George Cuvier

DISCOURSE
ON
THE REVOLUTIONARY UPHEAVALS
ON THE SURFACE OF THE GLOBE
AND ON THE CHANGES WHICH THEY HAVE
PRODUCED
IN THE ANIMAL KINGDOM

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http://records.viu.ca/~johnstoi/cuvier/illustrations.pdf
into the browser.

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[1] [*Translator's note*: Cuvier's text has words in the margins to indicate the start of important sections. These remarks in the margins have been made headings in the following text and are listed above in the Table of Contents].

Introductory Note

Georges Cuvier (1769-1832) was a major scientific figure in the early 19th century, a brilliant and enormously influential naturalist in France and throughout Europe. His work on the comparative anatomy of living and fossil animals, especially vertebrates, was a major landmark in the history of modern biology. Cuvier was, like many other naturalists at the time, a staunch opponent of the theory of evolution, above all as that theory had been presented by his colleague Jean-Baptiste Lamarck in *Philosophie zoologique* (1809).

Cuvier's *Discourse on the Revolutions On the Surface of the Earth* was originally (in a somewhat different form) the preface to his larger work *Research into the Fossil Remains of Quadrupeds* (published in 1812, 1821, and 1825). The *Discourse* was immediately popular and was later published as an independent work, went through several editions, and was translated into a number of different languages.

In the *Discourse*, Cuvier has at least three main purposes. First, he wishes to review the present state of knowledge in geology, paleontology, and comparative anatomy, particularly with a view to listing some of the many competing contemporary theories about the formation of the earth and to explaining why there is so much confusion. Second, he wants to demonstrate conclusively that the earth's surface has undergone at least three major catastrophes (not simply one, as Biblical literalists were insisting), thus making the case for a scientific position known as *catastrophism* (changes have come about by a series of unique general upheavals, rather than by slow, constant processes or by local disasters). And finally he wishes to demonstrate, equally conclusively, that the last such catastrophe was fairly recent (a few thousand years ago at most) and thus that the present forms of human society are not nearly as ancient as many people have been claiming.

Cuvier's opposition to the theory of evolution rests upon some important scientific claims. To begin with, he argues that there could have been no uninterrupted continuity in the development of life, because the sudden universal catastrophes, which brought about mass extinctions, cannot be explained in terms of present forces at work on the surface of the earth (hence, the claim of the uniformitarians, like Lamarck, that the history of the earth's surface can be accounted for in terms of present forces constantly working at present rates, is simply wrong). Moreover, there is not sufficient time since the last catastrophe for the development of new species. In addition, his principle of the correlation of parts in organic beings (one of his most important contributions to anatomy) indicates that simple changes in particular organs would not assist an animal, which is a complex coordinated whole; hence, the minor organic transformations upon which evolution depends would lead to extinction rather than to new species. Also the fossil record provides insufficient evidence of transitional types, an essential requirement of evolutionary theory in Lamarck (and later in Darwin). Finally, on the basis of his wide experience with the organic structure of animals, Cuvier argues that there are naturally fixed limits to the variations within species, beyond which new varieties are not possible.

As Cuvier himself admits, his argument raises some significant questions of its own. For example: Why are there no human fossils? If there is no continuity between the extinct animals of past ages and present species, where were the latter species during the catastrophes? Where did our present species come from?

Cuvier's objections to evolution, although set aside by Darwinian theory, have by no means been entirely dismissed (catastrophism, for example, has made something of a comeback in recent years), and many of his most important ideas have been incorporated into modern biology.

Cuvier's argument in the *Discourse* is remarkable for its clarity, for its grasp of many different areas of science, and, perhaps more than anything else, for its astonishing range. His analysis takes into account, not merely the findings of many of his scientific contemporaries and his own remarkable research results, but also the often questionable evidence in ancient writings from widely different cultures, as well as the claims of ancient and modern astronomers about the significance of astronomy and astrology in arguments about the age of the earth. It would be difficult to find a modern scientific argument which involves such a detailed look at ancient books and monuments and at the commentaries upon them. These qualities make Cuvier's argument an exceptionally interesting and accessible scientific work from the most vital era of pre-Darwinian biology, the first decades of the 19th century.

One factor of particular interest, too, is Cuvier's use of evidence from the French expedition to Egypt in 1798 (particularly in his discussions of the zodiac and in his report on the ibis, included as an appendix to the *Discourse*). Although that campaign had ended in military failure in 1801, it produced an enormous wealth of scientific information of great interest and importance to those dealing with the history of the earth, the development of animal life, and the history of human societies. Much of this information was still being processed and catalogued and published in the first decades of the 19th century, as one can see from different editions of the *Discourse* (later editions, including the Third, which is the basis for the translated text here, draw much more upon the Egyptian material than did the first version).

The major publication prompted by this material from Egypt was called *Description de l'Égypte*, a series of volumes on ancient and modern Egypt produced by the 160 scholars who accompanied the military expedition and who shipped a great many valuable artifacts home (everything from mummified birds to temple ceilings). The first volume was published in 1810 and the last in 1829. Its full name was *Description de l'Égypte, ou Recueil des observations et des recherches qui ont été faites en Égypte pendant l'expédition de l'armée française [Description of Egypt, or collection of observations and research which was made in Egypt during the expedition of the French Army*). Cuvier routinely refers to the entire publication in his footnotes as "the great work on Egypt," and sometimes he provides a partial title.

Translator's Note

The footnotes in the following translation all come from Cuvier's text, other than those in square brackets with the initial phrase *Translator's*

note. The comments in italics and within square brackets in the text itself (usually an explanatory phrase) have been inserted by the translator.

DISCOURSE
ON
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By M. le Baron CUVIER

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Third French Edition

Paris, 1825

FOREWORD

Since the English and German translations of this *Discourse* have appeared separately, some people have wanted a French edition to be made available as well, something distinct from the major work it introduces.[1] In acceding to this wish, we have sought to benefit from the observations of the different foreign editors and to follow the progress made since the publication of the last edition in a science cultivated nowadays more keenly than ever. Finally, we thought it necessary to end the text with a summary listing of the species of animals which the author has discovered and described in the major work, so that people who do not have the leisure time to plumb these difficult matters thoroughly could derive from this text at least a general idea and appreciate both the rational arguments based upon these findings and the important consequences which result from them for the history of the earth and of human beings.

In my work on *Fossil Bones*, I set myself the task of recognizing to which animals the fossilized remains which fill the surface strata of the earth belong. This project meant I had to attempt to travel along a path where we had so far still taken only a few tentative steps. As a new sort of antiquarian, I had to learn to restore these memorials to past upheavals and, at the same time, to decipher their meaning. I had to collect and put together in their original order the fragments which made up these animals, to reconstruct the ancient creatures to which these fragments belonged, to create them once more with their proportions and characteristics, and

[1] [*Translator's note*: The *Discourse* offered here was, in a slightly different form, the introduction to Cuvier's work on the comparative anatomy of fossil quadrupeds. In this third edition Cuvier gave the *Discourse* its present title.]

finally to compare them to those alive today on the surface of the earth. This was an almost unknown art, which assumed a science hardly touched upon up until now, that of the laws which govern the coexistence of forms of the various parts in organic beings. Thus, I had to prepare myself for these studies through a much longer research on existing animals. Only an almost universal review of present creation could provide the nature of a proof for my results concerning this life created long ago. But at the same time such a study had to provide me with a large collection of no less demonstrable rules and interconnections, and in the course of this exploration into a small part of the theory of the earth, the entire animal kingdom in some way could not escape finding itself subjected to new laws.

Thus, I was sustained in this double task by the interest which it promised to have, both for the universal science of anatomy, the essential basis of all those sciences dealing with organic entities, and equally for the physical history of the earth, the foundation of mineralogy, geography, and, we can say, even of human history and everything which is most important for human beings to know about themselves.

If one finds it interesting to follow in the infancy of our species the almost eradicated traces of so many extinct nations, how could one not also find it interesting to search in the shadows of the earth's infancy for the traces of revolutionary upheavals which have preceded the existence of all nations? We admire the force with which the human spirit has measured the movements of planets, something nature seemed to have concealed for ever from our view; human genius and science have stepped beyond the limits of space; some observations developed by reasoning have unveiled the mechanical workings of the world. Would there not also be some glory for human beings to know how to step beyond the limits of time and to recover, through some observations, the history of this earth and a succession of events which have preceded the birth of mankind? No doubt the astronomers have proceeded more rapidly than the naturalists. The theory of the earth at the present time is rather like the one in which some philosophers believed that the sky was made of freestone and the moon was as big as the Peloponnese. But, following Anaxagoras, Copernicus and Kepler opened up the road to Newton. And why one day should natural history not have its own Newton, as well?

EXPOSITION

In this discourse I propose above all to present the plan and result of my work on fossil bones. I will try also to sketch a rapid picture of the attempts made up to the present time to rediscover the history of the earth's upheavals. No doubt, the facts which I have discovered form only a really small part of those which must make up this ancient history; but several of these lead to significant consequences, and the rigorous way in which I have proceeded in determining them encourages me to believe that people will look on them as points definitely settled, things which will constitute

a special age in science. Finally, I hope that their newness will excuse the fact that I focus the major attention of my readers on them.

My object will be, first, to show by what connections the history of the fossil bones of land animals is linked to the theory of the earth and the reasons why they have a particular importance in this respect. Then I will develop the principles on which rests the art of sorting out these bones, or, in other words, of recognizing a genus and distinguishing a species by a single bone fragment, an art on whose reliability depends the reliability of all my work. I will give a quick indication of new species, of genera previously unknown, which the application of these principles has led me to discover, as well as of the various sorts of formations which contain them. And since the difference between these species and those today does not exceed certain limits, I will show that these limits are considerably greater than those which today distinguish the varieties of a common species. I will thus reveal just where these varieties can go, whether by the influence of time, or of climate, or finally of domestication.

In this way, I will proceed to the conclusion (and I shall invite my readers to conclude with me), that there must have been great events to bring about the much greater differences which I have recognized. I will develop then the particular revisions which my research must introduce into the opinions accepted up to the present time about the earth's revolutions. Finally I will examine up to what point the civil and religious history of people agrees with the results of the observations dealing with the physical history of the earth and with the probabilities which these observations set concerning the time when human societies could have established permanent homes and arable fields and when, consequently, societies could have taken on a lasting form.

THE FIRST APPEARANCE OF THE EARTH

When the traveller passes through those fertile plains where tranquil waters nourish with their regular flow an abundant vegetation and where the ground, trodden by numerous people and decorated with flourishing villages, rich cities, and superb monuments, is never troubled except by ravages of war or by the oppression of men in power, he is not tempted to believe that nature has also had its internal wars and that the surface of the earth has been overthrown by revolutions and catastrophes. But his ideas change as soon as he seeks to dig through this soil, today so calm, or when he takes himself up into the hills which border the plain; his ideas expand, so to speak, with what he is looking at. They begin to embrace the extent and the grandeur of these ancient events as soon as he climbs up the higher mountains of which these are the foothills, or when, by following the stream beds which descend from these mountains, he moves into their interior.

THE FIRST PROOFS OF UPHEAVALS

The lowest and most level land areas show us, especially when we dig there to very great depths, nothing but horizontal layers of material more or less varied, which almost all contain innumerable products of the sea. Similar layers, and similar products, form the hills up to quite high elevations. Sometimes the shells are so numerous that they make up the entire mass of soil by themselves. They occur at elevations higher than the level of all seas, where no sea could be carried today by present causes. Not only are these shells encased in loose sand, but the hardest rocks often encrust them and are penetrated by them throughout. All the parts of the world, both hemispheres, all continents, and all islands of any size provide evidence of the same phenomenon. The time is past when ignorance could continue to maintain that these remains of organic bodies were simple games of nature, products conceived in the bosom of the earth by its creative forces, and the renewed efforts of certain metaphysicians will probably not be enough to make these old opinions acceptable. A scrupulous comparison of the forms of these deposits, of their make up, and often even of their chemical composition shows not the slightest difference between these fossil shells and those which the sea nourishes. Their preservation is no less perfect. Most commonly one observes there neither shattering nor fractures, nothing which signifies a violent movement. The smallest of them keep their most delicate parts, their most subtle crests, their slenderest features. Thus, not only have they lived in the sea, but they have been deposited by the sea, which has left them in the places where we find them. But this sea has remained in these locations; it has remained there for a sufficient length of time and with a sufficient calm to form there deposits so regular, so thick, so extensive, and in places so solid, that they are full of the remains of marine animals. The sea basin therefore has provided evidence of at least one change, whether in extent or location. See what results already from the first inspections and the most superficial observation.

The traces of upheavals become more impressive when one moves a little higher, when one gets even closer to the foot of the great mountain ranges. There are still plenty of shell layers. We notice them, even thicker and more solid ones. The shells there are just as numerous and just as well preserved. But they are no longer the same species. Also, the strata which contain them are no longer so generally horizontal. They lie obliquely, sometimes almost vertically. In contrast to the plains and the low hills, where it was necessary to dig deep to recognize the succession of layers, here we see them on the mountain flank, as we follow the valleys produced by their tearing apart. At the foot of the escarpments, immense masses of debris form rounded hillocks, whose height is increased by each thawing and each storm.

And those upright layers which form the crests of secondary mountains do not rest on the horizontal layers of hills which serve as their lower stages.

By contrast, they sink under these hills, which rest on the slopes of these oblique strata. When we bore into the horizontal strata near mountains with oblique layers, we come across these oblique layers deep down. Sometimes, when the oblique layers are not very high, their summits are even crowned with horizontal strata. The oblique layers are therefore older than the horizontal layers. Since it is impossible, at least for most of them, not to have been formed horizontally, evidently they have been lifted up again and were in existence before the others which rest on top of them.[1]

Thus, before forming these horizontal layers, the sea had formed other strata. These were for some reason or other broken, raised up, and overturned in thousands of ways. As several of these oblique layers which the sea formed in a previous age rise higher than the horizontal layers which succeeded them and which surrounded them, the causes which gave these layers their oblique orientation also made them protrude above the level of the sea and turned them into islands or at least reefs and uneven structures, whether they were raised again by an extreme condition or whether the subsidence caused by a extreme condition with an opposite effect made the waters sink. The second result is no less clear or less proven than the first for anyone who will take the trouble to study the monuments which provide evidence for these results.

PROOFS THAT THESE REVOLUTIONS HAVE BEEN NUMEROUS

But the revolutions and changes which are responsible for the present state of the earth are not limited to the upsetting of the ancient strata and to the ebbing of the sea after the formations of new layers.

When we compare together in greater detail the various layers and the products of life which they conceal, we soon realize that this ancient sea did not continuously deposit the same type of rock nor the remains of animals of the same species, and that each of its deposits did not extend over all the surface which the sea covered. Successive variations took place, of which only the first ones were almost universal; the others appear to have been considerably less. The older the layers, the more each of them is uniform over a great extent; the newer the layers, the more they are limited, the more they are subject to variation over small distances. Thus, the changes in the strata were accompanied and followed by changes in the nature of the liquid and of the materials which it held in solution. When certain layers, appearing above the water, split the surface of the sea with islands and with protruding ranges, different changes could have taken place in several particular ocean basins.

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[1]Even if we accept that the idea which some geologists hold, that certain strata were formed in the oblique position in which we find them now, is true for some which would have been crystallized, as Greenough claims, like the deposits which encrust the entire insides of jars where gypsum waters are brought to a boil, it is quite impossible to apply this idea to those strata which contain shells or rounded stones, which could not have waited, suspended in this way, for the formation of the binding material which had to hold them together.

We know that in the midst of such variations in the nature of the liquid, the animals which it nourished could not have stayed the same. Their species, even their genera, changed with the layers; and although there are some returns of species within small distances, it is true to state, in general, that the shells of the ancient layers have forms unique to them, that they disappear gradually and do not show up any more in the recent layers, even less in the present sea, where we never discover species analogous to them. Even several of their genera are not found there. The shells of recent layers, by contrast, are generically similar to those which live in our seas. In the most recent and least solid of these layers and in certain recent and limited deposits there are some species which the most practised eye would not be able to distinguish from those which the neighbouring coasts nourish.

Thus, in animal nature a succession of variations has taken place, brought about by changes in the liquid where the animals lived or at least by variations which corresponded to those changes. And these variations have by degrees brought the classes of aquatic animals to their present condition. Finally, when the sea left our continents for the last time, its inhabitants did not differ much from those which the sea still feeds today.

We say *for the last time*, because if we examine with even greater care the remains of these organic creatures, we come to discover in the middle of the marine strata, even the most ancient ones, layers full of animal or vegetable products from land and fresh water. In the most recent layers (i.e., the ones closest to the surface) there are some where land animals are buried under masses of marine creatures. Thus, not only did the different catastrophes which moved the layers gradually make the various parts of our continent rise up from the bosom of the waves and reduce the size of the sea basin, but this basin has been shifted in several directions. Often the regions transformed into dry land have been covered again by the seas, whether they have sunk, or the waters have been merely carried above them. As for the particular matter of the soil which the sea uncovered in its last retreat, the part which human beings and terrestrial animals live on right now, it had already been dry land once and had nourished at that time quadrupeds, birds, plants, and land forms of all sorts. Thus, the sea which left that land had previously invaded it. The changes in the heights of the oceans did not therefore consist only in one withdrawal more or less gradual, more or less universal. It was a matter of a succession of various irruptions and retreats. The result of these has definitely been, however, a general lowering of the sea level.

PROOFS THAT THESE REVOLUTIONS HAVE BEEN SUDDEN

But it is also really important to note that these irruptions and these repeated retreats were not all slow and did not all take place gradually. On the contrary, most of the disasters which brought them on have been sudden. That is especially easy to demonstrate for the last of these catastrophes, which by a double movement inundated and later left dry our

present continents or, at least, a great part of the land which forms them today. That catastrophe left in the northern countries the cadavers of great quadrupeds locked in the ice, preserved right up to our time with their skin, hair, and flesh. If they had not been frozen as soon as they were killed, decay would have caused them to decompose. On the other hand, this permanent freezing was not a factor previously in the places where these animals were trapped. For they would not have been able to live in such a temperature. Hence the same instant which killed the animals froze the country where they lived. This event was sudden, instantaneous, without any gradual development. What is so clearly demonstrated for this most recent catastrophe is hardly less so for the ones which came before it. The rending, rearranging, and overturning of more ancient layers leave no doubt that sudden and violent causes placed them in the state in which we see them. The very force of the movements which the bodies of water experienced is still attested to by the mountain of remains and rounded pebbles interposed in many places between the solid layers. Thus, life on this earth has often been disturbed by dreadful events. Innumerable living creatures have been victims of these catastrophes. Some inhabitants of dry land have seen themselves swallowed up by floods; others living in the ocean depths when the bottom of the sea was lifted up suddenly were placed on dry land. Their very races were extinguished forever, leaving behind nothing in the world but some hardly recognizable debris for the naturalist.

Such are the conclusions to which we are necessarily led by the objects which we meet at every step and which we can verify at every instant in almost every country. These huge and terrible events are clearly printed everywhere for the eye which knows how to read the story in their monuments.

But what is even still more astonishing and what is no less certain is that life has not always existed on the earth and that it is easy for the observer to recognize the point where life began to deposit her productions.

PROOFS THAT THERE WERE REVOLUTIONARY UPHEAVALS BEFORE THE EXISTENCE OF LIVING THINGS

Let us keep climbing. Let us move up towards the great mountain ridges, towards the terraced summits of the great ranges. Soon these remains of marine animals, these innumerable shells, will become increasingly rare and will disappear altogether. We will reach layers of a different sort, which will contain no vestiges of living things at all. However, they will show by their crystallization and by their very stratification that they were also formed in a liquid state. Their oblique orientation and their escarpments will indicate that they also have been overturned. The manner in which they slant under the strata with shells will reveal that they were formed before them. Finally the height of their bare and bristling peaks rising above all these layers with shells will show that these summits had already left the water when the layers with shells were formed.

Such are the famous primitive or primordial mountains which cross our continents in different directions, rising up above the clouds, separating river basins, holding in their perpetual snow the reservoirs which supply the rivers' sources, and forming something like the skeleton and rough framework of the earth.

From a long way away the eye perceives in the indentations which split up the crests, in the sharp peaks which bristle there, evidence of the violent manner in which they were uplifted, very different from those rounded mountains or hills with long flat surfaces where the recent mound always remains in the condition in which it was peacefully deposited by the most recent seas.

These signs become more evident as one approaches. The valleys do not have gentle slopes any more or those jutting angles facing indentations opposite, which seem to indicate the beds of some ancient water course. They grow bigger or smaller without any rule. Their waters sometimes extend into lakes; at other times they hurtle down in torrents. Sometimes their rocks come suddenly together and form transverse dams, from which these same waters fall in cataracts. The ripped apart strata, revealing on one side a sharp perpendicular edge, present on the other side large obliquely oriented sections of their surface. They do not correspond in height. Those which, on one side, form the summit of an escarpment, disappear on the other and do not reappear any more.

However, some great naturalists have managed to demonstrate that, in the middle of all this disorder, a certain order still reigns and that these immense ranges, as bristling and overturned as they all are, themselves follow a succession which is almost the same in all the large mountain ranges. The granite, they say, which forms the central crests of most of these ranges and which is the highest of all the rocks, is also the rock which disappears under all the others. It is the most ancient of those which we have been given to see in the place which nature put it, whether it owes its origin to a universal liquid which, in earlier times, held everything in solution, or whether it was the first rock established by the cooling of a large fused mass or even by evaporation.[1] Foliated rocks lean on the flanks of the granite and form the lateral crests of these large mountain ranges. Schists, porphyries, sandstones, and talus are mixed together in the strata. Finally granular marbles and other calcareous rocks without shells, resting on schists, form the outer peaks, lower terraces, and foothills of these ranges, and are the last work by which this unknown liquid, this sea without inhabitants, seemed to have prepared the materials

[1]The Marquis of Laplace's conjecture that the materials which make up the earth could at first have been vapours *[sous forme élastique]* and, in cooling, taken on successively the consistency of liquid and finally solidified, is well backed up by the recent experiments of Mitscherlich. From all the constituent parts, he has created several of the mineral types which make up the primitive mountains, by having them crystallize through the heat in a high-temperature furnace.

for the mollusks and zoophytes which soon must have deposited on the bottom an immense quantity of their shells or their coral. We even see the first products of these mollusks, these zoophytes, showing up in small numbers here and there among the latest layers of these primitive formations or in the part of the earth's crust which geologists have called the transitional areas. In these places we meet here and there layers with shells interposed with some granites more recent than the others, among various schists and between some late beds of granular marble. The life which wished to seize hold of this earth seems in these early times to have fought with inert nature, which had previously dominated. Only after a relatively long time did life clearly get the upper hand, so that to life alone belonged the right to continue and to increase the solid outer layer of the earth.

Thus, it cannot be denied that the masses which today form our highest mountains were originally in a liquid state; for a long time they were covered by waters which did not sustain any living thing. Changes did not take place in the nature of the materials deposited only after the appearance of life. The masses formed previously changed, as well as those which were formed later. They have similarly provided evidence of the violent alterations in their positions. Some of these transformations took place at the time when these masses existed by themselves and were not covered with layers of shells. We have the proof of that in the overthrusting, tearing apart, and fissures which can be observed in their strata, as well as in those of later land masses, which, indeed, are more numerous and more marked.

But these primitive structures have experienced still other upheavals since the creation of the secondary formations and have perhaps caused or at least shared some of those which these secondary formations have themselves undergone. There are, in fact, considerable sections of primitive rocks totally bare, although in a lower location than many of the secondary formations. How could these not have been covered over again unless they been made to appear since the creation of these secondary formations? We find many voluminous blocks of primitive materials scattered in certain countries on the surfaces of secondary formations, separated by deep valleys or even by the arms of the sea from the peaks and crests where these blocks could have originated. It must be the case either that some eruptions threw them there or that the low places which stopped their movement did not exist at the time of their transport, or finally perhaps that the motion of the waters which carried them surpassed in violence anything which we can imagine nowadays.[1]

[1]Saussure's and Deluc's Travels provide a multitude of these sorts of facts. And these geologists have concluded that these effects could scarcely have been produced except by enormous eruptions. De Buch and Escher have concerned themselves more recently with this problem. The report of the latter, included in La Nouvelle Alpina of Stein-Müller, Volume I, presents a remarkable overall picture of this matter. Here is an approximate summary: Those blocks scattered in the low lands of Switzerland or Lombardy originate

Here then is a collection of events, a series of periods earlier to the present times, whose sequence can be verified without doubt, although the lengths of the intervals cannot be defined with precision. There are so many items which indicate the measure and the direction of this ancient chronology.

EXAMINATION OF THE CAUSES WHICH ARE STILL AT WORK TODAY ON THE SURFACE OF THE EARTH

Let us now consider what happens today on the earth; let us analyze the causes which still disturb its surface and determine the possible extent of their effects. This part of earth's story is all the more important, because for a long time we thought we could explain earlier revolutionary upheavals by present causes, just as we readily explain past events in political history, when we know well the passions and the intrigues of our own times. But we are going to see that unfortunately things are not the same in the history of physics. The thread of the processes is broken; nature's march has changed; and none of the agents which she uses today would have been sufficient to produce these ancient works.

There now exist four active causes which contribute to altering the surface of our continents: rains and thaws, which erode the steep mountains and throw debris at their feet; the moving waters, which carry away this debris and go on to deposit it in places where their current slows down; the sea, which undermines the foot of high coasts to create cliffs there and which throws back mounds of sand onto coasts of low elevation; and finally

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in the Alps and have come down the length of the valleys. There are samples of them everywhere, of every size, right up to fifty thousand cubic feet, in the large stretch which separates the Alps from the Jura. They occur on the slopes of the Jura facing the Alps right up to elevations of four thousand feet above sea level. They are on the surface or in the shallow layers of sediments, but not in those of sandstone, molasse *[soft sandstone]* or puddingstone, which fill almost all the space in question. They are found sometimes isolated, sometimes piled up. The height of their location is independent of their size. Only the small ones appear at times a little worn. The large ones are not at all eroded. Those which belong to each river basin are found, upon inspection, to be of the same composition as the mountain summits or the flanks of the valley heights where the waters of this river arise. We already see them in these valleys, and they accumulate there, especially in those places which come in front of a certain narrowing. They have moved over the passes when the passes are not more than four thousand feet. And then we see them on the back side of the crests in the cantons between the Alps and Jura and even on the Jura. They are seen in the greatest numbers and at the highest elevations facing the entrances to the Alpine valleys. Those in between were not carried so high. In the Jura mountains, further from the Alps, they do not occur except in narrow places facing the openings of the closer ranges.

From these facts, the author infers that the transport of these blocks has taken place since the time when the sandstone and the puddingstone were deposited, that the transport was perhaps brought about by the last of the earth's upheavals. He compares this transport to that which still takes place with torrents. But the objection concerning the massive size of these blocks and of the deep valleys down which they must have passed seems to us to constitute a major criticism of this part of his hypothesis.

volcanoes, which break through solid strata and raise or scatter on the surface piles of the material which they emit.[1]

COLLAPSES

In all those places where the broken strata expose their edges on sheer faces, every spring and even with each storm, fragments of their materials fall at the bottom, pieces which become round by rolling over each other. The pile of these fragments takes on a slope determined by the laws of cohesion, so as to form in this way at the foot of the escarpment a mound more or less high according to the quantity of the falling material. These mounds form the sides of the valleys in all the high mountains and get covered with a rich vegetation when the falling rocks from above begin to get less frequent. But their lack of solidity makes them subject to collapse themselves when they are undermined by streams. And thus it is that towns, rich and populous districts, find themselves buried under what falls from a mountain, that the course of rivers is interrupted, and that lakes form in places previously fertile and pleasant. But these large landslides are fortunately rare, and the major influence of these hills of debris is to furnish materials for the destructive work of water torrents.

ALLUVIAL DEPOSITS

The waters falling on the crests and summits of mountains, the vapours condensing there, or the melting snows descend by an infinite number of small rivulets down along the slopes; they remove small bits of the slope and leave traces of their passage in light grooves. Soon these trickles come together in more clearly marked channels, which cut into the surface of the mountains. They flow out through deep valleys, which collect water at the foot of the mountains, and thus go on to form the streams and rivers which carry back to the sea the waters which the sea had given to the atmosphere. When the snows melt or there is a storm, the volume of these mountain waters, suddenly augmented, rushes forward with a speed proportional to the slopes. The waters go on to collide violently with the foot of the mounds of debris which cover the sides of all the high valleys. They carry away with them the already rounded fragments which make up these mounds; they smooth and polish them further by friction. But as they come to more level valleys, where their current slows down, or to larger basins where they can spread out, the waters deposit on the shore the largest stones which they have been rolling. The smaller debris is deposited lower down. Only the smallest pieces or the most imperceptible silt particles reach the large channel of the river. Often, indeed, the course of these waters, before forming the large river lower down, must cross a large, deep lake, where the silt is deposited, and from the lake the water

[1]On the changes in the surface of the earth known by history or by tradition and consequently brought about by causes presently at work, see the German work of von Hof, in 2 volumes in-8°. Goth. 1822 and 1824. The facts have been collected there with equal care and scholarship.

comes out clear again. But the lower rivers and all the streams which arise in the lower mountains or in the hills produce also in the areas through which they run effects more or less analogous to those of the high mountain torrents. When they are swollen by large rainstorms, they attack the foot of earthy or sandy hills which they encounter in their flow and carry material from it onto the low areas, which they flood. Each inundation takes away a certain amount. Finally, when the rivers reach large lakes or the sea, when the speed which carries along the silt particles begins to stop completely, the particles are deposited on the shores of the river mouth. They end up creating there land which pushes the shore out, and if this coast is such that the sea, in its turn, throws up sand and contributes to this accumulation, there are thus created provinces, entire kingdoms, generally the most fertile and soon the richest in the world, if the governments let industry do its work there in peace.

DUNES

The effects which the sea produces in the absence of an interaction with rivers are much less pleasant. When the coast is low and the bottom sandy, the waves push the sand towards the shore. With each backward surge the sand dries off a little, and the wind, which almost always blows from the sea, throws it onto the beach. Thus, dunes are formed, these small mountains of sand which, if human industry does not manage to fix them in place with suitable vegetation, move slowly but inexorably towards the interior lands and cover fields and houses, because the same wind which lifts the sand from the shore onto the dune throws it from the top of the dune onto the side away from the sea. If the sand and the water lifted off with it are of the sort which can form a durable binding material, the shells and bones thrown onto the shore will become encrusted with it; the woods, trunks of trees, and plants which grow close to the sea will be covered over with these aggregates. And thus will originate what can be called hardened dunes, like the ones which are seen on the coasts of New Holland *[Australia]*. One can get a clear idea of them in the description which the late Perron has left.[1]

CLIFFS

When, by contrast, the coast is elevated, the sea, which can throw nothing up on it, carries on a destructive action. Its waves eat away at the foot and make all the height into a steep cliff, because the highest parts find themselves without support and fall continually into the water. There they are agitated in the flood tides until the softest and the loosest parts disappear. After being forcibly rolled around in all direction by the waves, the hardest parts form rounded pebbles or that sand which finishes by accumulating in sufficient quantity to serve as a rampart at the foot of the cliff.

[1]In his Voyage aux Terres Australes, Vol. I, p. 161.

Such is the action of the waters on the firm land. We see that it usually occurs in a process of levelling off and that this levelling off does not go on indefinitely. The debris from the great mountain crests carried into the valleys; their particles from the hills and the plains carried right to the sea; alluvial deposits extending the coasts at the expense of the high places—these are the limited effects to which vegetation generally sets some limit. And this process assumes the preexistence of mountains, valleys, plains, and, in short, all the unevenness of the earth, and it could not therefore have been the origin of this unevenness. The dunes are a phenomenon even more limited, both with regard to their height and their horizontal extent. They have no connection at all with those enormous masses whose origin geology is searching for *[deserts]*.

As to the action which the waters carry out in their own depths, we cannot understand that very well; we can, however, to a certain extent determine its limits.

DEPOSITS UNDER THE WATERS

Lakes, ponds, swamps, openings to the sea where the streams fall, particularly when the latter come down steep neighbouring hillsides, deposit on their bottoms piles of silt, which would end up by filling in the waters if we did not take the trouble to clean them out. The sea also throws its sludge and sediments into ports and coves, into all places where its waters are the most tranquil. The interactions of the currents shape into piles or throw up onto beaches the sand which they take forcibly away from the bottom of the sea, in the process creating also sand banks and shallows.

STALACTITES

Certain waters, after having dissolved the calcareous substances by means of the carbonic acid which is present in them in large amounts give rise to crystals when this acid can evaporate, thus forming stalactites and other concretions. There exist strata which have crystallized haphazardly in fresh water sufficiently extensive to be compared to some of those which the ancient sea left. Everyone knows the famous limestone quarries in the neighbourhood of Rome, and the rocks of this stone which the River Teverone tears away and continuously works into different shapes. These two sorts of actions can combine; the deposits accumulated by the sea can be solidified by stalactites. When, by chance, springs with a great deal of calciferous material or containing some other substance in solution happen to fall on the places where these mounds are formed, then there can appear aggregates where the products of the sea and those of fresh water can combine. The shores of Guadeloupe are like this; they provide shells of the sea and land and human skeletons all together. Another similar example is the sandpit in the region of Messina, described by Saussure, where the sandstone is formed by the sands which the sea deposits there and which consolidate in that location.

LITHOPHYTES

In the torrid zone, where there are numerous species of lithophytes and where they develop prolifically, their stony trunks are intertwined into rocks and reefs and rise right up to the level of the water, close off the entry to ports, and create terrible traps for navigators. By throwing sand and silt on the top of these reefs, the sea sometimes raises the surface above its own level and turns them into islands which a rich vegetation soon brings alive.[1]

ENCRUSTATIONS

It is also possible that in some places animals with shells, as they die, leave behind their petrified remains and that, in association with silt of varying solidity or with other binding materials, they form extensive deposits or varieties of shelled layers. But we do not have any proof that the sea might today encrust these shells with a covering as compact as marbles or sandstones, or even the rough limestone which we see enveloping the shells in our own strata. Even less do we find that the sea deposits anything of the more solid strata, the ones with more silica, formed before the layers containing shells.

In short, all these causes combined would not appreciably change the level of the sea, would not lay down a single stratum above this level, and, most importantly, would not produce the slightest mound on the surface of the earth.

It has been well urged that the sea has experienced a general diminution and that people have observed this in some places on the shores of the Baltic Sea.[2] But whatever the causes of these phenomena, it is certain that they are not universal and that in the majority of ports where people are very interested in observing the height of the sea and where established ancient works provide adequate means to measure the variations, the average sea level is constant. There is no general lowering, no universal encroachment of the land on the sea. In other places, like Scotland and several points in the Mediterranean, people think they have perceived, by

[1]See Observations faites dans la mer du Sud, by R. Forster. [*Translator's note*: a lithophyte is a plant that grows on rock].

[2]It is a common opinion in Sweden that the sea is decreasing and that people ford or go on dry land in many places where that was not possible earlier. Some very knowledgeable men have shared this popular view; and von Buch adopts it so far as to suppose that the entire land mass of Sweden is rising little by little. But it is remarkable that people have not made or at least not published the consistent and precise observations necessary to confirm a fact put forward for so long, something which would not admit of the slightest doubt if, as Linnaeus claims, this difference in level proceeds at a rate of four and five feet per year.

contrast, that the sea is rising and today covers beaches previously above sea level.[1]

VOLCANOES

The action of volcanoes is more limited, even more local than all those which we have just mentioned. Although we do not have any clear idea about how nature maintains these violent furnaces at such great depths, we do judge clearly by their effects the changes which they could have produced on the surface of the earth. When a volcano announces its presence, after some tremors, some shaking of the earth, it creates an opening for itself. Some rocks and cinders are thrown far out, and lavas erupt. The most viscous part runs out in long trails. The less viscous part stops at the edge of the opening and raises its contour, forming there a cone complete with a crater. Thus, volcanoes pile up on the surface materials previously buried in the depths, after having modified those materials. They form mountains. They have in earlier times covered some parts of our continents and have given rise suddenly to islands in the middle of the sea. But these mountains and islands were always composed of lavas. All their materials have gone through the effects of fire. Their shape is determined in accordance with the nature of materials which have run down from an elevated place. The volcanoes thus do not raise up or knock over the strata which cross their opening. And if some causes working in these depths have contributed in some cases to raise large mountains, these are not volcanic actions as they exist in our times.

Thus, to repeat what we have said, it is vain for someone to seek in the forces which affect the surface of the earth today causes sufficient to produce the upheavals and catastrophes whose traces the earth's surface shows us. And if someone wishes to resort to constant external forces known nowadays, among them he will not find sufficient reasons for such revolutionary upheavals.

CONSTANT ASTRONOMICAL CAUSES

The pole of the earth moves in a circle around the pole of the ecliptic;[2] its axis inclines more or less on the plane of this same ecliptic. But these two movements, whose causes nowadays are understood, are carried out in known directions and within known limits, and they are not at all proportional to effects like those whose magnitude we have just established. In

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[1]Robert Stevenson, in his Observations on the Bed of the North Sea and of the Channel, maintains that the level of these seas has continually risen very perceptibly during the last three centuries. Fortis says the same thing about certain places in the Adriatic Sea. But the example of the Temple of Serapis, near Pozzouli, proves that the edges of this sea can naturally rise and sink locally in many places. On the other hand, there are thousands of docks, roads, and other construction works built along the sea by the Romans, from Alexandria right up to Belgium, whose height relative to the sea has not varied.

[2][*Translator's note*: The ecliptic is the circle described by the apparent motion of the sun through the stars, as seen from the earth.]

every case, their excessive slowness would prevent them from being capable of explaining the catastrophes which we have just shown to have been sudden.

This last rationale applies to all slow actions which people have imagined, without doubt in the hope that their existence could not be denied, for it would always be easy to maintain that their very slowness renders them imperceptible. Whether this is true or not is inconsequential. Such forces explain nothing, since no slow action could have produced these sudden effects. Thus, whether there was a gradual diminution of the waters, whether the sea carried solid material in all directions, whether the temperature of the earth decreased or increased, none of these has overturned the strata, enclosed in ice large quadrupeds with their flesh and pelt, put on dry land shell fish still as well preserved today as if they had been caught while still alive, or finally destroyed entire species and genera.

These arguments have forcibly impressed the great majority of naturalists. And among those who have sought to explain the present state of the earth, hardly anyone has attributed it entirely to slow causes, even less to causes working before our very eyes. This need to seek causes different from those which we see at work now is the same need which has led them to dream up so many extraordinary conjectures and made them commit errors and lose themselves in contradictions, so that the very name of their science, as I have said elsewhere, has for a long time been a subject of mockery for some prejudiced people who looked only at the systems which this situation created and who forgot the long and important series of established facts which it has made known.[1]

ANCIENT SYSTEMS OF GEOLOGISTS

For a long time we have accepted only two events, two periods of changes on the earth: the Creation and the Flood. All the efforts of geologists have tended to explain the present state of the earth by imagining a certain original state, later modified by the Flood. Each of them has speculated also about the nature of the causes, the actions, and effects of these events.

Thus, according to one,[2] the earth was first given a smooth and light crust which covered seas in the depths and which broke open to produce the Flood. Its debris formed the mountains. According to another,[3] the Flood was caused by a momentary suspension of mineral cohesion. The mass of earth was entirely dissolved, and the mixture penetrated by shellfish. According to a third,[4] God raised the mountains in order to make the

[1]When I made these remarks, I announced a fact which we witness every day. But I did not maintain that I was expressing my own opinion, as some worthy geologists appear to have believed. If some ambiguity in my phrasing was the cause of their mistake, I make my apologies to them here.

[2]Burnet, Telluris Theoria sacra. Lond. 1681.

[3]Woodward, Essay towards the natural history of the Earth , London, 1702.

[4]Scheuchzer, Mém. de l'Acad. 1708.

waters which had produced the Flood flow out, and put the mountains in places where there were the most rocks, because otherwise it would have been impossible for them to stay up. A fourth created the earth with the atmosphere of a comet and had it overwhelmed by the tail of another comet.[1] The heat which remained from its first origin excited all the living creatures to sin. Thus, they were all drowned, except the fish, who had apparently less excitable passions.

We see that, while entrenching themselves entirely within the limits set by the Book of Genesis, naturalists still gave themselves a sufficiently wide scope. They found themselves soon at an impasse. And when they succeeded in seeing the six days of the Creation as so many indefinite periods, so that centuries of time did not matter to them, their systems took flight in proportion to the lapses of time which they had at their disposal.

Even the great Leibnitz amused himself, like Descartes, by making the earth an extinguished star, a glazed globe, on which vapours, falling down at the time of its cooling, formed the seas which later deposited calcified earth.[2]

Demaillet covered the entire globe with water for thousands of years. He had the waters gradually ebb. All the land animals at first lived in the sea. Even man started as a fish. And the author asserts that it is not rare to meet in the ocean fish which are still only half human, but from them the species will become completely human one fine day.[3]

Buffon's system is merely a development of Leibnitz's, only with the addition of a comet which, by a violent shock, caused the sun to emit the liquid mass of the earth at the same time as the masses of all the planets. From this theory one result is firm dating. For, by the present temperature of the earth, we can know how long it has been cooling. And since the other planets left the sun at the same time as the earth, we can calculate how many centuries the large ones still have to cool and to what point the small ones are already frozen.[4]

MORE RECENT SYSTEMS

In our time, freer spirits than ever before have also wished to busy themselves with this important subject. Certain writers have reproduced and enormously extended Demaillet's ideas. They claim that all was liquid at the beginning, that the liquid engendered at first very simple animals, like monads or other microscopic infusorian species, and that, with the passage of time and the development of different habits, the animal races became more complex and diversified to the point where we see them today. It was all these races of animals who converted the water of the sea by degrees

[1]Whiston, A New Theory of the Earth (London, 1708).

[2]Leibnitz. Protogæa. Act. Lips. 1683; Gott. 1749.

[3]Telliamed. Amsterd. 1748.

[4]Théorie de la terre, 1749; and Époques de la nature, 1775.

into calcified earth. The plants (on the origin and changes of which no one tells us anything) for their part turned this water into clay. But these two earths, by force of being stripped of the characters which life had imprinted on them, resolved themselves, in the last analysis, into silica. And lo and behold, for this reason the oldest mountains contain more silica than the others. All solid parts of the earth therefore owe their origin to living things, and without that life the earth would be still entirely liquid.[1]

Some other writers have preferred Kepler's ideas. Like this great astronomer, they give the earth itself vital faculties. According to them, a fluid circulates in the earth, and an assimilation takes place just as in animated bodies. Each of its parts is alive. Every elementary molecule has instinct and will; they attract and repel each other according to antipathies and sympathies; each sort of mineral can change immense masses into its own nature, as we convert our food into flesh and blood. The mountains are the respiratory organs of the earth, and the schists are the organs of secretion. Through them sea water is decomposed to create the volcanic eruptions. The seams finally are the decaying parts, the abscesses of the mineral kingdom, and the metals a product of decay and illness. That is why almost all of them feel unpleasant.[2]

Even more recently, a philosophy which substitutes metaphors for rational argument, starting with the system of absolute identity or pantheism, ascribes the origin of all phenomena or, what in its eyes is the same thing, of all beings, to polarization, like the two electricities, by calling all opposition, all difference, polarization. Whether we consider situation, nature, or function, this belief sees opposition in the following succession: God and the world, in the universe the sun and the planets, in each planet the solid and the liquid, and following this course, changing as necessary its tropes and its allegories, it reaches even the final details of organic species.[3]

I must confess, however, that above we have selected extreme examples and that not all geologists have carried the airing of their conceptions as far as those we have just cited. However, among those who have proceeded with more reserve and who have not looked for methods outside ordinary physics or chemistry, how much diversity and contradiction still rule!

