Art. VII.—Lamarck.

1. *Philosophie Zoologique.* 2 vols. Paris: 1809.
2. *Histoire Naturelle des Animaux sans Vertèbres.* 7 vols. Paris: 1815—1822.

THE reception which Lamarck's writings have met with in this country has been somewhat peculiar. The views contained in his work, the "Philosophie Zoologique," were strongly opposed to the opinions on theology and philosophy generally prevailing here at the time of its publication, and the work was in consequence for some fifty years attacked or ridiculed by nearly every author who noticed it. After the publication of Mr. Darwin's work on the Origin of Species, theories of evolution, from being denounced as irreligious, or ridiculed as fantastic, came into favour with a large and influential number of scientific men; some who had been loudest in condemning Lamarck being as forward in supporting Darwin. Lamarck's position was, however, little improved by the change. The opponents of Darwinism often directed their blows against Lamarck, but its adherents seldom cared to defend him, but rather passed over his speculations as unimportant or erroneous. They naturally did not wish to have their own views confounded with those of one who had been so frequently attacked. It is true that Lamarck can have no claim to be considered as even foreshadowing Mr. Darwin's theories on Natural Selection, atavism (the recurrence to the form of a remote ancestor), cross-breeding, or many other principles adduced to explain the origin of the animals now existing. Yet, on the other hand, Lamarck must be considered as the first great naturalist who believed and endeavoured to prove that all animals now living are descended from those previously existing, however different the forms of the two may be. While Cuvier and most of the naturalists and geologists of his times were continually inventing cataclysms, convulsions, and separate creations, to account for the actual condition of the globe and the races which inhabit it, Lamarck steadfastly refused to believe in any such general catastrophe, and ascribed the formation both of modern species and the features presented by the earth's crust to the continuous and slow operation of the natural agents which he saw still working. By slight modifications, and in conformity with a regular law of progress, highly organized beings had, he declared, been moulded and developed out of the simplest forms. The laws which Lamarck laid down, the causes to which he referred these changes and modifications, were real and active;

and, although he may have exaggerated their importance and power of producing the results he attributed to them, yet this is an error which he shares with nearly every great discoverer. Not only is every one tempted to overrate the importance and sphere of operation of a principle first discovered by himself, but unless principles were overrated there would be but little chance of the real importance of many of them being recognised. It is frequently only by endeavouring to explain every phenomenon by a single cause that phenomena not to be so explained are investigated, and that the existence of other causes becomes apparent; so that errors in our conception of the nature of the cause first known are detected.

But Lamarck's merit is not confined to his early perception of the uniformity and gradual upward progress of nature. He first arranged the animal kingdom in two great branches, one comprising annulate animals, or those whose bodies are divided into segments, such as insects, worms, prawns, and the like; and the other branch comprising polyps, mollusks, and vertebrate animals, which last he believed to be derived from the mollusks. With proper allowance for the great advance of our knowledge of the lower forms of animals made since the days of Lamarck, this arrangement is substantially the same as that adopted by Professor Huxley, in his treatises on "Comparative Anatomy," London: 1864; and "Classification," ibid. 1869; with, however, some important exceptions. In these works the vertebrates stand by themselves, instead of being placed in the molluscous branch. The theory that vertebrates are descended from mollusks had, however, even before the publication of the last work, been advanced by Hæckel, in Germany, in consequence of the researches of the Russian naturalist, Kowalevsky, which showed a great resemblance to exist between vertebrates and ascidians in the early stages of their development. These last are a family of animals of low organization, which were at first classed with polyps, but afterwards placed by Lamarck in a class intermediate between the latter and the mollusks with bivalve shells. Lamarck himself, however, looked for forms intermediate between mollusks and vertebrates in a much more highly organized order, the naked-gilled sea-slugs.

In geology, although Lamarck's views are often extremely speculative, yet he always insisted on the continuous nature of geological changes, and attributed the present forms of hill and valley to the continual wearing action of rain and atmospheric changes, a theory which, in a modified form, finds advocates among many of the ablest living geologists. Physics and meteorology were treated by him with even greater boldness

and industry, although but little success. He seems to have believed in an atomic theory, but to have been led by the old doctrines of phlogiston and caloric to indulge in many rash speculations on the nature and effects of those imponderable fluids, by the action of which he, like most physicists and chemists of that time, endeavoured to explain the phenomena presented by heat, electricity, and the other natural forces. He built on the theories of chemistry in vogue when he began his scientific studies, and persistently refused to recognise the merit of the admirable reasoning and researches of Lavoisier and his followers. In Botany, Lamarck's works are numerous, and were, when published, of considerable value. The first scientific work he published was the "Flore Française:" in it he altogether abandoned the prevailing system of Linnæus, and established another equally artificial, but which, by the principle of dual or dichotomous division, led more quickly to the determination of the species and genus of any particular plant. This system, which is said to have been created in six months, was in its turn abandoned by its author, who afterwards adopted the views of Jussieu, the founder of the Natural System of botany, by whom the later additions of the "Flore Française" were brought out, either alone or in conjunction with Lamarck. The other botanical works of Lamarck consist chiefly in descriptions of genera and species. (See the "Dictionnaire de Botanique," and the "Illustration des Genres," both parts of the "Encyclopédie Méthodique"), in which he seems to have displayed some of the ability he afterwards showed in the "Histoire Naturelle des Animaux sans Vertèbres."

It is this last work, and that on the fossil shells found in the beds round Paris, that have chiefly kept alive the reputation of Lamarck. His great contemporary, Cuvier, considers the determination of the genera and species in these works as his great and peculiar merit, and affects to pity him for being led to the conclusion that, after all, these genera and species were but artificial creations useful to systematists, but not existing in nature. (Eloges iii. 199.) It is certainly impossible not to admire Lamarck when we consider that the publication of this great and laborious work was only begun when he had already reached his seventieth year; and that he was in his fiftieth year when he began the study of the invertebrata, which he undertook, not because he was particularly attracted by it, but because, as the last appointed in the Cabinet du Roi, he had, on its reconstruction, to content himself with the subject least pleasing to his colleagues. When once he had entered upon it he pursued it with unflagging energy in spite of old age and failing sight. Always ready to

improve and modify his theories and classifications, he continued, year after year, to introduce such new groups and divisions as were suggested by the researches of Cuvier, or other anatomists, while he laboured by studying the forms preserved on the various museums to subdivide these groups into natural families and genera; and at the same time he constantly struck out more distinct and bolder theories on the general nature of living beings. The same indomitable resolution and calm courage which made him, at seventeen, abandon his prospects in the church, and set out to join the French army; which made him, immediately after his arrival (when the death of all the officers around him had placed him in command), refuse to retreat from the post assigned to him on the battle-field until he had received the order from his general; which afterwards led him a second time to abandon his career, and endeavour, in a humble position to gain the means for a medical education, sustained him in the penury and blindness which were the lot of his old age. If the same qualities have sometimes led him to too daring flights of imagination, or too great confidence in the correctness of his own views, or if they have given an air almost of arrogance to his statements, we must remember that without them Lamarck would never have accomplished his splendid achievements in science.

