# MEMOIR

OF

# LOUIS AGASSIZ.

## 1807-1873.

BY

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# BIOGRAPHICAL MEMOIR OF LOUIS AGASSIZ.

Mr. PRESIDENT AND GENTLEMEN OF THE ACADEMY:

For some time past there has been among us a vacant place which cannot easily be filled. The extraordinary personal qualities of character, as well as the talents and attainments of its former occupant, render such a task indeed almost impossible. We, in common with all prominent scientific associations of the country, sorely miss in our meetings the genial countenance, the quick, intellectual eye, the animated words of a colleague who was one of the framers of this Academy, and who never, to his last hour, ceased to be its truest friend and one of the most active contributors. Such indeed was our lamented LOUIS AGASSIZ. His untimely death, under the weight of labors disproportionate even to his giant strength, we deeply mourn with all those who have at heart the progress of the science of nature.

Mr. President, you have seen fit to entrust to me the duty of reviewing the life and labors of our departed associate, both for our own benefit and for that of the world at large. While I am deeply sensible of the honor thus conferred on me, I do not less deeply feel the weight of responsibility attached to the office, and almost wish that it had devolved upon one more specifically acquainted with the recent development of zoölogical science. But perhaps your choice was determined by the fact, well known to you, that, owing to circumstances and to intimate relations of friendship, I have been enabled to watch, not only with the deepest interest as a lover of science, but with brotherly fondness, every step of Agassiz in his onward progress from the days of his youth to the time of his death. With these opportunities of obtaining a full insight into his scientific life, and confidently hoping for an ample measure of your indulgence, I felt that it would be ungracious on my part to decline to perform, to the best of my ability, this last duty towards a beloved friend and life-long associate.

Agassiz, in more senses than one, is a unique figure in the history of the scientific progress of our day. In Europe he already occupied among men of science a position in some manner exceptional, I may say privileged, which no other scientific man of equal or even superior merit has enjoyed. In this country, during the last quarter of a century, he has been in the popular mind, more than any other man, the representative of the faithful, unflinching devotee of natural science.

In both hemispheres he found crowds of enthusiastic admirers; in both he became the centre of a marvelous scientific activity, the guide of numerous followers in the investigation of the mysteries of nature. Such facts reveal an individuality of uncommon power which deserves our special attention.

In tracing this rapid sketch it is not my object to intrude upon the sacred domain of private life, into which the public gaze has no right to penetrate; nor will you expect of me so much a rehearsal of the minute circumstances of his life, so often told, as a record of the phases of his scientific career, and such details as throw light upon the character of his native power, the use he made of his opportunities for development, and the glorious results to which he attained.

Near the shore of the quiet Lake of Morat, in Canton de Vaud, Switzerland, on the gentle slope of a lovely hill called the "Vuilly," facing the majestic group of the Bernese Alps, nestles among cultivated fields and vineyards the modest village of Motier. In passing the humble parsonage the traveler's attention is arrested by a tablet of black marble bearing in fresh cut letters this inscription: Louis Agassiz, célèbre Naturaliste, est né dans cette maison, le 28 Mai, 1807. (Louis Agassiz, the celebrated naturalist, was born in this house, May 28, 1807.) This is the simple memorial of the villagers, expressing their pride in the illustrious son of their former pastor.

Here, in the midst of a nature so rich in beauty, the first born son of a charming family, Agassiz passed his infancy and early boyhood with his younger brother and two sisters, under the fostering care of a mother distinguished alike by her intelligence, her wisdom, and the sweet dignity of her manners. His father was a descendant of that sturdy and noble race of French Huguenots, the flower of their nation, driven from their native land by the folly of a demented despot. His mother, Mademoiselle Rose Mayor, was the daughter of a highly esteemed physician of Lausanne. From both,

Agassiz inherited some traits of character, but above all he was a true Swiss, craving free development, undaunted by obstacles, and filled with that instinctive disregard for the shackles of the mere conventionalities of social rank which he retained through life.

Somewhat later his father accepted a call as pastor in the ancient and picturesque city of Orbe, at the foot of the Jura, on the banks of the clear stream of the same name, which, at a short distance higher up, gushes from the bosom of the mountain a ready-made river.

Who can doubt the influence of these magnificent scenes upon the impressible mind of young Agassiz in awakening, developing, and directing his innate love of nature? In both these early places of abode he found, in a rich and varied vegetation, food for his first studies in botany. To the renowned brook trout of the Orbe, and to the fish of the neighboring lakes, objects of his boyish sports, we can trace the early predilection of his observing mind for that class of vertebrates, and the starting point of his classic work on the Salmonidæ, as well as of his extensive studies on the fresh-water fishes, by which he was led to his still more important researches on the fishes of ancient days. In the Jura mountains he found later most of the materials for his great work on the Echinoderms. There also he discovered marks of the presence, in geological times, of gigantic glaciers, descended from the distant Alps.

From his very home he could see looming up before his eyes the snowy heights of the Bernese Oberland; the Jungfrau, with its immaculate white robe; the Schreckhorn and the Finsteraarhorn with their dark, jagged peaks, too steep to retain the snow; both Eigers, with their sharply defined forms, together with scores of other peaks, including Mt. Blanc. Who can count it an accident that these noble heights should afterwards have become the theatre of his celebrated researches on the glaciers? These coincidences show that at this early age Agassiz already possessed that disposition of mind so indispensable to the true naturalist, which leads him to derive his knowledge of nature from nature itself, and not from the observations of others.

The young Louis began a course of classical studies, at the age of eleven, in the College of Bienne, in the neighboring canton of Berne, and was for two years longer a student at the Academy of Lausanne. He then, in 1824, entered upon a course of professional studies in the Medical School of Zurich, where he spent two years.

The sports of his younger days were the collecting, observing, and classifying objects of natural history, to which he devoted every leisure hour. He now began a more methodical study of the science of nature, greatly encouraged by one of his professors, the distinguished zoölogist Schinz. Following the custom of European students, of seeking instruction from the masters in each special department, he left Zurich to pursue his studies in the University of Heidelberg. Here he devoted himself to physiology and anatomy under Tiedeman, the great teacher of the day, to zoölogy under Leuckart, and to botany under Bischoff.

It was in this most charming of German university towns that he found a new friend in a fellow-student whose acquaintance was to mark an important epoch in his life. Alexander Braun, the distinguished botanist and philosopher, the discoverer of the phyllotaxis, who at the time of his death, in March, 1877, occupied the high position of professor in the University of Berlin and the director of its splendid botanical garden, was then also studying in Heidelberg. Similar tastes and an equal enthusiasm for natural science drew these two young men together, and established between them a sympathy which soon ripened into an intimate and lasting friendship. Braun invited Agassiz to spend the long summer vacation of several months with him in Carlsruhe, Grand Duchy of Baden, in company with other friends interested in the same studies.

The terms in which he announced to his family the coming of the new guest is expressive of the fascination which Agassiz's genial nature and early attainments exerted upon all those who met him. "I bring to you," said Braun, in a letter to his father, "one who knows every fish which passes under the bridge, every bird which flies above our heads, every insect which crawls in the grass, every plant which grows on our mountain side," and indeed after his introduction into the family Agassiz seemed to make good the words of his friend.

It was my good fortune to be at this time an inmate of the Braun family, with whom some of my nearest relatives had been on terms of intimate friendship for several years before. I was delighted to hail the coming of my friend and countryman. The arrival of the eldest son of the house, already distinguished by previous scientific publications, with his three university friends, Agassiz, Carl Schimper, the gifted colaborer of Braun in the discovery of the phyllotaxis, and Imhoff, of Bâle, the future author of one of the best en-

tomological faunas of Switzerland and Southern Germany, was a stirring event, which threw new life into the quiet circle. After a short time devoted to a mutual acquaintance every one began to work. The acquisition of knowledge was the rule of the day. Social enjoyment, however great, was but the sweet condiment to more solid food. My remembrances of these few months of alternate work and play, attended by so much real progress, are among the most delightful of my younger days. Allow me to introduce you, for a few moments, into the interior of this gifted and cultivated family, in which the highest aspirations, both to artistic and intellectual excellence, were so happily blended with the good-natured simplicity of manners so characteristic of society in Southern Germany.

