THE

EARTH.

BY

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"THE HEAVENS," "THE SEA," "THE AIR," ETC., ETC.

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PREFACE.

Both the size and the purpose of this work are incompatible with the notion of its being a detailed description of the Earth, or a particular exposition of any one of the many sciences into which it is found necessary to divide anything like a thorough knowledge of our planet. The first of these must be sought for in the common works on descriptive geography, and the second lie scattered through the many volumes in which the doctrines of physical science, and the investigation and description of physical agencies and their effects, are treated. To have attempted to embody one of those sciences would have been attempting to do anew that which has already been more fully, and therefore more perfectly, done, than if every page of the following sections had been devoted to it. To have drawn up a mere list of those sciences and their subjects, would have been presenting feeble twigs instead of the bundle of rods, and without that cord of unity to which alone the strength of the bundle is owing.

Therefore, I have attempted to supply that which is not found in any one book, and probably not in any number of books, which have been hitherto published. I have attempted to give as clear and comprehensive a view as possible of the earth, considered as a whole, having equal regard to the causes or agencies which produce the more general terrestrial phenomena, and to the things in which, and the places where, these phenomena present themselves. For this purpose I have first attempted to show the great practical advantages which are derived from a proper knowledge of the earth, and the characters and relations of the several seas and lands of which its surface is composed. I have next attempted to show the great assistance which we derive from a really good map of the world in learning those details that form the basis on which the more argumentative and inferential part of the subject is founded. Having done so, I have cast a glance over the various lands, and the seas by which they are separated; pointing out the general character of each of the great natural divisions of the land, and hinting how these work together in bringing about all that occurs by natural causes. This being done, I have given some account of the agents and instruments which are chiefly influential in producing terrestrial phenomena; and I need not apprise any one who is acquainted with the subject, that the grand agent is the sun, and the grand instruments are, the air of the atmosphere and the water of the sea, which distribute the solar action over the surface of the earth, producing a state of things so very different from what would be if the air and the waters were as locally chained by gravitation as the more solid parts of the globe.

In treating of solar action, and its distribution, which form the grand elements of a proper understanding of the earth as the field of growth and the abode of life, which is the true and the useful understanding of the matter, I have thought proper, and have, indeed, felt it necessary, to proceed something in the way of analysis; and if, in the course of this analysis, one or two views have been opened up of the power and grandeur of some of the instruments of God's working which are new to the reader, he must not be startled at the vast height and the immensity of distance to which they beckon him to look; for we may rest assured that, in all cases where we can carry our analysis of nature as near as we can to the primal secondary cause, the mind feels itself trenching upon the bourne of infinitude, and our philosophy falls down in humble adoration before the throne, confesses its Maker, and exults and triumphs in the confession.

With a view to simplify this very sublime and very important matter as much as possible, I have first considered what would be the general effect of the sun upon a hemisphere of the earth, if both sun and earth were at perfect rest, situated at the same distance from each other as they are now, and if the sun-beams had precisely the same nature as they have at present, but that there were no moveable air or water, or any marked difference of surface, to modify their action. This is the elementary view, and the determination of it is a matter of geometry, partaking of all the certainty of that science; and this being once understood, the observed departures from it of themselves lead us to the investigation of their causes.

The full statement, or even the mere enumeration of all those causes, more especially the local ones, would have been incompatible with the space to which I was necessarily restricted; and therefore I have considered chiefly the two general sources of modification,—the daily rotation of the earth upon its own axis, and its annual motion round the sun in its orbit. By means of these, I have been enabled to state generally the effect which is produced by the reciprocal actions of the two hemispheres upon each other at different seasons of the year; and also, how those actions are farther modified by some of the more remarkable characters of the extensive divisions of the land; and thus I have been enabled to give a sort of general view of the phenomena of the year, though I fear it will be found both hasty and incomplete. My object is not, however, to teach scholastically, but to entice the reader to learn for himself practically, pleasantly, and profitably;—to stimulate the desire of knowledge, and to simplify the means of acquiring it, as well for the satisfaction and superiority which true knowledge gives us in this world, as for the confirmation which it affords of the fulfilment of our best hopes when to us this world shall be no more.

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Grove Cottage, Chelsea,
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THE EARTH.

SECTION I.

PRELIMINARY REMARKS.

The globe which we inhabit, of the dust of which we are formed, and to the dust of which each and all of us shall one day be gathered, is not only an important portion of the material creation, but, to us who dwell upon it, it is by far the most important. The other portions of created matter to which the general name of "the Heavenly Bodies" is given, and of which a short popular account will be found in our corresponding volume, "The Heavens," have much of grandeur and sublimity in them, and inspire not only him who contemplates them with the eye of knowledge, but the most ignorant and untutored of the human race, with feelings of wonder at their magnitude, and of reverence for their Maker, which it is as difficult to describe as it is impossible not to feel. But to our knowledge, the grandeur and the glory of the material heavens is a tale which is soon told: when we have measured them with the line, weighed them in the balance, ascertained their magnitudes, their shapes, their quantities of matter, the times of their rotations upon their own axes, their distances from great bulk of mankind, and becoming every day more and more closely linked with practical usefulness.

It is impossible to view this progress, or look forward to this result, without feelings of the most delightful description; and here we have this consolation, that hope and philosophy go hand and hand in the matter. It is no vain dream of an over-fervent fancy, no mist-formed spectre of the distempered mind, asserting without proof, and concluding without data; for we have only to look at the world, and, on whatsoever spot of the map our eye may alight, the impress of active improvement is clear and legible upon it.