It is but a small part of his voluminous writings that we now propose to examine. The discussion of the details of the characters of families and genera which he founded is unsuited for these pages. His divisions and distributions have lost much of their value. It is of the essence of such arrangements that they should, by increasing our knowledge of the forms comprised in them, serve as a foundation on which to build yet better distributions, by which after a time they are superseded. The enormous number of new forms which have been recognised, and the great advance in our knowledge of anatomy made in consequence of the improved microscopes and means of observation at our disposal, have rendered Lamarck's divisions inadequate to represent the animals and plants of which he treated as we now know them; and a critical examination of his system would be interesting only to persons studying the forms described in Lamarck's writings. On biology, however, Lamarck has written much which must always be interesting to students of the history of science as a part of human progress, and is perhaps particularly so at present. He was one of the first to recognise the importance of studying biology as a whole, which he speaks of in his "Histoire Naturelle" (vol. i. p. 49), as "une science particulière qui n'est encore fondée, qui n'a pas même de nom, dont j'ai proposé quelques bases dans ma Philosophie Zoologique, et à laquelle je

donnerai le nom de Biologie." His views on this subject were first published in two volumes—one published in 1797, under the title of "Mémoires de Physique et d'Histoire Naturelle;" and the other published in 1802, under the title of "Recherches sur l'Organisation des Corps Vivans." They were afterwards much expanded and developed in his "Philosophie Zoologique," published in 1809, which he refers to as a new edition of the "Recherches," and in the introduction, forming the greatest portion of the first volume of the "Histoire Naturelle des Animaux sans Vertèbres," published in 1815. It is to these two last works that we shall refer.

Like other evolutionists Lamarck considers that living beings for several series, the different individuals composing which, vary insensibly one from another, so that all divisions—such as classes, orders, and genera, and even species—are products not of nature, but of art. The best of such divisions have artificial limits, and none are really isolated, although from our ignorance of the connecting forms they may appear so to us; but if all races of living beings were known to us, all our present classes, orders, and genera would be merely families of different sizes, and it would be very difficult to assign limits to these divisions. So far therefore art is an essential element in the construction even of a natural system. But besides this necessary use of convention, many systematic distributions (such as the systems of Linnæus in Botany, of Fabricius in Entomology, and the distribution of Birds and Fishes in Lamarck's own time), are entirely artificial, and not in conformity with nature, whose order is single, unique, and essentially without division in each organic kingdom.

Lamarck might have mentioned his own classification of plants as one of the most striking instances of an artificial distribution. He does not define an artificial distribution, nor does he explain what he means by conformity to nature. Several of his expressions convey the idea that he inclined to the views of Bonnet and the Greek philosophers, who believed in a single, uninterrupted chain of beings. These views, however, he in the "Histoire Naturelle" (vol. i. p. 129), when pressed by Cuvier, distinctly disavows. In fact, he does not seem to have considered what principles ought to govern a natural distribution. Most systematists since Lamarck have adopted one of the three principles following:—(1) Conformity to a general type or plan of organization; (2 relationship or descent; (3) complexity of structure. Agassiz, in his "Essay on Classification" (ch. ii.), discusses the subject at some length. He lays down, that conformity to type is the principle which should determine the division of the animal kingdom into primary branches or sub-regna; while the division

into classes ought to be regulated by the different ways in which the type of each branch is worked out in the animals composing it; and the further subdivision into orders should depend on the complexity of organization in each class. He thus considers that there are three different kinds of large divisions of animals proper to be made, and differing from each other in essence, and not merely in the extent or number of species comprised in them. Lamarck, on the other hand, considers all divisions larger than genera to be merely families of greater or less extent, and agrees with Agassiz only in considering that external form should be the criterion of specific difference.

Cuvier, Oken, Von Baer, and Owen, all endeavour, more or less, to arrange animals according to type; while Huxley, Hæckel, and most of the zoologists who have adopted the views of Darwin, found their systems on a different principle—that of relationship, or nearness in descent; and they generally assume that uniformity of type, even in small details, can only exist in closely-related animals. This certainly cannot be considered as proved, and is opposed to the views of Owen, Mivart, and Bastian. Lamarck himself gives two tables of relationship according to descent—one at the end of his "Philosophie Zoologique," and the other in the supplement to the introduction to his "Histoire Naturelle" (vol. i. p. 457). They differ considerably from each other, but altogether from the classification he adopted; and, as this classification was sketched out by him in his courses of lectures long before the publication of either of these works, and was retained in them, it is clear that he did not consider genealogy to be the true principle on which to found a natural system. While absolutely rejecting, at least in the "Histoire Naturelle," the theory of a single uninterrupted chain of beings, he still appears to found his system on it. He nowhere recognises anything like a type or plan of organization, and is generally guided merely by the principle of complexity of organization. Agassiz ("Essay on Classification," p. 134), well observes of his system, that it combines abstract conceptions with structural considerations, and an artificial endeavour to arrange all animals in a continuous series. He himself seems to have felt the artificial nature of his method, and to have become somewhat dissatisfied with the results. (See the supplement to the introduction to his Hist. Nat., vol. i. p. 451.)

Lamarck considers all classifications formed by reasoning from a single organ to be unsatisfactory, and that the variations of the most important organs ought to carry the greatest weight in determining the relationship of animals. Thus the organs of sensation and respiration are better guides than those of circulation; and the organs of sensation, which give rise to the most eminent

faculties, are to be preferred to those of respiration. He criticises Aristotle's division of animals into those with blood and those without blood; and while approving of the division, thinks the characters ill chosen. In his doctrine as to the importance in classification of the organs of feeling, he agrees with Dr. Grant and Professor Owen, who also found their divisions of the Animal Kingdom on the characters of the nervous system. Lamarck's division into Apathetic, Sentient, and Rational animals, is really founded, however, not on the organs of sensation themselves, but on their functions or faculties.