Mr. Braun, the head of the family, held the office of postmaster general of the Grand Duchy of Baden, a department which he brought to a high degree of efficiency. He was a man of decided scientific tastes and ability. Mineralogy was his choice, and his collection of minerals ranked among the first in the land.

Mrs. Braun, a woman of uncommon intelligence and literary culture, was the leading spirit of the family, directing into harmonious action all the young and powerful elements under her control. Two sons and two daughters completed the immediate family.

The elder son, Alexander, we already know; the younger, Maxamilian, then a mere boy, inherited the tastes of his father. Later in life he became a skillful mining engineer, and for more than a score of years was chief director of the largest zinc mine of Europe, "La Vieille Montagne," in Morisnet, near Aix-la-Chapelle. Finding himself at the head of 6,000 rough and lawless miners, he attempted a moral reformation imperatively demanded both for the success of his operations and the welfare of the men themselves. In this he was eminently successful, and he had his recompense in the prosperity of that great establishment and in the love and respect of his men. He received from Paris a reward of honor spontaneously granted in acknowledgment of the great services rendered by him in the amelioration of the laboring classes.

The elder daughter, Cecilia, who a few years later became the wife of Agassiz and the mother of all his children, was a noble-minded young woman of rare moral excellence. A dignified serenity, tempered by much gentleness and simplicity of manner, won for her at once respect and affection. Her deeper feelings were

often veiled by a natural reserve, which, however, never assumed the appearance of coldness. Her talent for drawing was of the first order, and she was fond of placing it at the disposal of her favorite brother, Alexander. The drawings of natural objects which she executed for him, and later for Agassiz, commanded the admiration of all by their taste and exquisite correctness.

The younger daughter was already noted for her musical taste and ability, which afterwards developed into a high degree of excellence.

Add to these attractions the charm of the society of a few select and intimate friends, professors, clergymen, and artists, dropping in almost every evening, and you will easily understand how congenial, how fostering to all noble impulses, must have been the atmosphere of this family for the young and happy guests assembled under its hospitable roof.

The very place selected by Mr. Braun for building his residence was expressive of his tastes. It was opposite the large park which nearly surrounds the Grand Ducal Palace, with a view of its beautiful groves, peopled by innumerable nightingales which filled the evening air with their sweet melodies. Behind this curtain of green foliage, almost in sight of the house, was the rich botanical garden with its green-houses, which forms a part of the palace grounds. Within a few steps one of the principal gates of the city opens into a forest of grand old oaks, the Hartwald, which extends nearly to the Rhine. Attached to the Braun mansion, extending into its spacious garden, and secluded from the noise of the street, was a long wing containing a suite of rooms. The chambers in the upper story were destined for the guests; the lower story was devoted to science. The first room below was occupied by the father's rich collection of minerals; the others, full of dried and living plants, growing confervæ, microscopes, and costly books of reference, were the laboratories of his sons and friends. Here were deposited, compared, and submitted to close scrutiny the treasures collected day after day by the little band in the neighboring country. Here, too, were discussed at length with youthful ardor and audacity the theories suggested by the facts observed.

Months were thus spent in constant and immediate intercourse with nature, the subjects of investigation changing with the advancing season. Botany and entomology had first their turn, the collection and study of land and fresh-water shells keeping pace

with them. A delightful excursion to Baden Baden and into the heart of the Black Forest increased still more our stores, but the collection which arises most vividly before my mind is one of mushrooms, gathered in the late fall, chiefly in the forest of Hartwald. Such variety of strange forms, from the clumsiest to the most delicate, now such gorgeous colors, and then again such soft tints; in a word, such a profusion of beauty, unsuspected in this order of organisms, I had never seen before nor have I met with since. The fresh specimens were placed on white paper, the shedding of their spores carefully watched, and their generic and specific characters determined. On rainy days microscopic investigations, especially on the embryogeny of cryptograms, were resorted to, conducted by A. Braun. Practical demonstrations of the phyllotaxis, now gradually reduced to definite formula by Braun and Schimper and shown in various plant forms, but especially in pine cones, were of absorbing interest. The whole plan of the present animal kingdom in its relations to the extinct palæontological forms, was the theme of animated discussions. On the frontispiece of the "Principles of Zoölogy," by Agassiz and Gould, stands a diagram, first suggested by Schimper, at that time, and worked out by Agassiz, which embodies their views and may give a fair sample of the range of questions which already occupied these young brains at the age of twenty years.

It would be idle to attempt to determine the measure of mutual benefit derived by these young students of nature from their meeting under such favorable circumstances. It certainly was very great, and we need no other proof of the strong impulse they all received from it than the new ardor with which each pursued, and subsequently performed, his life-work. Carl Schimper alone, perhaps the most brilliant mind of all, but also the least balanced and the most erratic, was cut off before he could develop all that was in him.

The season of vacation, however, drew to a close. The universities reopened their doors, inviting once more the studious youths to the temple of knowledge. The grateful guests left with regret the happy home which had been theirs for a time, each to return to the university of his choice. I need not say that this first visit of Agassiz to the Braun mansion was not the last. New ties had been formed which drew him almost every year again to the friendly family of which he was to become a member.

Perhaps I ought to ask the indulgence of the Academy for having dwelt so long on these reminiscences of the early—I had almost said of the embryological—period of Agassiz's scientific life. But, if I do not greatly err, Agassiz's later career bears unmistakable marks of the impetus he received at that time from this providential association with equally gifted friends, somewhat older than himself—an association which continued throughout their university life. Mutual influence often opened new avenues of thought and gave a new direction to their investigations. One can hardly fail to perceive that Braun's already advanced studies on the embryogeny of plants suggested to Agassiz a similar series of investigations in the animal kingdom, and prompted, in a measure, that long array of embryological researches of which he was so fond and in which he was so successful.

The bold, but often unsound, generalizations of Carl Schimper, freely discussed in the little circle, drew Agassiz's attention to the principles of zoölogical classification, to which he afterwards devoted so much effort, and to the unity of plan in living and fossil animals, which led him later to those palæontological studies by which he has done so much service to science.

The University of Munich, which had just been reorganized with a galaxy of new professors, all leaders in natural science, medicine, and philosophy, offered attractions which decided the choice of Agassiz, as well as that of his new friend. We find him here with Braun, and somewhat later C. Schimper, from the autumn of 1827 to the summer of 1831, continuing his medical studies, but soon almost entirely absorbed by his zoölogical investigations and the preparation of his first works.

Here he met Döllinger, the founder of modern physiology; Oken, that original genius who inaugurated a classification of the animal kingdom on entirely new principles; Spix, the zoölogist, and Von Martius, the botanist, leaders of the joint Bavarian and Austrian corps of naturalists, recently returned from their scientific exploration of Brazil; Fuchs, the mineralogist; Schelling, the great philosopher, the rival of Hegel and the most illustrious representative of the philosophy of nature. By his enthusiastic devotion to science, and his already remarkable attainments, Agassiz, young as he was, soon gained the privilege of an intimate intercourse with most of them.

He was no less popular with his fellow-students, in whose sports

he heartily joined. At the same time the spirit of the little circle of Carlsruhe continued to live and develop. The three friends had taken lodgings together, and this little band soon became the centre and soul of a society of select young men, who met to discuss scientific subjects and give lectures, each on his favorite topic. The exercises of this debating club were so interesting that it was called "The Little Academy of Sciences," and the professors were often glad to cheer the young students by their presence and to take part in their discussions.