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[1]See La Physique de Rodig, p. 106, Leipzig, 1801; and page 169 of the second volume of Telliamed, as well as a countless number of new works in German. Lamarck is the one who has developed in recent times this system in France with the most persistence and the most sustained wisdom in his Hydrogéologie and Philosophie zoologique.

[2]The late Patin showed much spirit in maintaining these fantastic ideas in several articles in the Nouveau Dictionnaire d'Histoire naturelle.

[3]One needs to see this application of pantheism to geology especially in the works of Steffens and Oken.

DIVERGENCES OF ALL SYSTEMS

According to one, everything was precipitated successively by crystallization and deposited almost in the same way as it still exists. But the sea, which covered everything, ebbed by degrees.[1] According to another, the materials of the mountains are constantly eroded, carried by rivers, from where they go to the bottom of the sea, get heated by an enormous pressure, and form layers. One day the heat which hardens these layers will lift them up again violently.[2]

A third supposes the liquid divided into a multitude of lakes arranged in amphitheatres one above the other, which, after having deposited the strata with shells successively broke their dams to fill the ocean basin.[3] By contrast, according to a fourth, tides of seven to eight hundred toises have from time to time carried away the depths of the seas and thrown them on the mountains and hills, in the valleys, or on the original continental plains.[4]

A fifth has fall successively from the sky, like meteoric stones, the various fragments of which the earth is composed and which carry in the unknown beings whose remains they conceal the imprint of their foreign origin.[5] A sixth makes the earth hollow and places there a magnetic core, which moves itself, under the influence of comets, from one pole to the other, pulling with it the centre of gravity and the mass of the seas, thus alternately flooding the two hemispheres.[6]

We could cite still twenty other systems every bit as different as the above. And, just to make sure there is no mistake about it, our intention is not to criticize the authors of these systems. On the contrary, we recognize that these ideas have generally been conceived by men of intelligence and wisdom, who have not ignored the facts, several of whom have even travelled for a long time to examine them and have gathered a great deal of important scientific information.

CAUSES OF THESE DIVERGENCES

From where then could such disagreements come in the solutions to a common problem among men who set out with the same principles to resolve it? Could it not be the case that the conditions of the problem have never all been taken into account, that the problem remains, right up to

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[1]Delametherie introduces crystallization as the main cause in his Géologie.

[2]Hutton and Playfair: Illustrations of the Huttonian Theory of the Earth. Edin. 1802.

[3]Lamanon, in various places in the Journal de Physique, following Michaëlis and several others.

[4]Dolomieu, *ibid.* [*Translator's note*: A toise is equivalent to 6.39 English feet or 1.95 metres]

[5]Messrs de Marschall, Researches Respecting the Origin and Development of the Present Order of the Word, Giessen, 1802.

[6]M. Bertrand: Periodic Renewal of the Terrestrial Continents. Hamburg, 1799.

today, poorly defined and capable of several answers, all equally good when we generalize about this or that condition, all equally bad when a new condition has just been recognized or when our attention thinks back to some acknowledged but overlooked condition?

THE NATURE AND CONDITIONS OF THE PROBLEM

To abandon this mathematical language, we will say that almost all the authors of these systems, having paid attention only to certain difficulties which struck them more than others, determined to resolve those difficulties by more or less plausible means and put aside other difficulties, just as numerous and just as important. One person, for example, has seen only the difficulty of the changing level of the seas. Another has seen only the problem of having all the terrestrial substances dissolve in the same single liquid. Finally, yet another has seen only the problem of having animals which he thought were from the torrid zone living in the glacial zone. Exhausting their intellectual energies on these questions, they thought they had done everything in imagining some means or other of answering them. Furthermore, by neglecting in this way all other phenomena, they did not always dream of determining with precision the measure and the limits of those phenomena which they were seeking to explain.

This point is particularly true for the secondary formations, which, however, form the most important and the most difficult part of the problem. For a long time we have concerned ourselves only very slightly with sorting out the sequence of layers which place the strata on top of each other and the relationships between these layers and the plant and animal species whose remnants they contain.

Are there animals and plants which are unique to certain layers and which do not occur in others? What are the species which appear first or those which come later? Do these two types of species sometimes appear together? Is there an alternating pattern in their return or, in other words, do the first ones return for a second time, and then do the second ones disappear? Have these animals and plants all lived in the areas where we find their remains, or are there any which were transported there from somewhere else? Are they still alive today somewhere, or have they been destroyed completely, or in part? Is there a constant connection between the age of these layers and the similarity or dissimilarity between their fossils and living things? Is there a climatic connection between fossils and those living things which resemble them the most? Is it possible to conclude that the transport of these beings, if there was one, took place from north to south or from east to west, or by radiating out and mixing? And can we distinguish the epochs of these transports by the layers which carry the imprints of them?

What is there to say about the causes of the earth's present condition, if one cannot reply to these questions, if one has not yet sufficient reason for choosing between the affirmative and the negative? Now, it is only too true

that for a long time none of these points has been resolved beyond doubt and that we have hardly even dreamed that it would good to clarify them before making up a system.

Reason for the Neglect of these Conditions

We will discover the reason for this odd situation if we reflect that geologists have all been either museum naturalists, who hardly ever examined the structure of mountains on their own, or mineralogists, who have not studied with sufficient detail the innumerable varieties of animals and the infinite complexity of their various parts. The first have only made systems; the latter have provided excellent observations: they have truly laid down the foundations of the science. But they have not been able to raise an edifice upon it.

Progress of Mineral Geology

In fact, the purely mineral part of the important problem of the theory of the earth has been studied with an admirable care by de Saussure and developed astonishingly since by Werner and the numerous knowledgeable pupils he has trained.

The first of these famous men *[de Saussure]* for twenty years carefully traversed the most inaccessible areas, attacking in one way or another the mountains of the Alps by all their faces and fissures. He has revealed to us the entire disorder of the primitive formations and has traced very clearly the boundary which distinguishes them from the secondary formations. The second man *[Werner]*, profiting from the numerous excavations made in the country which has the oldest mines *[Saxony]*, has established the laws of the succession of strata. He has shown their respective ages and followed each of them in all its changes. From him, and from him alone, reliable geology will begin, so far as the mineral composition of the strata is concerned. But neither Werner nor de Saussure paid the strict attention necessary to sort out the species of organic fossils in each type of layer, since the time the number of known animals has increased so enormously.

True, other scholars studied the fossil remains of organic bodies. They collected them and drew copies of them by the thousands. Their works will be valuable collections of materials. But more occupied with animals or with plants, considered in themselves, than with the theory of the earth, or looking upon these petrified remains or these fossils as curiosities rather than as historical documents or, finally, contenting themselves with partial explanations for the deposit of each piece, they have almost always neglected to seek out general laws concerning the position or the relationship of the fossils to the strata.

Importance of Fossils in Geology

However the idea of this research *[into the relationships between the fossils and the strata]* was very natural. How did we not see that it is to fossils alone that we owe the birth of a theory of the earth, that, without

them, we would perhaps never have dreamed that in the formation of the earth there was a succession of epochs and a series of different events? Fossils alone, in fact, establish reliably that the earth has not always had the same crust, for we are certain that they must have lived on the surface before being thus buried deep below. It is only by analogy that we have applied to primitive formations the conclusion which the fossils provide directly about the secondary formations, and if we had only formations without fossils, no one could have claimed that these formations had not been formed all together.

Moreover, even though our knowledge of fossils has remained slight, it is once more through them that we have come to understand the little we do know about the nature of the earth's revolutionary upheavals. They have taught us that the layers which contain them were deposited gently in a liquid, that their variations corresponded to those of the liquid, that their exposure was brought about by the movement of this liquid, and that this exposure happened more than once. None of this would be certain without fossils

The study of the mineral aspects of geology, which is no less necessary and which, indeed, has for the practical arts a much greater utility, is nevertheless a lot less instructive concerning the matters under discussion.

We are in the most abysmal ignorance about the causes which could have created the variety in the materials which compose the strata. We do not even know the agents which could have held some of them in solution. We still argue about several, whether they owe their origin to water or to fire. Basically we could see before that we are in agreement on only a single point: we know that the sea has changed its position. And how do we know that, if not by the fossils?

The fossils which have given birth to the theory of the earth have, at the same time, thus given the principal clues, the only ones which up to this point have been generally recognized.

This idea was the one which encouraged me to busy myself with the subject. But the field is immense. One man alone could with difficulty deal cursorily with a very small part of it. It was therefore necessary to make a choice, and I soon made it. The class of fossils which is the object of this work *[quadruped fossils]* attracted me at first sight, because I saw that it was at one and the same time the most productive of precise results and yet less well understood; it was also richer in new subjects for research.[1]

[1]My work has proved, in fact, just how new this material still was when I began it, in spite of the excellent work of Camper, Pallas, Blumenbach, Merk, Soemmerring, Rosenmüller, Fischer, Faujas, Home, and other scholars whose publications I have taken the greatest care to cite in my chapters where they are relevant.

SPECIAL IMPORTANCE OF THE FOSSIL BONES OF QUADRUPEDS

It is noticeable, in fact, that the fossils of quadrupeds can lead, for several reasons, to more rigorous results than can any other remains from organic bodies.

First, they characterize in a more precise manner the upheavals which have affected them. Shellfish announce clearly that the sea where they were formed existed, but their changes in species could in a pinch result from slight changes in the nature of the liquid or merely in its temperature. They could have been a result of causes even more accidental. Nothing assures us that, in the depths of the sea, certain species, certain genera even, after having occupied the same fixed areas for greater or lesser periods of time, could not have been chased away by others. With the quadrupeds, by contrast, all is precise. The appearance of the bones of quadrupeds, especially those of their complete bodies in the strata, tells us either that the layer itself which carries them was in earlier times dry land or that dry land was at least formed in the immediate area. Their disappearance confirms that this layer was flooded or that the dry land ceased to exist. Thus, through these bones we learn with certainty the important fact of the repeated flooding by the sea. The seashells and the other marine products by themselves would not have taught us this. By a detailed study of these quadruped fossils we can hope to learn the number and ages of these inundations.

Second, the nature of the revolutions which have altered the surface of the earth must have had a more decisive effect on the terrestrial quadrupeds than on the marine animals. Since these revolutions consisted, in large part, of displacements of the sea floor and since the waters must have destroyed all the quadrupeds which they caught, if their flooding was universal, it could have made an entire class extinct. Or if the flooding at any one time reached only certain continents, it could have destroyed at least the species unique to these continents without having the same influence on the marine animals. By contrast, millions of aquatic individuals could have been left on dry land or buried under new strata or thrown violently onto the shore, and their race could nevertheless have been saved in some more peaceful places, from which the species would again propagate itself after the disturbance of the seas had stopped.

Third, this more complete action is also easier to grasp. Its effects are simpler to demonstrate. For since the number of the quadrupeds is limited and most of their species, at least the big ones, are known, we have more ways of assuring ourselves if the fossil bones belong to one of them or if they come from an extinct species. Since we are, by contrast, a very long way from understanding all the shellfish and sea fish and since we are probably still ignorant of the majority of those which live in the depths, it is impossible to know with certainty if a species for which one locates a fossil is not still living somewhere. Thus we see scholars stubbornly striving to assign the name of Pelagic shells, that is to say, shell fish of the

high seas, to belemnites, horned ammonites, and to other shell remains which have been seen only in the ancient strata. In so doing, they wish to claim that, if we have not yet uncovered any living specimens, that is because they live at depths inaccessible to our nets.

Without doubt naturalists have not yet crossed all the continents and do not even know all the quadrupeds which live in the countries they have traveled across. From time to time we discover new species of quadrupeds. And those who have not examined with care all the circumstances of these discoveries could believe as well that the unknown quadrupeds whose bones we find in our layers have remained hidden right up to the present time in certain islands which sailors have not yet encountered or in one or another of the vast deserts located in the middle of Asia, Africa, the two Americas, or New Holland *[Australia]*.

THERE IS LITTLE HOPE OF DISCOVERING NEW SPECIES OF LARGE QUADRUPEDS

However, if one examines closely the sorts of quadrupeds which we have discovered recently and the circumstances in which we have discovered them, one will see that there is little hope of some day finding those which we have so far seen only in fossils.

The moderately sized islands far from large land masses have very few quadrupeds, for the most part extremely small. When they do have large specimens, the fact is that they have been brought there from elsewhere. Bougainville and Cook found only pigs and dogs in the South Sea islands. The largest quadrupeds of the Antilles were the agoutis *[rodents of the guinea pig family]*.

True, the large land areas, like Asia, Africa, the two Americas, and New Holland have large quadrupeds, and generally species unique to each of them. Thus, every time people discovered these land masses whose location had kept them isolated from the rest of the world, they have found there a class of quadrupeds entirely different from what existed elsewhere. Hence, when the Spaniards crossed South America for the first time, they did not find there a single European, Asian, or African quadruped. The puma, jaguar, tapir, cabiai, llama, vicunas, sloths, armadillos, opossums, and all the monkeys were for them entirely new creatures of which they had no conception. The same thing happened again in recent times when we began to examine the coasts of New Holland and the adjacent islands. The strange conformations of the various kangaroos, phascolomes, marsupials, bandicoots, flying marsupials, platypuses, and spiny ant eaters, which broke all the rules and fell outside all systems, simply astonished naturalists.

Thus, if there remained some large continent to discover, we could again hope to learn about new species. Among these we could find some more or less similar to those whose remains the depths of the earth have revealed to us. But it is enough to glance at a map of the world and to look at the countless directions in which navigators have criss-crossed the ocean, in

order to conclude that there must be no more large land mass, unless it is in the region of the south pole, where the ice would not permit any remnant of life to survive. Thus, only in the interior of the large spaces of the earth can we still expect to come across unknown quadrupeds. But with a little reflection, we will soon see that such an expectation is hardly more justified with this region than with the islands.

No doubt, the European traveller does not easily cross the vast extents of territory, deserted or supporting only ferocious peoples. That is especially true as far as Africa is concerned. But nothing prevents the animals from crossing these areas in every direction and from moving towards the coasts. Where there would be large chains of mountains between the coasts and the interior deserts, they would always be interrupted by some narrow passes to allow the rivers to get through. In the burning deserts, the quadrupeds follow by preference the borders of the streams. The small tribes of the coasts also go up these streams and quickly learn, whether for themselves or from trade and the traditions of the tribes upstream, about all the noteworthy species which live right up to the stream's sources. Thus, at no historical period has it taken very long for the civilized nations who have spent time on the coasts of a large territory to know sufficiently well the large animals of the region or those with a striking shape.

Established facts fit this line of reasoning. Although the ancients did not go beyond the Imaeus and the Ganges rivers in Asia and although in Africa they did not go far south beyond the Atlas mountains,[1] they really knew about all the large animals in these two parts of the world. And even if they did not distinguish all the species, that is not because they could not see them or hear people talk about them, but because the similarity of these species did not allow them to recognize their characteristics. The only important exception which one might offer to counter my opinion is the Malacca tapir, recently sent from India by two young naturalists, students of mine, Duvaucel and Diard. This is, in fact, one of the finest discoveries to enrich natural history in recent times.

The ancients knew the elephant very well, and the history of this quadruped is more accurate in Aristotle than in Buffon. They were not ignorant even of some differences which distinguish African from Asian elephants.[2] The ancients knew about the two-horned rhinoceros, which modern Europe has not seen alive. Domitian displayed them in Rome and had them inscribed on his medallions. Pausanias describes them very well. The single-horned rhinoceros, although its home was far away, they knew equally well. Pompey put one on display in Rome. Strabo gave an accurate description of another one of them at Alexandria.[3] The Sumatra rhinoceros

[1][*Translator's note*: The Atlas mountains, in North Africa, separate the coastal lands from the Sahara desert to the south]

[2]See in Volume I of my Recherches the chapter des Éléphans.

[3]See in Volume II, first part, the chapter des Rhinocéros.

described by Bell and the one from Java, discovered and sent back by Duvaucel and Diard, do not appear to have inhabited the continental mainland. Thus, there is nothing astonishing in the fact that the ancients knew nothing about them. In addition, they perhaps could not have distinguished between the different rhinoceroses.

The hippopotamus was not so well described as the species mentioned earlier. But we find really exact depictions of them on the monuments representing things to do with Egypt which the Romans left, such as the statue of the Nile, the Palestrine mosaic, and a large number of medallions. In fact, the Romans saw these animals several times. Scaurus, Augustus, Antoninus, Commodus, Heliogabulus, Philip, and Carinus put them on display.[1]

The two species of camel, the Bactrian and the Arabian, were already very well described and characterized by Aristotle.[2]

The ancients knew about the giraffe, or camel leopard. They even saw one of them alive in Rome, in the circus, during the dictatorship of Julius Caesar, in the Roman year 708. Ten of them collected by Gordian III were killed in the secular games of Philip,[3] a fact which ought to astonish us moderns, who have seen only one, in the fifteenth century.[4]

If one reads with attention the descriptions of the hippopotamus provided by Herodotus and Aristotle, which are believed to be taken from Hecataeus of Miletus, one will find that they must have been made up of the descriptions of two different animals. One perhaps was the true hippopotamus, and the other was clearly the gnu (*Antilope gnu*, Gmel.), the quadruped which our naturalists heard about only at the end of the eighteenth century. It was the same animal of which we had fabulous accounts under the name of *catoblepas* or *catablepon*.[5]

The Ethiopian wild boar of Agatharchides, which had horns, was indeed our modern Ethiopian wild boar, whose enormous tusks deserve the name of horns almost as much as the elephant's tusks.[6]

The bubal *[species of antelope]* and the nagor *[Senegal antelope]* were described by Pliny;[7] the gazelle by Aelianus;[8] the oryx *[African antelope]* by Oppian;[9] axis deer have been described since the time of Ctesias;[1] the

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[1]See my chapter de l'Hippopotame in Volume I of Recherches.

[2]Hist. anim., Book II, cap I.

[3]Jul. Capitol., Gord. III, cap. XXIII.

[4]The animal which the Sultan of Egypt sent to Lorenzo de Medici and which is painted on the Poggio-Cajano frescos.

[5]See Pliny, lib. VIII, cap. XXXII; and especially Ælian., lib. VII, cap. V.

[6]Ælian., Anim., V, 27.

[7]Pliny, lib. VIII, cap. XV, and lib XI, cap. XXXVII.

[8]Ælian., Anim., XIV, 14.

[9]Opp., Cyneg., II, V. 445 ff.

agazel *[species of gazelle]* and corinna antelope are perfectly depicted on the Egyptian monuments.[2] Aelianus provides a good account of the yak, or *bos grunniens*, under the name of the ox whose tail serves to make fly swatters .[3]

The buffalo was not domesticated in the time of the ancients; but the Indian bull, which Aelianus mentions and which had horns sufficiently large to hold three amphoras, was indeed a variety of buffalo, called *arni*.[4] Even the wild bull with depressed horns, which Aristotle places in the territory of the Arachotai, can only be the ordinary buffalo.[5]

The ancients knew about cattle without horns,[6] African cattle, whose horns are attached only to the hide and move with it,[7] Indian cattle, which run as fast as horses,[8] cattle which are no bigger than a Billy goat,[9] sheep with large tails,[10] and Indian sheep as large as donkeys.[11]

Although the evidence the ancients give us on the aurochs *[wild oxen]*, reindeer, and elk is all jumbled up with fables, it always shows that they knew something about the animals, but that this knowledge, based on the accounts of crude people, had not been subject to a judicious critical evaluation.[12]

These animals still inhabit the countries where the ancients put them and have disappeared only in regions too cultivated for their habits. Aurochs and elks live today in the Lithuanian forests, which in previous times were continuous with the Hercynian forest. There are aurochs in the north of Greece, as in the time of Pausanias *[second century AD]*. The reindeer lives in the frozen territories up north, where it has always lived. There it changes colour, not through its own will but following the sequence of the seasons. It is through a series of hardly excusable misunderstandings that people have assumed that reindeer were found in the fourteenth century in the Pyrenees.[13]

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[1]Pliny, lib. VIII, cap. XXI.

[2]See the great work on Egypt, Antiq., IV, pl. XLIX and pl. LXVI.

[3]Ælian., Anim., XV, 14.

[4]*Idem,* III, 34.

[5]Arist. Hist. An., lib. II, cap. 5. [*Translator's note*: the Arachotae were located beyond the Indus river.]

[6]Ælian., II, 53.

[7]*Idem*, II, 20.

[8]*Idem*, XV, 24.

[9]*Idem, ibid.*

[10]*Idem*, Anim., III, 3.

[11]*Idem,* IV, 32.

[12]See in my Recherches, Volume IV, the chapter des Cerfs and the one des Bœufs.

[13]Having read in Du Fouilloux an abbreviated passage of Gaston-Phebus, Comte de Foix, where this nobleman describes a reindeer hunt, Buffon imagined that at the time of Gaston this animal was living in the Pyranees. The printed editions of Gaston were so

Even the white bear was seen in Egypt under the Ptolemies.[1] Lions and panthers were common at Rome during the games. People saw hundreds of them there and even some tigers. The striped hyena and the Nile crocodile appeared there. In the ancient mosaics preserved at Rome there are some excellent portraits of the rarest of these species. Among others, the striped hyena is seen perfectly represented in a portion kept in the Vatican Museum. While I was at Rome (in 1809), a paved mosaic of natural stones was discovered in a garden beside the Arch of Galienus, constructed in the Florentine style, depicting in a very good representation four Bengal tigers.

The Vatican Museum possesses a crocodile made of basalt almost perfect in its accuracy.[2] One can hardly doubt that the *hippotigre* was the zebra, which, however, lives only in the southern parts of Africa.[3]

It would be easy to show that the ancients noted with sufficient clarity almost all the species of monkeys in any way remarkable, under the names of pithecians, sphinxes, satyrs, cebuses, cynocephaluses, and cercopithecuses.[4]

The ancients knew and described rodents, including quite small species, when they had some noteworthy shape or characteristic.[5] But the small species are not relevant to our purpose, and it is sufficient for us to have shown that all the large species remarkable for some striking characteristic which we know about today in Europe, Asia, and Africa were already known to the ancients. From this we can readily conclude that if they did not mention the small ones or did not distinguish those which resemble each other closely, like the various gazelles and others, they were prevented from doing so by a lack of attention and method, rather than by climatic barriers. We conclude also that if eighteen or twenty centuries and the circumnavigation of Africa and the Indies have not added anything in this matter to what the ancients have taught us, it does not seem likely that the centuries to come will bring much to our posterity.

But perhaps someone will make a counterargument and say that the ancients, as we have just established, not only knew just as many large

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inaccurate that it was difficult to know exactly what this author wanted to say. But having reread his original manuscript, which is kept at the King's Library, I have confirmed that it was in *Xueden* and in *Nourvègue* (in Sweden and in Norway) that he said he had seen and chased reindeer.

[1]Athenaeus, lib. V.

[2]The only mistake is one extra claw on the rear foot. Augustus put thirty-six of the animals on public display. Dion, lib. LV.

[3]Caracalla killed one of them in the circus. Dion, lib. LXXVII. Conf. Gisb. Cuperi de Eleph. In nummis obviis, ex. II, cap. VII.

[4]See Lichtenstein: Comment. de Simiarum quotquot veteribus innotuerunt formis. Hamburg. 1791.

[5]The gerbil is engraved on medallions of Cyrene and indicated by Aristotle under the name of *two-footed Rat*.

animals as we do, but that they described several creatures which we do not have, that we are too quick to look upon these animals as fabulous creatures, that we should search for them again before believing that we have exhausted the history of created existence, and finally that among these allegedly fabulous animals, when we understand them better, perhaps will be found the originals of our unknown fossil species. Some will even think that these various monsters, essential embellishments in the heroic history of almost every people, are precisely those species which it was necessary to destroy in order to permit civilization to establish itself. Thus, the Theseuses and Bellerophons would have been more fortunate than all our people nowadays, who have effectively driven away harmful animals but have still not succeeded in getting rid of any completely.

It is easy to reply to this objection by examining the descriptions of these unknown living creatures and going back to their origins. The majority of them have a purely mythological source, and their descriptions bear the incontrovertible imprint of that, for one sees in almost all of them only the parts of known animals, recombined by a freewheeling imagination and contrary to all the laws of nature.

The ones the Greeks invented or arranged have at least a certain grace in their composition, similar to the arabesques which decorate some remains of ancient buildings, which the fertile paintbrush of Raphael has produced in great numbers. The forms which unite in them, no matter how repugnant to reason, offer shapes agreeable to the eyes. These are the light products of happy dreams, perhaps emblems in the eastern fashion, where people claimed to clothe in mysterious images some metaphysical or moral propositions. Let us excuse those who use up their time revealing the wisdom hidden in the sphinx of Thebes, or in the Pegasus of Thessaly, or in the minotaur of Crete, or in the chimera of Epirus. But let us hope that no one will seriously search for them in nature. One might as well look there for the animals in Daniel or the Beast of the Apocalypse.

Let us not seek in nature any more for the mythological animals of the Persians, offspring of an even more exalted imagination: the *marticore* or *destroyer of men*, which bears a human head on the body of a lion, with a scorpion's tail at the end,[1] the *griffon* or *guardian of treasures*, half eagle, half lion,[2] the *cartazonon*,[3] or wild ass, whose forehead is armed with a long horn.

Ctesias, who maintained that these animals exist, was considered, among many writers, an inventor of fables, whereas all he did was attribute reality to emblematic figures. These fantastic compositions have been found

[1]Plin., VIII, 31; Arist., lib. II, cap. XI; Phot., Bibl., art. 72; Ctes., Indic.; Ælian., Anim., IV, 21.

[2]Ælian., Anim., IV, 27.

[3]*Idem*, XVI, 20; Photius, Bibl., art. 72; Ctes., Indic.

sculpted in the ruins of Persepolis.[1] What did they signify? We will probably never know, but we can be sure they do not represent real living things.

Agatharchides, that other inventor of animals, probably drew his ideas from an analogous source. The monuments of Egypt still show us numerous combinations of parts of various species. The gods there are often represented with a human body and an animal head. We see there animals with human heads, which have produced the cynocephalids, sphinxes, and satyrs of the ancient naturalists. The custom of representing there in the same picture men of very different heights, the gigantic king or conqueror, the vanquished or the subjects three or four times smaller, would have given rise to the fable of the pygmies. In some recess of one of these monuments, which Agatharchides would have seen, his carnivorous bull, whose muzzle, split right up to the ears, spared no other animal.[2] But naturalists would certainly not swear by this creature, because nature does not combine cloven hooves or horns with incisor teeth.

Perhaps there were plenty of other figures just as strange, either in those monuments which could not last over time or in the temples of Ethiopia and Arabia which the Mahommedans and the Abyssinians destroyed in their religious zeal. The monuments in India swarm with them. But there the combinations are too extravagant to have fooled anyone: monsters with a hundred arms and twenty completely different heads are far and away too grotesque.

Even among the Japanese and the Chinese there are imaginary animals which they give out as real and which they even depict in their religious books. The Mexicans had them. It is the custom of all peoples, whether in the ages when their idolatry is not yet sophisticated or at a time when the meaning of these symbolic combinations has been lost. But who would dare to claim to find in nature these offspring of ignorance or superstition?

However, it has happened that some travelers, to enhance their reputation, have claimed to see these fantastic creatures or, through lack of attention and led into error by a slight resemblance, have confused something alive with them. The large monkeys appeared to be real cynocephalids, true sphinxes, or real men with tails. That is how Saint Augustine believed he had seen a satyr.

Some real animals poorly observed and poorly described would also have given birth to ideas about monsters, although founded on some reality. Consequently, no one can doubt the existence of the hyena, although this

[1]See Corneille Lebrun, Voyage en Moscovie, en Perse et aux Indes, Vol. II; and the German work of Heeren, on the commerce of the ancients.

[2]Photius, Bibl., art. 250; Agatharchid., Excerpt. hist., cap. XXXIX; Ælian., Anim., XVII, 45; Plin., VIII, 21.

animal does not have its neck supported by just one bone,[1] and it does not change its sex each year, as Pliny states.[2] Thus, the carnivorous bull is perhaps only a rhinoceros with two distorted horns. De Weltheim correctly states that the gold-bearing ants of Herodotus are *corsacs [Tartar foxes]*.

Among the ancients, one of the most famous animals is the *unicorn*. People have continued right up to our own time to seek it out or at least to find arguments to support its existence. Among the ancients, three animals are frequently mentioned as having only one horn in the middle of the forehead: the African oryx *[a species of antelope]*, which also has cloven hooves, hair going in the wrong direction,[3] a large size, comparable to that of a bull,[4] or even a rhinoceros,[5] and which people agree is shaped like a stag and a goat;[6] the *Indian ass*, which has an uncloven hoof, and the *monoceros*, to use the correct name, whose feet are sometimes compared to those of a lion,[7] sometimes to those of an elephant,[8] an animal which is consequently supposed to be a fissiped *[having divided toes]*. The unicorn horse[9] and the unicorn bull, are undoubtedly both related to the Indian ass, for even the bull has been depicted as having an uncloven hoof.[10] If these animals existed as distinct species, I raise the question whether we would not have at least the horns in our collections. And what unmatched horns do we have there other than those of the rhinoceros and the narwhal?

How, after that, can we rely on the crude figures traced by savages on the rocks?[11] Not knowing about perspective and wishing to portray an antelope with straight horns in profile, they would have been able to provide it with only one horn, and lo and behold, all of a sudden, an oryx! The oryxes of the Egyptian monuments are probably nothing other than products of the

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[1]I have even seen in the collection of the late Adrien Camper the skeleton of a hyena where several of the vertebrae of the neck were knitted together. It is probably the case that some similar specimen brought about the attribution of this characteristic in general to all the hyenas. This animal must be subject to this accident more than others, because of the formidable power of the neck muscles and the frequent use which it makes of them. When the hyena has seized something, it is easier to drag the entire animal than to take from it what it is holding. That is the reason the Arabs have made the hyena the symbol of invincible obstinacy.

[2]It does not change its sex, but it has in its perineum an orifice which could make one think it hermaphroditic.

[3]Arist., Anim., II, I, III, I; Plin., XI, 46.

[4]Herod., IV, 192.

[5]Oppien, Cyneg., II, vers. 55.

[6]Plin., VIII, 53.

[7]Philostorge, III, II.

[8]Plin., VIII, 21.

[9]Onesicritus, ap. Strab., lib. XV; Ælian., Anim., XIII, 42.

[10]Plin., VIII, 31.

[11]Barrow: Voyage to the Cape, Fr. Trans., II, 178.

crude style imposed on the artists of that country by their religion. Many of their profiles of quadrupeds display only one limb in front and one behind. Why would they have shown two horns? Perhaps in the hunt someone chanced to get some individual animals which had accidentally lost one horn, as happens often enough with chamois and saigas *[a form of antelope]*, and that would have been enough to confirm the error produced by these images. Probably this is the way people recently came across the unicorn in the mountains of Tibet.

Besides, not all the ancients by any means give the oryx just one horn. Oppian expressly gives it several,[1] and Aelianus refers to some oryxes who have four of them.[2] Finally, if this animal was a ruminant and had cloven hooves, it would certainly have the frontal bone divided in two, and, according to the very apt comment of Camper, would have been unable to carry a horn on the suture.

But it will be said, what animal with two horns could have provided the idea for the oryx and demonstrated characteristics with which people confirm its shape, even if one forgets about the notion of a single horn? I reply, with Pallas, that the animal is the antelope with straight horns, inappropriately named *pasan* by Buffon (*Antilope oryx*, Gmel). It lives in the deserts of Africa and must come right up to the borders of Egypt. That is the animal which the hieroglyphs appear to have depicted. Its form is close enough to that of a stag; it is equal in size to the bull; the hair on its back points towards the head; its horns form terrible weapons, as piercing as darts and as hard as iron. Its fur is off white; its face carries black traces and stripes. There we have all that the naturalists have said about it. As for the fables of the Egyptian priests which led to the adoption of its image among the hieroglyphic signs, these stories were not necessarily based on nature. Thus, whether people saw an oryx lacking one horn, whether they took it for a regular living specimen, typical of the entire species, whether this mistake adopted by Aristotle was copied by his successors, all that is possible, even natural. It will, however, prove nothing about the existence of a unicorn species.

As for Indian ass, if one reads about the properties which the ancients attributed to its horn as an antidote for poisons, one will see that they are exactly the same as those Eastern people nowadays attribute to the horn of a rhinoceros. In the earliest times, when this horn would have been brought among the Greeks, people would not yet have known about the animal which carried it. In fact, Aristotle makes no mention of the rhinoceros, and Agatharchides is the first to describe it. In the same way the ancients had ivory long before they knew about the elephant. Perhaps some of their travellers even named the rhinoceros the *Indian ass*, with just as much justification as the Romans called the elephant the *bull of*

[1]Oppien., Cyneg., lib. II, v. 468 et 471.

[2]De An., lib. XV, cap. 14.

Lucania. Moreover, everything which is said of the force, size, and ferocity of this savage ass fits the rhinoceros really well. Afterwards, when those who knew more about the rhinoceros found in the earlier authors reference to an *Indian ass*, they accepted it, for lack of any critical study, as a separate animal. Finally, from this name people would have concluded that the animal must have had uncloven hooves. There is indeed a very detailed description of the Indian ass in Ctesias,[1] but we have seen above that it was taken from the bas reliefs of Persepolis. Thus, it must be discounted in the reliable history of the animal.

When at last some slightly more exact descriptions were made, ones which talked about an animal with a single horn but with several digits, people made of it still a third species, named *monoceros*. These sorts of ambiguities are, by the way, all the more frequent in the ancient naturalists, since almost all of them whose works we have were simple compilers. Aristotle himself frequently mixed up facts borrowed from somewhere else with those which he had observed for himself. Finally, the skill of critical analysis was poorly understood then, just as much by the naturalists as by the historians, which is saying a great deal.

From all these reasons and digressions, the result is that the large animals which we know existed in ancient times were known by the ancients and that the animals described by the ancients and unknown in our time were imaginary. Moreover, it thus follows that not a great deal of time was needed for the large animals of the three major parts of the world to become known to the people who spent time on the coasts of those regions.

We can also conclude from this that we do not have any large species to discover in America. If some of them lived in that place, there would be no reason for us not know about them. In fact, for one hundred and fifty years we have not discovered one. The tapir, jaguar, puma, cabiai, lama, vicuna, red wolf, buffalo or American bison, anteaters, sloths, and armadillos are already in Margrave and in Hernandez, as in Buffon. One can even say that they are better there *[in the former]*, because Buffon has muddled up the history of the anteater, failed to recognize the jaguar and the red wolf, and confused the American bison with the aurochs of Poland. It is true that Pennant is the first naturalist clearly to distinguish the small musk ox, but travellers had been pointing it out for a long time. The horse with cloven hooves in Molina was not described by the first Spanish travellers, but it is more than doubtful that it exists, and the authority of Molina is too suspect to adopt his account. It would be possible to characterize better the stags of America and India, which have not been well described. But so far as they are concerned, the case is the same as with the various antelopes among the ancients. The lack of a good method for distinguishing them and not the absence of opportunities to see them has led to

[1] Ælian., Anim., IV, 52; Photius, Bibl., p. 134.

their not being better understood. We can therefore say that the moufflon *[wild sheep]* of the Blue Mountains is up to now the only American quadruped of some size whose discovery is entirely modern. And perhaps it is only an argali *[Asian mountain sheep]* which came across the ice from Siberia.

After that, how can we believe that the immense mastodons, the gigantic megatheriums, whose bones have been found in the earth in the two Americas, still live on this continent? How would they have escaped the notice of those small nomadic tribes, who continuously cross the country in every direction and who themselves recognize that these creatures do not live there any more, because they have dreamed up a fable about their destruction, saying that they were killed by the Great Spirit, to prevent them from wiping out the human race. But we recognize that this fable arose thanks to the discovery of bones, just like the story of the inhabitants of Siberia concerning their mammoth, which they maintain lives, like a mole, under the earth, and like all those fables about the tombs of giants which the ancients located everywhere elephant bones were found.

Thus, we can readily believe that if, as we pointed out a moment ago, none of the large species of quadrupeds today buried in the regular rock strata is similar to the living species which we know about, that is not the result of simple chance, nor because those very species for which we have only the fossil bones are hidden in the deserts and have evaded all travelers up to the present time. We must, by contrast, look upon this phenomenon as having universal causes, and the study of it as one of the most appropriate ways to go back to the nature of these causes.

THE FOSSIL BONES OF QUADRUPEDS ARE DIFFICULT TO DETERMINE

But if this study *[of quadruped fossils]* is more satisfying in its results than the study of the fossil remains of other animals, it is also bristling with far more difficulties. The shell fossils normally are present in their entirety, with all the characteristics which can make them similar to analogous specimens in the collections or publications of naturalists. Even the fish provide more or less complete skeletons. We can distinguish there almost always the general form of their bodies, and very frequently their generic characteristics and specific details which are derived from their hard parts. By contrast, with the quadrupeds, when we come up against the entire skeleton, for the most part we have difficulty drawing conclusions about characteristics deriving from the hair, the colours, and other marks which have vanished before they became fossilized. And it is extremely rare to find a fossilized skeleton even partially complete. Some isolated bones thrown all over the place, almost always broken and reduced to some fragments, that is all that our strata present to us from this class of animals, and that is the only resource of the naturalist. Also it can be said that the majority of observers, alarmed at the difficulties, have skimmed over the fossil bones of quadrupeds, have classified them in a vague way, according to superficial similarities, or have not even dared to give them a

name, so that this part of the history of fossils, the most important and most instructive of all, is also the least cultivated.[1]

PRINCIPLE OF DETERMINATION

Fortunately comparative anatomy possessed a principle which, well developed, was able to make all the trouble vanish: it is the principle of the correlation of structures in organic beings, by means of which each sort of creature could in a pinch be recognized by each fragment of each of its parts.

The entirety of an organic being forms a coordinated whole, a unique and closed system, in which the parts mutually correspond and work together in the same specific action through a reciprocal relationship. None of these parts can change without the others changing as well. Consequently, each of them, taken separately, points to and reveals all the others.

Thus, as I have said elsewhere, if the intestines of an animal are organized in such a way as to digest only meat and meat that is fresh, it is necessary also that its jaws be constructed to devour its prey, its claws to seize and tear it apart, its teeth to cut and chew it, the entire system of its organs of motion to rush and catch the prey, its sense organs to perceive it from far away. It is even necessary that nature has placed in its brain the required instinct to know how to hide itself and set traps for its victims. Such will be the universal conditions for the kingdom of the carnivores; all animals destined for this kingdom will infallibly combine them, because its race would not have been able to survive without them. But under these general conditions, there exist particular ones, relative to the size, species, and habitat of its prey, for which the animal is structured. And from each of these particular conditions result the modifications of detail in the forms which derive from the general conditions. Thus, not only the class, but the order and the genus, up to and including the species are found expressed in the form of each part.

In effect, in order for the jaw to be able to seize something, it must have a certain form of condyle *[rounded structure at the end of bones]*, a certain coordination between the points of resistance and power with the fulcrum, a certain volume in the temporal muscle, which demands a certain breadth in the pit which contains it, and a certain convex shape in the zygomatic arch under which it passes. This zygomatic arch must also have a certain strength to support the masseter muscle *[jaw muscle]*.

In order for the animal to be able to carry off its prey, it must have a certain power in the muscles which hold up the head, a factor which

[1]By this remark, I do not at all intend, as I have already said earlier, to denigrate the value of the observations of Camper, Pallas, Blumenbach, Sömmering, Merk, Faujas, Rosenmüller, Home, and so on; but their worthy labours, which I have found very useful and which I cite everywhere, are only partial, and several of these works have been published only since the first editions of this discourse.

results in a fixed shape for the vertebras where these muscles are attached to them and for the occiput *[back of the skull]* into which they fit. In order for the teeth to be able to cut through the meat, they must be incisors, and they must be more or less like incisors, according to whether they are more or less exclusively for biting through flesh. Their base must be even more solid in proportion to the quantity and size of the bones they would have to break apart. All these circumstances will have an effect also on the development of all the parts which serve to move the jaw.

In order for the claws to be able to seize the prey, there will have to be a certain mobility in the digits and a certain power in the nails. From this will result fixed forms in all the phalanges *[bones in the digits]* and the necessary distribution of muscles and tendons. The forelimbs will have to have a certain ability to turn, from which will result once more the fixed forms of the bones which make them up. But the bones of the forelimbs, which articulate with the humerus *[bone of the upper arm]*, cannot change their structure without bringing about changes in the humerus. The bones of the shoulder will have to have a certain firmness in the animals which use their front limbs for seizing prey, and from this will result once more particular structures for them. The interplay of all these parts will demand certain proportions in all the muscles, and the patterns of the muscles thus proportioned will again determine more particularly the structures of the bones.

It is easy to see that one can draw similar conclusions for the posterior extremities which contribute to the general rapidity of movement, for the structure of the trunk and the shapes of the vertebrae, which affect the ease and flexibility of movement; for the structures of the bones of the nose, eye socket, and ear, whose coordination is evident with the perfection of the senses of smell, sight, and hearing. In a word, the structure of the tooth entails the structure of the condyle, of the shoulder blade, of the nails, in just the same way as the equation of a curve controls all its characteristics. Moreover, by taking each separate characteristic as the basis of a particular equation, we can find both the ordinary equation and all the other properties whatsoever, even the claws, shoulder blade, condyle, femur, and all the other bones each taken separately, reciprocally indicating or being indicated by the tooth. Starting with each of them, the person who possesses rationally the laws of the organic economy could reconstruct the complete animal.

The general meaning of this principle is clear enough in itself not to require a fuller demonstration. But when it comes to applying it, there area great many cases where our theoretical knowledge of the coordination of structures would not be sufficient, unless it was based upon observation. We understand well, for example, that hoofed animals must all be herbivorous, because they have no way of seizing a prey. We also understand well that, not having any other use for their front legs than to hold up the body, they do not need a shoulder as strongly structured for power,

from which result the absence of a clavicle and acromion *[outer extremity of the shoulder blades]* and the narrowness of the shoulder blade. Not having any need to turn their forelimbs, their radius will be knitted together with the ulna or at least articulated by a gynglymus *[hinge joint]* and not by a ball-and-socket joint with the humerus. Their herbivorous diet will require teeth with flat crowns to grind the seeds and herbage. It will be necessary for the crowns to be uneven and, for this effect, that enamel parts must alternate there with bony parts. Since this sort of crown requires horizontal movements for grinding, the condyle of the jaw cannot be as tight a hinge as in the meat eaters. It will have to be flat and also mesh with a facet of the temporal bone, which will be more or less flat. The temporal sockets, which will serve as an attachment for only a small muscle, will be neither very large nor very deep, and so on. All these matters are deduced one from the other, more or less according to their generality and from the manner in which some are essential and exclusively the property of animals with hooves and the others, although equally necessary in these animals, will not be exclusive to them, but can occur in other animals, where the remaining conditions still permit.

