COSMOS

A Sketch of a Physical Description of the Universe

By Alexander
Von Humboldt

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A Sketch of the Physical Description of the Universe, Vol. 1

Alexander von Humboldt (1845)
Translated to English by Elise C. Otté (1866)
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Figure 1: Alexander von Humboldt in 1843

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CHAPTER 1

TRANSLATOR'S PREFACE.

I cannot more appropriately introduce the Cosmos then by presenting a brief sketch of the life of its illustrious author.[1] While the name of Alexander von Humboldt is familiar to every one, few, perhaps, are aware of the peculiar circumstances of his scientific career and of the extent of his labors in almost every department of physical knowledge. He was born on the 14th of September, 1769, and is, therefore, now in his 80th year. After going through the ordinary course of education at Göttingen, and having made a rapid tour through Holland, England, and France, he became a pupil of Werner at the mining school of Freyburg, and in his 21st year published an "Essay on the Basalts of the Rhine. "Though he soon became officially connected with the mining corps, he was enabled to continue his excursions in foreign countries, for during the six or seven years succeeding the publication of his first essay, he seems to have visited Austria, Switzerland, Italy, and France. His attention to mining did not, however prevent him from devoting his attention to other scientific pursuits, among which botany and the then recent discovery of galvanism may be especially noticed. Botany, indeed, we know from his own authority, occupied him almost exclusively for some years; but even at this time he was practicing the use of those astronomical and physical instruments which he afterward turned to so singularly excellent an account.

The political disturbances of the civilized world at the close of the last century prevented our author from carrying out various plans of foreign travel which he had contemplated, and detained him an unwilling prisoner in Europe. In the year 1799 he went to Spain, with the hope of entering Africa from Cadiz, but the unexpected patronage which he received at the court of Madrid led to a great alteration in his plans, and decided him to proceed directly to the Spanish possessions in America, "and there gratify the longings for foreign adventure, and the scenery of the tropics, which had haunted him from boyhood, but had all along been turned in the diametrically opposite direction of Asia. "After encountering various risks of capture, he succeeded in reaching America, and from 1799 to 1804 prosecuted there extensive researches in the physical geography of the New World, which have indelibly stamped his name in the undying records of science.

Excepting an excursion to Naples with Gay-Lussac and Von Buch in 1805 (the year after his return from America), the succeeding twenty years of his life were spent in Paris, and were almost exclusively employed in editing the results of his American journey. In order to bring these results before the world in a manner worthy of their importance, he commenced a series of gigantic publications in almost every branch of science on which he had instituted observations. In 1817, after twelve years of incessant toil, four fifths were completed, and an ordinary copy of the part then in print cost considerably more than one hundred pounds sterling. Since that time the publication has gone on more slowly, and even now, after the lapse of nearly half a century, it remains, and probably ever will remain, incomplete.

In the year 1828, when the greatest portion of his literary labor had been accomplished, he undertook a scientific journey to Siberia, under the special protection of the Russian government. In this journey – a journey for which he had prepared himself by a course of study unparalleled in the history of travel – he was accompanied by two companions hardly less distinguished than himself. Ehrenberg and Gustav Rose, and the results obtained during their expedition are recorded by our author in his *Fragments Asiatiques*, and in his *Asie Centrale*, and by Rose in his *Reise nach dem Oural*. If the *Asie Centrale* had been his only work, constituting, as, it does, an epitome of all the knowledge acquired by himself and by former travelers on the physical geography of Northern and Central Asia, that work alone would have sufficed to form a reputation of the highest order.

I proceed to offer a few remarks on the work of which I now present a new translation to the English public, a work intended by its author "to embrace a summary of physical knowledge, as connected with a delineation of the material universe."

The idea of such a physical description of the universe had, it appears, been present to his mind from a very early epoch. It was a work which he felt he must accomplish, and he devoted almost a lifetime to the accumulation of materials for it. For almost half a century it had occupied his thoughts; and at length, in the evening of life, he felt himself rich enough in the accumulation of thought, travel, reading, and experimental research, to reduce into form and reality the undefined vision that has so long floated before him. The work, when completed, will form three volumes. The first volume comprises a sketch of all that is at present known of the physical phenomena of the universe; the second comprehends two distinct parts, the first of which treats of the incitements to the study of nature, afforded in descriptive poetry, landscape painting, and the cultivation of exotic plants; while the second and larger part enters into the consideration of the different epochs in the progress of discovery and of the corresponding stages of advance in human civilization. The third volume, the publication of which, as M. Humboldt himself informs me in a letter addressed to my learned friend and publisher, Mr. H. G. Bohn, "has been somewhat delayed, owing to the present state of public affairs, will comprise the special and scientific development of the great Picture of Nature. "Each of the three parts of the Cosmos is therefore, to a certain extent, distinct in its object, and may he considered complete in itself We can not better terminate this brief notice than in the words of one of the most eminent philosophers of our own country, that, "should the conclusion correspond (as we doubt not) with these beginnings, a work will have been accomplished every way worthy of the author's fame, and a crowning laurel added to that wreath with which Europe will always delight to surround the name of Alexander von Humboldt."

In venturing to appear before the English public as the interpreter of "the great work of our age [2] I have been encouraged by the assistance of many kind literary and scientific friends, and I gladly avail myself of this opportunity of expressing my deep obligations to Mr. Brooke, Dr. Day, Professor Edward Forbes, Mr. Hind, Mr. Glaisher, Dr. Percy, aid Mr. Ronalds, for the valuable aid they have afforded me.

It would be scarcely right to conclude these remarks without a reference to the translations that have preceded mine. The translation executed by Mrs. Sabine is singularly accurate and elegant. The other translation is remarkable for the opposite qualities, and may therefore be passed over in silence. The present volumes differ from those of Mrs. Sabine in having all the foreign measures converted into corresponding English terms, in being published at considerably less than one third of the price, and in being a translation of the entire work, for I have not conceived myself justified in omitting passages, sometimes amounting to pages, simply because they might be deemed slightly obnoxious to our national prejudices.

NOTES

1. For the following remarks I am mainly indebted to the articles on die Cosmos in the twwo leading Quarterly Reviews.
2. The expression applied to the Cosmos by the learned Bunsen, in his late Report on Ethnology, in the Report of the British Association for 1847, p. 265.

CHAPTER 2

AUTHOR'S PREFACE.

In the late evening of an active life I offer to the German public a work, whose undefined image has floated before my mind for almost half a century. I have frequently looked upon its completion as impracticable, but as often as I have been disposed to relinquish the undertaking, I have again – although perhaps imprudently – resumed the task. This work I now present to my contemporaries with a diffidence inspired by a just mistrust of my own powers, while I would willingly forget that writings long expected are usually received with less indulgence.

Although the outward relations of life, and an irresistible impulse toward knowledge of various kinds, have led me to occupy myself for many years – and apparently exclusively – with separate branches of science, as, for instance, with descriptive botany, geognosy, chemistry, astronomical determinations of position, and terrestrial magnetism, in order that I might the better prepare myself for the extensive travels in which I was desirous of engaging, the actual object of my studies has nevertheless been of a higher character. The principal impulse by which I was directed was the earnest endeavor to comprehend the phenomena of physical objects in their general connection, and to represent nature as one great whole, moved and animated by internal forces. My intercourse with highly-gifted men early led me to discover that, without an earnest striving to attain to a knowledge of special branches of study, all attempts to give a grand and general view of the universe would be nothing more than a vain illusion. These special departments in the great dominion of natural science are, moreover, capable of being reciprocally fructified by means of the appropriative forces by which they are endowed. Descriptive botany, no longer confined to the narrow circle of the determination of genera and species, leads the observer who traverses distant lands and lofty mountains to the study of the geographical distribution of plants over the earth's surface, according to distance from the equator and vertical elevation above the sea. It is further necessary to investigate the laws which regulate the differences of temperature and climate, and the meteorological processes of the atmosphere, before we can hope to explain the involved causes of vegetable distribution; and it is thus that the observer who earnestly pursues the path of knowledge is led from one class of phenomena to another, by means of the mutual dependence and connection existing between them.

I have enjoyed an advantage which few scientific travelers have shared to an equal extent, viz., that of having seen not only littoral districts, such as are alone visited by the majority of those who take part in voyages of circumnavigation, but also those portions of the interior of two vast continents which present the most striking contrasts manifested in the Alpine tropical landscapes of South America, and the dreary wastes of the steppes in Northern Asia. Travels, undertaken in districts such as these, could not fail to encourage the natural tendency of my mind toward a generalization of views, and to encourage me to attempt, in a special work, to treat of the knowledge which we at present possess, regarding the sidereal and terrestrial phenomena of the Cosmos in their empirical relations. The hitherto undefined idea of a physical geography has thus, by an extended and perhaps too boldly imagined a plan, been comprehended under the idea of a physical description of the universe, embracing all created things in the regions of space and in the earth.

The very abundance of the materials which are presented to the mind for arrangement and definition, necessarily impart no inconsiderable difficulties in the choice of the form under which such a work must be presented, if it would aspire to the honor of being regarded as a literary composition. Descriptions of nature ought not to be deficient in a tone of lifelike truthfulness, while the mere enumeration of a series of general results is productive of a no less wearying impression than the elaborate accumulation of the individual data of observation. I scarcely venture to hope that I have succeeded in satisfying these various requirements of composition, or that I have myself avoided the shoals and breakers which I have known how to indicate to others. My faint hope of success rests upon the special indulgence which the German public have bestowed upon a small work bearing the title of *Ansichten der Natur*, which I published soon after my return from Mexico. This work treats, under general points of view, of separate branches of physical geography (such as the forms of vegetation, grassy plains, and deserts). The effect produced by this small volume has doubtlessly been more powerfully manifested in the influence it has exercised on the sensitive minds of the young, whose imaginative faculties are so strongly manifested, than by means of anything which it could itself impart. In the work on the Cosmos on which I am now engaged, I have endeavored to show, as in that entitled *Ansichten der Natur*, that a certain degree of scientific completeness in the treatment of individual facts is not wholly imcompatible with a picturesque animation of style.

Since public lectures seemed to me to present an easy and efficient means of testing the more or less successful manner of connecting together the detached branches of any one science, I undertook, for many months consecutively, first in the French language, at Paris, and afterward in my own native German, at Berlin (almost simultaneously at two different places of assembly), to deliver a course of lectures on the physical description of the universe, according to my conception of the science. My lectures were given extemporaneously, both in French and German, and without the aid of written notes, nor have I, in any way, made use, in the present work of those portions of my discourses which have been preserved by the industry of certain attentive auditors. With the exception of the first forty pages, the whole of the present work was written, for the first time, in the years 1843 and 1844.

A character of unity, freshness, and animation must, I think, be derived from an association with some definite epoch, where the object of the writer is to delineate the present condition of knowledge and opinions. Since the additions constantly made to the latter give rise to fundamental changes in pre-existing views, my lectures and the Cosmos have nothing in common beyond the succession in which the various facts are treated. The first portion of my work contains introductory considerations regarding the diversity in the degrees of enjoyment to be derived from nature, and the knowledge of the laws by which the universe is governed; it also considers the limitation and scientific mode of treating a physical description of the universe, and gives a general picture of nature which contains a view of all the phenomena comprised in the Cosmos.

This general picture of nature, which embraces within its wide scope the remotest nebulous spots, and the revolving double stars in the regions of space, no less than the telluric phenomena included under the department of the geography of organic forms (such as plants, animals, and races of men), comprises all that I deem most specially important with regard to the connection existing between generalities and specialities, while it moreover exemplifies, by the form and style of the composition, the mode of treatment pursued in the selection of the results obtained from experimental knowledge. The two succeeding volumes will contain a consideration of the particular means of incitement toward the study of nature (consisting in animated delineations, landscape painting, and the arrangement and cultivation of exotic vegetable forms), of the history of the contemplation of the universe, or the gradual development of the reciprocal action of natural forces constituting one natural whole; and, lastly, of the special branches of the several departments of science, whose mutual connection is indicated in the beginning of the work. Wherever it has been possible to do so, I have adduced the authorities from whence I derived my facts, with a view of affording testimony both to the accuracy of my statements and to the value of the observations to which reference was made. In those instances where I have quoted from my own writings (the facts contained in which being, from their very nature, scattered through different portions of my works), I have always referred to the original editions, owing to the importance of accuracy with regard to numerical relations, and to my own distrust of the care and correctness of translators. In the few cases where I have extracted short passages from the works of my friends, I have indicated them by marks of quotation; and, in imitation of the practice of the ancients, I have invariably preferred the repetition of the same words to any arbitrary substitution of my own paraphrases. The much-contested question of priority of claim to a first discovery, which it is so dangerous to treat of in a work of this uncontroversial kind, has rarely been touched upon. Where I have occasionally referred to classical antiquity, and to that happy period of transition which has rendered the sixteenth and seventeenth centuries so celebrated, owing to the great geographical discoveries by which the age was characterized, I have been simply led to adopt this mode of treatment, from the desire we experience from time to time, when considering the general views of nature, to escape from the circle of more strictly dogmatical modern opinions, and enter the free and fanciful do main of earlier presentiments.

It has frequently been regarded as a subject of discouraging consideration, that while purely literary products of intellectual activity are rooted in the depths of feeling, and interwoven with the creative force of imagination, all works treating of empirical knowledge, and of the connection of natural phenomena and physical laws, are subject to the most marked modifications of form in the lapse of short periods of time, both by the improvement in the instruments used, and by the consequent expansion of the field of view opened to rational observation, and that those scientific works which have, to use a common expression, become *antiquated* by the acquisition of new funds of knowledge, are thus continually being consigned to oblivion as unreadable. However discouraging such a prospect must be, no one who is animated by a genuine love of nature, and by a sense of the dignity attached to its study, can view with regret anything which promises future additions and a greater degree of perfection to general knowledge. Many important branches of knowledge have been based upon a solid foundation which Will not easily be shaken, both as regards the phenomena in the regions of space and on the earth; while there are other portions of science in which general views will undoubtedly take the place of merely special; where new forces will be discovered and new substances will be made known, and where those which are now considered as simple will be decomposed. I would, therefore, venture to hope that an attempt to delineate nature in all its vivid animation and exalted grandeur, and to trace the stable amid the vacillating, ever-recurring alternation of physical metamorphoses, will not be wholly disregarded even at a future age.

Pottdam, Nov., 1844.

NOTES

CHAPTER 3

INTRODUCTION.

3.1 REFLECTIONS ON THE DIFFERENT DEGREES OF ENJOYMENT PRESENTED TO US BY THE ASPECT OF NATURE AND THE STUDY OF HER LAWS.

In attempting, after a long absence from my native country, to develop the physical phenomena of the globe, and the simultaneous action of the forces that pervade the regions of space, I experience a two-fold cause of anxiety. The subject before me is so inexhaustible and so varied, that I fear either to fall into the superficiality of the encyclopedist, or to weary the mind of my reader by aphorisms consisting of mere generalities clothed in dry and dogmatical forms. Undue conciseness often checks the flow of expression, while diffuseness is alike detrimental to a clear and precise exposition of our ideas. Nature is a free domain, and the profound conceptions and enjoyments she awakens within us can only be vividly delineated by thought clothed in exalted forms of speech, worthy of bearing witness to the majesty and greatness of the creation.

In considering the study of physical phenomena, not merely in its bearings on the material wants of life, but in its general influence on the intellectual advancement of mankind, we find its noblest and most important result to be a knowledge of the chain of connection, by which all natural forces are linked together, and made mutually dependent upon each other; and it is the perception of these relations that exalts our views and ennobles our enjoyments. Such a result can, however, only be reaped as the fruit of observation and intellect, combined with the spirit of the age, in which are reflected all the varied phases of thought. He who can trace, through by-gone times, the stream of our knowledge to its primitive source, will learn from history how, for thousands of years, man has labored, amid the ever-recurring changes of form, to recognize the invariability of natural laws, and has thus, by the force of mind, gradually subdued a great portion of the physical world to his dominion. In interrogating the history of the past, we trace the mysterious course of ideas yielding the first glimmering perception of the same image of a Cosmos, or harmoniously ordered whole, which, dimly shadowed forth to the human mind in the primitive ages of the world, is now fully revealed to the maturer intellect of man kind as the result of long and laborious observation.