This period of four years was a most important one in Agassiz's scientific life; it was the last formative phase which shaped his subsequent life-work. While he continued with great zeal his original investigations on the fresh-water fishes he sedulously availed himself of the opportunities offered him by his distinguished teachers. With Oken he learned to consider life as a grand unit, and discussed the principles of classification, which occupied in his mind a place of paramount importance. With Döllinger he studied the embryonic development of animals, which remained to the end of his days a prominent subject of his investigations. Von Martius initiated him into the characteristic distribution of plants in tropical climates, especially in that most extensive of all forests in existence, the Selvas of the Amazon. To the influence of Schelling, to whose courses of lectures he listened every year, we may trace, if I judge aright, his deep conviction of the immaterial nature of the life principle, which caused him to consider the diversity of animal forms as the expression of as many thoughts of the Creator.

During these years also he published his first work and began the preparation of two others, which were to establish his reputation as an original investigator. Spix and Von Martius, the two Brazilian travelers, had hardly begun the publication of the results of their journey when Spix, who had charge of the zoölogical portion of the work, was removed by death. Von Martius, who was fully acquainted with the researches of Agassiz on the fresh-water fishes, immediately selected him to fill the vacancy, and entrusted to the youthful student of twenty-one years the description of the fishes collected during the expedition. A large folio volume, splendidly illustrated, published in 1830, was the result; and the manner in which Agassiz performed the difficult task, the original views which he was led, by the recognition of so many new types, to introduce in the classification of fishes, secured for him at once a

place among the best naturalists of the day. He thus obtained a first glimpse of the tenants of the Amazon, that queen of rivers, where it was his good fortune, before the close of his career, himself to make such grand discoveries.

This work completed, Agassiz took up again, with new zeal, his study of the fresh-water fishes of Europe. He devoted his vacations to long journeys, mostly on foot, through Germany and Switzerland, collecting and comparing the fishes of their lakes and rivers, visiting museums, and increasing his stores of natural objects of all kinds.

In thus following the strong bent of his mind, and what he felt to be his calling, Agassiz could hardly give to the professional study of medicine the amount of attention required. His father, becoming anxious about his course, which seemed unnecessarily to prolong his studies and to lead to no regular situation, told him that he would be unable to continue his slender allowance. After the success which attended his first great work, however, his parents felt more reconciled to his plans, and Agassiz, aided by a rich relative, was permitted to go on with his study of natural history. He needed, however, more resources for the preparation and publication of his "Natural History of the Fresh-Water Fishes of Europe." He applied to Cotta, whose name, as a publisher of large and generous views, is known to all the world of science and literature. Cotta, struck with the value of the materials already prepared, and, no doubt, with the genius of the young man, furnished him with means to continue his work and to retain the services of a young artist of talent, named Dinkel, whom he had trained, and whom he afterward employed until he left Europe for America.

Meanwhile Agassiz's attention had been drawn to fossil fishes by the examination of fine specimens from the fresh-water deposits of Glaris in Switzerland, Oeningen in Baden, and Solenhofen in Bavaria. He began to collect all he could obtain, to have drawings made of those which were accessible to him, and resolved to undertake a general work on fossil fishes, which was to become his most important contribution to science.

Before publishing the Brazilian Fishes, in the spring of 1829, he took the degree of Doctor of Philosophy in the University of Erlangen, and a year after passed a brilliant examination for Doctor of Medicine at Munich in April, 1830. His doctrinal dissertation was characteristic of the gallant young man. His theme was, "The

superiority of woman to man," "*Femina humana mari superior*," in which he takes the ground that, according to the law of geological progress, woman having been created last was the most perfect being.

Agassiz now went to Vienna to visit its museums, where he devoted himself especially to the examination of the fishes of the Danube. During his stay in this great scientific metropolis he formed an acquaintance with most of the leading naturalists, particularly with the zoölogist Fitzinger.

Having finished his university studies Agassiz returned to his home in the autumn of 1830, and the question of a situation which would give him a support and the means of continuing his labors pressed itself upon him. The same Providence which had helped him thus far again opened the way for him. His reputation had preceded him in Neuchâtel. One of its wealthy, most influential, and public-spirited citizens, Mr. Louis Coulon, and his son, bearing the same name, both passionately fond of natural history, formed the project of introducing the study of it into the college of their city. To this effect they presented to the institution the large collection which they had accumulated to form the nucleus of a museum of natural history. For the chair which was needed to complete the scheme they looked to their young countryman, already so honorably known. This professorship, however, was not established until the following summer.

Agassiz had now the greatest desire to visit Paris to avail himself of the immense collections of the Museum of the Jardin des Plantes, and especially to examine the fossil fishes it contained, but the means for a protracted sojourn were wanting. Help again came to him from an unexpected quarter. A friend of his father, Mr. Christinat, an humble clergyman, had just inherited a small sum of money and most generously handed it to him for the execution of this cherished project. Agassiz spent a part of the winter of 1831 and all the spring of 1832 in Paris. To make his scanty resources last as long as possible, he took a small and more than modest room in an unattractive street, but which had the merit of being near the Jardin des Plantes, and which on that account had become classic among the naturalists not blessed with an abundance of means. Of the great city he saw nothing; all his days were passed in the museum of that institution. It was here that he became acquainted with Humboldt, who knew him by reputation, and

was so much interested in him and in his researches that he delicately furnished him the means for prolonging his sojourn in Paris, and introduced him to Cuvier, to whom he had dedicated his work on the Brazilian fishes, but whom he only knew by correspondence. Aware that this eminent naturalist was himself gathering materials for a work on fossil fishes, Agassiz had little hope of gaining access to this part of the collections. What was his astonishment and delight when Cuvier, after seeing the extensive preparations Agassiz had made for a similar work, placed at his disposal his entire collection, including even the expensive drawings made from specimens in the British Museum and elsewhere, saying: "You are young and I am old; it is for you now to finish the work which it was my intention to perform and that you have so well begun." This was the bequest of the old master to a young and enthusiastic pupil, full of life and vigor. A few months later, 13th of May, 1832, Cuvier passed away.

Greatly encouraged by these high authorities Agassiz was more eager than ever to establish himself in some position where he could continue this work. Following his own inclination and the advice of Humboldt, he declined the brilliant offers made to him by him by Valenciennes, the colaborer of Cuvier, to become his associate in the continuation of the great "Histoire Naturelle des Poissons," and turned his eyes toward the projected chair in Neuchâtel. Allow me to quote here a part of a letter which Humboldt wrote at that time to Mr. Coulon, to recommend Agassiz for the position. It will show in what high esteem young Agassiz was held by the foremost scientists of the day, Cuvier, Humboldt, and Leopold von Buch:

"This is not so much a favor that I ask of you, sir," writes Humboldt, "as an expression of my sincere gratitude for your noble and generous action toward a young savant, Mr. Agassiz, who, by his talents, the variety and solidity of his attainments, and, what is still more precious, especially in the troubled times in which we live, by his amiability of character, has shown himself so worthy of your encouragement and of the protection of your enlightened government. I have known for years, and especially through our mutual friend, Mr. de Buch, that you have studied natural history with a success equal to your zeal, and that you have made beautiful collections, which are left open and free for the benefit of the public. It is a pleasure for me to see that your good-will is directed towards

a young man, dear to myself, and whom Cuvier, whose loss we shall ever deplore, would have recommended with the same affectionate warmth, founded on the fine work already accomplished. * * * I have strongly advised Mr. Agassiz not to accept the offers made to him at Paris since the death of Mr. Cuvier, and his resolution was formed in advance of my counsels. How fortunate it would be for him, and for the two excellent works in which he is now engaged, if he could this very year be established on the shores of your lake. Great favor will no doubt be accorded him by your worthy governor, General von Pfuhl, to whom I shall repeat my request, as he has honored me, as well as my brother, with a friendship which we highly prize. Mr. Leopold de Buch, almost as much interested as I am myself in the career of Agassiz and in his work on fossil fishes—the most important ever undertaken, and equally correct as to the zoölogical characters and to the formations—has promised me, before leaving Berlin for Bonn and Vienna, to add his entreaty to mine."