In the Hist. Nat. i. 324, Lamarck gives further explanations of his views of the art of making fit divisions of animals. The principles he lays down are, first, that animals must be grouped according to some system which is not an arbitrary one, that the series must then be divided, and the proper rank of each division determined; secondly, that in performing these operations, attention must be paid to the following relationships:—(1) The relations between individuals of the same species. These are the closest, and consist in peculiarities of form. (2) The relations between animals of the same group. These must be determined by considering, not the external form only, but also the whole interior organization in every part. (3) The relations between the groups themselves, which must be arranged in order according as they differ more or less from man. (4) The relations between unmodified organs. The commonest organs are the most important for fixing the rank of the division. Of two different plans of the same organ, the one most analogous to the plan of the organ in a superior group entitles its professor to a rank superior to that of the possessor of the organ formed with less analogy to such plan. Thus, as gills have a greater analogy to lungs than the branching air-tubes or tracheæ by which insects breathe, it follows that animals breathing by gills have a higher rank than those breathing by tracheæ, but a lower rank than those breathing by true lungs. (5) The relations between organs modified by use or circumstance, so that the plan of nature is disguised. Everything done by nature has a higher value than what has been effected by external circumstances. The distinction here drawn between nature and circumstances is one that Lamarck continually dwells on; and we shall recur to it hereafter. The third principle is that we ought to begin with the lowest organism, with the object of making the order of our distribution conformable to that of Nature, who works upwards by degrees from the lowest forms.

The artificial nature of these principles clearly appears, and has to a considerable extent influenced Lamarck's arrangement. However, like all persons who have laid down principles for clas-

sifying animals, he does not attempt to follow out strictly his own theories. He appears inclined to adopt a genealogical arrangement, but to have been beguiled by a wish to carry out his principles, and also by vague ideas of the tendency and designs of Nature.

The following is the arrangement given by Lamarck, both in the "Philosophie Zoologique" and the first volume of the "Histoire Naturelle."

APATHETIC ANIMALS.	
1. Infusoria.	
2. Polyps.	
3. Radiaria.	
4. Worms. (Epizoa.)	Invertebrate Animals.
SENTIENT ANIMALS.	
5. Insects.	
6. Arachnida.	
7. Crustacea.	
8. Annelids.	
9. Cirrhipods.	
10. Mollusks.	
INTELLIGENT ANIMALS.	
11. Fish.	
12. Reptiles.	Vertebrate Animals.
13. Birds.	
14. Mammals.	

The true principles on which a natural system should be founded must of course depend on the connexion between the beings to be classified. If Lamarck be correct in his doctrine that animals form a series on a number of branching series, each consisting of broadly distinguishable forms, it is difficult to see how any other principle than that of relationship or descent can be applied; and the lower limits at least of the divisions instituted must, in such a case as Lamarck has pointed out, be arbitrary. The higher limits, however, of many divisions would be strictly marked out conformably to nature by the extent to which development has advanced. Man would still mark out one of the boundaries of the class Mammalia, although, if all connecting forms were known, it might be impossible to draw any but a conventional boundary between reptiles and mammals. If, however, Mr. Mivart's view of the nature of the Animal Kingdom be the more correct one, type must be a leading principle in natural systems, though even in this case it might be difficult to assign

due limits to the divisions. It might be found that many forms partook of more than one type, and could only be arranged in one class rather than another, according to which type appeared to preponderate. In order to judge of Lamarck's classification we must, therefore, examine his theory of living beings.

Species and varieties, he considers, are like other divisions of animals, arbitrary and not natural. All forms have their origin in the simplest organized bodies which Nature is continually producing by spontaneous generation, and are derived from them by insensible alterations, so that animals make a branching series, which is continuous, except where forms are lost. The organs of an animal are modified by time and favourable circumstances. New species arise when the surroundings are changed, as when a plant, orginally a native of a moist plain, comes to grow on a dry hill-side. They may also, in some cases, be derived from hybrids. These changes of circumstances are not, however, the only cause of the formation of new species, for Lamarck in many places attributes to nature a continual power or tendency to develop new and more highly organized bodies. Thus he says (Phil. Zool. p. 221) :—

"Il sera en effet évident que l'état où nous voyons tous les animaux est d'une part le produit de la composition croissante de l'organisation, qui tend à former une gradation régulière ; et de l'autre part qu'il est celui des influences d'une multitude de circonstances très différentes, qui tendent continuellement à détruire la regularité de la composition de l'organisation."

Some passages might even lead one to suppose that Lamarck looked on nature as working by insensible gradations to a preappointed end, and as being hindered, and the symmetry of her plan impaired, by circumstances. Thus he explains the absence of a hard external skeleton in mollusks by the supposition that Nature in them is preparing to form the internal skeleton of vertebrates ; and therefore lays aside the hard shell provided for insects and crustaceans (Phil. Zool. p. 316 ; Hist. Nat. i. 147). He puts forward similar hypotheses to explain the absence of articulated limbs among annelids, or red-blooded worms (which, like Cuvier, he places above insects), and the absence of a double gangliated cord in mollusks (Phil. Zool. 313, *n.* 316). In the Hist. Nat. i. 133, he says :—

"Le plan des opérations de la Nature à l'égard de la production des animaux, est clairement indiqué par cette cause première et prédominante qui donne à la vie animale le pouvoir de composer progressivement l'organisation, et de compliquer et perfectionner graduellement, non seulement l'organisation dans son ensemble, mais encore chaque système d'organes particulier, à mesure qu'elle est parvenue à les établir . . . . Mais une cause étrangère à celle-ci, cause accidentelle et par conséquent variable, a traversé çà et là l'exécution de ce plan sans néanmoins le

détruire, comme je vais le prouver. Cette cause effectivement a donné lieu, soit aux lacunes, réelles de la série, soit aux ramaux finis qui en proviènnent dans divers points et en altèrent la simplicité, soit, enfin, aux anomalies qu'on observe parmi les systèmes d'organes particuliers des différentes organisations."

This second cause is found in the very different circumstances in which the various animals are placed.

