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TORONTO

ZOOLOGICAL PHILOSOPHY

AN EXPOSITION WITH REGARD TO THE NATURAL HISTORY OF ANIMALS

THE DIVERSITY OF THEIR ORGANISATION AND THE FACULTIES WHICH THEY DERIVE FROM IT; THE PHYSICAL CAUSES WHICH MAINTAIN LIFE WITHIN THEM AND GIVE RISE TO THEIR VARIOUS MOVEMENTS; LASTLY, THOSE WHICH PRODUCE FEELING AND INTELLIGENCE IN SOME AMONG THEM

BY

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GLOSSARY

Giving the original French of some of the more important words used in the course of this translation.

English.	French.
affective,	*affectant.*
affinities,	(biol.) *rapports.*
	(chem.) *affinités.*
amphibian,	*amphibie.*
analytic,	*décomposant.*
arbitrary opinion,	*arbitraire.*
argument,	*raisonnement.*
artificial devices,	*parties de l'art.*
centre of communication,	*centre de rapport.*
classification,	*distribution, classification.*
complexity,	*composition.*
crude,	*brut.*
crura cerebri,	*pyramides du cerveau.*
digression,	*écart.*
ego,	*moi.*
environment,	*circonstances, milieux environnants, etc.*
erethism,	*éréthisme.*
exciting cause,	*cause excitatrice.*
factor,	*cause influente, cause essentielle, etc.*
faculty,	*faculté.*
feeling,	*sentiment.*
function,	(zool.) *faculté, fonction.*
fungus,	*champignon.*
ganglionic longitudinal cord,	*moelle longitudinale noueuse.*
hypocephalon,	*hypocéphale.*
inclination,	*penchant.*
inference,	*conséquence.*
inner feeling,	*sentiment intérieur.*
integral molecule,	*molécule intégrante.*
intellect,	*intelligence.*
kinship,	*parenté.*
laburnum,	*cytise.*
lacteals,	*vaisseaux chyleux.*
limb,	*membre.*
main medullary mass,	*masse médullaire principale.*
matrix,	*gangue, matrice.*

ENGLISH.	FRENCH.
medulla oblongata,	*moelle allongée.*
mind,	*esprit.*
monas,	*monade.*
natural order,	*ordre naturel.*
need,	*besoin.*
nucleus (of sensations),	*foyer.*
orgasm,	*orgasme.*
peduncles of the cerebellum,	*jambes du cervelet.*
pelvis,	*bassin.*
procedure of nature,	*marche de la nature.*
propensity,	*penchant.*
proteus,	*protée.*
reproduction,	*génération.*
rudiment,	*ébauche.*
scale of nature,	*échelle de la nature.*
schematic classification,	*distribution systématique.*
sensibility,	*sensibilité.*
sensitive,	*sensible.*
serum,	*sanie.*
skill,	*industrie.*
soft radiarian,	*radiaire molasse.*
soul,	*âme.*
spinal cord,	*moelle épinière.*
spirits,	*esprits.*
spontaneous generation,	*génération directe* or *spontanée.*
stage,	*degré.*
synthetic,	*composant.*
radiarian,	*radiaire.*
root-collar,	*collet de la racine.*
unguiculate,	*onguiculé.*
ungulate,	*ongulé.*
vital knot,	*nœud vital.*
vital principle,	*arché-vitale.*
volatile,	*coercible.*
zoological philosophy,	*philosophie zoologique.*

INTRODUCTION.

§ 1. LIFE.

JEAN-BAPTISTE-PIERRE-ANTOINE DE MONET DE LAMARCK was born on Aug. 1st, 1744, at Bazantin, a village in Picardy, now known as the Department of the Somme. He was the eleventh and youngest child of his parents, and belonged to a family of nobility which had for generations past been devoted to military pursuits. A number of his brothers carried on the family tradition by entering the French army; but Jean himself was destined by his father for an ecclesiastical career, and was entered as a student at the Jesuit College at Amiens. Yet he himself had no inclination to the calling desired by his father; and on the death of the latter in 1760, he made immediate use of his new liberty to leave the Jesuit College and join the French army, which was then in Germany, near the end of the Seven Years' War. He bought a horse and rode through France and part of Germany, until he reached the French lines on the eve of the Battle of Fissingshausen. He carried with him a letter of introduction to the colonel of one of the infantry regiments; and on the following morning placed himself in a company of Grenadiers. The battle of Fissingshausen was fought and lost: the French retreated: all the officers of Lamarck's company were killed, and the command fell upon him. His courage was such that his colonel took him that very evening to the Field-Marshal, by whom he was appointed an officer.[1]

[1] This at least is the story told by all Lamarck's biographers. I venture nevertheless to suggest that it can hardly be accepted in the unquestioning way usually followed. The story is founded upon Cuvier's *Eloge de M. de Lamarck*, and that again is doubtless

PREFACE.

EXPERIENCE in teaching has made me feel how useful a philosophical zoology would be at the present time. By this I mean a body of rules and principles, relative to the study of animals, and applicable even to the other divisions of the natural sciences; for our knowledge of zoological facts has made considerable progress during the last thirty years.

I have in consequence endeavoured to sketch such a philosophy for use in my lessons, and to help me in teaching my pupils; nor had I any other aim in view. But in order to fix the principles and establish rules for guidance in study, I found myself compelled to consider the organisation of the various known animals, to pay attention to the singular differences which it presents in those of each family, each order, and especially each class; to compare the faculties which these animals derive according to its degree of complexity in each race, and finally to investigate the most general phenomena presented in the principal cases. I was therefore led to embark upon successive inquiries of the greatest interest to science, and to examine the most difficult of zoological questions.

How, indeed, could I understand that singular degradation which is found in the organisation of animals as we pass along the series of them from the most perfect to the most imperfect, without enquiring as to the bearings of so positive and so remarkable a fact, founded upon the most convincing proofs? How could I avoid the conclusion that nature had successively produced the different bodies endowed with life, from the simplest worm upwards? For in ascending the animal scale, starting from the most imperfect animals, organisation gradually increases in complexity in an extremely remarkable manner.

I was greatly strengthened in this belief, moreover, when I recognised that in the simplest of all organisations there were no special organs whatever, and that the body had no special faculty but only those which are the property of all living things. As nature successively creates the different special organs, and thus builds up the animal organisation, special functions arise to a corresponding degree, and in the most perfect animals these are numerous and highly developed.

These reflections, which I was bound to take into consideration, led me further to enquire as to what life really consists of, and what are the conditions necessary for the production of this natural phenomenon and its power of dwelling in a body. I made the less resistance to the temptation to enter upon this research, in that I was then convinced that it was only in the simplest of all organisations that the solution of this apparently difficult problem was to be found. For it is only the simplest organisation that presents all the conditions necessary to the existence of life and nothing else beyond, which might mislead the enquirer.

The conditions necessary to the existence of life are all present in the lowest organisations, and they are here also reduced to their simplest expression. It became therefore of importance to know how this organisation, by some sort of change, had succeeded in giving rise to others less simple, and indeed to the gradually increasing complexity observed throughout the animal scale. By means of the two following principles, to which observation had led me, I believed I perceived the solution of the problem at issue.

Firstly, a number of known facts proves that the continued use of any organ leads to its development, strengthens it and even enlarges it, while permanent disuse of any organ is injurious to its development, causes it to deteriorate and ultimately disappear if the disuse continues for a long period through successive generations. Hence we may infer that when some change in the environment leads to a change of habit in some race of animals, the organs that are less used die away little by little, while those which are more used develop better, and acquire a vigour and size proportional to their use.

Secondly, when reflecting upon the power of the movement of the fluids in the very supple parts which contain them, I soon became convinced that, according as this movement is accelerated, the fluids modify the cellular tissue in which they move, open passages in them, form various canals, and finally create different organs, according to the state of the organisation in which they are placed.

Arguing from these two principles, I looked upon it as certain that, firstly, the movement of the fluids within animals—a movement which is progressively accelerated with the increasing complexity of the organisation—and, secondly, the influence of the environment, in so far as animals are exposed to it in spreading throughout all habitable places, were the two general causes which have brought the various animals to the state in which we now see them.

I have not merely confined myself in the present work to setting forth the conditions essential to the existence of life in the simplest organisations, and the causes which have given rise to the growing complexity of animal organisation from the most imperfect to the most perfect of animals; but, believing that there is some possibility of recognising the physical causes of feeling, which is possessed by so many animals, I have not hesitated to take up this question also.

I was indeed convinced that matter can never possess in itself the property of feeling; and I imagined that feeling itself is only a phenomenon resulting from the workings of an orderly system capable of producing it. I enquired therefore what the organic mechanism might be which could give rise to this wonderful phenomenon, and I believe I have discovered it.

On marshalling together the best observations on this subject, I recognised that for the production of feeling the nervous system must be highly complex, though not so highly as for the phenomena of intelligence.

Following out these observations, I have become convinced that the nervous system, when it is in the extremely imperfect condition characteristic of more or less primitive animals, is only adapted to the excitation of muscular movements, and that it cannot at this stage produce feeling. In this particular stage it consists merely of ganglia, from which issue threads. It does not present any ganglionic longitudinal cord, nor any spinal cord, the anterior extremity of which expands into a brain which contains the nucleus of sensations and gives origin to the nerves of the special senses, or at least to some of them. When the nervous system reaches this stage, the animals possessing it then have the faculty of feeling.

Finally, I endeavoured to determine the mechanism by which a sensation was achieved; and I have shown that nothing more than a perception can be produced in an individual which has no special organs, and moreover, that a sensation produces nothing more than a perception whenever it is not specially remarked.

I am in truth undecided as to whether sensation is achieved by a transmission of the nervous fluid starting from the point affected, or merely by a communication of movement in that fluid. The fact, however, that the duration of certain sensations is dependent upon that of the impressions which cause them, make me lean towards the latter opinion. My observations would not have thrown any satisfactory light upon the subjects treated, if I had not recognised and been able to prove that feeling and irritability are two very different organic phenomena. They have by no means a common origin, as has been supposed; the former of these phenomena constitutes a faculty peculiar to certain animals, and demanding a special system of organs, while the latter, which does not require any special system, is exclusively the property of all animal organisation.

So long therefore as these two phenomena continue to be confused as to their origin and results, it will be only too easy to make mistakes in proffering explanations of the causes of the general phenomena of animal organisation. It will be so especially in making experiments for the purpose of investigating the principle of feeling and of movement, and finally the seat of that principle in the animals which possess these faculties.

For instance, if we decapitate certain very young animals, or cut the spinal cord between the occiput and the first vertebra, or push in a probe, there occur various movements excited by the pumping of air into the lungs. These have been taken as proof of the revival of feeling by dint of artificial respiration; whereas these effects are due partly to the irritability not being extinct, for it is known that it continues to exist sometime after the death of the individual, and partly to certain muscular movements which can still be excited by the inhalation of air when the spinal cord has not been altogether destroyed by the introduction of a long probe right down its canal.

I recognised that the organic act which gives rise to the movement of the parts is altogether independent of that which produces feeling, although in both cases nervous influence is necessary. I notice that I can work several of my muscles without experiencing any sensation, and that I can receive a sensation without any movement resulting from it. But for these observations, I too might have taken the movements occurring in a young decapitated animal, or in one whose brain had been removed, as signs of feeling, and I should have fallen into error.

I think that if the individual is disabled by its nature or otherwise from giving an account of a sensation which it experiences, and that if it only indicates by cries the pain which it is made to undergo, we have no certain sign for inferring that it receives sensation except from knowing that the system of organs which gives it the faculty of feeling is not destroyed, but retains its integrity. Muscular movements excited from without cannot in themselves prove an act of feeling.

Having fixed my ideas on these interesting objects, I gave attention to the *inner feeling*, that is to say, that feeling of existence which is possessed only by animals which enjoy the faculty of feeling. I brought to bear on the problem such known facts as are relevant, in addition to my own observations, and I soon became convinced that this inner feeling constituted a power which it was essential to take into consideration.

Nothing in fact seems to me so important as the feeling which I have named, considered both in man and in the animals which possess a nervous system capable of producing it. It is a feeling which can be aroused by physical and moral needs, and which becomes the source whence movements and actions derive their means of execution. No one that I know had paid any attention to it; and this gap in our knowledge of one of the most powerful causes of the principal phenomena of animal organisation rendered all explanations inadequate to account for these phenomena. We have, however, a sort of clue to the existence of that inner power when we speak of the agitations which we ourselves are constantly experiencing; for the word *emotion*, which I did not create, is often enough pronounced in conversation to express the observed facts.

When I had considered that the inner feeling was susceptible of being aroused by different causes, and that it then constituted a power capable of exciting actions, I was so to speak struck by the multitude of known facts which attest the actual existence of that power; the difficulties which had long puzzled me with regard to the exciting cause of actions appeared to me entirely surmounted.

Admitting that I had been fortunate enough to alight upon a truth in attributing to the inner feeling of animals which have it the power which produces their movements, I had still only surmounted a part of the difficulties by which this research is hampered. For it is obvious that not all known animals do or can possess a nervous system; consequently, all animals do not possess the inner feeling of which I am speaking; and in the case of those which are destitute of it, the movements which they are seen to execute must have another origin.

I had reached this point when I reflected that without internal excitations plant life would not exist at all, nor be able to maintain itself in activity. I recognised the fact that the same consideration applied to a large number of animals; and as I had very frequently observed that nature varies her means when necessary in order to attain the same end, I had no further doubt about the matter.

I think therefore that the very imperfect animals which have no nervous system live only by the help of excitations which they receive from the exterior. That is to say, subtle and ever moving fluids contained in the environment incessantly penetrate these organised bodies and maintain life in them, so long as the state of these bodies permits of it. Now this thought is one which I have many times considered, which many facts appear to me to confirm, against which none of those that are known to me seem to conflict, and finally which appears to me obviously borne out by plant life. It was therefore for me a flood of light which disclosed to me the principal cause which maintains movements and the life of organised bodies, and to which animals owe all that animates them.

I combined this consideration with the two preceding ones, namely, that which concerns the result of the movement of fluids in the interior of animals and that which deals with the effects of a change that is maintained in the environment and habits of these beings. I could thus seize the thread which connects the numerous causes of the phenomena presented in animal organisation, and I soon perceived the importance of this power in nature which preserves in new individuals all the changes in organisation acquired by their ancestors as a result of their life and environment.

Now I remarked that the movements of animals are never directly communicated, but that they are always excited; hence I recognised that nature, although obliged at first to borrow from the environment the *excitatory power* for vital movements and the actions of imperfect animals, was able by a further elaboration of the animal organisation to convey that power right into the interior of these beings, and that finally she reached the point of placing that same power at the disposal of the individual.

Such are the principal conclusions which I have endeavoured to establish and develop in this work.

This *Zoological Philosophy* thus sets forth the results of my studies on animals, their characters both general and special, their organisation, the causes of their development and diversity, and the faculties which they thence derive. In its composition I have made use of the bulk of the material which I was collecting for a projected work on living bodies under the title of *Biology*. This work will now remain, so far as I am concerned, unwritten.

The facts which I name are very numerous and definite, and the inferences which I have drawn from them appeared to me sound and necessary; I am convinced therefore that it will be found difficult to replace them by any others.

The number of new theories expounded in the present work are likely to give the reader an unfavourable impression, if only from the fact that the commonly received beliefs do not readily give way to any new ones which tend to contradict them. Now, since the predominance of old ideas over new favour this prejudice, especially when there is some contributory personal interest, it follows that, whatever difficulties there may be in the discovery of new truths in nature, there are still greater difficulties in getting them recognised.

But these difficulties, arising from various causes, are on the whole more advantageous than otherwise to the general progress of knowledge. By means of a rigorous hostility to the admission of new ideas as truths, a multitude of more or less specious but unfounded ideas which appear, soon after fall into oblivion. Sometimes, on the other hand, excellent opinions and solid thoughts are for the same reasons discarded or neglected; but it is better that a truth once perceived should have a long struggle before obtaining the attention it deserves, than that all that is produced by the ardent imagination of man should be too readily received.

The more I meditate on this subject, and particularly on the numerous causes which may bring about a change in our opinions, the more am I convinced, that except for the physical and moral facts[1] that no one can question, all else is but opinion or argument; and we well know that arguments can always be met by others. Thus, although it is obvious that there are great differences in the probability and even the value of the opinions of different men, it seems to me that we should be wrong to blame those who refuse to adopt our own.

Should we recognise as well founded only those opinions that are most widely accepted? Experience shows clearly enough that persons with the most developed intellect and the highest wisdom constitute at all times an extremely small minority. The fact can scarcely be questioned. Authorities in the sphere of knowledge should weigh one another's worth and not count one another's numbers, although indeed a true estimation is very difficult.

Seeing how numerous and rigorous are the conditions required for forming a sound judgment, it is still uncertain whether the judgment of individuals who have been set up as authorities by public opinion is perfectly sound on the topics on which they pronounce.

There are then few positive truths on which mankind can firmly rely. They include the facts which he can observe, and not the inferences that he draws from them; they include the existence of nature, which presents him with these facts, as also the laws which regulate the movements and changes of its parts. Beyond that all is uncertain, although some conclusions, theories, opinions, etc., have much greater probability than others.

We cannot rely on any argument, inference or theory, since the authors of these intellectual acts can never be certain that they have taken into account the true data, nor that they have admitted these

[1] By *moral* facts I mean mathematical truths; that is to say, the results of calculations whether of quantities or forces, and the results of measurements; since it is through intelligence and not through the senses that these facts become known to us. Now these *moral* facts are just as much positive truths as are those relating to the existence of bodies that we can observe.

only. There is nothing that we can be positive about, except the existence of bodies which affect our senses, and of the real qualities which belong to them, and finally the physical and moral facts of which we are able to acquire a knowledge. The thoughts, arguments and explanations set forth in the present work should therefore be looked upon merely as opinions which I propose, with the intention of setting forth what appears to me to be true, and what may indeed actually be true.

However this may be, in giving myself up to the observations from which my theories have arisen, I have obtained the pleasure which their resemblance to truth has brought me, and I have obtained also the recompense for the fatigues entailed upon me by my studies and meditations. In publishing these observations, together with the conclusions that I have drawn from them, my purpose is to invite enlightened men who love the study of nature to follow them out, verify them, and draw from them on their side whatever conclusions they think justified.

This path appears to me the only one that can lead to a knowledge of truth or of what comes nearest it, and it is clear that such knowledge is more profitable to us than the error which might fill its place. I cannot doubt therefore that it is this path which we must follow.

It may be noticed that I have dwelt with special pleasure on the exposition of the second and especially of the third part of this work, and that I have been greatly interested in them. None the less, the principles bearing on natural history which I have studied in the first part should be looked upon as possibly the most useful to science, since they are in general most in harmony with the opinions hitherto received.

I might have considerably extended this work by developing under each heading all the interesting matter that it permits of; but I have preferred to confine myself to such exposition as is strictly necessary for the adequate comprehension of my observations. I have thus spared my readers' time without exposing them to the risk of failing to understand me.

I shall have attained my end if those who love natural science find in this work any views and principles that are useful to them; if the observations which I have set forth, and which are my own, are confirmed or approved by those who have had occasion to study the same objects; and if the ideas which they succeed in giving rise to, whatever they may be, advance our knowledge or set us on the way to reach unknown truths.

PRELIMINARY DISCOURSE.

To observe nature, to study her productions in their general and special relationships, and finally to endeavour to grasp the order which she everywhere introduces, as well as her progress, her laws, and the infinitely varied means which she uses to give effect to that order: these are in my opinion the methods of acquiring the only positive knowledge that is open to us,—the only knowledge moreover which can be really useful to us. It is at the same time a means to the most delightful pleasures, and eminently suitable to indemnify us for the inevitable pains of life.

And in the observation of nature what can be more interesting than the study of animals? There is the question of the affinities of their organisation with that of man, there is the question of the power possessed by their habits, modes of life, climates and places of habitation, to modify their organs, functions and characters. There is the examination of the different systems of organisation which are to be observed among them, and which guide us in the determination of the greater or lesser relationships that fix the place of each in the scheme of nature. There is finally the general classification that we make of these animals from considerations of the greater or lesser complexity of their organisation; and this classification may even lead us to a knowledge of the order followed by nature in bringing the various species into existence.

Assuredly however, it cannot be disputed that all these enquiries, and others also to which the study of animals necessarily leads, are of very great interest to anyone who loves nature and seeks the truth in all things.

It is a peculiar circumstance that the most important phenomena for us to consider have only been available since the time when attention was devoted to the study of the least perfect animals, and since the researches on the various complications in the organisation of these animals became the main object of study.

It is no less curious that the most important discoveries of the laws, methods and progress of nature have nearly always sprung from the examination of the smallest objects which she contains, and from apparently the most insignificant enquiries. This truth, already established by many remarkable facts, will receive in the course of this work a new accession of evidence, and should convince us more than ever that in the study of nature no object whatever can be disregarded.

The purpose of the study of animals is not merely to ascertain their different races, nor to determine all the distinctions among them by specifying their special characters. This study further aims at acquiring a knowledge of the functions which animals possess, the causes of the presence and maintenance of life in them, and of the remarkable progression which they exhibit in the complexity of their organisation, as well as in the number and development of their functions.

At bottom, the *physical* and *moral* are without doubt one and the same thing. It is by a study of the organisation of the different orders of known animals that this truth can be set in the strongest light. Now since these products from a common origin, at first hardly separated, become eventually divided into two entirely distinct orders, these two orders when examined at their greatest divergence have seemed to us and still seem to many persons to have nothing in common.

The influence of the physical on the moral has however already been recognised,[1] but it seems to me that sufficient attention has not yet been given to the influence of the moral on the physical. Now these two orders of things which have a common origin re-act upon one another, especially when they appear the most widely separated; and we are now in a position to prove that each affects the variations of the other.

It seems to me that we have gone the wrong way to work in the endeavour to show the common origin of the two orders of results which, in their highest divergence, constitute what is called the *physical* and the *moral*.

For the study of these two kinds of objects, apparently so distinct, has been initiated in man himself. Now his organisation, having reached the limit of complexity and perfection, exhibits the greatest complication in the causes of the phenomena of life, feeling and function. It is consequently the most difficult from which to infer the origin of so many phenomena.

After the organisation of man had been so well studied, as was the case, it was a mistake to examine that organisation for the purposes of an enquiry into the causes of life, of physical and moral sensitiveness, and, in short, of the lofty functions which he possesses. It was first necessary to try to acquire knowledge of the organisation of the other animals. It was necessary to consider the differences which exist among them in this respect, as well as the relationships which are found between their special functions and the organisation with which they are endowed.

[1] See the interesting work of M. Cabanis entitled *Rapport du physique et du moral de l'homme.*

These different objects should have been compared with one another and with what is known of man. An examination should have been made of the progression which is disclosed in the complexity of organisation from the simplest animal up to man, where it is the most complex and perfect. The progression should also have been noted in the successive acquisition of the different special organs, and consequently of as many new functions as of new organs obtained. It might then have been perceived how *needs*, at first absent and afterwards gradually increasing in number, have brought about an inclination towards the actions appropriate to their satisfaction; how actions becoming habitual and energetic have occasioned the development of the organs which execute them; how the force which stimulates organic movements can in the most imperfect animals exist outside of them and yet animate them; how that force has been subsequently transported and fixed in the animal itself; and, finally, how it has become the source of sensibility, and last of all of acts of intelligence.

I may add that if this method had been followed, *feeling* would certainly not have been looked upon as the general and immediate cause of organic movements. It would never have been said that life is a consequence of movements executed by virtue of sensations received by various organs or otherwise; nor that all vital movements are brought about by impressions received by sensitive parts (*Rapport du physique et du moral de l'homme*, pp. 38 to 39, and 85).

This cause would appear to be justified up to a certain point in the most perfect animals, but if it held good with regard to all bodies which enjoy life, they would all possess the faculty of feeling. Now it could hardly be shown that this is the case in plants; it could hardly even be proved that it is the case in all known animals.

The supposition of such a general cause does not seem to me justified by the real methods of nature. When constituting life, she had no power to endow with that faculty the imperfect animals of the earlier classes of the animal kingdom.

With regard to living bodies, it is no longer possible to doubt that nature has done everything little by little and successively.

Hence, among the various subjects which I intend to discuss in the present work, I shall endeavour to make clear by the citation of recognised facts that nature, while ever increasing the complexity of animal organisation, has created in order the different special organs, as also the functions which the animals possess.

The belief has long been held that there exists a sort of scale or graduated chain among living bodies. Bonnet has developed this view; but he did not prove it by facts derived from their organisation; yet this was necessary especially with regard to animals. He was unable to prove it, since at the time when he lived the means did not exist.

In the study of all classes of animals there are many other things to be seen besides the animal complexity. Among the subjects of greatest importance in framing a rational philosophy are the effect of the environment in the creation of new needs; the effect of the needs in giving rise to actions, and of repeated actions in creating habits and inclinations; the results of increased or diminished use of any organ, and the means adopted by nature to maintain and to perfect all that has been acquired in organisation.

But this study of animals, especially of the least perfect animals, was long neglected; since no suspicion existed of the great interest which they exhibit. Moreover, what has been started in this respect is still so new that we may anticipate much more light from its further development.

When the study of natural history was actually begun, and naturalists inquired into both kingdoms, those who devoted their researches to the animal kingdom studied chiefly the vertebrate animals, that is to say *mammals*, *birds*, *reptiles* and, lastly, *fishes*. In these classes of animals the species are in general larger, and have their parts and functions better developed and more easily ascertainable than the species of invertebrate animals. Their study, therefore, seemed to present more of interest.

In fact the majority of invertebrate animals are extremely small, their functions are limited, and their organs much more remote from those of man than is the case of the more perfect animals. As a result, they have been to some extent despised by the vulgar, and down to our own time have only realised a very moderate amount of interest on the part of most naturalists.

We are beginning, however, to get over a prejudice so harmful to the progress of knowledge. During the few years that these singular animals have been closely examined, we have been compelled to recognise that the study of them is highly interesting to the naturalist and philosopher, because it sheds light, that could scarcely be otherwise obtained, on a number of problems in natural history and animal physics. It has been my duty in the Natural History Museum to

attend to the exhibit of the animals which I called *invertebrate*, on account of the absence in them of a vertebral column. My researches on these numerous animals, the accumulated observations and facts, and finally the increased knowledge of comparative anatomy which I gained from them, soon inspired me with the highest interest in the subject.

The study of *invertebrate animals* must, in fact, be of special interest to the naturalist for four reasons:—(1) The number of the species of these animals in nature is much greater than that of vertebrate animals. (2) Since they are more numerous, they are necessarily more varied. (3) The variations in their organisation are much greater, more sharply defined and more remarkable. (4) The order observed by nature in the successive formation of the different organs of animals is much better expressed in the mutations which these organs undergo in invertebrate animals. Moreover, their study is more fertile in helping us to understand the origin of organisation, with its complexity and its developments, than could possibly be the case in more perfect animals such as vertebrates.

Convinced of these truths I felt that, in the instruction of my pupils, I should not plunge into detail straight away, but should above all show them the general principles which hold good of all animals. I tried to give them a view of the whole and of the essentials which appertained to it, with the intention of taking subsequent note of the main groups into which that whole appears to be divided for purposes of comparison and more intimate knowledge.

The real way, no doubt, of acquiring a thorough knowledge of an object, even in its smallest details, is to begin by inspecting it in its entirety. We should examine first its bulk, extent, and the various parts which compose it. We should enquire into its nature and origin, and its connection with other known objects. In short, we should enquire into the general principles involved, from all possible points of view. The subject is then divided into its chief parts for separate study and examination in all the bearings likely to be instructive. By further dividing and sub-dividing these parts, and inspecting each successively, we arrive at the smallest, where we do not neglect the least details. Once these researches finished, the effects have to be deduced from them, so that little by little the philosophy of science is established, modified and perfected.

It is by this method alone that human intelligence can gain knowledge (in any science) that is at once vast, solid and coherent. It is solely by this kind of analysis that science makes real progress, so that allied objects are never confused, but can be perfectly known.

Unfortunately this method is not sufficiently used in the study of natural history. The recognised necessity for close observation of special objects has produced a habit of not going beyond these objects with their smallest details. They have thus become for most naturalists the chief subjects of study. This would, however, not really be a drawback for natural science, were it not for the steady refusal to see in the observed objects anything besides their form, dimensions, external parts, colour, etc., but those who give themselves up to such a study are contemptuous of the higher ideals, such as the enquiry into the nature of the objects which occupy them, into the causes of the modifications or variations which these objects undergo, and into the relations of these same objects with each other and with all other known objects, etc., etc.

It is because the method which I have just named is insufficiently followed out that we find so much divergence in what is taught on this subject, both in works on natural history and elsewhere. Those who have gone in exclusively for the study of species find it very difficult to grasp the general affinities among objects; they do not in the least appreciate nature's true plan, and they perceive hardly any of her laws.

I am convinced that it is wrong to follow a method which so greatly limits ideas. I find myself on the other hand obliged to bring out a new edition of my *Système des animaux sans vertèbres*, since the rapid progress of comparative anatomy and the new discoveries of zoologists, together with my own observations, enable me to improve that work. I have accordingly collected into a special work, under the title of *Zoological Philosophy*, (1) the general principles at stake in the study of the animal kingdom; (2) the observed facts which require to be considered in that study; (3) the principles which regulate the most suitable *classification* of animals, and an arrangement of them in their natural order; (4) lastly, the most important of the results which flow naturally from the accumulated observations and facts, and which constitute the true foundation of the *philosophy* of science.

The *Zoological Philosophy* is nothing but a new edition, re-cast, corrected and much enlarged, of my work entitled *Recherches sur les corps vivants*. It is divided into three main divisions, and each of these divisions is broken up into separate chapters.

Thus, in the first division, which sets forth the essential observed facts and the general principles of the natural sciences, I shall begin by a discussion of what I call *artificial devices* used among the sciences in question. I shall deal with the importance of the consideration of affinities, and with the notion that should be conveyed, when

we speak of *species* among living bodies. Afterwards, when I have treated of the general principles which concern animals, I shall adduce proof of the *degradation* of organisation which runs through the entire animal scale, placing the most perfect animals at the anterior extremity of that scale. On the other hand I shall show the influence of environment and habit on the organs of animals, as being the factors which favour or arrest their development. I shall conclude this division by a discussion of the *natural order* of animals, and by an account of their most suitable arrangement and classification.

In the second division I shall put forward my ideas as to the order and state of things which constitute the essence of animal life; and I shall indicate the conditions necessary for the existence of this wonderful natural phenomenon. Afterwards, I shall endeavour to ascertain the exciting cause of organic movements; of orgasm and of irritability; the properties of cellular tissue; the sole condition under which *spontaneous generation* can occur; the obvious effects of vital actions, etc.

Lastly, the third division will state my opinion as to the physical causes of feeling, of the power to act, and of the acts of the intelligence found in certain animals.

In this division I shall treat: 1st, the origin and formation of the nervous system; 2nd, the nervous fluid, which can only be known indirectly, but whose existence is attested by phenomena that it alone can produce; 3rd, physical sensibility and the mechanism of sensations; 4th, the reproductive power of animals; 5th, the origin of the will and the faculty of willing; 6th, ideas and the different kinds of them; 7th, lastly, certain peculiar acts of the understanding, such as attention, thoughts, imagination, memory, etc.

The reflections set forth in the 2nd and 3rd divisions doubtless comprise subjects that are very difficult to examine, and may even appear insoluble; but they are so full of interest that such attempts may possibly be profitable, either in the disclosure of unperceived truths or in pointing out the direction in which they may be sought.

PART I.

CONSIDERATIONS ON THE NATURAL HISTORY OF ANIMALS, THEIR CHARACTERS, AFFINITIES, ORGANISATION, CLASSIFICATION AND SPECIES.

CHAPTER I.

ON ARTIFICIAL DEVICES IN DEALING WITH THE PRODUCTIONS OF NATURE.

THROUGHOUT nature, wherever man strives to acquire knowledge he finds himself under the necessity of using special methods, 1st, to bring order among the infinitely numerous and varied objects which he has before him; 2nd, to distinguish, without danger of confusion, among this immense multitude of objects, either groups of those in which he is interested, or particular individuals among them; 3rd, to pass on to his fellows all that he has learnt, seen and thought on the subject. Now the methods which he uses for this purpose are what I call the *artificial devices* in natural science,—devices which we must beware of confusing with the laws and acts of nature herself.

It is not merely necessary to distinguish in natural science what belongs to artifice and what to nature. We have to distinguish as well two very different interests which incite us to the acquisition of knowledge.

The first is an interest which I call *economic*, because it derives its impetus from the economic and utilitarian needs of man in dealing with the productions of nature which he wants to turn to his own use. From this point of view he is only interested in what he thinks may be useful to him.

The other, very different from the first, is that *philosophic* interest through which we desire to know nature for her own sake, in order to grasp her procedure, her laws and operations, and to gain an idea of what she actually brings into existence. This, in short, is the kind of knowledge which constitutes the true naturalist. Those who approach the subject from this point of view are naturally few; they are interested impartially in all natural productions that they can observe.

To begin with, economic and utilitarian requirements resulted in the successive invention of the various *artificial devices* employed in natural science. When the interest of studying and knowing nature was first felt, these artificial devices continued to be of assistance in the prosecution of that study. These same artificial devices have therefore an indispensable utility, not only for helping us to a knowledge of special objects, but for facilitating study and the progress of natural science, and for enabling us to find our way about among the enormous quantity of different objects that we have to deal with.

Now the *philosophic interest* embodied by the sciences in question, although less widespread than that which relates to our economic requirements, compels us to separate what belongs to artifice from what is the sphere of nature. We have to confine within reasonable limits the consideration due to the first set of objects, and attach to the second all the importance that they deserve.

The artificial devices in natural science are as follows:

(1) Schematic classifications, both general and special.
(2) Classes.
(3) Orders.
(4) Families.
(5) Genera.
(6) The nomenclature of various groups of individual objects.

These six kinds of devices, commonly used in natural science, are purely artificial aids which we have to use in the arrangement and division of the various observed natural productions; to put us in the way of studying, comparing, recognising and citing them. Nature has made nothing of this kind: and instead of deceiving ourselves into confusing our works with hers, we should recognise that classes, orders, families, genera and nomenclatures are weapons of our own invention. We could not do without them, but we must use them with discretion and determine them in accordance with settled principles, in order to avoid arbitrary changes which destroy all the advantages they bestow.

It was no doubt indispensable to break up the productions of nature into groups, and to establish different kinds of divisions among them, such as classes, orders, families and genera. It was, moreover, necessary to fix what are called *species*, and to assign special names to these various sorts of objects. This is required on account of the limitations of our faculties; some such means are necessary for helping us to fix the knowledge which we gain from that prodigious multitude of natural bodies which we can observe in their infinite diversity.

But these groupings, of which several have been so happily drawn up by naturalists, are altogether artificial, as also are the divisions and sub-divisions which they present. Let me repeat that nothing

of the kind is to be found in nature, notwithstanding the justification which they appear to derive from certain apparently isolated portions of the natural series with which we are acquainted. We may, therefore, rest assured that among her productions nature has not really formed either classes, orders, families, genera or constant species, but only individuals who succeed one another and resemble those from which they sprung. Now these individuals belong to infinitely diversified races, which blend together every variety of form and degree of organisation; and this is maintained by each without variation, so long as no cause of change acts upon them.

Let us proceed to a few brief observations with respect to each of the six artificial devices employed in natural science.

Schematic classifications.—By schematic classifications, general or special, I mean any series of animals or plants that is drawn up unconformably to nature, that is to say, which does not represent either her entire order or some portion of it. It is consequently not based on a consideration of ascertained affinities.

The belief is now thoroughly justified that an order established by nature exists among her productions in each kingdom of living bodies: this is the order on which each of these bodies was originally formed.

This same order is individual and essentially without divisions in each organic kingdom. It becomes known to us through the affinities, special and general, existing among the different objects of which these two kingdoms consist. The living bodies at the two extremities of that order have essentially the fewest affinities, and exhibit the greatest possible differences in their organisation and structure.

It is this same order, as we come to know it, that will have to replace those schematic or artificial classifications that we have been forced to create in order to arrange conveniently the different natural bodies that we have observed.

With regard to the various organised bodies recognised by observation, there was at first no other thought beyond convenience and ease of distinction between these objects; and it has taken the longer to seek out the actual order of nature in their classification, inasmuch as there was not even a suspicion of the existence of such an order.

Hence arose groupings of every kind, artificial systems and methods, based upon considerations of such an arbitrary character that they underwent almost as many changes in their principles and nature as there were authors to work upon them.

With regard to plants, the *sexual system* of Linnæus, ingenious as it is, presents a general schematic classification: and, with regard to insects, the *entomology* of Fabricius presents a special schematic classification. All the progress made in recent times by the philosophy of natural science has been necessary, in France at least, to carry the conviction that the natural method should be studied. Our classifications should conform to the exact order found in nature, for that order is the only one which remains stable, independent of arbitrary opinion, and worthy of the attention of the naturalist.

Among plants, the natural method is extremely difficult to establish, on account of the obscurity prevailing in the character of the internal organisation of these living bodies, and of the differences presented by plants of different families. Since the learned observations of M. Antoine-Laurent de Jussieu, however, a great step has been made in botany in the direction of the natural method; many families have been constituted with direct reference to their affinities; but the general position of all these families among themselves, and consequently of the whole order, remains to be determined. The fact is that we have found the beginning of that order; but the middle, and especially the end, are still at the mercy of arbitrary opinion.

The case is different with regard to animals; their organisation is much more pronounced, and presents different systems that are easier to grasp. The work has, therefore, in their case made greater progress; as a result, the actual order of nature in the animal kingdom is now sketched out in its main outlines in a stable and satisfactory manner. It is only the boundaries of classes and their orders, of families and genera, that are still abandoned to arbitrary opinion.

If schematic classifications are still found among animals, these classifications are only minor, since they deal with objects belonging to one class. Thus, the hitherto received classifications of fishes and birds are still schematic classifications.

With regard to living bodies, the farther one descends from the general to the particular the less constant become the characters serving to determine affinities, and the more difficult to recognise is the actual order of nature.

Classes.—The name *class* is given to the highest kind of general divisions that are established in a kingdom. The further divisions of these receive other names: we shall speak of them directly. The more complete is our knowledge of the affinities between the objects composing a kingdom, the better and more natural are the classes established as the primary divisions of that kingdom, so long as attention has been paid to recognised affinities in forming them. Nevertheless, the boundaries of these classes, even the best of them, are clearly artificial; they will therefore continue to undergo arbitrary variations at the hands of authors so long as naturalists will not agree and submit themselves to certain general principles on the subject.

Thus, even though the order of nature in a kingdom should be thoroughly known, the classes which we are obliged to establish in it will always be fundamentally artificial divisions.

It is true, especially in the animal kingdom, that several of these divisions appear to be really marked out by nature herself; and it is certainly difficult to believe that mammals, birds, etc., are not sharply isolated classes formed by nature. This is none the less a pure illusion, and a consequence of the limitation of our knowledge of existing or past animals. The further we extend our observations the more proofs do we acquire that the boundaries of the classes, even apparently most isolated, are not unlikely to be effaced by our new discoveries. Already the *Ornithorhyncus* and the *Echidna* seem to indicate the existence of animals intermediate between birds and mammals. How greatly natural science would profit if the vast region of Australia and many others were better known to us!

If classes are the first kind of division that can be established in a kingdom, it follows that the divisions which can be established among the objects of one class cannot themselves be classes; for it is obviously inappropriate to set up class within class; that, however, is just what has been done: Brisson, in his *Ornithologie*, has divided the class of birds into various special classes.