It is somewhat of a proud boast to us of these kingdoms (a national pride is an honest pride when the direction of it is the good of all nations) to have been, if not the very foremost, at least the most energetic, in thus awakening the world to its own welfare; and when we behold the nations of the east, and of the west, of the north, and of the south, labouring with all their energies, and with every prospect of success, in bringing the ends of their several countries together, and uniting state with state, by means of improved river navigations, and canals, and railways, and steam-ships and carriages,—we cannot, nor need we, refrain from a little exultation, that these are the imperishable monuments of our Watts, our Smeatons, our Rennies, our Telfords, and our Nimmos. And there is a profitable lesson to ourselves in this exultation: for it was because these men grasped the volume of science with the one hand, and the necessities of mankind with the other, incorporating them with giant strength, that this world of the wonders of man's working was given to us.

Nor is it upon a few individuals thinly scattered that this impulse has come. It has taken hold alike of rulers and of nations. Either because they have become wearied and worn out with wars, or have gotten wiser, we find that a spirit is abroad, as well in the Mahometan world as in the Christian, though to different extents in different places, in consequence of physical, and social, and moral, and religious differences, which we are not called upon to investigate; and in consequence of this spirit the desire seems now to be, not to divide and conquer mankind, but to overcome and conquer those natural obstacles by which their peaceful and profitable intercourse with each other is impeded.

When we look upon the map of the world, and behold those chains of gigantic mountains upon whose snow-clad summits the continual strife of the elements elaborates that humidity which wells out in countless thousands of springs, seams the mountain slopes with deep ravines and brawling torrents, the action of which lays bare to man more of the internal structure of the earth than could have been disclosed by the labours of the whole human race; when we behold those rills, as they descend to the habitable parts, uniting themselves into streams equally ornamental and useful, equally efficient in aiding the labour of man, in the growth of materials, and in the turning of those materials into all that is necessary for man's most comfortable subsistence; and when we behold these uniting their waters again and again, until at last, through the regions of greatest fertility, and in some instances for full two thousand miles, capable of floating every article of commerce, the mighty river rolls its volume deep and placid to the ocean, as if it were absolutely supplicating the steam-ship in some such words as these—"Come, and bind into one brotherhood the various tribes of men which inhabit my banks. Come, and be the means of supplying all the world with the wonders of wealth which are watered by me and my tributary streams."

Much as has been done in the theoretical knowledge and the practical application of these very general and most interesting matters, they may be said to be still in their infancy; and every new step that is made only shows how much more of the bounty of the Creator remains behind for men to know and to do, and with how much more of the capacity both of knowing and of doing man has been endowed by this All-beneficent Being.

At first sight, and especially when viewed in the common way of taking the details of a subject one by one, and then endeavouring to combine them so as to obtain a knowledge of the whole, the study of THE EARTH appears a task almost hopeless; for the lifetime of man seems altogether too short for knowing all the plants on a single common, all the living creatures in a single lake, or all the birds in one forest; and then, when to these we add the endless variety of mineral substances which present themselves to us in the varied species of earths and stones, of metals and their compounds, and of the fossil remains of animals and of plants, some of them analogous to existing species, and others of which no living individuals or almost types are to be found, the catalogue exceeds the bounds of imagination itself, so that the most determined intellect might be turned away from it in the hopeless pain of its own feebleness.

But there is another mode of viewing matters of this vast magnitude and endless diversity ; and in this other mode there is both hope and enticement. There is nothing of material nature, as it addresses itself to us, which the mind is not capable of mastering, provided we go the right way to work ; and in order to see which is the right way, let us take a particular case—that of the British metropolis.

Suppose we had some wild man of the woods, who knew of no dwelling save the wigwam, the cave, or the hollow tree, for our pupil, and that we were to make him understand what London is like, how should we go about it ? Would we take the single houses, and describe in succession their materials, their structure, the arrangement of their several parts, and the advantage or disadvantages of each mode ? Assuredly not. As little could we hope to succeed by taking the details of all the streets and squares, and stating their several lengths, breadths, and directions, in terms of the length of the human foot, or of any other of those natural measures with which man in his most unlettered state is perfectly familiar. Nor should we fare better if, instead of the mere still-life of the metropolis, we attempted to detail to the woodsman the several nations, and ranks, and occupations of the vast multitudes wherewith this mighty city is thronged ; indeed, unless we could lay hold of some single, simple, and general feature of the city, which our pupil could in his own mind connect with what he already knew of men and their abodes in his own country, our labour would be in vain, and he would turn away from us, even though we addressed him in his own language, as if we were wasting his time in making him listen to sounds to which he could attach no meaning.

In respect of all subjects of which we know nothing, we stand in nearly the same relation as the tenant of the woods would do to the city; and, therefore, upon all subjects it becomes necessary that we should be presented with a first view, as clear and as simple, but at the same time as broad, as possible; and when we have fully mastered this, and seen all its bearings, and how we connected it with what we previously knew, we are prepared for another step. After this is fully mastered, we may take a second, after that a third, and then, if we "walk warily," we can go as far, and in due time as fast, as we please.

Still there are difficulties in getting a general view of the earth, which we do not meet with in any other subject. It presents us with so many elements; and these are so blended with each other in every thing, and every event which offers itself to our view, that we can hardly get hold of one element at once broad, strong, and secure enough for a foundation. Even if we leave out the influence of the sun, the moon, and other celestial bodies, upon the earth, there are three distinct subjects which demand our attention as substantive existences; and there is scarcely one point to which we can address ourselves wherein all the three are not to some extent or other blended together. These are, the *land*, or solid part of our planet; the *water*, or liquid part of it; and the *air*, or portion of it which exists in the state of a dry fluid or gas. It is impossible fully to understand the nature and capabilities of the earth, or of any one portion, or any one production which it furnishes, without having some general notion of, at least, the great laws of action in all the three; but we purpose to treat of the water in one separate volume, under the general appellation of THE SEA; and of the gaseous portion in another separate volume, under the general appellation of THE AIR; so that in this one we shall not explain any of the principles of either of these, though we may have occasion to refer to their distribution; and, indeed, as the three are intimately connected, in any view which can be taken of the natural history of our planet, however simple and elementary, we shall be obliged, in each of the three volumes, to assume as known, various matters contained in both of the others.