On the other hand, an even greater number of passages from Lamarck's writings might be adduced to show that both his primary and his secondary causes are alike due to the effect of circumstances. The increasing complexity of organism being perhaps, as in Mr. Herbert Spencer's theory, caused by the residual, and, to borrow an image from astronomy, secular effects of numerous opposing circumstances. Lamarck's general theory of life as dependent on the action of subtle fluids is given elsewhere, but there is nothing in it to show anything like an intention in nature to pass from one type to another, or to explain her disuse of organs already brought to a high degree of complication. On the contrary, he generally speaks (Hist. Nat. Introd. Part 3) as if all changes, and consequently all advance, were due to the effect of circumstances, new wants, and the action of his subtle fluids, caloric and electricity. Nor is there anything in his account of nature to countenance the theory of intelligence or design in her. Although in other parts of his works he appears to regard her as a Demiurgus, an intelligent but subordinate and finite being, fashioning the world, both animate and inanimate, according to her will; yet when he comes to treat of nature herself (Hist. Nat. Intr. Part 6) it appears that she is nothing but motion and a collection of laws. But a law in physics is really nothing but a way of grouping or describing, more or less accurately, all the similar phenomena presented by bodies; and however general it may be, and however many apparently different effects it may explain, still always remains nothing but a statement, that different bodies behave or move in a similar manner. Lamarck's definition of nature, in fact, amounts to saying that she is a collection of facts or phenomena presented by bodies.

Life, again, is described by him (l.c. p. 311) as having neither intention, end nor will, as blind and limited, and existing only by the will of a superior and infinite Power. Nature is distinct from the material universe (p. 314), and consists (p. 319), first, of motion, and, secondly, of all the constant and immutable laws which regulate the movements and changes of bodies. He attacks the notion (which he says is that of most persons), that nature and God are the same, and declares that God is the all-powerful Creator of nature, while nature is not a being or an

intelligence, but an order of things everywhere subjected; and that design or will is not to be attributed to her, but that the appearance of it is derived from the operation of fixed laws originally combined for the purpose or end which her Supreme Author had in view. This is the case among animals, in whose formation he refuses to admit the action of Cuvier's final causes. He says:—

"En effet dans chaque organisation particulière de ces corps, un ordre de choses préparé par les causes qui l'ont graduellement établi, n'a fait qu'amener par des développemens progressifs de parties, régis par les circonstances, ce qui nous paraît être un but, et ce qui n'est réellement qu'une nécessité. Les climats, les situations, les milieux habités, les moyens de vivre et de pourvoir à sa conservation, en un mot les circonstances particulières dans lesquelles chaque race s'est rencontrée ont amené les habitudes de cette race; celles-ci y ont plié et approprié les organes des individus; et il en est résulté que l'harmonie que nous remarquons partout entre l'organisation et les habitudes des animaux, nous paraît une fin prévue, tandis qu'elle n'est qu'une fin nécessairement amenée" (p. 324).

It appears on the whole, therefore, that if Lamarck did in any way, like Mr. Mivart, conceive a vital force working independently of, and often against circumstances, his views were ill-defined and confused. Though he often mentions nature as a force which gradually perfects the organs of animals, yet he dwells at greater length and more clearly on the power of circumstances in modifying them. He lays down, that circumstances create new wants in the intelligent animals, and produce changes in the nutrition and other vital actions of plants. Thus, changes in the latter are brought about by differences in the amount of moisture in meadows, or by cultivation in gardens. The leaves of the Ranunculus aquatilis, which grow under water, are of a quite different character to those growing in the air. In the higher animals new wants are created by changed circumstances, and produce new actions; and, as the employment of an organ strengthens and enlarges it, while the disuse of an organ makes it deteriorate, the organs become thus altered in an individual subjected to a different set of external circumstances, and these alterations are (at least, if both parents be affected in a similar way) preserved in the offspring. It is therefore, according to Lamarck, an error to suppose that the nature or condition of an organ has led to its employment for a particular purpose; the real fact being that its employment has modified the organ, and fitted it better to perform the duty required of it. He gives (Phil. Zool. vol. i. p. 248), several instances of organs modified by use or disuse. Thus the teeth of whales, the eyes of the mole, the feet of serpents, have been deteriorated or lost by dis-

use. The head of acephalous mollusks has on the other hand been lost by a somewhat different cause, the excessive development of the mouth. The shortening of the intestines of drunkards he also attributed to disuse. On the other hand, the webs between the toes of water birds, the feet of perchers, the long legs of waders, the tongue of the woodpecker, the legs and neck of the giraffe, and the hind legs of the kangaroo, are all instances of organs augmented and developed by excessive use; while the hoofs of many quadrupeds, the formation of the sloth, and the peculiar position of the eyes of the flat fish, are examples of the modifications of organs produced by the peculiar manner in which they are used.

It is not at first evident how use could furnish webs to the toes of swimming birds or animals, as the immediate effect of the resistance of the water would rather be to wear away and destroy all excrescences or webs on the foot. Perhaps Lamarck considered their development as an effect of over-nutrition, or as produced by continual streams of nervous fluid directed to the toes in swimming, producing a swelling or turgescence of the tissues, and forming channels, and thus pushing out the tissues covering the toes.

Lamarck extended his views to men, whom he considered as descended from the quadrumana. The difference in their structure was caused by men losing their habit of climbing trees, and being compelled during many generations to walk on their hind legs. Having obtained the mastery over other races, men took possession of all the spots which suited them, drove other animals into deserts, and thus arrested their development, while they multiplied their own wants, and, consequently, their mechanical powers (*industrie*) and faculties; and thus increased the distance between themselves and other animals. An erect position, he says, is sometimes assumed by the chimpanzee, and does not seem even now altogether natural to man, as is shown by the unwillingness of a fat, paunchy child to walk or stand. This is, we believe, the only place where Lamarck shows any perception of the law established by Mr. Darwin—that the young animal seems often not to have acquired the characteristics separating the adult from the neighbouring forms from which it has been developed.

The argument in favour of the fixity of species drawn from the fact that the mummies of animals found in Egypt present the same characters as existing animals, is not, according to Lamarck, conclusive. It proves only that species in Egypt have not varied for the last three or four thousand years, which is not surprising; as the climate and external circumstances affecting the animals in question have remained unaltered, and it is only

by changes of circumstances and length of time that new species or varieties are produced. Lamarck thinks that no species have been actually lost, except some large land animals extirpated by man. Other species, which seem to have disappeared, have really left descendants, but they, owing to continual changes of level and climate in different parts of the earth, have assumed forms different from those of their ancestors. There is therefore no evidence of any general catastrophe by which all the species in existence at one time were destroyed, although there have been many local catastrophes.