Each of these epochs of the contemplation of the external world – the earliest dawn of thought and the advanced stage of civilization – has its own source of enjoyment. In the former, this enjoyment, in accordance

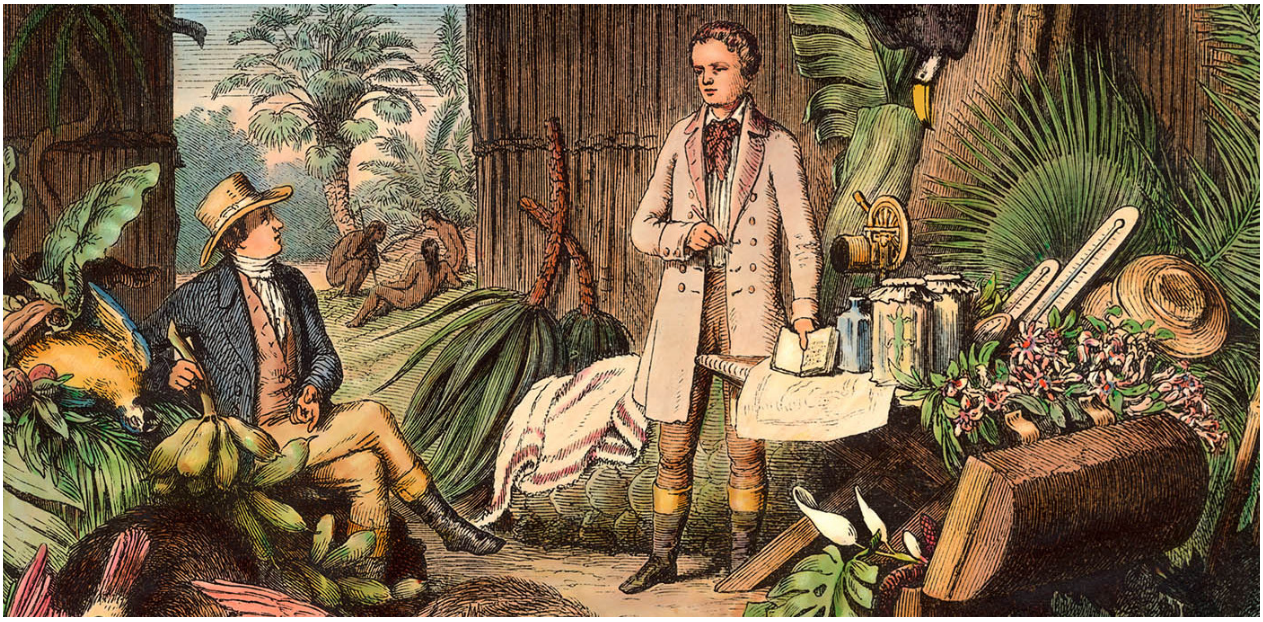


Figure 3.1: Alexander von Humboldt & Aimé Bonpland, Orinocco – Woodcut (1870) of Otto Roth from a drawing by H. Lademann. Image in the public domain.

with the simplicity of the primitive ages, flowed from an intuitive feeling of the order that was proclaimed by the invariable and successive reappearance of the heavenly bodies, and by the progressive development of organized beings; while in the latter, this sense of enjoyment springs from a definite knowledge of the phenomena of nature. When man began to interrogate nature, and, not content with observing, learned to evoke phenomena under definite conditions; when once he sought to collect and record facts, in order that the fruit of his labors might aid investigation after his own brief existence had passed away, the philosophy of Nature cast aside the vague and poetic garb in which she had been enveloped from her origin, and, having assumed a severer aspect, she now weighs the value of observations, and substitutes induction and reasoning for conjecture and assumption. The dogmas of former ages survive now only in the superstitions of the people and the prejudices of the ignorant, or are perpetuated in a few systems, which, conscious of their weakness, shroud themselves in a vail of mystery. We may also trace the same primitive intuitions in languages exuberant in figurative expressions; and a few of the best chosen symbols engendered by the happy inspiration of the earliest ages, having by degrees lost their vagueness through a better mode of interpretation, are still preserved among our scientific terms.

Nature considered rationally, that is to say, submitted to the process of thought, is a unity in diversity of phenomena; a harmony, blending together all created things, however dissimilar in form and attributes; one great whole ($\tau\pi\upsilon$) animated by the breath of life. The most important result of a rational inquiry into nature is, therefore, to establish the unity and harmony of this stupendous mass of force and matter, to determine with impartial justice what is due to the discoveries of the past and to those of the present, and to analyze the individual parts of natural phenomena without succumbing beneath the weight of the whole. Thus, and thus alone, is it permitted to man, while mindful of the high destiny of his race, to comprehend nature, to lift the vail that shrouds her phenomena, and, as it were, submit the results of observation to the test of reason and of intellect.

In reflecting upon the different degrees of enjoyment presented to us in the contemplation of nature, we find that the first place must be assigned to a sensation, which is wholly independent of an intimate acquaintance with the physical phenomena presented to our view, or of the peculiar character of the region surrounding us. In the uniform plain bounded only by a distant horizon, where the lowly heather, the cistus, or waving grasses, deck the soil; on the ocean shore, where the waves, softly rippling over the beach, leave a track, green with the weeds of the sea; every where, the mind is penetrated by the same sense of the grandeur and vast expanse of nature, revealing to the soul, by a mysterious inspiration, the existence of laws that regulate the forces of the universe. Mere communion with nature, mere contact with the free air, exercise a soothing yet strengthening influence on the wearied spirit, calm the storm of passion, and soften the heart when shaken by sorrow to its inmost depths. Every where, in every region of the globe, in every stage of intellectual culture, the same sources of enjoyment are alike vouchsafed to man. The earnest and solemn thoughts awakened by a communion with nature intuitively arise from a presentiment of the order and harmony pervading the whole universe, and from the contrast we draw between the narrow limits of our own existence and the image of infinity revealed on every side, whether we look upward to the starry vault of heaven, scan the farstretching plain before us, or seek to trace the dim horizon across the vast expanse of ocean.

The contemplation of the individual characteristics of the landscape, and of the conformation of the land in any definite region of the earth, gives rise to a different source of enjoyment, awakening impressions that are more vivid, better defined, and more congenial to certain phases of the mind, than those of which we have already spoken. At one time the heart is stirred by a sense of the grandeur of the face of nature, by the strife of the elements, or, as in Northern Asia, by the aspect of the dreary barrenness of the far-stretching steppes; at another time, softer, emotions are excited by the contemplation of rich harvests wrested by the hand of man from the wild fertility of nature, or by the sight of human habitations raised beside some wild and foaming torrent. Here I regard less the degree of intensity than the difference existing in the various sensations that derive their charm and permanence from the peculiar character of the scene.

If I might be allowed to abandon myself to the recollections of my own distant travels, I would instance, among the most striking scenes of nature, the calm sublimity of a tropical night, when the stars, not sparkling, as in our northern skies, shed their soft and planetary light over the gently-heaving ocean; Dr I would recall the deep valleys of the Cordilleras, where the tall and slender palms pierce the leafy vail around them, and waving on high their feathery and arrow-like branches, form, as it were, "a forest above a forest;"[1] or I would describe the summit of the Peak of Teneriffe, when a horizontal layer of clouds, dazzling in whiteness, has separated the cone of cinders from the plain below, and suddenly the ascending current pierces the cloudy vail, so that the eye of the traveler may range from the brink of the crater, along the vine-clad slopes of Orotava, to the orange gardens and banana groves that skirt the shore. In scenes like these, it is not the peaceful charm uniformly spread over the face of nature that moves the heart, but rather the peculiar physiognomy and conformation of the land, the features of the landscape, the ever-varying outline of the clouds, and their blending with the horizon of the sea, whether it lies spread before us like a smooth and shining mirror, or is dimly seen through the morning mist. All that the senses can but imperfectly comprehend, all that is most awful in such romantic scenes of nature, may become i source of enjoyment to man, by opening a wide field to the creative powers of his imagination. Impressions change with the varying movements of the mind, and we are led by a happy illusion to believe that we receive from the external world that with which we have ourselves invested it.

When far from our native country, after a long voyage, we read for the first time the soil of a tropical land, we expedience a certain feeling of surprise and gratification in recognizing, in the rocks that surround us, the same inclined schistose strata, and the same columnar basalt covered with cellular amygdaloids, that we had left in Europe, and whose identity of character, in latitudes so widely different, reminds us that the solidification of the earth's crust is altogether independent of climatic influences. But these rocky masses of schist and of basalt are covered with vegetation of a character with which we are unacquainted, and of a physiognomy wholly unknown, to us; and it is then, amid the colossal and majestic forms of an exotic flora, that we feel how wonderfully the flexibility of our nature fits us to receive new impressions, linked together by a certain secret analogy. We so readily perceive the affinity existing among all the forms of organic life, thai although the sight of a vegetation similar to that of our native country might at first be most welcome to the eye, as the sweet familiar sounds of our mother tongue are to the ear, we nevertheless, by degrees, and almost imperceptibly, become familiarized with a new home and a new climate. As a true citizen of the world, man every where habituates himself to that which surrounds him; yet fearful, as it were, of breaking the links of association that bind him to the home of his childhood, the colonist applies to some few plants in a far-distant clime the names he had been familiar with in his native land; and by the mysterious relations existing among all types of organization, the forms of exotic vegetation present themselves to his mind as nobler and more perfect developments of those he had loved in earlier days. Thus do the spontaneous impressions of the untutored mind lead, like the laborious deductions of cultivated intellect, to the same intimate persuasion, that one sole and indissoluble chain binds together all nature.

It may seem a rash attempt to endeavor to separate, into its different elements, the magic power exercised upon our minds by the physical world, since the character of the landscape, and of every imposing scene in nature, depends so materially upon the mutual relation of the ideas and sentiments simultaneously excited in the mind of the observer.

The powerful effect exercised by nature springs, as it were, from the connection and unity of the impressions and emotions produced; and we can only trace their different sources by analyzing the individuality of objects and the diversity of forces.

The richest and most varied elements for pursuing an analysis of this nature present themselves to the eyes of the traveler in the scenery of Southern Asia, in the Great Indian Archipelago, and more especially, too, in the New Continent, where the summits of the lofty Cordilleras penetrate the confines of the aerial ocean surrounding our globe, and where the same subterranean forces that once raised these mountain chains still shake them to their foundation and threaten their downfall.

Graphic delineations of nature, arranged according to systematic views, are not only suited to please the imagination, but may also, when properly considered, indicate the grades of the impressions of which I have spoken, from the uniformity of the sea-shore, or the barren steppes of Siberia, to the inexhaustible fertility of the torrid zone. If we were even to picture to ourselves Mount Pilatus placed on the Schreckhorn,[2] or the Schneekoppe of Silesia on Mont Blanc, we should not have attained to the height of that great Colossus of the Andes, the Chimborazo, whose height is twice that of Mount Ætna; and we must pile the Righi, or Mount Athos, on the summit of the Chimborazo, in order to form a just estimate of the elevation of the Dhawalagiri, the highest point of the Himalaya. But although the mountains of India greatly surpass the Cordilleras of South America by their astonishing elevation (which, after being long contested, has at last been confirmed by accurate measurements), they can not, from their geographical position, present the same inexhaustible variety of phenomena by which the latter are characterized. The impression produced by the grander aspects of nature does not depend exclusively on height. The chain of the Himalaya is placed far beyond the limits of the torrid zone, and scarcely is a solitary palm-tree to be found in the beautiful valleys of Kumaoun and Garhwal.[3] On the southern slope of the ancient Paropamisus, in the latitudes of $28°$ and $34°$, nature no longer displays the same abundance of tree-ferns and arborescent grasses, heliconias and orchideous plants, which in tropical regions are to be found even on the highest plateaux of the mountains. On the slope of the Himalaya, under the shade of the Deodora and the broad-leaved oak, peculiar to these Indian Alps, the rocks of granite and of mica schist are covered with vegetable forms almost similar to those which characterize Europe and Northern Asia. The species are not identical, but closely analogous in aspect and physiognomy, as, for instance, the juniper, the alpine birch, the gentian, the marsh parnassia, and the prickly species of Ribes.[4] The chain of the Himalaya is also wanting in the imposing phenomena of volcanoes, which in the Andes and in the Indian Archipelago often reveal to the inhabitants, under the most terrific forms, the existence of the forces pervading the interior of our planet.

Moreover, on the southern declivity of the Himalaya, where the ascending current deposits the exhalations rising from a vigorous Indian vegetation, the region of perpetual snow begins at an elevation of 11,000 or 12,000 feet above the level of the sea [5] thus setting a limit to the development of organic life in a zone that is nearly 3000 feet lower than that to which it attains in the equinoctial region of the Cordilleras.

But the countries bordering on the equator possess another advantage, to which sufficient attention has not hitherto been directed. This portion of the surface of the globe affords in the smallest space the greatest possible variety of impressions from the contemplation of nature. Among the colossal mountains of Cundinamarca, of Quito, and of Peru, furrowed by deep ravines, man is enabled to contemplate alike all the families of plants, and all the stars of the firmament. There, at a single glance, the eye surveys majestic palms, humid forests of bambusa, and the varied species of Musaceae, while above these forms of tropical vegetation appear oaks, medlars, the sweet-brier, and umbelliferous plants, as in our European homes. There, as the traveler turns his eyes to the vault of heaven, a single glance embraces the constellation of the Southem Cross, the Magellanic clouds, and the guiding stars of the constellation of the Bear, as they circle round the arctic pole. There the depths of the earth and the vaults of heaven display all the richness of their forms and the variety of their phenomena. There the different climates are ranged the one above the other, stage by stage, like the vegetable zones, whose succession they limit; and there the observer may readily trace the laws that regulate the diminution of heat, as they stand indelibly inscribed on the rocky walls and abrupt declivities of the Cordilleras.

Not to weary the reader with the details of the phenomena which I long since endeavored graphically to represent,[6] I will here limit myself to the consideration of a few of the general results whose combination constitutes the *physical delineation of the torrid zone*. That which, in the vagueness of our impressions, loses all distinctness of form, like some distant mountain shrouded from view by a vail of mist, is clearly revealed by the light of mind, which, by its scrutiny into the causes of phenomena, learns to resolve and analyze their different elements, assigning to each its individual character. Thus, in the sphere of natural investigation, as in poetry and painting, the delineation of that which appeals most strongly to the imagination, derives its collective interest from the vivid truthfulness with which the individual features are portrayed.

The regions of the torrid zone not only give rise to the most powerful impressions by their organic richness and their abundant fertility, but they likewise afford the inestimable advantage of revealing to man, by the uniformity of the variations of the atmosphere and the development of vital forces, and by the contrasts of climate and vegetation exhibited at different elevations, the invariability of the laws that regulate the course of the heavenly bodies, reflected, as it were, in terrestrial phenomena. Let us dwell, then, for a few moments, on the proofs of this regularity, which is such that it may be submitted to numerical calculation and computation.

In the burning plains that rise but little above the level of the sea, reign the families of the banana, the cycas, and the palm, of which the number of species comprised in the flora of tropical regions has been so wonderfully increased in the present day by the zeal of botanical travelers. To these groups succeed, in the Alpine valleys, and the humid and shaded clefts on the slopes of the Cordilleras, the tree-ferns, whose thick cylindrical trunks and delicate lace-like foliage stand out in bold relief against the azure of the sky, and the cinchona, from which we derive the febrifuge bark. The medicinal strength of this bark is said to increase in proportion to the degree of moisture imparted to the foliage of the tree by the light mists which form the upper surface of the clouds resting over the plains. Every where around, the confines of the forest are encircled by broad bands of social plants, as the delicate aralia, the thibaudia, and the myrtle-leaved Andromeda, while the Alpine rose, the magnificent befaria, weaves a purple girdle round the spiry peaks. In the cold regions of the Paramos, which is continually exposed to the fury of storms and winds, we find that flowering shrubs and herbaceous plants, bearing large and variegated blossoms, hs’fe given place to monocotyledons, whose slender spikes constitute the sole covering of the soil. This is the zone of the grasses, one vast savannah extending over the immense mountain plateaux, and reflecting a yellow, almost golden tinge, to the slopes of the Cordilleras, on which graze the lama and the cattle domesticated by the European colonist. Where the naked trachyte rock pierces the grassy turf, and penetrates into those higher strata of air which are supposed to be less charged with carbonic acid, we meet only with plants of an inferior organization, as lichens, lecideas, and the brightly-colored, dustlike lepraria, scattered around in circular patches. Islets of fresh-fallen snow, varying in form and extent, arrest the last feeble traces of vegetable development, and to these succeeds the region of perpetual snow, whose elevation undergoes but little change, and may be easily determined. It is but rarely that the elastic forces at work within the interior of our globe have succeeded in breaking through the spiral domes, which, resplendent in the brightness of eternal snow, crown the summits of the Cordilleras; and even where these subterranean forces have opened a permanent communication with the atmosphere, through circular craters or long fissures, they rarely send forth currents of lava, but merely eject ignited scoriae, steam, sulphureted hydrogen gas, and jets of carbonic acid.

