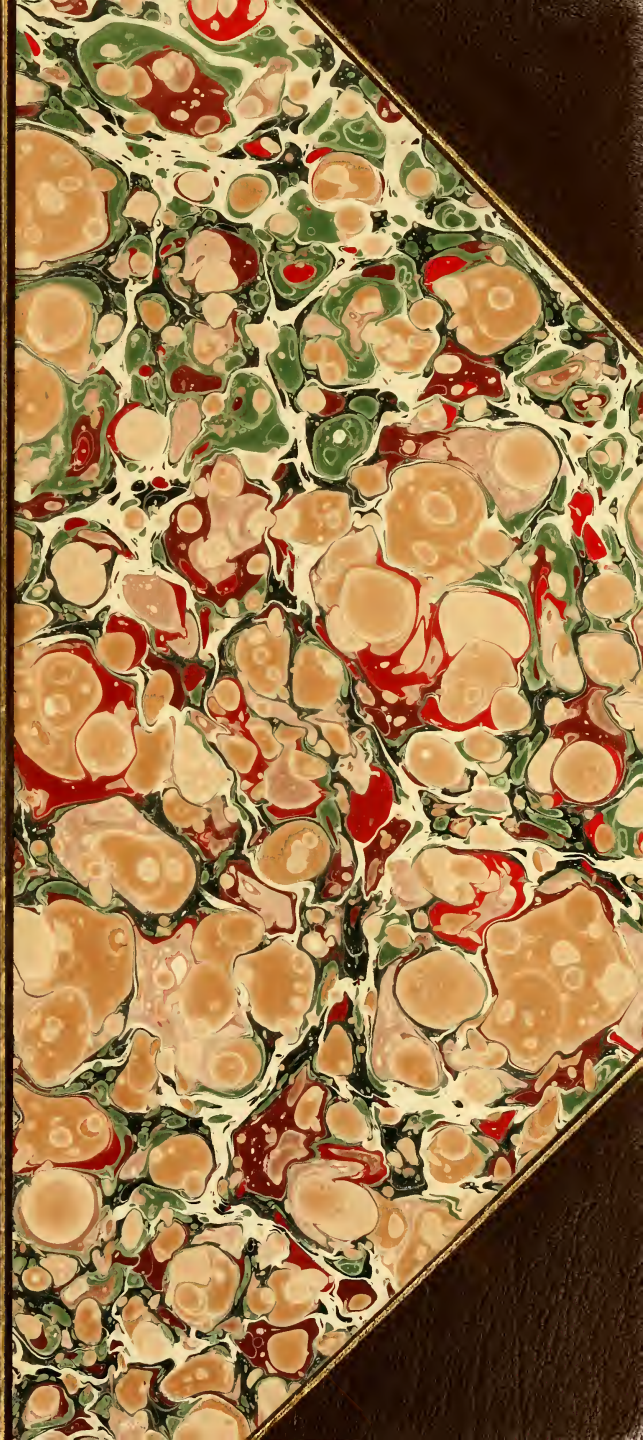

THE

RAMBLES OF A NATURALIST.

VOL. I.

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THE

RAMBLES OF A NATURALIST

ON THE

COASTS OF FRANCE, SPAIN, AND SICILY.

BY

A. DE QUATREFAGES,

MEMBER OF THE INSTITUTE,

PROFESSOR OF ETHNOLOGY AT THE MUSEUM OF NATURAL HISTORY
AT THE JARDIN DES PLANTES,
ETC. ETC.

TRANSLATED

(with the Author's sanction and co-operation)

BY

E. C. OTTÉ,

HONORARY MEMBER OF THE LITERARY AND PHILOSOPHICAL
SOCIETY OF ST. ANDREWS.

IN TWO VOLUMES.

VOL. I.

LONDON:
LONGMAN, BROWN, GREEN, LONGMANS, & ROBERTS.
1857.

TO

SIR DAVID BREWSTER, K.H.

D.C.L., F.R.S.

ONE OF THE EIGHT ASSOCIATES OF THE IMPERIAL INSTITUTE OF FRANCE,
CHEVALIER OF THE PRUSSIAN ORDER OF MERIT OF
FREDERICK THE GREAT,
PRINCIPAL OF THE UNITED COLLEGES OF ST. SALVATOR AND
ST. LEONARD'S, ST. ANDREWS,
ETC. ETC. ETC.

DEAR SIR DAVID,

I VENTURE to associate your name with the present volumes on the double ground that the learned Author is one of the most active members of the time-honoured Institute of France, which, by electing you one of its Eight Foreign Associates, has conferred upon you the highest honour that can be attained in the world of Science; and that M. de Quatrefages, like yourself, combines the faculty of abstruse research with the felicitous gift of popularising science in a spirit at once earnest and genial.

Hoping that you may be spared for many years to continue your important labours in those fields of science in which you have already reaped so rich a harvest,

I remain,

Dear Sir David,

Yours very truly,

E. C. OTTÉ.

ST. ANDREWS:
October 1857.

INTRODUCTION.

In writing for the *Revue des deux mondes* the articles which I now reprint with several modifications, I have to some degree been influenced by the wish of placing zoology in a more just and favourable light. Most persons form a very false idea of the natural sciences generally, and of zoology more particularly: indeed, by many persons the zoologist is looked upon merely as a man who can repeat by rote a more or less considerable number of barbarous names, and who is acquainted with a certain number of anecdotes in relation to the habits of animals — a species of information which, although it is no doubt very interesting in its way, is alike useless in a practical point of view and unworthy of occupying the serious attention of a cultivated mind.

This is a singular error, but it is one which readily admits of an explanation. There are few children into whose hands some little book on natural history has not fallen, but unfortunately most of these works are very ill adapted to give exact ideas of the dif-

ferent branches of this science. Erroneous impressions which are not corrected by any ulterior teaching must necessarily become thoroughly confirmed. And yet to judge of zoology by the collections of stories which amused our childish years, is very much the same thing as if we were to form a judgment of physical science from the tricks of a juggler, or of astronomy from what we learn by pointing a telescope in the open air at Saturn's ring or the mountains in the moon.

I have thought that the best means of bringing the educated classes to adopt more correct ideas was to leave zoology to defend itself by showing the great truths which it has discovered and the numerous facts which it comprises, and by indicating the problems of general physiology which it has solved and the profound questions of natural philosophy which no other science can so well enter upon. By this course I hoped to bring over to the ranks of its defenders a band of intellectual supporters, and I think I may venture to assert that experience has shown that my hopes were not unfounded.

Many utilitarians, while they admit the interest which is awakened by this order of facts and ideas, inquire, *Cui bono?* — This discouraging question, which was formerly addressed to all sciences, is now limited to zoology. It is admitted that mathematics are of some use; physics and chemistry have long since given proof of their utility by the deduction

of practical facts from abstruse theories. The cultivation of fruits and the sale of flowers, by giving a profitable occupation to thousands of persons, have popularised the study of botany, that elder sister of the other natural sciences which perhaps owes its first popularity to its early association with medicine; while mineralogy and geology, after having been long studied in consideration of the light which they might throw upon the practical working of mines, have of late been also applied to agriculture.

It is only within the last few years that zoology has been directly applied to any objects capable of yielding a profitable return. The light which this science was able to throw on the phenomena of life was not sufficient to attach to it the attention of the general public, who number among their body men of distinguished eminence in special departments, but who too often do not esteem any science but the one to which they are exclusively devoted. Many of our most distinguished savants are often as blind as the most illiterate of their fellow-citizens to the direct applications of any department of knowledge of which they are themselves ignorant. Thus, for example, they cannot comprehend that the breeding of agricultural stock and the cultivation of domestic animals — two most important problems regarding which our knowledge has hitherto been merely empirical — are only definitely based upon the science of zoology.

But zoology has not been behindhand in satisfying the requirements of our age. Recent experiments on artificial fecundation have drawn attention to long forgotten facts and have shown that the waters may yield as rich a harvest as the land. Notwithstanding some of those failures which are inseparably associated with first attempts, the future success of pisciculture as an industrial art is established beyond all question; and here we do not simply allude to the propagation of fish, but to that of all the aquatic animals which are useful to man. Without going beyond France, we shall find many results in proof of this success. Thus, for instance, M. Coste has acclimatised river fish in a pond at the Collége de France. MM. Géhin and Rémy have re-stocked several rivers from which the fish had long disappeared. M. Millet has this year thrown into the Lévrière more than two thousand trout of a year's growth, weighing collectively nearly 450 pounds, and all of them the produce of one well managed fish-preserve. The artificial rearing of leeches at Bordeaux has for years been a source of wealth to the proprietors; and owing to the exertions of these and other enterprising men France will soon cease to be dependent on foreigners for these useful Annelids. The town of La Rochelle possesses reservoirs for the breeding of shrimps and oysters, where the former are sheltered from the mud which would destroy them, and where the latter acquire from their first appearance the green colour which

characterises the celebrated Marennes oysters. We may next refer to the artificial oyster beds, which are readily constructed, and might indeed be planned, on the model of the mussel beds of Esnandes. Nor must we pass over in silence the introduction into Europe of new species of domestic animals—a subject to which the *Société d'acclimatation* is especially devoted. Next there is the artificial fattening of stock and the extraction of fatty matters, the first suggestion of which is due to zoologists; and, lastly, we must remind our readers of the immense development which the various artificial means of rearing animals will probably attain in the course of time. With such considerations before us, it surely can no longer be asked of zoology, *Cui bono?*

Thus much for utilitarianism. Man, if he were a mere material organism, only a little superior to the inert bodies in nature, would still owe some debt of gratitude to zoology. Man, however, combines with his material nature an intelligence and a soul. Every man worthy of the name has intellectual and moral wants as imperative as his physical necessities; and we may unhesitatingly venture to assert that no science satisfies in so high a degree as zoology the noble instincts which constitute the human species a kingdom apart in the realm of nature. Is there not then some degree of utility in such a result as this?

In the course of the present work I have fre-

quently referred to considerations of this kind. I have endeavoured to show how well adapted is the science of living creation to elevate the mind, at the same time that it brings back our thoughts towards Him who has created all things. I will not, therefore, here revert to this subject; but there is still another useful consequence to be deduced from zoological studies, to which I would now draw attention.

The number of animals known to us at the present day may be counted by hundreds of thousands, and the most retentive memory would be unable to grasp even the mere names of all the species. To guide us through this labyrinth, zoologists have devised systematic methods of classification which are based upon the very nature of the animals themselves. The animal kingdom has been distributed over a sort of framework, whose divisions correspond with so many groups of facts and ideas which rise gradually from isolated details to the most extended generalisations. It is impossible to occupy oneself assiduously with studies of this kind without becoming in some degree imbued with their spirit. If it is useful to learn from mathematics how to reason in a logical manner on purely abstract questions, and if it is useful to acquire by means of physics and chemistry a spirit of experimenting, would it not be still more interesting to the minds of youth if they were taught to observe, to classify, and to co-ordinate masses of

precise facts and ideas, based upon realities in such a manner as to enable them to seize upon their true relations and their most general consequences?

Would not the habits thus based upon a methodical system find constant application even in our daily lives? Considered from this point of view, there is no science that can replace the natural sciences generally, and zoology more particularly.

I have thus endeavoured to indicate the ideas by which I have been influenced in the composition of the present work, and it now only remains for me to say a few words regarding the mode of its execution.

In addressing myself to the habitual readers of the *Revue des deux mondes* I was speaking to an educated and intelligent class, who, however, have very little familiarity with the natural sciences. I was, therefore, obliged to proceed with some reserve, more especially at the beginning, and hence I almost always avoided entering into technical details, limiting myself almost exclusively to general questions. In this manner I often sought to imitate the physician who envelopes in honey the unsavoury medicine which might otherwise be repulsive to his patient, and hence I have interwoven descriptive or historical details in nearly all the chapters of the work.

Having yielded thus far to the necessities of the case, I devoted myself so much the more earnestly

to the principal aim which I had in view. Whenever I was speaking of scientific matters I never allowed myself in the slightest degree to sacrifice the substance to the form. Here I was anxious to act the part of the zoologist as rigidly as if I had been engaged in compiling a work for my brother zoologists. The facts which I have brought forward in these *Rambles* may be found either in my own memoirs or in the scientific works of others, whilst the ideas which I have here developed are precisely the same as those which I have at all times advocated. Considered in this respect, these volumes might be entitled *General Essays on Zoology and Physiology.* In the notes which I have added to the present edition of these *Rambles* I have entered somewhat more freely into the technical character of some of the questions under consideration; I have given references to a large number of different works and memoirs; and, finally, I have appended notices, which are of necessity very short, regarding the lives and the principal labours of the authors whom I have had occasion to quote.

If I should be blamed for spending time upon this attempt to popularise science which I might have devoted to original researches, I would venture to urge in extenuation that La Place wrote his *Exposition du Système du Monde,* Cuvier his *Discours sur les Révolutions du Globe,* Arago his *Notices,* Flourens his *Études* and his *Histoires,* and Humboldt his

Views of Nature and his *Cosmos.* It has seemed to me that I could scarcely be committing an error, when I attempted to follow such examples as these, by endeavouring in my turn to make others comprehend and appreciate a science to which I myself owe very many hours of unalloyed happiness.

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RAMBLES OF A NATURALIST.

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I HAD spent the spring of 1841 in studying some of the inferior forms of animal life which occur in the environs of Paris.* In the course of these researches I explored the ponds of Plessis-Piquet and Meudon, the stagnant pools around Vincennes, the basins in the gardens at Versailles, and even the ditches along

* [M. de Quatrefages here inserts a note on the classification of the animal kingdom, which, in consequence of its length, we have transferred to the Appendix. See Appendix, Note I.]

the high roads. My table was daily covered with vessels containing the water which I had brought home with me from these excursions; and while the aquatic plants that had been left undisturbed were exhibiting an active state of vegetation, the delicate filaments of their roots formed a place of retreat for thousands of those minute beings whose existence and marvellous organisation are only revealed to us by the microscope. There was the *Rotifer*, whose body, composed of rings fitting into one another like the tubes of a telescope, is provided on its anterior extremity with two wheel-like organs—a singular creature, which, although it can only truly live in water, inhabits the moss of our house-tops, dying each time the sun dries up its place of retreat, to revive as often as a shower of rain supplies it with the liquid necessary to its existence, and thus employing several years to exhaust the eighteen days of life which nature has accorded to it.* There was the *Hydatina senta*, an animalcule allied to the rotifer, whose aquatic existence is often cut short by drought, but whose ova, mingled with the dust of our roads, and borne aloft by the winds, are carried far from the place of their origin to some drop of water, where they undergo further development and secure the propagation of their species. The hydatina is an exquisite little creature of such pure crystalline transparency that the microscope†—that

* [A sketch of the natural history of the Rotifers and their allies is given in the Appendix, Note II.]

† [We have transferred to the Appendix, Note III., a short history of the microscope, which the author had given as a foot note.]

wonder-revealing instrument—can penetrate even to the inmost recesses of its organisation.* Then there was the *Brachionus*, another genus of the class of rotifers, which, on the slightest indication of the approach of danger, covers its long tail and ciliated head with its bristling cuirass. Next in order came some of those *Diatomaceæ*†, whose infinitely minute siliceous shields have offered a firmer resistance against the revolutions of our globe than the gigantic skeletons of the antediluvial monsters—organisms so microscopically minute that the point of a needle might at one touch crush hundreds of them, although their remains have combined to form entire rocks and extensive geological strata, known and worked for ages under the name of tripoli. Lastly there were *Planarias* ‡, and myriads of infusorial animal-

* *Hydatina senta* belongs to the class of the Rotifers. It was on this species that Ehrenberg made his first observations on the complicated organism of these little animals. The hydatina is of very common occurrence in the neighbourhood of Paris, especially in the spring, when it is to be met with in the little pools of stagnant water on the road-side, and in the ruts made by carriage wheels.

† The Diatoms constitute one of those groups regarding the position of which naturalists are still undecided; some holding them to be vegetables, while others regard them as animals. Some of them, as the Naviculas, exhibit a slow and regular motion which appears to be the result of spontaneity. Many present forms of geometrical regularity, and their siliceous shields, transparent as the purest crystal, are moreover, marked with tracings of such extreme delicacy that every improvement in the microscope reveals to us new and previously unobserved details.

‡ The Planarias belong to the great subdivision of the *Vermes*. They are flat, slightly elongated animals in which the two sexes are united; they are provided with a digestive apparatus, which ramifies over the whole body, and they move by the aid of vibratile cilia,

cules*, of every form and name, which multiply by self-division (fissiparous reproduction), so that it may literally be said that the son is half of his parent, and the grandson the quarter of his grandsire.

Such studies are highly attractive even when considered on the simple grounds of curiosity: this, however, is not their only claim upon our attention, for they possess another and a far greater source of interest. In the higher forms of animal life, the size and opacity of the organs do not allow of our studying the mechanism of their actions and functions in the living state; in their case we must content ourselves with the mere study of their anatomy. In the lower animals, on the other hand, we are enabled to trace the operations of nature at the very moment of their accomplishment: thus, for instance, in the animalcule we can follow the alimentary molecule from the very moment in which it is swallowed until it is rejected by the animal, after having yielded up all its nutritious matter. The changes which this molecule undergoes in its passage through the animalcule, and the successive action of the animal organs and fluids, are all displayed before

with which the entire surface of the body is covered. These worms, whose anatomical structure presents many singularities, have been carefully studied by many naturalists, amongst whom may be especially mentioned Von Baer, Dugès and De Quatrefages, Œrsted, Von Siebold and Dalyell.

* We have shown (see Appendix, Note I.) that the Infusoria must be provisionally regarded as forming a class of the subdivision of the *globular Zoophytes.* Amongst the principal writers on this group of animals we may especially mention O. F. Müller, Ehrenberg, and Dujardin.

our eyes, so that these crystalline organisms seem almost to invite science to raise a corner of the veil which conceals from us the mysteries of that which we term *life*.

In the midst of these attractive studies I found that the field of my researches was continually gaining in extent and beauty. But I was desirous, before I advanced further on my present path of inquiry, to obtain new materials for comparison, and to investigate, in a similar manner, those larger types of the inferior forms of animal life which are only to be found on the sea-shore. The ocean, to which I was still a stranger, attracted me in its varied coast lines, its innumerable zoological races, and its tides, which serve alternately to conceal and to reveal its treasures. These I resolved to explore; but the difficulty was to make a selection among the many different points of our western shores. At last, however, I was led to decide in favour of a group of islands situated to the north-west of the Bay of St. Michael's Mount, and designated by the pompous title of the *Archipelago of Chausey*. About the middle of June I packed up my dissecting instruments, a few books, numerous glass bottles and basins, my excellent Oberhäuser microscope, my study lamp, maps of the islands of Chausey and of the Bay of St. Michael's Mount, and thus equipped I set forth on my scientific campaign. I will spare my readers the details of my journey, as nothing could be more thoroughly commonplace. I passed through Normandy under a cold and foggy sky;

stopped one day at Caen, and then, without further delay, pursued my way to Granville.*

Here I made my first acquaintance with the ocean, and first learnt to understand the difference between the ebbing and flowing of the tides. How vastly different are the impressions produced by direct observation from those which we derive through books! The gradual disappearance of the beautiful beach, which I had just trodden; the sight of the waves dashing into foam against the rocks, which had only lately seemed so far removed from them; the gentle lifting up of the ships, fishing-smacks and boats from the bed of black mud, in which they had been securely moored; their successive rise, as each in its turn floated into deep water,—all these sights, everything around, filled me with sensations of wonder and admiration.

The tides are very strong at Granville and through the Channel generally; the difference between high and low water being sometimes as much as forty feet. At some points, as, for instance, round Mount St. Michael †, the space which is alternately covered and

* Granville is a little town in the department of La Manche. It is built on an elevated promontory which is almost entirely separated from the continent by a deep cutting. Its commodious and safe harbour was constructed in 1784, eight years after which the town made an honourable defence against the English. Its coasting trade, its oyster beds, and its cod fishery, render Granville one of the most busy of our smaller commercial sea-ports.

† The space surrounding Mount St. Michael which is alternately covered and left bare by the tide amounts to 80 or 100 square miles. This low and nearly level beach is intersected by several streams, which frequently change their course, and thus render this

exposed forms a zone of several leagues in extent. The imagination stands appalled at the idea of the fluid masses which are thus swayed from shore to shore by the attraction of the sun and moon; and although a four months' sojourn on the sea-coast familiarised me with this phenomenon, it in no degree tended to diminish the admiration which it awakened in my mind on the first day of my arrival.

The ancients characterised the land as their *Alma parens;* yet how much more worthy does the ocean seem of this title! The dweller on the earth must sow the seed, plant trees, or turn the soil with his plough before he can gather in the grain that is to nourish him, or pluck the fruit that is to quench his thirst. Months, nay years, may pass before his labours will be recompensed, and perhaps at the very moment when he is about to reap the reward of his toil, a blast of wind, or a hail-storm, comes utterly to destroy his hopes. The ocean demands no such protracted waiting, and gives birth to no such painful disappointments. The tide falls! — to work! to work! both young and old! there is room for all, and labour proportioned to every age and to every degree of strength. The men and their sturdy helpmates, spade in hand, turn up the sand, which has

coast extremely dangerous by tending to the formation of shifting sands. The mountain itself is merely a large granite rock measuring about 1600 yards in circumference at the base, and which rises to a height of between 400 and 500 feet. The summit is entirely covered with the castle which once played a prominent part in the wars of the Middle Ages; but is now merely employed as a state prison.

been covered by the sea for some hours, and soon their baskets are filled with cockles, razor-fishes, and venuses, which although less delicate, are more nourishing than oysters; besides these, there is also the sand-eel (*Ammodytes tobianus* et *A. lancea*), a little fish which is held in high esteem, but which is not as easily captured as the shell-fish, for it loves to hide itself under the sand, where it moves about with marvellous agility. During this time the young girls are dropping their pocket-like nets into the pools, which have been left by the retiring tide, busily employed in collecting shrimps, or in catching some lobster or crab, or perchance, even some stray shore-fish, which has been arrested before it could regain its distant place of retreat. Others, armed with a stick, terminating in a strong hook, scrape the sand below the stones and hollows of the rock, and from time to time draw forth a conger-eel with glistening skin, or some cuttle-fish or calamary, which vainly attempts to escape by shrouding itself in a cloud of ink. The children in the meantime gather from the rocks limpets, periwinkles, whelks, roaring buckies, ormers, or mussels, which hang clustering together like bunches of grapes, suspended by the threads of the byssus, which the animal weaves for itself. For two or three hours the beach is full of life and activity, whilst a whole population pours forth to seek its daily food; but soon the waves return towards the shore, the tide rises, and all hasten homeward, certain that the sea will replace the bounteous gifts which it is taking from them, and that in a few hours they may come forth again

to reap a harvest which has needed no season of planting or of sowing.

I was the bearer of a letter of introduction to M. Beautemps, the nephew of the celebrated engineer and hydrographer, to whom we are indebted for the magnificent hydrographical Atlas of the Coasts of France. I took the earliest occasion of presenting this letter, and, thanks to M. Beautemps, I made the acquaintance of M. Harasse, the proprietor of the islands of Chausey, and of M. Dubreuil, who was then in command of the coast-guard vessel, the *Moustique.* The former of these gentlemen gave me permission to establish myself on his property, and even accorded me the use of a room in one of the buildings set apart for the managers and for the preservation of the farm stores, whilst the latter undertook to convey me to my new residence.

At six o'clock the next morning I embarked on board the *Moustique,* which at once heaved its anchor and left the harbour of Granville. The sea was running very high, and the wind being against us, we were obliged to tack. To confess the truth, this voyage proved a severe trial to me, for after having earned the congratulations of the commander for my good sailorship, I was compelled to retreat to the cabin, where for three hours I remained a victim to all the horrors of sea-sickness. But at length these miseries were terminated by the *Moustique* gliding into the smoother water of the Chausey harbour, where the fresh north-west breeze soon restored my wonted courage.

In the course of a few minutes I had landed and

taken possession of my domicile. It was a large room, whose walls, blackened by damp, showed only here and there some problematical traces of former painting. On an uneven floor stood a large square table, another and smaller table, a few chairs, and a cupboard. A bed-frame, suspended from the ceiling by four ropes, and furnished with a few handfuls of straw and a mattress two inches thick, was to serve me in the place of a hammock. The apartment had one narrow and low window looking northward upon a small arm of the sea. It must be confessed that there was nothing very cheering in this *tout-ensemble;* but the attraction of novelty and the hope of future discoveries gave brightness to my walls and furniture, and diffused an air of comfort over everything; so that I was soon contentedly installed in my new quarters. The large table, firmly propped up against the wall, was converted into a working place, my microscope and lenses were arranged on the best lighted angle, some of my bottles stood near them, and the rest of the space was occupied by my forceps, scalpels, and crayons. I placed my books and the surplus of my bottles and jars on the chimney-piece. Large earthenware pans were ranged around the room. Everything, indeed, was disposed of in the best possible manner; but this admirable arrangement soon gave place to the disorder which so speedily takes possession of the quarters of a hard-working naturalist. The little table, which had at first been reserved for my meals, was speedily covered with my objects of research, and I was very often

compelled to substitute for it a chair, which required to be cleared for the purpose.

As soon as my preliminary arrangements were completed, I set forth to reconnoitre the territory which I intended to explore in the cause of zoology. The farm-house in which I was domiciled was built on the side of a small arm of the sea, called the *Sound of Chausey*. It consisted of two wings, one of which contained the stables, and apartments for the servants and men on the farm; the other was occupied by the baking-house, the manager's room, and the apartments reserved for the use of the proprietor. This double house was built of native granite, and constituted the capital of the archipelago; and the employés, who represented the aristocracy of the community, were so thoroughly sensible of their own importance that they had very little intercourse with the rest of the inhabitants.

Leaving the farm-buildings, I took the first path which presented itself, and crossed a marshy common, the favourite resort of the wild geese and ducks, which come in winter to breed on these inaccessible shores. A few paces further on a narrow and sandy isthmus led me to the foot of Gros Mont, the highest mountain of the archipelago, and from its elevated summit I could embrace in one glance all that the horizon encompassed. On every side of me was spread the ocean, which in the west was bounded only by the sky. To the south the view terminated with the coasts of Brittany, which scarcely rose above the line of the waves. Towards the east I could clearly distinguish the rugged shores of Nor-

mandy and the towers of Coutances, which may be seen, it is said, from a distance of thirty miles.* To the north I could discern Jersey, an island which, to the shame of our successive governments, still belongs to the English, and where the ancient customs of France and our beautiful *langue d'oil* have been preserved to the present day. At my feet the archipelago seemed to form a semicircle, intersected by channels, which were traversed from time to time by square-sailed boats, and studded over with its hundred of rocks and strangely-shaped islets, whose sides were either hollowed by deep creeks and bays, or flanked by bristling promontories.

Grande-Ile, on which I had taken up my abode, is about a quarter of a league in length, but of much less considerable breadth; indeed, its area scarcely equals that of the Jardin des Plantes. It descends in the east by a gentle slope to the Sound, whose narrow and deep channel is always open, and affords at all times perfectly safe anchorage. To the north rises Gros Mont, on which I was standing. Towards the south the island terminates in an elevated cape, called *Pointe-Marie.* The western coast is formed by a succession of hills, one of which, known as the Mont de Bretagne, is surmounted by the ruins of an ancient fort, commanding the beautiful beach of Port Homard. On the inner slope of these

* Coutances, which was formerly called *Cosedia* and subsequently *Constantia Castra*, is one of the most ancient towns of the department of La Manche. It has given its name to the territory known as Le Cotentin. Its cathedral is one of the most remarkable monuments of the ancient province of Normandy.

miniature mountains are several cultivated fields and two meadows, which extend as far as the farm buildings.

The rest of the island is uncultivated, and covered with that fine and close grass which grows on high mountains. The gramineæ enter largely into the composition of this herbage, but it is also intermingled with some pretty violet-coloured bulbous roots, and a large number of papilionaceous plants with golden-coloured corollas. The wild thyme was conspicuous everywhere, with its dark green patches, dotted over with little tufts of purple blossoms. Here and there a trailing rose-bush threw up small shoots of one or two inches in height, crowned with a delicate pink flower, or a berry as bright and as red as the finest coral. On the side of the rocks, which everywhere pierce the thin layer of vegetable mould, are thick bramble bushes, whilst the sheltered spots abound with peppermint, borage, and wild mustard. The portion of Mont de Bretagne which formerly served as a burying-ground has been planted with broom, which has thriven admirably, and now furnishes fuel for the ovens. To the north-west of Grande-Ile lies a group of smaller islands which present some slight vegetation. These are La Genetaie, Houssaie, La Meule, and Ile-aux-Oiseaux. To the north and west lie Enseigne, Plate-Ile, Deux Romonts, and Longue-Ile. Here the velvet-like sward, of which we have already spoken, is replaced by a high and mixed grass, which is cut every year.

During the revolutionary wars, Chausey remained uninhabited, owing to its exposure to the inroads of

the Jersey pirates. Two mammifers,—both belonging to the order of the Rodents, and both remarkable for their fecundity,—the rat and the rabbit, profited by the absence of human inhabitants, and disputed the possession of these deserted rocks. When France, yielding to her destiny, was compelled to submit to the Treaties of 1815, Chausey began to be re-peopled, and French and Englishmen, after their long contests on the fields of battle, combined together against the usurping quadrupeds. Guns, dogs, and traps were all brought into requisition; and to escape this war of extermination, the rats took refuge in the western islands, where they are suffered to remain unmolested excepting at the time of the hay harvest. Not even the remotest rocks, however, could serve as an asylum for the unfortunate rabbits, for the Jerseymen pursued them with their ferrets; and now, the last descendants of this once numerous population are disappearing, one by one, before the attacks of these formidable agents of destruction.

The only representative of the class of reptiles which I met with at Chausey was a pretty variety of the grey lizard*, remarkable for the brightness of its colours. Of birds, on the contrary, there were numerous species. The sparrows, those never-failing attendants on the footsteps of man, have established their general quarters in the ruins of the old castle.† Troops of linnets and goldfinches pass

* We have in France, according to Dugès, five species of lizards: (*Lacerta ocellata*, *L. viridis*, *L. velox*, *L. edwardsiana*, *L. stirpium*, and *L. muralis*.) The last of these, the grey lizard, that frequents old walls, is the most common of all.

† The *Fringilla domestica*, or common sparrow, is one of the most

incessantly from one little hillock to another, whilst the plaintive cry of the wheat-eater is heard at every instant, as he flits from rock to rock. In crossing the sands, which had been left dry by the last tide, I encountered a considerable number of shore birds, which had come thither in search of food. The sea-pies (*Hæmatopus*), and sand-pipers (*Tringa*) picked their way along every indentation of the shore; the god-wits (*Limosa*), and the curlews (*Numenius*), with

universally distributed species of birds. It is of European origin, but it has accompanied many of our navigators, penetrating even as far as New Holland. Every one is well acquainted with the effrontery, voracity, and fecundity of these common birds, and consequently it is easy to comprehend how much injury they must commit. M. Rouyer de la Bergerie estimates the amount of corn eaten by every sparrow annually to be about one bushel. From this we may judge of the immense quantity of grain which is annually lost through the depredations of these birds. It must, however, be admitted that these voracious thieves render a real service to agriculture. When first the young sparrow breaks through the egg, it requires to be fed with some substance more tender and soft than the ordinary cereals, and on this account the parent birds supply it with grubs. Bradley has calculated, from repeated observations, that a couple of old sparrows will convey to their nest no less than 40 grubs every hour, which would give 480 grubs for the twelve hours of the day, and 3360 for each week's consumption. These numbers will explain a circumstance which occurred thirty years ago. With a view of protecting the neighbourhood of Vienna from the voracity of these birds, an order was published that every cultivator of the ground should, in addition to his other contributions, furnish the heads of two sparrows. This regulation was faithfully obeyed, and the sparrows rapidly disappeared, but on the other hand, all the trees in the neighbourhood were being devoured by caterpillars. It was therefore found necessary to repeal the decree, and for a time at least to encourage by every means the multiplication of the same birds which had been so ruthlessly destroyed.

their long, slender, and curved beaks, swarmed in every muddy creek; the solitary heron sat mournful and motionless upon a stone by the water's edge, waiting, with its proverbial patience, until some imprudent prey should pass within reach of its beak, whilst above his head the sea swallows (*Sterna*), and gulls (*Larus*), described a thousand circles in their rapid flight as they uttered their discordant cries; and then, after gently sinking to the surface of the water, rose by a sudden movement of their wings, after having seized the fish, which their piercing sight had detected below the waves.

On returning from my first excursion, I skirted along the garden of the farm,—a badly kept plot of ground, in which grew a few dwarf apple-trees, and two poor fig-trees. Here, at the foot of a small hollow, and near a clump of young willows, I discovered the spring, whose existence has alone been able to render Chausey habitable. The presence of a spring upon this block of granite, at several leagues from the coast of the main land, is a very curious circumstance, and somewhat difficult of explanation. The neighbouring land is not sufficiently extensive, and is, moreover, too shallow to allow of the supposition that its infiltrations are adequate for the supply of this spring. On the other hand, it is not easy to suppose that it should owe its origin to the continent across the twisted strata of those igneous rocks; yet this latter hypothesis is the less improbable of the two. However this may be, the water of this spring, which never dries, is excellent, and the coast-guard vessels always resort to it for their own use, as

they find it far preferable to any which they can procure at the adjoining ports.

The Archipelago of Chausey is essentially formed of a bluish-grey granite, separated into more or less extensive strata, whose regular and uniform disposition is easily recognised to the south and south-west of Grande-Ile, as well as all round Enseigne. These strata, which are almost horizontal in the centre of the islands, incline towards the shore, and sink into the sea at an acute angle. Fissures, perpendicular to the plane of the strata, intersecting each other at various angles, divide the rock still more, and facilitate its working.* A red friable stone, known in the country as *rotten stone*, fills these interstices. Veins of pegmatite, which when decomposed forms the kaolin used in the manufacture of porcelain, intersect these granitic masses, which are also interspersed with detached portions of quartz

* There is a very curious circumstance connected with the working of the granite at Chausey which, however, is often observed in other rocks of a compact structure. Before any considerable mass of the stone is detached, a narrow line of about an inch in depth is traced along the rock, and into this groove wedges of soft iron are placed side by side. These wedges are then alternately struck with a moderate degree of force, when, after a certain time, a sort of musical sound is heard to proceed from the stone, which indicates that it has been split through the entire mass. Nothing now remains to be done but to detach the fragment which has been thus obtained. When the rock is very homogeneous, the fracture is prolonged with much regularity, until it meets the adjoining grooves, excepting in case of its coming in contact with *rotten stone*. I have seen this method employed to detach blocks of granite which were fully a foot in thickness and more than fifty feet square, and in all cases the sides of the mass were perfectly parallel and smooth.

and veins of mica. No part exhibits the slightest trace of the pudding-stone and rose granite of Jersey, or of the schist, trap, or quartz rocks so common at St. Malo. The rock of Chausey does not, either, resemble that of Granville; hence everything disposes us to regard this district as being merely indirectly connected with the neighbouring formations.

During high tide, an observer standing on Gros Mont sees only fifteen islands around him, and these are almost on a level with the surrounding liquid plain. One by one some isolated rock detaches itself from the green bed of the ocean, and arrests the waves as they break in white foam against its blackened summit. But soon the tide is seen to ebb; the sea, after some oscillation, begins to fall. The islands gradually become larger, girding themselves with a broad belt of moss-covered and blackened rocks, festooned by long pendants of brown fucus, which hang from their sides like the marble reeds with which sculptors adorn their statues of river gods. Numerous rocks, covered with the same vegetation, seem to emerge on every side and rapidly multiplying, end by mingling together into one mass. At length, long banks of yellow sands come to view, vast prairies of the zostera* rise from beneath the waves, and, uniting the points which had before been severed, convert the archipelago into

* *Zostera* constitutes a genus of marine plants which grow submerged in almost all seas, being usually found near the coast; the species to which we here refer (*Z. marina*) is remarkable for the length of its leaves, which look like long, narrow, and thin green ribbons.

one large island, whose circuit, which is about twenty-one miles, is broken here and there by the indentation of some few and narrow channels.

It is difficult to conceive anything more desolate than the appearance of certain parts of Chausey, more especially the north-west angle, at low tide. One might also fancy that the islands were the mere débris of some mountain hurled pell-mell into the middle of the ocean. Blocks of every variety of form and size are grouped together in a thousand different ways, some rising into pyramids, others graduated and cut into irregular tiers of steps, others again heaped together into confused masses like the ruins of some giant structure, at one place upheaved like colossal Druidical stones, at another entangled together like the rude materials of some Cyclopean edifice, or else suspended and so slightly poised, that a breath of air seems sufficient to overthrow them. The first appearance of this frightful picture of chaos leads one to refer the disorder to one of those great convulsions of nature which have upheaved mountain chains and excavated ocean beds. But this conjecture is incorrect; for the slow but incessant action of atmospheric agents, joined to the reiterated shock of the waves, has sufficed to produce this disarrangement, which moreover exists only on the surface. With a little attention, one may easily discover the regular stratification of the islands below these powerfully-shaken blocks, and we may thus the more readily explain a phenomenon which is of daily recurrence.

We have seen that the geological framework of

Chausey is entirely granitic, and very probably owed its existence to a special ebullition of that great central fire whose fluid lava has contributed to the formation of the thin crust which we inhabit. When this incandescent mass issued from the interior of the earth, it rapidly cooled. This cooling process was followed by the sudden retreat of the fluid masses, and this gave rise to intersecting fissures which were soon filled with débris that have produced the rotten stone. The latter is unable to offer any prolonged resistance to the shock of the waves; and, by its disintegration, it isolates the more compact blocks, which, notwithstanding their enormous weight, are often transported to considerable distances by the force of the sea. During my stay in the archipelago a section of rock, nearly 1000 tons in weight, was detached from the main mass, and hurled to a distance of several yards by the action of the waves, at a time when the fishermen were able to pursue their ordinary daily avocations.

It would appear that the Chausey islands have not always been as far removed from the continent as they are at the present time. According to a tradition which is universally diffused over the district, this granitic mass once formed the head of a dyke of rocks, protecting vast morasses and a considerable forest, which is now submerged beneath the waters. Some writers have even thought that they were justified by ancient documents in referring the probable date of this catastrophe to the year 709 of our era. Geological facts give a certain degree

of value to this popular belief; and the vegetable strata, known under the name of submarine forests, which occur in the vicinity of Mount St. Michael, appear to afford it full confirmation. When a violent tempest breaks upon the shore and upheaves the surface these ancient deposits, which are habitually covered with mud or white sand, sometimes come to view. Whenever this occurs the fine sands disappear beneath a blackish earth, which encloses entire trees, ranged in a uniform direction, in strata, above one another. The various species are easily distinguished; of these the oak, the yew, and the birch are the most common. The trunks of these trees seem first to have been reduced to a state of mould, and subsequently, on exposure to the air, to have regained consistency of texture and to have acquired a darker shade of colour. The oak especially exhibits the hardness and shining black tinge of ebony; and hence it is employed for the same purposes and used in the manufacture of ornamental furniture. These trees rest upon a soil which appears to have been meadow-land. We find among them reeds, grasses, ferns, &c. All these plants are in their natural positions, and have preserved all their most delicate parts; the reeds still contain a light medullary pith, and the roots of the ferns exhibit the delicate loose downy hairs with which they are covered during the period of their vegetation.

Whatever may have been the ancient relations subsisting between the Chausey isles and the mainland, the archipelago certainly, at one time, enjoyed a very different degree of importance from that which

it at present possesses. This little corner of the earth has its history no less than the greatest empires. There existed here in ancient days an abbey, which after having been originally independent became tributary to the monastery of Mount St. Michael, in conformity with a decree of Richard I. Duke of Normandy. It was originally held by the Benedictines; but towards the year 1343, Philip of Valois bestowed it upon the Cordeliers. The numbers of the religious community were very considerable at that time, as is proved by the registers of the Bishopric of Coutances, and as we find attested by the tombs, discovered some years ago when a part of Grande-Ile was laid down in pasturage land.

If we are to believe the current tradition, these early proprietors of Chausey were far from leading lives in conformity with their sacred character. Shipwrecks formed the principal branch of their revenues, and not contented with pillaging the wrecks, which chance or storms threw upon the coast, they kindled beacon-lights on the points of greatest danger in order to allure the trusting mariners to certain destruction. It is added that those poor wretches who escaped from shipwreck met with a speedy death on these inhospitable shores. The women alone were spared, and, when they refused to yield to the desires of the monks, they were precipitated into a cavern communicating with the sea, where the next tide must have terminated their troubles. I was shown in one corner of the ruins of the old fort a square ditch, half filled with stones, which I was assured had served as the opening to these terrible *oubliettes.*

It will readily be supposed that superstitious fears have become intimately associated with these lugubrious memorials of former times. When the ruins are shrouded in night, and when a sudden squall from the west throws over them the light spray of the waves, there is not an inhabitant of Chausey who would venture to approach them, or who would dare to expose himself to the risk of seeing the red flames which flicker round the court of the old castle, or of hearing the groans which, issuing from the sides of the rock, are lost amid the crash of the storm.

Chausey has, however, more modern and more cheerful traditions. I heard much of M. Beautemps-Beaupré and of his labours; and I was also informed that several years before two *gentlemen* had come to instal themselves on the island, accompanied by their young wives. For four months they had explored the shore, ransacked the sands, and examined the ledges of rocks. Besides this they had established, in the neighbourhood of the farm, tanks filled with sea-water, communicating with tubes, and in these portable pools and artificial rivers they had kept all kinds of marine animals. These practices had given rise to a very large consumption of lobsters and crabs, not that the gentlemen devoured them, but they cut them up, dismembered them, *syringed* them, and examined them with strange-looking instruments. When the husbands went out fishing their wives accompanied them, and in all respects led an equally exposed life. When they were not engaged in these excursions the latter devoted their time to household duties and to drawing. At this time an epidemic

form of fever was raging on the island. The two young couples visited the sick, and cured them with a marvellous plant, whose name no one knew. I had no difficulty in interpreting this legend, for I knew all the actors. The fact is, that it was at Chausey that MM. Milne Edwards and Audouin* commenced those inquiries which subsequently led to their introduction to the Academy. It was here that they entered upon those splendid researches on the circulation and the nervous system of the crustaceans, which, although they furnished a refutation of the opinions of Cuvier, were frankly recognised by that great man, whose heart was too noble to harbour any paltry feeling of jealousy. And it was Milne Edwards and Audouin who, through their medical knowledge, had been able to cure many sufferers by the aid of some hygienic precautions and a few cups of tea!

Towards the beginning of the sixteenth century, Chausey, having been abandoned by the monks, was transformed into a military post, and subsequently, a short time before the revolution, it fell into the hands of a private individual. During our maritime wars, a poor woman, the widow of a seafaring man, remained alone in the farm buildings; and her presence seems to have protected them from the attacks of the Jersey freebooters, who were then the only persons that frequented this little archipelago, their personal interest leading them, no

* [A sketch of the chief natural-history labours of Milne Edwards and Audouin is given in the Appendix, Note IV.]

doubt, to preserve a thrifty housewife, who was often called upon to prepare their scanty meals and perform other useful services for them. After the peace, *Mère Lebuffe*, as she was generally called, retained the management of the farm until her age and infirmities rendered it impossible for her to fulfil the duties of this office. At the time of my voyage she was still living at Granville, in the enjoyment of a pension which her old master had settled upon her in acknowledgment of her long and arduous services. At the present time, in consequence of the importance which Chausey has acquired, a special manager is appointed to take charge of the supplies of food. He has also under his orders a farmer, a baker, two farm-boys, and two women, who attend more particularly to the care of the cattle and to the indoors work.

The post of Manager of Chausey is in great request, and gives rise to as many intrigues as the portfolio of minister under a constitutional king could possibly excite. Thus revolutions are not of rare occurrence in this little government, and I had the pleasure of watching one through all its various phases. I had been received on my arrival by an old man, who had formerly acted as master of a coasting-trader, but who for a number of years had performed the important duties of vicegerent to M. Harasse. A few days afterwards vague rumours informed me that he was going to be superseded, and, accordingly, one fine morning, the *Utile*, a small coasting vessel which was constantly engaged in the service of the island, set sail with our great official and all his

family, and on its return to the archipelago brought us another manager. Those of the islanders who had been the promoters of this measure gave themselves an incredible amount of trouble to make a noise in honour of the new-comer. They lighted fires around the flagstaff, fired guns and pistols, and cried till they were hoarse, *Vive le Gouverneur!* There were only two or three of these enthusiasts, and during their demonstrations the rest of the population quietly pursued their labours, and did not even for a moment suspend any of their ordinary avocations. Was not this a miniature representation of the history of our great revolutions?

In addition to the persons who are employed upon the farm, and who form a special body, Chausey maintains three totally distinct classes of inhabitants; the stone-cutters, fishermen, and barilla-collectors. The highest of these three classes is, undoubtedly, the fishing community, whose seven or eight families inhabit a small cape on the opposite side of the port of Chausey. An old boat, turned on end at the foot of some rock, forms the roof of their cabins, and is kept in its place by stones cemented together with the argillaceous mud of the Sound. One of these huts, from ten to twelve feet square, and three to four feet high, serves as a sleeping-place for a whole family, including the father, mother, sons, daughters, nephews, and nieces, and often various friends who have been attracted by the prospect of a day's fishing at spring tide. These fisher families are natives of Blainville, a little port situated on the coast of Normandy, who resort year by year to Chausey to catch

the lobsters which supply the Paris market. They employ for this purpose baskets or creels in the form of a truncated cone, surmounted by an opening which is so adjusted that the lobster cannot escape after having once passed through the aperture. Every fortnight at neap-tide the produce of the fishing is carried to Coutances, where it is bought up in the gross and despatched to the capital.

The number of lobsters which each family takes during the season may be estimated at about a thousand or twelve hundred. Chausey, therefore, exports annually from eight to nine thousand of these crustaceans, the returns for which, paid at Coutances, amount to ten or twelve thousand francs. It would thus appear that each master-fisherman realises rather less than thirteen or fourteen hundred francs for his arduous labours, which are continued for nearly nine months.

The shrimp-fishing is left entirely to the women, nine or ten of whom carry on this humble branch of business. Supporting their nets upon their shoulders they follow every indentation of the shore, carefully searching the under surfaces of stones and the pools in which these little crustaceans lie concealed; with care they may collect as many as four and a half pounds weight in the course of the day: but this branch of fishing is impracticable excepting when the tides are low. The total produce cannot be estimated at more than from four to six hundred-weight for each person; this, therefore, would give about two and a half tons weight of shrimps for the annual supply of Chausey, the greater part of which

is also disposed of at Paris. This branch of commerce brings in about eight hundred francs a head to the Blainville women, or nearly eight thousand francs in all.

I should have found considerable difficulty in exploring the extreme points of the archipelago had I not met with one of the Blainville fishermen, who undertook to serve as my gondolier. This man, Master Hyacinthe Forcel, was a very worthy person, and under his guidance I was enabled safely to explore all the lagoons of my rocky Venice. Tall of stature and of athletic strength, he joined to these advantages, which are so invaluable in his profession, an amount of intelligence very rare in one of his class, while his courage was equal to any emergency. Always ready to expose his life to save that of others, he had rescued a number of persons from certain death, without having ever claimed the recompense which the State awards in these cases; but at length one of these acts of devoted heroism was witnessed by a Commissioner of Marine, who took care that this brave mariner should receive the medal to which he had so many claims.

The stone-cutters form the second caste, and compose the most considerable portion of the inhabitants of Chausey. The great works which, for the last few years, have been in the course of erection at Granville and St. Malo, have brought the granite of the archipelago into great demand; indeed, the paving-stones of the *trottoirs* of Paris have chiefly been obtained of late years from the same locality. During my stay the numbers of these quarrymen

amounted to one hundred and twenty or thirty: almost all the men were Bretons from St. Malo and its immediate vicinity. They lived in wooden barracks or huts, about ten of which, grouped around Port Marie, composed the hamlet known as the St. Malo village. Two of their huts were used as canteens, in which tobacco, cider, and brandy were sold; a third was employed as a smithy: each of the other huts served as a sleeping place for some dozen workmen, whose beds were ranged in tiers above each other. In almost every case the wife of one of the men was charged with the duty of cooking for the community, and in that case she shared the room with the rest, from whom she was only separated by a coarse canvas curtain.

Finally, we come to the barilla-collectors, who constitute the lowest class among the population. These workmen come, year by year, from the neighbourhood of Brest and Cherbourg, to collect the wrack, or seaweed, from the submerged rocks of Chausey, and convert it into soda by burning. The men disperse themselves in parties of six over the archipelago, and construct a sort of shed in the centre of the circuit they intend to explore, and here they take shelter for the night. At low tide they strip the fucus from the rocks*, and collect it into large masses, which are sustained upon the surface of the

* The different kinds of fucus employed in the fabrication of soda or for manuring the land on our western sea-coasts are the *Fucus nodosus*, commonly called in England, knobbed wrack, or sea-whistle, *F. vesiculosus*, known as bladder fucus, and *F. serratus*, known as black wrack, or prickly tang.

water by the numerous air-vessels with which these marine plants are provided. These raft-like floating masses are then directed towards the spot which has been selected for the scene of operation, and after being brought out of reach of the waves, are scattered over the sands. When the fucus is thoroughly dried it is raked together and burnt, and the ashes are then collected in a small kiln, and melted, forming the substance known in commerce as *barilla*. The red light given forth at night, and the long columns of smoke which issue by day from these smouldering heaps, produce a very picturesque effect from the midst of the rocks, but the odour emitted from the smoke is extremely offensive; and on the islands it is considered, although certainly most unjustly, that it may engender every kind of disease.

One occasionally meets, upon the most isolated points of the archipelago, with families of Jerseymen who have come either for the purpose of fishing or of collecting the wrack which serves to manure their land. Woe betide these poor fellows if they are detected by the coast-guard; no mercy is shown them; their lines and nets are unceremoniously taken from them and their boats put into pound. The islanders, moreover, frequently take upon themselves to inflict summary punishment on the marauders. During my stay a circumstance of this kind occurred which nearly brought about serious disturbances. Some fishermen had come over from Jersey at the time of spring-tide, and had actually begun to block up Port Homard at a few paces from the dwelling-houses. A party of stone-cutters hastened to the

spot, took possession of all the fish which the men had caught, and cut up their nets. This act was loudly blamed by several of their companions; and as the expedition occurred in the night of Saturday and Sunday, the discussions to which it gave rise at the canteen soon terminated in quarrelling. The opposing parties came to blows, and on the following day two of the men were laid up from the effects of the fight.

Scenes of this kind were by no means of rare occurrence in this remote region, where policemen are unknown, and where a half-civilised class of men are left to appeal, whenever it pleases them, to the right of the stronger. Dissensions would have been still more frequent had it not been for the presence of an old theological student of the name of Lecam, who, from some inaptitude for his calling, had been led to forsake his studies and enrol himself among the stone-cutters. This man, after having nearly completed his theological education, visited many large cities, where he so assiduously frequented theatres and other similar places of resort that he exhibited some slight degree of confusion in his recollections, and nothing was more amusing than to see him between two adversaries endeavouring to reconcile them, quoting a verse from the Proverbs or Ecclesiastes to one, and a passage from a modern drama or a couplet from a vaudeville to another, but ending almost always by re-establishing a good understanding between the opponents. His jovial humour, and his insatiable powers of eating and drinking, made him popular amongst all his com-

panions, with whom he was accustomed to start some philosophical discussion whenever he happened to be tired of singing. I used to hear these singular debates from my room, and I was frequently amused at the ingenuity and good sense shown by these simple workmen in the course of their arguments.

Thus the Norman and Breton races meet at Chausey, displaying a peculiarity of disposition and manners which separates them quite as thoroughly as the difference in their occupations. The stone-cutters lead nearly the same kind of life as the day-labourers of our large towns; almost all of them spend Sunday in drinking and keep Monday as a holiday. The fishermen are alike sober and industrious, whilst the barilla-collectors seem, by their coarse and brutal habits, to justify the proverbial expression, "*bête comme un barilleur.*" While the summer lasts, the narrow and sloping surface of Grande-Ile is enlivened by the presence of nearly two hundred persons. Night and morning the Blainville women resort to the sands of the archipelago, whilst the men, detaching their boats from the shore, row off in different directions to examine their lobster pots. The fires of the barilla-burners throw up their long columns of whitish smoke, or gleam through the darkness of night like so many beacon-lights. From morning till evening the noise of the pickaxe and hammer resounds from the depths of the quarries and the sides of the hills, while, from time to time, the banks re-echo with the rumbling crash produced by the blasting of the rock. But on the first appearance of the equinoctial rains of autumn, at the

first touch of cold, these nomadic populations disperse. The barilla-collectors are the first to take their departure, soon afterwards the numbers of the quarrymen diminish, and, last of all, the fishermen return to the sandy harbour of Blainville, when the islands are again left to the exclusive possession of the farming community, and of two or three families of stone-cutters.

My arrival in the island produced quite a sensation. On the very first day the whole of the little republic knew that a doctor had come to spend some time amongst them, and before three days had passed my talents had been brought into requisition. Being anxious to visit the western group of islands, I had just crossed to Genetaie, when I heard some one calling to me in a loud voice. I was soon joined by a young man, who, breathless and with tears in his eyes, implored me to come to the aid of his father. I returned in haste, and found that it was quite time that I should do so. Not being sufficiently acquainted with the course of the tides, I had set out too late, and the tide having turned, the sea had already covered the sand-banks which a short time before I had crossed without wetting my feet. Ten minutes more would have sufficed to shut off all means of return, and I should have been obliged to sleep in the open air, if it had not been for the accident which had happened to the poor bargeman. The serious nature of the occurrence had not been exaggerated. His finger had been caught by the rope of the capstan, whilst he was shipping a piece of stone of several thousand pounds' weight, and the joint was exposed

to a considerable extent. I at first thought that amputation would be inevitable, but to mutilate a workman's right hand is much the same as to deprive him of his daily bread. Everything ought to be risked in order to avoid such a fearful calamity. Although I needed the most indispensable objects for regularly dressing a finger in this state, I did my best, and my attempts were crowned with unexpected success. At the end of three weeks the wound had cicatrised, and Master Balüe preserved the use of his finger.

Certes! this was a case in which I might have exclaimed with our great Ambrose Paré, "I treated him, God healed him." The case nevertheless won for me a prodigious reputation on the island. As, moreover, my advice was given gratuitously, it was not long before I was assailed with consultations. One might almost have thought that the good people of Chausey availed themselves of the opportunity to be ill. It was not enough, however, to prescribe for them, it was equally necessary to make up my prescriptions; and this embarrassed me not a little at first, for, although tavern-keepers are to be met with at Chausey, the islands cannot yet boast of a druggist. Happily for me, the flora of the island came to my aid, by furnishing me with the principal elements of my materia medica. With the help of mallow, which grows abundantly over all the archipelago, I was at no loss to prepare cataplasms and emollient *tisanes;* docks, borage, peppermint and wild-thyme served me in the place of other tonic, sudorific, and stimulant agents. Whenever any more decidedly

pharmaceutical remedies were needed, I procured them from the main-land. By these means I was enabled to be of real use to these worthy people during my stay amongst them, and my attempts to serve them were rewarded by their unbounded affection. It would have been hardly safe for any one to enter into a quarrel with me, when, on a Sunday evening, their sentiments of regard for my person were warmed by generous libations, for at such a time the whole island would have risen as a single man to defend *Monsieur le docteur.*

I had not come to Chausey, however, to study statistics or practise medicine. The sole object of my travels was the sea; the sole aim of my inquiries was to unravel some of the many mysteries which lie buried beneath its sands or hidden below its waves. The oceanic world with its marine creation in no way resembles the world revealed to us in the interior of continents, nor can our streams, ponds, or rivers, however large, afford us any idea of it. Side by side with those colossal monsters which man learns to overcome within the dreary depths of ocean; side by side with innumerable productions that minister to our wants or our luxuries, and whose history is familiar to very children; side by side with these dwell widely differing and strangely organised races, whose very existence is known only to a few. To observe these creatures we need enter upon no perilous enterprise such as the capture of the whale demands; we require no immense nets such as are used in catching the tunny, herring, or mackerel; we need no heavy dredge to scrape the bottom of the sea

and detach from its rocky sides the millions of oysters which daily load our tables; none of these are required; we need only walk along the shores from which the sea has just retreated. An indifferent or careless observer might, indeed, perceive nothing more than sand, mud, and stones. But pause a a moment, stoop, and look down at your feet, and everywhere you will see life teeming around you in the form of myriads of strangely shaped and marvellously organised beings. First there are bodies formed like stones, then there are stones which have been in turn transferred from the animal to the vegetable kingdom *; here we meet with plants so nearly allied to animals that they have long been classed amongst them †; next we encounter animals, which so closely resemble plants in respect to their stems, branches, and buds, that naturalists for ages believed in their vegetable nature. ‡ On every side the sands and mud have been disturbed, tracked, burrowed, and pierced by marine worms; the stones are covered with molluscs, polypes, and zoophytes of every kind, and even the very rocks seem rent

* The greater part of the *Nullipores*, which were at one time ranked amongst plants, and subsequently among the *Polypes*, by the side of the *Millepores*, have been found by M. Decaisne to be mere stony concretions.

† The *Corallina*, which has successively been placed in the three kingdoms of nature, is decidedly an alga, and consequently a plant, as M. Decaisne has shown by his researches. These plants, however, become very rapidly encrusted with calcareous salts, a circumstance which explains the difficulties attending their examination, and the errors to which it has given rise.

‡ [A brief notice of the history of this controversy is given in the Appendix, Note V.]

asunder to furnish a retreat within their narrow crevices for entire families of living beings.

In physical science man controls, to a certain extent, the object of his investigations. Thus, for instance, in the examination of a machine he may successively study each of the parts, consider their respective actions, and judge of the effect of the whole. It is very different, however, in the case of the natural sciences generally, and especially of zoology. Here we must wait and watch. The multiplicity of vital acts in animals which occupy the highest places in the scale of being too frequently conceals the truth from us, while it is impossible for us to imitate the physicist in isolating a single phenomenon; for when we do this, the whole is lost to our inquiry, and the animal ceases to exist. But in proportion as we descend the scale of being, we find that organisation is simplified, and that life, without being altered in its essential nature, is to a certain degree modified in its manifestations. The animal machine, if we may use the expression, is shown to us piece by piece, as if to reveal the action of its several parts, and to demonstrate to us the great laws of physiology apart from all accessory phenomena. These laws are the same for the highest mammal and the lowest zoophyte; the same for man, whose complicated anatomy has been studied for ages past, and for the sponge, whose organs appear to be blended into one sole living homogeneous mass, the smallest particle of which participates in all the properties accorded to the entire organism. It will be readily conceived how much interest attaches to observations such as

these, which nature itself seems to have prepared for us, and how much science may be advanced by the profound study of beings so insignificant in appearance. I was most anxious to commence my observations, and I, therefore, lost no time after I was once domiciled in setting to work with hearty good will.