If we then go down the orders or subdivisions of the class of animals with hooves and examine what modifications the general conditions undergo or rather what particular conditions attach to them, according to unique characteristics of each of these orders, the reasons for these subordinate conditions begin to appear less clear. We still understand well enough in broad terms the need for a more complicated digestive system in species where the dental system is less perfect. Thus, we can say that those animals in which this or that order of teeth is missing must have been ruminants rather than something else; we can deduce from that a certain form of oesophagus and corresponding structures in the vertebrae of the neck, and so on. But I doubt whether we would have guessed, unless observations had noted the point, that ruminants would all have cloven hooves and that they would be the only animals to have them. I doubt whether we would have guessed that frontal horns occur only in this one class, that those among them which had sharp canines for the most part would lack horns, and so on.

However, since these interconnections are constant, they certainly must have a sufficient cause. But as we have no knowledge of that, we must make up for the inadequacy in the theory by means of observation. That serves to establish for us empirical laws which become almost as certain as rational laws, when they rest on observations which have been repeated often enough, with the result that nowadays anyone who sees only the track of a cloven hoof can from that conclude that the animal which left this imprint was a ruminant. And this conclusion is just as certain as any other in physics or morality. This single track reveals to the observer the structure of the teeth, of the jaws, of the vertebrae, and of all the bones in

the limbs, thighs, shoulders, and pelvis of the animal which has just passed by. That mark is more certain than all of Zadig's.[1]

That there are, however, hidden reasons for all these interrelationships, that is something which observation itself can glimpse independently of general philosophical principles. In effect, when we create a table of these interrelationships, we notice there not only a specific consistency, if one can express oneself this way, between the structure of some organ and the structure of some other different organ, but we also notice a classic consistency and corresponding gradation in the development of these two organs, a fact which shows, almost as well as effective deduction, their mutual influence.

For example, the dental system of the non-ruminant hoofed animals is in general more perfect than that of animals with cloven hooves, or the ruminants, because the former have incisors or canine teeth, and almost always both of these on both jaws; and the structure of their feet is in general more complicated, because they have more digits or the phalanges are less buried in the hoof, or more distinct metacarpals and metatarsal bones, or more numerous tarsal bones, or a fibula more distinct from the tibia, or finally because they often combine all these features. It is impossible to provide reasons for these interconnections, but what proves that they are not at all products of chance is that every time an animal with cloven hooves shows in the arrangement of its teeth some tendency to resemble the animals which we are discussing, it shows also a similar tendency in the structure of its feet. Thus the camels which have canine teeth and even two or four incisors on the upper jaw have an extra tarsal bone, because their scaphoid is not knitted to the cuboid, and very small claws with corresponding distal phalanges *[bones at the end of the toes]*. Chevrotins *[small species of deer]*, whose canines are very developed, have a distinct fibula along the entire length of the tibia, while the other animals with cloven hooves have for a complete fibula only a small bone joined at the base of the tibia. There is thus a constant harmony between two organs apparently extremely different from one another. And the gradations of their structures correspond without interruption, even in the cases where we cannot give a reason for their interrelationships.

Now, in thus adopting the method of observation as a supplementary means when our theory leaves us adrift, we reach details calculated to astonish. The least facet of bone and the least apophysis *[protuberance of bone]* have a determined character, relative to the class, order, genus, and species to which they belong, to the point where every time we have only one bony extremity well preserved, we can, with effort and with the assistance of a little skill in analogy and effective comparison, determine all those things just as certainly as if we possessed the entire animal. I experimented with this method on portions of known animals many times,

[1][*Translator's note*: Zadig, the hero in a story by Voltaire, is an expert tracker.]

before placing in it my total trust concerning fossils. But the method has always been so infallibly successful that I have not the slightest doubt about the certainty of the results which it has given me.

It is true that I enjoyed all the help which I could have required and that my fortunate position and diligent research for close to thirty years made available to me skeletons of all the genera and sub-genera of quadrupeds, even of many of the species in certain genera and several individual skeletons in some species. With such resources it was easy for me to make many comparisons and to verify in all their details the applications which I made of my laws.

I cannot deal any further with this method, and I must postpone such a discussion to the large work on comparative anatomy which I will soon publish, where one will find all its rules. However, an intelligent reader will already be able to derive a large number of these rules from the work on fossil bones, if he takes the trouble to follow all the applications which we have made of them there. He will see that this method alone has guided us and that it has almost always enabled us to link each bone to its species when it was from a living species, to its genus when it was a bone from an unknown species, to its order when it was from a new genus, and finally to its class when it belonged to an order not yet established, and to assign to it, in these three latter cases, the characteristics appropriate to distinguish it from the orders, genera, or the species most similar to it. Naturalists before me have not done much with this method for entire animals. In this way, we have determined and classified the remains of more than one hundred and fifty mammals or oviparous quadrupeds.

TABULATED GENERAL RESULTS OF THESE STUDIES

Considered according to their relationship with species, more than ninety of these animals were certainly unknown to naturalists up to the present time; eleven or twelve have a such a close resemblance to known species that we can hardly entertain any doubt of their identity; the others show many traits which resemble known species, but the comparison could not yet be made with them in a sufficiently scrupulous manner to erase all doubts. Considered according to their relationship with genera, of the ninety unknown species, almost sixty belong to new genera; the other species are related to known genera or sub-genera.

It is helpful also to consider these animals according to the classes and the orders to which they belong.

Of the one hundred and fifty species, about a quarter are oviparous quadrupeds, and all the others are mammals. Among the latter, more than half belong to non-ruminant hoofed animals. However, on the basis of these numbers it would still be premature to establish any conclusion concerning the theory of the earth, because they are not at all in proportions sufficiently significant statistically for the numbers of genera or species which could be buried in our strata. The bones of the large species, which

more easily catch the attention of workers, have been more extensively collected, while those of the small species have been commonly neglected, unless chance has made them fall into the hand of a naturalist or unless some particular circumstance, like their extreme abundance in certain places, has attracted public attention.

RELATIONSHIPS BETWEEN SPECIES AND THE STRATA

What is more important, indeed what constitutes the most essential object of all my work and establishes its true relationship with the theory of the earth, is to know in which strata we find each species and whether there are any universal laws relative to the zoological subdivisions or to the greater or lesser similarity between those species and those of today. The recognized laws in this matter are excellent and very clear.

First, it is certain that the oviparous quadrupeds appear much earlier than the viviparous quadrupeds, that they are even more abundant, stronger, and more varied in the ancient strata than on the present surface of the earth.

The ichthyosaurs, the plesiosaurus, several turtles, and several crocodiles are under the chalk in the lands commonly called the Jura. The monitors *[a species of lizard]* of Thuringia could be even older, if, as the Werner school maintains, the copper schists which contain them in the middle of so many varieties of fish believed to be fresh-water creatures are among the most ancient beds of the secondary formation. The immense saurians *[species of reptile]* and the huge turtles of Maestricht are in the chalk formation itself. But these are marine animals.

This first appearance of bony fossils seems therefore already to announce that there existed dry lands and fresh waters before the formation of the chalk. But neither at this period nor during the time when the chalk was formed, nor even long after that, is there any encrustation of fossilized bones of terrestrial mammals or, at least, the small number of them which people claim are found there forms only an almost inconsequential exception.

We begin to find the bones of marine mammals, that is to say, of lamantins *[manatees]* and seals, in the rough limestone with shells which covers the chalk in our regions. At that level, however, there is still no bone of a terrestrial mammal.

In spite of the most through research, I have not be able to discover any distinct trace of this class of animals *[terrestrial mammals]* before the formations deposited on top of the rough limestone. To be sure, some lignites and molasse contain them, but I doubt very much whether these formations are all, as is believed, earlier than this limestone. The places where they have furnished bones are too limited, too few in number, so that one is obliged to assume some irregularity or some change in their

formation. By contrast, as soon as we reach the formations above the rough limestone, the bones of land animals show up in large numbers.

Thus, since it is reasonable to believe that the shell fish and fish did not exist at the time when the primordial formations were established, we must also believe that the oviparous quadrupeds began at the same time as the fish, as early as the first ages which produced the secondary formations, but that the terrestrial quadrupeds did not come, at least in considerable numbers, until a long time later, when the rough limestones which contain most of our species of shell creatures, although in species different from ours, had already been laid down.

We should note that these rough limestones, the ones which supply Paris with construction materials, are the last layers which indicate a long and tranquil period of the sea above our continents. After them we certainly find again formations full of shells and other products of the sea, but these are loose formations, of sands, of marls, of sandstones, and of clays, which reveal a more or less disturbed means of transport rather than a calm precipitation. If there are there some regular rocky layers of no considerable extent below or above these transported formations, they generally show indications of having been deposited in fresh water.

Thus, almost all the known bones of viviparous quadrupeds are either in formations made from fresh water or in these formations of transported material. Consequently, there is every reason to believe that these quadrupeds began to live or at least to leave their remains in the layers which we can excavate only since the penultimate retreat of the sea, during the conditions which preceded its last irruption.

But there is also an order in the disposition of these bones among themselves, and this order reveals once more a very remarkable succession among the species.

In the deposits we are quite sure of, at first all the genera unknown today, the palaeotheriums, the anoplotheriums, and so on, belong in the most ancient of formations of those under consideration here, those which rest immediately on top of the rough limestone. These are principally the ones which fill the regular layers deposited by fresh waters or certain beds of transported material, formed a very long time ago, composed in general of sands and round pebbles. These were perhaps the first alluvial deposits of this ancient world. We also find with them some lost species of known genera, but in small numbers, and some oviparous quadrupeds and fish, all apparently fresh-water creatures. The beds which contain them are always covered to a greater or lesser extent by beds of transported material filled with shells and other marine products.

The most famous of these unknown species which belong to known genera or to genera very closely related to those that we do know, like the fossil elephants, rhinoceroses, hippopotamuses, and mastodons, are not found with these older genera. We find them only in the formations of trans-

ported material, sometimes with sea shells, sometimes with shells from fresh water, but never in the regular rocky layers. Everything found with these species is either unknown, like them, or at least doubtful.

Finally, the bones of species which appear the same as ours are buried only in the last alluvial deposits formed on the edges of rivers or on the bottoms of ancient ponds or dried up swamps, or in the depths of peat layers, or in the cracks and caverns of some escarpments, or finally a little distance below the surface in those places where they could have been buried by rock slides or by human beings. Their shallow position has also made these bones, the most recent of all, almost always the least well preserved.

We must not believe, however, that this classification of the various deposits is as clear as the classification of the species nor that it displays a similarly demonstrable character. There are numerous reasons why this is not the case.

Firstly, all my determinations of species were made on the bones themselves or on good diagrams. However, often I could not personally observe all the places where these bones were discovered. Very frequently I was obliged to rely on vague or ambiguous details, provided by people who did not clearly realize themselves what it was necessary to observe. Even more frequently I have not found any of that information at all.

Secondly, in this matter it is possible to have infinitely more ambiguity than with the bones themselves. The same ground can appear recent in those places where it is shallow and old in those places where it is covered by the layers which have succeeded it. Some ancient formations could have been transported by partial floods and have covered recent bones. They could have collapsed on them, buried them, and mixed them up with old marine material which they had previously hidden. Some ancient bones could have been washed away by water and later caught again in recent alluvial deposits. Finally, some recent bones could have fallen in fissures or caverns in ancient rocks and there have been enveloped by stalactites or other encrustations. It would be necessary in each case to analyze and take into account all of these circumstances which could hide the true origin of the fossils. And rarely have the people who collected these bones suspected this need. Thus, the result has been that the true features of their deposit have almost always been neglected or misunderstood.

Thirdly, there are some doubtful species which have affected to a greater or lesser extent the reliability of results for such a long time that we will not reach clear distinctions concerning them. Thus, the horses and buffaloes, which are found with the elephants, do not yet have any specific and particular characteristics. And for many years to come geologists unwilling to adopt my chronological sequence of ages for the bony fossils will be able to derive from these doubtful species an argument, and do so all the more conveniently because they will take it from my book.

But while admitting that these epochs are susceptible to some objections from people who will consider some particular case casually, I am no less persuaded that those who take into account the totality of the phenomena will not be stopped by these small partial difficulties. They will recognize with me that there has been at least one and very probably two stages in the class of quadrupeds before the one which today lives on the earth's land surface.

Here I anticipate one more objection; indeed, people have already made it to me.

THE LOST SPECIES ARE NOT VARIETIES OF THE LIVING SPECIES

Someone will say to me: Why would the present races not be modifications of these ancient ones which we find among the fossils, modifications produced by local circumstances and climatic changes, carried to this extreme difference by the long succession of years?

This objection must appear especially strong to those who believe in the indefinite possibility of changes in the structure of forms in organic bodies and who think that through habit over centuries all species could change themselves from one species into another or result from a single one of their species.[1]

However, we can reply to them following their own logic that, if the species have changed by degrees, we ought to have found traces of these gradual modifications, that we ought to have discovered certain intermediate structures between the palaeotherium and today's species, and that up to the present time this has not happened at all. Why have the depths of the earth not preserved monuments of such a curious genealogy, unless it is because the earlier species were as unchanging as our own, or at least because the catastrophe which destroyed them did not leave them time to develop their variations?

As for the naturalists who recognize that the varieties keep within certain limits fixed by nature, in order to respond to them, we must examine just how far these limits extend, a curious study, extremely interesting in itself for its infinity of interrelationships, and yet a subject which people have concerned themselves with very little up to now.

My research assumes the definition of species which serves as the basic use made of the term, understanding that the word species means *the individuals who descend from one another or from common parents and those who resemble them as much as they resemble each other*. Thus, we call varieties of a species only those races more or less different which can arise from it by reproduction. Our observations on the differences among the ancestors and the descendants are therefore for us the only reasonable

[1] [*Translator's note*: Cuvier is here addressing, among other ideas, Lamarck's evolutionary theory, first published in 1809]

rule, because all the others would take us back to hypotheses without proof.

Now, by taking the word *variety* in this way, we observe that the differences which constitute it depend on fixed circumstances and that their extent increases according to the intensity of these circumstances.

Thus the most superficial characteristics are the most variable. Colour is closely related to sunlight; the thickness of the hair to heat; size to the abundance of nourishment. But in a wild animal even these varieties are strongly limited by what is natural for this animal, which does not willingly stray from the places where it conveniently finds everything necessary to maintain the species and which spreads out to a distant place only when it finds there the same combination of these conditions. Thus, although the wolf and the fox live from the torrid zone right up to the glacial zone, they hardly give evidence, in this immense space, of another variety except for a little more or a less beauty in their fur. I have compared the skulls of foxes from the north and of foxes from Egypt with those of foxes from France, and I have found only individual differences. Those wild animals who are hemmed in by more limited spaces vary much less again, above all the carnivores. A more abundant mane is the only difference between the Persian and the Moroccan hyenas.

The herbivorous wild animals demonstrate a little more significantly the influence of the climate, because with them it is linked to the influence of food, which is going to differ in amount and quality. Thus, elephants will be larger in one forest than in another. They will have slightly longer tusks in the places where their food is better for the formation of the ivory material. It will be the same for reindeer and stags in relation to their forests. But let someone take two elephants, as different as can be, and let him see if there is the least difference in the number or the articulations of the bones, in the structure of their teeth, and so on. Moreover, the herbivorous species in the wild appear less widely dispersed than the carnivores, because the type of food and the temperature restrict them.

Nature takes care also to prevent the alteration of species which could result from interbreeding, by the mutual aversion which she has created in them. It takes every trick, all the power of man, to bring about these unions, even with species which resemble each other the most. And when the offspring are fertile, something which happens very rarely, their fertility does not go on beyond a few generations and would probably not take place without the continuation of the care which aroused it. Hence, we do not see in our woods individuals intermediate between the hare and the rabbit, between the red deer and the fallow deer, between the marten and the stone marten.

But the empire of man alters this order. It develops all the variations to which the type of each species is susceptible and derives from them products which the species, left to themselves, would never have produced.

Here the degree of variations is still proportional to the intensity of their cause, which is slavery.

The degree of variation is not very high in the semi-domesticated species, like the cat. Softer hair, more vibrant colours, a stronger or weaker build, that is all that this shows. But there is no constant difference between the skeleton of an Angora cat and the skeleton of a feral cat.

In the domestic herbivores, which we transport to all sorts of climates and which we subject to all sorts of treatment, to which we apportion different forms of work and food, we do obtain larger variations, but still entirely superficial. Some variation in size, longer or shorter horns, at times missing entirely, a stronger or weaker hump of fat on the shoulders—these constitute the differences among bulls. And these differences remain for a long time, even in races transported out of the country where they were formed, when one takes care to prevent crossbreeding.

Like this as well are the innumerable varieties of sheep, whose differences are a matter chiefly of the wool, because that is what man has given the most attention to. The varieties are a little fewer in the horse, although they are still very noticeable. In general, the forms of the bones vary little; their connections, articulations, and the structure of the large molar teeth never vary.

The little development in the tusks of the domestic pig and the fusion of its cloven hooves in a few of its types are the extreme of the differences which we have produced in the domestic herbivores.

The most marked effects of the influence of man are revealed in the animal of which he has made the most complete conquest, the dog, that species so devoted to ours, that individual animals themselves have apparently sacrificed for us their identity, their interests, their own feeling. Carried by human beings throughout the entire universe, subjected to all causes capable of influencing their development, matched in their unions at the will of their masters, dogs vary by colour, by the abundance of their hair, which they even lose entirely sometimes, in their nature, in their size, which can differ by a factor of five in linear dimensions (equivalent to more than a factor of one hundred in weight), in the shape of the ears, of the nose, and of the tail, in height relative to the legs, in the progressive development of the skull in domestic varieties, from which the very form of their head develops, sometimes skinny with a tapering muzzle and a flat forehead, sometimes a short muzzle and a bulging forehead, to the point where these apparent differences between a mastiff and a water spaniel or a greyhound and a pug are stronger than those of any wild species of a similar natural genus. Finally, and this is the greatest amount of variation known up to this point in the animal kingdom, there are types of dogs who have one digit more on the rear foot, along with the corresponding tarsal bones, as there are, in the human species, some families with six digits.

But in all these variations, the relationships of the bones remain the same, and the structure of the teeth never changes to an appreciable degree. At the very most there are some individuals in which an additional false molar develops, whether on one side or on the other.[1] There are thus characteristics in the animals which resist all influences, whether natural or human, and nothing indicates that the passage of time has, so far as they are concerned, more effect than the climate and domestication.

I know that some naturalists rely a great deal on the thousands of centuries which they add up with the stroke of a pen. But in such matters we can hardly judge what a lengthy time would produce, except by multiplying mentally what a lesser time produces. I have therefore sought to collect the oldest documents on the structures of animals. There are none at all still extant as old or as abundant as those Egypt has provided us. That country offers us, not only the pictures, but the very bodies of the animals embalmed in its catacombs.

In ancient Rome I have examined with the greatest care the pictures of animals and birds engraved on the numerous obelisks which have come from Egypt. In their overall shapes, the only thing which could have been the object of the artists' attention, all these figures bear a perfect resemblance to the species as we see them today.

Anyone can examine the copies of them which Kirker and Zoega produced. Without retaining the purity of outline in the originals, they still offer very recognizable figures. We can easily distinguish there the ibis, vulture, owl, falcon, Egyptian goose, pewit, the corn crake, the Haje viper or asp, the ceraste *[horned viper]*, the Egyptian hare with its long ears, even the hippopotamus. In the numerous monuments engraved in the great book on Egypt, we see sometimes the rarest animals, the algazel *[species of gazelle]*, for example, which was not seen in Europe until some years ago.[2]

My knowledgeable colleague, Geoffroy Saint-Hilaire, impressed with the importance of this research, has taken care to collect from the tombs and temples of Higher and Lower Egypt as many mummies of animals as he could. He brought back embalmed cats, ibises, birds of prey, dogs, monkeys, crocodiles, and the head of a bull. We certainly do not observe more differences between these creatures and those which we see today than between human mummies and today's human skeletons. We could find differences between the mummies of the ibis and the ibis as naturalists have described it right up to the present time. However, I have resolved all doubts in a report on this bird, a document which is found in a supple-

[1]See the report by my brother on the varieties of dogs, which is included in the Annales du Muséum du histoire naturelle. This work was carried out at my request with skeletons of all the varieties of dog, which I had expressly prepared.

[2]The first image which we have of it naturally depicted is in Description de la Ménagerie, by my brother. We see it perfectly represented, Descript. de L'Égypte. Antiq., Volume IV, Plate XLIX.

ment to this discourse, where I have shown that the ibis is now still the same as it was at the time of the pharaohs.[1] I am very aware that I refer there only to individual specimens two or three thousand years old. But it is always a matter of going back as far one can.

Thus, in the known facts, there is nothing which can in the least support the public opinion that the new genera which I have discovered or established among the fossils, any more than those which other naturalists have established, the *palaeotheriums*, *anoplotheriums*, *megalonyx*, *mastodons*, *pterodactyls*, *ichtyosaurus*, and so on, could have been the ancestors of some animals today, those differentiated from them only by the influence of time or climate. And even if it were true (something I am still far from believing) that fossil elephants, rhinoceroses, elks, and bears do not differ from present animals more than dogs differ among themselves, we would not be able to conclude from that the identity of species, because the dogs types have been subjected to the influence of domesticity, which the other animals have neither been subjected to nor could endure.

Moreover, when I maintain that the rock strata contain the bones of several genera and the loose strata contain the fossil bones of several species which no longer exist, I do not claim that a new creation must have produced those species existing today. I say only that they did not exist in the places where we see them at present and that they must have come there from somewhere else.

Let us suppose, for example, that a huge irruption of the sea covers the continent of New Holland with a mountain of sand or other debris. The sea will bury there the bodies of kangaroos, phascolomes *[wombats]*, dasyures *[small carnivorous marsupials]*, perameles *[bandicoots]*, flying phalangers *[species of Australian marsupial]*, echidna *[species of ant eater]* and ornithorhynchus *[duck-billed platypus]*, and will destroy entirely the species of all these genera, because none of them exists now in other countries.

Suppose this same revolution changes into dry land the numerous small straits which separate New Holland from the continent of Asia. It will open the way for elephants, rhinoceroses, buffaloes, horses, camels, tigers, and all the other Asian quadrupeds. These will come to populate a land where they have been previously unknown.

Suppose then that a naturalist, having diligently studied all this living nature, decides to search through the soil on which it dwells. He will find there the remains of totally different creatures.

In effect, what New Holland would be in the hypothesis which we have just made is what Europe, Siberia, and large a part of America are. And perhaps some day people will find, when they examine other regions and

[1] [*Translator's note*: For Cuvier's report on the ibis, see the appendix at the end of this text of the *Discourse*.]

even New Holland itself, that they all provide evidence for revolutions similar to my hypothetical one (I would almost say evidence for reciprocal exchanges of their products). For, pushing the hypothesis further, after this movement of Asian animals into New Holland, let us conjecture a second revolution which destroys Asia, their original homeland. Those who observed them in New Holland, their second home, would be just as much at a loss to know where they could have come from, as people can be now to find the origin of our animals.

I will apply this method of looking at things to the human species.

THERE ARE NO HUMAN FOSSIL BONES

It is certain that no one has yet found human bones among the fossils. And that is one more proof that the fossil races were not varieties of present animals, because they could not have undergone the influence of human beings.

I say that no one has ever found human bones among the fossils, meaning, of course, among the properly named fossils or, alternatively put, in the regular strata on the surface of the earth. For in the peat bogs, alluvial deposits, and cemeteries, people could unearth human bones, just as they could the bones of horses or of other common species. Such bones could also be found equally well in the fissures of rocks and in the grottoes where a stalactite would have formed around them. But in the layers which contain the ancient races, among the palaeotheriums and even among the elephants and the rhinoceroses, no one has ever discovered the least remnant of human beings. Around Paris, there are scarcely any workers who do not believe that the bones with which our gypsum quarries teem are in large part bones of human beings. But as I have seen several thousands of these bones, I am in a good position to state that there has never been a single one from our species. I have examined at Pavia the groups of fossil remains brought there by Spallanzani from the island of Cerigo. And in spite of this well-known observer's assertion, I affirm equally that it is impossible to claim that any of them comes from a human being. The *homo diluvii testis* of Scheuchzer has been reassigned, since my first edition, to its true genus, that of the salamanders. And in an examination which I made of it since in Harlem, with the kind permission of Van Marum, who allowed me to uncover parts buried in the rock, I obtained a complete proof of what I had stated. We see, among the bones found at Canstadt, a fragment of a jaw bone and some human artifacts. But we know that the area was disturbed without due care and that no one kept any notes of the various levels where each item was discovered. Everywhere else fragments alleged to be human have turned out to be, upon examination, from some animal, whether they have been examined in nature or simply from drawings. Still more recently it has been claimed that human fossils have been discovered in Marseilles, in a long neglected

rock.[1] It was impressions of *tuyaux marins*.[2] The true fossil bones of human beings have been cadavers which had fallen into the fissures or been left in ancient mine shafts or covered with encrustations. And I extend this claim to include the human skeletons discovered at Guadeloupe in a rock formed of fragments of madrepore *[coral variety]* thrown up by the sea and fused by a calcareous solution.[3] The human bones found near Koestriz and mentioned by von Schlotheim, were publicized as having been excavated

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[1]See the Journal de Marseilles and des Bouches-du-Rhone, of 27 Sept., 25 Oct., and 1 Nov., 1820.

[2]I assured myself of this point through the drawings which Cottard, professor at the College of Marseilles, sent to me. [*Translator's note*: *tuyaux marins* is a species related to coral.]

[3]These more or less mutilated skeletons are found near the port of Moule, on the north-west coast of the mainland of Guadeloupe, in a type of glacis *[gently sloping bank]* pressed against the steep edges of the island, which the water covers over for the most part at high tide and which is only a tufa *[porous stone]* formed and daily increased by the very tiny debris of shells and corals which the waves tear away from rocks. The piles of this material cohere strongly in the places which are most often dry. One recognizes through a magnifying lens that several of these fragments have the same red tint as a section of coral contained in the reefs of the island. Such formations are common in all the Antilles Archipelago where the Negroes know them by the name of *Maçonne-bon-dieu*. The more violent the movement of the water, the more rapid their growth. They have extended the plain of Cayes to San Domingo, where the lay of the land is somewhat analogous to the beach at Moule, and sometimes debris of jars and other human artifacts are found there at a depth of twenty feet. People have made a thousand conjectures and even imagined events to explain these Guadeloupe skeletons. But taking into account all the circumstances, Moreau de Jonnès, a correspondent from the Academy of Sciences, who has been to these locations and to whom I owe all the above details, thinks that it is simply a matter of corpses of people who perished in some shipwreck. They were discovered in 1805 by Manuel Cortez y Campomanes, at the time a staff officer serving in the colony. General Ernouf, the governor, had one of the skeletons extracted with much difficulty; it lacked a head and almost all the upper extremities. It was placed in Guadeloupe, and people waited to have a more complete one in order to send them both together to Paris. Then the English captured the island. On finding the skeleton at headquarters, Admiral Cochrane shipped it to the English Admiralty, who offered it to the British Museum. It is still in this collection, where Koenig, Curator of the Mineralogy Section, described it for the Trans. phil. of 1814 and where I saw it in 1818. Koenig observed that the rock in which the skeleton was held was not at all cut, but seems to have been simply inserted, like a distinct nucleus, in the surrounding block. The skeleton there is so close to the surface, that people must have noticed it by the projection of a few of its bones. They still contain animal parts and all their calcium phosphate. The gangue *[mineral vein]*, totally composed of bits of coral and dense calcareous rock, quickly dissolves in nitric acid. Koenig recognized there some fragments of *millepora miniacea [species of coral]*, of some *madrepores [species of coral]*, and of shells which he compares to *helix acuta* and *turbo pica [species of mollusk]*. More recently, General Donzelot had another of these skeletons brought out, which is on display in the Royal Museum. We provide a diagram of it (Plate 1) *[see p. 150 below]*. The corpse has tucked up knees. A little bit of the upper jaw remains, the left half of the lower jaw, almost all of one side of the trunk and the pelvis, and a large section of the left upper and lower extremities. The gangue is noticeably a travertine *[form of limestone]* in which are embedded shells from the neighbouring sea and land shell creatures who still live today on the island, namely, Ferrusac's *bulimus guadalpensis*.

from very ancient layers. But this respectable scholar hastened to make known how much this claim is still subject to doubt.[1] The same point holds for human artifacts. The pieces of iron found in Montmartre are pins which the workers use to insert the powder and which sometimes break in the rock.[2]

However, human bones are preserved just as well as those of animals when they are in the same circumstances. In Egypt we do not observe any difference between the human mummies and those of quadrupeds. In excavations carried out some years ago in the ancient church of Sainte Genevieve I collected human bones interred under the earliest group, which could have even belonged to some princes of Clovis's family, whose structures were still very well preserved.[3] On the battlefields, we do not see the skeletons of men more altered than those of horses, if we make allowance for the size. And we do find, among the fossils, animals as small as the rat still perfectly preserved.

Everything therefore leads to the belief that, in epoch of the upheavals which buried these fossil bones, the human species did not exist at all in the countries where the bones are discovered. For there would have been no reason why the human species would have escaped entirely such universal catastrophes and why their remains are not found nowadays like those of other animals. But I do not wish to conclude from this that human beings did not exist at all before this period. They could have inhabited some regions of small extent from where they repopulated the earth after these terrible events. Perhaps also the places where they remained were entirely destroyed and their bones buried in the bottom of the present seas, with the exception of a small number of individuals who continued the species. Whatever the case may be, the establishment of human beings in the countries where we have said the fossils of land animals are located, that is to say, in the largest part of Europe, Asia, and America, is necessarily not only after the revolutionary upheavals which buried these bones, but also after those revolutions which brought about the exposure of those layers containing them and which are the last ones the earth has undergone. From this it is clear that one cannot derive either from these bones themselves or from the variously sized mounds of stones or earth which cover them a single argument in support of the antiquity of the human species in these various countries.

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[1]See von Schlotheim's Treatise on Petrifications. Gotha, 1820, page 57; and his letter in Isis of 1820, eighth issue, supplement no. 6.

[2]No doubt I must mention those fragments of sandstone which people sought to make such a fuss about last year (1824), the ones in which they claimed they saw a petrified man and a horse. The single circumstance that this was a matter of a man and a horse with their flesh and skin depicted should have let the whole world know that this could only concern one of nature's games and not a true petrifaction.

[3]The late Fourcroy provided an analysis of them. (Annales du Muséum, tome X, page I.). [*Translator's note*: Clovis (c. 466-511 AD), first king of the Franks].

PHYSICAL PROOFS OF THE NEWNESS OF THE PRESENT STATE OF THE CONTINENTS

On the contrary, by closely examining what has happened to the surface of the earth since it has become dry land for the last time and the continents have taken on their present shape, at least in their somewhat elevated areas, we see clearly that this last revolution and consequently the establishment of our present societies could not be very old. It is one of the most firmly established results and, at the same time, the least attended to in legitimate geology, a result even more valuable because it links up natural and civil history in an uninterrupted chain.

By measuring the effects produced in a given period by causes at work today and by comparing these effects with those which they have produced since they started working, we can successfully determine almost the instant when their action began. That time must be the same as the moment when our continents took on their present form or when the last sudden retreat of the waters occurred.

In fact, starting from this retreat, our present escarpments began to crumble and to form at their bases hills of debris, our present rivers began to flow and create their alluvial deposits, our present vegetation began to spread out and produce soil, our present cliffs began to be eroded by the sea, our present dunes began to be thrown up by the wind, just as from that same time period human colonies began or began again to spread out and to establish settlements in places where nature permitted. I am not talking at all about our volcanoes, not only because of the irregularity of their eruptions, but also because nothing proves that they could not have existed under the sea, and thus they cannot serve as the measure of the time which has passed since its last retreat.

DEPOSITS OF MATERIAL

Deluc and Dolomieu are the ones who have most carefully studied the development of the deposits, and although strongly opposed on a number of the points concerning the theory of the earth, they agree on the following: alluvial deposits grow very quickly, and they must have increased in size much more quickly still at their beginnings, when the mountains provided more materials for the rivers. Nevertheless, their extent is still quite limited in size.

Dolomieu's Mémoire sur l'Égypte[1] tends to show that, at the time of Homer, the spit of land on which Alexander had his city built did not yet exist, that one could quickly sail around the Island of Pharos in the gulf since named *Lake Mareotis*, and that this gulf had at that time the length indicated by Menelaus, about fifteen to twenty leagues.[2] It therefore would

[1]Journal de Physique, volume xlii, p. 40 ff.

[2][*Translator's note*: Menelaus tells the story of his adventures in Egypt in Homer's *Odyssey*.]

have required only the nine hundred years which elapsed between Homer and Strabo to arrange things the way the latter describes them and to reduce this gulf to the shape of a lake six leagues long. What is more certain is that since then matters have again changed considerably. The sands which the sea and the wind have thrown up have formed, between the Isle of Pharos and the old city a tongue of earth two hundred toises long *[approximately 1300 feet]*, on which the new city was built. These sands blocked the nearest mouth of the Nile and reduced Lake Mareotis to almost nothing. During this time, the Nile's alluvial material was deposited along the rest of the shore and extended it enormously.

The ancients were not ignorant of these changes. Herodotus says that Egyptian priests looked upon their country as a gift of the Nile. What that means, he adds, is that the Delta has appeared in a short time.[1] Aristotle already makes the case that Homer speaks of Thebes as if the city were the only one in Egypt and says nothing at all about Memphis.[2] The Canopic and Pelusiac mouths *[of the Nile]* were in earlier times the main outlets, and the shore extended in a straight line from one to the other. This is how it still appears in the maps of Ptolemy. Since then the water has directed itself into the Bolbitine and Phatnitic mouths. At their outlets the largest sedimentary deposits have formed and given the coast a semi-circular contour. The towns of Rosetta and Damietta, built beside the sea at these outlets, less than one thousand years ago, are today two leagues from it. According to Demaillet, it would have taken only twenty-six years to push out a cape in front of Rosetta half a league long.[3]

The increase in the height of land in Egypt goes on at the same time as this extension of its surface area, and the bottom of the river bed rises in the same proportion as the adjacent plains, a development which in each century makes the flooding much higher than the marks which it has left in the preceding centuries. According to Herodotus, a time lapse of nine hundred years would have been sufficient to establish a difference in level of seven to eight cubits *[approximately 12.5 ft].*[4] At Elephantine, the flooding today rises seven feet above the greatest heights which it reached under Septimus Severus, at the start of the third century *[AD]*. At Cairo, in order for the flooding to be considered sufficient for irrigation, it must exceed by three and a half feet the required height in the ninth century *[AD]*. The ancient monuments of this famous land are all more or less buried at the base. The loess *[loam deposit]* brought by the river even covers by several feet the artificial mounds on which the old cities rest.[5]

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[1]Herod. *Euterpe*, V et XV.

[2]Arist., Meteor., lib. I, cap. XIV.

[3]Demaillet, Description de l'Égypte, p. 102 and 103.

[4]Herod., Euterpe, XIII.

[5]See the Observations sur la vallée d'Égypte et sur l'exhaussement séculaire du sol qui la recouvre, by Girard (the great work sur l'Égypte, éd. mod Mém, Volume II, page 343). In this regard we will again make the point that Dolomieu, Shaw, and other respectable

The alluvial deposits in the Rhone delta are no less remarkable. Astruc provides details of them in his Histoire naturelle du Languedoc. Through a careful comparison of the descriptions of Mela, Strabo, and Pliny with the state of places at the beginning of the eighteenth century and by relying on several writers of the Middle Ages, he proves that the arms of the Rhone have extended themselves by three leagues in eighteen hundred years, that similar deposits took place to the west of the Rhone, and that numerous locations situated on the edge of the sea or of large pools of water six and eight hundreds years ago are today several miles inland.

Anyone can learn in Holland and in Italy how quickly the river beds of the Rhine, Po, and Arno rise nowadays when they are held in by dikes, and how far their estuaries move out into the sea by forming long promontories on their sides and judge from these facts how few centuries these rivers have taken to deposit the low plains which they now cut through.

Many towns which were flourishing sea ports in well-known historical periods are today a few leagues inland. Several have even been ruined by the consequences of this change in position. Venice with difficulty maintains the lagoons which separate her from the mainland. In spite of all her efforts, she will inevitably one day be linked to the mainland.[1]

We know from what Strabo said that at the time of Augustus Ravenna was in lagoons, as Venice is today. And at present Ravenna is one league from the shore. Spina was founded on the sea's edge by the Greeks, and by the time of Strabo it was ninety stades from it *[about 16 km]*. Today it is destroyed. Adria in Lombardy, which gave its name to the sea *[the Adriatic]* of which it was the principal port somewhat more than twenty centuries ago, is now six leagues from it. Fortis has even made a plausible case that during an older epoch the Euganian mountains could have been islands.

My scholarly colleague at the Institute, de Prony, inspector general of bridges and roads, has written me very valuable information concerning the explanation for these changes to the shore of the Adriatic. After having been commissioned by the government to examine the countermeasures which could be applied to the destruction caused by the flooding of the Po, he confirmed that this river, since the time it was enclosed in dikes, has raised the height of the river bed to such an extent that its water level is now higher than the roofs of the houses in Ferrara. At the same time, its deposits have moved out into the sea so rapidly that, by comparing the ancient maps with the present conditions, one sees that the shore has gained more than six thousand toises *[approximately 39,000 ft]* since 1604;

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authors estimate these secular elevations much higher than does Girard. It is unfortunate that no one has anywhere tried to examine the thickness of these formations over the original soil, above the natural rock.

[1]See Forfait's Mémoire sur les lagunes de Venise (Mém. de la Classe physique de l'Institut, Volume V, page 213).

this means one hundred and fifty or one hundred and eighty feet per year, and in some places two hundred.[1] The Adige and the Po are today higher

[1]Extract from the Researches of de Prony, sur le Système hydraulique de l'Italie.

Displacement of the part of the shore of the Adriatic taken up by the mouths of the Po.

Part of the shore of the Adriatic, comprised of the space between the southern extremities of the lake or the lagoons of *Comacchio* and the lagoons of Venice, has undergone since ancient times considerable changes, attested to by the accounts of most trustworthy authors and by the fact that the present state of the soil in the lands situated near the shore does not permit any doubts about the matter. But it is impossible to give exact details the of the various stages of these changes and, above all, precise measurements for the ages before the twelfth century of our era.

However, we are sure that the town of *Hatria*, nowadays *Adria*, was in earlier times on the edge of the sea. That is a well-established and known point about the original shore. The shortest distance to the present shore, taken at the mouth of the Adige, is twenty-five thousand metres (we will soon see that the point at the promontory of the alluvial deposits formed by the Po has advanced further into the sea by ten thousand metres than the mouth of the Adige). Concerning its antiquity, the inhabitants of this town have exaggerated pretensions on many points. But it cannot be denied that Adria is one of the most ancient towns in Italy. It gave its name to the sea which washed its walls. Some excavations undertaken inside the town and in the region have confirmed the existence of a layer of earth filled with debris of Etruscan pottery, without any mixture of artifacts of Roman make. Etruscan and Roman artifacts are discovered mixed together in a higher layer, on which people have found the vestiges of a theatre. The former and the latter strata are buried well below the present soil. I saw at Adria some curious collections where the monuments which they contain are separated and classified. Some years ago I observed to the prince viceroy how historically and geologically interesting it would be if large-scale work on the excavations of Adria could be undertaken to determine the heights in relation to the sea, as much for the original soil as for the successive beds of alluvial deposits. He was very pleased with my ideas in this matter. I do not know if my suggestions have had any effect.

By following the shore as one leaves *Hatria*, which was situated at the base of a small bay, to the south one used to find a branch of the *Athesis* (the Adige) and the *Fossa Philistina [Philistine Trench]*, whose trace corresponds to what could been the Mincio and the Tartaro combined, if the Po still ran to the south of Ferrara. Then came the *Delta Venetum*, which seems to have occupied the spot where the lake or the lagoon of Comacchio is located. This delta was crossed by the seven mouths of the *Eridanus*, previously called *Vadis*, *Padus*, or *Podincus*, which had on its left bank, at the point where its mouths branched, the city of *Trigopolis*, whose position must be close to Ferrara. Seven lakes enclosed in the delta had the name *Septem Maria [Seven Seas]*, and *Hatria* was sometimes called the *Urbs Septem Marium [City of the Seven Seas]*.

Going back up the shore on the north side, after leaving *Hatria*, one found the principal mouth of the *Athesis*, also called *Fossa Philistina [Philistine Trench]*, and then the *Aestuarium Altini*, an inland sea, separated from the large sea *[Adriatic]* by a line of islets, in the middle of which was located a small archipelago of other islets, called the *Rialtum*. It is on this small archipelago that Venice today rests. The *Aestuarium Altini* is the lagoon of Venice, which does not link up with the sea any more except by five straits, for the islets have united to form a continuous dike.

To the east of the lagoons and to the north of the town of *Este* are located the *Euganian* mountains, forming, in the middle of a vast alluvial plain, an isolated and noteworthy group of peaks, in the neighbourhood of which people locate the famous fall of Phaeteon. Some authors maintain that enormous masses of burning material, thrown by volcanic explosions in the mouths of the Eridan, gave rise to this story. It is certainly true that in the vicinity of Padua and Verona one finds many volcanic products.

The details which I have collected on the deposits on the Adriatic coast at the mouths of the Po begin to have a certain accuracy in the twelfth century. At this time all the waters of the Po ran south of Ferrara into the *Po di Volano* and the *Po di Primaro*, branches which surrounded the space occupied by the lagoon of Comacchio. The two mouths in which the Po later broke through to the north of Ferrara are called the river *di Corbola* or *di Longola* or *del Mazorno* and the river *Toi*. The first, the more northerly, met the *Tartaro* or the *Biano* canal near the sea; the second was enlarged at Ariano by a branch of the Po, called the river *Goro*.

The sea shore was oriented approximately north-south at a distance of ten or eleven thousand metres from the meridian of Adria. It passed the point where the western corner of the wall of *Mesola* is now located, and *Loreo*, to the north of Mesola, was only about two hundred metres away.

Towards the middle of the twelfth century, the large waters of the Po broke through the dikes which held them back on the left bank, near the little town of *Ficarolo*, situated nineteen thousand metres to the north-west of Ferrara, spilled over into the northern part of the territory of Ferrara and into the Polesine of Rovigo, and ran in the two channels of Mazorno and Toi mentioned above. It appears well established that the work of man contributed a great deal to this diversion of the Po's waters. The historians who talked about this remarkable achievement do not differ among themselves, except for a few details. Since the tendency of the river to follow the new channels which people made for it grew from day to day more forceful, its two branches of the *Volano* and *Primaro* quickly diminished, and were, in less than a century, reduced almost to the condition which they are in nowadays. The river system established itself between the estuary of the Adige and the point called *Porto di Goro* today. When the two channels into which the river was first diverted became insufficient, new ones were dug. And at the start of the seventeenth century, its main mouth, called *Sbocco di Tramontana*, was located very close to the mouth of the Adige. This approach alarmed the Venetians, who in 1604 dug the new channel called *Taglio di Porto Viro* or *Po delle Fornaci*, by means of which the *Bocca Maestra* was diverted from the Adige to the south.