In the earliest stages of civilization, the grand and imposing spectacle presented to the minds of the inhabitants of the tropics could only awaken feelings of astonishment and awe. It might, perhaps, be supposed, as we have already said, that the periodical return of the same phenomena, and the uniform manner in which they arrange themselves in successive groups, would have enabled man more readily to attain to a knowledge of the laws of nature; but, as far as tradition and history guide us, we do not find that any application was made of the advantages presented by these favored regions. Recent researches have rendered it very doubtful whether the primitive seat of Hindoo civilization – one of the most remarkable phases m the progress of mankind – was actually within the tropics Airyana Vaedjo, the ancient cradle of the Zend, was situated to the northwest of the upper Indus, and after the great religious schism, that is to say, after the separation of the Iranians from the Brahminical institution, the language that have previously been common to them and to the Hindoos assumed among the latter people (together with the literature, habitat, and condition of society) an individual form in the Magodha or Madhya Desa,[7] a district that is bounded by the great chain of Himalaya and the smaller range of the Vindhya. In less ancient times the Sanscrit language and civilization advanced toward the southeast, penetrating further within the torrid zone, as my brother Wilhelm von Humboldt has shown in his great work on the Kavi and other languages of analogous structure,[8]

Notwithstanding the obstacles opposed in northern latitudes to the discovery of the laws of nature, owing to the excessive complication of phenomena, and the perpetual local variations that, in these climates, affect the movements of the atmosphere and the distribution of organic forms, it is to the inhabitants of a small section of the temperate zone that the rest of mankind owe the earliest revelation of an intimate and rational acquaintance with the forces governing the physical world. Moreover, it is from the same zone (which is apparently more favorable to the progress of reason, the softening of manners, and the security of public liberty) that the germs of civilization have been carried to the regions of the tropics, as much by the migratory movement of races as by the establishment of colonies, differing widely in their institution from those of the Phœnicians or Greeks.

In speaking of the influence exercised by the succession of phenomena on the greater or lesser facility of recognizing the causes producing them, I have touched upon that important stage of our communion with the external world, when the enjoyment arising from a knowledge of the laws, and the mutual connection of phenomena, associates itself with the charm of a simple contemplation of nature. That which for a long time remains merely an object of vague intuition, by degrees acquires the certainty of positive truth; and man, as an immortal poet has said, in our own tongue – Amid ceaseless change seeks the unchanging pole.[9]

In order to trace to its primitive source the enjoyment derived from the exercise of thought, it is sufficient to cast a rapid glance on the earliest dawnings of the philosophy of nature, pr of the ancient doctrine of the Cosmos. We find even among the most savage nations (as my own travels enable me to attest) a certain vague, terror-stricken sense of the all-powerful unity of natural forces, and of the existence of an invisible, spiritual essence manifested in these forces, whether in unfolding the flower and maturing the fruit of the nutrient tree, in upheaving the soil of the forest, or in rending the clouds with the might of the storm. We may here trace the revelation of a bond of union, linking together the visible world and that higher spiritual world which escapes the grasp of the senses. The two become unconsciously blended together, developing in the mind of man, as a simple product of ideal conception, and independently of the aid of observation, the first germ of a Philosophy of Nature.

Among nations least advanced in civilization, the imagination revels in strange and fantastic creations, and, by its predilection for symbols, alike influences ideas and language. Instead of examining, men are led to conjecture, dogmatize, and interpret supposed facts that have never been observed. The inner world of thought and of feeling does not reflect the image of the external world in its primitive purity. That which in some regions of the earth manifested itself as the rudiments of natural philosophy, only to a small number of persons endowed with superior intelligence, appears in other regions, and among entire races of men, to be the result of mystic tendencies and instinctive intuitions. An intimate communion with nature, and the vivid and deep emotions thus awakened, are likewise the source from which have sprung the first impulses toward the worship and deification of the destroying and preserving forces of the universe. But by degrees, as man, after having passed through the different gradations of intellectual development, arrives at the free enjoyment of the regulating power of reflection, and learns by gradual progress, as it were, to separate the world of ideas from that of sensations, he no longer rests satisfied merely with a vague presentiment of the harmonious unity of natural forces; thought begins to fulfill its noble mission; and observation, aided by reason, endeavors to trace phenomena to the causes from which they spring.

The history of science teaches us the difficulties that have opposed the progress of this active spirit of inquiry. Inaccurate and imperfect observations have led, by false inductions, to the great number of physical views that have been perpetuated as popular prejudices among all classes of society. Thus by the side of a solid and scientific knowledge of natural phenomena there has been preserved a system of the pretended results of observation, which is so much the more difficult to shake, as it denies the validity of the facts by which it may be refuted. This empiricism, the melancholy heritage transmitted to us from former times, invariably contends for the truth of its axioms with the arrogance of a narrow-minded spirit. Physical philosophy, on the other hand, when based upon science, doubts because it seeks to investigate, distinguishes between that which is certain and that which is merely probable, and strives incessantly to perfect theory by extending the circle of observation.

This assemblage of imperfect dogmas, bequeathed by one age to another – this physical philosophy, which is composed of popular prejudices – is not only injurious because it perpetrates error with the obstinacy engendered by the evidence of ill-observed facts, but also because it hinders the mind from attaining to higher views of nature. Instead of seeking to discover the mean or medium point, around which oscillate, in apparent independence of forces, all the phenomena of the external world, this system delights in multiplying exceptions to the law, and seeks, amid phenomena and in organic forms, fur something beyond the marvel of a regular succession, and an internal and progressive development. Ever inclined to believe that the order of nature is disturbed, it refuses to recognize in the present any analogy with the past, and, guided by its own varying hypotheses, seeks at hazard, either in the interior of the globe or in the regions of space, for the cause of these pretended perturbations.

It is the special object of the present work to combat those errors which derive their source from a vicious empiricism and from imperfect inductions. The higher enjoyments yielded by the study of nature depend upon the correctness and the depth of our views, and upon the extent of the subjects that may be comprehended in a single glance. Increased mental cultivation has given rise, in all classes of society, to an increased desire of embellishing life by augmenting the m.ass of ideas, and by multiplying means for their generalization; and this sentiment fully refutes the vague accusations advanced against the age in which we live, showing that other interests, besides the material wants of life, occupy the minds of men.

It is almost with reluctance that I am about to speak of a sentiment, which appears to arise from narrow-minded views, or from a certain weak and morbid sentimentality – I allude to the fear entertained by some persons, that nature may by degrees lose a portion of the charm and magic of her power, as we learn more and more how to unvail her secrets, comprehend the mechanism of the movements of the heavenly bodies, and estimate numerically the intensity of natural forces It is true that, properly speaking, the forces of nature can only exercise a magical power over us as long as their action is shrouded in mystery and darkness, and does not admit of being classed among the conditions with which experience has made us acquainted. The effect of such a power is, therefore, to excite the imagination, but that, assuredly, is not the faculty of mind we would evoke to preside over the laborious and elaborate observations by which we strive to attain to a knowledge of the greatness and excellence of the laws of the universe.

The astronomer who, by the aid of the heliometer or a double-refracting prism,[10] determines the diameter of planetary bodies; who measures patiently, year after year, the meridian altitude and the relative distances of stars, or who seeks a telescopic comet in a group of nebulae, does not feel his imagination more excited – and this is the very guarantee of the precision of his labors – than the botanist who counts the divisions of the calyx, or the number of stamens in a flower, or examines the connected or the separate teeth of the peristoma surrounding the capsule of a moss. Yet the multiplied angular measurements on the one hand, and the detail of organic relations on the other, alike aid in preparing the way for the attainment of higher views of the laws of the universe.

We must not confound the disposition of mind in the observer at the time he is pursuing his labors, with the ulterior greatness of the views resulting from investigation and the exercise of thought. The physical philosopher measures with admirable sagacity the waves of light of unequal length which by interference mutually strengthen or destroy each other, even with respect to their chemical actions; the astronomer, armed with powerful telescopes, penetrates the regions of space, contemplates, on the extremest confines of our solar system, the satellites of Uranus, or decomposes faintly sparkling points into double stars differing in color. The botanist discovers the constancy of the gyratory motion of the chara in the greater number of vegetable cells, and recognizes in the genera and natural families of plants the intimate relations of organic forms. The vault of heaven, studded with nebula and stars, and the rich vegetable mantle that covers the soil in the climate of palms, can not surely fail to produce on the minds of these laborious observers of nature an impression more imposing and more worthy of the majesty of creation than on those who are unaccustomed to investigate the great mutual relations of phenomena. I can not, therefore, agree with Burke when he says, "it is our ignorance of natural things that causes all our admiration, and chiefly excites our passions."

While the illusion of the senses would make the stars stationary in the vault of heaven. Astronomy, by her aspiring labors, has assigned indefinite bounds to space; and if she have set limits to the great nebula to which our solar system belongs, it has only been to show us in those remote regions of space, which appear to expand in proportion to the increase of our optic powers, islet on islet of scattered nebulae. The feeling of the sublime, so far as it arises from a contemplation of the distance of the stars, of their greatness and physical extent, reflects itself in the feeling of the infinite, which belongs to another sphere of ideas included in the domain of mind. The solemn and imposing impressions excited by this sentiment are owing to the combination of which we have spoken, and to the analogous character of the enjoyment and emotions awakened in us, whether we float on the surface of the great deep, stand on some lonely mountain summit enveloped in the half-transparent vapory vail of the atmosphere, or by the aid of powerful optical instruments scan the regions of space, and see the remote nebulous mass resolve itself into worlds of stars.

The mere accumulation of unconnected observations of details, devoid of generalization of ideas, may doubtlessly have tended to create and foster the deeply-rooted prejudice, that the study of the exact sciences must necessarily chill the feelings, and diminish the nobler enjoyments attendant upon a contemplation of nature. Those who still cherish such erroneous views in the present age, and amid the progress of public opinion, and the advancement of all branches of knowledge, fail in duly appreciating the value of every enlargement of the sphere of intellect, and the importance of the detail of isolated facts in leading us on to general results. The fear of sacrificing the free enjoyment of nature, under the influence of scientific reasoning, is often associated with an apprehension that every mind may not be capable of grasping the truths of the philosophy of nature. It is certainly true that in the midst of the un versal fluctuation of phenomena and vital forces – in that inextricable net-work of organisms "by turns developed and destroyed – each step that we make in the more intimate knowledge of nature leads us to the entrance of new labyrinths; but the excitement produced by a presentiment of discovery, the vague intuition of the mysteries to be unfolded, and the multiplicity of the paths before us, all tend to stimulate the exercise of thought in every stage of knowledge. The discovery of each separate law of nature leads to the establishment of some other more general law, or at least indicates to the intelligent observer its existence. Nature, as a celebrated physiologist[11] has defined it, and as the word was interpreted by the Greeks and Romans, is "that which is ever growing and ever unfolding itself in new forms."

The series of organic types becomes extended or perfected in proportion as hitherto unknown regions are laid open to our view by the labors and researches of travelers and observers; as living organisms are compared with those which have disappeared in the great revolutions of our planet; and as microscopes are made more perfect, and are more extensively and efficiently employed. In the midst of this immense variety, and this periodic transformation of animal and vegetable productions, we see incessantly revealed the primordial mystery of all organic development, that same great problem of metamorphosis which Göthe has treated with more than common sagacity, and to the solution of which man is urged by his desire of reducing vital forms; to the smallest number of fundamental types. As men contemplate the riches of nature, and see the mass of observations incessantly increasing before them, they become impressed with the intimate conviction that the surface and the interior of the earth, the depths of the ocean, and the regions of air will still, when thousands and thousands of years have passed away, open to the scientific observer untrodden paths of discovery. The regret of Alexander can not be applied to the progress of observation and intelligence.[12] General considerations, whether they treat of the agglomeration of matter in the heavenly bodies, or of the geographical distribution of terrestrial organisms, are not only in themselves more attractive than special studies, but they also afford superior advantages to those who are unable to devote much time to occupations of this nature. The different branches of the study of natural history are only accessible in certain positions of social life, and do not, at every season and in every climate, present like enjoyments. Thus, in the dreary regions of the north, man is deprived for a long period of the year of the spectacle presented by the activity of the productive forces of organic nature; and if the mind be directed to one sole class of objects, the most animated narratives of voyages in distant lands will fail to interest and attract us, if they do not touch upon the subjects to which we are most partial.

As the history of nations – if it were always able to trace events to their true causes – might solve the ever-recurring enigma of the oscillations experienced by the alternately progressive and retrograde movement of human society, so might also the physical description of the world, the science of the Cosmos, if it were grasped by a powerful intellect, and based upon a knowledge of all the results of discovery up to a given period, succeed in dispelling a portion of the contradictions which, at first sight, appear to arise from the complication oi phenomena and the multitude of the perturbations simultaneously manifested.

The knowledge of the laws of nature, whether we can trace them in the alternate ebb and flow of the ocean, in the measured path of comets, or in the mutual attractions of multiple stars, alike increases our sense of the calm of nature, while the chimera so long cherished by the human mind in its early and intuitive contemplations, the belief in a "discord of the elements,"seems gradually to vanish in proportion as science extends her empire. General views lead us habitually to consider each organism as a part of the entire creation, and to recognize in the plant or the animal not merely an isolated species, but a form linked in the chain of being to other forms either living or extinct. They aid us in comprehending the relations that exist between the most recent discoveries and those which have prepared the way for them. Although fixed to one point of space, we eagerly grasp at a knowledge of that which has been observed in different and far-distant regions. We delight in tracking the course of the bold mariner through seas of polar ice, or in following him to the summit of that volcano of the antarctic pole, whose fires may be seen from afar, even at mid-day. It is by an acquaintance with the results of distant voyages that we may learn to comprehend some of the marvels of terrestrial magnetism, and be thus led to appreciate the importance of the establishments of the numerous observatories which in the present day cover both hemispheres, and are designed tp note the simultaneous occurrence of perturbations, and the frequency and duration of magnetic storms.

Let me be permitted here to touch upon a few points connected with discoveries, whose importance can only be estimated by those who have devoted themselves to the study of the physical sciences generally. Examples chosen from among the phenomena to which special attention has been directed in recent times, will throw additional light upon the preceding considerations. Without a preliminary knowledge of the orbits of comets, we should be unable duly to appreciate the importance attached to the discovery of one of these bodies, whose elliptical orbit is included in the narrow limits of our solar system, and which has revealed the existence of an ethereal fluid, tending to diminish its centrifugal force and the period of its revolution.

The superficial half-knowledge, so characteristic of the present day, which leads to the introduction of vaguely comprehended scientific views into general conversation, also gives rise, under various forms, to the expression of alarm at the supposed danger of a collision between the celestial bodies, or of disturbance in the climatic relations of our globe. These phantoms of the imagination are so much the more injurious as they derive their source from dogmatic pretensions to true science. The history of the atmosphere, and of the annual variations of its temperature, extends already sufficiently far back to show the recurrence of slight disturbances in the mean temperature of any given place, and thus affords sufficient guarantee against the exaggerated apprehension of a general and progressive deterioration of the climates of Europe. Encke's comet, which is one of the three interior comets, completes its course in 1200 days, biit from the form and position of its orbit it is as little dangerous to the earth as Halley's great comet, whose revolution is not completed in less than seventy-six years (and which appeared less brilliant in 1835 than it had done in 1759): the interior comet of Biela intersects the earth's orbit, it is true, but it can only approach our globe when its proximity to the sun coincides with our winter solstice.

The quantity of heat received by a planet, and whose unequal distribution determines the meteorological variations of its atmosphere, depends alike upon the light-engendering force of the sun; that is to say, upon the condition, of its gaseous coverings, and upon the relative position of the planet and the cential body.

There are variations, it is true, which, in obedience to the laws of universal gravitation, affect the form of the earth's orbit and the inclination of the ecliptic, that is, the angle which the axis of the earth makes with the plane of its orbit; but these periodical variations are so slow, and are restricted within such narrow limits, that their therinic effects would hardly be appreciable by our instruments in many thousands of years. The astronomical causes of a refrigeration of our globe, and of the diminution of moisture at its surface, and the nature and frequency of certain epidemics – phenomena which are often discussed in the present day according to the benighted views of the Middle Ages – ought to be considered as beyond the range of our experience in physics and chemistry.