I was especially impatient to explore the Sacaviron, a narrow channel which separates Meule from Ile-aux-Oiseaux, whose zoological treasures have been made known by MM. Audouin and Milne Edwards. After having been disappointed, on account of the prevalence of storms, I was at length enabled to visit it during the magnificent weather of our July spring tide. Imagine a narrow and deep valley, with precipitous rocks on either side, shining brightly in the sun wherever the granite had been denuded of its covering of fucus by the knife of the barilla-collector. At the bottom of this wild ravine, from which the ocean retreats only three or four times a year, a small stream of clear and limpid sea-water flows over pebbles which have been dyed every shade of colour by different kinds of Fucus, Coralline, Spongodium*, and other species of Algæ. In this spot, where every stone is a world within itself, I was able to contemplate in its incredible variety the domain of the lower marine animals; here I could admire in all their glory those unknown wonders of the deep of which even our best museums afford not the least idea; for these animal forms droop and, as it were, fade from view whenever

* The *Spongodium* is a plant belonging to the family of the Algæ, looking very much like a green sponge.

they are removed from their native element. The Turbo, the Buccinum, with its brown and white markings, the Rissoa, with its small, closely-twisted shell, and the Acorn shell*, with its pyramidal test, covered every stone and rock. In sheltered nooks I found the pretty little rose-coloured Cowrie, and large Chitons†, animals in which the back is covered by a solid cuirass composed of moveable pieces like the olden greaves. Then there was the Thetys‡, a kind of sea slug of a fine orange colour, which bears its tuft of branchiæ on the hindermost part of the back, and the Haliotis, with its nacreous shell, surrounded by a triple row of fringes. The vaulted roof of the little caverns, which had been formed by the crumbling away of the rocks, was clothed with a mammillated stratum of Simple Ascidians, a species of molluscs which live and die without ever having moved from the same spot; while from this bright red ceiling there hung, like so many girandoles, transparent crystal-like Clavellinæ, and the bright Botrylli,

* The acorn shells (*Balanus*) constitute a genus of the class of the Cirripedes—animals allied in many respects to the Crustacea, but which undergo certain metamorphoses, which led Cuvier, even after he had studied their anatomy, to place them amongst the Mollusca. The discovery of their true nature is due to the Irish naturalist, J. W. Thomson (see his *Zoological Researches and Illustrations*).

† The Cowries (*Cypræa*), which are well known to all conchologists and amateur shell collectors, are molluscs belonging to the class of the *Gasteropods*. *Chitons* belong to the same class of molluscs, and are remarkable for the division of their test, or shell, which exhibits a series of imbricated semicircular rings placed along the back.

‡ The *Thetys* belongs to the same class, but it has no trace of a test.

whose conglomerated masses exhibit the colours and translucence of the agate. The smoother stones were all covered with Compound Ascidians, which were spread over the surface in shining green, brown, red, or violet patches, interspersed with markings of geometrical regularity, which severally indicated the different family groups of these singular beings. Among these animals, all of which belong to the great division of the mollusca, appeared thousands of zoophytes, while Star-fishes of the finest carmine, and grayish-brown Ophiuras, with their five long and slender arms, lay hidden beneath the stones. Above them the Flustra spread out its little stony weft, Sertularias and Campanularias raised aloft their arborescent polyparies, resembling miniature shrubs; while the Eschara threw its microscopic cellules over the stems and fronds of the marine plants.* Sponges of every form and colour were intertwined among the branches of the fucus and attached to the sides of the rocks, either in thick masses or in interlacing meshes of delicate network. Here and there the Thetya† might be seen, with its rounded lobes bristling with little spicula, side by side with the finger-like masses of the Alcyonium and the Lobularia‡;

* The *Flustræ* and *Escharæ*, which were long regarded as zoophytes, are now considered as Polyzoa, belonging to the class of the Bryozoa. The Sertulariæ and the Campanulariæ are zoophytes.

† The *Thetya* is a kind of sponge having a globular form and a compact structure. This group, which is very imperfectly understood, has been made the subject of profound investigation by M. Valenciennes, who, however, has not yet published the result of his observations.

‡ The *Alcyonium* and *Lobularia* are polypes living in colonies upon one common mass.

sometimes too a Holothuria*, with its long, polygonal, whitish body, would slowly move across this living carpet by means of its sucker-like feet, spreading abroad its coronet of arborescent tentacles. How rapidly the hours passed, amid this profusion of life, while I was filling my boxes and bottles! How gladly would I have admired, examined, and carried off all that I saw! But I was soon forced to think of returning. The long riband-like fronds of the laminarias or oarweeds, which hitherto had been inclined towards the sea, wavered for a moment, and bending gently backward, they soon turned landward, their plaited bands undulating more and more rapidly as they yielded to the swell of the flowing current. The ocean was resuming its sway, and I was compelled to have recourse to my boat, not, however, until I had promised myself the pleasure of speedily returning to the same rich field of discovery.

The wandering annelids (*annélides errantes*) occupied my special attention during my earliest explorations.† Hitherto I had only known this numerous family of animals (commonly designated sea-worms) through engravings; but, although I had

* The family of the Holothurias belongs to the class of the Echinoderms.

† The Annelids constitute a very remarkable class of animals, to which I have devoted special attention, and many of my results will be referred to in the following pages. (We may refer on this subject to the works of Savigny and of M. Edwards, as well as to the joint Memoirs of MM. Edwards and Quatrefages, in the *Annales des Sciences Naturelles.*)

formed a tolerably exact idea of their organisation, I had not the slightest conception how many points of interest attached themselves to a study of these forms. When I had once surprised within their obscure retreats the Polynoa, with its broad brown scales; the Phyllodoce, with its hundred bright green rings; the Eunice, with its purple crest; the Terebella, surrounded by a cloud of innumerable living cables, which serve it in the place of arms; and when I had seen displayed before my eyes the rich fan of the Sabella, and the enamelled collar of the Serpula, I no longer smiled, as I had formerly done, at the thought of a naturalist having endowed two of these creatures with the charming names of Matilda and Herminia. These despised creatures seemed to me now no less worthy of a naturalist's homage than the most brilliant insect or the fairest flower. Let no one cite the violet as a pattern of modesty! the coquette! See how she shows from afar her fresh tuft of green leaves, and scatters abroad the sweet perfume which invites you to gather her! More skilful than her rivals, she knows that mystery is the greatest of all attractions, and that the rose itself loses by displaying her charms in broad day-light; therefore it is that she seeks the obscurity of our woods and the friendly shelter of the hedge-sides, but, like Virgil's shepherdess, she only conceals herself for the sake of being sought for. Now turn to the annelids! What do they lack when compared with the most splendid inhabitants of earth or air? yet they shun the light, they withdraw themselves from our view, but with no design to attract; and the naturalist alone knows

where to seek the strange wonders, which are hidden within the recesses of the rock and beneath the sandy beds of the ocean.

You may smile at my enthusiasm if you will, but come and judge for yourself. All is prepared! Our firmly adjusted microscope is furnished with its lenses, which magnify thirty diameters. Our lamp gives a light almost as white as that of a jet of gas, while a large lens, mounted upon a moveable foot, receives the rays of light and concentrates them upon our field of view. We have just placed upon the stage of our instrument a little trough filled with sea-water, in which an Eunice is disporting itself. See how indignant it is at its captivity; how its numerous rings contract, elongate, twist into a spiral coil, and at every movement emit flashes of light, in which all the tints of the prism are blended in the brightest metallic reflections. It is impossible in the midst of this tumultuous agitation to distinguish anything definitely. But it is more quiet now; lose no time, therefore, in examining it; see how it crawls along the bottom of the vessel, with its thousand feet moving rapidly forward and emitting bundles of darts from the broad knobs with which they are furnished. See what beautiful plumes adorn the sides of the body; these are the branchiæ, or organs of respiration, which become vermilion as they are swelled by the blood, whose course you may trace along the whole length of the great dorsal vessel. Look at that head enamelled with the brightest colours; here are the five antennæ, delicate organs of touch, and here in the midst of them is the mouth,

which, at first sight, seems merely like an irregularly puckered opening. But watch it for a few moments, see how it opens and protrudes a large proboscis, furnished with three pairs of jaws, and possessing a diameter which equals that of the body, within which it is enclosed as in a living sheath. Well! is it not wonderful? Is there any animal which can contend with it for the prize of decoration? the corslet of the brightest beetle, the speckled wings of the butterfly, the sparkling throat of the humming bird, would all look pale when compared with the play of light flashing in large patches over the rings of its body, glowing in its golden threads and sparkling over its amber and coral fringes.

Let us next examine these two Cirrhatulæ which belong to one and the same species, although they differ so much in colour. The one which was captured under a stone that had been washed several times daily by a rapid current, is of a dull red, relieved by golden markings. The other, found in the slimy mud that formed the bed from which a meadow of Zostera seemed to derive its rank luxuriance, had borrowed from the soil which it inhabited a deep and velvet-like blackness, over which there played a bright bluish iridescence. In this animal the branchial plumes give place to long filaments, which move in all directions around it, and extend afar as if they were so many living cables. They are at once its arms and branchiæ, and the blood, as by turns it ebbs and flows, dyes them of the richest shade of carmine, or leaves them of a faint amber-coloured yellow. See how they lengthen their

pointed snouts, surmounted by a double crescent-formed eye; how they gather themselves together to escape from the gleam of light which has fallen upon them. Look at the tangled skein which they have formed, it is a hundred times more inextricable than the knot which Alexander cut. But here the coils are living, and as they glide through and into one another, they incessantly bind and loosen the glistening knots, amid the sparkling play of their luminous reflections. During this time the animated threads, as they detach themselves from the glowing mass, catch up grains of sand and particles of slime, and in a few minutes, before you can distinguish the mechanism by which all this is effected, the annelids are sheltered under a flexible and plaited envelope, formed of fragments, which, thickening more and more as they cluster together, become at length converted into a kind of case, which encloses the Cirrhatula as the shell encloses the nut.

Now let us take a lens of higher power, move the lamp in such a manner as to let its rays fall upon the reflector of our microscope, and let us examine a few of the hairs taken from the animals which we have been describing. Every annelid has two bundles of hairs on the outer edge of its feet, and these threads, which, notwithstanding their extreme delicacy, are far stiffer than an ordinary hair, appear to be placed on either side of the animal to protect it against its enemies. A moment's consideration will suffice to confirm this view, for there is scarcely perhaps a single weapon invented by the murderous genius of man whose counterpart and model could

not be found amongst this class of animals. Here are those curved blades whose point presents a double and prolonged cutting surface, sometimes on the concave edge, as in the yatagan of the Arabs, sometimes on the convex border, as in the Oriental scimitar. Next we meet with weapons of offence and defence which remind us of the broadsword of our cuirassiers, the *sabre-poignard* of the artillery-man, and the *sabre-baïonnette* of the Vincennes chasseur. Then again we have harpoons, fish-hooks, and cutting-blades of every form, loosely attached to the extremity of a sharp handle. These moveable pieces are intended to remain in the body of the enemy, whilst the handle which supported them becomes a long spike as sharp as it was before. Here we have straight or curved poignards, cutting hooks, arrows, with the barbs curved backwards in order the better to tear the wound, but carefully provided with a sheath to protect the fine indentations from being blunted by friction or broken by any unforeseen shock. Finally, if the enemy should disregard his first wounds and the weapons which have struck him from afar, there darts from every foot a shorter but stronger spear, which is brought into play by a special set of muscles as soon as the combatants are sufficiently near to grapple in close fight.

It is not without reason that nature has endowed these amazons with more finely polished and sharply pointed weapons than any wielded by paladins of old. Destined to live by rapine, and exposed to the attacks of a thousand enemies, they need them both

as means of attack and defence. Almost all are nourished with living victims. Some wait in ambush for the passing of small Crustaceans, Planarias, or other minute animals, and seize their prey with their proboscis, or entwine them in the folds of their thousand arms. Others again, more active than the rest, pursue their victims over the sand or through thick tufts of Corallines, Nullipores, and various marine plants. Some attach themselves to shells, and after perforating them devour the inhabitant. The Hermella, a species of the tubicolous annelids, thus commits great havoc amongst oyster beds, destroying numerous colonies of this much cherished mollusc. The annelids are in their turn pursued by a multitude of carnivorous animals. Fishes wage a rude war against them, and if one more imprudent than the rest should abandon its retreat, or be exposed to view by the movement of the waves, it rarely escapes the murderous teeth of some whiting, eel, sole, or plaice. It it asserted that the latter kind of fish are well acquainted with the mode of drawing them from the sand; the same is the case with the Turbo and the Buccinum; but crabs, lobsters, and a great number of other crustaceans, constitute their most formidable enemies, for the solid carapace by which these animals are covered protects them entirely from the formidable arms of the annelids.

It was with a keen feeling of curiosity that, in the course of my excursions, I studied the manners of these bellicose races, and watched the skirmishes which terminated almost invariably in a feast, for which the vanquished supplied the viands in person.

I often amused myself by provoking these assaults. One day, for instance, I threw a large Arenicola* into a pool of several feet in extent. A troop of little shrimps, who were sedately enjoying themselves in the clear element, dispersed in alarm, startled by the noise made by the fall of this strange body, but, recovering themselves in a moment, they rallied, and whilst the annelid was endeavouring to bury itself in the sand, one of the youngest, and, consequently, also the most venturous of the party, seized the creature by the middle of its body. Emboldened by this example the others lost no time in imitating it, and the poor Arenicola was pulled about in all directions until a full-grown shrimp, darting from behind a tuft of Corallines, dispersed his feebler comrades and appropriated the booty to himself. I soon saw, however, that he would be compelled to divide the spoils, for at that very instant there poured forth from the moving sand some score of small Turbos and Buccinums, who, conscious that a victim was at hand, wished to participate in the feast. Without any sign of uncertainty or hesitation they moved straight forward towards the Arenicola, whose body was covered in the twinkling of an eye with these voracious molluscs. I thought his fate definitively settled, when a small shore-crab (Cancer Mœnas) issued from beneath a stone, put to flight

* The common fisherman's worm (*Arenicola piscatorum*) is one of the commonest annelids on our coast, where it is used for bait. It is moreover one of the most curious in reference to its organisation, as M. Milne Edwards has well shown in his *Memoirs on the Circulation of the Annelids.*

the shrimp, and by dragging off the Arenicola very nearly upset all the Turbos, who forthwith hurried back to their sandy haunts. Then, however, a large edible Crab (Cancer Pagurus) appeared upon the scene, and the poor little Mœnas was obliged in his turn to beat a retreat in order to escape out of reach of the formidable pincers of his stronger kinsman. But he still kept a watchful eye over the dainty morsel which he had once tasted, and taking advantage of a moment when the larger crab was withdrawing from the field from some temporary emotion of alarm, he rapidly seized the long disputed Arenicola, and carried it for safety to some distance from the water's edge, where he might devour it at his ease on dry ground.

During the early period of my sojourn at Chausey, I was employed in acquiring a general idea of the fauna of the district, and I found among the different species which it possessed that there were many hitherto undescribed forms. If I had felt any desire for this kind of inquiry, I might undoubtedly have reaped a rich harvest, but I confess I have never had the slightest taste for that modification of science, which rests satisfied with examining the exterior of an animal, and then pinning it on a cork or putting it into a bottle, with its name duly inscribed on a label.

There can be no doubt that the preliminary labour of compiling systematic lists was indispensably necessary, and I am far from wishing to detract from the debt of gratitude which we owe to the patient and laborious observers who have drawn up classified

catalogues of living species, or to those who are adding to them daily. We ought, however, strenuously to avoid the grave error of reducing zoology to the standard of a mere appraiser's craft. He who knows nothing of an animal beyond the name and place apportioned to it in a more or less well devised system of nomenclature, no more deserves the title of a naturalist than a librarian's assistant deserves the name of *savant*, because he knows by heart the titles of all his books, and their local and numerical arrangement in the press in which they are kept. No! in the case either of a book or of an animal we must go deeper than the binding, we must penetrate below the skin. True zoology, or that form of it towards which all other branches of natural science ought to converge, consists in studying the relations of organised beings and their connexion with the inorganic world, in investigating the play of the organs as animated instruments of these mysterious affinities; in penetrating into their mechanism; in following them in their modifications, in order to distinguish, if possible, between what is essential and what is incidental; in ascending from all these effects to the cause, and thus perhaps penetrating at some future day into the arcana of life; this is the end and aim of true zoology, the rest merely constitute the means.

Without, therefore, neglecting new species belonging to known genera, I was far from seeking for them. My principal object was to make anatomical and physiological observations; and investigations of this nature certainly do not lose any of their value by being pursued in reference to some already named

species. But even in this respect I was favoured beyond my expectations, for I discovered entirely new types or species belonging to genera hitherto unknown in our seas, and whose organisation it had therefore been impossible to study.

The human mind is so constituted that it appears to abhor all that is easy of acquisition. We see this exemplified both in the arts and sciences. Thus, whenever a new problem is started, you will have twenty solutions before you meet with the simplest explanation.

Naturalists seem carefully to obey this law of our nature. The Desman of Siberia was known more than half a century before that of the Pyrenees *, and whilst naturalists have cast their dredge into the waters of the seas which wash the Moluccas, Philippines and Antilles, we scarcely know anything of the marine productions of the Channel, the Bay of Biscay, or the Gulf of Lyons. Yet new species are to be found within a few leagues of us, and there is scarcely a naturalist who has gone to spend a few days on our sea coasts without having had the gratification of making some such discovery.

Let me speak to you for a moment or two of one

* The genus Desman (*Mygale*), includes only two living species, one of which was discovered in Siberia by Pallas, whilst the other was found in France at a much later period. It would appear that this latter species is limited to the small rivers that flow from the Pyrenees. The Desman is a small insectivorous mammal, exhaling a powerful odour of musk, which is produced by a special liquid secreted by the glands which are situated near the base of the tail. M. Lartet has discovered the remains of fossil Desmans in the rich osseous deposits of Sansan.

of those zoophytes, which up to the present time have remained hidden in the sand of Chausey. Setting aside the self-love natural to a discoverer, I venture to affirm that it merits the distinction on more grounds than one. It is a species of Synapta* belonging to a genus of the family of the Holothuridæ, whose representatives had hitherto been met with only in the warmest seas of the old and new world. Imagine to yourself a rose-coloured crystal cylinder, about eighteen inches in length and one inch in diameter, marked along its whole length by five minute bands of white silk, and surmounted by a pale white living flower, whose twelve petals are gracefully curved backwards. In the midst of these tissues, whose delicate texture seems to surpass the most exquisite products of our industry, you must suppose an intestine of gauze-like tenuity, but completely filled up with large grains of granite, whose fine points and salient angles may be distinctly seen by the naked eye. It was this circumstance which especially struck me in the animal, for it appeared literally to partake of no other nourishment than the coarse sand surrounding it. But

* I have given to this curious species the name of *Synapta Duvernaea*, in honour of my former Professor and much esteemed friend M. Duvernoy, who was a member of the Institute, and a Professor at the *Jardin des Plantes* and the *Collége de France*. As the compatriot of Cuvier, for he was born at Montbélliard, he early attached himself to that illustrious Naturalist, and brought out, in concert with Dumeril, the first edition of the *Anatomie Comparée*; at the death of Cuvier, M. Duvernoy succeeded him at the *Collége de France*, while he afterwards succeeded M. de Blainville in the chair of Comparative Anatomy at the Museum.

what unexpected wonders were revealed to my sight, when, by means of the scalpel and microscope, I penetrated to its inmost organism! In this animal, the walls of whose body were scarcely one-fiftieth of an inch in thickness, I could trace seven distinct layers of tissue, a skin, muscles, and membranes. I perceived that the petal-like tentacles were furnished with cupping glasses, by which the Synapta was enabled to ascend the polished surface of a glass; and finally I discovered that this animal, which appeared destitute of every means of attack or defence, was actually protected by a kind of mosaic, formed of small calcareous shields, bristling with double hooks, whose points, serrated like the arrows of the Carib, had even penetrated the skin of my hands.

After having preserved several living Synaptas for some time in a vase of sea-water, I observed that they underwent a process of self-consumption. First they distended the posterior portion of their bodies by suffering the fluid to accumulate there, which incessantly circulates between the intestine and the integuments; by this means a stricture was speedily produced, and the final separation suddenly effected. Scarcity of food seemed to be the sole cause of these spontaneous amputations. It almost appeared as if the animal, feeling that it could not supply the whole of its body with nourishment, suppressed those parts which it might cost the entire organism too much to maintain; somewhat on the same principle as that by which all useless mouths are banished from a besieged town. This

singular method of struggling against famine is maintained to the last moment; for at the end of a few days there frequently remained nothing more of the animal than a little spherical ball, crowned with tentacles. The Synapta had by degrees cut away the whole of its body in order to keep life in its head.

In one of his inspired songs the prophet exclaims, "The heavens declare thy glory, O Jehovah!" and assuredly there is no one who has not at times felt his heart lifted above earthly things, when on a fine summer's night he has watched the stars, as they stood forth like so many diamonds upon the deep azure of the celestial vault, shedding upon us from afar their scintillating light. There is no one, probably, who at the rising of the sun has not felt something of the same emotion which the Philosopher of Ferney experienced, when on the first occasion of his witnessing this splendid spectacle, he knelt in adoration before the majesty of the Creator, exclaiming: "Mon Dieu! vous êtes grand! qui pourrait ne pas croire en vous." Yet we find that the contemplation of celestial phenomena is capable of associating sceptical ideas with the most exalted sentiments of admiration. The immutable movements of the stars seem at every turn to give evidence of the control of fatality, and hence has arisen that belief in astrology which has prevailed so universally amongst enlightened nations. The discoveries of modern science, by destroying whatever was superstitious in these applications of astronomy, have perhaps rather tended to confirm this

general tendency. It might be argued that the wonderful laws revealed by Kepler and Newton,* have demonstrated, even more strongly than was before conjectured, that necessity was the sole determining cause of the movements of the planetary worlds; and what need, it is asked, can there be of a superior intelligence to regulate that which is necessary? Thus we find some of the names which have become glorious in astronomy, inscribed among the ranks of atheism. On the other hand, those who study living beings are every moment encountering such a vast accumulation of unexpected facts, that they may perhaps at first sight be tempted to believe in the absence of order. But the further they advance on this path of inquiry, in which nature so frequently presents herself under the aspect of the marvellous, the less frequently these apparent deviations from order will arrest their attention, while mutual relations which before were not even suspected will be ever presenting themselves to view, and contrasts of the most striking character will give way to harmony and obvious unity of purpose. Although some facts may indeed seem to militate against general opinion, and the most rational theories may appear to crumble into dust before a reality which the observer was unable to foresee, he will not be the less ready to trace the touch of that all-wise and all-powerful hand, which has everywhere diffused life over the surface of our globe,

* [A brief sketch of the chief scientific discoveries of Kepler and Newton is transferred to the Appendix, Note VI.]

and regulated its development. We therefore see nothing extraordinary in the cry of adoration which escapes from Linnæus at the very introduction of his immortal *Systema Naturæ* *; while we can as easily comprehend the feeling which actuated an illustrious naturalist, when he began and ended one of his last works with the exclamation, "Glory be to God!"

After spending the day in the toilsome labour of digging up sand and rolling over large masses of rock, I returned to the farm to recruit my strength with a frugal meal, and then prepared for my night work by ascending to Mont de Bretagne to watch the evening mist gradually descend upon the neighbouring islands. For some time after I had regained my solitary den, I could hear Master Lecam's songs repeated in full chorus by his companions; on some occasions too, sounds reached me which told of disputes which were waxing high under the influence of the cyder-cup; but these noises soon died away in the direction of the village of the St. Malo men, leaving the silence of the night unbroken by any sound save the crash of the waves as they beat against the point of Port Marie, or the blast of the west wind as it swept across the surf at Epails. My table, whose area of four feet square was crowded with the products of my explorations, now became a source of enjoyment, far more attractive than any of the numerous splendid spectacles which were being

* [A notice of the Life and Labours of Linnæus is transferred to the Appendix, Note VII.]

presented at the same hour before the eyes of the affluent idlers of our large towns. My forceps, needles, and compressor * secured the objects of my research; my microscope and lenses revealed an infinite world to my eyes, my pencils and brushes enabled me to secure rough illustrations of these treasures to be filled up at some future time with more care and exactitude; while my pen was employed in hastily drawing up the notes necessary to give permanence to my recollection of what I had seen. I saw one fact linking itself to other facts, I felt one thought awaken other thoughts, and this mutual reaction between observation and intelligence was the source of unspeakable enjoyment. Yes! in this remote spot of earth, whose desolate aspect could not fail to strike the beholder with profoundly sombre impressions, in this large room in which the cold and the dampness seemed to struggle for preeminence, in the absence of all material comforts, I can truly say that I enjoyed the most unalloyed pleasure that has as yet

* The compressor is a small instrument which may be almost termed the hand of the microscopist. It was invented in Germany by Purkinje, and has been considerably improved by subsequent observers. The instrument consists essentially of a metallic plate, pierced in the centre by an opening, which is covered by a glass plate. A second glass plate worked by a moveable ring can be applied with exactness to the former plate. The ring is attached to one of the extremities of a stem, which turns upon two pivots, and is provided at the opposite extremity with a vice, which enables the observer gradually to draw together, or separate the glass plates. In the compressor which I have invented, these plates are extremely thin, and the instrument is arranged in such a manner that it may be turned round to show successively the two opposite faces of the object placed between the two glass plates.

fallen to my lot. When ascending to the origin of all these harmonies, I found that the Eternal Power was the source from whence this admirable order sprang; when through marvel to marvel my thoughts rose from creation to the Creator, it was from the very depths of my soul that I adored Him in His works, and united with Geoffroy de Saint-Hilaire * in the cry of "Glory be to God!"

And now perhaps you may understand how it was that I could so easily forget myself in the midst of my occupations. Indeed it often happened that I did not seek my hammock-bed until my fingers were so stiffened with cold that I was unable to handle my instruments with the necessary precision. The Blainville fishermen, whose huts faced my window, were often surprised to find at three o'clock in the morning, that my lamp, whose light they had watched before they went to rest, was still burning. I believe this fact has left a more permanent impression than any of the other circumstances connected with my stay on the island. The good people thought that I lived without sleep, and occasionally gave expression, with the utmost *naïveté*, to their extreme surprise.

It may perhaps excite astonishment to hear of cold and dampness, considering that I was at Chausey during the months of July and August. But this surprise will vanish, if we call to mind the character of the summer of 1841 even at Paris; and that I was in the midst of the sea at three leagues' distance

* [A biographical sketch of Geoffroy de Saint-Hilaire is given in the Appendix, Note VIII.]

from that western coast of France, where a fine day, even in ordinary seasons, is a thing of very rare occurrence. I scarcely saw the sun above half a dozen times, during the three months of my sojourn. Either rain or mist accompanied me on nearly all my rambles. I often returned home so thoroughly drenched, that, from want of a sufficient supply of clothing, I was obliged to remain in bed while my clothes were drying before the fire of the farm-house kitchen. The south-west wind, which beat full upon my door, had so completely loosened all the joints, that in the slightest storm, I was inundated. A few days after my arrival, I awoke one morning with six inches of water under my bed: in order to avoid being entirely surrounded, I was obliged to cut a hole in the most sloping part of the floor, and by means of this precaution I had for the future a river instead of a lake in my room. All my steel instruments were covered with rust; the metallic mirror of my camera lucida was entirely ruined, and I had some difficulty in protecting the brass work of my microscope. The salt melted in my salt-cellar; and a pound of sugar, which had been forgotten for a fortnight at the bottom of my cupboard, was converted into syrup.

But these disagreeables were soon forgotten, if I were able, at the spring-tide of new or full moon, to proceed in Master Hyacinthe's boat to the islands of Enseigne or Corbières, or to Ile-aux-Oiseaux. The low ledges of rock which I wished to explore could only be reached by long and often most tedious *detours*, in which I was obliged to cross banks of slimy mud, at the risk of sinking knee-deep, or

to scramble across broken and fucus-covered rocks. I found my early habits of sure-footed mountain climbing of the greatest service to me on these occasions. I generally achieved the most glorious success in these awkward emergencies, and my humble companions appeared not a little surprised to see a *gentleman* cross their sharp-pointed rocks and slippery inclines with the quickness and security that I displayed. As soon as I reached the water's edge, I began to roll away the stones; and as it was generally the largest which served as lurking places for the more curious animals, I had to employ all my strength in this work. The epidermis of my hands was very soon worn off against the small Balani, which covered the rocks, and converted them into living rasps. After two days' work it had become so exceedingly thin, that the slightest contact was productive of pain. I then directed my efforts to the sand, of which I am sure I must have turned up some hundred cartloads. Two iron shovels, made by the island smiths, were twisted and broken in these explorations. The third stood the test, but then about ten pounds of iron had been employed in fabricating its broad spatula, terminating in a steel point, and attached to a handle half an inch in thickness. Although this instrument is rather heavy, it has been of great use to me, and I recommend it to all naturalists who purpose exploring the coast.

Violent exercise on the sea-side is probably fully as bracing and conducive to the acquisition of strength as the games of the Circus or a dip in the Eurotas; at all events I returned from these excur-

sions with true Spartan appetite. As may readily be supposed, my bill of dinner fare was a very limited one. A lobster constituted almost always the main dish of the repast, taking the place of the classic *bouilli* of our humbler households. The Norman dairy-woman, who was serving her apprenticeship in the art of cooking at my expense, generally added a whiting or a plaice caught the same morning. Every ten or twelve days, I received a piece of fresh meat from the main land; and I feel confident that the frequenters of Véry's or Les Frères Provençaux never promised themselves a greater gastronomic treat than I did when I beheld a piece of boiled beef or mutton smoking before me. Sometimes a grateful fisherman presented me, by way of fee, with a plate of shrimps, or Master Balüe would bring me a dish of artichokes from the continent in token of his gratitude to me for saving his finger. The sour home-made cider of the farm formed my beverage, although I generally tempered this debilitating drink with a few glasses of the wine which was sold on the island under the pompous title of Bordeaux.

This kind of life, so varied in its uniformity, was interrupted from time to time by the visits of coasting vessels. Their arrival was a regular holiday for me, and I was not sorry, by joining the mess on board, to return for a few hours to the civilised world. Sometimes they brought with them a party of gay passengers, who had been induced by the prospect of a day's fishing to brave the horrors of sea-sickness. One day even the *Espiègle* touched at Chausey with a party on board, consisting of several worthy

mothers of families and a whole swarm of joyous laughing young girls, who were not a little proud of the charming and untroubled passage which they had made. It would be difficult to describe all I felt in assisting them to scramble up the rocky landing-place from their boat. To a poor recluse like me, who for three months had seen no one more attractive than the sturdy women of Blainville and the wives of the quarrymen, these young girls appeared alike charming and beautiful; but whether or not, they really were so, I do not know. I never saw them again!

My active and solitary life had made me accessible to a crowd of impressions which easily become effaced when brought in contact with the world. I had regained the superabundant activity of youth both in respect to my physical and moral nature. I experienced all the pleasure of a child in leaping over barriers, climbing sharp and high rocks, and crossing the most difficult chasms. When I gazed upon the boundless horizon of the sea from the summit of some lofty hill, or on the wide expanse of beach; when I listened to the thousand sounds around me, which seemed like so many voices speaking in an unknown tongue, I felt my heart beat beneath the impression of those vague and ardent thoughts which seem to be the heritage of almost all in youth, linked as they are with the recollections of the happiest period of our early years.

But time passed on: my note books were filled, my portfolios stored with drawings and sketches. I had

completed that portion of my inquiries which presented the greatest interest, and at the very moment when I ought to have entered upon another series of investigations, I felt in its full force the painful sense of solitude. A feeling of home-sickness seized upon me; I did not long struggle against it, but packing up my books, instruments and collections, I at once engaged my passage on board the *Della*, a small vessel which was employed in transporting to St. Malo the produce of the quarries of Chausey.

It was one of those lovely days, which occasionally visit us at the approach of the equinox, and which seem to belong alike to the summer which is passing away and the autumn which is already beginning. The sun was shining in a deep blue sky, interspersed with a few light clouds. The sea was beautiful, and its long lines of waves were breaking into sparkling foam, as they moved in the bright sunbeams before a gentle breeze from the north-east. Notwithstanding the heavy cargo which filled her hold, the *Della* made rapid way, and we had soon left the shore far enough behind us to enable me to embrace in one glance the whole of the archipelago, whose remotest recesses had now become so familiar to me. Before me lay Grande-Ile, with its ancient castle commanding Port Homard, and flanked on either side by the Great and Small Epail, which advanced into the sea like gigantic sword-blades. On my right, Ile-Longue and the two Romonts were half hidden in the clouds of smoke which rose from the barilla fires. To the left lay the chain of larger islands, La Genetaie, with its high upheaved rocks, La Houssaie, and the

Corbières encircled by a belt of rocks rising little higher than the water's edge. By degrees these various objects grew confused, and blended into one another; the sun set, casting a last rosy tint over the evening mist as it descended upon Chausey, enveloping islands and rocks within its gauze-like tissue. Soon all objects had passed out of sight; the sky, sea, and land were blended into one horizon, and Chausey had disappeared, perhaps for ever, from my view. The thought awakened a deep feeling of sadness. I had passed many happy hours on those desolate rocks, and who could tell what the world, to which I was returning, had yet in store for me!

The wind had fallen, not a breeze remained to swell the sails, and we cast anchor till the next morning, when the *Della* resumed her course, running at a mile's distance from the coast of Cancale, whose hills, dotted with tufts of trees and country houses, were glowing in the purple tints of the rising sun. We soon doubled the desolate point of Petit Bé, where the waves are always breaking against the last resting-place of an illustrious writer, who caused his grave to be hollowed out on the summit of this rock, as if the agitations of his well spent life had not sufficed him, and as if even after death he yearned to linger among the storms of this world.* We were at St. Malo †, whose dark granite houses, rising in

* Chateaubriand caused his tomb to be erected during his lifetime on the rocky platform of Petit Bè, where a simple cross of granite serves as a signal to ships arriving from a distance.

† The St. Malo men have always been known as skilful traders and adventurous sailors. Their renown in the days of Louis XIV.

tiers a hundred feet above the waves, looked like so many beacon-towers, keeping watch for the coming of an English flag, and ready to raise the cry to summon her brave St. Malouins to the scene of action. A few moments more, and the *Della* cast her anchor, and I was again on terra firma.

was so well established, that the vessel which bore the Lord High Admiral's flag was, according to custom, to carry a crew which, including officers, marines, and sailors, were all to be natives of St. Malo.

CHAP. II.

THE ARCHIPELAGO OF BRÉHAT.

Journey from Paris to Paimpol.—The Archipelago of Bréhat.—Its geological structure.—Ruins on some of the inhabited islands.—Grande-Ile. — Le Paon. — Population ; probable admixture of Basque and Breton blood. — Mildness of the climate. — The terrestrial Fauna ; the Black Rat.— The maritime Fauna. — The animal series. — Ideal and derivative types. — Relations of organised beings to one another. — General ideal type of a perfect animal. — Division of physiological labour. — Higher and lower animals : organic permanence of the former ; organic variability of the latter.— Subdivision of the Articulata.— True Annelids or Worms. — Tubicolous Annelids ; Chlorœma ; Amphicora ; Terebella ; Sabella. — Errant Annelids ; Chætopterus ; Echiurus ; Sipunculus ; Dujardinia. — Anatomy of Eunice sanguinea. — Doyerina ; Aphlebina. — Organisation of Nemertes ; remarkable simplification. — Excursion to the lighthouse of Héhaux.—Description of the tower.—Illuminating apparatus.— Historical notices : Borda, Lemoine, Buffon, Arago, Fresnel, the younger François.— Departure from Bréhat.

I HAD left the Archipelago of Chausey and the harbour of St. Malo, firmly resolved, some day or other, to revisit the shores of Brittany. The four months which I had spent in earnest research had indeed familiarised me with the zoological riches of its sandy coast, and its granite-guarded creeks and bays; but the profound study of even the smallest animal demands prolonged and assiduous investigation. Much had been left undone on my

first excursion. My portfolios were full of imperfect notes; my sketches were many of them unfinished, being, in fact, mere outlines, hastily drawn, and serving more as guides to my memory than as faithful representations of the objects I had seen. I determined therefore to supply the many deficiencies which seemed either to suggest the existence of some mystery to be revealed or of some truth to be demonstrated. Having taken this resolution, it only remained for me to make choice of my future station. The magnificent atlas of the *Hydrographie française*, enabled me to trace on paper the entire reefs of rocks, which appear to be thrown around ancient Armorica as if to defend it alike from the fury of the waves and the assaults of hostile fleets. In the midst of the innumerable small islands which have been so minutely represented by the skilful engineers who worked under the direction of M. Beautemps-Beaupré, the little Archipelago of Bréhat, lying to the north-west of Saint-Brieuc, attracted my attention by the resemblance it appeared to present to that of Chausey. This resemblance seemed indicative of future success, and without further hesitation I took my departure for the department of Côtes du Nord.

My journey from Paris to Saint-Brieuc presented nothing worthy of notice. On leaving the diligence, I was obliged to go in search of some kind of conveyance, to transport myself and my various items of luggage to Paimpol, the small seaport town from whence I was to embark for the Island of Bréhat. After many inquiries and much searching, I at

length discovered a crazy sort of vehicle, which, even before it was loaded, seemed too heavy for the half-starved white pony which was to draw it. I hesitated for some time whether or not I should trust myself in this sorry equipage, which would, I feared, break down on the road. The owner declared, however, in the strongest and most impressive manner, that his conveyance would carry me to my destination as fast as any diligence: therefore, as I had no other alternative, I resigned myself to the conviction he endeavoured to force upon me, and I am bound to say that the event justified his assertions. My little horse was of the true Breton breed, and therefore had descended in a direct line from those ancient Gallic steeds which, even before the conquests of Cæsar, were known to the Romans, and esteemed by them as highly as the celebrated racers of Crete. On the first touch of the whip, he started off on a fast trot, and on the second application he broke into a gallop. The driver, who was as lithe and talkative as a Spanish muleteer, kept up this ardour on the part of his steed by a multitude of encouraging epithets, half French, half low Breton, while he took good care at the same time to season his remarks with repeated strokes of the whip. The same rapid pace was maintained the whole way, excepting when we ascended or descended the precipitous hills by which the road is broken at every turn, yet notwithstanding these interruptions, we passed over the thirty miles, which separate Saint-Brieuc from Paimpol, almost as rapidly as the *messageries royales* would have done.

On leaving Saint-Brieuc, the road descends into a narrow and deep gully. The schistous character of its mountain sides was at once discernible by the irregularity of their profile, which differs so essentially from the sharply-cut outline of granite formations or the rounded forms characterising sandstone and limestone districts. But, notwithstanding the abrupt and wild appearance of the country through which we passed, it presented the greatest possible attractions to me, from the recollections it awakened in my mind of the valleys of the Cévennes, amongst which I spent my early childhood. There were the same sharply defined mountains, with their acutely cut angles and salient lines, the same stunted but hardy vegetation, drawing a scanty subsistence from among the débris of rocks, which rise on every side in slender pyramids, wreathed with long spine-clad festoons of brambles interspersed with tufts of waving furze. Here, near every brightly gushing mountain rivulet, were the same patches of verdure, clothing the steep hill-side with a soft velvety carpet of grass, where even the cattle could scarcely keep their footing on their steep and slippery pasture ground. By the way-side, in the hollows of the rocks, at the foot of the trees, I saw the same plants and flowers which I had so often gathered when a child. To complete the resemblance, a winding brook pursued its course through the valley. The clear waters leapt over the pebbles, broke in foam against the larger stones, and fell in bright cascades from the embankments which had been thrown up to collect a larger body of water to turn some huge

wheel or impel some system of machinery, the noise of which resounded from afar. However much the inhabitant of a level country may boast of the fertility of his plains, the majesty of his rivers, or the wealth of his cities, he can never comprehend the sentiments of tender affection with which a mountaineer looks at any spot which recalls to him the image of his native district.

The road wound gradually upwards from this valley until we reached a steep ascent, which brought us to a gently sloping plain, which we did not again leave; and here in an instant was displayed before our eyes a landscape, differing in all respects from the country which we had traversed. We had emerged from one of those fissures in the earth's crust which owe their origin to the upheaval of granitic masses and which still preserve traces of their violent origin. In another moment we found ourselves on a soil which had been deposited by the action of water — a mode of formation of which everything around bore evidence. The surface of the soil was undulating and rounded: the sides of the road exhibited, below a vegetable soil, parallel strata of pebbles, which had obviously once formed a part of the neighbouring rocks. The solitude of a wild mountain gorge was succeeded by the cheerful brightness of a softer, although not less picturesque, landscape. The road wound among hills covered with rich harvests, or crossed tracts of fallow land broken up into patches by hawthorn hedges and long rows of oak trees. The sturdy trunks of the trees rose from a narrow band of grass, bright with wild

flowers, among which the birds were chirping and incessantly flitting about. The noise made by my clattering vehicle created an immense panic amongst the feathered throng: the sparrows took suddenly to flight in large troops; the robin-redbreast fled to its coverts; the greenfinch hopped to a high branch, where, encouraged by distance, he warbled forth a joyous song as we passed; whilst the large crested lark, waiting till we were close to him, would suddenly rise, and, remaining suspended in the air for an instant, would again alight at a stone's throw from us upon some elevated mound of earth, from whence he watched us, shaking the while his little crest of grey feathers. The sky itself lent variety to the scene, as at every moment the tints of the landscape changed from the bright hues of a golden sunlight to the sombre colouring imparted by some heavy cloud, as it was driven across the heavens before a keen breeze from the west. This wind, which at first was very supportable, gradually became sharper and sharper, penetrating through my clothing with a peculiarly searching intensity, which made me suspect that we were approaching the ocean. I looked around to catch a glimpse of the Atlantic; and, on turning a hill, at the extremity of a short valley covered with meadows and interspersed with clumps of trees, the boundless expanse of waters lay spread before me like some immense green plain, seamed and veined with the white lines of its foaming waves.

Another half-hour brought us to Paimpol, and the next day I embarked for Bréhat. My first care on

arriving was to secure food and lodging; and in this I was essentially successful, although I experienced some difficulty in regard to the latter point, for I was compelled to content myself with an unfurnished lodging, and to hire a bed from one person, a table from another, and a bench and shelves from a third. At length my arrangements were sufficiently completed to admit of my unpacking my books, instruments, and bottles. These preliminaries so completely occupied the whole day, that I had to defer the commencement of my explorations till the following morning. By break of day I was on foot, searching for some elevated point, from whence I might survey at a glance the whole extent of my island. This I found to be impossible, for Bréhat is a perfect little continent, with plains, elevated table-land, and chains of mountains which effectually mask one another, all of course in the miniature style, and on a scale proportioned to the size of the island, which measures about two miles from north to south. I was obliged therefore to examine the whole in detail; and after briefly consulting the map, I began my excursions.

Bréhat, taken as a whole, may be said to present very nearly the form of the figure eight, deeply indented by innumerable little bays and bristling with a multitude of small capes. It was formerly divided into two distinct islands, which were separated during high tide by an arm of the sea about twenty yards in width. At the period when Vauban was examining our coast-line with a view of organising the best means of defence against maritime

attacks, a broad causeway was thrown up between the islands under his directions, and a communication thus secured between the two during all conditions of the tide. The bay which separates these two northern and southern portions is a muddy basin tolerably well sheltered from the north wind, and called La Corderie. The sailors however appear with good reason to prefer Port Clos, a little bay entering the most southern shore of the island and facing the coast of Brittany. Here the land, after rising in a gradual slope towards the sea, appears suddenly to open and separate into two rugged promontories, which, curving inwards at their extreme points, serve as a protecting breastwork to the circular basin enclosed within their area. So sheltered is this bay, that during the high tides of the equinoxes, and in heavy gales, when the whole ocean seems to be raging against the island, which it encircles in one belt of white foam, the middle of Port Clos is scarcely rippled by the waves which its natural dykes throw back on either side of it.

With the exception of these and a few other spots, where small craft might find safe anchorage, the entire circuit of the island presented nothing but a steep rocky coast, where it was difficult even for mere sloops to make a landing. Granite occurs here in every kind of form and variety, associated with several species of the neighbouring rocks. Pegmatite, which by its decomposition yields kaolin, occurs either in slight veins intersecting each other in all directions, or in masses of a beautiful red colour and crystallised in large grains. Other veins of syenite

of tolerable thickness run through the general mass in an almost constant direction from north-east to south-west. Here and there quartz occurs in detached masses of a dull white colour, or in veins as transparent as the purest crystal; whilst grains of iron in the state of peroxide are occasionally met with in these rocky formations. I could nowhere observe the homogeneous and compact structure which has made the granite of Chausey so deservedly celebrated; indeed the rock of Bréhat appears, from the numerous veins which intersect it, and from the diversity of its character at every few feet, to be utterly valueless in a commercial point of view.

This difference of structure in the rocks of Bréhat and Chausey explains the difference observable in the general aspect of the coasts of the two islands. At Chausey, the massive strata of granite, after undergoing a slow disintegration under the action of the currents and waves, leave enormous blocks standing isolated from the general mass, which, from the very disorder of the formations around them, present a certain appearance of imposing grandeur. There is nothing of this kind to be seen at Bréhat, where the isolated rocks are little more than large detached stones. There are many points along the coasts of Chausey where the sea breaks against the rocks with a violence that gives the observer the idea of some vast convulsion of nature; for the scene around seems to suggest an analogy with the fragments of an upheaved and broken world. Now, although there are such fragments at Bréhat, they have nothing striking in their character, and I have seen many a feudal

tower in Alsatia and Germany whose ruins might be advantageously compared in point of grandeur with the rocks and boulders of this coast.

Several islands and an infinite number of rocks grouped around Bréhat, combine to form a little archipelago, which extends in a south-westerly direction towards the mouth of the River Pontrieux, and is longitudinally divided by the principal island into two unequal parts. To the east lie Logodec, Lavrec, and Raguenez-Meur, which are separated from Bréhat by a tortuous arm of the sea, named La Chambre; to the west Béniguet, Raguenez-Bras and Grouezen extend in a straight line along the shore of a second channel, called Le Kerpont, which is celebrated in the district for the violence of its currents. None of these islands equal Bréhat in extent or importance. Béniguet, indeed, can boast of a few farm-houses and about thirty inhabitants, but the others are deserted. They are not, however, the less carefully cultivated on that account, for every rock, whose summit is covered by a few square feet of mould, is strictly appropriated and used as pasture ground for cattle or sheep; or, where the proprietor is not possessed of any of these animals, the grass is given up to a few goats, who here find ample scope for the indulgence of their instinctive love of climbing.

It would seem that at some remote period the inhabitants were more equably scattered over the islands of the archipelago. Several of these isolated masses of rock still exhibit the remains of former buildings, which were probably occupied by fisher-

men or smugglers. L'Ile Verte, situated on the eastern margin of the archipelago, even possessed at one time a monastery, which was dependent upon the rich Abbey of Beauport. Without being able to define the precise period when this religious asylum was founded, it is easy to see from the mere appearance of the ruins that it must have been erected, probably in times of trouble, to serve the purpose of a citadel quite as much as of a convent. The buildings occupy the entire surface of the island, and look down from every side upon a deep precipice. Even at low tide, the rocks on which they are placed are almost entirely encompassed by the waves and washed by impetuous currents. The only point of approach is guarded by two large isolated rocks, which serve the purpose of a breakwater; and here the remains of two parallel dykes formed by enormous blocks of unhewn stone still mark the position of the landing place. A steep ascent led from the shore to a narrow and arched postern door cut in a wall, nearly ten feet in thickness.

This solitary means of entrance was guarded on either side by two towers, whose foundations may still be traced among broken stones and rampant weeds. A straight path leading directly from the door divided the extensive range of buildings into two nearly equal parts. No portion of this ancient edifice is standing: the path of which I have spoken is choked with brambles and fennel; while waving corn and straggling peas and beans have usurped the place of vast halls, whose site may still be traced by the pieces of wall which yet remain. At the ex-

tremity of the edifice, which faced the open sea, the walls of a narrow donjon or keep surmount a precipitous rock. I asked myself whether it had been intended as a place of refuge, or as a beacon tower, and whether the light which gleamed from its summit was reared on high to announce to the storm-tossed mariner that friendly aid was near to succour him, or whether it was planted there by pirates thirsting for their bloody waifs, like the monks of Chausey. In vain did I interrogate the oldest of the fishermen who frequented L'Ile Verte: none could explain the mystery; for tradition does not inform us whether the dwellers of this rocky fastness were pious cenobites or wily brigands, nor does it even reveal to us the cause or the period of the destruction of the monastery.

Concealed as it were behind a belt of granite, and exhibiting nothing to the eye of the distant observer but rock-capped hills, Bréhat appears to present the aspect of an inhospitable soil, incapable of maintaining life. A cursory view of the interior of the island at once proves the fallacy of this appearance, for a closer examination of the ground shows that the whole of this rocky base is covered with a stratum of vegetable soil, whose extreme fertility has been improved by careful industry. I have seen very few parts of France in which the land was so completely and usefully employed. There are many points, indeed, at which the rocky skeleton of the island may be seen projecting upwards, in the form of heavy masses or sharp needles; but the base of these rocks is covered with crops of grain and ve-

getables, whose abundance affords ample testimony of the richness of the soil. Communication between the different parts of the island is maintained by means of roads traversing each other in all directions, and whose proportions are strictly calculated to meet the wants of a locality, in which not a cart or horse is to be seen. Very few of these paths admit of more than two men walking abreast, and the broadest of all, extending from one end of the island to the other, which may be regarded as a sort of first-class line, scarcely allows of two cows passing each other. All these roads, however, are carefully marked along the fields which they cross, and tended and trimmed like garden walks,—a circumstance which contributes in a great degree to give the country a general air of order and plenty, very different from the misery and want of cleanliness which have usually been regarded as the inseparable companions of the peasantry of Lower Brittany.

This rich and smiling district is interspersed here and there with small groups of habitations, distinguished by the title of villages, and all bearing names in which the concurrence of the sounds *ker* and *ec* produce words which seem rather inharmonious to French ears. The chief of these settlements is known as the Bourg; and here stand the town-house and the church,— buildings in which the most momentous events of human life are transacted, alike in the humblest village and the proudest city. There are moreover two schools in the place, kept by pious brothers and sisters of the Church. Three or four taverns in great request on Sundays, and a reading

room where two newspapers are taken, combine to secure supremacy to the Bourg, and to constitute it the true capital of the island. For the rest, here as in all the other villages, the country maintains its characteristic physiognomy. The streets, although narrow and irregular, are always clean. The houses are generally surrounded by small gardens, planted with flowers and fruit-trees, and resemble in many respects the rural habitations of Alsatia, which is perhaps the most genuinely rich province of France.

These remarks apply more especially to the southern half of the island. Immediately after crossing Vauban's causeway and passing the neighbouring houses, the character of the country changes suddenly, everything bearing a wild and rugged aspect. The rocks are more numerous and more elevated, and in proportion as they encroach upon the soil they render it less fertile. Vegetation is less active; the crops are less luxuriant, wheat being here replaced by oats; while in many parts nothing is to be seen but broom and ferns. The habitations seem to have succumbed to the same laws of decadence, for they gradually become lower and more squalid, courts and gardens disappear, and finally, on reaching Kerwareva, the last village which we pass in going northward, nothing is to be seen but huts built of rough stone, imperfectly cemented with the mud from the shore, and covered with sods. The inhabitants even exhibit an air of roughness and almost wildness in their persons, which contrasts with the greater polish of their more southern neighbours. In the south every one speaks French, or at all events under-

stands the language when others speak it; but in the north I rarely succeeded in making myself understood when I wished to obtain the simplest information. I learnt subsequently that wholly local customs prevail in the north, and that Breton words are in use there which are not heard in the other parts of the island; indeed the inhabitants of the north of Bréhat are distinguished, even by their accent, from those of the south.

At some distance from Kerwareva rises the Pointe du Paon, forming the northern extremity of the island, which alone presents any of that character of wild beauty so common at Chausey. The very rarity of these features tends perhaps to augment their charm by imparting to them an air of grand sublimity. Beyond the last houses of the village, the empire of man seems to give place to the elements of air and water, which here dispute the supremacy over this desolate region. A barren heath lies before us, where stunted ferns divide the thin crust of vegetable soil with the straggling plants which spring up from a layer of bog, rendered brackish by being constantly sprinkled by the foam of the waves. Soon the ferns even cease to appear. Lowly as they are, they are ever being bent and broken beneath the lash of the storms, which pour with full force upon this exposed slope. Here and there fine soft grass as smooth as velvet replaces the ruder vegetation, but it is unable to extend to the extreme point, for there the sea reigns supreme, or rather it may be said to carry on a never-ceasing warfare with the giant rocks, which

alone protect this part of the island from its encroachments.

The Paon is composed of two enormous banks of granite, which, upheaved from the sea's bottom, rise far above the contiguous land, inclining towards one another as if for mutual protection. The sea has opened for itself a narrow passage between the perpendicular rocks, which reminds us of Roland's Pass. The traveller at first advances between these two walls on a level with the beach, without encountering any obstacle beyond a few large stones rubbed smooth by the friction of the waters, but at the end of a few paces a subterranean rumbling of waters warns him to retrace his steps. Before him yawns a chasm which is scarcely three feet across at its mouth, but which widens towards high-water mark, until it expands into a colossal funnel. A block of granite, weighing many hundreds of tons, which must have been detached by some storm from the rocks above, rests like a massive bridge upon the two opposite banks of the gulf which it spans. When the heavy sea strikes the shore, the waves rush with accelerated force through the narrow enclosure of these rocks, and in striving to force their way below the bridge exert an incalculable amount of force, which enables them to raise the enormous mass. When this obstacle is passed, the waves break into foam and mist, which are projected vertically upwards in a huge white column, and the bridge falls back to its unshaken supports, to be again and again upheaved as the rushing waters rise beneath it. This struggle, which has probably endured for ages, will

only terminate with the rupture of this transverse rocky mass, unless the overhanging walls, shaken by their incessant warfare with the ocean, should succumb, and in their fall bury the huge bridge and the Pass of the Paon in one common wreck.

This remarkable spot enjoys an immense reputation both at Bréhat and on the neighbouring coasts as a place of divination. The young girl, who wishes to know how long she has yet to wait before she can exchange the circlet of betrothal for the marriage ring, goes unaccompanied to the point of the Paon at the time of low water during the spring-tide. She picks up a pebble on a particular part of the beach, and advancing to the entrance of the passage throws the stone into the yawning chasm. If the stone falls to the very bottom of the abyss without rebounding against the rock, the maiden returns to her home with a lightsome step, for she knows to a certainty that she will marry before the year is closed. Woe be to the poor thing if the stone has swerved from its course, for every rebound of the pebble against the rock, adds a year of weary waiting; and thus the maidens who consult the oracles too often return with saddened hearts. The chasm of the Paon which has been hollowed out by the constant rushing of the waters between the two banks of rocks is by no means perpendicular; hence it requires a certain address, which few women possess, to throw a stone with unerring aim to the bottom without touching the sides; indeed the main essential to the success of the charm is that the stone should be thrown at random.

The island of Bréhat forms a separate commune, and numbers about fifteen hundred inhabitants. The population, isolated in its own remote corner of the world, combines the niggardly and prying spirit of the inhabitants of small towns with the egotistical and exclusive character of islanders. The Bréhatain does not consider himself a Frenchman; he scarcely regards himself as a Breton; and every stranger is looked upon as a sort of Pariah, whose society is sedulously shunned alike by the richest proprietor and the poorest day-labourer.

The country people extend this kind of interdict to their compatriots of the opposite coast, notwithstanding the community of manners, and more especially of language, by which they are associated. During my stay a young girl from the Continent, who had been engaged as a servant by one of the islanders, refused to remain in service in Bréhat, because, according to her statement, there was not a woman who would speak to her when they met at the well, or in coming out of church. This strongly marked spirit of local attachment may perhaps be explained by tracing the origin of the population amongst whom it is so strikingly manifested. The Bréhatains constitute a perfectly distinct variety of the Breton race. They very rarely exhibit the round head, full face, blue eyes and light or reddish hair, which appear to constitute the characteristic traits of the Breton type. Among the Bréhatains, on the contrary, one meets frequently with long and delicately chiselled oval faces, associated with large expressive black eyes and fine soft

black or chestnut hair. These characteristics seem to betray a southern origin. It is highly probable indeed that the daring Basque seamen of the middle ages should have amalgamated with the natives of Bretagne on their annual visits to its shores in search of cod and mackerel, or when engaged in the pursuit of the whale, and that the Bréhatain race should have sprung from the fusion of the Vascon and Armorican blood.

I ought to observe, however, that my remarks are of necessity limited to the women of the island. Every Bréhatain seems born a sailor, and as soon as he is old enough to serve as a cabin boy he leaves the island; after a time he returns to take a wife from among his compatriots, but marriage does not bind him more closely to terra firma. It is only when the weight of years compels him to relinquish the dangers and exposure of a sailor's life that he permanently settles on shore. In consequence of these habits, the indigenous population of the island is composed almost exclusively of women, children, and old men, the latter of whom are all superannuated seamen. In 1832 Bréhat contained one vice-admiral, six commanders of vessels, and several lieutenants. At this period the cholera cut off almost the whole generation of old seamen, who had survived the storms and troubles of the long wars of the Republic and the Empire. At the present day there only remain some few lieutenants and one captain, the grandson of the brave Cornic, who was alike celebrated for his courage and for the persecutions which his merit brought upon him at the

hands of those holding higher command than himself.

The emigration of the male population leaves in the charge of the women the entire superintendence of all field labours, in addition to the care of their households. They are also obliged to combine with the culture of the fields the labour of procuring the fuel necessary for the long and tempestuous season of winter, and to prepare the food required for home consumption. On an island like Bréhat, the land is too fully occupied to leave space for the growing of trees; which, moreover, could not be made available till after the lapse of many years. Fruit trees are the only trees to be seen in the island. All the wood used for firing comes from the main land; but as it is very expensive, it is reserved for the houses of the rich, while the poorer people burn the broom and ferns, which they collect from the less fertile parts of the island. They also use the Fucus detached from the rocks, and even strips of turf, which they dry with all the roots attached to the mould. Unfortunately, however, both these kinds of fuel have the inconvenience of emitting a great deal of smoke and a very unpleasant odour; on this account a substance, known as *bois d'herbes*, is generally preferred. It will be necessary, however, to explain the meaning of the term.