Even when the subject is thus restricted, the story of the earth is a long as well as an interesting one; and it involves several sciences, each of which treated singly affords materials for many and extensive works; and all of those sciences may be said to involve two distinct parts—a present state, and a past or progressive history.

It may not be amiss to enumerate a few of the leading sciences, the union of which constitutes the natural history of the earth, and to add some short definitions of them. The chief are the following:—

1. GEOGRAPHY, which means the description

or the representation of the earth, and which may be communicated in part by writing and in part by pictorial representation. The latter kinds of representations are called *globes*, when they are models or miniatures of the earth ; but in general the model applies to the general shape only, and not to the details, which are represented in the same manner on the globe, or model, as on the flat surface. Representations of the earth on flat surfaces are called *maps*, or, when their object is more particularly to represent the seas, or extensive collections of water, and only the shore of the land—that is, the lines where land and water meet—they are called *charts*. The word Geography, literally, means the description, or the artificial representation, of the earth, and of course it applies to every means by which the earth, or any portion of its surface, can be represented.

This single science of geography is so extensive that it requires sub-division into a number of branches. The leading one is *Physical Geography*, which treats of the earth in the most general sense, and not of its productions or inhabitants, though it embraces many of the causes upon which the diversities of these depend, whether these causes operate more particularly in the solid nature of the earth itself or through the instrumentality of the water or the air, or both of these jointly.

Natural Geography treats more particularly of the productions of the earth, the plants, and the animals ; but to their distribution upon the earth's surface rather than to the nature, liability, and uses of the individuals, or the classification of them into systems. The particular science which takes up the details of animated nature, where physical geography leaves off, is called *Zoology*, which means "the *voice* of life;" and the science which, in like manner, takes up the subjects of the vegetable world is called *Botany*, which means simply "of or concerning grasses, or that which is browsed by domestic animals." Sometimes the latter science is called *Phytology*, which means "the voice of plants;" and as such it is more accurately descriptive of its subject than the word botany; though as the latter has come into general use, the alteration would not be desirable. To these may be added the science of *Mineralogy*, which means "the *voice* of minerals"—that is, of those substances which are not either animal or vegetable, but which are constituent parts of the solid earth in the simplest view that we can take of it. The termination "logy," which is used in these names of sciences, is a very expressive one—it is from the Greek, *logos*—that which of itself declares itself; and it always applies to the nature of the subjects, and in this respect stands distinguished from the termination, "graphy," which means the mere description of the external appearance.

Besides those divisions of geography which have been stated in the above paragraphs, and which form part of the natural history of the earth, considered as the subject of man's observation, there are several sub-divisions which treat of man, the observer, in the various distinctions, and in the progressive history of the race. But though this branch of the subject may require to be noticed incidentally, in the course of these pages, it does not properly form part of the natural history of the earth, considered as a separate subject of study.

2. Geology, which means "the *voice* of the earth"—that is, the account which, taken as a whole, it is capable of rendering up to human investigation, in its present state, its past history, and, as far as experience warrants the conjecture, its condition in future times.

This, though it is one of the subjects to which the attention of mankind has been drawn ever since they had so far advanced in improvement as to be capable of speculating about the causes of things, yet the materials of our knowledge of this science lie deep in the earth, and the events of which it affords the evidence lie in times so remote that it is very difficult to connect them with the present times, or even any times of which we have a human record. There is, however, a degree of grandeur in this science which renders it peculiarly attractive; and this grandeur comes more closely home to us than that of the heavenly bodies. In the deepest mine, under the summit of the loftiest mountain, which has been trod by human foot, there are traces of the universality of that wonderful working to which allusion has been made, and which, throughout the whole globe, and in every portion of it which we can by possibility examine, proclaims, in language not to be mistaken, that it is a *production;* and that, diversified as are its parts, and eventful as has been its history, it is the result of one creative fiat, and obedient to one law; that all its changes, however mighty or however minute, and all its productions, however varied, are linked together in a most mysterious manner—a manner which leads the mind irresistibly to the belief of a Creative Power and a Ruling Providence.

3. Meteorology, or the doctrine of the air; but, except in the case of an allusion, this will be referred to another volume. It is not possible, however, to give any account of the earth without making some allusions to the atmosphere, because it is the medium in which all growth and life take place; it being probable that there is no production, even of the deepest parts of the ocean, which can come into being or be supported without the agency of, at least, some portion of air, how small soever such portion may be in some cases. The same may also be said of water, and therefore it will be necessary to have frequent allusion to that liquid even in this volume.

What have been stated are the general divisions of the substantive part of our globe; but, in addition to them, there are what we may call the active powers of nature, and which we are never able to obtain separately, or bring to the ordinary test by which we judge of the presence of matter, —that of having gravitation or weight. Those active powers are so subtle that we can speak only of their effects, and are unable to tell anything about their natures, or how they agree or disagree, any farther than these effects make known to us. We are also ignorant as to the number of those active powers of nature, and whether those which we call by the same name are in all cases the same, or those which we call by different names are in all cases different; but we cannot be wise beyond our powers of observation, and therefore we must yield to our own weakness, and fairly confess that this part of the subject is, in its principles, altogether beyond our depth. Still the effects of those agencies are as open to our notice as the most familiar piece of matter upon which their effects can be displayed; and when we attempt to get to first principles, even in the case of that matter which is palpable to the eye and the touch, we find that we can explain nothing but the appearances, and that the general word *matter* is really as much beyond our comprehension as any of the others.