Physical astronomy presents us with other phenomena, which can not be fully comprehended in all their vastness without a previous acquirement of general views regarding the forces that govern the universe. Such, for instance, are the innumerable double stars, or rather suns, which revolve round one common center of gravity, and thus reveal in distant worlds the existence of the Newtonian law; the larger or smaller number of spots upon the sun, that is to say, the openings formed through the luminous and opaque atmosphere surrounding the solid nucleus; and the regular appearance, about the 13th of November and the 11th of August, of shooting stars, which probably form part of a belt of asteroids, intersecting the earth's orbit, and moving with planetary velocity.

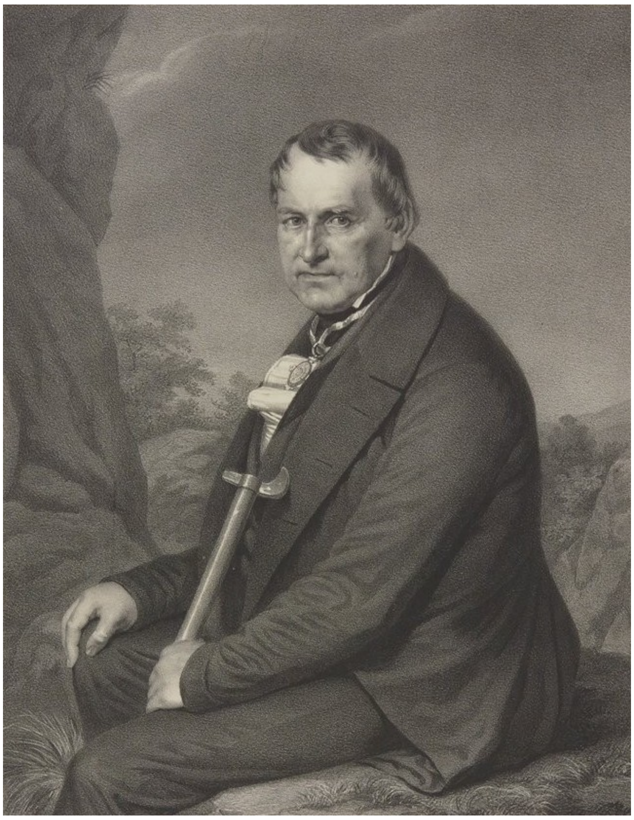


Figure 3.2: Christian Leopold von Buch (26 April 1774 – 4 March 1853) was a German geologist and paleontologist and is remembered as one of the most important contributors to geology in the first half of the nineteenth century. (From Wikipedia). Image: Lithograph by C. Fischer based on a painting by Carl Joseph Begas, 1850. Public domain.

Descending from the celestial regions to the earth, we would fain inquire into the relations that exist between the oscillations of the pendulum in air (the theory of which has been perfected by Bessel) and the density of our planet; and how the pendulum, acting the part of a plummet, can, to a certain extent, throw light upon the geological constitution of strata at great depths 1 By means of this instrument we are enabled to trace the striking analogy which exists between the formation of the granular rocks composing the lava currents ejected from active volcanoes, and those endogenous masses of granite, porphyry, and serpentine, which, issuing from the interior of the earth, have broken,

Figure 3.3: Aimé Jacques Alexandre Bonpland (22 August 1773 – 11 May 1858) was a French explorer and botanist who traveled with Humboldt in Latin America from 1799 to 1804. He co-authored volumes of the scientific results of their expedition. Portrait of Bonpland in the public domain.

as eruptive rocks, through the secondary strata, and modified them by contact, either in rendering them harder by the introduction of silex, or reducing them into dolomite, or, finally, by inducing within them the formation of crystals of the most varied composition. The elevation of sporadic islands, of domes of trachyte, and cones of basalt, by the elastic forces emanating from the fluid interior of our globe, has led one of the first geologists of the age, Leopold von Buch, to the theory of the elevation of continents, and of mountain chains generally. This action of subterranean forces in breaking through and elevating strata of sedimentary rocks, of which the coast of Chile, in consequence of a great earthquake, furnished a recent example, leads to the assumption that the pelagic shells found by M. Bonpland and myself on the ridge of the Andes, at an elevation of more than 15,000 English feet, may have been conveyed to so extraordinary a position, not by a rising of the ocean, but by the agency of volcanic forces capable of elevating into ridges the softened crust of the earth.

I apply the term volcanic in the widest sense of the word, to every action exercised by the interior of a planet on its external crust. The surface of our globe, and that of the moon, manifest traces of this action, which in the former, at least, has varied during the course of ages. Those who are ignorant of the fact that the internal heat of the earth increases so rapidly with the increase of depth that granite is m a state of fusion about twenty or thirty geographical miles below the surface,[13] can not have a clear conception of the causes, and the simultaneous occurrence of volcanic eruptions at places widely removed from one another, or of the extent and intersection of circles of commotion in earthquakes, or of the uniformity of temperature, and equality of chemical composition observed in thermal springs during a long course of years. The quantity of heat peculiar to a planet is, however, a matter of such importance – being the result of its primitive condensation, and varying according to the nature and duration of the radiation – that the study of this subject may throw some degree of light on the history of the atmosphere, and the distribution of the organic bodies imbedded in the solid crust of the earth. This study enables us to understand how a tropical temperature, independent of latitude (that is, of the distance from the poles), may have been produced by deep fissures remaining open, and exhaling heat from the interior of the globe, at a period when the earth's crust was still furrowed and rent, and only in a state of semi-solidilication; and a primordial condition is thus revealed to us, in which the temperature of the atmosphere, and climates generally, were owing rather to a liberation of caloric and of different gaseous emanations (that is to say, rather to the energetic reaction of the interior on the exterior) than to the position of the earth with respect to the central body, the sun.

The cold regions of the earth contain, deposited in sedimentary strata, the products of tropical climates; thus, in the coal formations, we find the trunks of palms standing upright amid Coniferae, tree ferns, goniatites, and fishes having rhomboidal osseous scales;[14] in the Jura limestone, colossal skeletons of crocodiles, plesiosauri, planulites, and stems of the cycadeae; in the chalk formations, small polythalamia and bryozoa, whose species still exist in our seas; in tripoli, or polishing slate, in the semi-opal and the farina-like opal or mountain meal, agglomerations of siliceous infusoria, which have been brought to light by the powerful microscope of Ehrenberg[15] and, lastly, in transported soils, and in certain caves, the bones of elephants, hyenas, and lions. An intimate acquaintance with the physical phenomena of the universe leads us to regard the products of warm latitudes that are thus found in a fossil condition in northern regions not merely as incentives to barren curiosity, but as subjects awakening leep reflection, and opening new sources of study.

The number and the variety of the objects I have alluded t;o give rise to the question whether general considerations of physical phenomena can be made sufficiently clear to persons who have not acquired a detailed and special knowledge of descriptive natural history, geology, or mathematical astronomy? I think we ought to distinguish here between him whose task it is to collect the individual details of various observations, and study the mutual relations existing among them, and him to whom these relations are to be revealed, under the form of general results. The former should be acquainted with the specialities of phenomena, that he may arrive at a generalization of ideas as the result, at least in part, of his own observations, experiments, and calculations. It can not be denied, that where there is an absence of positive knowledge of physical phenomena, the general results which impart so great a charm to the study of nature can not all be made equally clear and intelligible to the reader, but still I venture to hope, that in the work which I am now preparing on the physical laws of the universe, the greater part of the facts advanced can be made manifest without the necessity of appealing to fundamental views and principles. The picture of nature thus drawn, notwithstanding the want of distinctness of some of its outlines, will not be the less able to enrich the intellect, enlarge the .sphere of ideas, and nourish and vivify the imagination.

There is, perhaps, some truth in the accusation advanced against many German scientific works, that they lessen the value of general views by an accumulation of detail, and do not sufficiently distinguish between those great results which form, as it were, the beacon lights of science, and the long series of means by which they have been attained. This method of treating scientific subjects led the most illustrious of our poets[16] to exclaim with impatience, "The Germans have the art of making science inaccessible."An edifice can not produce a striking efTect until the scaffolding is removed, that had of necessity been used during its erection. Thus the uniformity of figure observed in the distribution of continental masses, which all terminate toward the south in a pyramidal form, and expand toward the north (a law that determines the nature of climates, the direction of currents in the ocean and the atmosphere, and the transition of certain types of tropical vegetation toward the southern temperate zone), may be clea,rly apprehended without any knowledge of the geodesical and astronomical operations by means of which these pyramidal forms of continents have been determined. In like manner, physical geography teaches us by how many leagues the equatorial aids exceeds the polar axis of the globe, and shows us the mean equality of the flattening of the two hemispheres, without entailing on us the necessity of giving the detail of the measurement of the degrees in the meridian, or the observations on the pendulum, which have led us to know that the true figure of our globe is not exactly that of a regular ellipsoid of revolution, and that this irregularity is reflected in the corresponding irregularity of the movements of the moon.

The views of comparative geography have been specially enlarged by that admirable work, *Erdkunde im Verhdltniss zur Natur und zur Geschichte*, in which Carl Ritter so ably delineates the physiognomy of our globe, and shows the influence of its external configuration on the physical phenomena on its surface, on the migrations, laws, and manners of nations, and on all the principal historical events enacted upon the face of the earth.

France possesses an immortal work, *L' Exposition du Systeme du Monde*, in which the author has combined the results of the highest astronomical and mathematical labors, and presented them to his readers free from all processes of demonstration. The structure of the heavens is here reduced to the simple solution of a great problem in mechanics; yet Laplace's work has never yet been accused of incompleteness and want of profundity.

The distinction between dissimilar subjects, and the separaition of the general from the special, are not only conducive to the attainment of perspicuity in the composition of a physical history of the universe, but are also the means by which a, character of greater elevation may be imparted to the study of nature. By the suppression of all unnecessary detail, the great masses are better seen, and the reasoning faculty is enabled to grasp all that might otherwise escape the limited range of the senses.

The exposition of general results has, it must be owned, been singularly facilitated by the happy revolution experienced since t he close of the last century, in the condition of all the special i-ciences, more particularly of geology, chemistry, and descrip'ive natural history. In proportion as laws admit of more general application, and as sciences mutually enrich each other, ind by their extension become connected together in more numerous and more intimate relations, the development of general truths may be given with conciseness devoid of superficiality. On being first examined, all phenomena appear to be isolated, and it is only by the result of a multiplicity of observations, combined by reason, that we are able to trace the mutual relations existing between them. If, however, in the present age, which is so strongly characterized by a brilliant course of scientific discoveries, we perceive a want of connection in the phenomena of certain sciences, we may anticipate the revelation of new facts, whose importance will probably be commensurate with the attention directed to these branches of study. Expectations of this nature may be entertained with regard to meteorology, several parts of optics, and to radiating heat, and electro-magnetism, since the admirable discoveries of Melloni and Faraday. A fertile field is here opened to discovery, although the voltaic pile has already taught us the intimate connection existing between electric, magnetic, and chemical phenomena. Who will venture to affirm that we have any precise knowledge, in the present day, of that part of the atmosphere which is not oxygen, or that thousands of gaseous substances affecting our organs may not be mixed with the nitrogen, or, finally, that we have even discovered the whole number of the forces which pervade the universe?

It is not the purpose of this essay on the physical history of the world to reduce all sensible phenomena to a small number of abstract principles, based on reason only. The physical history of the universe, whose exposition I attempt to develop, does not pretend to rise to the perilous abstractions of a purely rational science of nature, and is simply a phydcal geography, combined ivith a description of the regions of space and the bodies occupying them. Devoid of the profoundness of a purely speculative philosophy, my essay on the Cosmos treats of the contemplation of the universe, and is based upon a rational empiricism, that is to say, upon the results of the facts registered by science, and tested by the operations of the intellect. It is within these limits alone that the work, which I now venture to undertake, appertains to the sphere of labor to which I have devoted myself throughout the course of my long scientific career. The path of inquiry is not unknown to me, although it may be pursued by others with greater success. The unity which I seek to attain in the development of the great phenomena of the universe is analogous to that which historical composition is capable of acquiring. All points relating to the accidental individualities, and the essential variations of the actual, whether in the form and arrangement of natural objects in the struggle of man against the elements, or of nations against nations, do not admit of being based only on a rational foundation – that is to say, of being deduced from ideas alone.

It seems to me that a like degree of empiricism attaches to the Description of the Universe and to Civil History; hut in reflecting upon physical phenomena and events, and tracing their causes by the process of reason, we become more and more convinced of the truth of the ancient doctrine, that the forces inherent in matter, and those which govern the moral world, exercise their action under the control of primordial necessity, and in accordance with movements occurring periodically after longer or shorter intervals.

It is this necessity, this occult but permanent connection, this periodical recurrence in the progressive development of forms, phenomena, and events, which constitute nature, obedient to the first impulse imparted to it. Physics, as the term signifies, is limited to the explanation of the phenomena of the material world by the properties of matter. The ultimate object of the experimental sciences is, therefore, to discover laws, and to trace their progressive generalization. All that exceeds this goes beyond the province of the physical description of the universe, and appertains to a range of higher speculative views.

Emanuel Kant, one of the few philosophers who have escaped the imputation of impiety, has defined with rare sagacity the limits of physical explanations, in his celebrated essay On the Theory and Structure of the Heavens, published at Konigsberg in 1755. The study of a science that promises to lead us through the vast range of creation may be compared to a journey in a fardistant land. Before we set forth, we consider, and often with distrust, our own strength, and that of the guide we have chosen. But the apprehensions which have originated in the abundance and the difficulties attached to the subjects we would embrace, recede from view as we remember that with the increase of observations in the present day there has also arisen a more intimate knowledge of the connection existing among all phenomena. It has not unfrequently happened, that the researches made at remote distances have often and unexpectedly thrown light upon subjects which had long resisted the attempts made to explain them within the narrow limits of our own sphere of observation. Organic forms that had long remained isolated, both in the animal and vegetable kingdom, have been connected by the discovery of intermediate links or stages of transition. The geography of beings endowisd with life attains completeness as we see the species, genera, and entire families belonging to one hemisphere, reflected, as it were, in analogous animal and vegetable forms in the opposite hemisphere. These are, so to speak, the equivalents which mutually personate and replace one another in the great series of organisms. These connecting links and stages of transition may be traced, alternately, in a deficiency or an excess of development of certain parts, in the mode of junction of distinct organs, in the differences in the balance of forces, or in a resemblance to intermediate forms which are not permanent, but merely characteristic of certain phases of normal development. Passing from the consideration of beings endowed with life to that of inorganic bodies, we find many striking illustrations of the high state of advancement to which modern geology has attained. We thus see, according to the grand views of Elie de Beaumont, how chains of mountains dividing different climates and floras and different races of men, revea) to us their relative age, both by the character of the sedimentary strata they have uplifted, and by the directions which they follow over the long fissures with which the earth's crust is furrowed. Relations of superposition of trachyte and ol syenitic porphyry, of diorite and of serpentine, which remain in the rich platinum districts of the Oural, and on the south-western declivity of the Siberian Alti, are elucidated bythe observations that have been made on the plateaux of Mexico andAntioquia, and in the unhealthy ravines of Choco. The most important factson which the physical history of the world has been based in modern times,have not been accumulated by chance. It has at length been fullyacknowledged, and the conviction is characteristic of the age, that thenarratives of distant travels, too long occupied in the mere recital ofhazardous adventures, can only be made a source of instruction where thetraveler is acquainted with the condition of the science he would enlarge,and is guided by reason in his researches.

It is by this tendency to generalization, which is only dangerous in its abuse, that a great portion of the physical knowledge already acquired may be made the common property of all classes of society; but, in order to render the instruction imparted by these means commensurate with the importance of the subject, it is desirable to deviate as widely as possible from the imperfect compilations designated, till the close of the eighteenth century, by the inappropriate term of popular knowledge. 1 take pleasure in persuading myself that scientific subjects may be treated of in language at once dignified, grave, and animated, and that those who are restricted within the circumscribed limits of ordinary life, and have long remained strangers to an intimate communion with nature, may thus have opened to them one of the richest sources of enjoyment, by which the mind is invigorated by the acquisition of new ideas. Communion with nature awakens within us perceptive faculties that had long lain dormant; and we thus comprehend at a single glance the influence exercised by physical discoveries on the enlargement of the sphere of intellect, and perceive how a judicious application of mechanics, chemistry, and other sciences may be made conducive to national prosperity.