Just as nature is everywhere governed by laws, so too artifice should be subjected to rules. If there are none, or if they are not followed, its products will be vacillating and its purpose fail.

Some modern naturalists have introduced the custom of dividing a class into several sub-classes, while others again have carried out the idea even with genera; so that they make up not only sub-classes but sub-genera as well. We shall soon reach not only sub-classes but sub-orders, sub-families, sub-genera and sub-species. Now this is a thoughtless misuse of artifice, for it destroys the hierarchy and simplicity of the divisions, which had been set up by Linnæus and generally adopted.

The diversity of the objects belonging to a class either of animals or plants is sometimes so great as to necessitate the formation of many divisions and sub-divisions among the objects of that class; but it is to the interest of science that artificial devices should always have the greatest possible simplicity. Now that interest allows, no doubt, of any divisions and sub-divisions that may be necessary; but it is opposed to each division having a special denomination. A stop must be put to the abuses of nomenclature; otherwise the nomenclature would become more difficult to understand than the objects themselves.

Orders.—The name order should be given to the main divisions of the first rank into which a class is broken up. If these divisions leave scope for the formation of others by further sub-division, these sub-divisions are no longer orders; and it would be very inappropriate to give them the name.

The class of molluscs, for example, are easily divided into two large main groups, one having a head, eyes, etc., and reproducing by copulation, while the other has no head, eyes, etc., and carry out no copulation to reproduce themselves. *Cephalic* and *acephalic* molluscs should be regarded as the two orders of that class; meanwhile, each of these orders can be broken up into several remarkable groups. Now this fact is no sufficient reason for giving the name order or even sub-order to each of the groups concerned. These groups, therefore, into which orders are divided should be regarded as sections or as large families, themselves susceptible of still further subdivisions.

Let us maintain in our artifical devices the great simplicity and beautiful hierarchy established by Linnæus. If we are under the necessity to make many sub-divisions of orders, that is to say, of the principle divisions of a class, by all means let us make as many as may be necessary, but do not let us assign to them any special denomination.

The orders into which a class is divided should be determined by the presence of important characters extending throughout the objects comprised in each order; but no special name should be assigned to them that is applicable to the objects themselves.

The same thing applies with regard to the sections that we have to form among the orders of one class.

Families.—The name family is given to recognised parts of the order of nature in either of the two kingdoms of living bodies. These parts of the natural order are, on the one hand, smaller than classes and even than orders, but, on the other hand, they are larger than genera. But however natural families may be and however well constituted their genera are according to their true affinities, the boundaries of these families are always artificial. The more indeed that the productions of nature are studied, and new ones observed, the greater the continual variations in the boundaries of families that are made by naturalists. Some divide one family into several new ones, others combine several families into one, while others again make additions to a family already known, increase it, and thus thrust back the boundaries which had been assigned to it.

If all the races (so-called *species*) belonging to a kingdom of living bodies were thoroughly known, as well as their true affinities, so that the sorting out of these races and their allocation in various groups were in conformity with their natural affinities, the classes, orders, sections and genera would be families of different sizes, for all these divisions would be larger or smaller parts of the natural order.

On such an assumption, nothing doubtless would be more difficult than to assign the boundaries between these different divisions; arbitrary opinion would produce incessant variation, and there would be no agreement except where gaps in the series made clear demarcations.

Fortunately for the practicability of the artifice which we have to introduce into our classifications, there are many races of animals and plants that are still unknown to us, and will probably remain so, since insuperable obstacles are placed in our way by the places where they live and other circumstances. The gaps thence arising in the series, whether of animals or plants, will leave us for a long time still, and perhaps for ever, the means of setting up the majority of the divisions.

Custom and indeed necessity require that a special name should be given to each family and to each genus so as to be applicable to the objects it contains. It follows that alterations in the boundaries, extent and determination of families will always cause a change in their nomenclature.

Genera.—The name of genus is given to combinations of races or so-called species that have been united on account of their affinities, and constitute a number of small series marked out by characters arbitrarily selected for the purpose.

When a genus is well made, all the races or species comprised in it resemble one another in their most essential and numerous characters. They differ only among themselves in characters less important, but sufficient to distinguish them.

Well made genera are thus really small families, that is to say, real parts of the actual order of nature.

Now we have seen that the series to which we give the name of family are liable to vary as to their boundaries and extent, according to the opinions of authors who arbitrarily change their guiding principles. In the same way the boundaries of genera are exposed to infinite variation because different authors change at will the characters employed to determine them. Now a special name has to be assigned to each genus; and every change in the constitution of a genus involves nearly always a change of name. It is difficult therefore to exaggerate the injury done to natural science by perpetual alterations of genera, which multiply synonymy, overburden nomenclature, and make the study of these sciences difficult and disagreeable.

When will naturalists agree to abide by general principles for uniform guidance in the constitution of genera, etc., etc.? The natural affinities, which they recognise among the objects which they have brought together, mislead them nearly all into the belief that their genera, families, orders and classes actually exist in nature. They do not notice that the good series which they succeed in forming by study of affinities do in truth exist in nature, for they are large or small parts of her order, but that the lines of demarcation which they are obliged to set up at intervals do not by any means so exist.

Consequently, genera, families, sections of various kinds, orders and even classes are in truth artificial devices, however natural may be the series which constitute these different groups. No doubt they are necessary and have an obvious and indispensable utility; but if the advantages, which these devices bring, are not to be cancelled by constant misuse, the constitution of every group must be in accordance with principles and rules that naturalists once for all have agreed to follow.

Nomenclature.—We come now to the sixth of the artificial devices which have to be employed in natural science. By nomenclature is meant the system of names assigned either to special objects, such as a race or a species, or to groups of these objects, such as a genus, family or class.

Now nomenclature is confined to the names given to species, genera, families and classes. It has therefore to be distinguished from that other artificial device called *technology*, which refers solely to the denominations applied to the parts of natural bodies.

"All the discoveries and observations of naturalists would necessarily have fallen into oblivion and been lost to society, if the objects observed and determined had not each received a name to serve as a recognition mark when speaking of them or quoting them." (*Dict. de Botanique*, art. "Nomenclature.")

It is quite clear that nomenclature in natural history is an artificial device, and is a means that we have to resort to for fixing our ideas in the sphere of natural observed productions, and to enable us to pass on either these ideas or our observations on the objects concerned.

No doubt this artificial device should like the others be controlled by settled rules that are generally adhered to; but I am bound to remark that its universal misuse, of which complaints are so justly made, arises principally from extrinsic causes which daily increase also in the other artificial devices already named.

In fact, lack of settled rules as to the formation of genera, families and even classes, exposes these artificial devices to all the vagaries of arbitrary judgment; nomenclature undergoes a continuous succession of changes. It never can be fixed so long as this lack of rules continues; and synonymy, already immense, will continue to grow and become more and more incapable of repairing a confusion which annihilates all the advantages of science.

This would never have happened if it had been recognised that all the lines of demarcation in the series of objects composing a kingdom of living bodies are really artificial, except those which result from gaps to be filled. But this was not perceived: there was not even a suspicion of it. Almost to the present day naturalists have had no further object in view than that of setting up distinctions. Here is evidence of what I mean:

"In fact, in order to procure and keep for ourselves the services of all natural bodies within our reach, that we can subordinate to our needs, it was felt that an exact and precise determination of the characters of each body was necessary, and consequently that the details of organisation, structure, form, proportion, etc., etc., should be sought out and determined, so that they could for all time be recognised and distinguished from one another. This is what naturalists are now doing up to a certain point.

"This part of the work of naturalists has made the most advance. Immense efforts have rightly been made for about a century and a half to perfect it, because it assists us to a knowledge of what has been newly observed, and serves as reminder of what was previously known. Moreover, it fixes our knowledge with regard to objects whose properties are or will hereafter become of use to us.

"But naturalists attach too much weight to forming lines of demarcation in the general series both of animals and plants; they devote themselves almost exclusively to this kind of work, without considering it under its true aspect or coming to any agreement as to the framing of settled rules in this great enterprise for fixing the principles of determination. Hence the intrusion of many abuses; for each one arbitrarily changes the principles for the formation of classes, orders and genera: and numerous different groupings are incessantly being set before the public. Genera undergo continual variation without limit, and the names given to nature's productions are constantly being changed as a result of this thoughtless proceeding.

"As a result, synonomy in natural history is now terribly widespread. Science every day becomes more obscure; she is surrounded by almost insurmountable difficulties; and the finest effort of man to set up the means of recognising and distinguishing the works of nature is changed into an immense maze, into which most men naturally hesitate to plunge." (*Discours d'ouvert. du cours de* 1806, pp. 5 and 6.)

Here we have a picture of the results of omitting to distinguish what really belongs to artifice from what is in nature, and of not having endeavoured to discover rules for the less arbitrary determination of the divisions which have to be established.

CHAPTER II.

IMPORTANCE OF THE CONSIDERATION OF AFFINITIES.

Among living bodies the name affinity has been given to features of analogy or resemblance between two objects, that are compared in their totality, but with special stress on the most essential parts. The closer and more extensive the resemblance, the greater the affinities. They indicate a sort of kinship between the living bodies which exhibit them; and oblige us in our classification to place these bodies in a proximity proportional to their affinities.

How great has been the progress of natural science since serious attention began to be given to affinities, and especially since their true underlying principles have been determined!

Before this change, our botanical classifications were entirely at the mercy of arbitrary opinion, and of artificial systems of any author. In the animal kingdom the invertebrate animals comprising the larger part of all known animals were classified into the most heterogeneous groups, some under the name of insects, some under the name of worms; where the animals included are from the point of view of affinity widely different from one another.

Happily this state of affairs is now changed; and, henceforth, if the study of natural history is continued, its progress is assured.

The principle of natural affinities removes all arbitrariness from our attempts at a methodical classification of organised bodies. We have here the law of nature which should guide us to the natural method. Naturalists are forced to agree as to the rank which they assign, firstly to the main groups of their classification, and afterwards to the individuals of which these groups are composed; finally, they are obliged to follow the actual order observed by nature in giving birth to her productions.

Thus, everything that concerns the affinities of the various animals should be the chief object of our researches, before making any division or classification among them.

The question of affinities does not apply only to species; for we have also to fix the general affinities of all the orders into which groups are united or divided from the comparative point of view.

Affinities, although possessing very different values according to the importance of the parts exhibiting them, can none the less be extended to the conformation of the external parts. If the affinities are so great that not only the essential parts, but also the external parts present no determinable difference, then the objects in question are only individuals of the same species. If on the other hand, notwithstanding a large degree of affinity, the external parts exhibit appreciable differences, though less than the essential resemblances; then the objects in question are different species of the same genus.

The important study of affinities is not limited to a comparison of classes, families, or even of species; it includes also a consideration of the parts of which individuals are composed. By comparison together of corresponding parts we obtain a firm basis for recognising either the identity of individuals of the same race or the difference between individuals of distinct races.

It has, in truth, been noted that the proportions and relations of the parts of all individuals composing a species or a race always remain the same, and so appear to be preserved forever. From this it has been rightly inferred that, by examining detached parts of an individual, one could decide to what species, old or new, these parts belong.

This power is very favourable to the progress of knowledge at the present time. But the conclusions drawn from it can only hold good for a limited period; since the races themselves undergo changes in their parts, in proportion to any considerable change in the circumstances which affect them. As a matter of fact, since these changes only take place with an extreme slowness, which makes them always imperceptible, the proportions and relations of the parts always appear the same to the observer, who does not really see them change. Hence, when he comes across any species which have undergone these changes, he imagines that the differences which he perceives have always existed.

It is none the less quite true that by a comparison of corresponding parts in different individuals, their affinities, nearer or more remote, can be easily and certainly determined. It can therefore be known whether these parts belong to individuals of the same race or of different races.

It is only the general inference that is unsound, having been drawn too hastily. This I shall have more than one opportunity of proving in the course of the present work.

Affinities are always incomplete when they apply only in an isolated case; that is to say, when they are decided from an examination of a single part taken by itself. But, although incomplete, the value of affinities based upon a single part depends upon the extent to which the part from which they are taken is essential, and *vice versa*.

There are then determinable differences among affinities, and various degrees of importance among the parts which display them; in fact, the knowledge of affinities would have had no application or utility unless the more important parts of living bodies had been distinguished from the less important, and unless a principle had been found for estimating the true values of these important parts.

The most important parts for exhibiting the chief affinities are, among animals, the parts essential to the maintenance of life, and among plants, the parts essential to reproduction.

In animals, therefore, it is always the internal organisation that will guide us in deciding the chief affinities. And in plants, it will be in the parts of fructification that affinities will be sought.

But in both cases the parts most important for seeking out affinities vary. The only principle to be used for determining the importance of any part, without arbitrary assumptions, consists in enquiring either how much use nature makes of it, or else the importance to the animal of the function of that part.

Among animals, whose affinities are mainly determined by their internal organisation, three kinds of special organs have rightly been chosen from among the others as the most suitable for disclosing the most important affinities. They are, in order of importance, as follows:

(1) *The organ of feeling.* The nerves which meet at a centre, either single as in animals with a brain, or multiple as in those with a ganglionic longitudinal cord.

(2) *The organ of respiration.* The lungs, gills and tracheae.

(3) *The organ of circulation.* The arteries and veins, which usually have a centre of action in the *heart.*

The first two of these organs are more widely used by nature, and therefore more important than the third, that is to say, the organ of circulation; for the latter disappears in the series after the crustaceans, while the two former extend to animals of the two classes which follow the crustaceans.

Finally, of the two first, the organ of feeling has the more importance from the point of view of affinities, for it has produced the most exalted of animal faculties, and moreover without that organ muscular activity could not take place.

If I were to refer to plants, among which the reproductive parts alone are of importance in deciding affinities, I should set forth these parts in their order of importance as follows:

(1) The embryo, its accessories (cotyledons, perisperm) and the seed which contains it.

(2) The sexual parts of flowers, such as the pistil and stamens.

(3) The envelopes of the sexual parts; the corolla, calyx, etc.

(4) The pericarp, or envelope of the seed.

(5) The reproductive bodies which do not require fertilisation.

These generally received principles give to natural science a coherence and solidity that it did not previously possess. Affinities are no longer at the mercy of changes of opinion; our general classifications become necessary inferences; and according as we perfect them by this method they approach ever more closely to the actual order of nature.

It was, in fact, due to the perception of the importance of affinities that the attempts of the last few years were originated to determine what is called the natural method; a method which is only a tracing by man of nature's procedure in bringing her productions into existence.

No importance is now attached in France to those artificial systems which ignore the natural affinities among objects; for these systems give rise to divisions and classifications harmful to the progress of natural knowledge.

With regard to animals, there is no longer any doubt that it is purely from their organisation that their natural affinities can be determined. It is, in consequence, chiefly from comparative anatomy that zoology will obtain the data for such determination. But we should pay more attention to the facts collected in the works of anatomists than to the inferences which they draw from them; for too often they hold views which might mislead us and prevent us from grasping the laws and true plan of nature. It seems to be the case that whenever man observes any new fact he is always condemned to rush headlong into error in attempting to explain it; so fertile is his imagination in the creation of ideas. He is not sufficiently careful to guide his judgment by the general principles derived from other facts and observations.

When we consider the natural affinities between objects, and make a sound estimate of them, we can combine species on this principle, and associate groups with definite boundaries forming what are called genera. Genera can be similarly associated on the principle of affinities, and united into higher groups forming what are called families. These families, associated in the same way and on the same principle, make up orders. These again are the primary divisions of classes, while classes are the chief divisions of each kingdom.

We must then be guided everywhere by natural affinities in composing the groups which result by dividing each kingdom into classes, each class into orders, each order into sections or families, each family into genera, and each genus into different species if there is occasion for it.

There is thorough justification for the belief that the complete series of beings making up a kingdom represents the actual order of nature, when it is classified with direct reference to affinities; but, as I have already pointed out, the different kinds of divisions which have to be set up in that series to help us to distinguish objects with greater ease do not belong to nature at all. They are truly artificial although they exhibit natural portions of the actual order instituted by nature.

It should be added that in the animal kingdom, affinities should be decided mainly from a study of organisation. The principles employed for settling these affinities should not admit of the smallest doubt. We shall thus obtain a solid basis for *zoological philosophy*.

It is known that every science must have its philosophy, and that it cannot make real progress in any other way. It is in vain that naturalists fill their time in describing new species, in grasping all the shades and small details of their varieties, in enlarging the immense list of catalogued species, in establishing genera, and in making incessant changes in the principles which they use. If the philosophy of science is neglected her progress will be unreal, and the entire work will remain imperfect.

It is indeed only since the attempt has been made to fix the extent of affinity between the productions of nature that natural science has obtained any coherence in its principles, and a philosophy to make it really a science.

What progress towards perfection is made every day in our classifications since they were founded upon the study of affinities!

It was through the study of affinities that I recognised that infusorian animals could no longer be put in the same class as polyps; that radiarians also should not be confused with polyps; and that soft creatures, such as medusae and neighbouring genera, which Linnæus and even Bruguière placed among the molluscs, were essentially allied to the echinoderms, and should form a special class with them.

It was again the study of affinities which convinced me that worms were a separate group, comprising animals very different from radiarians, and still more from polyps; that arachnids could no longer be classed with insects, and that cirrhipedes were neither annelids nor molluscs.

Finally, it was through the study of affinities that I succeeded in effecting a number of necessary alterations even in the classification of molluscs, and that I recognised that the pteropods, which are closely allied to but distinct from the gastropods, should not be placed between the gastropods and the cephalapods, but between the acephalic molluscs and the gastropods; since these pteropods, like all acephalic animals, have no eyes and are almost without a head, not even excepting *Hyalea*. (*V.* the special classification of molluscs in Chap. VIII., at the end of Part I.)

When the study of affinities among the different known families of plants has made us better acquainted with the rank held by each in the general series, then the classification of these living bodies will leave nothing more to arbitrary judgment, but will come more closely into conformity with the actual order of nature.

The study of the affinities among observed objects is thus clearly so important that it should now be regarded as the chief instrument for the progress of natural science.

CHAPTER III.

OF SPECIES AMONG LIVING BODIES AND THE IDEA THAT WE SHOULD ATTACH TO THAT WORD.

It is not a futile purpose to decide definitely what we mean by the so-called *species* among living bodies, and to enquire if it is true that species are of absolute constancy, as old as nature, and have all existed from the beginning just as we see them to-day; or if, as a result of changes in their environment, albeit extremely slow, they have not in course of time changed their characters and shape.

The solution of this question is of importance not only for our knowledge of zoology and botany, but also for the history of the world.

I shall show in one of the following chapters that every species has derived from the action of the environment in which it has long been placed the *habits* which we find in it. These habits have themselves influenced the parts of every individual in the species, to the extent of modifying those parts and bringing them into relation with the acquired habits. Let us first see what is meant by the name of species.

Any collection of like individuals which were produced by others similar to themselves is called a species.

This definition is exact; for every individual possessing life always resembles very closely those from which it sprang; but to this definition is added the allegation that the individuals composing a species never vary in their specific characters, and consequently that species have an absolute constancy in nature.

It is just this allegation that I propose to attack, since clear proofs drawn from observation show that it is ill-founded.

The almost universally received belief is that living bodies constitute species distinguished from one another by unchangeable characteristics, and that the existence of these species is as old as nature herself. This belief became established at a time when no sufficient observations had been taken, and when natural science was still almost negligible. It is continually being discredited for those who have seen much, who have long watched nature, and who have consulted with profit the rich collections of our museums.

Moreover, all those who are much occupied with the study of natural history, know that naturalists now find it extremely difficult to decide what objects should be regarded as species.

They are in fact not aware that species have really only a constancy relative to the duration of the conditions in which are placed the individuals composing it; nor that some of these individuals have varied, and constitute races which shade gradually into some other neighbouring species. Hence, naturalists come to arbitrary decisions about individuals observed in various countries and diverse conditions, sometimes calling them varieties and sometimes species. The work connected with the determination of species therefore becomes daily more defective, that is to say, more complicated and confused.

It has indeed long been observed that collections of individuals exist which resemble one another in their organisation and in the sum total of their parts, and which have kept in the same condition from generation to generation, ever since they have been known. So much so that there seemed a justification for regarding any collection of like individuals as constituting so many invariable species. Now attention was not paid to the fact that the individuals of the species perpetuate themselves without variation only so long as the conditions of their existence do not vary in essential particulars. Since existing prejudices harmonise well with these successive regenerations of like individuals, it has been imagined that every species is invariable and as old as nature, and that it was specially created by the Supreme Author of all existing things.

Doubtless, nothing exists but by the will of the Sublime Author of all things, but can we set rules for him in the execution of his will, or fix the routine for him to observe? Could not his infinite power create an *order of things* which gave existence successively to all that we see as well as to all that exists but that we do not see?

Assuredly, whatever his will may have been, the immensity of his power is always the same, and in whatever manner that supreme will may have asserted itself, nothing can diminish its grandeur.

I shall then respect the decrees of that infinite wisdom and confine myself to the sphere of a pure observer of nature. If I succeed in unravelling anything in her methods, I shall say without fear of error that it has pleased the Author of nature to endow her with that faculty and power.

The idea formed of species among living bodies was quite simple, easy to understand, and seemed confirmed by the constancy in the shapes of individuals, perpetuated by reproduction or generation. Such are a great number of these alleged species that we see every day.

Meanwhile, the farther we advance in our knowledge of the various organised bodies which cover almost every part of the earth's surface, the greater becomes our difficulty in determining what should be regarded as a species, and still more in finding the boundaries and distinctions of genera.

According as the productions of nature are collected and our museums grow richer, we see nearly all the gaps filled up and the lines of demarcation effaced. We find ourselves reduced to an arbitrary decision which sometimes leads us to take the smallest differences of varieties and erect them into what we call species, and sometimes leads us to describe as a variety of some species slightly differing individuals which others regard as constituting a separate species.

Let me repeat that the richer our collections grow, the more proofs do we find that everything is more or less merged into everything else, that noticeable differences disappear, and that nature usually leaves us nothing but minute, nay puerile, details on which to found our distinctions.

How many genera there are both among animals and plants, among which the number of species referred to them is so great that the study and determination of these species are well nigh impracticable! The species of these genera, arranged in series according to their natural affinities, exhibit such slight differences from those next them as to coalesce with them. These species merge more or less into one another, so that there is no means of stating the small differences that distinguish them.

It is only those who have long and diligently studied the question of species, and who have examined rich collections, that are in a position to know to what extent species among living bodies merge into one another. And no one else can know that species only appear to be isolated, because others are lacking which are close to them but have not yet been collected.

I do not mean that existing animals form a very simple series, regularly graded throughout; but I do mean that they form a branching series, irregularly graded and free from discontinuity, or at least once free from it. For it is alleged that there is now occasional discontinuity, owing to some species having been lost. It follows that the species terminating each branch of the general series are connected on one side at least with other neighbouring species which merge into them. This I am now able to prove by means of well-known facts.

I require no hypothesis or supposition; I call all observing naturalists to witness.

Not only many genera but entire orders, and sometimes even classes, furnish instances of almost complete portions of the series which I have just indicated.

When in these cases the species have been arranged in series, and are all properly placed according to their natural affinities, if you choose one, and then, jumping over several others, take another a little way off, these two species when compared will exhibit great differences. It is thus in the first instance that we began to see such of nature's productions as lay nearest to us. Generic and specific distinctions were then quite easy to establish; but now that our collections are very rich, if you follow the above-mentioned series from the first species chosen to the second, which is very different from it, you reach it by slow gradations without having observed any noticeable distinctions.

I ask, where is the experienced zoologist or botanist who is not convinced of the truth of what I state?

How great the difficulty now is of studying and satisfactorily deciding on species among that multitude of every kind of polyps, radiarians, worms, and especially insects, such as butterflies, *Phalaena*, *Noctua*, *Tinea*, flies, *Ichneumon*, *Curculio*, *Cerambix*, chafers, rose-chafers, etc.! These genera alone possess so many species which merge indefinably into one another.

What a swarm of mollusc shells are furnished by every country and every sea, eluding our means of distinction and draining our resources.

Consider again, fishes, reptiles, birds and even mammals; you will see that except for gaps still to be filled, neighbouring species and even genera are separated by the finest differences, so that we have scarcely any foothold for setting up sound distinctions.

Is there not an exactly similar state of affairs in the case of botany, which deals with the other series, consisting of plants?

How great indeed are the difficulties of the study and determination of species in the genera *Lichen*, *Fucus*, *Carex*, *Poa*, *Piper*, *Euphorbia*, *Erica*, *Hieracium*, *Solanum*, *Geranium*, *Mimosa*, etc., etc.

When these genera were constituted only a small number of species belonging to them were known, and it was then easy to distinguish them; but now that nearly all the gaps are filled, our specific differences are necessarily minute and usually inadequate.

Let us see what are the causes which have given rise to this undoubted state of affairs; let us see if nature affords any explanation, and whether observation can help us.

We learn from a number of facts that, according as the individuals of one of our species change their abode, climate, habits, or manner of life, they become subject to influences which little by little alter the consistency and proportions of their parts, their shape, properties and even their organisation; so that in course of time everything in them shares in these mutations.

In the same climate, very different habitats and conditions at first merely cause variations in the individuals exposed to them; but in course of time the continued change of habitat in the individuals of which I speak, living and reproducing in these new conditions, induces alterations in them which become more or less essential to their being; thus, after a long succession of generations these individuals, originally belonging to one species, become at length transformed into a new species distinct from the first.

Suppose, for example, that the seeds of a grass or any other plant that grows normally in a damp meadow, are somehow conveyed first to the slope of a neighbouring hill where the ground although higher is still rich enough to allow the plant to maintain its existence. Suppose that then, after living there and reproducing itself many times, it reaches little by little the dry and almost barren ground of a mountain side. If the plant succeeds in living there and perpetuating itself for a number of generations, it will have become so altered that botanists who come across it will erect it into a separate species.

The same thing happens in the case of animals that are forced by circumstances to change their climate, habits, and manner of life: but in their case more time is required to work any noticeable change than in the case of plants.

The idea of bringing together under the name of species a collection of like individuals, which perpetuate themselves unchanged by reproduction and are as old as nature, involved the assumption that the individuals of one species could not unite in reproductive acts with individuals of a different species.

Unfortunately, observation has proved and continues every day to prove that this assumption is unwarranted; for the hybrids so common among plants, and the copulations so often noticed between animals of very different species, disclose the fact that the boundaries between these alleged constant species are not so impassable as had been imagined.

It is true that often nothing results from these strange copulations, especially when the animals are very disparate; and when anything does happen the resulting individuals are usually infertile; but we also know that when there is less disparity these defects do not occur. Now this cause is by itself sufficient gradually to create varieties, which then become races, and in course of time constitute what we call species.

To assist us to a judgment as to whether the idea of species has any real foundation, let us revert to the principles already set forth; they show:

(1) That all the organised bodies of our earth are true productions of nature, wrought successively throughout long periods of time.

(2) That in her procedure, nature began and still begins by fashioning the simplest of organised bodies, and that it is these alone which she fashions immediately, that is to say, only the rudiments of organisation indicated in the term *spontaneous generation.*

(3) That, since the rudiments of the animal and plant were fashioned in suitable places and conditions, the properties of a commencing life and established organic movement necessarily caused a gradual development of the organs, and in course of time produced diversity in them as in the limbs.

(4) That the property of growth is inherent in every part of the organised body, from the earliest manifestations of life; and then gave rise to different kinds of multiplication and reproduction, so that the increase of complexity of organisation, and of the shape and variety of the parts, has been preserved.

(5) That with the help of time, of conditions that necessarily were favourable, of the changes successively undergone by every part of the earth's surface, and, finally, of the power of new conditions and habits to modify the organs of living bodies, all those which now exist have imperceptibly been fashioned such as we see them.

(6) That, finally, in this state of affairs every living body underwent greater or smaller changes in its organisation and its parts; so that what we call species were imperceptibly fashioned among them one after another and have only a relative constancy, and are not as old as nature.

But objections may be raised to the allegation that nature has little by little fashioned the various animals known to us by the aid of much time and an infinite variation of environment. It may be asked whether this allegation is not refuted by the single fact of the wonderful variety observed in the *instinct* of various animals, and in the marvellous *skill* of all kinds which they exhibit.

Will anyone, it may be asked, venture to carry his love of system so far as to say that nature has created single-handed that astonishing diversity of powers, artifice, cunning, foresight, patience and skill, of which we find so many examples among animals? Is not what we see in the single class of insects far more than enough to convince us that nature cannot herself produce so many wonders; and to compel the most obstinate philosopher to recognise that the will of the Supreme Author of all things must be here invoked, and could alone suffice for bringing into existence so many wonderful things?

No doubt he would be a bold man, or rather a complete lunatic, who should propose to set limits to the power of the first Author of all things; but for this very reason no one can venture to deny that this infinite power may have willed what nature herself shows us it has willed.

This being so, if I find that nature herself works all the wonders just mentioned; that she has created organisation, life and even feeling, that she has multiplied and diversified within unknown limits the organs and faculties of the organised bodies whose existence she subserves or propagates; that by the sole instrumentality of *needs*, establishing and controlling habits, she has created in animals the fountain of all their acts and all their faculties, from the simplest to instinct, to skill, and finally to reason; if I find all this, should I not recognise in this power of nature, that is to say in the order of existing things, the execution of the will of her Sublime Author, who was able to will that she should have this power?

Shall I admire the greatness of the power of this first cause of everything any the less if it has pleased him that things should be so, than if his will by separate acts had occupied itself and still continued to occupy itself with the details of all the special creations, variations, developments, destructions and renewals, in short, with all the mutations which take place at large among existing things?

Now I hope to prove that nature possesses the necessary powers and faculties for producing herself that so much excite our wonder.

The objection is still raised however that everything we see in living bodies indicates an unchangeable constancy in the preservation of their form. It is held that all animals whose history has come down to us for two or three thousand years have always been the same, and neither lost nor acquired anything in the perfection of their organs and the shape of their parts.

Not only had this apparent stability passed for an undoubted fact, but an attempt has recently been made to find special proofs of it in a report on the natural history collections brought from Egypt by M. Geoffroy. The authors of the report express themselves as follows:

"The collection has in the first place this peculiarity, that it may be said to contain animals of all periods. It has long been asked whether species change their shape in the course of time. This question, apparently so futile, is none the less necessary for the history of the world, and consequently for the solution of innumerable other questions which are not foreign to the gravest subjects of human worship.

"We have never been in so good a position to settle this question, in so far as concerns a large number of remarkable species and some thousands that are not remarkable. It appears as though the superstition of the ancient Egyptians were inspired by nature for the purpose of leaving a record of her history."

. . . .

"It is impossible," continue the authors of the report, "to control our flights of imagination, on seeing still preserved with its smallest bones and hair, perfectly recognisable, an animal which two or three thousand years ago had in Thebes or Memphis its priests and altars. But without giving rein to all the ideas suggested by this approach to antiquity, we shall confine ourselves to the announcement that this part of M. Geoffroy's collection shows that these animals are exactly similar to those of to-day." (*Annales du Muséum d'Hist. natur.*, vol. i. pp. 235 and 236.)

I do not refuse to believe in the close resemblance of these animals with individuals of the same species living to-day. Thus, the birds that were worshipped and embalmed by the Egyptians two or three thousand years ago are still exactly like those which now live in that country.

It would indeed be very odd if it were otherwise; for the position and climate of Egypt are still very nearly what they were in those times. Now the birds which live there, being still in the same conditions as they were formerly, could not possibly have been forced into a change of habits.

Furthermore, it is obvious that birds, since they can travel so easily and choose the places which suit them, are less liable than many other animals to suffer from variations in local conditions, and hence less hindered in their habits.

Indeed there is nothing in the observation now cited that is contrary to the principles which I have set forth on this subject; or which proves that the animals concerned have existed in nature for all time; it proves only that they inhabited Egypt two or three thousand years ago; and every man who has any habit of reflection and at the same time of observing the monuments of nature's antiquity will easily appreciate the import of a duration of two or three thousand years in comparison with it.

Hence we may be sure that this appearance of stability of the things in nature will by the vulgar always be taken for reality; because people in general judge everything with reference to themselves.

For the man who forms his judgment only with reference to the changes that he himself perceives, the eras of these mutations are stationary states which appear to him to be unlimited, on account of the shortness of the existence of individuals of his own species.

Moreover, we must remember that the records of his observations, and the notes of facts which he has been able to register, only extend back a few thousand years; which is a time infinitely great with reference to himself, but very small with reference to the time occupied by the great changes occurring on the surface of the earth. Everything seems to him to be *stable* in the planet which he inhabits; and he is led to repudiate the signs which exist everywhere in the monuments heaped up around him, or buried in the soil which he tramples underfoot.

Magnitudes are relative both in space and time: let man take that truth to heart, and he will then be more reserved in his judgments on the stability which he attributes to the state of things that he observes in nature. (See the Appendix, p. 141, of my *Recherches sur les corps vivants.*)

In order to admit the imperceptible changing of species, and the modifications which their individuals undergo according as they are forced to change their habits and contract new ones, we are not reduced to a mere consideration of the very short spaces of time comprised in our observations; for, in addition to this induction, a number of facts collected many years ago throw enough light on the question to free it from doubt; and I can now affirm that our observations are so far advanced that the solution sought for is patent.

Indeed not only do we know the results of anomalous fertilisations, but we also now know positively that a compulsory and sustained alteration in the habitats and manner of life of animals works after a sufficient time a very remarkable mutation in the individuals exposed to it.

Consider the animal which normally lives in freedom in plains where it habitually exerts itself by swift running; or the bird which is compelled by its needs to pass incessantly through large spaces in the air. When they find themselves imprisoned, the one in the dens of a menagerie or in our stables, the other in our cages or back yards, they undergo in course of time striking alterations, especially after a succession of generations in their new state.

The former loses a great part of his swiftness and agility; his body thickens, the strength and subtleness of his limbs diminish, and his faculties are no longer the same; the latter becomes heavy, can scarcely fly, and takes on more flesh in all his parts.

In Chapter VI. of this Part I., I shall have occasion to prove by well-known facts the power of changes of conditions for giving to animals new needs, and leading them on to new actions; the power of new actions when repeated to induce new habits and inclinations;

finally, the power resulting from the more or less frequent use of any organ to modify that organ either by strengthening, developing and increasing it, or by weakening, reducing, attenuating it, and even making it disappear.

With regard to plants, the same thing may be seen as a result of new conditions on their manner of life and the state of their parts; so that we shall no longer be astonished to see the considerable changes that we have brought about in those that we have long cultivated.

Thus, among living bodies, nature, as I have already said, definitely contains nothing but individuals which succeed one another by reproduction and spring from one another; but the species among them have only a relative constancy and are only invariable temporarily.

Nevertheless, to facilitate the study and knowledge of so many different bodies it is useful to give the name of species to any collection of like individuals perpetuated by reproduction without change, so long as their environment does not alter enough to cause variations in their habits, character and shape.

Of the Species Alleged to be Lost.

I am still doubtful whether the means adopted by nature to ensure the preservation of species or races have been so inadequate that entire races are now extinct or lost.

Yet the fossil remains that we find buried in the soil in so many different places show us the remains of a multitude of different animals which have existed, and among which are found only a very small number of which we now know any living analogues exactly alike.

Does this fact really furnish any grounds for inferring that the species which we find in the fossil state, and of which no living individual completely similar is known to us, no longer exist in nature? There are many parts of the earth's surface to which we have never penetrated, many others that men capable of observing have merely passed through, and many others again, like the various parts of the sea-bottom, in which we have few means of discovering the animals living there. The species that we do not know might well remain hidden in these various places.

If there really are lost species, it can doubtless only be among the large animals which live on the dry parts of the earth; where man exercises absolute sway, and has compassed the destruction of all the individuals of some species which he has not wished to preserve or domesticate. Hence arises the possibility that animals of the genera *Palaeotherium*, *Anoplotherium*, *Megalonix*, *Megatherium*, *Mastodon*, of M. Cuvier, and some other species of genera previously known, are no longer extant in nature: this however is nothing more than a possibility.

But animals living in the waters, especially the sea waters, and in addition all the races of small sizes living on the surface of the earth and breathing air, are protected from the destruction of their species by man. Their multiplication is so rapid and their means of evading pursuit or traps are so great, that there is no likelihood of his being able to destroy the entire species of any of these animals.

It is then only the large terrestrial animals that are liable to extermination by man. This extermination may actually have occurred; but its existence is not yet completely proved.

Nevertheless, among the fossil remains found of animals which existed in the past, there are a very large number belonging to animals of which no living and exactly similar analogue is known; and among these the majority belong to molluscs with shells, since it is only the shells of these animals which remain to us.

Now, if a quantity of these fossil shells exhibit differences which prevent us, in accordance with prevailing opinion, from regarding them as the representatives of similar species that we know, does it necessarily follow that these shells belong to species actually lost? Why, moreover, should they be lost, since man cannot have compassed their destruction? May it not be possible on the other hand, that the fossils in question belonged to species still existing, but which have changed since that time and become converted into the similar species that we now actually find. The following consideration, and our observations throughout this work, will give much probability to such an assumption.

Every qualified observer knows that nothing on the surface of the earth remains permanently in the same state. Everything in time undergoes various mutations, more or less rapid according to the nature of the objects and the conditions; elevated ground is constantly being denuded by the combined action of the sun, rain-waters and yet other causes; everything detached from it is carried to lower ground; the beds of streams, of rivers, even of seas change in shape and depth, and shift imperceptibly; in short, everything on the surface of the earth changes its situation, shape, nature and appearance, and even climates are not more stable.

Now I shall endeavour to show that variations in the environment induce changes in the needs, habits and mode of life of living beings, and especially of animals; and that these changes give rise to modifications or developments in their organs and the shape of their parts. If this is so, it is difficult to deny that the shape or external characters of every living body whatever must vary imperceptibly, although that variation only becomes perceptible after a considerable time.

Let us then no longer be astonished that among the numerous fossils found in all the dry parts of the world, and constituting the remains of so many animals which formerly existed, there are so few of which we recognise the living representatives.

What we should wonder at, on the contrary, is finding amongst these numerous fossil remains of once living bodies, any of which the still existing analogues are known to us. This fact, proved by our collections of fossils, suggests that the fossil remains of animals whose living analogues we know are the least ancient fossils. The species to which each of them belongs doubtless has not had time to undergo variation.

Naturalists who did not perceive the changes undergone by most animals in course of time tried to explain the facts connected with fossils, as well as the commotions known to have occurred in different parts of the earth's surface, by the supposition of a universal catastrophe which took place on our globe. They imagined that everything had been displaced by it, and that a great number of the species then existing had been destroyed.

Unfortunately this facile method of explaining the operations of nature, when we cannot see their causes, has no basis beyond the imagination which created it, and cannot be supported by proof.

Local catastrophes, it is true, such as those produced by earthquakes, volcanoes and other special causes are well known, and we can observe the disorder ensuing from them.

But why are we to assume without proof a universal catastrophe, when the better known procedure of nature suffices to account for all the facts which we can observe ?

Consider on the one hand that in all nature's works nothing is done abruptly, but that she acts everywhere slowly and by successive stages ; and on the other hand that the special or local causes of disorders, commotions, displacements, etc., can account for everything that we observe on the surface of the earth, while still remaining subject to nature's laws and general procedure. It will then be recognised that there is no necessity whatever to imagine that a universal catastrophe came to overthrow everything, and destroy a great part of nature's own works.

I have said enough on a subject which presents no difficulty. Let us now consider the general principles and essential characters of animals.

CHAPTER IV.

GENERAL PRINCIPLES CONCERNING ANIMALS.