During the four centuries which passed between the end of the twelfth century up to the end of the sixteenth, the alluvial deposits of the Po won from the sea a considerable extent of land. The northern mouth, the one which took over the Mazorno canal and formed the *Ramo di Tramontana*, was in 1600 twenty thousand metres from the longitude of Adria, and the southern mouth, the one which overran the Toi channel, was in the same period seventeen thousand metres from this meridian. Thus, the shore was pushed out by nine or ten thousand metres in the north, and six or seven thousand metres in the south. Between these two mouths which I have just been speaking about was located a cove or a part of the shore which had moved out less, called *Sacca di Goro*.

The huge work of putting dikes on the river *[the Po]* and a considerable part of the excavations on the southern sides of the Alps took place in this period from the thirteenth to the seventeenth centuries.

The Taglio di Porto Viro sets the direction of the alluvial deposits in the axis of the huge promontory which the mouths of the Po now create. As the channels reaching the sea grew longer, the annual quantity of deposits increased at an alarming rate, as much from the diminution of the slope of the waters (a necessary consequence of the elongation of the river bed) as from the confinement of these waters between dikes and from the way in which the excavations helped the flowing torrents carry mountain soil down into the plains. Soon the bay of the Sacca di Goro was filled in, and the two promontories formed by the two main mouths united into a single one, whose apex now is located thirty-two or thirty-three thousand metres from the meridian of Adria. Consequently, in two centuries, the mouths of the Po have gained about fourteen thousand metres from the sea.

From the facts I have just quickly summarized, the results are as follows: (1) in ancient times, to which no accurate date can be assigned, the Adriatic Sea washed the walls of

than all the terrain which lies between them, and only by opening new river beds for them in the lower areas which they deposited earlier will people be able to prevent the disasters with which the rivers now threaten them.

The same causes have produced the same effects along the branches of the Rhine and the Meuse. Thus, the richest cantons in Holland constantly face the alarming spectacle of rivers suspended twenty and thirty feet above their land.

Wiebeking, director of bridges and highways in the Kingdom of Bavaria, has written a report on this development, such an important matter for people and governments to understand well, where he shows that this characteristic of raising the level of their beds belongs to a greater or lesser extent to all rivers.

The deposits along the shores of the North Sea have not progressed any less rapidly than in Italy. One can easily follow them in Friesland and in the country of Groningen, where people know the time period of the first dikes constructed by the Spanish governor Gaspar Robles in 1570. One hundred years later, in some places, three-quarters of a league of land had already been gained outside these dikes, and the city of Groningen itself, built partly on ancient soil, on limestone which does not belong at all to the present sea and where one finds the same shells as in our rough limestone in the regions of Paris, the city of Groningen is only six leagues from the sea. Having been in these areas, I can confirm, by my own testimony, facts which, by the way, are very well known; Deluc has already widely publicized most of them.[1] One could observe the same phenomenon and with the same accuracy all along the coasts of East Friesland, in the country of Bremen and Holstein, because we know the ages when the new lands were enclosed for the first time and we can measure in those places what has been gained since.

This strand formed by rivers and the sea, which has an admirable fertility, is for these territories a gift all the more precious, because the ancient soil, covered with heather or peat bogs, resists cultivation almost everywhere. Only the alluvial deposits provide for the subsistence of the inhabited towns built all along this coast since the Middle Ages. These places would

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Adria; (2) in the twelfth century, before people had opened a passage at Ficarolo for the waters of the Po on the left *[northern]* bank, the sea shore was nine to ten thousand metres from Adria; (3) in 1600 the points of the promontories formed by the two principal mouths of the Po were located in front of the Taglio di Porto Viro, at an average distance of eighteen thousand five hundred metres from Adria, a fact which makes the growth rate of the alluvial deposits since the year 1200 twenty-five metres per year; (4) the single tip of the promontory formed by the mouths today is thirty-two or thirty-three thousand metres from the meridian of Adria; from which one concludes an average rate of progress for the alluvial deposits of about seventy metres per year during these last two centuries, a much faster rate in relation to the slightly older ages. (De Prony)

[1]In different places of the two last volumes of his Lettres à la Reine d'Angleterre.

not perhaps have attained this degree of prosperity without the rich lands which the rivers prepared for them and which they continuously increase.

If the size which Herodotus attributes to the Sea of Azov,[1] which he makes almost equal to the Euxine Sea *[Black Sea]*, had been expressed in less vague terms and if one knew precisely what he meant by the Gerrhus,[2] we would find there still more strong proofs of the changes produced by the rivers and of their speed. For the alluvial deposits of the rivers would have been able by themselves,[3] since that time—that is to say, in the past two thousand and two or three hundred years—to reduce the sea of Azov to what it is, close the course of the Gerrhus, or of that branch of the Dneiper which would have emptied into the Hypacyris and with it into the Carcinite or Olu-Degnitz Gulf, and reduced the Hypacyris itself almost to nothing.[4] We would be no less certain about it, if it was clearly established that the Oxus or Sinoun, which now empties into the Aral Sea, in earlier times emptied into the Caspian Sea. But we have enough confirmed facts at hand not to put forward any ambiguous examples and not to lay ourselves open to criticism by making the geographical ignorance of the ancients the basis of our physical propositions.[5]

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[1]Melpom., LXXXVI.

[2] *Ibid.,* LVI.

[3]People have also wanted to attribute this supposed diminution of the Black Sea and the Sea of Azov to the breakthrough of the Bosphorus, which would have happened at the alleged time of Deucalion's Flood. However, to establish the fact of this decrease we rely on the successive diminutions of the extent attributed to these seas in Herodotus, in Strabo, and so on. But it is too evident that if this diminution came about from the breakthrough of the Bosphorus, it would have had to have been completed long before Herodotus and date from the time of Deucalion.

[4]See Rennel's Géographie d'Hérodote, p. 56 ff, and a part of the work of Dureau de Lamalle, entitled Géographie physique de la mer Noire, etc. Today only the very small river of Kamennoipost could represent the Gerrhus and the Hypacyris, such as they were described by Herodotus.

N.B. Dureau, page 170, claims that Herodotus made the Borysthene and the Hypanis empty into the Palus Meotide. But Herodotus (Melpom., LIII) says only that these two rivers empty together into the same lake, that is to say, into the Liman, as is the case today. Herodotus did not make the Gerrhus and the Hypacyris go any further.

[5]For example, Dureau de Lamalle, in his Géographie physique de la mer Noire, refers to Aristotle (Meteor., I.I, c. 13) as "teaching us that in his time there existed still several ancient periodes *[accounts of voyages]* and peripli *[manuscripts with ports and coastal landmarks]* confirming that there was a canal leading from the Caspian Sea into the Palus Meotide." Now, here is what the words of Aristotle amount to at the cited reference (Duval edition, I, 545, B.): "From Paropamisus descend, among other streams, the Bactus, the Choaspes and the Araxe, from which the Tanais, which is a branch of it, originates, into the Palus Meotide." Who does not see that this gibberish, which is not based either on peripli or on periodes is only the strange idea of Alexander's soldiers, who took the Jaxarte or Tanais of the Transoxian for the Don or Tanais of Scythia? Arrian and Pliny made the distinction in this matter, but it appears that it had not been made at the time of Aristotle. Why do we want to derive geological documents from geographers like these?

THE MARCH OF THE DUNES

We spoke above about dunes, or those mounds of sand which the sea throws up on low coasts when its bottom is sandy. Everywhere where human industry has not known how to fix them in place, these dunes advance inland as irresistibly as the alluvial deposits of the rivers advance into the sea. They push in front of them ponds formed by rain waters in the terrain along which they run and which they block from linking up with the sea. In many places they proceed at an alarming rate. Forests, buildings, cultivated fields—the dunes overrun everything. Those in the Gulf of Gascony *[Bay of Biscay]* have already covered a large number of villages mentioned in medieval land titles, and right now in the single department of Landes, they threaten ten of them with inevitable destruction.[1] One of these villages, Mimisan, has fought for twenty years against the dunes, and one dune more than sixty feet high is approaching the town, so to speak, as one looks at it.

In 1802, ponds overran five beautiful small farms in the village of Saint Julien.[2] For a long time they have covered an old Roman road which led from Bordeaux to Bayonne and which was seen again forty years ago when the waters were low.[3] The River Adour, which, in historical time, passed ancient Boucat and emptied into the sea at Cape Breton, has now been diverted by more than a thousand toises.

The late Bremontier, inspector of bridges and highways, who undertook major projects on the dunes, estimated their progress at sixty feet per year, and in certain places at seventy-two feet. According to his calculations, they would need only two thousand years to reach Bordeaux. And to judge from their present length, they must have started to form a little more than four thousand years ago.[4]

The covering over of cultivated land in Egypt by the sterile sands of Libya, which the west wind blows there, is a phenomenon of the same sort as the dunes. These sands have overrun a number of towns and villages, whose ruins are still evident. This has happened since the Mohammedan conquest of the country, for one sees the tips of the minarets from some mosques sticking up through the sand.[5] With such rapid progress, these sands would have undoubtedly filled the narrow parts of the valley if so many centuries had elapsed since they started being blown there.[6] Nothing at all would remain between the Libyan mountain range and the Nile. Here again is a chronometer whose measurement would be easy and interesting to obtain.

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[1]See the Rapport sur les Dunes du golfe de Gascogne, by Tassin. Mont-de-Marson, an X.

[2]Bremontier, Mémoire sur la fixation des dunes.

[3]Tassin, *loc. cit.*

[4]See the Mémoire of Bremontier.

[5]Denon. Voyage en Égypte.

[6]We could refer here to all the travellers who have crossed the western edge of Egypt.

PEAT BOGS AND ROCK FALLS

The peat bogs produced so widely in northern Europe by the accumulation of debris of peat moss and other water mosses also provide a means of measuring time. They grow at a specific rate for each location. They thus surround the small hillocks of the terrain on which they form. Several of these hillocks have been buried within human memory. In other places the peat bog moves down the length of valleys, proceeding as glaciers do. But glaciers melt along their lower edges; the peat bog is not held back by anything. By sounding the bog right down to solid ground, one assesses its age, and one finds, for peat bogs as for dunes, that they cannot have arisen an indefinitely long time ago. The case is the same for rock falls which occur extremely quickly at the foot of all escarpments and which are still a long way from covering them over. But since we have not yet applied precise measurements to these two sorts of causes, we will not dwell upon them any more.[1]

We always see that everywhere nature tells us the same thing; everywhere she informs us that the present order of things does not go back very far; and what is quite remarkable, everywhere man speaks to us as nature does, whether we consult people's authentic traditions or whether we examine their moral and political state and the intellectual development which they had reached at the moment when their authentic monuments begin.

THE HISTORY OF PEOPLES CONFIRMS THE NEWNESS OF THE CONTINENTS

Although at first glance the traditions of some ancient peoples who trace their origin back so many thousands of centuries seem forcibly to contradict the newness of the present world, in fact when we examine these traditions a little more closely, it does not take us long to notice that there is nothing historical about them. We are soon convinced, by contrast, that real history and everything which it has preserved for us in the form of reliable documents dealing with the first establishment of nations confirm what the natural monuments have announced.

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[1]These phenomena are dealt with very well in the Letters of Deluc to the Queen of England, in the places where he describes peat bogs in Westphalia, and in his Letters to Lametherie, included in the Journal de Physique of 1791, and so on, and also in those which he addresses to Blumenbach, which have been printed in French, in a single volume, Paris, 1798. To this can be added the very interesting details which he provides in his Voyages géologiques, Volume I, on the islands of the west coast of the Duchy of Schleswig and on way in which they have been joined up again, whether to each other or to the mainland, by alluvial deposits and peat bogs, as well as on the irruptions which from time to time have destroyed them or separated some parts.

As for rock falls, Jameson, in a note in the English translation of this Discourse, refers to a remarkable example of them taken from the rocky escarpments called *Salisbury Crag*, near Edinburgh. Although not particularly high, their abruptly vertical faces are not yet at all hidden by the mass of debris which has collected at their bases and which, nonetheless, increases each year.

No chronology of any of our peoples in the West goes back in an unbroken chain more than three thousand years. None of them can offer us a sequence of events linked together with some credibility before this time period, nor even two or three centuries later. Northern Europe has a history only since its conversion to Christianity. The history of Spain, Gaul, and England dates only from the Roman conquests. The history of north Italy before the founding of Rome is today almost unknown. The Greeks claim that they possessed the art of writing only since the Phoenicians taught them thirty-three or thirty-four centuries ago. For still a long time after that their history is full of fables, and they did not go back further than three hundred years earlier for the first vestiges of their consolidation as a people. For the history of western Asia we have only some contradictory extracts which go back, with little coherence, merely twenty-five centuries.[1] By combining what we collect of the oldest with some historical details, we would hardly extend the figure to forty centuries.[2]

The first pagan historian whose work we have, Herodotus, is two thousand three hundred years old.[3] The earlier historians which he could have consulted do not date from the century before him.[4] One can even judge what they were like by the extravagances which remain to us, extracts from Aristeas of Proconnesus and some others.

Before them there were only the poets, Homer being the oldest we have. Homer, the master and the eternal model for all the West, preceded our age only by two thousand seven hundred or two thousand eight hundred years.

When these first historians talk of ancient events, whether of their own country or of neighbouring states, they refer only to the oral traditions and not to public works. Only a long time after them did people produce the so-called extracts of the Egyptian, Phoenician, and Babylonian annals. Berossus wrote only in the reign of Seleucus Nicator *[c. 358-281 BC]*, Hieronymus only in the reign of Antiochus Soter *[324-261 BC]*, and Manetho only in the reign of Ptolemy Philadephus *[308-246 BC]*. All three of them are only of the third century before Jesus Christ.

Whether Sanconiatho *[c. 950 BC]* is a real or imaginary author, we know nothing at all about him before Philon of Byblos published a translation of him under Hadrian, in the second century after Jesus Christ, and even if people had known his work, so far as the earliest times are concerned, they would have found there, as with all writers of this type, only a puerile

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[1]To Cyrus, about 650 BC.

[2]To Ninus, about 2348 BC, according to Ctesias and those who followed him, but only to 1250 BC according to Volney, following Herodotus.

[3]Herodotus lived 440 years before Jesus Christ.

[4]Cadmus, Pherecydes, Aristeas of Proconnesus, Acusilaus, Hecataeus of Miletus, Charon of Lampascus, and so on. See Vossius, de Histor. Græc., lib. I, and especially his fourth book.

theogony or a metaphysics so disguised under allegories that it is unrecognizable.

One single people has preserved for us written prose records from before the time of Cyrus: the Jewish people. The part of the Old Testament called the *Pentateuch* has existed in its present form at least since the schism of Jeroboam *[c. 930 BC]*, because the Samaritans hold to it just as the Jews do. That means that the text is now certainly more than two thousand eight hundred years old.

There is no reason not to attribute the writing of Genesis to Moses himself, a fact which would put it back by five hundred years more, to thirty-three centuries. And reading the text is sufficient to make one notice that it was composed in part with pieces of previous works. Therefore, we can entertain not the slightest doubt that this is the most ancient writing which our western tradition possesses.

Now, this work and all those which have been created since, however foreign their authors might have been both to Moses and to his people, depict for us the nations on the edges of the Mediterranean as recent. They show them to us still as semi-barbarians some centuries previously; in addition, they all tell us of a universal catastrophe, an irruption of the waters, which brought about an almost total rebirth of the human race. And for the age of this catastrophe they do not go back a very long time.

The Pentateuch texts, which extend this period the most, do not date it at more than twenty centuries before Moses, and consequently at no more than five thousand and four hundred years before us.[1]

The poetic traditions of the Greeks, sources of all our pagan history for these distant epochs, have nothing which contradicts the records of the Jews. On the contrary, they agree with them admirably concerning the ages which they assign to the Egyptian and Phoenician settlers, who gave Greece the first germs of civilization. We see there that in about the same century when the Israelite tribes left Egypt to take into Palestine the sublime faith in a single God, other colonies left the same country to carry into Greece a cruder religion, at least on the surface, whatever the additional secret doctrines which the religion reserved for its initiates; while still others came from Phoenicia and taught the Greeks the art of writing and everything concerning navigation and trade.[2]

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[1]The Septuagint dates it at five thousand three hundred and forty-five; the Samaritan text at four thousand eight hundred and sixty-nine; the Hebrew text at four thousand one hundred and seventy-four.

[2]We know that the chronologers differ by several years concerning each of these events, but these combined migrations nonetheless formed the special and very noteworthy character of the fifteenth and sixteenth centuries before Jesus Christ.

Thus, by following only the calculations of Usserius, Cecrops would have come from Egypt to Athens around 1556 BC; Deucalion would have settled on Parnassus around 1548;

No doubt there is a great deal lacking after that which would make up a continuous history, because for a long time after the founding of these colonies people still talked of a host of mythological events and adventures, in which the gods and heroes took part, and because people link these leaders to real history only by genealogies which are plainly fabricated.[1] However, what is even more certain is that everything which had preceded their arrival could only have been preserved in very confused memories and could have been supplied only by pure inventions, similar to those of our monks in the Middle Ages concerning the origins of the European peoples.

Thus, not only should one not be surprised that there were plenty of doubts and contradictions, even in ancient times, concerning the dates of Cecrops, Deucalion, Cadmus, and Danaus—and it would be childish to attach the least importance to some opinion or other about the precise dates of Inachus[2] or Ogyges[3]—but if anything can surprise us, it is that these people were not placed infinitely earlier. It is impossible that there was not in this matter some ascendancy of received traditions, from which the inventors of the fables could not depart. One of the dates assigned to the flood of Ogyges even accords so well with the one which has been assigned to Noah's Flood, that it is hardly possible that it was not taken from some source in which it was the latter flood which was meant.[4]

Cadmus would have arrived from Phoenicia at Thebes around 1493; Danaeus would have come to Argos around 1485; Dardanus would have settled on the Hellespont around 1449.

All these national leaders would have been just about contemporaries of Moses, the date of whose exodus is 1491. Incidentally, on the coordinated times of Moses, Danaus, and Cadmus, see Diodorus, Book XI; in Photius, page 1152.

[1]Everyone knows the genealogies of Apollodorus and the way the late Clavier sought to take advantage of them to derive some sort of primitive history of Greece. But when one has read the genealogies of the Arabs and of the Tartars and all those which our old monastic chroniclers have dreamed up for the different sovereigns of Europe and even for individual ones, it is really easy to understand that the Greek writers must have done for the earliest times in their country what has been done for all the others in those ages when critical method did not illuminate history.

[2]1856 or 1823 BC, or still other dates, but always about 350 years before the main Phoenician or Egyptian colonists.

[3]The common date for Ogyges, according to Acusilaus, followed by Eusebius, is 1796 BC, and consequently several years after Inachus.

[4]Varro dates the Flood of Ogyges, which he calls the *First Flood*, four hundred years before Inachus (*a priore cataclismo quem Ogygium dicunt, ad Inachi regnum*), and consequently at 1600 years before the first Olympiad. That would make it 2376 BC. And the date of Noah's Flood, according to the Hebrew text, is 2349 BC. The difference is only twenty-seven years. Varro's testimony was mentioned by Censorinus, *de Die natali*, cap. xxi. True, Censorinus wrote only in the year 238 AD, and, according to Julius Africanus, ap. Euseb., Praep. cv, it seems that Acusilaus, the first author who dated a flood in the time of the reign of Ogyges, made this prince a contemporary of Phoroneus, something which brings it very close to the first Olympiad. Julius Africanus puts an interval of only one thousand and twenty years between the two ages. And in Cesorinus there is even a passage which corresponds to this view. Also some people wish to read in Varro's work

As for Deucalion, whether this prince is regarded as a real or fictional person, if one follows a little the way in which his flood was introduced into Greek poetry and the various details with which it was successively enriched, it becomes clear that this was only a tradition of the great cataclysm, altered and dated at the same epoch as Deucalion by the Hellenes because Deucalion was seen as the originator of the Hellenic nation and because they confused his history with that of all the leaders of the nations reborn after the disaster.[1]

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which we have just quoted, following Cesorinus, *erogitium* in place of *Ogygium*. But what is a *cataclisme érogitien* which no one has ever mentioned?

[1]Homer and Hesiod knew nothing of Deucalion's flood, any more than they knew of Ogyges' flood.

The first surviving author in whom one finds a mention of the first is Pindar (Od. Olymp. ix). He has Deucalion land on Parnassus, set himself up in the town of Protogenia (first birth) and there recreate his people with rocks. Briefly put, he reports the fable, later universalized to all humanity by Ovid, but applies it to only one nation.

The first historians after Pindar (Herodotus, Thucydides and Xenophon), make no mention of any flood, neither at the time of Ogyges, nor at the time of Deucalion, although they do speak of the latter as one of the first kings of the Hellenes.

Plato, in the Timaeus, says only a few words on the flood, as well as on Deucalion and Pyrrha, to begin the account of the great catastrophe which, according to the priests of Sais, destroyed Atlantis. But in this short passage he speaks of the flood in the singular, as if it was the only one. He even expressly states further on that the Greeks knew of only one. He places the name of Deucalion immediately after the name of Phoroneus, the first of men, without mentioning Ogyges. Hence, for him, it is again a general event, a truly universal flood, and the only one which happened. He thus looked upon it as identical with the flood of Ogyges.

Aristotle (Metero., I, 14) seems the first to have thought of this flood as only a local inundation, which he locates near Dodone and the river Achelous, but near the Achelous and Dodone in Thessaly.

In Apollodorus (Bibl., I, § 7), Deucalion's flood reacquires all its importance and mythological character. It takes place at the time of the transition from the Age of Bronze to the Age of Iron. Deucalion is the son of the titan Prometheus, the maker of human beings. He remakes the human race from stones. However, Atlas, his uncle, and Phoroneus, who was alive before him, and several other earlier people preserve many descendants.

As we move forward to more recent writers, certain circumstantial details are added which resemble more closely those which Moses reports. Thus Apollodorus gives Deucalion a chest as a means of saving himself; Plutarch talks about doves by means of which he *[Deucalion]* sought to learn if the waters had ebbed, and Lucian talks of animals of every species which he had taken on board with him, and so on.

As to the combination of the traditions and the hypothesis by which people have recently sought to conclude that the breaking through of the Bosphorus in Thrace was the cause of Deucalion's Flood and even the opening of the pillars of Hercules, thus discharging into the Archipelago the waters of the Euxine Sea *[the Black Sea]*, which was previously much higher and more extensive that it has been since this event, it is no longer necessary to concern oneself with this in detail, since it has been confirmed by Olivier's observations that, if the Black Sea had been as high as people assume, it would have found several escape channels through the passes and plains of lower elevation than the present shores of the Bosphorus, and by Count Andreossy's observation that if a cascade had fallen suddenly one day through this new passage, not only would the small quantity of water

The fact is that every Greek tribe which preserved its separate traditions began them with its own particular flood, because every one of them retained some memory of the universal deluge which was common to all people. When in later years, people wanted to subject these various traditions to a common chronology, they thought they perceived different events, because the totally uncertain dates, all perhaps false, but each one looked upon as authentic in its own county, did not agree with each other. Thus, in the same way that the Hellenes had Deucalion's Flood, because they looked upon Deucalion as their founding father, the Autochthones of Attica had Ogyges' Flood, because it was from Ogyges that they began their history. The Pelasgians of Arcady had a flood which, according to later writers, forced Dardanus to move towards the Hellespont.[1] Samothrace, one of the islands where there was set up in the more distant ages a priestly succession, a regular cult, and continuous traditions, also had a flood which was thought to be the most ancient of all,[2] and which was attributed to the break through of the Bosphorus and the Hellespont. People retained some idea of a similar event in Asia Minor[3] and in Syria,[4] and afterwards the Greeks attached the name Deucalion to this event.[5]

But none of these traditions dates the disaster very long ago. And they all make sense concerning the date and other circumstances, according to the variations always present in accounts not firmly established in writing.

THE EXCESSIVE ANTIQUITY ATTRIBUTED TO CERTAIN PEOPLE HAS NO HISTORICAL BASIS

People who wish to attribute to the continents and to the establishment of nations a very distant antiquity are therefore obliged to address themselves to the Indians, to the Chaldeans, and to the Egyptians, three peoples who, in fact, appear to be the most ancient civilizations of the Caucasian race, but three peoples extraordinarily similar among themselves, not only in their temperament, their climate, and the nature of the soil which they inhabit, but even more in the political and religious constitution which

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which would have been able to run through all at once by such a narrow opening have been spread out over the immense extent of the Mediterranean without causing there a tide of a few toises, but also the simple natural slope necessary for the running out of the water would have reduced to nothing their excess height on the shores of Attica.

See in addition on this subject the note which I have published at the front of the third volume of Ovid, in Lemaire's collection.

[1]Dionysus of Halicarnassus. Antiq. rom., Book 1, Chapt. LXI.

[2]Diodorus de Sicile, Book V., Chapt. XLVII.

[3]Etienne of Byzantium, voce Iconium; Zenodotus, Prov., cent. vi, no. 10; and Suidas, voce Nannacus.

[4]Lucian., de Deâ Syrâ.

[5]Arnobius, Contra Gent., lib. v, p. m. 158, even speaks of a Phrygian rock from which people claim Deucalion and Pyrrha took their stones.

they gave themselves. This very constitution ought to make the evidence equally suspect.[1]

Among all three, a hereditary caste was entrusted exclusively with their religion, laws, and sciences. Among all three this caste had its allegorical language and secret doctrine; among all three, this caste reserved to itself the privilege of reading and explicating the sacred books in which the gods themselves had revealed all knowledge.

We understand what history could have developed into in such hands, but without indulging in great efforts of reasoning we can know the facts by examining what history has become among the one of these three nations which is still in existence: among the Indians.

The truth is that history does not exist at all. In the midst of this infinity of books of mystical theology or of abstruse metaphysics which the Brahmins possess and which the ingenious perseverance of the English has succeeded in making known, there is nothing which might be able to instruct us coherently about the origin of their nation and about the vicissitudes of their society. They even maintain that their religion forbids them from preserving the memory of what is happening in the present age, the age of misfortune.[2]

According to the Vedas, the first of the revealed works and the foundation for the Hindus' entire belief system, the literature of this people, like that of the Greeks, begins with two great epics: the *Ramaian* and the *Mahabarat*, a thousand times more monstrous in their marvels than the *Iliad* and the *Odyssey*, even though one sees in it also traces of a metaphysical doctrine like those which we conventionally call sublime. The other poems, which with the two first ones make up the large body of Puranas, are only legends or verse stories, written at different times by different authors, no less extravagant in their fictions than the major poems. People have believed that they recognize in some of these writings events or men's names somewhat similar to those which the Greeks and Latins spoke about. It is mainly through these similarities in the names that Wilfort tried to derive from these Puranas some sort of agreement with our chronology of the ancient western world, a concordance which reveals in each line the hypothetical nature of his assumptions and which, besides, can be accepted only by discounting absolutely the dates provided by the Puranas themselves.[3]

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[1]This resemblance of institutions goes to the point where it is very natural to assume a common origin for them. It must not be forgotten that many ancient writers thought Egyptian institutions came from Ethiopia and that Syncellus, page 151, tells us positively that the Ethiopians came from the banks of the Indus at the time of King Amenophtis.

[2]See Polier, Mythologie des Indous, Volume I, pages 89 and 91.

[3]See the important work of Wilfort, on the chronology of the kings of Magadha, emperors of India, and on the epochs of Vicramaditjya (or Bikermadjit), and of Salivahanna. Mém. de Calcutta, Volume IX, in-8°., page 82.

The lists of kings which the pandits or Indian doctors claimed to have drawn up in accordance with the Puranas are only simple catalogues without details or are embellished with absurd details, like those the Chaldeans and the Egyptians had, like the ones Trithemus and Saxo Grammaticus gave northern people.[1] These lists do not agree at all. None of them presupposes history or registries or records. Even their origins could have been made up by the poets, whose works were their source. The pandit who provided them to Wilfort admitted that he arbitrarily filled the spaces between the famous kings with imaginary names,[2] and he maintained that his predecessors had done the same. If that is true of the lists which the English get hold of nowadays, how would it not be true of those which Abou-Fazel produced as extracts of the Annals of Kashmir[3] and which, in addition, as completely full of fables as they are, go back only four thousand three hundred years. More than one thousand two hundred of them are full of the names of princes whose reigns are quite indeterminate in length.

Even the era according to which the Indians today calculate their years, which begins fifty-seven years before Jesus Christ and which is named after a prince called *Vicramaditjia* or *Bickermadjit,* carries this name only according to a sort of convention. For one finds, according to the time frames attributed to Vicramaditjia, that there were at least three and perhaps up to eight or nine princes of this name, all of whom have similar legends, who all had wars with a prince called *Saliwahanna*. Moreover, people do not clearly know if this fifty-seven years before Jesus Christ is the date of the birth, of the reign, or of the death of Vicramaditjia, whose name it carries.[4]

Finally, the most authentic Indian texts, by their intrinsic and very recognizable characters, give the lie to the antiquity which people attribute to them. Their Vedas or sacred books, according to them revealed by Brahma himself from the time of the earth's origin and edited by Viasa (a name which signifies only a compiler) at the beginning of the present age, if one judges the matter by the calendar which is found joined to it and on which they rely, as well as by the position of the colures which this calendar shows, could go back three thousand two hundred years, which would be just about the era of Moses.[5] Perhaps indeed those who believe

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[1]See Jones, on the chronology of the Hindus, Mém. de Calcutta, edition in-8°, Volume II, page 111; French translation, p. 164. See also Wilfort on this same subject, *ibid*, Volume V, p. 241, and the lists which he provides in his work cited higher up, Volume IX, page 116.

[2]Wilfort, Mém de Calcutta, in-8°., volume ix, p. 133.

[3]Ayeen-Acbery, Volume II, page 138 of the English translation. See also Heeren, Commerce des Anciens, first volume, second section, page 329.

[4]See Bentley, on the astronomical systems of the Hindus and their connection with history, Mém. de Calcutta, Volume VIII, page 243 of the edition in-8°.

[5]See the Mémoire of Colebrocke on the Vedas, Mém de Calcutta, Volume VIII of the edition in-8°, page 493.

the statement of Megasthenes,[1] that in his time *[300 BC]* the Indians did not know how to write, those who consider that none of these ancient writers made any mention of the superb temples and immense pagodas, such remarkable monuments in the Brahmins' religion, and those who know that the epochs in their astronomical tables were calculated after the event, and badly calculated, and that their astronomical treatises are modern and backdated, such people will be persuaded to have a great deal less faith in this alleged antiquity of the Vedas.

However, in the midst of all the Brahmin fables are revealed certain traces whose agreement with what emerges from historical monuments further west is astounding. Thus, their mythology establishes clearly the successive destructions which the surface of the earth has suffered and must undergo in the future. And they date the last one only a little less than five thousand years ago.[2] One of these revolutions, which is dated in truth infinitely far away from us, is described in terms which almost correspond to those of Moses.[3] Wilfort even maintains that in another event from this mythology there is a person featured who resembles Deucalion in his origin, in his name, in his adventures, right up to the name and the adventures of his father.[4]

[*Translator's Note:* The colures mentioned here are two large circles, intersecting at right angles over the poles; one passes through the equinoctial and the other through the solsticial point on the ecliptic. The colures thus divide up the ecliptic into four equal parts. Cuvier uses the colures later as a fixed point of reference when he is discussing the precession of the equinoxes. See note 174 below.]

[1]Megasthenes apud Strabo., lib xv, p. 709, Almel.

[2]The one which gave birth to the present age or *cali yug* (the earthen age): it goes back four thousand nine hundred and twenty-seven years (three thousand one hundred and two years before Jesus Christ). See Legentil, Voyage aux Indes, Volume I, page 235; Bentley, Mém. De Calcutta, Volume VIII of the edition in-8°., page 212. That is only fifty-nine years older than Noah's Flood, according to the Samaritan text.

[3]The character Satyavrata there plays the same role that Noah does: he saves himself with seven pairs of saints. See Will. Jones, Mém. de Calcutta, Volume 1 in-8°, page 230, and the French translation in-4, page 170; and in the Bagavadam (or Bagvata), the translation by Fouché d'Obsonville, page 212.

[4]Cala Javana, or, in the common language, Cal-Yun, to whom his followers could have given the epithet *deva*, *deo* (god), having attacked Krishna (the Indian Apollo) at the head of the northern people (the Scythians, as Deucalion was, according to Lucian) was repulsed by fire and water. His father Garga had for one of his surnames *Pramathesa* (Prometheus); and according to another legend, he was devoured by the eagle Garuda. These details Wilfort took from the Sanskrit drama entitled Hari Vansa (in his Mémoire sur le mont Caucase, among those in de Calcutta, Volume VI of the edition in-8°, page 507). Charles Ritter, in his Vestibule de l'histoire européenne avant Hérodote, concludes that the entire Deucalion story was of foreign origin and was brought to Greece with the other legends of that part of Greek culture which came from the North and which preceded the Egyptian and Phoenician colonists. But if it is true that the constellations in the Indian celestial sphere have also the names of Greek characters—that one sees Andromeda there under the name of *Antarmadia*, Cepheus under the name of *Capiia*, and so on—one would perhaps attempt, with Wilfort, to draw an entirely opposite conclusion.

Another matter equally worth mentioning is that in these lists of kings, as dry and lacking in history as they are, the Indians date the start of their human rulers (those of the race of the sun and the moon) at a era which is just about the same as that when Ctesias, in a list of exactly the same sort, begins the kings of Assyria (about four thousand years before the present time).[1]

This deplorable state of historical knowledge was necessarily that of a people where the hereditary priests of a cult, grotesque in its exterior forms and cruel in many of its precepts, alone had the privilege of writing, preserving, and interpreting books. Some legend created to make fashionable a place of pilgrimage and fabrications appropriate to impress more deeply the respect for their caste must have interested them more than all historical truths. Among the sciences, they could have cultivated astronomy, which gave them credit as astrologers, and mechanics, which helped them raise monuments, symbols of their power and objects of superstitious veneration for the people, and geometry, the basis of astronomy, as of mechanics, and an important help in agriculture on the huge alluvial plains which could not have been cleared and made fertile without the aid of many canals. They could have encouraged the mechanical or chemical arts which supplied their trade and contributed to their and their temples' luxury. But they must have dreaded history, which illuminates for human beings their mutual relationships.

What we see in India we must therefore expect to discover in all places where the priestly races, institutionalized like that of the Brahmins and established in similar countries, arrogated to themselves the same imperial rule over the mass of the people. The same causes lead to the same results. In fact, with a little reflection on the fragments which remain to us of the Egyptian and Chaldean traditions, we perceive that they were no more historical than the Indian traditions.

To judge the nature of the chronicles which the Egyptian priests claimed to possess, it is sufficient to remember the extracts which they themselves provided at different times to different people.

The priests of Sais, for example, told Solon, about 550 BC, that since Egypt was not subject to massive floods they had preserved, not only their own records, but those of other people; that the towns of Athens and Sais had been built by Minerva, the former nine thousand years before, the second only eight thousand, and to these dates they added the well known fable of the Atlantes, about the resistance with which the ancient Athenians opposed their conquests, as well as all the Romanesque description of

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Unfortunately, among scholars, much doubt is starting to be cast on the authenticity of this writer's alleged documents.

[1]Bentley. Mém. de Calcutta, Volume VIII, page 226 of the edition in-8°., note.

Atlantis,[1] a description in which are found deeds and genealogies similar to those of all mythological stories.

A century later, about 450 *[BC]*, the priests at Memphis gave Herodotus totally different accounts.[2] According to them, Menes, the first king of Egypt, had built Memphis and enclosed the Nile within dikes, as if operations like that would have been possible for the first king of a country. Since then they had had three hundred and thirty other kings up to Mœris, who reigned, according to them, nine hundred years before the period when they were speaking (1350 BC).

After these kings came Sesostris, who pushed his conquests as far as Colchis.[3] There were, in total, up to the time of Sethos, three hundred and forty-one kings and three hundred and forty-one grand priests, in three hundred and forty-one generations, over a time period of eleven thousand three hundred and forty years. In this period, as if to serve as a guarantee for their chronology, these priests maintained that the sun rose twice where it sets, without anything having changed in the climate or in the country's productions, and without any god, then or previously, having shown himself or having reigned in Egypt.

To this outline, which, despite all the explanations which people have claimed to provide for it, demonstrated such a gross ignorance of astronomy, they added fairy tales about Sesostris, Pheron, Helene, Rhampsinite, about the kings who had the pyramids built, about an Ethiopian conqueror, named *Sabacos*, stories entirely worthy of the context into which they were inserted.

The priests of Thebes fared better. They showed Herodotus—and previously they had shown Hecataeus—three hundred and forty-five wooden colossi, representing three hundred and forty-five Grand Priests who had succeeded each other, father to son, all men, all born one from the other, but who had been preceded by gods.[4]

Other Egyptians told him they had exact registries, not only of the reign of men but also of the gods. They calculated seventeen thousand years from Hercules up to Amasis, and fifteen thousand since Bacchus. Pan had come still earlier than Hercules.[5] Evidently those people took as history any allegory relevant to a pantheistic metaphysics, which created without their knowing it the foundation of their mythology.

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[1]See the Timaeus and the Critias of Plato.

[2]Euterpe, chapter XCIX and following.

[3]Herodotus believed he recognized connections between the Colchians and the Egyptians in their faces and colour. But it is infinitely more likely that the black Colchians whom he mentions were an Indian colony drawn by the ancient trading established between India and Europe, by the River Oxus, the Caspian Sea, and the Phasis. See Ritter, Vestibule de l'histoire ancienne avant Hérodote, chapt. 1.

[4]Euterpe, Chapter CXLIII.

[5]*Ibid.*, CXLIV.

In Herodotus, slightly reasonable history starts only at the time of Sethos. Moreover, something which it is important to notice, this history begins with an event which agrees with the Hebrew annals, the destruction of the army of Sennacherib, King of Assyria.[1] This agreement is maintained for the reigns of Necho and Hophra or Apries .[2]

Two centuries after Herodotus (around 260 BC), Ptolomy Philadelphos, prince of a foreign people, wished to know the history of the country of which events had made him the governor. Once again, a priest, Manetho, took upon himself the task of writing it for him. He no longer maintained that he drew his history from the registries or from the archives but from the sacred books of Agathodæmon, son of the second Hermes and father of Tat, which had been copied on the columns erected before the flood, by Tot or the first Hermes, in the seriadic land *[Far East].*[3] These people—the second Hermes, Agathodaemon, and Tat—are characters no one had previously mentioned at all, any more than they had talked about this seriadic land or these columns. This flood is itself an event entirely unknown to the Egyptians of earlier times and something which Manetho does not mention in what remains to us of his dynasties. The product is similar to the source, not only crammed full of absurdities but unique absurdities impossible to reconcile with those which the priests of earlier times had mentioned to Solon and Herodotus.

Vulcan starts the series of divine kings. He reigns nine thousand years. The gods and demi-gods reign one thousand nine hundred and eighty-five years. Neither the names, nor the successions, nor the dates of Manetho are close to what was published before and after him. He must have been so obscure and muddled that there is no agreement between him the others; for it is impossible to match the extracts of his work which Josephus, Julius Africanus, and Eusebius give. There is no agreement even on the total of the years of these human kings. According to Julius Africanus, it comes to five thousand one hundred and one; according to Eusebius, to four thousand seven hundred and twenty-three; according to Syncellus, to three thousand five hundred and fifty-five. It might be possible to believe that the difficulties with the names and the dates arose from copyists. But Josephus cites at length a passage in which the details manifestly contradict the extracts of his successors.

A chronicle, certified as old,[4] which some judge earlier than Manetho (others judge it later) provides yet other calculations. The total time span of its kings is thirty-six thousand five hundred and twenty-five years. Of these, the Sun ruled for thirty thousand, the other gods for three thousand

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[1]Euterpe, CXLI.

[2]*Ibid.*, CLIX, and in the fourth book of Kings, chapter 19, or in the second of the Paral., chapter 32.

[3]Syncell., page 40.

[4]Syncell., page 51.

nine hundred and eighty-four, the demi-gods for two hundred and seventeen. There remain for human beings only two thousand three hundred and thirty-nine years. In addition, one reckons from this only one hundred and thirteen generations, in place of Herodotus' three hundred and forty.

A scholar of a different order from Manetho, the astronomer Eratosthenes, discovered and published, in the reign of Ptolomy Euergetes, about 240 BC, a special list of thirty-eight kings of Thebes, beginning with Menes and continuing for one thousand and twenty-four years. We have an extract of it which Syncellus copied in Apollodorus.[1] Almost none of the names found there corresponds to the other lists.

Diodorus went to Egypt in the reign of Ptolomy Auletes, about 60 BC, and thus two centuries after Manetho and four centuries after Herodotus. He collected the history of the country, also from the mouths of the priests, and he, once again, took down something totally different.[2] It was no longer Menes who built Memphis, but Uchoreus. A long time before him Busiris II had built Thebes.

The eighth grandfather of Uchoreus, Ozymandias, was lord of Bactria and had put down revolts there. A long time after him, Sesoosis completed conquests even further away. He went right to the Ganges and returned by way of Scythia and the Tanais. Unfortunately, these kings' names are unknown to all the preceding historians, and none of the people whom they conquered has preserved the least memory of them. As to the gods and heroes, according to Diodorus, they ruled for eighteen thousand years, and the human sovereigns for fifteen thousand: four hundred and seventy kings were Egyptian, four Ethiopian, without including the Persians and the Macedonians. These fairy stories, by the way, in which everything is intermingled, match very well the puerility of Herodotus' tales.

In 18 AD, Germanicus, nephew of Tiberius, drawn by the desire to learn about the antiquities of this famous land, came to Egypt, risking the displeasure of a prince as suspicious as his uncle. He went up the Nile as far as Thebes. No longer did the priests talk to him of Sesostris or Ozymandias as a conqueror, but of Rameses. At the head of seven hundred thousand men he had overrun Libya, Ethiopia, Media, Persia, Bactria, Scythia, Asia Minor and Syria.[3]

Finally, in Pliny's famous article on the obelisks we find again the names of kings whom we have not seen anywhere else: Sothies, Mnevis, Zmarreus,

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[1]Syncell., pages 91 ff.

[2]Diod. Sic., lib. I, sect. II.

[3]Tacit., Annal., Book II, Chapt. LX.

NB According to the interpretation which Ammien has preserved for us (Book XVII, Chapt. IV) of the hieroglyphs on the Theban obelisk which is now in Rome in the Piazza of Saint John of Lateran, it appears that Ramestes was there described in the Eastern fashion as the lord of the inhabitable earth and that the history presented to Germanicus was only a commentary on this inscription.

Eraphius, Mestires, a Semenpserteus, contemporary of Pythagoras, and so on.[1] A certain Ramises, who one can believe is the same as Rameses, is there made a contemporary of the siege of Troy.

I am aware that people have tried to reconcile these lists, by assuming that the kings carried several names. As far as I am concerned, I consider more than the contradictions in these various narratives, but I am struck above all by the mixture of real events, attested to by great monuments, with childish exaggerations, and it seems to me infinitely more natural to conclude from them that the Egyptian priests had no historical sense whatsoever. Inferior even to the Indian priests, they did not even have consistent and continuous stories. They preserved only some more or less erroneous lists of their kings and some memories of the main ones, above all of those who had taken the trouble to write their names on the temples and the other great works which beautify the country. But these memories were confused; they rested only on a traditional narrative given to painted representations or sculptures on the monuments, narratives based solely on hieroglyphic inscriptions devised like the one for which we have a translation,[2] in very general terms, which through oral transmission changed in their details, at the whim of those who passed them on to foreigners. Consequently, it is impossible to ground any proposition about the relative antiquity of the present continents on the scraps of these traditions, which were so incomplete already in their own time and which have become totally unrecognizable in the writings of those who have transmitted them to us.