Lamarck gives two tables showing the origin and descent of animals. The one in the "Philosophie Zoologique," ii. 463, the other, six years later, in the "Histoire Naturelle," i. p. 457. In the first, Lamarck makes two branches of the animal kingdom, which are, however, of very different importance. The first branch comprises the Infusoria, Polyps, and Radiaria (sea urchins, star fish, jelly fish, &c.) or nearly all the forms classed by Cuvier as Radiata, with the exception of intestinal worms. These, together with Planaria, Gordius and Nais, make up Lamarck's class of worms, which forms the root of his second branch, and from which he derives all the higher forms of animals. These again make two branches, one composed of insects, spiders, lobsters, and other segmented animals with jointed limbs, the other of the annelids or ring-worms, the cirrhipeds or barnacles, and the mollusks. From the last the vertebrates spring. First fishes, then reptiles, then birds, and from these the mono-treme mammals, the duck-bill and echidua. The other mammals, however, he derives, not from birds, but from reptiles, from which he considers amphibious mammals, such as the seal and the manatee to have sprung; while they in their turn gave rise to the three remaining divisions—the unguiculate or clawed, the ungulate or hoofed, and the cetacea or whales. It is obvious, therefore, that Lamarck did not consider the lowest mammals to be necessarily the earliest developed, since he derived cetaceans by a process of degradation from amphibious mammals.

The view presented of the probable descent of animals in Lamarck's second table is a great improvement on the first. He still keeps two great series of animals, but they are better connected than those of the first table. The first series commences with Infusoria, from which Lamarck supposes the Polyps to have sprung. These give rise to two different classes. First, the Radiaria; and, secondly, Ascidians, and through them to the acephalous and other Mollusks. Except that Lamarck includes Cuvier's Echinoderms in his Radiaria, instead of giving a position near the worms, a modern evolutionist could object but little to this part of the table. The second, or articulate series, is

not in such close conformity with modern ideas. The worms give rise to two classes, Annelids (ringed red-blooded worms) and Epizoa (parasites generally found attached to the eyes or gills of fish). These Epizoa Lamarck believed to be the source from which insects and the other Articulates with jointed limbs were derived. The Cirrhipeds (Barnacles) Lamarck rightly places with these animals, although Cuvier long after continued to class them among Mollusks, in consequence of the resemblance of their shells to those of Bivalves. Lamarck himself so far gives importance to this resemblance as to place Cirrhipeds above Crustaceans, in accordance with his theory of the importance of organs analogous to those of a superior class. The Vertebrates are here placed by themselves, unconnected with either series of invertebrate animals, although from several passages of the "Histoire Naturelle" it appears that Lamarck had not abandoned his theory that they were derived from the Mollusca.

In the first chapter of the second book of his "Phil. Zool." Lamarck endeavours to define the class of inanimate bodies. He recurs to the subject of the difference between them and living beings in the first volume of his "Histoire Naturelle des Animaux sans Vertèbres," where his views are given at greater length, and in some respects with more precision. In the "Philosophie Zoologique" he considers that inorganic substances are distinguished by having no individuality, by many of them being homogeneous (wholly solid, liquid or fluid), by their having no need of movement or nutrition, by their increasing by juxta-position, and not by intussusception, and by their not originating from germs or being subject to death. From this definition it is impossible to know whether or not Lamarck intended to include substances derived from living beings, such as wood, wax, &c., in the class he was defining. All the characters he mentions are mere negations of characters of living beings, and might be more forcibly and concisely expressed by the words "inorganic" and "not living." Homogeneity, while it cannot be predicated of all inorganic substances, is a property (so far as our present knowledge extends) of some organic beings. An Amœba has all the appearance of a particle of animated jelly, and has a better claim to be called homogeneous than granite or most rocks, and as good a claim as wax or butter. In fact, it is evident that Lamarck, at the time he was writing this definition, had living beings in view, and would, had he cared to frame a logical work, have defined them instead of inorganic bodies. It would perhaps be as easy to make a satisfactory definition of unelectrified bodies as of inanimate or inorganic bodies. Many of the latter are subject to forces producing crystallization, but this, though a positive character, cannot be predicated of colloids such as gum, &c. One

common character is indeed attributed to all minerals by Lamarck—that of being derived from dead animals or plants. Stated broadly, as by him, this is an impossibility. He shows himself that the material constituents of all living beings were once inorganic. So that the old problem of the hen and the egg appears in an insoluble form.

In the second chapter of the Philosophie Zoologique, book ii., Lamarck attempts a definition of life, which he represents as producing various phenomena that yet do not constitute it. Life, he says (p. 403), in the parts of a body which possesses it, is an order and state of things which allows organic movements therein; these movements, which constitute active life, result from the action of a stimulative cause which excites them. This is not very clear. He goes on to lay down that active life requires stimuli, and a state of things which bestows the faculty of obeying them. This state of things consists in the existence of supple parts formed of cellular tissue and of liquid parts. The necessary exciting causes are to be found in the various subtle (imponderable) fluids which permeate all things, and which are in a continual state of agitation, produced by the motion of the earth, the varying positions of the heavenly bodies, and the seasons. Of such fluids the most important, perhaps the only ones concerned in producing life, are caloric and the electric fluid. To plants and to the lower animals the fluids in the surrounding media are sufficient to furnish the necessary stimuli; but in higher animals a continual production and renewal of the exciting fluids goes on. Some change even seems to take place in the nature of the fluids, the electric fluid being, as it were, animalized and converted into galvanic and nervous fluids. In plants only the liquid portions are acted on by the exciting causes, and their movements are probably due to caloric. In animals, however, the caloric produces swellings and contractions of the soft tissues as well as movements of the liquid parts. The caloric of higher animals is, according to Lamarck, derived from arterial blood.

It is to the important part played by heat that Lamarck attributes the great development of living beings in summer-time and in tropical climates. Water, light, and air, in addition to heat, are essential to the production of living beings. The phenomena of torpidity and hybernation are due to a loss of caloric; but in hybernating animals this loss is only partial, as is shown by the fact that, if the cold be increased, the animal awakes and becomes very restless. The chief effect of caloric on animated beings is to produce "orgasme"—a sort of tension or swelling, perhaps allied to tonicity. This "orgasme" exists in the soft parts of animals, and also, though obscurely, in plants, in which, however, it never gives rise to irritability, which is a power of moving in answer to

an external stimulus, rapidly and repeatedly, or as often as the stimulus is applied. The want of irritability is the great mark by which plants are to be distinguished from animals, but they also differ in having no digestive faculty, in their mode of growth, and in their chemical characters.

In the first volume of the Histoire Naturelle Lamarck again takes up the subject, and defines vegetables as being (1) unable to contract suddenly and repeatedly as often as a stimulus is applied to them; (2) unable to displace themselves; (3) having only their liquid parts capable of motion; (4) being without special internal organs, although possessing a number of vessels and canals; (5) without digestion, but only elaboration of the fluids which nourish them; (6) having displacement of fluid, but no circulation; (7) having two growths, one ascending, the other descending, from a vital nodus (nœud vital), situated at the origin of the root; (8) tending to grow perpendicular to the plane of the horizon; (9) being generally compound.