The chair was created, Agassiz was appointed, and he returned to Switzerland in the autumn of 1832. His collections were bought for a considerable sum of money, one-third of which was furnished, at the suggestion of Humboldt, by the Prince of Neuchâtel, King Frederick William IV of Prussia, another by the city of Neuchâtel, and the rest by one of its generous citizens, Count Louis de Pourtalès. This enabled Agassiz to begin his projected publications the following year.

These events mark an epoch in the life of Agassiz. The period of preparation is over. At twenty-five years of age a season of intense intellectual activity, rich in fruitful results, now opens before him, embracing all the time of his sojourn in Neuchâtel until his departure for America in 1846. During these fourteen years of incessant labor were achieved, among many others, those of his works which have made the deepest impress upon progressing science—his "*Recherches sur les Poissons Fossiles*" and his "*Système glaciaire.*" He was then in the full vigor of early and mature manhood, when man's intellectual powers are at their height and enable him to open new paths in unexplored regions of the field of Science.

Endowed with an impulsive nature, a vivid imagination, and an inexhaustible buoyancy of spirits, coupled with a consciousness of

exuberant strength, nothing seemed impossible to his scientific ardor.

It was characteristic of him that his plans for any enterprise were always so gigantic as to be out of proportion to the means at his command.

This proved true of the publication of his work on fossil fishes, which he began immediately in 1833, at his own expense. When costly books were to be purchased, artists provided, plates lithographed, help secured, visits to distant museums undertaken, the question of expense was never considered, but rather systematically set aside as an undue interference. "These things are needed for the work" was his uniform answer to friendly remonstrances; to his mind this was enough. Draftsmen of superior talent, trained by himself to the greatest accuracy—Weber, Dinkel, and Sonrel—were constantly in his employ at a regular salary. Dinkel spent seven years in England alone, drawing the fossil fishes placed at Agassiz's disposal by the owners of the richest collections. At the suggestion of Agassiz an extensive lithographic establishment was created in Neuchâtel, which was almost entirely dependent upon him for work. Generous help, it is true, was tendered him from various quarters; by the King of Prussia, at the instance of Humboldt; by the noble friends whom he had gained in several visits to England, Lord Enniskillen, Sir Philip Egerton, Sir Francis Egerton—the last of whom not only allowed him the use of his rich collection of fossil fishes, but bought of him all his drawings, leaving them at his disposal for his publications. Aid also came from the Geological Society of London, as well as from his own relatives; yet it is easy to understand that the weight of an enterprise on such a scale of magnitude was too heavy for him to carry. Still, undaunted by almost inextricable difficulties, he struggled manfully on, during ten long years, till he had completed the work. His "*Recherches sur les Poissons Fossiles*" were published from 1833 to 1843, in five quarto volumes of descriptive text, with an Atlas of nearly four hundred admirably executed plates, and were fitly dedicated to Humboldt.

This work marks a new era in the geological history of the life system. Unlike the mammals described by Cuvier, which appear only at a later period, the Fishes are present through nearly all the geological ages, almost from the beginning of life. Agassiz was thus enabled, by a careful study of this class, to establish on a solid

foundation of facts the precise nature of these laws of gradual progress which give a significance and a peculiar charm to the history of life on our planet.

The sensation produced in the scientific world by this publication was as great as it was universal. It can only be compared to the enthusiasm excited ten years before by Cuvier's "Researches on the fossil bones of the Basin of Paris" and his admirable "Discours sur les Révolutions du Globe," which forms its preface.

Philosophic Germany hailed the new work with delight. Just at the time of the issue of the first volume of the Poissons Fossiles in 1834, when myself a student at the University of Berlin, well do I remember my pleasure in listening to the glowing eulogium bestowed on Agassiz's labors by that deep student of nature and Christian philosopher, Steffens, the colleague and rival in genius of Schelling and Hegel. Agassiz, he said, had demonstrated by facts the very laws he had himself proclaimed from philosophical deductions some twenty years before.

In England and France Agassiz found an equally warm appreciation, and he was soon acknowledged as the first authority in this difficult department of geological science. More than ever museums were open to him. All the fossil fishes of the old red sandstone of England and Scotland which could be obtained, both from public and private collections, were placed at his disposal by the British Association for the Advancement of Science, and their description was published as a monograph, forming a valuable addition to his main work.

It had been his intention to publish a series of similar monographs of the fishes of the various formations in their geographical associations, which would have been of great interest. It is much to be regretted that the multiplicity of new objects which absorbed his attention prevented the execution of this plan.

Before taking leave of these remarkable works, which are the greatest contribution of Agassiz to geology and the most lasting foundation of his well-earned glory, allow me to cast a rapid glance at the most important of the new truths they proclaimed, which were, at that time, a real revelation to science. As most of them have long been a part of the common treasure of knowledge—housholds word of every geologist—we are too apt to forget to whom they are due and the efforts of patience and of genius their discovery required. This review may help us better to realize how

great an advance Palæontology owes to the investigations of Agassiz.

1st. It is well to notice his new classification of fishes founded on more rational principles. By careful researches he had found a remarkable correspondence between the external dermatic covering and the skeleton and internal organization of fishes; he accordingly divided the class into four orders, the Placoids, Ganoids, Ctenoids, and Cycloids, distinguished by striking differences in the structure of their scales.

This view, says Pictet, was the stroke of genius which characterizes the whole work; it was the key to Agassiz's success in classifying the fossil fishes of which often no other parts are found but the scales. The order of their succession in geological times as well as their organization showed the division to be a natural one.

2d. Again, admitting a progressive change from the lower to the higher forms of life, in the successive ages, it was natural to look for the appearance first of the lowest archetypes, the radiates; next the mollusks, articulates, and vertebrates. Agassiz showed that no such linear series exists, but that they appear simultaneously, and not by gradual stages, and, moreover, in great variety of forms and immense number of individuals, a ready-made fauna.

In this primordial fauna Agassiz included the Fishes as representatives of the Vertebrates. This, however, was an error, as has been demonstrated by the fact that the fishes are not only absent from the primordial fauna, but are not found before the very end of the Silurian age.

3d. The earliest forms in each archetype are by no means the lowest in that group, as the Trilobites, for instance, among the articulates, Brachiopods and Cephalopods among the mollusks.

4th. The Vertebrates alone begin the true historic series, terminating with Man. The successive appearance of their classes marks the great steps in the path of progress, the ages in the life system, while the Invertebrates play, in this respect, altogether a secondary part.

5th. Each class, each group, has a history peculiar to itself. Among the Invertebrates, for example, the Cephalopods of the primordial fauna grow more diversified in the Devonian, culminate, both in number of species and beauty of forms, in the Mesozoic, then rapidly decrease, and are scarcely seen at the present time. Among the fishes the Ganoids and Placoids appear at once in great

diversity. They have their predominance in the Palæozoic time and linger through the periods anterior to the Cretaceous formations, but their most typical families die out before the present era, in which only a few specimens are left. In the Cretaceous the Ctenoids and Cycloids make their appearance, as diversified in their origin as the two orders preceding them, and culminate at the present time.

6th. The early types of a class present characters analogous to those of the embryo of an individual of the highest type of the class, and the following ones, in the geological succession, are analogous to the forms through which the same individual embryo passes during the phases of its development: The Trilobite, of Palæozoic times, typifies the form of the embryo of the crab; the Macrourans, of the Mesozoic, the middle stage; the more recent Brachyurans, the last form of the full-grown crab. The succession of forms is the same in the development of the class as in the phases of growth of the individual crab. In fishes the inequality of the lobes of the tail (heterocercal), so characteristic of the palæozoic types, is found in the embryo of many of the Ctenoids and Cycloids, while the lobes become symmetrical in the full-grown animal.