A more accurate knowledge of the connection of physical phenomena will also tend to remove the prevalent error that o all branches of natural science are not equally important in relation to general cultivation and industrial progress. An arbitrary distinction is frequently made between the various degrees of importance appertaining to mathematical sciences, to the study of organized beings, the knowledge of electromagnetism, and investigations of the general properties of matter in its different conditions of molecular aggregation; and it is not uncommon presumptuously to affix a supposed stigma upon researches of this nature, by terming them "purely theoretical/' forgetting, although the fact has been long attested, that in the observation of a phenomenon, which at first sight appears to be wholly isolated, may be concealed the germ of a great discovery. When Aloysio Galvani first stimulated the nervous fiber by the accidental contact of two heterogeneous metals, his cotemporaries could never have anticipated that the action of the voltaic pile would discover to us, in the alkalies, metals of a silvery luster, so light as to swim on water, and eminently inflammable; or that it would become a powerful instrument of chemical analysis, and at the same time a thermoscope and a magnet. When Huygens first observed, in 1678, the phenomenon of the polarization of light, exhibited in the difference between the two rays into which a pencil of light divides itself in passing through a doubly refracting crystal, it could not have been foreseen that, a century and a half later, the great philosopher. Arago would, by his discovery of chromatic polarization, be led to discern, by means of a small fragment of Iceland spar, whether solar light emanates from a solid body or a gaseous covering, ox whether comets transmit light directly or merely by reflection.[17]

An equal appreciation of all branches of the mathematical, physical, and natural sciences is a special requirement of the present age, in which the material wealth and the growing prosperity of nations are principally based upon a more enlightened employment of the products and forces of nature. The most superficial glance at the present condition of Europe |hows that a diminution, or even a total annihilation of national prosperity, must be the award of those states who shrink with slothful indifierence from the great struggle of rival nations in the career of the industrial arts. It is with nations as with nature, which, according to a happy expression of Göthe[18] "knows no pause in progress and development, and attaches her curse on ,all inaction."The propagation of an earnest and sound knowledge of science can therefore alone avert the dangers of which I have spoken. Man can not act upon nature, or appropriate her forces to his own use, without comprehending their full extent, and having an intimate ac quaintance with the laws of the physical world. Bacon has said that, in human societies, knowledge is power. Both must rise and sink together. But the knowledge that results from the free action of thought is at once the delight and the indestructible prerogative of man; and in forming part of the wealth of mankind, it not unfrequently serves as a substitute for the natural riches, which are but sparingly scattered ovei the earth. Those states which take no active part in the general industrial movement, in the choice and preparation of natural substances, or in the application of mechanics and chemistry, and among whom this activity is not appreciated by all classes of society, will infallibly see their prosperity di minish in proportion as neighboring countries become strengthened and invigorated under the genial influence of arts and sciences.

As in nobler spheres of thought and sentiment, in philosophy, poetry, and the fine arts, the object at which we aim ought to be an inward one – an ennoblement of the intellect – so ought we likewise, in our pursuit of science, to strive after a knowledge of the laws and the principles of unity that pervade the vital forces of the universe; and it is by such a course that physical studies may be made subservient to the prognss of industry, which is a conquest of mind over matter. By a happy connection of causes and effects, we often see the useful linked to the beautiful and the exalted. The improvement of agriculture in the hands of freemen, and on properties of a moderate extent – the flourishing state of the mechanical arts freed from the trammels of municipal restrictions – the increased impetus imparted to commerce by the multiplied means of contact of nations with each other, are all brilliant results of the intellectual progress of mankind, and of the amelioratioff of political institutions, in which this progress is reflected. The picture presented by modern history ought to convince those who are tardy in awakening to the truth of the lesson it teaches.

Nor let it be feared that the marked predilection for the study of nature, and for industrial progress, which is so characteristic of the present age, should necessarily have a tendency to retard the noble exertions of the intellect in the domains of philosophy, classical history, and antiquity, or to deprive the arts by which life is embellished of the vivifying breath of imagination. Where all the germs of civilization are developed beneath the spgis of free institutions and wise legislation, ihere is no cause for apprehending that any one branch of icnowledge should be cultivated to the prejudice of others. All afford the state precious fruits, whether they yield nourishment to man and constitute his physical wealth, or whether, more permanent in their nature, they transmit in the works of mind the glory of nations to remotest posterity. The Spartans, notwithstanding their Doric austerity, prayed the gods to grant them "the beautiful with the good."[19]

I will no longer dwell upon the considerations of the influence exercised by the mathematical and physical sciences on all that appertains to the material wants of social life, for the vast extent of the course on which I am entering forbids me to insist further upon the utility of these appHcations. Accustomed to distant excursions, I may, perhaps, have erred in describing the path before us as more smooth and pleasant than it really is, for such is wont to be the practice of those who delight in guiding others to the summits of lofty mountains: they praise the view even when great part of the distant plains lie hidden by clouds, knowing that this half transparent vapory vail imparts to the scene a certain charm from thus pojver exercised by the imagination over the domain of the senses. In like manner, from the height occupied by the physical history of the world, all parts of the horizon will not appear equally clear and well defined. This indistinctness will not, however, be wholly owing to the present imperfect state of some of the sciences, but in part, likewise, to the unskillfulness of the guide who has imprudently ventured to ascend these lofty summits.

The object of this introductory notice is not, however, solelj to draw attention to the importance and greatness of the phys ical history of the universe, for in the present day these are tor. well understood to be contested, but likewise to prove how, without detriment to the stability of special studies, we may be enabled to generalize our ideas by concentrating them in one common focus, and thus arrive at a point of view from which all the organisms and forces of nature may be seen as one living, active whole, animated by one sole impulse. "Nature,"as Schelling remarks in his poetic discourse on art, "is not an inert mass; and to him who can comprehend her vast sublimity, she reveals herself as the creative Ibrce of the universe – before all time, eternal, ever active, she calls to life all things, whether perishable or imperishable."

By uniting, under one point of view, both the phenomena of our own globe and those presented in the regions of space, we embrace the limits of the science of the Cosmos, and con vert the physical history of the globe into the physical history of the universe, the one term being modeled upon that of the other. .This science of the Cosmos is not, however, to be regarded as a mere encyclopedic aggregation of the most important and general results that have been collected together from special branches of knowledge. These results are noth ing more than the materials for a vast edifice, and their combination can not constitute the physical history of the world, whose exalted part it is to show the simultaneous action and the connecting links of the forces which pervade the universe. The distribution of organic types in different climates and at diflerent elevations – that is to say, the geography of plants and animals – differs as widely from botany and descriptive zoology as geology does from mineralogy, properly so called. The physical history of the universe must not, therefore, be confounded with the Encyclopedias of the Natural Sciences as they have hitherto been compiled, and whose title is aa vague as their limits are ill defined. In the work before us, partial facts will be considered only in relation to the whole"

The higher the point of view, the greater is the necessity for a systematic mode of treating the subject in language at once animated and picturesque.

But thought and language have ever been most intimately allied. If language, by its originality of structure and its native richness, can, in its delineations, interpret thought with grace and clearness, and if, by its happy flexibility, it can paint with vivid truthfulness the objects of the external worldj it reacts at the same time upon thought, and animates it, as it were, with the breath of life. It is this mutual reaction which makes words more than mere signs and forms of thought; and the beneficent influence of a language is most strikingly manifested on its native soil, where it has sprung spontaneously from the minds of the people, whose character it embodies. Proud of a country that seeks to concentrate her strength in intellectual unity, the writer recalls with delight the advantages he has enjoyed in being permitted to express his thoughts in his native language; and truly happy is he who, in attempting to give a lucid exposition of the great phenomena of the universe, is able to draw from the depths of a language, which, through the free exercise of thought, and by the effusions of creative fancy, has for centuries past exercised so powerful an influence over the destinies of man.

3.2 LIMITS AND METHOD OF EXPOSITION OF THE PHYSICAL DESCIIPTION OF THE UNIVERSE.

I have endeavored, in the preceding part of my work, to explain and illustrate, by various examples, how the enjoyments presented by the aspect of nature, varying as they do in the sources from whence they flow, may be multiplied and ennobled by an acquaintance with the connection of phenomena and the laws by which they are regulated. It remains, then, for me to examine the spirit of the method in which the exposition of the physical description of the universe should be conducted, and to indicate the limits of this science in accordance with the views I have acquired in the course of my studies and "travels in various parts of the earth. I trust I may flatter myself with a hope that a treatise of this nature will justify the title I have ventured to adopt for my work, and exonerate me from the reproach of a presumption that would be doubly reprehensible in a scientific discussion.

Before entering upon the delineation of the partial phenomena which are found to be distributed in various groups, 1 would consider a few general questions intimately connected together, and bearing upon the nature of our knowledge of the external world and its different relations, in all epochs of history and in all phases of intellectual advancement. Under this head will be comprised the following considerations:

1. The precise limits of the physical description of the universe, considered as a distinct science.

2. A brief enumeration of the totality of natural phenomena, presented under the form of a general delineation of nature.

3. The influence of the external world on the imagination and feelings, which has acted in modern times as a powerful impulse toward the study of natural science, by giving animation to the description of distant regions and to the delineation of natural scenery, as l'ar as it is characterized by vegetable physiognomy and by the cultivation of exotic plants, and theii arrangement in well- contrasted groups.

4. The history of the contemplation of nature, or the progressive development of the idea of the Cosmos, considered with reference to the historical and geographical facts that have led to the discovery of the connection of phenomena.

The higher the point of view from which natural phenomena may be considered, the more necessary it is to circumscribe the science within its just limits, and to distinguish it from all other analogous or auxiliary studies.

Physical cosmography is founded on the contemplation of all created things – all that exists in space, whether as substances or forces – that is, all the material beings that constitute the universe. The science which I would attempt to define presents itself, therefore, to man, as the inhabitant of the earth, under a two-fold form – as the earth itself and the regions of space. It is with a view of showing the actual character and the independence of the study of physical cosmography, and at the same time indicating the nature of its relations to general fhysics, descriptive natural history, geology, and comparative geography, that I will pause for a few moments to consider that portion of the science of the Cosmos which concerns the earth. As the history of philosophy does not consist of a mere material enumeration of the philosophical views "entertained in different ages, neither should the physical description of the universe be a simple encyclopedic compilation of the sciences we have enumerated. The difficulty of defining the limits of intimately-connected studies has been increased, because for centuries it has been customary to designate various branches of empirical knowledge by terms which admit either of too wide or too limited a definition of the ideas which they were intended to convey, and arc, besides, objectionable from having had a different signification in those classical languages of antiquity from which they have been borrowed. The terms physiology, physics, natural history, geology, and geography arose, and were commonly used, long before clear ideas were entertained of the diversity of objects embraced by these sciences, and consequently of their reciprocal limitation. Such is the influence of long habit upon language, that by one of the nations of Europe most advanced in civilization the word "physic"is applied to medicine, while in a society of justly deserved universal reputation, technical chemistry, geology, and astronomy (purely experimental sciences) are comprised under the head of "Philosophical Transactions."

An attempt has often been made, and almost always in vain, to substitute new and more appropriate terms for these ancient designations, which, notwithstanding their undoubted vagueness, are now generally understood. These changes have been proposed, for the most part, by those who have occupied themselves with the general classification of the various branches of knowledge, from the first appearance of the great encyclopedia (Margarita Philosophica) of Gregory Reisch,[20] prior of the Chartreuse at Freiburg, toward the close of the fifteenth century, to Lord Bacon, and from Bacon to D'Alembert; and in recent times to an eminent physicist, Andre Marie Ampère. [21]

The selection of an inappropriate Greek nomenclature has perhaps been even more prejudicial to the last of these attempts than the injudicious use of binary divisions and the excessive multiplication of groups.

The physical description of the world, considering the universe as an object of the external senses, does undoubtedly require the aid of general physics and of descriptive natural history, but the contemplation of all created things, which are linked together, and form one whole, animated by internal forces, gives to the science we are considering a peculiar character. Physical science considers only the general properties of bodies; .it is the product of abstraction – a generalization of perceptible phenomena; and even in the work in which were laid the first foundations of general physics, in the eight books on physics of Aristotle,[22] all the phenomena of nature are considered as depending upon the primitive and vital action of one sole force, from which emanate all the movements of the universe. The terrestrial portion of physical cosmography, for which I would willingly retain the expressive designation of 'physical geography', treats of the distribution of magnetism in our planet with relation to its intensity and direction, but does not enter into a consideration of the laws of attraction or repulsion of the poles, or the means of eliciting either permanent or transitory electro-magnetic currents. Physical geography depicts in broad outlines the even or irregular configuration of continents, the relations of superficial area, and the distribution of continental masses in the two hemispheres, a distribution which exercises a powerful influence on the diversity of climate and the meteorological modifications of the atmosphere; this science defines the character of mountain chains, which, having been elevated at different epochs, constitute distinct systems, whether they run in parallel lines or intersect one another; determines the mean height of continents above the level of the sea, the position of the center of gravity of their volume, and the relation of the highest summits of mountain chains to the mean elevation of their crests, or to their proximity with the sea-shore. It depicts the eruptive rocks as principles of movement, acting upon the sedimentary rocks by traversing, uplifting, and inclining them at various angles; it considers volcanoes either as isolated, or ranged in single or in double series, and extending their sphere of action to various distances, either hy raising long and narrow lines of rocks, or hy means of circles of commotion, which expand or diminish in diameter in the course of ages. This terrestrial portion ot the science of the Cosmos describes the strife of the liquid element with the solid land; it indicates the features possessed in common by all great rivers in the upper and lower portion of their course, and in their mode of bifurcation when their basins are unclosed; and shows us rivers breaking through the highest mountain chains, or following for a long time a course parallel to them, – either at their base, or at a considerable distance, where the elevation of the strata of the mountain system and the direction of their inclination correspond to the configuration of the table-land. It is only the general results of comparative orography and hydrography that belono to the science whose true limits I am desirous of determining and not the special enumeration of the greatest elevations oi our globe, of active volcanoes, of rivers, and the number oi their tributaries, these details falling rather within the domair of geography, properly so called. We would here only con sider phenomena in their mutual connection, and in their re lations to different zones of our planet, and to its physical con stitution generally. The specialities both of inorganic and qv ganized matter, classed according to analogy of form and com position, undoubtedly constitute a most interesting branch of study, but they appertain to a sphere of ideas having no affinity with the subject of this work.

The description of different countries certainly furnishes us with the most important materials for the composition of a physical geography; but the combination of these differeni descriptions, ranged in series, would as little give us a true image of the general conformation of the irregular surface of our globe, as a succession of all the floras of different region? would constitute that which I designate as a Geography of Plants. It is by subjecting isolated observations to the processs of thought, and by combining and comparing them, that we are enabled to discover the relations existing in common be tween the climatic distribution of beings and the individuality of organic forms (in the morphology or descriptive natuj il history of plants and animals); and it is by induction that we are led to comprehend numerical laws, the proportion of natural families to the whole number of species, and to designate the latitude or geographical position of the zones in whose plains each organic form attains the maximum of its development. Considerations of this nature, by their tendency to generaUzation, impress a nobler character on the physical description of the globe, and enable us to understand how the aspect of the scenery, that is to say, the impression produced upon the mind by the physiognomy of the vegetation, depends upon the local distribution, the number, and the luxuriance of growth of the vegetable forms predominating in the general mass. The catalogues of organized beings, to which was formerly given the pompous title of Systems of Nature, present us with an admirably connected arrangement by analogies of structure, either in the perfected development of these beings, or in the different phases which, in accordance with the views of a spiral evolution, affect in vegetables the leaves, bracts, calyx, corolla, and fructifying organs; and in animals, with more or less symmetrical regularity, the cellular and fibrous tissues, and their perfect or but obscurely developed articulations. But these pretended systems of nature, however ingenious their mode of classification may be, do not show us organic beings as they are distributed m groups throughout our planet, according to their different relations of latitude and elevation above the level of the sea, and to climatic influences, which are owing to general and often very remote causes. The ultimate aim of physical geography is, however, as we have already said, to recognize unity in the vast diversity of phenomena, and by the exercise of thought and the combination of observations, to discern the constancy of phenomena in the midst of apparent changes. In the exposition of the terrestrial portion of the Cosmos, it will occasionally be necessary to descend to very special facts; but this will only be in order to recall the connection existing between the actual distribution of organic beings over the globe, and the laws of the ideal classification by natural families, analogy of internal organization, and progressive evolution.