The motions of plants he considers to be due to mechanical causes, such as the action of elastic fluids, of springs (as in the action of certain plants in discharging their pollen), or to the action of the sun in drying up or driving away the fluids in particular parts. Some of the motions, like those of Confervæ and Oscillatoriæ, are slow, and not altered by external stimuli; while others, as in the case of the sensitive plant, can only be repeated after long intervals.

The facts established since the time of Lamarck show the futility of his theories. It is impossible to distinguish the movements of the ciliæ of Zospores, or of the amœbiform poisonous matter of the nettle from those of the ciliæ of infusoria or of Amœba. The second and third of Lamarck's characters are incorrect; the fifth and sixth are only verbal. How does elaboration differ from digestion, or circulation from displacement? The other characters are neither true of all plants, nor peculiar to them; and even if they were, they are not sufficiently important to separate plants from animals.

Animals, according to Lamarck, are distinguished by nine characters, generally corresponding to the characters of plants already enumerated. The first and second, fifth and eighth, consist in the possession of irritability and the power of moving. The third character is that animals execute no movements without stimulus, and can repeat such movements as often as the stimulus is employed; while, according to the fourth character, the movements show no comprehensible relation to their cause. The other characters are that animals are nourished by foreign compound substances, which they generally have the power of digesting; that they present great disparities in the composition

of their organization, and that they have no tendency to grow vertically.

It appears to us that definitions, in order to be useful, should consist either in a short explanation or description of the essential characters of the class, or in a description of one or more characters to be found in each member of the class, and serving as a test whether a given object does or does not belong to the class. In the second case it is important that the test should be accurate, but not that the character chosen should be important. Of this nature are the characters serving to discriminate between neighbouring genera in Zoology. In the first case, however, the characters chosen should be important; and if possible should disclose the essence, the actual nature and reason for existence of the class. This can hardly ever be done, except in pure mathematics and artificial or verbal sciences, such as Grammar, Heraldry, or Rhetoric. Our definitions share in the imperfections of our knowledge; and all we can do, when seeking to define a class of the components of which we know as little as we do of animals, is to take the characters which seem to be the most important and most universal, and state them as clearly and concisely as is possible. So long as the real nature of matter, of space, and of force is unknown, it is impossible to understand properly or define adequately life or feeling. The definitions can be but provisional, and in such it is not absolutely necessary that the characters chosen should be accurately coextensive with the class.

Judged from this point of view some of Lamarck's characters are, for his time, as important and indicative of the real nature of the class as any that could be chosen. In particular, the character which attributes to animals the power of executing movements, not communicated but excited, and bearing no comprehensible relation to their exciting cause, and the character which lays stress on the stream of matter continually flowing through the bodies of living beings, appear to us especially good. It is interesting to compare Lamarck's definition of animals with Mr. Herbert Spencer's definitions of Life, which he says ("Principles of Biology," p. 74) consists in "the definite combination of heterogeneous changes, both simultaneous and successive, in correspondence with external coexistences and sequences;" or (p. 80) "the continuous adjustment of internal relations to external relations." These definitions are very ingenious, but do not throw much light on the nature of life, or of the effects produced by it; nor do they afford a test by which to decide whether a given substance is or not endued with life. Mr. Spencer himself admits that the characters are not strictly coextensive with the class; indeed he holds that no characters can be strictly coextensive consistently with the doctrine of Evolution.

Living beings are produced by generation, which Lamarck holds may be either spontaneous or from parents similar to the offspring. Direct or spontaneous generations take place continually among the simple forms to be found at the beginning of the animal and vegetable series, and most other animals and plants are derived from these earliest forms. Being ignorant of the eggs both of Polyps and Infusoria, he argues in favour of the occurrence of direct generations from the destruction which, during a rigorous winter, must overtake all the inhabitants of freshwater pools. He at one time considered that direct generation occurred only among the lowest forms, but he was later induced to believe that intestinal worms, and even external parasites of comparatively high organization, might be generated directly from corpuscles formed in the animals infested, and analogous in some degree to the corpuscles which reproduce the form of the parent. He thus recognises the two sorts of direct generation which Dr. Bastian has called respectively Abiogenesis, generation from inorganic matter; and Heterogenesis, or generation of a new and distinct animal or plant from organic matter or living bodies. Dr. Grant in his "Tabular View of the Animal Kingdom" (London, 1861), declares it is impossible to draw any definite line of demarcation between the various cells which build up one of the higher animals such as blood corpuscles, bone cells, &c., and the lowest isolated and independent animals. Mr. H. Spencer also propounds a somewhat similar theory, considering higher animals to be aggregates of the second or even third order, built up out of cells or aggregates of the first order. (Principles of Biology, ii. p. 77–112.) These views, however, are by no means the same as those of Lamarck, whose parasites spring from germs and not from cells. According to the observations of Pouchet and Bastian, a germ-like period of quiescence is the invariable precursor of every great heterogenetic change in any living body, and the particles from which the new being will arise are at first aggregated together so as to present the appearance of an egg or germ, which Pouchet calls the spontaneous egg. If the correctness of these observations were established, it would be a curious corroboration of Lamarck's surmise.

Lamarck goes on to explain the production of the simplest organic forms by direct generation. Gelatinous and mucilaginous bodies are alone fitted to receive life. Into the mass of these the ambient subtle fluids penetrate, increase the interstices, and produce a cellular tissue, in which various fluids and liquids can enter and move. Caloric here plays the most important part. The lower animals are entirely formed of this cellular tissue. In the higher animals and plants this tissue is modified. Vessels are wrought in it by the motion of fluids; membranes, such as

bark and skin, are formed by its compression; and all other organs are derived from and developed by it. Lamarck in forming his theory seems to have confounded the areolar or fibrous tissue enveloping the muscles and other organs with the primordial cells from which many organs originate.