ANIMALS in general are living beings with very curious properties, well calculated to astonish us and excite our study. These beings, infinitely varied in shape, organisation, and faculties, are capable of moving themselves or some of their parts without the impulse of any movement from without. Their irritability is due to an *exciting cause* which in some originates from within, while in others it comes entirely from without. Most of them possess the property of locomotion, and all have parts that are highly irritable.

We find that in their movements some crawl, walk, run or leap ; others fly, rising into the atmosphere and passing through wide spaces ; others again live in the waters and swim about there freely.

Animals are not, like plants, able to find close by within their reach the material on which they feed ; and the predatory animals are actually obliged to go forth and to hunt, chase and seize their prey. It was necessary therefore that they should have the power of motion and even of locomotion, in order to procure the food which they require.

Moreover, those among animals which multiply by sexual reproduction are not hermaphrodite enough to be sufficient to themselves. Hence it was farther necessary that they should be able to travel about for the purpose of effecting acts of fertilisation, and that the environment should provide facilities for it to those which, like oysters, cannot change their position.

Thus the needs of animals have endowed them with the property of moving parts of their bodies, and of carrying out locomotion which subserves their own survival and that of their races.

In Part II. we shall enquire into the origin of this extraordinary faculty, as of the other important faculties found among them ; but it suffices at present to draw attention to certain obvious points.

(1) Some only move themselves or their parts when their irritability has been stimulated; but they experience no feeling: these are the most imperfect animals;

(2) Others, in addition to the movements that their parts can undergo through stimulated irritability are capable of experiencing sensations, and possess a very vague inner feeling of their existence; but they only act by the internal impulse of an inclination which leads them towards some or other object; so that their will is always dependent and controlled;

(3) Others again not only exhibit in some of their parts movements resulting from their stimulated irritability; not only are they capable of receiving sensations, and possess an inner feeling of their existence, but they have besides the faculty of forming ideas, although confused ones, and of acting by a free will, subject however to inclinations which lead them exclusively towards certain special objects;

(4) Finally, others (and these are the most perfect) possess in a high degree all the aforementioned faculties; in addition they are able to form clear and precise ideas of the objects which affect their senses and attract their attention; to compare and combine their ideas up to a certain point; to form judgments and complex ideas; in short to think, and to have a will that is less bound down and permits them to introduce more or less variation into their activities.

Life in the most imperfect animals has no energy of movement; and irritability alone suffices for the execution of vital movements. But since vital energy increases in proportion to complexity of organisation, there arrives a time when nature has to improve her methods in order to provide for the necessary activity of vital movements; for this purpose she has utilised muscular activity in establishing the circulatory system, so that the fluids can move with greater rapidity. This rapidity itself is increased in proportion to the increase of the muscular power which works it. Finally, since no muscular activity can take place without nervous influence, this has become everywhere necessary for the acceleration of the fluids in question.

Thus nature has been able to add muscular activity and nervous influence to an irritability which was no longer adequate. But this nervous influence, which gives rise to muscular activity, never does so by means of feeling, as I hope to show in Part II. I shall then prove that sensibility is by no means necessary to the execution of vital movements, even in the most perfect animals.

The various animals which exist are thus clearly distinguished from one another, not only by peculiarities of external shape, consistency of body, size, etc., but, in addition, by the faculties which they possess. Some, such as the most imperfect, are extremely limited

in that respect, having no other faculty but those of life in general, and being unable to move except by a power outside them; while others have faculties, progressively more numerous and important, up to the most perfect animals, which exhibit a capacity calculated to excite our wonder.

These remarkable facts no longer surprise us, when we recognise that every faculty is based upon some special organ or system of organs, and when we observe that organisation gradually becomes more complex as we pass from the most imperfect animal, which has no special organ whatever and consequently no faculty but those of life in general, to the most perfect and richly endowed animal. Thus all the organs, even the most important, arise one after the other in the animal scale, and afterwards become successively more perfect through the modifications impressed on them, by which these organs come to harmonise with the state of organisation of which they are part. Hence, by their combination in the most perfect animals, they constitute the highest degree of organisation, giving rise to the most numerous and important faculties.

The examination of the internal organisation of animals; of the various systems presented by that organisation in the animal scale; and, finally, of the special organs, is then the subject of study most deserving of our attention.

If animals, considered as productions of nature, are rendered extremely remarkable by their faculty of locomotion, a great many of them are still more so by their faculty of feeling.

I have said that this faculty of locomotion is very limited in the most imperfect animals, among which it is not voluntary and is only carried out by external stimuli. It then becomes gradually more perfect and ultimately takes its source within the animal itself, and becomes at length subject to its will. In just the same way, the faculty of feeling is still very obscure and limited in the animals among which it begins to exist; but it then develops gradually, and when it has reached its highest development it ultimately gives rise in the animal to the faculties which constitute intelligence.

Indeed the most perfect among animals have simple and even complex ideas; they have passions and memory and they dream, that is to say, they experience involuntary recurrences of their ideas and even of their thoughts; and they are up to a certain point capable of learning. How wonderful is this result of the power of nature!

Nature thus succeeds in endowing a living body with the faculty of locomotion, without the impulse of an external force; of perceiving objects external to it; of forming ideas by comparison of impressions received from one object with those received from others; of comparing or combining these ideas, and of forming judgments which are merely ideas of another order; in short, of thinking. Not only is this the greatest marvel that the power of nature has attained, but it is besides a proof of the lapse of a considerable time; since nature has done nothing but by slow degrees.

As compared to the periods which we look upon as great in our ordinary calculations, an enormous time and wide variation in successive conditions must doubtless have been required to enable nature to bring the organisation of animals to that degree of complexity and development in which we see it at its perfection. If an inspection of the numerous diverse strata composing the external crust of the earth furnishes unimpeachable testimony of its great antiquity; if the very slow but continuous displacement of the sea-bottom,[1] certified by the numerous monuments left everywhere about, gives further confirmation of its prodigious antiquity; then the belief is justified that the state of perfection at which the organisation of the most perfect animals has arrived, contributes to exhibit that truth in the strongest possible light.

But in order that this new proof may be securely based, it will first be necessary to bring into evidence the facts concerning the actual progress of organisation; it will be necessary to verify if possible the reality of that progress; finally, it will be necessary to collect the best established facts and to identify nature's methods in bringing her productions into existence.

Meanwhile, let us note that although the term *productions of nature* is generally accepted for indicating the beings which constitute each kingdom, it seems none the less that no definite idea is attached to that expression. Apparently, prejudices of special origin prevent the recognition of the fact that nature possesses the faculty of herself bringing so many different beings into existence; of causing incessant though very slow variations in living races; and of maintaining everywhere the general order that we observe.

Let us leave aside all opinion whatever on these great subjects; and to avoid any error of imagination let us everywhere consult nature's own works.

In order to be able to bring under our attention the totality of existing animals, and to place these animals under an aspect easily understood, we must remember that all the natural productions that we can observe have long been divided by naturalists into three kingdoms, under the name of animal kingdom, vegetable kingdom and mineral kingdom. By this division, the existences comprised in each of these kingdoms are compared together under a common standard; although some have a very different origin from others.

[1] *Hydrogéologie*, p. 41 *et seq.*

For some time past I have found it more convenient to employ another primary division which is better calculated to give an idea of the beings dealt with. Thus, I distinguish the natural productions comprised in the three aforementioned kingdoms into two main branches:

1. Organised living bodies;
2. Crude bodies without life.

Living beings, such as animals and plants, constitute the first of these two branches of the productions of nature. They possess, as everyone knows, the faculties of alimentation, development, reproduction, and they are subject to death.

But what is not known so well, since the fashionable hypotheses do not permit of the belief, is that living bodies form for themselves their own substances and secretions, as a result of the activity and functions of their organs and of the mutations wrought in them by organic movements (*Hydrogéologie*, p. 112). What is still less known is that the exuviae of these living bodies give rise to all the composite matters, crude or inorganic, that are to be found in nature, matters of which the various kinds increase in course of time and according to the conditions, by reason of the disintegration which they imperceptibly undergo. For this disintegration simplifies them more and more, and after a long period leads to the complete separation of their constituent principles.

These are the various crude and lifeless matters, both solid and liquid, which compose the second branch of the productions of nature, and most of which are known under the name of *minerals*.

It may be said that an immense hiatus exists between crude matters and living bodies, and that this hiatus does not permit of a linear arrangement of these two kinds of bodies, nor of any attempt to unite them by a link, as has been vainly attempted.

All known living bodies are sharply divided into two special kingdoms, based on the essential differences which distinguish animals from plants; and in spite of what has been said I am convinced that these two kingdoms do not really merge into one another at any point, and consequently that there are no animal-plants, as implied by the word *zoophyte*, nor plant-animals.

Irritability in all or some of their parts is the most general characteristic of animals; it is more general than the faculty of voluntary movements and of feeling, more even than that of digestion. Now all plants, as I have elsewhere shown, are completely destitute of irritability, not even excepting the so-called sensitive plants nor those which move certain of their parts on being touched or brought into contact with the air.

It is known that irritability is a faculty essential to the parts or to certain parts of animals, and that it is never suspended or annihilated so long as the animal is alive and the part possessing it has suffered no injury. Its effect is seen in a contraction which takes place instantly throughout the irritable part on contact with a foreign body; a contraction which ends with its cause, and which is renewed whenever the part after relaxation is irritated by new contacts. Now nothing of this kind has ever been observed in any other part of plants.

When I touch the extended branches of the sensitive plant (*Mimosa pudica*), instead of a contraction I observe in the joints of the disturbed branches and petioles a relaxation, which permits these branches and petioles of the leaves to droop, and causes the leaflets themselves to sink down upon one another. When once that sinking has been produced it is useless to touch again the branches and leaves of this plant; no effect follows. A longish time is required, unless it is very hot, for the distension of the joints of the small branches and leaves of the sensitive plant; when all these parts will again be raised and spread out, ready to fall together once more upon a contact or slight shaking.

I cannot see in this phenomenon any relation to the irritability of animals. I reflected however that during growth, especially when it is hot, there are produced in plants many elastic fluids, part of which are incessantly being exhaled. Hence I conceived that in leguminous plants these elastic fluids might accumulate, especially in the joints of the leaves, before being dispelled, and that they might then distend these joints and keep the leaves or leaflets spread out.

In this case, the slow dissipation of the elastic fluids in question set up in leguminous plants by the approach of night; or the sudden dissipation of the same fluid set up in *Mimosa pudica* by a slight shaking, will give rise for leguminous plants in general to the phenomenon known under the name of sleep, and for the sensitive plant to that wrongly attributed to irritability.[1]

It follows from the observations which I shall set forth below, and from the inferences which I have drawn from them, that in general

[1] I have developed in another work (*Hist. Nat. des végétaux*, édition Déterville, vol. i. p. 202) other analogous phenomena observed in plants such as *Hedysarum girans*, *Dionaea muscipula*, the stamens of the flowers of *Berberis*, etc.; and I have shown that the curious movements observed in the parts of certain plants chiefly in hot weather are never the result of a real irritability essential to any of their fibres; but that they are sometimes hygrometric or pyrometric effects, sometimes the results of elastic relaxations which take place under certain circumstances, and sometimes of a swelling and drooping of parts by the local accumulations and more or less rapid dissipations of elastic and invisible fluids which are being exhaled.

it is not true that animals are sensitive creatures endowed without exception with the power of producing acts of will, and consequently with the faculty of voluntary locomotion. Hence the definition of animals hitherto given to distinguish them from plants is altogether unsuitable; in consequence, I have already proposed to substitute the following as more in harmony with the facts, and more suitable to characterise the beings which compose the two kingdoms of living bodies.

Definition of Animals.

Animals are organised living bodies, which have irritable parts at all times of their lives; which nearly all digest the food on which they live; and which move, some by acts of will, either free or dependent, and others by stimulated irritability.

Definition of Plants.

Plants are organised living bodies whose parts are never irritable, which do not digest or move either by will or true irritability.

We see from these definitions, which are much sounder and more accurate than those hitherto received, that animals are primarily distinguished from plants by the irritability which all or some of their parts possess, and by the movements that they can produce in these parts, or which are set up by external causes as a sequence of their irritability.

It would doubtless be wrong to agree to these new ideas merely on authority; but I think that every unprejudiced reader who takes into consideration the facts and observations which I shall set forth in the course of the present work will be unable to deny them preference over the ancient ones for which I am substituting them; since the latter are obviously contrary to all observation.

We shall terminate this general outlook upon animals by two somewhat curious considerations: one concerning the extreme multiplicity of animals on the surface of the earth and in the waters, the other concerning the means adopted by nature to ensure that their number shall never become injurious to the preservation of her productions and of the general order which should exist.

Of the two kingdoms of living bodies that comprising the animals appears much richer and more varied than the other: at the same time it exhibits more wonderful phenomena in its organisation.

The surface of the earth, the waters, and to some extent even the air are populated by an infinite multitude of diverse animals, the races of which are so varied and numerous that a large proportion of them will probably always evade our researches. This is rendered the more likely since the enormous extent of water, its depth in many places, and the prodigious fertility of nature in the smallest species will doubtless be for all time an almost insuperable obstacle to the progress of knowledge.

A single class of the invertebrate animals, such as insects for instance, equals the entire vegetable kingdom in the number and diversity of its contained objects. The class of polyps is apparently much more numerous still, but we shall never be able to flatter ourselves that we know all the animals which make it up.

As a result of the rapid multiplication of the small species, and particularly of the more imperfect animals, the multiplicity of individuals might have injurious effects upon the preservation of races, upon the progress made in perfection of organisation, in short, upon the general order, if nature had not taken precautions to restrain that multiplication within limits that can never be exceeded.

Animals eat each other, except those which live only on plants; but these are liable to be devoured by carnivorous animals.

We know that it is the stronger and the better equipped that eat the weaker, and that the larger species devour the smaller. Nevertheless, individuals rarely eat others of the same race as themselves; they make war on different races.

The multiplication of the small species of animals is so great, and the succession of generations is so rapid, that these small species would render the globe uninhabitable to any others, if nature had not set a limit to their prodigious multiplication. But since they serve as prey to a multitude of other animals, and since the duration of their life is very short and they are killed by any fall of temperature, their numbers are always maintained in the proper proportions for the preservation of their own and other races.

As to the larger and stronger animals, they might well become dominant and have bad effects upon the preservation of many other races if they could multiply in too large proportions; but their races devour one another, and they only multiply slowly and few at a time; and this maintains in their case also the kind of equilibrium that should exist.

Lastly, man alone, considered apart from all that is special to him, seems to be able to multiply indefinitely, for his intelligence and powers protect him from any limit of multiplication due to the voracity of any animal. He exercises a supremacy over them, so that instead of having to fear the larger and stronger races of animals, he is capable rather of extinguishing them, and he is continually keeping down their numbers.

But nature has given him numerous passions which unfortunately develop with his intelligence, and thus set up a great obstacle to the extreme multiplication of individuals of his species.

It seems, in fact, that man is himself responsible for continually keeping down the numbers of his kind; for I have no hesitation in saying that the earth will never be covered by the population that it might support; several of its habitable regions will always be sparsely populated in turns, although the period of these fluctuations are, so far as we are concerned, immeasurable.

By these wise precautions, everything is thus preserved in the established order; the continual changes and renewals which are observed in that order are kept within limits that they cannot pass; all the races of living bodies continue to exist in spite of their variations; none of the progress made towards perfection of organisation is lost; what appears to be disorder, confusion, anomaly, incessantly passes again into the general order, and even contributes to it; everywhere and always the will of the Sublime Author of nature and of everything that exists is invariably carried out.

Before devoting ourselves to showing the degradation and simplification existing in the organisation of animals, when we proceed according to custom from the most complex to the simplest, let us examine their true arrangement and classification, as well as the principles employed for this purpose. It will then be easier for us to recognise the proofs of the degradation in question.

CHAPTER V.

ON THE TRUE ARRANGEMENT AND CLASSIFICATION OF ANIMALS.

For the progress of zoological philosophy and the object that we have in view, it is necessary to enquire into the true arrangement and classification of animals; to consider how such an arrangement came about; to ascertain what principles should be observed in setting up that general arrangement; and, finally, to investigate what remains to be done in order to bring that arrangement into the closest harmony with the actual order of nature.

But in order that our studies may be profitable, we must first determine the essential aims of an arrangement and of a classification of animals; for these two aims are very different in nature.

The aim of a general arrangement of animals is not only to possess a convenient list for consulting, but it is more particularly to have an order in that list which represents as nearly as possible the actual order followed by nature in the production of animals; an order conspicuously indicated by the affinities which she has set between them.

The aim of a classification of animals, on the other hand, is to furnish points of rest for our imagination, by means of lines of demarcation drawn at intervals in the general series; so that we may be able more easily to identify each race already discovered, to grasp its affinities with other known animals, and to place newly discovered species in their proper position. This device makes up for our own shortcomings, facilitates our studies and our knowledge, and is absolutely necessary for us; but I have already shown that it is a produce of artifice, and that despite appearances it corresponds to nothing real in nature.

An accurate determination of affinities between objects will always begin by fixing in our general arrangements the place of the large groups or primary divisions; then that of the lesser groups, and lastly that of the species or special races that have been observed. Now here is the inestimable advantage accruing to science from a know-

ledge of affinities. Since these affinities are the actual work of nature, no naturalist will ever be able or indeed desire to alter the consequences of a recognised affinity. The general arrangement will thus become ever more perfect and less arbitrary, according as our knowledge of affinities becomes greater.

The case is different with classifications: that is to say, with the various lines of demarcation that we have to draw at intervals in the general list both of animals and plants. In truth, so long as there are gaps remaining to be filled in our list owing to many animals and plants not having yet been observed, we shall always find these lines of demarcation, which appear to be drawn by nature herself; but this illusion will vanish as our observations accumulate. Have we not already witnessed the effacement of a great number, at least in the smaller divisions, by reason of the numerous discoveries of naturalists during the last half century? Except for the lines of demarcation resulting from gaps to be filled, those which we shall always have to draw will be arbitrary and therefore changeable, so long as naturalists do not adopt some conventional principle for their guidance.

In the animal kingdom such a principle is that *every class should comprise animals distinguished by a special system of organisation.* The strict execution of this principle is quite easy, and attended only with minor inconveniences.

In short, although nature does not pass abruptly from one system of organisation to another, it is possible to draw boundaries between each system, in such a way that there is only a small number of animals near those boundaries and admitting of doubt as to their true class.

The other lines of demarcation which sub-divide classes are usually more difficult to establish, since they depend on less important characters; and for this reason are more arbitrary.

Before examining the true classification of animals, let me endeavour to show that the list of living bodies should form a series, at least as regards the main groups; and not a branching net-work.

Classes should form a Series in the Arrangement of Animals.

Man is condemned to exhaust all possible errors when he examines any set of facts before he recognises the truth. Thus it has been denied that the productions of nature in each kingdom of living bodies can really be arranged in a true series according to their affinities; and that there exists any scale in the general arrangement either of animals or plants.

Naturalists, for instance, have noticed that many species, certain genera and even some families appear to a certain extent isolated in their characters; and several have imagined that the affinities among living beings may be represented something after the manner of the different points of a compass. They regard the small well-marked series, called natural families, as being arranged in the form of a reticulation. This idea, which some modern writers think sublime, is clearly a mistake, and is certain to be dispelled when we have a deeper and wider knowledge of organisation; and especially when the distinction is recognised between what is due to the influence of environment and habits and what is due to the greater or less progress in the complexity or perfection of organisation.

Meanwhile I shall show that nature, by giving existence in the course of long periods of time to all the animals and plants, has really formed a true scale in each of these kingdoms as regards the increasing complexity of organisation; but that the gradations in this scale, which we are bound to recognise when we deal with objects according to their natural affinities, are only perceptible in the main groups of the general series, and not in the species or even in the genera. This fact arises from the extreme diversity of conditions in which the various races of animals and plants exist; for these conditions have no relation to the increasing complexity of organisation, as I shall show; but they produce anomalies or deviations in the external shape and characters which could not have been brought about solely by the growing complexity of organisation.

We have then only to prove that the series constituting the animal scale resides essentially in the arrangement of the main groups composing it, and not in that of species, nor always even of genera.

The series to which I have alluded can then only be made out among the larger groups; since each of these groups, constituting the classes and bigger families, comprises beings whose organisation is dependent on some special system of essential organs.

Thus each distinct group has its special system of essential organs; and it is these special systems which undergo a degradation as we pass from the most complex to the simplest. But each organ taken by itself does not proceed so regularly in its degradations: and less so in proportion to its lesser importance and greater susceptibility to modification by environment.

In fact, the organs that have little importance or are not essential to life are not always at the same stage of perfection or degradation; so that if we follow all the species of a class we shall see that some one organ of any species reaches its highest degree of perfection, while some other organ, which in that same species is quite undeveloped or imperfect, reaches in some other species a high state of perfection.

These irregularities in the perfection and degradation of inessential organs are found in those organs which are the most exposed to the influence of the environment; this influence involves similar irregularities in the shape and condition of the external parts, and gives rise to so great and singular a diversity of species that, instead of being arranged like the main groups in a single linear series as a regularly graduated scale, these species often constitute lateral ramifications around the groups to which they belong, and their extremities are in reality isolated points.

A much more powerful and lasting set of conditions is necessary to modify any internal system of organisation than to alter the external organs.

I observe, however, that in cases of necessity nature passes from one system to another without a break, if they are closely allied; it is indeed by this faculty that she succeeded in fashioning them all in turn, passing from the simplest to the most complex.

So true is it that she has this faculty, that she even passes from one system to another not merely in two different allied families but in one individual.

Those systems of organisation in which respiration is carried on by true lungs are nearer to the systems requiring gills than to those requiring tracheae; thus, nature not only passes from gills to lungs in allied classes and families, as is seen among fishes and reptiles, but she does so even during the existence of one individual: which possesses in turn first one and then the other system. It is known that the frog, in its imperfect condition of tadpole, breathes by gills; while in its more perfect condition of frog it breathes by lungs. But nowhere does nature pass from the system of tracheae to the pulmonary system.

It may then be truly said that in each kingdom of living bodies the groups are arranged in a single graduated series, in conformity with the increasing complexity of organisation and the affinities of the object. This series in the animal and vegetable kingdoms should contain the simplest and least organised of living bodies at its anterior extremity, and ends with those whose organisation and faculties are most perfect.

Such appears to be the true order of nature, and such indeed is the order clearly disclosed to us by the most careful observation and an extended study of all her modes of procedure.

We have seen the necessity of paying attention to the question of affinities, in drawing up our arrangements of the productions of nature; hence we are no longer able to arrange the general series in any way we like. Our knowledge of nature's methods continues to increase in proportion to our studies of the affinities between objects or various groups of objects; and this knowledge compels us to conform to her order.

The first result obtained from the use of affinities in placing the groups in a general scheme is that the two extremities of the order must be occupied by the most dissimilar beings, since they are the most distant from one another from the point of view of affinities, and consequently of organisation. Hence it follows that if one of the extremities of the order is occupied by the most perfect of living bodies, having the most complex organisation, the other extremity of the order must necessarily be occupied by the most imperfect of living bodies, namely, those whose organisation is the simplest.

In the general arrangement of known plants according to the natural methods, that is according to affinities, only one extremity is thoroughly known; and that is occupied by the cryptogams. If the other extremity is not determined with equal certainty, it is due to the fact that our knowledge of plant organisation is much less advanced than our knowledge of the organisation of a great number of known animals. Hence it follows that in the case of plants we have as yet no certain guide to the affinities between the large groups, as we have to those among genera and families.

The same difficulty does not exist in the case of animals, and both extremities of their general series are thus definitely fixed; for as long as importance is attached to the natural method, and hence to affinities, the mammals will of necessity occupy one extremity of the order, while the infusorians will be placed at the other.

For animals then, as well as for plants, there exists in nature an order arising, like the objects which it calls into existence, from powers conferred by the Supreme Author of all things. Nature is herself only the general and immutable order created everywhere by this Sublime Author; she is the sum total of the general and special laws to which that order is subject. By these powers, which she continues unchangeably to make use of, she has given and still continues to give existence to her productions; she is incessantly varying and renewing them, and thus maintains everywhere the entire order which results.

We were obliged to recognise this order of nature in each kingdom of living bodies; and we are already in possession of various parts of it, in our better constituted families and genera. We shall now see that in the animal kingdom it is established in its outlines in a way that leaves no scope for arbitrary opinion.

But the great number of divers animals that we have come to know, and the brilliant light shed by comparative anatomy on their organisation, now place it in our power definitely to draw up the general list of all known animals, and to assign definitely the rank of the main divisions that may be established in the series which they constitute. This it behoves us to recognise; it would indeed be difficult to dispute.

Let us now pass to the actual arrangement and classification of animals.

The True Arrangement and Classification of Animals.

Since the purpose and principles both of a general arrangement and of a classification of living animals were not at first perceived when these subjects were studied, the works of naturalists long suffered from this imperfection of our ideas. The same thing happened in the science of natural history as has happened in all others to which much attention was given, before any principles had been thought out to constitute a basis and to guide their labours.

Instead of subjecting the classification which had to be made in each kingdom of living bodies to an arrangement which should be quite unfettered, attention was entirely devoted to disposing objects in convenient classes, so that their arrangement was thus abandoned to arbitrary opinion.

The affinities among the larger groups in the vegetable kingdom, for example, were very difficult to grasp; and artificial systems were long made use of in botany. They facilitated the making of convenient classifications based upon arbitrary principles, so that every author drew up a new one according to his fancy. Thus the proper arrangement of plants according to the natural method was then always sacrificed. It is only since we have recognised the importance of the parts concerned with fruiting, and the greater importance of some than others that the general arrangement of plants began to make progress towards perfection.

As the case of animals is different, the general affinities which characterise the main groups are much easier to perceive: so that several of these groups were identified at the very beginning of the study of natural history.

Aristotle indeed divided animals primarily into two main divisions or, as he called it, two classes, viz.:

1. Animals that have blood:
   - Viviparous quadrupeds.
   - Oviparous quadrupeds.
   - Fishes.
   - Birds.
2. Animals that have no blood:
   - Molluscs.
   - Crustaceans.
   - Testaceans.
   - Insects.

This primary division of animals into two main groups was fairly good, but the character taken by Aristotle for discrimination was bad. That philosopher gave the name of *blood* to the chief fluid in animals which has a red colour. He imagined that all animals which he placed in his second class only possessed white or whitish fluids; and he thereupon regarded them as having no blood.

Such apparently was the first outline of a classification of animals; it is at any rate the oldest of which we have any knowledge. But this classification also furnishes the earliest example of an arrangement, though in the opposite direction from the order of nature; since we may notice in it a progression, though a very imperfect one, from the most complex to the simplest.

That erroneous direction has been generally followed ever since in the arrangement of animals; and this has clearly retarded our knowledge of nature's procedure.

Modern naturalists have endeavoured to improve upon Aristotle's division by giving to the animals in the first class the name of red-blooded animals, and to those in his second class that of white-blooded animals. It is now well known how defective is this character; since there are some invertebrate animals (many annelids) which have red blood.

In my opinion the essential fluids of animals do not deserve the name of blood, except when they circulate in arteries and veins; for the other fluids are so degraded, and the combination of their principles so imperfect, that it would be wrong to assimilate them to fluids which have a true circulation. One might as well attribute blood to a plant as to a radiarian or polyp.

In order to avoid ambiguity and hypothesis, I divided the entire known animal world in my first course of lectures at the Museum in the spring of 1794 (the year II. of the republic) into two perfectly distinct groups, viz.:

Animals that have vertebrae.
Animals without vertebrae.

I called the attention of my pupils to the fact that the vertebral column, among animals provided with it, indicates the possession of a more or less perfect skeleton and of a plan of organisation on the same plane; whereas its absence among other animals not only distinguishes them sharply from the first, but shows that their whole plan of organisation is very different from those of vertebrate animals.

From Aristotle to Linnæus nothing of note appeared with regard to the general arrangement of animals; but in the course of last century naturalists of the highest distinction made a large number of special observations on animals, and especially on many invertebrate animals. Some recorded their anatomy with greater or less fulness, while others gave an accurate and detailed history of the metamorphoses and habits of a great number of these animals; as a result of their valuable observations, we have become acquainted with many facts of the greatest importance.

At length Linnæus, a man of high genius and one of the greatest of naturalists, after having marshalled the facts and taught us the necessity for great accuracy in the determination of all kinds of characters, gave us the following classification for animals.

He divided known animals into six classes, based upon three stages or characters of organisation.

Classification of Animals, established by Linnæus.

Classes.	
I. Mammals. II. Birds.	*First Stage.* Heart with two ventricles: blood red and warm.
III. Amphibians (Reptiles). IV. Fishes.	*Second Stage.* Heart with one ventricle: blood red and cold.
V. Insects. VI. Worms.	*Third Stage.* A cold serum (in place of blood).

Except for the inversion displayed by this arrangement as by all others the four first divisions proposed are now definitely established, and will henceforth always obtain the assent of zoologists as to their position in the general series. For this we are primarily indebted to the illustrious Swedish naturalist.

The case is different with regard to the two final divisions of the arrangement in question; they are wrong and very badly disposed. Since they comprise the greater number of known animals of the most varied characters, they should be more numerous. Hence it has been necessary to re-constitute them and substitute others.

We have seen that Linnæus, and the naturalists who succeeded him, gave very little attention to the necessity for increasing the number of divisions among animals which have a cold serum in place of blood (invertebrate animals), and whose characters and organisation are so greatly varied. Hence they have divided these numerous animals into two classes only, viz. insects and worms; so that everything which was not regarded as an insect, that is to say all invertebrate animals that have not jointed legs, were referred without exception to the class of worms. They placed the class of insects after the fishes, and the worms after the insects. According to this arrangement of Linnæus, the worms constituted the final class of the animal kingdom.

These two classes are still maintained in the same order in all the editions of the *Systema Naturae* published subsequently to Linnæus. The essential vice of this arrangement, as regards the natural order of animals, is obvious; it cannot be denied that Linnæus's class of worms is a sort of chaos in which the most disparate objects are included. Yet the authority of that savant carried so much weight among naturalists, that no one dared to change this monstrous class of worms.

With a view to bringing about some useful reform in this respect, I suggested in my first course the following arrangement for invertebrate animals, which I divided not into two classes, but into five in the following order.

Arrangement of Invertebrate Animals set forth in my First Course.

1. Molluscs;
2. Insects;
3. Worms;
4. Echinoderms;
5. Polyps.

These classes were then identical with some of the orders which Bruguière had suggested in his arrangement of worms (which I did not adopt), and with the class of insects as defined by Linnæus.

The arrival of M. Cuvier in Paris however, towards the middle of the year III. (1795), drew the attention of zoologists to the organisation of animals. I then saw with much satisfaction the conclusive evidence which he produced in favour of the priority of rank accorded to molluscs over insects in the general series. This I had already impressed in my lessons; but it had not been favourably received by the naturalists of this capital.

The change which I had thus instituted, from a consciousness of the inadequacy of the prevailing arrangement of Linnæus, was thoroughly consolidated by M. Cuvier by the most definite facts, several of which, it is true, were already known but had not attracted our attention in Paris.

I took advantage of the light shed since his arrival by this savant over every section of zoology, and particularly over invertebrate animals which he called white-blooded animals. I then added in turn new classes to my arrangement; I was the first to establish them; but, as we shall see, such of those classes as were adopted were only adopted reluctantly.

The personal interests of authors are doubtless a matter of complete indifference to science, and also apparently to those who study it. Nevertheless, a knowledge of the history of the changes undergone during the last fifteen years by the classification of animals is not without its uses: the following are those which I have instituted.

First, I changed the name of my class of echinoderms to *radiarians*, in order to unite with them the jelly-fishes and neighbouring genera.

This class, notwithstanding its utility and inevitableness, has not yet been adopted by naturalists.

In my course in the year VII. (1799) I established the class of *crustaceans*. At that time M. Cuvier, in his *Tableau des animaux*, p. 451, still included crustaceans with insects; and although this class is essentially distinct, yet it was not till six or seven years later that a few naturalists consented to adopt it.

The following year, that is to say, in my course of the year VIII. (1800) I suggested the *arachnids* as a class by itself, easy and necessary to distinguish. From that time its characters have constituted a sure indication of an organisation peculiar to these animals; for it is impossible to believe that they arose from an organisation exactly similar to the insects. Insects undergo metamorphosis, propagate only once in the course of their life, and have only two antennae, two eyes with facets and six jointed legs; while the arachnids never undergo metamorphosis, and exhibit various characters besides which differentiate them from insects. This fact has since been partly confirmed by observation. Yet this class of arachnids is still not admitted into any other work than my own.

M. Cuvier had discovered the existence of arterial and venous vessels in various animals, which used to be confused under the name of worms with other animals of very different organisation. I immediately took this new fact into consideration for the improvement of my classification; and in my course in the year X. (1802) I established the class of *annelids*, placing them after the molluscs and before the crustaceans, as required by their organisation.

By giving a special name to this new class I was able to keep the old name of worms for the animals which have always borne it, and whose organisation was remote from the annelids. So I continued to place the worms after the insects, and to distinguish them from the radiarians and polyps with which they can never again be united.

My class of annelids, published in my lectures and in my *Recherches sur les corps vivants* (p. 24), was several years before being admitted by naturalists. For the last two years however this class has begun to gain recognition; but since it is held desirable to change the name of it and to call it by the name of worms, they do not know what to do with the worms properly so-called which have no nerves or circulatory system. In this difficulty they combine them with the class of polyps, although their organisation is very different.

These instances of perfection at first attained in a classification, then destroyed and subsequently re-established by the necessity of things, are not rare in natural science.

Linnæus in fact united several genera of plants which Tournefort had formerly distinguished as in the case of *Polygonum*, *Mimosa*, *Justicia*, *Convallaria*, and many others; and now botanists are re-establishing the genera which Linnæus had destroyed.

Finally last year (in my course of 1807) I established among invertebrate animals a new class—the tenth—that of *infusorians*; because after a careful examination of the characters of these imperfect animals, I was convinced that I had been wrong to place them with the polyps.

Thus, by continuing to collect facts from observation and from the rapid progress of comparative anatomy, I instituted successively the various classes which now compose my arrangement of invertebrate animals. These classes, to the number of ten, are arranged in order from the most complex to the simplest as usual, viz.:

Classes of Invertebrate Animals.

Molluscs.	Insects.
Cirrhipedes.	Worms.
Annelids.	Radiarians.
Crustaceans.	Polyps.
Arachnids.	Infusorians.

I shall show, when I come to deal with each of these classes, that they constitute necessary groups, since they are based upon a study of organisation; and that although races may, nay must, exist near the boundaries, half way between two classes, yet these groups are the best attainable by artifice. They will therefore have to be recognised, so long as the interest of science is our chief concern.

By adding to these ten classes into which the invertebrates are divided, the four classes of vertebrate animals identified and determined by Linnæus, we shall have a classification of all known animals into the following fourteen classes, set out once more in the opposite order to that of nature.

1. Mammals. 2. Birds. 3. Reptiles. 4. Fishes.	Vertebrate animals.
5. Molluscs. 6. Cirrhipedes. 7. Annelids. 8. Crustaceans. 9. Arachnids. 10. Insects. 11. Worms. 12. Radiarians. 13. Polyps. 14. Infusorians.	Invertebrate animals.

The above represents the true arrangement of animals, and also the classes established among them.

We now have to examine a very important problem, which appears never to have been fathomed nor discussed; but the solution of which is necessary; it is this:

All the classes, into which the animal kingdom is divided, necessarily form a series of groups arranged according to the increasing or decreasing complexity of their organisation. In drawing up this series, ought we to proceed from the most complex to the simplest, or from the simplest to the most complex?

We shall endeavour to give the solution of this problem in Chap. VIII. which concludes this part; but we must first examine a very remarkable fact, most worthy of our attention, which may lead us to a perception of nature's procedure, when bringing her diverse productions into existence. I refer to that remarkable degradation of organisation which is found on traversing the natural series of animals, starting from the most perfect or the most complex towards the simplest and most imperfect.

Although this degradation neither is nor can be finely graduated as I shall show, it so obviously and universally exists in the main groups, including even the variations, that it doubtless depends on some general law which it behoves us to discover and consequently to search for.

CHAPTER VI.

DEGRADATION AND SIMPLIFICATION OF ORGANISATION FROM ONE EXTREMITY TO THE OTHER OF THE ANIMAL CHAIN, PROCEEDING FROM THE MOST COMPLEX TO THE SIMPLEST.

AMONG the problems of interest for zoological philosophy, one of the most important is that which concerns the degradation and simplification observed in animal organisation on passing from one extreme to the other of the animal chain, from the most perfect animals to those whose organisations are the simplest.

Now the question arises whether this is a fact that can be established; for, if so, it will greatly enlighten us as to nature's plan and will set us on the way to discover some of her most important laws.

I here propose to prove that the fact in question is true, and that it is the result of a constant law of nature which always acts with uniformity; but that a certain special and easily recognised cause produces variations now and again in the results which that law achieves throughout the animal chain.

We must first recognise that the general series of animals arranged according to their natural affinities is a series of special groups which result from the different systems of organisation employed by nature; and that these groups are themselves arranged according to the decreasing complexity of organisation, so as to form a real chain.

We notice then that except for the anomalies, of which we shall ascertain the cause, there exists from one end to the other of this chain a striking degradation in the organisation of the animals composing it, and a proportionate diminution in the numbers of these animals' faculties. Thus if the most perfect animals are at one extremity of the chain, the opposite extremity will necessarily be occupied by the simplest and most imperfect animals found in nature.

This examination at length convinces us that all the special organs are progressively simplified from class to class, that they become altered, reduced and attenuated little by little, that they lose their

local concentration if they are of the first importance, and that finally they are completely and definitely extinguished before the opposite end of the chain is reached.

As a matter of fact, the degradation of which I speak is not always gradual and regular in its progress, for often some organ disappears or changes abruptly, and these changes sometimes involve it in peculiar shapes not related with any other by recognisable steps.

Often again some organ disappears and re-appears several times before it is definitely extinguished. But we shall see that this could not have been otherwise; for the factor which brings about the progressive complexity of organisation must have had varied effects, owing to its liability to modification by a certain other factor acting with great power. We shall however see that the degradation in question is none the less real and progressive, wherever its effects can be seen.

If the factor which is incessantly working towards complicating organisation were the only one which had any influence on the shape and organs of animals, the growing complexity of organisation would everywhere be very regular. But it is not; nature is forced to submit her works to the influence of their environment, and this environment everywhere produces variations in them. This is the special factor which occasionally produces in the course of the degradation that we are about to exemplify, the often curious deviations that may be observed in the progression.

We shall attempt to set forth in full both the progressive degradation of animal organisation and the cause of the anomalies in the progress of that degradation, in the course of the animal series.

It is obvious that, if nature had given existence to none but aquatic animals and if all these animals had always lived in the same climate, the same kind of water, the same depth, etc., etc., we should then no doubt have found a regular and even continuous gradation in the organisation of these animals.

But the power of nature is not confined within such limits.

It first has to be observed that even in the waters she has established considerable diversity of conditions: fresh-water, sea water, still or stagnant water, running water, the water of hot climates, of cold climates, and lastly shallow water and very deep water; these provide as many special conditions which each act differently on the animals living in them. Now the races of animals exposed to any of these conditions have undergone special influences from them and have been varied by them all the while that their complexity of organisation has been advancing.

After having produced aquatic animals of all ranks and having caused extensive variations in them by the different environments provided by the waters, nature led them little by little to the habit of living in the air, first by the water's edge and afterwards on all the dry parts of the globe. These animals have in course of time been profoundly altered by such novel conditions; which so greatly influenced their habits and organs that the regular gradation which they should have exhibited in complexity of organisation is often scarcely recognisable.