I had been struck from my first arrival with the circumstance, that although there were a large number of cows on the island, I had not met with any of those unpleasant traces of their presence which they generally leave on their track. I very

soon discovered that these unsightly remains of digestion were carefully collected by the islanders, who pounded them together with chopped straw, and employed the compound as a substitute for wood or other fuel. The method of drying this substance consists in spreading large masses of it against the sides of a rock or wall, and leaving it exposed to the action of the sun and air until it is thoroughly dried and can be detached in large flat cakes. I have often seen otherwise well kept houses covered with this singular tapestry, which certainly would seem more in harmony with the religious ideas of the Hindoos than with those which we entertain in France in relation to cleanliness. I have been informed that the *bois d'herbes* gives a clear and bright flame free from smoke or from any offensive smell.

In addition to the native Bréhatains, the island contains an isolated colony of strangers. Bréhat serves as one of the principal stations for the coast-guard, and there is generally a large number of these officers on the island, who are constantly engaged in trying to overcome the artifices and incessant activity of the smugglers. On account of the importance of the island in the event of a maritime war, several officials connected with the war administration are always quartered at Bréhat. Like a true fortress, the place has its commandant, who, however, is only a non-commissioned officer; its garrison, which consists of seventeen men, including the sergeant and corporal in command; its second in command, who is no less a personage than the mayor, and the master

of the fortifications, a worthy citizen, who has the charge of the coast-guard ammunition. There is not any very great harmony among these petty military authorities, who all advance pretensions to supremacy, and whose quarrels would be even more vindictive if it were not for the calm and pacifying spirit of the keeper of the ammunition, who alone, from the nature and extent of the materials entrusted to his care, is invested with any real importance.

The climate of Bréhat is remarkably mild; snow rarely falls, and it is only in extremely severe seasons that the earth retains the white coating of winter for more than a day or two. Owing to this circumstance many plants thrive on the island which are commonly regarded as peculiar to southern climates. The myrtle, amongst others, grows freely in the open air, and attains a considerable size, contributing greatly to the adornment of the better class of houses, which are frequently covered with the shining green foliage of these beautiful shrubs, interspersed with which are festoons of roses trained on trellis work; and yet Bréhat is situated very nearly in the same latitude as Alsace, and Strasburg lies about half a degree further south, notwithstanding which the river on which this city is built freezes every year to such a thickness that the inhabitants are able with safety to skate upon its surface. Now in order to obtain ice thick enough for this purpose, we must assume that the temperature has remained far below the freezing point for some days. This difference of temperature between two localities placed at the same distance from the pole, is explained by one of those great

phenomena which modern science has been able to elucidate in regard to the surface of the earth. It is to the Gulf Stream that Bretagne generally, and Bréhat in particular, owes these climatic relations which at first sight seem so extraordinary. This great current of waters, after being warmed by the heat of the equator and of the tropics, emerges from the Gulf of Mexico, and taking the direction of Europe, separates into different branches, one of which, driven northward by the Spanish peninsula, strikes upon the shores of Bretagne. Here it penetrates into the channel, and surrounds Bréhat with its still tepid waves. While, however, it protects this little island from the rigour of winter, it entails upon it an extreme degree of humidity, to which medical men refer the rheumatic affections, and more especially the stubborn forms of ophthalmia, which afflict a large proportion of the population.

Although Bréhat presents considerable resemblance to the largest island of Chausey in respect to the nature of its soil, climate and vegetation, it differs in having an area eight or ten times larger. If we bring this circumstance to bear in examining the animals which inhabit this island, we shall find that we may aptly apply to these two islands that beautiful law of general zoology, which was propounded by the genius of our great Buffon, and after having been long denied by naturalists, is now daily acquiring additional confirmation in proportion to the constant advances made in science. Buffon laid it down as a principle, that the numbers and size of the different species of animals living upon a continent

or an island, correspond with the extent of land appropriated to them, so that they diminish in number and size in proportion to the diminution of the habitable space around them. This proposition is true with regard to the case in point. We find at Bréhat all the species of mammals, birds and reptiles belonging to Chausey, while each of these classes is represented by several additional forms; in the first division, we have the ermine and polecat, in the second the linnet and blackbird, and in the third the common adder and the newt. The aquatic birds seem, however, to present an exception to the rule, for there are fewer species than at Chausey, and those which are met with are of a smaller size; this apparent contradiction may, however, be explained by the fact that the channels of Bréhat are not so well stocked with fish as those in the Chausey archipelago, and that consequently there is nothing to attract these birds, which, moreover, are distinguished by their wandering habits from the true representatives of the native fauna.

It is worthy of notice that the Mammals of Bréhat number amongst their representatives two species of the genus *Mus*, namely, the mouse and the black rat. The black rat, which has become more and more rare, is disappearing daily from the continent of Europe in consequence of a revolution, not less bloody, though less generally known than those which the barbarians of the north brought in former times upon the empires of the more civilised world. For ages, the mouse, which was the only representative of this family known to the ancients, lived at our ex-

pense with no enemy to fear in its quasi-domestic state save man, whom it pillaged, and the cat, which the lords of creation had called to their aid against an adversary which had been rendered formidable by its very diminutiveness and timidity. During the middle ages, the black rat, coming no one knew from whence, spread itself over Europe and attacked the mouse, who, too feeble to resist his ferocious antagonist, was obliged to share with him his old haunts, only escaping complete destruction by retiring within his narrow galleries, whither the enemy could not pursue him. At the beginning of the last century, the Norway, or brown rat, brought by merchant vessels from India, appeared in Europe, and at once began to wage an exterminating war against the black rat. Its greater strength, ferocity, and fecundity enabled it rapidly to gain ground. This rat first appeared in England in 1730; twenty years later it was observed in France; but at the period when Buffon wrote his immortal work, it was only met with in the environs of Paris, and had not yet penetrated to the city. At the present day it is the only rat met with in the capital and in the greater part of the provinces. Its partiality for the water and the readiness with which it swims have enabled it to follow the courses of rivers, and by ascending the smallest affluents it has contrived to diffuse itself over the whole country. It has driven the black rat before it, exterminating it in many of our provinces, and forcing it to take refuge in mills, or isolated farms. At Chausey I could not see a single specimen of the black rat, whilst its formidable

enemy abounds everywhere, and will most probably soon traverse the narrow arm of the sea, which separates Bréhat from the continent, so that the last of the black rats will without doubt, in the course of a few years, fall a victim to the fury of its voracious congener.

The interest which appertains to these terrestrial and aerial populations had not, however, been the attraction which drew me to Bréhat, and I therefore prepared, the day after my arrival, to explore my domain. As soon as the sea had retired from the shore, I set forth with a tin box suspended from a leather belt which was strapped across my shoulders, my pockets well filled with tubes and bottles, and my broad iron spud in my hand. The first few hours of this exploration were painfully unsatisfactory. Full of the recollections of the zoological treasures which the Sacaviron of Chausey so bountifully displays, it was long before I could discover anything worthy of notice in the midst of the desolate barrenness which surrounded me on all sides. The channels of Bréhat present a singular appearance, owing to the violent currents by which they are constantly traversed. Wherever the force of the waves finds free scope, it undermines and disintegrates the rocks, which crumble into fragments too small and unstable to afford shelter to any large number of animals, whilst the sands are too well washed to furnish an adequate supply of food. The few sheltered points which the coast presents are generally encumbered with detritus, reduced to the condition of semi-fluid mud, and covered with immense tracts of Zostera, forming a

treacherous bottom, which gives way beneath the feet of those who unwarily trust in its seeming security.

I could not see any of that muddy sand which seems so favourite a place of resort for Annelids, nor did I discover any of those picturesque grottoes, in which simple and compound Ascidians, Sponges and Alcyons clothe the roof, from which they hang suspended like living stalactites. My courage sank, I confess, but still I persevered, investigating everything that fell in my way. By degrees my hopes revived, until at length my discouragement entirely gave place to the most gratifying assurance of success. I found that there were certain points where the sand and mud were blended together in proportions which seemed to promise a rich harvest, and I discovered that entire populations were sheltered beneath the very rocks which I had so heartily condemned. In truth, it required the skill and hard blows of a true quarryman to dislodge these animals from their retreats. I saw that I had hard work before me, but I thought only of the recompense by which my labours would assuredly be rewarded, and the difficulties of the search did not appal me. Without further consideration, I set to work, and from the first day my expeditions were crowned with success, for I always returned home laden with treasures which afforded ample materials for work.

In the present state of modern science, the inferior animals present a very great degree of interest. In the former chapter, while describing my mode of life at Chausey, I endeavoured to show how the anatomist, who reveals the material instruments of life, and

the physiologist, who attempts to penetrate into the inmost recesses of their structure for the purpose of studying their modes of action, will often find that the simpler types of animal life furnish us with numerous data for the elucidation of many of the problems which nature has presented to us, although these data may have been unsuccessfully sought for in beings of higher development. An intimate acquaintance with these classes, which have hitherto been too much neglected, is equally necessary to the zoologist who, with a just appreciation of what is due to the character of his science, avails himself of the light afforded by anatomy and physiology, while he does not neglect the study of the relations by which living beings are connected together. I will, however, somewhat more fully develop my views of this subject.

When, after the first attempts to classify animal species, naturalists arrived at some general ideas, the fact of the relative superiority and inferiority of the animals which they studied must have been one of the first things which struck them. At the one extremity of the chain of comparison stood a portion of the Mammalia, at the other appeared the Worms and Zoophytes. The numerous intermediate forms presenting themselves between these extreme limits gave rise to the idea of an uninterrupted animal series, extending through a succession of progressive degradations, from man, who comprehends and controls nature by his intelligence and perfect organisation, down to the sponge, which appears from its ambiguous structure to be equally referrible to either

of the three kingdoms of nature.* This doctrine, which was generally adopted, was simple, and ap-

* Bonnet, who was one of the principal supporters in Natural History of this doctrine of continuity, which Leibnitz employed to a certain extent as the basis of his philosophy, was born at Geneva, in 1720, and died in the same town in 1793. This natural philosopher devoted himself with much ardour to microscopical studies, and his researches on the reproduction of the Aphides, on Fission, and on Vegetation proved that he possessed, to a high degree, a talent for observation. In consequence of partial loss of sight, he abstained from scientific pursuits, and devoted himself to those philosophical and religious meditations which the contemplation of nature inspires. Cuvier justly and forcibly denounced the false and dangerous views which Bonnet had endeavoured to introduce into science by this doctrine of continuity, and although this hypothesis is generally abandoned at the present day it was also maintained by Ducrotay de Blainville, who was born at Arques, in 1778, and who died in Paris in 1850, after having attained to the dignity of a seat in the Institute, and to a Professor's chair at the Jardin des Plantes and the Faculty of Sciences at Paris. In his youth he was exposed to many vicissitudes, for while a student at the Military School at Beaumont, he escaped from the establishment and concealed himself on board a vessel of war, from whence he came to Paris, and was successively a pupil at the Conservatoire of Music, and a student in a painter's *atelier*. Up to the age of twenty-seven he had not directed his attention to science, when a lecture, which he accidentally heard from Cuvier, decided his vocation. Two years afterwards he took the degree of Doctor of Medicine, and had become the intimate friend of Cuvier; but his irritable and captious temper did not allow him to maintain these friendly relations. He was no sooner nominated Professor by *concours* to the Faculty of Sciences than he began to wage war against the labours of the man who had been the first to give him a helping hand. This opposition, which often warped his judgment and made him unjust, continued to the end of his life. Blainville's reputation was due in a great measure to this determined opposition to Cuvier, although he undoubtedly possessed a keen and vigorous intellect. He lectured exceedingly well, and he has left several important works, amongst others the

peared to be logical. But nature, who is always simple in the laws by which she is regulated, is very rarely simple in the manifestation of those laws. In the production of living beings as well as in the creation of organic bodies, nature in her ascending progress has followed no mathematical straight line; her creations are developed in all directions. Science in its unceasing progress has elucidated this truth, and in the present day the words *zoological series* and *animal scale* are employed by the great majority of naturalists merely in a figurative and relative sense.

But if the unity of the animal series is a chimera, what general idea can we substitute for this conception of our predecessors? On the first examination of a species we perceive that it possesses two kinds of characters. The first kind isolates it from contiguous species, and individualises it in space and time; the second connects together a certain number of these individualities, and associates them in more or less strictly defined groups. What we have just said of species may be equally well observed in respect to elementary groups; and it is by the appreciation of more or less general characters, that the naturalist, passing on through ascending groups, reaches the *kingdom*, which embraces all the secondary divisions known as sub-kingdoms, divisions and sub-divisions, classes, orders, families, tribes, and genera. To ascertain the subordination

Manuel de Malacologie, *Manuel d'Actinologie*, *Histoire des Sciences de l'Organisation*, and a host of memoirs. It is to be regretted that his magnificent *Ostéographie* remained unfinished at his death.

of these different groups, to recognise their true relations by an exact appreciation of their resemblances and differences, and to calculate to a certain extent their proximity or divergence, this is the problem which modern science proposes to solve, — a problem of immense difficulty, towards the solution of which we are undoubtedly advancing, although it must be admitted that our progress is effected with a tardiness necessitated by the character of the inquiry.

Many centuries will probably elapse before naturalists will acquire sufficient knowledge of animals definitely to establish primary, secondary, and tertiary groups. There are some groups, however, which may be regarded as thoroughly fixed, even in the present day. Whenever we study one of these truly natural groups, whenever we weigh and appreciate all its characters, we are led almost involuntarily to conceive some ideal or virtual type which might reunite these characters in the highest possible degree. But there will always be a discrepancy between this type and its manifestation in existing species. It is thus that Man and Woman have never hitherto presented a complete realisation of the beauty which painters and sculptors have dreamed of, and which a few of them have imperfectly succeeded in tracing on canvass or in chiselling from the rock.

In all natural groups, we encounter a certain number of species which present, in a high degree, the characteristic impress of their type. There are others, on the contrary, in which this impression

seems to have become indistinct. Now, these modifications of type may be the result of three different causes, acting either conjointly or separately. The distinctive characters may have been partly or wholly obliterated; they may be intensified, or lastly they may be complicated with extraneous characteristics, whose tendency is either to destroy existing relations or to establish new affinities. As long as these alterations do not pass beyond certain limits, the animal, although he has to some extent departed from his ideal type, still bears some affinity to it; but once pass these limits, and we have a new type.

When the changes to which we refer result from the suppression of characters which are essential to the first group, or when different or even opposite characters are manifested, the types can obviously exhibit only very slight affinity with one another. Such is not the case, however, when the modifications arise solely from the exaggeration or diminution of an existing character. Then the new type will be merely a *derivative* of the former: and however great the apparent diversities by which it is distinguished may be, the source from which it has emanated will always admit of being traced. Thus, by way of illustration, we may instance Mammals, Birds and Fishes, which all belong to one primitive type, that of the Vertebrata, although they form three well marked and distinct types. On the other hand, we may cite the bat, which moves through the air, and the whale, which pursues its course through the waves of the sea: yet the first is not on this account a bird, nor is the second a fish, but both are mammals

modified for flying or for swimming; they are *derivatives* of the great types of the Mammalia. It will be readily understood that there is no fixed limit to the number of these derivatives, and that every primitive type may engender several, whose divergences will vary in accordance with the intensity and diversity of the modifications from which they have originated.

At this point of our inquiries, the entire mass of beings which we have been studying will appear to us to be decomposed into a somewhat limited number of primitive types, around which their *immediate derivative types* are disposed at various distances, and in accordance with a certain order. These are in their turn surrounded by *secondary derivatives*, and so on in a consecutive series. Existing species may all be classified within this theoretical animal kingdom, being distributed in accordance with the degree of resemblance which they present to their ideal types. It is thus that the celestial bodies, grouped together in a thousand different ways, gravitate around one another, with their planetary attendants circling round them either isolated or accompanied by satellites. On our earth, no less than in celestial space, we find that nature faithfully adheres to those wondrous laws of analogy which she observes in all her grander manifestations, and thus we behold on the surface of our globe the same spectacle of unity and harmony which, in the immensity of space, strikes the senses with the profoundest impressions of wonder and admiration.

The absolute ideal type of the animal has never

been realised. The perfect animal, if it could exist on the earth, should combine within itself the rarest qualities which are now disseminated over a great number of different species. It should move with the sure-footedness and velocity of the *Dziggeta*, that wild species of the genus horse which, according to the traditions of the Mongols, serves as the steed of the god of fire; it should pass through the air with the rapidity of the swift, and sustain its flight like the frigate bird, which is met with six hundred miles from land, and which can therefore traverse a space of more than twelve hundred miles without for an instant stopping the play of its wings, the length of which precludes the possibility of its pausing to rest on the surface of the waves. This perfect animal should be able to plunge to the depths of the sea, and cleave the tempestuous waves with the rapidity of the dolphin and the persistence of the shark, which follows in the wake of a vessel from America to Europe, and thus, without pausing, accomplishes a voyage of some three thousand miles, whose extent may be said to be tripled or quadrupled by the thousand detours which intervene along the route. To these faculties, which appertain to the province of locomotion, he should join the strength of the elephant or whale, and the unerring scent of the hound, the delicate touch of the bat, the acute hearing of the mole, and the piercing sight of the condor, which, soaring above the Cordilleras, detects the smallest prey browsing in the plain more than four thousand yards below him. He should combine, for means of attack and defence, the formidable claws

and terrible jaws of the tiger, with the impenetrable cuirass of the crocodile, and the envenomed tooth of the rattlesnake. Finally, all these different attributes should be united in a body, combining the grace of the kitten with the majestic calmness of the lion in repose, and adorned with the dazzling colours of the humming bird and the bird of paradise.

Existing animals exhibit only partial analogies with the imaginary creature, whose principal characteristics we have endeavoured to trace. The types of existing species fall far short of this standard of perfection, although some approach it more nearly than others. Hence arise *superior* and *inferior types*, and hence also we have widely differing, although not less equally perfect, types. The study of these different degrees of perfection of type, and of the subordination to which they give rise, probably presents a greater difficulty than any other branch of zoological research. The success of such inquiries will be greatly influenced by the naturalist bearing in mind the principle of the *division of labour* which the following comparison may tend to illustrate and explain.

In the early infancy of human industry, the tiller of the ground turns up the earth with the spade which he has himself forged; he reaps the flax he has sowed, and cleans, combs and spins it himself. Next he constructs a rude loom, fabricates a rough spindle, and proceeds to weave according to his best ability the fabric which is to serve for his clothing. As time passes he is enabled to provide himself with more perfect tools from some neighbour, who passes

his life in manufacturing farming utensils, looms or spindles. Still later, he sells his yarn to a weaver, who has never handled a blacksmith's hammer, a woodsman's axe, or a carpenter's saw. In proportion as each department of labour is left in the hands of persons who devote themselves exclusively to its execution, or, in other words, in proportion as *labour is subdivided*, the final result is rendered more and more perfect.

It is the same with animals. In order to insure the accomplishment of nutrition and reproduction, that is to say, the preservation of the individual and of the species, many secondary functions are necessarily brought into play. Again, in order that these processes may be performed with readiness and completeness, it is necessary that each should be performed by some special organ or physiological instrument. In other words, *it is essential to subdivide the functional labour as far as possible.* Such is the general character of the highest types, as, for instance, of the majority of the Mammalia. In the lower types, on the contrary, two or more functions are apportioned to the same organ, until as we descend to the Sponge and the Amœba, which constitute the last representatives of the animal kingdom, we find that all the functions are confounded in one organised living mass, exhibiting nothing more than a homogeneous pulp, the result of the entire fusion of all the organic elements.

It follows from this, that an animal, or an organism, becomes degraded *whenever the functional labour exhibits a diminished tendency towards subdivi-*

sion. This second principle, which is in some degree the counterpart of the former, is not the less important in zoological investigation. It is essential to understand in what manner certain progressively lower types may approximate towards some one other type, since it is only by an inquiry of this kind that we shall be enabled to attach any precise signification to the epithet *inferior*, which is often employed in the vaguest manner. For example, the mammals are unquestionably more perfect than the fishes. These two types are, however, each degraded in their respective directions; thus we have *higher mammals* and *higher fishes* as well as *lower mammals* and *lower fishes*, and the same difference of perfection is manifested in all the great divisions of the animal kingdom.

It is from a misconception of the principles which we have here briefly touched upon that most of our illustrious masters have fallen into grave errors. It is true that we occasionally meet with expressions in some of their writings which seem to imply that they had confused notions of these facts; still no one had clearly demonstrated or applied them before M. Milne Edwards, who has expressed himself in the most explicit manner in reference to this subject both in his lectures and his published works, more especially in the introduction to his great work on the history of the Crustaceans. If on my part I have arrived at analogous results, it is certainly entirely owing to the fact of my having followed the example set more than twenty years ago by that naturalist, and devoting myself, with the same per-

severance which he had shown, to the study of the lower animals on the borders of the sea.

In fine, types are the more fixed in proportion as they are more perfect. In those animals which approximate the most closely to this standard, the organism is extremely complicated, and it would seem that nature does not necessarily interfere with essential characters in producing a large number of derivatives. In the Vertebrata, for instance, whose primordial type gives origin to four classes, viz., mammals, birds, reptiles, and fishes, the general plan merely undergoes different secondary modifications. The external forms are changed to facilitate some special mode of locomotion; the lungs become metamorphosed into branchiæ, in order to allow of respiration in the water, but yet we find, in passing from the ape, which by its organisation approximates most closely to man, and descending to the lowest type of fishes, that nearly the same functions are fulfilled by a nearly equal number of organs disposed in an analogous if not an identical manner.* Those whose attention has been mainly directed towards the higher animals can form no idea of the extent to which organic degradation is carried; and hence, whenever their inquiries happen to lead them to

* The *Amphioxus* forms one of the most remarkable exceptions to this general rule. This fish, if we may call it by that name, exhibits, in the Vertebrata, an example of extreme degradation, which we should not have expected to meet with in any but the Invertebrata. It ought therefore to be formed into a special class, if it did not appear strange to constitute so important a subdivision for one or at most only two species.

inferior types, they are naturally induced to reject as foreign to their primitive types the greater number of the lower derivatives presented to their notice. This fact explains how Cuvier*, notwithstanding his marvellous genius, should so completely have misunderstood certain relations, as to incorporate certain Mollusca and Articulata among the Zoophytes, without perceiving the incongruity of such an association.

The case is different with the groups which belong to the primordial type of the Invertebrata. For the three great divisions of the Mollusca, Articulata, and Radiata present in each of their classes fundamental differences, and characters which occasionally present considerable opposition to one another. At the head of each of these series we find animals in which the division of labour is carried quite as far perhaps as in the Vertebrata themselves.† In proportion, however, as we deviate from these culminating points, the functions become more circumscribed, or merge

* [A sketch of the Life and Labours of Cuvier is given in the Appendix, Note IX.]

† We may cite the Insects as an illustration. To form an adequate idea of the complicated organism of these animals, we need only examine Lyonnet's plates on the Anatomy of the Caterpillar of the Goat Moth (the *Cossus ligniperda*), and those by M. Strauss-Durckheim, on the Anatomy of the Cockchafer. It is sufficient to remark that the former of these observers has counted 1647 muscles in the body and 228 in the head of the caterpillar, which would give a total of 1875 distinct muscles serving for the voluntary movements of the caterpillar, whilst in man there are not more than 529. To these 1875 voluntary muscles we must add, according to Lyonnet, 2186 muscles belonging to the digestive apparatus, which will give us a total of 4061 for the entire number of muscles in the body of a caterpillar.

into one another, the mechanism becomes simplified, and the entire organism is degraded, until at length on reaching the extreme limits we discover a multitude of ambiguous creatures, whose true relations it is extremely difficult to determine. One might almost fancy that nature was proposing to herself apparently insoluble problems for the mere pleasure of sporting with the difficulties which she sometimes surmounts in the most direct manner, while at other times she eludes them by the most unexpected contrivances and the most marvellous combinations. Each type, although remaining fundamentally the same, clothes itself as it were in a thousand different forms, leading the naturalist astray at every step he takes in his encounter with this veritable Proteus. Let him not lose courage, but pursue the god under all his metamorphoses, and sooner or later he will assuredly compel him to reveal his secrets. Then, if, strengthened by the knowledge of these revelations, he should return to the study of higher animals, he will see the darkness vanish, and a way opened across many of the barriers which he had before regarded as impassable.

Let us take by way of illustration one of those principal groups termed by Cuvier *embranchements;* for instance, the group of the Articulata. The essential character of this group consists in the tendency of the organism to divide into rings, arranged like strings of beads, each ring presenting an exact repetition of the same forms and organs as the other rings. In the Articulata all the organs are in pairs, so that a longitudinal section of one of these animals

exhibits two exactly symmetrical lateral halves of the body. We will now proceed to consider the limits within which these conditions of the ideal type are either modified or fully accomplished.

The first glance we take at this group of the Articulata shows that it is separated into two great divisions. In the former, namely, that of true Articulata with jointed limbs, the rings instead of forming a string of separate segments are united and soldered together, to form groups of organs. The body of the animal is thus divided into three parts, representing the three great regions of the body in the Mammalia, that is to say, the head, thorax, and abdomen. These three parts of the body, which are always very distinct in insects, may to some extent blend into one another. Thus, in the Myriapods or Millepedes, the thorax and abdomen can no longer be severally distinguished; whilst in the case of the Arachnidans, which include all the spiders and the scorpions, it is the head which is amalgamated with the thorax. These three classes respire atmospheric air, while Crustaceans (lobsters, crabs, &c.) are essentially aquatic. We refer here only to a very small number of characters, but how different would the case be, if, penetrating into the interior, we could comprehend the whole of these organisms! We should find that in one case air, that fluid without which no living being can exist, is diffused throughout the entire body by means of an admirable network of tracheæ, or canals, whose structure is almost exactly similar to that of an elastic webbing*,

* True *Tracheæ* are only to be met with in Insects, Myriapods, and one section of Arachnidans.

whilst in another case it can only act upon the mass of the blood, which it is to vivify, by the intervention of a single organ called a branchia or a lung, according to its external or internal position.* We should find that the blood was either enclosed in vessels †, or diffused over the entire body, bathing every part of the organs which it was destined to nourish.‡ We should discover wants of every kind giving rise to a multitude of instincts, and necessitating a hundred differently varied forms of organic apparatus, whilst each of the classes to which we have already referred, would appear to be surrounded by a system of groups, depending upon different types, whose final representatives would merge into one another, on the confines of these little worlds.

The Insects, Myriapods, Arachnidans and Crus-

* Some Arachnidans respire by means of sacs enclosing lamellæ, which constitute the respiratory organs. This apparatus, which is commonly designated by the term lungs, differs considerably from the true lung of the Vertebrata. All the Crustacea, on the contrary, including even those which live in the air, as the Oniscus, respire by means of branchiæ.

† We find that Crustaceans, Arachnidans, &c., possess a heart and a distinct vascular system.

‡ In Insects the heart is prolonged into a *dorsal vessel*, and in most cases the blood on issuing from this organ is immediately diffused in the *lacunæ*, or intercellular spaces. There is sometimes, however, a rudimentary vascular system (Dugès, Blanchard), but in all the Articulata, properly so called, there is always a more or less considerable interruption in the vascular circle, so that the blood is finally poured into the lacunæ. In the Crustaceans, for example, the arterial apparatus is well developed, but there are no veins. (See the Memoirs of MM. Audouin and Milne Edwards, of which we have already spoken.)

taceans constitute the most perfect Articulata. The Worms, which compose the second great division of this group, that of *Annelids properly so called*, belong to a very inferior type. They also vary still further in their external figure, as well as in their organisation. In describing my sojourn at Chausey, I endeavoured to give an idea of the group of wandering Annelids, those bellicose Amazons, with their roving dispositions and independent mode of life; but I have not said anything of their sisters, the tubicolous Annelids, those modest recluses, who as soon as they emerge from the egg begin to construct for themselves a habitation, from which they never again depart. This habitation, which is lengthened and widened according to the increasing bulk of the proprietor, is a tube, either calcareous or composed of a substance somewhat similar to leather or to wetted parchment. It completely envelopes the Annelid, which ascends and descends in the interior without the necessity of rolling back its body, for its feet are constructed in such a manner that they can move backwards or forwards with equal ease and facility. These animals therefore pass their lives in a position somewhat similar to that of a child in swaddling-clothes. The tube, which is closed at the posterior extremity, exhibits a circular opening in front, which serves as a kind of window through which these hermits are enabled to take a view of the world around them, to seize upon any prey which may happen to pass in their way, and to expose their blood to the vivifying action of the water, which serves them in the place of the air

which we breathe. Do not therefore accuse them of curiosity or coquetry, because you see them so constantly display their richly ornamented heads. But rather take advantage of this habit engendered by necessity, and carefully examine these marvellous forms. No microscope or lens can aid us here. Do but drop into a basin of sea-water this fragment of rock and this old shell, whose surface is covered with Serpulas, Vermilias, and Cymospires. Observe the prudent caution with which that little round plate rises above each tube, which it is designed to close hermetically so that your eyes cannot penetrate to the interior. This is the shutter of the house; see, it is moving, the animal will soon show himself. Look, and you will see below that operculum bud-like patches of dark violet or rich carmine in one part, and of a blue or orange tint in another, while still further on appear tufts of every hue. See them expand little by little until they have displayed the whole of their thousand coloured branches, similar in form to a plume of ostrich or marabout feathers. You are a witness of the evolution of veritable flowers, more beautiful by far than the blossoms of our gardens, for these are living flowers. On the least shock, on the slightest shaking of the fluid, these brilliant petals close, and disappearing with the rapidity of lightning, they retire within their stony tubes, whence they may defy their enemies from beneath the shelter of their operculum.

Here we have the Chætopteri, allies of the errant Annelids, which look as if the middle of their bodies had been crushed, while they carry their intestine

exposed to view within three of their segments; next come the Echiuridæ, whose zoological affinities with this class are merely shown by the external indications afforded by the presence of several exsertile and retractile hooks; here too we have the Sipunculidæ, whose cylindrical bodies exhibit neither members nor the slightest trace of division into rings*; the Dujardiniæ, which possess no apparent respiratory organs, and whose feet, furnished with long silken threads, do not serve the purpose of locomotion, animals which move through the water by means of little tufts of vibratile cilia, arranged on each side of the body like the paddles of a steamboat. To the tubicolous Annelids belong the Chloremæ, which have green blood, circulating through a body surrounded by velvety hairs, embedded in a sort of transparent jelly, and which can conceal their heads and branchiæ in a kind of box, formed of intertwined silken threads. Here, too, we find the Amphicoræ, animals which are provided with eyes at the extremity of their tails as well as in their heads; the Terebellæ, which, realising the fable of Briareus, extend their hundreds of arms to a distance of nearly a yard in search of the grains of sand and broken shells, with which their temporary abodes are constructed; and, lastly, there are the Sabellæ, whose fan-like branchiæ often measure upwards of a foot in diameter when fully expanded; besides these there are hundreds of other equally curious species, of

* The Echiurus and the Sipunculus were placed by Cuvier amongst the Radiata, by the side of the Holothuriæ.

which the painter's art alone could convey even a feeble idea.

We have hitherto examined only the exterior of our Annelids. Let us now proceed to consider their organisation. Look at this Eunice sanguinea, a magnificent creature of common occurrence at Bréhat, where it may sometimes be found measuring more than two feet and a half in length.* You might suppose perhaps that in consequence of its size, very little difficulty would be experienced in making a detailed dissection of this animal. But if you make the attempt you will soon perceive your error. The body is divided into rings, which are not above a line and a half in length, although they measure from eight to ten lines in width. It is no easy task, I can assure you, to seek within this limited space the muscles which move the animal, the intestine which receives its food, the vessels which nourish it, and the nerves which animate it: while, to add to the difficulty, you will find that all these tissues bear the closest resemblance to each other. But do not be discouraged; fix your Annelid upon a piece of black wax, cover it with a shallow layer of water, take a simple lens, and provide yourself with a delicate pair of pincers and cataract needles to serve the purpose of the scalpel. Remove the richly iridescent skin, whose intertwined net-work, as you will

* *Eunice sanguinea* belongs to the group of the errant Annelids. This is the largest species of our coast. I have frequently met with specimens two feet in length, but in the Indian Seas they are often five or six feet long, on which account the Indian species is known as the *Eunice gigantea*.

see by the microscope *, imparts to it its brilliant colours, lift up layer after layer, and when the organs are gradually exposed to view, I promise you that all your labours will be more than repaid.

You must begin with the nervous system, which is an apparatus of such predominating influence that it has been termed the impersonation of the animal itself. Observe, first, how the brain is situated within the head on the dorsal surface of the body; from whence it gives off nerves to the eyes and antennæ, the organs of sight and touch. In the rear it gives origin to a secondary nervous system, which is entirely distributed through the proboscis and œsophagus; in the front another special system supplies the lips, and no doubt communicates to them the property of taste. On the sides two bands are given off, which form a ring round the buccal cavity and are again joined together on the ventral surface below the digestive apparatus. At this point there is a kind of ladder-like structure, composed of two cords, stretched from one extremity of the body to the other, and connected together in each ring by an oblong mass, called a *ganglion*. These ganglia are the nervous centres which animate the rings, any one of which may be at once destroyed by the removal or destruction of the ganglion belonging to it. From each of these centres, five nervous trunks are given off on each side, which distribute their branches to the intestine, and to the muscles of the

* The brilliant colours of the Eunice and other Annelids are due to a phenomenon of polarization caused by the interlaced arrangement of the very delicate fibres of the epidermis.

body and of the feet. As there are about 300 rings, it follows that this Annelid must have one brain or chief nervous centre, 300 secondary centres, and 3000 nervous trunks, without counting those of the lips and the proboscis.

Let us next consider the apparatus destined to accomplish the process of alimentation. At the bottom of this funnel-like mouth, there is a large proboscis furnished with powerful muscles, and armed with eight horny jaws. Take care of your fingers! these sharp and curved teeth might very easily penetrate through the epidermis, and draw blood. Beyond this tube you will perceive an œsophagus, and further on a series of large sacs, each of which corresponds to one of the rings, and is separated from the two contiguous sacs or pouches by a strong constriction. You see that the animal which we are dissecting has not less than 280 stomachs.

Between the muscles and the intestines, on the dorsal surface of the body, you will admire those two sinuous vessels, filled with bright red blood. These two large veins receive the blood which has served for the nutrition of the body, and which therefore requires to be subjected to the action of the air. A venous trunk conveys this blood to the branchiæ, beginning at the twenty-fifth ring, where you will see that it forms, on either side of the body, a double series of tufts, which are alternately of an amber or scarlet tint, as the blood enters or flows from them. A second vessel passes from the branchiæ, and opens into a large artery, placed on the median

line, below the intestine. This artery gives off on either side, and in each ring, a large trunk, whose base expands and swells into a sac, which, by its contractions, propels the blood into the branches, which distribute it to all the organs. Passing over numerous details, we will merely observe that our Eunice possesses, independently of the great canals which run from one extremity of the body to the other, 550 branchiæ, 600 hearts, and a similar number of primary arteries and veins.

Now we have need of great patience, as we endeavour to disentangle those interlaced muscular bundles which form the flesh of the rings and give motion to the feet, to their two bundles of sharp and cutting setæ, and to the four aciculæ which are as conical and strong as a huntsman's spear. There are no less than thirty distinct muscles in the fleshy part of each ring, whilst each inter-annular partition exhibits as many as ten. On either side, two large muscles are attached to the centre of the ring, and the base of the feet, which they move either forward or backward. A sac, composed of about ten muscular bundles, surrounds each tuft of setæ, as well as the aciculæ, which it serves to extrude; on either side, eight muscles serve to retract these tufts, and to give motion to the different parts of the foot. Thus, each ring is supplied by about 120 muscles; and if we take into account those of the proboscis and head, we shall find that the entire animal moves by the action of more than 30,000 muscles.*

* I have not yet been able to complete my observations on the

This, truly, is an instance of complicated anatomy. We must observe, however, that we have been examining one of the species which approach most nearly to the ideal type of the Annelid. It furnishes a very high term of comparison in the group, and exhibits a very strongly manifested example of the division of labour. Let us now take the Doyerina, which recalls to me the rocks of Chausey. Although it is only a few lines in length, our microscope will magnify it to several feet, and we shall readily be able to distinguish its organs when enlarged in the same proportion. Well! here we have a manifest proof of simplification; the skin is here converted into a diaphanous covering, the muscles of the trunk are blended into two or three scarcely distinguishable layers; those of the inter-annular partitions have vanished, and their place is supplied by a simple membrane; and those of the feet are nothing more than homogeneous cords composed of contractile substance. The digestive and nervous centres are nearly the same, but their accessory parts have undergone obvious reductions. Then, moreover, the circulatory organs have been reduced to a single dorsal trunk, while the organs of respiration have disappeared. Let us next examine this Aphlebina, which was captured amongst the Corallinas of Bréhat. Here the degradation is still more

anatomy of the Eunice as perfectly as I could have wished; the numbers therefore which I have given may vary within certain limits, but they may at all events be regarded as approximating very closely to the truth.

manifest. The body is a mere sac, in which there lies immersed a nearly straight intestine; here are no internal partitions and no circulatory organs, the liquid, which represents the blood being moved only by bands of vibratile cilia, which are placed in a slanting position upon the base of each foot.

But if we would observe the extreme limit to which degradation of type may attain in the Articulata, we must descend to the class of Worms, properly so-called. Here great size is often associated with extreme simplicity of organisation; a circumstance which is nowhere else exhibited in so high a degree, not excepting even the Radiata. The Nemertes Borlasii presents a remarkable instance of this.* Figure to yourself an animal from thirty to forty feet in length, and only five or six lines in width, flat as a riband, of a brown or violet colour, and smooth and shining as varnished leather. Such is the Nemertes, whose anatomy had never before been studied, although the animal had been long known. This gigantic worm lurks under stones and in the hollows of rocks, where it may be met with rolled into a ball and coiled into a thousand seemingly inextricable knots, which it is incessantly loosening and tightening by the contraction of its muscles. This animal is nourished by sucking the Anomia, a kind

* The Nemertes constitute a numerous and interesting group; and I have devoted considerable time and attention to their study. The species referred to in the text is the *Borlasia Angliæ*. Fishermen state that they have seen these animals more than a hundred feet long.

of small oyster, which attaches itself to various substances under water. When it has exhausted the food around it, or when it wishes to change its position, it extends its long, dark-coloured, riband-like body, which is terminated by a head, bearing some resemblance to that of a serpent, although it has neither the large mouth nor the formidable teeth of the latter animal. In observing it in motion, the eye is unable to detect any contraction, or any apparent cause by which it is enabled to move, and it is only by the aid of the microscope that we learn that the Nemertes glides through the water by means of excessively fine vibratile cilia, which are protruded from every part of the surface of the body. It pauses, gently moves from side to side, as if endeavouring to investigate the ground, until it at length succeeds in finding a stone to suit its purpose, lying perhaps some fifteen or twenty feet from its former retreat. It then begins to unwind its coils, in order to arrange itself in its new domicile, and in proportion as one knot is loosened another forms at the opposite extremity. We may remark that the contractility of the tissues of this animal is so great, that a Nemertes thirty feet long scarcely exhibits one tenth of this length after being immersed in alcohol, when it will be found to measure no more than two and a half or three feet.

All the great apparatus of life is represented in the organisation of the Nemertes, although it is here reduced to its simplest expression. The nervous system does not form that œsophageal ring, which

has long been regarded as characteristic of the type. Here it is composed simply of two lateral ganglia, from whence proceed two cords, which extend to the extremity of the body, and give off merely very small threads. Two large vessels, placed on either side, accompany these nervous trunks, a third winds along the median line; all three are simple, without ramifications of any kind. The mouth consists of a circular orifice, which is scarcely visible, and opens into a long tube, separated by a constriction from the intestine, which terminates in a *cul-de-sac*. Thus the same opening serves for the introduction of the food, and for the rejection of the undigested residua. As if to compensate for the low degree of development in these organs, the ovaries, which are placed on either side of the body, are of very considerable dimensions. This very circumstance, however, is in itself an indication of the inferiority of the animal. These degraded species are besides exposed to a thousand chances of destruction in the earlier period of their existence; at a more advanced age, they usually serve for the food of higher forms of animals. Hence nature has provided largely for their multiplication. Many of them literally become transformed into ovigerous sacs. Thus, for instance, in the case of a Nemertes, measuring from eight to ten feet in length, we cannot estimate the number of ova at less than four or five hundred thousand.

It may be readily believed that I devoted myself with no common ardour to these attractive studies, the pursuit of which was almost hourly attended with renewed successes. At Bréhat, moreover, I

was able to study with more steadiness and good-will than I had done at Chausey. I had secured a lodging at the house of the keeper of the artillery stores of the island, and by having some one at hand with whom I could enter into friendly interchange of thoughts, I escaped from that sense of isolation which is one of the most enervating impressions that the heart of man is capable of feeling. I took pleasure in studying in the person of my host that class of subaltern officers who daily render to the state services as obscure as they are laborious, with no prospect before them but that of obtaining a trifling pension, or, in the case of a few amongst them, the cross of the Legion of Honour. Detz was one of this favoured number, and his thirty years' service had certainly thoroughly earned for him the bit of red riband which decorated his button-hole. When I resided with him, his time was divided between the performance of his modest military duties and the cultivation of his garden. It was a real pleasure to me to hear his long stories of the service he had seen, and, like all old soldiers, he was always ready to relate his past experience. I often sought relaxation from my labours by pacing up and down his little domain with him, while he narrated the events of his campaigns in Germany, and detailed all his sufferings in the English prisons and his adventures at the taking of Algiers, pausing from time to time to show me, with well-founded pride, some fine specimens of his horticultural skill.

Sometimes, too, when my body and mind, overfatigued by too long a walk, or by too protracted at-

tention to the labours of my anatomical investigations, made me feel the need of complete repose, I would betake myself to the beach, where, stretched full length on the grassy slope of some hill, I gave the rein to my thoughts. If you still preserve any of those illusions which, day by day, are vanishing amid the turmoils of life, if you regret the dreams that have fled never to return, go to the ocean side, and there on its sonorous banks you will assuredly recall some of the golden fancies that shed their radiance over the hours of your youth. If your heart have been struck by any of those poignant griefs which darken a whole life, go to the borders of the sea, seek out some lonely beach, an Archipelago of Chausey, or an Isle of Bréhat, beyond reach of the exacting conventionalities of society; and when your spirit is well-nigh broken with anguish, seek some elevated rock, where your eye may at once scan the heaving ocean and the firmament above; listen to the grand harmonious voices of the winds and waves, as at one moment they seem to murmur gentle melodies, and at another to swell in the thundering crash of their majesty; mark the capricious undulations of the waves, as far as the bounds of the horizon, where they merge into the fantastic figures of the clouds, and seem to rise before your eyes into the liquid sky above. Give yourself up to the sense of infinitude, which is stealing over your mind, and soon the tears you shed will have lost their bitterness; you will feel ere long that there is nothing in this world which can so thoroughly alleviate the sorrows of the heart as the contemplation of nature, and of the

sublime spectacle of creation, which leads us back to God.

Twilight often surprised me in the midst of my reveries, and often, too, the shades of night fell around me, while I lay stretched beneath the star-bespangled deep azure canopy of heaven. I could then see another star shining in the far distance, which had been lighted by the hand of man. From the position I had chosen I could recognise the beacon towers of Héhaux, of which the seamen of the islands had spoken to me with the liveliest expressions of enthusiasm, and which I had frequently watched by day, as it stood out like a black line drawn along the whitish background of the sky. I would not leave Bréhat without visiting it. A few slight services had secured me the good-will of the officer of customs, who willingly consented to take me to Héhaux. Accordingly, one splendid day in October, we left the harbour of La Corderie in a pinnace manned by six sturdy seamen. The weather was splendid; not a cloud obscured the sky, which was reflected on the mirror-like surface of the ocean, whose depths it seemed to double. Impelled by the combined action of a light wind, which swelled our two small square sails, and of the rapid current imparted to the waters of Kerpont by the force of the tide, our pinnace shot across the waves as a sledge glides over the snow. Sometimes, indeed, we passed through a whirling eddy, which shook every part of our frail craft, and betrayed the vicinity of some submarine rock; but we soon regained the unruffled sea, and without having taken cognisance of the

rapid rate at which we were moving, we saw Bréhat sink below the distant horizon behind us, whilst rock after rock, and islet after islet, seemed at every moment to emerge from the waves towards which we were advancing.

After having first directed our course towards the north, we passed the island of Saint-Modé to our left, and looked with interest at its batteries, where, almost buried in the grass, lie heavy pieces of cannon, ready to peal forth their hoarse thunders at the first signal of war, and to defend the entrance of the roads of Pontrieux. Here too is the chapel with its holy relics, which, if we may trust the testimony of those who live in the vicinity, possess the virtue of expelling from the island every kind of parasitical insect. We passed rapidly between Pen-ar-rest and the plateau of the Sirlots, whose hidden rocks prove a dangerous obstacle to the course of vessels passing from Brest to Pontrieux. Steering towards the north-east, we coasted along Roch Louet and its shelving rocks, which although at a distance of more than two miles from the shore are united with it by means of a natural dyke of boulders, called the Sillon, which has been formed by the two opposite currents which ebb and flow twice each day within the basins of Pontrieux and Tréguier. Here the tide left us, the wind fell, and our sails flapped loosely against the masts. The sailors now began to pull with vigour, and soon the pinnace resumed its former course beneath the measured strokes of the long oars, leaving a white line of foam behind it. The nearer we drew to Héhaux, the taller

seemed the beacon tower, which stood forth from the sky with its lofty granite column and glass lantern, protected by that magical rod which is able to attract and safely conduct to earth the destructive force of the thunderbolt. We landed, and at once began our inspection of this colossal rock, which has been upreared by the hand of man on the Epées de Tréguier, which, once the dread of the seaman, have become his protecting guides through the storms and darkness of night.

The Héhaux lighthouse would be regarded as a most remarkable monument, even in our principal towns, but standing, as it does, alone in the midst of the ocean, it acquires by its very isolation a character of severe grandeur, which impresses the mind most powerfully. Figure to yourself a wall of granite, where the current and the storm do not even permit the hardiest Fucus to take root, with here and there a twisted and deeply wave-worn mass projecting beyond the rest of the rocky ledge. It is here that the architect has laid the foundation of the tower. The base, which is of a conical form, is surmounted by a circular gallery. The lower portion curves gracefully outwards, spreading over the ground like the root of some colossal marine plant springing up from the foundation stones which have been inserted far within the rock. On this base, which measures about twenty yards across, rises a column, twenty-six feet in diameter, surmounted by a second gallery, whose supports and stone balustrades call to mind the portcullis and battlements of some feudal donjon. From the

summit to the base, this part of the edifice is composed of large blocks of whitish granite arranged in regular strata, and carefully dovetailed into one another. As far as a third of the height of the building the rows of stones are bound together by granite joggles, which at the same time penetrate into the two superposed stones. The stones have been cut and arranged with such precision that there has hardly been any necessity for using cement, which has only been employed in filling up a few imperceptible voids, and hence the lighthouse, from the base to the summit, seems to form one solid block, which is more homogeneous and probably more compact than the rocks which support it. The platform which crowns this magnificent column at an elevation of more than 140 feet above high-tide water-mark, is surmounted by a stone cupola, at once solid and graceful, supported by pillars which are separated by large panes of glass. It is within this frame of glass that the beacon is lighted, which may be distinctly seen from every direction at a distance of twenty-seven miles.

At low tide the sea leaves a space of several hundred square yards uncovered round the base of the edifice; at high tide it entirely surrounds it. It is then that the tower of Héhaux rises in its solemn isolation from the midst of the waves, as if it were a standard of defiance upraised by the genius of man against the demon of the tempest. At times one might almost fancy that the heavens and the sea, conscious of the outrage offered to them, were leagued together against the enemy which seems to

brave them by its impassibility. The north-west wind roars round the towers, darkening its thick glass windows with torrents of rain and drifts of snow and hail. These impetuous blasts bear along with them from the far-spread ocean colossal waves, whose crests not unfrequently reach the first gallery, but these fluid masses slide away from the round and polished surfaces of the granite, which leave them no points of adhesion, and darting their long lines of foam above the cupola, they break with thundering roar against the rocks of Stallio-Bras, or the boulders of Sillon. The tower supports these terrific assaults without injury, although it bends, as if in homage, before the might of its foes. I was assured by the keepers, that during a violent storm, the oil in the lamps of the highest rooms, presents a variation of level exceeding an inch, which would lead us to assume that the summit of the tower describes an arc of about a yard in extent. This very flexibility seems, however, in itself to be a proof of durability. At all events we meet with similar conditions in several monuments which for ages have braved the inclemency of recurring seasons. The spire of Strasburg Cathedral, in particular, bends its long ogives and slender pinnacles beneath the force of the winds, while the cross on its summit gently oscillates at an elevation of more than 450 feet above the ground.

To construct a monument on these rocks, which seemed the very focus of all the storms which raged on that part of our coasts, was like building an edifice in the open sea. Such a project must indeed have

appeared at first sight to be almost impracticable. After their third season of labour, the workmen completed the foundations of the tower and fixed the key-stone of the cupola. In vain did difficulties of every kind combine with the winds and waves to oppose the work; human industry has come forth victorious from the struggle, and although a thousand difficulties and dangers beset the labourers, no serious accident to them or their work troubled the joy of their triumph. Only on one occasion was science at fault. In order to facilitate the arrival of the stones, which had to be brought from a distance of several leagues and cut at Bréhat, the skilful engineer, who had furnished all the plans and superintended their execution, wished to construct a wooden pier for the disembarkation of the stones at the spot where they were required. Several of the older seamen objected to the plan as impracticable, but M. Reynaud, who was not familiar with the sea, and who, moreover, was proud of having stemmed the current of rapid rivers, trusted to the stability of his massive piles, clamped together with iron and bronze. But he was soon compelled to admit his mistake. The first storm sufficed to scatter over the waters the whole of these ponderous and solid materials, like so many pieces of straw. The learned pupil of our scientific schools could no longer refuse to adopt the advice of the humble workmen of Bréhat. A crane was attached to the summit of a rock, to which boats could be moored, and the materials for building were then drawn up to a railway which had been thrown

over the precipice that separated this natural landing-place from the site of the tower.

Now that we have admired the exterior of the lighthouse, follow me into the interior by the help of these steps which have been formed by the insertion of bars of copper into the stone. Let us pause for a moment to admire the ponderous bronze doors which hermetically seal the entrance, before we plunge into those vaults which look as if they had been cut out of the solid rock. We are in the first story, surrounded by stores of wood and ropes and workmen's tools. Above, we perceive cases of zinc, which we are told contain oil to feed the lamps and water for the use of the men employed in the building. In the third story is the kitchen, with its pantry and larder on a level with the first gallery. We need not enter the three apartments appropriated to the use of the men, for, beyond being very simple and clean, there is nothing to record concerning them. But we have now reached the seventh story, and we must rest for a few moments in this little octagonal saloon, with its bright wainscoted walls and polished floor. It is set apart for the use of the engineers, when they come to inspect the condition of the lighthouse. Here, in the midst of the ocean, at an elevation of more than a hundred feet above the level of the sea, you will find the comfort and almost the elegance of a Parisian apartment. Here are commodious berths, mahogany furniture, and a fire-place ornamented with bronze and surmounted by a marble slab. You will discover in the most trifling arrangements the same intelligent economy that

presides over the fitting up of our ships, in which the space seems doubled by the judicious use which is made of the smallest corner of available room.

Let us now return to the spiral staircase which has brought us thus far, and which will carry us at once to the portion of the edifice which is more particularly destined to fulfil the special purpose for which the tower is designed. The eighth story contains vessels of oil, glasses, revolving lamps, some admirable instruments intended for meteorological observations, a thermometer, barometer, and chronometer. Here the spiral staircase terminates in a flattened arch which supports a slender pillar, cut into steps, which are the only means of communication with the watch-tower above, in which the men take it by turns to keep guard every night. You will be surprised on looking round to perceive that the apartment is coated with differently coloured marbles, which line the walls and vaulted roof and even cover the floor. But this luxury, which may appear to you to be so much out of place, has been introduced from necessity. The apparatus for lighting the building enters the room through a circular aperture in the ceiling, and hence the most extreme cleanliness became necessary, which could alone be obtained by the aid of perfectly polished surfaces.

Let us now ascend the tenth and last flight of steps. Here we are beneath the cupola, and look upon one of those magnificent gifts by which science from time to time enriches mankind, as if to refute the discouraging question that is often asked, *Cui bono?* You see before you the machinery by which

a fixed light is maintained in a lighthouse of the first order. I think some explanation will be necessary here to make you understand the destination and effect of the different parts of an instrument, in which, at first sight, you perceive nothing more than a kind of huge glass barrel, whose hoops are represented by prisms of the same substance, and which is furnished, both above and below, with a row of shades or screens, composed of several series of inclined mirrors.

The ancients, who were much more addicted to navigation than is usually supposed to have been the case, seem to have recognised from the remotest antiquity the necessity of maintaining signals, which might indicate to the navigator the dangers to be avoided in his course, and the channels by which he might safely steer his small craft, which was adapted only for coasting voyages. From the Black Sea to the Ocean, almost every promontory was surmounted by an altar, column, or tower, from whence clouds of smoke issued by day, while its fires guided the seamen during the darkness of night. Almost all these ancient *Phari* were at the same time temples consecrated to some divinity, whose name they bore. The priests who tended them, were the astronomers of those remote ages, who instructed the seaman how to steer his way along the neighbouring shores. Some antiquarians of our own day have believed that this circumstance furnished an explanation of many mythological fables. Thus in their eyes, the god Proteus, who was consulted by Menelaus on his return from the Trojan war, is only one of these

beacon heights discovered by the Greek prince when he had wandered from his right course, and at which he received the necessary instructions for finding his way to his native country. According to the same authorities, the solitary eyes of the Cyclops betoken the fires lighted on the promontories of Sicily, while the tradition which records that these giants expired beneath the darts of Apollo, signifies merely that these beacon lights, which were comparatively useless through the day, were extinguished on the rising of the sun. These buildings were frequently of very considerable size; indeed, the height of the *Pharos* erected by Sostratus of Cnidos, on the low coast of Alexandria, about 300 years before the Christian era, very greatly exceeded that of any modern lighthouse.

This excessive elevation is, however, quite unnecessary for the attainment of the object proposed. The difficulty in making a beacon-light visible from a very remote distance does not consist in obtaining any great degree of altitude, but in giving to the light such an intensity as will enable it to traverse a considerable space without being materially diminished. It was in this respect that the ancient *Phari*, which were lighted by ordinary fires, were especially defective, although they may perhaps have been sufficiently powerful to aid the timorous sailors of that age. When men acquired a profounder knowledge of astronomy, and when the invention of the mariner's compass opened all seas to navigation, a number of the old beacons might perhaps be safely dispensed with, although it would, at the same time,

be necessary to augment the intensity and penetrating power of the light employed. The problem became from that time a more complex one. It was necessary to augment the intensity of the light, and still more necessary to collect and bring horizontally back to the sea the rays which, escaping in all directions, were lost in space, either by falling at the foot of the light-house, or by uselessly diffusing themselves over the neighbouring land.

Many attempts have been made to effect this double object. The substitution, by Argand, of lamps with a double current of air was the first step in advance. An Englishman, named Hutchinson, towards the close of the eighteenth century, first conceived the idea of placing behind these lamps a metallic mirror, which projected forward a part of the scattered rays. A Frenchman, the Chevalier de Borda, carried this mode of lighting to the highest degree of perfection, by employing as a reflector a *parabolic* mirror which owes to the particular curvature of its walls, the property of transmitting, in the same direction, all the rays emanating from a luminous centre placed in its focus; and of thus projecting forwards a sort of cylinder, composed of all the rays emitted from this centre.* But this advantage involved in itself a very serious inconvenience, for the cylinder of light presented very

* The invention of the parabolic mirror is not the only service that Borda has rendered to navigation. He was the founder of the schools of naval architecture, and he has left several works, amongst others, a *Voyage en diverses parties de l'Europe et en Amérique.* Borda died in 1799.

nearly the same diameter as the mirror itself. Compared with the area of the sea, it was like one simple ray of light, which could only render the lighthouse visible to a spectator standing in a direct line before it.

Borda's invention would therefore have proved of no use if it had not been for a very ingenious idea suggested by a person named Lemoine, who had formerly been Mayor of Calais. His plan consisted in placing Borda's apparatus on a moveable axis, which, by its rotatory movement, presented the mirror to every part of the horizon in succession. The observer, who is placed at a great distance from the lighthouse perceives it only during the time required for the cylinder of reflected light to pass before his eyes, the building at other times seeming to him to be shrouded in complete darkness. This latter circumstance, far from injuring the effect proposed, presents, on the contrary, great advantages. By arranging round one and the same axis a certain number of reflectors, which are all provided with their respective lamps, each revolution of the machine will present as many luminous flashes as there are mirrors, while a certain time will elapse between their successive occurrences, during which the spectator is plunged in obscurity. By varying the number and duration of these intervals, one may give a special character of individuality to a certain number of lighthouses, which is in itself a very essential condition, since it is only by this means that vessels arriving from a distance are able to recognise the precise point of the shore in sight, and

to steer their course with safety. Where the light alternately appears and disappears in the manner we have described, the apparatus for lighting is said to be on the principle of a *revolving* light.

Borda's mode of lighting can, unfortunately, only be applied to lighthouses of this kind; and is inapplicable for buildings which are illumined by a *fixed light*, that is to say, where the light must be visible from every point of the horizon at one and the same time. This method of illumination must, however, necessarily be adopted, since it is impossible to vary the lights and obscurations in such a manner as to impart to each lighthouse sufficient individuality of character to distinguish it from all others. Much, therefore, remained to be done. There had existed in France for many years a lighthouse-commission, the members of which, occupied with a hundred other duties, had scarcely done anything towards the solution of this problem, when M. Arago* proposed to undertake a series of experiments, on condition that he might receive as his coadjutors in the work MM. Mathieu and Fresnel†, whose ad-

* [A short biographical sketch of Arago is given in the Appendix, Note X.]

† Fresnel, who was a Member of the Institute, ranks amongst the most illustrious cultivators of physical science. He especially devoted himself to the study of the most delicate phenomena of light. "Among the great observers, who have preceded him," says M. Pouillet, "we can mention no one who has exhibited more inventive power in his experiments, more precision in his measurements, or greater depth of thought in his deductions." It is to Fresnel that we are indebted for that solid basis on which the now generally accepted *undulatory theory* rests, which consists in regarding

mirable discoveries on the properties of light had pre-eminently fitted him to grapple with this subject. The disinterested zeal of these three men led to the rapid attainment of numerous valuable results. MM. Arago and Fresnel, by following the plan suggested by Rumford, gave a most unexpected degree of perfection to the lamp with a double current of air. They constructed an apparatus having four concentric wicks, which were supplied with oil by clockwork, and whose illuminating power was so great that a single wick was equivalent to twenty-two of the best Carcel lamps. Fresnel replaced Borda's mirrors, in which the light is concentrated by *reflection*, by lenses which the rays traverse, and which throw them by *refraction* into the desired direction.