7th. Applying the results of these admirable researches to the geological history of the whole life system he lays down the important general law "that the successive creations have undergone phases of development analogous to those observed in the gradual growth of the embryo, and similar to the gradations which characterize the ascending series of the present animal creation in its totality."

8th. This community of laws which binds the living beings of the past ages by indissoluble ties to those of the present time shows that they form together one grand *Life System*, in which the fossils supply the links needed to fill up the numerous gaps found in the series of animal forms now in existence. (Poissons Fossiles, page 168.) "I do not doubt," he adds, "that we shall soon be brought to combine, in a single view, the results of palæontological and zoölogical researches, including comparative anatomy, as soon as we shall attempt to establish a complete system of the natural affinities in the totality of the animal kingdom, and that we shall have to give more and more weight to the order of the geological succession of the types in their systematic arrangement."

9th. In view of the fact that all the fundamental types appear

simultaneously at the beginning of life, and that the mode of their subsequent development takes place by sudden steps, Agassiz declares his conviction "that these types do not descend from one another by direct procreation, or by successive transformation, but that they are materially independent, though forming an integral part of a grand systematic whole, whose connection is to be sought in the creative intelligence of its author." (Vol. 1st, page 170.)

10th. Summing up these results and rising to still higher considerations he expresses, in the last page, the views of the order of creation suggested by his studies. "Such facts," he writes, "loudly proclaim principles which science has not yet discussed, but which palæontological researches place before the eyes of the observer with increasing persistency; I mean the relation of the creation to the Creator. * * If I have refrained from expressing my conviction on this subject till the last moment it is not because I shrank from the discussions, sure to arise on the announcement of these results, but because I did not wish to call them out before being able to place them on purely scientific ground and to sustain them by satisfactory demonstrations rather than by a profession of faith. More than 1,500 species of fossil fishes with which I havebecome acquainted say to me that the species do not pass gradually from one to the other, but appear and disappear suddenly without direct relations with their predecessors; for I do not think that it can be seriously maintained that the numerous types of Cycloids and Ctenoids, which are nearly all contemporaneous with each other, descend from the Placoids and Ganoids. It would be as well to affirm that the mammals, and man with them, descend directly from fishes. All these species have a fixed time for coming and going; their existence is even limited to a determined period. And still they present, as a whole, numerous and more or less close affinities, a determined coördination in a system of organization which has an intimate relation with the mode of existence of each type, and even of each species. More still, there is an invisible thread which is unwinding itself, through all the ages, in this immense diversity, and offers as a final result a continuous progress in this development of which man is the termination, of which the four classes of vertebrates are the intermediate steps, and the invertebrates the constant accessory. Are not these facts manifestations of a thought as rich as it is powerful, acts of an intelligence as sublime as provident?

* * * This is, at least, what my feeble intellect reads in the works of creation."

Whatever be the opinions which many may entertain as to the interpretation of some of these generalizations, the vast importance of these results of Agassiz's studies may be appreciated by the incontestible fact that nearly all the questions which modern palæontology has treated are here raised and in a great measure solved. They already form a code of general laws which has become a foundation for the geological history of the life system, and which the subsequent investigations of science have only modified and extended, but not destroyed. Nowhere did the mind of Agassiz show more more power of generalization, more vigor, or more originality. The discovery of these great truths is truly his work; he derived them immediately from nature by his own observations. Hence it is that all his later zoölogical investigations tend to a common aim, viz., to give by further studies, equally conscientious but more extensive, a broader and more solid basis to these laws, which he had read in nature and which he had proclaimed, at that early date, in his immortal work. Let us not be astonished that he should have remained faithful to these views to the end of his life. It is because he had *seen* that he *believed*, and such a faith is not easily shaken by new hypotheses.

Agassiz had thus nobly accomplished the task entrusted to him by the founder of palæontology. He had completed, by his "Recherches sur les Poissons Fossiles," the work begun by the great author of the "Recherches sur les Ossements Fossiles du Bassin de Paris."

While this central work was progressing the activity of his mind allowed him to carry on simultaneously a multitude of other investigations and publications. Under his magnetic influence Neuchâtel soon became a centre of scientific activity such as it never was before nor has been since. The City Museum of Natural History, begun by the rich collections of Coulon and Agassiz and under their fostering care, was gradually increased by the contributions of other friends, and grew into a model of taste and arrangement. Many rich citizens united to send, in 1839, an already distinguished Swiss naturalist, Von Tchudy, partly a pupil of Agassiz, to South America as collector for the museum, and the scientific world owes the remarkable books on the Andes, published by this gifted traveler, to the investigations which began with that expedition. A

society of natural sciences, of which Agassiz was the first secretary, was started in December, 1832, and the bulletin of its proceedings, as well as the series of its quarto memoirs, richly illustrated with plates and maps, give evidence to this day of its vitality.

The impulse imparted by Agassiz soon showed itself by deeds. To members of this society were due some of the chief contributions on the geology of the Jura. A. de Montmollin recognized the Neocomian, until then regarded as belonging to the Jurassic layers, as a distinct formation, constituting the lowest members of the Cretaceous series, since identified everywhere and admitted as one of its normal formations. Gressly, one of the pupils of Agassiz, well known by his important publications on the geology of the Jura; Nicolet, who gave a valuable description of the valley of La Chaux de Fonds, which has become typical of the Jurassic valleys—all partook of Agassiz's enthusiasm for scientific researches. The publication of the quarto memoirs of the Helvetic Society of Natural Sciences, with their numerous plates, was transferred to Neuchâtel under the superintendence of Agassiz.

Meanwhile he was continuing his investigations on the fresh-water fishes. In 1834 he published a description of new species of *Cyprinus* from the lake of Neuchâtel (Mem. Soc. and Sc. Nat. Sc., Neuch., vol. I). In his study was made the first and entirely successful attempt at an artificial fecundation of fishes, an art which has since become, as the academy is well aware, of such vast economic importance. An atlas of exquisite plates, destined for his projected "History of the Fresh-Water Fishes, but comprising only the family of *Salmones*, was executed, under his immediate supervision, by his skillful lithographer, Nicolet. We truly wonder at their beauty, and at their perfection of color and outline, when we remember that they were almost the first essays of the newly-invented art of chromolithography, and produced at a time when France and Belgium were showering rewards on very inferior work of this kind as the foremost speciments of progress in that art. The expense of the work executed on this scale of excellence became altogether too great and it had to be discontinued. Agassiz, however, in 1839, associated with him in his work Carl Vogt, a young physiologist, pupil of Prof. Valentin, in Bern, who carried on, under Agassiz's direction, a series of researches on the anatomy and physiology of the Salmones, which were embodied in a volume published in 1844. In the preface Agassiz informs us that the Osteology and

Neurology are due to him; the remainder and the drawings to Carl Vogt.

While studying so closely the fishes Agassiz did not neglect the other classes of animals. The Invertebrates received a large share of his attention.

In 1834 he published, as a preparatory work, a Prodromus of the Echinoderms, which was followed in 1839 and 1840 by a description of the fossil Echinoderms of Switzerland, and also by several monographs from 1841 to 1842, for which he associated with himself Desor for the descriptive part and Valentin for the anatomy of the genus Echinus. Another large quarto volume, with nearly 100 plates, was published in 1840 to 1845 under the title of "Etudes critiques sur les mollusques fossiles," the main object of which was to discuss anew the identity of fossil species of different geological formations, the relations to the living ones, and the question of their classification. Another illustrated memoir, "Iconography of the tertiary shells believed to be identical with the living ones," was issued in 1845.

The prominent feature of these various works was that they were all undertaken not simply to increase the number of described species, but with the view of elucidating some principle deemed important by their author.

This is perhaps the place to notice a faculty of Agassiz, which was one of the secrets of his success as a naturalist. He was endowed with a most exquisite sense of form. At a glance he perceived, as by intuition, the characteristic form of an animal as well as its minute details. This once vividly impressed on his plastic imagination would never be forgotten. It was astonishing to see how, in passing his eye over a large collection, he would at once detect the new forms which he had not seen before and add them to his treasure of mental photographs.