It follows from these discussions on the limits of the various sciences, and more particularly from the distinction which must necessarily be made between descriptive botany (morphology of vegetables) and the geography of plants, that in the physical history of the globe, the innumerable multitude of organized bodies which embellish creation are considered rather according to zones of habitation or stations, and to differently inflected isotherTual bands, than with reference to the principles of gradation in the development of internal organism. Notwithstanding this, botany and zoology, which constitute the the descriptive natural history of all organized beings, are tha fruitful ssbUices whence we draw the materials necessary to give a solid basis to tho study of the mutual relations and connection of phenomena.

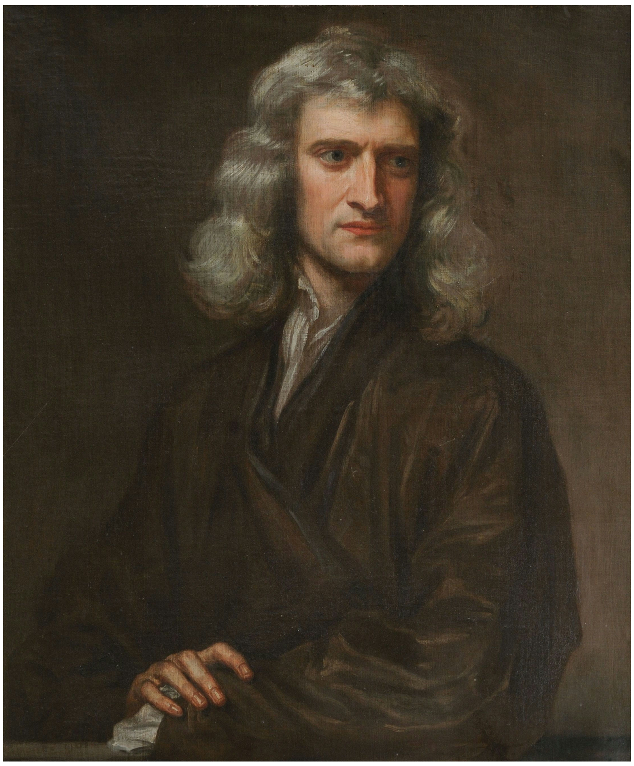
We will here subjoin oi.e important observation by way of elucidating the connection of which we have spoken. The first general glance over the vegetation of a vast extent of a continent shows us forms the most dissimilar – Graminese and Orchideae, Coniferae and oaks, in local approximation to one another; while natural families and genera, instead of being (ocally associated, are dispersed as if by chance. This dispersion is, however, only apparent. The physical description of the globe teaches us that vegetation every where presents numerically constant relations in the development of its forms land types; that in the same climates, the species which are wanting in one country are replaced in a neighboring one by other species of the same family; and that this law of substitution, which seems to depend upon some inherent mysteries of the organism, considered with reference to its origin, maintains in contiguous regions a numerical relation between the species of various great families and the general mass of the phanerogamic plants constituting the two floras. We thus find a principle of unity and a primitive plan of distribution revealed in the multiplicity of the distinct organizations by which these regions are occupied; and we also discover in each zone, and diversified according to the families of plants, a slow but continuous action on the aerial ocean, depending upon the influence of light – the primary condition of all organic vitality – on the solid and liquid surface of our planet. It might be said, in accordance with a beautiful expression of Lavoisier, that tho ancient marvel of the myth of Prometheus was incessantly renewed before our eyes.

If we extend the course which we have proposed, folrowing in the exposition of the physical description of the earth to the sidereal part of the science of the Cosmos, the delineation of the regions of space and the bodies by which they are occupied, we shall find our task simplified in no common degree. If, acoorditig to ancient but unphilosophical forms of nomenclature, we would distinguish between physics, that is to say, general considerations on the essence of matter, and the forces by which it is actuated, and chemistry, which treats of the nature of Bubstances, their elementary composition, and those attractions that are not determined solely by the relations of mass, we nmst admit that the description of the (earth comprises at wice physical and chefnical actions. In addition to gravitation, which must be considered as a primitive force in nature, we observe that attractions of another kind are at work around us, both in the interior of our planet and on its surface. These forces, to which we apply the term chemical affinity, act upon molecules in contact, or at infinitely minute distances from one another,[23] and which, being differently modified by electricity, heat, condensation in porous bodies, or by the contact of an intermediate substance, animate equally the inorganic world and animal and vegetable tissues. If we except the small asteroids, which appear to us under the forms of Aërolites and shooting stars, the regions of space have hitherto presented to our direct observation physical phenomena alone; and in the case of these, we know only with certainty the effects depending upon the quantitative relations of matter or the distribution of masses. The phenomena of the regions of space may consequently be considered as influenced by simple dynamical laws – the laws of motion.

The effects that may arise from the specific difference and the heterogeneous nature of matter have not hitherto entered into our calculations of the mechanism of the heavens. The only means by which the inhabitants of our planet can enter into relation with the matter contained within the regions of space, whether existing in scattered forms or united into large spheroids, is by the phenomena of light, the propagation of luminous waves, and by the influence universally exercised by the force of gravitation or the attraction of masses. The existence of a periodical action of the sun and moon on the variations of terrestrial magnetism is even at the present day extremely problematical. We have no direct experimental knowledge regarding the properties and specific qualities of the masses circulating in space, or of the matter of which they are probably composed, if we except what may be derived from the fall of Aërolites or meteoric stones, which, as we have already observed, enter within the limits of our terrestrial sphere. It will be sufficient here to remark, that the direction and the excessive velocity of projection (a velocity wholly planetary) manifested by these masses, render it more than probable that they are small celestial bodies, which, hving attracted by our planet, are made to deviate from their orig-inal course, and thus reach the earth enveloped in vapors, and in a high state of actual incandescence. The familiar aspect of these asteroids, and the analogies which they present with the minerals composing the earth's crust, undoubtedly afford ample grounds for surprise;[24] but, in my opinion, the only conclusion to be drawn from these facts is, that, in general, planets and other sidereal masses, which, by the influence of a central body, have been agglomerated into rings of vapor, and subsequently into spheroids, being integrant parts of the same system, and having one common origin, may likewise be composed of substances chemically identical. Again, experiments with the pendulum, particularly those prosecuted with such rare precision by Bessel, confirm the Newtonian axiom, that bodies the most heterogeneous in their nature (as water, gold, quartz, granular limestone, and different masses of Aërolites) experience a perfectly similar degree of acceleration from the attraction of the earth. To the experiments of the pendulum may be added the proofs furnished by purely astronomical observations. The almost perfect identity of the mass of Jupiter, deduced from the influence exercised by this stupendous planet on its own satellites, on Encke's comet of short period, and on the small planeta Vesta, Juno, Ceres, and Pallas, indicates with equal certainty that within the limits of actual observation attraction is determined solely by the quantity of matter.[25]

This absence of any perceptible difference in the nature of matter, alike proved by direct observation and theoretical deductions, imparts a high degree of simplicity to the mechanism of the heavens. The immeasurable extent of the regions of space being subjected to laws of motion alone, the sidereal portion of the science of the Cosmos is based on the pure and abundant source of mathematical astronomy, as is the terrestrial portion on physics, chemistry, and organic morphology; but the domain of these three last-named sciences embraoes the consideration of phenomena which are so complicated, and have, up to the present time, been found so httle susceptible of the application of rigorous method, that the physical science of the earth can not boast of the same certainty and simplicity in the exposition of facts and their mutual connection which characterize the celestial portion of the Cosmos. It is not improbable that the difference to which we allude may furnish an explanation of the cause which, in the earliest ages of intellectual culture among the Greeks, directed the natural philosophy of the Pythagoreans with more ardor to the heavenly bodies and the regions of space than to the earth and its productions, and how through Philolaiis, and subsequently through the analogous views of Aristarehus of Samos, and of Seleucus of Erythrea, this science has been made more conducive to the attainment of a knowledge of the true system of the world than the natural philosophy of the Ionian school could ever be to the physical history of the earth. Giving but little attention to the properties and specific differences of. matter filling space, the great Italian school, in its Doric gravity, turned by preference toward all that relates to measure, to the form of bodies, and to the number and distances of the planets,[26] while the Ionian physicists directed their atten tion to the qualities of matter, its true or supposed metamor phoses, and to relations of origin. It was reserved for the powerful genius of Aristotle, alike profoundly speculative and practical, to sound with equal success the depths of abstraction and the inexhaustible resources of vital activity pervading iae material world.

Several highly distinguished treatises on physical geography are prefaced by an introduction, whose purely astronomical sections are directed to the consideration of the earth ici its planetary dependence, and as constituting a part of that great system which is animated by one central body, the sun. This course is diamet-



rically opposed to the one which I propose following. In order adequately to estimate the dignity of the Cosmos, it is requisite that the sidereal portion, termed by Kant the natural history of the heavens, should not be made subordinate to the terrestrial. In the science of the Cosmos, according to the expression of Aristarehus of Samos, the pioneer of the Copernican system, the sun, with its satellites, was nothing more than one of the innumerable stars by which space is occupied. The physical history of the world raust, therefore, begin with the description of the heavenly bodies, and with a geographical sketch of the universe, or, I would rather say, a true map of the world, such as was traced by the bold hand of the elder Heftchel. If, notwithstanding the srnallness of our planet, the most considerable space and the most attentive consideration be here afforded to that which exclusively concerns it, this arises solely from the disproportion in the extent of our knowledge of that which is accessible and of that which is closed to our observation. This subordination of the celestial to the terrestrial portion is met with in the great work of Bernard Varenius,[27] which appeared in the middle of the seventeenth century. He was the first to distinguish between general and special geography, the former of which he subdivides into an absolute, or, properly speaking, terrestrial part, and a relative or planetary portion, according tc the mode of considering our planet either with reference to its surface in its different zones, or to its relations to the sun and moon. Ii redounds to the glory of Varenius that his work on General and Comparative GeograpJiy should in so high a degree have arrested the attention of Newton. The imperfect state of many of the auxiliary sciences from which this writer was obliged to draw his materials prevented his work from cnrrespondmg to the greatness of the design, and it was reserved for the present age, and for my own country, to see the delineation of comparative geography, drawn in its full extent, and in all its relations with the history of man, by the sldllful hand of Carl Ritter.[28]

The enumeration of the most important results of the astronomical and physical sciences which in the history of the Cosmos radiate, toward one common focus, may perhaps, to a certain degree, justify the designation I have given to my work, and, considered within the circumscribed limits I have proposed to myself, the undertaking may be esteemed less adventurous than the title. The introduction of new terms, especially with reference to the general results of a science which ought to be accessible to all, has always been greatly in opposition to my own practice; and whenever I have enlarged upon the established nomenclature, it has only been in the specialities of descriptive botany and zoology, where the introduction of hitherto unknown objects rendered new names necessary. The denominations of physical descriptions of the universe, or physical cosmography, which I use indiscriminately, have been modeled upon those of physical descriptions of the earth, that is to say, physical geography, terms that have long been in common use. Descartes, whose genius was one of the most powerful manifested in any age, has left us a few fragments of a great work, which he intended publishing under the title of Monde, and for which he had prepared him self by special studies, including even that of human anatomy. The uncommon, but definite expression of the science of the Cosmos recalls to the mind of the inhabitant of the earth that we are treating of a more widely-extended horizon – of the assemblage of all things with which space is filled, from the remotest nebulae to the climatic distribution of those delicate tissues of vegetable matter which spread a variegated covernig over the surface of our rocks.

The influence of narrow-minded views peculiar to the ear lier ages of civilization led in all languages to a confusion of ideas in the synonymic use of the words earth and tvo7'ld, while the common expressions voyages round the world, map of the world, and neio world, afford further illustrations of the same confusion. The more noble and precisely-defined expressions of system of the world, the planetary world, and creation and age of the world, relate either to the totality of the substances by which space is filled, or to the origin of tho whole universe. It was natural that, in the midst of the extreme variability of phenomena presented by the surface of our globe, and the aerial ocean by which it is surrounded, man should have been impressed by the aspect of the vault of heaven, and the uniform and regular movements of the sun and planets. Thus the word Cosmos, which primitively, in the Homeric ages, indicated an idea of order and harmony, was subsequently adopted in scientific language, where it was gradually applied to the order observed in the movements of the heavenly bodies, to the whole universe, and then finally to the world in which this harmony was reflected to us. According to the assertion of Philolaiis, whose fragmentary works have been so ably commented upon by Böckh, and conformably to the general testimoiiy of antiquity, Pythagoras was the first who used the word Cosmos to designate the order that reigns in the universe, or entire world.[29] From the Italian school of philosophy, the expression passed, in this signification, into the language of those early poets of nature, Parmenides and Empedocles, and from thence inta the woiks of prose writers. We will not here enter into a discussion of the manner in which, according to the Pythago rean views, Philolaiis distinguishes between Olympus, Uranus, or the heavens, and Cosmos, or how the same word, used in a plural sense, could be applied to certain heavenly bodies (the planets) revolving round one central focus of the world, or to groups of stars. In this work I use the word Cosmos in conformity with the Hellenic usage of the term subsequently to the time of Pythagoras, and in accordance with the precise definition given of it in the treatise entitled 'De Mundo', which was long erroneously attributed to Aristotle. It is the assemblage of all things in heaven and earth, the universality of created things constituting the perceptible world. If scientific terms had not long been diverted from their true verbal signification, the present work ought rather to have borne the title of Cosmography, divided into Uranogrdphy and Geography. The Romans, in their feeble essays on philosophy, imitated the Greeks by applying to the universe the term mundus, which, in its primary meaning, indicated nothing more than ornament, and did not even imply order or regularity in the disposition of parts. It is probable that the introduction into the language of Latium of this technical term as an equivalent for Cosmos, in its double signification, is due to Ennius,[30] who was a follower of the Italian school, and the translator of the writings of Epicharmus and some of his pupils on the Pythagorean philosophy.

We would first distinguish between the physical history and the physical description of the world. The former, conceived in the most general sense of the word, ought, if materials Ibi writing it existed, to trace the variations experienced by the universe in the course of ages from the new stars which have suddenly appeared and disappeared in the vault of heaven, from nebula) dissolving or condensing – to the first stratum of cryptogamic vegetation on the still imperfectly cooled surface of the earth, or on a reef of coral uplifted from the depths of ocean. The physical description of the world presents a picture of all that exists in space – of the simultaneous action of natural forces, together with the phena meaa which they produce.

But if we would correctly comprehend nature we must not entirely or absolutely separate the consideration of the present state of things from that of the successive phases through which they have passed. We can not form a just conception of their nature without looking back on the mode of their formation. It is not organic matter alone that is continually undergoing change, and being dissolved to form new combinations. The globe itself reveals at every phase of its existence the mystery of its former conditions.

We can not survey the crust opound our planet without recognizing the traces of the prior existence and destruction of an organic world. The sedimentary rocks present a succession of organic forms, associated in groups, which have successively displaced and succeeded each other. The different super imposed strata thus display to us the faunas and floras of different epochs. In this sense the description of nature is inti mately connected with its history; and the geologist, who is guided by the connection existing among the facts observed, can not form a conception of the present without pursuing, through countless ages, the history of the past. In tracing the physical delineation of the globe, we behold the present and the past reciprocally incorporated, as it were, with one another; for the domain of nature is like that of languages, in which etymological research reveals a successive development, by showing us the primary condition of an idiom reflected ni the fornflS of speech in use at the present day. The study of the material world renders this reflection of the past peculiarly manifest, by displaying in the process of formation rocks of eruption and sedimentary strata similar to those of former ages. If I may be allowed to borrow a striking illustration from the geological relations by which the physiognomy of a country is determined, I would say that domes of trachyte, cones of basalt, lava streams (coulees) of amygdaloid with elongated and parallel pores, and white deposits of pumice, intei-mixed with black scoriae, animate the scenery by the associations of the past which they awaken, acting upon the imagination of the enlightened observer like traditional records of an earlier world. Their form is their history.

The sense in which the Greeks and Romans originally employed the word history proves that they too were intimately convinced that, to form a complete idea of the present state of the universe, it was necessary lo consider it in its successive phases. It is not, however, in the definition given by Valerius Flaccus,[31]' but in the zoological writings of Aristotle, that the word history presents itself as an exposition of the results of experience and observation. The physical description of the word by Pliny the elder bears the title of Natural History, while in the letters of his nephew it is designated by the nobler term of History of Nature. The earher Greek historians did not separate the descriptions of countries from the narrative of events of which they had been the theater. With these writers, physical geography and history were long intimately associated, and remained simply but elegantly blended until the period of the development of political interests, when the agitation in which the lives of men were passed caused the geographical portion to be banished from the history of nations, and raised into an independent science.