The best polished surface absorbs very nearly *half* the quantity of light which strikes it. The other half alone is reflected, and is therefore the only part that can be made available. In traversing a glass of moderate thickness, the same quantity of light is only diminished by about one twentieth of its original amount. These well-known facts led in England to the employment of glasses resembling those which are used for ordinary lenses. The adoption of this form rendered it necessary to use glasses of considerable thickness, in consequence of which the light experienced even more diminution in traversing

light, not as an emission from luminous bodies, but as produced by the vibration of an universally diffused agent, which we designate under the name of ether. According to this theory, the phenomena of light and of sound closely resemble one another.

these lenses than in the case of the metallic reflectors. This mode of lighting was not therefore attended by any practical results, while even the name of the person with whom the arrangement originated is now forgotten.

With the view of overcoming the difficulty to which we have referred, Fresnel conceived the idea of decomposing his lenses into several elements. The central glass was an ordinary lens of small diameter and consequently of inconsiderable thickness. He formed the others of prisms, which were arranged round the centre in concentric circles, whose curvatures were so calculated that their focus coincided with that of the lens itself. It would have been impossible to cut and polish such large glass circles; Fresnel therefore constructed them of separate pieces which he cemented together with isinglass. Thus was realised one of the conceptions of our illustrious Buffon *, whose genius seems to have comprehended all departments of science. He, too, had conceived the idea of constructing polyzonal lenses, but supposing it necessary that the different parts of the series should all be formed of one piece, he had regarded this plan as impracticable. The merit of the invention, belongs therefore, exclusively to Fresnel†, who was ignorant of Buffon's suggested plan till he had himself realised his own theoretical conceptions.

* [A notice of the life and works of Buffon is given in the Appendix, Note XI.]

† [M. de Quatrefages is probably not aware that Sir David Brewster described a method of constructing large lenses of several pieces in 1812, ten years before the publication of Fresnel's celebrated memoir.]

The following numbers will at once show the superiority possessed by the new mode of lighting when compared with that yielded by Borda's mirrors. A polyzonal lens having a diameter of thirty inches, and illumined by a single lamp with four wicks, transmits the rays to a distance of thirty-six miles; it projects eight times more light towards the horizon than the best reflector, and the effect which it produces in the direction of its axis is equal to that which would be emitted from 4000 combined jets of gas.

The lenses which we have described are alone applicable to lighthouses having revolving lights, and in this respect they resemble parabolic mirrors; but a great advantage of the new system is that it may be equally well used for fixed lights. To adapt it to the latter mode of illumination, all that has to be done is to metamorphose the lens into a ring dilated in the middle, and to arrange above and below it a sufficient number of prisms analogous to those of which we have already spoken. In this manner the light is thrown simultaneously to all points of the horizon, only, instead of being united into a cylinder, it forms a kind of horizontal sheet. It will therefore be readily understood that lighthouses with fixed lights cannot present the same area of illumination as those which are provided with revolving lights. In both cases the lamp is surrounded by a ring of glass of the same height, which receives nearly the same quantity of light in either case. But while in a revolving light the entire

illuminating power is concentrated by lenses in either eight or sixteen directions only, in a fixed light it spreads over all points of the circle, diminishing in intensity in proportion to the greater extent of surface over which it is diffused.

A lamp which is placed in the centre of a fixed or moveable apparatus emits its rays in all directions, and consequently a large number pass above and below the lenses. To avoid this loss, Fresnel proposed to re-collect these rays upon reflecting prisms, which have the property of destroying only a small quantity of the light which traverses them. This idea was actually applied to lighthouses of small dimensions, but it had hitherto been regarded as impossible to construct curved prisms of a size suitable for buildings on a large scale. These prisms were replaced by a system of concave mirrors covered with tinfoil, and arranged in horizontal zones above and below the apparatus. Now we have already seen that half the light is destroyed by this mode of reflection; hence it was most desirable that the prismatic rings should be formed on a large scale. The problem which had hitherto been regarded as insoluble was successfully solved by a Parisian artisan, M. François who, in 1844, presented to the Academy of Sciences one of the eight staves, which when combined form the reflecting cupola, as exemplified in the lighthouse of Skerryvore in Scotland, the construction of which is in exact accordance with Fresnel's plans. The importance of this improvement will be best understood when we consider that the light reflected by the tinned mirrors is

equal to that of 133 combined jets of gas, whilst the light transmitted by M. François' cupola is equal to that of 214 jets, which would give an augmentation of 81 jets of gas for the available light.

MM. Arago and Fresnel commenced their observations in 1819; four years later the lamp with concentric wicks was invented, the polyzonal lenses were tested, and the new mode of lighting tried in the Corduan lighthouse at the mouth of the Gironde, where, a century before, the first trial was made of illuminating by revolving lights and by parabolic mirrors. The result fully realised all the hopes that had been entertained of this method, and in 1825, in consequence of a remarkable report drawn up by Vice-Admiral de Rossel, one general plan was adopted for the lighting of the coasts of France. Twenty-seven lighthouses of the first order were distributed along a coast-line of about 1200 miles. These edifices stand forth like so many advanced guards to signalise to the sailor, returning from the open sea, the name of the shore he is approaching. With this view these buildings have been so arranged that a tower with a fixed light invariably intervenes between two towers carrying revolving lights, differing most distinctly from one another. Five lighthouses of the second order and seventeen of the third, together with thirty-five port-lights intervene between every two first-class lighthouses, to point out the dangers which are always multiplied in proportion to the increasing vicinity of land, and to indicate the safe channels. Everywhere reflecting mirrors are being replaced by this system of lenses.

Other nations are following the example of France. As they formerly copied the revolving apparatus invented by Lemoine and the reflectors suggested by Borda, they now borrow Fresnel's lenses and the lamp devised by Fresnel and Arago, whilst they resort to Paris for nearly all the apparatus employed in lighting their own coast-lines. We have therefore some right to declare with just pride, that it is to France that mankind owes all the essential progress which has been made in reference to a question so vastly important to the security of navigation, and consequently so intimately associated with the interests of commerce and humanity.

After having carefully examined and admired every portion of the magnificent lighthouse of Héhaux I returned to my daily avocations at Bréhat. But the bad weather was setting in; I often came home from my excursions wet through and shivering with cold, so that I felt it was time to think of taking my departure. My good friend the custom-house officer once more lent me his pinnace, and I left Bréhat enriched with numerous drawings, notes, and collections of animals, many of which were carefully preserved in spirits.* My passage was alike rapid and agreeable, and with scarcely a stoppage I returned to Saint Brieuc by the same road which I had pursued three months before. The country was still looking beautiful, although the decline of the year

* All the objects which I collected in this and the following expeditions have been deposited in the Museum, and now form a portion of the collection connected with the chair held by M. Valenciennes.

had shed a certain tone of quiet melancholy over the face of the landscape. The thousand varied tints of autumn had replaced the bright, but uniform verdure of spring; the oaks were scattering their dried and yellow leaves before the wind, and the birds had departed with the flowers of summer. Scarce a blossom remained but the golden rods of the broom, which, interspersed among the purple tufts of the heather, gave to the distant hills a rich tinge of ochre which was rendered still brighter beneath the rays of the setting sun.

CHAP. III.

THE COASTS OF SICILY.

THE GROTTO OF SAN-CIRO.—TORRE DELL' ISOLA.

Departure for Naples with MM. Milne Edwards and Blanchard. — Arrival in Sicily; aspect of the Bay of Palermo.— Excursions to the grotto of San-Ciro.— Osseous caverns; osseous *breccias.* — Installation on board the Santa Rosalie. — Departure from Palermo. — The grottoes of Mont Pellegrino. — The Blatta orientalis.—Arrival at Torre dell' Isola.—The Padre Antonino.— Structure of the coast. — Our sailors. — Explorations.— Transparence of the water in the bay. — Principal species belonging to the littoral districts. — Causeways built by the Vermetus. — Occupations; mode of life.—Departure for Castellamare.

A SCIENTIFIC commission, consisting of M. Milne Edwards, M. Blanchard, and myself, was appointed, in the Autumn of 1843, to visit the coasts of Sicily by the Minister for Public Instruction, the Jardin des Plantes, and the Academy of Sciences.* In accordance with our plan of travelling together, we all left Paris on the 20th of March, 1844, and on the 28th of the same month we reached Naples. In eight days we had traversed the whole of France; we had taken a glance at Lyons and Marseilles,

* [A sketch of the history and constitution of the Jardin des Plantes, and of the Academy of Sciences is given in the Appendix, Note XII.]

slept at Genoa, and visited its palaces; anchored at Livorna; admired the baptistery, and the leaning tower of the Campo Santo at Pisa; and yawned with *ennui* within the narrow precincts of Civita-Vecchia, until at length we beheld the sun emerging from behind Castellamare, striking the profile of Vesuvius, gilding Pausilippus and Cape Miseno, empurpling the waters of the bay, and flashing from the white houses of that city, of which, it has been said, nothing is left to those who have seen it but to die.

But Naples, notwithstanding its many seductions, was unable long to detain us. We were all anxious to reach Sicily, and as soon as we were enabled, by the friendly aid of our ambassador, M. de Montebello, to obtain the papers which it was indispensably necessary for us to procure, we embarked in the *Palermo*, the first of a new line of steam packets which has now established a regular communication between the island and the continent. The passage, which was even then so tedious and uncertain, is now effected in eighteen, or at most twenty hours. We left Naples at four o'clock, and before long we had passed Capri, which rose to our left, with its rugged rocks — the silent witnesses of the crimes of Tiberius and of the daring valour of our soldiers. We watched the setting sun, as it gilded with its last rays the serrated peaks of the Calabrian shores, until its fires were extinguished in the limpid waters of the bay, giving place to one of those nights of the south, when all things around are bathed in transparent shadows, which throw a veil of beauty

over sky and earth unknown in northern latitudes. When we came on deck at break of day, the last of the Calabrian heights was disappearing on the horizon, whilst before us Sicily was growing more and more distinct, as it gradually rose to view from the blue waters of the sea. Before noon we had doubled Cape di Gallo, and were gazing with admiration on that lovely valley so justly termed the *Conca d'Oro.*

It cannot be denied that the Bay of Naples presents a strikingly beautiful appearance, as it breaks upon the sight of the traveller entering it from the open sea. For myself, however, I must admit that I prefer the aspect of the Bay of Palermo. At Naples the landscape is deficient in harmony. As the spectator looks towards the steep incline on which the city is built, he finds nothing on which his eyes can rest between the sky and the water's edge but the crowded buildings of Monte-Falcone and the bastions of Saint Elmo. The low shore of Portici, covered with its white villas, seems nothing more than a prolonged suburb, stretching as far as Castellamare. There is no intermediate object to attract the eye before it rests upon the gracefully rounded outline of this shore; beyond it there is no distant background. Man predominates too much in this landscape, in which nature is only seen in the isolated mass and smoking cone of Vesuvius. This magnificent object, rising detached from the midst of the picture, produces by its very isolation a more striking effect; devoid of harmony with all around, it stands forth like some ever present impending evil, throwing

a tinge of gloom over the brightest features of the scene.

At Palermo we have nothing of this kind. Everywhere around discordant contrasts are brought into harmony with the general character of the landscape. Man and nature meet here, not as antagonists, but simply as rivals: and both everywhere present, have combined to produce a scene which seems to have been planned by some artist of consummate skill. From the deck of our steamer we could trace the bay as it penetrated inland, following a slightly easterly direction, and bounded on either side by verdant banks exposed to the cool north-east breeze, and sheltered from the force of the rough sea winds. At the extremity of this gulf, between the leafy heights of Olivezza and La Flora, rose Palermo with its crowded shipping, and those rounded domes, and slender spires, which give it something of the character of an eastern city.

The sombre masses of green in the more distant parts of the landscape, indicated the site of groves of orange *, lemon, and carob trees which terminate the

* The Orange and the Citron are two different species of the genus *Citrus*, which also include the Lemon (*C. limonum*), the Seville Orange (*C. vulgaris*), &c. These two trees which in the present day are so widely distributed over the southern parts of Europe are natives of Asia, and it may not be unwelcome to our readers if we extract from M. Duchartre a few historical details in reference to their acclimatation.

The Citron-tree (*C. medica*) grows spontaneously in Media, from whence it was no doubt originally introduced into Persia. It is difficult to determine the period of its introduction into Europe. Theophrastus, Virgil, and Pliny mention the tree, and the last of

Conca d'Oro.* Glancing upward along the mountain slopes, which were beginning to exhibit the first appearance of spring vegetation, we descried Morreale †

these informs us that its fruit was brought from Persia to Rome, where it was employed as a medicine, and more especially as an antidote against poison. Attempts seem to have been made at that time, but unsuccessfully, to acclimatize it in Italy, and it was not till two centuries later that it was introduced into Sicily and Naples. In the tenth century it had extended over the whole of Liguria. Towards the twelfth century it reached Menton and Hyères, but it was not until the fifteenth century that the Citron-tree reached the colder countries of Europe. The Orange-tree (*C. aurantium*) did not reach Europe till long after the Citron. It seems to have originated in India beyond the Ganges, and it did not reach Malta till towards the end of the tenth century. During the Crusades in the thirteenth century it was carried into Italy, from which it spread as far as Hyères. Before this time, however, the Arabs had introduced it into Spain. In 1336, the Dauphin Humbert bought at Nice twenty Orange plants, which he carried into Dauphiné. At the beginning of the sixteenth century there was only a single tree of this kind in the north of France. It had been planted at Pampeluna in 1412, and bought by the Constable de Bourbon; it was however confiscated with all other property belonging to the Constable in 1523, and transported to Fontainebleau. This tree which is consequently, now in 1854, 442 years old. may still be seen at the orangery of Versailles, where it is shown to visitors under the name of *François I.*, the *Grand Connétable*, or the *Grand Bourbon.*

* The Carob (*Ceratonia siliqua*) is a fine tree, growing to a medium height. The fruit is a large flattened pod, enclosing a sweet and pleasantly flavoured pulp. In the south of Europe, and more especially in the East, where the Carob grows spontaneously, this pulp is used for preserves, essences, &c., while a species of syrup is extracted from it in Egypt, in which different kinds of fruit are preserved.

† Montréal or Morreale is a town containing about 7000 or 8000 inhabitants, and has been gradually formed around the cathedral. This edifice, which was founded in 1174, by William the Good, is

with its ancient cathedral, founded by the early Norman kings; while high above, in the distant background, rose the magnificent mountain range, which encircles this rich landscape as in a frame, stretching for many miles into the interior of the island. Rising in six distinct slopes, these mountain chains exhibit, at an altitude of more than 4000 feet above the sea, their rugged sides and sharply defined peaks, still covered, when we first saw them, with the winter's snow. Sloping downward in a semicircle, as if to embrace and defend the open valley at their base, these Alpine ranges project on either side, at ten miles' distance from one another, far into the sea, terminating on the left in Cape Zafarano, which protects with its compact masses the palaces of Bagaria, and on the right in the Capo di Gallo, whose bright limestone summit glittered in the light more than 1800 feet above our heads, while adjoining it rises Mount Pellegrino among whose precipices winds the steep road leading to Saint Rosalia's cave.* Sheltered by these colossal

situated upon a projecting spur of the mountain, overlooking a magnificent valley, and is one of the most beautiful and curious architectural monuments of Sicily. Its bronze gates, covered with bas-reliefs, are justly celebrated. The interior is almost entirely lined with mosaics, while the pavement is formed of porphyries, and many-coloured marbles. The church contains several mausoleums, amongst others those of William the Good, and of his father William the Bad, and here also is preserved the heart of St. Louis. The convent of the Benedictines, which is annexed to the church, possesses the best painting by Pietro Novelli, the Raphael of Sicily. It represents St. Benedict, the founder of the Order, distributing bread to his disciples.

* This holy patroness of Sicily, for whom every good Sicilian

bulwarks, the surface of the bay, which was scarcely ruffled, reflected as in a mirror this glorious spectacle,

professes the most profound devotion, lived, according to the legend, in the twelfth century, and died on the 4th of September, 1160. The family traced their origin to Charlemagne, and her father, Sinibald, was lord of Mont Quisquina and Delle Rose. At the age of fifteen, Rosalia escaped from the house of her parents and concealed herself in a dark cavern on Mont Quisquina, where she continued to live for a long time alone and unknown. Urged by unknown motives she abandoned her first retreat, and retired to Mont Pellegrino, taking up her abode in a grotto, where the absence of light and constant humidity maintained a perpetual winter. It was here that she died, and here her bones were found, in 1625, in consequence of information given by the saint herself, who appeared to several persons. These relics are still preserved in the Cathedral of Palermo.

The fête of Saint Rosalia, which is celebrated in the month of September, is kept as a national holiday throughout the entire country. The preparations begin many months in advance, and at Palermo the festival lasts for a whole week, each day having its special ceremonies and diversions. This festival has been too often described to require that I should enter into any details concerning it, but yet I cannot abstain from alluding to the magnificent spectacle presented in the interior of the cathedral during the general illuminations. The entire body of the church, the walls, pillars and vaulted roof are thrown into a perfect blaze of light by thousands of small wax tapers, suspended by threads, which are so fine as to be quite invisible from a short distance. This mode of arranging the lights produces the effect of innumerable stars broadcast over every portion of the edifice. The fireworks, moreover, deserve special notice, for I have never seen any in Paris which could be compared to them. Our rockets may indeed be better directed, and our fireballs may rise higher, but the profusion and the disorder in which the former are employed at Palermo during an illumination produce a most striking effect; in watching them you might almost suppose that you were following the movements of living beings urged by some capricious impulse to meet, chase, and encounter one another in all directions. The fireballs as they burst fall in a gold or silver shower upon the surface of the sea,

displaying before us the image of Palermo *la felice,* which seemed slumbering in a balmy atmosphere amid the gentle murmurs of the waves, as they flowed softly back from its shores.

How painful, when the thoughts are elevated by the contemplation of scenery at once sublime and beautiful, to be abruptly recalled to earth by some importunate and trivial consideration. Almost before our vessel had reached the harbour it was literally stormed by a crowd of seamen closely akin to the native lazzaroni, and in an instant we were plunged into all the miseries of landing, which in our case were of more serious moment than they might have been to travellers in general, as our trunks and boxes were filled with instruments, bottles, and glass vessels of different kinds; no wonder then, that we dreaded the prospect of encountering the delays, risks, and difficulties appertaining to a search by custom-house officers. Fortunately for us our own apprehensions were the only evils we experienced on

where their brightness is gradually extinguished amid the gentle undulations of the waves. Besides these we saw some fireworks which were perfectly unique of their kind. Some of these appeared like large banana trees, blazing from the base to the summit in a rich deep green fire, which is probably produced by means of alcohol and a salt of copper. The crowning piece of this pyrotechnical exhibition was a representation of a castle in a state of siege, which was being bombarded and burnt in the midst of a thunderstorm, and the combined effects of the thunder, fireballs and the conflagration were most admirably given. The castle, moreover, was 200 feet in length, and of a proportional height, while the line of fireworks directed against it measured more than 500 feet in length, and was arranged in several successive rows.

this occasion. The Duke of Serra di Falco *, the director general of this department, having been apprised of our arrival had given orders that we should be exempted from all investigation, and thus, to the great surprise of the sailors who transported our baggage, we were permitted to proceed without any delay to the Hôtel de France.

Without loss of time we set forth to explore the city, for in our uncertainty in reference to our future destination we were unwilling to leave Palermo without having examined the principal objects of interest which it contains. Under the guidance of able ciceroni, whose hospitable zeal was unwearied, we visited those ancient buildings which once were used as mosques, and where verses of the Koran may still be read upon the pillars and walls which have now for so many years past been consecrated to Christian worship. It was with feelings of intense astonishment that we traversed palaces, churches, and cloisters carved and encrusted like buhl cabinets, where the most precious marbles, enamels, malachite, and lapis-lazuli were blended and grouped together in a thousand different devices, rising in one place in columns chiseled by the hands of Greek or Arab workmen, clothing elsewhere the walls and ceiling with the most delicately coloured tracery, or forming deeply fluted masses, which hang suspended like softly tinted drapery fresh from the

* The Duke of Serra di Falco, Corresponding Member of the Institute, is the author of a large work entitled, *Le antichità della Sicilia*, and of several other works treating of the history of his native country.

loom of the skilful weaver, everywhere exhibiting the most fantastic lines and the most brilliant arabesques, the whole combining to produce an effect of inconceivable richness, which certainly in some respects merited the judgment passed upon it by the severe and classic taste of our guides. "C'est le délire de l'art," exclaimed the archæologist Don Antonio Gallo, a sentiment which the Canon Piccolo endorsed by a meaning and contemptuous smile. Perhaps they were right; be that as it may, we protested against the severity of their criticism. After duly appreciating the imposing character which appertains to the nude simplicity of the high and sombre aisles of our northern cathedrals, one may well be permitted to regard with admiration those *chiese*, in which the glorious light of a southern sun heightens the splendour of the profusely magnificent ornaments, and seems to aid the labour of the artist by clothing the exterior of the edifice in inimitable tints of red and golden amber.

Everything around Palermo thoroughly accorded with the character of novelty which had so powerfully impressed us on first examining the exterior of its monuments. In the Conca d'Oro the vegetation, which is entirely southern and almost African in its character, exhibits the most marvellous activity. Rendered fruitful by the heat and by the abundant supply of water, which has been artificially conveyed from inexhaustible sources and distributed through innumerable aqueducts, the land scarcely lies fallow one month in the twelve. Hence those of our northern trees which we saw intermixed among the

date and carob trees of the gardens of Olivezza or La Flora were of gigantic dimensions. On this prolific soil the olive grows to be a high and leafy tree, while the cypress is as tall as our poplars. The public walks are planted with citron and orange trees: these trees too form a forest extending from three to four miles, between Palermo and Morreale, and rising along the first declivities of Mont Cucchio and Mont Griffone, only cease where vegetable mould has almost wholly disappeared, giving place to the cactus and aloe, which in these climates may be said to represent our brushwood and brambles.

One of our first excursions in the environs of the town was to visit the Grotto of San-Ciro, which enjoys a certain amount of reputation in the scientific world, in consequence of having furnished palæontologists with some curious fossil bones. We left Palermo by the Termini Gate, and following a road which ran in the midst of rich gardens we passed the Constable's Bridge, whose foundation is referred to the reign of the sons of Tancred, and soon found ourselves skirting the mountains which constitute the eastern limits of the Conca d'Oro. While we were pausing at the foot of Mont Griffone, Prince Gragnatelli, one of the most distinguished chiefs of the Sicilian opposition, who had served as our guide in this short expedition, drew our attention to a vast and ponderous square building standing in the midst of the plain. The windows were narrow, like mere loopholes, and the doors low and arched, and if it had not been for the thickness of the walls, the building might have been taken for a

large farm-house in ruins. Yet this edifice, which the humblest citizen of our own day would have despised as a country house, was, nevertheless, the favourite sojourn of the Norman kings, who repaired to it to recruit from the fatigues of war. It still bears its original significant name of *Delizie*. A very cursory examination of this building shows that if the rude warriors who inhabited it knew how to secure the aid of the fine arts to do honour to a religion whose indulgence they were often obliged to invoke, they gave themselves very little trouble about decoration when their personal comforts alone were concerned. Facing this ancient palace is a low opening in the side of the mountain, supported by a double arch, which forms the entrance into a grotto enclosing a large basin, from whence there flows a brook of fresh water. This limpid stream, which fertilises all the adjoining district, is named, in accordance with a genuine Sicilian hyperbole, the *Mare dolce*. This grotto was formerly enclosed in the limits of the palace grounds, and no doubt served as a bathing hall for the valiant conquerors of Sicily.

We were obliged to leave our carriage soon after we had passed this fresh-water sea, and to climb the mound of débris which is deposited at the base of Mont Griffone. An enclosed path led us between fields of cactus to the entrance of the grotto of San-Ciro, an irregular excavation, forty or fifty feet in depth, and from twenty to thirty feet in height, whose naked walls still show traces of the tools employed by the workmen who first excavated it.

There is nothing in this cavern meriting the attention of the ordinary tourist, but it possessed a decided interest in our eyes, since it presented a fine example of an *osseous cavern* or rather *breccia*, showing us at a glance how some of those osseous deposits have been formed in which modern science has succeeded in reading the history of a world unseen by human eye.

It is well known what importance has been assigned to fossil remains since Cuvier first opened to geologists a new path of inquiry, and established the science of palæontology. These remains of an extinct fauna are generally distributed through the interior of different strata; but in some localities we find them collected in masses. It had already long been known that the caverns of the Hartz mountains and of Franconia contained masses of fossil bones; but it was shown by Dr. Buckland, one of the most celebrated geologists of England, that these countries were by no means peculiar in this respect. By breaking up the calcareous crust, which forms the lower surface of many of the caverns, and removing the pebbles and sand, which were concealed below the stalagmites*, he laid bare palæontological treasures

* The name of *Stalactites* has been given to those calcareous deposits shaped like elongated cones, which are often attached to the roofs of caverns, whilst the deposits of the same nature which cover the soil are known by the name of *stalagmites*. Both these deposits are formed by the water which filters from the rock, and which dissolves a certain quantity of calcareous salts, which it leaves as it flows off drop by drop, and evaporates on coming in contact with the air. Every *stalactite* must therefore have its corresponding *stalagmite*, but while the former increases incessantly from above downwards, the latter increases from below upwards,

whose existence had never before been suspected. He found that the mud, forming the lowest stratum, and which is almost always black and fetid, was often interspersed with numerous skeletons of bears, hyenas, and sometimes even of dogs, wolves, and jaguars, belonging to species of much larger size than their existing congeners. The bones of Ruminants and Rodents, and often too, those of Birds and large Pachyderms were blended with the bones of these carnivorous forms, and we can still trace the marks on their surfaces of the terrible teeth by which they were broken. These circumstances led Dr. Buckland to the conclusion that caverns of this kind had probably been used as places of resort both by the carnivorous animals, whose remains have been preserved in them, and by the victims which once served to appease their hunger. This very plausible explanation was generally received, and did not for a long time meet with any decided contradiction.

Science, however, speedily recorded other facts, which could not be made to harmonise with the theory of the English geologist. It was discovered that rocks of compact limestone, whose mass presented no trace of fossils, were yet traversed by veins which were entirely filled with bones, impacted in a matrix differing entirely from the rock itself. These veins very frequently presented no appearance of any lateral aperture, while the débris contained within them in some instances completely filled

and on meeting they become joined together. It is this mode of deposition which gives rise to those beautiful colonnades which are found in certain grottoes.

them up. They could not, therefore, possibly have served as a retreat for the animals whose remains they contained. The bones, moreover, which were found under these conditions, exhibited, almost always, traces of having been fractured, while they frequently also were polished as if by continued friction. In order to explain these different circumstances, it was conjectured that such veins were ancient fissures which had become filled up with skeletons, which were washed into them from the surrounding soil by currents of water.

This theory, which was specially maintained by several French geologists, received a most striking confirmation in the year 1842. MM. Constant Prévost* and Desnoyers discovered in the environs of Paris, but more especially at Montmorency and Fontainebleau, a large number of ancient fissures, similar to those which are of such frequent occurrence on the shores of the Mediterranean, where some of them are still in the act of formation. In the former they met with the characteristic remains of palæontological faunas, while in the latter they found only the remains of existing animals, and they were able to

* M. Constant Prévost, who is a Member of the Institute, and Professor of the Faculty of Sciences at Paris, is more especially known for the extreme perseverance with which he has always opposed the ideas that have been admitted by most modern geologists regarding the cataclysms to which our globe owes its present configuration. In the opinion of M. Constant Prévost the phenomena which are daily being enacted before our eyes, and the forces which we see in action, suffice to explain all the facts of geology, and to account for all the modifications which have been experienced by the crust of our planet.

convince thmselves that the latter are daily being augmented in proportion as new deposits are accumulated by the action of currents of water. These observations which complete, without controverting, the researches of Dr. Buckland, have led to the distinction which is now made between *osseous caverns* and *osseous breccias*, of which we have just spoken.

We must class amongst the latter the grotto of San-Ciro. Before it was dismantled it presented the appearance of a slope of about twenty feet in height, abutting against the side of the mountain, and composed almost entirely of bones agglutinated by calcareous infiltrations or cemented by a small quantity of quartzose sand and indurated clay. It seemed as if the entrance of the cavern had been closed in and the interior almost entirely filled up by a rock of a particular composition. There were the remains of elephants, hippopotami, deer, stags, and several kinds of dogs intermingled with sea shells. This latter circumstance, added to the traces of perforations in the walls of the cavern, which may be attributed to certain marine molluscs, led Dr. Christie to conjecture that this fissure must have been formed below the waters of the ocean, and that it must have been subsequently upheaved by some of those convulsions of nature of which Sicily everywhere affords undoubted evidence.

Whatever the true explanation of its occurrence may be, the mass of organic remains accumulated in this spot was at all events so considerable that it awakened the speculative genius of certain English travellers. The cavern of San-Ciro was converted into

a regular source of export, and the fossils were shipped to London where they were converted into *animal black!* At the time of our visit the devastation was complete, and we had some difficulty in detaching from the vaulted roof a few broken fragments which appeared to us to have belonged to an elephant.

In the mean time we did not lose sight of the principal object of our mission. M. Blanchard, whose duty it was to collect Insects to complete the collections of the Museum, had already explored the environs of Palermo and the Conca d'Oro. M. Milne Edwards and myself had, in the meanwhile, been equally busy in examining the neighbouring sea shore, breaking up the rocks by the water's edge, and turning over the stones on our path. All that we had hitherto seen of the marine tribes of animals redoubled our anxiety to begin our work in earnest. We tried as far as lay in our power to hasten the preparations for our departure, but it was no trifling business to complete our equipment. We desired to explore the coast line of Sicily step by step, as it were, with entire liberty to arrange and alter our plans as we might deem desirable; we wished to be able to pass rapidly along any sandy shore which we knew would present nothing of interest, and again to stop wherever weed-covered rocks announced that our researches would probably be attended with success. To do this, it was indispensable that we should be so amply supplied with the necessaries of life that we need not diverge from our course in search of provisions. It would have been impossible to effect a journey by land with an independence of

this kind; it was only by sea that we could fully carry out our plans, and we resolved to circumnavigate the island in a boat of our own.

There were, however, many difficulties in the way. We carried with us, amongst other apparatus, a double forcing-pump, intended to aid in the submarine explorations which M. Milne Edwards purposed conducting. This pump could not be properly worked without being securely fixed with sufficient space around it to move a balance beam resembling those used in fire engines. The common fishing boats of the country were too small and fragile for this purpose, while a *speronare* was, on the other hand, too large to suit our views, as it would have been unable to enter shallow bays, or to follow all the irregularities of the rocky coasts; and, lastly, it was indispensably necessary that we should procure the services of sailors who could speak Italian, for the Sicilian idiom, which is an incoherent mixture of all the various tongues spoken by the numerous powers who have in turn ruled Sicily, was wholly unintelligible to us.

After many fruitless visits to the harbour, we at length discovered the kind of boat we wanted. It was thirty feet long and six feet across, and carried fore and aft a sort of false deck about a yard square. Along either side there ran a board about a foot across, to which the seats of the rowers were secured. This boat had made several trials of her speed and strength in the passage from Naples to Palermo. Finally, her name possessed a certain local charm, which was quite irresistible, for she bore the graceful

appellation of *La Santa Rosalia.* Being intended for fishing operations on a large scale, she had a crew of seven men, five of whom certainly seemed active and strong fellows, and of these, two spoke Italian after a certain fashion of their own. M. Milne Edwards, who was the natural leader of our expedition, lost no time in entering into treaty with the master; and, by the useful intervention of our friend M. Pierrugues, whose obliging and active zeal in our service was indefatigable, a bargain was soon struck. For the sum of thirty-six tari or sixteen francs a day, the *Santa Rosalia* and her crew were placed at our entire disposal.

Without further delay we began the stowage of our vessel. Our packing cases, which were installed under the hindmost oarsman's seat, established a separation, rather moral than real, between the portion of the boat which was set apart for the men and our special quarters in the stern. We were enabled, by means of moveable stancheons, to spread an awning across our domain by way of shelter against the sun or rain. A few shelves, nailed against the sides and protected by the upper boarding, served as the depository of our boxes, glass bottles, tubes, and instruments. The bunker below the helmsman's bench was made to contain the three cushions, which we dignified with the name of mattresses, together with the large sailors' capes which were intended to take the place of sheets and blankets. Our pump, which was securely fixed in the bows, contributed not a little towards the peculiar aspect presented by our vessel, which excited the

strangest commentaries among the numerous groups of lazzaroni, which were watching these incomprehensible preparations. As soon as our arrangements were completed, we said a last farewell to the newly found friends, who by their kind attentions had made our stay at Palermo appear so short, and hastened to take our places in the boat which, at the captain's command of *Voga!* glided rapidly through the water that broke into foam beneath the strokes of our six oarsmen. The captain, who sat crouched upon our miniature quarter-deck, which was exclusively devoted to him, guided the helm and directed our course. We soon passed the entrance of the harbour, which is protected by the Castello di Molo, and, turning the boat's head to the left, we advanced towards the west.

Our voyage commenced under favourable auspices. The sky was clear, the sea calm, and our boat coasted along one of the most enchantingly picturesque parts of these lovely shores. Above us, conspicuous in its wild grandeur, rose Mont Pellegrino, whose perpendicular sides descend abruptly to the very water's edge. Half way up its inclined slope, the Villa Belmonte proudly displays the somewhat fantastic graces of its castellated gateways, its pavilions, and its kiosques, loaded with ornaments in the Sicilian style of architecture, and surrounded by plantations of elegant shrubs, which overhang the sea-washed rocks. Below, as if to contrast with the works of art on the heights above, nature had produced one of those beautiful effects which would be a study to the painter. The porosity and unequal

density of the calcareous stone of which the beach is formed, have made it yield in every direction to the force of the waves, which have entered every crevice and washed over every point, until the entire mass has been undermined and broken up on all sides. These semi-arches, which are crowned and garlanded by the cactus and other shrubs, give rise to a perfect labyrinth of grottoes, which defies all description. It would require the skill of the most accomplished artist to give an idea of the marvellous admixture of forms, colours, and effects produced by the vast halls, in which a far larger pinnace than ours might have found shelter; where irregular porticoes, with strangely contorted pillars, seemed cut out of colossal agates; and where all the most widely differing colours, from milky white to blood red or raven black, were blended together, varied and contrasted in the most striking manner. But no artist's touch could convey an idea of those submarine grottoes, those narrow and deep fissures in which the waves which had only just rippled over the arches at the water's edge, were engulfed and swallowed up amid the strangest and wildest sounds. The slight ripple raised by our small bark sufficed to awaken these singular voices of the shore, which fell upon the ear like the prolonged cry of some colossal monster whose rest had been abruptly disturbed. What then must be the awful rush of sounds given forth from these thousand mouthed openings when they meet the shock of the high waves as they are driven onwards by the blast of the tempest!

However, we had already doubled the Capo di

Gallo, and were running against a stiff breeze, when the increased motion which had been imparted to our boat by the change in our course, warned MM. Edwards and myself that we had still something to learn in our sea apprenticeship. We at once fell victims to all the horrors of sea-sickness. Yielding to our misery, we threw ourselves upon our mattresses, and were content to cast a glance from time to time at the shore which flitted past as we lay stretched full length at the bottom of the boat. M. Blanchard had long since passed through the ordeal, and it cost us many a sigh of envy to find that the most violent rolling and pitching produced no other effect upon him than to increase his appetite. It was, however, very fortunate for the whole party that our companion did not share our weakness, for M. Edwards and myself, although lying close together, completely occupied the space allotted for our reserved quarters. Our shoulders pressed against the sides of the boat, while our feet rested below the first bench, against which two of the men had braced their legs and bare feet. If, therefore, M. Blanchard had also been compelled to betake himself to the bottom of the boat, he would have been reduced to the extremity of stretching himself under these living arches of the rowers' legs and arms, in an atmosphere which was the very reverse of agreeable.

We had left Palermo somewhat late in the day, and night surprised us when we were opposite to a little sandy bay, commanded by the dismantled tower of Sferacavallo. We were obliged to inaugurate our expedition by passing our first night on

board. The men ran the boat close into land, and made her fast by a grappling iron. Having arranged two oars crossways at each extremity of the bark, they rested the mast of our latteen sail upon this rude framework and covered the whole with tarpaulin. We opened our box of provisions by the light of a smoky lamp, and made our first bivouacing meal on rancid sausage and the *cacio cavallo* of the district, the taste of which bears some resemblance to old Gruyère cheese. Having re-arranged our mattresses and put on our weather-proof capes, M. Edwards and myself stretched ourselves at full length, while M. Blanchard took up his quarters for the night at our feet; our men, in the meanwhile, had stowed themselves away as best they could, some between the benches, others on the sails and ropes, and soon the gentle rocking of the boat, as it was moved by the feeble oscillations of the waves, had buried alike naturalists and seamen in profound sleep.

There was an unforeseen circumstance, however, which unfortunately soon came to destroy any romantic sentiments that the strange nature of our position might otherwise have tended to encourage. Seven Sicilian sailors, whose ordinary fare is garlic and onions, sleeping in clothes which have probably served them well for many long years, did not conduce to the purity of the atmosphere of a narrow and low tent, which the keenness of the night air had compelled us to keep perfectly closed. These exhalations were, moreover, blended with a far worse odour, some whiffs of which had already several times

in the day affected us most disagreeably. We were not long in discovering the cause. While we were at supper, we had noticed in the half light around us, several insects, somewhat like bugs, of an inch in length, which we knew to be the cockroach (Blatta orientalis). These insects, which were formerly unknown in Europe, have been carried by commerce to all our larger towns, and are well known to the bakers of Paris under the name of *Noirot* or *Canquerlin.** Their long oval body, which is brown above and yellowish-brown below, is as flat as that of a bug; but the odour which they exhale is far stronger and more nauseating than that given off by the

* The genus *Blatta*, belonging to the order of the Orthoptera, comprises a large number of species, several of which are found in France, without on that account being indigenous in the country. One of our indigenous species was known to the ancients, who called it *lucifuga*, in consequence of its aversion to light. All these insects appear, however, to be similar in this respect.

Among all the *Blattæ* which have been imported, and which are unfortunately too well acclimatised amongst us, I will instance our common kitchen Cockroach, *Blatta orientalis*, which is the one referred to in the text, and the American Cockroach, *Blatta americana*. The former of these appears to have been brought to Europe in trading vessels from the Levant. This species is partial to heat, and generally takes up its abode near bakers' ovens or furnaces. It is said that the Cricket pursues and destroys it. The American Cockroach was not introduced into Paris until the beginning of the present century, when, as we learn from M. Duméril, it was imported in 1802 into the hothouses at the Museum, from packing cases which had been used in the transport of plants. This species is much larger than the preceding one, measuring three inches in length, inclusive of the antennæ. It is said to do much damage in the sugar plantations in America, but we do not think that it has been found very destructive in the Jardin des Plantes.

smaller vermin. Like the latter, however, they are nocturnal in their habits. Concealed all day in some dark retreat, they emerge at night from their hiding places, and wander forth in search of food. Sugar, broken pieces of bread or meat, all seem alike acceptable to them, and even if nothing better is to be had, they will attack old leather. Their fecundity fully equals their voracity, and they occasionally swarm in such myriads on board trading vessels, that they will sometimes destroy the entire cargo and render the vessel unfit for further service. Such were the tenants which the *Santa Rosalia* harboured in every crevice of her timbers, and which as soon as night approached, came forth by thousands, diffusing around and over us a pestiferous stench. The most energetic means that we could devise, proved inadequate for their destruction. During the course of our voyage we frequently caused the men to haul the boat ashore, and wash it thoroughly with sea-water, while we even attempted to plug up every hole and crevice in her sides; but it was all labour lost, for the cockroaches speedily re-appeared as numerous and as pestiferous as ever. We were compelled to resign ourselves to the evil, in the hope that habit might diminish the disgust which these unbidden guests occasioned us.

Yet, notwithstanding the disagreeable discovery which it brought us, our first night's bivouac passed off most admirably. At break of day the next morning, we awoke our crew, and got speedily under weigh, being extremely impatient to reach some station which might prove more favourable for our

researches. Fortune befriended us; for in doubling a small promontory we perceived an islet whose contour was broken in all directions by the projection of sharp rocks along the water's edge, which, no doubt, afforded numerous and snug retreats for those Molluscs, Annelids, and other marine populations, which we were desirous of studying. On consulting our map, we found that this was the Isola delle Femine, situated opposite to the tongue of land and rocky ledge, on which stands the village of Torre dell' Isola di Terra, inhabited by a population of fishermen. We at once landed, and while one of the sailors was boiling some eggs for our breakfast, by aid of a fire of sticks, we examined the beach, and soon saw enough to convince ourselves that we could not select a more promising spot for our first halting place.

Elated at the discovery we had made, we proceeded with much satisfaction to despatch our breakfast of hard boiled eggs, deliberating the while upon the chances of meeting with anything like available accommodation among the fishing population of the place. While we were thus engaged, a superannuated custom-house officer approached, and with great demonstrations of respect, implored *our Excellencies* to proceed to the village, where we would, he assured us, find no difficulty in meeting with suitable accommodation. This mark of attention surprised us not a little; but we soon discovered the source to which we owed it. It appeared that, independently of the letters with which we had been furnished, and which were all potent against the supervisions and exactions

of the customs and the quarantine, the Duke of Serra di Falco and the Duke of Cacamo, Director General of the Sanitary Commission, had also sent a circular to all their subordinates, informing them of our arrival, and instructing them to afford us all the assistance in their power. We were expected at all the stations along the coast, and from the very outset we experienced the favourable effects of these powerful recommendations. Following our aged guide, we therefore at once proceeded towards the village, where we were met by the curé of this little congregation, who eagerly pressed us to take up our abode in his house, an offer which we gratefully accepted.

The village of Torre dell' Isola is a sort of fief appertaining to the Count of Capaci. The houses, of which there are about a hundred, are low and small, but outwardly clean. They have almost all been built at the expense of the proprietor, who lets them to his tenantry for a trifling rent. The village numbers about 1200 inhabitants. Living upon a tongue of land, covered with sand and rocks, among which nothing but the wild cactus can take root and thrive, the population is of necessity entirely devoted to fishing. At the time of our arrival, almost all the men were absent, and were not expected to return until after the season of the Sardine fishery, for the sea like the land, has its harvest seasons, which come almost on a fixed day, with this advantage, however, which is entirely in the favour of the maritime harvests, that they require no preliminary expenditure of labour in sowing or planting.

The manor house overlooks the little harbour of this maritime community. It had been originally constructed to serve the double purpose of affording accommodation to the lord of the manor and to prepare the tunnies which were taken in the neighbourhood of the island; but for many years past the fish have forsaken their old haunts, and the proprietors have become absentees. The building is therefore now appropriated to the curé of the village, who, at the time of our visit, was a poor Dominican, who, for forty-one tari, or less than twenty francs a month, celebrated mass every Sunday, confessed the dying, performed the service of marriage, and baptized the newly born. Notwithstanding his poverty, this good pastor, who loved animals of every kind, managed to keep five or six cage birds, a few chickens, three cats, and two dogs. I asked myself whether it were possible that he could feed the poor creatures; their starved appearance certainly warranted a doubt on the subject. The dogs, especially, were in an inconceivably meagre condition, and looked like animal machines reduced to their simplest forms. It seemed as if the poor wretches had grown up in a state of continual starvation.

The Padre Antonino, who, with the exception of his pets, was the sole occupant of the ancient residence of the counts of Capaci, was able, without ncommoding himself, to give up to our use three large apartments, in which every thing betokened the most complete neglect. It was only with extreme difficulty that one could still trace the outlines of ancient frescoes which had once covered the naked

walls and adorned the cracked ceilings, but which had long since crumbled into dust from the corrosive action of the damp sea air. The lofty windows, with their rotten frames, seemed as if they would break into fragments in our hands when we tried to open them. Time had coated the few panes which still remained with so thick a layer of dust, that they had lost all transparency and seemed to be converted into plates of ground glass. It need scarcely be observed that there was nowhere a vestige of furniture, but yet we were only too happy to meet with a lodging of this kind, which afforded us shelter and ample space for our investigations, within a few paces of the sea. We lost no time in taking possession of our new quarters. The panes of glass were washed, and where they had been broken in the lower frames their place was supplied by sheets of paper, to protect our working tables from the draughts which might otherwise have interfered with our observations. Long planks, ranged side by side, and supported by firm wooden props, afforded admirable standing room for the basins of sea-water destined to receive our various animal treasures. The bedsteads, on which we placed our mattresses, were constructed on similar principles, and our microscopes were carefully placed in front of the windows. Before the close of the day everything was ready, and after partaking of a meal very similar to our last night's supper, we tried to get rest and sleep upon our planks, which were only softened by the addition of the inch and a half of wool and cotton which constituted our entire bedding.

One feels a very slight degree of reluctance to leave a bed of this kind, and we consequently found no difficulty in beginning our labours by break of day. M. Blanchard betook himself, well provided with nets and other apparatus for hunting insects, to the landward side of the peninsula; while M. Edwards, embarking on board the Santa Rosalia, proceeded in search of marine animals; and I undertook to explore the beach of the peninsula. My task was not an easy one, for the village was entirely surrounded by a broad margin of strangely dislocated calcareous rock. At some points the stone resembled an enormous sponge, torn and cracked into fissures and irregular cavities, and studded with bristling points. At other parts of the beach, the rock seemed to be split into thin laminæ, regularly separated by long and deep fissures. There was no alternative but to move incessantly up and down, like a man alternately ascending and descending a height of two or three feet, or to stride over chasms while you maintained your equilibrium upon some needle-like projection, or upon a rocky ledge as sharp as the blade of a knife. Although accustomed from childhood to climb rocks, I was not prepared for such unusual difficulties, and I found that it required the utmost care to avoid meeting with some dangerous accident.

Yet this peculiarity in the character of the rock was in itself a guarantee of its riches. In proportion as these fissures penetrated further into the sea they became converted into so many small basins, while the sharp edged rocks which rose around them served

as sheltering walls, within which the Molluscs, Annelids, and Crustaceans, whose habits lead them to resort to the sea-washed beach, find commodious retreats, that are impenetrable to all enemies save naturalists. Indeed, I soon found reason to rejoice at those inequalities of the ground which a few moments before I had so heartily denounced. My tin boxes, tubes, and bottles, were soon filled to overflowing, and I hurried back to our common quarters, where I was speedily joined by M. Edwards, who had also returned laden with treasures. Poor M. Blanchard alone came back empty-handed and in no very good humour. Trusting to his geographical charts and to the statements of travellers, he had believed that there exists no real winter in these favoured climes; but in Sicily, as in France, nature has her times of rest, and the insects which were destined in a few weeks to fill the air with their swarming myriads, were still slumbering within their subterranean galleries, or in their silky wrappers, in the larval and chrysalis state.

Our companion was, however, soon consoled for his own disappointment when he saw our well filled bottles and basins. What mattered it, that one of the three was unsuccessful, when the other two were laden with booty? Although we had come to Sicily with very distinct plans of work, each one had it in his power to double his time and his resources by availing himself of the labours of his companions. On our table lay side by side large specimens of the Buccinum, which were peculiarly well adapted to furnish materials for the researches which M. Blan-

chard intended making in reference to the nervous system of the Mollusca; Beroïdæ, radiate gelatinous animals belonging to the Acalephæ, creatures as transparent as glass, and which had already formed the subject of several important works by M. Edwards, but whose singular organisation still presents innumerable problems for future solution; and Annelids, together with phlebenterous Gasteropods*, the study of which had been the special object of my voyage. We had, therefore, each a rich and noble field of inquiry opened to us, and, like industrious workmen, we lost no time in bringing forth the tools which were to aid us in our scientific labours; thus, in a few moments, our forceps, scalpels, compressors, and microscopes were in full operation.

I must not forget to mention that we were careful before we set to work in good earnest, to partition to each of the crew his special duties, and to arrange our household in a systematic manner. The master, Perone, who, as Captain, was necessarily associated with his boat, became the leader of our fishing excursions; and his dexterity, keen sight, and athletic strength, fully justified the confidence we had placed in him in this capacity. The two sailors who spoke Italian were appointed to perform any special personal services that we might require. Carmel was a fine fellow, about five and twenty years old, whose quickness, intelligence, and willingness to oblige, seemed to adapt him most thoroughly to be our valet de chambre; his comrade, Juseppe

* I shall explain the meaning of the word *Phlebenterata* and *Phlebenterism* in Chapter V., on Trapani.

Artese, combined the double functions of steward and cook. It must be confessed, however, that few persons had less claim to be regarded as a cook than this unfortunate individual, who never could be taught how to salt a dish of macaroni, or how to stew a fowl in rice, without converting the materials into a dish of hot water and sodden meat. He scarcely had managed to learn how to boil our eggs at the end of the season. Still, poor as his culinary talents most undoubtedly were, we were obliged to content ourselves with them. For the rest, he was honest enough in his way, for, as far as we could discover, he contented himself with a profit of cent. per cent. upon all the purchases which he made on our account.

The duties confided to Carmel and Artese, gave them a wonderful degree of importance in their own eyes, and this superiority was admitted without much hesitation by their comrades. There was even a certain distinction established between the two, and we were amused at the manifestations of the different grades which existed among the members of this hierarchy. Thus, for instance, if we asked Carmel to bring us some sea-water, he would, without vouchsafing a word, take the bucket, and in a minute or two we would hear him call to his companion, "O Pepe! Il Signor Grande," a title by which the men designated M. Edwards, "il Signor Grande, bol' agua di mar!" "Bene," was the reply of Artese, who, taking the bucket, went downstairs as far as the outer door, from whence he hailed the captain, giving his orders in the same

form in which he had received them. Perone repeated them to his men, who, carrying out the same principle, passed the orders on, until it almost invariably happened that the bucket was brought back to us by Raphaële, the slave and drudge of the crew. This fellow, although strong and robust, was lazy to excess, and always tried to do as little as possible of any labour that had to be done; but then he was a Neapolitan, and on account of this alone, he had to endure ridicule of every kind, and was constantly exposed to the jibes of the other sailors, who were proud of being Sicilians and natives of Palermo, and hence, whenever there was any extra job to be done, it was invariably thrown upon this poor wretch, notwithstanding the innumerable artifices to which he had recourse to avoid the threatened imposition.

When these arrangements were completed, no further delay interfered with the prosecution of our studies. Every morning when the weather was good, one of us went out in the boat with Perone—an opportunity which was not neglected for laying in a supply of fish for the day's consumption. The boat was generally brought close to the Isola delle Femine, on account of the excellent fishing ground in the vicinity. I saw the sea here under an aspect entirely new to me. The ocean does not exhibit those absolute and profound calms which are observed in inland seas where the surface of the water is often as smooth as a mirror, permitting the eye to distinguish the minutest details at an incredible depth. I was at first often deceived by this

marvellous transparency into the belief that I could grasp some Annelid or Medusa, which seemed to be swimming at only a few inches distance from me. Our patrone watched the proceeding with a sarcastic smile, and taking a long pole with a small net attached to one of its extremities, he, to my intense astonishment, plunged it many feet below the surface before it came in contact with the objects which I had imagined I could grasp in my hand.

This marvellously limpid condition of the water produced another charming illusion. Leaning over the side of the boat, we could see flitting beneath our eyes a vision of plains, valleys, and hills, in one place with bare and rugged sides, in another, clothed with verdant herbage, or dotted over with tufts of brownish shrubs, and in all respects calling to mind the distant view of a passing landscape. But it was not the varied outlines of a terrestrial scene on which our eyes were riveted, for we were scanning the rugged contour of rocks, more than a hundred feet below us, amid submarine precipices, along which the undulating sands, the sharply cut angles of the stone, and the rich tufts of brightly coloured red weeds and glossy fucus fronds, lay revealed to sight with such incredible preciseness and clearness, as completely to deprive us of the power of separating the real from the ideal. After gazing intently for a while at the picturesque scene beneath our eyes, we scarcely perceived the intervening liquid element which served for its atmosphere and bore us on its clear surface. We seemed to be suspended in empty space, or, rather, realising one

of those dreams in which the imagination often indulges, we appeared to be soaring like a bird, and to contemplate from some aërial height the thousand varied features of hill and dale.

Strangely formed beings were harbouring within these submarine retreats, and imparted to them a most characteristic physiognomy. Here and there a solitary fish darted forth like a lonely sparrow issuing from its covert: next, a crowded shoal came forth like a flock of pigeons or swallows, and winding their way along the large stones, would search the tufts of waving Algæ, until the sight of our boat passing above their heads would put the entire band to flight with every demonstration of fear. The Gorgonidæ*, Caryophyllidæ†, and a hundred different kinds of Polyzoaries

* The *Gorgonia* is a genus of polypes, belonging to the order of the Alcyonidæ. Their polyparies, which are horny, widely ramified, and often expanded like a broad fan, are very common in Natural History museums.

† The *Caryophyllia* belongs to the order of the *Z*oanthoïd Polypes, so called from their resemblance to certain flowers. We may consider, as the type of this order, the common Actinias, which are very abundant on every sea-shore, but here the individuals are isolated. In a large number of the Zoanthoïd Polypes, however, and more especially in the Caryophyllia, the individuals are aggregated, and in general their integuments and the reflected folds of the membrane lining the visceral cavity, are incrusted with calcareous salts, so as to form solid polyparies. (On the Polypes, we may refer to the different works of Milne Edwards, and especially to that which he is now publishing in conjunction with M. Haime.)

These Zoanthoïd Polypes are the principal agents in the formation of those Coral islands and Madrepore reefs, which render the navigation of the Indian Seas so dangerous. In these latitudes every isolated rock, if it be only covered with from thirty to forty feet of water, becomes the seat of a colony of these Polypes, which multiply with

were blooming in tufts of living flowers, or ramified into little shrubs, every spur and bud of which was

a most incredible rapidity. One generation builds its superstructure on the stony beds formed by preceding polypes, until the entire mass, increasing both in extent and thickness, finally reaches the surface of the ocean. In the tropics most of these islands are surrounded by a sort of rampart or breakwater, whose external walls, which are almost always perpendicular, inevitably break in pieces every vessel that strikes upon them. It is by a similar process that the different seas of these regions are studded with rocks nearly reaching to the surface of the water, and which are the more dangerous to the navigator, in consequence of their escaping his observation, while the depth of the sea surrounding them lulls him into a state of deceptive security even in cases where constant soundings are made.

Coral islands consist of a narrow margin of slightly elevated land, which in some cases circumscribes a very extended space. This ring is either entirely formed by the coral structure, or by the association of it with other rocks. The lake or lagoon which is enclosed by this ring is sometimes very deep in all parts, at other times it declines into a funnel-like excavation, while in some cases it is interspersed with submerged rocks. There are, in general, several narrow passages which communicate between the ocean and the lagoon. In some cases, however, the ring is incomplete, and is only represented by a large number of individual segments, while, on the other hand, it is not unfrequently complete in every part, forming a garland of verdure round a calm and motionless lake, whilst the sea beyond breaks with violence against its coral walls. The greater portion of these strange formations is necessarily composed of the inner lake; thus, for instance, the island of Taritari presents a surface of 110 square miles, of which only four belong to the land, the remaining 106 being composed of the lagoon.

Several theories have been advanced to explain the formation of coral islands, and one of the most generally received opinions consists in admitting the existence of numerous submarine craters, the margins of which are at a depth suitable to the life and labours of the polypes; whilst the centre of the crater, and the sides of the mountain from which it originates, have been suddenly engulfed in

an animal, and which, by their interlacing stems, their variegated branches and budding shoots, can scarcely be distinguished from true vegetables. Enormous dark brown Holothurias were creeping over the sand or climbing slowly up the rocks, waving their crown of tentacles, while beside them lay Star-fishes of bright pomegranate hues, motionless with their radiating arms extended around them. Molluscs, resembling in form a snail or a slug, although different in size and colour, were dragging themselves slowly onwards like their terrestrial brethren; while crabs, having the form of enormous spiders, were striding over them in their rapid and sideway course, pausing only from time to time to seize them with their formidable pincers. Other crustaceans, allied to our shrimps and lobsters, sported among the tufted algæ,

the sea, and thus become uninhabitable to these minute beings. It will readily be understood that in such a case, the mass of the polyparies, on reaching the level of the waves, will, in fact, exhibit a band of reefs surrounding a free space. The débris accumulated on these ridges forms a stratum of mould on their surface, which is soon covered with the rich vegetation of the tropics that grows up from the seeds which the sea or the winds have scattered over this recent soil.

Mr. Dana, who is one of the most eminent among the American naturalists, has recently offered an explanation of these formations, which at once accounts for the facts, while it explains several objections that present themselves to the preceding theory. This naturalist is of opinion that islands which have been slowly engulfed in the sea, actually existed formerly at the same spots where we now find coral islands. The present ring would, therefore, in this case, mark the limits of the ancient shore. On this hypothesis we can conceive the formation of lagoons thirty miles in diameter, although such a diameter would be remarkable in the case of a crater. (See the works of [Darwin and] Dana on *Coral Reefs and Islands.*)

coming forth only for a moment into the pure light of the sky, and then, at the least indication of danger, bounding with a vigorous stroke of their tail back to the shelter of their sombre retreats. Amongst these animals, whose forms were more or less familiar to us, were other species, belonging to types which rarely or never reach our northern latitudes. There was the Comatula*, a near ally of the Asteridæ, and which, to a certain extent, represents in existing creation the Crinoidæ, which, although nearly extinct in our own day, are very common in a fossil state.† There were strings of crystal-clear Salpæ, paradoxical molluscs, which are alternately oviparous and viviparous, and whose successive generations are alternately

* The *Comatula* is an Echinoderm, whose arms, instead of being simple like those of the Ophiura, or ramified like those of the Euryale, are furnished with a double series of pinnæ, which give them the appearance of the leafy stems of certain plants. The organisation of the Comatulas has been studied by several naturalists, and amongst others by M. Dujardin.