Though, according to his own statement, he had no talent for drawing on paper, when in the heat of an exposition before the black-board, his hand would reproduce, almost instinctively, the vivid image which he had in his mind in singularly correct outlines. If Agassiz has sometimes been charged with increasing unnecessarily the number of species, it is no doubt owing to that strong discriminative power which allowed him to see differences unperceived by others. These minute researches, however, had an excellent influence in introducing a greater precision in palæontological determi-

nations. We may ascribe to the same cause the fact of his finding reasons to deny the identity of almost every species belonging to different geological ages, and even of any tertiary species with those of modern times.

Hence, also, he never planned and published a work without an abundance of illustrations. By his advice Gressly constructed relief maps of the Jura to illustrate its geology. Another, on a large scale, of the Canton of Neuchâtel is still preserved in the museum of that city.

In order to multiply the types referred to in the above-mentioned works, and thus facilitate his studies, he had some 500 specimens of his collection reproduced in plaster casts—a method on which he wrote a special memoir and which has since been in universal use.

Two other works, only instrumental for researches, but implying a vast amount of labor, were prepared. The "Nomenclator Zoölogicus," in 1841, contained an enumeration of all the *genera* of the animal kingdom, with the etymology of their names, the names of those who first proposed them, and the date of their publication, the nomenclature of each class having been submitted to the revision of naturalists, masters each in their respective branch. Another extensive publication, the "Bibliotheca Zoölogica and Geologica," in some measure a complement to the first and containing a list of all the authors named in it, with notices of their works, appeared under the auspices of the Royal Society of England, and was issued, with emendations and additions by H. Strickland and Sir W. Jardine, in four octavo volumes, after Agassiz's departure from Switzerland.

Well-nigh overwhelmed by all these enterprises carried on together, and every day increasing, Agassiz, who was as little inclined to write as he was indefatigable in investigating, felt the necessity of help in this direction. In 1837 he found in the ready and elegant pen of Edward Desor, a former student of law, the aid he needed. He engaged him as a secretary—with his usual kindheartedness received him in his family and made him his associate in all his studies. Though entirely unprepared by his previous training Desor, endowed with a quick mind, fulfilled his new functions with great success, and under the direction of his employer became, in a measure, his colaborer in the field of science, especially for the descriptive part. He was Agassiz's constant companion in his expeditions on the glaciers, and took a prominent part in the

final elaboration of the results of their studies, as well as in the publication of his works on the Echinoderms, and after their separation continued an independent and honorable career in the field of science.

In casting a glance at these varied labors we cannot but admire the extraordinary industry displayed by Agassiz in this remarkable decade of his life, and also his marvelous power in inciting, directing, and organizing the work of the numerous helpers whom he knew how to employ. All those engaged with him caught a sparkle of his ardor and worked with a will—all drew a direct benefit from their intercourse with him. The artists felt their powers raised to a higher degree of perfection by his demands on their talent; the others learned how to see and observe, and every day became conscious of new progress in the path of knowledge.

But this was not all. In the midst of these zoölogical labors an event occurred which, for a time, diverted the mind and powers of Agassiz into an apparently entirely new channel. In the summer of 1836 he paid a visit to his venerable friend, Jean de Charpentier, director of the mines of the Canton de Vaud. This veteran geologist, two years before, in a communication to the Helvetic Society of Natural Sciences, had attributed the transportation of erratic boulders to the agency of enormous glaciers of ancient times. Agassiz, desirous to examine the facts upon which so startling a statement was based, spent five months with him at his charming residence in Bex, not far from the entrance of the Rhône into the lake of Geneva. Here, surrounded by erratic boulders of all sizes; almost in sight of the classic group of the gigantic blocks of Monthey, descended from Mt. Blanc; near the glacier of the Diablerets, where the moraines, the polished and grooved surfaces, the *roches moutonnées*, could be observed; where the transportation of the boulders lower down could be followed; and with such a guide and expounder of the glacial phenomena as Charpentier he had every opportunity he could desire for his purpose. He came home full of enthusiasm and thoroughly convinced of the reality of the facts he had seen and of the soundness of the conclusions of Charpentier. The presence of Alpine boulders on the slopes of the Jura had been attributed from the time of de Saussure and de Buch to immense torrents descended from the Alps. Agassiz found there, the same year, the polished and smooth surfaces which to every practiced observer gives unmistakable proof of the former existence of a gla-

zier. For the first time he realized the astounding and apparently incredible fact that the vast plain of Switzerland between the Alps and the Jura, now covered with cities and cultivated fields, was, in days long gone by, overlaid by a sheet of ice 2,400 feet in thickness. He did not stop there. With characteristic boldness he applied to the whole globe a state of things which he had found true on this one particular spot. He conceived the idea of a universal glacial era extinguishing all life at the end of the tertiary age and separating it from the present geological epoch—the historical age of man. The following summer, in 1837, he embodied his new ideas in an inaugural address delivered as president, for the year, of the Helvetic Society of Natural Science, in session at Neuchâtel.

This bold theory, so strange, apparently so improbable, so contrary to all accepted notions, took every one by surprise. Coming as it did from a recognized and favorite leader in science it could not help making a great sensation. By some it was received with open contradiction, by a few as deserving attention, by the venerable Leopold de Buch, the old patron of erratic boulders, with wrath and scorn; by most with a smile of incredulity. This communication, no doubt, contained some very crude notions which had to be abandoned—many assertions unsupported by the facts known at the time; but the grand idea of a universal glacial era, as one of the geological phases of the earth—that happy guess, as one might call it—was started and was destined to make its way in spite of all contradictions. Now, thanks to the growing number of well-established facts which lead to this conclusion, the evidence of its reality is so overwhelming that it is accepted by all, though in a modified and limited form, as a geological truth no longer to be controverted.

From this time on the glacial question occupied a large share of Agassiz's time and attention. His enthusiasm on this theme was unbounded. Almost every summer, from 1837 to the time of his departure from Switzerland, was employed in investigations among the glaciers of the Alps.

To give to the theory the necessary base of facts two orders of observations were indispensable—one purely physical, the glacier and its phenomena; the conditions of its formation and growth, the law of its motion, its moraines, its action on the ground over which it moves; the other geological, the erratic phenomena, the law of the distribution of the Alpine boulders and fragments, and of their

extension, both horizontal and vertical. As the history of these researches requires a brief mention of the part taken in them by myself I beg leave of the Academy to say a few words on this subject.

In the spring of 1838 I had the pleasure of a visit from my dear friend Agassiz in Paris, where I then resided. The main topic of conversation was, of course, the glaciers. He put me au courant of Charpentier's views, as yet imperfectly published (his book having been issued only two years later, 1840), and, adding his own idea of a general glacial era, he urged me to turn my attention to these phenomena. I asked to be allowed to suspend my judgment until my own observations should justify my adhesion to so startling a theory, but promised to visit the glaciers that very summer. I did so, and an exploring tour of six weeks in the Central Alps rewarded me beyond my expectation. The glacier of the Aar, on which Agassiz began two years later (1840) his regular system of observations, taught me the law of the moraines. The glacier of the Rhône gave me the law of the more rapid advance of the centre of the glacier and that of the formation of the crevasses, both transversal and longitudinal. The glacier of Gries showed me the laminated or ribboned (blue bands) structure of the ice deep down in the mass of the glacier and the law of the more rapid advance of the top over the bottom. On the southern slope of Mont Blanc, the great glacier of la Brenva, with its twin rocks, rising like two dark eyes from the middle of the ice (they are indeed called by the mountaineers the "eyes of the glacier") made me understand that the motion of the glacier takes place by a gradual displacement of its molecules under the influence of gravity, giving it a sort of plasticity, and not by a simultaneous gliding of its whole mass, as believed by de Saussure. All these laws, deducted from a first but attentive study of the phenomena of the glaciers, were at that time, excepting that of the moraines, new for science. They were expounded by me and illustrated by diagrams at the meeting of the Geological Society of France in session at Porrentruy the same summer of 1838, and I had the great satisfaction of seeing them fully confirmed by the subsequent observations of Agassiz and others, which furnished the precise numerical data then wanting for their complete elucidation. This paper, however, though duly mentioned in the proceedings of the Geological Society (Bulletin, Vol. IX, page 407), was not printed, owing to a protracted illness

of its author in the winter following. But on the occasion of a claim by Prof. J. D. Forbes to the discovery of the laminated or ribboned structure of the ice the portion relative to this subject was printed, and the whole manuscript, on a motion of Agassiz, was deposited, by a formal vote, as a voucher in the archives of the Society of Natural Sciences of Neuchâtel, the original draft being now in my hands.

