among *Crustacea* it is natural to suppose that genera may be discovered reminding us of *Eryon* or of *Pemphyx* *Gampsonyx*, or some *Amphipods*, and *Isopods* aping still more closely the *Trilobites* than *Serolis*, or *Limuloids* approaching that extinct family. The classification, embryology, and order of succession of *Echinoderms* is now so well known, that it is perhaps still more easy to anticipate the character of discoveries in this branch of the animal kingdom than in any other. I expect confidently, to find *Spatangoids* approaching *Holaster*, *Toxaster*, *Ananchytes*, *Hemipneustes* or *Metaporhinus*, and others akin to *Dysaster*, *Echinolamps* approaching *Pygurus*, *Nucleolites* tending to *Clypeus*, *Galerites*, like *Pyrina* or *Globator*, etc., etc., and again *Cidarids* akin to *C. glandifera* and *clavigera* with *Glypticus*-like species, and *Codiopsis*, *Cœlopleurus*, *Cyphosoma*, and *Salenia*.

Among *Starfishes* the types of *Goniaster* and *Luidia* are likely to prevail, with simple rayed *Euryaloid* genera, and among *Crinoids* a variety of genera reminding us of *Pentremites*, *Marsupites*, *Pentacrinus*, *Apiocrinus*, and *Eugeniocrinus*.

The question of the affinities of *Millepora* will probably receive additional evidence, and genera connecting more closely the *Rugosa* and *Tabulata* with one another, and with the *Acalephs* may be expected in the shapes of branching *Heliopores* and the like.

With the monograph of *Pourtales* upon the deep-sea corals before me, it would be sheer pretence to say anything concerning the prospect of discovering new representatives of this or that type. His tables point them out already.

But, there is a subject of great interest likely to be elucidated by our investigation, — the contrast of the deep-sea faunæ of the northern with those of the southern hemisphere. Judging from what Australia has already brought us, we may expect to find that the animal world of the southern hemisphere has a more antique character, in the same way as North America may be contrasted with Europe, on the ground of the occurrence in the United States of animals and plants now living here, the types of which are only found fossil in Europe.

A few more words, upon another subject. During the first three decades of this century, the scientific world believed that the erratic boulders, which form so prominent a feature of the surface geology of Europe, had been transported by currents arising from the rupture of the barriers of great lakes among the Alps, or started from the north by earthquake waves.

Shepherds first started the idea that within the valleys of Switzerland these huge boulders had been carried forward by glaciers, and Swiss geologists, Venetz and Charpentier foremost among them, very soon proved that this had been the case. This view, however, remained confined to the vicinity of the Alps in its application, until I suggested that the phenomenon might have a cosmic importance, which was proved when I discovered, in 1840, unmistakable traces of glaciers in Scotland, England, and Ireland, in regions which could have had no connection whatever with the elevation of the Alps. Since that time the *glacial period* has been considered by geologists as a fixed fact, whatever may have been the discrepancies among them as to the extent of these continental masses of ice, their origin, and their mode of action.

There is, however, one kind of evidence wanting to remove every possible doubt that the greater extension of glaciers in former ages was connected with cosmic changes in the physical condition of our globe. All the phenomena related to the glacial period must be found in the southern hemisphere with the same characteristic features as in the north, with this essential difference, that everything must be reversed; that is, the trend of the glacial abrasion must be from the south northward; the lee side of abraded rocks must be on the north side of hills and mountain ranges, and the boulders must have been derived from rocky exposures lying to the south of their present position. Whether this is so or not has not yet been ascertained by direct observation. I

expect to find it so throughout the temperate and cold zones of the southern hemisphere, with the sole exception of the present glaciers of Tierra del Fuego and Patagonia, which may have transported boulders in every direction. Even in Europe, geologists have not yet sufficiently discriminated between local glaciers and the phenomena connected with their different degrees of successive retreat on one hand, and the facts indicating the action of an expansive and continuous sheet of ice moving over the whole continent from north to south. Unquestionably, the abrasion of the summits of the mountains of Great Britain, especially noticeable upon Schiehallion, is owing to the action of the great European ice-sheet during the maximum extension of the glacial phenomena in Europe, and has nothing to do with the local glaciers of the British Isles.

Among the facts already known from the southern hemisphere are the so-called rivers of stone of the Falkland Islands, which attracted the attention of Darwin during his cruise with Captain Fitzroy, and which have remained an enigma to this day. I believe it will not be difficult to explain their origin in the light of the glacial theory, and I fancy now they may turn out to be nothing but ground moraines, similar to the "Horsebacks" of Maine.

You may ask what the question of drift has to do with deep-sea dredging? The connection is closer than may at first appear. If drift is not of glacial origin, but the product of marine currents, its formation at once becomes a matter for the Coast Survey to investigate, and, I believe, it will be found in the end, that, so far from being accumulated by the sea, the drift of the lowlands of Patagonia has been worn away to its present extent by the continued encroachment of the ocean in the same manner as the northern shores of South America and of Brazil have been.

Hoping some, at least, of my anticipations may prove true,

I remain, ever truly yours,

LOUIS AGASSIZ.

PROF. BENJAMIN PEIRCE,

Superintendent Coast Survey, Washington, D. C.