Heat, light, electricity, and magnetism are the names which we give to those active powers which are understood to affect all matter, but to affect different kinds of matter in different ways; and the general effect of all of these may be said to be the counteracting of the gravitation of matter, and the tendency of equalizing their own action; but, at the same time, there are means of concentrating them in particular pieces of matter, so that the one portion may be made to act upon the other. In nature, there is probably no limit to the power of these agents—nothing in what we call substantive matter that can resist them. We all know the devouring effects of common fire; we all feel the genial, and sometimes overpowering, heat of the sun-beams; and all of us may read of the terrible displays made by volcanoes, and by, in all probability, the same agent, shaking the earth to pieces, and upheaving, from the bottom of the ocean, mountains and islands, which spread smoke and ashes over many miles of the sea—shoot up columns of flame, mingled with jets of boiling water, vast clouds of steam, and volleyed stone, hundreds of fathoms up in the air, while the waters around are boiling like a mighty cauldron, and the dead bodies of their finny inhabitants floating in countless numbers upon the surface.

And we may read of vast pieces of molten stone bursting from the summit or side of a mountain, with seven-fold the heat of a furnace, and rolling onward for many miles, in a march of terrible devastation, so that, even when the stream does not appear in the day-light to be in a state of ignition, but advances like a wall of bricks, the strongest castles which man can build crumble into dust ere yet it reaches them, and every tree and every green thing is turned to the blackness of ashes, while the powerful result of the operation of heat is barely in view. Or, it may happen that this burning flood is more headlong and impetuous, and converts in brief space a whole city into a ruin, but a ruin hidden from the view of man by that direful covering which, as it cools, hardens into one consolidated mass of rock, entombing alike frail man and the most boasted productions of his art; or it may rain upon them mountains of ashes, by which, while yet in the air, it shall be as dark as midnight. And as, in such a case as this, there are no means of escape, for it must be instant suffocation, a splendid city may be thus blotted out from the world's history, and remain in its tomb of ashes during the lapse of centuries, to be again discovered by accident, and engage the attention of the curious, and claim the wonder of all mankind, as has been the case with Herculaneum, and some of the other buried cities of Italy.

Such are some of the effects of the agent which we call heat, displayed upon the great and terrific scale in nature; and if we have positive evidence of these occurrences in several cases, and at several times, we have no reason to doubt that other cases, even far more terrific and far more extensive, have taken place, where there was none left, and probably none existed to tell the tale. And, though we have no human record of any result of the action of heat upon a more extensive scale than the overflowing of that district, the production of a mountain, or the raising of an island from the bottom of the sea, yet we have other evidence which is not less convincing, in vast tracts of country, which are now raised to a considerable elevation above the common level of the waters, which, from the countless number of shells, and other animal remains, which are in them, all clearly of a murrain character, must, at one period of the world's history, have not only been at the bottom of the sea, but must have been far, miles probably, in some instances, below the mean surface, and, from the thickness of the strata in which they are found, must have remained accumulating in that wonderful storehouse, the bottom of the deep, for a very long period of time. In the very centre of England, between the sources of those rivers which flow to the eastern sea on the one hand, and to the western on the other, we have countless remains of fishes, and deep sea-shells, and fragments of creatures, of various kinds, all of which must at some time or other have tenanted the deep waters; and there are other places where similar remains are found, at an elevation of two or three miles, and that too in immense ridges of mountains, in which it has not, at least hitherto, been discovered that there is a single trace of volcanic action at or near the surface.

We shall have occasion to revert to these matters when we have made a beginning of the main subject of our work; and we have mentioned them now only to show that the earth itself not only has action in itself, as well as those productions and inhabitants of it of which we can see the progress, but also that islands and continents, the most stupendous mountains, and the all-encircling sea, partake of that mortality which is the lot meted out by its Maker to every material thing. And, though we cannot number the years of a country with the same certainty as we can number the days of its inhabitants, and consequently are unable to form a conjecture as to the number of centuries, or millions of centuries, which an entire globe may last, before the purpose of the Almighty concerning it is fulfilled, yet herein we see that the law is one, and that the differences are all finite in extent, in power of endurance, and consequently in duration itself. Thus we can see the force of the sublime declaration of Holy Writ—"The heavens shall pass away as a scroll when it is rolled together, and the elements shall melt with fervent heat." When this shall happen must remain unknown to us, because not a single ray of light comes to us from the depth at which it is hid, except the certainty that it shall come, the part which we must bear in it, and the means by which that part can be made joyful to us; but still, in so far as we can judge of the state of our globe, it speaks as powerfully of the existence and the attributes of its Creator as if it were endowed with the tongues of angels.

When we have said elsewhere, that those active powers of creation of which heat is one of the most general and the most energetic, either as a species or as a modification, we would not be understood as meaning that it is confined to what we call dead matter; for so far is this from being the case, that it is so intimately connected with that which we call the principle of life, both in animals and in vegetables, that there are just as good reasons for concluding that those principles, as we call them, are all modifications of some one energy—some one created energy, which is too mighty for our comprehension, and yet which is less than nothing in the sight of God.

As, however, our object in the study of all the more mighty subjects in nature, and indeed of every subject upon which we would be truly wise, is to "divide and conquer," after we have got some general notion of what we are to divide, and how we are to conquer, we shall, in the sequel, consider the actions of those powers or principles in separate sections, yet still endeavouring so to blend the one with the other as not entirely to lose sight of that whole which is the subject of our general inquiry.

But before we enter upon these, we must have some simple foundation—some tablet, as it were, upon which to record whatever may present itself to our view worthy of remembrance, either on its own account, or for the sake of the light which it may throw upon something else. For this purpose there is nothing better, and indeed nothing else, than the common geographical description of the surface of the earth, with the distribution of the land over it, which must include a slight notice of the positions of the several parts of the sea, as the boundary of the land. In addition to this, it is requisite to notice the different appearances of characters of the different portions of the land, both with regard to geographical position, and seasonal and local influence. We must do this in a more broad and general style than is done in the common books of geography; for we have the whole earth, as it were, before us at once, and therefore we must be in a condition for making our mental journeys from one part of it to another in such brief space as that they may come into as close juxta-position as thought can follow thought.