These results which I have long studied, and shall definitely prove, lead me to state the following zoological principle, the truth of which appears to me beyond question.

Progress in complexity of organisation exhibits anomalies here and there in the general series of animals, due to the influence of environment and of acquired habits.

An examination of these anomalies has led some to reject the obvious progress in complexity of animal organisation and to refuse to recognise the procedure of nature in the production of living bodies.

Nevertheless, in spite of the apparent digressions that I have just mentioned, the general plan of nature and the uniformity of her procedure, however much she varies her methods, are still quite easily distinguished. We have only to examine the general series of known animals and to consider it first in its totality and then in its larger groups; the most unequivocal proofs will then be perceived of the gradation which she has followed in complexity of organisation; a gradation which should never be lost sight of by reason of the aforementioned anomalies. Finally, it will be noticed that whenever there have been no extreme changes of conditions, that gradation is found to be perfectly regular in various portions of the general series to which we have given the name of families. This truth becomes still more striking in the study of species; for the more we observe, the more difficult, complicated and minute become our specific distinctions.

The gradation in complexity of animal organisation can no longer be called in doubt, when once we have given positive and detailed proof of what we have just stated. Now since we are taking the general series of animals in the opposite direction from nature's actual order when she brought them successively into existence, this gradation becomes for us a remarkable degradation which prevails from one end to the other of the animal chain, except for the gaps arising from objects which are not yet discovered and those which arise from anomalies caused by extreme environmental conditions.

Let us now cast an eye over the complexity and totality of the animal series, in order to establish positively the degradation of organisation from one extremity to the other; let us consider the facts presented and let us then pass rapidly in review the fourteen classes of which it is primarily composed.

The general arrangement of animals set forth above is unanimously accepted as a whole by zoologists: who dispute only as to the boundaries of certain classes. In examining it I notice a very obvious fact which would in itself be decisive for my purpose; it is as follows:

At one extremity of the series (that namely which we are accustomed to consider as the anterior) we find the animals that are most perfect from all points of view, and have the most complex organisation; while at the opposite extremity of the same series we find the most imperfect that exist in nature—those with the simplest organisation and to all appearances hardly endowed with animality.

This accepted fact, which indeed cannot be questioned, becomes the first proof of the degradation which I propose to establish; for it is a necessary condition of it.

Another fact brought forward by an examination of the general series of animals and furnishing a second proof of the degradation prevailing in their organisation from one extremity to the other of their chain, is the following:

The first four classes of the animal kingdom contain animals that are in general provided with a vertebral column, while the animals of all the other classes are absolutely destitute of it.

It is known that the vertebral column is the essential basis of the skeleton, which cannot exist without it; and that wherever there is a vertebral column there is a more or less complete and perfect skeleton.

It is also known that perfection of faculties is a proof of perfection of the organs on which they rest.

Now although man may be above his rank on account of the extreme superiority of his intelligence as compared with his organisation, he assuredly presents the type of the highest perfection that nature could attain to: hence the more an animal organisation approaches his, the more perfect it is.

Admitting this, I observe that the human body not only possesses a jointed skeleton but one that is above all others the most complete and perfect in all its parts. This skeleton stiffens his body, provides numerous points of attachment for his muscles and allows him an almost endless variation of movement.

Since the skeleton is a main feature in the plan of organisation of the human body, it is obvious that every animal possessed of a skeleton has a more perfect organisation than those without it.

Hence the invertebrate animals are more imperfect than the vertebrate animals; hence, too, if we place the most perfect animals at the head of the animal kingdom, the general series exhibits a real degradation in organisation; since after the first four classes all the animals of the following classes are without a skeleton and consequently have a less perfect organisation.

But this is not all: Degradation may be observed even among the vertebrates themselves; and we shall see finally that it is found also among the invertebrates. Hence this degradation follows from the fixed plan of nature, and is at the same time a result of our following her order in the inverse direction; for if we followed her actual order, if, that is to say, we passed along the general series of animals from the most imperfect to the most perfect, instead of a degradation in organisation we should find a growing complexity and we should see animal faculties successively increasing in number and perfection. In order to prove the universal existence of the alleged degradation, let us now rapidly run through the various classes of the animal kingdom.

MAMMALS.

Animals with mammae, four jointed limbs, and all the organs essential to the most perfect animals. Hair on certain parts of the body.

Mammals (*Mammalia,* Lin.) should obviously be at one extremity of the animal chain, viz. that which contains the most perfect animals and the richest in organisation and faculties; for among them alone are found those with the most developed intelligence.

If perfection of faculties is a proof of that of the organs they are based upon as I said above, all mammals (and they alone are truly viviparous) must have the most perfect organisation, since it is agreed that these animals have more intelligence, more faculties and a more perfect set of senses than any others; moreover their organisation approaches most nearly to that of man.

Their organisation exhibits a body whose parts are stiffened by a jointed skeleton, which is generally more complete in these animals than in the three other classes of vertebrates. Most of them have four articulated limbs appended to the skeleton; and all have a diaphragm between the chest and abdomen; a heart with two ventricles and two auricles; red warm blood; free lungs, enclosed within the chest, through which the blood passes before being driven to the other parts of the body; lastly, they are the only viviparous animals, for they are the only animals in which the foetus although enclosed within its membranes is always in communication with its mother and develops at the expense of her substance, and in which the young feed for some time after their birth on the milk of her mammae.

It is then the mammals that must occupy the first rank in the animal kingdom by virtue of their perfection of organisation and greatest number of faculties (*Recherches sur les corps vivants,* p. 15). After the mammals we no longer find a definitely viviparous reproduction, nor lungs limited by a diaphragm to the chest and receiving all the blood which has to be driven to the rest of the body, etc., etc.

Among the mammals themselves it is in truth not easy to distinguish what is really due to degradation from what is the effect of environment, manner of life and long-established habits.

Nevertheless, traces of the general degradation of organisation may be found even among them; for those whose limbs are adapted for grasping objects have a higher perfection than those whose limbs are adapted only for walking. It is among the former that man is placed in respect of his organisation. Now it is clear that since the organisation of man is the most perfect, it should be regarded as the standard for judging of the perfection or degradation of the other animal organisations.

Thus the three divisions, into which the class of mammals is unequally broken up, exhibit among themselves, as we shall see, a conspicuous degradation in the organisation of the animals they contain.

First division: unguiculate mammals; they have four limbs, flat or pointed claws at the end of their digits but not investing them. These limbs are in general adapted for grasping objects or at least for hooking on to them. It is among these that the animals with the most perfect organisation are found.

Second division: ungulate mammals; they have four limbs and the extremity of their digits is completely invested by a rounded horn called a hoof. Their feet serve no other purpose than that of walking or running on the ground, and cannot be employed either for climbing trees, or for grasping any object or prey, or for attacking and rending other animals. They feed exclusively on vegetable substances.

Third division: exungulate mammals; they have only two limbs and these limbs are very short, flat and shaped like fins. Their digits are invested by skin and have no claws or horn. Their organisation is the least perfect of all mammals. They have no pelvis, nor hind feet; they swallow without previous mastication; finally they habitually live in the water; but they come to the surface to breathe air. They have received the name of *cetaceans.*

Although the *amphibians* also live in the water, coming out of it occasionally to crawl upon the shore, they really belong to the first division in the natural order, and not to that which comprises the cetaceans.

Henceforth we have to distinguish the degradation of organisation which arises from the influence of environment and acquired habits, from that which results from the smaller progress in the perfection or complexity of organisation. We must be careful therefore about going into too much detail in this respect; because as I shall show the environment in which animals habitually live, their special habitats, the habits which circumstances have forced upon them, their manner of life, etc., have a great power to modify organs; so that the shapes of parts might be attributed to degradation when they are really due to other causes.

It is obvious for example that the amphibians and cetaceans must have greatly shortened limbs, since they live habitually in a dense medium where well-developed limbs would only impede their movements. It is obvious that the influence of the water alone must have made them such as they are, by interfering with the movements of very long limbs with solid internal parts; and that consequently these animals owe their general shape to the influence of the medium they inhabit. But with regard to that degradation which we are seeking among the mammals themselves, the amphibians must be far removed from the cetaceans because their organisation is much less degraded in its essential parts. Amphibians then have to be joined to the unguiculate mammals, while the cetaceans should form the last order of the class, as being the most imperfect mammals.

We now pass to the birds; but I must first note that there is no gradation between mammals and birds. There exists a gap to be filled, and no doubt nature has produced animals which practically fill this gap, and which must form a special class if they cannot be comprised either among the mammals or among the birds.

This fact has just been realised, by the recent discovery in Australia of two genera of animals, viz.:

Ornithorhyncus } Monotremes (Geoff.).
Echidna }

These animals are quadrupeds with no mammae, with no teeth inserted and no lips; and they have only one orifice for the genital organs, the excrements and the urine (a cloaca). Their body is covered with hair or bristles.

They are not mammals, for they have no mammae and are most likely oviparous.

They are not birds; for their lungs are not pierced through and they have no limbs shaped as wings.

Finally, they are not reptiles; for their heart with only two ventricles removes them from that category.

They belong then to a special class.

BIRDS.

Animals without mammae, with two feet and two arms shaped as wings; the body covered with feathers.

The second rank clearly belongs to the birds; for while we do not find among these animals so many faculties or so much intelligence as among the animals of the first rank, they are the only ones except the monotremes which have like mammals a heart with two ventricles and two auricles, warm blood, the cavity of the cranium completely filled by the brain, and the trunk always enclosed by ribs. They have, then, qualities common to mammals, but not found elsewhere; and consequently affinities with them that are not to be found in any animals of the posterior classes.

But the birds when compared with the mammals display an obvious degradation of organisation which has nothing to do with the influence of the environment. They are for instance naturally devoid of mammae, organs with which only animals of the highest rank are provided and which belong to a system of reproduction that is no longer found in the birds nor in any of the animals of subsequent ranks. In short they are essentially oviparous; for the system of truly viviparous animals, which is adapted to animals of the first rank, is not found in the second nor does it again re-appear. Their foetus is enclosed in an inorganic envelope (the egg-shell) and soon ceases communication with the mother and can develop without feeding on her substance.

The diaphragm, which among mammals completely separates somewhat obliquely the chest from the abdomen, here ceases to exist, or becomes very incomplete.

The vertebrae of the neck and tail are the only mobile parts in the vertebral column of birds. Since movements of the other vertebrae of that column are not necessary to the animal, they are not performed and they thus place no obstacle to the large development of the sternum which now makes such movement almost impossible.

The sternum of birds indeed gives attachment to the pectoral muscles, which have become very thick and strong by reason of their energetic and almost continuous movements. The sternum has thus become extremely large and carinate in the middle. This, however, is due to the habits of these animals and not to the general degradation that we are investigating. The truth of this is exemplified by the fact that the mammal called a bat has also a carinate sternum.

All the blood of birds passes through their lungs before reaching the other parts of the body. Thus they breathe exclusively by lungs like the animals of the first rank; and this is not the case with any known animal after them.

We now come to a very strange peculiarity which is connected with the environment of these animals. They live more than other vertebrates in the air, and are almost continually rising into it and passing through it in every direction. They have adopted a habit of swelling their lungs with air in order to increase their volume and make themselves lighter; and this habit has caused the organ to adhere to the sides of the chest so that the air within, being rarefied by the heat of the place, has had to pierce through the lung with its investing membranes and to penetrate every part of the body even to the inside of the great bones which are hollow, and to the quills of the large feathers.[1] It is, however, only in the lungs that the blood of birds undergoes the necessary influence of the air; for the air which penetrates to the other parts of the body has another use than that of respiration.

Thus the birds, which have been rightly placed after the mammals, exhibit an obvious degradation in their general organisation: not because their lung has a peculiarity not found among the former, for this is due like their feathers only to their acquired habit of launching themselves into the air; but because they no longer have the system of reproduction proper to the most perfect animals, but only that which characterises most of the animals of the posterior classes.

It is very difficult to ascertain among the birds themselves the degradation of organisation which we are now studying; our knowledge of their organisation is still too vague. Hence it has hitherto been a matter of convention which order should be placed at the head of this class and which at the end.

We may reflect however that aquatic birds (like the palmipeds), as also the waders and gallinaceans, have this advantage over all other birds that their young on coming out of the egg can walk and feed. We may pay special attention to the fact that among the palmipeds, the penguins and king-penguins, whose almost featherless wings are merely oars for swimming and of no use for flight,

[1] If it is true that in the case of birds the lungs are pierced through and the hair changed into feathers as a result of their habit of rising into the air, I may be asked why bats have not also feathers and pierced lungs. I reply that it seems to me probable that bats, which have a more perfect organisation than birds, and hence a complete diaphragm to impede the swelling of their lungs, have not been able to pierce them through nor to swell themselves out with air sufficiently for that fluid even by an effort to reach the skin and so to give to the horny matter of the hair the faculty of branching out into feathers. Among birds, in fact, air is introduced as far as the hair bulbs; changing their bases into quills and compelling this same hair to break up into feathers; an event which cannot occur in the bat, where the air does not penetrate beyond the lung.

thus approximate in some ways to the monotremes and cetaceans. We shall then recognise that the palmipeds, waders, and gallinaceans should constitute the first three orders of birds, and that the doves, passerines, birds of prey and climbers should form the last four orders of the class. Now, from what we know of the habits of the birds of these last four orders, we find that their young on coming out of the egg can neither walk nor feed by themselves.

On this principle the climbers are the last order of birds; moreover, they are the only ones which have two posterior digits and two anterior. This character, which they possess in common with the chameleon, appears to justify us in placing them near the reptiles.

REPTILES.

Animals with only one ventricle in the heart and still possessing a pulmonary respiration though incomplete. Their skin is smooth or provided with scales.

In the third rank are naturally and necessarily placed the reptiles; and they will furnish us with new and stronger proofs of the degradation of organisation from one extremity of the animal chain to the other, starting from the most perfect animals. In fact, their heart, which has only one ventricle, no longer displays that conformation which belongs essentially to animals of the first and second ranks, and their blood is cold, almost like that of the animals of the posterior ranks.

We find another proof of the degradation of the organisation of reptiles in their respiration. In the first place they are the last animals to breathe by true lungs; for after them we find no respiratory organ of this nature in any of the succeeding classes, as I shall endeavour to show when speaking of molluscs. Next, the lung has in their case usually very large chambers, proportionally less numerous, and is already much simplified. In many species this organ is absent in youth and is then replaced by gills, a respiratory organ which is never found in animals of the anterior ranks. Sometimes the two kinds of respiratory organs are present together in the same individual.

But the strongest proof of degradation in the respiration of reptiles is that only part of their blood passes through the lungs, while the rest reaches the parts of the body without having undergone the influence of respiration.

Finally, among reptiles the four limbs essential to the most perfect animals begin to be lost, and indeed many of them (nearly all the snakes) lack them altogether.

Independently of the degradation of organisation indicated by the shape of the heart, by the temperature of the blood which scarcely arises above the level of the environment, by the incomplete respiration and by the almost regular simplification of the lung, it is found that reptiles differ considerably among themselves; so that there are greater differences of organisation and external shape among the animals of the various orders of this class than among those of the two preceding classes. Some habitually live in the air, and of these, such as have no legs can only crawl; others live in the water or on its banks, sometimes withdrawing into the water and sometimes going into open places. There are some that are clothed in scales and others that have a naked skin. Lastly, although they all have a heart with one ventricle, in some there are two auricles, while in others there is only one. All these differences are due to environment, manner of life, etc.; conditions which doubtless act more strongly upon an organisation that is still remote from the goal to which nature is tending, than they could do on one more advanced towards perfection.

Reptiles are oviparous animals (including even those in which the eggs are hatched in the body of the mother); their skeleton is modified and usually very degraded; their respiration and circulation are less perfect than those of mammals and birds; and they all have a small brain which does not fill the cavity of the cranium. Hence they are less perfect than the animals of the two preceding classes, and in their turn confirm the fact that the degradation of organisation increases, according as we approach the most imperfect animals.

Within this class of animals themselves, independently of the modifications in their parts due to environment, we find in addition traces of the general degradation of organisation; for in the last of their orders (the batrachians) the individuals, when they are first born, breathe by gills.

If the absence of legs observed among snakes were regarded as a result of degradation, the ophidians ought to be the last order of reptiles; but it would be a mistake to suppose this. The fact is that snakes are animals which for purposes of concealment have adopted the habit of crawling directly on the ground, and their body has thus acquired a considerable length, out of proportion to its size. Now elongated legs would have impeded their efforts in crawling and concealing themselves; while very short legs, of which there could only be four since these animals are vertebrates, would have been incapable of moving their body. Thus the habits of these animals have caused the disappearance of their legs; although the batrachians,

which have legs, are more degraded in organisation and nearer to the fishes.

The proofs of the important principle which I am stating will be based upon positive facts; they will consequently always hold good in contact with the arguments that are brought against them.

FISHES.

Animals breathing by gills, with a smooth or scaly skin; the body provided with fins.

On following the course of that degradation undergone by organisation as a whole and of the diminution in the number of animal faculties, we see that the fishes must of necessity be placed in the fourth rank, that is, after the reptiles. Their organisation in fact is even less advanced towards perfection than is that of reptiles, and is consequently more remote from that of the most perfect animals.

It is true no doubt that their general shape, the absence of a constriction between the head and body to form a neck, and the various fins which for them take the place of limbs, are results of the influence of the dense medium they inhabit, and not of the degradation of organisation. But that degradation is none the less real and very great, as we may convince ourselves by an examination of their internal organs; so that we are forced to assign to fishes a lower rank than to reptiles.

We no longer find in them the respiratory organ of the most perfect animals; for they have no true lung, and in its place have only gills or vascular pectinate folds arranged on both sides of the neck or head, four altogether on each side. The water which these animals breathe goes in by the mouth, passes between the folds of the gills, and bathes the numerous vessels which run there. Now since the water is mixed with air or contains it in solution, that air although small in quantity acts upon the blood of the gills and there achieves the function of respiration. The water then issues through open holes on either side of the neck.

Note that this is the last time that the respired fluid enters by the animal's mouth in order to reach the organ of respiration.

These animals, like those of the posterior ranks, have no trachea or larynx or true voice (including even those called *grondeurs* [1]) or eyelids, etc. These organs and faculties are here lost and are not again found throughout the animal kingdom.

Yet the fishes are still part of the division of vertebrate animals;

[1] [The Grey Gurnard. H.E.]

but they are the last of them and they terminate the fifth stage of organisation, being in common with reptiles the only animals which have:

A vertebral column;
Nerves, terminating in a brain, which does not fill the cranium;
A heart with one ventricle;
Warm blood;
Lastly, a completely internal ear.

Fishes thus display an oviparous reproduction; a body without mammae, of a shape adapted for swimming; fins which are not all invariably analogous with the four limbs of the most perfect animals; a very incomplete skeleton curiously modified and rudimentary in the last animals of this class; only one ventricle in the heart and cold blood; gills instead of lungs; a very small brain; the sense of touch incapable of giving knowledge of the shapes of bodies; and apparently without any sense of smell, for odours are only conveyed by air. It is clear that these animals strongly confirm in their turn also the degradation of organisation that we have undertaken to follow throughout the animal kingdom.

We shall now see that fishes are primarily divided into what are called bony fishes, which are the most perfect of them, and cartilaginous fishes, which are the least perfect. These two facts confirm the degradation of organisation within the class itself; for among the cartilaginous fishes the softness and cartilaginous condition of the parts intended to stiffen their bodies and aid their movements indicate that it is among them that the skeleton ends or rather that nature has sketched its first rudiments.

By continually following the order of nature in the inverse direction, the eight last genera of this class should include the fishes whose branchial apertures have no operculum or membrane and are nothing but holes at the sides or under the throat; finally the lampreys and hag-fishes should terminate the class, for these fishes differ greatly from all others by the imperfection of their skeleton and in having a naked slimy body without lateral fins, etc.

Observations on the Vertebrates.

The vertebrate animals, although differing greatly from one another as regards their organs, appear to be all formed on a common plan of organisation. On passing from the fishes to the mammals, we find that this plan becomes more perfect from class to class and that it only reaches completion in the most perfect mammals; but we may also notice that this plan while approaching perfection has undergone numerous modifications, some of them very large, through the influence of the environment of the animals and of the habits which each

race has been forced to contract by the conditions in which it is placed.

Hence we see, on the one hand, that if vertebrates differ markedly from one another in their organisation, it is because nature only started to carry out her plan in their respect with the fishes; that she made further advances with the reptiles; that she carried it still nearer perfection with the birds, and that finally she only attained the end with the most perfect mammals.

On the other hand, we cannot fail to recognise that if the perfection of the plan of organisation of the vertebrates does not everywhere show a regular and even gradation from the most imperfect fishes to the most perfect mammals, the reason is that nature's work has often been modified, thwarted and even reversed by the influence exercised by very different and indeed conflicting conditions of life upon animals exposed to them throughout a long succession of generations.

Annihilation of the Vertebral Column.

On reaching this point in the animal scale the vertebral column becomes entirely annihilated. Since this column is the basis of every true skeleton, and since this bony framework is an important part of the organisation of the most perfect animals, it follows that all the invertebrate animals, which we are about to investigate in turn, must have an organisation still more degraded than that of the four classes that we have just passed in review. Henceforth, therefore, the supports for muscular activity will no longer reside in any internal parts.

Moreover, none of the invertebrate animals breathes by cellular lungs; none of them has any voice nor consequently any organ for this faculty; finally they mostly appear devoid of true blood, that is to say, of that fluid which in the vertebrate is essentially red, but which only owes its colour to the intensity of their animalisation, and proves especially a real circulation. How grave an abuse of words it would be to give the name of blood to the thin and colourless fluid which moves slowly through the cellular substance of the polyps! We might as well apply the name to the sap of plants.

Besides the vertebral column, we also lose here the iris which is characteristic of the eyes of the most perfect animals; for such of the invertebrates as have eyes have no distinct irises.

Kidneys in the same way are only found among the vertebrates, and fishes are the last animals where this organ is met with. Henceforward there is no more spinal cord, no more great sympathetic nerve.

A final very important observation is that among vertebrates, and especially in the neighbourhood of that extremity of the animal scale where the most perfect animals are found, all the essential organs are isolated or have each an isolated seat in as many special places. We shall soon see that the complete contrary holds good according as we approach the other extremity of the scale.

It is then obvious that all the invertebrate animals have a less perfect organisation than any of those which possess a vertebral column; while the organisation of mammals is that which from all aspects includes the most perfect animals and is beyond question the true type of the highest perfection.

Let us now enquire whether the classes and large families into which the long series of invertebrate animals is divided also exhibit, when we compare them together, an increasing degradation in the complexity and perfection of their organisation.

INVERTEBRATE ANIMALS.

On reaching invertebrate animals we enter upon an immense series of diverse creatures, the most numerous of any existing in nature, the most curious and interesting with regard to the variations observed in their organisation and faculties.

On observing their condition, we are convinced that in bringing them successively into existence, nature has proceeded gradually from the simplest to the most complex. Now since the purpose in view has been to attain a plan of organisation which should admit of the highest perfection (that of the vertebrates)—a plan very different from those which nature had hitherto used to reach this point—we may be sure that among these numerous animals we shall not meet with a single system of organisation progressively perfected, but with various quite distinct systems, each one taking its start at the point where each organ of highest importance began to exist.

For instance, when nature attained to the creation of a special organ for digestion (as in the polyps) she then gave for the first time a special constant shape to the animals provided with it; seeing that the infusorians with which she began everything could not possess either the faculty endowed by this organ, or the kind of shape and organisation favourable to its functions.

She subsequently established a special organ for respiration, and in proportion as she varied this organ in order to perfect it and to accommodate it to the animal's environment, she diversified their organisation, in so far as the existence and development of the other special organs rendered it necessary.

When afterwards she succeeded in producing the nervous system, it then immediately became possible to create the muscular system. Thereupon, fixed points for the attachments of the muscles became necessary, and also paired parts so as to constitute a symmetrical shape. Hence have resulted various schemes of organisation due to the environment and to the parts acquired, which could not previously have come about.

When finally she secured sufficient movement in the contained fluids of the animal to permit a circulation to be organised, there again resulted important peculiarities of organisation which distinguished it from the organic systems in which there is no circulation.

In order to perceive the truth of what I have stated and to furnish evidence of the degradation and simplification of organisation (since we are following the order of nature in the inverse direction) let us rapidly run through the various classes of invertebrate animals.

MOLLUSCS.

Soft unjointed animals which breathe by gills and have a mantle. No ganglionic longitudinal cord; no spinal cord.

The fifth rank, as we descend the graduated scale of the animal series, necessarily belongs to the molluscs; for they have to be placed a stage lower than the fishes since they have no vertebral column, but they are yet the most highly organised of invertebrate animals. They breathe by gills, which vary greatly not only in their shape and size, but in their position within or without the animal according to the genera, and the habits of the races comprised in these genera. They all have a brain; nerves without nodes, that is to say, without a row of ganglia stretching down a longitudinal cord. They have arteries and veins and one or several single-chambered hearts. They are the only known animals which, although possessing a nervous system, have neither a spinal cord, nor a ganglionic longitudinal cord.

Gills, which are essentially intended by nature to carry out respiration during immersion in the water, have been subjected to modification both in function and shape in those aquatic animals which have been constantly exposed for generations to contact with the air, and even in some cases have stayed in it altogether.

The respiratory organ of these animals has imperceptibly become accustomed to the air; and this is no mere supposition: for it is known that all the crustaceans have gills and yet there are crabs (*Cancer* *ruricola*) which habitually live on land and breathe air quite naturally with their gills. Eventually this habit of breathing air with gills became a necessity to many molluscs which acquired it: it even modified the organ in such a way that the gills of these animals, having no further need for so many points of contact with the respired fluid, became adherent to the walls of the cavity which contains them.

As a result we may distinguish among molluscs two kinds of gills.

The first kind consist of networks of vessels running through the skin of an internal cavity which is not protruded and can only breathe air: these may be called aerial gills.

The second kind are organs nearly always protruded either within or without the animal and forming fringes or pectinate lamellae or edgings, etc.: these can only achieve respiration by means of the contact of fluid water, and may be called aquatic gills.

If the differences in the habits of animals produce differences in their organs, it will be useful in describing the special characters of certain orders of molluscs to distinguish those which have aerial gills from those whose gills can only breathe water; but in any case they are always gills and it appears to us quite improper to say that the molluscs which breathe air possess a lung. How often the abuse of words and wrong applications of names have served to distort objects and lead us into error!

After all, is the difference so great between the respiratory organ of *Pneumoderma*, which consists in a vascular network running over an external skin, and the vascular network of snails, which runs over an internal skin? Yet *Pneumoderma* appears to breathe nothing but water.

Let us further enquire for a moment if there are any affinities between the respiratory organ of air-breathing molluscs and the lung of vertebrates.

A lung is essentially a peculiar spongy mass composed of more or less numerous cells into which air is always entering in nature. The entrance is effected through the animal's mouth and thence by a more or less cartilaginous canal called the trachea, which usually sub-divides into branches known as bronchi, culminating in the cells. The cells and bronchi are alternately filled and emptied of air by successive swellings and shrinkings of the cavity of the body containing the mass; so that distinct alternate inspirations and expirations are characteristic of a lung. This organ can only tolerate the contact of air and is highly irritated by water or any other material. It is therefore different in character from the branchial cavity of certain

molluscs, which is quite peculiar, exhibits no alternate swelling and shrinking, never has a trachea or bronchi and in which the respired fluid never enters by the animal's mouth.

A respiratory cavity which has neither trachea nor bronchi nor alternate swelling and shrinking, and in which the respired fluid does not enter by the mouth, and which is adapted either for air or water, cannot be a lung. To confuse such different things by the same name is not to advance science but to retard it.

The lung is the only respiratory organ that can give the animal the faculty of having a voice. After the reptiles no animal has a lung; nor therefore a voice.

I conclude that it is not true that there are molluscs which breathe by lungs. If some in nature breathe air, so also do certain crustaceans and all insects; but none of these animals has true lungs, unless the same name is to be given to very different objects.

The molluscs also furnish proof of the progressive degradation that we are investigating in the animal chain; for their general organisation is less perfect than that of fishes. But it is not so easy to recognise the same degradation among the molluscs themselves; for it is difficult to distinguish in so numerous and varied a class what is due to the degradation in question, from what is caused by the environment and habits of these animals.

The only two orders into which the large class of molluscs is divided, are strongly contrasted by the importance of their distinctive characters. The animals of the first of these orders (cephalic molluscs) have a very distinct head, eyes, jaws or a proboscis and reproduce by copulation.

All the molluscs of the second order (acephalic molluscs) on the contrary are destitute of a head, eyes, jaws, proboscis; and they never copulate for the purpose of reproduction.

Now it can hardly be denied that the second order of molluscs is inferior to the first as regards perfection of organisation.

It is important, however, to remember that the absence of head, eyes, etc., in the acephalic molluscs is not wholly due to the general degradation of organisation, since we find again at lower stages of the animal chain, animals which have a head, eyes, etc. We have here again apparently one of those deviations in the progress of perfection of organisation that are produced by environment, and consequently by causes foreign to those which make for a gradual increase of complexity in animal organisation.

When we come to consider the influence of the use of organs and of an absolute and permanent disuse, we shall see that a head, eyes, etc., would in fact have been of very little use to molluscs of the second order, because the large development of their mantle would have prevented the functioning of these organs.

In conformity with that law of nature which requires that every organ permanently disused should imperceptibly deteriorate, become reduced and finally disappear, the head, eyes, jaws, etc., have in fact become extinct in the acephalic molluscs: we shall see elsewhere many other examples of the same thing.

In the invertebrates nature no longer finds in the internal parts any support for muscular movement; she has therefore supplied the molluscs with a mantle for that purpose. Now the strength and compactness of this mantle of the molluscs is proportional to the necessity entailed by their locomotion and means of support.

Thus in the cephalic molluscs, where there is more locomotion than in those which have no head, the mantle is closer, thicker and stronger; and among the cephalic molluscs, those which are naked (without shells) have in addition a cuirass in their mantle which is stronger than the mantle itself and greatly facilitates the locomotion and contraction of the animal (slugs).

But if, instead of following the animal chain in the opposite direction from the actual order of nature, we followed it from the most imperfect animals to the most perfect, we should then easily perceive that nature when she was about to start the plan of organisation of the vertebrates, was forced in the molluscs to abandon the use of a crustaceous or horny skin as a support for muscular action, and to prepare to transfer these fulcra into the interior of the animal. In this way the molluscs are to some extent in the midst of this change of system of organisation; they have in consequence only feeble powers of locomotive movements and they all carry out such movements with remarkable slowness.

CIRRHIPEDES.

Animals without eyes which breathe by gills and have a mantle and jointed arms with a horny skin.

The cirrhipedes, of which only four genera [1] are yet known, should be considered as a special class, since these animals cannot belong to any other class of invertebrate animals.

They approach the molluscs by their mantle and should be placed immediately after the acephalic molluscs, since like them they have neither head nor eyes.

Yet the cirrhipedes cannot be a part of the class of molluscs; for

[1] *Anatifa, Balanus, Coronula,* and *Tubicinella.*

their nervous system is characterised like the animals of the three following classes by a ganglionic longitudinal cord. They have moreover jointed arms with a horny skin and several pairs of transverse jaws. They are therefore of lower rank than molluscs. Their fluids move by a true circulation with arteries and veins.

These animals are fixed on marine bodies and in consequence carry out no locomotion; their principal movements are those of their arms. Now although they have a mantle like the molluscs, nature could not obtain from it any assistance for the movements of their arms, and was forced to create in the skin of those arms fulcra for their muscles. Hence the skin is coriaceous and almost horny like that of crustaceans and insects.

ANNELIDS.

Animals with elongated annulated bodies without jointed legs, breathing by gills and having a circulatory system and a ganglionic longitudinal cord.

The class of annelids necessarily comes after that of cirrhipedes, because no annelid has a mantle. We are moreover compelled to place them before the crustaceans, because they have no jointed legs and it would not do to interpose them in the series of those which have; nor does their organisation permit us to place them lower than the insects.

Although these animals in general are still very little known, the rank to which their organisation entitles them proves that in their case again the degradation of organisation is continued; for from this aspect they are inferior to the molluscs in that they have a ganglionic longitudinal cord; they are inferior also to the cirrhipedes, which have a mantle like molluscs; and the fact that they have not jointed legs prevents us from interposing them in the series of those which are so organised.

Annelids owe their elongated form to their habits of life, for they either live buried in damp earth or in mud or actually in the water, mostly in tubes of various materials which they enter and leave at will. Thus they are so like worms that all naturalists hitherto have confused the two.

Their internal organisation shows a very small brain, a ganglionic longitudinal cord, arteries and veins in which circulates blood that is usually coloured red; they breathe by gills, sometimes external and protruding, and sometimes internal and hidden or invisible.

CRUSTACEANS.

Animals with a jointed body and limbs, crustaceous skin, a circulatory system, and breathing by gills.

We now enter upon the long series of animals, whose body and limbs are jointed, and whose integuments are hard, crustaceous, horny or coriaceous.

The solid or hard parts of these animals are all on the exterior. Since nature created the muscular system very little in advance of the earlier animals of this series, and since she had need of solid support to endow it with energy, she was obliged to establish the method of articulation in order to secure the possibility of movement.

All the animals that exhibit this method of articulation were held by Linnæus and subsequently as forming only a single class, to which was given the name of insects; but it was at length recognised that this large series of animals has several important divisions which must be distinguished.

The class of crustaceans, which had thus been confused with that of insects, although all the ancient naturalists had always kept it apart, is a division indicated by nature and must be maintained. It should follow immediately upon the annelids and occupy the eighth rank in the general series of animals; this is required by their organisation and is not a matter of arbitrary opinion.

The crustaceans indeed have a heart, arteries and veins; a transparent and almost colourless circulating fluid, and they all breathe by true gills. This is unquestionable and will always constitute a difficulty in the way of those who persist in placing them among the insects on account of their having jointed legs.

If the crustaceans are completely distinguished from the arachnids and insects by their circulation and respiratory organ, and if their rank is therefore obviously superior, they yet share one trait of inferiority of organisation with the arachnids and insects as compared with the annelids; that, namely, of being a part of the series of animals with jointed limbs: a series in the course of which the circulatory system and consequently the heart, arteries and veins are seen to diminish and disappear, and in which again the branchial system of respiration is likewise lost. The crustaceans therefore again confirm the continuous degradation of organisation in the direction in which we are following the animal scale. The transparency and extreme thinness of the fluid which circulates in their vessels, like that of insects, is a further proof of their degradation.

As to their nervous system, it consists of a very small brain and a

ganglionic longitudinal cord. This is a sign of poverty of that system observed among the animals of the two preceding and the two following classes; for the animals of these classes are the last in which a nervous system is still to be seen.

It is in the crustaceans that the last traces of an organ of hearing have been identified; after them it is no more found in any animal.

Observations.

Here ends the existence of a true circulatory system, that is to say, of a system of arteries and veins, which is part of the organisation of the most perfect animals and with which those of all the preceding classes are provided. The organisation of the animals of which we shall now speak is still more imperfect than that of the crustaceans, which are the last in which a circulation is actually to be found. The degradation of organisation is thus clearly in progress; since according as we advance along the series of animals, all features of resemblance are successively lost between the organisation of those we come to and that of the most perfect animals.

Whatever may be the nature of the movement of the fluids in the animals of the classes that we are about to traverse, that movement is secured by less active methods, and constantly tends to become slower.

ARACHNIDS.

Animals breathing by limited tracheae, undergoing no metamorphosis, and having throughout their lives jointed legs and eyes in their head.

On continuing the order that we have hitherto followed, the ninth rank in the animal kingdom necessarily belongs to the arachnids; they have so much affinity with the crustaceans that we shall always have to bring them together, immediately following one another. They are however entirely distinct; for the arachnids furnish us with the first example of a respiratory organ lower than gills,—one never met with in animals which have a heart, arteries and veins.

Arachnids in fact breathe only by stigmata and air-carrying tracheae, which are respiratory organs analogous to those of insects. But these tracheae, instead of extending throughout the body as in the insects, are limited to a small number of sacs: this shows that nature is bringing to an end in the arachnids the method of respiration which she had to employ before the establishment of gills, just as she brought to an end in the fishes or later reptiles that which she had to make use of, before she could form a true lung.

If the arachnids are quite distinct from the crustaceans, through not breathing by gills but by very limited air-carrying tracheae, they are also to be distinguished from the insects. It would be quite as improper to combine them with the insects of which they lack the classic character and from which they differ even in internal organisation, as it would be to confuse the crustaceans with the insects.

The arachnids, indeed, although having strong affinities with the insects are essentally distinct from them:

1. In that they never undergo metamorphosis, that they have at birth the shape and all the parts of an adult and that, consequently, they have eyes in their head and jointed legs throughout their lives. This is an order of things that follows from the nature of their internal organisation and therein differs greatly from that of insects;

2. In that in the arachnids of the first order (pedipalp-arachnids) we begin to see the outlines of a circulatory system;[1]

3. In that their respiratory system, although of the same order as that of insects, is nevertheless very different; since their tracheae are limited to a small number of sacs, and do not constitute the very numerous air-canals extending throughout the animal's body that are witnessed in the tracheae of insects;

4. Lastly, in that the arachnids procreate several times in the course of their life; a faculty which the insects do not possess.

These considerations suffice to show how faulty are those arrangements in which the arachnids and insects are combined into one class, through paying exclusive regard to the joints in these animals' legs, and the more or less crustaceous skin which covers them. It is almost as if we were to consider only the more or less scaly integuments of reptiles and fishes, and thus to combine them into one class.

The general degradation of organisation that we are seeking throughout the entire animal scale is extremely obvious in the arachnids: these animals indeed breathe by an organ inferior in organic perfection to lungs and even to gills, and have only the rudiments of a circulation apparently not yet finished off. They thus confirm in their turn the continuous degradation in question.

This degradation may even be observed in the series of species belonging to that class; for the arachnids with antennae, making up the second order, are sharply distinguished from the others, are very inferior to them in progress of organisation, and come close to the insects; they differ from the latter however in undergoing no metamorphosis; and as they never launch themselves into the air, it is very probable that their tracheae do not generally extend throughout all parts of their bodies.

[1] "It is especially in the spiders that this heart may be easily observed: it may be seen beating through the skin of the abdomen in species that are not hairy. On removing this skin, a hollow oblong organ is seen, pointed at the two ends, with the anterior end directed towards the thorax and from the sides of which there issue visibly two or three pairs of vessels" (Cuvier, *Anatom. comp.* vol. iv. p. 419).

INSECTS.

Animals which undergo metamorphoses, and have in the perfect state two eyes and two antennae in their head, six jointed legs and wo tracheae which extend throughout their body.

As we continue to follow the inverse order from that of nature, the insects necessarily succeed the arachnids. They constitute that immense series of imperfect animals which have no arteries or veins; which breathe by air-carrying tracheae not limited to special parts; lastly, which are born in a state less perfect than that in which they reproduce; and which consequently undergo metamorphoses.

In their perfect state all insects without exception have six jointed legs, two antennae and two eyes in their head, and most of them also have wings.

The insects necessarily occupy the tenth rank of the animal kingdom in the order that we are following; for they are inferior to the arachnids in perfection of organisation since they are not born like these latter in their perfect state, and they only procreate once in the course of their life. It is particularly in the insects that we begin to observe that the organs essential to maintenance of life are almost equally distributed, and in most cases situated throughout their bodies instead of being isolated in special places, as is the case in the most perfect animals. The exceptions to this rule gradually disappear, so that it becomes ever more striking in the lower classes of animals.