If this assertions needed other proofs, they would be found in the list of the sacred works of Hermes, which the Egyptian priests carried in their solemn processions. Clement of Alexandria gives us the names of all forty-two of them,[3] and, as with the Brahmins, there is not found there even one epic or book which sets itself up as a narrative or establishes by any manner whatsoever any significant action or event.

The younger Champollion's fine research and his astonishing discoveries about the language of the hieroglyphs,[4] far from overthrowing these conjectures, confirm them. This ingenious antiquarian read, in a series of hieroglyphic pictures in the Temple of Abydos,[5] the first names of a certain number of kings organized in sequence, one after the other. When one section of these first names (the last ten) was found on various other

[1]Pliny, lib. XXXVI, cap. VIII, IX, X, XI.

[2]That of Ramestes in Ammien, *loc. cit.*

[3]Stromat., lib. VI, page 633.

[4]See the Précis du Système hiéroglypyhique des anciens Égyptiens by Champollion the younger, page 245, and his Lettre à M. le Duc de Blacas, pages 15 ff. [*Translator's note*: Jean-Francois Champollion (1790-1832) deciphered Egyptian hieroglyphs (starting in 1822). His work was a major breakthrough in studies of Egypt.]

[5]This important bas-relief is engraved in Le Voyage à Méroë, by Caillaud, Volume II, Plate XXXII.

monuments, accompanied by proper names, he concluded from this that they are those of the kings who carried these proper names, a hypothesis which gave him almost the same kings and in the same order as those from which Manetho created his eighteenth dynasty, the one which drove away the priests. However, the catalogue is not complete; in the pictures of Abydos six of the names in Manetho's list are missing. There are some which bear no relation to his. Finally, there is unfortunately a gap before the most noteworthy of all, that Rameses, who appears to be the same as the king represented on such a large number of the most beautiful monuments with the attributes of a grand conqueror. According to Champollion, in the list of Manetho, it would be Sethos, head of the nineteenth dynasty who, in fact, was indicated as powerful in ships and cavalry and as having led his armies into Cyprus, Media, and Persia. Champollion thinks, along with Marsham and many others, that it is this Rameses or this Sethos who is the Sesostris or the Sesoosis of the Greeks. This opinion is plausible, in the sense that the representations of the victories of Rameses, probably achieved over Egypt's nomadic neighbours or, at the most, in Syria, gave rise to these fantastic ideas of immense conquests, attributed, by some other confusion, to a Sesostris. But in Manetho, a prince named Sesostris, designated as the conqueror of Asia and Thrace,[1] is inscribed in the twelfth dynasty, not in the eighteenth.[2] Also Marsham maintains that this twelfth dynasty and the eighteenth dynasty are one and the same. Manetho would thus not himself have understood the lists which he was copying. Finally, if one accepts this in its entirely, together with the true historicity of the bas-relief of Abydos, and its agreement, whether with the part of the lists of Manetho which appears to coincide with it or with the other hieroglyphic inscriptions, the immediate result is that the alleged eighteenth dynasty, the first one about which the ancient chronologists begin to agree a little, is also the first which has left on the monuments traces of its existence. Manetho could have consulted this documentary evidence and other similar ones. But it is no less true that a list, a series of names or portraits, of the sort there are all over the place, is far from being a history.

Given what has been established and is known about the Indians and what I have just shown to be so likely for the inhabitants of the valley of the Nile, surely we must assume the same also for the inhabitants of the Euphrates and Tigris valleys? Settled, like the Indians and the Egyptians,[3] on a great trading route, in vast plains through which they had to cut numerous canals, like them taught by a hereditary priesthood, allegedly the holders of secret books, privileged possessors of the sciences, astrologers,

[1]Syncell., page 59.

[2]Canon., page 353.

[3]All the ancient mythology of the Brahmins relates to the plains where the Ganges flows, and it is clearly there that they made their first settlements.

builders of pyramids and other huge monuments,[1] surely they must be like them also in other essential points? Surely their history must equally reduced itself to legends? I am almost brave enough to claim not only that this is probable, but that this is demonstrated by the evidence.

Neither Moses nor Homer yet speaks to us of a large empire in High Asia. Herodotus states that the supremacy of the Assyrians lasted only five hundred and twenty years, and that their origin goes back only eight centuries before his time.[2] After having been in Babylon and consulted the priests, he did not even learn about the name Ninus as a king of the Assyrians and speaks of him only as the father of Agron,[3] the first Heraclid king of Lydia. He does, however, make him the son of Belus, such is the confusion in the memories from that time. If he speaks of Semiramis as one of the queens who left large monuments at Babylon, he dates her only seven generations before Cyrus.

Hellanicus, a contemporary of Herodotus, far from describing the construction of anything at Babylon by Semiramis, attributes the foundation of that city to Chaldaeus, the fourteenth successor of Ninus.[4]

Berossus, a Babylonian priest, who wrote almost one hundred and twenty years after Herodotus, assigns a startling antiquity to Babylon. But it is to Nebuchadnezzar, a relatively modern prince, that he attributes the city's principal monuments.[5]

Concerning Cyrus himself, such a remarkable prince, whose story must have been so well known and popular, Herodotus, who lived only one hundred years after him, holds that there existed already three different opinions. And in fact, sixty years later, Xenophon gives us a biography of this prince entirely the opposite of the one by Herodotus.

Ctesias, almost a contemporary of Xenophon, maintains that he derived from the royal archives of the Medes a chronology which pushes back by more than eight hundred years the origin of the Assyrian monarchy, still leaving at the head of the list of these kings this same Ninus, son of Belus, whom Herodotus made a Heraclid. At the same time he attributes to Ninus and to Semiramus western conquests of an extent totally incompatible with the contemporary history of the Jews and the Egyptians.[6]

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[1]The descriptions of the ancient Chaldean monuments are very similar to those which we see of the Indian and Egyptian monuments. But these monuments were not preserved in the same fashion because they were constructed only out of bricks dried in the sun.

[2]Clio, cap. XCV.

[3]Clio, cap. VII.

[4]Etienne of Byzantium at the word Chaldæi.

[5]Josephus (contre Appion), lib. I, cap. XIX.

[6]Diod. Sic., lib. II.

According to Megasthenes, it was Nebuchadnezzar who made these amazing conquests, pushing through Libya right up to Spain.[1] One sees that, at the time of Alexander, Nebuchadnezzar had quite usurped the reputation which Semiramis had had in the time of Artaxerxes. But no doubt people will think that Semiramis and Nebuchadnezzar conquered Ethiopia and Libya in just about the same way that the Egyptians make Sesostris or Ozymandias the conqueror of India and Bactria.

How would things stand if we now examined the different accounts concerning Sardanapalus, in which a famous scholar believed he had found proofs of the existence of three princes with this name, all three victims of similar disasters,[2] almost in the same way another scholar finds in India at least three Vicramaditjias, also three heroes with similar adventures.

Apparently following the scanty agreement in all these accounts, Strabo thought he could say that the authority of Herodotus and Ctesias was not equal to that of Hesiod or Homer.[3] Also Ctesias was hardly more fortunate with his copiers than Manetho; and it is very difficult today to reconcile the extracts of his work which Diodorus, Eusebius, and Syncellus have given us.

When one finds oneself in such uncertainties in the fifth century before Jesus Christ, how can one accept that Berossus was able to clarify them in the third century *[BC]*? How can one add any more credence to the four hundred and thirty thousand years which he establishes before the flood, to the thirty-five thousand years which he puts between the flood and Semiramis, and to the registers of one hundred and fifty thousand years which he boasts of having consulted?[4]

People talk of lofty public works in remote provinces which carry the name of Semiramis; people also maintain that they have seen in Asia Minor and in Thrace columns erected by Sesostris.[5] But with these things it is just as it is in Persia nowadays: the ancient monuments, perhaps even some of the ones mentioned above, carry the name Roustan; in Egypt or in Arabia they carry the name Joseph or Solomon. It is an ancient custom of the Orientals and probably of all ignorant peoples. Our peasants call all ancient Roman excavations Caesar's Camp.

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[1]Josephus (contre Appion), lib. I, cap. VI; and Strabo, lib. XV, page 687.

[2]See in Les Mémoires de l'Académie des Belles-Lettres, Volume V, the report of Fréret on the history of the Assyrians.

[3]Strabo, lib. XI, page 507.

[4]Syncellus, pages 38 and 39.

[5]N.B. It is very remarkable that Herodotus does not say that he saw monuments of Sesostris except in Palestine and does not mention Ionian ones except on the testimony of others, adding to that the point that Sesostris is not named in the inscriptions and that those who have seen these monuments attribute them to Memnon. See Euterpe, chapter CVI.

In a word, the more I think about it, the more I am persuaded that there is no ancient history at all in Babylon or in Ecbatana, any more than in Egypt and in India. And instead of importing mythology into history, the way Evhemere or Bannier do, I think we must bring a significant historical awareness into mythology.

Only at the period which we commonly call the second dynasty in Assyria does the history of the Assyrians and the Chaldeans begin to become clear, in the era when Egyptian history also becomes clarified, when the kings of Nineva, Babylon, and Egypt start to meet and to fight each other in the Syrian and Palestinian theatre.

Nevertheless, the writers in these areas, or those who had consulted their traditions—Berossus, Hieronymus, and Nicolaus of Damascus—apparently agreed in speaking about a flood. Berossus even described it in circumstances so similar to those of Genesis, that it is almost impossible that what he says about it is not taken from the same sources, even though he moves the date of it back by a great many centuries, at least so far as one can judge from the muddled extracts of his writings which Josephus, Eusebius, and Syncellus have preserved for us. But we should note—and with this observation we will conclude the matter of the Babylonians—that these numerous centuries and this grand sequence of kings placed between the flood and Semiramis are something new, entirely unique to Berossus, something which Ctesias and those who followed him had no idea of and which was not even adopted by any of the pagan writers after Belrossus. Justin and Velleius consider Ninus the first of the conquerors, and those who, against all probability, put him the furthest back, have only forty centuries between then and now.[1]

The Armenian authors of the Middle Ages almost agree with some of the texts of Genesis, when they date the Flood four thousand nine hundred and sixteen years in the past; and we can believe that, having collected the old traditions and perhaps mined the old chronicles of their country, they made an authoritative narrative more in favour of the newness of people. But when we reflect on the fact that their historical literature dates only from the fifth century *[AD]* and that they knew Eusebius, we understand that they must have followed his chronology and that of the Bible. Moses of Chorene expressly states that he has followed the Greeks, and we see that his ancient history is based on Ctesias.[2]

However, it is certain that the tradition of the Flood existed in Armenia well before the conversion of the inhabitants to Christianity, and the town which, according to Josephus, was called *The Place of the Descent*, still

[1]Justin, lib. I, cap. I: Velleius Paterculus, lib. I, cap. VII.

[2]See Moses of Chorene, Histor. Armeniae., lib. I, cap. I.

exists at the foot of Mount Ararat and carries the name *Nachidchevan*, which in fact means the same thing.[1]

In this matter, what we say is just as relevant to today's Arabs, Persians, Turks, Mongols, and Abyssians, as much as to the Armenians. Their ancient books, if they had any, do not exist any more. They have no ancient history other than what they have recently put together and which they have modelled on the Bible. Thus, what they say about the Flood is borrowed from Genesis and adds nothing to the authority of that book.

It was interesting to look into the opinion of the ancient Persians on this question, before it was modified by Christian and Islamic beliefs. We find their views recorded in their Boundehesh, or Cosmogony, a work which dates from the time of the Sassanids *[205-310 AD]*, but which is clearly an extract or translation of older works. Anquetil du Perron rediscovered this work among the Parsees of India. The total lifetime of the world must be only twelve thousand years: thus it could not yet be very old. The appearance of *Cayoumortz* (the bull-like man, the first human) is preceded by the creation of a great flood.[2]

As to the rest, it would be just as useless to ask from the Parsees a serious history for ancient times as it would from the other oriental people. The Mages have not left any more than the Brahmins or the Chaldaeans. To prove that I would only need as evidence the uncertainties concerning the epoch of Zoroaster. It is even claimed that the little history which they could possess, the part which concerned the Achemenides, the successors to Cyrus up to Alexander, has been expressly altered, in accordance with an official order from a Sassanid ruler.[3]

To recover the authentic dates of the beginning of the empires and the traces of the major disaster, it is thus necessary to go all the way to the great deserts of Tartary. To the east and north lives another race, all of whose institutions and behaviour differ as much from ours as do their form and temperament. They speak in monosyllables; they write in arbitrary hieroglyphics; they have only a political morality without a religion, for the superstitions of Fo have come to them from the Indians. Their yellow skin, their protruding cheeks, their narrow and slanted eyes, and their scanty beards make them so different from us that one is tempted to believe that their ancestors and ours escaped from the great disaster *[the Flood]* in two different areas. But, whatever may be the case, they date their flood in almost the same epoch as we do.

The Chouking is the most ancient of the Chinese books.[4] People affirm that the book was drawn up by Confucius with scraps of earlier works

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[1]See the preface of the brothers Whiston on Moses of Chorene, page 4.

[2]Zendavesta d'Anquetil, Volume II, page 354.

[3]Mazoudi, ap. Sacy, manuscripts of the Bibliothéque du Roi, Volume VIII, page 161.

[4]See the preface of the edition of the Chouking, published by de Guignes.

about two thousand two hundred and fifty-five years ago. Two hundred years later, they say, came the persecution of the literate and the destruction of books in the reign of Emperor Chi-Hoangti, who wished to wipe out traces of the feudal government established under the dynasty previous to his. Forty years later, in the reign of the dynasty which had overthrown the one to which Chi-Hoangti belonged, a part of Chouking was put together from memory by a literate old man, and another part was rediscovered in a tomb. But close to half was lost for ever. Now, this book, the most authentic in China, begins the history of the country with an emperor named *Yao*, whom it represents to us as busy making the waters flow, waters *which, rising right up to the sky, still washed the feet of the highest mountains, covered the lower hills, and made the plains impassable*.[1] This Yao dates, according to some, from four thousand one hundred and sixty-three years ago, according to others, from three thousand nine hundred and forty-three years before the present. The difference of opinions about the time comes to exactly two hundred and eighty-four years.

Some pages further on, we are shown Yu, a minister and engineer, reestablishing channels for the waters, raising dikes, digging canals, and settling the taxes for each province in all of China, that is to say, in an empire of six hundred leagues in every direction. But the impossibility of such operations, after such events, demonstrates clearly that we are dealing here only with a moral and political fiction.[2]

More modern historians have added a sequence of emperors before Yao, but with a host of fantastic circumstances, not daring to assign fixed periods to them, constantly differing among themselves, even on the number and their names and without having the approval of all their fellow countrymen. Fouhi, with his snake's body, bull's head, turtle teeth, and his no less monstrous successors are as absurd as Enceladus and Briareus and are just as likely to have lived.[3]

Is it possible that simple chance produces such a striking result and makes the Assyrian, Indian, and Chinese monarchies originate by tradition almost forty centuries ago? Would the ideas of peoples who have had so little mutual relations, whose language, religion, and laws have nothing in common, agree on this point if they were not based on the truth?

We will not ask about the precise dates of the Americans, who had nothing at all of real writing and whose most ancient traditions went back only a few centuries before the arrival of the Spaniards. However, people still claim to perceive some traces of a flood in their crude hieroglyphics. They

[1]Chouking, French translation, page 9.

[2]It is the Yu-Kong or the first chapter of the second part of the Chouking, pages 43 to 60.

[3][*Translator's note*: Enceladus and Briareus are famous and fantastic Greek monsters].

have their Noah, or their Deucalion, like the Indians, the Babylonians, and the Greeks.[1]

The most degraded of the human races, the Negroes, whose shapes most closely approximate the brute animals and whose intelligence has not grown to the point of arriving at a regular government or the least appearance of coordinated knowledge, has preserved no written records or traditions at all. That race cannot therefore enlighten us about what we are looking for, although all their characteristics show us clearly that they escaped the great catastrophe in a place different from the Caucasian and Altaic races. They had perhaps been separated from them for a long time when this catastrophe happened.

But, it is asserted, if the ancient peoples have left us no history, their long existence as a national entity is no less attested to by the progress which they have made in astronomy, by observations whose date is easy to determine, and even by monuments still standing which themselves carry their dates.

Thus the length of the year which the Egyptians are alleged to have reckoned according to the helical rising of Sirius is found correct for a period between the year 3000 BC and the year 1000 BC, a period in which also fall the traditions of their conquests and of the great prosperity of their empire. This accuracy proves how far they had taken the precision of their observations and makes one realize that they were busy for a long time at such work.

To appreciate this reasoning, we must go into some explanations here. The solstice is the moment of the year when the Nile flooding begins. To this date the Egyptians must have paid the most scrupulous attention. Having at the start made, on the basis of faulty observations, a civil or sacred year of three hundred and sixty-five days exactly, they wished to preserve it for superstitious reasons, even after they had perceived that this year did not agree with the natural or tropic year, and did not bring back the seasons on the same days.[2] However, what was important to them to keep track of

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[1]See the outstanding and magnificent work of von Humboldt on the Mexican monuments.

[2]Geminus, a contemporary of Cicero, explains their motives at length. See the edition which Halma has published in an appendix of Ptolemée, page 43.

[*Translator's Note:* Cuvier's long discussion of Egyptian astronomy perhaps requires some brief background information. The Egyptians had, in effect, four calendars, all in varying degrees inaccurate: the first was the lunar calendar (which Cuvier does not discuss). The second was the *civil* or *sacred year*, which consisted of 365 days, and the inaccuracy in this system (of one quarter of a day too little per year) was made up later by the addition of an extra month in some years. The third year was the *solar year* of 365.25 days, measured by the movement of the sun through the sky to the same point of reference, what is called the *tropic year*. This year was measured by the helical rising of Sirius, a very bright star which, once a year, rises just before the sun. The term helical rising or setting is applied to the rising of a star when it first emerges from the sun's rays and becomes visible just before sunrise, or of its setting when it is last visible just after sunset.

for organizing their agricultural operations was the tropic year. Therefore they had to search in the sky for a visible sign of its return, and they imagined that they would find this sign when the sun came back to the same position, relative to some perceptible star. And so they applied themselves, like almost all people who start such research, to observing the helical rising and setting of the stars. We know that they selected in particular the helical rising of Sirius, first, no doubt because of the beauty of the star and above all because in these ancient times this helical rising of Sirius almost coincided with the solstice and announced the flood, which was for them the most important of phenomenon of this kind. From that fact, it even came about that Sirius, under the name of Sothis, played the largest role in all their mythology and in their religious rites. Assuming therefore that the return of the helical rising of Sirius and the tropic year were the same in length and finally in the belief they had recognized that this length was three hundred and sixty-five and one quarter days, they devised a time period according to which the tropic year and the ancient year, the sacred year of only three hundred and sixty five days, would have come back on the same day, a period which, according to these very inexact records, was necessarily one thousand four hundred and sixty-one sacred years long, or one thousand four hundred and sixty of the improved years, to which they gave the name Sirius.

They took for the point of departure of this period, which they called the Year of Sothis or the Great Year, a civil year, whose first day was or had been also that of a helical rising of Sirius. And we know, by the reliable testimony of Censorinus, that one of these Grand Years came to an end in 138 AD.[1] Consequently, it had started in 1322 BC, and the one which preceded it had started in 2782 BC. In fact, by the calculations of Ideler, it is known that Sirius had a helical rising on 20 July in the Julian year of 139, a day which matched in that year the very first of Thot or the first day of the Egyptian Sacred Year.[2]

But not only is the position of sun, in relationship to the stars of the ecliptic, or the sidereal year *[365.256 days]*, not the same as the tropic year,

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This last method, which Cuvier discusses in detail below, is difficult to apply accurately (for reasons he mentions), and it fails to take into account the phenomenon called the *precession of the equinoxes*, the fact that, in addition to its motion around the sun and around its own axis, the earth's spin has a slow wobble (caused by the gravitational attraction of the other planets), so that any fixed spot like the helical rising of Sirius in effect moves in a complete circle every 26,000 years.

The fourth calendar year, the *Sothic Year* or the *Great Year*, was a very long period between the times when the helical rising of Sirius (which marked the start of the tropic year) and the start of the civil year of 365 days fell on the same day. The time between such a common start for both years, as Cuvier notes, is 1461 sacred years or 1460 tropic years. Further notes occur below.]

[1]All this system was worked out by Censorinus: de Die natali, cap. XVIII and XXI.

[2]Ideler. Recherches historiques sur les observations astronomiques des anciens, translated by Halma, in the appendix to his Canon de Ptolomée, pages 32 ff.

because of the precession of the equinoxes, but the helical year of a star, or the period of its helical rising, above all when it is far from the ecliptic, differs again from the sidereal year, and differs from it variously according to the latitudes of the places where one makes the observations. What is really noteworthy, however, and what Bainbridge[1] and Father Petau[2] have already observed,[3] is that by a remarkable combination of positions, under the latitude of High Egypt, at a particular epoch and during a certain number of centuries, the year of Sirius was really, more or less, three hundred and sixty-five days and a quarter, so that the helical rising of this star returned, in fact, on the same day of the year of the Julian Year, on 20 July, in 1322 BC and in 138 AD.[4]

From this significant coincidence in this far-gone age, Fourier, who has confirmed all these relations with a great deal of work and by numerous calculations, concludes that since the Egyptians understood so perfectly the length of the year of Sirius, they must have determined it on the basis of observations made very precisely over a long time, observations which went back at least to two thousand five hundred years before our era and which could not have been made either much before nor much after this time interval.[5]

Certainly this result would be very striking, if through these observations made directly on Sirius itself they had established the length of the Year of Sirius. But some experimental astronomers affirm that it is impossible that the helical rising of a star could have served as the basis for the exact observations in such a matter, above all in a climate where *the view of the horizon is always so full of vapour that on the good nights one never sees stars of the second and third magnitudes a few degrees above the horizon, and that even the sun, at its rising and setting, is entirely misshapen*.[6] They maintain that if the length of the year was not known in some other manner, they could have been wrong about it by one or two days.[7] They therefore have no doubt that this time of three hundred and sixty-five and a quarter days was the length of the tropic year, poorly reckoned by the

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[1]Bainbridge. Canicul.

[2]Petau. Var. Diss., lib. V, cap. VI, page 108.

[3]See also La Nauze, sur l'année égyptienne, Académie des belles-lettres, Volume XIV, page 346; and the report of Fourier, in the great work on Egypt, Mém., Volume I, page 803.

[4]Petau, *loc.cit.* Ideler states that this concurrence of the helical rising of Sirius also took place in 2782 BC. (Recherches historiques in le Ptolomée of M. Halma, Volume V, page 37). But for the Julian year 1598 AD, which is also the last occurrence of a Great Year, Father Petau and Ideler differ greatly from each other. The latter puts the helical rising of Sirius on 22 July; the former puts it on the 19 or 20 August.

[5]See in the great work on Egypt, Antiquités, Mémoires, Volume I, page 803, the ingenious report of Fourier entitled Recherches sur les sciences et le gouvernement de l'Égypte.

[6]These are the words of the late Nouet, astronomer on the Egyptian expedition. See Volney, Recherches nouvelles sur l'histoire ancienne, Volume III.

[7]Delambre. Abrégé d'Astronomie, page 217; and in his note on the paranatellons, Histoire d l'Astronomie du moyen âge, page lij.

observation of a shadow or by the point where the sun rises each day and identified through ignorance with the helical year of Sirius, so that it would be pure chance which would have set with such precision the length of the latter for the period in question.[1]

Perhaps one will also conclude that people capable of such exact observations, who would have continued them for such a long time, would not have given sufficient importance to Sirius to have dedicated a cult to it. For they would have seen that the relationships between its rising and the tropic year and the flooding of the Nile were only temporary and had taken place only at a fixed latitude. In fact, according to Ideler's calculations, in 2782 BC Sirius was seen in High Egypt on the second day after the solstice; in 1322 BC on the thirteenth day, and in 139 AD on the twenty-sixth day.[2] Today its helical rising occurs more than a month after the solstice. The Egyptians, therefore, would have given priority to finding the period which would restore the coincidence of the beginning of their Sacred Year with that of the true tropic year. And then they would have recognized that their great period must have been one thousand five hundred and eight Sacred Years and not one thousand four hundred and sixty-one.[3] And yet we certainly do not find any trace of this period of one thousand five hundred and eight years in antiquity.

In general, can we defend the idea that, if the Egyptians had had such a long sequence of precise observations, their disciple Eudoxus, who studied thirteen years among them, would have brought to Greece a more perfected astronomy, less crude maps of the sky, and charts more coherent in their various sections?[4]

Why would the Greeks not have known about the precession *[of the equinoxes]* except in the works of Hipparchus, if they had been recorded in the Egyptian registers and manifestly written in the characters on the ceilings of their temples? Finally, how could Ptolemy, who wrote in Egypt, not have deigned to make use of any Egyptian observations?[5]

There is more. Herodotus, who lived so long among the Egyptians, does not make any mention of those six hours which they added to the Sacred Year, nor about that long Sothic period which resulted from it. He firmly states, on the contrary, that the Egyptians make their year three hundred and sixty-five days long and that the seasons return at the same point, so that in his time they did not appear yet to have any doubt about the need

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[1]Delambre. Rapport sur le Mémoire de M. de Paravey sur la sphère, in Volume VIII of the nouvelles Annales des Voyages.

[2]Ideler, *loc. cit.*, page 38.

[3]See Laplace, Système du Monde, Third Edition, page 17; and the Annuaire of 1818.

[4]On the crudity of the determinations in the celestial sphere of Eudoxus, see Delambre, in the first volume of his Histoire de l'Astronomie ancienne, pages 120 ff.

[5]See the preliminary discussion in the Histoire de l'Astronomie du moyen âge, by Delambre, pages viij ff.

for this quarter of a day.[1] Thales, who had visited the Egyptian priests less than a century before Herodotus, also informed his contemporaries only of a year with merely three hundred and sixty-five days.[2] And if one reflects upon the fact that the colonies which left Egypt fourteen or fifteen centuries before Jesus Christ, the Jews and the Athenians, all brought the lunar year with them, one will perhaps conclude that the year of three hundred and sixty-five days did not even exist yet in Egypt in these distant centuries.

I am not overlooking that Macrobius attributes to the Egyptians a solar year of three hundred and sixty-five days and a quarter.[3] But this comparatively recent author came a long time after the establishment of the fixed Alexandrian year and could have confused the time periods. Diodorus [4] and Strabo[5] give such a year only to the Thebans. They do not say that it was a general custom, and they did not come until a long time after Herodotus.

Thus the Sothic year, the Grand Year, must have been a relatively recent invention, since it is the result of a comparison between the civil year and the alleged helical year of Sirius. And that is the reason it is spoken of only in the works of the second and third centuries after Jesus Christ,[6] and that only Syncellus in the ninth century seems to refer to Manetho as mentioning it.

In spite of what people say about it, we get the same notions from the astronomical knowledge of the Chaldeans. That a people who lived in the vast plains, under an always clear sky, had taken to observing the movements of the stars, even from the age when they were still nomadic and when the stars alone could direct them at night, that was natural to assume. But since when were they astronomers, and just how far did they pursue their astronomy? That is the question. One wishes that Callisthenes had sent Aristotle some of their observations, which went back to 2200 BC. But this fact is reported only by Simplicius,[7] in what he says following Porphyry, six hundred years after Aristotle. Aristotle himself said nothing; no real astronomer has said anything about it. Ptolomy reports and uses ten observations of eclipses really made by the Chaldeans. But they go back only to Nabonassar (721 BC). They are crude. The time in them is expressed only in hours and half hours, and the darkness only in

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[1]Euterpe, Chapter IV.

[2]Diog. Laert., lib. I, in Thalet.

[3]Saturnal., lib. I, cap. XV.

[4]Bibl., lib. I, pag. mea 46.

[5]Geogr., page 102.

[6]On the probable newness of this period see the excellent dissertation by Biot, in his Recherches sur plusieurs points de l'astronomie égyptienne, pages 148 ff.

[7]See Delambre, Histoire de l'Astronomie, Volume I, page 212. See also his analysis of Geminus, *ibid.*, page 211. Compare this with Ideler's Mémoires, sur l'Astronomie des Chaldéens, in the fourth volume of Halma's Ptolomée, p. 166.

half or in quarters of a diameter. However, as they had reliable dates, the Chaldeans must have had some knowledge of the true length of the year and some method of measuring time. They appear to have known about the eighteen-year period which brings back lunar eclipses in the same sequence and which the simple inspection of their records could immediately have provided for them. But it is certain that they did not understand either how to account for or how to predict solar eclipses.

Because he did not understand a passage of Josephus, Cassini, and after him Bailly, claimed to find there a lunar-solar time of six hundred years which would have been known from the time of the first patriarchs.[1]

Thus everything leads to the belief that the great reputation of Chaldeans was created for them in recent times by unworthy successors who, under the same name, sold horoscopes and predictions throughout the Roman empire and who, to give themselves more credit, attributed to their uncivilized ancestors the honour of discoveries made by the Greeks.

As to the Indians, everyone knows that Bailly, believing that the epoch which serves as the point of departure for some of their astronomical tables had indeed been observed, wished to derive from that a proof of the great antiquity of the science among these people or at least in the nation which had handed down its knowledge to them. But all this system, dreamed up with such effort, falls apart on its own, now that it has been proven that this epoch was adopted after the event on the basis of erroneous retrospective calculations with a false result.[2]

Bentley recognized that the tables of Tirvalour, on which, above all, Bailly's assertion rested, must have been calculated about 1281 AD (about five hundred and forty years ago), and that the Surya Siddhanta, which the Brahmins regarded as their most ancient scientific treatise in astronomy and which they maintained had been revealed more than twenty million years before, could have been composed only about seven hundred and sixty years ago.[3]

Solstices and equinoxes mentioned in the Puranas and calculated according to the positions which the signs of the Indian zodiac seem to assign to them, such as we believe we understand them, appeared to have an enormous antiquity. A more precise study of these signs or *nacchatrons* has revealed recently to Paravey that this is only a matter of the solstices twelve hundred years before Jesus Christ. This author claims at the same

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[1]See Bailly, Histoire de l'astronomie ancienne; and Delambre, in his work on the same subject, Volume I, page 3.

[2]See Laplace, Exposé du Système du Monde, page 330; and the report by Davis on the astronomical calculations of the Indians, Mém. de Calcutta, Volume II, page 225 in the edition in octavo.

[3]See the reports of Bentley on the antiquity of Surrya Sidhanta, Mém. de Calcutta, Volume VI, page 540; and on the astronomical systems of the Indians, *ibid.*, Volume VIII, page 195 in the octavo edition.

time that the location of these solstices is so crudely fixed that one cannot vouch for their determination within nearly two or three centuries. These are the same as those of Eudoxus and Tcheoukong.[1]

It is well attested that the Indians carried out no observations and that they did not possess any of the necessary instruments for that. It is true that Delambre, along with Bailly and Legentil, acknowledges that they had procedures for making calculations which, without proving how ancient their astronomy was, at least show their originality.[2] However, we cannot make the same conclusion about their celestial sphere. For apart from their twenty-seven *nacchatrons* or lunar houses, which look a great deal like those of the Arabs, they have in the zodiac the same twelve constellations as the Egyptians, Chaldeans, and the Greeks.[3] And if one brings in Wilfort's claims, their constellations outside the zodiac would also be the same as the Greek ones and would carry names which are only slight alterations of them.[4]

Yao is the one to whom people attribute the introduction of astronomy into China. He sent, says the Chouking, astronomers towards the four cardinal points of his empire to examine which stars were predominant in the four seasons, and to regulate what was to be done at each time of year,[5] as if was necessary to spread one's efforts widely for such a task. About two hundred years later, the Chouking speaks of a solar eclipse, but in absurd circumstances, as in all tales of this type. For a general and the entire Chinese army are made to march against two astronomers, on the ground that they have not predicted the event very well.[6] And we know that, more than two thousand years after that, Chinese astronomers had no means of predicting solar eclipses accurately. In 1629 of our era, at the time of their

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[1]Reports still in manuscript form by de Paravey, sur la sphère de la Haute-Asie.

[2]See the profound treatise on the astronomy of the Indians in l'Histoire de l'Astronomie ancienne by Delambre, Volume I, pages 400 to 556.

[3]See the report of Sir William Jones on the antiquity of the Indian zodiac, Mém. de Calcutta, Volume II, page 289 in the octavo edition, and in the French translation, Volume II, page 332.

[4]Here are Wilfort's own words, in his report on the testimony of the ancient Indian books concerning Egypt and the Nile, Mémoires de Calcutta, Volume III, page 433 of the edition in-8°.:

"When I asked my pandit, who is knowledgeable in astronomy, to point out for me in the sky the constellation of Antarmada, he directed me immediately to Andromeda, which I had taken pains not to show him as an asterism known to me. Then he brought me a very rare and most curious book, in Sanskrit, where there was a specific chapter on the Upanashatras or constellations outside the zodiac, with drawings of Capeya, of seated Casyape, holding a lotus flower in her hand, of Antarmada enchained with a fish near her, and of Parasica holding the head of a monster which he had killed, dripping blood and with snakes for hair."

Who would not recognize there Perseus, Cepheus and Cassiopeia? But let us not forget that Wilfort's pandit has become very suspect.

[5]Chouking, pages 6 and 7.

[6]Chouking, pages 66 ff.

dispute with the Jesuits, they did not even understand how to calculate the shadows *[of the eclipse]*.

The true eclipses, reported by Confucius in his chronicle of the empire of Lou, begin only one thousand four hundred years after that, in 776 BC, hardly half a century earlier than the eclipses of the Chaldeans reported by Ptolemy. This only goes to show that nations which escaped the destruction *[of the great flood]* at the same time, when the circumstances were similar, reached in about the same period of time the same degree of civilization. Now, one could believe, given the identity in the names of the Chinese astronomers under different reigns (they all appear, according to Chouking, to have been called *Hi* and *Ho*), that in this distant period their profession in China, as in India, Egypt, and Babylon, was hereditary. The only older Chinese observation which does not contain in itself proof of its own falsity would be that of the shadow *[of the eclipse]* made by Tcheou-Kong around 1100 BC; even so, that is at the very least really crude.[1]

Thus, our readers can judge that the inferences drawn about the lofty perfection of the astronomy of ancient peoples no more conclusively favour the excessive antiquity of these peoples than do the testaments that they gave themselves.

But if this astronomy had been more perfect, what would that prove? Has one calculated the progress which a science ought to have made in the midst of nations who had no other sciences in any sense of the word, among whom the serenity of the sky, the needs of the pastoral or agricultural life, and superstition would make the stars the object of general contemplation, where the academies of the most respected men were charged with maintaining a record of interesting phenomena and passing on the memory of them, where the hereditary basis of the profession saw to it that the children were from the cradle on nourished with the knowledge acquired by their ancestors? Among the numerous individuals for whom astronomy was the only occupation might have arisen one or two geometrical spirits, and everything which these peoples knew could have been discovered in a few centuries.

Let us imagine that, since the time of the Chaledeans, true astronomy has had only two ages, that of the school of Alexandria, which lasted four hundred years, and our own, which has not been around for quite so long. The age of the Arabs added hardly anything to that. The other centuries have been irrelevant to astronomy. The time between Copernicus and the author of *la Méchanique celeste* was less than three hundred years, and

[1]See in the Connaissance des Temps de 1809, page 382, and in the Histoire de l'Astronomie ancienne by Delambre, Volume I, page 391, the extract of a report by P. Gaubil on the observations of the Chinese.

people want the Indians to have required thousands of years to reach their shapeless theories?[1]

THE ASTRONOMICAL MONUMENTS LEFT BY THE ANCIENTS DO NOT BEAR THE EXCESSIVELY DISTANT DATES WHICH PEOPLE BELIEVE THEY HAVE SEEN IN THEM

People have therefore turned to another sort of argument. They have maintained that independently of what these people could have known, they left monuments which carry, in the state of the sky which they depict, a certain date, and a very distant one. The zodiacs sculpted in two temples in Upper Egypt appeared, some years ago, to furnish entirely convincing proofs for this assertion. They present the same figures of the constellations of the zodiac we use today, but arranged in a specific way. People believed they saw in this arrangement a representation of the condition of the sky at the moment when these monuments were designed, and they thought it would be possible to infer from the depicted zodiacs the date of the construction of the structures which contain them.[2]

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[1]The English translator of this discourse refers, on this subject, to the example of the celebrated James Ferguson, who was a shepherd in his childhood and who, while looking after the flock during the night, himself had the idea of making a celestial map, and designed one, better perhaps than any Chaldean astronomer. People say something quite similar about Jamerey Duval.

[*Translator's note*: the author of la Méchanique celeste (Celestial Mechanics) was the famous French mathematician and astronomer Pierre-Simon Laplace, 1749-1827].

[2]Thus at Dendera (the ancient Tentyris), a town below Thebes, in the portico of the large temple whose entrances faces the north (see the great work on Egypt, Antiquities, Vol. IV, Plate. XX), one sees on the ceiling the signs of the zodiac moving in two bands, one of which is along the eastern side and the other along the opposite side. Each band is enclosed by the figure of a woman as long as it is; her feet are toward the entrance, her head and arms towards the back of the portico. Consequently the feet are to the north and the heads to the south.

The Lion *[Leo]* is at the head of the band on the western side; it is facing towards the north or towards the feet of the figure of the woman, and it itself has its feet facing the eastern wall. The Virgin *[Virgo]*, the Balance *[Libra]*, the Scorpion *[Scorpio]*, the Archer *[Sagittarius]*, and the Goat *[Capricorn]* follow the Lion, moving in the same line. The last of these is found towards the back of the portico and near the hands and the head of the large female figure. The signs on the eastern band begin at the end where the other band finishes, and thus face towards the back of the portico or towards the arms of the large figure. They have their feet towards the lateral wall on their side, and their heads in a direction different from those of the band opposite. The Water Carrier *[Aquarius]* goes first, followed by the Fish *[Pisces]*, the Ram *[Aries]*, the Bull *[Taurus]*, and the Twins *[Gemini]*. The last in the series, which is the Crab *[Cancer]* or rather the Beetle, for the Greek crab was replaced in the zodiacs of Egypt with this insect, is placed to the side on the limbs of the large figure. In the place which it should have occupied is a globe placed on the summit of a pyramid made up of little triangles representing types of rays, in front of the base of which is a large female head with two small horns. A second Beetle is placed on the side and across on the first band, in the angle which the feet of the large figure form with its body, in front of the space where Leo goes slightly behind it. At the other end of this same band, Capricorn is very nearly at the back, by the arms of the large figure, and on the band on the left Aquarius is a bit apart from it. However, Capricorn is

not repeated, like Cancer. The division in this zodiac, from the entry, occurs therefore between Leo and Cancer; or if one thinks that the repetition of the Beetle marks a division in the sign, it takes place in Cancer itself. But the division at the back occurs between Capricorn and Aquarius.

In one of the interior rooms of the same temple was a circular planisphere inscribed in a square, the same one which was brought to Paris by Lelorrain and which is seen in the Bibliothéque du Roi. One notes there also the signs of the zodiac among many other figures which appear to represent the constellations (see the great work on Egypt, Antiquitiés, Vol. IV, Plate xxi).

Leo there is aligned with one of the diagonals of the square; Virgo, which follows it, is aligned with a perpendicular line oriented towards the east; the other signs go in their known order up to Cancer, which, instead of completing the chain by coming back to the level of Leo, is placed above it, closer to the centre of the circle, so that the signs are on a slight spiral line.

This Cancer, or rather the Beetle, goes in a direction opposite to the other signs. Gemini is oriented to the north, Sagittarius to the south, and Pisces to the east, but not very precisely. On the eastern side of this planisphere is a large female figure, her head facing towards the south and her feet towards the north, like the woman of the portico.

Thus, one could also raise some doubt about where in this second zodiac the series of signs must have started. According to whether one takes one of the perpendiculars or one of the diagonals or the place where one section of the series passes over the other section, one will judge that it is divided at Leo or rather between Leo and Cancer, or finally perhaps at Gemini.

At Esne (the ancient Latopolis), a town located above Thebes, there are some zodiacs on the ceilings of two different temples. The one in the large temple, whose entrance faces the east, is on two continuous and parallel bands along the south side of the ceiling (see the great work on Egypt, Vol. I, Plate LXXIX).

The female figures which enfold them are not placed lengthwise but sideways, so that one is across near the entrance or the east, her head and her arms towards the north and her feet towards the lateral wall or towards the south, and the other is in the back of the portico across from and facing the first.

The band closest to the axis of the portico or on the north presents first, on the side of the entrance or on the east and towards the head of the female figure Leo placed a little behind and moving towards the back, its feet pointing to the side of the lateral wall; behind Leo, at the start of the band, are two smaller lions, in front of them is the Beetle, and then Gemini going in the same direction; then Taurus and the Ram and Pisces, close together, placed across on the middle of the band; Taurus has its head towards the lateral wall, the Ram towards the axis. Aquarius is further away, and is oriented in the same direction as the first three signs, towards the back.

On the band closest to the side wall and on the north, one sees first, but rather far from the back wall or the west, Capricorn moving in a direction opposite to Aquarius, and oriented towards the east or the entrance of the portico, its feet turned towards the side wall. Very close to it is Sagittarius, which thus matches Pisces and Aries. It also goes towards the entrance, but its feet are turned towards the axis in a direction opposite to Capricorn.

A certain distance in front, very close together, are Scorpio and a woman holding a balance. Finally, a little in front, but still far enough away from the front or eastern end, is Virgo, preceded by a sphinx. Virgo and the woman who holds the balance also have their feet towards the wall, so that Sagittarius is the only one which is placed with its head the wrong way around in relation to the other signs.

To the north of Esne is a small isolated temple, equally aligned towards the east, whose portico again has a zodiac (see the important work on Egypt, Antiquités, Volume I, Plate LXXXVIIl). It is on two bands on the sides and spread apart. The one along the south side

But to arrive that way at the great antiquity which people claimed they deduced from this assumption, it is necessary to suppose, firstly, that the division in the zodiacs had an established relationship with a certain condition of the sky, depending on the precession of equinoxes, which makes the colures move around the zodiac in twenty-six thousand years, that for example, it indicates the position of the point of the solstice, and, secondly, that the condition of the sky depicted was precisely the one which was in place at the time when the monument was built. These two assumptions, it is clear, themselves involve a great many others.

In fact, are the figures in these zodiacs those of the constellations, the real groups of stars which nowadays carry the same names, or simply what astronomers call signs, that is to say, the divisions of the zodiac as it leaves behind one of the colures, whatever place that colure happens to be in?

Is the point where people have divided these zodiacs necessarily the time of the solstice? Is the division on the side of the entrance necessarily that of the summer solstice? Does this division indicate, even generally, a phenomenon which depends upon the precession of the equinoxes?

Could this not refer to some epoch in which the rotation would be less? For example, at the moment of the tropic year when this or that Egyptian sacred year began, which were shorter than the true tropic year by almost six hours and which circled through the zodiac in one thousand five hundred and eight years.

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begins with Leo, who goes towards the back or the west, its feet turned towards the wall or the south. It is preceded by the Beetle, and the beetle by Gemini going in the same direction. Taurus, by contrast, goes to meet them, oriented towards the east; but Aries and Pisces are in the original direction towards the back or facing west.