Nor is it with a view to studying the earth alone that this ready and accurate reference to the position and appearance of every spot of it is of great value to us; for the map of the world—that is, the representation of the earth's surface—may be regarded as our artificial memory, or rather as the frame-work of our knowledge, every thing of which we have the means of informing ourselves. All that exists to astonish, to delight, to serve, and to teach us, as physical beings, exists on the earth; and the different parts of the earth, even those which are the farthest asunder, and physically most different from each other, in their climates, in their productions, and their inhabitants, are still so beautifully adapted to each other, that even here we see the unity of purpose, and how localities, as well as human beings, are evidently formed for being the helpmates of each other. In this there is wisdom, if we had but patience and prudence to work it out; for if countries are kindred, it surely follows that their rational inhabitants ought to be brothers; that as land sympathizes with land, much more ought man to sympathize with man; and that if, as we shall afterwards show, the thirsty sands of Africa and the great mountains in America work together so as to render our air in England much more balmy, and our fields to wave much more richly with corn than they otherwise would, then ought we to make our fellow-men sharers with us in the benefits of our science, and withal to bestow upon them the light of Divine Truth.

SECTION II.

GEOGRAPHICAL REPRESENTATION, OR MAP, OF THE EARTH'S SURFACE.

In this case, we consider it best to introduce a slight notice of the representative map, before we speak of even the figure and magnitude of the represented earth, because the representation can be viewed as a whole and at one glance, whereas all of the real earth which can be seen at one view, under ordinary circumstances, is so exceedingly small a fraction of its surface, that it is calculated to afford no notion whatever of the whole. Direct personal observation is here necessarily a matter of mere detail, and of detail which we are unable to generalize without having recourse to celestial observation; and hence the singular form which the ancients, and even the monkish delineators of the middle ages, gave to the map of the world. With the latter, it was very much a work of mere fancy; for the city of Jerusalem was placed in the centre, as if all the earth depended upon it.

We mentioned that the earth is sometimes represented by the globe or model, and sometimes by the plain picture or map; and, for all useful purposes, the map is beyond comparison the more serviceable of the two, not only in the details of geography, but more especially the studying the earth as a whole, in the relations of its different parts, and the results which we draw from the comparison of these with each other. The globe, no doubt, gives mere beginners some notion of the figure of the earth; and, if the picture upon its surface is correctly drawn, it shows all the countries, or portions of land, in their natural proportions to each other, or, as it is usually called, upon the same scale. There are also various problems, relative to the situation of places on the earth, and the apparent motions of the sun and moon, which can be solved in a rude way by means of a globe; but still these solutions are so very rude that, after all, the very best globe that can be made is little else than a mere toy; and, as is the case with the most scientific toys, it is doubtful whether it may not, in some instances at least, do as much harm as good. The chief objections to it, however, are the unwieldiness and expense of a globe sufficiently large for admitting of even a moderate representation of the details, and the fact that the larger the globe is, the less of its surface can be seen, at one view, at a readable distance.

From these objections the map of the world is entirely free; for we may represent the whole in one picture upon a pretty large scale, at a moderate price, and in a portable form, and we can have separate portions on a scale so large as to admit of very considerable minuteness in detail. The great advantage, however, with a view to studying the natural characters of the earth as a whole, is the fact that the two halves, or hemispheres, of the surface can be placed in two circular portions, in close juxta-position with each other, and that thus the relative positions of all places may be seen at a glance.

It is true that, as is the case with all human representations of natural objects, whether by pictures or by words, the map of the world, or of any considerable portion of it, possesses some imperfections. This will readily appear when we call to mind that the representation and the represented surface are not surfaces of the same kind; so that it is not possible to express the one in terms of the other. The map is on a plane or level, and is all turned one way, while the surface of the earth is turned every way, being directed at all times to all possible points in absolute space. As our object is not to teach either the principles of geography or the construction of maps, it will suffice for us to mention that there is a geometrical law according to which we can construct a map of the world, which, though on different scales in all places which are at different places from the centres of the circular spaces which represent the two hemispheres, but in which all places equally distant from either of those centres are upon exactly the same scale, and the variation throughout the whole of which can be calculated with perfect accuracy.

The best form for this purpose is what is called the *stereographic projection*, which means the representation "drawn in the solid;" and we may merely mention the principle upon which it is projected. Imagine, then, a transparent globe, with all the features of the earth marked upon it, and that a circular plane, also transparent, is placed within this globe so as to divide it exactly into two hemispheres. The particular direction of this plane is not an absolutely necessary condition to the accuracy of the map; but the plane of the earth's axis, or that passing through the poles, and at right angles to the plane of the equator, is the one which is most convenient for general purposes, and in this position of the plane the equator is represented by a straight line passing through the centres of both the circular spaces, or of both the hemispheres, as they are called. Neither is it absolutely necessary that the position of this plane should be fixed in respect of longitude, or of the direction of east and west; but the most convenient is on the meridian of 20° west and 160° east of the meridian of London, because the only countries which are divided in this position are some unimportant portions of the north-east of Asia, the island of Iceland, and, probably, a portion of Greenland, which last is very imperfectly known, and not generally approachable on account of the ice.

These positions of the globe and the plane being understood, the draftsman is supposed to place his eye in exactly such a situation as that the crossings of the equator and central meridian on both sides of the plane are exactly opposite to each other, and his eye quite close to the surface of the sphere. In this situation of things he is supposed to look at the opposite hemisphere, and trace upon the plane the figures of that hemisphere, by passing a pencil or any other instrument that will make marks in all the places in which they appear to his eye. One hemisphere being traced in this manner, the draftsman is understood to substitute a fresh plane, and look towards the other hemisphere from the centre of the surface of the first, tracing that other one in a manner exactly similar; and thus the stereographic projection of the two hemispheres is obtained. It must be understood that the draftsman traces his representation from behind each hemisphere, where to his view it is reversed; and that when it is represented upon the paper, or other plain surface which is to carry the map, it must be put in the opposite direction to that in which the draftsman sees it. The reason of this is very obvious, as anything viewed on the one side is reversed in respect of the view from the other; as for instance, if a building stands due east and west, the east end of it is towards one's right hand if viewing it from the south, but toward one's left hand if viewing it from the north.