It remains to be considered whether, by the operation of thought, we may hope to reduce the immense diversity of phenomena comprised by the Cosmos to the unity of a principle, and the evidence afforded by rational truths. In the present state of empirical knowledge, we can scarcely flatter ourselves with such a hope. Experimental sciences, based on the observation of the external world, can not aspire to completeness; the nature of things, and the imperfection of our organs, are alike opposed to it. We shall never succeed in exhausting the immeasurable riches of nature; and no generation of men will ever have cause to boast of having comprehended the total aggregation of phenomena. It is only by distributing them into groups that we have been able, in the case of a few, to discover the empire of certain natural laws, and and simple as nature itself The extent of this empire will no doubt increase in proportion as physical sciences are more perfectly developed. Striking proofs of this advancement have been made manifest in our own day, in the phenomena of electro-magnetism, the propagation of luminous waves and radiating heat. In the same manner, the fruitful doctrine of evolution shows us how, in organic development, all that is formed is sketched out beforehand, and how the tissues of vegetable and animal matter uniformly arise from the multiplication and transformation of cells.

The generalization of laws, which, being at first bounded by narrow limits, had been applied solely to isolated groups of phenomena, acquires in time more marked gradations, and gains in extent and certainty as long as the process of reasoning is applied strictly to analogous phenomena; but as soon as dynamical views prove insufficient where the specific properties and heterogeneous nature of matter come into play, it is to be feared that, by persisting in the pursuit of laws, we may find our course suddenly arrested by an impassable chasm The principle of unity is lost sight of, and the guiding clew is rent asunder whenever any specific and peculiar kind of action manifests itself amid the active forces of nature. The law of equivalents and the numerical proportions of composition, so happily recognized by modern chemists, and proclaimed under the ancient form of atomic symbols, still remains isolated and independent of mathematical laws of motion and gravitation.

Those productions of nature which are objects of direct observation may be logically distributed in passes, orders, and families. This form of distribution undoubtedly sheds some light on descriptive natural history, but the study of organized bodies, considered in their linear connection, although it may impart a greater degree of unity and simplicity to the distribution of groups, can not rise to the height of a classification based on one sole principle of composition and internal organization. As different gradations are presented by the laws of nature according to the extent of the horizon, or the limits of the phenomena to be considered, so there are likewise differently graduated phases in the investigation of the external world. Empiricism originates in isolated views, which are subsequently grouped according to their analogy or dissimilarity. To direct observation succeeds, although long afterward, the wish to prosecute experiments; that is to say, to evoke phenomena under different determined conditions. The rational experimentalist does not proceed at hazard, but acts under the guidance of hypotheses, founded on a half indistinct and more or less just intuition of the connection existing among natural objects or forces. That which has been conquered by observation or by means of experiments, leads, by analysis and induction, to the discovery of empirical laws. These are the phases in human intellect that have marked the different epochs in the life of nations, and by means of which that great mass of facts has been accumulated which constitutes at the present day the solid basis of the natural sciences.

Two forms of abstraction conjointly regulate our knowledge, namely, relations of quantity, comprising ideas of number and size, and relations of quality, embracing the consideration of the specific properties and the heterogeneous nature of matter. The former, as being more accessible to the exer cise of thought, appertains to mathematics; the latter, from Its apparent mysteries and greater difficulties, falls under the domain of the chemical sciences. In order to submit phenomena to calculation, recourse is had to a hypothetical construction of matter by a combination of molecules and atoms, whose number, form, position, and polarity determine, modify, or vary phenomena.

The mythical ideas long entertained of the imponderable substances and vital forces peculiar to each mode of organization, have complicated our views generally, and shed an uncertain light on the path we ought to pursue.

The most various forms of intuition have thus, age aftei age, aided in augmenting the prodigious mass of empirical knowledge, which in our own day has been enlarged with ever-increasing rapidity. The investigating spirit of man strives from time to time, with varying success, to break through those ancient forms and symbols invented, to subject rebellious matter to rules of mechanical construction.

We are still very far from the time when it will be possible for us to reduce, by the operation of thought, all that we perceive by the senses, to the unity of a rational principle. It may even be doubted if such a victory could ever be achieved in the field of natural philosophy. The complication of phenomena, and the vast extent of the Cosmos, would seem to oppose such a result; but even a partial solution of the problem – the tendency toward a comprehension of the phenomena of the universe – will not the less remain the eternal and sublime aim of every investigation of nature.

In conformity with the character of my former writings, as well as with the labors in which I have been engaged during my scientific career, in measurements, experiments, and the investigation of facts, I limit myself to the domain of empirical ideas.

The exposition of mutually connected facts does not excludeurogt; the classification of phenomena according to their rational connection, the generahzation of many specialities in the geat mass of observations, or the attempt to discover laws. Conceptions of the universe solely based upon reason, andthe principles of speculative philosophy, would no doubt assin a still more exalted aim to the science of the Cosmos. I amfai from blaming the efforts of others solely because their sucess has hitherto remained very doubtful. Contrary to the wihes and counsels of those profound and powerful thinkers who have given new life to speculations which were already familiar to the ancients, systems of natural philosophy have in our own country for some time past turned aside the minds of men from the graver study of mathematical and physical sciences. The ahuse of better powers, which has led many of our noble but ill-judging youth into the saturnalia of a pure ly ideal science of nature, has been signalized by the intoxication of pretended conquests, by a novel and fantastically symbolical phraseology, and by a predilection for the formulae of a scholastic rationalism, more contracted in its views than any known to the Middle Ages. I use the expression "abuse of better powers,"because superior intellects devoted to philosophical pursuits and experimental sciences have remained strangers to these saturnalia. The results yielded by an earnest investigation in the path of experiment can not be at variance with a true philosophy of nature. If there be any contradiction, the fault must lie either in the unsoundness of speculation, or in the exaggerated pretensions of empiricism, which thinks that more is proved by experiment than is actually derivable from it.

External nature may be opposed to the intellectual world, as if the latter were not comprised within the limits of the former, or nature may be opposed to art when the latter is defined as a manifestation of the intellectual power of man; but these contrasts, which we find reflected in the most cultivated languages, must not lead us to separate the sphere of nature from that of mind, since such a separation would reduce the physical science of the world to a mere aggregation of empirical specialities. Science does not present itself to man until mind conquers matter in striving to subject the result of experimental investigation to rational combinations. Science is the labor of mind applied to nature, but the external world has no real existence for us beyond the image reflected within ourselves through the medium of the senses. As intelligence and forms of speech, thought and its verbal symbols, are united by secret and indissoluble links, so does the external world blend almost unconsciously to ourselves with our ideas and feelings. "External phenomena, "says Hegel, in his Philosophy of History,' are in some degree translated in our inner representations. "The objective world, conceived and reflected within us by thought, is subjected to the eternal and necessary conditions of our intellectual being. The activity of the mind exercises itself on the elements furnished to it by the perceptions of the senses. Thus, in the early ages of mankind, there manifests itself in the simple intuition of natural facts, and in the efforts made to comprehend them, the germ of the philosophy of nature. These ideal tendencies vary, and are more or less powerful, according to the individual characteristics and moral dispositions of nations, and to the degrees of their mental culture, whether attained amid scenes of nature that excite or chill the imagination.

History has preserved the record of the numerous attempts that have been made to form a rational conception of the whole world of phenomena, and to recognize in the universe the action of one sole active force by which matter is penetrated, transformed, and animated. These attempts are traced in classical antiquity in those treatises on the principles of things which emanated from the Ionian school, and in which all the phenomena of nature were subjected to hazardous speculations, based upon a small number of observations. By degrees as the influence of great historical events has favored the development of every branch of science supported by observation, that ardor has cooled which formerly led men to seek the essential nature and connection of things by ideal construction and in purely rational principles. In recent times, the mathematical portion of natural philosophy has been most remarkably and admirably enlarged. The method and the instrument (analysis) have been simultaneously perfected. That which has been acquired by means so difierent – by the ingenious application of atomic suppositions, by the more general and intimate study of phenomena, and by the improved construction of new apparatus – is the common property of mankind, and should not, in our opinion, now, more than in ancient times, be withdrawn from the free exercise of speculative thought.

It can not be denied that in this process of thought the results of experience have had to contend with many disadvantages; we must not, therefore, be surprised if, in the perpetual vicissitude of theoretical views, as is ingeniously expressed by the author of Giordano Bruno,[32] most men see nothing in philosophy but a succession of passing meteors, while even the grander forms in which she has revealed herself share the fate of comets, bodies that do not rank in popular opinion among the eternal and permanent works of nature, but are regarded as mere fugitive apparitions of igncor vapor. "We would here remark that the abuse of thought, and the false track it too often pursues, ought not to sanction an opinion derogatory to intellect, which would imply that the domain of mind is essentially a world of vague fantastic illusions, and that the treasures accumulated by laborious observations in philosophy are powers hostile to its own empire, it does not become the spirit which characterizes the present age distrustfully to reject every generalization of views and every attempt to examine into the nature of things by the process of reason and induction. It would be a denial of the dignity of human nature and the relative importance of the faculties with which we are endowed, were we to condemn at one time austere reason engaged in investigating causes and their mutual connections, and at another that exercise of the imagination which prompts and excites discoveries by its creative powers.

NOTES

1. This expression is taken from a beautiful description of tropical forest scenery in *Paul and Virginia*, by Bernardin de Saint Pierre.

2. These comparisons are only approximative. The several elevations above the level of the sea are, in accurate numbers, as follows:

   The Schneekoppe or Riesenkoppe, in Silesia, about 5270 feet, according to Hallaschka. The Righi, 5902 feet, taking the height of the Lake of Lucerne at 1426 feet, according to Eschman. (See *Compte Rendu des Mesures Trigonomériques en Suisse*, 1840, p. 230.) Mount Athos, 6775 feet, according to Captain Gaultier; Mount Pilatus, 7546 feet; Mount Ætna, 10,871 feet, according to Captain Smyth; or io,874 feet, according to the barometrical measurement made by Sir John Herschel, and communicated to me in writing in 1825, and 10,899 feet, according to angles of altitude taken by Cacciatore at Palermo (calculated by assuming the terrestrial refraction to be 0.076); the Schreck horn, 12,383 feet; the Jungfrau, 13,720 feet, according to Tralles; Mont Blanc, 15,775 feet, according to the different measurements considered by Roger (Bibl. Univ., May, 1828, p. 24-53), 15,733 feet, according to the measurements taken from Mount Columbier by Carlini in 1821, and 15,V48 feet, as measured by the Austrian engineers fi'ora Trelod and the Glacier d'Ambin.

   The actual height of the Swiss mountains fluctuates, according to Eschman's observations, as much as 25 English feet, owing to the varying thickness of the stratum of snow that covers the summits. Chimborazo is, according to my trigonometrical measurements, 21,421 feet (see Humboldt, *Recueil d'Obs. Astr.*, tome i., p. 73), and Dhawalagiri, 28,074 feet. As there is a difference of 445 feet between the determinations of Blake and Webb, the elevation assigned to the Dhawalagiri (or white mountain, from the Sanscrit *dhawala*, white, and giri, mountain) can not be received with the same confidence as that of the Jawahir, 25,749 feet, since the latter rests on a complete trigonometrical measurement (see Herbert and Hodgson in the *Asiat. Res.*, vol. xiv., p. 189, and Suppl. to *Encycl. Brit.*, vol. iv., p. 643). I have shown elsewhere (*Ann. des Sciences Naturelles*, Mars, 1825) that the height of the Dhawalagiri (28,074 feet) depends on several elements that have not been ascertained with certainty, as azimuths and latitudes (Humboldt, *Asie Centrale*, t. iii., p. 282). It has been believed, but without foundation, that in the Tartaric chain, north of Thibet, opposite to the chain of Kuen-lun, there are several snowy summits, whose elevation is about 30,000 English feet (almost twice that of Mont Blanc), or, at any rate, 29,000 feet (see Captain Alexander Gerard's and John Gerard's *Journey to the Boorendo Pass*, 1840, vol. i., p. 143 and 311). Chimborazo is spoken of in the text only as one of the highest summits of the (jhain of the Andes; for in the year 1827, the learned and highlj-gifted traveler, Pentland, in his memorable expedition to Upper Peru (BtJivia), measured the elevation of two mountains situated to the east of Lake Titicaca, viz., the Sorata, 25,200 feet, and the Illimani, 24,000 feet, both greatly exceeding the height of Chimborazo, which is only 21,421 feet, and being nearly equal in elevation to the Jawahir, which is the highes mountain in tbo Himadaya that has as yet been acciu'ately measured Thus Mont Blanc is 5646 feet below Chimborazo; Chimborazo, 3779 feet below the Sorata; the Sorata, 549 feet below the Jawahir, and prob ably about 2880 feet below the Dhawalagiri. According to a new measurement of the Illimani, by Pentland, in 1838, the elevation of this mountain is given at 23,868 feet, varying only 133 feet from the measurement taken in 1827. The elevations have been given in this note with minute exactness, as erroneous numbers have been introduced into many maps and tables recently published, owing to incorrect reductions of the measurements.

[In the preceding note, taken from those appended to the Introduction in the French translation, rewritten by Humboldt himself, the measurements are given in meters, but these have been converted into English feet, for the greater convenience of the general reader.] – Tr.

3. The absence of palms and tree-ferns on the temperate slopes of the Himalaya is shown in Don's *Flora Nepalensis*, 1825, and in the remarkable series of lithographs of Wallich's *Flora Indica*, whose catalogue contains the enormous number of 7683 Himalaya species, almost all phanerogamic plants, which have as yet Ijeen but imperfectly classified. In Nepaul (lat. $26\frac{1}{2}^\circ$ to $27\frac{1}{4}^\circ$) there has hitherto been observed only one species of palm, Chama3rops martiana, Wall. (*Plantae Asiat.*, lib. iii., p, 5, 211), which is found at the height of 5250 English feet above the leve of the sea, in the shady valley of Bunipa. The magnificent tree-fern Alsophila brunoniana. Wall, (of which a stem 48 feet long has been in the possession of the British Museum since 1831), does not grow in Nepaul, but is found on the mountains of Silhet, to the northwest of Calcutta, in lat. $24°50'$. The Nepaul fern, Paranema cyathöides, Don, formerly known as Sphaeroptera barbata, Wall. (*Plantae Asiat.*, lib. i. p. 42, 48)y is, indeed, nearly related to Cyathea, a species of which 1 have seen in the South American Missions of Caripe, measuring 33 feet in height; this is not, however, properly speaking, a tree.

4. Ribes nubicola, R. glaciale, R. grossularia. The species which compose the vegetation of the Himalaya are four pines, notwithstanding the assertion of the ancients regarding Eastern Asia (Strabo, hb. 11, p. 510, Cas.), twenty-five oaks, four birches, two chestnuts, seven maples, twelve willows, fourteen roses, three species of strawberry, seven species of Alpine roses (*rhododendra*), one of which attains a height of 20 feet, and many other northern genera. Large white apes, having black faces, inhabit the wild chestnut- tree of Kashmir, which grows to a height of 100 feet, in lat. $33°$ (see Carl von Hügel's *Kaschmir*, 1840, 2d pt. 249). Among the Coniferae, we find the Pinus deodwara, or deodara (in Sanscrit, *déwa-daru*, the timber of the gods), which is nearly allied to Pinus cedrus. Near the limit of perpetual snow flourish the large and showy flowers of the Gentiana venusta, G. Moorcroftiana, Swertia purpurescens, S. speciosa, Parnassia armata, P. nubicola, Pœonia Emodi, Tulipa stellata; and, besides varieties of European genera peculiar to these Indian mountains, true European species, as Leontodon taraxacum, Prunella vulgaris, Galium aparine, and Thlaspi arvense. The heath mentioned by Saunders, jn Turner's Travels, and which had been confounded with Calluna vulgaris, is an Andromeda, a fact of the great est importance in the geography of Asiatic plants. If I have made use, in this work, of the unphilosophical expressions of *European genera, European species, growing wild in Asia, &c.*, it has been in conse-

quence of the old botanical language, which, instead of the idea of a large dissemination, or, rather, of the coexistence of organic productions, has dogmatically substituted the false hypothesis of a migration, which, from predilection for Europe, is further assumed to have been from west to east.