Nowhere hitherto has the general degradation of organisation been more manifest than in the insects, whose organisation is less perfect than that of the animals of any of the preceding classes. This degradation comes out even within the various orders into which insects are naturally divided; for those of the three first orders (Coleoptera, Orthoptera, Neuroptera) have mandibles and maxillae in their mouths; those of the fourth order (Hymenoptera) begin to possess a sort of proboscis; finally, those of the four last orders (Lepidoptera, Hemiptera, Diptera and Aptera) have really nothing more than a proboscis. Now paired maxillae are nowhere found again in the animal kingdom, after the insects of the three first orders. With regard to wings, the insects of the six first orders have four, all of which or only two serve for flight. Those of the seventh and eighth have only two wings or else they are quite aborted. The larvae of the insects of the two last orders have no legs and are like worms.

It appears that the insects are the last animals which have a quite distinct sexual reproduction and are probably oviparous.

Lastly, we shall see that insects are rendered highly remarkable by what is called their skill; but this alleged skill is far from being the product of any thought or any combination of ideas on their part.

Observation.

Just as among the vertebrates the fishes display in their general conformation and anomalies of organisation the product of the action of their environment; so the insects among the invertebrates exhibit, in their shape, organisation and metamorphoses, the obvious effects of the action of the air in which they live; for most of them launch themselves into it and habitually maintain themselves there like birds.

If the insects had had lungs, if they had been able to swell themselves out with air, and if the air which penetrates into every part of their body could have there become rarefied like that which is introduced into the body of birds, their hair would no doubt have changed into feathers.

Lastly, if among invertebrate animals we are surprised to find so few affinities between the insects which undergo remarkable metamorphoses and other classes of invertebrates, let us remember that these are the only invertebrate animals which launch themselves into the air and there execute movements of progression; we shall then no longer be surprised that such peculiar conditions and habits must have produced peculiar results.

The insects are allied only to the arachnids by their affinities, and in fact these two are in general the only invertebrate animals that live in the air; but no arachnid has the faculty of flight; none therefore undergoes metamorphosis; and when I come to treat of the influence of habits, I shall show that these animals, being accustomed to remain on the surface of the earth and to live in retreats, must have lost a part of the faculties of insects and acquired characters which conspicuously distinguish the two groups.

Extinction of Several Organs essential to the Most Perfect Animals.

After the insects it appears that there is a rather large gap in the series remaining to be filled by animals not yet observed; for in this part of the series several organs essential to the most perfect animals

suddenly drop out and are really annihilated, since they are not found again in the classes which remain to be considered.

Disappearance of the Nervous System.

Here for instance the nervous system (the nerves and their centre of communication) completely disappears, and is no more found in any of the animals of the succeeding classes.

In the most perfect animals, this system consists of a brain which appears to serve for carrying out acts of intelligence. At its base is the nucleus of sensations from which issue nerves and also a dorsal spinal cord which sends out other nerves to various parts.

Among the vertebrates the brain becomes regularly reduced, and as its volume diminishes the spinal cord becomes larger and seems to take its place.

Among the molluscs which constitute the first class of the invertebrates the brain still exists, but there is no spinal cord nor a ganglionic longitudinal cord, and as ganglia are rare the nerves do not appear to have nodes.

Lastly, in the five following classes the nervous system is approaching its end and is reduced to the very small rudiments of a brain and to a longitudinal cord from which issue nerves. Thereafter there is no longer a separate nucleus for sensations, but a multitude of small nuclei scattered throughout the length of the animal's body.

Hence among insects, the important system of feeling comes to an end; a system which at a certain stage of development gives birth to ideas and which in its highest perfection can produce all the acts of intelligence; which, lastly, is the source whence muscular action derives its power and without which sexual reproduction apparently could not exist.

The centre of communication of the nervous system is situated in the brain or at its base or in a ganglionic longitudinal cord. There is still a longitudinal cord when there is no longer any obvious brain; but when there is neither a brain nor a longitudinal cord, the nervous system ceases to exist.

Disappearance of the Sexual Organs.

Here again all traces of sexual reproduction disappear; indeed among the animals about to be cited it is no longer possible to recognise organs for true impregnation. We shall, however, still find among the animals of the two following classes kinds of ovaries, abounding in oviform corpuscles that are alleged to be eggs; but I look upon these supposed eggs which can develop without previous fertilisation as buds or internal gemmules; they establish a connection between internal gemmiparous reproduction and sexual oviparous reproduction.

The strength of habit is so great that man always perseveres in the same view of things, even when it is contrary to the evidence.

Thus botanists, accustomed to observing the sexual organs of a great number of plants, affirm that all without exception have such organs. Consequently several botanists have made every conceivable effort to discover stamens and pistils in cryptogamic or agamic plants; and they have preferred to attribute arbitrarily and without proof these functions to parts of whose use they are ignorant, rather than admit that nature may attain the same end by different means.

It was believed that every reproductive body is a seed or egg, that is to say, a body which must undergo the influence of sexual fertilisation in order to be reproductive. This is what caused Linnæus to say: *Omne vivum ex ovo.* But we now know well plants and animals which reproduce entirely by means of bodies that are neither seeds nor eggs, and which consequently do not require sexual fertilisation. These bodies are therefore differently fashioned and develop in another manner.

The following is the principle to be observed in judging of the method of reproduction in any living body.

Any reproductive corpuscle which *without having any investment to break through* lengthens, grows and becomes a plant or animal similar to that from which it sprang, is not a seed nor an egg; it undergoes no germination and does not hatch after beginning to grow, and its formation requires no sexual fertilisation: thus it does not contain an embryo in an investment which has to be broken through, as does the seed or egg.

Now, if you follow attentively the development of the reproductive corpuscles of algae, fungi, etc., you will see that the result of the lengthening and growth of these corpuscles is to take imperceptibly the shape of the plant from which they spring; that they do not break through any investment as does the embryo in the seed or egg.

Similarly, if you follow the gemma or bud of a polyp like a hydra, you will be convinced that this reproductive body does nothing but lengthen out and grow; that it breaks through no investment; in short, that it does not hatch like a chicken or silkworm coming out of its egg.

It is then clear that all reproduction of individuals does not come about by means of sexual fertilisation; and that when sexual fertilisation does not occur there is not really a true sexual organ. Now as no organ for fertilisation is to be distinguished in the four classes following the insects it appears that this is the point in the animal chain at which sexual reproduction ceases to exist.

Disappearance of the Organ of Sight.

Here again the organ of sight, so useful to the most perfect animals, is entirely extinguished. This organ began to be deficient in some of the molluscs and cirrhipedes and in most of the annelids, and is only found afterwards in the crustaceans, arachnids and insects in a very imperfect state and of little or no use; after the insects it does not re-appear in any animal.

Here again, finally, the head altogether ceases to exist,—an essential part of the body of the most perfect animals and the seat of the brain and nearly all the senses; for the swelling at the anterior extremity of the body of some worms like *Taenia* is caused by the arrangement of their suckers and is not the seat of a brain nor of any organ of hearing, sight, etc., since there are no such organs in the animals of the neighbouring classes. Hence this swelling cannot be considered as a true head.

We see that at this part of the animal scale the degradation of organisation becomes extremely rapid, and strongly foreshadows the greatest simplification of animal organisation.

WORMS.

Animals with soft elongated bodies, without head, eyes or jointed legs, and no longitudinal cord or circulatory system.

We now come to worms, which have no vessels for circulation; including those known under the name of intestinal worms, and some others not intestinal whose organisation is quite as imperfect. They are animals with soft more or less elongated bodies, which undergo no metamorphosis and are all destitute of a head, eyes and jointed legs.

The worms should be placed immediately after the insects and before the radiarians, and occupy the eleventh rank in the animal kingdom. It is among them that we note the origin of the tendency of nature to establish the system of articulations, a system that she subsequently carried to completion in the insects, arachnids and crustaceans. But the organisation of the worms is less perfect than that of the insects, since they have no longitudinal cord, head, eyes or true legs, so that we are forced to place them after the insects; lastly, the new kind of shape, which nature initiates in them on passing from a radiating arrangement of the parts to the system of articulations, shows that the worms should be placed even before the radiarians. After the insects, moreover, the plan followed by nature in the animals of preceding classes is lost sight of, viz. that general shape of the animal which consists of a bilateral symmetry of the parts, so that each part is opposite to another exactly like it.

In the worms we no longer find this bilateral symmetry, nor do we yet witness the radiating arrangement of the organs both internal and external which characterises the radiarians.

After I established the annelids, some naturalists called them by the name of worms; and as they did not then know what to do with the animals now under discussion, they united them with the polyps. I leave the reader to imagine what may be the affinities and classic characters that justify the union in one class of *Taenia* or *Ascaris* with a hydra or any other polyp.

Several worms still appear to breathe like insects by tracheae of which the external openings are kinds of stigmata; but there is reason to believe that these limited or imperfect tracheae are water-carrying and not air-carrying like those of insects; because these animals never live in the open air, but are continuously in the water or bathed by fluids which contain water.

As no organ for fertilisation is distinguished in them, I suppose that sexual reproduction does not occur in these animals. It may be however that, just as there exists a primitive circulation in arachnids so there may exist a sexual reproduction in the worms, as is suggested by the various shapes of the tail of *Strongylus*; but observation has not yet fully established such reproduction in these animals.

Objects which are found in some of them and supposed to be ovaries (as in *Taenia*) appear to be merely clusters of reproductive corpuscles which do not require fertilisation. These oviform corpuscles are internal, like those of sea-urchins, and not external like those of *Coryne*, etc. Polyps exhibit similar differences in the situation of their gemmules; it is therefore probable that the worms are internally gemmiparous.

Animals like the worms, which have no head, eyes, legs or perhaps sexual reproduction, provide further evidence in their turn of the continuous degradation of organisation that we are seeking throughout the animal scale.

RADIARIANS.

Animals with regenerating bodies, destitute of a head, eyes or jointed legs; with the mouth on the inferior surface and a radiating arrangement of the parts both internal and external.

In the usual order the radiarians occupy the twelfth rank in the lengthy series of known animals, and constitute one of the three last classes of invertebrates.

When we reach this class we find animals with a general shape and arrangement of the parts and organs, both internal and external, that nature has not employed in any of the animals of the anterior classes.

The radiarians indeed conspicuously exhibit in their internal and external parts that radiating arrangement around a centre or axis, which constitutes a special shape not hitherto used by nature. Its rudiments are found in the polyps, which accordingly come next.

Nevertheless, the radiarians form a stage in the animal scale quite distinct from the polyps; so that we can no more confuse radiarians with polyps than we can class crustaceans with insects or reptiles with fishes. Among the radiarians indeed, not only do we find again organs apparently intended for respiration (tubes or kinds of water-bearing tracheae), but we discover in addition special organs for reproduction, such as kinds of ovaries of various shapes to which there is nothing analogous in the polyps. Moreover, the intestinal canal of the radiarians is not generally a cul-de-sac with a single opening as in all the polyps; their mouth is always on the inferior surface and displays a special arrangement which is quite different from that commonly found in polyps.

Although the radiarians are very remarkable animals, and as yet little known, what we do know of their organisation plainly points to the rank which I am assigning to them. Like the worms, radiarians have no head, eyes, jointed legs, circulatory system or perhaps nerves. Yet the radiarians necessarily come next to the worms, for the latter have nothing in the arrangement of their internal organs that suggests a radiating shape, and it is among them that the system of articulations begins.

If the radiarians are destitute of nerves, they cannot have the faculty of feeling, but are simply irritable; this fact seems to be confirmed by observations made on living star-fishes, whose arms have been cut off without their showing any sign of pain.

In many radiarians fibres may still be distinguished; but can we call these fibres muscles? Not unless we are justified in saying that a muscle can function without nerves. Do not plants show us that cellular tissue may be reduced to fibres? Yet we cannot possibly regard these fibres as muscular. In my opinion it does not follow that because a living being has distinguishable fibres, it must therefore have muscles; I hold that where there are no nerves, there is no muscular system. There is reason to believe that in animals without nerves the fibres which are still to be found possess the faculty by mere irritability of producing movements which replace those of the muscles, although less energetically.

Not only does it appear that the muscular system has ceased to exist in the radiarians, but also there seems to be no sexual reproduction. There is indeed nothing to show or even to suggest that the little oviform bodies, the clusters of which are called ovaries in these animals, undergo any fertilisation or are true eggs: this is rendered still less probable by the fact that they are found in all individuals alike. Hence I regard these little oviform bodies as already perfected internal gemmules, and the clusters of them in special places as nature's preliminary step towards sexual reproduction.

The radiarians in their turn contribute to prove the general degradation of animal organisation; for on reaching this class of animals we find a shape and a new arrangement of the parts and organs that are far removed from the animals of the preceding classes. Furthermore they appear to be destitute of feeling, muscular movement and sexual reproduction; among them the intestinal canal no longer has two exits, the clusters of oviform corpuscles disappear, and the body becomes completely gelatinous.

Observation.

It appears that in very imperfect animals such as the polyps and radiarians, the centre of movement of the fluids does not exist except in the alimentary canal; it is here that it is first established, and it is through this canal that the subtle surrounding fluids enter, mainly for the purpose of stimulating the movement of the fluids which belong to these animals themselves. What would plant life be without external stimuli? What indeed would be the life of the most imperfect animals without this factor, that is, without the caloric and electricity of the environment?

The radiating form has no doubt been acquired as a consequence of this method, which nature employs feebly at first in the polyps and afterwards with greater vigour in the radiarians; for the subtle surrounding fluids which enter the alimentary canal are expansive and must by incessant repulsion from the centre towards every point of the circumference give rise to this radiating arrangement of the parts.

This is the reason why in the radiarians the intestinal canal, although still very imperfect, since it has usually only one opening, is none the less provided with numerous radiating vasculiform and often branched appendages.

This again is no doubt the reason why in the soft radiarians, such as jelly-fishes, etc., we may observe a continual isochronous movement, a movement which very probably results from the alternative movements of the masses of subtle fluids, which penetrate into the interior

of these animals and escape again, after having spread throughout all their parts.

Let it not be said that the isochronous movements of the soft radiarians are signs of respiration; for nature does not exhibit in any animal after the vertebrates those alternate and measured movements of inspiration and expiration; whatever the respiration of radiarians may be, it is extremely slow and involves no appreciable movement.

POLYPS.

Animals with sub-gelatinous and regenerating bodies, with no special organ but an alimentary canal with only one opening. Terminal mouth supplied with radiating tentacles or a ciliated and rotatory organ.

With the polyps we reach the penultimate stage of the animal scale, that is to say, the last but one of the classes which have to be established among animals.

Here the imperfection and simplicity of organisation are very striking, so that the animals of this group have scarcely any faculties left, and their animal nature has long been doubted.

They are gemmiparous animals with homogeneous bodies, usually gelatinous, and with very regenerative parts, not displaying the radiating shape (for it is only here that nature began it) except in radiating tentacles around their mouth, and having no special organ but an intestinal canal, which has only one opening and is therefore incomplete.

The polyps may be described as much more imperfect animals than any of those which make up the preceding classes, for they have no brain, longitudinal cord, nerves, special respiratory organs, vessels for the circulation of fluids nor ovary for reproduction. The substance of their body is to a great extent homogeneous and composed of a gelatinous and irritable cellular tissue in which fluids move slowly. Lastly, their viscera are entirely reduced to an imperfect alimentary canal, rarely folded on itself or provided with appendages, and usually resembling a mere elongated sac, always with a single opening which serves at once for mouth and anus.

There can be no justification for the statement that, although we find in these animals no nervous system, respiratory organ or muscle, etc., yet these organs still exist infinitely reduced and distributed or dissolved throughout the general substance of the body, and equally divided up in every molecule instead of being collected in special places; consequently that every point in their body can experience every kind of sensation, muscular movement, will, ideas and thought; this would be an altogether gratuitous, baseless and improbable supposition. On such a supposition a hydra must have in every part of its body all the organs of the most perfect animals, and hence every point in the body of this polyp must see, hear, distinguish odours, tastes, etc.; and also must have ideas, form judgments, think and, in short, reason; each molecule of the body of a hydra or any other polyp would in itself be a perfect animal; and the whole hydra would be a more perfect animal even than man, since each of its molecules would be equivalent, as regards the completion of organisation and faculties, to an entire individual of the human species.

There is no reason why such an argument should not be extended to the *Monas*—the most imperfect of known animals—and even to plants themselves, which also possess life. We should then attribute to each molecule of a plant all the aforementioned faculties, though restricted within limits set by the nature of the living body of which it is part.

Assuredly it is not to this that the study of nature leads us. This study teaches us, on the contrary, that wherever an organ ceases to exist, the function depending on it ceases likewise. Any animal which has no eyes or whose eyes have been destroyed cannot see; and although in the last analysis the various senses derive their origin from touch, of which they are only special modifications, yet no animal which is without nerves, the special organ of feeling, could experience any kind of sensation; for it has not the intimate feeling of its existence, it has not the central nucleus to which sensation has to be conveyed, and consequently it could not feel.

Thus the sense of touch, which is the basis of the other senses and is spread throughout every part of the bodies of animals which have nerves, no longer exists in those which, like the polyps, have no nerves. Among the latter, the parts are nothing more than merely irritable; they are so in a very high degree, but they are devoid of feeling and hence of every kind of sensation. In order that a sensation may arise, an organ is first necessary to receive it (nerves); and then some central nucleus must exist (a brain or ganglionic longitudinal cord) to which this sensation may be conveyed.

A sensation is always the sequel of an impression received and immediately conveyed to an internal nucleus, where the sensation is formed. Interrupt the communication between the organ which receives the impression and the nucleus where the sensation is formed, and all feeling will immediately cease. This principle can never be disputed.

No polyp can really be oviparous; for it has no special organ for

reproduction. Now in order to produce true eggs, it is necessary not only that the animal should have an ovary, but in addition that it or some other individual of its species should have a special organ for fertilisation, and it cannot be shown that the polyps have such organs; in place of them we are well aware of the buds which some of them produce for purposes of multiplication; and on paying them a little attention we note that these buds are themselves nothing more than somewhat isolated portions of the animal's body,—portions less simple than those employed by nature for the multiplication of the animalcules which compose the last class of the animal kingdom.

Polyps, being highly irritable, only move by external stimuli foreign to themselves. All their movements are necessary results of impressions received, and are in general carried out without any act of will; they are thus without any possibility of choice, since they cannot have any will.

They invariably and inevitably move towards the light, just like the branches and leaves or flowers of plants, although in their case the movement is slower. No polyp pursues its prey, nor seeks for it with its tentacles; but when some foreign body touches these same tentacles, they hold it and carry it to the mouth, and the polyp swallows it without making any distinction as to its suitability or the reverse. It digests and feeds on the body if it is capable of being digested, but rejects it entirely if it remains some time untouched in the alimentary canal; finally, it brings up such of the débris as can be no more broken up; but in all this, there is the same necessity in the action and never any possibility of choice to vary it.

The distinction of the polyps from the radiarians is very wide and glaring; nowhere in the interior of the polyps is the radiating arrangement to be found: their tentacles alone have this arrangement, thus resembling the arms of the cephalapod molluscs, with which however they certainly cannot be confused. Moreover the polyps have a superior terminal mouth, while the mouth of the radiarians is otherwise situated.

It is altogether improper to give the polyps the name of zoophytes, which means animal-plants; because they are entirely and completely animals. They have faculties absent in plants, that, for instance, of true irritablity and generally of digestion; and, lastly, their nature has nothing essentially in common with that of a plant.

The only affinities existing between polyps and plants are: (1) A similar simplification of organisation; (2) the faculty possessed by many polyps of adhering to one another with a common conmunication by their alimentary canal, and of forming compound animals; (3) the external shape of the groups formed by these combined polyps, a shape which has long caused these groups to be taken for true plants, since they are often branched almost in the same way.

Whether polyps have one or several mouths, there is always an alimentary canal to which they lead and consequently an organ for digestion, of which all plants are destitute.

If the degradation of organisation that we have observed in all classes starting from the mammals is anywhere obvious, it is assuredly among the polyps, whose organisation is reduced to an extreme simplification.

INFUSORIANS.

Infinitely small animals with gelatinous, transparent, homogeneous and very contractile bodies; with no distinct special organ internally, but often oviform gemmules; and having externally no radiating tentacles nor rotatory organs.

At length we reach the last class of the animal kingdom, comprising the most imperfect animals from all points of view; that is, those which have the simplest organisation, possess the fewest faculties and seem all to be mere rudiments of animal nature.

Hitherto I have placed these small animals in the class of polyps, of which they constituted the last order under the name of amorphous polyps, since they have no constant shape peculiar to them all; but I have recognised the necessity of separating them to form a class apart, though this in no wise changes the rank that I had assigned to them. The only result of this change is to establish a line of demarcation which appears to be called for, on account of the greater simplicity of their organisation and their lack of radiating tentacles and rotatory organs.

Since the organisation of the infusorians becomes ever more simple as we pass down their genera, the last of these genera shows us in some degree the limit of animality, the limit at all events of what we can reach. It is especially in the animals of the second order of this class that we can verify the entire disappearance of any trace of an intestinal canal and mouth; so that they have no special organ whatever nor any digestion.

They are only very tiny gelatinous, transparent, contractile and homogeneous bodies, consisting of cellular tissue, with very slight cohesion and yet irritable throughout. These tiny bodies, which look like animated or moving points, feed by absorption and continual imbibition; and they are doubtless animated by the influence of the subtle surrounding fluids, such as caloric and electricity, which stimulate in them the movements constituting life.

If we were to imagine that such animals possess all the organs known in other animals, but that these organs are dissolved throughout their bodies, how absurd such a supposition would be!

The extremely slight cohesion between the parts of these tiny gelatinous bodies is an indication that such organs cannot exist, since they could not possibly carry on their functions. It is clear that in order that any organs may have the power of reacting on fluids and of carrying on their appropriate functions, their parts must have enough cohesion and firmness to give them strength; now this is not to be imagined in the case of these fragile animalcules. It is exclusively among the animals of this class that nature appears to carry out direct or spontaneous generations, which are incessantly renewed whenever conditions are favourable; and we shall endeavour to show that it is through this means that she acquired the power after an enormous lapse of time to produce indirectly all the other races of animals that we know.

Justification for the belief that the infusorians or most of them owe their existence exclusively to spontaneous generation is found in the fact that all these fragile animals perish during the reduction of temperature in bad seasons; and it surely will not be suggested that such delicate bodies could leave any bud sufficiently hardy to be preserved and to reproduce them in warm weather.

Infusorians are found in stagnant waters and infusions of plant or animal substances, and even in the seminal fluid of the most perfect animals. They are found just the same in all parts of the world, but only in conditions suitable for their existence.

Thus on examining in turn the various systems of organisation of animals from the most complex to the simplest, we have seen the degradation of animal organisation beginning even in the class that comprises the most perfect animals and thence advancing progressively from class to class, although with anomalies due to environment, and finally ending with the infusorians. These last are the most imperfect animals and the simplest in organisation,—the animals in which the degradation that we have traced reaches its limit. Animal organisation is then reduced to a simple homogeneous gelatinous body with very slight cohesion, destitute of special organs, and entirely formed of a very delicate and primitive cellular tissue, which appears to be vivified by subtle surrounding fluids incessantly penetrating it and exhaling from it.

We have seen each special organ in turn, including even the most essential, become slowly degraded till it is less special, less isolated, and finally completely lost and gone, long before reaching the other extremity of the order we are tracing; and we have noticed that it is chiefly among the invertebrate animals that the extinction of special organs occurs.

It is true that even before leaving the division of vertebrates, we already witness great changes in the perfection of organs ; while some even disappear altogether, such as the urinary bladder, the diaphragm, the organ of voice, the eyelids, etc. The lung, for instance, which is the most perfect respiratory organ, begins its degradation in the reptiles and ceases to exist in the fishes, not to reappear again in any invertebrate animal. Finally, the skeleton, the appendages of which constitute the basis of the four extremities or limbs possessed by most vertebrates, begins its deterioration mainly in the reptiles and comes entirely to an end with the fishes.

But it is in the division of invertebrates that the extinction takes place of the heart, brain, gills, conglomerate glands, vessels for circulation, the organs of hearing and sight, that of sexual reproduction and even that of feeling, as also of movement.

As I have already said, we should vainly seek in a polyp, such as the hydra or most animals of that class, the slightest vestiges either of nerves (organs of feeling) or of muscles (organs of movement) ! Irritability, with which every polyp is highly endowed, alone replaces the faculty of feeling which no polyp possesses, since it has not the essential organ for it.

It also replaces the faculty of voluntary movement, since all will is an act of the organ of intelligence, and this animal is absolutely destitute of any such organ. All its movements are necessary results of the impressions on its irritable parts of external stimuli ; and they are carried out without any scope for choice.

Put a hydra in a glass of water, and set this glass in a room where daylight only enters by one window and therefore only from one side. When this hydra has fixed on some point of the sides of the glass, turn the glass so that the light strikes it on the opposite side to that where the animal is. You will then always see the hydra go with a slow movement and place itself where the light strikes, and stay there so long as you do not change this point. This is the same in those parts of plants which, without any act of will, lean towards the side from which the light comes.

Doubtless wherever a special organ no longer exists, the function which it supports also ceases to exist ; and we may furthermore clearly observe that according as an organ is degraded and reduced, the function resulting from it becomes proportionally more vague and imperfect. Thus, we find that on descending from the most complex towards the simplest, the insects are the last animals which have eyes ; but there is sound reason for the belief that they see very dimly and make little use of them.

Thus on traversing the chain of animals from the most perfect to the most imperfect, and on examining in turn the various systems of organisation distinguished in the course of this chain, the degradation of organisation and of each organ up to their complete disappearance is seen to be a positive fact which we have now verified.

This degradation comes out even in the nature and consistency of the essential fluids and flesh of animals. For the flesh and blood of mammals and birds are the most complex and animalised materials that can be obtained from the soft parts of animals. Hence after the fishes these materials are progressively degraded until in the soft radiarians, the polyps and the infusorians, the essential fluid has only the consistency and colour of water and the flesh is nothing more than a gelatinous scarcely animalised material. The bouillon made from such flesh would scarcely be found very nourishing or strengthening by any one who tried to live upon it.

Whether or no we recognise these interesting truths, they will nevertheless always be forced upon the attention of those who closely observe facts, and who, overcoming prevailing prejudices, consult the phenomena of nature and study her laws and regular procedure.

We shall now pass to the examination of another kind of subject, and shall endeavour to prove that the environment exercises a great influence over the activities of animals, and that as a result of this influence the increased and sustained use or disuse of any organ are causes of modification of the organisation and shape of animals and give rise to the anomalies observed in the progress of the complexity of animal organisation.

CHAPTER VII.

OF THE INFLUENCE OF THE ENVIRONMENT ON THE ACTIVITIES AND HABITS OF ANIMALS, AND THE INFLUENCE OF THE ACTIVITIES AND HABITS OF THESE LIVING BODIES IN MODIFYING THEIR ORGANISATION AND STRUCTURE.

WE are not here concerned with an argument, but with the examination of a positive fact—a fact which is of more general application than is supposed, and which has not received the attention that it deserves, no doubt because it is usually very difficult to recognise. This fact consists in the influence that is exerted by the environment on the various living bodies exposed to it.

It is indeed long since the influence of the various states of our organisation on our character, inclinations, activities and even ideas has been recognised; but I do not think that anyone has yet drawn attention to the influence of our activities and habits even on our organisation. Now since these activities and habits depend entirely on the environment in which we are habitually placed, I shall endeavour to show how great is the influence exerted by that environment on the general shape, state of the parts and even organisation of living bodies. It is, then, with this very positive fact that we have to do in the present chapter.

If we had not had many opportunities of clearly recognising the result of this influence on certain living bodies that we have transported into an environment altogether new and very different from that in which they were previously placed, and if we had not seen the resulting effects and alterations take place almost under our very eyes, the important fact in question would have remained for ever unknown to us.

The influence of the environment as a matter of fact is in all times and places operative on living bodies; but what makes this influence difficult to perceive is that its effects only become perceptible or recognisable (especially in animals) after a long period of time.

Before setting forth to examine the proofs of this fact, which deserves our attention and is so important for zoological philosophy, let us sum up the thread of the discussions that we have already begun.

In the preceding chapter we saw that it is now an unquestionable fact that on passing along the animal scale in the opposite direction from that of nature, we discover the existence, in the groups composing this scale, of a continuous but irregular degradation in the organisation of animals, an increasing simplification in their organisation, and, lastly, a corresponding diminution in the number of their faculties.

This well-ascertained fact may throw the strongest light over the actual order followed by nature in the production of all the animals that she has brought into existence, but it does not show us why the increasing complexity of the organisation of animals from the most imperfect to the most perfect exhibits only an *irregular gradation*, in the course of which there occur numerous anomalies or deviations with a variety in which no order is apparent.

Now on seeking the reason of this strange irregularity in the increasing complexity of animal organisation, if we consider the influence that is exerted by the infinitely varied environments of all parts of the world on the general shape, structure and even organisation of these animals, all will then be clearly explained.

It will in fact become clear that the state in which we find any animal, is, on the one hand, the result of the increasing complexity of organisation tending to form a regular gradation; and, on the other hand, of the influence of a multitude of very various conditions ever tending to destroy the regularity in the gradation of the increasing complexity of organisation.

I must now explain what I mean by this statement: *the environment affects the shape and organisation of animals*, that is to say that when the environment becomes very different, it produces in course of time corresponding modifications in the shape and organisation of animals.

It is true if this statement were to be taken literally, I should be convicted of an error; for, whatever the environment may do, it does not work any direct modification whatever in the shape and organisation of animals.

But great alterations in the environment of animals lead to great alterations in their needs, and these alterations in their needs necessarily lead to others in their activities. Now if the new needs become permanent, the animals then adopt new habits which last as long as the needs that evoked them. This is easy to demonstrate, and indeed requires no amplification.

It is then obvious that a great and permanent alteration in the environment of any race of animals induces new habits in these animals.

Now, if a new environment, which has become permanent for some race of animals, induces new habits in these animals, that is to say, leads them to new activities which become habitual, the result will be the use of some one part in preference to some other part, and in some cases the total disuse of some part no longer necessary.

Nothing of all this can be considered as hypothesis or private opinion; on the contrary, they are truths which, in order to be made clear, only require attention and the observation of facts.

We shall shortly see by the citation of known facts in evidence, in the first place, that new needs which establish a necessity for some part really bring about the existence of that part, as a result of efforts; and that subsequently its continued use gradually strengthens, develops and finally greatly enlarges it; in the second place, we shall see that in some cases, when the new environment and the new needs have altogether destroyed the utility of some part, the total disuse of that part has resulted in its gradually ceasing to share in the development of the other parts of the animal; it shrinks and wastes little by little, and ultimately, when there has been total disuse for a long period, the part in question ends by disappearing. All this is positive; I propose to furnish the most convincing proofs of it.

In plants, where there are no activities and consequently no habits, properly so-called, great changes of environment none the less lead to great differences in the development of their parts; so that these differences cause the origin and development of some, and the shrinkage and disappearance of others. But all this is here brought about by the changes sustained in the nutrition of the plant, in its absorption and transpiration, in the quantity of caloric, light, air and moisture that it habitually receives; lastly, in the dominance that some of the various vital movements acquire over others.

Among individuals of the same species, some of which are continually well fed and in an environment favourable to their development, while others are in an opposite environment, there arises a difference in the state of the individuals which gradually becomes very remarkable. How many examples I might cite both in animals and plants which bear out the truth of this principle! Now if the environment remains constant, so that the condition of the ill-fed, suffering or sickly individuals becomes permanent, their internal organisation is ultimately modified, and these acquired modifications are preserved by reproduction among the individuals in question, and finally give rise to a race quite distinct from that in which the individuals have been continuously in an environment favourable to their development.

A very dry spring causes the grasses of a meadow to grow very little, and remain lean and puny; so that they flower and fruit after accomplishing very little growth.

A spring intermingled with warm and rainy days causes a strong growth in this same grass, and the crop is then excellent.

But if anything causes a continuance of the unfavourable environment, a corresponding variation takes place in the plants: first in their general appearance and condition, and then in some of their special characters.

Suppose, for instance, that a seed of one of the meadow grasses in question is transported to an elevated place on a dry, barren and stony plot much exposed to the winds, and is there left to germinate; if the plant can live in such a place, it will always be badly nourished, and if the individuals reproduced from it continue to exist in this bad environment, there will result a race fundamentally different from that which lives in the meadows and from which it originated. The individuals of this new race will have small and meagre parts; some of their organs will have developed more than others, and will then be of unusual proportions.

Those who have observed much and studied large collections, have acquired the conviction that according as changes occur in environment, situation, climate, food, habits of life, etc., corresponding changes in the animals likewise occur in size, shape, proportions of the parts, colour, consistency, swiftness and skill.

What nature does in the course of long periods we do every day when we suddenly change the environment in which some species of living plant is situated.

Every botanist knows that plants which are transported from their native places to gardens for purposes of cultivation, gradually undergo changes which ultimately make them unrecognisable. Many plants, by nature hairy, become glabrous or nearly so; a number of those which used to lie and creep on the ground, become erect; others lose their thorns or excrescences; others again whose stem was perennial and woody in their native hot climates, become herbaceous in our own climates and some of them become annuals; lastly, the size of their parts itself undergoes very considerable changes. These effects of alterations of environment are so widely recognised, that botanists do not like to describe garden plants unless they have been recently brought into cultivation.

Is it not the case that cultivated wheat (*Triticum sativum*) is a plant which man has brought to the state in which we now see it? I should like to know in what country such a plant lives in nature, otherwise than as the result of cultivation.

Where in nature do we find our cabbages, lettuces, etc., in the same state as in our kitchen gardens? and is not the case the same with regard to many animals which have been altered or greatly modified by domestication?

How many different races of our domestic fowls and pigeons have we obtained by rearing them in various environments and different countries; birds which we should now vainly seek in nature?

Those which have changed the least, doubtless because their domestication is of shorter standing and because they do not live in a foreign climate, none the less display great differences in some of their parts, as a result of the habits which we have made them contract. Thus our domestic ducks and geese are of the same type as wild ducks and geese; but ours have lost the power of rising into high regions of the air and flying across large tracts of country; moreover, a real change has come about in the state of their parts, as compared with those of the animals of the race from which they come.

Who does not know that if we rear some bird of our own climate in a cage and it lives there for five or six years, and if we then return it to nature by setting it at liberty, it is no longer able to fly like its fellows, which have always been free? The slight change of environment for this individual has indeed only diminished its power of flight, and doubtless has worked no change in its structure; but if a long succession of generations of individuals of the same race had been kept in captivity for a considerable period, there is no doubt that even the structure of these individuals would gradually have undergone notable changes. Still more, if instead of a mere continuous captivity, this environmental factor had been further accompanied by a change to a very different climate; and if these individuals had by degrees been habituated to other kinds of food and other activities for seizing it, these factors when combined together and become permanent would have unquestionably given rise imperceptibly to a new race with quite special characters.

Where in natural conditions do we find that multitude of races of dogs which now actually exist, owing to the domestication to which we have reduced them? Where do we find those bull-dogs, greyhounds, water-spaniels, spaniels, lap-dogs, etc., etc.; races which show wider differences than those which we call specific when they occur among animals of one genus living in natural freedom?

No doubt a single, original race, closely resembling the wolf, if indeed it was not actually the wolf, was at some period reduced by man to domestication. That race, of which all the individuals were then alike, was gradually scattered with man into different countries and climates; and after they had been subjected for some time to the influences of their environment and of the various habits which had been forced upon them in each country, they underwent remarkable alterations and formed various special races. Now man travels about to very great distances, either for trade or any other purpose; and thus brings into thickly populated places, such as a great capital, various races of dogs formed in very distant countries. The crossing of these races by reproduction then gave rise in turn to all those that we now know.

The following fact proves in the case of plants how the change of some important factor leads to alteration in the parts of these living bodies.

So long as *Ranunculus aquatilis* is submerged in the water, all its leaves are finely divided into minute segments; but when the stem of this plant reaches the surface of the water, the leaves which develop in the air are large, round and simply lobed. If several feet of the same plant succeed in growing in a soil that is merely damp without any immersion, their stems are then short, and none of their leaves are broken up into minute divisions, so that we get *Ranunculus hederaceus*, which botanists regard as a separate species.

There is no doubt that in the case of animals, extensive alterations in their customary environment produce corresponding alterations in their parts; but here the transformations take place much more slowly than in the case of plants; and for us therefore they are less perceptible and their cause less readily identified.

As to the conditions which have so much power in modifying the organs of living bodies, the most potent doubtless consist in the diversity of the places where they live, but there are many others as well which exercise considerable influence in producing the effects in question.

It is known that localities differ as to their character and quality, by reason of their position, construction and climate: as is readily perceived on passing through various localities distinguished by special qualities; this is one cause of variation for animals and plants living in these various places. But what is not known so well and indeed what is not generally believed, is that every locality itself changes in time as to exposure, climate, character and quality, although with such extreme slowness, according to our notions, that we ascribe to it complete stability.

Now in both cases these altered localities involve a corresponding alteration in the environment of the living bodies that dwell there, and this again brings a new influence to bear on these same bodies.

Hence it follows that if there are extremes in these alterations, there are also finer differences: that is to say, intermediate stages which fill up the interval. Consequently there are also fine distinctions between what we call species.

It is obvious then that as regards the character and situation of the substances which occupy the various parts of the earth's surface, there exists a variety of environmental factors which induces a corresponding variety in the shapes and structure of animals, independent of that special variety which necessarily results from the progress of the complexity of organisation in each animal.

In every locality where animals can live, the conditions constituting any one order of things remain the same for long periods: indeed they alter so slowly that man cannot directly observe it. It is only by an inspection of ancient monuments that he becomes convinced that in each of these localities the order of things which he now finds has not always been existent; he may thence infer that it will go on changing.

Races of animals living in any of these localities must then retain their habits equally long: hence the apparent constancy of the races that we call species,—a constancy which has raised in us the belief that these races are as old as nature.

But in the various habitable parts of the earth's surface, the character and situation of places and climates constitute both for animals and plants environmental influences of extreme variability. The animals living in these various localities must therefore differ among themselves, not only by reason of the state of complexity of organisation attained in each race, but also by reason of the habits which each race is forced to acquire; thus when the observing naturalist travels over large portions of the earth's surface and sees conspicuous changes occurring in the environment, he invariably finds that the characters of species undergo a corresponding change.

Now the true principle to be noted in all this is as follows:

1. Every fairly considerable and permanent alteration in the environment of any race of animals works a real alteration in the needs of that race.

2. Every change in the needs of animals necessitates new activities on their part for the satisfaction of those needs, and hence new habits.

3. Every new need, necessitating new activities for its satisfaction, requires the animal, either to make more frequent use of some of its parts which it previously used less, and thus greatly to develop and enlarge them; or else to make use of entirely new parts, to which the needs have imperceptibly given birth by efforts of its inner feeling; this I shall shortly prove by means of known facts.

Thus to obtain a knowledge of the true causes of that great diversity of shapes and habits found in the various known animals, we must

reflect that the infinitely diversified but slowly changing environment in which the animals of each race have successively been placed, has involved each of them in new needs and corresponding alterations in their habits. This is a truth which, once recognised, cannot be disputed. Now we shall easily discern how the new needs may have been satisfied, and the new habits acquired, if we pay attention to the two following laws of nature, which are always verified by observation.

First Law.

In every animal which has not passed the limit of its development, a more frequent and continuous use of any organ gradually strengthens, develops and enlarges that organ, and gives it a power proportional to the length of time it has been so used; while the permanent disuse of any organ imperceptibly weakens and deteriorates it, and progressively diminishes its functional capacity, until it finally disappears.

