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CONTENTS

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ALEXANDER AGASSIZ: HIS LIFE AND SCIENTIFIC WORK[1]

ALEXANDER AGASSIZ, our distinguished alumnus and my friend, died at sea in mid-ocean on board the S. S. *Adriatic* on Easter morning, March 27, 1910. When this information was received in England by wireless message, it was believed that some mistake had been made, for only a few days previously he had parted with scientific friends in London apparently in most excellent health. The sad news was too speedily confirmed. A few days later I had occasion to speak before an assemblage of scientific men and oceanographers, and I said his death was a great loss to American science, to the science of oceanography, and to all people who take an interest in the progress of natural knowledge. On this occasion I propose to show that this statement was fully justified, and that a truly great man passed from the world when Alexander Agassiz died.

Alexander Agassiz was the only son of the famous naturalist, Louis Agassiz, by his first wife, Cecile Braun, and was born at Neuchâtel in Switzerland on December 17, 1835. His school days were spent at his birthplace and at the Bürger School at Freiburg, in Baden, Germany, where his maternal uncle was a professor in the university, where his mother and sisters then resided, and where he also came under the influence of a great biologist, Professor Theo. von Siebold. Here were laid the foundations of an education in the French

[1] Memorial address delivered in Sanders Theater, Cambridge, Mass., March 22, 1911, at the request of the president and fellows of Harvard College. Reprinted from the Bulletin of the Museum of Comparative Zoology at Harvard College.

and German languages and in science, which proved a great advantage in his future career. His mother was an artist, and we have hints that her temperament was very different from the placid uniformity which is said to have been characteristic of his father. The father and son are said by Dr. Walcott, who knew them both well, to have apparently belonged to absolutely different types.[2] When I sometimes observed outbursts of indignation, and impatience in Alexander Agassiz, I was always reminded of a passage in the quarrel between Cassius and Brutus in the play of Julius Cæsar.

Cassius exclaims:

Have you not love enough to bear with me,
When that rash humor which my mother gave me
Makes me forgetful?

And Brutus replies,

Yes, Cassius; and from henceforth,
When you are over-earnest with your Brutus,
He'll think your mother chides, and leave you so.

In 1849, at the age of thirteen years, the young Agassiz joined his father in America, and his later education took place at Harvard College and the Lawrence Scientific School at Cambridge, Mass., where the elder Agassiz occupied the chair of natural history. He used to refer with much pleasure and satisfaction to the manner in which he was befriended, soon after his arrival in the country, by Augustus Lowell, the father of our President Lowell. In 1855 Alexander Agassiz graduated at Harvard. Two years later he took the degree of S.B. in civil engineering, and later a second S.B. degree in natural history. Between 1856 and 1859 he taught in the Agassiz School, and here it was he first met, as a pupil, the young lady who was to become his wife. In 1859 he was appointed an assistant in the United States Coast Survey, and worked in California and Washington Territory.

[2] *Boston Evening Transcript,* April 6, 1910.

In 1860, at the age of twenty-six, he married Anna Russell. It was a love match, and the young couple started out with a very slender income. In the same year Agassiz was appointed assistant zoologist in the Museum of Comparative Zoology at Cambridge, founded by his father. His connection with this institution lasted as long as he lived—a full half century. During half of that period he acted as curator, succeeding his father. On resigning the curatorship in September, 1898, he served on the faculty of the museum as secretary. In 1902 he was made director of the University Museum.

In 1863 Agassiz became interested in coal mining in Pennsylvania, but afterwards turned his attention to the copper mines of Lake Superior, acting as superintendent of the Calumet and Hecla mines from March, 1867, to October, 1868. It was in consequence of his ability, attention, devotion and business habits that these mines turned out a great financial success at a later date. Up to the time of his death he was president of this successful company.

In 1869 he had a severe illness at Cambridge from the effects of over-work, anxiety and exposure at Calumet, from which it is believed he never fully recovered. The years immediately preceding this illness had been full of all the financial and other worries connected with mine superintendence and the care of a large and growing business. Still even at this busy period we find the dominant note of Alexander Agassiz's life continuously sounded—the desire to add to the sum of natural knowledge.

As a boy he had accompanied his father on his cruise in the *Bibb* off Nantucket, and in 1851 he aided in the survey of the Florida Reefs. Before he had reached the age of thirty over twenty publications had

appeared from his pen in various American scientific journals, the subjects ranging from the flight of lepidoptera and beaver dams to the position of sandstones on the shores of Lake Superior, and zoological classification.