† The Crinoids, Stone Lilies, or Encrinites (*Encrinus*), form a remarkable group among the *Echinoderms*. Their body resembles in many respects that of the Comatula, but instead of being free like the latter, the Encrinites are affixed to the extremity of a long peduncle, which is itself composed of solid pieces, which are articulated, or, more correctly speaking, superposed upon one another and connected by soft parts. These small discs often exhibit the form of a star, composed of five regularly arranged points. The Encrinites constitute one of our commonest forms of fossils, and it was long supposed that the type had entirely disappeared from our existing Fauna, but in the last century the Academician Guettard discovered in the collection of M. Boisjourdain, a specimen of a living Encrinite which he described, and which is now in the Museum. Living Encrinites are, however, of very rare occurrence near our shores, although they are said to be very common in the seas washing the coast of Florida and the island of Barbadoes.

isolated and joined together in floating colonies.* Here, too, we beheld enormous swarms of those large spherical Beroës†, whose singular organisation has been made known by M. Edwards, countless Medusæ‡,

* These strange facts in reference to the reproduction of the Salpæ were discovered by Chamisso, the witty author of Peter Schlemil. He was the first who discovered that these Molluscs live alternately isolated and in chains, and that these two modes of existence recur in regular succession, and moreover, that the aggregated individuals are always oviparous, whilst the isolated individuals are always viviparous. These facts, which were published in 1819, were for a long time discredited; but phenomena of a similar nature which had not been previously observed have been discovered in other groups of animals, and the researches of Krohn have thoroughly demonstrated the accuracy of Chamisso's observations. This subject is further noticed in Chapter IV., on the Gulf of Castellamare. Krohn's memoir may be referred to in the *Annales des Sciences Naturelles.*

† The family of the Beroïdæ belongs to the class of the Acalephæ. (See the researches of M. Edwards in the *Annales des Sciences Naturelles.*)

‡ The Medusæ constitute another family in the class of the Acalephæ. This group has been made the subject of a great number of speculations, and has led to numerous researches which have thrown much light on several very important questions. Reaumur, trusting too much to first impressions, considered that the greater number of the Medusæ were simple masses of living jelly. M. Duméril, a member of the Institute, and the early friend of Cuvier, injected the cavity of these animals with milk, when he saw the fluid diffuse itself into a multitude of canals, which were all arranged with the greatest regularity. This fact we believe first revealed the existence of a true organisation in these singular animals. Long after the observations of M. Duméril, Ehrenberg published a memoir on the Aurelia (*Medusa Aurita*), in which he showed that this species possesses a remarkably complicated organisation. The researches of Will, Agassiz, Huxley, and others, although differing in reference to some points from the results which had been obtained by the learned Berlin observer, have fully

whose extraordinary metamorphoses have already modified in so many respects the views which were formerly entertained in reference to the propagation of animal species, the Firolæ*, and the Diphyes †,

confirmed the general conclusions to be deduced from his work, viz. that these pretended masses of living jelly are by no means homogeneous, as some naturalists still suppose, and that the transparency of their tissues was the only reason which could have led observers into this error. The reproduction of the Medusæ which has been studied in more recent times by MM. Sars, Siebold, Van Beneden, Dujardin, &c., exhibits the most marvellous phenomena, to which we shall have occasion to refer in our next chapter on the Gulf of Castellamare. [The Medusæ had been long previously injected by John Hunter.]

* The Firolæ (*Pterotrachæa*) are Gasteropodous Molluscs. This genus consists exclusively of marine species, all of which swim in the open sea instead of creeping over a solid surface. It will readily be understood that the mode of life which differs so essentially from that of most other gasteropods must have induced great modifications in the organisation of the Firolæ. Their external forms are, indeed, very singular, for in these animals we find that the fleshy disc, which serves as a foot in Snails and Slugs has been changed into a broad and vertical swimming organ, the extremity of the body being, moreover, lengthened and flattened to fulfil analogous functions. The whole body is perfectly transparent, excepting only the mass of the liver, which possesses a certain degree of opacity, and thus constitutes a sort of coloured nucleus. The Firolæ have no shells, in which respect they differ from the Carinariæ, which, although they resemble them in most particulars, possess a shell which, however, only covers the mass of the liver, and which in the Mediterranean species (*C. Cymbium*) constitutes a beautiful object much prized in our Conchological collections on account of its transparency and extreme delicacy.

† The Diphyes, which are placed by Cuvier in the class of Acalephæ, approach very nearly to the Stephanomias, to which we shall presently refer. The organisation of these animals, which for a long time continued to be very imperfectly understood, has lately been made the object of two very important memoirs by Kölliker and Vogt.

which are so diaphanous that they can scarcely be distinguished from the water in which they move, and finally the graceful Stephanomiæ, whose living garlands of crystals and blossoms, more delicate than the preceding species, disappear on drying, and in the morning leave not even a cloud to mark their presence in the goblet which they had adorned the previous evening.*

In our anxiety to study these derivatives of rare,

The former of these observers is Professor of Anatomy and Physiology at Würzburg, and is well known to all naturalists for his numerous works, most of which are devoted to histology and the anatomy of the lower animals. Few German naturalists have better understood the advantages to be derived from a study of the marine species, and Professor Kölliker has already made several expeditions to the shores of the Mediterranean for the purpose of carrying out his various researches.

Vogt, who had formerly been a Professor at Giessen, and in 1848 was nominated Deputy to the Parliament at Frankfort, where he distinguished himself by his advocacy of ultra-liberal opinions, is at the present time Professor at the University of Geneva. This naturalist began his labours in conjunction with M. Agassiz, and amongst other memoirs he supplied a treatise on the embryology of the Salmon in the *Histoire des Poissons d'eau douce*, which is still the chief authority on the development of animals of this class. Professor Vogt has published a great number of memoirs, both in the French and German scientific journals. After having remained for nearly two years at Nice, in order the better to study marine animals, he commenced the publication of his researches by a most interesting memoir on the Siphonophora, a group established by Eschscholz, which corresponds very nearly to the *Acalephès Hydrostatiques* of Cuvier, and which includes the Diphyes, the Stephanomias, &c., of which we have already spoken.

* The Stephanomias, even to unscientific persons, are amongst the most curious objects that we meet with in the marine world. I shall have occasion to revert at a future page to these singular creatures.

or imperfectly known types, we waged a ruthless war against them. A drag made in the form of a bag, was fixed to the stern of our boat to collect the smallest of these animal forms. Nets made in the shape of pockets and attached to long rods, still further lengthened by Master Perone's method of making the rod tight to a line, were lowered to a depth of twenty feet or more below the surface, from whence they brought up the animals, which they had thus arrested in the midst of their course through the water. Large tin vessels, not unlike a deep skimmer, captured them as they floated to the surface. A dredge, provided with a heavy cutting edge, scraped along the muddy or weed-grown bottom, carrying away immense bunches of the large oar-weeds, which supplied us with numerous colonies of animals that had taken refuge within their tangled branches. When the bottom was too uneven or stony to admit of the employment of this method, one of the sailors would immediately strip, and, plunging head foremost, soon reappeared with his trophy, which he deposited at our feet, quite satisfied and proud at receiving our approving *bene!* in return for his services. Occasionally, when our success at sea did not equal our expectations, we ran into shore, and, landing on the nearest accessible point, we devoted our attention to the littoral species. Here our tactics were of a totally different nature, for the exigencies of the case demanded great expenditure of strength in turning up huge stones, or in breaking away the rocks, and in these excursions hammers and heavy levers

worked by our men, replaced our hempen nets and silk bags.

Our labours among the rocks were rendered both easier and more successful, owing to a remarkable circumstance, of which I do not remember to have seen any notice. Whenever calcareous rocks, like those of Torre dell' Isola projected into the sea, we found that they were surrounded by a kind of causeway, almost exactly on a level with the surface of the water, and which, without varying very much in width, yet followed all the sinuosities of the shore, filling up the shallow cavities in some places, and forming solid archways in others, and thus affording a smooth and easy path to all those who might not object to have their legs splashed by the waves, no very formidable evil in pleasant weather. At the first glance, one would suppose that this white and compact cement must have been consolidated by the hand of man; it is, however, only the work of one or two species of small Molluscs, belonging to the genus Vermetus.* Like certain Annelids, these

* The Vermeti (*Vermetus*) are Molluscs belonging to the class of the Gasteropods which live attached to rocks, and construct a tortuous tube, somewhat similar to those of certain tubiculous Annelids. On this account they were placed by Linnæus and his successors near the Serpulæ. A French naturalist, Adanson, was the first to recognise the true zoological position of this genus, which is represented by several living, and by many fossil species. Adanson, who made these animals the subject of his researches, had, at the early age of fourteen, cherished the idea of establishing a new classification to supersede the Linnæan system. In 1748, when he was twenty-one years of age, he undertook at his own expense a voyage to Senegal, where he spent five years in studying the natural history of that country. He returned to France with

Molluscs live united together in almost incredible numbers, and their interlaced tubes almost exclusively combine to form this kind of causeway, which encircles a considerable part of the rocky coasts of Sicily.

Thousands of animals had found shelter within the irregular cavities produced by this agglomeration. Here were Spheromæ*, small crustaceans resembling our woodlice, and which, like them, roll themselves into a ball to escape the pursuit of their enemies. Near them might be seen numerous Ophiuræ, radiated animals allied to the Asteridæ†, whose long and slender arms exhibit the singular property of emitting bright sparks almost every time the animal moves. Here too, were the Syllis and the Polynoe, small Annelids even more phosphorescent than the Ophiuræ, the Nemertes, those worms of whose marvellously simple organisation I have already spoken in the preceding chapter, and a multitude of Planariæ, a group nearly allied to the Nemertes, whose anatomy when compared

immense collections, and with the materials for his great work, the *Histoire de Sénégal*, which, together with his valuable observations on the Baobab and the Gum-bearing trees, procured him a seat in the Academy of Sciences.

* The *Sphæroma* belongs, like the Oniscus, to the order of the Isopods.

† Between these two genera, which at first sight present a great resemblance to one another, there exist very considerable differences. The arms of the Asterias or Star-fishes are furnished on their lower surfaces with pedunculated suckers, which enable them to crawl along the smoothest rocks. These suckers are wanting in the Ophiuræ. In the Star-fishes the stomach throws out prolongations as far as the extremity of the arms, but this is not the case with the Ophiuræ.

with that of the latter tribes is found to exhibit a most remarkable kind of compensation.* All these species proved real treasures to us, and it was with no common eagerness that, armed with hammers, we pursued them to the inmost recesses of their narrow caverns, where we rapidly contrived to fill our vials and boxes with a rich supply of specimens. When the object of our researches was thus successfully achieved, we hurried back to the village, and at once immersed our captives in large glass vessels, filled with clear sea-water, in which we were able to trace their slightest movements; and selecting those individuals which were doomed to be the first victims to science, we entered enthusiastically into the enjoyments yielded by unchecked indulgence in our favourite studies.

How rapidly the hours passed, as each, following some clue, opened by former studies or presented by the suggestion of the moment, contributed his share towards the thorough elaboration of the rich mine that had been thrown open to us, while his personal gain seemed tripled by the labours and discoveries of his companions, added to his own! To me especially this companionship added an inexpressible charm to my studies, from the contrast it presented to my former experience of solitude at Chausey, St. Malo, Bréhat, and St. Vast la Hougue. To understand what solitude really is, one must be

* In the Nemertes the intestine is simple and only slightly developed, whilst in the Planarias, on the contrary, it ramifies throughout the entire body, and is moreover highly complicated.

thrown, as I had been, amongst the marvels of living creation, separated from all friends, and far from any human being capable of understanding or sharing one's delight; one must have felt the want of sympathy in the midst of one's own genuine enthusiasm, and known what it was to pine for communion with other minds susceptible of intelligence, a feeling which after a time takes complete possession of the isolated observer of nature. How different was my present position when I was one of three zealous labourers! One or other of our party was constantly calling upon his companions to examine some curious detail, or some unlooked-for marvel, and thus our knowledge and our enjoyments were continually multiplied by this active interchange of the facts, reflections, and ideas, suggested by a constant supply of fresh objects of observation. Wherever a shadow of doubt impaired the exactness of any observation, the grounds on which it was based were at once tested with the most perfect good humour, but at the same time with scrutinising severity; and this perpetual control added very considerably to our enjoyment by impressing a character of certainty on each individual result.

As may readily be conceived, our time was completely absorbed by these attractive occupations. In the evenings when our eyes and hands imperatively demanded some rest from their prolonged occupation by the microscope and scalpel, we would sally forth, and, leaving the village, proceed to a wood of the *Cactus Opuntia*, where, stretched at full length beneath the trees, whose summits rose to a height of

fifteen or twenty feet, we watched the setting of the sun. From the middle of an isolated hillock, crowned by a ruined tower, and situated almost in the centre of our peninsula, we could see the glorious orb of day descend towards the sea, whose waves seemed to kindle into flame as they came in contact with it, until it finally disappeared behind Cape Santo Vito, bathing the rocky beach and neighbouring valley of Capaci in those marvellous violet tints which shed an aerial transparency over the heaviest outlines of mountain scenery. We then returned to our quarters, to partake of the meagre dinner, prepared for us by Artese; but if on any occasion, deceived by the short twilight of these southern latitudes, we had been surprised by the rapid approach of night, we were sure on our way homewards to meet our sailors, armed to the teeth and ready at the slightest hint of danger to draw in our defence. In the eyes of our honest tars, every landsman they met was an object of suspicion, perhaps a brigand, incessantly on the watch to waylay unwary travellers. The mountaineers in our neighbourhood were especially shunned by all our crew as persons of the most detestable reputation; and during the first few days of our arrival we had some difficulty in persuading our men not to follow us on every occasion. Their fears may not, however, have been entirely unfounded, for Padre Antonino admitted that the natives of the neighbouring mountain district were scarcely among the best of mankind, while at the same time he showed us his well-loaded carbine, and the other arms which he invariably kept at hand in case of need.

For twenty days we had a constant calm, which proved most favourable to our researches, and certainly was not suffered to pass unprofitably by. Our portfolios and note-books were already well filled, although the observations which we had undertaken were still very incomplete, when one morning we perceived, on awakening, that there was a heavy sea running, and that the waves were breaking noisily upon the beach. Our yesterday's stores had been all exhausted before night; we had therefore only to look forward to a lost day, with a prospect of bad weather continuing for some time to come. We at once saw that the only way of profiting by this forced state of inactivity would be to continue our voyage. Acting upon the spur of the moment, we instantly gave our orders, and in less than an hour, our instruments, jars, and bottles were safely stowed away in their former places on board the *Santa Rosalia*, and our bedding and wrappers put out of sight under the poop. Before we took our leave of Padre Antonino, we gave him, at his request, a certificate attesting our sense of his hospitality, which, however, we were careful not to accept as a gratuitous attention, and once more pressing his hand, and wishing him a hearty *farewell*, we took our old places on the deck of the *Santa Rosalia*, and, unfurling our large latteen sail, shot rapidly towards Castellamare.

CHAP. IV.

THE COASTS OF SICILY.

THE GULF OF CASTELLAMARE—SANTO VITO.

General aspect of the Gulf.— Formation of clouds in a clear sky.— Castellamare. — Excursion to the ruins of Segesta. – Departure for Santo-Vito. — Misadventures there. — Ants. — Researches of M. Edwards on the Acalephæ, Beroïdæ, and Stephanomiæ.— My observations on the mode of reproduction of the Syllis. — Reproduction of the Medusæ.— Curious approximation between the Animal and the Vegetable Kingdoms. —Medusæ and Fungi. — Studies of a different kind, leading to the same result. — General consequences.

On leaving Torre dell' Isola we steered westward, passing on the left Capaci and Carini, with their rich valleys, which terminate in a low and sandy beach. Impelled by a fair wind, we had soon passed Point Omo Morto, when taking a sharp turn towards the south, we speedily made the Gulf of Castellamare, the largest of the numerous bays which intersect the coast-line of Sicily. The marvellous clearness of the air, of which our foggy atmosphere cannot give the most distant idea, enabled us to embrace in one glance this magnificent bay of water, which penetrates nearly fifteen miles into the interior, forming a well defined semicircle, whose opposite banks present the most marked contrast. To the east, the distant summits of Belvedere, Montelepre, Montemitro, Firicino, and Mount Boni-

fato, merged by gradually decreasing slopes into the plains of Partinico, whose fields, covered with rich harvests and dense woods of olive trees, extended to the very edge of the water. To the west the eye rested on Mont Baïda, which rose abruptly from the shore, extending its chain of arid rocks as far as Cape Santo Vito, whilst at the extremity of the gulf, Mount Inici seemed to rise in sullen grandeur from the bosom of the waves, scarcely leaving a strip of land broad enough to support the little town, which is crowded together at the foot of its grey uncovered sides.

The wind had fallen, and, with a less rapid but more regular motion, we were borne onwards by the measured strokes of our oarsmen. The slow rate at which we were approaching Castellamare enabled us at our leisure to observe the curious spectacle which had struck us on our first arrival in Sicily. To the verge of the horizon the sky was intensely clear, not even a streak of mist being visible in the deep azure vault on which we gazed: yet around Mount Inici, about a third of the way from its summit, fleecy masses of ever changing clouds were resting on the sides of the mountain, some disappearing for an instant only to be re-formed at another point; while others again, rising like some aerial veil from the rocks below, which seemed to have created them, floated away in circling wreaths, and soon vanished from view.

The general laws of physics afford a ready solution of this phenomenon, which certainly seems, at first sight, somewhat difficult of comprehension.

Water, that element which is almost as necessary as air to the existence of organised beings, enters into the composition of our atmosphere in two different ways. It sometimes becomes entirely invisible, in consequence of actual *dissolution*, in which case we must have recourse to the instruments known as hygrometers, to reveal its existence; under other circumstances, its molecules, re-united into small hollow spheres, float in the air in the form of infinitely minute vesicles which, by their union, produce those visible vapours which we term mist or clouds. The mere process of cooling is sufficient to cause the invisible vapour to pass suddenly into the latter condition; for, as in the case of all other gases, the air when cold cannot dissolve as much water as when it is warm. Now when the rays of the sun strike upon the exposed sides of a rugged mountain, the strata of air, which are in immediate contact with this surface, become rapidly heated, and at the same time become blended with a certain quantity of invisible vapour which has been drawn from the soil by the action of heat. Having become at once lighter and more humid, they rise along this inclined plane, forming ascending currents. They cool on reaching a certain altitude, when the invisible vapour, assuming the form of vesicles, becomes suddenly apparent to the eyes of the observer; but new quantities of heated air, being continually added, mix with the cold strata of these elevated regions, and warm them; and thus vapour, which alternately appears and disappears under the action of these diverse influences, presents all those movements and

irregular transformations which so faithfully reveal to the eyes of the observer the struggle which is going on in the atmosphere between heat and cold.

We entered the little port of Castellamare about three o'clock in the afternoon, when, in faithful obedience to Sicilian habits, the chiefs of the Departments of Customs and Quarantine were taking their siesta. Their subordinates, acting upon their general orders, made some show of preventing our disembarkation, but despotism, where it does prevail, is a very convenient institution for those whom it favours; and, in a country like Sicily, where officials are the living impersonations of the law, our letters of recommendation were all-potent in placing us above ordinary regulations. With the magical names of Serra di Falco and Cacamo on our lips, we stepped on shore without further interruption; and, in the course of a few minutes, we saw a party of *Doganelli* and *Sanitarii* hastening towards us, eager to entreat our Excellencies to forgive them for not having been in waiting to receive us; and we, after the fashion of good princes, generously extended to them our gracious pardon.

But a more serious difficulty soon presented itself, when we began to make inquiries concerning lodgings; for although Castellamare is a tolerably-well frequented sea-port, and numbers from ten to twelve thousand inhabitants, it does not contain the humblest inn or tavern in which a traveller can hire a night's lodgings. Fortunately for us, Artese, who had made numerous coasting voyages, had generally some friend in every port who was ready

to offer his services to the travellers for the *honour* of the thing, as he expressed it, and probably also a little in consideration of the recompense which our cook did not fail to promise in our names. After a considerable amount of talking, gesticulating, and bargaining, we were installed in a room, which was cleared for our accommodation of a pile of half-rotten onions, which had impregnated the air with such a sharp and nauseating smell, that we would almost have preferred the dreadful nuisance of the cock-roaches. I need scarcely observe that we were left to furnish our apartment as we could. As at our preceding halting place, we were readily supplied with planks and tressles, while our mattresses and capes, brought from the Santa Rosalia, supplied us with all we needed for beds and bedding.

Castellamare is the only point along the whole extent of the gulf which bears its name in which ships can find a safe haven in case of storms; a circumstance which readily explains the degree of importance attached to this little port. Every precaution had indeed been taken, in past ages, for the defence of the place, and the old town was originally built upon a promontory of calcareous rock, which projects far into the sea. A broad and deep trench was interposed between it and the main land; high walls, which were in part cut out of the solid rock, surrounded it on every side; whilst, at its extremest seaward point, a formidable donjon rose threatening on high, upreared on foundations which had been laid far below the level of the waves. A low vaulted chapel, decorated with the Cross of the

Templars, leads to the inference that these warrior-monks may have presided over the erection of the fortifications, which, although they may once have been regarded as impregnable, notwithstanding their low position, have lost all their value as means of defence since the invention of artillery. For this reason, the works were long since entirely abandoned. The castle has fallen into ruins, and its crumbling remains are given up to a population of beggars, whom we saw lounging in rags upon the broken steps of doors, still surmounted by proud armorial devices. A stone bridge of two arches has replaced the ancient drawbridge; and the town, escaping from its turreted enclosure, has spread in all directions round the harbour, and even crept up the lower heights of the mountain side, from whence, year by year, straight and wide streets, bordered by two-storied houses, are extending further and further into the neighbouring fields.

We had flattered ourselves that we should find ample materials for observation and study at Castellamare, but from the very first day of our arrival we discovered our mistake. In one direction we found a long stretch of sand and boulders, while on the opposite side of the gulf huge rocks descended precipitously into the sea, exhibiting no trace of life beyond a few isolated tufts of Fucus and an occasional branch of Gorgonia and Caryophyllia. We were therefore under the necessity of planning a speedy retreat before we were thoroughly settled in our new quarters; we resolved, however, first to

visit the Temple of Segesta*, which is situated about six miles from Castellamare in a desolate region, known in the present day as the *Contrada Barbara.*

The following day we set forth, accompanied by Carmel, and guided by the *Deputato Sanitario* in person, who had politely volunteered to serve us in the capacity of *cicerone.* For some time we followed a road which, here and there, afforded evidence of having been worked by the hand of man; but after leaving this beaten track, we entered a veritable Sicilian path. Here it needed a vast amount of faith to trust to our mules' legs rather than to our own, but in a little while we were re-assured by the steady carriage and the marvellous instinct of these animals, which seemed to guide them securely in the midst of rolling stones, holes, and sharp-edged rocks, and we soon gained sufficient confidence in their safe-footedness to direct our whole attention to the surrounding landscape. The path gradually wound upwards round the mountain above Castellamare, carrying us at first through a country rich in vineyards, and groves of olive, orange, and citron trees, and interspersed with farms and cottages, but the character of the scenery gradually changed, growing more picturesque and wild at every step we took. Half-way up this elevation, every trace of culture had disappeared, and nothing was to be seen

* The ruins of Segesta, one of the most important cities of ancient Sicily, are enclosed between the mountains which, rising at the foot of the Bay of Castellamare, are continued throughout the whole distance between Alcamo and Trapani.

before us but vast arid plains, abutting to the right on the rugged and barren side of Mount Inici. In the midst of this desolation, a sudden turn in the road brought us to a point of view which made us pause with wonder and admiration. At about three quarters of a mile from us, in the midst of a desert, which looked as if it had hitherto escaped from all contact with human industry, and placed upon a high hill as upon a pedestal, rose one of the most magnificent monuments of ancient art. The Temple of Segesta stood before us, marvellous in its perfect preservation. Not one of its thirty-six columns, nearly thirty feet in height, and more than six feet in diameter, has tottered on its pedestal. Not a stone is detached from the simple cornice which crowns the edifice with its severe lines. Only here and there a few slender grasses, some bunches of fennel or the fan-like leaves of the Chamærops have attached their roots to the smooth pediment or within the narrow chinks which separate the solid blocks of stone, whose sharply cut angles look as if they were fresh from the hand of the workman. The only sign of decadence consists in the general tint of the whole edifice, which could only be reproduced by the deepest tones of burnt sienna or oxide of iron.

What feelings of painful indignation must affect the artist on discovering, as he looks upon this august monument of a past age, that it has been wantonly disfigured through the vanity of a modern prince. The base of the edifice having been concealed beneath vast accumulations of earth, King

Ferdinand caused the soil to be removed which covered the sub-basements and floor, and, wishing to immortalise this act of royal munificence, caused a long slab of not very white marble to be inserted, like some huge stain, on the noble front of the edifice, displaying in large letters, whose gilding is already half worn off, the pompous inscription, *Ferdinandi I. Regis Augustissimi Providentia Restituit, Anno* 1781. Let us further add that this very august monarch had neither the merit of suggesting nor of completely carrying out this measure. The honour of the undertaking is for the most part due to the Duke of Serra di Falco, who here, as in a hundred other places, has left traces of his intelligent and generous activity.

From the temple we proceeded to the theatre, the stage of which is in perfect preservation; the lower tiers of seats are also in a tolerable condition, in consequence of their having been cleared from the ruins, with which they had been encumbered, by the orders of the Duke of Serra di Falco and King Ferdinand. This theatre, with the temple, are the sole remains of that proud and opulent Segesta, which was once the formidable rival of Agrigentum and Syracuse. Of the city and its palaces not a fragment of wall remains. Nature herself seems to have succumbed to this inexplicable devastation. Around this miraculously preserved temple, around this theatre which, by an equally singular fate, has escaped the universal ruin, the same magnificent scene still meets the eye which once entranced the gaze of Æneas and his companions. From the

summit of the hill, on which the spectators watched the mimic scene, the eye glances from the abrupt declivities of Mount Inici to the waters of the gulf and Point Omo-Morto, rendered blue by distance, until, ascending to the peaks of Bonifato, it loses itself in a labyrinth of mountains, whose graduated summits, compressed together like so many solid waves, blend into one mass, which skirts the horizon from Mount Eryx to Corleone. But throughout this vast amphitheatre, by which the spectator is surrounded, the silence and stillness of the tomb reign supreme, without any manifestation of active life. Concealed by its rocks, Calatafimi scarcely reveals the presence of its ruined Saracenic fortress, while Alcamo is completely hidden behind an undulation of the ground. Built upon the bare and rugged sides of a mountain, which appears exclusively to belong to it, the feudal stronghold of the Marquises of Cardillo seems to dominate in solitary grandeur over this desert region, heightening the general character of this strange scene by calling to mind the sombre conceptions of some of our novelists.

Yet, notwithstanding the profound emotions excited by this grand scene, we did not forget that we were naturalists. There were a few insects buzzing among the wild grass and tall fennel, which here grows to be more than six feet high; and M. Blanchard, who was not slow in availing himself of the opportunity thus afforded him of beginning his collection, was fortunate enough, amongst other captures, to possess himself of a splendid butterfly,

the sole European representative of a genus which belongs essentially to Africa. This prize was *Syntomis phegeënis*, which at first sight looks more like a large fly than a butterfly, for its body is long, the wings are narrow and thrown backwards, whilst in colour it is steel gray or blue, spotted with yellowish white. In the meanwhile M. Edwards and myself were trying to capture some reptiles, destined for the curious menagerie which had been opened at the Jardin des Plantes by M.M. Duméril and Bibron. After lifting a great number of stones with an immense expenditure of labour, we succeeded in entrapping in our boxes some pretty varieties of lizards and a very fine skink. This animal, which very much resembles a lizard, presents no well marked line of demarcation between the head, neck, body, and tail, and is covered with smooth scales, as glossy as if they had been varnished. This little creature has long enjoyed an immense reputation in medicine. Pliny extolled its flesh as a certain specific against poisoned wounds; and ancient formularies attribute to it every kind of property, whether depurative, stimulative, anthelmintic, analeptic, aphrodisiac, anticancerous, &c. Even at the present day Orientals regard it as a sort of universal panacea. It is not surprising that in lands where people still believe in these imaginary virtues, the skink should be hunted with the most indefatigable zeal. In the deserts of Lower Egypt the natives wage a ruthlessly exterminating war against these unfortunate lizards; and, after having killed and dried them, send them in sacks to Cairo and Alex-

andria, where they constitute an important article of commerce.

The day after our excursion to Segesta, we left the little harbour of Castellamare, which had proved so unpropitious for our researches; and scudding rapidly along the western shore of the gulf, directed our course to Santo-Vito. The aspect of this shore presented very little to attract our attention. A compact calcareous rock advanced its sharply-pointed ledges to the water's edge, or raised its rugged sides above the waves. Here and there we could discern a deep grotto or cave, but we could see nothing within, save some fine groups of orange-coloured Caryophylliæ; and this sight, far from attracting us, invariably led to the reiteration of the order to advance, for experience had taught us that the presence of these lovely polypes proclaimed the most complete sterility in all other respects. Occasionally the wall of rocks, along which the Santa Rosalia was slowly making her way, disclosed an irregular fissure, which served as the entrance to some little *cale*, with a sandy or shingle bottom. These indentations, however insecure they seemed against the effect of storms, were always commanded by one or more towers erected upon some rugged eminence. The number of these edifices, which we had first regarded as lighthouses, excited our curiosity. On questioning our men, we learnt that they were works of defence erected to protect the neighbourhood from the attack of pirates from the African coast, who, stimulated by the vicinity of the shore, or influenced perhaps by the traditions of the past

rule of their predecessors, still ventured on these veritable *razzias* on the soil of Sicily, which had been rescued from their ancestors by the sons of Tancred. There are nearly 200 of these towers, which were, until lately, incessantly guarded by an army of 10,000 men, who were distributed among these garrisons, where they were ever on the watch to sound an alarm at the first appearance of any suspicious-looking felucca or brigantine. Since the conquest of Algiers these precautions have been no longer needed. The soldiers have returned to the towns; and the towers, which now stand deserted on these desolate shores, afford a striking proof, by their neglected condition, of the importance of the services which France has rendered to humanity and civilisation.

In the meantime we were approaching the Cape of Santo-Vito, where, according to the assurance of our men, we should find, in the *Santuario*, as good accommodation as we could desire, together with abundance of provisions — a luxury which we had only enjoyed in retrospect since our departure from Palermo. We were the more impatient to reach this promised land in consequence of the cold rain and stormy wind which had begun to chill and stiffen our limbs beneath the insufficient shelter of our slight tent. At last we reached the object of our desires, and the first glance sufficed to show that the architect who had erected this edifice had thought more of insuring the safety of the inhabitants than of displaying any elegance of structure. The church of Santo-Vito looks precisely like some strong tower

of the middle ages. A large and lofty square tower pierced with narrow loop-holes, serves as a belfry; the walls of this inaccessible donjon are so enormously thick, that they look as if they would prove quite strong enough to resist heavy artillery; indeed they seem as if it would need a regular siege to master the building, however feeble the garrison might be by which it was manned. At the foot of the tower stand a few houses of recent date, whose numbers are increasing rapidly now that there is nothing more to fear from Algerine pirates. The relics of Santo-Vito enjoy a vast reputation all along the coast, and a great number of pilgrims come year by year to seek relief from bodily and mental ills through their miraculous virtues, giving their offerings in return for these benefits, by which means the sanctuary in which the treasures are preserved secures a considerable annual revenue.

The incumbent of this rich cure has the title of Canon, and has his residence at the upper part of the belfry. The remainder of the platform is occupied by tolerably spacious rooms, destined for the accommodation of the pilgrims. We had reckoned upon being able to install ourselves in these comfortable quarters, but the lord of the mansion did not seem at all disposed to share with us his aerial lodging. He received us with a dry suspicious manner, and did not even deem it necessary to employ any demonstrations of politeness in recommending us to seek some better lodging than the small room which, as he stated, was the only one he had to offer us. This seemed scarcely to be the opinion of the house-

keeper of the Padre, a handsome Sicilian brunette, with a well-rounded figure and sparkling black eyes, who examined us with ill-disguised inquisitiveness. Unfortunately, however, she was not consulted on this occasion, and we were compelled to go elsewhere for a lodging. After much useless searching, Artese at length discovered two rooms, lighted by unglazed casements, and having a perfectly dark closet adjoining to them, which could only be reached by ascending a ladder which was suspended from a trap door. After bringing all the available furniture of the village into requisition, he contrived to secure three chairs and two tables, but not a pair of tressles or a single plank could we procure, and on this occasion our mattresses were simply spread upon the bare floor. These first difficulties once overcome, our factotum re-assumed his former functions of cook, and devoted his attention to the matter of provisions. Here, however, he was scarcely more fortunate than in respect to the lodging; for during the whole time of our stay at Santo-Vito, with the exception of one old hen, which was scarcely rendered eatable by a very prolonged course of boiling, our fare consisted exclusively of eggs and *cacio cavallo.*

It will, therefore, readily be seen that our expedition was not one of unalloyed enjoyment. There certainly was no great merit on the part of M. Blanchard and myself in cheerfully supporting the disagreeables inseparable from our mode of life, for we were young and had to win a reputation. But when a man of M. Milne Edwards's age, who has devoted twenty years of his life to the prosecution

of labours of the most incontestable importance, and who has thus attained a distinguished place in the foremost rank of science, renounces the comfort and quiet of his own home for the sake of prosecuting new researches, exposing himself cheerfully to all the privations and fatigues which we endured, with no other hope of reward but the success of the inquiries he was prosecuting, it must be admitted that he gives the strongest proof of devotion to science, and acquires by the very act an influence and authority which no one will dispute who can appreciate the honourable manner in which they have been won.

It must be admitted, however, that all these minor miseries were very quickly forgotten when they were accompanied by the acquisition of ample materials for study; but, at Santo-Vito this just compensation was not always awarded us in return for our many privations. The same wind which drove an icy rain through the casements to our working tables threw the angry waves upon the exposed beach, and either carried away the little marine animals, of which we were in search, or compelled them to take shelter in the depths of the sea, far beyond the reach of all our means of capture. It thus happened that we frequently returned empty-handed from our excursions. M. Blanchard, however, was enabled to carry on some very curious observations. The rocks were covered with numbers of the Vermetus, which, protected by their solid and interlaced tubes, can brave with impunity the shocks of the tempest. The abun-

dance in which these annelids occur upon the beach of Santo-Vito enabled our companion to examine them in detail; whilst the frequent occurrence of large Tritons (a gasteropodous mollusc) afforded him the means of prosecuting his observations on the nerves of these animals with equal zeal and success. On land he collected several fine specimens of insects, belonging to the family of the Melasoma, which are indigenous in the sand of this beach. He convinced himself that zoologists, deceived by trifling external differences, have multiplied species beyond measure by mistaking for them simple varieties; while he was enabled, at the same time, to rectify a more serious error in relation to the sexual differences which had led to a similar result; as, for instance, in the case of the genera Erodias, Tentyria, and several others, in which the male and female of the same species had often been separated on the supposition that they were specifically different.

Among the insects which attracted the attention of our travelling companion, we ought specially to mention Ants, since the coast of Sicily abounds in several of those species which appertain to warm climates. The history of Bees* owes perhaps a portion of its popularity to the pleasant fictions of mythology with which it has been associated, but

* It is well known that the economy of Bees has been made the subject of numerous researches. M. Dujardin has recently published in the *Annales des Sciences Naturelles*, an exceedingly curious memoir on the mixture of intelligence and instinct which we observe in these insects. The most complete work, however, on the subject is that by the elder Huber, which he entitles *Histoire des Abeilles*.

the history of Ants is not the less marvellous, although it has not hitherto been made the theme of a poet's song. In the ant, even more than in the bee, the observer may note a strange blending of instinct and reason manifested in extremely complex acts. Their different families, which are all subjected to the rule of a purely republican form of government, exhibit the most complete differences in their habits. Besides some species, whose colonies invariably inhabit only trees, where they can find both nourishment and shelter, there are others, which live exclusively in dark underground excavations, where the light of day never penetrates. Some of these curious insects, meriting to a certain extent the reputation with which the imaginative faculties of some writers have endowed them, toil to gather together the food required for the day's and the morrow's consumption. Others again, who understand how to procure the necessaries, and, perhaps, even the superfluities of life, without giving themselves so much trouble, imitate the habits of pastoral nations, and rear actual herds and flocks of plant-lice (Aphides), watch over their young charges during their infancy, construct places of shelter for them, or put them out to pasture within the ants' nest, repaying themselves for all these cares by drawing abundant nourishment from the saccharine fluid which these little creatures secrete. Finally, there are some ant-communities which, despising all domestic cares, emulate the warlike tribes of old in their overbearing haughtiness and contempt for labour, and contrive to secure to themselves the services of slaves. One of

the species which we found at Cape Santo-Vito seems to have belonged to these tribes of Amazons, and if chance had favoured us we should no doubt have witnessed some of those razzias, which Huber * has compared to expeditions for kidnapping negroes; for we might have seen, as that naturalist did, how the soldier ants marched forth in serried columns to lay siege to the ant-nest, and, after carrying it by assault, notwithstanding a desperate resistance, returned triumphant, bringing with them eggs or young larvæ, which, in the course of time, become developed, and are brought up as slaves, having to perform all those services for their victors which the Lacedæmonians were wont to exact from their Helots. As want of time and opportunity prevented us from witnessing in person any of those curious scenes which ants have exhibited to more fortunate observers, we determined at all events to possess ourselves of a specimen of their industry. One of their subterranean cities was, therefore, most carefully removed by M. Blanchard, who was anxious to present a specimen of this kind to the museum. M. Edwards succeeded, in the mean time, by a happy coincidence of circumstances, in completing at Santo-Vito two series of admirable observations in relation to the organisation of the Beroïdæ

* The younger Huber devoted himself to the study of Ants, with the same industry which his father exhibited in investigating the habits and manners of Bees. The observations which he made on these insects, have been fully confirmed in reference to many curious points, which at first sight seemed almost incredible. (See his work entitled *Histoire des Fourmis.*)

and Stephanomiæ, which he had made the object of careful study during our stay at Torre dell' Isola. He was also enabled to extend to new species, and completely to verify his previous observations on the distinction of the sexes in the Medusæ, and on the organisation of the Æquoridæ.

Naturalists have given the name of Medusæ to animals of an exclusively marine character, whose bodies resemble an inverted bell, or rather, perhaps, a mushroom, whose stem is replaced by more or less numerous appendages. Sometimes this singular creature is altogether colourless, and as transparent as crystal. Sometimes, again, it is embellished by the most vivid colours, presenting an opaline translucence, or looking as if it had been adorned with the richest enamel. These singular animals continued for a long time to be despised by naturalists, who, as was the case with Reaumur, looked upon them merely as masses of living jelly. Modern science, however, by its more searching mode of inquiry, has succeeded in penetrating into the mystery of these organisms. M. Duméril, one of the first naturalists who directed his attention to the Medusæ, found on injecting the internal cavities with milk, that the liquid was distributed through canals, arranged with almost mathematical regularity. His researches were subsequently still further developed by different observers, and it would almost appear, that the more the organisation of these animals is studied and comprehended, the more convinced have naturalists become that, so far from being simple, it is in the highest degree complicated. In animals of

the genera Aurelia, Chrysaora, and Rhizostoma, digestive cavities, systems of circulation, and reproductive organs of the most characteristic nature, have been discovered; while Ehrenberg, the illustrious microscopist of Berlin, penetrating still further, has isolated the ultimate elements of the organism, and detected the existence of a sensorial apparatus, which he regarded — and very probably with justice — as actual eyes.

However, among the Medusæ as well as in almost all the great animal families, the organic machine presents very different degrees of complication and perfection. Beside the genera to which we have referred, there are others which, being of a much more simple structure, and having no inferior appendages, appear to be in a condition of the most marked degradation, and, therefore, would seem to warrant the opinion advanced by some observers, that they may, under certain restrictions, be characterised by Reaumur's designation of *vivified jelly*. As no organs of reproduction had been discovered in the Eudorea or Æquorea, Eschscholz, a German naturalist, was of opinion that the Medusæ might, consequently, be divided into two groups, distinguished by the presence or absence of these organs. M. Edwards has demonstrated that this distinction was based upon incomplete observations; he found in the Æquorea nearly all the organs which had been discovered in the Aurelia; and he further showed that the sexes were distinct and recognisable by characteristic marks. It will readily be understood that these results were of the utmost import-

ance, since by establishing the presence of the most fundamental functions of the living being, they demonstrated the existence of uniformity in the entire family of the Medusidæ.

After discovering facts of this singular nature in the study of the Medusæ, this naturalist could scarcely have failed to direct his attention to the Beroïdæ, their near allies. The external characters of these animals present a degree of variability which would lead one to infer the existence of very considerable organic modifications. Their bodies, which are either of an enamel or crystal-like consistence, assume the most diverse forms. First, we have the Beroës, properly so called, some of which resemble inverted cones; next the Callianiridæ, with long festooned bodies, bearing on either side a kind of broad wing; again, there are the Cydippes, perfect spheres, which, like little balloons, trail after them two long contractile cords; lastly, there is the Cestus, looking like a smooth thick ribbon, several feet in length, and more than three inches in width, which bears the poetic name of *Venus's girdle.* If we have reference to external forms alone, we shall find that the members of this great family of the Beroïdæ have scarcely any character in common, excepting the form and mode of action of the organs of motion. These organs consist of small ciliated plates (or more correctly speaking, vibratile cilia, aggregated in lamelliform groups), ranged above one another, and disposed in rows on different points of the body. These plates, which are almost microscopical, are

incessantly vibrating and striking the surrounding liquid, through which, notwithstanding their minute size, they enable the creature to move with tolerable rapidity, by means of the infinite number of their impulsions, although these animals are often of comparatively large dimensions.

Yet notwithstanding this great diversity in their external forms, the Beroïdæ present a remarkable uniformity of organisation. The internal cavities are more or less elongated, the circulatory canals are more or less ramified, but we everywhere discover the same organic arrangements. Whether they resemble the Cestus or the Cydippe, all these genera, although differing so widely in appearance, seem to have been cast in the same mould, if we merely have regard to their anatomical characters, which, moreover, are very remarkable. Considered in relation to these, the Beroïdæ approximate to the Medusæ, and diverge most completely from the Acephalous Molluscs, among which certain modern authors have attempted to place them next in order to the oyster and other kindred bivalves.* We need only advance the following fact in support of our statements. In the Acephalous Molluscs the alimentary tube presents two openings, one of which serves for the admission of the food, and the other for the ejection of the indigestible residue; whilst in the Beroïdæ, as in all the

* Amongst others De Blainville held this opinion; but we are probably doing him no injustice in inferring that he was chiefly led to this view from the desire to differ from Cuvier. This naturalist, however, also placed all the *Siphonophora* among the Mollusca.

Medusidæ, there is only a single opening, which is alternately employed for both purposes.

One of the most important results of M. Edwards's researches on the Beroïdæ has been the recognition of their nervous system. The existence or absence of this apparatus in the lower animals has always been a much-disputed question. Some of the most illustrious naturalists have wholly denied its presence; and Cuvier, although he did not go quite so far, undoubtedly inclined towards these views, as he suffered them to influence him in the establishment of his fourth division of the animal kingdom—that of the Radiata. The admirable discoveries of Ehrenberg have led, in our own day, to the correction of these somewhat premature views; and very probably observers may sometimes have been led from a natural reaction to admit rather more in theory than the reality warranted them in concluding. The importance of the question and the authority of the illustrious men who profess such widely different opinions in reference to this question, combine to impart the highest value to every well-established fact that bears upon the subject. Let us not omit to mention, then, that M. Edwards has discovered in the Beroïdæ a central nervous system, or a kind of brain, from whence issue threads, which are distributed over the whole body. These facts in some respects confirm the less completely elaborated results which Ehrenberg obtained from his observations on the Medusæ. It would thus appear that the Beroïdæ, and very probably also the Medusæ, actually possess that important organic system which

Cuvier thought we might regard as the representative of the entire animal.*

Systematic naturalists have arranged, next to the Medusæ and Beroïdæ, the Stephanomiæ, which, together with other hydrostatic Acalephæ, must probably be ranked amongst the most extraordinary of the animals which the marine world offers to our notice. Imagine an axis of flexible crystal, sometimes more than a yard in length, around which are attached by long and equally transparent peduncles, hundreds of small bodies, either elongated in form, or flattened, and looking like the buds of a flower; and then intersperse in this garland beads of the most vivid red, blended among an infinite number of variously-sized filaments. Add motion and life to all these parts, bearing in mind that each one is an organ possessed of special functions; the one being destined to seize the food, another to digest it, a third to assure the propagation of the species, a fourth to carry on the respiration, and a fifth perhaps to serve as eyes; and after the consideration of all these marvels, you will still have only a feeble idea of the wonderful nature of this organisation. It constitutes a kind of colony, not composed of distinct individuals, as in the case of Polypes, but of freely floating organs.† It would be much the same as

* In an important memoir on the organisation of the Medusæ, M. Agassiz has described a continuous and complicated nervous system; while Ehrenberg had only detected the presence of isolated ganglia. [The nervous system of the Beroë was first described by Grant.]

† Since the hydrostatic Acalephæ or Siphonophora have been better known, some naturalists have proposed a new point of view

if, in the case of man, the hand, mouth, stomach, intestine, and lungs, indefinitely multiplied, were attached to as many threads, issuing from an isolated vertebral column. All these organs intermix and become incessantly blended together round the slender axis which connects them. The organs of locomotion are alone grouped into one mass, apart from the rest, at the anterior extremity. They consist of a considerable number of small bells soldered together to the central stem, with the opening directed backwards. These little bells are all incessantly dilating and contracting. By these alternate movements the water contained within their cavities is forcibly driven out, and the little bells being pushed forward by the resistance of the liquid, draw after them the other parts of the body. This peculiar structure, which has no analogue in the animal kingdom, places the Stephanomiæ apart from all other animals; hence it is only by a careful study of their embryology, that we can hope, by the discovery of their real affinities with other types, to ascertain their correct place in our zoological system.

Of the three naturalists of our expedition, I was

from which to consider the structure of these singular beings. According to them each of the Siphonophora is a colony of distinct, but incomplete individuals, some of which are charged with the functions of locomotion, others with those of nutrition, &c. Although this method of considering these organisms may at first surprise us, we must admit that recent facts have come to light in reference to the lower animals, which seem to give it a certain character of probability. At all events, new researches would appear necessary to decide this question, which perhaps can only be completely solved by the study of their embryology.

decidedly the most unsuccessful; for during the whole time of our sojourn at Santo-Vito, I did not see a single phlebenterous mollusc, whilst even the annelids were of rare occurrence. I had, however, the opportunity of devoting my attention to a genus belonging to this group, and although I did not complete my observations until a later period, I was enabled to lay before my companions the curious facts which I had discovered on the coasts of the Channel during my stay at Bréhat, in reference to the mode of propagation of the Syllis.

It was formerly believed, in accordance with the observations of the old Danish zoologist, Müller, that these little errant annelids, which are only from two to three inches long, were *fissiparous;* that is to say, that one individual being first single and entire, could separate into two halves, each of which acquiring rapidly either a head or a tail, became a perfect animal, destined to live precisely in the same manner as the original being from which it had sprung. This mode of generation, which is common enough in simple animals, was very remarkable in the case of the genus Syllis, in which the organisation is of a somewhat complicated kind. It must be remembered, however, that very different conditions prevail among the animals of this genus.

When a Syllis is about to reproduce itself, a number of rings become developed at its posterior extremity, the first ring being soon organised into a head, provided with eyes and antennæ. The two annelids, parent and offspring, continue, however, to be united by the skin and the intestine, in such a

manner that the latter animal lives solely upon the remains of the food swallowed by the former. During this period of its existence the newly formed Syllis betrays by its movements that it enjoys an independent life and will; for I have often been able to detect a struggle between the two, each wishing to go its own way. In these cases, the one which had sprouted like a bud from the primary stock was almost always vanquished, and finally compelled to follow its parent, although on this younger animal alone depend the preservation and continuance of the species. After the lapse of a certain time, it might be observed to become filled so rapidly with ova that the diameter of its body was almost doubled, whilst not a single egg could be detected in the interior of the body of the primary animal.

When the eggs have attained a certain degree of development, the division is completely effected, and the new Syllis finally enjoys its liberty. Soon, however, the eggs increase so much that they rupture the body, and the animal dies; while the germs which were contained within it escape, and are diffused in all directions. All these phenomena are accomplished precisely in the same manner in the males. They also produce buds, which become developed into perfect animals; but here the individuals of the secondary formation contain, in the place of eggs, that mysterious liquid, whose contact, like the torch of Prometheus, seems to awaken life. Like their sisters, they live only a few days, and perish in fulfilling the task assigned to them by nature. This, I believe, is the first

known example of animals of independent life being formed solely to serve as *reproductive machines.*

These facts, which were received with incredulity by those naturalists who only see living nature through the medium of their own collections, were repeatedly verified by my two companions; and, subsequently, M. Edwards discovered that these phenomena were not without a parallel. In the course of our voyage, he found another species of marine annelid, a near ally of the genus Myriana, which separates into as many as seven segments, each having a distinct head, but all united together by the skin and the alimentary canal into a wreath or chaplet. Now here, as in the case of the Syllis, the primary individual, which certainly deserved to be regarded as the head of the family, did not contain a single egg, whilst the six other individuals to which it had given birth were gorged with ova.

A circumstance which is well deserving of notice is, that in the case of the Syllis the young animals which are formed by this mode of fission do not resemble the primary animals. Even before they are separated from the parent stock they differ in so marked a manner from it with regard to their external characters, that zoologists, who would judge solely from the exterior appearance of animals, have thought themselves obliged, in obedience to their principles, to establish two distinct species, or, perhaps, even two genera of these animals, of which one is merely a portion of the other. What is to be said of principles which bring about such consequences as these, if it be not that they must inevitably lead to errors, which are

not the less real because they are not always self-evident? Still more, what can we say of men who, in the face of these and a thousand other equally significant facts which have been established by modern science, still maintain that true zoology rests exclusively on such principles?

In reflecting on the singular mode of propagation presented by the Syllis and the Myriana, one is led to ask a question which, at first sight, may appear sufficiently strange. Have the primary individuals any distinct sex? To this query we must reply, Evidently not; for they are neither males nor females, none of them in reality playing the part either of fathers or mothers; they neither impregnate nor are impregnated. Acting all in the same manner, and as stems, giving off buds, they all equally give birth to *secondary individuals.* It is only in the latter that the sexual characteristics become apparent, and that we are enabled to observe the development of ova and of the liquid which is to fecundate these germs of a new generation. The young which are developed from these ova do not, however, exhibit the characteristics of their immediate progenitors, but they resemble the primary individuals. Thus, for instance, in the animals of which we are speaking, the offspring never presents the characteristics of its father or mother.* But there are still

* The Danish naturalist, Steenstrup, has published a very interesting work on the Alternations of Generation. He has united and grouped together all the facts which present any analogy with the one to which I have already referred, and from these he deduces a general theory. According to him, the kind of alternation of which

stranger facts than these. For a long time, zoologists, who were guided solely by external characters, admitted into the great division of the Radiata two distinct classes, one of which includes the Acalephæ, and the other the Polypes. The former of these embraces the extensive family of the Medusæ, of which we have already spoken. Among Polypes the family of the Hydroida comprises animals which are almost always fixed, grouped into colonies, united by one common part; in some cases like the stem of a creeping plant; in others, ramified like little shrubs; in others, again, expanded into a sort of plate or

we are speaking consists in this, that in certain animals, neuter individuals produce, by budding, sexual individuals, which in their turn propagate by the ordinary methods; from whence it results that in these animals the offspring, instead of resembling their parents, resemble their grand-parents. Steenstrup has given the name of *Ammen* (Nurses) to those neuter individuals which produce sexual individuals. Although the work of Steenstrup is composed in a spirit at once absolute and contracted, it is not the less valuable for the great services which it has rendered to science, by showing that a number of phenomena, which had previously been regarded as isolated, are, in fact, connected together by the most unexpected links. In a remarkable work, to which the prize of the Academy of Sciences has been awarded, Van Beneden has made a broad and most felicitous application of these views to the history of intestinal worms, whilst he has at the same time developed and enlarged Steenstrup's theory by regarding alternate generation as a special case of a more general phenomenon, which he terms *Digenesis*, in opposition to the phenomenon of *Monogenesis*. According to this author we observe in nature two general modes of reproduction. The one is effected by the intervention of sexual individuals, the other without any such intervention. Every animal in which these two methods occur, either simultaneously or successively, is termed *digenetic*; every animal in which one of these methods only occurs is termed *monogenetic*.

leaf, covered by Polypes crowded together like the different blades of a tuft of grass. Yet it would actually appear, from the discoveries of MM. Siebold*, Sars†, Loven, Dujardin, Van

* Carl von Siebold, Professor at the University of Munich, has contributed more perhaps than any other naturalist in Germany to diffuse amongst his countrymen a taste for the study of the Invertebrata. He has not only published a series of excellent reports on the progress of our knowledge of the lower animals, but has also largely contributed numerous observations to this department of science. He was the first who seems to have recognised the singular metamorphoses of the Medusæ, and the phenomena which accompany the formation of the embryo in the Planariæ. In the admirable chapter on the development of intestinal worms which he contributed to Burdach's great work on Physiology, he opened a path of inquiry which has since been followed by many successive investigators, and which has finally led to the solution of a problem which had almost been regarded as insoluble. But of all his works the most useful, and at the same time the one most generally known, is the Manual of Comparative Anatomy, which he published conjointly with Stannius, and in which he has incorporated all the facts at present known in relation to the Invertebrata. It would be impossible to condense a larger number of facts, and more valuable data in a smaller number of pages, and hence this manual has been regarded as a standard work from its first appearance. It has been translated both into French and English.

† Sars, a clergyman at Bergen in Norway, has availed himself of the advantages afforded by his vicinity to the sea for studying the lower marine animals, to whose mode of development he has devoted the most persevering attention, together with a remarkable amount of learning and ingenuity. We owe to him some of the most curious and unexpected discoveries by which this branch of science has been enriched. Amongst these, we may mention the facts which he has ascertained in reference to the metamorphoses of the Nudibranchiate Gasteropods, and with regard to the early condition and subsequent metamorphoses of several of the Echinoderms—a subject which has been subsequently investigated with special care and ingenuity by the physiologist Müller. Sars shares with Siebold the honour of having discovered the remarkable mode of propagation in the Medusæ, which he followed through all its phases.

Beneden*, and others, that some of the hydroid Polypes are merely the transitory forms which certain Medusæ undergo before they arrive at their more perfect state.

It must not be supposed that this metamorphosis can be compared to that of insects. In the latter, each germ or egg produces a larva, which maintains its special individuality through all its changes into the grub, caterpillar, chrysalis, or butterfly. But in the Radiata, the phenomena are very much more complicated. The egg of the Medusa first produces an ovoid, ciliated larva, very similar to certain of the Infusoria. After having enjoyed its liberty for a time, this larva becomes fixed, undergoes an alteration of form, and gradually lengthening, is converted into the stem of a hydroid polypary, from which sprout, like so many leaves, an indefinite number of well-characterised Polypes. After a time this same stem produces new buds, which, instead of presenting the form of Polypes, gradually assume the characters of the Medusæ. These buds or gemmules, which are at first adherent, become detached, and finally appear as true Acalephæ. Abandoning their stationary brethren, they begin a wandering life; whilst the polypary from which they originated continues to vegetate in its old place, and to throw out new Polypes. Thus in the Radiata which we have been considering, one sole germ, after having

Amongst other works Sars is publishing a general treatise on the Littoral Fauna of Norway, of which two parts have at present appeared.

* [A sketch of the scientific labours of Van Beneden is given in the Appendix, Note XIII.]

undergone the first modification, appears to generate two entirely dissimilar sorts of animals—one group of which, ever rooted to the stone where they were first developed, make common property of a part of their individuality, whilst the others, being free and isolated, enjoy a completely independent existence. Who would not exclaim that a miracle had come to pass if he saw a reptile emerge from the egg dropped by the hen in his poultry yard, and the reptile give birth at once to an indefinite number of fishes and birds? Yet the generation of the Medusæ is fully as marvellous as the apparently incredible occurrence which we have been supposing.

Are these phenomena the less important because they occur in inferior animals, which have not hitherto been sufficiently observed? Most assuredly not. To the zoologist who is truly worthy of the name, and who, without dwelling upon the more or less curious modifications of form, endeavours to penetrate to the mysteries which they conceal—to the inquirer who, in his desire to form a correct idea of creation, endeavours to comprehend all the relations established between the thousand elements of this magnificent whole—these facts have as much value as if they were manifested in man's nearest analogue among the mammalia. M. Dujardin has well observed that one of the first consequences to be deduced from these facts, is to exhibit the inexactitude of the notions generally admitted in zoology regarding the nature of *species*. All the definitions hitherto given by the most distinguished zoologists are principally based on resemblances

among individuals, and yet we have seen, both in the Syllis and in the Medusæ, that this supposed resemblance does not exist between the offspring and the parents, or even between the former. The purely biological idea of the succession of beings must therefore in future be substituted for the wholly morphological idea of identity of character among them.

With these results, which touch upon the fundamental questions of zoology, we must associate others of a more general nature. For many ages the animal and vegetable kingdoms were, in the eyes of the learned as well as the unlearned, separated by definite limits. At the present day, this is no longer the case. In proportion as attempts were made to define more exactly the pretended differences which, it was conjectured, must, of necessity, exist between these great divisions of animated creation, it was found that one by one they gradually disappeared. At the summit of either kingdom of nature, the naturalist cannot be deceived as to the animal or vegetable nature of the object he is examining; but in proportion as he descends, and departs from this highest point in the field of inquiry, new analogies and resemblances are constantly presenting themselves to his notice, until the moment at length arrives when the most scrupulous examination is insufficient to afford complete certainty. At the extremity of the two series, there exist entire families, for the possession of which botanists and zoologists have contended for ages, and whose ambiguous nature has never yet been determined, notwithstanding the combined efforts of these observers.

But it is principally in the different modes of their reproduction, and during the earliest periods of existence, that the most multiplied and intimate relations manifest themselves.

Let us give a few examples the better to illustrate these relations. It is well known that in animals the concurrence of two agents is necessary in the greater number of cases to assure the perpetuity of species. It is the same with plants. Among the latter, flowers are generally both male and female, thus realising one of the most graceful fictions of pagan mythology. Around the pistil which encloses the ovule are grouped the stamens, whose pollen is destined to fecundate this germ and to determine its development under the form of seed or fruit. In many cases, however, the sexes are separated. Growing sometimes on the same tree, and sometimes on different trees, the male and female flowers require the aid of some intermediate agent to effect their union, and thus the female plant remains barren until the winds convey to it the vivifying emanations by which alone it can be fructified. These diverse relations are all to be met with in the animal kingdom. Here also the myth of the son of Venus and Mercury becomes a reality, although in the case of many species the realisation is complicated by many peculiar conditions. Here too the movement of the waves, or the current of rivers, supplies the place of the winds of heaven, and effects an union which would otherwise be impossible between individuals which are fixed like plants to the soil on which they originated.

We may, however, instance a very remarkable difference between animals and plants in respect to the relations which we have been considering. Among the former, the sexes may generally be recognised throughout the whole of life, by external or internal characters. This is not the case with plants. The male and the female date-tree grow side by side, and exhibit no difference until the moment when the appearance of the flowers reveals their different characteristics. In the animal kingdom, the Syllis presents us with a similar fact. At ordinary times we find only individuals which are in no way distinguished from one another. But no sooner has the season of reproduction arrived, than like the palm-tree, which throws forth its flower, the Annelid produces new parts, which are added to the older organs, and which alone assume the characters essential to the two sexes. Thus in the case in point, the tree and the animal are alike neuter up to a certain period. At a subsequent epoch we find the tree manifesting its sex by the appearance of flowers, the animal by the production of a secondary individual, which may therefore be regarded as a veritable animal flower, appearing on the primary stock.