The two hemispheres are placed horizontally in the map of the world, and from one's left hand to one's right hand is from west to east in it, and from right to left is from east to west. Thus the hemisphere to one's right is the eastern hemisphere, that to one's left the western hemisphere, the top is the north, with the north pole at the middle of the semicircle which bounds each, that is, at the terminations of the straight meridians. And the south and south pole are in like manner situated at the bottom of the map. The right-hand sides of places are thus their east sides, the left-hand sides are their west sides, their upper sides are north, and their under sides are south, and direction towards any of those boundaries is direction toward that point of the compass for which it stands. Only this must be received with some explanation, as it is perfectly true only in the case of the equator and the straight meridians.

What we have now stated is the principle upon which the stereographic projection is formed; but this principle is reduceable to the drawing of lines and circles, which, for the reason formerly stated, we are not called upon to explain.

The surface of each of the two represented hemispheres is divided into a net-work by means of circular arches, meridians all meeting at the poles in each hemisphere, and parallels of latitude in the cross direction. The meridians have every degree of curvature from the straight line joining the poles to the semicircle bounding either side of the hemisphere; and, therefore, the central meridian is shorter than any of the others, bearing to the bounding semicircle the proportion of about 100 to 157, or rather less than two to three. The meridians are drawn at every 10° of latitude, and the distances between them are in proportion to their lengths, and, of course, countries near the margin of the map are broader in proportion from east to west than those near the centre. The parallels of latitude are also drawn at every 10°, and they are so contrived as that the lengths of places from the centre toward the boundary, both northward and southward, increase in the same proportion as the breadths; and thus the distortion which is inseparable from the expression of a hemisphere by means of a plane circular surface is the same both ways.

There is another distortion to which we must attend, in order that our map may not give us erroneous notions of the positions of places with regard to each other, and the actual shapes which they have upon the globe itself; and this is the varying curvature of all the meridians, with the exception of the central ones; and the varying curvature of all the parallels, with the exception of the equator. In consequence of this, countries which lie near the margin of the map, or indeed at any considerable distance from the centre of either hemisphere, are bent toward the bounding circle in their north and south or latitudinal direction, and toward the centre of the map in their east and west or longitudinal one.

The boundary circles on the margin of the map are usually divided into single degrees, and sometimes into smaller parts, and the equator is divided in a similar manner; and if the scale of the map be sufficiently large, it is easy, by dividing the compartments of the net work formed by the meridians and parallels by the eye, to find any place from its latitude and longitude, or conversely the latitude and longitude of any place if the place itself is observed; and in this manner the map readily becomes an easily consulted index to the geographical positions of all the details which are marked on it.

The only means by which these details can be laid down in their proper places in the map is from their latitudes and longitudes, ascertained by celestial observation; so that it is by means of the heavenly bodies that we are enabled to get a correct picture of the earth. As the latitudes and longitudes of only a few points, as compared with the wide surface of the earth, have been ascertained, there is much to be filled in without this accuracy; but still the fixed points are the important ones, being those which are most remarkable for their natural properties, or most interesting to mankind; and the vast number of travellers and observers who now visit all quarters of the globe, generally furnished with instruments of observation and capable of using them, are making constant improvements in this part of the science; and for this reason it is desirable for every one who would know the details of the earth's surface accurately to procure a map of the newest construction possible. The date of the printing is, however, no sure guide in this matter, for the laying down of all the places correctly is not only very laborious, and consequently very costly, but it requires the combined qualities of a thorough knowledge of geography and of the means by which those latitudes and longitudes that are the data have been ascertained, together with a very judicious head and a very skilful hand.

We have given this account of the map in preference to giving a map itself; first, because no map which could be brought within the size of the volume, or sold for more than double the price, could be of much real use, more especially as he who would study the natural characters of the earth must have a map on which those characters can be represented so as to give a moderately accurate idea of the general features of the surface; and secondly, because a map inserted in a book cannot be constantly before the reader, but must be turned to when wanted, which is both a tedious and a clumsy mode of procedure. Unless the rivers, the mountains, and all those other prominent figures which are our means of judging of the earth, are marked with sufficient clearness and on a scale sufficiently large to enable the eye readily to make out their general forms, all the notions which the student can obtain of them are purely imaginary; and as there is in any case only one right, and innumerable wrongs, it requires no argument to show that they who fancy an earth to themselves for featureless miniatures, such as are generally inserted in elementary works of geography, and such indeed as can be afforded in these works, may have some crude notions of "a world of their own;" but in this case there must be as many different worlds as there are imaginers, and all of them unlike the reality.

Such is the importance of studying intimately and correctly a good map of the world upon a scale as extensive as possible, that, independently altogether of the characters of the earth itself considered as a whole, no one is properly qualified for acting his part well in the common business of life, and no one is capable of duly appreciating the value of history, enjoying a book of travels, or in short of talking like a rational being about any of those countless foreign substances which are now met with as the materials of articles of use or ornament, or as portions of food in almost every house within these kingdoms; and though we are not advocates for any morbid excess of legislation upon any of those points in the domestic conduct and economy of the people which do not trench in anywise upon morality, and orderly and becoming behaviour, yet it would be no bad rule to set the stigma of the neighbourhood upon every person who presumes to use any one of these articles without being able to tell whence it comes, what are the general characteristics of its native country, how it is grown, or otherwise obtained, or how it is fetched to this country, and what advantage there is in the using of it, whether as a means of innocent enjoyment or as a stimulus to our industry at home.