The great majority, however, of these papers deal with marine organisms, such as medusæ, salpæ, annelids, actinæ, echinoderms and various pelagic larvæ. These papers, as well as the fact that he published in 1865, conjointly with his stepmother, Mrs. E. C. Agassiz, a popular book on marine life entitled "Seaside Studies in Natural History," show that even in his early career he was fascinated by the ocean, its myriad inhabitants and their conditions of existence. It could not well be otherwise, considering the intellectual atmosphere by which he was surrounded. He took a keen interest in the explorations of his friend, Pourtalès, off the coasts of Florida, and assisted in the description of his collections. In fact Agassiz's early manhood coincided with the great renewal of interest in the physical and biological conditions of the great ocean basins. Maury and Brooke had taught men how to sound correctly the deep sea, and Maury had published his "Physical Geography of the Sea" and a depth chart of the whole North Atlantic. Bailey had examined microscopically the deep-sea deposits under the gulf stream; Pourtalès had discussed the formation of green-sand in the same deposits, and the older Agassiz had pointed out the bearing of these new facts on the question of the permanence of continents and ocean basins. The observations of Lovén and Michael Sars had shown that, if there was a zero of life in the great oceans, it must lie at a much greater depth than Forbes had indicated from his observations in the Mediterranean. Wallich, Huxley and Haeckel had expounded their views on the habitat of the Globigerinæ, the shells of which covered the floor of the ocean, and of some organisms brought up from a great depth on sounding lines. The renowned "Bathybius" had been described as a living carpet on the ocean-floor and was accepted by the scientific world. Wyville Thomson, Jeffreys and Carpenter had conducted deep-sea explorations in the *Lightning, Porcupine* and *Shearwater,* capturing in great depths crinoids, irregular sea urchins and other marine creatures which were reminiscent of fossil forms.

All these fresh and striking facts, and the speculations connected therewith, must have been present in the mind of the young naturalist when recovering from his severe illness in 1869. One can well imagine how earnestly he desired to take an active part in the new explorations and investigations which were either then being carried out or were projected for the near future. At this time an unexpected occurrence enabled him to realize a long wished-for opportunity of visiting and examining the echini collections in European museums and of becoming personally acquainted with the British naturalists then engaged in oceanographical work and deep-sea exploration. One day when recovering from his illness he chanced to meet his friend, Mr. James Lawrence, of Boston. Lawrence remarked, "How ill you are looking!" and Agassiz replied that he thought he was dying. "Nonsense," said Lawrence, "what you need is rest and change of scene." "I can not afford it," was the reply. "Oh yes! you can," said Lawrence, "I'll be your banker." Agassiz never referred to this incident without emotion. He always felt that he owed his life to Mr. Lawrence.

Mr. and Mrs. Agassiz sailed for Europe in the autumn of 1869, with their children

and were absent from Boston for fully a year. This was a period of convalescence and of great pleasure and enjoyment; it was also a period of great activity and hard work. His first visit was to Wyville Thomson, who was then professor at Belfast, in Ireland. Years previously they had been in correspondence about the distribution and development of echinoderms, and Agassiz was, of course, anxious to see him and to learn all about the *Lightning* and *Porcupine* expeditions, in which Wyville Thomson had taken part, and concerning which he had just published a statement of results. The subsequent correspondence shows that this, as well as another visit towards the end of 1870, gave the greatest satisfaction to both naturalists as well as to their wives. Agassiz then proceeded to visit and examine the echini collections in nearly every museum in Europe. The great majority of the original type specimens described by the principal writers on the subject during the nineteeth century thus passed through his hands and were critically compared with specimens from the Museum of Comparative Zoology in Cambridge and from the recent deep-sea expeditions. A few extracts from his own letters will best indicate his progress, occupations and impressions during this visit to Europe.

Wyville Thomson had written to Agassiz after his visit to Belfast that he had lost or mislaid some deep-sea specimen, and Agassiz, jocularly, replied from London, assuring him that he had "taken nothing away from Ireland except a bad cold."

From Copenhagen he writes to Wyville Thomson: "What a pleasant place this is! My wife wishes me to send her kindest regards to Mrs. Thomson and yourself. I am here after a most successful trip through Germany, and am on my way to Stockholm. By the time I get through, we shall have been in every place where there is anything to be seen in the way of type echinoderms. I am getting on famously as far as the material for the echini catalogue is concerned. In Berlin I saw many nice things from Japan. I am just finishing the echinoids here with Lütken, who is a most charming fellow. . . ."

From Switzerland (Leuk, August 8, 1870) he writes: "I have done now with my examination of the Echini collections, having now seen them all, and I hope I shall not be prevented from getting out my catalogue very rapidly after my return home."

From Lausanne (August 23, 1870) he again writes to Wyville Thomson: "We have just come back from a charming trip to the mountains, had pleasant weather the whole time, besides doing us all a great deal of good. I am happy to say I am now picking up fast, and if I keep up at the present rate trust to be perfectly well this fall when I go home. We hope to be in London last part of October. We sail 8th November, and I shall manage if possible to take a run to Belfast and see what you have got (that is from the *Porcupine* expedition.) . . . I hope you will have the best of luck on your new trip, and find something more astounding than Rhizocrinus, Pourtalèsia or Calveria. Mrs. Agassiz wishes me to thank you very much for your kind invitation, and to send her kindest remembrances to yourself and Mrs. Thomson."

Here are some extracts from his letters immediately after his arrival at home:

"We had a capital passage; except two days when it was rough, it was quite pleasant, the whole not lasting more than a little over eight days from Queenstown, which for the season was admirable. I found father much better than I had hoped

to see him again. He manages to come to the museum for an hour or so a day, sees a few of his friends every day, and keeps going just enough to be employed. He improves daily, and I see no reason why he should not have a long period of usefulness yet, though of course nothing like his old work can now be expected from him again. . . .''