Second Law.

All the acquisitions or losses wrought by nature on individuals, through the influence of the environment in which their race has long been placed, and hence through the influence of the predominant use or permanent disuse of any organ; all these are preserved by reproduction to the new individuals which arise, provided that the acquired modifications are common to both sexes, or at least to the individuals which produce the young.

Here we have two permanent truths, which can only be doubted by those who have never observed or followed the operations of nature, or by those who have allowed themselves to be drawn into the error which I shall now proceed to combat.

Naturalists have remarked that the structure of animals is always in perfect adaptation to their functions, and have inferred that the shape and condition of their parts have determined the use of them. Now this is a mistake: for it may be easily proved by observation that it is on the contrary the needs and uses of the parts which have caused the development of these same parts, which have even given birth to them when they did not exist, and which consequently have given rise to the condition that we find in each animal.

If this were not so, nature would have had to create as many different kinds of structure in animals, as there are different kinds of environment in which they have to live; and neither structure nor environment would ever have varied.

This is indeed far from the true order of things. If things were really so, we should not have race-horses shaped like those in England;

we should not have big draught-horses so heavy and so different from the former, for none such are produced in nature; in the same way we should not have basset-hounds with crooked legs, nor grey-hounds so fleet of foot, nor water-spaniels, etc.; we should not have fowls without tails, fantail pigeons, etc.; finally, we should be able to cultivate wild plants as long as we liked in the rich and fertile soil of our gardens, without the fear of seeing them change under long cultivation.

A feeling of the truth in this respect has long existed; since the following maxim has passed into a proverb and is known by all, *Habits form a second nature.*

Assuredly if the habits and nature of each animal could never vary, the proverb would have been false and would not have come into existence, nor been preserved in the event of any one suggesting it.

If we seriously reflect upon all that I have just set forth, it will be seen that I was entirely justified when in my work entitled *Recherches sur les corps vivants* (p. 50), I established the following proposition:

"It is not the organs, that is to say, the nature and shape of the parts of an animal's body, that have given rise to its special habits and faculties; but it is, on the contrary, its habits, mode of life and environment that have in course of time controlled the shape of its body, the number and state of its organs and, lastly, the faculties which it possesses."

If this proposition is carefully weighed and compared with all the observations that nature and circumstances are incessantly throwing in our way, we shall see that its importance and accuracy are substantiated in the highest degree.

Time and a favourable environment are as I have already said nature's two chief methods of bringing all her productions into existence: for her, time has no limits and can be drawn upon to any extent.

As to the various factors which she has required and still constantly uses for introducing variations in everything that she produces, they may be described as practically inexhaustible.

The principal factors consist in the influence of climate, of the varying temperatures of the atmosphere and the whole environment, of the variety of localities and their situation, of habits, the commonest movements, the most frequent activities, and, lastly, of the means of self-preservation, the mode of life and the methods of defence and multiplication.

Now as a result of these various influences, the faculties become extended and strengthened by use, and diversified by new habits that are long kept up. The conformation, consistency and, in short, the character and state of the parts, as well as of the organs, are

imperceptibly affected by these influences and are preserved and propagated by reproduction.

These truths, which are merely effects of the two natural laws stated above, receive in every instance striking confirmation from facts; for the facts afford a clear indication of nature's procedure in the diversity of her productions.

But instead of being contented with generalities which might be considered hypothetical, let us investigate the facts directly, and consider the effects in animals of the use or disuse of their organs on these same organs, in accordance with the habits that each race has been forced to contract.

Now I am going to prove that the permanent disuse of any organ first decreases its functional capacity, and then gradually reduces the organ and causes it to disappear or even become extinct, if this disuse lasts for a very long period throughout successive generations of animals of the same race.

I shall then show that the habit of using any organ, on the contrary, in any animal which has not reached the limit of the decline of its functions, not only perfects and increases the functions of that organ, but causes it in addition to take on a size and development which imperceptibly alter it; so that in course of time it becomes very different from the same organ in some other animal which uses it far less.

The permanent disuse of an organ, arising from a change of habits, causes a gradual shrinkage and ultimately the disappearance and even extinction of that organ.

Since such a proposition could only be accepted on proof, and not on mere authority, let us endeavour to make it clear by citing the chief known facts which substantiate it.

The vertebrates, whose plan of organisation is almost the same throughout, though with much variety in their parts, have their jaws armed with teeth; some of them, however, whose environment has induced the habit of swallowing the objects they feed on without any preliminary mastication, are so affected that their teeth do not develop. The teeth then remain hidden in the bony framework of the jaws, without being able to appear outside; or indeed they actually become extinct down to their last rudiments.

In the right-whale, which was supposed to be completely destitute of teeth, M. Geoffroy has nevertheless discovered teeth concealed in the jaws of the foetus of this animal. The professor has moreover discovered in birds the groove in which the teeth should be placed, though they are no longer to be found there.

Even in the class of mammals, comprising the most perfect animals, where the vertebrate plan of organisation is carried to its highest completion, not only is the right-whale devoid of teeth, but the ant-eater (*Myrmecophaga*) is also found to be in the same condition, since it has acquired a habit of carrying out no mastication, and has long preserved this habit in its race.

Eyes in the head are characteristic of a great number of different animals, and essentially constitute a part of the plan of organisation of the vertebrates.

Yet the mole, whose habits require a very small use of sight, has only minute and hardly visible eyes, because it uses that organ so little.

Olivier's *Spalax* (*Voyage en Égypte et en Perse*), which lives underground like the mole, and is apparently exposed to daylight even less than the mole, has altogether lost the use of sight: so that it shows nothing more than vestiges of this organ. Even these vestiges are entirely hidden under the skin and other parts, which cover them up and do not leave the slightest access to light.

The *Proteus*, an aquatic reptile allied to the salamanders, and living in deep dark caves under the water, has, like the *Spalax*, only vestiges of the organ of sight, vestiges which are covered up and hidden in the same way.

The following consideration is decisive on the question which I am now discussing,

Light does not penetrate everywhere; consequently animals which habitually live in places where it does not penetrate, have no opportunity of exercising their organ of sight, if nature has endowed them with one. Now animals belonging to a plan of organisation of which eyes were a necessary part, must have originally had them. Since, however, there are found among them some which have lost the use of this organ and which show nothing more than hidden and covered up vestiges of them, it becomes clear that the shrinkage and even disappearance of the organ in question are the results of a permanent disuse of that organ.

This is proved by the fact that the organ of hearing is never in this condition, but is always found in animals whose organisation is of the kind that includes it: and for the following reason.

The substance of sound,[1] that namely which, when set in motion by the shock or the vibration of bodies, transmits to the organ of hearing the impression received, penetrates everywhere and passes through any medium, including even the densest bodies: it follows that every animal, belonging to a plan of organisation of which hearing is an essential part, always has some opportunity for the exercise of this organ wherever it may live. Hence among the vertebrates we do not find any that are destitute of the organ of hearing; and after them, when this same organ has come to an end, it does not subsequently recur in any animal of the posterior classes.

It is not so with the organ of sight; for this organ is found to disappear, re-appear and disappear again according to the use that the animal makes of it.

In the acephalic molluscs, the great development of the mantle would make their eyes and even their head altogether useless. The permanent disuse of these organs has thus brought about their disappearance and extinction, although molluscs belong to a plan of organisation which should comprise them.

Lastly, it was part of the plan of organisation of the reptiles, as of other vertebrates, to have four legs in dependence on their skeleton. Snakes ought consequently to have four legs, especially since they are by no means the last order of the reptiles and are farther from the fishes than are the batrachians (frogs, salamanders, etc.).

Snakes, however, have adopted the habit of crawling on the ground and hiding in the grass; so that their body, as a result of continually repeated efforts at elongation for the purpose of passing through narrow spaces, has acquired a considerable length, quite out of proportion to its size. Now, legs would have been quite useless to these animals and consequently unused. Long legs would have interfered

[1] Physicists believe and even affirm that the atmospheric air is the actual substance of sound, that is to say, that it is the substance which, when set in motion by the shocks or vibrations of bodies, transmits to the organ of hearing the impression of the concussions received.

That this is an error is attested by many known facts, showing that it is impossible that the air should penetrate to all places to which the substance producing sound actually does penetrate.

See my memoir *On the Substance of Sound*, printed at the end of my *Hydrogéologie*, p. 225, in which I furnished the proofs of this mistake.

Since the publication of my memoir, which by the way is seldom cited, great efforts have been made to make the known velocity of the propagation of sound in air tally with the elasticity of the air, which would cause the propagation of its oscillations to be too slow for the theory. Now, since the air during oscillation necessarily undergoes alternate compressions and dilatations in its parts, recourse has been had to the effects of the caloric squeezed out during the sudden compressions of the air and of the caloric absorbed during the rarefactions of that fluid. By means of these effects, quantitatively determined by convenient hypotheses, geometricians now account for the velocity with which sound is propagated through air. But this is no answer to the fact that sound is also propagated through bodies which air can neither traverse nor set in motion.

These physicists assume forsooth a vibration in the smallest particles of solid bodies; a vibration of very dubious existence, since it can only be propagated through homogeneous bodies of equal density, and cannot spread from a dense body to a rarefied one or *vice versâ*. Such a hypothesis offers no explanation of the well-known fact that sound is propagated through heterogeneous bodies of very different densities and kinds.

with their need of crawling, and very short legs would have been incapable of moving their body, since they could only have had four. The disuse of these parts thus became permanent in the various races of these animals, and resulted in the complete disappearance of these same parts, although legs really belong to the plan of organisation of the animals of this class.

Many insects, which should have wings according to the natural characteristics of their order and even of their genus, are more or less completely devoid of them through disuse. Instances are furnished by many Coleoptera, Orthoptera, Hymenoptera and Hemiptera, etc., where the habits of these animals never involve them in the necessity of using their wings.

But it is not enough to give an explanation of the cause which has brought about the present condition of the organs of the various animals,—a condition that is always found to be the same in animals of the same species; we have in addition to cite instances of changes wrought in the organs of a single individual during its life, as the exclusive result of a great mutation in the habits of the individuals of its species. The following very remarkable fact will complete the proof of the influence of habits on the condition of the organs, and of the way in which permanent changes in the habits of an individual lead to others in the condition of the organs, which come into action during the exercise of these habits.

M. Tenon, a member of the Institute, has notified to the class of sciences, that he had examined the intestinal canal of several men who had been great drinkers for a large part of their lives, and in every case he had found it shortened to an extraordinary degree, as compared with the same organ in all those who had not adopted the like habit.

It is known that great drinkers, or those who are addicted to drunkenness, take very little solid food, and eat hardly anything; since the drink which they consume so copiously and frequently is sufficient to feed them.

Now since fluid foods, especially spirits, do not long remain either in the stomach or intestine, the stomach and the rest of the intestinal canal lose among drinkers the habit of being distended, just as among sedentary persons, who are continually engaged on mental work and are accustomed to take very little food; for in their case also the stomach slowly shrinks and the intestine shortens.

This has nothing to do with any shrinkage or shortening due to a binding of the parts which would permit of the ordinary extension, if instead of remaining empty these viscera were again filled; we have to do with a real shrinkage and shortening of considerable extent,

and such that these organs would burst rather than yield at once to any demand for the ordinary extension.

Compare two men of equal ages, one of whom has contracted the habit of eating very little, since his habitual studies and mental work have made digestion difficult, while the other habitually takes much exercise, is often out-of-doors, and eats well; the stomach of the first will have very little capacity left and will be filled up by a very small quantity of food, while that of the second will have preserved and even increased its capacity.

Here then is an organ which undergoes profound modification in size and capacity, purely on account of a change of habits during the life of the individual.

The frequent use of any organ, when confirmed by habit, increases the functions of that organ, leads to its development and endows it with a size and power that it does not possess in animals which exercise it less.

We have seen that the disuse of any organ modifies, reduces and finally extinguishes it. I shall now prove that the constant use of any organ, accompanied by efforts to get the most out of it, strengthens and enlarges that organ, or creates new ones to carry on functions that have become necessary.

The bird which is drawn to the water by its need of finding there the prey on which it lives, separates the digits of its feet in trying to strike the water and move about on the surface. The skin which unites these digits at their base acquires the habit of being stretched by these continually repeated separations of the digits; thus in course of time there are formed large webs which unite the digits of ducks, geese, etc., as we actually find them. In the same way efforts to swim, that is to push against the water so as to move about in it, have stretched the membranes between the digits of frogs, sea-tortoises, the otter, beaver, etc.

On the other hand, a bird which is accustomed to perch on trees and which springs from individuals all of whom had acquired this habit, necessarily has longer digits on its feet and differently shaped from those of the aquatic animals that I have just named. Its claws in time become lengthened, sharpened and curved into hooks, to clasp the branches on which the animal so often rests.

We find in the same way that the bird of the water-side which does not like swimming and yet is in need of going to the water's edge to secure its prey, is continually liable to sink in the mud. Now this bird tries to act in such a way that its body should not be immersed in the liquid, and hence makes its best efforts to stretch and lengthen its legs. The long-established habit acquired by this bird and all its race of continually stretching and lengthening its legs, results in the individuals of this race becoming raised as though on stilts, and gradually obtaining long, bare legs, denuded of feathers up to the thighs and often higher still. (*Système des Animaux sans vertèbres*, p. 14.)

We note again that this same bird wants to fish without wetting its body, and is thus obliged to make continual efforts to lengthen its neck. Now these habitual efforts in this individual and its race must have resulted in course of time in a remarkable lengthening, as indeed we actually find in the long necks of all water-side birds.

If some swimming birds like the swan and goose have short legs and yet a very long neck, the reason is that these birds while moving about on the water acquire the habit of plunging their head as deeply as they can into it in order to get the aquatic larvae and various animals on which they feed; whereas they make no effort to lengthen their legs.

If an animal, for the satisfaction of its needs, makes repeated efforts to lengthen its tongue, it will acquire a considerable length (ant-eater, green-woodpecker); if it requires to seize anything with this same organ, its tongue will then divide and become forked. Proofs of my statement are found in the humming-birds which use their tongues for grasping things, and in lizards and snakes which use theirs to palpate and identify objects in front of them.

Needs which are always brought about by the environment, and the subsequent continued efforts to satisfy them, are not limited in their results to a mere modification, that is to say, an increase or decrease of the size and capacity of organs; but they may even go so far as to extinguish organs, when any of these needs make such a course necessary.

Fishes, which habitually swim in large masses of water, have need of lateral vision; and, as a matter of fact, their eyes are placed on the sides of their head. Their body, which is more or less flattened according to the species, has its edges perpendicular to the plane of the water; and their eyes are placed so that there is one on each flattened side. But such fishes as are forced by their habits to be constantly approaching the shore, and especially slightly inclined or gently sloping beaches, have been compelled to swim on their flattened surfaces in order to make a close approach to the water's edge. In this position, they receive more light from above than below and stand in special need of paying constant attention to what is passing above them; this requirement has forced one of their eyes to undergo a sort of displacement, and to assume the very remarkable position found in the soles, turbots, dabs, etc. (*Pleuronectes* and *Achirus*). The position of these eyes is not symmetrical, because it results from an

incomplete mutation. Now this mutation is entirely completed in the skates, in which the transverse flattening of the body is altogether horizontal, like the head. Accordingly the eyes of skates are both situated on the upper surface and have become symmetrical.

Snakes, which crawl on the surface of the earth, chiefly need to see objects that are raised or above them. This need must have had its effect on the position of the organ of sight in these animals, and accordingly their eyes are situated in the lateral and upper parts of their head, so as easily to perceive what is above them or at their sides; but they scarcely see at all at a very short distance in front of them. They are, however, compelled to make good the deficiency of sight as regards objects in front of them which might injure them as they move forward. For this purpose they can only use their tongue, which they are obliged to thrust out with all their might. This habit has not only contributed to making their tongue slender and very long and contractile, but it has even forced it to undergo division in the greater number of species, so as to feel several objects at the same time; it has even permitted of the formation of an aperture at the extremity of their snout, to allow the tongue to pass without having to separate the jaws.

Nothing is more remarkable than the effects of habit in herbivorous mammals.

A quadruped, whose environment and consequent needs have for long past inculcated the habit of browsing on grass, does nothing but walk about on the ground; and for the greater part of its life is obliged to stand on its four feet, generally making only few or moderate movements. The large portion of each day that this kind of animal has to pass in filling itself with the only kind of food that it cares for, has the result that it moves but little and only uses its feet for support in walking or running on the ground, and never for holding on, or climbing trees.

From this habit of continually consuming large quantities of food-material, which distend the organs receiving it, and from the habit of making only moderate movements, it has come about that the body of these animals has greatly thickened, become heavy and massive and acquired a very great size: as is seen in elephants, rhinoceroses, oxen, buffaloes, horses, etc.

The habit of standing on their four feet during the greater part of the day, for the purpose of browsing, has brought into existence a thick horn which invests the extremity of their digits; and since these digits have no exercise and are never moved and serve no other purpose than that of support like the rest of the foot, most of them have become shortened, dwindled and, finally, even disappeared.

Thus in the pachyderms, some have five digits on their feet invested in horn, and their hoof is consequently divided into five parts; others have only four, and others again not more than three; but in the ruminants, which are apparently the oldest of the mammals that are permanently confined to the ground, there are not more than two digits on the feet and indeed, in the solipeds, there is only one (horse, donkey).

Nevertheless some of these herbivorous animals, especially the ruminants, are incessantly exposed to the attacks of carnivorous animals in the desert countries that they inhabit, and they can only find safety in headlong flight. Necessity has in these cases forced them to exert themselves in swift running, and from this habit their body has become more slender and their legs much finer; instances are furnished by the antelopes, gazelles, etc.

In our own climates, there are other dangers, such as those constituted by man, with his continual pursuit of red deer, roe deer and fallow deer; this has reduced them to the same necessity, has impelled them into similar habits, and had corresponding effects.

Since ruminants can only use their feet for support, and have little strength in their jaws, which only obtain exercise by cutting and browsing on the grass, they can only fight by blows with their heads, attacking one another with their crowns.

In the frequent fits of anger to which the males especially are subject, the efforts of their inner feeling cause the fluids to flow more strongly towards that part of their head; in some there is hence deposited a secretion of horny matter, and in others of bony matter mixed with horny matter, which gives rise to solid protuberances: thus we have the origin of horns and antlers, with which the head of most of these animals is armed.

It is interesting to observe the result of habit in the peculiar shape and size of the giraffe (*Camelo-pardalis*): this animal, the largest of the mammals, is known to live in the interior of Africa in places where the soil is nearly always arid and barren, so that it is obliged to browse on the leaves of trees and to make constant efforts to reach them. From this habit long maintained in all its race, it has resulted that the animal's fore-legs have become longer than its hind legs, and that its neck is lengthened to such a degree that the giraffe, without standing up on its hind legs, attains a height of six metres (nearly 20 feet).

Among birds, ostriches, which have no power of flight and are raised on very long legs, probably owe their singular shape to analogous circumstances.

The effect of habit is quite as remarkable in the carnivorous mammals as in the herbivores; but it exhibits results of a different kind.

Those carnivores, for instance, which have become accustomed to climbing, or to scratching the ground for digging holes, or to tearing their prey, have been under the necessity of using the digits of their feet: now this habit has promoted the separation of their digits, and given rise to the formation of the claws with which they are armed.

But some of the carnivores are obliged to have recourse to pursuit in order to catch their prey: now some of these animals were compelled by their needs to contract the habit of tearing with their claws, which they are constantly burying deep in the body of another animal in order to lay hold of it, and then make efforts to tear out the part seized. These repeated efforts must have resulted in its claws reaching a size and curvature which would have greatly impeded them in walking or running on stony ground: in such cases the animal has been compelled to make further efforts to draw back its claws, which are so projecting and hooked as to get in its way. From this there has gradually resulted the formation of those peculiar sheaths, into which cats, tigers, lions, etc. withdraw their claws when they are not using them.

Hence we see that efforts in a given direction, when they are long sustained or habitually made by certain parts of a living body, for the satisfaction of needs established by nature or environment, cause an enlargement of these parts and the acquisition of a size and shape that they would never have obtained, if these efforts had not become the normal activities of the animals exerting them. Instances are everywhere furnished by observations on all known animals.

Can there be any more striking instance than that which we find in the kangaroo? This animal, which carries its young in a pouch under the abdomen, has acquired the habit of standing upright, so as to rest only on its hind legs and tail; and of moving only by means of a succession of leaps, during which it maintains its erect attitude in order not to disturb its young. And the following is the result:

1. Its fore legs, which it uses very little and on which it only supports itself for a moment on abandoning its erect attitude, have never acquired a development proportional to that of the other parts, and have remained meagre, very short and with very little strength.

2. The hind legs, on the contrary, which are almost continually in action either for supporting the whole body or for making leaps, have acquired a great development and become very large and strong.

3. Lastly, the tail, which is in this case much used for supporting the animal and carrying out its chief movements, has acquired an extremely remarkable thickness and strength at its base.

These well-known facts are surely quite sufficient to establish the results of habitual use on an organ or any other part of animals. If on observing in an animal any organ particularly well-developed, strong, and powerful, it is alleged that its habitual use has nothing to do with it, that its continued disuse involves it in no loss, and finally, that this organ has always been the same since the creation of the species to which the animal belongs, then I ask, Why can our domestic ducks no longer fly like wild ducks? I can, in short, cite a multitude of instances among ourselves, which bear witness to the differences that accrue to us from the use or disuse of any of our organs, although these differences are not preserved in the new individuals which arise by reproduction: for if they were their effects would be far greater.

I shall show in Part II., that when the will guides an animal to any action, the organs which have to carry out that action are immediately stimulated to it by the influx of subtle fluids (the nervous fluid), which become the determining factor of the movements required. This fact is verified by many observations, and cannot now be called in question.

Hence it follows that numerous repetitions of these organised activities strengthen, stretch, develop and even create the organs necessary to them. We have only to watch attentively what is happening all around us, to be convinced that this is the true cause of organic development and changes.

Now every change that is wrought in an organ through a habit of frequently using it, is subsequently preserved by reproduction, if it is common to the individuals who unite together in fertilisation for the propagation of their species. Such a change is thus handed on to all succeeding individuals in the same environment, without their having to acquire it in the same way that it was actually created.

Furthermore, in reproductive unions, the crossing of individuals who have different qualities or structures is necessarily opposed to the permanent propagation of these qualities and structures. Hence it is that in man, who is exposed to so great a diversity of environment, the accidental qualities or defects which he acquires are not preserved and propagated by reproduction. If, when certain peculiarities of shape or certain defects have been acquired, two individuals who are both affected were always to unite together, they would hand on the same peculiarities; and if successive generations were limited to such unions, a special and distinct race would then be formed. But perpetual crossings between individuals, who have not the same peculiarities of shape, cause the disappearance of all peculiarities acquired by special action of the environment. Hence, we may be sure that if men were not kept apart by the distances of their habitations, the crossing in reproduction would soon bring about the disappearance of the general characteristics distinguishing different nations.

If I intended here to pass in review all the classes, orders, genera

and species of existing animals, I should be able to show that the conformation and structure of individuals, their organs, faculties, etc., etc., are everywhere a pure result of the environment to which each species is exposed by its nature, and by the habits that the individuals composing it have been compelled to acquire; I should be able to show that they are not the result of a shape which existed from the beginning, and has driven animals into the habits they are known to possess.

It is known that the animal called the *ai* or sloth (*Bradypus tridactylus*) is permanently in a state of such extreme weakness that it only executes very slow and limited movements, and walks on the ground with difficulty. So slow are its movements that it is alleged that it can only take fifty steps in a day. It is known, moreover, that the organisation of this animal is entirely in harmony with its state of feebleness and incapacity for walking; and that if it wished to make other movements than those which it actually does make it could not do so.

Hence on the supposition that this animal had received its organisation from nature, it has been asserted that this organisation forced it into the habits and miserable state in which it exists.

This is very far from being my opinion; for I am convinced that the habits which the ai was originally forced to contract must necessarily have brought its organisation to its present condition.

If continual dangers in former times have led the individuals of this species to take refuge in trees, to live there habitually and feed on their leaves, it is clear that they must have given up a great number of movements which animals living on the ground are in a position to perform. All the needs of the ai will then be reduced to clinging to branches and crawling and dragging themselves among them, in order to reach the leaves, and then to remaining on the tree in a state of inactivity in order to avoid falling off. This kind of inactivity, moreover, must have been continually induced by the heat of the climate; for among warm-blooded animals, heat is more conducive to rest than to movement.

Now the individuals of the race of the ai have long maintained this habit of remaining in the trees, and of performing only those slow and little varied movements which suffice for their needs. Hence their organisation will gradually have come into accordance with their new habits; and from this it must follow:

1. That the arms of these animals, which are making continual efforts to clasp the branches of trees, will be lengthened;

2. That the claws of their digits will have acquired a great length and a hooked shape, through the continued efforts of the animal to hold on;

3. That their digits, which are never used in making independent movements, will have entirely lost their mobility, become united and have preserved only the faculty of flexion or extension all together;

4. That their thighs, which are continually clasping either the trunk or large branches of trees, will have contracted a habit of always being separated, so as to lead to an enlargement of the pelvis and a backward direction of the cotyloid cavities;

5. Lastly, that a great many of their bones will be welded together, and that parts of their skeleton will consequently have assumed an arrangement and form adapted to the habits of these animals, and different from those which they would require for other habits.

This is a fact that can never be disputed; since nature shows us in innumerable other instances the power of environment over habit and that of habit over the shape, arrangement and proportions of the parts of animals.

Since there is no necessity to cite any further examples, we may now turn to the main point elaborated in this discussion.

It is a fact that all animals have special habits corresponding to their genus and species, and always possess an organisation that is completely in harmony with those habits.

It seems from the study of this fact that we may adopt one or other of the two following conclusions, and that neither of them can be verified.

Conclusion adopted hitherto: Nature (or her Author) in creating animals, foresaw all the possible kinds of environment in which they would have to live, and endowed each species with a fixed organisation and with a definite and invariable shape, which compel each species to live in the places and climates where we actually find them, and there to maintain the habits which we know in them.

My individual conclusion: Nature has produced all the species of animals in succession, beginning with the most imperfect or simplest, and ending her work with the most perfect, so as to create a gradually increasing complexity in their organisation; these animals have spread at large throughout all the habitable regions of the globe, and every species has derived from its environment the habits that we find in it and the structural modifications which observation shows us.

The former of these two conclusions is that which has been drawn hitherto, at least by nearly everyone: it attributes to every animal a fixed organisation and structure which never have varied and never do vary; it assumes, moreover, that none of the localities inhabited by animals ever vary; for if they were to vary, the same animals

could no longer survive, and the possibility of finding other localities and transporting themselves thither would not be open to them.

The second conclusion is my own: it assumes that by the influence of environment on habit, and thereafter by that of habit on the state of the parts and even on organisation, the structure and organisation of any animal may undergo modifications, possibly very great, and capable of accounting for the actual condition in which all animals are found.

In order to show that this second conclusion is baseless, it must first be proved that no point on the surface of the earth ever undergoes variation as to its nature, exposure, high or low situation, climate, etc., etc.; it must then be proved that no part of animals undergoes even after long periods of time any modification due to a change of environment or to the necessity which forces them into a different kind of life and activity from what has been customary to them.

Now if a single case is sufficient to prove that an animal which has long been in domestication differs from the wild species whence it sprang, and if in any such domesticated species, great differences of conformation are found between the individuals exposed to such a habit and those which are forced into different habits, it will then be certain that the first conclusion is not consistent with the laws of nature, while the second, on the contrary, is entirely in accordance with them.

Everything then combines to prove my statement, namely: that it is not the shape either of the body or its parts which gives rise to the habits of animals and their mode of life; but that it is, on the contrary, the habits, mode of life and all the other influences of the environment which have in course of time built up the shape of the body and of the parts of animals. With new shapes, new faculties have been acquired, and little by little nature has succeeded in fashioning animals such as we actually see them.

Can there be any more important conclusion in the range of natural history, or any to which more attention should be paid than that which I have just set forth?

Let us conclude this Part I. with the principles and exposition of the natural order of animals.

CHAPTER VIII.

OF THE NATURAL ORDER OF ANIMALS, AND THE WAY IN WHICH THEIR CLASSIFICATION SHOULD BE DRAWN UP SO AS TO BE IN CONFORMITY WITH THE ACTUAL ORDER OF NATURE.

I HAVE already observed that the true aim of a classification of animals should not be merely the possession of a list of classes, genera and species, but also the provision of the greatest facilities for the study of nature and for obtaining a knowledge of her procedure, methods and laws.

I do not hesitate to say, however, that our general classifications of animals up to the present have been in the inverse order from that followed by nature when bringing her living productions successively into existence; thus, when we proceed from the most complex to the simplest in the usual way, we increase the difficulty of acquiring a knowledge of the progress in complexity of organisation; and we also find it less easy to grasp both the causes of that progress and of the interruptions in it.

When once we have recognised that a thing is useful and indeed indispensable for the end in view and that it is free from drawbacks, we should hasten to carry it into execution although it is contrary to custom.

This is the case with regard to the way in which a general classification of animals should be drawn up.

We shall see that it is not a matter of indifference from which end we begin this general classification of animals, and that the beginning of the order is not a mere matter of choice.

The existing custom of placing at the head of the animal kingdom the most perfect animals, and of terminating this kingdom with the most imperfect and simplest in organisation, is due, on the one hand, to that natural prejudice towards giving the preference to the objects which strike us most or in which we are most pleased or interested; and, on the other hand, to the preference for passing from the better known to what is less known.

When the study of natural history began to occupy attention, these reasons were no doubt very plausible; but they must now yield to the needs of science and especially to those of facilitating the progress of natural knowledge.

With regard to the numerous and varied animals which nature has produced, if we cannot flatter ourselves that we possess an exact knowledge of the real order which she followed in bringing them successively into existence, it is nevertheless true that the order which I am about to set forth is probably very near it: reason and all our acquired knowledge testify in favour of this probability.

If indeed it is true that all living bodies are productions of nature, we are driven to the belief that she can only have produced them one after another and not all in a moment. Now if she shaped them one after another, there are grounds for thinking that she began exclusively with the simplest, and only produced at the very end the most complex organisations both of the animal and vegetable kingdoms.

The botanists were the first to set an example to the zoologists as to the proper way of drawing up a general classification in order to represent the actual order of nature; for it is with the Acotyledons or agamous plants that they constitute the first class among plants, that is to say, with the simplest in organisation and the most imperfect under every aspect, plants in short which have no cotyledons, no recognisable sex, no vessels in their tissue, and which in fact are composed of nothing but cellular tissue more or less modified according to their various expansions.

What botanists have done in the case of plants, we should now do with regard to the animal kingdom; and we should do it, not only because nature herself indicates it and reason demands it, but also because the natural order of classes in accordance with their growing complexity of organisation is much easier to determine among animals than it is in the case of plants.

While this order represents most closely the order of nature, it also makes the study of objects much easier, advances our knowledge of the organisation of animals with its increasing complexity from class to class, and exhibits still more clearly the affinities existing among the various stages of complexity of animal organisation, and the external differences that we commonly utilise for the characterisation of classes, orders, families, genera and species.

To these two principles, whose validity can scarcely be questioned, I add another, viz.: that if nature, who has not succeeded in endowing organised bodies with eternal existence, had not had the power of giving these bodies the faculty of reproducing others like themselves to carry on and perpetuate the race in the same way, she would have been forced to create directly all races, or rather she would only have been able to create a single race in each organic kingdom, viz. the simplest and most imperfect animals and plants.

Moreover, if nature had not been able to endow the organising activity with the faculty of gradually increasing the complexity of organisation by accelerating the energy of the movement of the fluids and hence that of organic movement, and if she had not preserved by reproduction all the progress made in complexity of organisation and all acquired improvements, she would assuredly never have produced that infinitely varied multitude of animals and plants which differ so greatly from one another both in their organisation and in their faculties.

Finally, she could not create at once the highest faculties of animals, for they are only found in conjunction with highly complex systems of organs: and she had to prepare slowly the methods by which such systems might be brought into existence.

Thus, in order to establish the state of affairs that we now see in living bodies, the only direct production that is required from nature, that is to say, the only production that occurs without the co-operation of any organic activity, is in the case of the simplest organised bodies, both of animals and plants; these she continues to produce every day in the same way at favourable times and places. Now she endows these bodies, which she has herself created, with the faculties of feeding, growing, multiplying, and always preserving the progress made in organisation. She transmits these same faculties to all individuals organically reproduced throughout time and the immense variety of ever-changing conditions. By these means living bodies of all classes and orders have been successively produced.

In the study of the natural order of animals, the very definite gradation existing in the growing complexity of their organisation and in the number and perfection of their faculties is very far from being a new truth for it was known even to the Greeks;[1] but they could not set forth its underlying principles and proofs, because they lacked the necessary knowledge.

Now, in order to facilitate an acquaintance with the principles which have guided me in the exposition that I am about to give, and in order to bring home more closely the gradation observed in the complexity of organisation from the most imperfect animals at the head of the series to the most perfect at the end of it, I have divided into six distinct stages the various modes of organisation recognised throughout the animal scale.

[1] See the *Voyage du jeune Anacharsis*, by J. Barthélemy, vol. v. pp. 353, 354.

Of these six stages of organisation, the first four comprise the invertebrate animals, and consequently the first ten classes of the animal kingdom according to the new order that we are going to follow; the two last stages comprises all the vertebrate animals and consequently the four (or five) last classes of animals.

By this method it will be easier to study and follow the procedure of nature in the production of the animals that she has brought into existence; to recognise throughout the animal scale the progress made in complexity of organisation and everywhere to verify both the accuracy of the classification and the propriety of the rank assigned by examining such characters and facts of organisation as are known.

In lecturing on invertebrates at the Museum, I have for some years past followed this plan of always proceeding from the simplest to the most complex.

In order to bring out more clearly the arrangement and totality of the general series of animals, I shall first present a table of the fourteen classes into which the animal kingdom is divided, confining myself to a very brief account of their characters and of the stages of organisation which they include.

TABLE

OF THE ARRANGEMENT AND CLASSIFICATION OF ANIMALS ACCORDING TO THE ORDER MOST IN CONFORMITY WITH THE ORDER OF NATURE.

INVERTEBRATE ANIMALS.

CLASSES	
I. INFUSORIANS. Amorphous animals, reproducing by fission or budding; with bodies gelatinous, transparent, homogeneous, contractile and microscopic; no radiating tentacles, or rotatory appendage; no special organ, even for digestion. II. POLYPS. Reproducing by budding; bodies gelatinous and regenerating, but with no other internal organ than an alimentary canal with a single aperture. Terminal mouth, surrounded by radiating tentacles or furnished with ciliated or rotatory organs. They mostly form compound animals.	*1st Stage.* No nerves; no vessels; no specialised internal organ except for digestion.

Classes	Characters	Stage
III. Radiarians.	Suboviparous animals, free, with regenerating bodies, destitute of head, eyes, or jointed legs; parts arranged radially. Mouth on inferior surface.	*2nd Stage.* No ganglionic longitudinal cord; no vessels for circulation; a few internal organs in addition to those of digestion.
IV. Worms.	Suboviparous animals, with soft regenerating bodies; undergoing no metamorphosis, and never having eyes, jointed legs, nor a radial arrangement of the internal parts.	
V. Insects.	Oviparous animals, which undergo metamorphosis, and have, in the perfect state, eyes in their heads, six jointed legs, and tracheae which spread everywhere; a single fertilisation in the course of their life.	*3rd Stage.* Nerves terminating in a ganglionic longitudinal cord; respiration by air-carrying tracheae; circulation absent or imperfect.
VI. Arachnids.	Oviparous, having always jointed legs, and eyes in their heads, and undergoing no metamorphosis. Limited trachae for respiration; a primitive circulation; several fertilisations in the course of their life.	
VII. Crustaceans.	Oviparous, with jointed body and limbs, crustaceous skin, eyes in their head, and usually four antennae; respiration by gills; a ganglionic longitudinal cord.	*4th Stage.* Nerves terminating in a brain or a ganglionic longitudinal cord; respiration by gills; arteries and veins for circulation.
VIII. Annelids.	Oviparous, with elongated and ringed bodies; no jointed legs, rarely any eyes; respiration by gills; a ganglionic longitudinal cord.	
IX. Cirrhipedes.	Oviparous, with a mantle and jointed arms, the skin of which is horny; no eyes; respiration by gills; ganglionic longitudinal cord.	
X. Molluscs.	Oviparous, with soft moist bodies, unjointed, and with a variable mantle; respiration by gills of various shapes and situations; no spinal cord, nor ganglionic longitudinal cord, but nerves terminating in a brain.	

VERTEBRATE ANIMALS.

Classes	Characters	Stage
XI. Fishes.	Oviparous, and without mammae; respiration complete and always by gills; two or four primitive limbs; fins for locomotion; no hair or feathers on the skin.	*5th Stage.* Nerves terminating in a brain which is far from filling the cranial cavity; heart with one ventricle, and the blood cold.
XII. Reptiles.	Oviparous, and without mammae; respiration incomplete, usually by lungs which exist either throughout life or during the latter part of it; four limbs, or two, or none; no hair or feathers on the skin.	
XIII. Birds.	Oviparous, and without mammae; four jointed limbs, two of which are shaped as wings; respiration complete, by adherent lungs, which are pierced through; feathers on the skin.	*6th Stage.* Nerves terminating in a brain which fills the cranial cavity; heart with two ventricles, and the blood warm.
XIV. Mammals.	Viviparous, and possessing mammae; four jointed limbs, or two only; respiration complete, by lungs not pierced through; hair on some part of the body.	

The above is a table of the fourteen classes of known animals arranged in the order most in conformity with that of nature. The arrangement of these classes is such that we shall always be obliged to adhere to it even though we may refuse to adopt the lines of demarcation between them; because this arrangement is based on a study of the organisation of the living bodies concerned, and because this highly important study reveals affinities among the objects comprised in each division, and determines the rank of each division throughout the series.

For these reasons no solid grounds can ever be found for changing the general features of this classification, though changes may be made as to detail, particularly in the divisions that are subordinate to the classes; because the affinities between the objects comprised in the sub-divisions are more difficult to determine and leave more to arbitrary opinion.

Now in order to bring home more closely the conformity of this arrangement of animals with the actual order of nature, I shall set forth the general series of known animals divided into its main groups, proceeding from the simplest to the most complex according to the principles indicated above.

My object in the exposition is to enable the reader to recognise the rank in the general series that is occupied by the animals which I have often had occasion to cite in the course of the present work, and to save him the trouble of having recourse to other works on zoology for this purpose.

I shall, however, here give merely a list of genera and of the main groups; but this list will suffice to show the extent of the general series, the arrangement of it that is most in conformity with nature, and the places necessarily occupied by classes and orders as well perhaps as by families and genera. We must of course refer to the good works on zoology that we possess for a study of the details of all the animals named in this list, for that does not come within the scope of the present work.

GENERAL CLASSIFICATION OF ANIMALS.

Forming a series in conformity with the actual order of nature.

INVERTEBRATE ANIMALS.

They have no vertebral column and consequently no skeleton; those which have fulcra for the movement of their parts have them under the integument. They lack a spinal cord and exhibit great variety in the complexity of their organisation.

FIRST STAGE OF ORGANISATION.

No nerves or ganglionic longitudinal cord; no vessels for circulation; no organs of respiration; no specialised internal organ but that for digestion.

(*Infusorians and Polyps.*)

INFUSORIANS.

(Class I. of the Animal Kingdom.)

Amorphous animals, reproducing by fission; with bodies gelatinous, transparent, homogeneous, contractile, and microscopic; no radiating tentacles, or rotatory appendage; internally no special organ, even for digestion.