Let us pursue this curious parallel, and see what mode of production already observed in the vegetable kingdom may be compared to that which we have found to exist in several of the Medusidæ.

Every one is acquainted with the *Agaricus campestris*, that mushroom which is artificially propagated to supply the great quantities which are

employed in Parisian cookery.* The entire vegetable is not eaten, but simply that portion which

* The ancients were acquainted with several different processes for artificially multiplying the edible Mushrooms. Menander tells us that one of these methods consisted in covering a shoot from a fig-tree with manure, and watering it frequently. According to Tarentinus, the same result may be obtained by keeping the ashes of vegetables in a constant state of humidity, at the same time that they are exposed to the action of the air. Dioscorides assures us that Mushrooms may be obtained by scattering the powdered bark of the poplar-tree over a well manured soil, and Tarentinus informs us that the poplar Mushroom (*Agaricus umbellicatus*), which was named Ægerita by the ancients, could be rapidly propagated by watering offshoots of the black or white poplar with wine and hot water. The ancients seem also to have been well acquainted with the artificial Mushroom beds, such as are so extensively cultivated in the neighbourhood of Paris.

The Mushroom which is chiefly propagated in France in these artificial beds is the *Agaricus edulis*. but different species are procured in other countries by somewhat similar means; thus Rumphius informs us that two kinds of edible Mushrooms, both belonging to the genus Boletus, are procured at Amboyna by different artificial processes; the former species (*B. Moschocaryanus*,) sprouts from the decayed outer shells of the Nutmeg, and is so scarce that it is only met with at the tables of the rich; while the other (*B. Saguarius*), which springs up from the decayed wood of the Sago palm (*Sagus farinacea*), collected together for the purpose, is so abundant, that it is employed for fattening pigs. A few years ago, a new species, the Naples Mushroom (*Agaricus Neapolitanus*), was accidentally discovered, and since then has spread rapidly over different parts of Italy. It had been the habit with the nuns of a convent in Naples to throw into the shady corner of their garden the coffee grounds remaining after each day's meal. A new Mushroom was observed to have shot up from these substances while in a state of fermentation; on tasting it, it was found to be excellent, and from that period it has been customary in many houses at Naples to cultivate this Mushroom by collecting coffee grounds in an unvarnished flower pot, which is kept constantly moist, and in the shade. It is found that the Mushrooms shoot up from this soil in about six months.

may in some degree be regarded as the flower of a singular production, known in botany by the name of *Mycelium.* This production is composed of a number of very fine filaments forming a kind of network, on which is developed the fleshy substance, vulgarly known as the mushroom. Now the Mycelium of an isolated Agaricus bears considerable resemblance to other vegetable productions, and to those kinds of mould or *mucor* which are formed upon decayed wood in damp and dark places. Botanists, however, seeing that they were propagated without any change of form, divided them into special groups, one of which is named *Mucedinæ.* Some years ago, however, it was discovered by M. Dutrochet*, who

* Dutrochet, a member of the Institute, was born in 1776, and died at Paris in 1847. He did not devote himself to science until a comparatively late period of his life, when happening by accident to procure the works of Spallanzani, he was so deeply impressed by the value of the labours of this illustrious physiologist, that he resolved, if possible, to follow in his steps, a resolution which he immediately put into practice by directing his attention to the Rotifers, and to the singular faculties which we have already described in them. He then successively investigated the different membranes of the fœtus, the development of birds, the formation of bone, the regeneration of feathers, &c. In the midst of his researches, he, for the first time, was led to consider phenomena, which, although they had already been seen by others, had either been neglected or forgotten. M. Dutrochet, fully comprehending the importance of these phenomena, studied them with much attention, and soon obtained general results, which led him to the discovery of Endosmosis — a discovery which he made known in 1826, and which will immortalise his name.

Up to that period, the rising of the sap in the tree, as well as the passage from one cavity into another, of the different liquids contained in plants no less than in animals, had been attributed to

was especially distinguished for the success with which he was enabled to arrive at great results through the observation of minute phenomena, that under the influence of certain circumstances, a well characterised mucedina may produce an agaricus, which at first sight seems as remarkable as if we were to see an oak sprouting from a bramble.

Here the resemblance to the Medusæ is most remarkable. From the bands, which are disposed under the head of the mushroom, a spore or reproductive body is discharged; in the same manner as in the Medusæ, the ovary, which is placed below the umbrella, throws off an ovum which becomes converted into a ciliated larva. This larva, attaching itself to some substance, produces a polypary, in the same manner as the spore through its development gives birth to a mycelium. This product, if subjected to certain conditions, will maintain its original form, and will merely throw off branches in the same manner as the polypary will produce polypes. Both may, moreover, be reproduced under this form, either

capillary action, or to imbibition. Although these explanations were found to be incomplete and vague, no better ones had as yet been offered. M. Dutrochet now showed that when two liquids differing in nature and in density are separated from one another by a thin membrane, there is developed in this membrane a special force, which causes one of the liquids to pass through it; and he further showed that this phenomenon continues until the equilibrium is more or less completely reestablished between the liquids which bathe the two sides of the membrane. He called this force *endosmose* when it caused the liquid to flow into the apparatus which served for his experiments, and *exosmose* when it tended to expel it. Fundamentally, however, these forces are identical, and they may both be designated under the name of endosmose.

by adherent or free gemmules. Deceived by these appearances, naturalists would lose the trace of their origin, and isolate them from the Agaricæ or the Acalephæ; but let the conditions be changed, and the mycelium ceasing to appertain to the Mucedinæ will produce an agaricus, and the polype will engender a medusa.* Now, if the mushroom is nothing more than the floral organ of the mycelium, we are quite justified in concurring with the opinion enounced by M. Dujardin, that a medusa is the animal flower of a polype.

Nothing would be easier than to multiply these examples, and to furnish additional proofs of the fact, that in the different processes by which the duration

* The observation of this fact in reference to the Medusæ is due to M. Dujardin. For several years this observer had kept Algæ with several of the lower marine animals in vessels of sea-water. In 1841 he observed a small Zoophyte attached to the walls of one of his glasses. This beautiful polype, which I have several times had the pleasure of observing, was allied to the *Syncorina* and designated by M. Dujardin by the name of *Stauridia*. It consists of a transparent tube, adhering to the sides of the vessel, and throwing out in different directions its branches, which terminate in a polype-like body having four arms arranged crossways. For fifteen months M. Dujardin had seen these Stauridias multiply by budding, when he one day perceived that some of these buds presented an unusual appearance. He watched their development, and had the pleasure of seeing them change into beautiful little Medusæ, which, after being detached from the common trunk, successively acquired several organs, in which they had previously been deficient, amongst others, those which were destined to serve for the reproduction of the species. M. Dujardin has given to these Medusæ, the name of *Cladonema*, and he has since extended his researches to other species. (See the Memoirs of M. Dujardin on the Development of the Medusæ and the Hydroid Polypes in the *Annales des Sciences Naturelles.*)

of species is secured, both in the animal and vegetable kingdom, nature, to a certain extent, recopies herself. Following in the steps of all zoologists who have studied polypes, we might instance those animals which are reproduced after the manner of plants by gemmules, shoots, or bulbs. On the other hand, we might learn from M. Adolphe Brongniart how the granulations of the *fovilla* are agitated by such violent movements as to deceive even the most experienced observers. MM. Decaisne*, Thuret†, and other botanists might show us how the fecundating corpuscles of certain of the lower orders of plants borrow one of the most essential characters of animality, and move by the aid of vibratile cilia in

* M. Decaisne, a member of the Institute, and professor at the Jardin des Plantes, has published, amongst other works, some very important researches on the reproductive organs of the Fuci. He was the first to show the error of regarding as animals those corpuscles provided with flagelliform filaments which in these plants play the same part as the pollen in organisms of a higher class in the vegetable kingdom.

† M. Thuret, who has made some extremely curious observations on the reproduction of the Algæ, has discovered the existence of vibratile cilia which give motion for several hours to the spores of different Confervæ. His later communications to the Academy on the fecundation of the Fucaceæ contain several important facts, which led to the establishment of relations of affinity between the two kingdoms of nature, even in respect to the mechanism of fecundation. M. Thuret was the first who attempted to effect artificial fecundation in these plants, from which he obtained several hybrids. These labours, together with those of several German botanists, show every day more and more how unfounded are the opinions that have been frequently advanced, in reference to the transmutations experienced by certain organisms, which, lying upon the confines of the animal and vegetable kingdoms, have been supposed to pass alternately from the one to the other.

the same manner as Infusoria; and finally we might instance those spores of the freshwater Algæ, true *vegetable larvæ*, which, before they become finally fixed, move freely about in the glass in which we are observing them; thus appearing to realise the metamorphosis of an animal into a plant. We should thus observe the gradual disappearance of all those well-marked differential characters by which our predecessors in their imperfect knowledge attempted to fix the limits of the two kingdoms of nature, and we should find that all such distinctions vanish, not excepting even those derived from chemistry, as has been proved by M. Payen's * curious analyses of young tissue, and by the remarkable phenomena which accompany the fecundation of the Arum. †

* M. Payen, a member of the Institute and professor at the Conservatoire des Arts et Métiers, is one of our most distinguished chemists, whose name has become popular in consequence of the practical utility of the greater number of his works. In the memoir to which we have referred, M. Payen shows that at the moment of their first appearance, the young vegetable tissues are fully as nitrogenous as the animal tissues, and that it is only in growing older that they become overcharged, so to speak, with carbon. It had hitherto been supposed that one of the essential differences between the two kingdoms consisted in this—that nitrogen predominated in the chemical composition of animals, as carbon does in the chemical composition of vegetables; it is obvious, however, from M. Payen's researches, that this idea must now be abandoned.

† Lamarck and Bory de Saint-Vincent were the first who drew the attention of naturalists to the development of heat which accompanies fecundation in several species of the family of the Aroideæ, and this phenomenon has been studied with much care by several observers, and amongst others by Beck and Bergman. These experimentalists have observed in certain cases that the temperature of the Spadix rose to 109° 4′ Fahrenheit, whilst the surrounding air stood at only 70°. In the *Arum cordifolium*, the

It is impossible not to recognise in this uniformity of action the influence of one sole and constant cause. Considered from this point of view, life, or that mysterious force which alike animates the alga and the oak, the infusorium and the elephant, becomes manifest to us as a universal cause, whose intimate nature eludes our search and escapes our grasp, but which, appreciable through its characteristic phenomena, remains always and everywhere the same in its essential nature, notwithstanding the infinite variety of its manifestations.

temperature of the flower rose to 120°, while that of the external air was only 66°, and consequently the flower had a temperature of its own of 54°. This phenomenon seems to be more especially developed in the male flower. Whilst the temperature rises, we also find that the respiratory process, which we observe in all flowers, at the same time acquires an exceptional degree of energy. All the different parts absorb large portions of oxygen, and exhale a corresponding quantity of carbonic acid. The phenomena which we have here indicated have been principally studied in the *Arum vulgare* and *cordifolium*, but they have also been noticed in many species of the same family, and the reason of their not having been elsewhere observed, may undoubtedly be owing to the fact, that the heat thus produced is too feeble to be perceived by our unaided organs.

We must further observe that several other equally remarkable circumstances are often associated in vegetables with the important act of fecundation. Such, for instance, are the spontaneous movements which we observe at this time in the stamens of the Nettle, the Pellitory, the Rue, and the Barberry-tree, and in the stigma of the Cactus, Passion-flower, &c.

CHAP. V.

THE COASTS OF SICILY.

TRAPANI. — THE ISLANDS OF FAVIGNANA.

Journey to Trapani. — The ancient splendour of that city. — The doves of Venus Erycina; the women of San-Juliano.—Departure for the Islands of Favignana. — Cordial reception. — Geological structure of the islands. — Cultivation of the land and sources of industry. — Tunny fishery. — Researches on the circulation. — Independence of functions.—Progressive perfection of organisms. —Phlebenterism. — The labours of M. Edwards, and my own researches. — The opposition which these labours at first experienced.—Applications.— General consequences.

THE rain, cold, and wind, which had met the *Santa Rosalia* on her arrival at Santo-Vito, still continued. We found it almost impossible to pursue our labours in our windowless rooms; and our explorations among the rocks, which were incessantly washed by the waves, became every day more difficult and less successful. We therefore found it necessary at once to seek new quarters. This time we determined to proceed by land; and whilst our boat was contending, under the able command of Perone, against the rough gales that continued to blow from the west, we, in the prosecution of our land journey, were following a mule track which, winding along the extreme edge of the rugged mountain side, never deviated far from the sea, excepting when the over-

hanging rocks made it necessary to traverse the barren heath which skirted along the beach. A few hours' march enabled us to reach the sandy tongue of land at the extreme point of which rises Trapani; but the rough gait of our mules and the uncouth apparatus which served us in the place of a saddle seemed to double the distance. The feeling of intense enjoyment with which we took possession of the not over-soft beds of the Albergo di Napoli will be readily understood by every one who, like ourselves, had been shaken all day long on the back of a Sicilian mule, or had slept, as we had done, for a month past, between a plank and a sailor's capè.

Placed at the extreme western point of Sicily, and possessing a tolerably good harbour, Trapani, with its 30,000 inhabitants, still enjoys a certain degree of importance. One may easily see that this town has known better days. Here, as in all the cities of the western part of Sicily which we had already visited, there still remained mournful vestiges of former splendour which had long since given place to misery. Grass grew abundantly in the broad straight streets; on every side were palaces now in ruins, scarcely able to afford shelter to the few beggars who had appropriated them. Trapani is rich in such contrasts between the past and the present. We were especially struck by the remains of a palace which had been erected by William de Porcelets, the only one of all the French nobles whose life was spared in the massacre of the Sicilian Vespers.* The walls are covered, from the base-

* William de Porcelets was lord of Calatafimi and governor

ment to the cornices, with sculpture; everywhere trophies and statues are interspersed amid the armorial bearings of this proud family, whose cognisance was a boar and an eagle. The only part of this once princely residence which is still occupied is the ground floor, now used as a stable.

Built upon the site of the ancient Drepanum Trapani has not preserved any remains of Greek, Carthaginian, or even Roman architecture; the Temple of Venus, which was situated at about three miles from the town, on the summit of Mount Eryx, has been successively replaced by a Saracenic fortress, and by the convent of San-Juliano; but if the works of man have disappeared from this corner of the earth, where once the most powerful nations of bygone times were brought in contact with one another, nature has ever remained the same. Facing the harbour, we still behold the same rock described by Virgil, which served as the goal for the boat-race which formed part of the funereal games celebrated in honour of Anchises. This rock is called *la Colombara*, and, as in the time of Venus Erycina, it still serves as a meeting-place for the doves of the region at the periods of their annual migrations.

of the town and castle of Pouzzoles at the time of the massacre. He owed his safety to the justice and loyalty with which he had always treated the conquered Sicilians. These virtues, as well as courage, were, moreover, hereditary among the Porcelets, for the grandfather of William had saved the life of Richard Cœur de Lion, and had inspired the Saracens with so much confidence, that they refused to treat with the crusading princes until they had received his guarantee of good faith, and we find in history frequent other references to the chivalric character of this family.

These birds, which the zeal of the Christian Neophytes vainly attempted to banish from the country, have maintained their old habitats, and defying in the present day the shot of the sportsman, as in the middle ages they defied the thunders of excommunication, they still come year by year to build their nests among the grottoes and the rocky recesses which abound along the shore.

For the rest it would almost seem, as if to spite the saint who had thrown down her altars, the Goddess of Beauty still continued to shed her favours over the land which had once been consecrated to her worship. The women of the village of San-Juliano, which is built on the ancient Mount Eryx, have the reputation of being the most beautiful in the land of Sicily. Admitting that such is the fact, we might perhaps discover a natural explanation of this circumstance in that transmission of generic characteristics, to which man is no less subjected than the lower animals. The priestesses of the Erycinean Venus, who were no vestals, were selected with much care from amongst the loveliest maidens of Greece, Sicily, and Italy. This choice source of origin would, most probably, in the course of ages, diffuse some of its elements of beauty among the neighbouring tribes; and this circumstance can hardly have failed to influence their physical development. We are therefore probably not wrong in conjecturing, that the superior charms of the women of San-Juliano still afford evidence of this origin, by an impress of beauty which has defied the action of time.

We were doomed to experience at Trapani the same disappointment which we had already felt at Castellamare. A single glance sufficed to show us that we had nothing to hope from the bare and rugged rocks which bounded the town to the north; and still less, perhaps, from the immense salt marshes situated to the south, which were then being worked with extreme industry. We at once determined to try our luck elsewhere. The ancient Ægades, now known as the Islands of Favignana, were situated at about nine miles distant; and, owing to the transparency of the atmosphere, we were actually enabled with the naked eye to trace the rocks and the deep indentations of the coast line which were indicated on our charts. This little archipelago promised to afford us all the conditions which were most favourable to the prosecution of our researches. A cursory examination confirmed these conjectures; and, as soon as the *Santa Rosalia* joined us, we lost no time in embarking, hopeful of better success in this new station.

Lying altogether out of the ordinary routes, and possessing scarcely any sources of commerce, the Islands of Favignana have very rarely been visited by foreigners. From time to time they had been visited by some Englishman who was engaged in buying up Sicilian wines, but no Frenchman had landed upon any of the islands within the memory of the oldest inhabitant. It may, therefore, be easily understood what an immense sensation was produced on the arrival of letters from the Dukes of Serra di Falco and of Cacamo, which announced the

speedy coming of three French naturalists, who were specially recommended to the good offices of those in authority. Even on the occasion of the short excursion which I had made to the islands in order to reconnoitre the locality, I had been received with marked attention. Signor Gaspardo, chief of the Quarantine, had come with great ceremony to receive me. His father, Signor Bartholini, one of the principal people on the island, had entertained us most liberally at his house; while Signor Georgio, the Commander of Fort St. Catharine, had freely placed his country house at the disposal of the *scienziati francesi*, to whom it would naturally form a most convenient abode, owing to its being situated close to the sea side, at about three miles' distance from the village.

We landed in a small bay facing our future residence, where we found a crowd of workmen busily employed in rendering it worthy of its expected occupants. Some were rubbing down the walls, whilst others were whitewashing the three apartments which were destined for our use. The wife of the Commander of the Fort, surrounded by three or four maid-servants, was actually herself engaged in the labour of pouring buckets-full of water over the cracked bricks, which formed the flooring of the rooms; whilst her handmaidens were scrubbing away with all their might. Our sudden arrival produced very much the same effect that one might suppose would follow on throwing a stone into an ant-hill; there was a perfect confusion of cries, exclamations, and interjections, ending in a torrent

of excuses for not being ready to receive us on our arrival. The signora left her pails in haste and rode away upon a donkey, which, after an absence of two hours, returned laden with mattresses, blankets, and pillows. A set of kitchen utensils and a ready-cooked dinner also arrived by the same mode of conveyance, and were, as may easily be conceived, not the least welcome part of the supplies. We, in the meanwhile, had not been idle; for we had spent this two hours' interval in landing our instruments and other apparatus. As a large piece of enclosed land lay between us and the beach, we had to make a considerable détour before we could reach our boat. The Commander of the Fort at once perceived the great inconvenience to which this exposed us, and without a moment's delay he gave orders for knocking down a portion of a wall, and thus opened to us a direct passage across his vineyard. I am bound to admit that the wall consisted only of a heap of dry stones, which were generally adjusted every evening; still we may question whether many proprietors in our own country would have been equally ready to take measures for saving a guest from any inconvenience of this kind.

It must not be supposed, however, that this liberal and magnificent way of treating strangers was wholly disinterested. The Sicilians with whom we were thus brought in contact, while they placed themselves unreservedly at our disposal, *per l'onore*, as they themselves would express it, do nevertheless count a little upon the *complimento* which they may receive in return. In these districts, in which no

traces of the usages of modern civilisation seem as yet to have penetrated, and where one does not even meet with anything like the *posadas* of Spain, the stranger receives, it is true, the hospitality of an ancient form of manners, but it is with the understanding that it shall be acknowledged by some equivalent or other. He who entertains looks for a return for his hospitality, and he is apt to take it in very bad part if his guest should in this particular deviate from the ordinary usage. We had occasion to appreciate this condition of things on our departure from Favignana. Having set forth with the idea that travelling in Sicily would be very much the same thing as travelling in France, we had neglected to provide ourselves with such articles as might appropriately be offered as parting gifts. At Torre dell' Isola and at Castellamare we had managed very well in acquitting ourselves of all obligation through the simple payment of money, which had been received without the slightest scruple both by Padre Antonino and by Artese's friend, but we dared not attempt a similar mode of acknowledgment in the case of the Signori of Favignana. We left them, therefore, with purely verbal thanks; and, at the moment at which we were bidding him adieu, the Signor Georgio found it impossible to conceal the vexation he felt in perceiving that our gratitude was expressed in mere words. We took care, however, on a future occasion to prove to him that his guests had neither been forgetful nor ungrateful recipients of his attentions.

The obliging hospitality of our Favignana friends

speedily enabled us to commence our researches in the little archipelago of the Ægades, which had never yet been visited by any naturalist. The field which was thus opened to our explorations consisted of some naked rocks, forming so many islets, and three principal islands, Favignana, Levanzo, and Maritimo. We thought it would be of no use to extend our excursions as far as the two latter of these; for Maritimo was too far distant, and Levanzo was entirely formed of calcareous rock, which rose in abrupt mountains, and was so completely devoid of all vegetation that it could not support many terrestrial species. We were, moreover, well acquainted with the nature of this rock; for we had always found it associated with Caryophyllia, the presence of which, as I have already remarked, invariably indicates great poverty, when considered from a zoological point of view. We did not, therefore, waste any time in examining the coasts of either of these islands; one of which is entirely deserted, while the other has no inhabitants beyond the few men who garrison the small fort, and work the telegraph which is situated on the island.

Favignana, moreover, was in itself sufficient to occupy the whole of our time. Larger than either of its sister islands (for it measures about twenty miles in circuit), it also presented a much greater variety in its geological constitution. Its central part is entirely occupied by a range of mountains, similar to those of Levanzo, and about 1000 or 1200 feet in height. The highest point of the range is occupied by Fort St. Catharine, a state prison, which

during the different revolutions of Naples has acquired a mournful celebrity. To the east and west of the island, the calcareous rock underlies a stone of a very different character and known to geologists as Palermo limestone. This stone, which is soft and friable, is almost entirely composed of the fossil remains of the lower animals. On making an examination with a microscope, or even with the naked eye, we discover an incredible variety of zoophytes, an infinite number of sponges, and many different kinds of Polyparies. A cubic foot of this stone would in itself afford materials for an entire collection, and if the sea with its living population had not absorbed all our time, we should certainly have possessed ourselves of many highly interesting samples of this rock. In the midst of these fossil remains, which are very small and sometimes even microscopical, belonging, as they do, to the lowest representatives of animality, we find scattered here and there the remains of sea-urchins and of star-fishes, and the shells of oysters and pectens; but these animals, which were at once more elevated in the scale of being and of much more considerable dimensions, constitute only a very small part of the materials which enter into the composition of the rock. In this respect the limestone of Favignana affords another proof of a very general but most remarkable fact. When we examine the animal remains buried within the strata of the earth's crust, in the hope of tracing the history of the past, we cannot fail to recognise the important part which has been played in the geology of our globe by animals, whose significance in this respect

seems to bear an inverse proportion to their size and the degree of development manifested in their organisation. The higher animals, or, in other words, those in which the animal machine had arrived at its highest degree of perfection, have left but feeble traces of their existence. We know of only three or four cases in which osseous debris have been found to contain the remains of the Monkey tribe, while in the case of Mastodons*, Elephants, and even gigantic Reptiles†, very few perfect skeletons have been found; and science has therefore gratefully treasured the isolated fragments of their remains which from time to time have been brought to light. The inferior animals, on the contrary, have contributed most materially in forming the solid crust which we inhabit. In the case of certain mountains, more than half their structure consists of shells, whilst some entire strata are exclusively composed of infusoria, which are so infinitely small that hundreds of their carapaces crumble into dust beneath the point of a needle. The study of these inferior beings, which is so important to the phy-

* [A note on the Fossil Remains of the Mastodon is transferred to the Appendix, Note XIV.]

† The Reptiles preceded the Mammals on the surface of the globe, and they were present in a highly developed state during the secondary period. Among the species then existing, several possessed very strange forms; amongst others we may instance the Plesiosauri, which lived in the water, and had the body of a lizard, with a serpent's head on a very long neck; and the Pterodactyli, which flew like bats, by means of a membrane, supported by one of the digits of their anterior members, &c. Many of these species were of very large size; some of them being, according to Cuvier, upwards of fifty feet in length.

siologist and the zoologist, is not the less suggestive to the geologist of the gravest subjects of meditation.

The loose and porous structure of the Palermo limestone permits rain-water to accumulate within it, as in a sort of sponge, and thus provides the thin stratum of earth covering the rock with the humidity necessary to counteract the effect of the longest droughts. These waters, the further course of which is stopped by the more dense limestone whose strata form the basis of the whole island, combine to form subterranean reservoirs, which feed a large number of wells and inexhaustible springs. On this account the cultivation of the island is concentrated upon the points occupied by this beneficent rock, which alone prevents Favignana from becoming, like Levanzo, a dreary and uninhabitable desert.

The capital of Favignana is situated nearly in the centre of the island, on the side of a small harbour, which penetrates far inland. It contains from 300 to 400 tolerably well-built houses, and numbers about 3000 inhabitants, who appeared to us to enjoy a degree of general prosperity unknown in the villages of the coast. But although a state of general competency seemed to prevail amongst this isolated population, it appeared to us to be very deficient in other respects; and we observed amongst the inhabitants, various customs which showed significantly enough that they were still in the infancy of civilisation. One instance will suffice by way of illustration. There is no public clock at Favignana, and it seems that no

better method had suggested itself for supplying this deficiency than to charge a man with the accomplishment of its functions. This person, who took up his abode in the keep of one of the fortresses which defend the village, warned his fellow-citizens of the march of time by striking the hours with a hammer on a bell. A sand hour-glass served him by way of indicator. As may readily be conceived, this animal machine was very easily put out of order, and we had more than one opportunity of convincing ourselves that, in point of regularity, the man-clock of Favignana was very inferior to one of Breguet's chronometers.

The number of the population is almost doubled by that of the garrisons of the three forts, by that of the officials of the custom house and quarantine, and above all by that of the convicts who are incarcerated within the prisons of Fort St. John — those terrible dungeons, which, together with the cells of the ordinary prisoners, are deep excavations hollowed out of the rock, and from which escape is almost impossible. The greater number of the unfortunate beings confined here were expiating the crimes of murder, or of theft accompanied by violence; their number during our stay amounted to nearly 2000.

The products of Favignana are very limited, and quite inadequate for the maintenance of the inhabitants. The land immediately round the town is more fertile than in any other part of the island, and is generally enclosed in gardens, in which grow excellent vegetables, together with magnificent

orange, lemon, and pomegranate trees.* In the eastern part of the island we met with a few cornfields, but with that exception the soil seemed to be abandoned to vineyards and some plantations of cactus, a plant which may be said to mark the limits of vegetation. There are only a very few horned cattle to be seen on the island, and hence Favignana is obliged to supply her population with meat, oil, and cereals from abroad, in exchange for which she gives her wines. Being entirely without manufactures, she is obliged to obtain from foreigners, not only articles of luxury, but even many of the necessaries of life. To judge by the samples which fell under our notice, France and England would seem to share in the office of provisioning this remote corner of the globe, where the two countries are to a certain extent represented by their productions. Everything that relates to the material wants of life is of English origin; knives, forks, dinner-services, all bear, with few exceptions, the name of London. Everything akin to elegance, everything that can call up an idea, has come to Favignana from the provinces of France, if not from Paris. The chimney-pieces were adorned with our porcelain vases, the walls were hung with our papers, and

* The pomegranate tree (*Punica granatum*) is a native of Mauritania, from whence it was imported by the Romans at the time of their wars with Carthage. This tree was cultivated by them with much care; and while we are only acquainted with three varieties, the Romans at the time of Pliny possessed as many as six, one of which called *Apyrenum*, bore fruits containing seeds without pips.

everywhere our eyes encountered engravings of the Rue Saint-Jacques, of Napoleon, his marshals and his battles.

The inhabitants of Favignana are not the proprietors of the lands which they cultivate; for the entire archipelago is the property of a noble Genoese family, the Palavicini, who rarely visit this maritime fief, which they govern through the agency of a steward. I do not know what the rents may be which are derived from the cultivation of the soil; but they cannot be very considerable, and the proprietor, no doubt, derives the greatest part of his revenues from the produce of the sea. The lords of Favignana have the exclusive right of fishing over a very large tract of water; while, of course, they have the entire monopoly of the produce of the archipelago, and these rights derive great value from the vast shoals of the tunny which frequent these seas. It is well known that this fish appears every year in immense numbers in the neighbourhood of Gibraltar, where they separate into two columns, one following the shores of Africa, whilst the other makes its way along the coasts of Europe. The successive appearance of these shoals in different localities, and their inexplicable disappearance on the approach of cold weather, led for a long time to the belief that they made actual migrations, similar to those of birds. In this respect the tunny resembled the herring and the mackerel, which had at all times been regarded as migratory fish; but M. Valenciennes having confirmed by personal observation the doubts which had already been ad-

vanced in reference to this point by Lacépède and Noel de la Moriniere, showed that these pretended voyages had really no existence. Neither the tunny nor the herring leaves its native country. The fact is, however, that during winter, they seek shelter from the cold at a depth to which no net can reach, and when the sun has warmed the surface of the sea and their season of reproduction has arrived, they leave those abysses of the deep, and approach the neighbouring shores, in order to deposit their eggs in warm and shallow waters.

At all events the tunny is undoubtedly a source of wealth to the shores which it frequents. Either fresh, salted, or smoked, it is an object of commerce, which annually leads to the circulation of thousands of thousands, and hence this fish has at all times been the object of remorseless pursuit. Aristotle, Pliny, Athenæus, and Oppian, have all transmitted to us details of the different methods employed by the ancients for its capture. Since then, every age and every people seem to have furnished their contingent of murderous inventions. The most formidable means devised for capturing this unfortunate fish is undoubtedly the *madrague,* which is said to have been first employed by the inhabitants of Martigues. This apparatus is not merely the *libouret* of the Bayonnese or the grand *couple* of the Basque fishermen, which are gigantic lines carrying many hundred baited hooks, and which are worked by a boat's crew of eight or ten men ; nor is it like the *courantille* of the Provence fishermen, for this contrivance is merely a kind of *seine* from 1500 to 2000

feet in length, which is often thrown over a space measuring more than six or eight miles across. The *madrague* is an actual park, with its walks and alleys all terminating in a vast labyrinth, composed of chambers, which open into one another, and all of which lead to the chamber of death, or the *corpou*, which is situated at the extremity of the structure. This vast enclosure, the walls of which sometimes extend upwards of three miles, is both secured and raised by means of immense lines and nets weighted with stones, supported by cork buoys, and secured with anchors in such a manner as to resist the most violent storms to which it would be exposed during the usual fishing season. It may easily be conceived that the materials constituting an apparatus of this kind, are of enormous size and bulk; on this account a steam-boat is chartered every year to convey the entire apparatus from Palermo to Favignana. The arm of the sea which lies between this island and Levanzo is peculiarly well adapted for the establishment of a *tonnara*, as the Sicilians call it, and the right of fishing in this locality alone is valued at 60,000 francs.

When first we arrived at Torre dell' Isola, we saw this steamer on her way to Favignana, and from that time, till we landed on the island, men had been continually at work in fixing the *madrague;* it was now completed, and some tunnies had already been seen within the first compartments of the apparatus. We had a great desire to witness one of these fishings, of which Joseph Vernet's picture gives a tolerably good idea. The reports of our

own sailors, whose eyes sparkled at the very mention of the word *tonnara*, had increased our anxiety to be present on one of these occasions, which are regarded by the inhabitants of the Sicilian islands in the light of festivals. Signor Bartholini kindly undertook to inform us of the time at which we were to hold ourselves in readiness to join the other boats engaged in the fishing, and we lost no time in obeying his directions. One morning on looking out, we saw that flags had been raised on every elevated point of the island to serve as signals for calling together the fishermen of the neighbourhood to take part in the *tonnara*. Scarcely any, I believe, failed to appear at the common rendezvous. Every bark between Trapani and Mazara had hoisted her sails, and by the break of day, far as the eye could reach, the sea seemed to be covered with a moving fleet of sailing boats, whose hundred broad lateen sails, converging to one and the same point, presented the most picturesque appearance. The Santa Rosalia was soon in the midst of this numerous flotilla; and by the energetic efforts of our sailors, whose strength and activity seemed to be doubled for the occasion, we reached the *madrague* in good time to follow all the scenes of the sanguinary drama which was about to be enacted.

If any of our readers should deem these expressions exaggerated, we would beg them to come and judge for themselves, and embark with us on board one of those large boats which, in the midst of the sea, have combined to enclose a space of about one hundred square feet. Between 500 and 600 tunnies,

impelled from chamber to chamber by the valves which close behind them, have at length reached the last compartment, or the *chamber of death.* This enclosure is provided with a movable floor formed of netting, which can be raised from the bottom to the surface of the water by means of ropes. All night long men have been labouring to lift the huge apparatus, little by little, and now each of its margins rests upon one of the sides formed by the boats. Facing us is the proprietor of the fishery, surrounded by his staff and by a charming group of ladies, who have come from Palermo to witness the spectacle which is about to be exhibited. To the right and to the left are stationed the two principal boats, which convey the band of fishermen. These boats, which are entirely empty, lie ready to receive their cargo, the only thing that breaks the even line of their decks being a long beam, which passes from one extremity to the other, and leaves a narrow sort of gangway on the edge of the boat, where stand at least two hundred fishermen, who have come, in some cases, from a distance of more than fifty miles to take part in this exciting sport. Half naked, with deeply-bronzed limbs, these athletic men stand side by side, all awaiting, with the same eager impatience, for the moment of action. Their eyes are sparkling beneath their scarlet Phrygian caps; their hands are grasping the instruments of death—broad, sharp, and cutting hooks, which are either inserted into a long pole, or fitted to the end of a short, massive handle, which is deeply cut to enable the hand to obtain a firmer hold of the weapon. In the midst of the

enclosure, a little black rowing boat manned by two oarsmen contains the master-fisherman, from whom emanate all orders, and who is ever at hand to encourage and lead on the workmen, or to carry reinforcements from side to side, as they may be needed.

During all this time the capstans, which are fixed at the extremities of the net, have never ceased turning; and as the moving floor of the *corpou* gradually rises, the tunnies begin to appear, and on looking through the transparent water we see the fish darting uneasily from one side to the other of the vast enclosure in which they are imprisoned. Some of them rise to the surface or even spring out of the water; but woe be to those who rise near one of the boats, for no sooner does the fish appear than hands of iron are stretched forth to bury their sharpened points in its sides. Even though they may be wounded, the fish generally escape from the first attack; for being full of life and strength, and in the enjoyment of entire liberty of motion within the large basin that encloses them, they tear themselves from the hands of their enemies, leaving only a few bleeding shreds of flesh attached to the hooks; but still the capstan turns remorselessly to the modulated songs of the sailors, and the net rises higher and higher. The master-fisherman is always at hand in his little boat to drive the tunnies towards the edges of the net; wounds are now dealt on every side; and soon some fish, more deeply struck than his companions, slackens his course, showing from time to time his broad silvery sides, along which the black blood is streaming forth. At every new stroke his

resistance diminishes, and soon the victim pauses for an instant; but that instant is enough; a dozen hooks are at once buried in his flesh, a dozen arms are bent to lift him to the surface of the water. In vain the skin has given way; each hook that loses its hold is raised on high only to be buried still deeper in the quivering flesh, and soon the unfortunate animal is drawn to the side of the boat; in another moment he is seized by two men, who each grasping one of his large pectoral fins lift him to the beam which is placed behind them, and throw him into the hold.

But the net is always remorselessly rising, and now the entire shoal of tunnies is exposed to view. Pressed close to one another, these monster fishes are throwing themselves in despair against the flexible walls of the *corpou*, at one moment showing their black yellow-spotted backs, at another moment cleaving the surface of the water with their large crescent-shaped fins. Here and there a few swordfish with their long pointed snouts may be seen interspersed among the tunnies. Animated by the sight of the victims which lie exposed to their attack, the sailors strike with redoubled force, and the fishing becomes a massacre. One can no longer individualise the separate actors in this drama; the serried crowd seems to be composed of nothing but violently moving heads, bleeding arms, which rise and fall, and harpoons which flash and cross one another as they are hurled against the victims. All eyes are sparkling, all lips are uttering cries of triumph, clamour, and encouragement. The waters of the *corpou* are tinged with blood, and every moment

another fish has been hurled across the beam; the dead and the dying lie heaped together in such vast multitudes, that the hulls of the boats are almost hidden beneath the load of their half-living cargoes.

After two hours of carnage symptoms of exhaustion begin to appear, the tunnies come but rarely to the surface, and at length their enemies begin to lose patience. A boat is then loosened from either side of the enclosure, and the two principal barks are brought within half their former distance of one another. The capstans are now again brought into play, the impatient fishermen all lend a hand, and now the hooks are inserted in the meshes of the net; but these efforts, which are somewhat irregular, do not at first produce any great results. Soon, however, the master-fisherman's whistle is heard: at once the men break into a song of measured rhythm, their movements become more regular, and pulling in unison with the words which they sing, the net is made to rise higher and higher. Soon it is almost on a level with the surface of the water, and now it is time to resume the labour in good earnest. The master-fisherman's boat now, for the first time, takes an active part in the labours of the day. Its crew of picked men pursue the tunnies within the narrow limits to which they are now circumscribed, and, striking them with long harpoons, urge them forward against the hooks which are projected from the boats, and which speedily secure them.

I must confess that this spectacle, which we had so anxiously desired to witness, left us melancholy and discontented, for we had been most painfully

affected by the exhibition of such wholesale butchery. Perhaps the impression produced on our minds would have been different if the fishermen had had a shadow of danger to encounter, or if the tunnies had been able to offer the slightest resistance in their struggles for freedom; and it seemed to us impossible to avoid feeling the deepest emotion in witnessing so unequal a strife, and in observing the mute anguish in which the convulsive movements of the victims were the only indications of the agony which was so wantonly inflicted upon them. It was quite different with our sailors, who were perfectly radiant with delight. As fishermen, they could only see and judge of things after the fashion of their calling, and the fishing had been superb. In three hours 554 fish had been harpooned, weighing on an average 176 lbs. Besides this, the chambers of the *madrague* still contained about 400 captives; the proprietor might therefore count, at the very beginning of the season, upon having caught about seventy tons of the tunny fish, which would, at the least, be equivalent to the sum of 43,000 francs (1720*l.*) Here then, in one fishing, nearly enough had been gained to pay the whole expenses of the *tonnara.*

A small island, in which every inch of productive ground has to be wrested from the naked rock, is necessarily not well adapted for the multiplication of independent animal species. For this reason, Favignana possesses hardly any animals beyond those which have been subjugated to the use of man, or which live at his expense, or which, from their in-

significance, are not made the objects of his pursuit. Here, as everywhere else, the dog and the cat share his dwelling, which, at the same time, affords shelter to the rat and the mouse. The ox, the horse, and the ass, aid him in his labours, but beyond these there are no mammals to be found on the island. Some of the slender-billed Passerinæ (*Motacilla* *), and a few little birds living upon grain, were hovering about the fields and amongst the orange groves; whilst magnificent falcons, which were formerly in great request for the noble sport of falconry, soared incessantly above the peaks of the most inaccessible rocks. Lizards, skinks, and the black snake, are the representatives of the class of reptiles, and lie concealed beneath the stones upon the beach. Insects buzz among the hedges or burrow round the roots of shrubs; but there are not many different species to be met with, and M. Blanchard very soon collected numerous representatives of each of them.

But while the air and the land were so deficient in animals worthy of interest, the sea afforded us ample compensation. In this respect Favignana more than answered our expectations, for no place could be better adapted for zoological investigations. In several parts of the island the two kinds of rocks of which we have already spoken, lay in juxtaposition to one another, within a few inches below the level of the sea, which, wearing away the limestone rock, had laid bare a more compact stone, the inequalities of which formed many recesses and small basins,

* [This family includes most of our smaller singing birds.]

which almost looked as if they had been hollowed out by the hand of man. Besides this, the waves, which had penetrated between the interstices of the two ranges of rock, too hard to be entirely broken through, opened a channel inland and gradually formed small grottos, which were sometimes partially vaulted over, and at other times wholly exposed and uncovered. Many of these cavities gave a miniature representation of the well-known phenomenon observed in the grotto of Capri. When our boat, lying at the entrance of one of these caves, intercepted the direct rays of light, they passed below our keel, and, being refracted in the crystal liquid, gave rise to the same effect as that produced by a prism, and bathed the rocks and the foam-crested waves in the richest azure tints.

We found at Favignana almost all the animals of which we had lost sight ever since we left Torre dell' Isola. The Medusæ and their kindred allies were, however, of much rarer occurrence, probably in consequence of having been carried away by some opposing currents. We met with only a few Alcinoës *, some large Beroïdæ, and an infinite number of Pelasgiæ. The recesses and the basins to which I have already referred were, however, unusually rich in all littoral species. The annelids especially presented numerous varieties. It was at Favignana that M. Milne Edwards found his Myriana, which bears a chaplet of six individuals united end to end in such a manner that the last of all has no other nourishment but the food which

* The genus Alcinoë belongs to the family of the Beroïdæ, of which I have already spoken.

has been previously digested by its parent, and its five brothers or sisters. It was also here that this naturalist entered upon a series of observations on the development of the annelids, to which we shall refer in the sequel. M. Blanchard continued his researches on the nervous system of the Mollusca, and the result of each day's labour seemed to reveal to him some new and unexpected complications. I. in my department, was fortunate in obtaining a profusion of Nemertes and of Phlebenterous Molluscs. We had therefore ample materials for work, and so thoroughly did we avail ourselves of our opportunities, that almost the only occasions in which our labours were interrupted, were when we chanced to receive a visit from some one or other of the islanders, who were desirous of verifying by their own eyes the accuracy of the reports which had been spread in reference to the marvellous powers of our instruments.

The researches on the circulation of the Mollusca which M. Milne Edwards began at Favignana, and continued during all the rest of our voyage, and the observations which I had been led to make on the same subject during my renewed investigations relative to the Phlebenterata, gave rise to very keen discussions, the report of which has even penetrated beyond the precincts of our academic circles. The facts under consideration touched upon such general questions and militated against such long-received opinions, that we could not expect they would be easily accepted. M. Milne Edwards in the introductory remarks at the head of the exposition of his

views, showed how certain results which at first sight seemed to be inexplicable, become easy of comprehension when they are judged by that principle of the *division of labour* of which we have elsewhere spoken.* I have also considered in many memoirs the questions which refer to this order of ideas. Numerous investigations were soon entered upon, and pursued in the same direction, both in France and in other countries, and the results which have been arrived at seem daily to confirm more and more the principles, or, to speak more accurately, the *tendencies* of this school of physiological zoology, which at its dawn met with so violent an opposition. We will endeavour to give a general and comprehensive idea of the facts established by it, and the consequences to which they lead.

We know that one of the principal differences which separates inorganic bodies from living beings, consists in the necessity for nutrition in the case of the latter. The mineral, when once formed, will, if placed beyond the action of external influences, endure for ever without suffering loss or gain. In the plant and in the animal, an incessant circulation of matter expels from the organism some of the elements which previously had formed a part of it. These elements require to be replaced by others, and to effect this is the end and object of nutrition. Four important functions, which are themselves accomplished by the aid of several secondary functions, concur in the accomplishment of this fundamental

* See Chapter II. on the Archipelago of Bréhat.

act—viz., digestion, which prepares the food; absorption, which separates the useless parts, isolates the essential principles, and causes them to penetrate into the organism; circulation, which transports these principles to all the points at which their presence is necessary; and, finally, respiration, which restores to the nutrient liquids, after they have been changed by their sojourn in the organs, the vivifying action by which they are characterised.

In the superior animals—that is to say, those in which the organisation acts in the highest degree of perfection—each of these functions is accomplished by the aid of special organs. The first naturalists who endeavoured to penetrate into the mysteries of the mechanism of life, directed their studies only to these complicated organisms, and, being forcibly struck by this fact, they declared that the function was at all times and in all cases *dependent* on the organ. In other words, that where no special instrument was present for the accomplishment of the function, that function could not exist. However rational this principle may appear to be, it is not the less a profound error; for we find that among the lower grades of the animal scale there are no distinct organs, and yet these animals feed and are nourished —that is to say, they *digest, absorb, and respire,* and plastic fluids *circulate* through all their tissues.

We will take, by way of illustration, one of those fresh-water Hydras so common in the neighbourhood of Paris, which were first recognised by Trembley, and to the study of which M. Laurent * has con-

* M. Laurent, formerly a Navy surgeon, who died recently

secrated two years of unremitting labour. This animal resembles the finger of a glove with its aperture surrounded by long, hollow, flexible, and contractile prolongations. These organs serve the polype like so many arms, enabling it to seize larvæ and other small aquatic animals, which are rapidly digested after their introduction into the cavity of the body. Let us take the moment in which it has just swallowed one of these larvæ, and, proceeding with caution, let us try to tear it away. Rather than relinquish its prey, the polype will suffer itself to be turned inside out like the finger of a glove, to which we have already compared it, when that which formed the exterior skin will become a membrane clothing the digestive cavity, and *vice versâ.* Yet the animal is none the worse for this; it will remain on the watch, seize and digest its prey precisely as it did before. Let us go still farther; let us cut this Hydra into twenty or thirty pieces, and still each of these fragments will continue to be nourished. They will soon begin to grow, and in the course of a few days we shall have twenty or thirty complete Hydras obtained by this apparently barbarous process.

With these incontestable facts before us we must admit, that in these simple beings the function is *independent* of the organ—that is to say, that each part of the body is equally adapted simultaneously to perform all the physiological acts; but it is at the

at Paris, devoted himself with much perseverance to the study of the lower fresh-water animals. We are also indebted to him for several curious observations on the embryology of some of the terrestrial molluscs.

same time evident that these different acts, being all accomplished at the same point, cannot be executed with the same degree of perfection as if each of them resulted from the action of a special instrument. We can, therefore, fully comprehend the full value of the principle which was developed more than twenty years ago by M. Milne Edwards, and which may be summed up in the following terms:—the successive degrees of perfection attained by the different organisms in the animal kingdom depend upon the extent to which functional labour * is divided.

An attentive study of the circulation, when considered in all its bearings, is well adapted to demonstrate the very suggestive nature of this principle; while at the same time it shows how it leads to the coordination of facts, which at first sight appear to be incongruous or even in direct antagonism. This function is effected in the higher animals by the aid of a very complicated apparatus, the principal parts of which have received the names of *heart*, *arteries*, *veins*, *lymphatics*, and *lacteals*. The heart sends the blood through the arteries towards every part of the body, from which this fluid is returned to it through the veins. The lymphatics convey to the same circulatory centre the *lymph*, which is a transparent liquid, exuding, if we may use the expression, from all the organs. The lacteals transport to the same centre the *chyle*, which is the immediate product of digestive absorption. These different liquids, which are enclosed in veritable tubes, follow with admirable

* I have already referred to these views in Chapter II., on the Archipelago of Bréhat.

regularity one invariable and determinate direction, during the whole life of the animal. It is not the same with the lower animals. Here, as we have seen in the instance of the Hydra, the circulation is often confounded with the other functions of nutrition. Between these two extremes, however, there must necessarily be many intermediate connecting links.

Even the class of Polypes presents some instances of progressive development. Let us open one of those animals which, connected by hundreds upon a sort of common stem, of which they represent the flowers, produce the substance known as *coral.* In these animals the mouth terminates in a sort of pouch or bag, suspended in the cavity of the body, and constituting an actual stomach, into which the food penetrates. After the latter has been sufficiently digested, the animal rejects by its mouth the coarser residue, and opening an orifice which is situated at the other extremity of the bag, it only suffers the portions of food adapted for its maintenance to penetrate into the interior. From this special cavity within each animal are given off canals, which, being prolonged into the common part or the polypary, communicate freely with similar canals coming from all the other polypes — an arrangement by which the entire colony profits from the nourishment taken separately by each individual.

Something similar to this exists in the case of some of the Medusæ, while in others the functional labour begins to be more definitely characterised. These animals, as we have already said, resemble an in-

verted bell, the place of the tongue being supplied by the mouth which serves as an entrance to the stomach; in the Lesueuria this first cavity is followed by a second, to which the coarser parts of the food do not penetrate. The liquids which enter this cavity are carried towards the circumference by one system of canals, whilst other special vessels carry them back to their starting point. This movement reminds us to a certain degree of that of the blood in the mammals; but here it is the stomach which fulfils the functions of the heart, whilst the same canals serve the part of intestines, arteries, and veins.

These vessels, moreover, do not convey any special liquid meriting the name of *blood*. It is not even *chyle*, properly so called. The water in which the animal lives penetrates—one might almost say accidentally—into its interior. In its passage it takes up the substances which have been digested by the stomach, and conveys them into the cavity of the body which they are to nourish. In passing away again, this same water carries with it, indiscriminately, the remains of these substances, and the elements of which the organism strives to free itself. At the same time it also serves the purposes of respiration, no less than those of digestion and circulation. Here, as we see, all the organs are still confounded; and this very confusion explains the evident imperfection of the animals which we have been considering.

The isolation of these functions by the appearance of organs specially appropriated to each of

them, is in itself a great step in advance; but nature never proceeds by sudden starts, and this perfection is brought about by very gradual steps. When once the digestive cavity is complete, we may assume that there will also be present in the animal some liquid specially designed for the maintenance of the organs. Here, too, a preliminary absorption is necessary to enable the materials furnished by digestion to blend with this kind of blood, but still respiration continues for some time to be effected by the aid of already existing organs, or by the digestive apparatus itself. A very large number of Annelids respire through the skin only, while many Crustaceans have no other branchiæ than their feet. In the larvæ of those large insects known as dragon flies, we observe a still more curious phenomenon. Here the intestine presents a considerable dilatation at its posterior extremity. The water penetrates into this cavity, from which it is propelled at the will of the animal. Here, then, we have the respiratory apparatus. It is easy to ascertain this by holding one of these larvæ out of the water, and then, after a time, restoring it to its native element. We shall find that it will draw in and eject the liquid with the same kind of anxious precipitation that is exhibited by a half-suffocated mammal; but while the latter breathes through a mouth, the larva of the dragon-fly respires through the opposite extremity of its alimentary canal.

The circulation presents an almost infinite variety in the modes of its successive development. Very often it is altogether wanting; in the lower types

of the Articulata and Mollusca, no trace of vessels can be detected. The general movements of the animal communicate motion to the liquid which is enclosed between the walls of the body and the intestine, and sometimes more or less irregular currents are produced by vibratile cilia, arranged in bands or groups; but there is no heart to give a definite impulse, no arteries to distribute the nutrient fluid to the surface of the body, nor veins to return it to the centre of the organism. In this case there can be no distinction between arterial and venous blood, or between lymph and chyle; and here the liquid, which fills all the organic interstices, receives the products of digestion directly and immediately.

In some cases the intestinal apparatus compensates by a very singular arrangement for this absence of circulatory organs; for we find this apparatus charged with the duty of distributing to all parts of the body the nutrient elements, which it is specially destined to prepare. In these cases, we perceive that it is complicated by the presence of prolongations or appendages which reach the most distant points of the organism. In the Nymphon and the Pycnogonum — crustaceans which bear considerable resemblance to certain field spiders — the intestine penetrates to the very extremities of the feet and claws, very much in the same way as if, in man, the stomach were to be prolonged across the neck, arms, and legs, to the jaws, wrists, and ancles.

Nature is much less economical of her forces than

we are apt to suppose, and often when two means present themselves for attaining the same object, she employs both at once. The arrangement to which we have referred is to be met with in certain Molluscs, of which some, at any rate, possess a heart. Here, there are indeed no veins, but a more or less complete arterial system conveys successively to all the different parts of the body the liquid enclosed in the general cavity; nevertheless the stomach sends forth prolongations to all the appendages, including even the tentacles on the forepart of the head, which, in the case of the snail, are improperly designated as *horns*. In obedience to the simple laws of physics, the products of digestion contained within these prolongations must necessarily transude and mix with the liquid which fills the body of the animal. These prolongations, therefore, actually play the part of arteries by conveying materials of nutrition to the points where they are to be used. These same prolongations also fulfil the functions of lacteals. The latter never convey directly to the arteries the chyle which they have collected from the surface of the intestine. In order to render this liquid suitable to the maintenance of the organism, it requires to be exposed to the modifying action of the air in the lungs or branchiæ which it reaches in association with the venous blood. In the Molluscs to which we refer there exist no branchiæ which admit of a comparison with those of other animals of the same class; but here their functions are performed by the small richly coloured papillæ which cover the bodies of these

animals. The prolongations of the stomach are all carried into the interior of these small protuberances, and consequently the chyle, on issuing from the intestine, is at once brought into the midst of the respiratory apparatus, where it cannot fail to undergo *immediately* the vivifying influence which it requires. Such are the facts which led me to that theory of *phlebenterism*, which, after being violently attacked by several French naturalists, has met with a much more favourable reception amongst foreigners, and more especially amongst German zoologists. In the detailed examination of the remarkable group which furnished me with my facts, I was necessarily led into some errors; but time and renewed researches have only tended more and more to confirm the essential and general results which I discovered.*

When considered from this point of view, the class of the Mollusca is indeed very remarkable. Without departing from its limits, we find the circulation exhibiting the most different degrees of complication, and that even in animals often closely allied to one another, and in which we might therefore have been led *à priori* to believe that the organisation was almost identical. Nevertheless, the circulatory system still remains *incomplete*, there being no perfect continuity between the venous and the arterial apparatus. Consequently, the blood which was propelled from the heart cannot return to it until it has been diffused through all the interorganic spaces or lacunæ, and hence it must neces-

* [An abstract of the discussions on the subject of Phlebenterism is given in the Appendix, Note XV.]

sarily fill the general cavity of the body. Here it bathes the greater part of the viscera, and receives without any intermediate aid the nutrient elements which have been elaborated by the alimentary canal; hence it will be understood that if we must admit the presence of venous and arterial blood in the higher Molluscs, we are yet unable to distinguish either lymph or chyle.

The Articulata furnish precisely similar facts. Several of the results which have been obtained from these animals had already long before been admitted into the science of zoology; but in consequence of not perceiving the relations which connect them with what occurs in other groups, physiologists had been led to regard them merely as strange and characteristic exceptions. Thus, from the time when the researches of MM. Audouin and Milne Edwards received the prize of the French Institute, in 1827, the absence of veins where the heart and arterial system were both present, was looked upon as exclusively characteristic of lobsters, crabs, and other animals belonging to the class of the Crustacea. The absence of any circulatory organ was, they thought, limited to Insects and to a portion of the Arachnida, and they endeavoured to explain this fact, which was the more striking from its peculiar isolation, by the modification which the respiratory apparatus presents in these cases.

Insects, indeed, have neither lungs nor branchiæ; but in them the air passes through a variable number of openings into a system of tubes, called tracheæ, whose singular structure bears the most striking

resemblance to an elastic webbing. These tracheæ ramify over the whole body, and, consequently, as Cuvier remarked, the air seems in insects to go in search of the blood, whilst the contrary is the case in other animals. The explanation was logical, for every movement of this liquid seemed as if it were useless, since it could be incessantly revivified on the spot. A more attentive observation has, however, shown that insects possess a true circulation, for a long contractile dorsal vessel here plays the part of a heart. The blood moves freely through the interstices of the organs, yet each one of its portions circulates successively through every part of the organism; but then the circulation is performed almost entirely in *lacunæ*. We may readily observe, under the microscope, the existence and direction of all these currents, which are made apparent by the globules in the liquid. The circulatory circle is therefore incomplete in all the Invertebrata of which we have spoken, and hence it is the more remarkable that the class of the Annelids should possess an uninterrupted circulation. We undoubtedly meet among the lower forms of this group of animals with many totally deficient in an apparatus of circulation, while some species exhibit a mere rude outline of such a system; but the greater number certainly possess a perfectly closed system of sanguiniferous vessels. Even in the Nemertes, whose animal machine presents a most remarkable degree of simplification, the blood pursues its course without ever leaving the contractile tubes within which it is contained. In these animals, however,

as in all the Annelids, properly so called, there is no heart; whilst the vessels, which are everywhere of equal calibre, do not give origin to any secondary branches. In respect to the circulation, the lower Articulata present a much greater similarity to the Vertebrata than to Insects or the higher Molluscs, whose organisation is nevertheless very far superior to their own.*

Even the Vertebrata obey the common law, and in the lower representatives of this type —in the fishes —we still meet with examples of this lacunary circulation. This important fact, which could not have been anticipated a few years ago, was discovered at Paris simultaneously, although independently, by two anatomists, MM. Natalis Guillot † and Robin,

* This is a very important result, which moreover derives confirmation from the comparative study of several other groups. We still meet with some naturalists, who, guided solely by their preconceived ideas, wish to insist that there must be not only necessary physiological relations between each functional apparatus, but they would make it appear that there is an anatomical dependence among them, which is regulated by laws, which exist only in their own imagination. In the eyes of these naturalists, no apparatus can be simplified or degraded without inducing a corresponding simplification and degradation in all the others. In refutation of such views, it is sufficient to refer those who uphold them to the study of the circulation in Insects and in Annelids.

† M. Natalis Guillot, who is physician to several of the Paris hospitals, affords a happy illustration of the manner in which scientific pursuits can be combined with the practice of a laborious profession. His *Exposition Anatomique de l'Organisation des Centres Nerveux*, which gained for him the prize offered by the Brussels Academy of Sciences, will ever remain one of the most trustworthy works on this difficult subject. M. Guillot has published numerous memoirs illustrative of various other points in comparative anatomy and physiology.

who have shown that in the Rays there are certain portions of the body in which the blood-vessels cease all at once, and where the blood flows freely into cavities, whose arrangement recalls to mind that which exists in some of the lowest animals. M. Robin in following his first researches, has extended these results to several species of the family of the Squalidæ. We are convinced that the question will not remain where it now is, and that in the course of a few years we shall undoubtedly meet with facts in the highest Mammals, and even in man himself, which, if not entirely similar, are at least almost analogous. The results at which MM. Dujardin and Natalis Guillot have arrived by the study of the minute structure of the liver, appear to offer a certain guarantee of the success which will attend the investigations undertaken in this direction.