In March, 1871, he writes (from Cambridge)—''I am just getting out a new edition of the Seaside Studies, which will, however, be a mere reprint''—and in March, 1872: ''I hope you will accept the offer to go round the globe, and if you go may you get all the antediluvial things left. I am greatly afraid father's expedition is not going to result as well as we hoped; the vessel is a great disappointment, five weeks out of ten they have spent repairing. They have left Rio, and the next mail trust to hear from them in the Straits of Magellan.''

In April, 1872, he says: ''Don't be alarmed by the number of my epistles. But I wanted to acknowledge at once the safe arrival of the 'Calveria' and of the 'Phormosoma.' I need not tell you how greatly obliged I am to you. . . .''

The ''Revision of the Echini''[3] began to appear the year after his return from Europe. This is the best known of the works of Alexander Agassiz and at once stamped the writer as the leading authority on the subject. Part I. deals with the literature, nomenclature, synonymy and geographical distribution of the echini, and extends to 242 pages. Part II. deals with the echini of the east coast of the United States, including a report on the deep-sea echini collected in the Straits of Florida by Pourtalès in 1867–1869, and extends to 136 pages. Part III. contains the descriptions of the species of recent echini, and extends to 251 pages. Part IV. deals with the structure and embryology of the echini, and extends to 141 pages. The text thus occupies 770 quarto pages, and is illustrated by seven maps showing the geographical distribution and 87 plates giving full figures and details, in addition to numerous wood-cuts in the text. This report represents an immense amount of work and close study, and it became the standard for all subsequent investigations dealing with this class of animals.

Agassiz throughout his active scientific life was a constant student of echinoderms. He worked on starfishes and crinoids, but the principal object of his interest was the recent echini. His first publication on this fascinating group of animals was in 1863, and his last in 1909, covering a term of forty-six years, a long period of sustained interest and work. He described a considerable part of the deep-sea species and genera known to science in his monographs on the deep-sea echini collected by the *Challenger, Blake* and *Albatross* expeditions. He described as new, about one third of the known recent echini, of which there are some 450 species.

In addition to systematic work, he published on the development and morphology of echini as well as on their geographical and bathymetrical distribution. His work was almost wholly on recent forms, but in several of his works, especially the revision, and *Challenger* report, there is discussion of, and some observations on, fossil echini.

The three years immediately succeeding his return from Europe in December,

[3] ''Revision of the Echini,'' Illustr. Cat. Mus. Comp. Zool. (Cambridge, Mass.), No. VII., 1872–1874; by Alexander Agassiz. It was divided into four parts for purposes of publication; Parts I. and II. were issued together in 1872, the introduction being dated August, 1872, Part III. in September, 1873, and Part IV. in January, 1874.

1870, were the most active, fruitful and enjoyable of his whole life. His financial position had greatly improved and his mind was crowded with new schemes and new ideas with reference to the study of the ocean. He visited the *Challenger* expedition when the ship reached Halifax in May, 1873. He was enthusiastic about our captures, and he could teach us much we did not know, especially about echinoderm and annelid larvæ. I remember he showed us how he had proved that *Tornaria* was the larva of *Balanoglossus*. All the younger men of the expedition were pronounced evolutionists or Darwinists, and the name of Agassiz conjured up opposition to such views, but the impression made by Alexander Agassiz was excellent in every direction, the general judgment being that the younger Agassiz was a very different man from his distinguished father. It was freely prophesied that he would have a very brilliant scientific future. He was buoyant, cheerful, confident and possessed a fund of dry humor. He was rather above medium height, with brown eyes and dark complexion. He had a fine presence, dignified bearing and gracious manners. The following note received on board the *Challenger* some months after his visits indicates conscious capacity and the overflowing joy of life: "We are all flourishing here after a very successful summer at Penikese, about which you must have seen plenty in the papers. The museum is getting fuller than an egg, and I don't know what we shall do for room. We have just secured the collection of Wachsmuth—the finest collection of *crinoids* there is from the west, and with what we have, our collection is now superb. I shall attack them soon I hope." (Cambridge, October 24, 1873.)

The scene, the outlook on life, was suddenly changed. His father, Louis Agassiz, died on December 14, 1873. His beloved wife, Anna Russell, who had tenderly nursed and watched at the bed-side of her father-in-law during his last illness, caught cold from exposure on the night of his death, and died from pneumonia within ten days thereafter.

This was a terrible blow to Alexander Agassiz. The light and brightness of his life had suddenly been extinguished. A cloud fell upon him which nothing on this earth could completely clear away. His mental attitude towards the future is plainly stated in a letter written from Peru in March, 1875, and received on board the *Challenger* when we were voyaging in the Pacific. It evoked the deep sympathy of the *Challenger* naturalists. He says:

> I hear of your whereabouts through the papers occasionally, though lately I have not seen anything concerning your movements, as I have been wandering about in Chili and Peru, out of the way of all newspapers. I could not stand the associations of my house after the terrible ordeal I had to pass through, and for about five months I have been listlessly running from place to place trying to wake up an interest in outside matters. It is all well enough as long as I am on the move, and there is the excitement of constantly seeing new things and new people, but when I am settled down for any length of time, and attempt to do any continuous work, it is impossible for me to throw off my troubles, and life seems unendurable. Yet I can not deny that I have had a great deal of pleasure on my trip to South America, and under ordinary circumstances it would have been to me a great store of future enjoyment. As it is I look upon it as so much time passed, and really dread the moment when I shall reach home, or rather my house, for no place can henceforth be a home to me.