If I mention this circumstance it is because the regretable omission of the publication of my paper was the occasion of the unfortunate misunderstanding which estranged two such men as Agassiz and Forbes, and which I feel bound in a measure to explain.

Two years later, in 1840, Agassiz invited Forbes, whose attention had just been turned to the study of the glaciers, to be his guest on the glacier of the Aar, where he had just established himself with his assistants for a protracted season of observations, offering to make him acquainted with the results thus far obtained by his own exertions. Forbes accepted. In one of their common excursions the peculiar laminated structure of the ice was noticed. Forbes, who had never heard of it, believed he had made the discovery of a new and important fact. Agassiz, who two years before had been present at the meeting at Porrentruy and had heard the paper read by me in the Geological Society of France, remembered the description of the phenomenon, probably well nigh forgotten amid the crowd of other apparently more important questions which were agitated at that stage of the study of the glaciers, and he maintained its earlier discovery. Such an occurrence was so natural in these circumstances that we wonder, not that it should have happened, but rather that it could have become the cause of so much trouble.

The foundation of the Academy of Neuchâtel, in 1839, with the object of furnishing a University course of studies to the post-graduates of the College, brought me back to my native town. Having accepted a call to one of its twelve professorships, I became the colleague of Agassiz. The investigation of the glacial phenomena could now be pursued with more advantage by dividing our forces. Agassiz having chosen to continue his studies on the glaciers, which had already engaged so much of his attention, I left this field and took charge of the intricate question of the erratic boulders, the glacial drift, and the ancient extension of the glaciers. To the elucidation of this geological part of the question I devoted, absolutely

single handed, seven laborious summers, from 1840 to 1847, only giving myself, at the end of my working season, the pleasure of a visit of a few days to the lively band of friends established on the glacier of the Aar, in order to learn the results of their doings and to communicate mine to them.

The first serious studies of Agassiz and his companions were made on the grand group of glaciers descending from the snowy crests of Monte Rosa, and of which the glacier of Gorner forms the centre. The result was a first publication, "Etudes sur les glaciers," in 1840, accompanied by a superb atlas of thirty-two plates, which makes its greatest value, and has furnished most of the illustrations which we find to this day in our scientific text-books.

In 1840, however, he finally selected, as most appropriate to his purpose from its easy access and vast extent, the glacier of the Aar, in the very heart of the Bernese Oberland, and at the foot of its highest peak, the Finsteraarhorn. Here, on the medial moraine, in the very midst of the glacier, not far from the confluence of its two main branches, the Ober Aar and the Lauter Aar glaciers, stood a large boulder conveyed by its slow motion from the foot of the mountain. This was selected as the abode of the little band. Under one of its projecting corners six men found room to repose on its icy floor. A blanket suspended in front protected them from the frosty air of the night; another served as a common covering for the whole company; a block of ice outside, crowned by a flat stone, made their kitchen, presided over by a practiced guide. This was the "Hôtel des Neuchâtelois," which soon became celebrated throughout Europe. Later, when yielding to repeated frosts, the boulder crumbled to pieces, it was replaced by a large tent scarcely more comfortable.

Instruments were procured, and boring apparatus destined to send self-registering thermometers to the depths of the glacier to ascertain its temperature. The position of eighteen of the most prominent blocks on the glacier was determined by careful triangulation by a skillful engineer, and measured year after year to establish the rate of motion in every part. The difference in the rate of motion in the upper and lower part of the glacier, as well as at different seasons of the year, was ascertained; the amount of annual melting was computed and the phenomena connected with it studied. The surrounding peaks, the Jungfrau, the Schreckhorn, the Finsteraarhorn, most of them until then reputed unscalable, were ascended

and the limit of glacial action discovered; in short, all the physical laws of the glaciers were brought to light.

Meanwhile the geological question of the erratic boulders and deposits, which I had undertaken, was gradually being solved. The existing documents on the erratic deposits of the Central Alps were then very few. The older observations of de Saussure, de Buch, and Deluc, on the Alpine drift of the Swiss plain and on the erratic boulders of the Jura, and a few of Escher de la Linth in the eastern part of Switzerland, were entirely inadequate to the purpose. The classical work of Charpentier on the erratic deposits of the Rhône Basin had not yet been published. The various erratic regions had to be determined by their characteristic rocks; their true limits, as yet entirely unknown, had to be fixed and their lines of contact sharply defined; their boulders traced step by step from the top of the Jura across the plains and Alpine valleys to their parent rocks, in the heart of the snowy Alps; the height of their limit along the mountain slopes measured; the glacial marks and polished and scratched rocks carefully noted. This was done. Thus eight erratic basins were recognized on the northern slope of the Alps: those of the Isère, the Arve, Rhône, Aar, Reuss, Linmat, Sentis, and Rhine, and four on the southern slope, the Adda and Lago di Como, Lugano, Ticino and Lago Maggiore, and Val d'Aosta.

Moreover, a question left hitherto untouched, the distribution in each basin of the rocks special to it, was minutely examined and the final results of all the laws observed in the arrangement of the erratic fragments were shown to be identical with the laws of the moraines.

This identity and the absolute continuity of the erratic phenomena, from the heart of the Alps down the slopes of the valleys and beyond to the Jura, left no alternative but to admit the ancient existence of mighty glaciers, as vast as the erratic regions themselves, meeting in the plain of Switzerland, stemmed by the wall of the Jura and having a thickness of over 2,000 feet.

It was the intention of Agassiz to embody the results of these combined studies in a publication, "The Système Glaciaire, by Agassiz, Guyot, and Desor," in 3 vols., the 1st to contain the Glaciers, by Agassiz; the 2d, the Alpine erratics, by myself; the 3d, the erratic phenomena outside of Switzerland, in Europe and America, by E. Desor. The 1st vol. alone was published in Paris, in 1847, under the the title of "Nouvelles Recherches sur les

Glaciers." The Revolution of 1848 and its consequences put an end to this project. The 5,000 specimens of erratic rocks of Switzerland, the vouchers for the results obtained, and only partially published, are now in this country. This unique collection is exhibited, with explanatory maps, in a special room of the Geological Museum of Princeton College.

Here end the contributions of Agassiz to the science of the glaciers. Many of his conclusions may be contested, but the main laws of their mechanism were established. Little remained but the more delicate questions whose solution required the science of special physicists.

If to Venetz and Charpentier belongs the honor of having first proved the transportation of the Swiss erratic boulders by the agency of ice, and the existence of great glaciers formerly extending to the Jura, to Agassiz we must award the merit of having given to these facts their full geological significance, of having brought them before the world at large and having made the glacial question, as it were, the order of the day. By his sacacity he found glacial action where it was never suspected before; pointed it out to the astonished and unbelieving English geologists on their own soil; found it in North America, traced it with undoubted evidence in the temperate regions of South America, and believed, though hardly with sufficient reason, that he had seen it on the vast plains of the Amazon. He proved the phenomenon to be well nigh universal.

This period, it must be owned, was but an episode in Agassiz's scientific career, but it was a brilliant one, which carried his name far beyond the limits of the scientific world.