The circulation, therefore, which is at first entirely lacunary, is consequently reduced to a sort of vague agitation, which, as it gradually becomes regulated, assumes a more and more vascular character, in proportion as we rise higher in the animal scale. This is the general fact or tendency which predominates in the progressive development of the circulatory apparatus.

The same tendency is to be met with in organisms in the act of formation, whether we examine the development of a normal germ, or whether we study the manner in which certain accidental tissues are constituted. The *area vasculosa*, in which the embryo of the bird seems to draw the first elements necessary to its evolution, presents at first nothing

more than a sort of membranous disc hollowed out into irregular lacunæ. These may be regarded, according to M. Milne Edwards, as so many small lakes communicating with one another by means of tortuous canals. In proportion as the organisation of the embryo advances, these canals become enlarged, the lakes change into streams, and the canals which had at first been simply hollowed out of the actual substance of the tissues, becoming enclosed, are invested with a tubular membrane, and thus pass into the condition of vessels properly so called. Precisely similar phenomena occur in the false membranes which often supervene on an inflammatory affection of the thoracic organs. Here also the plastic matter becoming organised under the abnormal influence of excessive vitality, gives rise to lacunæ, which becoming converted into vessels, are soon brought into communication with some of the pre-existing branches of the circulating system. In the presence of such an array of facts, derived from wholly different sources, it seems scarcely unreasonable to think that the same order of things may be generally present, and that usually, if not always, a lacuna has preceded a vessel.

Such, indeed, was the conclusion at which M. Milne Edwards arrived in opposition to the cellular theory of Schwann, one of the most distinguished pupils of the celebrated Müller.* According to the German physiologist, all parts of the animal body have been primarily composed of simple cells. This universal

* [A sketch of the scientific labours of Professor Müller is given in the Appendix, Note XVI.]

element, by its gradual development and modification, would produce, according to circumstances, either muscular fibres, the parenchyma of the glands, or the matrix of the osseous tissue. According to the same theory, the vessels are in like manner cells, which being at first spherical, become gradually elongated, until, combining together, they constitute by their reunion the thousand vascular ramifications of the body.

This theory numbers amongst its partisans many distinguished physiologists. It is certainly highly attractive from its simplicity, and from the manner in which it enables us to embrace all the phenomena of development, while it establishes the existence of ultimate relations between the two great divisions of organised creation. A similar theory has indeed been long adopted by botanists, who regard it as the expression of all the facts to be observed in plants. We have seen, however, that the case is different with respect to animals, although here we believe that the cellular theory furnishes several useful results. It may be well adapted to guide us in the study of certain animal tissues which present remote relations to those of plants; but when applied to the entire animal kingdom, it can no longer be accepted as true.

We will add another example to those already given. It had long been known that in the Anodonta—a species of fresh-water mussel, very common in the neighbourhood of Paris—the heart is traversed by the last portion of the intestine. M. Edwards, moreover, in studying the organisation of the Pa-

tellæ and the Haliotides, has recognised that in these Molluscs, the aorta (or large artery given off directly from the heart) encloses a portion of the buccal apparatus. These curious facts cannot be explained by the cellular theory. Indeed, we cannot understand how a cell, in the course of its development, could enclose, within its interior, organs which had first been situated outside of it; it would rather tend to displace them in proportion as it increased in volume. It is easy, on the contrary, to suppose that these organs which have been formed in the midst of a perfectly free space, must have been surrounded by walls which, being subsequently formed, convert the lacuna into a vessel or a heart.

The general ideas of which we have endeavoured to give a brief abstract, met, as we have already remarked, with a most violent opposition. They were stigmatised with the epithets of incredible, absurd, and ridiculous; whilst many of the facts on which they were based, were regarded as impossible. It was at Paris, we regret to say, that this opposition was most strongly manifested, which would have been worthy of respect if it had always originated in purely scientific and conscientious convictions; but it unfortunately was too often to be attributed to motives of personal rivalry. Foreigners, in a more disinterested spirit, comprehended the value of these results, and promptly recognised and accepted them. The most distinguished physiologists of England, Belgium, Germany, Denmark, and Sweden, gave these questions their most serious attention; and the greater number soon expressed their concurrence

in these newly enounced views. In France, even, the importance of these ideas could not be wholly denied, and they soon forced themselves on the attention of the Faculty of Medicine of Paris, which certainly cannot be accused of any inconsiderate love of scientific innovation. In several of his public lectures, M. Andral developed these new theories, exposed and demonstrated the facts on which they were based, and the important consequences which might result from them by aiding us to arrive at a more exact appreciation of many of the physiological and pathological phenomena which are daily observed in the human subject. We see, therefore, that a careful study of the inferior animals is not to be regarded as purely speculative — a view which is unfortunately still too generally adopted.

APPENDIX.

Note I.

Among those persons into whose hands these volumes may fall, there will probably be some who are not well acquainted with the different branches of natural history, and who are most especially deficient in the knowledge of the names and distribution of zoological groups. I have, therefore, considered that it would be desirable to furnish my readers with a brief synopsis of classification, which might at the same time serve as a kind of vocabulary. In order to avoid entering too much into detail, I have limited myself to the enumeration of *classes* (passing over the subordinate groups), *orders*, *families*, and *genera*. Those readers who may desire to advance further into this department of natural history, and who may be anxious to examine plates of the animals they are studying, will do well to consult, as works of general reference, the elementary treatises of M. Milne Edwards, more particularly his *Éléments de Zoologie*, in 2 vols., and the illustrated edition of Cuvier's *Règne Animal*, published under the direction of his most distinguished pupils.

Adopting in this respect the ideas first enounced by several German authors, we will admit the existence of four kingdoms of nature—viz. the *mineral*, *vegetable*, *animal* and *hominal* kingdoms. Man is the exclusive representative of the last of these kingdoms, which, there-

fore, includes only one species; this unity, apart from all other considerations, having been demonstrated by modern science.

Two Sub-kingdoms.

ANIMAL KINGDOM.	Vertebrata. Invertebrata.

Four Classes.

Sub-kingdom of the VERTEBRATA.	Mammalia. Aves. Reptilia. Pisces.

Three Divisions.

Sub-kingdom of the INVERTEBRATA.	Articulata. Mollusca. Radiata.

Two Sub-divisions.

Division of ARTICULATA.	True Articulata. Vermes.

	Five Classes.	EXAMPLES.
Sub-division of TRUE ARTICULATA.	Insecta -	Beetles, Butterflies, Flies.
	Myriapoda -	Scolopendra, Centipede.
	Arachnida -	Spiders, Scorpions, Mites.
	Crustacea -	Crayfish, Crabs, Wood-lice.
	Cirrhopoda -	Acorn-shells.

	Seven Classes.	
Sub-division of VERMES.*	Annelida -	Sabella, Hermella, and almost all the Marine Worms.
	Rotifera -	Rotifer, Hydatina.
	Gephyria -	Sipunculus, Echiurus.
	Lumbricini -	Earth-worm, Nais.
	Hirudinei -	Leeches, Branchellion.
	Turbellaria -	Planaria, Nemertes.
	Helminthes -	Intestinal worms.

* In order not to complicate these essentially elementary tables, I have not represented the *collateral affinities* or *analogies*, to which I long ago drew attention, and which are now recognised by the most distinguished naturalists. I would here observe that I subdivide the Vermes into two series, characterised by the union of the two sexes in one individual, or by their separation in two individuals.

Two Sub-divisions.

Division of MOLLUSCA.	True Mollusca. Molluscoida.

	Five Classes.	EXAMPLES.
Sub-division of the TRUE MOLLUSCA.	Cephalopoda -	Cuttle-fish, Octopus, Calamary.
	Pteropoda -	Hyalea, Clio.
	Gasteropoda -	Snails, Slugs, Whelks, Cowries.
	Acephala -	Oysters, Mussels, Shipworms.
	Brachiopoda -	Terebratula, Lingula.

Two Classes.

Sub-division of the MOLLUSCOIDA.	Tunicata -	Biphora, Simple and Compound Ascidians.
	Bryozoa -	Plumatella, Alcyonella, Eschara, Flustra.

Two Sub-divisions.

Division of the RADIATA or ZOOPHYTES.	Radiated Zoophytes. Globular Zoophytes.

From this distinction result *corresponding terms* or *zoological analogies*, of which I subjoin a table that has been drawn up in accordance with the present state of science.

Diœcious Vermes (sexes separate).	Monœcious Vermes (sexes united in the same individual).
Annelida - - - - -	Lumbricini.
Rotifera - - - - -	——
Grephyria (?) - - - -	——
Malacobdellæ - - - -	Hirudinei.
Miocœles - - - -	Turbellariæ.
Nematodes - - - - -	——
—— - - - - - -	Cestoides.

For further information regarding the question of the two series the reader may consult my memoirs on the Polyophthalmia, and on the nervous system in the Leeches and Earth-worms (*Ann. des Sc. Naturelles*, 3e série, t. xiii. et xviii.), as well as Van Beneden's work, entitled *Les Vers Cestoïdes ou Acotyles.*

	Three Classes.	EXAMPLES.
Sub-division of the RADIATED ZOOPHYTES.	Echinodermata	Sea-urchins, Star-fishes, Holothurias.
	Acalephæ -	Jelly-fishes, Beroës, Stephanomias.
	Polypi -	Coral-animals, Sea Anemonies, Fresh-water Hydras.
	Two Classes.	
Sub-division of the GLOBULAR ZOOPHYTES.	Porifera -	The Sponges.
	Infusoria.* -	Monads, Volvoces, Amœba.

NOTE II.

The Rotifers of which we have spoken were discovered by Leuwenhoeck, who was the first to recognise the singular property which these animals possess of alternately dying and being resuscitated, according as they are dried or provided with the water necessary for the maintenance of their vitality. These Rotifers have become the type of a *class*, which is already very numerous and of which many species, undergoing the same conditions of life, also possess the same faculties. Besides these Rotifers, the Tardigrades, which belong to the Acari, and are consequently included in the class of the Arachnidans, and certain Paste-eels, which belong to the Helmin-

* The place at present assigned by zoologists to the Infusoria must be regarded merely as provisional. The extreme minuteness of these animals renders their study very difficult, and it is daily becoming more probable that this group is far from being homogeneous, and that it contains a great number of organisms (minute vegetable forms, larval worms, &c.) which have nothing in common except their smallness. The most important modern contributions to the history of the Infusoria, are those of Ehrenberg and Dujardin, especially Ehrenberg's splendid volume, entitled *Die Infusions-Thierchen*, Berlin, 1838, and Dujardin's *Histoire des Infusoires*, Paris, 1841, published in the *Suites à Buffon.*

thes, have all shown similar phenomena. These species are all of very minute dimensions. It will probably not be unwelcome to our readers if we give them some of the principal results which have been obtained from the study of these curious animals.

Leuwenhoeck *, Baker †, and Spallanzani ‡, made their

* Leuwenhoeck, who was born at Delft, in Holland, in 1632, and died in 1723, is justly regarded as the founder of micrography. His long life was devoted to the study of the world of infinitesimal beings, and to the improvement of the instruments adapted for these observations. The *compound microscopes* known in his day were very imperfect, and subject to many errors, which induced Leuwenhoeck to employ only *simple microscopes*, that is to say, very small lenses of short focal lengths, which he made himself, and fixed between two plates of metal, that had been pierced with a very narrow opening. Each instrument was only intended to serve for a small number of objects, and Leuwenhoeck always kept a great many of these glasses by him in readiness for use. The collection of these microscopes, which he bequeathed to the Royal Society of London, consists of twenty-six plates, all provided with their several lenses. It was by means of these simple instruments, that he made those numerous observations which have won for him a European reputation. During his stay in Holland, Peter the Great came to visit him, and by way of acknowledgment of the honour done him, the micrographer showed the czar the circulation of the blood in the tail of an eel. Notwithstanding his assiduous labours Leuwenhoeck preserved excellent sight to the end of his life—a blessing which has not been the lot of all his imitators.

† Henry Baker was born in London, and died in 1774. He was one of the precursors of the Abbé de l'Epée, but while he devoted his attention to the discovery of methods for teaching deaf mutes the art of speaking, he also made many micrographical observations, and Spallanzani speaks of him in terms of high commendation.

‡ The Abbé Spallanzani, who was one of the most remarkable savants of the eighteenth century, was born at Scandiano, in 1729, and in early life distinguished himself by his literary acquirements, while he also held the chair of Logic, Metaphysics, and Greek Philosophy at Reggio. He soon, however, devoted his attention

observations exclusively upon Rotifers which had been taken from the dust that had collected round the gutters on the tops of houses. These animals certainly occur in such localities, but in much smaller quantities than in the little tufts of moss which shoot up between the tiles and slates on the house-tops, whilst very few are to be met with among the moss that grows upon walls cemented with lime. Our observations upon the Rotifers apply equally to different species of Tardigrades, which are of much more rare occurrence. They may be obtained by moistening moss and then squeezing it as if it were a sponge, when the water which flows from it will dislodge both the sand and the animalcules which inhabit it.

Although the different species that I have indicated may die and be resuscitated several times in succession,

exclusively to the natural sciences, which he was called upon to teach at the University of Pavia, where he remained for the rest of his life. He died in 1799. Spallanzani has left a large number of memoirs and many works, the most important of which have been translated into French by Sennebier, the librarian of Geneva. Spallanzani may be regarded as one of the founders of experimental physiology, and his researches on digestion and generation prove that he possessed, in a most exceptional degree, a true genius for experimentalising. Modern science has undoubtedly added to his discoveries in reference to these difficult questions, but it has in no respect changed the general results at which he arrived, and if he was occasionally less happy in his microscopical observations, the fault may be especially referred to the imperfect instruments then in use. In his zeal for science he often made himself the subject of his experiments, not unfrequently at the risk of his life. He displayed a similar ardour in his scientific travels; thus, when he was anxious to confirm his observations on volcanoes for his work on the Two Sicilies, he, although at the time more than sixty years of age, approached the crater of Stromboli when it was in a state of eruption, and ventured so near the burning lava of Vesuvius, that he very nearly experienced the same fate as Pliny the Elder.

this faculty has its limits, and each experiment generally proves fatal to one or more individuals. Thus in alternately drying and moistening the same sand, we shall find that on each repetition of the process a smaller number of animalcules come to life. Spallanzani in his experiments on the Rotifers did not find that any of them revived after the sixteenth alternation of draught and humidity; Paste-eels, however, bore seventeen of these experiments.* This diminution of the singular faculties possessed by these animals is equally apparent after they have been kept for a long period of time. Spallanzani, after having well dried some sand, which was very rich in Rotifers, kept it for more than three years, merely moistening some portions of it every five or six months. He found that the number of individuals which were thus resuscitated, continued to diminish progressively, and it is much to be regretted that this able observer did not continue his experiments somewhat longer. Baker, however, who after Needham continued to observe Paste-eels, went still farther; for he kept the paste from which they had been taken, without moistening it in any way, for twenty-seven years, and at the end of that time he found that the eels revived on being immersed in a drop of water. If they had exhausted their life all at once, and without any intermissions, these Rotifers and Paste-eels would not have lived beyond sixteen or eighteen days.

* These Anguillulæ, whose name alone is sufficient to indicate their general form, were discovered by Needham, a distinguished naturalist of the eighteenth century. He was born in 1713, and successively resided at Lisbon, London, and Paris, where he occupied himself with microscopical investigations conducted under the directions of Buffon. Having been called to Brussels to direct the organisation of the Academy which had been founded by Maria Theresa, he settled in that city, and remained there until his death in 1781.

The Tardigrades, and those eel-like creatures which are found in the same locality with the Rotifers, furnished Spallanzani with phenomena entirely similar to those of which I have been speaking.

These results, which were confirmed in the last century, have been generally received as exact, and were explained by the extreme simplicity of organisation, which was supposed to be the attribute of all these animals. But after Ehrenberg* showed that a relatively high organisation was in no way incompatible with microscopical dimensions, and when he published

* Ehrenberg, a German by birth, a corresponding member of our Institute, and perpetual secretary to the Academy of Sciences at Berlin, has perhaps exercised a greater and more useful influence than any other living naturalist. He was probably the first in Germany who attacked the basis of that obscure system of those *philosophers of nature*, which had predominated so much amongst Germans; and he has great merit for having directed the zoological and physiological sciences in the path of observation and experiment. Ehrenberg is especially celebrated for his researches on the smallest forms of organic life—observations which have justly placed him in the first rank of modern micrographers. His discoveries on the organisation of the Infusoria and Rotifera gave a new impulse to this department of science, which had not advanced since the times of Leuwenhoeck and O. F. Müller. His researches on Fossil Infusoria prove that these infinitely small beings have left much more considerable traces in the geological strata of the globe than even mastodons or elephants. Finally, his memoirs on the organic structure of some of the lower animals of larger size, and amongst others the Medusæ, have served as the starting point from whence have emanated numerous researches which are still being prosecuted, and which have completely changed the ideas that had been entertained of fully the half of the animal creation. Among the numerous writings of Ehrenberg, we may especially cite his great works on the Infusoria, entitled *Die Infusions-Thierchen als volkommene Organismen* and *Mikrogeologie*, as well as his memoirs on the organisation of the Acalephæ, and all his publications on Fossil Infusoria.

his splendid researches on Hydatina senta, and demonstrated that this near ally of the Rotifers possessed a most unexpected complication of organs, some doubts began to arise. It was then asked, whether desiccation had been thorough and complete in the individuals experimented upon by Spallanzani, Baker, and their cotemporaries. A naturalist who had been led by his previous researches to direct his attention to this question, pursued the inquiry with the rigour which characterises modern investigations.* Mosses filled with the different species of which we have spoken were desiccated under the receiver of the air-pump. They were left there for a week, being placed by the side of vessels filled with sulphuric acid, which would absorb every trace of humidity. On being removed, the mosses were placed in a stove, the temperature of which was raised as high as 267° Fahr., and yet, when they were again immersed in water, I am able to testify conjointly with MM. Dumas, Edwards and De Jussieu, that a certain number of individuals had resisted all these trials, and became as lively as if nothing had happened. Not a doubt, therefore, remained in our minds as to the exactness of the facts announced by Spallanzani.

In order to conform to the expressions in common use I adopt the words *death* and *resuscitation*, but a false idea would be formed of my meaning were these words to be taken in their rigorous and strict signification. When a Rotifer is dried, withered, and loses its power of motion, and when it thus assumes the appearance of a shapeless grain of dust, there is no actual *death;* life is only suspended

* M. Doyère has published, in the *Annales des Sciences Nat.*, 1841, an anatomical work of the highest interest on the anatomy of the Tardigrades. His experiments on the revivification of the Rotifers, Paste-eels, and Tardigrades, appeared in the same peridical in 1842.

in it, or, to speak more exactly, has become *latent.* This adult animal is thus brought into a condition, through which a great number of germs have passed, as for instance, almost all seeds, and even the bird's egg. The egg in the body of the mother participates in the life of the individual which gives it birth; it then becomes individualised, and life ceases to be manifested in it by sensible phenomena, but it is not on that account to be regarded as dead. Once laid, the egg may be preserved for a very long time, provided it be placed in certain circumstances of drying, cold, &c.

If, however, it be placed under a hen which is sitting, or if even it be merely introduced into one of those apparatuses which the ancient Egyptians knew so well how to construct on a large scale, life will soon be manifested within it, and the germ will revive from its torpor and become developed. In this egg, therefore, life must have been for a long time present, although in the *latent state.* This explanation must not be regarded as too rash; for the physical world presents us with many very similar facts. The heat which is expended in melting ice, or in converting a liquid into vapour, disappears so thoroughly, that the thermometer can no longer detect its presence; but it is not, therefore, destroyed, it is only concealed; that is to say, it has passed into the *latent state.*

The phenomenon which we observe when Rotifers, Paste-eels, and Tardigrades, are desiccated, is of a precisely similar character. In all living organisms a certain quantity of water is necessary for the exercise of the functions, that is to say, for the *manifestations* of life. By removing this water, we suspend these *manifestations.* In most animals, such suspensions cannot take place without injuring the organism to so great a degree as to prevent the accomplishment of its functions, in which

case real death is induced. That which is exceptional, therefore, in these species is, that desiccation in their case produces merely a sort of syncope from which they recover on being supplied with water.

A certain number of the lower plants present phenomena precisely similar to those which we have described in the case of animals. We may here specially instance the Nostoc, one species of which is not uncommon. This Alga when well developed presents itself under the form of brownish or dull green folded or even crumpled patches, about one-fifth or one-sixth of an inch in thickness, and sometimes as much as from two to three inches in diameter. These patches shrivel up under the action of dryness, until they are scarcely visible, but a shower of rain is sufficient to restore them to their former dimensions.* It follows from the experiments of Spallanzani and of Léman that when the Nostoc is dry, vegetation is arrested, and that it recommences as soon as the organism is again furnished with water. We think, however, that the observations which have been made on this plant are scarcely so precise as those on the Rotifers and Tardigrades.

Note III.

We draw a distinction in physics between the simple microscope, and the compound microscope. The former is, in fact, nothing more than a lens constructed of one or two glasses. In this instrument the observer looks directly

* M. Dujardin has made us acquainted with the extremely simple structure of the Nostocs. The entire plant is formed of strings of greenish microscopical globules immersed in a transparent mucilaginous substance. (See *Mémoire sur le Nostoc*, and *le Manuel complet de l'Observateur au Microscope*, by M. F. Dujardin.)

at the object which he wishes to examine. The second may be considered as a combination of two lenses, one of which, the *object-glass*, serves to produce in the body of the instrument an image which is received by the other (the *eye-piece*), which transmits it to the eye. In the compound microscope, the observer, properly speaking, does not look at the object itself, but at the image of the object.

Simple microscopes, or, to speak in more general terms, magnifying glasses, appear to have been known to the ancients; at least, among the engraved stones which have come down to us from Greek or Roman artists, there are some in which the truly microscopical details cannot be seen by the naked eye, and it is therefore very difficult to suppose that they could have been executed without the employment of some auxiliary agent. It might, however, be suggested that the ancients made use, for the purpose, of simple glass spheres, filled with water, similar to the one which Seneca employed to read small and indistinct written characters.

Soon after the invention of spectacles, that is to say, towards the beginning of the fourteenth century, it would at all events appear that lenses, properly so called, were fabricated, and that attempts had been made to render their magnifying powers more considerable. All the early micrographers used simple lenses, which, as in the case of Leuwenhoeck, they frequently fabricated for themselves; and the splendid discoveries of Malpighi *,

* Malpighi, a celebrated Italian physician and anatomist, was born in the neighbourhood of Bologna in 1628; after having been Professor of Anatomy at the University of that city, he successively filled the same post at the Universities of Pisa and Messina. Having been called to Rome as physician to Pope Innocent XII., he took up his abode in that city, where he died in 1694. Malpighi may be considered as one of the founders of Comparative Anatomy and Experimental Physiology.

Swammerdam *, and Lyonnet † were made by instruments such as these. The numerous difficulties which attended the fabrication of such small lenses, induced several observers to endeavour to find some substitute for them. In this manner successive trials were made with pure water, sulphuric acid, and castor oil, which were used

* Swammerdam was born at Amsterdam in 1637, and died in 1680, from the effects of a hypochondriacal affection aggravated by excessive devotion to study. In one of his fits of melancholy he threw a great part of his manuscript into the fire, imagining that it was an offence against God to attempt to unravel the anatomical structure of insects! On another occasion he sold for a paltry sum a mass of his manuscripts, which were recovered at a great cost by Boerhaave, and published under the title of *Biblia Naturæ*. Swammerdam appears to have been one of the first who practised the art of anatomical injections; but his chief celebrity rests upon his anatomical researches on Insects.

† Lyonnet, who was born at Maestricht, and died at the Hague in 1789, devoted himself for a time to the study of the bar, and even pleaded several important causes. By way of relaxation he employed himself in studying the natural sciences, and more especially the history of Insects. He had originally intended to publish a general work on the subject, but having been annoyed to find that several of his discoveries had already been published by other naturalists, he resolved to undertake a work in which he would not have to fear competition from any one. With this object in view, he undertook to study the anatomy of an Insect more thoroughly in detail than human anatomy had ever been studied, and he chose a species of Phalena or Moth, whose larva gnaws the bark of willow trees, elms, &c. (*Cossus ligniperda*). Lyonnet had proposed to himself to study successively the larva or caterpillar, the nympha or chrysalis, and the perfect insect; but in consequence of his public duties he was unable for several years to do more than complete the first part of his work. This treatise, which was entitled *le Traité anatomique de la Chenille du Saule*, appeared in 1762, in a large quarto volume, accompanied by eighteen plates, which had been engraved by the author himself. "This work," says Cuvier, "is the *chef-d'œuvre* of anatomy and engraving" — a eulogy which it merits even at the present day.

by suffering a very small drop to fall upon an opening cut in a metallic plate. The liquid, which of itself assumed a somewhat spherical form, was thus, for a time at least, able to serve in the place of a lens. Canada balsam, turpentine, and several different varnishes were also employed for the same purpose.

One of those chances of which superior minds alone know how to avail themselves secured to the micrographers of the day that of which they had so long been in search. In 1665, a young Dutchman, named Hartsoeker, when holding a glass thread in the flame of a candle, perceived that the melted extremity assumed a spherical form.* Hartsoeker who had seen Leuwenhoeck manufacture lenses, now attempted to place his own little spheres of glass between two pieces of lead, through which he made an aperture with the point of a pin; on observing a hair with this instrument he discovered to his great joy that he was the possessor of a capital microscope. From that time microscopists very often employed Hartsoeker's method, and Le Baillif, amongst others, enjoyed for a long period of his life a great reputation for his skill in arranging such glasses.

All the lenses of which we have spoken present great inconveniences, for their use is fatiguing to the eye, the field of view is very limited, and the magnification is never very great. In 1813, the celebrated English

* Hartsoeker, who was born in 1647, and died in 1725, was only eighteen years of age when he discovered the art of constructing simple microscopes with a glass thread. This discovery has, however, been disputed, and some authors have ascribed it, perhaps justly, to the celebrated English mathematician Hooke, to whom we owe the invention of portable watches. Hartsoeker made use of the globules to prosecute some very interesting inquiries, and he contests with Leuwenhoeck the claim to the discovery of those animalcules which since their time have been found to exist in the generative fluid of all animals.

natural philosopher, Sir David Brewster, suggested that diamonds should be used in the construction of simple microscopes. Pritchard of London, and C. Chevalier and Oberhaüser of Paris, made several attempts to carry this suggestion into effect, and they constructed several lenses of precious stones. The results, however, did not answer the expectations which had been entertained, and it was soon found necessary to relinquish the use of such costly materials. Opticians were then led to reconsider an idea which had been repeatedly thrown out, but which it remained for Wollaston to develope with his usual talent. This idea consisted in the superposition of several lenses, and at last, in 1829, C. Chevalier, following the principle of the English philosopher, constructed his *doublet*, which yields to the observer almost all the advantages that can be obtained from a simple microscope. This instrument consists of a compound lens of two plano-convex glasses separated by a diaphragm, and whose plane sides are both directed towards the object. This lens is supported by a small solidly fixed beam, whose horizontal arm may be turned in every direction above the object.

The history of the compound microscope exhibits far less continuous progress than that of the simple microscope. This instrument, which was, very probably, invented by Galileo *, in 1612, or perhaps by

* This illustrious astronomer, whose name is one of the most familiar in science, was born at Florence in 1564, and died in 1642. From his youth he had devoted himself to mathematics, and he lectured on this science at the Universities of Pisa and Padua. Having heard of the discovery of the telescope in Holland, Galileo immediately tried to construct an instrument of the kind, and soon invented the telescope which still bears his name. With this instrument he discovered the phases of Venus, the Sun's spots, and Jupiter's satellites. The result of his astronomical discoveries

Drebbel*, in 1619, was at first a kind of telescope six feet in length, and sometimes from six to seven inches in diameter. Although it was modified by different physicists, it remained until a comparatively recent date in so imperfect a condition, that observers looked upon it chiefly as a sort of experimental toy, and therefore contented themselves with using a simple microscope.

The greatest defect of the compound microscope was that the images were confused, and their outlines marked with coloured fringes. This defect depends upon the very nature of light, and for a long time it appeared impossible to correct it. However, the attentive study of the human eye led to the discovery of means for making magnifying glasses achromatic. In 1757, an English instrument maker, Dollond, constructed telescopes which were perfectly achromatic.

Hence it seemed the simplest thing to apply the same process to the microscope, but the difficulty increases so much with the smallness of the glasses, that Dollond himself does not appear to have made the attempt, for we find that his microscopes remained unchanged.

confirmed him more and more in the ideas which he had already entertained in relation to the movement of our globe, and from that moment he maintained the system of Copernicus with a tenacity and energy that drew upon him the rigours of the Inquisition. It is well known that at the very moment in which, to escape from this terrible tribunal he had abjured what were termed his errors, he exclaimed in striking his foot on the ground, "and yet it moves." Distinguished in physics no less than in astronomy, Galileo discovered the laws of the pendulum and the weight of the atmosphere, which his disciple Torricelli fully demonstrated by inventing the barometer.

* Drebbel was a celebrated alchemist, who was born in Holland, and died in London in 1634. To him is attributed the invention of the thermometer and the discovery of the means of producing a bright and permanent scarlet dye.

It was only at the beginning of the present century that any serious attempts were made to solve this problem of applied optics. In 1816, the distinguished optician Frauenhofer, of Munich, constructed a tolerably perfect microscope, although it had only a low magnifying power. At the meeting of the Academy of Sciences, April 5th, 1824, M. Selligue, one of our most ingenious mechanicians, exhibited an achromatic microscope, constructed according to his own plan by MM. Vincent and Charles Chevalier. From this moment the most rapid progress was made in the construction of microscopes. In 1825, the Chevaliers, and in 1827, M. Amici *, constructed instruments very superior to those of their predecessors. That constructed by M. Amici, more especially, excited the warmest expressions of admiration when it was brought to Paris; but it was nevertheless excelled in 1834 by that of M. C. Chevalier. About this time, MM. Oberhaüser and Trécourt devised their *platine à tourbillon*, while they also improved their lenses. A systematic competition was now established between them and the Chevaliers, by which science profited very considerably. Subsequently to this, M. Dujardin † invented his excellent illuminating

* M. Amici, who is a Professor of Physics at Modena, has attached his name to several optical instruments. He has invented a catoptric microscope, a new *camera lucida*, &c. M. Amici himself constructs the glasses which he uses for his instruments, and he has thus succeeded in obtaining more powerful and perfect object-glasses than any of his competitors. His glasses, however, possess the very serious defect of being easily affected by moisture; and I have heard of one instance in which an object-glass, that was bought of the learned Professor for a thousand francs, was utterly unfit for use after having been carried for some way by sea, although it had actually never been employed by its owner.

† M. Dujardin, one of the most distinguished of our naturalists, is now Professor of Zoology in the Faculty of Sciences at Rennes,

apparatus, M. Oberhaüser devised his *microscope pancratique*, while the Nachets added several ingenious accessories to their special movement. The impulse which had been given to this branch of scientific invention originated in France, but was soon followed in other countries, and it may be said that the possible limits which micrographers hoped to attain thirty years ago have long since been exceeded.

The qualities which a good microscope ought to possess are to give the image witb distinctness. The observer ought to be able to see as well in his instrument as he sees on the table at the distance of distinct vision. Our skilful workmen of the present day can fulfil these requirements until they reach a magnification of 400 or 450 diameters.* Beyond that limit, the outlines become less clear, and the images grow more and more confused. However, it is sometimes of use to go higher than this, and we may even, if we wish it, exceed a thousand

after having held the chair of Geology in the Faculty of Sciences at Toulouse. This fact is in itself sufficient to indicate a variety of acquisitions, whose extent can only be appreciated by those who are personally acquainted with him. M. Dujardin has especially devoted his attention to the lower organisms, and, in this respect, he has enriched science with many extremely important discoveries. We may instance, amongst others, the fundamental fact which he discovered in reference to the Rhizopoda, which, according to this observer, can fabricate for themselves, as it were, the members which may be momentarily necessary to them, this being effected by means of the homogeneous substance of their body. Independently of a very great number of special memoirs, which for the most part have appeared in the *Annales des Sciences Naturelles*, M. Dujardin has published, in the *Suites à Buffon*, works on the Infusoria and on Intestinal Worms.

* The magnifying power of a microscope or lens is estimated in diameters. To obtain the magnification of the entire surface, we must square the given number; thus, a magnifying power of 450 diameters will in reality enlarge the object 202,500 times.

diameters with a sufficiently strong light.* It is necessary that the instrument should be solidly mounted, and should admit of being easily worked. The more simple it is, the less space will it occupy, and consequently it will be the more readily adapted to the requirements of the observer. Some of the arrangements adopted in our day seem to be so perfect as to leave nothing to be desired.†

Note IV.

M. Milne Edwards, who is a member of the Institute (Academy of Sciences), Professor at the Jardin des Plantes, and in the Faculty of Sciences of Paris, is incontestably one of the leaders of zoology in its present state. His labours, which are as important as they are numerous, have justly secured to him the high position which he holds, whilst his elementary works have rendered his name universally popular. M. Milne Edwards, at an early age, made the Invertebrata the objects of his scientific research, and he soon understood that in order distinctly to comprehend the history of these animals, it was necessary to study them in their native *habitats.* In association with his friend and fellow-labourer, M. Audouin, he was the first to set the example of those prolonged sojourns on the sea coast which are alone able to afford opportunities for the serious

* A magnifying power of a thousand diameters will enlarge the surface of the object 1,000,000 times. It will be readily understood that the clearness of the images must of necessity diminish in proportion to the height of the magnifying power, since the same quantity of light has here to form a much larger image.

† See for farther details, M. Dujardin's Manual, and the work of M. C. Chevalier, to which we are indebted for the principal historical details already given. This treatise is entitled, *Des Microscopes et de leur usage.* [We may refer our English readers to Quekett's *Practical Treatise on the use of the Microscope.*]

study of those animals to which at the present day so much interest is attached, and their example has since been often imitated. M. Edwards has published a very considerable number of original memoirs in the *Annales des Sciences Naturelles*, the zoological department of which has been under his direction for twenty years, and which in his hands has become one of the most remarkable scientific periodicals of the age.* Amongst the general works of this naturalist we may instance, among others, his *Histoire des Crustacés*, which forms part of the *Suites à Buffon*, his *Histoire des Polypiers*, which was published conjointly with M. J. Haime, and the *Eléments de Zoologie*, which has become a classical text book.

The scientific merits of M. Edwards are not so much dependent upon the number and extent of his labours as upon their general tendencies. In addition to special facts, the author has always sought for generalities.

Thus, after having given the anatomy of the Crustaceans, he adds a memoir on the tegumentary skeleton of these animals, which is entirely conceived in the spirit of the philosophical schools, although executed with a rigour which is very often wanting in works of that nature. His elucidation of the general history of these Articulata necessarily led to the consideration of their geographical

* The *Annales des Sciences Naturelles* first appeared in 1824, under the joint direction of MM. Audouin, Brongniart and Dumas, and were then devoted equally to zoology, botany, geology, and mineralogy. Since 1834 the two latter sciences have not been included, and the second series, which continued to appear for ten years, was under the direction of MM. Audouin and Edwards for zoology, and MM. Brongniart, Guillemin, and Decaisne for botany. In 1844 the third series was commenced, the zoological department being under the sole direction of M. Edwards, whilst MM. Brongniart and Decaisne superintended that of botany. In 1854 the *Annales* entered upon their fourth series under the same editors.

distribution, and this study led him to the theory of the centres of creation,—a view which is daily being confirmed by additional palæontological results. In his works, as well as in his memoirs, M. Edwards has always given great prominence to external description and to anatomy, and moreover he never separates the study of the function from that of the organs. It was by assuming this point of view that he was led to propose the *principle of the division of physiological labour*, a principle which has thrown an entirely new light upon some of the most difficult questions in Zoology. M. Edwards has given a general resumé of his scientific views in a work entitled *Éléments de Zoologie Générale.*

We must not confound M. Milne Edwards, the zoologist, with his elder brother, William Edwards, who was also a member of the Institute (Academy of Moral and Political Sciences). This brother died at Paris in 1844, and was much older than the zoologist. After having studied medicine he first turned his attention to experimental physiology, and published on this subject a capital work, which has been too much neglected by some of our modern physiologists, and which bore the title *De l'Influence des Agents Physiques sur la Vie.* He afterwards turned his attention to ethnology, which soon entirely absorbed him. His researches on the Gaels and the Kimri, the results of which he applied to several European nations, were the means of obtaining for him a place in the Institute. The latter years of his life were devoted to the prosecution of a great work on languages which he was unable to complete, and of which one part appeared after his death under the title of *Recherches sur les Langues Celtiques.*

Audouin, a member of the Institute (Academy of Sciences) and Professor at the Jardin des Plantes, was born at Paris, in 1797, and died in 1841. Although ori-

ginally intended for the bar, and afterwards for the medical profession, he nevertheless felt himself invincibly drawn towards zoology, and a happy accident aided him in this pursuit. In one of his entomological excursions he was met by Al. Brongniart, who felt himself attracted towards the young student, in whom he thought he recognised the same ardour by which he was himself animated. He assisted him by his advice, and Audouin derived so much benefit from their intercourse, that he qualified himself to discharge the duties of the chairs held by Lamarck* and Latreille †,

* Lamarck, a member of the Institute (Academy of Sciences) and Professor at the Jardin des Plantes, was born at Bargentin in 1744, and died at Paris in 1829. As the younger son of a noble family, he had been destined for the church, and entered at the Theological College; but, on the death of his father, he made his escape, and enlisted in the army under the command of Maréchal de Broglie. He very soon distinguished himself, and was raised to the rank of lieutenant in consequence of his daring conduct in action, but a serious illness and the annoyances of the service induced him very speedily to renounce the career of arms. He came to Paris with the view of studying medicine, or rather of following his favourite pursuit of botany. About this time he invented the dichotomic classification, which enables us very readily to ascertain the name of the plant or animal which we may desire to determine. Subsequently to this he published his *Flore Française*, drawn up in accordance with his own views, which Buffon caused to be printed at the royal press, and which achieved a great success. He was soon nominated keeper of the collections at the Jardin du Roi, and when the Convention reorganised the Museum, he was appointed to lecture on the Invertebrata. He was then nearly fifty years of age, and the subject was perfectly new to him, yet he devoted himself so assiduously to the task that he even succeeded before long in throwing an entirely new light upon this imperfectly known subdivision of the animal kingdom. Unfortunately his incessant labours injured his sight, and he became

† See next page for note.

both of whom had become aged and infirm. Having been called upon to replace the latter of these distinguished men, Audouin devoted himself to the study of entomology, and he was engaged in exploring the south of France with the view of studying the insects which attack the olive trees, when he was carried off by a painful illness. MM. Audouin and Edwards, united by a friendship which was never weakened by the similarity of their aims and the identity of their objects, published conjointly several memoirs, amongst others the work to which we have often referred, entitled *Recherches sur le Littoral de la France.* M. Audouin has also pub-

completely blind. This misfortune was, however, alleviated by the cares of his daughter, who, to a certain extent, worked for him, and wrote under his dictation. Lamarck has published a great number of works, of which three are especially conspicuous from their size and importance; *Flore Française*, *Zoologie Philosophique*, and especially the *Histoire Naturelle des Animaux sans Vertèbres*, which has nobly earned for him the title of the French Linnæus.

† Latreille, who received from his cotemporaries the title of the *Prince of Entomology*, was born at Brives in 1762, and died at Paris in 1833. He was a member of the Institute (Academy of Sciences), and of almost all the Academies of Europe, yet few men have led a more unostentatious, and even laborious life. First, as a young man occupying the position of an obscure parish priest, he narrowly escaped death during the evil times of the revolution. Subsequently he filled the place of mere assistant at the Museum, and did not attain the rank of professor until after the death of Lamarck. "They give me bread to eat now that I have no teeth left," he exclaimed on learning his nomination to the chair, which he was destined to occupy for only four years. Science truly is sometimes an unjust parent, for Latreille was one of her most illustrious sons. By his publication of his *Genera Crustaceorum et Insectorum*, he divided with Cuvier the honour of having introduced the natural method into zoology. The greater number of his other works are equally remarkable, and his *Histoire des Crustacés et Insectes* is a work which serves as a model for all those which may succeed it.

lished several memoirs on *pure and applied Entomology;* amongst others an *Elementary Treatise on the Tegumentary Skeleton of Insects*, a work on the *Muscardine* and another on the *Pyrale*, which did not appear till after his death.

Note V.

The controversy alluded to in the text regarding the nature of these organisms applies to all polypes, including those of the Coral. These animals had been described and named as plants even by Marsigli, who carefully studied them in their living state. Peysonnel, a surgeon of the Royal French Navy, was the first to recognise the veritable nature of their pretended flowers, and he made known his discovery to Réaumur.* But this illustrious

* Réaumur, who was born at La Rochelle in 1683, and died in 1757, deserves to be regarded as one of the most distinguished scientific men of France. From his earliest age he devoted himself to science, and all his labours were preceded by the serious study of mathematics. His first memoirs on Geometry gained him admittance to the Academy of Sciences at the age of twenty-four. Although he was possessed of an independent fortune, he laboured with unwearied ardour, and occupied himself with the most varied subjects. Every one is aware of the fact, that he invented the thermometer which bears his name. The practical arts are, moreover, indebted to him for the suggestion of a method for transforming forged iron into steel, while to him are also due several improvements in the fabrication of porcelain, and the introduction into France of the manufacture of articles of block-tin. It was, however, in his works on natural history, that he exhibited the greatest originality, and even true genius. He devoted his attention first to Molluscs and Zoophytes, not only with the view of describing their external forms,but in order to discover and explain the most obscure phenomena of their lives. It was also from this point of view that he studied Insects ; and the work which he has left on this subject, under the title of *Mémoires pour servir à l'Histoire des Insectes*, may be considered as a masterpiece of exact and minute observation.

naturalist, pre-occupied with old ideas, and wishing as he himself said, to respect the reputation of a fellow-labourer, whose previous works he esteemed, did not think it necessary immediately to communicate the result to the Academy. He did, however, make it known in 1727, but without himself adopting it. Peysonnel's discovery was contested until the experiments made by Trembley *, on the fresh-water hydra had exhibited in the latter a naked type of the Coral Animal and other Zoophytes. All doubts were at length finally removed by the works of two members of the Academy, Guettard † and Bernard de Jussieu, who, in 1741, visited the sea coast with the view of verifying Peysonnel's observations.

Note VI.

Kepler, who was born in Würtemburg in 1571, and died at Ratisbon in 1630, was to a certain extent the precursor of Newton. He was one of the first who applied mathematics to physics; he completed the *Rudolphine Tables,* which had been begun by Tycho Brahe ‡, reformed the Calendar, and published several

* Trembley, who was born at Geneva in 1700, and died in 1784, has immortalised his name by the discovery of the fresh-water hydras, and by the curious and exact experiments which he made on these animals.

† Guettard, a distinguished physician and mineralogist, was born at Etampes in 1715, and died at Paris in 1786.

‡ Tycho Brahe, who was born in 1546, and died in 1601, remains celebrated in the history of astronomy for his love of that science and for the invention of a system which may be regarded as intermediate between those of Ptolemy and Copernicus. According to him, the earth occupies the centre of our system, but the sun in turning round the earth is accompanied by the superior planets, which serve it in the capacity of satellites. This system, which appeared to reconcile the progress achieved by modern science with

works on astronomy; but of all his labours, that which has rendered his name immortal is the discovery of the laws of the motion of the planets and of the comets round the sun. We will here give these laws, referring our readers to works on astronomy for more ample details.

1st. The orbits of the planets and the comets are ellipses, of which the sun occupies one of the foci.

2nd. The area described by the radius vector of a planet or a comet in its movement round the sun, is proportional to the time.

3rd. The squares of the times of the revolution of the planets and comets round the sun are proportional to the cubes of the mean distances from the sun.

It has been asserted that Kepler was led by accident to these splendid mathematical discoveries, under the instigation of those mystic ideas to which he so willingly abandoned himself. We do not know what degree of truth there may be in this allegation, but it is very certain that this great astronomer was moved by deep religious impressions. We possess a proof of this in the beautiful prayer which terminates one of his works, and which has been introduced in the opening part of Buckland's *Reliquiæ Diluvianæ*. It will no doubt afford satisfaction to our readers if we give a translation which has been made of this prayer.

"Before I leave this table on which I have made all my calculations, I must raise my eyes and my hands towards heaven, and devoutly address my humble prayer to the author of all light. O Lord, by the sublime light

the famous text in the Book of Joshua, was long held in high esteem amongst theologians. It is now entirely exploded. Tycho Brahe had erected his observatory of Uranibourg, on a little island of the Baltic, which he rendered celebrated by his labours and by several important discoveries.

which Thou hast spread over all nature, raise our desires to the divine light of Thy grace, in order that we may be, one day, transported into the eternal light of Thy glory! I give Thee thanks, Lord and Creator, for all the pleasure that I have enjoyed, and for the ecstacy which I have experienced from the contemplation of the work of Thy hands. Now that I have completed this volume, which contains the fruit of my labours, and have devoted all the intelligence that Thou hast given me in composing it, I proclaim before men all the greatness of Thy works; I have explained to them these evidences as far as it has been permitted to my spirit to comprehend their infinite extent. I have devoted all my energies to raise myself to the height of truth, through the paths of philosophy; and if it has happened to me, a miserable worm, conceived and nourished in sin, to say anything unworthy of Thee, make me to know it, in order that I may efface it. Have I suffered myself to be carried away by the seductions of presumption in presence of the admirable beauty of Thy works? Have I thought too much of my own renown amongst men by raising this monument which ought to be consecrated entirely to Thy glory? O, if it be thus, receive me in Thy clemency and Thy mercy, and grant me this grace that the work which I have just completed may ever be powerless to do evil, and may contribute to Thy glory and to the salvation of souls!"

Isaac Newton, who was born at Woolsthorpe in Lincolnshire, in 1642, and died in London in 1727, was one of those geniuses of which all humanity may well be proud. It is asserted that he had already made the greater number of the discoveries which have immortalised his name at the age of twenty-four. He has left several treatises on Mathematics, Physics, and Astronnomy, among the most remarkable of which we may instance

his *Optics* and his *Principia;* and on the latter of these rests his principal title to fame. In this work he has developed, in a manner which all astronomers declare to be truly admirable, the doctrine of *universal attraction,*—a doctrine which has furnished a key to a host of phenomena, and on which the entire system of modern astronomy is based. Without going too much into details which would carry us beyond the plan of this work, we will briefly recapitulate the principles established by Newton.

1st. All the particles of matter diffused through the universe mutually attract one another directly as their mass, and inversely as the square of the distance.

2nd. This force is independent of time, it acts through all substances whatever may be their nature, and their state of rest or motion.

3rd. When two spherical bodies attract one another, the attraction is exerted precisely as if the entire mass were concentrated in the centre of each sphere, and consequently as if each of them formed only one sole particle.

4th. Two spherical bodies, obedient to the action of attraction, describe each round the other, considered as fixed, concave curves belonging to conic sections: they likewise describe similar curves round their common centre of gravity. These curves will be ellipses, parabolas, or hyperbolas according to the conditions which are present.

5th. In each case, the angular velocity with which the line joining the centres moves will be in an inverse ratio to the square of their mutual distance, and the areas described by this line will be equal in equal times.

For a long time experience has proved that these laws govern our solar system, and recent discoveries on the motions of double stars have proved that they

equally regulate the course of the most distant stellar groups.

Newton's labours brought him at an early age both honours and riches. All the different Academies of Europe were anxious to enrol him among their members, and at the age of fifty-four he was appointed Master of the Mint, a lucrative position, which enabled him to leave at his death a fortune of about 28,000*l.** Perhaps this may be regarded as a misfortune, as far as science is concerned, for, being engaged in the duties of his office, Newton did not pursue his scientific investigations.

Like Kepler, Newton was very religious, and naturally disposed to entertain mystic ideas. Even in the midst of his scientific labours he was engaged in making a commentary on the Apocalypse. After having all his life enjoyed perfect health, he died from stone in the bladder after twenty days of the most intense suffering; but although the perspiration often stood on his brow from the torture which he endured, he was never heard to utter a complaint, nor was his serenity of mind disturbed.

Note VII.

Linnæus, who was born at Roeshult in 1707, and died at Upsala in 1778, was one of those rare geniuses from whom we date a new era in science. Like all men who feel themselves called to some definite vocation, but who are prevented in early life from following the bent of their own inclinations, his youth was one of trouble and privation. His father, who was a poor Protestant clergyman, and who destined his son to succeed him in

* [Sir David Brewster makes Newton's fortune even larger than the sum mentioned by De Quatrefages, namely, 32,000*l.* See his *Memoirs of Sir Isaac Newton*, vol. ii. p. 396.]

his pulpit, had placed the boy at school when he was ten years of age: instead, however, of attending to his classes and learning his Latin grammar, the child ran about the fields picking up wild flowers. The punishments of his master, and the threats of his father were alike unable to overcome this instinctive inclination, and being considered incorrigible, the boy was at length apprenticed to a shoemaker. In this capacity he had the good fortune of attracting the attention of a physician, named Rothman, who lent him the works of Tournefort, and recommended him to Stobœus, Professor of Botany, who employed him to copy manuscripts for him, and who, being struck by the strange tastes of the youth, sent him at his own expense to the university of Upsala. The allowance made to Linnæus was, however, anything but munificent; and to increase his means he gave lessons, and occasionally even, availing himself of the art which he had learned during his apprenticeship, mended the shoes of his brother students. Happily for himself, he soon rose to some distinction, and the Professor of Botany, after having first entrusted him with the management of the botanical garden, employed him as his substitute in lecturing, and some time afterwards the town of Upsala engaged him to make a scientific expedition to Lapland; an undertaking in which he exhibited no less personal courage than ardour in the cause of science.

Having met on his return with the annoyances which the local jealousies of a little town are apt to entail upon all who have the talent of raising themselves above the ordinary standard of their fellow-citizens, Linnæus would have been thoroughly disheartened if there had not been a feeling which tended to keep alive his ambition. A young girl, to whom he was much attached, and who reciprocated his affection, exacted a promise from him

that before their marriage he would travel for three years, in order to acquire that reputation to which he was so well entitled to aspire. Linnæus took his departure for Leyden, where the reputation of Boerhaave * was then attracting a crowd of disciples. He reached this town without resources of any kind; but the great Dutch physician knew how to appreciate the stranger, and through his means he was soon made known to a rich amateur passionately fond of natural history. This generous patron threw open his collections and his library to the young Swede, who, in testimony of his gratitude for these favours, immortalised the name of his benefactor in the title of one of his first works.† At Leyden, Linnæus received the degree of Doctor of Medicine, after which he visited England and France. It was during one of his two visits to Paris that he contracted that friendship with Bernard de Jussieu, of which his correspondence affords numerous proofs.

On his return to Sweden, Linnæus did not at first meet with the reception which ought to have been awarded to his already celebrated name; but at length, through the good services of De Geer ‡ and the Count

* Boerhaave, who was born at Voorhout in 1668, and died in 1738, has left a name celebrated in the annals of medicine. His reputation was so great, that letters were sent to him from India and America, bearing the sole address of Boerhaave in Europe. He left a large number of works, which, even at the present day, possess some points of interest from the efforts which he made to reconcile the vitalism of Hippocrates with the chemical views of Sylvius, and the solidism of Hoffmann.

† This work was entitled *Hortus Cliffortianus;* Cliffort being the name of his rich and generous friend.

‡ De Geer, who was born in 1720, and died at Stockholm in 1778, belonged to a baronial family in Sweden. He devoted the large fortune which he possessed to the promotion of science and to the aid of the unfortunate. From his youth he had been an ardent entomologist, endeavouring to follow in the steps of Réaumur.

de Tessin *, he was appointed physician to the king in 1739, and was at length enabled to marry the young girl, who had divined his genius, and secured his glory.

In 1741, Linnæus was named Professor of Botany at the University of Upsala, where the high character of his lectures and of the works which he soon published, attracted a crowd of pupils from all parts of the world, who spread abroad the fame of their great teacher. He was soon rewarded with academic and civic honours; but without suffering himself to be intoxicated with his good fortune, he continued his labours unremittingly, centering his happiness in the circle of his family and in the pursuit of science. For thirty-two years he preserved all his original activity, but then a marked feebleness of memory appeared as the precursor of those infirmities which rendered his old age painful. Two attacks of apoplexy deprived him of almost all his faculties, and he finally died of dropsy at the age of seventy-one. Sweden knew at any rate how to appreciate the loss which she had sustained, and the funeral of Linnæus was conducted with all the pomp which is usually reserved for princes of the blood royal, while King Gustavus the Third himself composed the funeral oration.

Linnæus may be regarded as one of our greatest scientific lawgivers; and he influenced all scientific movements, not only in his own country but throughout all Europe. Some few minds, either from a faithful

His memoirs bear the impress of a keen and patient intellect, associated in a high degree with talents for observation. He published in French a large work entitled, like that of Réaumur, *Mémoires pour servir à l'Histoire des Insectes.*

* In gratitude for the patronage and friendship of the Count, Linnæus has immortalised his name by dedicating to him his *Systema Naturæ.*

adherence to established errors, or in consequence of having entertained more advanced ideas, alone escaped his influence; and it was very probably on both these grounds that Buffon constantly showed himself so inimical to the views of the illustrious Swede.

Linnæus not only worked himself, but he gave out the subjects of theses, proposed problems to be solved, and sent forth his pupils to explore all regions which promised to yield a rich harvest to the natural sciences, and he thus largely diffused around him the most active and emulous zeal for science. His works, which were written in Latin, are distinguished by a style which is at once very correct and picturesque, and which occasionally exhibits a remarkable character of elevation and energy. We would especially instance the preface to his *Systema Naturæ*, and his description of the general characters of the Class of the Reptiles in the same work.

The writings of Linnæus are essentially descriptive; and, at the present day, when science has made such rapid progress, we must throw ourselves back into the time at which he wrote in order fully to comprehend the magnitude of the services which he has rendered. Before his time all classifications, including those of botany, were extremely imperfect both in respect to principle and in application. The *genera* which were tolerably well defined, bore a single distinctive name, but each *species* was designated by a descriptive phrase; and it will easily be understood that this kind of phraseology would become very cumbrous in proportion as the number of species was augmented. Hence it became extremely difficult for the memory to preserve any precise impressions of any considerable number of species, while it was almost impossible to grasp at the general relations. Linnæus created the *binary nomenclature*, in which every animal and vegetable being is

designated by two names, one a substantive, which indicates the genus, the other an adjective, which designates the species, and which may be said to correspond to our family and baptismal names. He was thus enabled to devise simple and precise systems of classification, which rested upon a basis which was at once more extended and more solid than any adopted by his predecessors. These classifications, which were received at the time with enthusiasm, are still made use of by botanists. Linnæus did not, however, deceive himself in reference to the artificial nature of all systems generally, and of his own more especially; he felt that there must be something superior to his own method, and in his *Fragments of the Natural Method* he aimed at more general views; but the proper time was not yet come; and this glory was reserved for two Frenchmen, Laurence de Jussieu in botany, and Cuvier in zoology.

Note VIII.

Geoffroy Saint-Hilaire, a member of the Institute, and a professor at the Jardin des Plantes, and in the Faculty of Sciences, was born at Etampes in 1772, and died at Paris in 1844, leaving a name which ranks amongst the most illustrious in the annals of modern science. This renown is due more especially to those great and noble ideas which he advocated throughout the whole of his life, and which he either introduced or restored to the field of zoological inquiry. This general direction of his researches, which was continued for nearly half a century, explains the diversity of the judgments which have been passed upon him by his successors. To appreciate these different opinions, and to analyse all that is just or exaggerated in them, renders a serious discussion of these facts and doctrines

absolutely necessary. It is impossible to separate Geoffroy from his immediate predecessors or his cotemporaries, nor can we form an exact idea of the value of his labours, unless we also take into account the rapid progress which has been made since his death. A subject of this kind ought not to be hastily disposed of in a note; and I hope, on some future occasion, to be able to discuss it more in detail in a work, the idea of which has long been present to my mind. I will here subjoin a short and almost exclusively biographical notice of this great man.

Being destined by his family for the clerical profession, Geoffroy Saint-Hilaire was provided, at the age of twelve, with a Canon's stall, and was sent to prosecute his studies at the College of Navarre. Here he attended the classes of the physicist and naturalist Brisson, who speedily awakened in him a taste for the natural sciences. On leaving college he attended the lectures of Haüy*

* Haüy was a member of the Institute, and professor at the Jardin des Plantes, and in the Faculty of Sciences. He was born at Paris in 1742, and died at the same place in 1822. As the son of a common workman, he appeared destined to follow the same career, when his intelligence and his devotion attracted the favourable notice of the superior of a monastery, who undertook the charge of securing to him the first rudiments of instruction. He was soon sent as a chorister to one of the churches at Paris, from whence he proceeded to the College of Navarre, and after that to the College Lemoine, where he became second master. Here he also contracted a friendship with Lhomond the grammarian, and, to adapt himself to the tastes of his friend, turned his attention to botany. He now for the first time understood his true vocation, and devoted himself with the greatest assiduity to the study of mineralogy, which was then taught at the Jardin des Plantes by Daubenton.

Haüy was thirty-eight years of age when he began his mineralogical studies. At this time Linnæus had already shown that the regular form of crystals is due to the action of forces, which obey definite laws. Romé de Lisle had made a considerable step in

and of Daubenton*, and the relations which were soon established between the masters and their pupil were attended with the happiest results to science, for they decided the future prospects of Geoffroy, and saved the life of Haüy. Indeed, the latter, who had been imprisoned as a refractory priest a few days before the

advance by recognising that the angles are constant in different crystals of the same variety. The true laws of crystallisation remained unknown until Haüy was led to their discovery by a fortunate accident. Struck by the regularity of fracture which was observable in a piece of calcareous spar that accidentally escaped from his hands, and was broken in pieces, Haüy collected the fragments, examined them carefully, and reduced them into still smaller parts, by which he was led to perceive the constant relations existing between the different forms which he thus obtained. He now resumed the study of physics and mathematics, with the elements of which he had once been well acquainted. Breaking successively all the specimens contained in his own private collection, he measured and calculated the angles by methods which he had himself invented, and, referring the almost infinite number of forms which occur in nature to a small number of primary forms, he finally created an entirely new science—that of crystallographic mineralogy. The humble teacher had thus acquired for himself a renown to which few men of science attain. Honours and dignities were offered to Haüy from every quarter. Both the republic and the empire in turn sought him out in his retreat, and offered for his acceptance the first chairs in their gift, and the most important scientific missions; but without being dazzled by these flattering marks of attention, Haüy remained faithful to his old habits of work and humble privacy. Forgotten by the Bourbons after the restoration, he died, leaving no wealth beyond the collection on which he had based all his discoveries. This collection, which was so valuable on many accounts, was first bought for a very small sum by an Englishman; but having subsequently, through the zeal of M. Dufrénoy, been repurchased for France, it is now preserved in the galleries of the Jardin des Plantes.