Even here, however, what I have called the dominant note of his life—the desire to get new knowledge—rings out strongly, for the rest of this distressful letter is taken up with a detailed description of his

exploration of Lake Titicaca. He had taken his museum assistant with him to help in making collections for the museum at Cambridge; he had chartered the only available vessel, had taken water and air temperatures, had dredged and tow-netted and constructed a bathymetrical chart of this elevated lake, 12,500 feet above sea level—altogether a most interesting description from all points of view.

The Alexander Agassiz before the death of his wife in 1873 was, in my opinion, a very different man from the Alexander Agassiz after that sad event. The first Alexander Agassiz I had seen, but I knew him only very slightly. I have pictured him as he appears to me from his correspondence, from what I have heard from his intimates, and from his own lips. The second Alexander Agassiz I knew well, long and intimately; he was during the last thirty-four years one of my most intimate and valued scientific friends.

During his visit to the *Challenger* at Halifax he promised to come to England on the return of the expedition to see our deep-sea treasures. When he arrived in Edinburgh I referred to the death of his wife, but he held up his hands and said, "I can not bear it." His expression was such that the subject was never again mentioned, although he frequently spoke about his boys. He spent fully two months in Edinburgh, but would not at that time attend any social functions. Every day from early morning till as long as day-light lasted he assisted me in opening boxes and bottles and in separating out the various groups of marine organisms, especially selecting the echini, which he was to take to America, having consented to describe this group of organisms for the report on the scientific results of the expedition. While this work was going on we had abundant opportunity for discussing the work and results of the expedition and every aspect of the new science of the sea. I was relatively young, and often recounted to him the comic and other incidents of the voyage, and he would smile and seem amused. His attitude was, however, in striking contrast to the boisterous merriment of Haeckel when engaged with me in the same place and in similar occupations. On the conclusion of his visit he wrote to Wyville Thomson on January 23, 1877:

> I can't tell you what a pleasant time I have had in Edinburgh, thanks to you and Lady Thomson. It is really the first time since the death of father and my wife that I have felt in the least as if there were anything to live for, and I hope you have put me on the track to get into harness again and do my share of the work I have to do, if not with pleasure, at least cheerfully.

During the last thirty-five years of his life Alexander Agassiz's activities and interests were many and varied. The control and direction of the Calumet and Hecla mines demanded frequent visits to the west, and there we find him conducting valuable experiments in the distribution of underground temperatures in the great depths of the mine. We also find him producing carbonic acid gas to put out a disastrous fire in the mines—said to be the first time this method was thus employed on a large scale.

The first American attempt to found a zoological station at Penikese having failed, he established a zoological laboratory at Newport to take its place, equipping it with all the necessary appliances and accommodations for twelve students. This institution was carried on for twenty-five years—till it was no longer necessary owing to the establishment of the Woods Hole Marine Biological Station.

The important series of oceanographical or deep-sea investigations with which his name is so closely associated have won for

him the gratitude of all subsequent generations of scientific workers. He directed three expeditions in the Atlantic in the U. S. S. *Blake,* and three in the Pacific in the U. S. S. *Albatross.* These dealt especially with the deep-sea, and yielded an immense number of new organisms and new observations concerning the physical, chemical, biological and geological conditions of the great ocean basins. Agassiz, being a practical engineer, was able to suggest many improvements in deep-sea instruments and methods; the wire rope for dredging and a modified trawl for deep-sea work were among these improvements. The general account of the Atlantic expeditions is published in two volumes entitled "Three Cruises of the *Blake,*" and the general accounts of the Pacific expeditions are to be found in the bulletins and memoirs of the Museum of Comparative Zoology. It would be difficult to overestimate the value of the zoological and other collections amassed during these most excellent and extensive explorations.

If we can say that we now know the physical and biological conditions of the great ocean basins in their broad general outlines—and I believe we can do so—the present state of our knowledge is due to the combined work and observations of a great many men belonging to many nationalities, but most probably more to the work and inspiration of Alexander Agassiz than to any other single man. Agassiz's researches in the Atlantic resulted in very definite knowledge concerning the submarine topography of the West Indian region and of the animals inhabiting these seas at all depths—probably we know more of this submarine area than of any other area of equal extent in the world because of his explorations. He arrived at the general result that the deep-sea animals of the Gulf of Panama were more closely allied to those in the deep waters of the Caribbean Sea than the Caribbean forms were to those of the deep Atlantic. Hence he concluded that the Caribbean Sea was at one time a bay of the Pacific Ocean, and that since Cretaceous times it had been cut off from the Pacific by the uprise of the Isthmus of Panama.