New combinations of matter are being continually formed by living bodies, by means of their organic movements, with the aid of the affinities or relations of matter, and the tendency which all compound bodies have to self-destruction, a tendency which arises from some of the combined principles in such bodies requiring to be fixed by the restraint of an external force. Hence come secretions and assimilations. In youth the parts of the body are soft; nutrition is consequently more than sufficient to supply the waste of the tissues, and the animal increases in size. As time goes on, the softer portions of the tissues are more easily lost or dissipated in the continual flux of matter than the harder portions; while in the repairs effected by nutrition, the harder portions are comparatively more numerous. Thus the tissues gradually harden, and further growth becomes impossible. At first the surplus nutriment collected by every part of the body serves the reproductive faculty, and goes to form a small but similar body. As the hardness still increases, nutrition is carried on with greater difficulty, and at length ceases to be sufficient to maintain the body in a state in which vital movements can be carried on, and the animal dies. This view, which accounts for the resemblance between parents and their offspring by supposing that organs in the latter are formed out of particles derived from the corresponding organ in the former, was probably suggested to Lamarck by Buffon's theory of organic molecules. It is reproduced, although with many improvements and additions, in Mr. Darwin's theory of Pangenesis, but is much older than any of these authors. Lucretius (Bk. iv. l. 1212), reproducing the atomic theory of the Greeks, says:—

> Fit quoque, ut intendum similes existere avorum
> Possint, et referant proavorum sæpe figuras,
> Propterea, quia multa modis primordia multis
> Mista suo celant in corpore sæpe parentes,
> Quæ patribus patres tradunt a stirpe profecta;
> Inde Venus varia producit sorte figuras,
> Majorumque refert voltus, vocesque, comasque.

The theories all seem to rest on some materialistic idea, that a particular force can be transmitted from one body to another by a transmission of some of the actual particles impressed with or moving in obedience to such force.

After giving this account of the general effect of life, Lamarck proceeds to discuss the principal faculties peculiar to different animals. He commences with his usual serene conviction of the truth of his own theories, and all facts to be deduced therefrom, by inveighing against the folly of expecting to find organs in animals lower in the scale of life than those in which rudimentary organs appear. As circulation is first sketched out in the class of insects, it is useless to seek for anything of the sort in Radiaria. It is equally absurd to attribute anything like respiratory functions to the leaves of plants. After this rather unfortunate beginning, he examines seven of the chief faculties. He defines—1. *Digestion*, as consisting in the destruction of the state of aggregation of the particles of aliment, and in a change of state and quality fitting the aliment, to form chyle and to repair the essential fluid: and 2. *Respiration*, as the process by which the essential fluid is repaired, after sudden alterations of it, where nutrition is too slow a process. The alterations intended are those arising from the supposed sudden dissipation of caloric, electricity, and nervous or other subtle fluids necessary for producing motion and other vital functions. Lamarck, however, while he recognises oxygen as the most important principle of this reparation, makes no allusion to any development of heat from the combination of such oxygen. He divides the special systems of respiratory organs into four sorts, which are Lungs and Tracheæ, fitted for breathing air; and Branchiæ and Aquiferous Tracheæ, adopted for breathing water: the last being found in Radiaria (echinoderms and jelly-fish). In animals not having a definite circulation, respiration is effected in organs diffused over the whole body, the respired fluid carrying its influence to every part, and the essential fluid not travelling further than the respired fluid. In animals having a circulation, on the other hand, the respired fluid is admitted into a special organ, and there is a special circulation of the essential fluid, either complete or incomplete, within such organ. A very slow movement of the essential fluid takes place among the infusoria, and probably a more rapid one among the polyps. In higher animals a separate system of organs is required to carry on the definite circulation which these obtain. This system is first sketched out in the Arachnida (spiders, mites, &c.), and formed in the Crustacea. The theory—that respiration is intended to effect changes in the circulating fluid—seems open to some question. The ultimate object is to provide the organs of the body with the oxygen necessary to enable them to carry on the vital functions, and the alteration which undoubtedly takes place in the blood seems generally to be but a means of carrying the oxygen to these organs. The other functions

Lamarck mentions are those of the muscles, of sensation, of sex, of circulation and intelligence.

In the third part of his Phil. Zool. Lamarck develops at some length his theory of sensation, instinct, thought and will, as dependent on the motions of a subtle fluid, which he considers to be probably an animalized form of electricity. He believes that the fluids to which he attributed irritability and motion in animals may, like their blood, become more complex and retainable—"*contenable*"—in the higher animals, although still remaining invisible. A special fluid traverses the nerves, and being used and lost in them, is continually being separated from the blood of the arteries to make up the loss. The blood itself, as we have seen, is restored by means of respiration to its former state. The great separation of this fluid from the blood takes place in the grey matter of the brain, and other nervous centres, which is in a great measure composed of small arteries.

The nervous system always consists of two parts. (1) A central mass, from which, the fluid necessary to excite the muscles to contract, starts, and to which, the fluid conveying sensation comes. In vertebrata this centre is probably the ring (Pons Varolii?) of nervous matter round the continuation of the spinal cord into the brain, the medulla oblongata, or the medulla oblongata itself. In insects, the first bilobed ganglion is also a centre; but these animals may have several centres. The centres are the parts first formed, and though other parts may be larger and more developed, this is only the effect of the general law that exercise promotes growth. (2.) The nerves are the second portion. They consist of a medullary pulp, covered by a sheath, which retains the subtle fluid continually traversing them. They are, however, open at their extremities to enable the fluid to communicate with the various parts of the body. The pulp is secreted from the blood, or essential fluid of the animal. A special sheath covers every nerve-fibre, in addition to the fibrous envelope of the whole. The nerves were produced after the formation of the various centres by the movements of the special subtle fluid, working out channels and passages by which more easily to arrive at the place where it was required.

This view of the origin of nerves is not unlike the one given by Mr. Herbert Spencer (Biology. Section 302).

Movements, when effected by irritability in the lowest animals, are, as has been seen, due entirely to external stimuli; but Lamarck repeatedly lays down that muscular action is always accompanied by nervous action, of which it is the earliest and commonest effect. In higher animals sensation or feeling is also produced in the nervous system, and in higher animals still, which have a

special organ (the hemispheres of the brain or hyper-cephalon, as Lamarck terms it)—consciousness, thought, moral feeling, and will, also result. The precise action of the nervous system in those animals, in which it subserves muscular action only, is not laid down with any accuracy by Lamarck. He states that such action may be produced in three ways—(1) by external action; (2) by the internal feeling not regulated by the will; and (3) by such feeling regulated to a greater or less extent by the will. In all animals in which a nervous system exists, he considers it probable that the internal feeling exists. Its action, however, will be best understood by first taking the phenomena of feeling.