If folks could once be led to this, it is incalculable to conceive how much more delightful it would make the world we live in; because it would enable us to live mentally, and in our mental life consists our real enjoyment in all the world at once. Thus, for instances, we should be enabled to drink our coffee in the groves of Yemen, with turbaned Arabs and loaded camels around us; and under that balmy sky we could look athwart the Red Sea, which is there in one place an assemblage of worm-built reefs, extending line upon line, and white with the foam produced by an angry wind, and in another place reeking with the steam of volcanic fires, while the bottom is as gay as a garden with the vegetation of the deep, and the waters are literally encumbered with living creatures. So might we drink our tea in some fantastic alcove in the pleasure-grounds of a Chinese mandarin, and enjoy the characters of that most singular country, which has remained changeless for hundreds of years, amid all the vicissitudes, reverses, and progressions of our part of the world. We should never taste the stimulating flavour of cinnamon without being borne in thought to Ceylon, with its rich fields of rice, its beautiful copses which furnish this wholesome and exhilirating spice,—its tangled and swampy woods, with their herds of gigantic elephants,—its more dry and inland forests, peopled with countless thousands of apes, which make the early morn literally hideous with their cries, and the females of some of which may be occasionally found descending to the brook in order to wash the faces of their little ones; so also we should never taste a clove or a nutmeg without being wafted to the spicy islands of the Oriental Archipelago, where all is the vigour of growth and beauty, and the richness of perfume, where perpetual health is wafted on the gentle gale of the widest ocean of the globe, where some of the fruits combine the qualities of the most racy of their own tribe with the substantial nourishment of delicate animal food, and the admixture of a cooling ice and a cheering cordial,—while the trees around us would be thronged with the loveliest of birds, and the birds of Paradise, with their long and filmy feathers, streaming in every direction through the air, like meteors—meteors which shine but do not burn.

But we must stop, for there is no end of the catalogue, and it is an exhibition of which we must not see too much at a passing glance, lest it should wile us from our proper purpose. And we have mentioned those few particulars merely to let those who are yet in ignorance of the subject know how well the world is worth our studying; how richly the earth which we inhabit has been endowed by its bountiful Maker; how full the feast which it affords to all; and yet how varied, how free from surfeiting, how healthful.

Now, as we have already said, not only might, and *should*, every commodity of every region transport us to that region, and make it render up to our enjoyment all that it possesses; but a map of the world, which has been duly studied, brings the whole before us the moment we glance at it, nor is it confined to the external appearance, and the productions, and the present population, of the several countries; for in proportion to the extent of our knowledge will be the extent of the reminiscence which this most powerful talisman will conjure up. Truly, it is magic, but it is magic of nature's exhibiting—the magic of the effect of infinite wisdom and goodness, without deception, without anything to mislead or corrupt, and with every thing to inform the head and soften the heart.

As we look upon those two circular spots of paper, the whole of the human race, from Adam downward, rise in succession to our view; and every event, pictured to itself, stands out as fresh and as forcible in its colours as if it were before our mortal eyes. Now we see the congregating clouds and the flashing lightnings, and hear the dismal sounds of the volleyed thunder, and the rending earth, as "the windows of heaven are opened, and the fountains of the great deep broken up," in order to drown the world, sunk in iniquity beyond all mercy and forgiveness; but in the very depth of the tempest terrors, behold the ark of deliverance, for the man who was faithful amid an offending race, riding safely on the top of the swelling waters; and no sooner is the purpose accomplished, and execution done upon the guilty, than, lo! "the bow of hope is seen in the cloud, and a promise of mercy is declared to a renovated world."

Again we might call—or rather there would arise without our calling—any one scene in the world's history, whether sacred or profane. We might march through the divided waters with the delivered Israelites, and, standing safely on the shore, behold the overwhelming of Pharaoh and his host. So might we continue the stream of history down to the present hour, adding nation after nation as it arose, and losing it in the sandy desert of oblivion when it perished from the scroll; and in tracing the sacred story we should be enabled, if we brought sufficient knowledge to the task, to ascertain, in a manner beyond all doubt, that the history of the Old Testament is so faithful to the natural character of the countries in which the scenes of it are laid, and so entirely free from all allusion to other countries,—so different, indeed, from every human record, in this respect, that it cannot but be true to the letter.

It is the same with every art which mankind have practised, and every science which they have studied. If we once are in possession of the knowledge, and have had the map in juxta-position with us in the study of it, the map will not suffer us to forget it, but will faithfully bring to our recollection, at all times, every thing, of weal or of wo, that has happened to our kind; and not to our kind only, but to all the creatures that now tenant the earth, or have formerly tenanted it, in every one of its varied localities; and the revolutions which the earth itself has undergone,—either violently, by those convulsions that are now and then taking place, or more slowly and silently, but with equal certainty, in the lapse of ages,—may be equally brought to our recollection by this invaluable record. The map will not furnish us with the knowledge at the first, but it will keep for us what we have acquired.

In every case, indeed, we deceive ourselves, if we imagine that there is any short road to the acquiring of knowledge,—that is, of original knowledge,—while we ourselves are ignorant. If we know nothing, we can learn nothing. This may seem paradoxical, but it is a truth, and a very important truth ; for, before we can have a complete knowledge and understanding of any one subject whatever, we must previously have acquired that essential element of all knowledge, capacity,—the use, so to speak, of our own mind ; and we must not at all wonder that this should require general training, or educating, before we can apply it usefully to particular subjects. There is a general education of the hand, and also of the eye, and indeed of all the organs of the senses ; though in the case of these it takes place so early in life that we do not notice its progress. There is, however, no doubt of its existence ; and we can no more hope that the mind can intuitively know, than the hand can intuitively execute. Therefore, the truly valuable part of all education consists, not in teaching the knowledge of individual subjects, but in so disciplining the mind as to teach it how knowledge of all kinds may be acquired.

SECTION III.

FORM, MAGNITUDE, AND GENERAL FEATURES OF THE EARTH.