When the *Challenger* expedition carried her explorations down through the central southern Pacific, she found a rather puzzling state of things. In deep water relatively very few animals were captured on the bottom of the ocean when compared with those taken in the great southern ocean or nearer continental shores; those obtained were, however, of rather pronounced archaic types. The deposits in the same area were of surpassing interest; large quantities of a deep-brown clay were hauled up, in which were imbedded enormous numbers of manganese nodules and concretions, some of them being formed around sharks' teeth, ear bones and other bones of whales, and others around volcanic fragments mostly converted into palagonite. Sometimes hundreds of sharks' teeth and dozens of whales' ear bones were captured in a single haul, and most of them belonged to extinct species. Small zeolitic crystals and crystal balls were also mixed up in these red-brown clays, evidently formed *in situ.* More extraordinary still were the minute spherules having a hard black coating and an interior of pure iron and nickel, as well as other minute spherules, called chondres, found hitherto only in meteorites. These spherules are believed to have an extra-terrestrial origin, and to have formed at one time the tails of meteorites or falling stars. This was a strange assemblage of things, and some scientific men argued that such a condition of matters must be regarded as local and accidental.

Now Alexander Agassiz explored anew this region of the earth's surface the furthest removed from the shores of continental land, and he found that the same condition of things extended over vast areas of the Pacific Ocean. Here we have almost certainly the region of minimum accumulation on the sea-floor, and recent investigations indicate that there is in these deep deposits more radio-active matter than anywhere else in the solid crust of our planet. A satisfactory and clear understanding of the phenomena has not yet been obtained, but Agassiz's researches take us a long way on the road to a solution of some exceedingly interesting and important oceanic problems.

During the last thirty years of his life, Agassiz became very greatly interested in all coral-reef problems, and organized very many extended expeditions, almost entirely at his own expense, with the view of studying coral reefs, coral islands, and upraised coral formations. It would be wearisome to give even an abstract of all the publications by himself and his assistants dealing more or less directly with these subjects. It can truly be said that he visited, explored and described with much detail every important coral-reef region of the world, in the Atlantic, Pacific and Indian oceans.

Agassiz's special interest in the coral-island problem was apparently first awakened during his visit to Edinburgh in 1876. I had sketched out a series of papers to be presented to the Royal Society of Edinburgh during that session, and he heard the first of these read, viz., "The Distribution of Volcanic Débris over the Floor of the Ocean, its Character, Source and some of the Products of its Disintegration and Decomposition." He became rather enthusiastic about the results arrived at in the paper. Another of these papers dealt with the distribution of carbonate of lime over the floor of the ocean and with coral-reef formations. One of the most striking results of the *Challenger* expedition was the discovery of enormous numbers of pelagic calcareous algæ, pelagic foraminifera and pelagic mollusca in the surface and sub-surface waters everywhere within tropical and sub-tropical regions, but the dead calcareous shells of these pelagic organisms were not distributed with similar uniformity over the floor of the ocean. In some places they formed pteropod and globigerina oozes, but in the very greatest depths not a trace of these shells could be found in the red clays which covered the bed of the ocean. It was observed that the thinner and more delicate shells disappeared first from the marine deposits with increasing depth, and only the thicker and more compact shells or their fragments reached the greater depths. These conclusions were verified again and again during the cruise of the *Challenger,* and subsequently by Agassiz in his expeditions. Evidently the calcareous shells were removed by the solvent action of sea-water as they fell towards, or shortly after they reached, the bottom of the ocean. In the shallower depths the majority of the shells reached the bottom before being completely dissolved, and there accumulated. The solvent action was also retarded in these lesser depths through the sea-water in direct contact with the deposit becoming saturated, and therefore unable to take up more lime. The explanations thus given to account for the disappearance of carbonate of lime from deep-sea deposits were then applied to the interpretation of the phenomena of coral atolls and barrier-reefs. It was argued that all the characteristic features of atolls and barrier-reefs could be explained by a reference to the biological, mechanical

and chemical processes everywhere going on in the ocean without calling in the extensive subsidences demanded by the theories of Darwin and Dana.

Agassiz almost at once adopted these views, saying, "I never really accepted the theories of Darwin and Dana; it was all too mighty simple. Besides," he added, "this new view is founded on observation and can be verified, and I'll attempt to do it, and will visit coral-reef regions for the purpose."

Darwin, it will be remembered, stated that his whole theory was thought out on the west coast of South America before he had seen a true coral reef.[4] The method of Agassiz was to see every true coral-reef region of the world before he formed any theory.

Darwin's theory of coral reefs may be briefly stated as follows: The corals commence by forming fringing reefs along a shore. The shore commences to subside, but the corals grow directly upwards. In course of time a lagoon-channel is formed between the growing reef and the subsiding shore-line. When this process continues for a sufficient length of time the central island completely disappears beneath the waves, and the lagoon of an atoll occupies ultimately the place of the island. The fringing reef thus develops into the barrier reef, and the barrier reef develops into the atoll.

Agassiz writes in 1909 that the result of his studies on coral reefs has been "to dissent *in toto* from the views of Dana and Darwin regarding the mode of formation of barrier reefs and atolls."