On the band on the north wall, Aquarius is near the back or the west, moving towards the entrance or the east, his feet turned towards the wall, preceded by Capricorn and Sagittarius, who move in the same direction. The other signs are lost. But it is clear that Virgo must have gone at the front of this band, beside the entrance.

Among the additional figures of this small zodiac, one should notice the two rams with wings placed crosswise, one between Taurus and Gemini, the other between Scorpio and Sagittarius, and each one almost in the middle of the band, the second one, however, slightly closer to the entrance.

It was at first thought that in the grand zodiac of Esne the division of the entry was between Virgo and Leo, and that at the back was between Pisces and Aquarius. But Hamilton, de Jollois, and Villiers believed that they saw in the sphinx which precedes Virgo a repetition of Leo analogous to the repetition of Cancer in the great zodiac of Dendera. Consequently, according to them, the division should take place in Leo. In fact, without this explanation, there would be only five signs on one side and seven on the other.

As to the small zodiac to the north of Esne, we do not know whether some emblem analogous to the sphinx was found there, because this section is destroyed (British Review, February, 1817, p. 136; and the follow up to the Critical Letter on Zodiacomania, p. 330).

[*Translator's Note*: A number of Internet sites offer photographs and drawings of these zodiacs].

Finally whatever sense it might have had, did people want to mark in this way the time when the zodiac was carved or the date when the temple was built? Did people not think of recalling an earlier condition of the sky at some religiously significant time, whether they had observed it or whether they had derived it by some retrospective calculation?

After a single run through of such questions one must sense how complex they are and how any solution one adopted would be controversial and not very capable of serving in itself as a reliable answer to another problem, like that of the antiquity of the Egyptian nation. Moreover, one can state that among those who have tried to derive a date from these facts, there have been as many opinions as authors.

The scholarly astronomer Burkard, after a first glance, reckoned that at Dendera the solstice is in Leo and, as a consequence, two signs less distant than today, and that the temple is at least four thousand years old.[1] At the same time he assigned an age of seven thousand years to the temple at Esne, without anyone knowing very much about how he intended to reconcile these numbers with what is known about the precession of the equinoxes.

The late Lalande, seeing that Cancer was repeated on the two bands, imagined that the solstice was passing in the middle of this constellation. But since this was what happened in Eudoxus's celestial sphere, he concluded that some Greek could have represented this sphere on the ceiling of an Egyptian temple, without knowing that it depicted a condition of the sky which had not existed for a long time.[2] As one sees, this conclusion was quite contrary to Burkard's.

Dupuis was the first who thought it necessary to seek proofs of the idea, somehow accepted on trust, that it was a matter of the solstice. Concerning the large zodiac of Dendera, he saw such proofs in the globe at the summit of the pyramid and in several emblems placed near different signs, which—sometimes according to ancient writers, like Plutarch, Horus Apollo, or Clement of Alexandria, sometimes according to his own conjectures—must have represented phenomena which really would have been those of the seasons affected by each sign.

As for the rest, he maintained that this state of the sky provides the date of the monument and that we have at Dendera the original and not a copy of the sphere of Eudoxus, which led him to the date 1468 BC, in the reign of Sesostris. However, the number of nineteen boats placed under each band gave him the idea that the solstice could have well been in the nineteenth degree of the sign, which added 248 years more.[3]

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[1]Description des pyramides de Gizé, by Grobert, page 117.

[2]Connaissance des temps pour l'an XIV.

[3]Observations sur le zodiaque de Dendera, in the Revue philosophique et littéraire, 1806, deuxième trimestre, pages 257 ff.

When Hamilton[1] noticed that at Dendera the Beetle in the area of the ascending signs is smaller than the one on the other side, an English writer concluded from that fact that the solstice could have been closer to its actual point than the middle of Cancer, something which could take us back to 1000 or 1200 BC.[2]

The late Nouet judged that this globe, these rays and this horned head or head of Isis represented the helical rising of Sirius, maintains that people wanted to mark an epoch of the Sothic period, but that they wished to mark it by the place which the solstice occupied. Now, in the last but one of these periods, the one which took place from 2782 to 1322 BC, the solstice went from thirty degrees forty-eight minutes of the constellation Leo to thirteen degrees thirty-four minutes of Cancer. In the middle of this period it was therefore at twenty-three degrees, thirty-four minutes of Cancer. The helical rising of Sirius took place then some days after the solstice. That is just about what was indicated, according to Nouet, by the repetition of the Beetle and by the image of Sirius in the rays of the sun paced at the start of the band on the right. According to this way of looking at it, he concludes that this temple is from 2052 BC, and the temple of Esne from 4600 BC.[3]

All these calculations, even if we acknowledge that the division marks the solstice, would still be susceptible to many modifications. To begin with, it appears that their authors assumed constellations all of thirty degrees, like the signs, and did not reflect that there was a good deal wrong with this conception that they are all equal to each other, at least as we depict the constellations nowadays and as the Greeks passed them on to us. In reality the solstice, which is today on this side of the first stars of the constellation Gemini, must have left the first stars of the constellation of Cancer only forty-five years after Jesus Christ. It left the constellation Leo only one thousand two hundred and sixty years before the same era. It would be a matter once more of knowing when people stopped putting the constellation which sun entered after the solstice at the head of the descending signs, and if that took place immediately the solstice had moved in a retrograde direction sufficiently to touch the preceding constellation.[4]

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[1] Ægyptiaca, page 212.

[2] See in the British Review of February 1817, pages 136 ff, Article VI on the origin and the antiquity of the zodiac. It is translated following Swartz's Critical Letter on Zodiacomania.

[3] See the report by Nouet in les Recherches nouvelles sur l'Histoire ancienne de Volney, volume III, page 328 to 336.

[4] My well-known scholarly colleague Delambre has been kind enough to give me the following note which illuminates the remarks which follow. See the table below:

THE EXTENT OF THE CONSTELLATIONS IN THE ZODIAC AS WE DEPICT THEM ON OUR GLOBES AND THE TIME WHICH THE COLURES WOULD HAVE NEEDED TO PASS THROUGH THEM

Stars	Longitude in 1800	Year of the Equinox	Year of the Solstice	Stars	Longitude in 1800	Year of the Equinox	Year of the Solstice
ARIES				LIBRA			
γ	1 0 23 40	-389	6869	1 α	7 11 0 44	-14113	-7633
β	1 1 10 40	-441	6921	2 α	7 12 18 0	-14246	-7926
α	1 4 52 0	-710	7190	β	7 16 35 0	-14514	-8034
η	1 5 18 50	-742	7222	γ	7 22 20 34	-14929	-8449
2 0	1 6 14 16	-810	7290	γ Scorp.	7 27 41 0	-15312	-8832
ζ	1 19 8 50	-1739	8219	ξ	7 28 30 15	-15372	-8892
2 τ . tail	1 20 51 0	-1862	8342	ξ	7 28 30 15	-15372	-8892
Duration	20 27 20	1473	1473	Duration	17 29 31	1259	1259
TAURUS				SCORPIO			
ξ	1 19 6 0	-1735	-8215	1 A	7 28 50 6	-15396	-8916
η	1 27 12 0	-2318	-8798	β	8 0 23 48	-15508	-9028
α	2 6 59 40	-3024	-9504	α	8 6 57 38	-15980	-9500
β	2 19 47 0	-3944	-10424	ζ	8 12 35 30	-16387	-9907
ζ	2 22 0 0	-4104	-10584	λ	8 21 47 27	-17049	-105569
a. Coch.	2 24 42 40	-4300	-10780	λ	8 21 47 27	-17049	-105569
Duration	35 36 40	2565	2565	Duration	22 57 21	1653	1653
GEMINI				SAGITTARIUS			
Propus	2 28 9 20	-4547	-11027	γ	8 28 28 20	-17530	-11050
η	3 0 39 0	-4727	-11207	λ	9 3 32 56	-17895	-11415
γ	3 6 18 40	-5134	-11614	ζ	9 10 50 28	-18421	-11941
δ	3 15 44 0	-5813	-12293	ψ	9 14 15 15	-18667	-12187
Castor	3 17 27 30	-5937	-12417	ω	9 23 2 19	-19299	-12819
Pollux	3 20 28 9	-6154	-12634	g	9 25 39 25	-19487	-13007
φ	3 22 27 10	-6926	-12776	g	9 25 39 25	-19487	-13007
Duration	24 17 40	1749	1749	Duration	27 11 50	1957	1957
CANCER				CAPRICORN			
1 ω	3 24 21 55	6475	+45	1st	9 29 39 15	-19775	-13295
ζ	3 28 32 0	6734	-254	2 α	10 1 3 58	-19877	-13397
β	4 1 28 20	6906	-426	β	10 1 15 30	-19891	-13411
γ	4 4 45 0	7182	-702	ι	10 14 53 30	-20872	-14392
1 α	4 10 18 50	7583	-1103	γ	10 18 59 28	-21166	-14586
2 α	4 10 50 36	7621	-1141	μ	10 23 1 12	-21458	-14978
κ	4 13 23 0	7804	-1324	μ	10 23 1 12	-21458	-14978
Duration	1 9 15	1369	1369	Duration	23 21 17	1683	1683
Stars	Longitude in 1800	Year of the Equinox	Year of the Solstice	Stars	Longitude in 1800	Year of the Equinox	Year of the Solstice
LEO				AQUARIUS			
κ	4 12 30 0	-7740	-1260	ε	10 8 56 0	-20444	-13964
α	4 27 3 10	-8788	-1908	β	10 20 36 30	-21285	-14805
δ	5 8 30 0	-9612	-3132	α	11 0 34 0	-22001	-15521
β	5 18 50 55	-10357	-3877	ζ	11 6 7 0	-22400	-15920
β	5 18 50 55	-10357	-3877	2 ψ	11 13 56 12	-22963	-16483
β	5 18 50 55	-10357	-3877	5 A	11 18 3 28	-23260	-16780
Duration	36 20 55	2617	2617	Duration	39 7 28	2816	2816
VIRGO				PISCES			
ω	5 19 2 22	-10371	-3891	β	11 15 49 0	23095	16615
β	5 24 19 0	-10750	-4271	λ	11 23 49 0	23675	17195
η	6 2 2 40	-11307	-4827	δ	12 11 22 0	24939	18459
δ	6 8 41 40	-11786	-5306	σ	12 24 26 0	25879	19399
α	6 21 3 15	-12676	-6196	α	12 26 34 58	26034	19554
λ	7 4 9 50	-13620	-7140	α	12 26 34 58	26034	19554
μ	7 7 17 40	-13845	-7365	α	12 26 34 58	26034	19554
Duration	48 15 18	3474	3474	Duration	40 45 58	2939	2939
Average Duration	30 0 0	2160		Sirius	3 11 20 10	0° -5487	270° -18447

CONSTRUCTION AND USE OF THE TABLE

The longitudes of the stars for 1800 have been taken from the Berlin tables. They are those of Lacaille or Bradley or Flamsteed. The first and last stars of each constellation have been taken and some of the brightest intermediate stars.

The third column indicates the year in which the longitude of the star was 0, that is to say, the year in which the star was located in the spring equinoctial colure.

The last column indicates the year in which the star was in the solsticial colure, whether in the winter or in the summer.

For Aries, Taurus, and Gemini, the winter solstice was chosen, and for the other constellations the summer solstice was chosen, so as not to go too far back and not to come too close to modern times. Moreover, it will be very easy to find the alternate solstice, by adding the half period of twelve thousand nine hundred and sixty years. The same rule will serve to find the time when the star was or will be in the autumn equinox.

The sign - indicates the years before our era; the sign + the year of our era; finally the last line, following each sign under the name *Duration*, gives the extent of the constellation in degrees and the time which the equinox or the solstice uses to pass through the constellation from one side to another.

The precession of fifty seconds per year has been assumed, just as it is presented by the comparison of the catalogue of Hipparchus with modern catalogues. Thus, we have the convenience of round numbers and an accuracy we can rely on**.**

The entire time period is thus twenty-five thousand nine hundred and twenty years; the half period is twelve thousand nine hundred and sixty years; and the quarter period is six thousand four hundred and eighty years. The twelfth part or one sign is two thousand one hundred and sixty years.

It should be noted that the constellations leave empty spaces between them and that sometimes they overlap each other. Thus, between the last star of Scorpio and the first of Sagittarius, there is an interval of six and two-third degrees. By contrast, the last star of Capricorn is more advanced by fourteen degrees longitude than the first star of Aquarius.

Thus, even independently of the irregular movement of the sun, the constellations would provide a very unequal and faulty measurement of the year and its months. The signs of thirty degrees provide a more convenient and less defective means. But the signs of the zodiac are only a geometrical conception. We cannot either distinguish them or observe them. They change their location continually by the retrograde motion of the equinox.

People have been able at all times crudely to determine the equinoxes and the solstices. Over time, people were able to notice that the sight of the night sky was no longer exactly the same as it was in ancient times at the equinoxes and the solstices. But people have never been able to observe precisely the helical rising of a star. They always had to be in error by some days about that. Thus, it was often talked about, without people being able to have a reading on which they could rely. Before Hipparchus, we do not see anything, either in books or in traditions, which we can subject to calculation. And that is what has proliferated the systems so much. People have argued without understanding each other. Those who are not astronomers can carry on the science of the Chaldeans, Egyptians, and so on, and so on, ideas as beautiful as they please; there will result from that no real inconvenience at all. We could lend such people the modern spirit and knowledge, but we cannot borrow anything from them, for they have either had nothing or have left nothing. Astronomers will never derive from the ancients anything of the slightest use. Let us leave to the scholars their vain conjectures and confess our absolute ignorance on matters which are of little use in themselves and for which not a single monument remains.

The limits of the constellations vary following the authors one consults. One sees these limits grow larger or narrower when one goes from Hipparchus to Tycho, from Tycho to Hevelius, from Hevelius to Flamsteed, Lacaille, Bradley or Piazzi.

I have said elsewhere, the constellations are good for nothing, unless it is at the most for recognizing the stars more easily; whereas, the stars by themselves give fixed points to which one can relate movements, whether of the colures or of planets. Astronomy began only at the time when Hipparchus made the first catalogue of stars, measured the revolution of the sun and of the moon and their main irregularities. The rest gives only

Thus Jollois and Devilliers, with the sustained ardour to which we owe the precise knowledge of these famous monuments, always thought that the division towards the entry of the vestibule was the solstice and judged that Virgo must remain the first of the descending constellations as long as the solstice had not gone back at least to the middle of the constellation of Leo. Moreover, they believed, as we have said, that they saw Leo divided in the grand zodiac of Esne. They thus dated this zodiac only at 2610 BC.[1] Hamilton, who first noticed this division in the sign of Leo in the Esne

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shadows, uncertainties, and gross mistakes. Someone who wanted to take up his time disentangling this chaos would be wasting it.

Except for some considerations, I have said, all that I think on this subject. I have not had the presumption to convert anyone, for I really don't care if people adopt my opinions. But if they compare my reasons with the dreams of Newton, Herschel, Bailly, and so many others, it is not impossible that with time they come to lose the taste for these more or less brilliant chimeras *[the signs of the constellations]*.

I have tried to determine the extent of the constellations according to the catasterisms of Eratosthenes, who made mistakes. The matter is really impossible. It would be even worse if one consulted Hygens and especially Firmicus. As to the rest, here is what I have derived from Eratosthenes.

Constellation	Duration (Years)	
Ram	1747	
Bull	1826	
Gemini	1636	
Cancer	1204	
Leo	2617	
Virgo	3307	
Claws	. . . . .	1089 (*)
Scorpio	1823	
Sagittarius	2138	
Capricorn	1416	
Aquarius	1196	
Pisces	2936	

Eratosthenes made only one constellation of Scorpio and the Claws. He indicates the start of the Claws but does not indicate the end; and since he gives eight thousand one hundred and twenty-three years to what is properly called Scorpio, there would remain one thousand and eighty-nine years for the Claws, if we assume that there was no empty space between the two constellations.

As for the Chaldeans, the Egyptians, the Chinese, and the Indians, there is nothing to think about. There is absolutely nothing one can get from them. What I believe about them is in the preliminary discourse of my Histoire de l'Astronomie du moyen âge, pages XXVII and XVIII.

See also the note added to Rapport sur les Mémoires de M. de Paravey, Volume VIII of Nouvelles Annales des Voyages, and reproduced by de Paravey in his summary of his Mémoires sur l'origine de la Sphère, pages 24 and from 31 to 36.

See further the Analyse des travaux mathématiques de l'Académie in 1820, pages 78 and 79. DELAMBRE

[1]See the great work on Egypt, Antiquités, Mémoires, Volume I, page 486.

zodiac, reduces the length of time when the solstice occurred there to 1400 BC.

A large number of other systems concerning the same subject still appear. Rhode, for example, has proposed two of them: the first put the zodiac in the portico of Dendera back to 591 BC; according to his second proposal, he extends the date to 1290 BC.[1] Latreille established the date of this zodiac at 670 BC, the date of the planisphere at 550 BC, the date of the zodiac of the large Esne temple at 2550 BC, the date of the small one at 1760 BC.

But there is an inherent difficulty with all the dates which begin from the two-fold supposition that the division indicates the solstice and that the position of the solstice marks the date of the monument. The inevitable consequence of these assumptions is that the zodiac in Esne must be at least two thousand and perhaps three thousand years older than the one in Dendera.[2] This result clearly destroys the hypothesis. For no one with any education in art history will find it possible to believe that two structures so similar in their architecture were so separated by time.

The sense of this impossibility, united always with the belief that this division of the zodiacs indicates a date, has made people find recourse in another conjecture, that the builders wished to mark the Egyptian sacred year when the monument was erected. Since these years lasted only three hundred and sixty-five days, if the sun at the beginning of one was located in the beginning of a constellation, it would have been almost six hours late returning there at the beginning of the following year, and after one hundred and twenty-one years it would have to have been located only at the beginning of the preceding sign. It seems natural enough that the builders of a temple might have wished to mark approximately in what period of the great year, the Sothic year, the building had been erected, and the indication of the sign by which the sacred year then began would be a good enough way to do that. In this way, one could understand that one hundred and twenty to one hundred and fifty years could have elapsed between the temple at Esne and the one at Dendera.

But, in this way of looking at it, one still has to determine in which of the Great Years the construction of these buildings would have taken place: either the one which finished in 138 AD or the one which finished in 1322 BC, or some other.

The late Visconti, the first author of this hypothesis, selected the Sacred Year whose start corresponded to the sign of Leo, and judged, following

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[1]Rhode, Essai sur l'âge du zodiaque et l'origine des constellations, in German, Breslau, 1809, in-4., p. 78.

[2]According to the tables in the above note *[the long footnote by Delambre on the previous pages]*, the solstice remained three thousand four hundred and seventy-four or at least three thousand three hundred and seven years in the constellation of Virgo, of all of them the one which takes up a larger space in the zodiac, and two thousand six hundred and seventeen years in the sign of Leo.

the appearance of the signs, that they had been drawn in an age when the opinions of the Greeks were not unknown in Egypt. He could select only the end of the last Great Year or the time lapse between the year 12 and the year 138 AD,[1] which seemed to him to agree with the Greek inscription which he did not yet understand well but which he had heard mentioned was a reference to a Caesar.

Testa, seeking the date of the monument with another set of ideas, went so far as to suppose that if Virgo is shown at the head of the zodiac in Esne, then people wished to represent there the era of Actium, as it had had been established for Egypt by a decree of the senate (cited by Dion-Cassius), and which started in the month of September, the day on which Augustus had captured Alexandria.[2]

De Paravey considered these zodiacs from a new perspective, which could take into account at the same time the revolutions of the equinoxes and of the Great Year. Supposing that the circular planisphere in Dendera must have been oriented toward the east and that the north-south axis is the line of the solstices, he saw the summer solstice in the second Gemini and the winter solstice in the backside of Sagittarius. The line of the equinoxes would have passed by Pisces and Virgo. That gave him as a date the first century of our era.

According to this way of looking it, the division of the zodiac in the portico could no longer correspond to the colures, and it was necessary to look elsewhere for the mark of the solstice. De Paravey noticed that there were among all the signs some female figures carrying a star on their heads and going in the same direction, and he observed that the one who comes after Gemini is the only one turned in a direction opposite to the others. He concluded that she indicates the *turning point* of the sun or the tropic and that this zodiac thus corresponds with the planisphere.

By applying the idea of orientation towards the east to the small zodiac of Esne, one would find the solstices there between Gemini and Taurus and between Scorpio and Sagittarius. They would even be marked there by the change in direction of Taurus and by the winged rams placed across from these two places. In the large zodiac of the same town, the marks of the solstices would be a position across from Taurus and the reverse position of Sagittarius. Thus, there would be nothing more between the dates of Esne and Dendera other than one missing portion of the constellation, still quite a long gap for such similar buildings.

A test by the late Delambre on the circular planisphere appeared to confirm these conjectures which support the newness of the structure. For by placing the stars on the projection of Hipparchus, according to this astron-

[1]Translation of Herodotus, by Larcher, Volume II, p. 570.

[2]See the dissertation of the abbot Dominique Testa: Sopra due zodiaci nouvellamente scoperte nell' Egitto. Rome, 1802, page 34.

omer's theory and the position which he gave them in his catalogue, increasing all the longitudes so that the solstice passed by the second of the Gemini, he almost reproduced this planisphere. "This similarity," he says, "would have been even greater if he had adopted the longitudes as they are in the Ptolemy's catalogue for the year 123 of our era. By contrast, in going back by twenty-five or twenty-six centuries, one will change considerably the risings on the right and the declinations, and the projection will take on a totally different shape."[1] "All our calculations," added this important astronomer, "led us to this conclusion, that the sculptures are after the time of Alexander" *[i.e. after 320 BC]*.

In truth, when the circular planisphere was brought to Paris through the care of Saunier and Lelorrain, Biot, in a work based on precise measurements and very astute calculations, established that it represents, according to an exact geometrical projection, the state of the sky as it was in 700 BC.[2] But he was very hesitant to conclude from that that it had been carved at that time.

In fact, all these imaginative and scientific efforts, to the extent that they concern the time of the monuments, have become superfluous, since people, finishing up where one should naturally have started, if prejudice had not blinded the first observers, have taken the trouble to copy and restore the Greek inscriptions carved on these monuments, above all since Champollion has managed to decipher those which are expressed in hieroglyphics.

It is now certain, and the agreement between the Greek and the hieroglyphic inscriptions proves it, it is certain, we say, that the temples in which people carved these zodiacs were constructed under Roman rule. The portico of the Dendera temple, according to the Greek inscription of its frontispiece, is dedicated to the safety of Tiberius.[3] On the planisphere of the same temple, we read the title *Autocrator* in hieroglyphic characters;[4] and this probably refers to Nero. The little temple of Esne, the one whose origin people have dated at the latest between 2700 and 3000 BC, has a sculpted decorated column from the tenth year of Antoninus, from 147 AD, and it is decorated and sculpted in the same style as the zodiac close by.[5]

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[1]Delambre. Note at the conclusion of his report on the Mémoire de M. de Paravey. This report is printed in the Nouvelles Annales des Voyages, Volume VIII.

[2]See the work of Biot, entitled Recherches sur plusieurs points de l'astronomie égyptienne appliquées aux monumens astronomiques trouvés en Égypte. Paris, 1823, in-octavo.

[3]Letronne. Recherches pour servir à l'histoire de l'Égypte pendant la domination des Grecs et des Romains, page 180.

[4]Letronne, Recherches pour servir à l'histoire de l'Égypte pendant la domination des Grecs et des Romains, page xxxviij.

[5]*Idem*, pages 456 and 457.

There is more. It has been proven that the division of the zodiac in this or that sign has no relationship with the precession of the equinoxes or with the displacement of the solstice. A coffin with a mummy, recently brought back from Thebes by Caillaud and containing, according to the very legible Greek inscription, the body of a young man who died in the nineteenth year of Trajan's reign, or 116 AD,[1] shows a zodiac divided at the same point as those of Dendera.[2] And all the appearances are that this division indicates some astrological idea relevant to this individual, a conclusion which should probably also apply to the division of the zodiacs in the temples. It marks either the astrological significance of the moment of their erection or that of the prince to whose safety they were dedicated, or some such other similar moment concerning the position of the sun which it would have seemed important to note.

Thus have vanished for ever the conclusions which people wished to reach from some badly interpreted monuments, arguing against the recent age of continents and nations, and we would have been able to dispense with treating them in such detail if they had not been so recent and had not had such a continuing influence shaping some people's opinions.

THE ZODIAC IS FAR FROM CARRYING IN ITSELF A CERTAIN AND EXCESSIVELY ANCIENT DATE

But there are writers who have maintained that the zodiac carries in itself the date of its invention, on the ground that the names and figures given in its constellations are an indication of the position of the colures when it was invented. This date, according to several people, is so evident and so far back that whether the representations which we possess of this circle are more or less ancient is quite irrelevant.

These writers do not pay attention to the fact that this line of argument is complicated by three equally unsure assumptions: the country in which the zodiac is believed to have been invented, the sense which it is believed was given to the constellations which fill it, and the position the colures had in relation to each constellation when this meaning was assigned to it. One must change the date of the zodiac depending upon the alternative allegories people invent or upon the assumptions that these allegories bear a relationship to the constellation in which the sun was in the first degrees, or to the one in which it stands in the middle, or to the one which it was beginning to enter, that is to say, where it was in the final degrees or, finally, to the opposite constellation where evening arises, or whether one puts the invention of these allegories into another climate. The variations

[1] Letronne. Observations critiques et archéologiques sur l'objet des représentations zodiacles qui nous restent de l'antiquité, à l'occasion d'un zodiaque égyptien peint dans une caisse de momie qui porte une inscription grecque du temps de Trajan. Paris, 1824, in octavo, page 30.

[2] *Idem*, page 48 and 49.

possible in this matter can include up to half the revolution of the fixed stars, that is to say, thirteen thousand years and even more.

Thus Pluche, generalizing from some indications of the ancients, thought that Aries announces the sun beginning its ascent and the spring equinox, that Cancer announces the sun's retrograde at the summer solstice, that Libra, the sign of equality, indicates the autumn equinox,[1] and that Capricorn, a climbing animal, indicates the winter solstice, after which the sun comes back to us. In this way, by putting the inventors of the zodiac in a temperate climate, one would have rain under Aquarius, births of lambs and kids under Gemini, violent heat under Leo, harvests under Virgo, the hunt under Sagittarius, and so on, and the emblems would be quite appropriate. Then, by putting the colures at the start of the constellations or at least the equinox in the first stars of Aries, one would initially arrive only at a date of 389 BC, a time evidently too recent, which necessitated going back again by an entire equinoctial period or twenty-six thousand years. But if it is assumed that the equinox passed through the middle of the constellation, one will derive a date of almost 1000 or 1200 years earlier or at 1600 or 1700 BC. Several celebrated men have truly believed that this period was the age of the invention of the zodiac, and they have given the credit for it to Chiron, for other quite superficial reasons.[2]

But Dupuis, who required for the origin he claimed to attribute to all religions that astronomy—namely, the figures of the zodiac— had in some way preceded all other human institutions, looked for another climate to find other explanations for the symbols and to deduce from that a different date. If Libra is always taken as a sign of the equinox, but assuming this to be the spring equinox, and if one wants the zodiac to have been invented in Egypt, one will find, in fact, more quite plausible explanations for the climate of this country.[3] Capricorn, the animal with the tail of a fish, will indicate the beginning of the elevation of the Nile at the summer solstice; Aquarius and Pisces, the rising and the ebbing of the flood; Taurus, agricultural labour; Virgo, the harvest. And the emblems will mark the times when these things do indeed occur. In this hypothesis, the zodiac will be fifteen thousand years old,[4] if one assumes the sun is in the first degree of each sign, more than sixteen thousand years old if one assumes the sun is in the middle of each sign, and only four thousand years old, if one assumes that the symbol was given as a sign of the place opposite to

[1]Varro, de Ling. Lat., lib. VI, Signa, quod aliquid significent, ut libra æquinoctium; Macrob., Sat., lib. I, cap. XXI, Capricornus ab infernis partibus ad superas solem reducens capræ natural videtur imitari.

[2][*Translator's note*: Chiron was a mythical Greek centaur (half man, half horse) famous for his wisdom.]

[3]See the Mémoire sur l'origine des constellations in l'Origine des Cultes by Dupuis, Volume III, pages 324 ff.

[4]See the Mémoire sur l'origine des constellations in the l'Origine des Cultes by Dupuis, Volume III, page 267.

the sun's position.[1] Dupuis was attracted to the figure of fifteen thousand years, and that is the date on which he based the entire system of his famous work.

However, there is no shortage of people who, while accepting that the zodiac was invented in Egypt, dreamed up allegories applicable to later times. Thus, according to Hamilton, Virgo represented the land of Egypt when it was not yet made fertile by the Nile flooding; Leo represented the season when the land was most open to wild animals, and so on.[2]

This great antiquity of fifteen thousand years would bring with it in addition this absurd consequence: the Egyptians, these people who represented everything with symbols, who must have placed a high premium on the conformity of these symbols with ideas which they had to paint, would have preserved the signs of the zodiac for thousands of years after they no longer corresponded to their original meaning in any way.

The late Remi Raige sought to support Dupuis' view by an entirely new argument.[3] Having noticed that it was possible to find in the Egyptian names of the months (explicating them in oriental languages) a sense more or less analogous to the figures in the signs of the zodiac and finding in Ptolemy that *epifi* (which signifies Capricorn) begins on June 20, and consequently falls immediately after the summer solstice, he concluded that the origin of Capricorn itself was at the summer solstice; thus, he traced the origins of the other signs, as Dupuis had maintained.

But independently of all there is to guess about in these etymologies, Raige did not see that it is by pure chance that five years after the Battle of Actium, in 25 BC, at the establishment of the fixed Alexandrian year, the first day of Thoth corresponded to 29 August (in the Julian calendar), and has corresponded with it since then. It is only at this period that the Egyptian months began on days fixed in the Julian calendar year, but only at Alexandria. Even Ptolemy continued in his Almagest to use the ancient Egyptian year with its vague months.[4]

Why would people in some age or other not have given to the months the names of the signs or to the signs the names of the months just as arbitrarily as the Indians gave to their twenty-seven months twelve names

[1]Dupuis himself suggest this second hypothesis, *ibid.*, page 340.

[2]Ægyptiaca, page 215.

[3]See in the great work on Egypt, Antiquités, Mémoires, Volume I, the Mémoire of Remi Raige sur le zodiaque nominal et primitif des anciens Égyptiens. See also the table of Greek, Roman, and Alexandrian months in the Ptolemée of Halma, Volume III.

[4]See Recherches historiques sur les observations astronomiques des anciens by Ideler, a translation of which Halma has included in the third volume of his Ptolemée; and especially the report by Freret on Lanauze's opinion concerning the establishment of the Alexandrian year in the Mémoires de l'Académie des belles-lettres, Volume XVI, page 308.

chosen from among those of their lunar houses, for reasons which it is impossible to guess nowadays?[1]

The absurdity which there would have been in preserving for fifteen thousand years figures and symbolic names for constellations which no longer bore any relationship at all to their position would have been a lot more obvious if it had included preserving for the months the same names which were constantly on people's lips. The inconvenience of this arrangement would be felt all the time.

Moreover, what would have become of all these systems, if the figures and the names of the constellations in the zodiac had been given to them without any connection with the path of the sun, as their inequality, the extension of several of them outside the zodiac, and their manifest connections with the neighbouring constellations seem to demonstrate?[2]

And again, what would have happened if, as Macrobius explicitly states, each sign must have been a symbol of the sun, considered in one of its effects or its general appearance, without regard to the months through which it was passing, whether in the sign or in its opposite?[3]

Finally, what would be the case if the names had been assigned to the divisions of the space or time in an abstract manner, as astronomers do now to what they call the signs, and had been applied to constellations or groups of stars only at a time picked by chance, so that nothing more can be concluded about their significance?[4]

In all this there is as much as is necessary to upset an imagination well suited to search in astronomy for proofs of the antiquity of peoples. But even if these alleged proofs could be as certain as they are vague and empty of results, what would we be able to conclude from them to refute the huge catastrophe for which there remain for us documents which provide good evidence in other ways? It would be necessary only to admit, with some modern thinkers, that astronomy was among the bodies of knowledge preserved by the men which this catastrophe spared.

EXAGGERATIONS CONCERNING CERTAIN MINE WORKS

People have also greatly exaggerated the antiquity of certain mine works. A very recent author has maintained that the mines on the island of Elba, to

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[1]See the report of Sir William Jones on the antiquity of the Indian zodiac, Mém. de Calcutta, Volume II.

[2]See the Zodiaque expliqué, ou Recherches sur l'origine et la signification des constellations de la sphère grecque, translated from the Swedish by Swartz, Paris, 1809.

[3]Saturnal., lib. I, cap. XXI, sub fin. *Nec solus leo, sed signa quoque universa zodiaci ad naturam solis jure referentur*, and so on. It is only in the explication of Leo and Capricorn that he has recourse to some phenomenon concerning the seasons. Even Cancer is explained from a general point of view and relative to the slant of the sun's path.

[4]See the report of de Guignes concerning the Oriental zodiacs (Académie des belles-lettres, Volume XLVII.)

judge from their tailings, must have been worked for more than forty thousand years. But another author, who also carefully examined these tailings, has reduced this interval to a little more than five thousand years,[1] even assuming that the ancients took out each year only a quarter of what is taken out now. But what reason is there for believing that the Romans, for example, who used up so much iron for their armies, worked these mines so little? Moreover, if these mines had been exploited for four thousand years, why would iron be so little known in high antiquity?

General Conclusion Concerning the Time of the Latest Revolution

Thus, I am of the opinion, with Deluc and Dolomieu, that if there is something confirmed by geology, it is that the surface of our world has been the victim of a great and sudden upheaval, whose date cannot go back much beyond five or six thousand years, that this revolutionary upheaval pushed down the countries where human beings and the species of animals best known to us today previously used to live and made them disappear, that it, by contrast, made dry land of the bottom of the most recent sea and from it created the countries now inhabited, that since this revolution the small number of individuals which it spared have spread out and propagated throughout the territories recently made dry land, and consequently that it is only since this time that our societies have resumed a progressive development, created institutions, erected monuments, collected facts about nature, and put together scientific systems.

But these countries inhabited today, which the last revolutionary upheaval made dry land, had already been inhabited previously, if not by human beings, at least by terrestrial animals. Hence, at least one previous revolution had put them under water. And if one can judge by the different orders of animals whose remains we have found, they had perhaps undergone up to two or three irruptions of the sea.

Ideas About Later Geological Research Projects

These alternating upheavals appear to me now the most important geological problem to resolve or, rather, to define and outline well, since to resolve them entirely we would have to discover the cause of these events, a project with a totally different order of difficulty.

Let me repeat myself. We see with sufficient clarity what happens on the surface of the continents in their present state. We have grasped quite well the uniform movement and the regular sucession of the primitive formations. But the study of the secondary formations has scarcely been outlined. This marvellous series of unknown marine zoophytes and mollusks, followed by equally unknown reptiles and fresh-water fish, replaced in their turn by other zoophytes and mollusks more closely related to present ones; the still unknown terrestrial animals, mollusks, and other fresh-water animals which come later to occupy regions, to be

[1]See de Fortia d'Urban, Histoire de la Chine avant le déluge d'Ogygès, page 33.

hunted from them again, but by mollusks and other animals similar to those in our seas; the connections of these diverse creatures with the plants whose remains accompany theirs; the relationships of these two kingdoms with the mineral strata which contain them, the greater or lesser degree of uniformity of them both in the different basins—now there is a group of phenomena which appears to me to cry out imperiously today for the attention of philosophers.

Given the interest provided by the variety in the products of the partial or universal revolutions of this era and by the abundance of diverse species which alternate in their appearance on the scene, this study has none of the aridity of that of the primordial formations and does not, like the study of the latter, almost necessarily require hypothetical assumptions. The facts are so dense, so curious, and so evident, that they are sufficient, if I may put it this way, for the keenest imagination. And the conclusions which they sometimes bring, whatever reservations the observer makes about them, are not at all vague, nor do they have anything arbitrary about them. Finally, it is in the events closest to us that we can hope to find some traces of events further back in time and of their causes, if, however, it is still permitted, after so many attempts, to flatter oneself with such a hope.

These ideas have pursued me—I would almost say have tormented me—while I conducted my research on the fossil bones, the collection of which I have recently made public, studies which involve only such a small part of these phenomena from the penultimate age of the earth, but which are closely linked in an intimate way with all the others. It was almost impossible that the desire to study the universality of these phenomena would not arise, at least for the limited space around us. My excellent friend, Brongniart, in whom some other studies created the same desire, was kind enough to associate his efforts with mine. Thus, we laid the first foundations of our work on the regions around Paris. But this work, although it still bears my name, has become almost entirely my friend's undertaking, through the infinite trouble he has taken, since the conception of our first plan and since our journeys, with the profound examination of the objects and all the writing. I have placed Brongnairt's work, with his consent, in the second part of my *Researches*, in the part where I deal with the fossil bones of our vicinity. Although apparently relevant to quite a restricted area, it provides numerous results applicable to all geology, and in this respect it can be considered an integral part of the present discourse. At the same time it is certainly one of the finest adornments of my book.[1]

One sees there the history of the most recent changes which have occurred in a particular basin, and it leads us to right to the chalk, the extent of

[1]Some examples from the book have been separately collected under the title Description géologique des environs de Paris, by G. Cuvier and Al. Brongniart. Deuxième édition. Paris, 1822. In quarto.

which throughout the earth is infinitely greater than the extent of the materials in the Paris basin. Chalk, which people think is so modern, is found also much further back, in the centuries of the age before the last. It forms a sort of limit between the most recent formations, those for which we can reserve the name *tertiary*, and the formations which we call *secondary*, which were deposited before the chalk but after the primitive formations and those of the transition zones.

The recent observations of several geologists who have followed up our opinions, such as those of Buckland, Webster, Constant-Prevost, and those of Brongniart himself, have proved that these formations produced after the chalk are found in plenty of basins other than Paris, although with some variations, so that it has been possible to confirm there an orderly succession whose several stages extend to almost all the regions which have been observed.

A Summary of the Observations on the Successive Formations

The strata nearest the surface, these layers of silt and argillaceous sand mixed with rounded pebbles from distant places and full of the bony remains of terrestrial animals, in large part unknown or at least strange, seem especially to have covered all the plains, filled the base of all caves, and blocked all cracks in the rocks within their range. Buckland has described this layer with particular care under the name *diluvium*. It is very different from other equally furnished layers deposited continuously by torrents and rivers, which contain only bones of animals native to the territory. These Buckland designates by the name *alluvium*. Today the strata *[the diluvium]* form, in the eyes of all geologists, the most obvious proof of the immense inundation which was the last of the earth's catastrophes.[1]

Between this diluvium and the chalk are formations alternately full of products of fresh water and of salt water. These mark the irruptions and retreats of the sea, which this part of the earth has undergone since the deposition of the chalk: at first marls and millstone (buhrstone) rocks or cave flint filled with fresh-water shell fish, similar to those of our swamps and ponds; under them marls, sandstones, limestones, in which all the shells are from the sea—oysters, and so on.

At deeper levels are the fresh-water formations of a more ancient period, namely those famous gypsum quarries of the regions of Paris, which have made it so easy to decorate the buildings of this great city and in which we have discovered entire genera of land animals which had not been noticed earlier, not even a single trace.

[1]See the important work by professor Buckland, entitled Reliquiæ diluvianæ. London, 1823, in quarto, pages 185 ff; and the article EAU by Brongniart, in the fourteenth volume of the Dictionnaire des sciences naturelles.

These rest on no less remarkable strata of the limestone rocks from which our capital city is constructed. From the varying amounts of material buried in these rocks, the patience and the wisdom of French scholars and of several keen collectors have already assembled more than eight hundred species of shell fish, all from the sea, but for the most part unknown in today's seas. They contain nothing else, except the bones of fish, cetaceans, and other marine mammals.

Under this marine calcareous rock is, once again, a fresh-water formation, formed of clay, in which are interspersed large beds of lignite or of mineral coal of an origin more recent than pit coal. Among these shells consistently from fresh water, one also sees bones. But remarkably, these are bones of reptiles and not of mammals. Crocodiles and turtles fill the layer, and we do not see here the genera of lost mammals which the gypsum contains. They did not yet exist in the region when these clays and lignites were formed.

This fresh-water landform, the oldest which has been recognized with certainty in our regions, and which is at the base of all the formations which we have just listed, is itself carried on and surrounded on all sides by chalk, an immensely thick and extensive formation, which is found in territories far distant, such as Pomerania and Poland, but which in our regions dominates with a sort of continuity in Berry, Champagne, Picardy, in high Normandy, and in a part of England, and thus forms a large circle or rather a huge basin in which the formations we have just mentioned are contained. But these formations cover the edges of the chalk basin in those places where those edges were less elevated.

In fact, it is not only in our basin that these types of formations were deposited. In other areas where the surface of the chalk made similar cavities for them, even in those where there was no chalk and where the older formations by themselves acted as a support, conditions often led to deposits more or less similar to ours and collected the same bodies of organic creatures. Our formations with two stages of fresh-water shells have been seen in England, Spain, and right up to the edges of Poland. The marine shells deposited among them are found all along the Apennines.

Some of the quadrupeds of our gypsum quarries, our palæotheriums, for example, have also left their bones in the gypsum formations of Velay and in the quarries of rock called molasse in the south of France.

Thus the partial upheavals which occurred in our region between the time of the chalk and the time of the great flood, during which the sea broke over our provinces or retreated from them, took place also in many other regions. For the earth this was a long sequence of various torments, probably quite rapid, since the deposits which they left do not show anywhere much thickness or solidity. The chalk was the product of a more tranquil and less isolated sea. It contains only marine products, among which there are, however, some very remarkable vertebrate animals, but

all from the class of reptiles and fish, large turtles, immense lizards, and other similar creatures.

The formations before the chalk, in the hollows of which chalk itself is deposited, just as the formations of our regions are deposited in hollows of the chalk, form a large part of Germany and England. The efforts which the scholars of these two countries have made recently agree with ours. Inspired by the same facts and combining with them those which the school of Werner had previously discovered, these efforts will soon leave us wanting nothing in order to understand these formations. Von Humboldt and de Bonnard have given the most complete and instructive tables of these facts for Germany and France; Buckland and Conybeare have done the same for England.

Here is what von Humboldt was kind enough to outline as a supplement to my work: not only the secondary formations, but all the sequence of strata, from the most ancient we know about right up to the most modern ones nearest the surface.[1] This is in some way a summary of the efforts of all geologists. See the attached table.

Under the chalk are green sands whose lower strata preserve some remains. Deeper are the ferruginous sands; in many countries these two clump together in layers of sandstones, in which are also seen lignites, amber, and reptile remains.

Below comes the great mass of the layers which make up the chain of the Jura and the mass of those mountains which continue from the Jura in Schwabia and Franconia, the principal ranges of the Apennines and the multitudes of strata in France and England.

These are the calcareous schists rich in fish and crustaceans, immense layers of oolites or of a grainy limestone rock, limestone marls, and gray pyrites characterized by ammonites, by oysters with curved valves, called *gryphae*, and by reptiles, but more and more peculiar in their forms and characteristics.