* Daubenton was a member of the Academy of Sciences, and a professor at the Jardin des Plantes, as well as at the Collége de France. He was also a fellow labourer of Buffon.

September massacres, would undoubtedly have been put to death, if his pupil had not employed the same ardour in rescuing him which he exhibited all his life, whenever his judgment or his feelings were appealed to. Not satisfied with having stimulated the colleagues of the illustrious mineralogist to bestir themselves until the Academy took a decided step, which was followed by an order of liberation, Geoffroy, at much personal risk, visited his master while in prison. A few days afterwards he exposed himself still more in trying to save his old professors at the College of Navarre. Invested with the insignia of an Inspector of Prisons, he entered, on the morning of the 2nd of September, into the College of Saint Firmin, after having prepared everything for the escape of his friends, who, however, refused to leave, from the fear of aggravating the position of the prisoners who still remained in the building. Geoffroy then, as a last resource, showed them a wall which could be easily scaled, and by which they might, when they pleased, make their escape. He then went to pass the night of the 2nd and 3rd of September at the spot indicated, where he aided twelve priests in making their escape. It was only at the break of day, when he was assisting the twelfth of the fugitives, that a musket ball struck him, penetrating through his clothes, and thus affording him conclusive evidence that the building was already in the possession of the assassins, and that his devotion could, therefore, be of no farther avail.

Haüy, who had been saved by Geoffroy, obtained for him the post of sub-keeper and demonstrator at the Jardin des Plantes. On the 10th of June of the following year, 1793, a decree of the Convention organised the plan of instruction at the Museum, and founded twelve chairs in that institution. Geoffroy was nominated in this decree as professor of the zoology of ver-

tebrate animals. At first he refused to accept the chair, saying that, as his studies had been all directed to mineralogy, he was incapable of lecturing on zoology. Daubenton, however, insisted with all the authority of a parent that he should accept the appointment. "Zoology," said he, to his young pupil, "has never been made the subject of lectures at Paris; everything, therefore, remains to be done. Do you make the beginning, and perform the duties of your chair in such a manner that twenty years hence it may be said *zoology is a science, and what is more, an entirely French science.*" Overcome by the persuasions of his master, Geoffroy at length accepted the professorship, and at once set resolutely to work. At this time he was one-and-twenty years of age.

Immediately after his installation, Geoffroy rendered a very signal service to the science which he was called upon to teach. The foundation of the Ménagerie at the Jardin des Plantes is entirely due to what may be called an act of youthful temerity. From one of those caprices which seem occasionally to have actuated the conduct of those who held power at this period, the police had received instructions to forbid the exhibition of living animals in Paris, and to confiscate three itinerant menageries, which were then being exhibited, and convey them to the Museum. On the 4th of November, 1793, Geoffroy, to his great surprise, was informed that a number of tigers, panthers, white bears, and other animals, together with eagles, crocodiles, serpents, &c., were at the gate of the Museum. They were to be received, fed, lodged, and maintained, although the garden possessed neither space, money, nor keepers. Geoffroy, however, did not hesitate a moment, but ordered the vans and cages which contained these animals, to be placed in the court under his own window, retaining the ex-proprietors

as keepers, and taking upon himself the responsibility of all the expenses. Some of his colleagues were alarmed at the consequences, and blamed his conduct, whilst others approved of it; nevertheless, Geoffroy persevered, and in the course of a month, a vote of the Assembly confirmed the happy initiative of the young professor. But the decree of the Convention. which bears the date of the 11th of September, 1794, only gave an official confirmation to an establishment which had been in existence for more than a year.

Here we must record an event of much consequence in the history of science, and which is highly honourable to Geoffroy. The Abbé Tessier, who had taken refuge in the provinces, wrote to his colleague, Parmentier, "I have found a treasure in the wilds of Normandy." It was thus that Tessier described a young man, who, while discharging the humble duties of a private tutor, devoted all his leisure time to Natural History. He wrote in a similar strain to Lamarck and to Geoffroy entreating them to draw this young naturalist to Paris. To aid his friend in the accomplishment of his wishes, Geoffroy requested that the young man might send him some of his manuscripts, and immediately on the receipt of a communication from the stranger, wrote thus to his unknown correspondent, "Come to Paris without loss of time; come and assume the place of a new Linnæus, and become another founder of Natural History." It was thus that Cuvier, for it was he, was called to Paris by the prophetic summons of Geoffroy. An intimate friendship was soon established between the two; and although this friendship may afterwards have appeared to be broken by the keenness of scientific discussions, we have pleasure in certifying from personal knowledge that it revived with all the intensity of earlier days as soon as one of the two antagonists was struck by some of those trials which fall

upon the great as well as the humble. The existence of this friendship is apparent in the earlier works of these two illustrious men, for many of their researches which they had carried on conjointly, were alternately drawn up by only one or the other, although they were always signed in the names of both.

The campaign of Egypt put an end to these joint labours, for Geoffroy was easily induced to follow the young general whose exploits in Italy had already gained him so high a reputation. Having fallen into the sea during his voyage, and not knowing how to swim, Geoffroy was saved almost by accident. On his arrival in the land of Egypt which so forcibly appealed to his ardent imagination, he everywhere accompanied our troops, evincing as much ardour and energy in the accomplishment of his scientific mission as our soldiers displayed in fulfilling their duty. Having reached the ruins of Thebes, he spent three weeks within the tombs of that ancient capital, examining and studying the mummies of animals, with the view of comparing them with living species; the result of his assiduous labours was an immense quantity of notes and drawings, the greater part of which were subsequently published. It is well known how this expedition terminated which had begun under such brilliant auspices. The remains of our army were compelled to capitulate; and availing themselves of the circumstances, the English wished to secure to their country the glory of publishing all the discoveries that had been made by our savants. They demanded that all the materials, notes, and drawings, that had been obtained at the cost of such extreme labour and in the midst of so many real dangers, should all be resigned to them, while they offered to allow our compatriots to superintend the publication, and promised in addition to secure for them an honourable position in

England. Some were disposed to yield, when Geoffroy indignantly declared that, rather than give up his papers and notes, he would burn them with his own hands at the moment the English entered Alexandria. Carried away by his example, all his colleagues declared their determination to do the same. Nothing could, of course, be attempted in the face of such resolution, and the English plenipotentiary was therefore compelled to draw back, while France secured the glory of publishing the great work on Egypt.

In 1808 Geoffroy was charged with a scientific mission to Portugal, the object of which was to obtain from the collections in that kingdom all the specimens which were wanting in those of France. Far from abusing his position, Geoffroy carried with him duplicates from the Jardin des Plantes, and limited himself to making exchanges, which were equally advantageous to both parties. The Canons of St. Vincent, surprised at conduct to which they were so little accustomed, wished to make Geoffroy a rich present, but this he refused. His liberal and noble conduct, however, reaped its reward on a future occasion; for when foreigners, having in their turn become victors, came to ransack our museums at Paris, and to recover all that had been taken from them, the minister of Portugal having been invited to remove from the museum everything that belonged to his own country, replied that he had nothing to claim, for everything had passed in good will, and that M. Geoffroy, far from abusing his authority, had not only replaced through duplicates everything that had been given to him, but he moreover classified and labelled the great collection of Ajuda. Thus, owing to the magnanimity of Geoffroy, the Jardin des Plantes was one of the very few establishments of Paris whose collections did not suffer by our disasters in 1815.

From this time forth Geoffroy undertook no more expeditions, but devoted himself exclusively to science. Although he was elected deputy for his native town, he never took part in the debates, and very soon renounced a position which drew him away from his studies. In the latter years of his life he was stricken with total blindness, and we have often had occasion to admire the serenity with which he supported this misfortune. His resignation was indeed rendered more easy to him by the cares of a devoted family. "I am almost happy in being blind," he sometimes remarked, "since it has made me better understand how much I am beloved." The physical repose to which he was condemned, seemed only to redouble his intellectual activity, and to his last hour he was occupied with those abstruse questions of natural philosophy which had influenced and guided his scientific life. He died happy in being able to leave his scientific heritage in the hands of a son *, and a friend.†

* M. Isidore Geoffroy Saint-Hilaire, who is a member of the Institute, and a professor at the Jardin des Plantes, and in the Faculty of Sciences, has more especially directed his attention to general zoology. His treatise on Teratology, in which he has applied ordinary methods to the description and classification of monstrosities, will always serve as a starting point for those who may occupy themselves with this important branch of the natural sciences. At the present time, he is publishing a great work, entitled *Histoire Générale des Règnes Organiques*, and it is easy to foresee that, being penetrated with a deep veneration for the memory of his illustrious father, he will endeavour in this work, as he has done in all his other writings, to develope the doctrines which have been handed down to him. This sentiment of filial piety has already led him to write a special work, entitled *Vie, Travaux et Doctrine Scientifique de Geoffroy Saint-Hilaire.* M. Isidore Geoffroy has also specially studied the collateral affinities of animals, or *zoological analogies*, and on the considerations which he has deduced from this order of ideas, he has established a mode of classification which he has called *parallel classification*, and which he

† See next page for note.

Without wishing to pass any judgment in the present place on the labours of Geoffroy, or to assign to them the rank which they merit, a few general remarks may afford a more exact idea of their nature. His works are very numerous, and, to judge by their titles, one might be tempted to believe that there was no connection between them. Such, however, is not the case. Amongst all these memoirs, which are dispersed in almost all the scientific periodicals of that epoch, there are scarcely any which have not been undertaken with the view of demonstrating or of verifying some principle or some general idea; and all these principles and ideas were comprised by Geoffroy in the fundamental thought of the unity of the organic plan of the animal kingdom. We may therefore form some idea of the immense range of the observations and researches to which he devoted himself.

has applied to the class of Mammalia. Having for a long time been placed at the head of the Ménagerie of the Museum, M. Isidore Geoffroy has necessarily been led to occupy himself with many practical questions, and it is to him especially that we owe the foundation of the *Société pour l'Acclimatation des Animaux utiles.*

† M. Serres, a member of the Institute, and professor at the Jardin des Plantes, is at the present time the leader of the school of transcendental anatomy in France. He has published several important works, in which the fundamental idea is that all higher animals pass through all the inferior grades of being before they arrive at their definite state: thus, for instance, man is considered to have begun as an infusorial monad, becoming successively a mollusc, an articulate animal, a fish, a reptile, a bird, an ordinary mammal, and finally a man. In this theory, which was taught as early as 1796 by Kielmaier, a professor at Tübingen, embryology is a true transitory comparative anatomy, while comparative anatomy is a permanent embryology. Without wishing to discuss the value of these views, we may observe that M. Serres has displayed much talent and ingenuity in their support. The principal works in which this author has expounded his doctrines are *l'Anatomie Comparée du Cerveau* and *le Précis d'Anatomie Transcendante.*

Among the questions which Geoffroy had to consider in maintaining his general proposition, that of monstrosities was the most beset with difficulties. To refer aberrant forms to regular forms, — to seek to trace in the development of these singular beings the laws of normal development, — to demonstrate that in these pretended sports of nature, ordinary forces are only brought into play in accordance with common laws, — to employ apparent deviations to discover those laws and forces which escape our attention when their action is exercised without any obstacle, — to determine the causes of their perturbations, — and thus to arrive at an idea of monstrosity, not in the vague and unphilosophical manner of Montaigne, but to judge of it with such precision as to be able to characterise and classify monsters in the same manner as in the case of normal beings,—this is the problem on the solution of which Geoffroy entered full of confidence in his own powers ; a confidence which has been justified in respect at least to all the principal points of the inquiry. This work, which is one of the most remarkable of the eventful period in which it was undertaken, would be sufficient to immortalise the name of its author.

Four essential principles have especially guided Geoffroy in these researches, which were alike delicate in method and elevated in character : —

I. The principle of *Les Affinités electives* of organic elements, which he subsequently generalised under the name of *La loi d'attraction du soi pour soi.*

II. The principle of *Analogues*, according to which he considers that those organs mutually represent each other which have identical relations with other parts of the organism.

III. The principle of *Connexions*, in virtue of which an organ becomes atrophied, or disappears from one animal

and reappears in another, rather than change its relations.

IV. The principle of the *Balancement des organes*, from whence it results that one organ cannot be excessively developed unless some other organ which is connected with it becomes proportionally atrophied. The first of these principles applies more particularly to teratological and embryological studies, whilst the three others ought always to be present in the minds of those who study anatomy.

In all these anatomical labours, Geoffroy has made himself the ardent and earnest champion of the doctrine of epigenesis against the doctrine of evolution, which was then generally admitted, and which Cuvier himself maintained; and the very rapid progress of modern science incontestably tends to confirm the view adopted by Geoffroy.

The first memoirs which he published referred to descriptive zoology, a study to which he often returned, although his habitual train of thought had led him to very different researches. Among works of this kind for which zoological science is indebted to him, we must not omit to mention his researches on the Bats. This exceptional group among the Mammalia attracted him by its very singularity, and by the difficulties which had repulsed his predecessors. Already, in 1797, he had shown, in a very remarkable memoir, that the ordinary rules of classification were perfectly applicable to this group, all the then known species of which he divided into distinctly circumscribed genera. Subsequently on different occasions he resumed the same subject with marked predilection, describing a great many new species, and creating several genera, all of which have been adopted. He has given the substance of these labours in a special article in the *Dictionnaire Classique d'Histoire Naturelle*,

where he has presented many general considerations which admit of being applied to almost all the aberrant groups which can be referred to any definite type. (Consult for farther details the work of M. Isidore Geoffroy already referred to, and *l'Éloge Historique de Geoffroy Saint-Hilaire*, by M. Flourens.)

Note IX.

Georges Cuvier *, who was born at Montbéliard in 1769, and who died at Paris in 1832, has left a name of which not only his country but all humanity may well be proud. It would employ more space than I can afford to give to this subject in the present volumes, were I to enumerate all his works, and consider not only their importance, and the influence which they have exerted, but also those traces of weakness and imperfection which they exhibit in common with all human labours. I must, therefore, limit myself, as in the case of Geoffroy Saint-Hilaire, to a short and almost exclusively biographical notice, postponing to some future period the scientific history of these two celebrated men.

From his childhood Cuvier gave evidences of his future greatness. At four years of age he was able to read, and at the age of six he gave an explanation of Hero's fountain, and of an enchanted poniard used in the tricks of a juggler. At thirteen years of age, he had read and re-read Buffon, and even copied all the plates, and he organised amongst the children of his own age a natural history society, of which he was himself the president. At the age of fourteen he had terminated

* The following details have been principally taken from the *Notice Historique* of the Life and Works of Cuvier, published by M. Duvernoy his compatriot, pupil, friend, and successor; for M. Duvernoy succeeded Cuvier in the two most important chairs of the natural sciences in France.

his classical studies, and was, moreover, acquainted with algebra, geometry, and surveying. The son of a brave Protestant officer, who had no resources beyond his small retiring pension, Cuvier was destined for the ministry, and offered himself as a competitor for one of the scholarships which his native town possessed at the university of Tübingen. It fortunately happened that he was prevented from entering this profession in consequence of the injustice of the examiner, whose duty it was to assign their relative places to the respective candidates; and Cuvier, finding himself third upon the list, renounced his original intentions. Soon after this, he was presented to the grand niece of Frederick the Great, and to Charles, reigning Duke of Wurtemburg, to whom the principality of Montbéliard then belonged; and his precocious merit having procured him the favour of these distinguished individuals, he was sent as a Bursar to the Academy of Stutgard, where he replaced Schiller.

In this remarkable institution, the pupils prepared themselves for every kind of professional career, being first obliged to attend a complete course of classics, and next to devote two years to the study of philosophy, mathematics, and the physical sciences. These different branches of learning were, however, taught in the German language, which was unknown to Cuvier, who could only speak French. In a few months he had, however, overcome so thoroughly this difficulty as to stand first in all the examinations, and thus obtained the cross of honour, which was to be awarded to the pupil who, in the course of one year, had carried off eight prizes in the higher departments of science.

Cuvier, feeling that he must now choose a profession, decided on entering the financial department of the government service. According to the regulations of the Academy, the candidates who wished to enter upon this

profession, were obliged to attend a curriculum, which included the following branches of knowledge: — 1. Civil law; 2. Botany; 3. Geography in relation to commerce; 4. Practical geometry; 5. The drawing of plants; 6. Theoretical and practical economy; 7. The knowledge of the economy of rivers, lakes, and forests; 8. Zoology; 9. Mineralogy; 10. Chemistry; 11. The science of police; 12. The knowledge of mines; 13. Hydraulics; 14. Numismatics; 15. Civil architecture; 16. Technology; 17. The commercial laws of nations; 18. The principles of taxation; 19. Book-keeping; 20. Finances; 21. The practical details of the office. We thus see that the smaller states of Germany exact from those into whose hands they entrust the public money, many more guarantees than are required in France from the members of our government.

The items in this list which relate to the natural sciences, were not sufficient to satisfy Cuvier's inclination towards these studies. As a child he had admired Buffon, as a young man he studied Linnæus, and at a later period of his life he drew a comparison between these two great geniuses in so admirable a manner, that it was easy to observe the degree of influence which each of them had exercised over him. He first turned his attention to botany, and discovered in the neighbourhood of Stutgard several plants which had escaped the notice of his professor. He quickly communicated to his fellow pupils the ardour with which he was himself inspired, and he soon organised a natural history society of a more serious character than that of Montbéliard. Several of the members of this juvenile association have left celebrated names; among them we may instance the botanist Marschall of Bieberstein, who afterwards became Minister of State to the Duke of Nassau; Autenrieth, well known to all physiologists; Jaeger, physician to

the King of Wurtemburg; Pfaff, Councillor of State in Denmark; and Hartmann, the distinguished entomologist and physician. The society met weekly to read and discuss memoirs, and the author of the best work was decorated with an order, the design of which was due to the same hand which afterwards traced the model for our academic prizes. It is a remarkable fact that neither human nor comparative anatomy formed a part of these scientific recreations. Up to that time, Cuvier still belonged to the age in which he lived, and limited himself to descriptive zoology.

As soon as his studies were completed, Cuvier found it necessary to turn his knowledge to account. The Count d'Hericy, proprietor of the Castle of Fiquainville in Normandy, required a tutor for his children, and Cuvier accepted the office. This change of residence proved a most fortunate circumstance; for hitherto he had devoted himself more especially to botany and entomology, and even during the early period of his sojourn in Normandy he was engaged in the serious study of insects, and sent to his friends at Stutgard a general classification of this group, together with memoirs on several genera. Soon, however, the nature of his occupations was changed, and the scope of his ideas enlarged. The ocean lay at his very feet, and Cuvier could not long remain insensible to the new paths of inquiry which were thus opened to him. He saw that an unknown world was displayed before him, and he resolutely applied himself to his new labours. We find from his correspondence, that this period was occupied by his researches on the Molluscs, one of the earliest of the works which made him known, and which even at the present day constitutes one of his principal titles to fame. We may also see with what a keen appreciation and nice discrimination he was already able to judge the greatest

leaders of science, as, for instance, Linnæus, Fabricius, and others; for if he saw where they erred, he also knew how to indicate the remedy. Two letters written to his friend Hartmann, and which M. Duvernoy has preserved, are extremely remarkable in this respect; for we find in them some of those great ideas, which he was destined subsequently to develope, well and clearly expressed, and we may thus trace as it were the germ of those immense labours which subsequently occupied the whole of his life.

Cuvier remained for eight years in Normandy. I have already related in my note on Geoffroy Saint-Hilaire how he was called to Paris, and how Cuvier responded to that appeal in a spirit alike noble and intelligent. Mertrud, then a man of eighty, was Professor of Comparative Anatomy at the Jardin des Plantes, and through the influence of Geoffroy Cuvier was nominated first as his assistant, and shortly afterwards as his successor. His future, therefore, seemed provided for, although his present position was a very unsatisfactory one. It was at the time of the Directory, and the monetary embarrassments of the existing government were felt in all the different establishments devoted to public instruction; and in a letter of Cuvier's to Hartmann, he informs him that twelve months' salary is still due to the professors at the Jardin des Plantes, on which account he adds that he is almost disposed to envy the fate of the elephants, "for if their food has been obtained on credit, they at all events do not know it, and consequently are not mortified by it."

These straitened circumstances soon gave place, however, to competency, and subsequently even to the wealth which was derived from several lucrative posts. We must not omit to mention that science at all times profited by every change for the better in Cuvier's circum-

stances. The money which he received from the state was in a great degree expended in the acquisition of the books which were necessary to his labours, and in the purchase of natural history objects which were placed amongst the collections of the Museum. With the view of obtaining the latter, he applied to all parts of the world, and, thanks to his great name, all parts of the world responded to the appeal. It was only by such means that he was able in the course of a few years to found and thoroughly to complete his splendid collections of comparative anatomy and fossil bones.

Cuvier had been nominated a member of the Institute in 1796, when he was twenty-six years of age. Four years afterwards, his colleagues in the Department of Sciences chose him for their secretary. The office was then a biennial one ; and when, in 1802, it was made perpetual, his nomination was confirmed by the entire section. From this period till his death Cuvier discharged the high and difficult functions of this post; and his annual reports of the progress of the physical sciences, of which he was himself the representative, are amongst the noblest testimonies of the vastness and power which can be exhibited by the human intellect. Two other sections of the Institute, namely, the French Academy and the Academy of Inscriptions, subsequently numbered him amongst their members. Although already professor at the Museum, Cuvier was soon called to occupy, in the College of France, the chair which had been formerly held by Daubenton ; he was, besides this, named successively, by Napoleon, Inspector General of the University, as well as Councillor of the University and Councillor of State, while Louis XVIII. named him Chancellor of the University, a baron, and Grand Officer of the Legion of Honour, and Louis Philippe made him a peer of France. Immediately on his death

France raised to him, in the Gallery of Geology at the Museum, a statue which represents him holding in his left hand the terrestrial globe, which appears to crumble beneath the touch of his right hand, and opens to reveal to him its secrets.

These honours were well deserved; for Cuvier possessed not only that instinct of divination which, in many persons, constitutes their sole claim to genius — not only inexhaustible patience — not only a mind of the most comprehensive grasp — not only that marvellous good sense which almost instinctively, as it were, separates the true and the false; but he possessed all these attributes in their very highest degree; and it is on this account that he stands forth amongst his cotemporaries, and appears to the eyes of posterity as a man of genius in the full extent of the term — a truly great man.

Cuvier appears to have had a passion for work as other men have a passion for pleasure. Nothing short of this necessity for labour, which was inherent in his nature, would have sufficed for the accomplishment of the works which he has left. Convinced that in the natural sciences the clearest intelligence is apt to become confused if it deviates for a moment from the path of direct observation, Cuvier began by combining together his facts; and it was by means of separate monographs that he intended to collect materials for a general comparative anatomy, which should comprehend the result of all his inquiries respecting organisation.

The number of independent works, notes, memoirs, articles, scientific or administrative reports, and *éloges* left by Cuvier is immense. It would be impossible to enter into a detailed account of all his labours; but we cannot pass over in silence those three great works, either of which would have been sufficient to give its author immortality. These works are *l'Anatomie com-*

parée, les Recherches sur les Ossements Fossiles, and *le Règne Animal.* In the first, Cuvier added numerous observations to the incomplete details which had been collected before his time, arranging the different elements into one great systematic whole, and thus substituting a science in the place of a mere mass of scattered facts. In the second, he appears as the sole creator and founder of a perfect science — Palæontology. He styled himself the *Antiquaire d'une espèce nouvelle ;* and it was in this character that he explored the bowels of the earth, in whose ancient archives he discovered the traces of extinct Faunas, which appeared to be revivified at his voice, in order to reveal to us the revolutions of the globe which we inhabit. In his third work, he comprehended the entire animal creation, and endeavoured, for the first time, to introduce into zoology a classification founded on the natural method, which should, as far as possible, serve as the expression of the science, and as the surest means of advancing its progress. Yet these three works were in his eyes mere preparatory labours, or rather notes and data for that *Grande Anatomie* which was always present in his mind, but which he was never able to complete ; for a savant is, perhaps, less able to realise his ideal than even the artist.

Cuvier died without leaving any children. He had married Madame Duvaucel, the widow of a former *fermier-général.** Two sons and two daughters resulted from this marriage, but they all died in early life.

* In the reign of terror, twenty-eight *fermiers-généraux* were put to death on the 8th of May, 1794, and amongst them was Lavoisier, the founder of modern chemistry, who was, moreover, a man of true genius. It is well known that when some of his friends made a faint attempt to save his life, one of the rulers of the day exclaimed, "The French republic has no need of savants to conquer her enemies."

His younger brother, who had been called by him to Paris, and who had become his confrère at the Academy, did not survive him many years, and both brothers died of the same form of pulmonary disease.* The son of Frederick Cuvier entered into the service of the government, and thus the name of Cuvier has no longer any representative in science. (For further information on the life and writings of Cuvier, we may refer to the work of Duvernoy, which has been already noticed, and that of M. Flourens, entitled *Cuvier; Histoire de ses Travaux.*)

Note X.

François Arago, who was born at Estagel in 1786, and died at Paris in 1853, was a member of the Institute,

* Frederick Cuvier was born at Montbéliard in 1773, and died at Strasbourg in 1838. He was very inferior to his brother, and in his childhood he had even given up his studies, and been apprenticed to a watchmaker; but when once he was brought in contact with his illustrious brother, he appreciated the duties which such a position involved, and began completely to re-educate himself. He soon devoted his attention to the natural sciences, and, in aiding his brother to classify and arrange the collections of the Jardin des Plantes, he became a naturalist. Having been appointed in 1804 to the directorship of the Ménagerie, he found ample subjects of study in harmony with his tastes and capacity. He now began to investigate the instincts of animals, and more especially of mammals, and his memoirs on this subject are extremely important. He was the first among naturalists who clearly distinguished in animals between a blind instinct and intelligence, and he showed in several of their actions the union of these two widely different faculties. In this respect he may be said to have been far superior to all his predecessors, not excepting Réaumur and Buffon. He has also left several important works, namely, *Des Dents des Mammifères; l'Histoire des Cétacés*, which forms part of the *Suites à Buffon;* and, in conjunction with Geoffroy Saint-Hilaire, *l'Histoire des Mammifères.*

perpetual secretary of the Academy of Sciences, member of the Bureau des Longitudes, and Director of the Observatory. This illustrious man, who has only lately closed his chequered career, was the eldest son of a numerous family. Although he had been destined by his father for the bar, Arago at first chose the profession of arms, and prepared himself without the help of any masters for his examinations at the Polytechnic School, which he entered with the highest honours. His remarkable aptitude for the exact sciences attracted the attention of Monge, who secured his services for the observatory. When, in 1806, the French Government wished to complete the measurement of an arc of the meridian, which had been begun by Delambre and Mechain, and interrupted by the death of the latter, they selected Arago and M. Biot (who was twelve years his senior, and already a member of the Institute) to conclude this undertaking.* They were associated in this labour with the Spanish Commissioners, Chaix and Rodriguez.

* M. Biot, who is a member of the Institute (Academy of Sciences, and Academy of Inscriptions and Belles-Lettres), has survived his old fellow labourer, and is now one of the Deans of the Institute. In 1853 he completed the fiftieth anniversary of his election to the Institute, and this very rare circumstance gave occasion to a demonstration of affection and esteem which was alike honourable to M. Biot and the Institute. Notwithstanding his great age, M. Biot has lost none of that scientific ardour which he so frequently exhibited throughout his earlier life. We owe to this physicist a very considerable number of works, treating both of experimental and mathematical physics, and of pure mathematics. The *Traité Analytique des Courbes et des Surfaces du Second Dégré*, and the *Traité de Physique Expérimentale et Mathématique* have passed through several editions. M. Biot has directed much attention to the astronomy of the Egyptians, Chaldeans, and Chinese. He was for a long time aided in these historical researches by his son Edouard Biot, who has been prematurely removed by death.

M. Biot returned to Paris, and Arago, who had remained in order to effect the geodetic junction of Majorca with Ivica and Formentera, happening to be on Spanish soil at the moment when the war burst out, was taken for a spy, and imprisoned, but, having made his escape, he took refuge at Algiers. When on the point of returning to France, he was retaken by a Spanish pirate, and sent, together with all the crew, to the galleys of Palamos. Having been claimed by the Dey of Algiers, he was at length enabled to return to Paris, where the fame of his works and of his various adventures secured for him the friendship of some of the most distinguished men of that period.

On the death of Lalande, Arago was appointed, in his twenty-fourth year, to succeed him as a member of the Institute. He subsequently became an examiner at the School of Metz, a member of the Bureau des Longitudes, and a professor at the Polytechnic School; but he resigned the latter post when the Academy of Sciences selected him in 1830 for their perpetual secretary. Arago was remarkably well adapted to discharge the difficult duties of this office. His ready conception, and his easy and clear style, enabled him to comprehend and to analyse, in a mode at once critically exact and singularly popular, the numerous memoirs on all varieties of subjects which were presented to the Academy at every meeting. It was in consequence of these qualities that the elementary lectures on astronomy which he delivered at the observatory were always numerously attended. The fame of these lectures, which were begun in 1812, and which he annually delivered until a short time before the Revolution of 1848, was one of the causes which gave early celebrity to the name of Arago. The academic *éloges* which he read at the public meetings of the Academy, and the notices which he inserted in the *Annuaire du*

Bureau des Longitudes, and in which he made the most complicated questions of science accessible to every cultivated mind, had a similar result. Finally, the political part which he played in the ranks of the opposition, both during the Restoration and under Louis Philippe, contributed also very materially to increase his reputation, by making him known to many persons who took no interest in science. Very few savants, and certainly none in our day, have ever enjoyed during their life a more widely diffused popularity.

Arago, who in the eyes of the world in general was regarded as the first of living astronomers, scarcely paid any attention to astronomy properly so called. It was especially as a physicist that he excelled, and in several departments of natural philosophy he made important discoveries. We owe to him, amongst other things, the knowledge of chromatic polarisation, of magneto-electricity, and magnetism by rotation. He published very few complete memoirs. His papers were often left unfinished, whilst he also occasionally delegated to others the task of accomplishing the experiments of which he had conceived the general plan. With the exception of his notices and *éloges*, Arago published very little; and it is probable that the forthcoming edition of his works, which is now in the course of publication, will contain many hitherto unpublished memoirs.

This is not the place in which to speak of Arago as a politician. Every one is well acquainted with the part which he played in public affairs. He at all times took his place in the extreme opposition; but it is certain that he was very ill adapted to bear the excitement of a public life. After his last election as deputy, under Louis Philippe, he returned home ill and suffering from the agitation caused by finding that he had given occasion to a popular movement, which it was feared might lead

to the effusion of blood. How terrible then must have been the effect produced on his mind by the agitations of the republic, and above all by the sanguinary days of June, 1848! Indeed, from this period, his health declined rapidly, and notwithstanding a naturally robust constitution, he sank under the effects of an incurable diabetes.

More than two years before his death Arago almost entirely lost his sight; but, although he could no longer read, he continued to fulfil the duties of perpetual secretary to the Academy. Before each meeting, the different memoirs and papers that were on the list for the day were read over to him. At the proper time, when one of his colleagues informed him of the title of the paper before him, he would give an account of each memoir, not certainly with all the charm of diction that he at one time displayed, but still with so much clearness of mind, that those who were not aware of the true state of the case would have supposed that he had himself studied the memoirs which he described. (See F. A. Barral, *Notice sur François Arago.*)

Note XI.

Buffon, who was born at Montbard in 1707, and died at the Jardin des Plantes at Paris in 1788, was one of the most remarkable geniuses of his native country. His father, who was a Councillor in the Parliament of Burgundy, possessed a considerable fortune; hence, after having terminated his classical studies in the most brilliant manner, he was able to indulge his tastes for study without any of those pre-occupations of mind which too often stifle, or at all events check, the development of the most promising talents. Having made the acquaintance of young Lord Kingston, who was travelling with his tutor, a man of much cultivation and learn-

ing, Buffon, in company with his friends, travelled over great part of France and Italy, and even remained for some time in England. On his return, he translated Hales's *Vegetable Statics* and Newton's *Fluxions*, and affixed to each of these works a preface which gave early indication of his mental power. His translations were soon followed by works in different departments of physics, geometry, and rural economy; among these works we may mention the *Experiences sur la Force des Bois*, *Dissertation sur la cause du Strabisme*, and especially the *Mémoire sur les miroirs pour brûler à des grandes distances*, which contains an account of experiments which realise all that the ancients have said regarding the burning-glasses of Archimedes.* These labours led to his admission into the Academy of Sciences, in his thirty-second year. Hitherto nothing had indicated the fame which he would one day obtain as a naturalist; but having been appointed to the superintendence of the Jardin du Roi in 1739, Buffon at once recognised all the importance of this position, which had been entirely neglected by the physicians of the king, to whom this office was considered by right to belong. From this moment he laid down that plan of his future studies which was to occupy his entire life; and in order to construct that magnificent temple to science with which the world is familiar, he summoned to his aid those zealous naturalists Daubenton †, Gueneau de Montbeillard, and the

* The invention by Archimedes of burning-glasses which consumed the Roman galleys at considerable distances, when they were engaged in the siege of Syracuse, was always regarded as a fabulous account, until Buffon showed the possibility of such an occurrence.

† Daubenton, who was born at Montbard in 1716, and died at Paris in 1800, was by far the most eminent of Buffon's collaborateurs, for it was he who supplied all the anatomical notices contained in the first fifteen volumes of the *Histoire Naturelle*. One edition of

Abbé Bexon, who prepared the materials from which Buffon constructed his great work. But even in these preparatory labours, they were guided by Buffon, who never shrank from devoting himself to the study of details which other observers might have thought unworthy of their notice.

Buffon, as M. Flourens has well observed, was influenced by two leading passions, that of work, and that of fame. Being convinced, however, that the one leads infallibly to the other, he worked for twelve or fourteen hours daily. He generally passed four months of the year at Paris, and the remaining eight on his property at Montbard. Here, in a high tower erected in the midst of fields and woods, he composed his great *Histoire Naturelle.** This work, the fruit of fifty years' incessant study, was published in several parts, and hence

the Mammalia was published by Buffon without any of these anatomical notices, in consequence of which Daubenton refused to continue his labours for his illustrious master, and soon published in his own name a great number of memoirs on Zoology, properly so called, and on its applications to rural economy. We also owe to him the introduction into France of the merino sheep, which had been vainly attempted by Colbert; but his principal title to glory rests upon the fact, that his researches in comparative anatomy made him rank as the precursor of Cuvier in this branch of science. Daubenton was a professor at the Jardin des Plantes, and at the School of Medicine.

* *Histoire Naturelle, Générale et Particulière, avec la description du Cabinet du roi;* such is the title of this immortal work. The first, which is also the best of all the editions, appeared between 1749 and 1789, consisting of thirty-six quarto volumes. Since then the *Histoire Naturelle* has been very frequently re-edited, sometimes in the most deplorable manner, as for instance by Sonnini, who, by transposing different parts, entirely destroyed the sequence of the ideas, and prevented the reader from following out the views of the author in their full development. (See *Histoire des Travaux et des Idées de Buffon*, by M. Flourens.)

it does not present that unity of plan that we should have expected to find in the writings of so great a man. It is not, perhaps, the less interesting on that account, for here we may follow, step by step, the progressive development of his views. He not only laboured incessantly to improve his style, but he was indefatigable in his endeavours to increase his mental culture. Thus he was ever as ready to abandon a false idea, as to expunge a feeble expression, and on this account some of his later writings are very superior to those which preceded them both as to matter and style.

Buffon lived to see his own statue erected in the Jardin du Roi, bearing this inscription: *Natura par Ingenium:* a homage which he accepted as a just tribute to his merits.* After his death, his services in the cause of science were much depreciated by many naturalists, whose opinion gradually spread to the public, and in our own time he is looked upon by many as a mere compiler. Such a result was inevitable, for Buffon and Linnæus were cotemporaries, and the views which the latter held regarding the necessity of a rigorous classification, and which Buffon unjustly rejected without duly understanding, were soon universally adopted. The pupils of Linnæus, moreover, carried the views of their master to such extreme lengths that in their eyes the nomenclature became the science itself. Those who regarded natural history from this point of view, could obviously not appreciate the genius of Buffon: but yet this great man invariably found defenders among the

* Buffon was fully conscious of his own merits, and occasionally showed his self-appreciation in the most naïve manner. He was once asked how many truly great men the world had produced; on which he answered, "Five: Newton, Bacon, Leibnitz, Montesquieu, and myself."

leading minds of the day, and Cuvier, as well as Geoffroy Saint Hilaire, fully recognised the value of his labours.

If, however, the scientific claims of Buffon's works have been made a matter of dispute, there can be no doubt as to their literary merits. Excepting MM. D'Alembert and Daubenton, who both disliked him, and excepting a few of the naturalists, who thought that a work of science should exhibit a greater amount of simplicity, his cotemporaries always did justice to his style, which, although somewhat pompous, is really dignified, always clear and often precise, and admirably depicts that which had been only hitherto imperfectly described. Posterity has in this respect confirmed the judgment of his cotemporaries. But it was not without great labour that Buffon attained this degree of perfection, for his letters to his friends are written in a bald and trivial style, and in reading them, we can readily comprehend how much trouble it must have cost the author to have composed those magnificent passages which are scattered through his works, and we may even believe the statement that has been handed down to us, that the *Epoques de la Nature* were recopied eleven times before they were finally sent to press.

Buffon was tall, and had a handsome and expressive face, and his whole air and carriage were dignified and impressive. His disposition was kind, benevolent, and serene. Although he was keenly attacked on different occasions, yet he only deigned once or twice to reply to the invectives directed against him, and he then reproached himself for having been guilty of a weakness in defending himself at the expense of time which might have been better employed. He died from stone in the bladder, after suffering excruciating agony, and left one son, who perished by the guillotine.

(For further particulars in reference to the life and

works of Buffon, see *l'Éloge historique*, by Cuvier, and the work of M. Flourens, to which we have already referred.)

Note XII.

The Jardin des Plantes and the Académie Française were both founded by a royal decree in 1635. Guy de la Brosse, who was physician to Louis XIII., and at whose suggestion the garden had been established, was appointed its first superintendent.

The garden was established for an entirely utilitarian purpose, as is implied by its original name of *Le Jardin des Plantes Médicinales*. It had already begun to assume a more developed form and a more scientific character under the management of the celebrated Fagon first physician to Louis XIV., who in 1683 resigned the functions of Professor of Botany in favour of Tournefort.* Although the garden was much neglected by the successors of Fagon, it revived under the director-

* Tournefort, who was born at Aix in 1656, and died at Paris in 1708, had devoted himself to botany from his childhood, and before he left college he was already well acquainted with all the plants of Provence. To increase his botanical knowledge, he made successive tours to the Alps, the Pyrenees, and Catalonia ; and, being called to Paris by Fagon, he devoted all his leisure time to botanical excursions, and thus successively visited Spain, Portugal, England, and Holland. After being elected member of the Academy of Sciences, he published in 1694 his *Eléments de Botanique*, which marks an epoch in science by the progress it made in the classification, and more especially in the determination of genera. The reputation which this work gained for him, facilitated the accomplishment of a more important journey than any he had made on his own resources ; for, on the instigation of the Academy, he received from the Government a special mission to visit the Levant. He published the scientific narrative of this expedition, together with several other memoirs.

ship of Dufay, and more especially under that of Buffon, who made his own reputation conducive to the advantage of the establishment.

When the revolutionary rulers began to think of reconstructing what they had previously destroyed, the old *Jardin du Roi* was reconstituted by the Convention in accordance with a report given in by Lakanal with the title of *Muséum d'Histoire Naturelle.* The list of professors nominated by the law of the 10th of June, 1793, is most remarkable. All were more or less illustrious, and some of them were truly great men, as we may see from the following names: — Cuvier, Daubenton, Desfontaines, Dolomieu, Fourcroy, Geoffroy Saint-Hilaire, Haüy, Laurent de Jussieu, Lacépède, Lamarck, Latreille, Thouin, Vauquelin. It may be well conceived that under such men as these, the impulse given to the natural sciences by Tournefort and Buffon was in no danger of relaxing; and during fifty years there was scarcely one great discovery made in these branches of knowledge, which did not emanate from the *Jardin des Plantes.* Notwithstanding our various revolutions, all different forms of government, which succeeded one another with such rapidity for more than half a century, seem fully to have comprehended the glory that an establishment of this kind reflected upon the country; for although other nations may have partly imitated it, in all essential points it is unique of its kind. The first Empire, the Restoration, and the Monarchy of July have all in turn contributed to improve and enrich this great centre of science.

The Academy of Sciences, which was founded in 1666, disappeared like all other institutions of the same kind, during the worst times of the revolution.* On the

* There was only one among all the scientific or literary societies existing in France, which was enabled regularly to hold its meet-

first organisation of the Institute in the year III. of the Republic (1795), it was again established under the title of *Classe des Sciences Physiques et Mathématiques.* Napoleon retained this name when he reconstituted the Institute in the year XI. (1803); but it resumed its old name of Académie des Sciences in 1816, in consequence of a decree passed to that effect by Louis XVIII.

This Academy comprises all the sciences properly so called, each department being represented by only six *titular members* in the sections of Geometry, Mechanics, Astronomy, Physics, Chemistry, Mineralogy, Botany, Rural Economy, Anatomy and Zoology, Medicine and Surgery, and by three *titular members* in the section of Geography and Navigation. A special section is reserved for men whose labours do not lead them directly to any one of the preceding sections, as well as for those who have employed the advantage of high rank or of a large fortune in aiding and promoting the cause of science. This is the section of the free members, of whom there are *ten;* the two perpetual secretaries are not included in this number; and when a member reaches this position, which is the highest in the scientific hierarchy, his place is filled up in the section to which he belonged. The Académie des Sciences includes moreover *eight foreign associate members,* who must be chosen from among foreigners; and who, during a temporary residence in Paris, enjoy all the rights of titular members. These associates, who are selected indifferently from any of the various departments, may, therefore, be considered as the supreme leaders of science abroad and hence this title is justly regarded as the most honourable of any that can

ings, and publish its reports, through the darkest periods of the days of terror. This was the Société Philomathique, an offshoot from the celebrated Société d'Arcueil, and which, in memory of its origin, bears upon its tickets of admission these words, *Science et Amitié.*

be attained by the study of the sciences, properly so called. Even to be proposed as a foreign associate is an honour of which the most illustrious philosophers of all countries are ambitious. There is additionally attached to each section a class of corresponding members, who may be either natives or foreigners, and collectively number one hundred.

The Académie Française, the Academy of Inscriptions and of the Belles-Lettres, that of the Fine Arts, and that of Moral and Political Sciences, have each their special constitution.

The five Academies of which we have spoken together constitute the entire body of the *Institut de France;* which, in accordance with every successive form of government, has in turn been characterised as *National*, *Royal*, or *Imperial.* To the Convention belongs the honour of having thus grouped into one whole all the scientific, artistic, and literary associations of France; and to succeeding governments the honour, which is perhaps scarcely less, of having resisted the excitement of the day, and of having steadily maintained the line of conduct first adopted by the members of the Convention.

At the period of its constitution, according to the law of the 5th Fructidor, in the year III. (22nd August, 1795), the Institute comprised only three sections (viz.: the section of Physical and Mathematical Sciences, that of Moral and Political Sciences, and that of Literature and the Fine Arts). Napoleon, when First Consul, increased this number to four by dividing the section of Moral and Political Sciences. Louis XVIII. maintained, with slight modifications, the same form of organisation, but he gave to each section the title of Academy, and finally in 1832 Louis Philippe re-established the section of Moral and Political Sciences under the title of an Academy.

Note XIII.

Van Beneden, who is professor at the University of Louvain, is one of the most active and distinguishhed of our modern zoologists. He has published numerous works and memoirs on almost all the important groups belonging to the sub-kingdom of the Invertebrata. Amongst his various publications, I may instance his *Exercises Anatomiques*, which principally refer to the Molluscs, and his *Recherches sur les Bryozoaires d'eau douce et d'eau salée.* For the last few years, M. Van Beneden has devoted himself specially to the study of intestinal worms, and he has already published the results of a series of very important researches, which gained for him the prize offered by the Academy of Sciences of Paris in 1853.

I regret that I cannot here give a circumstantial account of this splendid work, in which the author has considered, from every point of view, the difficult and complex subject of the development of these animals. This work, which will be printed at the expense of the Academy, is still unpublished; but those persons who take an interest in the question may form a general idea of the results obtained by the author, by consulting the analysis which I drew up, in my capacity as reporter to the Commission appointed to award the prize. I will here merely observe that this work, together with the less extended researches of Dr. Küchenmeister, have shown, with almost unquestionable certainty, that a large number of the intestinal worms are produced by processes analogous to those which we meet with in many other animals, as, for instance, in the Acalephæ; and that, before they attain their perfect state, they must pass through different conditions, corresponding in some degree to those which I have described in reference to the Medusæ. It is, however, farther shown that

these complicated metamorphoses can only be effected by the aid of certain migrations*; thus, for instance, if we observe a young intestinal worm in one animal species, we shall find it completely developed in some other species; generally, moreover, the first species in which the intestinal worm passes the earliest period of its existence is herbivorous; and the second, or the one in which it attains its definite form, is carnivorous. It is, therefore, by eating herbivorous animals that the carnivora become infected with the parasites to which we are now referring; and this would appear to be a law, from which even man, at least in a certain number of cases, is not exempt. It is by eating raw, or badly cooked pork, that a worm is swallowed in its larval condition (Cysticercus), which, after reaching the digestive canal, becomes converted into a Tænia or a Bothriocephalus, parasites which have been commonly confounded under the name of the tape-worm.

Note XIV.

The Mastodons were mammals resembling in all respects our existing elephants, excepting that their teeth were very different. Their bones have been found

* Dr. Küchenmeister, a physician at Zittau, was the first who instituted regular experiments to demonstrate what had already been suspected by several naturalists; viz., that a Cysticercus is nothing more than a young Tænia. He clearly proved that such was the case, and moreover that the state of the Cysticercus was a normal, and not a teratological or abnormal state, as had been supposed by several of our most distinguished helminthologists. Dr. Küchenmeister has extended his researches to the Cænurus, which has its abode in the interior of the brain of the sheep. He showed that these strange worms were also the larvæ, or rather the nurses (Ammen) of the Tænia, and that they in their turn were produced from the matured ova of the latter.

in all parts of the world that have been well explored, including the Australasian continent. This last fact, which has been confirmed by Professor Owen, is very remarkable.* All the existing Mammals of that country belong to the group of the Marsupials, and the fossil Fauna presents the same character in all its species, with the exception of the Mastodons, which thus seem to have been true Cosmopolitans. This genus comprises, in the present day, about a dozen species, one of which, the great Mastodon (M. giganteus,) was at least as large as our largest elephants. The fossil remains of Mastodons are of common occurrence; and the skeleton is often found entire, and in a vertical

* Richard Owen, a corresponding member of the Institute, has earned for himself the first rank among naturalists for his discoveries in Anatomy and in Palæontology. The nature, number, and value of his labours have gained for him among his countrymen the title of the English Cuvier, by a similar figure of speech to that which makes us name Laplace the French Newton. Professor Owen's studies have been directed to nearly every department of the animal kingdom; and, amongst many other valuable contributions, we are indebted to him for some very curious researches on several of the rarest of our Molluscs, whose organisation was scarcely, if at all understood. He has also made us completely acquainted with the anatomical characters of the Marsupial Mammals; but of all the works of this learned naturalist, the most important perhaps are those which refer to the history of fossil vertebrate animals, which have placed their author at the head of all living palæontologists. In addition to a great number of special memoirs on the four classes of this sub-kingdom, Professor Owen has published, under the title of *Odontography*, a magnificent work on the teeth. In studying the minute structure of these organs he has shown that we may recognise the family, not unfrequently the genus, and sometimes even the species of a fish by the mere fragment of a tooth, even where the original shape had been entirely destroyed by friction.

position, as, for instance, in the Valley of the Ohio, as if the animal had died after having sunk into the mud.

The presence of the bones of Mastodons in the superficial strata of the earth has given rise to many fabulous accounts; thus they have, at different times, been considered to belong to the skeletons of giants. The Indians of North America have even introduced them into their legends; and the Creeks pretend that the Great Spirit annihilated this gigantic species lest it should destroy all other living beings. One male is said to have escaped in a wounded condition, who still lives among the great lakes, where he took refuge. The aborigines of Canada regard the Mastodon as the origin of *still existing* species, and they call this animal the *father of the buffaloes.*

Note XV.

As the discussions relating to Phlebenterism have spread even beyond the limits of the scientific world, we think a brief sketch of the subject may be expedient.

Cuvier, and after him *all* zoologists, maintained that, in the Mollusca, there existed a system of closed vessels, by which the circulation was accomplished in these animals, exactly in the same manner as in the Mammalia. A few exceptional facts had indeed been noted by Cuvier himself in the Aplysias, by Milne Edwards in the Ascidians, and by Professors Owen and Valenciennes in the Nautilus; when the study of a small Nudibranchiate Gasteropod on our sea coasts led me to the consideration of this and several other analogous questions. Amongst other characteristics hitherto regarded as some of the most constant in the Mollusca, anatomists had always admitted the existence of a simple intestine, and of a distinct and well developed liver. Now, in studying

the Eolidina, I proved: firstly, that the intestine ramifies and sends prolongations to the dorsal papillæ, which had hitherto been regarded as ordinary branchiæ *; secondly, that the liver does not exist as a distinct organ, but that the intestinal prolongations, of which I have spoken, are invested with a granular covering, resembling certain hepatic organs; and, thirdly, that the food penetrates through the entire extent of the ramified canals of the intestine.

At the same time I found in the Eolidina a heart and a tolerably well developed arterial system, but I could not distinguish any veins; nevertheless, I was so thoroughly imbued with the ideas of Cuvier that it was long before I was willing to admit the non-existence of these vessels. Nor was I convinced that there were really no veins in the Eolidina, until I had followed the same blood-corpuscle throughout its entire circuit — until I had seen it issue from the heart, and pass through the arteries by whose walls its movements were regulated, and until it was conveyed through every part of the general cavity, and finally carried back to the heart.

The species of which I have spoken was the subject of my first memoir, which was received without much opposition. I had looked upon the Eolidina merely as a degraded and consequently as an exceptional species; but having had occasion at Bréhat to study several of the allied species, I was led to take a more general view of the subject. As I could not suppose that Cuvier and Blainville † had been deceived in reference to this

* Previous to my researches, Milne Edwards had ascertained this fact in the Calliopea of Risso; and Loven, a Swedish naturalist, had also recognised it in several species.

† Cuvier and Blainville had at their disposal Eolidæ, whose size adapted them admirably for dissection, yet neither of them have referred to the remarkable characters which I have described in respect

special point, which I had observed in the organisation of the Mollusca, I placed these animals in a special group, and named them *Phlebenterous Gasteropods.* At the same time I made known the facts which I had obtained, and the conclusions to which they had led me. The greater number of these facts admitted of being readily verified by any one conversant with the use of the microscope, who would take the trouble of spending a few days at the seaside. These views, however, were too much opposed to accepted ideas, to be received with much favour, and some persons went so far as to deny the possibility of the observations which I had published, declaring that they were *à priori* opposed to all established facts and all sound principles.

In several elaborate memoirs referring to this subject, M. Souleyet, a distinguished navy surgeon, made himself one of the chief organs of this opposition.* He constantly appealed to the names of Cuvier and Blainville, and thus gave to his statements a certain degree of plausibility and popularity; and in no gentle terms, referred to

to these Molluscs. There can be no doubt that Cuvier must have endeavoured to form a correct idea of their anatomy; and he must have observed some of these curious facts, but in consequence of their being so much at variance with what he had elsewhere observed, he may have supposed himself to be mistaken, and on that account refrained from publishing them.

* M. Souleyet died on one of his voyages. His death caused me deep regret, for all persons who were on intimate terms with my opponent have always spoken of him as a man of perfect good faith and as one devoted to the cause of science. He would therefore, no doubt, have finally suffered himself to be persuaded by the mass of proofs which have been collected since our discussions. Independently of the memoirs undertaken at the time of this contest, M. Souleyet has left several memoirs, and the zoological portion of the *Voyage autour du Monde*, performed by La Bonité, in which are contained many observations of great interest.

their preparations. Phlebenterism was declared to be entirely exploded, and characterised as a mere chimera.

It so happened, however, that my opponents, who were agreed in declaring me convicted of flagrant errors (*I have considerably softened these expressions*), were far from agreeing amongst themselves. It is curious to compare in this respect the remarks of M. Souleyet in France, and Professor Allman in England, in respect to the Acteons*, one of the most curious genera of this group. That which is regarded by the one as a *circulatory apparatus* is in the eyes of the other a complete *respiratory apparatus*. That which the one calls a *sanguiniferous vessel*, the other calls an *aquiferous trachea;* the *auricle* of the one is in the eyes of the other a *sac*, communicating externally by means of an orifice. Finally, while the one declares that Acteons are Molluscs, allied to the Eolidæ, as I had previously stated was the case, the other, who is the representative of old ideas, would have these animals remain near the Aplysiæ. These fundamental discrepancies do not, however, prevent these naturalists from congratulating each other on the perfect accordance of their views. (See the memoirs of Allman in the *Annals of Natural History*, and of Souleyet in the *Comptes rendus.*)

This mistake on the part of two conscientious naturalists in reference to their reciprocal mode of seeing the same thing was the more remarkable, because they were

* Contrary to what has been stated, the genus Acteon comprises several species differing essentially from one another. In the place of dorsal papillæ, we find in all of them a broad, but thin expansion, which is prolonged posteriorly in the shape of a leaf, and surrounds the body. The intestinal ramifications are distributed throughout the whole of this lamina, which, moreover, encloses the reproductive organs.

here disputing concerning the circulatory apparatus, and yet my remarks in reference to this organ had excited more incredulity than all my other statements. In the eyes of those who ascribed a very exaggerated part to the vascular apparatus, in accordance with their embryological theories, these facts were the less acceptable, because they entirely destroyed their *à priori* system, while to the greater number it seemed equally impossible, from what Cuvier and Blainville had said on this subject, to admit the existence of Gasteropodous Molluscs without veins: and thus to many persons *Phlebenterism* was synonymous with the *absence of a circulation.* I have, however, shown in the text that this was by no means the view I had advanced.*

Milne Edwards first undertook independently, and afterwards in conjunction with Valenciennes, a series of observations on the circulation of the Mollusca, which soon led to the very unexpected results to which we have referred in the text, viz., that in *all* the Mollusca the circulatory apparatus is incomplete; that there are interruptions in the circulatory circle of *all* these animals, and that consequently in *all* the blood must flow into lacunæ. These facts and conclusions of the French Academicians were soon independently confirmed by MM. Pouchet, Van Beneden, and Owen, and it was not long before they were admitted in almost every country of Europe. In Paris alone there was a small group of incredulous inquirers, who were more or

* On my return from Sicily, and on the first outbreak of this discussion, I defined Phlebenterism as an anatomical arrangement, which is generally characterised by ramified prolongations of the digestive tube, in virtue of which the digestive apparatus to a certain extent supplies the place of the circulatory apparatus, and aids in the process of respiration. This definition has been constantly forgotten by my opponents.

less interested in denying these facts, and who persisted in the old ideas; and there may even now be some who adhere to similar views. It follows, from these researches, that the statements which I made in reference only to the Phlebenterous Molluscs actually applied to this entire division of the animal kingdom, while that which I had myself regarded as an exception, from too great a faith in the infallibility of our illustrious predecessors, was found to be in reality the general law.

The question of the circulation of the Molluscs being once determined, it only remained to consider those facts and ideas which seem to me to group themselves around the word *Phlebenterism.* Here, too, I must be permitted to observe that all my general results and deductions have been successively confirmed and adopted. In entering upon this hitherto unexplored path of inquiry, I had doubtless been guilty of many errors and omissions, and in some cases especially, I had attached too much importance to negative results; but, during my Sicilian expedition, before any controversy had been excited on the subject, I had rectified some errors, and filled up many of those deficiencies, which, I may almost venture to say, are inevitable in a first inquiry. At the present time the word *Phlebenterism,* in the signification that I have attributed to it, with all the consequences that I have deduced from the facts which had led me to advance it, has been adopted in Germany and elsewhere even in elementary works.

Note XVI.

Johann Müller, a corresponding member of the Institute, and a professor at the University of Berlin, must be considered as the leader of modern physiology

in Germany. Carried away by the theories of Oken*, he was in early life, I have been assured, a follower of the nature-philosophy; but having speedily adopted other views, he commenced a series of investigations on the higher animals, undertaken from a purely physiological point of view, which soon made his name celebrated, and obtained for him the elevated position which he now occupies. He has given a collected view of his doctrines in his *Handbuch der Phisiologie*, which was regarded as a standard work from its first appearance, and has been translated into several languages. During the last few years Müller has devoted his attention to the lower marine animals; and with the view of better studying them he has made several voyages along the shores of the Baltic and the Adriatic; and his researches on the Amphioxus, on the family of the Myxinoïdæ, on the larvæ of the Echinoderms, &c., have acquired for him a most eminent position among scientific naturalists.

His son, Maximilian Müller, appears to be following in the steps of his father. Amongst other memoirs, he has published a very interesting article on the anatomy of several marine worms.

The living physiologist, Johann Müller, must not be confounded with his namesake, Otto Frederic Müller, a

* Oken, a German naturalist, founded the school of *Natur-philosophie*, the object of which was to refer the entire creation to one *à priori* unity. We owe to him several important anatomical and zoological works, which, however, are almost always spoiled by the exaggeration of his theoretical dogmas. The following anecdote may show how far he carried his extreme views. Walking one day with a friend, who informed me of the incident, he stopped before a house, which was then being built, and exclaimed, with an accent of the most intense indignation, "How is it possible that men can continue to build four storeyed houses when they have only three stories of their own, the belly, chest, and head?"

celebrated Danish naturalist, who was born in 1730, and died in 1784. He had no fortune; but, aided by the advice and counsels of his mother, who was a woman of superior mind, he contrived, by force of perseverance, to complete his studies. He began by giving lessons in music, and he continued to teach various branches of knowledge as fast as he himself acquired them. Having become tutor to a young man of fortune, he took advantage of the leisure afforded him by this position to occupy himself with the natural sciences. His first writings speedily brought him into notice, and he was provided with a high and lucrative office; but having had the good fortune of marrying a woman who was both wealthy and highly cultivated, he gave up his office, and devoted himself exclusively to science.

The zoological labours of O. F. Muller were directed principally to the Invertebrata; and his *Vermium Terrestrium et Fluviatilium Historia,* his *Zoologica Danica*, and his works on the Hydrachniæ, and on the Infusoria, have placed him among the best and most laborious observers of the eighteenth century.

END OF THE FIRST VOLUME.

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