In 1902, after his visit to the Maldives, he wrote to me as follows:

> This will be the end of a most successful expedition, perhaps to me the most interesting visit to a coral-reef group I have made. For certainly I have learned more at the Maldives about atolls than in all my past experience in the Pacific and elsewhere. I should never have forgiven myself had I not seen the Maldives with my own eyes and formed my own opinion of what they mean.—Such a lot of twaddle—it's all wrong what Darwin has said, and the charts ought to have shown him that he was talking nonsense. . . . At any rate I am glad that I always stuck to writing what I saw in each group and explained what I saw as best I could, without trying all the time to have an all-embracing theory. Now, however, I am ready to have my say on coral reefs and to write a connected account of coral reefs based upon what I have seen. It will be a pleasure to me to write such a book and illustrate it properly by charts and photographs. But it will be quite a job with my other work on hand. I hope to live to 100! or rather I don't hope, but ought to! to finish all.

Later, in 1907, he writes: "I have started on my coral-reef book, but it is a job, a good deal more than I expected. If I stay at home I ought to make good progress." Later in the same year he says: "I fancy I shall have all the time I want to write out my popular account of coral reefs. I have made a fair beginning, and hope to keep the material within reasonable bounds and not allow it to run away with me." Four months before his death he wrote: "I have worked hard at my coral-reef book," and only a few days before his death he told me in London that he had really sketched out this book three times, but found it very difficult indeed to deal satisfactorily with the mass of information that had been collected. It was his intention, he stated, to write this book during the present year practically for the fourth and last time, leaving out all criticism of the work of others and stating exactly what he had himself observed and his own views.

When in 1903 he addressed the Royal Society of London on coral reefs, he simply described what he had seen in the various

[4] See "Life and Letters of Charles Darwin," Vol. I., p. 70, London, 1887.

coral-reef regions, and did not enter into any controversial matters. The real point of his address came out in the subsequent discussion, viz., that in all his investigations and voyages he had not seen one single atoll or barrier-reef which could be said to be an illustration of the Darwinian theory of coral reefs. It was evident to a large number of naturalists who had themselves observed in the field that the subsidence theory was no more necessary to account for the characteristic features of atolls and barrier reefs than the elevation theory of Darwin—published about the same time—was necessary to account for the Parallel Roads of Glen Roy in Scotland.[5]

It is difficult to account for the heated controversies which have raged around the coral-reef question. Possibly these would never have taken place had the subsidence theory not been associated with the name of Darwin. Very many of the public did not seem to realize that this theory of coral reefs was the work of Darwin when young and inexperienced, and had nothing whatever to do with the theory of natural selection. When the late Duke of Argyll published his famous article entitled "A Conspiracy of Silence," in the nineteenth century (September, 1887), he gave *Bathybius* and *coral-reef theories* as illustrations, and many people regarded the article as a suggestion that Darwinists and evolutionists were disposed to burke free discussion. This was hotly resented by Huxley and others, while some naturalists seem to have believed they were called upon to defend Darwin's coral-reef theory, although they had never seen or examined a coral-reef. Agassiz kept severely aloof from all these controversies, although he writes that he was much amused by the style of various articles and controversies. In one letter to me (March, 1888) he writes: "I am glad to see by last *Nature* that you are taking a hand in the coral discussion now that it has reached *hard bottom* and no longer deals with imaginary quantities, impossible algebra and metaphysical squibs."

All scientific men must regret that Agassiz was not spared to publish the long-expected summary of his coral-reef work, and to learn that he has not left behind any manuscript suitable for publication giving a connected statement of his views. Such a work from his pen would doubtless have been a splendid edifice erected on the magnificent foundation of observation laid with so much expense, trouble and care in the elaborate memoirs on the coral-reef regions he had visited in all parts of the world.

Throughout all these coral-reef investigations I have been in substantial agreement with Agassiz's views. In these circumstances I need make no apology for giving a short statement of the conclusions at which, I think, Agassiz had arrived as a result of his coral-reef investigations.

Agassiz claimed, I believe, to have shown that existing atolls and barrier reefs in no way indicate, even approximately, the former position of the shore lines around islands or along coasts now deeply submerged beneath the ocean.

The submerged banks from which atolls and barrier reefs now arise have been formed—that is, they have been built up or leveled down—in a great variety of ways, and at very different times. Each coral-reef region must in this regard be studied by itself, account being taken of

[5] See "Observations on the Parallel Roads of Glen Roy, and of other parts of Lochaber in Scotland, with an attempt to prove that they are of marine origin," *Phil. Trans.*, 1839, p. 39; *Edin. New Phil. Journ.*, Vol. XXVII., p. 395, 1839.

the surrounding physical and geological conditions.

The reefs themselves have been very largely—in some instances, predominantly—made up of lime-secreting organisms other than the so-called reef-building corals, such as calcareous algæ, foraminifera and corals other than true reef builders, many of which have a wide depth range.

The characteristic features of coral-reefs—the central shallow lagoon and the surrounding rim of living coral with deep water outside—are mainly to be explained by biological, chemical and mechanical activities continuously in operation at the present time, there being vigorous growth of all lime-secreting organisms wherever the conditions of life are most favorable, and less vigorous growth and even death of these organisms where the conditions are unfavorable. A detailed study of the favorable and unfavorable conditions for different species in an existing atoll seemed to Agassiz a great desideratum at the present time and I am delighted to learn that this is now being undertaken by American naturalists under the auspices of the Carnegie Institute.