Large strata of sand and sandstone, often bearing the imprint of vegetative life, support all these layers of the Jura, and themselves rest on a calcareous rock to which, because of the innumerable shells and zoophytes which fill it, Werner gave the far too general name *shell-bearing limestone*. Other layers of sandstone, of the type which is called variegated sandstone, separate these layers of sand and sandstone from a still more ancient limestone which has been called, no less inappropriately, Alpine limestone, because it makes up the High Alps in Tyrol but which, in fact, is seen nowadays in our eastern provinces and in all South Germany.

[1] [*Translator's note*: In Cuvier's text this paragraph appears in a footnote and the accompanying chart (p. 112) on a fold-out page].

TABLE OF THE GEOLOGICAL FORMATIONS IN THE ORDER OF THEIR SUPERPOSITION
by Al. Von Humboldt

ALLUVIAL DEPOSITS			Tertiary Formations
LAKE FORMATIONS WITH MILLSTONE			
SANDSTONE AND FONTAINBLEAU SANDS			
FOSSILIZED GYPSUM		SILICA LIMEST ONE	
ROUGH LIMESTONE (LONDON CLAY)			
TERTIARY STANDSTONE WITH LIGNITES			
(Plastic clay, --Molasse, --Nagelflue)			
CHALK *Ananchites*	white tufaceous chloritic		
Green sand, Weald clay *lignites*) Ferruginous sand	(Secondary Standtone with		Secondary Fomrations
Ammonites with fish and crustaceans crustaceans	Jurassic Limestone *Planulites*	Schist beds	
Quadersandstein, or white sandstone, sometimes above the lias		Coral rag. Dive clay Oolites and Caen limestone Marley or calcareous lias with *Gryphaea arcuata*	
Muschelkalk *Ammonites nodosus*			
Marls with fibrous gypsum Arenacous beds sandstone	Saliferous variegated		
Product. adculeat. (Alpine limestone) Magesian limestone	*Zechstein*		
Quartziferous Porphyry	Coordinate formations of porphyry, red sandstone, and coal		Transition Formations
Transition Formations Schists with Lydian stone, greywacke, diorites, euphotides Limestones with orthoceratis, trilobites, and wuomphalites			
Primitive Formations Clayslates (Thonschiefer) Micaslates Gneiss Granites			Primitive Formation

In the shell-bearing limestone occur the large deposits of gypsum and rich beds of salt, and under these are seen thin layers of the copper schists so rich in fish, among which there are also fresh-water reptiles. The copper schist rests on a red sandstone of the same age as those famous deposits of mineral or pit coal, our modern natural resource, remnant of the first flourishing vegetation which adorned the face of the earth. The trunks of ferns whose imprints they have preserved tell us just how much these ancient forests differed from ours.

One then moves down immediately into the transition formations where the first nature, dead and purely mineral, seems to have disputed still the empire of organizing nature; black limestones, schists which offer only crustaceans and shells of genera now extinct alternate with remains of primitive formations and tell us that we are reaching the most ancient formations which we have been given to know, those old foundations of the present envelope of the earth, to the marbles and primitive schists, gneiss, and finally granites.

Such is the precise order of the successive formations in which nature has wrapped the earth. Geology has derived it by combining the insights of mineralogy with what the sciences of organic structures have provided. This order, so new and so factually interesting, has been acquired for geology only in the time since the subject preferred the solid riches given by observation to fantastic systems and contradictory conjectures about the first origin of worlds and about all these matters, ideas which, bearing no resemblance at all to the phenomena of our present physics, could not find in it, by way of an explanation, either materials or touchstone. Some years ago, most geologists could have been compared to historians interested only in that part of the history of France which had happened among the Gauls before Julius Caesar. But then these historians come to their own assistance by constructing their narratives with the knowledge of later facts. The geologists of whom I am speaking neglected precisely these later facts, which alone could throw some light on the night of earlier times.

To conclude this discourse, I have only to present the results of my own research, or, alternatively put, the summary of my major work. I will list the animals which I have discovered in the inverse order from that which I have just followed in enumerating the land formations. As I went down into the sequence of strata, I went back sequentially in time. I am now going to consider the oldest formations, indicate the animals which they contain, and, moving up from one age to the next, indicate what there is in each one successively, as we approach the present day.

ENUMERATION OF FOSSIL ANIMALS RECOGNIZED BY THE AUTHOR

We have seen that zoophytes, mollusks, and certain crustaceans begin to appear from the time of the transition formations. Perhaps there are even fish bones and skeletons from that time. But it will be a long time yet before we find the remains of animals which live on dry land and breathe normal air *[l'air en nature]*.

The large strata of coal and the trunks of palms and ferns whose imprints they preserve, even if we assume already dry lands and atmospheric vegetation, do not yet show bones of quadrupeds, not even oviparous quadrupeds.

Only a little higher, in the bituminous copper schist, does one see the first trace of quadrupeds, and, what is really remarkable, the first ones are reptiles of the lizard family, very similar to the large monitors which live

today in the torrid zone. Several individuals of this species have been found in the mines in Thuringa,[1] among innumerable fish of a genus now unknown, but which, according to their relationships with today's genera, appear to have lived in fresh water. Everyone knows that monitors are also fresh-water animals.

A little higher comes the Alpine limestone, and on it the shelled limestone rich in Entrochus and Encrinites, which forms the foundation of a large part of Germany and Lorraine. This layer has shown the fossil bones of a very large sea turtle, whose carapace could have been from six to eight feet long, and of another oviparous quadruped of the family of lizards with a large size and a very pointed muzzle.[2]

Moving upward again across sandstones which present only imprints of vegetable life of large reeds, bamboos, palms, and other monocotyledonous plants, we come to different layers of limestone called Jura limestone, because it forms the main stone of this chain. In this formation the class of reptiles undergoes all its development and spreads out into diverse forms and gigantic sizes.

The middle part, composed of oolites and lias or gray limestone with gryphites, contains the remains of two genera—the most extraordinary of all—which united the characteristics of the class of oviparous quadrupeds with organs of movement similar to those of cetaceans.

The *ichtyosaurus*,[3] discovered by Sir Everard Home, has the head of a lizard but prolonged in a tapering muzzle, armed with conical and pointed teeth, enormous eyes in which the sclerotic lining is reinforced with a frame of bony pieces, a spine made up of flat vertebrae like checkers, concave on their two faces, like those of fish, spindly sides, a sternum and shoulder bones like those of lizards and duck-billed platypuses, a small weak pelvis, and four limbs, in which the humerus and the femur bones are short and fat, and the other bones, flat and close to each other, like paving stones, make up, enveloped by the skin, flippers all of a piece, almost without articulation. These are, in short, analogous in use and in structure to those of the cetaceans. These reptiles lived in the sea. On land they could not do anything other than crawl like seals. However they breathed atmospheric air *[l'air élastique]*. Of these the remains of four species have been found:

The most scattered (*I. communis*) has blunt conical teeth; its length sometimes runs to more than twenty feet. The second (*I. platyodon*), at least as big, has tightly packed teeth, carried on round and bulging roots. The third (*I. tenuirostris*) has spindly and pointed teeth and a thin, elongated

[1]See my Recherches sur les ossemens fossiles, Volume V, second part, page 300.

[2]See my Recherches sur les ossemens fossiles, Volume V, second part, pages 355 and 525.

[3]See my Recherches, Volume V, second part, page 447.

muzzle. The teeth of the fourth species (*I. intermedius*), are between those of the preceding species and the first one (*I. communis*). These last two species do not reach half the size of the first two.[1]

The *plesiosaurus*, discovered by Conybeare, must have appeared even more monstrous than the ichtyosaurus. It also had limbs, but already somewhat longer and more flexible. Its shoulder and pelvis were more solid. Moreover, its vertebrae already developed more the forms and the articulations of those in lizards. But what distinguished this animal from all the oviparous and viviparous quadrupeds was a spindly neck as long as its body, composed of thirty or more vertebrae, a higher number than in the neck of all the other animals, rising above the trunk as a snake's body is capable of doing, and ending in a very small head, in which are seen all the essential characteristics of the lizard's head.

If anything could provide justification for the hydras and other monsters whose figures are so often repeated in the monuments of the Middle Ages, it would without question be this plesiosaurus.[2] Already five species of this animal are known, of which the most widespread (*P. dolichoderius*) reaches more than twenty feet in length. A second (*P. recentior*), found in more modern strata, has flatter vertebra. A third (*P. carinatus*) displays a ridge in the lower surface of its vertebrae. Finally, a fourth and a fifth species (*P. pentagonus* and *P. trigonus*) have five and three ridges on the vertebrae.[3] These two genera are spread over all the lias. They have been discovered in England, where this rock is exposed on long cliffs; but they have also been found in France and Germany.

With them lived two species of crocodiles, whose bones are also deposited in the lias, among the ammonites, terebratules, and other shell creatures of this ancient sea. We have their bones in our cliffs at Honfleur, where were found the remains on the basis of which I announced the animal's characteristics.[4]

One of these species, the *long-beaked gavial*, had a longer muzzle and a narrower head than the gavial or long-beaked crocodile of the Ganges. The body of its vertebrae was convex in front, whereas, in our crocodiles today, it is convex in the back. They have been found in the lias of Franconia and of France. A second species, the *short-beaked gavial*, had a muzzle of moderate length, less tapering than the gavial of the Ganges, but more than our crocodiles of Santo Domingo. Its vertebrae were slightly concave on both ends.

But these crocodiles are not the only ones which these strata of secondary limestone collected. The fine oolite quarries in Caen have provided a very

[1] See my Recherches, Volume V, second part, page 456.

[2] See my Recherches sur les ossemens fossiles, Volume V, second part, pages 475 ff.

[3] See my Recherches sur les ossemens fossiles, volume V, second part, pages 485 and 486.

[4] *Ibid.*, page 143.

remarkable specimen of them, whose muzzle, as long as and more pointed than that of the long-nosed gavial, is followed by a more expanded head in the back and a larger temporal fosse. With its stony scales pitted with round dimples, this animal was the most heavily armoured of all the crocodiles.[1] Its teeth on the lower jaw are alternately longer and shorter. There is still another specimen in the oolite in England, but we know of it only by some portions of its skull, which is not sufficient to provide a complete idea of the animal.[2]

Another really remarkable genus of reptiles whose remains, already existing at the time of the lias concretions, are abundant, above all, in the oolite and in the higher sands, is the *megalosaurus*, so aptly named, because it has the form of lizards, particularly the monitors, whose serrated incisor teeth it also has. Its size was so enormous that, if we assume that it had the proportions of the monitors, it must have exceeded seventy feet in length. This was a lizard as large as a whale.[3] Buckland discovered the animal in England, but we have them also in France, and some of its bones were found in Germany, if not of the same species, at least of a species impossible to link to another genus. We owe the first description to Von Soemmerring. He discovered the bones in the higher strata of the oolite, in the limestone schists in Franconia, long famous for the numerous fossils which they provide for the collections of the curious, formations which are going to become a lot more famous through the services which their use in lithography provides to the arts and sciences.

The crocodiles continue to show up in these schists, and they are always crocodiles with the long muzzle. Von Soemmerring has described one (*C. priscus*) in which the entire skeleton of a small individual was preserved almost as it could have been in our display cabinets.[4] It is one of those which looks the most like a present-day gavial of the Ganges. Nevertheless the symphysis *[joined bones]* of the lower jaw is shorter, its lower teeth are alternately and regularly longer or shorter, and it has ten extra vertebrae in the tail.

But these same schists contain much more remarkable animals, the flying lizards, which I have called *pterodactyls*. These are reptiles with a very short tail, a very long neck, an extremely elongated muzzle and armed with sharp teeth, carried on long limbs, whose anterior extremity has an excessively long digit, which evidently bore a membrane suitable for keeping them up in the air, together with four other digits of ordinary dimensions, terminated by hooked claws. One of these strange animals, whose appearance would be terrifying if one saw it nowadays, could have

[1]See my Recherches sur les ossemens fossiles, Volume V, second part, page 127.

[2]We are waiting for a fuller understanding of this from Conybeare's research.

[3]See my Recherches sur les ossemens fossiles, Volume V, second part, page 343.

[4]See my Recherches sur les ossemens fossiles, volume V, second part, page 120.

been the size of a thrush.[1] The other is the size of a common bat.[2] But it appears by some fragments that there existed larger species of this animal.[3]

A little above the limestone schists is the almost homogeneous limestone of the Jura mountain range. It also contains some bones, but always of reptiles: fresh-water crocodiles and tortoises, which it contains in large numbers, especially in regions around Soleur. They have been studied with much care by Hugi. According to the fragments which he has already collected, it is easy to recognize a considerable number of species of *fresh-water tortoise* or *emydes*, which only some final discoveries will be able to characterize precisely, but several of which are already distinctive in their size and shapes among all the known emydes.[4]

Among these innumerable oviparous quadrupeds, of all sizes and shapes, in the midst of these crocodiles, tortoises, flying reptiles, immense megalosauruses, monstrous plesiosauruses, there show up for the first time, according to reports, some small mammals. It is certain that the jaw bones and some other bones discovered in England belong to this class, and especially to the family of didelphides *[genus of marsupials]* or to the insectivores.

One could suspect, however, that the rocks which enclose these have been subject to some local recomposition after the time of the original formation of the strata. Whatever the case, for a long time yet we find that the class of reptiles dominated exclusively.

The ferruginous sands deposited above the chalk in England contain an abundance of crocodiles, tortoises, megalosauruses, and above all a reptile which again presents a very particular characteristic, that of using its teeth like our herbivorous mammals. We owe the discovery of this last animal to Mantell, of Lewes in Sussex, as well as the discovery of other large reptiles in the sands below the chalk.[5] He has named the animal *iquanodon*.

In the chalk itself there are only reptiles. We see there the remains of tortoises and crocodiles. The famous tufa quarries in the mountains of St Pierre, near Maestricht, which belong to the chalk formation, have provided, alongside some very large sea turtles and an extraordinary number of marine shells and zoophytes, a genus of lizards no less gigantic than the megalosaurus, which Camper's research and Faujas's drawings of the bones, in his history of this mountain, have made famous.

It was twenty-five feet long and more; its large jaws were armed with very strong conical teeth, slightly curved and raised on a ridge, and it carried

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[1] See my Recherches sur les ossemens fossiles, Volume V, second part, pages 358 ff.

[2] *Ibid.*, page 376.

[3] See my Recherches sur les ossemens fossiles, Volume V, second part, page 380.

[4] *Ibid.*, page 225.

[5] See in my Recherches sur les ossemens fossiles, Volume V, second part, pages 161, 232 and 350.

some of these teeth also on its palate. More than one hundred and thirty vertebrae have been counted in its spine; these are convex in front and concave in the back. Its tail was high and flat, forming a large vertical structure.[1] Conybeare has proposed recently that this animal be called *mosasaurus*.

The clays and the lignites which lie above the chalk still offered me only crocodiles,[2] and I have every reason to believe that the lignites which in Switzerland have provided bones of the beaver and the mastodon belong to a more recent age. Indeed, it is only in the rough limestone which lies on top of those clays that I started to find mammal bones. They still all belong to marine mammals, to unknown dolphins, manatees, and walruses.

Among the dolphins, there is one whose muzzle, longer than in any known species, has along a good part of the length of the lower jaw a symphysis almost as in a gavial. It was found near Dax by the late president de Borda.[3] Another, from the faluns *[shelly limestone]* in the department of the Orne, also had a long snout, but a slightly different structure.[4]

The entire genus of manatees today inhabits seas in the torrid zone, and the genus of walruses, of which we know only one living species, is confined to the glacial sea. However, we find fossil bones of these two genera together in the strata of rough limestone in the middle of France. And this conjunction of species, the most similar members of which are nowadays in opposite zones, will happen more than once. Our fossil manatees are different from the ones we know, with a longer head differently configured.[5] Their ribs are very recognizable, from the rounded thickness to the density of their tissue, and they are not uncommon in our different provinces. As for the fossil walrus, we have only some small fragments insufficient to characterize its species.[6]

Only in the strata which come after the rough limestone or at most in those which could have been formed at the same time as the limestone, but in lakes of fresh water, does the class of land mammals begin to appear in a certain abundance.

I consider the animals whose remains are buried in the molasse and ancient gravel strata in the south of France, in the mixed gypsum and limestone, such as those in the vicinity of Paris and Aix, and in the freshwater layers of calcareous clay covered over by the marine strata in Alsace,

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[1] See my Recherches sur les ossemens fossiles, Volume V, second part, pages 310 ff.

[2] *Ibid.*, page 163.

[3] See my Recherches sur les ossemens fossiles, Volume V, first part, page 316.

[4] *Ibid.*, page 317.

[5] *Ibid.*, page 266.

[6] See my Recherches sur les ossemens fossiles, Volume V, first part, page 234; and second part, page 521.

Orleans, and Berry—I consider these animals as coming from the same time as the first land mammals and as having lived together with them, but perhaps in different places.

This animal population has a very remarkable character in the frequency and the variety of certain genera of pachyderms, which are entirely lacking among the quadrupeds today and whose characteristics more or less resemble those of tapirs, rhinoceroses, and camels.

These genera, whose discovery is entirely due to me, are as follows: the *palaeotheriums*, the *lophiodons*, the *anoplotheriums*, the *anthracotheriums*, the *cheropotames*, and the *adapis*.

The palaeotheriums looked like tapirs in their overall shape, in the shape of the head, notably the shortness of the bones of the nose, a feature which indicates that they had, like tapirs, a small proboscis, and finally in the six incisor and the two canine teeth on each jaw. But they were like the rhinoceros in their molar teeth, the upper ones of which were square, with projecting crests configured in various ways, and the lower ones in the shape of double crescents, and in their feet, all four divided into three digits. By contrast, in the tapirs those in front have four digits. This genus is one of the most widely distributed and with the most numerous species in the formations of this era.

Our gypsum quarries in the vicinity of Paris are full of them. Bones of seven species are found. The first (*P. magnum*) is as large as a horse. Three others are the size of a pig, but one (*P. medium*) with narrow long feet, one (*P. crassum*) with wider feet, one (*P. latum*) with still broader and much shorter feet; the fifth one (*P. curtum*), the size of a sheep, is very much lower with feet again wider and shorter in proportion to the preceding type; a sixth (*P. minus*) is the size of a small sheep, with spindly feet in which the lateral digits are shorter than the others; finally there is one (*P. minimum*) which is no bigger than a hare; it also has spindly feet.[1]

Palaeotheriums are also found in other regions of France: in Puy in Velay, in the beds of gypsum marl, one species (*P. velaunum*)[2] very similar to *P. medium*, but which differs from it by some details of the lower jaw; in the vicinity of Orleans, in the strata of marl, a species (*P. aurelianense*)[3] which is different from others because its lower molars have the backward slope of their crescents split into a double point and there are some differences in the elevations of the upper molars; near Issel, in a layer of gravel or molasse, along the slopes of the Black Mountain, a species (*P. isselanum*)[4] which has the same characteristics as the specimen from Orleans, whose

[1]See my Recherches sur les ossemens fossiles, in all Volume III, and especially page 250; and Volume V, second part, page 505.

[2]*Ibid.*, Volume V, second part, p. 505.

[3]*Ibid.*, Volume III, page 254, and Volume IV, pages 498 and 499.

[4]*Ibid.*, Volume III, page 258.

size is smaller. But the palaeotherium has been found especially in the molasse in the Department of the Dordogne no less abundantly than in our gypsum quarries in Paris. Duke Decaze discovered bones of three species of palaeotheriums in the quarries of a single park. They appear different from all those of our vicinity. [1]

The *lophiodons* look still a little more like tapirs than the palaeotheriums; their lower jaws have transverse mounds like those in tapirs. They differ from the latter, however, because the front teeth are simpler, the last of all has three mounds, and the upper teeth are rhomboidal and marked with ridges in a manner very similar to the teeth of a rhinoceros.

We do not yet know the shape of their muzzle and the number of their digits. I have discovered up to twelve species of them, all in France, buried in the marl formed in fresh water, and filled with limnes and planorbis, which are shelled animals of ponds and swamps.

The largest is located near Orleans, in the same quarry as the palaeotheriums; it is rather like the rhinoceros. In the same place there is another smaller one of them; a third is located in Montpellier; a fourth near Laon; two near Buschsweiler, in Alsace; five near Argenton, in Berry; and one of three is located near Issel, where there are still two others. There is also a very large one near Gannat. [2]

These species differ among themselves in their size, which in the smallest ones must hardly have been equal to that of a three-month-old lamb; and by features in the shapes of their teeth, which would be too long and detailed to outline here.

The *anoplotheriums* have been found up to the present time only in isolated gypsum quarries in the vicinity of Paris. They have two characteristics which are not observed in any other animal: feet with two digits in which the metacarpals and the metatarsals remain distinct and do not knit together into shin bones like those in ruminants, and teeth in a continuous series with no gaps. Only human beings have teeth so close together without empty spaces between them. The teeth in the anoplotheriums consist of six incisors on each jaw; one canine and seven molars on each side, as many above as below; their canines are short and like the outer incisors. The three first molars are packed tightly together; the four others are, on the upper jaw, square with transverse crests and a small cone between them; on the lower jaw they are in a double crescent, but without a neck at the base. The last one has three crescents. Their heads are an oblong shape and do not indicate that the muzzle ended in a trunk or a snout.

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[1] See my Recherches sur les ossemens fossiles, Volume V, second part, page 505.

[2] See my Recherches sur les ossemens fossiles, Volume II, first part, pages 177 and 218; Volume III, page 394; and Volume IV, page 498.

This extraordinary genus, which cannot be compared to anything in living nature, is subdivided into three sub-genera: those properly called *anoplotheriums*, in which the anterior molars are still quite thick and the lower back molars have crescents with a simple crown; the *xiphodons*, in which the front molars are thin and made for cutting and the lower back molars have across from the concavity in each of their crescents a point which also through use acquires a crescent shape, so that as a result the crescents are double, as in the ruminants; the *dichobunes*, in which the outer crescents are also pointed at the start and which also have on their lower rear molars a paired series of points.

The most common anoplotherium in our gypsum quarries (*An. commune*) is an animal as high as a wild boar but much longer, carrying a very long and very substantial tail, so that in total it has almost the proportions of an otter, but with a greater size. It probably swam well and inhabited lakes, in the depths of which its bones have been encrusted with the gypsum which was deposited there. We have one somewhat smaller specimen, but otherwise quite similar (*An secundarium*).

As yet we know about only one xiphodon, but a very remarkable animal—the one which I call *An gracile*. It is svelte and light, like the most beautiful gazelle.

There is a dichobune almost the size of a hare, which I call *An. leporinum*. Apart from the characteristics of its sub-genre, it differs from the anoplotheriums and the xiphodons by two small spindly digits which it has on each foot beside two large digits. We do not know if these lateral digits are present in the two other dichobunes, which are small, hardly bigger than the Indian pig.[1]

The genus of antracotheriums is almost intermediate between the palaeotheriums, the anoplotheriums, and the pigs. I have named them in this way because two of their species have been found in the lignites of Cadibone, near Savone. The first came close to a rhinoceros in size; the second was much smaller. Specimens have been found also in Alsace and in Velay. Their molars are similar to those of anoplotheriums, but they have protruding canines. [2]

The genus *cheropotame* comes from our gypsum quarries, where it accompanies the palaeotheriums and the anoplotheriums but where it is much rarer. Its back molars are square on the top, rectangular on the bottom, and have four strong conical projections surrounded by smaller projections. The front ones are short cones slightly compressed and with

[1]On the anoplotheriums, see all Volume III of my Recherches, and particularly pages 250 and 396.

[2]See my Recherches sur les ossemens fossiles, Volume III, page 398 and 404; Volume IV, page 501; Volume V, second part, page 506.

two roots. Its canines are small. We do not yet know its incisors or its feet. I have only one species of them, the size of a Siamese pig.[1]

The genus *adapis* similarly has only one species, at most the size of a rabbit; it comes also from our gypsum quarries and must take closely after the anoplotherium.[2]

Thus, there are almost forty species of pachyderms from genera entirely extinct. So far as their sizes and shapes are concerned, the present animal kingdom offers by comparison only two tapirs and a daman *[rock badger]*. This large number of pachyderms is all the more remarkable, in that the ruminants, nowadays so numerous in the deer and gazelle genera, which reach such a great size in the genus of cattle, giraffes, and camels, do not show up in the formations now under discussion.

I have not seen the slightest remains of them in our gypsum quarries, and all that has reached me about them consists of some fragments of a stag the size of a roe deer, but of another species, collected with the palaeotheriums of Orleans and in one or two other small pieces from Switzerland, perhaps of doubtful origin.[3]

But, for all that, our pachyderms were not the only inhabitants of the territories in which they lived. In our gypsum quarries, at least, we find with them carnivores, rodents, several types of birds, crocodiles, and tortoises. And these two last genera accompany the pachyderms also in the molasses and the marls of the middle and south of France.

At the head of the carnivores I place a bat discovered very recently in Montmartre, properly a member of the genus Vespertilions *[insectivorous bats]*.[4] The existence of this genus at such a distant time is all the more surprising, because neither in this formation nor in those which succeeded it, have I seen another trace of the Cheiropteres *[bats]* or the quadrumanes *[animals with an opposable digit on its front and back limbs]*. No bone, no monkey or lemur tooth has ever presented itself to me in my long research.

Montmartre has also provided bones of a fox distinct from ours, which differs equally from the jackals, Arctic foxes, and the different species of foxes which we know in America;[5] the bones of a carnivore connected to coons and coatis *[carnivorous member of raccoon family]*, but bigger than those which are known;[6] bones of a particular species of genet *[civet cat]* [1]

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[1] *Ibid.*, Volume III, page 260.

[2] See my Recherches sur les ossemens fossiles, Volume III, page 265.

[3] See my Recherches sur les ossemens fossiles, Volume IV, page 103.

[4] I owe my knowledge of this to the Comte de Bournon; and as I have not described it in my large work, I am providing a depiction of it in Plate II, figures 1 and 2. [*Translator's note*: see p. 151 below]

[5] See my Recherches sur les ossemens fossiles, Volume III, page 267.

[6] *Ibid.*, page 269.

and of two or three other carnivores which are impossible to figure out because of a lack of sufficiently complete pieces.

Even more noteworthy still, there are skeletons of a small possum, a relative of the marmoset, but different, and consequently an animal whose genus today is confined to the New World.[2] Some skeletons of two small rodents of the dormouse genus,[3] as well as the head of an animal in the squirrel genus,[4] have also been collected there.

Our gypsum quarries are richer in the bones of birds than any of the other strata, earlier or later. Entire skeletons are found there, together with parts of at least ten species of all the orders.[5]

The crocodiles of the time we are speaking of are close to our common crocodiles in the shape of the head; whereas, in the layers of the Jura era we see only species related to the gavial. There was in Argenton a crocodile species remarkable on account of its compact and sharp teeth, serrated on the cutting surface, like those of certain monitors.[6] We also see some remains of them in our gypsum quarries.[7]

The tortoises of this time are all from fresh water. Some belong to the sub-genus of emydes; and there are examples of them larger than all the living ones we know about, whether in Montmartre,[8] or especially in the molasses of Dordogne.[9] The others are trionyx or soft-shelled tortoises.[10] This genus, which can be easily distinguished by the vermiculated surface of the bones of its carapace and which exists today only in the rivers of hot countries, such as the Nile, Ganges, and Orinoco, was very abundant in the territories where the palaeotheriums lived. There is an infinite amount of their debris in Montmartre and in the molasses of Dordogne and other gravel deposits in the south of France .[11]

The fresh-water lakes around which these diverse animals lived and into which their bones were deposited, nourished, other than tortoises and crocodiles, some fish and shell fish. All those which have been collected are as foreign to our climate and also even as unknown in present waters

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[1] *Ibid.*, page 272.

[2] See my Recherches sur les ossemens fossiles, Volume III, page 284.

[3] *Ibid.*, pages 297 and 300.

[4] *Ibid.*, Volume V, second part, page 506.

[5] *Ibid.*, Volume III, pages 304 ff.

[6] See my Recherches sur les ossemens fossiles, Volume V, second part, page 166.

[7] *Ibid.*, Volume III, page 335; Volume V, second part, page 166.

[8] *Ibid.*, Volume III, page 333.

[9] *Ibid.*, Volume V, second part, page 232.

[10] *Ibid.*, Volume III, page 329; Volume V, second part, page 222.

[11] See my Recherches sur les ossemens fossiles, Volume V, second part, pages 223 and 227.

as the palaeotheriums and the other quadrupeds which were their contemporaries.[1] Even the fish belong in part to unknown genera.

Thus, it cannot be doubted that this population, which we could call from the middle age, this first large production of mammals, has been entirely destroyed. In fact, wherever we discover the remains of them there are large deposits of marine formations above them, so that the sea has overwhelmed the countries where these races lived and remained on top of them for quite a long time.

Were the lands inundated by the sea at this time considerable in size? The study of these ancient layers formed in lakes does not yet allow us to determine that point.

I include with them our gypsum quarries and those in Aix, several pits of marls and molasse, at least those of the south of France. I think I can also include portions of the molasse in Switzerland and of lignites of Liguria and Alsace, where we find quadrupeds of the families which I have just made known. But I do not see that any of these animals has yet been found in other countries. The fossil bones in Germany, England, and Italy are all either older or more recent than those which we have just been talking about, and belong either to the ancient races of reptiles from the Jurassic formations and copper schists or to the deposits of the last universal inundation, to diluvian formations.

One is therefore justified in believing, until we have proof to the contrary, that in the time when these numerous pachyderms lived the earth offered them only a small number of plains sufficiently fertile for them to be able to multiply there, and perhaps these plains were insulated regions, separated by large enough areas of higher mountain ranges, where we do not see that our animals have left traces.

Thanks to the research work of Adolphe Brongniart, we know also the nature of the plant life which covered these relatively few lands. In the same strata as our palaeotheriums, trunks of palm trees and many other of these fine plants whose genera do not flourish except in hot countries are being collected. Palms, crocodiles, trionyx are always found in greater or lesser numbers in the very place where the ancient pachyderms are located.[2]

But the sea which covered these areas and destroyed their animals, left large deposits which form still today, at a shallow depth, the base of our large plains. Then the sea retreated again and opened up an immense surface area for a new population, the one whose remains fill the sandy and alluvial silt strata of all the known countries.

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[1] *Ibid.*, Volume III, page 338.

[2] See my Recherches sur les ossemens fossiles, Volume III, pages 351 ff.

To this peaceful marine deposit, in my view, must belong some cetaceans very similar to those of our day: a dolphin related to our killer whale,[1] as well as a whale very like our fin back,[2] both unearthed in Lombardy by Cortesi; a large whale head found inside the precincts of Paris itself,[3] and described by Lamanon and Daubenton; and an entirely new genus, which I discovered and named *ziphius*, and which already consists of three species. It is similar to the sperm whale and bottle-nosed whale.[4]

In the population which fills our shallow and loose strata and which lived on the deposits we have just been discussing, there are no more palaeotheriums, anoplotheriums, nor any of these remarkable genera. The pachyderms, however, are still dominant there, but gigantic pachyderms, elephants, rhinoceroses, hippopotamuses, accompanied by innumerable horses and several large ruminants. Carnivores the size of a lion, tiger, and hyena desolated this new animal kingdom. In general, its character, even in the extreme north and on the shores of today's glacial sea, resembled that which only the very hot areas present to us today, and yet no species there was absolutely the same.

Among these animals is found above all the elephant called the *mammoth* by the Russians (*Elephas Primigenius*. Blumenb.), fifteen and eighteen feet high, covered by a coarse red wool coat with long, stiff, black fur which formed a mane along the back; its enormous tusks were implanted in sockets longer than those in our modern elephants. But for the rest it looked quite like an Indian elephant.[5] It left thousands of corpses, from Spain right up to the shores of Siberia, and it is found all over North America, so that it was scattered on both sides of the ocean, if, at any rate, the ocean existed then where it is today. Everybody knows that its tusks are still so well preserved in cold countries that they can be put to the same uses as fresh ivory. And, as we have remarked earlier, individual specimens have been found with their flesh, skin, and fur, which have remained frozen since the last catastrophe on earth. The Tartars and the Chinese imagined that this animal lives under the earth and dies as soon as it sees daylight.

After this animal and almost its equal, came also in the countries which form the two present continents, the *mastodon with narrow teeth*, which was like an elephant, armed, like it, with enormous tusks, but tusks covered with enamel, lower on its limbs, and in which the molar teeth covered with round bumps and a thick shining enamel for a long time gave

[1] See my Recherches sur les ossemens fossiles, Volume V, first part, page 309.

[2] *Ibid.*, page 390.

[3] *Ibid.*, page 393.

[4] See my Recherches sur les ossemens fossiles, Volume V, first part, pages 352 and 357.

[5] See my Recherches sur les ossemens fossiles, Volume I, pages 75 to 195 and 335; Volume III, pages 371 and 405; Volume IV, page 491.

rise to what people called western turquoise.[1] Its remains, common enough in temperate Europe, are not as frequent in the north; but they are found in the mountains of South America along with two related species.

North America possesses an immense number of the remains of the *large mastodon*, a type larger than the preceding one, proportionately as high as an elephant, with tusks no less enormous; its molar teeth, bristling with points, made people for a long time take it for a carnivore.[2] Its bones were very thick and solid. People claim to have found everything up to its hoofs and its stomach, still preserved and recognizable, and it has been stated that the stomach was full of crushed tree branches. The savages believe that this race was destroyed by the gods, out of fear that it would wipe out the human race.

With these enormous pachyderms lived two genera of slightly smaller rhinoceroses and hippopotamuses. The hippopotamus of this era was especially common in the countries which today make up France, Germany, and England. It was particularly common in Italy. Its resemblance to the present African species was such that it is necessary to make a detailed comparison to grasp the distinctions.[3] At that time there was also a species of small hippopotamus the size of a wild boar, to which one cannot compare anything nowadays.

There were at least three large rhinoceroses, all with two horns. The species most widely distributed in Germany and England (my *Rh. tichorhinus*), which, like the elephant, is found right up to the vicinity of the borders of the glacial sea, where it also has left entire individual specimens, had an elongated head, very strong nasal bones, supported by a partition of nostrils made of bone and not simply cartilage, and finally it lacked incisor teeth.[4]

Another rarer species from more temperate areas (*Rh. incisivus*)[5] had incisor teeth, as do our present East Indian rhinoceroses, and resembled, above all, the Sumatra rhinoceros.[6] Its distinctive characteristics stemmed from some slightly different features of the head.

The third (*Rh. leptorhinus*) lacked incisors, like the first species and like the Cape rhinoceros today, but it was distinguished by a more pointed

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[1]See my Recherches sur les ossemens fossiles, Volume I, pages 250 to 265 and 335; Volume IV, page 493.

[2]See my Recherches sur les ossemens fossiles, Volume I, pages 206 to 249; Volume III, page 376.

[3]See my Recherches sur les ossemens fossiles, Volume I, page 304 to 322; Volume III, page 380; Volume IV, page 493.

[4]*Ibid.*, Volume II, first part, page 64; and Volume IV, page 496.

[5]See my Recherches sur les ossemens fossiles, Volume II, first part, page 89; Volume III, page 390; and Volume V, second part, page 501.

[6]*Ibid.*, Volume III, page 385.

muzzle and more spindly limbs.[1] Its bones are buried especially in Italy, in the same layers as those of the elephants, mastodons, and hippopotamuses.

Next there is a fourth species (*Rh. minutus*) equipped, like the second species, with incisor teeth, but much smaller in size, hardly larger than a pig.[2] This species is undoubtedly rare, for remains have so far been collected only in some places in France.

To these four genera of the large pachyderms was added a tapir equal to them in size, which was consequently more than double, perhaps triple, the linear dimensions of the American tapir.[3] This animal's teeth are found in several places in France and Germany and almost always accompany those of the rhinoceros, mastodons, or elephants.

These are again joined, but in what seems to be a very small number of places, by a large pachyderm; all we know about it is the lower jaw. Its teeth were in double crescents and wavy. Fisher, who discovered it among the bones in Siberia, has named it *Elasmotherium*.[4]

The horse genus also existed from that period on.[5] Its teeth are found by the thousands among those species which we have just named in almost all the strata which contain them. But it is not possible to say whether or not this was one of the species alive nowadays, because the skeletons of these species bear such a resemblance, that one cannot distinguish them on the basis of isolated fragments.

The ruminants were infinitely more numerous than at the age of the palaeotheriums. Indeed, their numerical proportion must have differed relatively little from what it is today. But we have learned that several species were different.

We can speak with much confidence above all about a stag of superior size, even bigger than the elk, which is common in the marl quarries and the peat bogs of Ireland and England, and whose remains have also been unearthed in France, Germany, and Italy in the same strata which contain elephant bones. Its antlers, large and branched, are up to twelve and fourteen feet from one tip to the other, if one follows the curves.[6]

The distinction is not so clear for the bones of deer and cattle which have been collected in certain caves and in the cracks of some rocks. At times, especially in the caves in England, they are accompanied by elephant, rhinoceros, and hippopotamus bones, together with those of a hyena,

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[1] *Ibid.*, Volume II, first part, page 71.

[2] See my Recherches sur les ossemens fossiles, Volume II, first part, page 89.

[3] *Ibid.*, second part, page 165.

[4] See my Recherches sur les ossemens fossiles, Volume II, second part, page 95.

[5] *Ibid.*, page 109.

[6] See my Recherches sur les ossemens fossiles, Volume IV, page 70.

which is found also in several layers furnished with the same pachyderms. Consequently, they are of the same age. But it is still no less difficult to say in what respect they differ from cattle and deer today.

The cracks in the rocks of Gibraltar, Cette, Nice, Uliveto near Pisa, and in other places on the edges of the Mediterranean are full of a hard red cement which surrounds fragments of the rock and of fresh-water shells, along with many bones of quadrupeds, most broken. This formation has been called fossil breccias. The bones which fill these breccias sometimes provide enough characteristics to establish that they come from unknown animals, at least in Europe. Four species of deer are found there, for example; three of them have teeth with characteristics seen only in the deer of the Indian archipelago. Near Verona, there is a fifth species, whose antlers surpass in volume those of the stags in Canada.[1]

In certain places, together with the bones of the rhinoceros and of other quadrupeds of this time, one finds also those of a deer so similar to a reindeer, that it would be very difficult to assign it distinctive characteristics. And what is even more extraordinary, the reindeer are today confined to the most frozen climates of the north, while all the genera of rhinoceros belong to the hot zone.[2]

In the strata under discussion exist the remains of a species very like a fallow deer, but about one third taller,[3] and innumerable quantities of antlers very similar to those of deer today,[4] as well as bones very similar to those of the aurochs[5] and to those of domestic cattle,[6] two very distinct species, which naturalists who have preceded us confused very inappropriately. However, the entire heads, similar to those of these two animals, as well as to that of the musk ox in Canada,[7] which have often been unearthed, do not come from locations suitably confirmed for us to be able to ensure that these species were contemporaries of the large pachyderms which we have just mentioned.

The fossil breccias on the edges of the Mediterranean have also provided two species of lagomys *[tailless hare]*,[8] an animal whose genus does not exist today except in Siberia, two species of rabbits,[9] campagnols *[field mice]*, rats the size of a water rat and of a mouse.[10] The caves in England

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[1] See my Recherches sur les ossemens fossiles, Volume IV, pages 168 to 225.

[2] See my Recherches sur les ossemens fossiles, Volume IV, page 89.

[3] *Ibid.*, page 94.

[4] *Ibid.*, page 98.

[5] *Ibid.*, page 148; and Volume V, second part, page 509.

[6] *Ibid.*, page 150; Volume V, second part, page 510.

[7] See my Recherches sur les ossemens fossiles, Volume IV, page 155.

[8] *Ibid.*, pages 199 to 204.

[9] *Ibid.*, pages 174, 177 and 196; Volume V, first part, page 55.

[10] *Ibid.*, pages 178, 202 and 206; Volume V, first part, page 54.

show them as well.[1] The fossil breccias even contain bones of shrews and lizards.[2]

There are in certain sandy strata of Tuscany teeth of a porcupine,[3] and in sandy strata in Russia heads of a species of beaver larger than ours, which Fischer has called *trogontherium*.[4]

But it is especially in the class of vertebrates without teeth *[Edentata]*, that the animal races of the age before the last become much larger than their descendants today and even grow quite enormous.

The *megatherium* combines some of the generic characteristics of the armadillo with some of those of the sloth. In size it equals the largest rhinoceroses. Its nails must have been of a monstrous size and strength; its entire frame has an excessive solidity. So far they have been unearthed only in the sandy strata of North America.[5]

The characteristics of the *megalonyx* resembled the megatherium a great deal, but it was a little smaller. It nails were longer and sharper. Some bones and complete digits of this animal have been found in certain caves of Virginia and on an island off the coast of Georgia.[6]

The remains of these two enormous animals without teeth have so far shown up only in America. But Europe possesses one which yields nothing to them in power. We know about it only from one sole distal phalynx *[bone at the end of the toe]*. But this phalynx is sufficient to convince us that it was very similar to a pangolin *[scaly ant eater]*, but to one nearly twenty-four feet long. It lived in the same areas as the elephants, rhinoceroses, and huge tapirs. For its bones have been found with theirs in a sand quarry in the state of Darmstadt, not far from the Rhine.[7]

The fossil breccias also contain, but very rarely, bones of carnivores,[8] which are much more numerous in the caves, that is to say, in the larger and more complex cavities than in the cracks or seams in the breccia. The Jura Mountains in particular have some well-known examples of them in the section which extends into Germany, where for centuries people have taken them away and destroyed innumerable quantities, because they attributed to these bones special medicinal virtues. Nevertheless, there still remain enough of them to astonish the imagination. These are mainly the bones of a species of very large bear (*Ursus spelaeus*), characterized by a

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[1] *Ibid.*, Volume V, first part, page 55.

[2] *Ibid.*, Volume IV, page 206.

[3] See my Recherches sur les ossemens fossiles, Volume V, second part, page 517.

[4] *Ibid.*, first part, page 59.

[5] *Ibid.*, page 174; et second part, page 519.

[6] See my Recherches sur les ossemens fossiles, Volume V, first part, page 160.

[7] *Ibid.*, page 193.

[8] See my Recherches sur les ossemens fossiles, Volume IV, page 193.

more rounded forehead that any of our living bears.[1] With these bones are mixed those of two other species of bear (*U. arctoideus* and *U. priscus*);[2] those of a hyena (*H. fossilis*), related to the spotted hyena of the Cape, but different in some details of the teeth and structures of the head;[3] those of two tigers or panthers,[4] of a wolf,[5] fox,[6] wolverine,[7] weasels, genets *[species of civet cat]* and other small carnivores.[8]

One can again here call attention to this remarkable mixture of animals, versions similar to which live today in climates as far separated as the Cape, country of the spotted hyenas, and Lapland, country of present-day wolverines. Thus we have seen in a cave in France a rhinoceros and a reindeer beside each other.

Bears are rare in the loose strata. It is said, however, that some of the large cave-dwelling type have been found in Austria and in Hainaut. And there is in Tuscany an unusual species of it, noteworthy for its compact canines (*Urs. cultridens*).[9] The hyenas are seen more frequently. We have found them in France, alongside elephant and rhinoceros bones. A short time ago in England a cave was discovered which contained huge quantities of them, where they were of all ages. The soil there even gave clear evidence of their excrement. It appeared that they had lived there a long time and dragged in bones of elephants, of rhinoceroses, of hippopotamuses, of horses, of cattle, of deer, and of various rodents which are there with them and carry the perceptible marks of the hyenas' teeth. But what must the soil of England have been when these enormous animals were used there as prey for ferocious beasts? These caves contain also bones of tigers, wolves, and foxes. But the bones of bears are excessively rare there.[10]

Whatever the case, we see that in that era whose animal population we have just reviewed, the class of carnivores was numerous and powerful. It included three bears with round canines, one bear with compact canines, a large tiger or lion, another cat the size of a panther, a hyena, a wolf, a fox, a wolverine, a marten or skunk, and a weasel.