The soft character of the nerves, and especially of their medullary pulp, renders it impossible to adopt Hartley's view, and to consider them as vibrating cords, or transmitting impressions by vibrations of their component matter. They, however, all contain a portion of the subtle nervous fluid, which, by its movements or compressions and the shocks it receives, gives rise both to sensation and the emotions of the internal feeling. Every impression given to any particular part produces a shock to the whole amount of nervous fluid contained in the nervous system. This shock is propagated along the nerve to the centre, and thence to every part of the system, and afterwards produces a reaction, which comes from every part of the system except the particular nerve first affected, and is consequently propagated along such nerve, the only one not reacting. This causes the sensation to be referred to the extremity of this nerve, in the part originally impressed. On the other hand, the internal feeling is due to a general shaking of the nervous fluid, not accompanied by any reaction. The continual small impressions such fluid receives give rise to the feeling of personal identity, "*le moi*," while the more violent impressions produce actions and thoughts by sending portions of the nervous fluid to the brain, or directly to the muscles. By this automatic or involuntary actions are produced, as when a man starts at a loud sound, or flings down a hot iron. Consciousness only arises when a part of the nervous fluid traverses the special organ (the hyper-cephalon), in which its movements leave traces of its currents. These traces produce alterations in the currents which afterwards traverse the same part, and by these means feelings and moral sensibilities are produced, which by such alteration or modification of the movements of the nervous fluid give rise to corresponding actions. Habits in man and the higher animals, and instincts in the lower ones, (especially remarkable in insects,) are actions produced by the nervous fluid moving along courses which have been worn out by repeated currents flowing in the same or similar directions. The internal

feeling has thus a threefold faculty. First, to give notice of sensations whereby physical sensibility is produced; secondly, to give consciousness of ideas and thoughts by sending portions of the nervous fluid to move in the channels or courses already worn in the hyper-cephalon, whereby moral sensibility is produced, as hereafter mentioned; and, thirdly, to make the animal act instinctively or involuntarily. Only a small part of the nervous fluid is at the disposition and will of the animal, and this part is speedily used up in continual movements or intellectual operations, and requires to be reproduced before the animal can go on acting or thinking. It is thus that the sense of fatigue arises, the muscles not being themselves altered.

Conscious will and ideas arise from the motion of the nervous fluid in the organs of intelligence, the cerebral lobes or hyper-cephalon. This organ does not react on the nervous fluid. It is composed of innumerable cavities, to which the nerve fibres lead. The act of attention is necessary to prepare the organ to be impressed; without such act, an impression will be perceived, but not felt; but when attention has prepared the channel, the agitation of the nervous fluid originally produced by an external object is communicated to nervous fluid which traverses the hyper-cephalon, and engraves traces of its course on that organ. A simple idea is thus produced, which can be recalled by the nervous fluid being directed on the traces of the original sensation, and with the aid of attention bringing back the features of such traces to the notice of the internal consciousness. Lamarck denies the existence of any innate ideas, though they would almost seem to be a necessary consequence of his theories. If the offspring bears the close resemblance to the parent which he attributes to it, and ideas are the results of channels actually sculptured in the brain, it would appear at least highly probable that the child would be born with the power of reproducing all the ideas of its parent. Lamarck considers dreams and madness caused by disturbed currents of the nervous fluid traversing various parts of the hyper-cephalon, and the traces of many ideas uncontrolled by the internal feeling.

In forming judgments, a stream of fluid is divided and directed by the internal feeling on to different traces of ideas already engraved in the brain, after tracing which, the different portions acquire as many modifications of their original motions as there are traces of simple ideas, and then reuniting, these different motions are combined into one complex movement which produces the judgment; complex ideas are derived from judgments, and complex ideas and judgments of the second order are obtained from complex ideas of the first order, in a manner similar to that in

which the complex ideas of the first order are derived from simple ideas.

Will is a determination by thought, and always the effect of a judgment. It is not really free, but the necessary result of the previous operation, as the quotient is in an arithmetical process. The appearance of irregularity in the workings of the will and the enormous variations in the results obtained from different people and at different times, arise from differences in the organ, produced by disposition, age, health, and other elements, all of which take part in the formation of the judgment. Attention is an act of the internal feeling acted on by a want or desire which directs a part of the nervous fluid which is at the disposition of the individual, on to the organ of intelligence. Preoccupation prevents this act, and then ideas or feelings do not engrave themselves on this organ.

The first thing that strikes one after reading Lamarck's attempted explanation of the processes of feeling, thought, and other acts of intelligence, is that even if it were true, it would explain nothing. There is the same difficulty, neither diminished nor increased, in the mind being conscious of a stream of nervous fluid in the hyper-cephalon, as in its being conscious of the pressure of a solid substance on the finger. It is possible, or at least conceivable, that such a stream may be an essential link in the chain connecting external phenomena with consciousness. It is certain that some operation in the lobes of the brain is such a link, but it is highly improbable that Lamarck's fanciful sketch represents what really takes place, and if it did, it would throw no light soever on the problem of consciousness. Lamarck has described a sort of hydraulic calculating machine which requires both to be originally set in motion and also to have its final results read off and interpreted by an intelligent mind. Such a mind he seems sometimes to attribute to what he calls the internal feeling, which, however, he often treats as only a sort of valve. In one respect he is particularly unfortunate. He has based all his explanations of life and intellect on theories of imponderable fluids, like the caloric invented by Black, and the various electric fluids. These theories had, even before Lamarck wrote his Philosophie, been assailed by Count Rumford. (Phil. Trans., A.D. 1798, and Sir Humphry Davy, Chemical Philosophy, 1812.) They were not, however, really overthrown till Joole and Mayer, respectively, published their views and experiments on the nature of heat, about 1842-3. Lamarck was so fond of imponderable fluids that he even considered sound to be propagated not by air, but by a peculiar imponderable fluid, which he elsewhere represents as a modified form of caloric. He based his theory on the discrepancy between the observed velocity of sound and

that calculated for it by Newton, and refused to admit the explanation of Lagrange and Laplace, who showed Newton's calculations to be defective in not taking account of the action of heat in increasing the elasticity of the air. These physical theories of Lamarck now impart to his biological speculations a much greater air of falseness and fancifulness than they really deserve. In order properly to do justice to them when comparing them with modern speculations on the same subject, they should be as it were translated out of the language of subtle fluids into that of transmutable forces. Lamarck has in several cases anticipated theories which have since been advocated with great ingenuity, but he has in such cases often disguised them in phraseology borrowed partly from ideas now exploded, and partly from his own imagination. His views of life generally agree with those of Mr. Darwin and Mr. H. Spencer in so far as they all endeavour to explain the phenomena of life by the action of ordinary physical forces, and refuse to recognise any special vital force or fluid. On the other hand, he held the doctrine of the daily recurrence of spontaneous generation, which doctrine is at the present day advanced chiefly by the advocates of the principle that some special form of force is necessary to produce vital phenomena. In mental philosophy, as we have seen, Lamarck altogether rejected the doctrine of the freedom of the will, while in religion his views seem to have been a curious mixture of Pantheism and Deism.