In small atolls, where the surrounding reef is very extensive relatively to the enclosed lagoon, the lagoon tends to become filled up by the accumulation of coral sand, the deposition of carbonate of lime by the living organisms of the atoll being in excess of that removed in solution and by mechanical means; where the atoll is large, and the encircling reef is—relatively to the size of the lagoon—small, then the lime removed from the lagoon by solution and currents is greater than that deposited by living organisms; hence the lagoon becomes deeper and wider. The lagoon of Diego Garcia appeared to have increased considerably in area in this way between 1837 and 1885.

It is undoubtedly true that many coral-reef regions have been recently elevated. The circular atoll and barrier reef can not be accepted as evidence of subsidence; the characteristic features of coral reefs would be very similar in a stationary, in a slowly sinking or slowly rising area, although each would show secondary modifications. It matters not whether the change of sea-level be due to crustal movement, to attraction of elevated continental land, or to the accumulation or the melting of polar ice-masses.

When coral plantations rise from a submerged bank, the corals and other lime-secreting organisms situated towards the seaward edge would from the first have the advantage; they would hence reach the surface, before the central portions, where the corals would be in a position more or less unfavorable for vigorous growth. A shallow lagoon would thus be formed, which might subsequently be cleared by solution, and mechanical action of many of its living coral plantations.

The coral atoll, on reaching the surface would, he admitted, in very many cases advance seawards on a talus of its own débris, expanding like a fairy ring, and it seemed to him more than probable that the boring at Funafuti atoll was driven down into such a talus, with an underlying Tertiary base.

The red earth which is found on coral islands and supplies the food for plant life, is chiefly derived from the disintegration and decomposition of floating pumice, which is frequently thrown up by the waves on the reefs.

These results of Agassiz depend on a far greater number of original observations, in widely scattered areas, than have been made by all the other authorities on coral reefs put together.

When we attempt to survey the life-work of Alexander Agassiz, we are aston-

ished at its amount, variety and quality. His activities in any one direction would have been an excellent record for any one man, but he was many sided. He was largely engaged in commercial undertakings and directed a great business during the whole latter half of his life; he carried on detailed researches and published splendid memoirs on the group of echinoderms—a subject on which he was regarded as the leading authority. In his deep-sea researches he added greatly to the world's knowledge of the great oceans, and inspired the investigations of a very large number of zoological and other specialists. In his study of coral-reefs he traveled more extensively than any man of his time—many thousands of miles—with one special object in view—to see with his own eyes the varied forms which these gigantic and beautiful natural structures assume under different conditions. We must likewise take into account his work in the laboratory and in the study, where the reports on his many voyages, cruises, travels and collections had to be prepared for publication. Again one must recall the services he has rendered to his *alma mater*—Harvard University—in his general assistance in administration, his special care of its museums, his donations for extensions in many directions, and lastly his altogether grand series of publications from the Museum of Comparative Zoology.[6] His great desire was to add to the sum of natural knowledge by his own work and by the impulse he could give to others imbued with a similar spirit and desire. He worked and struggled continuously and heroically with that end in view, and with those who are now engaged in working up his results and collections in all civilized countries he is still a living force, and will be so for many years to come, for he has arranged for the publication of all the results of these researches. I used to meet him nearly every year either in Europe or in America, when we spent a few days together discussing almost all oceanic problems. I am conscious of his effect on my life and all my scientific work. As an example of the influence he exerted we have only to look at the introduction to the three splendid volumes recently published on the medusæ of the world by Alfred Goldsborough Mayer, where the initiation and encouragement of a generous master and friend are gracefully acknowledged. Many instances might be cited to show how well and judiciously he applied his wealth to set agoing work which he considered worth doing, not only in his own time but also in the future. The large number of decorations and honors which were conferred on Alexander Agassiz by governments and universities and by learned societies in all parts of the world show abundantly how highly his scientific labors were appreciated by his contemporaries.

It has been truly said that man does not live by bread alone. History is crowded with instances illustrating the fact that men have cast off this mortal coil as so much worthless dross when impelled by the demands of some spiritual truth. Other men have endured the greatest hardships and privations in their endeavors to create the beautiful in form, in sound or in color. As it has been with the religious and artistic spirit in the past, so is it with the modern scientific spirit. The desire to find out the secrets of nature impels men to trudge over Arctic and Antarctic ice-fields with the satisfaction of all bodily requirements reduced to a minimum and burdened with a load of scientific instruments. Other men expose their bodies to the at-

[6] Fifty-two volumes of the *Bulletin* and thirty-two volumes of *Memoirs*.

tacks of pestilential microbes for the advance of knowledge and the betterment of man's estate, while Alexander Agassiz rises with difficulty, when overwhelmed with sickness, and has his mattress laid on the deck of the tossing steamer in order that he may the better record the message which the dredge or trawl has brought to light from the dark abysses of the Atlantic or Pacific Ocean. In such men the body has truly become merely the vehicle of the soul.

It has been said that Alexander Agassiz was a sad and reserved man. It must be admitted that during the latter part of his life he was not so moved by joyous impulses as in his earlier years. Those who knew him well did not find him reserved, and they can testify to the great pleasure he derived from a new discovery or a new view of the interrelations among natural phenomena.