OBSERVATIONS.

Of all known animals the infusorians are the most imperfect, the most simply organised and possessed of the fewest faculties; they certainly have not the faculty of feeling.

Infinitely minute, gelatinous, transparent, contractile, almost homogeneous and incapable of the possession of any special organ on account of the very delicate consistency of their parts, the infusorians are in truth mere rudiments of animalisation.

These fragile animals are the only creatures which do not have to carry on any digestion when feeding, and which in fact only feed by absorption through the pores of their skin and by an internal imbibition.

In this they resemble plants, which live entirely by absorption, carry on no digestion and in which the organic movements are only achieved by external stimuli; but the infusorians are irritable and contractile and perform sudden movements which they can repeat several times running; this it is that indicates their animal nature and distinguishes them essentially from plants.

TABLE OF INFUSORIANS.

ORDER 1.—NAKED INFUSORIANS.

They are destitute of external appendages.

Monas.	—
Volvox.	Bursaria.
Proteus [Amoeba. H. E.].	Colpoda.
Vibrio.	

ORDER 2.—APPENDICULATE INFUSORIANS.

They have projecting parts, like hair, kinds of horns or a tail.

Cercaria [Trematode. H. E.].
Trichocerca.
Trichoda.

Remarks. The monas, and especially *Monas termo*, is the most imperfect and simplest of the known animals, since its extremely minute body is nothing but a point which is gelatinous and transparent, but contractile. This animal then must be the one with which the animal series begins, when arranged according to the order of nature.

POLYPS.

(Class II. of the Animal Kingdom.)

Gemmiparous animals, with gelatinous, regenerating bodies, and having no internal organ except an alimentary canal with a single aperture.

Terminal mouth, surrounded by radiating tentacles, or furnished with ciliated or rotatory organs. They mostly adhere together, are in communication by their alimentary canal, and then form compound animals.

Observations.

We have seen that the infusorians are infinitely small and fragile animalcules without coherence, without a shape peculiar to their class, without any organs and hence without a distinct mouth and alimentary canal.

In the polyps the simplicity and imperfection of organisation, although very conspicuous, are less than in the infusorians. Organisation has clearly made some progress; for nature has already obtained a permanent and regular shape for the animals for this class; they are all provided with a special organ for digestion, and consequently with a mouth which leads into the alimentary sac.

Imagine a small, elongated gelatinous, highly irritable body, which has at its superior extremity a mouth furnished either with rotatory organs or with radiating tentacles serving as the entrance to an alimentary canal which has no other opening: and we shall have a good idea of a polyp.

Add to this that many of these little bodies become adherent and live together in a common life, and we shall then know the most general and curious fact that concerns them.

The polyps are more imperfect in organisation than the animals of the following classes, since they have no nerves for feeling, no special organs for respiration and no vessels for the circulation of their fluids.

TABLE OF POLYPS.

Order 1.—Rotifer Polyps.

They have ciliated and rotatory organs at their mouths.

Urceolaria.
Brachionus (?).
Vorticella [Infusorian. H. E.].

Order 2.—Polyps which form Polyparies.

[Hydrozoa, Anthozoa, Polyzoa, Sponge, etc. H. E.]

They have radiating tentacles around the mouth, and are fixed in a polypary which does not float upon the waters.

(1) *Polypary membranous or horny, without distinct bark.*

Cristatella.	Cellaria.
Plumatella.	Flustra.
Tubularia.	Cellepora.
Sertularia.	Botryllus [Ascidian. H. E.].

(2) *Polypary with a horny axis, covered with an encrustation.*

Acetabulum [Alga. H. E.].	Alcyon.
Corallina [Alga. H. E.].	Antipathes (black coral).
—	Gorgonia (sea-fan).
Sponge.	

(3) *Polypary with an axis partly or wholly stony, and covered with a bark-like encrustation.*

Isis.
Coral.

(4) *Polypary wholly stony, and without encrustation.*

Tubipora (organ-pipe coral).	Pavonia.
Lunulites.	Meandrina.
Ovulites.	Astrea.
Siderolites.	Madrepora.
Orbulites.	Caryophyllia.
Alveolites.	Turbinolia.
Ocellaria.	Fungia (mushroom-coral).
Eschara.	Cyclolites.
Retepora.	Dactylopora.
Millepora.	Virgularia.
Agaricia.	

Order 3.—Floating Polyps.

A free, elongated, polypary floating in the waters, with a horny or bony axis, covered with flesh that is common to all the polyps; radiating tentacles around the mouth.

Funiculina.	Encrinus [Echinoderm. H. E.].
Veretillum.	Umbellularia.
Pennatula (Sea-pen).	

Order 4.—Naked Polyps.

They have radiating tentacles, often multiple, at the mouth, and form no polypary.

Pedicellaria.	Zoantha.
Coryne.	Actinia (Sea-anemone).
Hydra.	

SECOND STAGE OF ORGANISATION.

No ganglionic longitudinal cord; no circulatory vessels; a few special internal organs (either tubes or pores, which draw in water or kinds of ovaries) in addition to those of digestion.

(*Radiarians and worms.*)

RADIARIANS.

(Class III. of the Animal Kingdom.)

Subgemmiparous animals, free or vagrant; with regenerating bodies and a radiating arrangement of the parts both internal and external and a complex digestive organ; mouth underneath, simple or multiple.

No head, eyes or jointed legs; a few internal organs in addition to those of digestion.

Observations.

This is the third main line of demarcation which has to be drawn in the natural classification of animals.

We here find altogether new forms which, however, belong in general to one type, viz. the radiating arrangement of the parts both internal and external.

We have no longer to deal with animals with elongated bodies, a superior terminal mouth, usually fixed in a polypary, and living together in great numbers which share a common life, but we have to deal with animals whose organisation is more complex than that of the polyps and which are not compound but always free, which have a conformation peculiar to themselves and assume in general the inverted position.

Nearly all the radiarians have tubes which draw in water and appear to be water-bearing tracheae, and in a great many of them are found peculiar bodies resembling ovaries.

From a memoir which I lately heard read at a meeting of the professors of the Museum, I learn that a skilful observer, Dr. Spix, a Bavarian doctor, has discovered the apparatus of a nervous system in star-fishes and sea-anemones.

Dr. Spix affirms that he has seen in the red star-fish, under a tendinous membrane which is suspended over the stomach like a tent, a plexus consisting of whitish nodules and threads, and in addition, at the origin of each arm, two nodules or ganglia communicating together by a thread and giving rise to other threads which go to the neighbouring parts. Among these are two very long ones which traverse the entire length of the arm and send out branches to the tentacles.[1]

According to the observations of this savant there are in each arm two nodules, a short prolongation of the stomach (*caecum*), two hepatic lobes, two ovaries and tracheal canals.

In sea-anemones Dr. Spix observed at the base of these animals below the stomach several pairs of nodules arranged about a centre and communicating together by cylindrical threads. These give rise to others which pass to the upper parts: he found moreover four ovaries surrounding the stomach, from the base of which issue canals which unite together and open at a point within the alimentary cavity.

It is surprising that the apparatus of such complicated organs should have escaped the notice of all those who have studied the organisation of these animals.

If Dr. Spix is correct in what he describes; if he is not mistaken by

[1] [Tube-feet. H. E.]

attributing to these organs a nature and functions that do not really belong to them (as has happened to so many botanists who imagined they saw male and female organs in nearly all the cryptogams), then the following result ensues:

1. That we must no longer refer the beginning of the nervous system to the insects;

2. That this system must be regarded as existing in a rudimentary form in the worms, radiarians and even in the sea-anemone, the last genus of the polyps;

3. That this however is no reason why all the polyps should possess the rudiments of this system; just as it does not follow that because some reptiles have gills, therefore they must all have them;

4. Finally, that the nervous system is none the less a special organ, not common to all living bodies; for, not only is it absent in plants, but it is absent also in some animals. As I have shown the infusorians cannot possibly have it, nor assuredly can it be possessed by the majority of polyps; thus we should seek it in vain in the hydras which belong nevertheless to the first order of polyps, that, namely, which is nearest to the radiarians, since it comprises the sea-anemones.

Thus, whatever truth there may be in the facts named above, the considerations set forth in this work as to the successive formation of the various special organs hold good at whatever point in the animal scale each of these organs begins; and it remains true that the various faculties of animals only take their origin from the existence of the organs underlying them.

TABLE OF RADIARIANS.

Order 1.—Soft Radiarians.

[Various Coelenterates, exclusive of Anthozoa. H. E.]

Bodies gelatinous; soft, transparent skin without jointed spines; no anus.

Stephanomia.	Physsophora.
Lucernaria.	Physalia.
Velella.	Aequorea.
Porpita.	Rhizostoma.
Pyrosoma [Tunicate. H. E.].	Medusa (jelly-fish).
Beroë.	

Order 2.—Echinoderm Radiarians.

Opaque, crustaceous or coriaceous skin, provided with retractile tubercles, or spines articulated on tubercles, and pierced with holes in series.

(1) Stellerides. *Skin not irritable, but mobile; no anus.*
Ophiura (brittle-star).
Asterias (star-fish).

(2) Echinoids. *Skin neither irritable, nor mobile; an anus.*

Clypeaster (cake-urchin).	Galerites.
Cassidites.	Nucleolites.
Spatangus (heart-urchin).	Sea-urchin.
Ananchytes.	

(3) Fistulides. *Elongated body, skin irritable and mobile; an anus.*

Holothuria (sea-cucumber).
Sipunculus [Gephyrean. H. E.].

Remark. *Sipunculus* is an animal very similar to the worms, but its recognised affinities with the holothurians have caused it to be placed among the radiarians, although it has not the characters of that group and must therefore be placed at the end of it.

As a rule, in a thoroughly natural classification the first and last genera of the classes are those in which the standard characters are least pronounced. Since the lines of demarcation are artificial, the genera which are close to these lines display the characters of their class less conspicuously than the others.

WORMS.

(Class IV. of the Animal Kingdom.)

Suboviparous animals with soft elongated bodies, no head, eyes, legs, or bundles of setae; destitute of a circulation, and having a complete, intestinal canal, that is, with two openings.

Mouth consisting of one or several suckers.

Observations.

The general shape of worms is quite different from that of radiarians, and their mouth, which is always formed as a sucker, has no analogy with that of polyps, where there is merely an aperture associated with radiating tentacles or rotatory organs.

The worms in general have an elongated body, very slightly contractile, although quite soft; and as regards their intestine they are no longer limited to a single aperture.

In the fistulide radiarians nature has begun to abandon the radiating structure and to give an elongated shape to the bodies of animals, the only shape which could conduct towards the end she had in view.

After having fashioned the worms, she will henceforth tend to establish a type that is symmetrical as regards parts in pairs. She could not have attained this type except through the type of articulations; but in the somewhat ambiguous class of worms, she has merely sketched out the rudiments of certain features of it.

TABLE OF WORMS.

Order 1.—Cylindrical Worms.

[Nematodes, cestodes, and other flat and round worms. H. E.]

Gordius [Nematode. H. E.].	Cucullanus.
Filaria (guinea-worm).	Strongylus.
Proboscidea [Turbellarian. H. E.].	Scolex [head of tapeworm. H. E.].
Crino.	Caryophyllaeus [Cestode. H. E.].
Ascaris [Nematode. H. E.].	Tentacularia.
Fissula.	Echinorhyncus [Acanthocephala. H. E.].
Trichocephalus [Nematode. H. E.].	

Order 2.—Bladder Worms.

"Bicorne."
Hydatis.

Order 3.—Flat Worms.

Taenia [Cestode. H. E.].	Lingula [doubtless a misprint for Ligula, a Cestode. H. E.].
Linguatula [Arthropod. H. E.].	Fasciola [*v.* Introd. H. E.].

THIRD STAGE OF ORGANISATION.

Nerves terminating in a ganglionic longitudinal cord; respiration by air-carrying tracheae; circulation absent or imperfect.

(*Insects and Arachnids.*)

INSECTS.

(Class V. of the Animal Kingdom.)

Oviparous animals which undergo metamorphoses, which may have wings, and which have in the perfect state six jointed legs, two antennae, two eyes with facets and a horny skin.

Respiration by air-carrying tracheae which spread everywhere; no circulatory system; two distinct sexes; a single copulation in the course of their life.

Observations.

On reaching the insects we find among the extremely numerous animals comprised in this class a state of affairs very different from what we have met with in the animals of the four preceding classes; so instead of a gradual progress in the complexity of animal organisation we find on reaching the insects that a considerable leap has been made.

Here for the first time, animals from the outward aspect exhibit a distinct head; very remarkable, although still imperfect, eyes; jointed legs arranged in two rows; and that symmetrical form of paired and opposed parts that we shall henceforth find employed by nature up to and including the most perfect animals.

On examining the interior of insects, we also see a complete nervous system, consisting of nerves which terminate in a ganglionic longitudinal cord; but although complete, this nervous system is still very imperfect, since the nucleus to which sensations are conveyed appears much broken up, and the senses themselves are few and ill-developed; lastly, we see a true muscular system, and sexes which are distinct but which as in plants can only provide for a single fertilisation.

It is true that we do not yet find any circulatory system; and we shall have to pass higher up the animal chain before we meet with this improvement in organisation.

It is characteristic of all insects to have wings in their perfect state; so that those which have none owe their condition to the fact that their wings have become habitually and permanently aborted.

Observations.

In the table which I shall now give, the number of genera is greatly reduced from what has been hitherto constituted among the animals of this class. Such a reduction appears to me to be required in the interests of study, and also of simplicity and clearness of method. I have not carried it so far as to be detrimental to our knowledge of the animals. If we were to utilise every appreciable peculiarity in the characters of animals and plants for indefinitely multiplying their genera, we should, as I have already said, merely encumber and darken science instead of serving it; we should make the study of it so complicated and difficult that it would only be practicable for those who were willing to devote their entire life to gaining a knowledge of the immense nomenclature and the minute characters selected for marking the distinctions between these animals.

TABLE OF INSECTS.

(A) Sucking Insects.

Their mouth has a sucking-organ with or without a sheath.

Order 1.—Apterous Insects.

A bivalve, three-jointed, proboscis, enclosing a sucking-organ of two setae.

Wings generally abortive in both sexes; larva without legs; pupa motionless, in a cocoon.

Flea.

Order 2.—Dipterous Insects.

An unjointed proboscis, straight or elbowed, sometimes retractile.

Two naked, membranous, veined wings; two balancers; larva worm-like, usually without legs.

Hippobosca (horse-fly).
Oestrus.
—
Stratiomys.
Syrphus (hover-fly).
Anthrax.
Fly.
Tabanus (gad-fly).
Rhagio.
—
Gnat.
—
Stomoxis.
Myopa.
Conops.
Empis.
Bombylus.
Asilus.
Tipula (crane-fly).
Simulium (sand-midge).
Bibio.

Order 3.—Hemipterous Insects.

Sharp, jointed beak, curved under the breast, serving as a sheath for a sucking-tube of three setae.

Two wings hidden under membranous elytra; larva hexapod; the pupa walks and eats.

Dorthesia.
Cochineal insect.
Psylla.
Plant-louse.
Aleyrodes.
Thrips.
—
Cicada.
Fulgora.
Tettigonia.
—
Scutellera.
Pentatoma.
Bed-Bug.
Coraeus.
Reduvius.
Hydrometra.
Gerris.
—
Nepa (water-scorpion).
Notonecta (water-boatman).
Nancoris.
Corixa (water-bug).

Order 4.—Lepidopterous Insects.

Sucking tube in two pieces, without a sheath, resembling a tubular proboscis, and rolled spirally when not in use.

Four membranous wings, covered with coloured and flour-like scales.

Larva with eight to sixteen legs; motionless chrysalis.

(1) *Antennae subulate or setaceous* [moths. H. E.].

Pterophorus.
Orneodes.
Cerastoma.
Tinea.
Noctua.
Phalaena.
Alucita.
Adella [Trichoptera. H. E.].
Pyralis.
—
Hepialus.
Bombyx (silk-worm).

(2) *Antennae swollen at some part of their length.*

Zygoena (burnet-moth).
Butterfly.
Sphinx (hawk-moth).
Sesia (clear-wing).

(B) Biting Insects.

The mouth exhibits mandibles, usually accompanied by maxillae.

Order 5.—Hymenopterous Insects.

Mandibles, and a sucking-tube of three more or less elongated pieces, whose base is enclosed in a short sheath.

Four wings, naked, membranous, veined and unequal; anus of the females armed with a sting or provided with a boring-apparatus; pupa motionless.

(1) *Anus of the females armed with a sting.*

Bee.	Ant.
Monomelites.	Mutilla (solitary ant).
Nomada.	Scolia.
Eucera.	Tiphia.
Andrena.	Bembex.
—	Crabro (digging-wasp).
Wasp.	Sphex.
Polistes.	

(2) *Anus of the females provided with a boring-apparatus.*

Chrysis.	Chalcis.
Oxyurus.	Cinips.
—	Diplolepis.
Leucopsis [Diptera. H. E.].	Ichneumon.
—	Wood-wasp.
Evania.	Oryssus.
Foenus.	Tenthredo (saw-fly).
—	Cimbex (saw-fly).

Order 6.—Neuropterous Insects.

Mandibles and maxillae.

Four wings, naked, membranous and reticulated; abdomen elongated, without sting or boring-apparatus; larva hexapod; metamorphosis variable.

(1) *Pupa motionless.*

Perla.	Hemerobius.
Nemoura.	Ascalaphus.
Caddis-fly.	Myrmeleon.

(2) *Pupa active.*

Nemoptera.	Raphidia.
Panorpa.	Ephemera.
Psocus.	—
Termes (white ant).	Agrion.
—	Aeshna (dragon-fly).
Corydalis.	Libellula (dragon-fly).
Chauliodes.	

Order 7.—Orthopterous Insects.

Mandibles, maxillae and galeae covering the maxillae.

Two straight wings, folded longitudinally, and covered by two almost membranous elytra.

Larva like the perfect insect, but with no wings or elytra; pupa active.

Grasshopper.	Locust.
Acheta.	Truxalis.
—	—
Mantis (praying-insect).	Cricket.
Phasma (stick- and leaf-insects).	Cockroach.
Spectrum.	Earwig.

Order 8.—Coleopterous Insects.

Mandibles and maxillae.

Two membranous wings, folded longitudinally when at rest, under two hard or coriaceous but shorter elytra. Larva hexapod, with a scaly head and no eyes; pupa inactive.

(1) *Two or three segments in all the tarsi.*

Pselaphus.	Lady-bird.
—	Eumorphus.

(2) *Four segments in all the tarsi.*

Erotylus.	Prionus.
Cassida.	Spondilus.
Chrysomela.	—
Galeruca.	Bostrichus.
Crioceris.	Mycetophagus.
Clythra.	Trogossita.
Cryptocephalus.	Cucujus.
—	—
Leptura.	Bruchus (pea-beetle).
Stencorus.	Attelabus.
Saperda.	Brentus.
Necydalis.	Curculio.
Callidium.	Brachycerus [Diptera. H. E.].
Cerambix.	

(3) *Five segments in the tarsi in the first pairs of legs, and four in those of the third pair.*

Opatrum.	Mordella.
Tenebrio (meal-worm beetle).	Rhipiphorus.
Blaps.	Pyrochroa (cardinal-beetle).
Pimelia.	Cossiphus.
Sepidium.	Notoxus.
Scaurus.	Lagria.
Erodius.	Cerocoma.
Chiroscelis.	Apalus.
—	Horia.
Helops.	Mylabris.
Diaperis.	Cantharis.
—	Melöe (oil-beetle).
Cistela.	

(4) *Five segments in all the tarsi.*

Lymexylon.
Telephorus.
Malachius.
Melyris.
Lampyris (glow-worm).
Lycus.
Omalysus.
Drilus.
—
Melasis.
Buprestis.
Click-beetle.
—
Ptilinus.
Death-watch.
Ptinus.
—
Staphylinus (rove-beetle).
Ips.
Dermestes.
Anthrenus.
Byrrhus (pill-beetle).
Hister.
Sphoeridinus.
—
Trox.
Cetonia (rose-chafer).

Oxyporus (rove-beetle).
Poederus (rove-beetle).
—
Cicindela (tiger-beetle).
Elaphrus.
Scarites.
Manticora.
Carabus.
Dyticus (water-beetle).
—
Hydrophilus (water-beetle).
Gyrinus (whirligig-beetle).
Dryops.
Clerus.
—
Necrophorus (burying-beetle).
Carrion-beetle.
Nitidula.
Goliathus.
Cockchafer.
Lethrus.
Geotrupes (dor-beetle).
Copris (dung-beetle).
Scarabaeus (chafer).
Passealus.
Lucanus (stag-beetle).

ARACHNIDS.

(Class VI. of the Animal Kingdom.)

Oviparous animals which have jointed legs throughout their lives and eyes in their head ; they undergo no metamorphosis and never have wings or elytra.

Stigmata and limited tracheae for respiration ; a rudimentary circulation ; several fertilisations in the course of their life.

Observations.

The arachnids, which come after the insects in the order that we have established, display obvious progress in the perfection of organisation.

Sexual reproduction, for instance, is found among them, and for the first time in its full capacity, since these animals copulate and procreate several times in the course of their life; whereas in the insects the sexual organs, like those of plants, can only achieve a

single fertilisation. Moreover, the arachnids are the first animals in which we find a rudimentary circulation, for according to M. Cuvier they have a heart, from the sides of which issue two or three pairs of vessels.

Arachnids live in the air like insects which have attained their perfect state ; but they undergo no metamorphosis, never have wings or elytra (nor is this due to any mere abortion), and they generally keep hidden or live in solitude, feeding on other animals or sucking blood.

In the arachnids, the method of respiration is the same as in the insects, but this method is on the verge of changing ; for the tracheae of arachnids are very limited, and do not extend throughout the body. These tracheae are reduced to a small number of vesicles, as we learn from M. Cuvier again (*Anatom.* vol. iv. p. 419) ; and after the arachnids this method of respiration does not recur in any of the succeeding classes.

This class of animals should be treated with much caution : many of them are venomous, especially those living in hot climates.

TABLE OF ARACHNIDS.

Order 1.—Arachnids with Pedipalps.

No antennae, but only pedipalps ; the head fused with the thorax ; eight legs.

Mygale.
Spider.
Scorpion.
—
Chelifer.
Galeodes.
Harvestman.
Trogulus.
Elais.

Phrynus.
Thelyphonus.
Trombidium.
—
Hydrachna.
Bdella.
Mite.
Nymphon.
Pycnogonum.

Order 2.—Arachnids with Antennae.

[Myriapods and a few insects. H. E.]

Two antennae ; the head distinct from the thorax.

Louse [Hemiptera. H. E.].
Ricinus.
—
Silver-fish [Aptera. H. E.].
Spring-tail.

—
Centipede.
Scutigera.
Julus (millipede).

FOURTH STAGE OF ORGANISATION.

Nerves terminating in a ganglionic longitudinal cord, or in a brain without a spinal cord; respiration by gills; arteries and veins for the circulation.

(Crustaceans, annelids, cirrhipedes and molluscs.)

CRUSTACEANS.

(Class VII. of the Animal Kingdom.)

Oviparous animals with jointed body and limbs, a crustaceous skin, several pairs of maxillae, eyes and antennae in the head.

Respiration by gills; a heart and vessels for circulation.

Observations.

The great changes that we find in the organisation of the animals of this class, indicate that in forming the crustaceans, nature has succeeded in making great progress in animal organisation.

In the first place, the method of respiration is altogether different from that employed in the arachnids and insects; and this method, which is characterised by the organs called gills, continues as far as the fishes. Tracheae will appear no more, and gills themselves disappear as soon as nature can form a cellular lung.

Then again the circulation, of which only rudiments are found in the arachnids, is thoroughly established in the crustaceans; for in them we find a heart and arteries for the dispatch of blood to the various parts of the body, and veins which bring back this fluid to the chief organ which sets it in motion.

We still find in the crustaceans the type of articulations, always used by nature in the insects and arachnids, to facilitate muscular movement by means of the induration of the skin; but hereafter nature abandons this type to establish a system of organisation in which it is no longer required.

Most crustaceans live either in brackish or salt water. Some, however, keep on land and breathe air with their gills: they all feed on animal substances.

TABLE OF CRUSTACEANS.

Order 1.—Sessile-eyed Crustaceans.

Eyes sessile and immovable.

Wood-louse.	Cephaloculus.
Ligia.	Amymone.
Asellus.	Daphnia.
Cyamus (whale-louse).	Lynceus.
Shrimp.	Osole.
Caprella.	Limulus [Apus, not the modern Limulus. H. E.].
—	Caligus.
Cyclops (water-flea).	Polyphemus.
Zoea [Decapod larva. H. E.].	

Order 2.—Stalk-eyed Crustaceans.

Two distinct eyes, raised upon movable stalks.

(1) *Elongated tail, furnished with swimming blades, or hooks or setae.*

Branchiopod.	Pagurus (hermit-crab).
Squilla.	—
Palaemon.	Ranina.
Crangon.	Albunea.
Palinurus (rock-lobster).	Hippa (sand-crab).
Scyllarus.	Corystes.
Galathea.	Porcellana.
Cray-fish.	

(2) *Tail short, without appendages, and applied to the lower surface of the abdomen.*

Pinnotheres.	Dorippe.
Leucosia.	Plagusia.
Arctopsis.	Grapsus.
Maia.	Ocypode.
—	Calappa.
Matuta.	Hepatus.
Orithyia.	Dromia.
Podophthalmus.	Cancer.
Portunus.	

ANNELIDS.

(Class VIII. of the Animal Kingdom.)

Oviparous animals with soft elongated bodies, with transverse rings; they rarely have eyes or a distinct head and are destitute of jointed legs.

Arteries and veins for circulation; respiration by gills; a ganglionic longitudinal cord.

Observations.

We find in the annelids that nature is striving to abandon the type of articulations which she always used in the insects, arachnids and crustaceans. Their soft elongated body, which in most of them simply consists of rings, makes these animals appear as imperfect as the worms with which they used to be confused. Since, however, they have arteries and veins and breathe by gills, these animals are quite distinct from the worms and should be placed with the cirrhipedes between the crustaceans and the molluscs.

They have no jointed legs,[1] and most of them have on their sides setae or bundles of setae which take the place of legs: they nearly all have suckers and feed only on fluid substances.

TABLE OF ANNELIDS.

ORDER 1.—CRYPTOBRANCH ANNELIDS.

Planaria [Triclad. H. E.].	Furia (?).
Leech.	Nais.
Lernea [Copepod. H. E.].	Lumbricus.
Clavella [Copepod. H. E.].	Thalassema.
—	

ORDER 2.—GYMNOBRANCH ANNELIDS.
[Polychaets. H. E.]

Arenicola.	—
Amphinoma.	Terebella.
Aphrodite.	Amphitrite.
Nereis.	Sabellaria.
—	Siliquaria [mollusc. H. E.].
Serpula.	Dentalium [mollusc. H. E.].
Spirorbis.	

CIRRHIPEDES.

(Class IX. of the Animal Kingdom.)

Oviparous and testaceous animals without a head or eyes, but having a mantle which covers the inside of the shell, jointed arms whose skin is horny, and two pairs of maxillae.

Respiration by gills; a ganglionic longitudinal cord; vessels for circulation.

OBSERVATIONS.

Although only a small number of genera belonging to this class are yet known, the character of the animals contained in these genera is so

[1] In order to perfect these animals' organs of locomotion, nature had to abandon the system of jointed legs, which are independent of a skeleton, and to establish the system of four limbs depending on an internal skeleton, which is characteristic of the most perfect animals; this is what she has done in the annelids and molluscs, where she has paved the way for commencing with the fishes the type of organisation peculiar to vertebrates. Thus in the annelids she has abandoned jointed legs, and in the molluscs she has gone still farther,—she has discarded the use of a ganglionic longitudinal cord.

singular that we have to set them apart as constituting a special class.

Seeing that the cirrhipedes have a shell, a mantle and no head or eyes they cannot be crustaceans; their jointed arms prevent us from placing them among the annelids, and their ganglionic longitudinal cord does not allow us to unite them with the molluscs.

TABLE OF CIRRHIPEDES.

Tubicinella.	Balanus.
Coronula.	Anatifa.

Remark. We see that the cirrhipedes still resemble the annelids by their ganglionic longitudinal cord; but in these animals nature is preparing to form the molluscs, since they have like them a mantle covering the inside of their shell.

MOLLUSCS.

(Class X. of the Animal Kingdom.)

Oviparous animals with soft unjointed bodies, and having a variable mantle.

Respiration by very diversified gills; no spinal cord, nor ganglionic longitudinal cord, but nerves terminating in an imperfect brain.

The majority are enclosed in a shell; others have one that is more or less completely embedded within them, and others again have none at all.

OBSERVATIONS.

The molluscs are the most highly organised of invertebrates; that is to say, their organisation is the most complex and the nearest to that of the fishes.

They constitute a numerous class which terminates the invertebrates, and which is sharply distinguished from the other classes by the fact that the animals composing it are the only ones which, although having a nervous system like many others, have neither a ganglionic longitudinal cord nor a spinal cord.

Nature is here about to begin the formation of the system of organisation of the vertebrates; and appears to be preparing for the change. Hence the molluscs, which have altogether lost the type of articulations, and the support given by a horny skin to animals belonging to this type, are very slow in their movements and appear in this respect even more imperfectly organised than the insects.

Finally, since the molluscs constitute a link between the invertebrates and the vertebrates, their nervous system is intermediate, and exhibits neither the ganglionic longitudinal cord of the invertebrates which have nerves, nor the spinal cord of the vertebrates. This is highly characteristic of them, and clearly distinguishes them from the other invertebrates.

TABLE OF MOLLUSCS.

Order 1.—Acephalic Molluscs.

[First group, *Brachiopods*; last group, *Tunicates*; the rest, *Lamellibranchs*. H. E.]

No head; no eyes; no organ of mastication; they reproduce without copulation. The majority have a shell with two valves which articulate at a hinge.

Brachiopods.

Lingula.
Terebratula.
Orbicula.

Ostracians.

Radiolites.	Oyster.
Calceola.	Gryphaea.
Crania [Brachiopod. H. E.].	Plicatula.
Anomia.	Spondylus.
Placuna.	Pecten.
Vulsella.	

Byssifera.

Pedum.	Crenatula.
Lima.	Perna.
Pinna.	Malleus.
Mytilus (mussel).	Avicula.
Modiola (?).	

Chamaceans.

Etheria.	Corbula.
Chama.	Pandora.
Diceras.	—

Naiads.

Unio (fresh-water mussel).
Anodonta.

Arcaceans.

Nucula.	Cucullaea.
Petunculus.	Trigonia.
Arca.	—

Cardiads.

Tridacna.	Isocardia.
Hippopus.	Cardium (cockle).
Cardita.	

Conchs.

Venericardia.	Lucinia.
Venus.	Cyclas.
Cytherea.	Galathea.
Donax.	Capsa.
Tellina.	

Mactraceans.

Erycina.	Lutraria.
Ungulina.	Mactra.
Crassatella.	—

Myarians.

Mya.
Panorpa.
Anatina.

Solenaceans.

Glycimeris.	Petricola.
Solen.	Rupellaria.
Sanguinolaria.	Saxicava.

Pholadarians (Boring-mussels).

Pholas.	Aspergillum.
Teredo.	—
Fistulana.	

Ascidians.

Ascidia.
Salpa.
Mammaria.

Order 2.—Cephalic Molluscs.

A distinct head and eyes, and two or four tentacles in the majority, jaws or a proboscis at the mouth; reproduction by copulation.

The shell of those, which have one, never consists of two valves articulated at a hinge.

(1) *Pteropods.*

Two opposite, swimming fins.

Hyalea.
Clio.
Pneumoderma.

(2) *Gastropods.*

(A) *Straight body, united to the foot throughout the whole or nearly the whole of its length.*

Tritonians.

Glaucus.	Tritonia.
Aeolis.	Tethys.
Scyllaea.	Doris.

Phyllidians.

Pleurobranchus.	Patella (limpet).
Phyllidia.	Fissurella.
Chiton.	Emarginula.

Laplysians.

Laplysia (sea-hare).	Bullaea.
Dolabella.	Sigaretus.

Limacians.

Onchidium.	Vitrina (glass-snail).
Limax (slug).	Testacella.
Parmacella.	—

(B) *Body spiral ; no syphon.*

Colymaceans.

Helix (snail).	Amphibulimus.
Helicina.	Achatina.
Bulimus.	Pupa.

Orbaceans.

Cyclostoma.	Planorbis.
Vivipara [Paludina. H. E.].	Ampullaria.

Auriculaceans.

Auricula.	Melania.
Melanopsis.	Limnaea.

Neritaceans.

Neritina.	Nerita.
Navicella.	Natica.

Stomataceans.

Haliotis.
Stomatia.
Stomatella.

Turbinaceans.

Phasianella.	Scalaria.
Turbo.	Turritella.
Monodonta.	Vermicularia (?).
Delphinula.	

Heteroclites.

Volvaria.
Bulla.
Janthina.

Calyptraceans.

Crepidula.	Solarium.
Calyptraea.	Trochus.

(C) *Body spiral : a syphon.*

Canalifera.

Cerithium.	Pyrula.
Pleurotoma.	Fusus.
Turbinella.	Murex.
Fasciolaria.	

Wing-shells.

Rostellaria.
Pteroceras.
Strombus.

Purpuraceans.

Cassis (helmet-shell).	Buccinum (whelk).
Harpa (harp-shell)	Concholepas.
Dolium (tun).	Monoceros.
Terebra (auger-shell).	Purpura.
Eburna.	Nassa.

Columellarians.

Cancellaria.	Mitra (mitre-shell).
Marginella.	Voluta.
Columbella.	

Convolutes.

Ancilla [Ancillaria. H. E.].	Ovula.
Oliva (olive-shell).	Cypraea (cowry).
Terebellum.	Conus (cone-shell).

(3) *Cephalopods.*

(A) *With multilocular test.*

Lenticulaceans. [Foraminifera. H. E.]

Miliola.	Discorbina.
Gyrogonita.	Lenticulina.
Rotalia.	Nummulites.
Renulites.	

Lituolaceans.

Lituola, Spirolinites } [Foraminifera. H. E.].	Orthoceras [Cephalopod. H. E.].
	Hippurites [Lamellibranch. H. E.].
Spirula [Cephalopod. H. E.].	Belemnites [Cephalopod. H. E.].

Nautilaceans.

Baculites.	Ammonites.
Turrilites.	Orbulites.
Ammonoceras.	Nautilus.

(B) *With unilocular test.*

Argonautaceans.

Argonauta.
Carinaria [Gastropod. H. E.].

(C) *Without test.*

Sepiated.

Octopus.
Calamary.
Cuttle-fish.

VERTEBRATE ANIMALS.

They have a vertebral column consisting of a number of short articulated bones following one another in succession. This column serves to support their body, it is the basis of their skeleton, constitutes a sheath for their spinal cord, and terminates anteriorly in a bony case containing the brain.

FIFTH STAGE OF ORGANISATION.

Nerves terminating in a spinal cord and a brain which does not fill up the cavity of the cranium; heart with one ventricle and cold blood.

(*Fishes and Reptiles.*)

FISHES.

(Class XI. of the Animal Kingdom.)

Oviparous vertebrate animals with cold blood; living in water, breathing by gills, covered with a skin either scaly or almost naked and slimy, and having for their locomotive movements only membranous fins supported by a bony or cartilaginous framework.

Observations.

The organisation of the fishes is much more perfect than that of the molluscs and animals of the anterior classes, since they are the first animals to have a vertebral column, the rudiments of a skeleton, a spinal cord and a cranium enclosing the brain. They are also the first in which the muscular system derives its support from internal parts.

Nevertheless their respiratory organs are still analogous to those of the molluscs, cirrhipedes, annelids and crustaceans; and like all the animals of the preceding classes, they are still without a voice and have no eyelids.

The shape of their body is adapted to their necessity for swimming; but they maintain the symmetrical shape of paired parts started in the insects; lastly, among them as among the animals of the three following classes, the type of articulations is altogether internal, and only occurs in the parts of their skeleton.

N.B.—In the preparation of the tables of vertebrate animals I have used M. Duméril's work entitled *Zoologie Analytique*, and I have permitted myself to make but few changes in his arrangement.

TABLE OF FISHES.

Order 1.—Cartilaginous Fishes.

Vertebral column soft and cartilaginous; no true ribs in a great number.

(1) *No operculum over the gills, and no membrane.*

Trematopneans. [Hole-breathing. H. E.]
Respiration through round holes.

1. *Cyclostomes.*

Gasterobranchus (hagfish, myxine).
Lamprey.

2. *Plagiostomes.*

Torpedo.
Skate.
Rhinobatus.
Squatina (angel-fish).
Squalus.
Aodon.

(2) *No operculum over the gills, but a membrane.*

Chismopneans. [Cleft-breathing. H. E.]
Gills opening by clefts at the sides of the neck; four paired fins.

3. ....

Batrachus [Teleost. H. E.].
Lophius (frog-fish) [Teleost. H. E.].
Balistes [Teleost. H. E.].
Chimaera [Elasmobranch. H. E.].

(3) *An operculum over the gills, but no membrane.*

Eleutheropomes. [Free operculum. H. E.]
Four paired fins; mouth under the snout.

4. ....

Polyodon [Ganoid. H. E.].
Pegasus [Teleost. H. E.].
Accipenser (sturgeon) [Ganoid. H. E.].

(4) *An operculum and a membrane over the gills.*

Teleobranchs. [Complete gills. H. E.]
[Teleosts. H. E.]
Gills complete, with an operculum and a membrane.

5. *Aphyostomes.* [Sucking-mouth. H. E.]

Macrorhyncus.
Solenostoma.
Centriscus (snipe-fish).

6. *Pteroptera.* [United fins. H. E.]

Cyclopterus (lump-sucker).
Lepadogaster.

7. *Osteoderms.* [Bony skin. H. E.]

Ostracion (copper-fish).
Tetraodon (globe-fish).
Ovoides.
Diodon (porcupine-fish).
Spherodon.
Syngnathus.

ORDER 2.—BONY FISHES.

Vertebral column with bony vertebrae, that are not flexible.

(1) *An operculum and membrane over the gills.*

Holobranchs. [Complete gills. H. E.]

Apode Holobranchs.

No inferior paired fins. [Eel-shaped. H. E.]

8. *Peropterous holobranchs.* [Finless. H. E.]

Coecilia [Amphibian. H. E.].
Monopterus.
Leptocephalus [immature eel. H. E.].
Gymnotus (Electric eel).
Trichiurus.
Notopterus.
Ophisurus.
Apteronotus.
Regalecus.

9. *Pantopterous Holobranchs.* [With all unpaired fins. H. E.]

Muraena (eel).
Ammodytes (sand-eel).
Ophidium.
Macrognathus.
Xiphias (sword-fish).
Anarrhichas (sea-wolf).
Comephorus.
Stromataeus.
Rhombus.

Jugular Holobranchs.

Inferior paired fins situated under the throat, or in front of thoracic fins.

10. *Auchenopterous Holobranchs.* [Fins on neck. H. E.]

Murenoid.
Calliomorus.
Uranoscopus.
Weever.
Cod.
Batrachoides.
Blenny.
Oligopod.
Kurtus.
Chrysostrome.

Thoracic Holobranchs.

Inferior paired fins situated under the pectorals.

11. *Petalosome Holobranchs.* [Blade shaped. H. E.]

Lepidopus.
Cepola (band-fish).
Taenioid.
Bostrichthys.
Bostrichoid.
Gymnetrus.

12. *Plecopod Holobranchs.* [Inferior fins united. H. E.]

Gobius (goby).
Gobioid.