The class of rodents, composed in general of weak and small species, has been little noted by the collectors of fossils; however, its remains, in the strata and deposits which we have been talking about, also have provided

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[1] *Ibid.*, page 351.

[2] *Ibid.*, pages 356 et 357.

[3] See my Recherches sur les ossemens fossiles, Volume IV, pages 392 and 507.

[4] *Ibid.*, page 452.

[5] *Ibid.*, page 458.

[6] *Ibid.*, page 461.

[7] *Ibid.*, page 475.

[8] *Ibid.*, page 467.

[9] See my Recherches sur les ossemens fossiles, Volume IV, pages 378 and 507; and Volume V, second part, page 516.

[10] See the excellent work of Buckland, entitled Reliquiae diluvianae.

unknown species. Especially remarkable is a species of lagomys *[tailless hare]* of the fossil breccias of Corsica and Sardinia, a little like the Alpine lagomys of the high mountains of Siberia. This just goes to show that it is certainly not always necessary to look in the hot regions for animals like those of the era before the last one.

These above animals are the main ones whose remains have been collected in this deposit of earth, of sands, and of silt, in this *diluvium* which covers our large plains everywhere, which fills our caves, and which blocks up the fissures of most of our rocks. Without doubt they constituted the population of the continents at the time of the great catastrophe which destroyed their races and which prepared the soil on which the animals today subsist.

Whatever similarities certain of these species present to those of our time, one cannot deny that the totality of this population had a very different character and that most of the races which made it up were destroyed.

What is astonishing is that among all these mammals, most of which have their cognates in the hot countries, there is not a single quadrumane, that no bone, nor a single tooth has been collected from a monkey, not even bones or teeth of monkeys from lost species.

And there are no human beings. All the bones of our species which we have collected with those which we have just been discussing got there accidentally;[1] and their number is infinitely small. That would surely not be the case if human beings had created settlements then in the countries which these animals inhabited.

Where was the human species at that time? Did this last and most perfect work of the Creator exist somewhere or other? Did those animals which now coexist with human beings on the earth and of which there is no trace at all among the fossils, were they all around them? Were the countries where humans lived with them overwhelmed when those places which they now inhabit, where a huge inundation could have destroyed the previous population, were restored to dry land? This is what the study of the fossils does not tell us, and in this discourse we must not turn to other sources.

What is certain is that we are now at least in the middle of the fourth succession of terrestrial animals, that after the age of reptiles, after that of the palaeotheriums, after that of the mammoths, the mastodons, and the megatheriums, came the age when the human species, aided by some

[1]See in Reliquiæ diluvianæ of Buckland the part which deals with the skeleton of a woman found with needles of bone in the Pavyland cavern and in my Recherches, Volume IV, page 193, the part which discusses a fragment of jaw bone found with the fossil breccias in Nice.

Von Scholtheim has collected some human bones in the rock fissures of Koestritz, where there are also some rhinoceros bones; but he himself indicates his doubts about the time when they were deposited.

domestic animals, peacefully dominates and makes the earth fertile, that it is only in the environments formed since this last age, in the alluvial deposits, in the peat bogs, in the recent concretions, that we find fossil forms of bones which belong entirely to animals known to be living today.

Such are the human skeletons of Guadeloupe, encrusted in travertine with land shells of schist and fragments of seashells and coral from the surrounding sea, the bones of cattle, of deer, of roe, of beaver, common in the peat bogs, and all the bones of human beings and domestic animals buried in the river deposits, cemeteries, and ancient battle fields.

None of these remains belongs either to the great deposition of the last catastrophe or to those of preceding ages.

APPENDIX
TO
DISCOURSE ON THE REVOLUTIONS
ON THE SUFACE OF THE EARTH

DETERMINATION OF THE BIRDS CALLED IBIS BY THE ANCIENT EGYPTIANS

Everyone has heard about the ibis, this bird to which the ancient Egyptian dedicated a religious cult, which they raised in the interior of their temples, which they allowed to wander freely in their towns, whose murder, even if involuntary, was punished with death,[1] which they embalmed with as much care as they did their own parents; about this bird to which they attributed a virginal purity, an inviolable attachment to their country, of which it was the emblem, an attachment so strong that it let itself perish from hunger when people wanted to take it somewhere else; about this bird which had sufficient instinct to know about the waxing and waning of the moon and, as a result, to regulate the amount of its daily nourishment and the development of its chicks; the bird which at the frontiers of Egypt stopped the snakes which would have brought destruction into this sacred land[2]—it filled the snakes with such fear that they were afraid even of its feathers[3]—this bird finally whose form the gods would have taken on if they had been forced to adopt a mortal shape, the form into which Mercury really was transformed when he wanted to travel all over the earth and teach men the arts and sciences.

No other animal ought to have been as easy to recognize as the ibis, for there is no other one like the ibis for whom the ancients have left us both excellent descriptions and accurate, even coloured, figures, as well as the body itself, painstakingly preserved with its feathers, under the triple envelope of a bitumen preservative, thick and tightly wound linen, and solid, well-plugged jars.

Nonetheless, of all the modern authors who have spoken about the ibis, Bruce, that traveller more famous for his courage than for the accuracy of his views in natural history, is the only one who has not been mistaken about the true species of this bird, and his ideas in this matter, no matter how precise they might have been, have not been adopted even by naturalists.[4]

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[1] Herod., 1.2

[2] Ælian., lib. II, cap. XXXV and XXXVIII.

[3] *Ibid.*, lib. I, cap. XXXVIII.

[4] Bruce, French translation, in-8°., Volume XIII, page 264, and atlas, Plate XXXV, under the name of *Abouhannès* [*Translator's Note*: James Bruce (1730-1794), was a Scottish traveller in North Africa and Ethiopia, who explored the sources of the Nile and reached the source of the Blue Nile in 1770. *His Travels to Discover the Source of the Nile* was published in 1790].

After several changes of opinion concerning the ibis, people appeared to have reached agreement at the time when I published the first edition of this work about giving the name ibis to a bird native to Africa, almost the size of a stork, with white plumage, black wing feathers, perched on long red legs, armed with a long, arched, pale-yellow beak, sharp on its edges, rounded at its base, and notched at its tip, and with a face covered by a red skin without feathers, which does not extend past the eyes.

Such is the ibis of Perrault,[1] the white ibis of Brisson,[2] the white Egyptian ibis of Buffon,[3] and the *Tantalus ibis* of Linneaus, in his twelfth edition.[4]

Blumenbach, while admitting that it is nowadays very rare, at least in Lower Egypt, maintained that the Egyptians had given divine honours to this same bird;[5] and yet Blumenbach had had the opportunity to examine the remains of the true ibis in a mummy which he opened in London.[6]

I shared the error of the famous men I have just named until the moment when I was able to examine some ibis mummies for myself.

This pleasure was afforded me for the first time by the late Fourcroy, to whom Mr. Grobert, a colonel of artillery, on his return from Egypt, had given two of these mummies, both taken from the shafts of Sakkara.[7] While opening these up with care, we noticed that the bones of the embalmed bird were very much smaller that those of the *Tantalus ibis* of the naturalists, that they were not much bigger than the bones of the curlew,

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[1]Description of a white ibis and of two storks, Paris Academy of Sciences, Volume III, Plate III, page 61 of the edition in-4°. in 1734, Plate XIII, Figure I. The beak is shown as truncated at the end, but that is an error by the illustrator.

[2]Numenius sordide albo rufescens, capite anteriore nudo rubro; lateribus rubro purpureo et carneo colore maculatis, remigibus majoribus nigris, rectricibus sordide albo rufescentibus, rostro in exortu dilute luteo, in extremitate aurantio, pedibus griseis . . . . *Ibis candida*. Brisson, *Ornithologie*, Volume V, page 349.

[3]Illuminated Plates, number 389, *History of Birds*, Volume VIII, in-4°., page 14, Plate I. This last image is a copy of the one by Perrault, with the same error.

[4][*Translator's Note*: Claude Perrault (1613-1688), an eminent French scholar, architect, and physician, who wrote on a wide range of subjects, including physics and natural history; Mathurin Jacques Brisson (1723-1806), French natural historian, who wrote on, among other things, birds (his Ornithologie was published in 1760); Buffon: Georges-Louis Leclerc, Comte de Buffon, (1707-1788), one of the most celebrated French naturalists in the eighteenth century, his famous Histoire Naturelle, published in forty-our volumes throughout his life and after his death, is one of the great landmarks in the history of natural science; Carl Linnaeus (1707-1778), Swedish physician and natural philosopher, famous for developing the binomial classification system, the foundation of modern taxonomy, his Systema Naturae was first published in 1735 and later editions were published regularly every few years (the tenth edition appeared in 1758); Johann Friedrich Blumenbach (1752-1840), German physician and natural scientist.]

[5]Handbuch der Naturgeschichte, page 203 in the edition of 1799; but in the 1807 edition he gave the name ibis to the bird to which it belongs.

[6]Transactions philosophiques for 1794.

[7][*Translator's note*: Sakkara, part of the necropolis of Memphis, is best known for the most ancient of Egypt's pyramids, the Step pyramid.]

that the beak was similar to the curlew's, only its length was a little less in proportion to its thickness—not at all like that of the tantalus—and finally that its plumage was white and its wing feathers marked with black, as the ancients said.[1]

We were convinced, therefore, that the bird which the ancient Egyptians embalmed was not the *Tantalus ibis* of the naturalists, at all, that it was smaller, and that it had to be looked for in the genus of the curlew.

After some research, we saw that the ibis mummies opened up in front of us by different naturalists, were similar to our own. Buffon expressly says that he had examined several and that the birds which they contained had the beak and the size of a curlew. Nonetheless, he blindly followed Perrault in taking the African tantalus for the ibis.

One of these mummies opened by Buffon is still in the Museum. It is similar to the one which we viewed.

Doctor Shaw, in the supplement to his Travels (English edition in-folio, Oxford, 1746, Plate V and pages 64 to 66) describes and carefully illustrates the bones of a similar mummy. The beak, he says, was six English inches long, similar to that of a curlew, etcetera. In a word, his description is entirely consistent with our own.[2]

Caylus (Recueil d'Antiquités, Volume VI, Plate XI, Figure I) depicts an ibis mummy the height of which, including its bandages, is only one foot, seven and one third inches, although he expressly states that the bird was set there on its feet, with its head straight, and that in its embalming no part of it was folded up.[3]

Hasselquist, who took a small white and black heron for the ibis, gives as his principal reason that the size of this bird, which is that of a crow, very closely corresponds with the size of the ibis mummies.[4] Then how could

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[1][*Translator's note*: Antoine Francois, comte de Fourcroy (1755-1809), French naturalist and teacher; Jacques Francois Louis Grobert, a French army officer on the Egyptian expedition; his Description des pyramides de Ghize appeared in 1801.]

[2][*Translator's note*: Thomas Shaw (1692-1751), English minister and traveller, whose *Travels in Barbary and the Levant* was first published in 1738.]

[3][Translator's note: Cuvier's text has "un pied sept pouces quatre lignes." The *ligne* was a unit of measurement equivalent to one twelfth of an inch. Anne Claude Phillippe de Tubiere Grimoard de Pestels de Levis, Comte Caylus (1692-1765), French archaeologist; his Recueil antiquités égyptiennes, étrusques, grecques, romaines et gauloises, was published in seven volumes (1752-1767).]

[4]Hasselquist Iter Palestinum *[Palestian Journey]*, page 249. Magnitudo gallinæ, seu cornicis *[the size of a hen, or crow]*; and page 250, vasa quæ in sepuleris inveniuntur, cum avibus conditis, hujus sunt magnitudinis *[vases which were found in the burial chamber, with birds in them, were of this size]*. [*Translator's note*: Frederic Hasselquist (1722-1752), Swedish naturalist and traveller (in Asia Minor), who had many specimens shipped home; his notes were published after his death (as Iter Palaestinum *[Palestian Journey]*) and translated into French and German (1762) and into English (1766)].

Linnaeus give the name *Ibis* to a bird as large as a stork? Above all, how could he have considered this bird the same as the *Ardea ibis* of Hasselquist, which, apart from its small size, had a straight beak? And how could this last mistake in synonymy have been preserved up to now in the *Systema naturae*?

A short time after this examination conducted at the home of Fourcroy, Oliver was kind enough to allow us see the bones which he had taken from two ibis mummies and to open two more of them with us. The bones we found there were similar to those in the mummies of Colonel Grobert; only one of the four was smaller, but it was easy to ascertain by the epiphyses *[rounded ends of the long bones]* that it came from a young individual.

The only figure of the beak of an embalmed ibis which did not completely agree with the objects which we had before our eyes was that of Edwards (plate CV). It is larger by one ninth; nonetheless, we do not doubt its accuracy, for Oliver also showed us a beak which was one eighth or one ninth longer than the others, as 180 to 165, similarly taken from a mummy. (See Plate VI, Figure 2). This beak merely demonstrates that among the ibises there were some individuals larger than others, but it proves nothing in favour of the tantalus, for the former beak does not have the shape of the tantalus' beak at all and is entirely similar to the beak of a curlew. Moreover, the beak of the tantalus is a third longer than the beak of our largest embalmed ibises, and two-fifths larger than the beaks of the smallest.

In addition we have checked that there are similar variations in the size of the beak in our curlews in Europe, according to the age and the sex. They are even more marked in the green curlew of Italy and in our godwits, and it appears that the variation is a common property of most of the species in the family of Woodcocks.

Finally, our naturalists returned from the expedition to Egypt with a rich harvest of objects, ancient and recent. My scholarly friend Geoffroy Saint-Hilaire, has been particularly busy collecting with the greatest care the mummies of all the species and with them has brought back a large number of ibis mummies, both from Sakkara and Thebes.[1]

The former ones were in the same condition as those which Grobert had brought back, that is to say, their bones had suffered some kind of semi-combustion and were without consistency. They shattered on the slightest contact, and it was very difficult to obtain complete samples among them and even more difficult to reattach them to make a skeleton.

The bones of those from Thebes were much better preserved, whether because of the hotter climate or because of the more efficacious care taken to prepare them. When Geoffroy gave up a few of them, my assistant,

[1] [*Translator's note*: Etienne Geoffroy Saint-Hilaire (1772-1844), a French naturalist, colleague and rival of Cuvier, a defender of Lamarck's evolutionary ideas.]

Rousseau, succeeded, thanks to patience, skill, and ingenious and delicate procedures, in putting together a complete skeleton from them, by stripping all the bones and reattaching them with very fine brass wire. This skeleton has been placed in the anatomical galleries of the Museum. It is one of the most beautiful ornaments of the place. We provide a picture of it in Plate IV *[see p. 154 below]*.

One sees that this mummy must have come from a bird held in domesticity in the temples, for its left humerus was broken and reset. It is probable that a wild bird which had had its wing broken would have perished before being healed, for lack of being able to chase its prey or to escape its enemies.

This skeleton enables us to determine without any equivocation the characteristics and proportions of the bird. We saw clearly that it was in all points a true curlew, a little larger than the one in Europe, but one whose beak was thicker and shorter. Here is a table comparing the dimensions of these two birds. Measurements for the ibis were taken from the skeleton of the mummy from Thebes and for the curlew from a skeleton which was previously present in our anatomical galleries. We have added to these the parts of the ibis from Sakkara which we were able to obtain complete.

PARTS	SKELETON of the ibis from Thebes	SKELETON of the Curlew	IBIS FROM SAKKARA	
			The largest	The smallest
Head and beak together	0.210	0.215	_____	_____
Head only	0.047	0.040	_____	_____
The fourteen vertebrae of the neck together .	0.192	0.150	_____	_____
The back	0.080	0.056	_____	_____
The sacrum	0.087	0.070	_____	_____
The coccyx	0.037	0.035	_____	_____
The femur	0.078	0.060	_____	_____
The tibia	0.150	0.112	_____	0.095
The tarsus	0.102	0.090	_____	_____
The middle digit *[foot]*	0.097	0.070	_____	_____
The sternum	0.092	0.099	_____	_____
The clavicle	0.055	0.041	_____	0.04
The humerus.	0.133	0.106	0.124	_____
The forearm	0.153	0.117	0.144	0.114
The hand	0.125	0.103	_____	_____

One sees from this table that the animal from Thebes was larger than our curlew, that one of the ibis birds from Sakkara occupies the middle ground between the one from Thebes and our curlew, and that the other was smaller than the curlew. Here one also sees that the different parts of the body of the ibis do not observe among themselves the same proportions as those of the curlew. The beak of the former, for example, is notably shorter, although all the other parts are longer, and so on.

However, these differences in the proportions do not go beyond the limits of what can be noticed in species of the same genus: the forms and characteristics which one can consider generic are absolutely the same.

It was thus necessary to look for the true ibis, not among these tantaluses of great size and with a sharp beak, but among the curlews. Note that by the name *Curlew* we mean, not the artificial genus formed by Latham and Gmelin out of all the wading birds with a beak curved lower down and a bare head, whether their beak is rounded or sharp, but rather a natural genus we call *Numenius*, which will consist of all the wading birds with beaks which are bent lower down, blunt and rounded, whether their heads are bare or covered with feathers. This is the genus curlew as Buffon conceived it.[1]

A glance over the specimens of birds in the King's collection allowed us to recognize a species which had so far neither been named nor described in the authors of systems, perhaps with the exception of Latham, and which, upon a careful examination, will manage to satisfy everything which the ancients, the monuments, and the mummies indicate to us as characteristics of the ibis.

We provide a drawing of this species here in Plate V *[see p. 155 below]*. It is a bird a little larger than the curlew; its beak is arched like that of the curlew, but a little shorter and perceptibly thicker in proportion, a little compressed at its base and marked on each side by a groove which, starting at the nostril goes all the way to the end, whereas in the curlew a similar groove disappears before it reaches the middle of the length of the beak; the colour of this beak is more or less black; the head and the upper two-thirds of the neck are completely bare of feathers, and the skin of this part is black. The plumage on the body, wings, and tail is white, with the exception of the ends of the large wing feathers, which are black; the last four secondary feathers have remarkably long slender barbs and fall down below the end of the wings when these are folded; their colour is a fine black with glints of violet. The feet are black. In its proportions the legs are thicker and the digits *[of the feet]* notably longer than those of the curlew;

[1]We firmly established this genus in our Règne Animal, Volume I, page 483, and it appears to have been adopted by naturalists. [*Translator's note*: John Latham (1740-1837), English physician and ornithologist; his *Index Ornithologicus* was published in 1790; Johann Friedrich Gmelin (1748-1804), German naturalist, professor of philosophy and medicine, who published his own version of Linnaeus' *Systema Naturae*].

the membranes between the bases of the digits are also more extended. The leg is entirely covered with small polygonal scales, or is what we call reticulated, and even the base of its digits has nothing but similar scales; whereas, in the curlew two-thirds of the leg and the entire length of the digits have scutules, that is to say, they are furnished with transverse scales. There is a reddish colour under the wing, around the root of the thigh and on the large anterior coverts. But this colour appears to be an individual characteristic or the result of an accident, for it does not reappear at all among other individuals otherwise completely similar.

This first individual came from the Stadtholder collection, and its native land was unknown. The late Desmoulins, an assistant naturalist at the Museum, who had seen two others, claimed that they came from Senegal: one of the two must even have been brought back by Geoffroy de Villeneuve.[1] But we will see further on that Bruce[2] found this species in Ethiopia, where it is called *abou hannès* (Father John), and that Savigny saw it in abundance in Lower Egypt, where people call it *abou mengel* (Father of the Sickle). It is probable that modern people will not take as literally true the assertion of the ancients that the ibis never left this country without perishing.[3]

Moreover, this assertion would be just as wrong for the *Tantalus ibis* as for our curlew, because the specimens which we have of it in Europe come from Senegal. For it was from there that Geoffroy de Villeneuve brought that one in the Museum of Natural History. It is even much rarer in Egypt than our curlew, because since Perrault no one claims to have seen it there or to have received one.

An individual without the tawny colour, but otherwise completely similar to the first, was brought back by de Labillardiere from his voyage in Australia, made with d'Entrecasteaux.[4]

Since then we have learned that when they are young these types of *Numenius* have the head and neck furnished with feathers in the part which becomes bare as they grow older and that the scapulas *[shoulder feathers]* there are less slender and are a paler and duller black. One specimen in this condition was brought back to us from Australia by the

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[1][*Translator's note*: Geoffroy de Villeneuve (1767-1831), author of *L'Afrique, ou histoire, moeurs, usages et coutumes africans: le Senegal* (Paris 1814)].

[2]Bruce, loc. cit.; and Savigny, Mémoire sur l'ibis, page 12.

[3]Ælian., lib. II, cap. XXXVIII. [*Translator's note*: Jules Lelorgne de Savigny (1777-1851), French scientist whom, at Cuvier's suggestion, Napoleon took with him on the expedition to Egypt, and who, on his return to France in 1802, worked on the material collected on that expedition].

[4][*Translator's note*: Jacques Julien de Labillardiere (1755-1834), French scientist who travelled extensively, notably to Australia (1791), and who published one of the first European accounts of the flora of Australia (*Novae Hollandiae Plantarum Specimen*, 1804-7). The expedition to Australia was led by Antoine Raymond Joseph de Bruni d'Entrecasteaux (1739-1793), a French navigator].

late Peron, which, I might add, was no different from ours and from de Labillardiere's, except for some black lines on the bastard feathers and on the large primary coverts *[mid-wing feathers]* and where the entire head and the top of the neck are furnished with blackish feathers.[1] Thus, the specimen which Savigny brought back from Egypt and which is depicted in Plate I of his Mémoire sur l'ibis and in the great work on Egypt, Birds, Plate VII, is not very old. The feathers on the head and at the back of the neck are grey rather than black; those on the front of the neck are white. Finally Bruce's drawing (Atlas, Plate XXXV) was also made of a young specimen observed in Abyssinia; it is almost identical to that of Savigny.

From Leschenault in Pondicherry we received one specimen of them similar to Peron's, in which, however, only the head and a little bit of the nape are furnished with blackish feathers; all the rest is covered with white feathers.[2] But it is no less certain that with all these birds the head and neck are bare when they are adults.

The late Macé sent the Museum several specimens of a species very closely related to this one from Bengal. Its beak is a little longer and less curved, only its primary feather has a little black on the two edges of its tip, and its secondary feathers are also slightly elongated and have a light blackish colour.

It seems, according to Savigny, page 25, that Levaillant observed another one of these which also has elongated secondary feathers, but in which the neck always keeps its feathers and in which the face is a red colour.[3]

The same Macé also sent us a tantalus very similar to the one which the naturalists have considered as the ibis, but in which the small coverts of the wings and a large band on the bottom of the breast are black with white speckles. The secondary feathers at the back are elongated and rose coloured. We know that in the tantalus ibis of the naturalists the small coverts of the wings are speckled with lilac and the underneath of the body is entirely white.

We provide here a table showing the parts of some of these birds which we could measure precisely in stuffed specimens. Let us compare these with the measurements of the skeletons of mummified ibises, and we will assess if it was possible to believe for a single moment that these mummies came from the tantalus *[see table on p. 141 below]*.

[1][*Translator's note*: Francois Auguste Peron (1775-1810), French naturalist, member of the expedition to Australia in 1791, who gathered a large collection of zoological specimens].

[2][*Translator's note*: Jean Baptiste Louis Claude Theodore Leschenault (1773-1826), French scientist on the voyage to Australia in 1791, plant collector who travelled to India in 1816 and later to South America].

[3][*Translator's note*: Francois Le Vaillant (1753-1824), French scientist, explorer, and collector, who wrote extensively on the birds of Africa].

Now if we go though the books of the ancients and their monuments and compare what they said about the ibis or the images which they drew of it with the bird we have just described, we will see that all the difficulties vanish and that all the evidence agrees with the best of all, which is the very bird itself preserved in the mummy.

PARTS OF THE BODY	TANTALUS IBIS of the naturalists	TANTALUS of India from Macé	NUMENIUS IBIS according to us the true ibis of the ancients	NUMENIUS IBIS measured by Mr. Savigny	NUMENIUS of Macé	NUMENIUS of Labillardière	NUMENIUS of Peron	NUMENIUS of Leschenault
Length of beak from corner to tip	0.210	0.265	0.125	0.154	0.148	0.165	0.131	0.132
Length of bare portion of leg	0.130	0.150	0.041	0.056	0.055	0.040	0.034	0.044
Length of tarsus	0.190	0.250	0.085	0.097	0.095	0.084	0.080	0.093
Length of middle digit [*toe*]	0.105	0.115	0.080	0.092	0.088	0.086	0.078	0.086

"The most common ibis," says Herodotus, Euterpe, no. 76, "has its head and the front of the neck bare, white plumage, except on the head, the nape of the neck, at the ends of the wings and of the rump, which are black.[1] Their beak and their feet look like those of the other ibises." And he

[1] *Ψιλή τήν κεφαλήν καί τήν δειρήν πασαν. Λευκή πτεροισι, πλήν κεφαλης, καί αύχένος καί άκρων των πτερυγων, καί πυγαίου άκρου [the head and the entire throat are bare; the feathers are white, except for the head and neck and the tips of the wings and the end of the tail].* The late Mr. Larcher, Hérodote *[Herodotus]*, translated into French, Volume II,

said about the latter: “they are the size of a crake, and totally black in colour, with feet similar to those of the crane and a hooked beak.”

How many of today’s traveller do not describe the birds they observe as well as Herodotus did the ibis!

How could one have applied this description to a bird which had no bare places except its face, which was red, to a bird which has a white rump which is not covered in the least, as ours is, with black wing feathers?

However, this last characteristic was essential to the ibis. Plutarch says (in De Iside et Osiride *[Concerning Isis and Osiris]*) that because of the way in which the white was cut through with black in the plumage of this bird one came across the shape of a crescent moon. The effect occurs because of the meeting of the black of the rear feathers of the wings with the black of the two ends of the wings, a meeting which forms, in the white, a large semi-circular notch which gives this white the figure of a crescent.

It is more difficult to explain what he wanted to say by proposing that the feet of the ibis form an equilateral triangle with its beak. However, one understands the assertion of Ælian that when the ibis pulls back its head and neck into its feathers, it looks a little like the shape of a heart.[1] Because of that it was the emblem of the human heart, according to Horus Apoll., c. 35.

From what Herodotus says about the nakedness of the throat and about the feathers which covered the top of the neck, he seems to have had before his eyes a specimen of medium age, but it is no less certain that the Egyptians were also very familiar with individuals with a completely bare neck. We see such birds represented in the bronze sculptures in the collection of Egyptian antiquities of Caylus (Volume I, Plate X, No. 4, and Volume V, Plate XI, No 1). This last figure is even so similar to our bird shown in Plate V that one could say that it was made from it.

The paintings of Herculaneum also do not leave any doubt; pictures nos. 138 and 140 in the edition of David, and Volume II, page 315, no. 59, and page 321, no. 60 of the original edition, which depict Egyptian ceremonies, show several ibises walking in the forecourts of the temples; they are perfectly similar to the bird which we have indicated: one recognizes there above all the blackness characteristic of the head and the neck, and one readily sees by the proportions of their shape compared to the people in the picture that this must have been a bird half a metre tall at the very most, and not a metre or so, like tantalus ibis.

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page 327, was well aware of the difference between these words: *αυχήν*, the nape of the neck, and *δείρη* or *δέρη*, the throat.

[1] Ælian., lib. X, cap. XXIX.

The mosaic in Palestrina also shows in its middle part several ibises perched on the buildings. They are in no way different from those in the paintings of Herculaneum.[1]

A sardonyx stone in the collection of Dr. Mead, copied by Shaw, app. tab. V, which depicts an ibis, seems to be a miniature of the bird which we describe.

A medallion of Hadrian, a large bronze, pictured in the museum of Farnese, Volume VI, Plate XXVIII, Figure 6, and another of the same emperor, in silver, pictured in Volume III, Plate VI, Figure 9, give us pictures of the ibis which, despite their small size, are sufficiently similar to our bird.

As for the figures of the ibis sculpted on the plinth of the statue of the Nile at Belvedere, and on the copy of it in the garden of the Tuileries, they are not sufficiently finished to serve as proofs. But among the hieroglyphs of which the Egypt Institute has had imprints made on location, there are several of them which depict our bird without doubt. We provide (Plate III, Figure 1) one of these impressions which Geoffroy was kind enough to pass on to us *[see p. 156 below]*.

We particularly stress this last figure, given that it is most authentic of all, having been made at the time and in the places where the ibis was worshipped, and being contemporaneous with the ibis mummies, while those which we have cited previously, which were made in Italy and by artists who did not profess in any way the Egyptian religion, could have been less faithful.

We owe to Bruce the justice of saying that he recognized the bird he describes under the name *abou hannès* as the true ibis. He expressly states that this bird seemed to him to resemble the one contained in the jars of mummies. In addition, he says that this *abou hannès* or *Father John* is very common on the banks of the Nile, whereas he never saw there the bird pictured by Buffon under the name the white ibis of Egypt.

Savigny, one of the naturalists on the Egyptian expedition, also claims that he did not find the *tantalus* in this country, but he captured many of our *numenius* near Lake Menzale in Lower Egypt, and he brought back their skins with him.

The abou hannès was included by Latham in his *index ornithologicus* under the name of *tanatlus æthiopicus*, but he made no mention of Bruce's conjecture that it should be identified as the ibis.

Travellers before and after Bruce seem to have all been mistaken.

[1] [*Translator's note*: The Palestrina mosaic, dating from the first century BC, depicts the Nile from Ethiopia to the Mediterranean. The mosaic, taken from Palestrina in the seventeenth century, is now in the National Museum of Prenestio in Rome].

Belon believed that the white ibis was the stork, in doing so he was evidently contradicting all the evidence.[1] Moreover no one shared his opinion on this point, except the apothecaries who took the stork as their symbol because they confused it with the ibis, to which people attributed the invention of clysters *[enema]*.[2]

Prosper Alpin, who reminds us that this invention is due to the ibis, does not provide any description of this bird in his Médecine des Égyptiens.[3] In his Histoire naturelle d'Égypte, his discussion of it only follows Herodotus, at the end of which he merely adds, undoubtedly following a passage of Strabo, which I will refer to further on, that this bird looks like a stork in its size and shape. He talks of having learned that there was an abundance of these birds, black and white, on the banks of the Nile, but it is clear even from the way he expresses himself that he did not believe he had seen any of them.[4]

Shaw says of the ibis that it is nowadays extremely rare and that he had never seen one.[5] His *emseesy* or ox-bird, which Gmelin very incorrectly refers to as the tantalus ibis, is the size of a curlew, with a white body and a red beak and red feet. It stays in the plains near the livestock. Its flesh does not taste good and is the first to rot.[6] It is easy to see that this bird is not the tantalus, even less so the ibis of the ancients.

Hasselquist did not know either the white ibis or the black ibis; his *ardea ibis* is a small heron which has a straight beak. Linnaeus did well to classify it, in his tenth edition, among the herons. But he was wrong, as I have said, to shift it later to the genus *tantalus*, as a synonym.

Demaillet (Description de l'Égypte, Part II, page 23) suggests that the ibis could be the bird peculiar to Egypt and that people call it *Pharaoh's capon* and at Aleppo *Saphan-bacha*.[7] It eats snakes. There are white ones and black and white ones. The bird follows for more than a hundred leagues the caravans which go from Cairo to Mecca, in order to feed on the carcasses of the animals which people kill during the journey; whereas, in every other season one does not see any of them on this route. But the author does not consider this conjecture certain. He even says that it is

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[1] [*Translator's note*: Pierre Belon (1517-1564), French naturalist, whose *Histoire de la nature des oiseaux* was published in 1555].

[2] Ælian., lib. II, cap. XXXV; Plut., de solert. an.; Cic., de nat. deor., lib. II; Phile de anim. prop., 16, etc.

[3] De Med. Ægypt. lib. I, fol. I, vers. Édition de Paris, 1646. [*Translator's note*: Prosper Alpin (1553-1617), Italian physician and naturalist, who wrote on Egyptians plants and Egyptian medicine].

[4] Rer. Ægypt., lib. IV, cap. I, tome I, page 199 in the Leyde edition, 1735.

[5] See the French translation, Volume II, page 167.

[6] See Shaw, French translation, Volume I, page 330.

[7] [*Translator's note*: Benoit de Maillet (1656-1656), French diplomat and naturalist, who wrote Description de l'Égypte (1735) and advanced a theory of evolution to explain the origin of the earth].

necessary to forget about listening to the ancients when they spoke in a manner that they did not wish to be understood. He finishes by concluding that the ancients perhaps vaguely included under the name of ibis all the birds which served Egypt by ridding it of dangerous reptiles, which this climate produces in abundance, birds like the vulture, falcon, stork, sparrow hawk, and so on.

He was right not to consider his Pharaoh's capon an ibis, for, although his description may be very imperfect and although Buffon believed he recognized the ibis in it, it is easy to make the judgment, based on what Pokocke also says about it, that this bird must be a carnivore, and in fact, we see by Bruce's drawing (Volume V, page 191 in the French edition) that Pharaoh's capon is nothing other than the rachama or the small white vulture with black wings (*vultur percnopterus* Linn.), a very different bird from the one which we have demonstrated above is the ibis.

Pococke says that it appears from the descriptions people give of the ibis and by the figures he saw of it in the temples of Upper Egypt, that it is a species of Crane. I have seen, he adds, a number of these birds in the islands of the Nile; for the most part they were dull gray in colour (French translation, edition in-12, Volume II, page 153). These few words are sufficient to show that he did not know the ibis any better than the others.[1]

The scholars have not been any more fortunate in their conjectures than the travellers. Middelton links the ibis with a bronze figure of a bird whose beak is curved, but short, with a very long neck and a head furnished with a small crest, a figure which never had any resemblance to the bird of the Egyptians (*antiq. monum.*, Plate X, page 129). Besides, this figure is not at all in the Egyptian style, and Middleton himself admits that it must have been made in Rome. Saumaise's On Solinus does not say anything relevant to the present question.[2]

As for the black ibis which Aristotle places exclusively around Pelusium,[3] it was believed for a long time that only Belon had seen it.[4] The bird which he describes under this name is a species of curlew to which he attributes a head similar to that of a cormorant, that is, apparently bald, a red beak and red feet;[5] but since he does not talk at all about the ibis in his travels,[6] I suspect that he made the connection only in France, through a comparison with the ibis mummies. What is certain is that this curlew with a red beak

[1][*Translator's note*: Richard Pococke (1704-1765), English traveller and bishop, whose Description of the East and Some Other Countries was published in 1743-45].

[2][*Translator's note*: Claude Saumaise (1588-1653), French classicist, whose major work was a commentary on Gaius Julius Solinus' *Polyhistor*; Solinus was a fourth century Latin scholar].

[3]Hist. anim., lib. IX, cap. XXVII, et lib. X, cap. XXX.

[4]Buffon, Histoire naturelle des oiseaux, in-4°., tome VIII, page 17.

[5]Belon. Nature des oiseaux, pages 199 et 200; et Portraits d'oiseaux, folio 44, vers.

[6]Observations de plusieurs singularités, etc.

and red feet is unknown in Egypt,[1] but that one very commonly sees there our European green curlew (*scol. facinellus*, Linn., enl. 819), that it is even more abundant than the white numenius,[2] and that since it resembles it in shape and size and its plumage could appear black from a distance, we can hardly doubt that what we have there is the true black ibis of the ancients. Savigny also had a portrait of one made in Egypt,[3] but it was based on merely a young specimen. Buffon's image is taken from the adult, but its colours are too light.

The mistake which presently governs concerning the white ibis began with Perrault, who was the first person, among the naturalists, to make known the present day tantalus ibis. This mistake, adopted by Brisson and by Buffon, passed into the twelfth edition of Linnaeus, where it got mixed up with the mistake of Hasselquist, which had been inserted into the tenth edition, so as to combine with it into a completely monstrous compound creature.

It was based on the idea that the ibis was essentially a bird hostile to snakes and, on this entirely natural conclusion, that in order to devour snakes it had to have a sharp beak, more or less analogous to the beak of the stork and the heron. This idea is itself the only good objection that one could make against identifying our bird as the ibis. How, one will say, could a bird with a feeble beak, a curlew, devour these dangerous reptiles?

One could reply that positive proofs, such as the descriptions of drawings and of mummies should always prevail over accounts of habits too often dreamed up without any other motive than justifying the different forms of worship accorded to animals. One could add that the snakes from which the ibis delivered Egypt have been represented to us as very venomous, but not very large. I thought I even had obtained a direct proof that mummified birds which had a beak absolutely similar to that of our bird were true eaters of snakes, because I found in one of their mummies some as yet undigested remains of the skin and scales of snakes, which I keep in our anatomical galleries.

But today, Savigny, who has made observations of the live animals and more than once dissected our white numenius, the bird which everything demonstrates was the ibis, maintains that it eats nothing but worms, fresh water shellfish, and other small animals of this kind. If we assume that this fact has no exceptions, all that one can conclude from it is that the Egyptians made up a false reason for an absurd form of worship, as has happened more than once to them and to others. It is true that Herodotus says he saw in a location on the edge of the desert, near Buto, a narrow gorge where there was stacked up a huge pile of bones and remains which people assured him were the leftover parts of winged snakes which

[1] Savigny. Mémoire sur l'ibis, page 37.

[2] *Idem*, *ibid.*

[3] See the great work on Egypt, Histoire naturelle des oiseaux, Plate VII, figure 2.

attempt to get into Egypt at the beginning of spring; they said the ibis prevented their passage.[1] But Herodotus does not tell us that he witnessed their combat or that he saw these winged serpents in their complete state. Thus, his entire account reduces itself to having observed a pile of remains, which could very well have been those of the multitude of reptiles and of other animals killed every year by the flood *[of the Nile]*, which naturally would have to transport the bodies to places where it ceases, right to the edges of the desert. These remains would tend to accumulate in a narrow gorge.

However, following this idea of the combat of the ibis against the snakes, Cicero also gives this bird a strong hooked beak.[2] Never having been in Egypt, he used a simple analogy to imagine that that should be the case.

I am aware that Strabo says somewhere the ibis resembles the stork in its shape and size,[3] and that this author ought to have known well enough because he mentions that in his day the streets and crossroads of Alexandria were so filled with these birds that they caused a great disturbance. But he would have been speaking from memory. His account cannot be acceptable when he goes against all the others and, above all, when the bird itself is there to refute it.

In the same way I will hardly be more concerned about the passage where Aelian reports that, according to the Egyptian embalmers, the intestines of the ibis are ninety-six cubits long *[approximately 150 feet]*.[4] The Egyptian priests of all classes said so many extravagant things about natural history that one cannot make a grand case out of something reported by one of their lowest classes.

One could make one more objection to me taken from the long slender black feathers which cover the rump of our bird, some traces of which one also sees in Bruce's drawing of the abou hannès.

The ancients, one will say, do not speak about them in their descriptions and their images do not show them. But I have something much better in this matter than a written report or a traced image. I have found precisely the same feathers in one of the mummies from Sakkara. I am carefully preserving them as being at once a remarkable monument of antiquity and a peremptory proof of the identity of species. Since these feathers have an uncommon shape and are not found, I believe, in any other curlew, they leave, in effect, no kind of doubt about the accuracy of my opinion.

I conclude this paper with a report of its results.

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[1]Euterpe, cap. LXXV. Herodotus says *a place in Arabia*, but one cannot see how a place in Arabia could be close *to the town of Buto*, which was in the western part of the delta.

[2]Avis excelsa, cruribus rigidis, corneo proceroque rostro *[A tall bird, with rigid legs, and a long horny beak]*. Cic., de Nat. deor., lib. I.

[3]Strab., lib. XVII.

[4]Ælian., anim., lib. X, cap. XXIX.

1. The tantalus ibis of Linnaeus should remain in a separate genus with the *tantalus loculator*. Their characteristic will be *rostrum læve, validum, arcuatum, apice utrinque emarginatum [a smooth beak, strong, arched, notched at the tip on both sides]*

2. The other tantaluses of the last editions should form a genus with the ordinary curlews: we can give them the name *numenius*. The characteristic of the genus will be *rostrum teres, gracile, arcuatum, apice mutico [a curved beak, slender, bow-shaped, with a blunt tip]*; for the special characteristic of the sub-genus of the ibises, it will be necessary to add *sulco laterali per totam longitudinem exarato [with a groove on the side indented along its entire length]*.

3. The white ibis of the ancients is not at all the ibis of Perrault and of Buffon, which is a *tantalus*, nor the ibis of Hasselquist, which is an *ardea*, nor the ibis of Maillet, which is a *vulture*. But it is a bird of the genus numenius, or curlew, in the sub-genus ibis, which had not been described and drawn before me other than by Bruce, under the name *Abou-hannès*. I call it NUMENIUS IBIS, *albus, capite et collo adulti nudis, remigum apicibus, rostro et pedibus nigris, remigibus secundariis elongatis nigro-violaceis [white, with the head and neck bare in the adult, with the tips of its flight feathers, its back, and its feet black, with elongated secondary flight feathers coloured a black-violet].*

4. The black ibis of the ancients is probably the bird which we know in Europe under the name *green curlew*, or the *scolopax falcinellus* of Linnaeus. It also belongs to the genus of curlew and to the sub-genus of ibis.

5. The tantalus ibis of Linnaeus, in the present state of our synonyms, includes four species of three different genera, as follows:

1. A tantalus, the ibis of Perrault and of Buffon;

2. An ardea, the ibis of Hasselquist;

3. and 4. Two numenius birds, the ibis of Belon and the ox-bird of Shaw.

Let people judge by this example and by so many others the state in which this work *Systema naturae* still finds itself, and consider how important it would be to purge by degrees the errors with which it teems and how we seem to be always overloading it some more, piling species, characteristics, and synonyms into it without choices and without criticism.

The general conclusion of all this work is that the ibis still exists in Egypt, as it did at the time of the Pharaohs, and that it is the fault of naturalists that we have been able to believe for some time that the species had become extinct or had altered its forms.

[Cuvier concludes his book with some Illustrations, available through this link: Illustrations. If the link does not work try http://records.viu.ca/~johnstoi/cuvier/illustrations.pdf]

A Note on the Translator

Ian Johnston is a retired college and university-college instructor, now an Honorary Research Associate at Vancouver Island University in Nanaimo, British Columbia. A number of his translations have been published by Richer Resources Publications, including the following:

Aeschylus, *Oresteia*
Aristophanes, *Birds*
Aristophanes, *Clouds*
Aristophanes, *Frogs*
Aristophanes, *Lysistrata*
Euripides, *Bacchae*
Euripides, *Medea*
Homer, *Iliad*
Homer, *Odyssey*
Kant, *Universal Natural History and Theory of the Heavens*
Nietzsche, *Beyond Good and Evil*
Nietzsche, *Birth of Tragedy*
Nietzsche, *Genealogy of Morals*
Sophocles, *Antigone*
Sophocles, *Oedipus the King*
Sophocles, *Philoctetes*.

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