It has also been said that he did not interest himself in the deeper philosophical aspects of the researches in which he was engaged. This I believe to be a mistake. He professed never to engage in discussions except where it was possible to verify one's conclusions by an appeal to observation or experiment. Although he did not publish papers dealing directly with philosophical subjects, still he was keenly interested in all evolutionary problems. He used to say that Darwin had probably explained the survival but not the arrival of species, and he looked forward to a great increase of knowledge from experiments in Mendelism. He believed that the mutation theory had received remarkable confirmation by experiments carried on in recent years. He believed that the doctrines of heredity, which had been so successfully applied to the improvement of domestic plants and animals, would, in the not very distant future, be in like manner applied for the elevation of the human species, the most important of all domestic organisms. He felt convinced that the modern theories as to electrons, the disruption of atoms, and as to energy configurations in the ether being the sole ultimate phenomenal basis of matter would in time profoundly affect the philosophical outlook of many naturalists and their mental attitude generally towards materialism and the riddles of the universe. The study of the world of physical and mental phenomena, he would say, was sufficient for this life. The deeper and more earnestly these were investigated, the brighter and more definite would become the glimpses of that eternal something lying behind all manifestations, which in the meantime he was content to reverence. His religious feelings seemed to be best expressed as a yearning after a higher and better life, which he held would become more attainable and more pronounced as mankind advanced in scientific knowledge. Like all great men he was

> A dreamer of the common dreams,
> A fisher in familiar streams:
> He chased the transitory gleams
> That all pursue,
> But on his lips the eternal themes
> Again were new.

Great he unquestionably was. Great in his power for work, great in his conception of duty, great in his desire to add to natural knowledge, great in the height of his love, great in the depth of his sorrow, great in his elevated personality, great in his admiration for his university, great in his patriotism, great in his ideas as to the destiny of our race, great in his influence for good, like the genial and vivifying rain from heaven. Like all of us he doubtless had faults, both hereditary and acquired. We know that

His life was gentle, and the elements
So mix'd in him, that Nature might stand up
And say to all the world, "This was a man!"

When his near relatives and dear friends affectionately laid his mortal remains beside those of his beloved wife last March in the Forest Hills Cemetery, well might they ask—

What hallows ground where heroes sleep?
'Tis not the sculptured piles you heap.
But strew his ashes to the wind,
Whose sword or pen has served mankind.
And is he dead, whose glorious mind
Lifts mine on high?
To live in hearts we leave behind
Is not to die.

JOHN MURRAY

CHARLES M. SCAMMON

CAPTAIN CHARLES M. SCAMMON, U. S. R. M., retired, senior officer of the service, died at his home, in East Oakland, Cal., May 2, in his eighty-sixth year. His death followed in less than twenty-four hours after that of his wife to whom he had been united for sixty-five years.

Captain Scammon was a native of Maine and came to the west coast in 1853, and for a time was engaged in the pursuit of whaling. He was the discoverer of the large lagoon on the west coast of Lower California in latitude 27° 50′, which has since borne his name. In 1861 he joined the revenue service with which he was connected until his death. He was detailed by the government to assist in the explorations of the Overland Telegraph Expedition in 1865, and commanded the flagship of their fleet for three years. To his intelligent and kindly cooperation the scientific corps of that expedition owed much of their success. Captain Scammon early became interested in the natural history of the marine mammals of the Pacific coast, and in those days before the invention of photographic dry plates, spared no trouble in gathering measurements, drawings and other data bearing on the cetacea. In 1874 these investigations were summed up in his finely illustrated quarto volume on the "Marine Mammals of the Northwestern Coast of North America," which forms the most important contribution to the life history of these animals ever published, and will remain a worthy monument to his memory.

WM. H. DALL

SCIENTIFIC NOTES AND NEWS

PROFESSOR E. C. PICKERING, director of the Harvard College Observatory, has been created knight of the Prussian order Pour le mérite. Simon Newcomb and Alexander Agassiz are the only other American men of science on whom this honor has been conferred.

DR. THEODORE WILLIAM RICHARDS, professor of chemistry at Harvard, who is going to England at the invitation of the Chemical Society to deliver the Faraday lecture, will be given the honorary degree of D.Sc. by the University of Manchester on July 8.

DR. FREDERICK W. TRUE, who has held the position of head curator of the department of biology in the U. S. National Museum since 1897, has been appointed assistant secretary of the Smithsonian Institution in charge of the library and exchanges.

LORD CURZON, of Kedleston, has been elected president of the Royal Geographical Society in succession to Major Leonard Darwin.

THE Hanbury medal of the London Pharmaceutical Society for 1911 has been awarded to M. Jean Eugène Léger, chief pharmacist to the Hôpital St. Louis, Paris.

THE Royal Academy of Sciences of Berlin has elected Dr. James George Frazer, fellow of Trinity College, Cambridge, and professor of social anthropology at Liverpool University, a member of the Philosophical-Historical Section.

THE American Philosophical Society at its recent meeting, elected the following residents of the United States to membership: George A. Barton, professor of Semitic languages, Bryn Mawr College; Bertram Borden Boltwood, professor of radio-chemistry, Yale Uni-