13. *Eleutheropod Holobranchs.* [Inferior fins free. H. E.]

Gobiomore.
Gobiomoroid.
Echeneis.

14. *Atractosome Holobranchs.* [Spindle-shaped. H. E.]

Scomber (mackerel).
Scomberoid.
Caranx (horse-mackerel).
Trachinote.
Caranxomorus.
Caesio.
Caesiomorus.
Scomberomorus.
Gasterosteus (stickleback).
Centropodus.
Centronotus.
Cephalacanthus.
Istiophorus.
Pomatomus.

15. *Leiopome Holobranchs.* [Smooth-operculed. H. E.]

Hiatula.
Coris (rainbow wrasse).
Gomphosus.
Osphronemus.
Trichopod.
Monodactyl.
Plectorhyncus.
Pogonias.
Labrus (wrasse).
Chilinus.
Cheilodipteron.
Ophiocephalus.
Hologymnosa.
Sparus.
Dipterodon.
Cheilio.
Mullet.

16. *Osteostome Holobranchs.* [Bony-mouthed. H. E.]

Scarus.
Ostorhincus.
Leiognathus.

17. *Lophionotous Holobranchs.* [Crested-back. H. E.]

Coryphaena.
Emipteronota.
Coryphaenoid.
Taenionotus.
Centrolophus.
Eques.

18. *Cephalotous Holobranchs.* [Large-headed. H. E.]

Gobiesox.
Aspidophora.
Aspidophoroides.
Cottus.
Scorpaena (scorpion-fish).

19. *Dactylous Holobranchs.* [Pectorals in distinct rays, like fingers. H. E.]

Dactylopterus.
Prionotus.
Trigla (gurnard).
Peristedion.

20. *Heterosomatous Holobranchs.* [Irregular-shaped. H. E.]

Pleuronectes.
Achirus.

21. *Acanthapome Holobranchs.* [Spiny opercula. H. E.]

Lutjanus.
Centropomus.
Bodianus.
Taenianotus.
Sciaena.
Micropterus (black bass).
Holocentrum.
Perca (perch).

22. *Leptosome Holobranchs.* [Slender-bodied. H. E.]

Chetodon.	Chetodipteron.
Acanthinion.	Pomacentrus.
Pomadasis.	Acanthopod.
Pomacanthus.	Selene.
Holacanthus.	Argyriosus.
Enoplosus.	Zeus.
Glyphisodon.	Galeoides.
Acanthurus.	Chrysostose.
Aspisurus.	Capros (boar-fish).

Abdominal Holobranchs.

Inferior paired fins placed a little in front of the anus.

23. *Siphonostome Holobranchs.* [Tube-like mouths. H. E.]

Fistularia.
Aulostoma.
Solenostoma.

24. *Cylindrosome Holobranchs.* [Cylindrical. H. E.]

Cobitis.	Amia [Ganoid. H. E.].
Misgurnus.	Butirinus.
Anableps.	Tripteronotus.
Fundulus.	Ompolk.
Colubrine.	

25. *Oplophore Holobranchs.* [Armed. H. E.] [Catfishes. H. E.]

Silurus.	Ageniosus.
Macropteronotus.	Macrorhamphosus (snipe-fish).
Malapterurus.	
Pimelodus.	Centranodon.
Doras.	Loricaria.
Pogonathus.	Hypostome.
Cataphractus.	Corydoras.
Plotosus.	Tachysurus.

26. *Dimerid Holobranchs.* [Two-membered. H. E.]

Cirrhites.	Polynemus.
Cheilodactylus.	Polydactylus.

27. *Lepidome Holobranchs.* [Scaly opercula. H. E.]

Mugil (grey mullet).	Chanos.
Mugiloid.	Mugilomorus.

28. *Gymnopome Holobranchs.* [Naked opercula. H. E.]

Argentina.	Clupanodon.
Atherina.	Gasteropleucus.
Hydrargyrus.	Mene.
Stolephorus.	Dorsuaria.
Buro.	Xystera.
Clupea (herring).	Cyprinus (carp).
Mystus.	

29. *Dermopterous Holobranchs.* [Skin-fins. H. E.]

Salmo., Osmerus (smelt)., Corregonus. } [Salmonidae. H. E.]

Characinus., Serrasalmo. } [Characinidae. H. E.]

30. *Siagonote Holobranchs.* [Long-jawed. H. E.]

Elops.	Sphyraena.
Megalops (tarpon).	Lepisosteus.
Esox.	Polypterus [Ganoid. H. E.].
Synodon.	Scombresox.

(2) *An operculum over the gills, but no membrane.*

Sternoptyges. [Bent sternum. H. E.]

31. . . . .

Sternoptyx.

(3) *No operculum over the gills, but a membrane.*

Cryptobranchs. [Gills hidden. H. E.]

32. . . . .

Mormyrus.
Stylophorus.

(4) *No operculum nor membrane over the gills: no inferior paired fins.*

Ophichthians. [Snake-fishes. H. E.]

33. . . . .

Unibranch aperture.	Murenophis.
Sphagebranchus.	Gymnomuraena.

Remark. Seeing that the formation of a skeleton begins in the fishes, those called cartilaginous are probably the least perfect fishes. Consequently the most imperfect of all should be Gasterobranchus, which Linnæus, under the name of *myxine*, had regarded as a worm.

Thus, in the order that we are following, the genus Gasterobranchus must be the first of the fishes, because it is the least perfect.

REPTILES.

(Class XII. of the Animal Kingdom.)

Oviparous vertebrate animals with cold blood; breathing incompletely by a lung, at all events in later life; and having the skin smooth or else covered either with scales or with a bony shell.

Observations.

Progress in the perfection of organisation is seen to be very remarkable in the reptiles when they are compared with fishes; for it is among them that we find lungs for the first time, and we know that it is the most perfect respiratory organ since it is the same as that of man; but it is still only rudimentary and indeed some reptiles do not have it in early life: as a matter of fact they only breathe incompletely, for it is only a part of the blood that passes through the lung.

It is also among them that for the first time we distinctly see the four limbs, which are included in the plan of the vertebrates and are appendages of the skeleton.

TABLE OF REPTILES.

Order 1.—Batrachian Reptiles [Amphibians. H. E.].

Heart with one auricle: skin naked: two or four legs: gills during immaturity: no copulation.

Urodela.

Siren.	Triton.
Proteus.	Salamander.

Anura.

Tree-frog.	Pipa.
Frog.	Toad.

Order 2.—Ophidian Reptiles (or Snakes).

[Snakes and Apodal Lizards. H. E.]

Heart with one auricle: elongated narrow body without legs or fins: no eyelids.

Homoderms.

Coecilia [Amphibian. H. E.].	Ophisaurus.
Amphisboena.	Slow-worm.
Acrochordus.	Hydrophis (sea-snake).

Heteroderms.

Crotalus.	Erix.
Scytale.	Viper.
Boa.	Coluber.
Erpeton.	Platurus.

Order 3.—Saurian Reptiles.

[Legged Lizards and Crocodiles. H. E.]

Double-auricled heart; body scaly and having four legs; claws on the digits; teeth in the jaws.

Tereticauds [Round-tailed. H. E.].

Chalcides.	Agama.
Scincus.	Lacerta.
Gecko.	Iguana.
Anolis.	Stellio.
Dragon.	Chamaeleon.

Planicauds [Flat-tailed. H. E.].

Uroplates.	Lophura.
Tupinambis.	Dracaena.
Basiliscus.	Crocodile [Crocodilia. H. E.].

Order 4.—Chelonian Reptiles.

Double-auricled heart; body with a carapace and four legs; jaws without teeth.

Chelonia.	Emys.
Chelys.	Tortoise.

SIXTH STAGE OF ORGANISATION.

Nerves terminating in a spinal cord, and in a brain which fills up the cavity of the cranium; heart with two ventricles and warm blood.

(*Birds and Mammals.*)

BIRDS.

(Class XIII. of the Animal Kingdom.)

Oviparous vertebrate animals with warm blood; complete respiration by adherent and pierced lungs; four jointed limbs, two of which are shaped as wings; feathers on the skin.

Observations.

Assuredly birds have a more perfect organisation than reptiles or any other animals of the preceding classes, since they have warm blood, a heart with two ventricles, and their brain fills up the cavity of the cranium,—characters which they have in common only with the most perfect animals composing the final class.

Yet the birds are clearly only the penultimate step of the animal scale; for they are less perfect than the mammals, in that they are still oviparous, have no mammae, are destitute of a diaphragm, a bladder, etc., and have fewer faculties.

In the following table it may be noticed that the first four orders include birds whose young can neither walk nor feed themselves, when they are hatched; and that the last three orders, on the other hand, comprise birds whose young walk and feed themselves as soon as they come out of the egg; finally, the 7th order, that of the palmipeds seems to me to contain those birds which are most closely related to the first animals of the following class.

TABLE OF BIRDS.

ORDER 1.—CLIMBERS.

Two digits in front, and two behind.

Levirostrate Climbers. [Slender-billed. H. E.]

Parrot.	Touraco.
Cockatoo.	Trogon.
Macaw.	Musophaga (plantain-eater).
Puff-bird.	Toucan.

Cuneirostrate Climbers. [Wedge-shaped beaks. H. E.]

Woodpecker.	Ani.
Wryneck.	Cuckoo.
Jacamar.	

ORDER 2.—BIRDS OF PREY.

A single digit behind; anterior digits entirely free; beak and claws hooked.

Nocturnal Birds of Prey.

Owl.
Eagle-owl.
Surnia.

Bare-necked Birds of Prey.

Condor.
Vulture.

Feather-necked Birds of Prey.

Griffon.	Buzzard.
Secretary-bird.	Goshawk.
Eagle.	Falcon.

ORDER 3.—PASSERES.

A single digit behind; the two front external ones united; tarsus of medium height.

Crenirostrate Passeres. [Notched beaks. H. E.]

Tanagra.	Ampelis (wax-wing, etc.).
Shrike.	Thrush.
Flycatcher.	

Dentirostrate Passeres. [Tooth-beaked. H. E.]

Hornbill.
Motmot.
Phytotoma (plant-cutter).

Plenirostrate Passeres. [Full-beaked. H. E.]

Grackle.	Crow.
Bird of Paradise.	Pie.
Roller.	

Conirostrate Passeres. [Conical beaks. H. E.]

Ox-pecker.	Crossbill.
Glaucopis.	Grosbeak.
Oriole.	Colius (mouse-bird).
Cacicus.	Finch.
Starling.	Bunting.

Subulirostrate Passeres. [Subulate beaks. H. E.]

Mannakin.	Lark.
Titmouse.	Wagtail.

Planirostrate Passeres. [Flat-beaked. H. E.]

Martin.
Swallow.
Nightjar.

Tenuirostrate Passeres. [Slender-billed. H. E.]

Kingfisher.	Bee-eater.
Tody.	Humming-bird.
Nuthatch.	Creeper.
Orthorincus.	Hoopoe.

ORDER 4.—COLUMBAE.

Soft, flexible beak, flattened at the base; brood of two eggs.

Pigeon.

ORDER 5.—GALLINACEANS.

Solid, horny beak, rounded at the base; brood of more than two eggs.

Alectride Gallinaceans. [Fowl-like. H. E.]

Bustard.	Guinea-fowl.
Peacock.	Curassow.
Tetras.	Penelope.
Pheasant.	Turkey.

Brachypterous Gallinaceans. [Short-winged. H. E.]

Dodo.	Rhea.
Cassowary.	Ostrich.

ORDER 6.—WADERS.

Tarsus very long, and denuded of feathers as far as the leg; external digits united at their base (waterside birds).

Pressirostrate Waders. [Narrow-beaked. H. E.]

Jacana.	Moorhen.
Rail.	Coot.
Oyster-catcher.	

Cultrirostrate Waders. [Cutting-beaked. H. E.]

Bittern.	Crane.
Heron.	Mycteria.
Stork.	Tantalus.

Teretirostrate Waders. [Round-beaked. H. E.]

Avocet.	Dunlin.
Curlew.	Plover.
Woodcock.	

Latirostrate Waders. [Broad-beaked. H. E.]

Boatbill.
Spoonbill.
Phoenicopterus (flamingo).

ORDER 7.—PALMIPEDS.

Digits united by large membranes; tarsus of low height (Aquatic birds, swimmers).

Penniped Palmipeds. [Fin-footed. H. E.]

Anhinga.	Frigate-bird.
Phaëton.	Cormorant.
Gannet.	Pelican.

Serrirostrate Palmipeds. [Serrated beaks. H. E.]

Merganser.
Duck.
Flamingo.

Longipen Palmipeds. [Long-winged. H. E.]

Gull.	Avocet.
Albatross.	Tern.
Petrel.	Scissor-bill.

Brevipen Palmipeds. [Short-winged. H. E.]

Grebe.	Penguin.
Guillemot.	King-penguin.
Auk.	

MONOTREMES. (Geoff.)

Animals intermediate between birds and mammals. These animals are quadrupeds without mammae, without any teeth inserted, without lips, and with only one orifice for the genital organs, the excrement and the urine; their body is covered with hair or bristles.

ORNITHORHYNCHUS.
ECHIDNA.

N.B.—I have already spoken of these animals in Chapter VI., page 74, where I showed that they are neither mammals, birds nor reptiles.

MAMMALS.

(Class XIV. of the Animal Kingdom.)

Viviparous animals with mammae; four jointed legs or only two; complete respiration by lungs, not pierced through externally; hair on parts of the body.

OBSERVATIONS.

Nature clearly proceeds from the simplest to the most complex in her operations on living bodies; hence the mammals necessarily constitute the last class of the animal kingdom.

This class undoubtedly comprises the most perfect animals, with the greatest number of faculties, the highest intelligence and, lastly, the most complex organisation.

Since the organisation of these animals approaches most nearly to that of man they display a more perfect combination of senses and faculties than any others. They are the only ones that are really viviparous, and have mammae to suckle their young.

The mammals thus exhibit the highest complexity of animal organisation, and the greatest perfection and number of faculties that nature could confer on living bodies by means of that organisation. They should thus be placed at the end of the immense series of existing animals.

TABLE OF MAMMALS.

ORDER 1.—EXUNGULATE MAMMALS.

Two limbs only: they are anterior, short, flattened, suitable for swimming, and have neither claws nor hoofs.

Cetaceans.

Right-whale.	Narwhal.
Rorqual.	Anarnak.
Physale.	Delphinapterus.
Cachalot.	Dolphin.
Sperm-whale.	Hyperodon.

ORDER 2.—AMPHIBIAN MAMMALS.

Four limbs: the two anterior short, fin-like, with unguiculate digits; the posterior directed backwards, or united with the extremity of the body, which is like a fish's tail.

Seal, Walrus } [Pinnipeds. H. E.].	Dugong, Manatee } [Sirenia. H. E.].

Observation.

This order is only placed here, on account of the general shape of the animals it contains. (See my observation, p. 74.)

ORDER 3.—UNGULATE MAMMALS.

Solipeds.

Horse.

Ruminants or Bisulcates.

Ox.	Deer.
Antelope.	Giraffe.
Goat.	Camel.
Sheep.	Musk-deer.

Pachiderms.

Rhinoceros.	Pig.
Hyrax.	Elephant.
Tapir.	Hippopotamus.

ORDER 4.—UNGUICULATE MAMMALS.

Four limbs; flattened or pointed nails at the extremity of their digits, which do not envelop them.

Tardigrades.

Sloth [Edentate H. E.].

Edentates.

Ant-eater.	Aardvark.
Pangolin.	Armadillo.

Rodents.

Kangaroo [Marsupial. H. E.].	Spalax.
Hare.	Squirrel.
Coendu.	Dormouse.
Porcupine.	Hamster.
Aye-aye [Lemur. H. E.].	Marmot.
Phascolomys [Marsupial. H. E.].	Vole.
Hydromys (Australian Water-rat).	Musk-rat.
Beaver.	Rat.
Cavy.	

Pedimana [Marsupials. H. E.].

Opossum.	Wombat.
Bandicoot.	Coescoës.
Dasyurus.	Phalanger.

Plantigrades.

Mole [Insectivore. H. E.].	Badger [Carnivore. H. E.].
Shrew [Insectivore. H. E.].	Coati [Carnivore. H. E.].
Bear [Carnivore. H. E.].	Hedgehog [Insectivore. H. E.].
Kinkajou [Carnivore. H. E.].	Tenrec [Insectivore. H. E.].

Digitigrades. [All carnivores. H. E.].

Otter.	Cat.
Mongoose.	Civet.
Skunk.	Hyaena.
Weasel.	Dog.

Chiroptera.

Galeopithecus [Insectivore. H. E.].	Noctilio.
Rhinolophus.	Bat.
Phyllostome.	Flying Fox.

Quadrumana.

Galago, Tarsius, Loris, Makis, Indris } [Lemurs. H. E.].	Baboon. Sapajou. Cebus. African Baboon. Pongo.
Guenon (Old-world Monkey).	Orang.

Remark. According to the order which I have adopted, the quadrumanous family comprises the most perfect of known animals, and especially the later genera of this family; and as a matter of fact the genus orang (*Pithecus*) is at the end of the entire order, just as the monas is at the beginning of it. How great is the difference in organisation and faculties between these two genera!

Naturalists who have considered man exclusively according to the affinities of his organisation, have formed a special genus for him with six known varieties, thus making him a separate family which they have described in the following manner.

BIMANA.

Mammals with differentiated unguiculate limbs; with three kinds of teeth and opposable thumbs on the hands only.

MAN.

Varieties.
- Caucasian.
- Hyperborean.
- Mongolian.
- American.
- Malayan.
- Ethiopian or Negro.

This family has received the name of Bimana, because in man it is only the hands that have a separate thumb opposite to the fingers while in the Quadrumana the hands and feet have the same character as regards the thumb.

Some Observations with regard to Man.

If man was only distinguished from the animals by his organisation, it could easily be shown that his special characters are all due to long-standing changes in his activities and in the habits which he has adopted and which have become peculiar to the individuals of his species.

As a matter of fact, if some race of quadrumanous animals, especially one of the most perfect of them, were to lose, by force of circumstances or some other cause, the habit of climbing trees and grasping the branches with its feet in the same way as with its hands, in order to hold on to them; and if the individuals of this race were forced for a series of generations to use their feet only for walking, and to give up using their hands like feet; there is no doubt, according to the observations detailed in the preceding chapter, that these quadrumanous animals would at length be transformed into bimanous, and that the thumbs on their feet would cease to be separated from the other digits, when they only used their feet for walking.

Furthermore, if the individuals of which I speak were impelled by the desire to command a large and distant view, and hence endeavoured to stand upright, and continually adopted that habit from generation to generation, there is again no doubt that their feet would gradually acquire a shape suitable for supporting them in an erect attitude; that their legs would acquire calves, and that these animals would then not be able to walk on their hands and feet together, except with difficulty.

Lastly, if these same individuals were to give up using their jaws as weapons for biting, tearing or grasping, or as nippers for cutting grass and feeding on it, and if they were to use them only for mastication; there is again no doubt that their facial angle would become larger, that their snout would shorten more and more, and that finally it would be entirely effaced so that their incisor teeth became vertical.

Let us now suppose that a quadrumanous race, say the most perfect, acquired through constant habit among all its individuals the conformation just described, and the faculty of standing and walking upright, and that ultimately it gained the supremacy over the other races of animals, we can then easily conceive:

1. That this race having obtained the mastery over others through the higher perfection of its faculties will take possession of all parts of the earth's surface, that are suitable to it;

2. That it will drive out the other higher races, which might dispute with it the fruits of the earth, and that it would compel them to take refuge in localities which it does not occupy itself;

3. That it will have a bad effect on the multiplication of allied races, and will keep them exiled in woods or other deserted localities, that it will thus arrest the progress of their faculties towards perfection; whereas being able itself to spread everywhere, to multiply without obstacle from other races and to live in large troops, it will create successively new wants, which will stimulate its skill and gradually perfect its powers and faculties;

4. Finally, that this predominant race, having acquired an absolute supremacy over all the rest, will ultimately establish a difference between itself and the most perfect animals, and indeed will leave them far behind.

The most perfect of the quadrumanous races might thus have become dominant; have changed its habits as a result of the absolute sway exercised over the others, and of its new wants; have progressively acquired modifications in its organisation, and many new faculties; have kept back the most perfect of the other races to the condition that they had reached; and have wrought very striking distinctions between these last and themselves.

The orang of Angola (*Simia troglodytes*, Lin.) is the most perfect of animals: it is much more perfect than the orang of the Indies (*Simia satyrus*, Lin.), called the orang-outang; yet they are both very inferior to man in bodily faculties and intelligence.[1] These animals often stand upright; but as that attitude is not a confirmed habit, their organisation has not been sufficiently modified by it, so that the standing position is very uncomfortable for them.

We know from the stories of travellers, especially as regards the orang of the Indies, that when it has to fly from some pressing danger it immediately falls on to its four feet. Thus, it is said, the true origin of this animal is disclosed, since it is obliged to abandon a deceptive attitude that is alien to it.

No doubt this attitude is alien to it, since it adopts it less when moving about, and its organisation is hence less adapted to it; but does it follow that, because the erect position is easy to man, it is therefore natural to him?

Although a long series of generations has confirmed the habit of moving about in an upright position, yet this attitude is none the less a tiring condition in which man can only remain for a limited period, by means of the contraction of some of his muscles.

If the vertebral column were the axis of the human body, and kept the head and other parts in equilibrium, man would be in a position of rest when standing upright. Now we all know that this is not the case; that the head is out of relation with the centre of gravity; that the weight of the chest and belly, with their contained viscera, falls almost entirely in front of the vertebral column; that the latter has a slanting base, etc. Hence it is necessary as M. Richerand observes, to keep a constant watch when standing, in order to avoid

[1] See in my *Recherches sur les corps vivants*, p. 136, some observations on the orang of Angola.

the falls to which the body is rendered liable by the weight and arrangement of its parts.

After discussing the questions with regard to the erect position of man, this observer expresses himself as follows: "The relative weight of the head, and of the thoracic and abdominal viscera, gives a forward inclination to the axial line of the body, as regards the plane on which it rests; a line which should be exactly perpendicular to this plane, if standing is to be perfect. The following fact may be cited in support of this assertion: I have observed that children, among whom the head is bulky, the belly protruding and the viscera burdened with fat, find it difficult to get accustomed to standing upright; it is only at the end of their second year that they venture to trust their own strength; they continue liable to frequent falls and have a natural tendency to adopt the position of a quadruped" (*Physiologie*, vol. ii., p. 268).

This arrangement of parts, as a result of which the erect position is a tiring one for man, instead of being a state of rest, would disclose further in him an origin analogous to that of the other mammals, if his organisation alone were taken into consideration.

In order to follow out the hypothesis suggested at the beginning of these observations, some further considerations must now be added.

The individuals of the dominant race in question, having seized all the places of habitation which were suitable to them and having largely increased their needs according as the societies which they formed became larger, had to multiply their ideas to an equivalent extent, and thus felt the need for communicating them to their fellows. We may imagine that this will have compelled them to increase and vary in the same degree the signs which they used for communicating these ideas; hence it is clear that the individuals of this race must have made constant efforts, and turned all their resources towards the creation, multiplication and adequate variation of the signs made necessary by their ideas and numerous wants.

This is not the case with other animals; for although the most perfect of them such as the Quadrumana mostly live in troops, they have made no further progress in the perfection of their faculties subsequent to the high supremacy of the race named; for they have been chased away and banished to wild and desert places where they had little room, and lived a wretched, anxious life, incessantly compelled to take refuge in flight and concealment. In this situation these animals contract no new needs and acquire no new ideas; their ideas are but few and unvaried; and among them there are very few which they need to communicate to others of their species. Very few different signs therefore are sufficient to make themselves understood by their fellows; all they require are a few movements of the body or parts of it, a few hissings and cries, varied by simple vocal inflections.

Individuals of the dominant race already mentioned, on the other hand, stood in need of making many signs, in order rapidly to communicate their ideas, which were always becoming more numerous and could no longer be satisfied either with pantomimic signs or with the various possible vocal inflections. For supplying the large quantity of signs which had become necessary, they will by various efforts have achieved the formation of articulate sounds. At first they will only have used a small number, in conjunction with inflexions of the voice; gradually they will have increased, varied and perfected them, in correspondence with the growth in their needs and their gain of practice. In fact, habitual exercise of their throat, tongue and lips in the articulation of sounds will have highly developed that faculty in them.

Hence would arise for this special race the marvellous faculty of speaking; and seeing that the remote localities to which the individuals of the race would have become distributed, would favour the corruption of the signs agreed upon for the transmission of each idea, languages would arise and everywhere become diversified.

In this respect, therefore, all will have been achieved by needs alone: they will have given rise to efforts, and the organs adapted to the articulation of sounds will have become developed by habitual use.

Such are the reflections which might be aroused, if man were distinguished from animals only by his organisation, and if his origin were not different from theirs.

ADDITIONS TO THE SUBJECT MATTER OF CHAPS. VII. AND VIII.

During the last few days of June 1809 the menagerie of the Museum of Natural History received a seal known under the name of sea-calf (*Phoca vitulina*) which was sent alive from Boulogne; and I had an opportunity of observing the movements and habits of this animal. Thereupon I acquired a still stronger conviction that this amphibian is much more allied to the unguiculate mammals than to the other mammals, notwithstanding the great differences in general shape between it and them.

Its hind legs, although very short like the fore-legs, are quite free and separate from the tail, which is small but quite distinct, and they can move easily in various ways; they can even grasp objects like true hands.

I noticed that this animal is able to unite its hind feet as we join our hands, and that on then separating the digits between which there are membranes, it forms a fairly large paddle, which it uses for travelling about in the water in the same way as fishes use their tail as a fin.

This seal drags itself about on the ground with some speed by means of an undulatory movement of the body, and without any help from its hind legs, which remain inactive and are stretched out. In thus dragging itself about, it derives help from its fore-legs only by supporting itself on the arms up to the wrists, without making any special use of the hands. It seizes its prey either with its hind feet or with its mouth, and although it sometimes uses its hands to rend the prey that it holds in its mouth, these hands appear to be used principally for swimming or locomotion in the water. Finally, as this animal often remains under water for a longish time and even feeds there in comfort, I have noticed that it easily and completely closes its nostrils just as we close our eyes; this is very useful to it when immersed in the liquid that it inhabits.

As this seal is well known, I shall give no description of it. My purpose here is simply to remark that the amphibians have their hind legs set on in the same direction as the axis of their body, for the simple reason that these animals are compelled to use them habitually as a caudal fin by uniting them and by separating the digits so as to form a large paddle. With this artificial fin they are then able to strike the water either to the right or left, and thus move rapidly in various directions.

The two hind legs of seals are so often united and used as a fin that they would not simply have this backward direction in continuance of the body but would be permanently united as in the walruses, were it not for the fact that the animals in question also use them very frequently for seizing and carrying off their prey. Now the special movements required by these actions prevents the hind legs of seals from becoming permanently united, and only allow them to be joined together momentarily.

Walruses, on the contrary, which are accustomed to feeding on grass, which they come and browse on the shore, only use their hind legs as a caudal fin; so that in most of them these legs are permanently united with one another and with the tail, and cannot be separated.

We find here a new proof of the power of habit over the form and state of the organs, a proof that I may add to all those already set forth in Chapter VII.

I might add still another very striking proof drawn from mammals. The faculty of flight would seem to be quite foreign to them; yet I can show how nature has gradually produced extensions of the animal's skin, starting from those animals which can simply make very long jumps and leading up to those which fly perfectly; so that ultimately they possess the same faculty of flight as birds, though without having any affinities with them in their organisation.

Flying squirrels (*Sciurus volans, aerobates, petaurista, sagitta, volucella*) have more recently acquired this habit of extending their wings when leaping, so as to convert their body into a kind of parachute; they can do no more than make a very long jump by throwing themselves to the bottom of a tree, or leaping from one tree on to another at a moderate distance. Now by frequent repetition of such leaps in the individuals of these races, the skin of their flanks is dilated on each side into a loose membrane, which unites the hind-legs to the fore-legs and embraces a large volume of air; thus saving them from a sudden fall. These animals still have no membranes between the digits.

The galeopithecus (*Lemur volans*) doubtless acquired this habit earlier than the flying squirrels (*Pteromis*, Geoffr.); the skin of their flanks is still larger and more developed; it unites not only the hind-legs with the fore-legs but also the tail with the hind-legs and the digits with each other. Now these creatures make longer leaps than the preceding, and even perform a sort of flight.

Lastly, the various bats are mammals which probably acquired still earlier than the galeopithecus the habit of extending their limbs and even their digits to embrace a great volume of air, and sustain themselves when they launch forth into the atmosphere.

From these habits, so long acquired and preserved, bats have derived not only lateral membranes but also an extraordinary lengthening of the digits of their four legs (except the thumb) which are united by very large membranes; so that these membranes of the hands, being continuous with those of the flanks and those which unite the tail to the two hind-legs, constitute in these animals great membranous wings with which they fly perfectly as we all know.

Such then is the power of habit: it has a remarkable influence on the shape of the parts and endows animals, which have long contracted certain habits, with faculties not possessed by those which have adopted different habits.

With regard to the amphibians, of which I spoke above, I should like here to communicate to my readers the following reflections that have been raised in me and ever more strongly confirmed by all the subjects I have dealt with in my studies.

I do not doubt that mammals originally came from the water, nor that water is the true cradle of the entire animal kingdom.

We still see, in fact, that the least perfect animals, and they are the most numerous, live only in the water, as I shall hereafter mention (p. 246); that it is exclusively in water or very moist places that nature achieved and still achieves in favourable conditions those direct or spontaneous generations which bring into existence the most simply organised animalcules, whence all other animals have sprung in turn.

We know that the infusorians, polyps, and radiarians live exclusively in the water; and that some worms even live in it while the rest dwell only in very moist places.

Now the worms appear to form one initial branch of the animal scale, and it is clear that the infusorians form the other branch. We may suppose therefore that such worms as are completely aquatic and do not live in the bodies of other animals, Gordius, for instance, and many others that we are not yet acquainted with, have doubtless become greatly diversified in the water; and that among these aquatic worms, those which afterwards became accustomed to exposure to the air have probably produced the amphibian insects such as gnats, mayflies, etc., etc., while these in turn have given existence to all the insects which live altogether in the air. Several races of these again have changed their habits as a result of their environment and contracted a new habit of living hidden away in solitude: hence the origin of the arachnids, nearly all of which live also in the air.

Finally, those arachnids that frequented water, and gradually became accustomed to live in it until at last they altogether ceased to live in the air, led to the existence of all the crustaceans; this is clearly indicated by the affinities which connect the centipedes with the millipedes, the millipedes with the woodlice, and these again with Asellus, shrimps, etc.

The other aquatic worms, which are never exposed to the air, would have developed in course of time into many different races with a corresponding advance in the complexity of their organisation. They would thus have led to the formation of the annelids, cirrhipedes and molluscs, which form together an unbroken portion of the animal scale.

There seems to us to be a great hiatus between the known molluscs and the fishes; yet the molluscs whose origin I have just named have led to the existence of the fishes through the medium of other molluscs that have yet to be discovered, and it is manifest that the fishes again have given rise to the reptiles.

As we continue to examine the probable origin of the various animals, we cannot doubt that the reptiles, by means of two distinct branches, caused by the environment, have given rise, on the one hand, to the formation of birds and, on the other hand, to the amphibian mammals, which have in their turn given rise to all the other mammals.

After the fishes had led up to the formation of the batrachian reptiles and these to the ophidian reptiles, both of which have only one auricle in their hearts, nature easily succeeded in giving a heart with a double auricle to the other reptiles, which became divided into two separate branches; subsequently she easily achieved the formation of a heart with two ventricles in animals originating from both these branches.

Thus among the reptiles which have a heart with a double auricle, the chelonians appear to have given existence to the birds; for, in addition to their various unmistakable affinities, if I were to place the head of a tortoise on the neck of certain birds, I should find hardly any incongruity in the general appearance of the factitious animals; in the same way the saurians, especially the planicauds, such as crocodiles, seem to have led to the existence of the amphibian mammals.

If the chelonian branch has given rise to the birds, we may suppose that the aquatic palmipeds, and especially the brevipens, such as the penguins and king-penguins, have brought about the formation of the monotremes.

Lastly, if the saurian branch gave rise to the amphibian mammals, it is highly probable that from this branch all the mammals have taken their origin.

I think the belief is justifiable, that the terrestrial mammals originated from those aquatic mammals that we call amphibians. These were divided into three branches by reason of the diversity arising in their habits in the course of time; one of these led to the cetaceans, another to the ungulate mammals, and the third to the various known unguiculate mammals.

Those amphibians indeed which preserved the habit of going on to the beach became divided, owing to their different manner of feeding. Some of them, being accustomed to browsing on grass, as for instance the walruses and manatees, gradually led to the formation of the ungulate mammals such as the pachyderms, ruminants, etc.; the others as, for instance, the seals, having acquired the habit of feeding exclusively on fishes and marine animals, brought about the existence of the unguiculate mammals through the medium of races which as they diversified became altogether terrestrial.

Those aquatic mammals, however, which acquired the habit of never coming out of the water and of only coming to the surface to breathe, probably gave rise to the various cetaceans with which we are acquainted. The cetaceans have been greatly modified in organisation by having dwelt for so long a period exclusively in the sea; hence it is now very difficult to recognise whence they derive their origin.

In consequence of the immense lapse of time during which these animals have lived in the sea without ever using their hind-legs for grasping objects, these unused legs have entirely disappeared, including their bones, and even the pelvis which served for their support and attachment.

The degeneration in the limbs of cetaceans under the influence of the environment and acquired habit is also seen in their fore-feet, which are entirely invested by skin so as not even to show the digits at the end of them; they thus consist of one fin on each side containing the skeleton of a concealed hand.

Seeing that the cetaceans are mammals, it is assuredly a part of their plan of organisation to have four limbs like all the rest, and consequently a pelvis for the support of their hind-legs. But, here as elsewhere, the loss of these parts is the result of an abortion due to a long disuse of them. When we remember that in seals which still have a pelvis, this pelvis is impoverished, reduced and does not protrude from their haunches, we shall feel that the cause must be the moderate use which these animals make of their hind-legs, and that, if they were to give up using them altogether, the hind-legs and even the pelvis would ultimately disappear.

The arguments which I have just adduced will doubtless seem to be mere guesses, since it is not possible to establish them on direct positive proofs. If we pay attention, however, to the observations set forth in the present work, and if we then closely examine the animals which I have cited and also the effects of their habits and environment, we shall find as a result of this examination that these guesses acquire a high degree of probability.

The table on p. 179 may facilitate the understanding of what I have said. It is there shown that in my opinion the animal scale begins by at least two separate branches, and that as it proceeds it appears to terminate in several twigs in certain places.

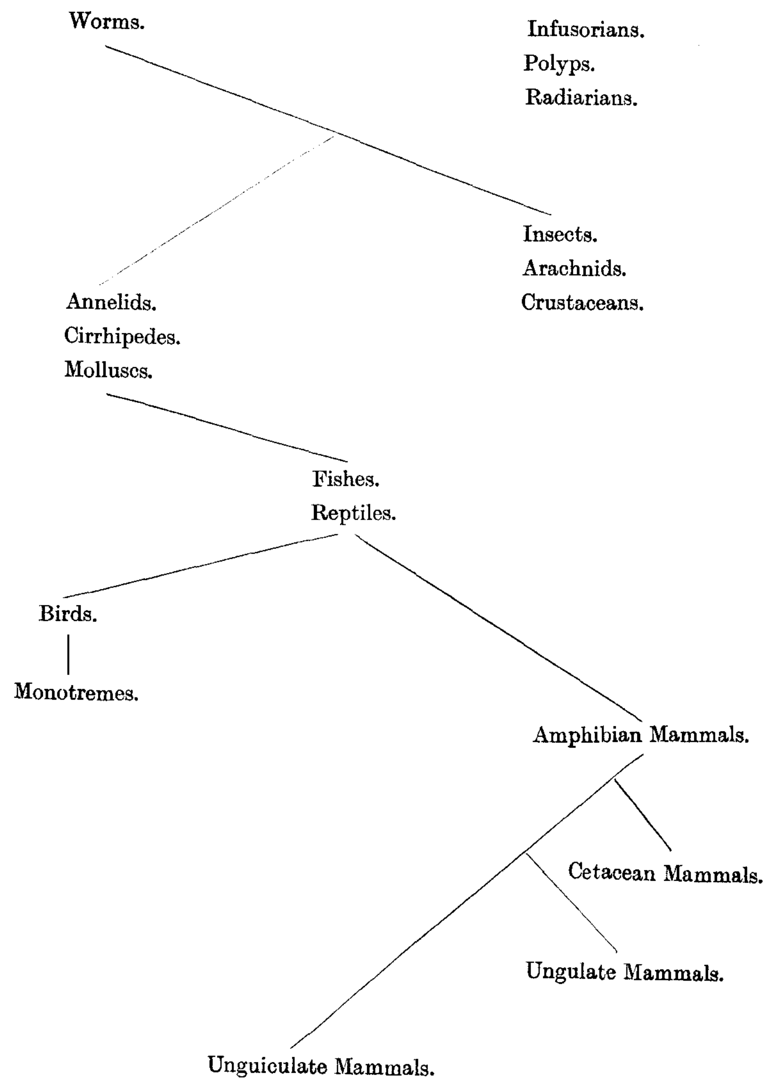
This series of animals begins with two branches, where the most imperfect animals are found; the first animals therefore of each of these branches derive existence only through direct or spontaneous generation.

There is one strong reason that prevents us from recognising the successive changes by which known animals have been diversified and been brought to the condition in which we observe them; it is this, that we can never witness these changes. Since we see only the finished work and never see it in course of execution, we are naturally prone to believe that things have always been as we see them rather than that they have gradually developed.

Throughout the changes which nature is incessantly producing in every part without exception, she still remains always the same in her totality and her laws; such changes as do not need a period much

TABLE

SHOWING THE ORIGIN OF THE VARIOUS ANIMALS.



longer than the duration of human life are easily recognised by an observer, but he could not perceive any of those whose occurrence consumes a long period of time.

To explain what I mean let me make the following supposition.

If the duration of human life only extended to one second, and if one of our ordinary clocks were wound up and set going, any individual of our species who looked at the hour hand of this clock would detect in it no movement in the course of his life, although the hand is not really stationary. The observations of thirty generations would furnish no clear evidence of a displacement of the hand, for it would only have moved through the distance traversed in half a minute and this would be too small to be clearly perceived; and if still older observations showed that the hand had really changed its position, those who heard this proposition enunciated would not believe it, but would imagime some mistake, since they had always seen the hand at the same point of the dial.

I leave my readers to apply this analogy to the subject in hand.

Nature—that immense assemblage of various existences and bodies, in all whose parts continually proceeds an eternal cycle of movements and changes controlled by laws—an assemblage that is only immutable so long as it pleases her Sublime Author to continue her existence—should be regarded as a whole made up of parts, with a purpose that is known to its Author alone, but at any rate not for the sole benefit of any single part.

Since each part must necessarily change and cease to exist to make way for the formation of another, each part has an interest which is contrary to that of the whole; and if it reasons, it finds that the whole is badly made. In reality, however, this whole is perfect, and completely fulfils the purpose for which it is destined.

PART II.

AN ENQUIRY INTO THE PHYSICAL CAUSES OF LIFE, THE CONDITIONS REQUIRED FOR ITS EXISTENCE, THE EXCITING FORCE OF ITS MOVEMENTS, THE FACULTIES WHICH IT CONFERS ON BODIES POSSESSING IT, AND THE RESULTS OF ITS PRESENCE IN THOSE BODIES.