5. On the southern declivity of the Himalaya, the limit of perpetual onow is $12,978$ feet above the level of the sea; on the northern declivity, or, -ather, on the peaks which rise above the Thibet, or Tartarian plateau, this limit is at $16,625$ feet from $30\frac{1}{2}^{\circ}$ to 32° of latitude, whik at the equator, iu the Audes of Quito, it is $5,790$ feet. Such is the result I have deduced from the combiuatiou of numerous data furnished by Webb, Gerard, Herbert, and Moorcroft. (See my two memoirs on the mountains of India, in 1816 and 1820, in the *Ann. de Chisnie et tU Physique*, t. iii., p. 303; t. xiv., p. 6, 22, 50.) The greater elevation to which the limit of perpetual snow recedes on the Tartarian dechvity is owing to the radiation of heat from the neighboring elevated plains, to the purity of the atmosphere, and to the infrequent formation of snow in an air which is both very cold and very dry. (Humboldt, *Asie Centrale*, t. iii., p. 281-326.) My opinion ou the difference of height of the snow-line on the two sides of the Himalaya has the high authority of Colebrooke iu its favor. He wrote to me in June, 1824, as follows: "I also find, from the data in my possession, that the elevation of the line of perpetual snow is $13,000$ feet. On the southern declivity, and at latitude $31°$, Webb's measurements give me $13,500$ feet, consequently 500 feet more than the height deduced from Captain Hodgson's ob servations. Gerard's measurements fully confirm your opinion that the line of snow is higher on the northern than on the southern side."It was not until the present year (1840) that we obtained the complete tnd collected journal of the brothers Gerard, published under the su pervision of Mr. Lloyd. (*Narrative of a Journey from Cawnpoor t the Boorendo Pass, in the Himalaya, by Captain Alexander Gerard ant John Gerard, edited by George Lloyd*, vol. i., p. 291, 311, 320, 327, and 341.) Many interesting details regarding some localities may be found in ttie narrative of A Visit to the Shatool,for the Purpose of determining the Line of Perpetual Snow on the southern face of the Himalaya, in At gust, 1822. Unfortunately, however, these travelers always confound the elevation at which sporadic snow falls with the maximum of th height that the snow-line attains on the Thibetian plateau. Captaiti Gerard distinguishes between the summits that rise in the middle o the plateau, where he states the elevation of the snow-line to be be-

tween 18,000 and $19,000$ feet, and the northern slopes of the chain o the Himalaya, which border on the defile of the Sutledge, and can n liate but little heat, owing to the deep ravines with which they ar . intersected. The elevation of the village of Tanguo is given at only 9300 feet, while that of the plateau surrounding the sacred lake of Maqasa is $17,000$ feet. Captain Gerard finds the snow-line 500 feet lower on the northern slopes, where the chain of the Himalaya is broken through, than toward the southern declivities facing Hindostan, and he there estimates the line of perpetual snow at $15,000$ feet. The moist striking differences are presented between the vegetation on the Thil etian plateau and that cliaracteristic of the southern slopes ot the Himalaya. On the latter the cultivation of grain is arrested at 9974 feet, and even there the corn has often to be cut when the blades are stiil green. The extreme limit of forests of tall oaks and deodars is $11,960$ feet; that of dwarf birches, $12,983$ feet. On the plains, Captain Gerard found pastures up to the height of $17,000$ feet; the cereals will grow t.t $14,100$ feet, or even at $18,540$ feet; birches with tall stems at $14,100$ feet, and copse or brush wood applicable for fuel is found at an eleva tion of upward of $17,000$ feet, that is to say, 1280 feet above the lower limits of the snow-line at the equator, in the province of Quito. It is very desirable that the *mean* elevation of the Thibetian plateau, which I have estimated at only about 8200 feet between the Himalaya and the Kuen-lun, and the difference in the height of the line of perpetual snow on the southern and on the northern slopes of the Himalaya, should be again investigated by travelers who are accustomed to judge of the general conformation of the land. Hitherto simple calculations have too often been confounded with actual measurements, and the elevations of isolated summits with that of the surrounding plateau. (Compare Carl Zimmerman's excellent *Hypsometrical Remarks in his Geographitchen Analyse der Karte von Inner Aden*, 1841, s. 98.) Lord draws attention to the difference presented by the two faces of the Himalaya and those of the Alpine chain of Hindoo-Coosh, with respect to the limits of the snow-line. "The latter chain,"he says, "has the table land to the south, in consequence of which the snow-line is higher on the southern side, contrary to what we find to be the case with respect to the Himalaya, which is bounded on the south by sheltered plains, as Hindoo-Coosh is on the north."It must, however, be admitted that the hypsometrical data on which these statements are based require a critical revision with regard to several of their details; but still they suffice to establish the main fact, that the remarkable configuration of the laud in Central Asia affords man all that is essential to the maintenance of life, as habitation, food, and fuel, at an elevation above the level of the sea which in almost all other parts of the globe is covered with perpetual ice. We must except the very dry districts of Bolivia, where snow is so rarely met with, and where Pentland (in 1838) fixed the snow-line at $15,667$ feet, between 16° and $17\frac{2}{4}^{\circ}$ south latitude. Tho opinion that I had advanced regarding the difference in the snow-line on the two faces of the Himalaya has been most fully confirmed by the barometrical observations of Victor Jacquemont, who fell an early sacrifice to his noble and unwearied ardor. (See his *Correspondance pendant son Voyage dans Vhtde*, 1828 a 1832, liv. 23, p. 290, 296, 299.) "Perpetual snow,"says Jacquemont, "descends lower on the southern than on the northern slopes of the Himalaya, and the limit constantly rises as we advance to the north of the chain bordering on India. On the Kioubrong, about $18,317$ feet in elevation, according to Captain Gerard, I was still considerably below the limit of perpetual snow which I believe to be $19,690$ feet in this part of Hindostan."(This estimate I consider much too high.)

The same traveler says, "To whatever height we rise on the southern declivity of the Himalaya, the climate retains the same character, and the same division of the seasons as in the plains of India the summer solstice being every year marked by the same prevalence of rain, which continues to fall without intermission until the autumnal equinox. But a new, a totally different climate begins at Kashmir, whose elevation I estimate to be 5350 feet, nearly equal to that of the cities of Mexico and Popayan"(*Correspond, de Jacquemont*, t. ii., p. 58 et 74). The warm and humid air of the sea, as Leopold von Buch well observes, is carried by the monsoons across the plains of India to the skirts of the Himalaya, which arrest its course, and hinder it from diverging to the Thibetian districts of Ladak and Lassa. Carl von Hügel estimates the elevation of the Valley of Kashmir above the level of the sea at 5818 feet, and bases his observation on the determination of the boiling point of water (see theil 11, s. 155, and *Journal of Geog. Soc*, vol. vi. p. 215). In this valley, where the atmosphere is scarcely ever agitated by storms, and in $34^{\circ}7'$ lat., snow is found, several feet in thickness, from December to March.

6. See, generally, my *Essai sur la Géographie des Plantes, et le Tableau physique des Regions Equinoxiales*, 1807, p. 80-88. On the diurnal and nocturnal variations of temperature, see Plate 9 of my *Atlas Géogr. et Phys. du Nouveau Continent*; and the Tables in my work, entitled *De distributione Geographica Plantarum, secundum casli iemperiem, et altitudinem Montium*, 1817, p. 90-116; the meteo-

rological portion of my *Asie Centrale*, t. iii., p. 212, 224; and, finally, the more recent and far more exact exposition of the variations of temperature experienced in correspondence with the increase of altitude on the chain of the Andes, given in Boussingault's Memoir, *Sur la profondeur a laquelle on irouve, sous les Tropiques, la couche de Temperature Invariable.* (Ann. de Chimie et de Physique, 1833, t. liii., p. 225-247.) This treatise contains the elevations of 128 points, included between the level of the sea and the declivity of the Antisana ($17,900$ feet), as well as the mean temperature of the atmosphere, which varies with the height between 81° and 35° F.

7. See, oa the Madhjadeca, properly so called, Lassen's excellent work, entitled *Indische Alter thunukunde*, bd. i., 8. 92. The Chinese give the name qf Mo-kie-thi to the southern Bahar, situated to the Bouth of the Ganges (see *Foe-Koue-Ki*, by *Chy-Fa-Hian*, 1836, p. 256). Djambu-dwipa is the name given to the whole of India; but the words also indicate one of the four Buddhist continents.

8. *Ueber die Kawi Spracke auf der Insel Java, nebst einer Einleitvng uber die Verschiedenheit des menschlichen Spray.hbaues und ihren Ein fiuss auf die geistige Entwickelung de Menschengeschlechf's*, von Wilhelm V. Humboldt, 1836, bd. i., s. 5-510.

9. This verse occurs in a poem of Schiller, entitled *Der Spaziergang* which first appeared in 1795, in the *Horen*

10. Arago's ocular micrometer, a happy improvement upon Rochon's prismatic or double-refraction micrometer. See M. Mathieu's note in Dfelambre's Histoire de l'Astronomie au dix-huitieme Siecle, 1827.

11. Cams, Von den Urtheilen des Knochen und Sckalen Geruates, 1828 $ 6

12. Plut,, in Vita Alex. Magni, cap. 7

13. The determinations usually given of the point of fusion are in general much too high for refracting substances. According to the very accurate researches of Mitscherlich, the melting point of granite can hardly exceed 2372° F.

    [Dr. Mantell states in *The Wonders of Geology*, 1848, vol. i., p. 34, that this increase of temperature amounts to 1° of Fahrenheit for every fifty-four feet of vertical depth.] – Tr.

14. See the classical work on the fishes of the Old World by Agassiz, Rech. sur les Poissons Fossiles, 1834, vol. i., p. 38; vol. ii., p. 3, 28,

34, App., p. 6. The whole genus of Amblypterus, Ag., nearly allied to Palaeoniscus (called also Palaeothrissum), lies buried beneath the Jura formations in the old carboniferous strata. Scales which, in some fishes as in the family of Lepidoides (order of Ganoides), are formed like teeth, and covered in certain parts with enamel, belong, after the Placoides, to the oldest forms of fossil fishes; their living representatives are still found in two genera, the Bichir of the Nile and Senegal, and the Lepidosieus of the Ohio.

15. [The polishing slate of Bilin is stated by M. Ehrenberg to form a series of strata fourteen feet in thickness, entirely made up of the siliceous shells of Gaillonellce, of such extreme minuteness that a cubic inch of the stone contains forty -one thousand millions ! The Bergmehl (mountain meal or fossil farina) of San Fiora, in Tuscany, is one masa of animal culites. See the interesting work of G. A, Mautell, On ik,e Medals of Creation, vol. i., p. 223.]- Tr.

16. Göthe, ill *Die Aphorismen uber Naturwissenschaft*, bd. 1.. s, 155 (*Werke kleine Ausgabe, von* 1833.")

17. Arago's Discoveries in the year 1811. – Delambre's Histoire de l'Ast., p. 652. (Passage already quoted.)

18. Göthe, in Die Aphorismen uber Naturwissenschqft. – Werhe, bd. 1.,

19. Pseudo-Plato. – Alcib., xi., p. 184, ed. Steph.; Plut., Instituta Laconica, p. 253, ed. Hutten.

20. The Margarita Philosophica of Gregory Reisch, prior of the Chartreuse at Freiburg, first appeared under the following title: Epitome omnis Philosopliice, alias Margarita Philosophica, tractans de omni generi scibili. The Heidelberg edition (1486), and that of Strasburg (1504), both bear this title, but the first part was suppressed in the Freiburg edition of the same year, as well as in the twelve subsequent editions, which succeeded one another, at short intervals, till 1535. This work exercised a great influence on the diffusion of mathematical and physical sciences toward the beginning of the sixteenth century, and Crasles, the learned author of L'Aperçu Historique des Méthodes en Géometrie (1837), has shown the great importance of Reisch's Encyclopedia in the history of mathematics in the Middle Ages. I have had recourse to a passage in the Margarita Philosophica, found only in the edition of 1513, to elucidate the important question of the relations between the statements of the geographer of Saint-Die, Hylacomilus (Martin Waldseemiiller), the first who gave

the name of America to the New Continent, and those of Amerigo Vespucci, Rene, King of Jerusalem and Duke of Lorraine, as also those contained in the celebrated editions of Ptolemy of 1513 and 1522. See my Examen Critique de la Géographie du Nouveau Continent, et des Progres de V Astronomic Nautique aux 15e et 16e Siecles, t. iv., p. 99-125.

21. Ampère, Essai snr la Phil, des Sciences, 1834, p. 25. Whewell, Philosophy of the Inductive Sciences, vol. ii., p. 277. Park, Pantoloey p. 87.

22. All changes in the physical world may be reduced to motion. Aristut., Phys. Ausc, iii., 1 and 4, p. 200, 201. Bekker, viii., 1, 8, and 9, p. 250, 2G2, 265. De Genere et Corr., ii., 10, p. 336. Pseudo-Arifttot., De Mnndo. i np. vi., p. 308.

23. On the question already discussed by Newton, regarding the difference existing between the attraction of masses and molecular attraction, see Laplace, Exposition du Systeme du Monde, p. 384, and supplement to book X. of the Mecaniqne Cileste, p, 3, 4; Kant, Metaph. Asfangx. grimde der Naturwisseiischaff, Sam. Werhe, 1839, bd. v., s. 309 (Meta. physical Principles of the Natural Sciences); Pectet, Physique, 1838. vol. i., p. 59-63

24. [The analysis of an aSrolite which fell a few years since in Mary land, United States, and was examined by Professor Silliman, of New Haven, Connecticut, gave the following results: Oxyd of iron, 24; oxyd of nickel, 1-25; silica, with earthy matter, 3-46; sulphur, a trace =28-71. Dr. Mantell's Wonders of Geology, 1848, vol. i., p. 51.']- Tr.

25. Poisson, Connaissances des Temps pour r Annie 1836, p. 64-66. Bessel, Poggendorf 's Annalen, bd. xxv., s. 417. Encke, Abkandlungen der Berliner Akademie (Trans, of the Berlin Academy), 1826, s. 257. Mitscherlich, Lehrbuch der Chemie (Manual of Chemistry), 1837 bd L 8. 352.

26. Compare Otfried MttUer's Dorien, bd. i., s. 365.

27. 'Geographia Generalis in qua affectiones generales tellurisexplicantur.' The oldest Elzevir edition bears date 1650, the second 1672,and the third 1681; these were published at Cambridge, under Newton'ssupervision. This excellent work by Varenius is, in the true sense of thewords, a physical description of the earth. Since the work 'HistoriaNatural de las Indias', 1590, in which the Jesuit Joseph de Acosta sketchedin so masterly a manner the delineation

of the New Continent, questionsrelating to the physical history of the earth have never been consideredwith such admirable generality. Acosta is richer in original observations,while Varenius embraces a wider circle of ideas, since his sojourn inHolland, which was at that period the center of vast commercial relations,had brought him in contact with a great number of well-iinformed travelers.'Generalis sive Universalis Geographia dictur quae tellurem in genereconsiderat atque affectiones explicat, non habita particularium regionumratione.' The general description of the earth by Varenius ('ParsAbsoluta', cap. i.-xxii.) may be considered as a treatise of comparativegeography, if we adopt the term used by the author himself ('GeographiaComparativa', cap. xxxiii.-xl.), although this must be understood in alimited acceptation. We may cite the following among the most remarkablepassages of this book: the enumeration of the systems of mountains; theexamination of the relations existing between their directions and thegeneral form of continents (p. 66, 76, ed. Cantab., 1681); a list of extinctvolcanoes, and such as were still in a state of activity; the discussion offacts relative to the general distribution of islands and archipelagoes (p.220); the depth of the ocean relatively to the height of neighboring coasts(p. 103); the uniformity of level observed in all open seas (p. 97); thedependence of currents on the prevailing winds; the unequal saltness of thesea; the configuration of shores (p. 139); the direction of the winds as theresult of differences of temperature, etc. We may further instance theremarkable considerations of Varenius regarding the equinoctial current fromeast to west, to which he attributes the origin of the Gulf Stream,beginning at Cape St. Augustin, and issuing forth between Cuba and Florida(p. 140). Nothing can be more accurate than his description of the currentwhich skirts the western coast of Africa, between Cape Verde and the islandof Fernando Po in the Gulf of Guinea. Varenius explains the formation ofsporadic islands by supposing them to be "the raised bottom of the sea:"'magna spirituum inclusorum vi, sicut aliquando montes e terra protusos essequidam scribunt' (p. 225). The edition published by Newton in 1681 ("auctior et emendatior") unfortunately contains no additions from this greatauthority; and there is not even mention made of the polar compression ofthe globe, although the experiments on the pendulum by Richer had been madenine years prior to the appearance of the Cambridge edition. Newton's'Principia Mathematica Philosophie Naturalis' were not communicated inmanuscript to the Royal Society until April, 1686. Much uncertainty seemsto prevail regarding the birth-place