But with the vast number of expensive publications and the expeditions to the glaciers, which cost him sometimes in a single summer nearly his salary for the whole year, it is not astonishing that he incurred pecuniary responsibilities which required years of labor in after life to discharge. Providence again opened the way to bring him out of these increasing difficulties. His old and generous friend, Humboldt, was again the instrument. For a long time he had mourned the direction which Agassiz's studies had taken. He believed him out of his track in devoting so much time and thought to the glaciers, and many of Agassiz's best friends shared in this opinion. Humboldt obtained for him from the King of Prussia a scientific mission the object of which was to compare the faunas of

the temperate regions in Europe and America. A sum was placed at his disposal for this purpose, while his salary was continued. He received at the same time an invitation from John A. Lowell, Esq., to lecture before the Lowell Institute in Boston. He spent the winter of 1845-46 in Paris, completing his researches on the Echinoderms by the aid of the immense collections always freely open to him.

After a short sojourn in England he sailed for Boston in September, 1846.

The scene of his labors is now transferred to the New World, and a new period of his life begins.

The same popularity and success which had always attended him in his own country followed him across the Atlantic, and new friends were ever ready to rally around him. His lectures in Boston and the principal cities of the United States excited the liveliest interest. In this new period, while prosecuting his investigations with redoubled zeal, on a wider field, admirably suited to the breadth of his mental grasp, Agassiz stands out before us prominently as the great teacher of natural science—a teacher not only of the few in the seats of learning, but of the nation at large. Before him America had had many able representatives of the science of nature, fully appreciated abroad, but too much ignored by the mass of the people at home, who had not yet espoused the cause. Sympathy and efficient aid had been wanting. The stirring appeals of Agassiz were heard and the nation nobly responded.

The founder of this academy, the enlightened and far-seeing head of the Coast Survey, Dr. A. D. Bache, furnished him the much-coveted opportunities for extending his researches among the marine animals on the Atlantic coast and Florida. The Thayer expedition to Brazil and the Amazon, the generous subscriptions for the publication of his "Contributions to the Natural History of the United States," the Anderson school at Penikese, are palpable evidences of the universal readiness to foster his cherished projects. The Scientific School of Cambridge, founded in 1847, the Agassiz Museum of Comparative Anatomy and Zoölogy, in 1857, and the universal interest in science now awakened are lasting monuments of his beneficent influence.

I am sure it is not in this Academy that we shall hear a dissenting voice as to the immense power he has exerted in this country in spreading the taste for natural science and elevating its standard.

How many leading students of nature are proud to call themselves his pupils and gratefully acknowledged their great indebtedness to his judicious training. How many who now occupy scientific chairs in our public institutions multiply his influence by inculcating his methods, thus rendering future success sure.

Public education had no better friend. He published an excellent little volume on the method of study in natural history. He was one of the corps of able teachers gathered together by the genial and intelligent State Secretary of Education of Massachusetts, Dr. Barnas Sears, which, by means of the Teachers' Institutes, actually revolutionized the methods of instruction. It was to me supremely touching to see the great naturalist, at Penikese, a few months before his death, devoting his last strength to a crowd of eager learners, directing them to the exclusive study of the book of nature, and showing them, by word and deed, how to observe it and how to be taught by these living realities.

Of his numerous labors since he landed on the American shores I will only mention his researches in the various families of Radiates; on the Florida reefs in behalf of the Coast Survey; his great work, "The Contributions to the Natural History of the United States," three volumes of which have been published, prefaced by a suggestive essay on Classification; the exhaustive embryology of the Turtle; his volume on the Expedition to Lake Superior; his "Journey to Brazil;" the Hassler expedition round Cape Horn, and so many others, to give even a short notice of which would carry me too far. I will only say that they all exhibit that superior talent of observation, true to the most minute details, while they show the same regard to the bearing which this new information might have on the higher principles of science, the same care to connect the observed phenomena in a code of doctrine. All the ideas brought out in his "Poissons Fossiles" reappear, but more matured and placed on a broader foundation. This is especially true of his remarkable essay on Classification.

It is on the broad principles laid down in this last work that the organization of the Cambridge Museum of Comparative Zoölogy is based. This latest enterprise, and surely the most enduring monument of Agassiz's scientific activity in America, is not an ordinary conception. Its triple series, *Zoölogical*, designed to illustrate the systematic affinities of the animals among themselves; the *Geographical*, showing their natural associations in the regions where they

live, including the *fossil types* to mark their successive appearance in geological times and their relation to the present creation; lastly, the *Embryological* series, unfolding the various grades of development, and enabling the student to compare them with the fossil types of early times; these three form a complete system demonstrating all the relations of the animal kingdom considered in itself and in connection with the surrounding world, past and present. It is a stereotyped form, a realization of his original ideas, developed throughout his life. No wonder that he devoted to this monumental work all his remaining strength to the very end of his days.

Permit me here to allude to one of the providential circumstances of Agassiz's life, which enabled him to perform so large an amount of work, and to do it cheerfully as well as efficiently. I mean his marriage, in 1849, with a distinguished daughter* of his adopted country, whom we all know without naming her, and all admire and respect. In this constant and devoted companion of his American life he found a wise and affectionate mother for his children. Her sound and firm judgment, her well-balanced mind, gave him a much-needed help and encouragement in the midst of sometimes complicated circumstances. Her literary talents, to which we owe the interesting record of his Brazilian journey, the picturesque account of the Florida reefs, and perhaps the final appearance of more than one of his late works, are acknowledged by all. Her deep and absolute devotion, her soothing influence, secured for him the peace of mind and heart so necessary for an undisturbed mental activity. To her also Science owes a tribute of gratitude.

Agassiz was born a naturalist as Raphael was born a painter. Nature was his first and last love; to live with her and study her was his life. His allegiance to her was unreserved. To be false to nature, or to belittle her—to warp her teachings, or to set them aside—was an offense which he resented almost as a personal one to himself. One of his last sayings (in the Atlantic Monthly) was that "philosophers and theologians have still to learn that a physical fact is as sacred as a moral principle."

Nature was his main teacher. From her he knew God as a personal mind; all wise, all powerful. Each specific form of plant or animal was to him a thought of God. The life system was God's

* Miss Elizabeth Cary, of Boston, Mass.

connected system of thought, realized by His power in time and space. These forms were not the result of blind physical forces. To these he conceded no power to produce any change in their permanent specific types. New species were new creations. Hence his constant and resolute opposition to Darwinism and to all evolution hypotheses. This zoölogical view he applied equally to mankind. Though a believer in the psychological unity of mankind, he maintained the doctrine of an original variety in the different types of man.

Such were his intellectual views of nature, but his heart taught him more. I remember the tear of emotion which glistened in his eye when he spoke with thankfulness of the gifts of a kind Providence to himself and the perfect happiness he had in every member of his family. If his mind recognized God's wisdom in nature, his heart surely felt that in God there is more than mind; there is tender love.

By his large contributions to Science in America, by his power of developing a true scientific spirit, to excite and popularize the taste for scientific researches, by his vast influence on the American mind, and his universal popularity, which he kept to the very last, Agassiz had become emphatically a *national man.*

On the 14th of December, 1873, Agassiz passed from the scene of his earthly labors to another and a wider sphere.

The elite of the nation attended the impressive funeral services in the chapel of Harvard University. The mournful sound of the tolling bells seemed to give expression to the heavy gloom which rested upon the large gathering and the entire city.

Well might the flags of the country descend to half mast and mourn so useful a citizen. Well might the representative men of the American Government and of cultivated society mingle their sorrow with that of the representatives of science and public education, for which he had done so much.

On his modest tomb, in Cambridge, under the hallowed shades of Mount Auburn Cemetery, a huge boulder of solid granite, transported from the glacier of the Aar, the theatre of his glorious investigations, fitly marks the resting place of his mortal remains; but Agassiz's memory will live in the hearts of all those who have known him well, and his name will shine forever in a high place in the Temple of Science.