With the understanding that we have the map of the earth, as described, or rather noticed, in last section, spread out before us,—which will save much detail and repetition, and enable us to bring the different points more closely together, so as that they may better illustrate each other,—we shall proceed to notice the subjects enumerated in the title of this section.

The earth, then, so far as we have been able to measure it, is a globular body, but not exactly a sphere, neither is it in all probability a perfect spheroid; of which, even not taking the inequalities of mountain and valley into consideration, every section, on a parallel, would be a perfect circle. The deviations from the spheroid, and even from the sphere, are so small, that for common geographical purposes they do not need to be taken into the account. But when we come to consider the natural history of the earth's mass, in so far as that mass can be the subject of consideration, these little irregularities are of importance, as connecting the form of the earth with the fact of its rotation on an axis, or imaginary line passing through the poles, and also with the fact of its being composed of materials, some of which are heavier and others lighter, and with that irregular distribution of those substances of different densities which we meet with in every part of it which is open to our inspection.

Newton calculated that, according to the laws of gravitation and motion, and the rate at which the earth turns on its axis, it should have a compression, or flattening at the poles, of about one two-hundred-and-thirtieth part; but then Newton's calculation was made upon the supposition of uniform density, or that of all parts of the earth being equally heavy. Now, the best experiments which have been made on the subject give to the general mass of the earth a density very considerably greater than the heaviest rocks which we meet with in any considerable quantity near the surface. The mass of rocks, which form the greater part of the solid crust of the earth, so far as they have been examined, do not exceed two and a-half times the weight of the same bulk of water; and as the metals, of which the quantity is comparatively small, at least near the surface, are the only substances heavier than this, we must suppose that, whatever they may be, there are materials in the interior of much greater density, because the average of the experiments which have been made, in order to ascertain the earth's density, gives a weight, bulk for bulk, about double that of the average rocks.

There is every reason to conclude, from what has occurred, both in the surveys for the measuring of the earth and in the experiments which have been made with the pendulum, with a view to the ascertaining of how much it is flattened at the poles, that certain portions, even near the surface, are considerably more dense than others; for there have been instances in the surveys, where the plumb-line has been deflected much more than any difference of the surface level would appear to warrant, and these have disturbed the apparent, or rather perhaps the assumed, regularity of the compression, which, beginning at the equator, amounts to about thirty miles at the poles. So also in the case of the pendulum, which is probably a more nice and delicate instrument than the plumb-line and the apparatus of celestial observation, there have been irregularities observed which show that our most careful endeavours to ascertain the exact form of our planet are still, to some extent, approximations; and that, before we can speak dogmatically about how much it differs from an exact sphere, we must know something more about the data.

The pendulum, such as that which regulates the motion of a common clock,—only for observations of this kind it must be very delicately made, and furnished with apparatus which would be foreign to our purpose to describe,—returns from the extent of its swing on the one side by the force of gravitation, or the tendency which the bob, or weighty piece at the lower end of it, has to fall to the earth; and the momentum, or accumulated force which it acquires from its return on the one side, carries it to the extent of its swing on the other; but, however delicately it is constructed, it loses something of its power every time that it passes the line joining the centre of the earth's gravitation and the centre from which it is suspended, so that without an impelling power to counteract this influence of the earth, it would in time be brought to a state of rest. In the common clock, the weight or spring which acts upon the train of machinery is the power which counterbalances the gravitation of the pendulum towards the earth, and keeps this part of the machine in motion ; and that there is considerable force exerted, is shown by the ticking of the clock, as the pallets attached to the pendulum and the teeth of the scapement wheel strike against each other.

The more powerful that the force of gravitation is, the more strongly, and therefore the more quickly, must it draw down the bob of the pendulum towards the earth's centre ; and because the earth is flattened toward the poles, and elevated round the equator, the poles are nearer the centre than the equatorial parts ; and, as the whole mass of the earth is the same, and the gravitation towards it, as depending on the mass, consequently the same at every point of its surface, whether that point be nearer to the centre or more distant from it, the difference of gravitation at the equator and the poles must be inversely as the squares of the distances of the surface at these places from the centre. Hence, reasoning from the form of the earth, we would conclude that the greater gravitation as we approach towards the poles would make a longer pendulum vibrate in the same time, than the diminished gravitation at the equator. Experiment shows this to be the fact ; and, indeed, it was from the circumstance of a pendulum adjusted to exact time, in the middle latitudes of Europe, making a clock go too slow when carried to a place near the equator, which gave the first practical proof of the elevation at the equator, and the flattening at the poles. The difference is no doubt exceedingly small, because the earth's deviation from a perfect globe is exceedingly small ; but still, though it is impossible to obtain extreme accuracy in experiments of so very nice a nature, yet the fact of a gradual flattening toward the poles is established. But we cannot expect that the particular form of the meridional curve, as determined by the pendulum, can be exactly the same as that determined by celestial observation. The pendulum gives the compression at the poles rather less than the other ; and it is probably nearer the truth, inasmuch as it depends wholly upon the earth, and is not affected by refractions or parallaxes, which we have always to contend with in celestial observation. Still, the two do not differ much from each other ; and it is satisfactory to find theoretical influence, as deduced from the motion of the earth, and two different modes of direct observation, all pointing to the same result.

We have made these remarks on the uncertainties and sources of small error, against which it is impossible to guard in our attempts to determine exactly the form of our planet, in order to caution those who are but little conversant with such subjects and operations not to be carried away by confident assertions that such and such measures are the absolute truth. Indeed, when we come to real practice, there is no such thing as absolute truth, probably no such thing as a perfectly exact yard measure, and though there were one, no man could pretend to say that he could certainly make another exactly the same. We can measure just as exactly as we can observe ; and though we take a very small part, and have a very small error,—as for instance, if we were to take an inch and multiply it up till we came to miles,—we should multiply the error in the very same proportion as we multiplied the whole quantity, and thus not be more accurate than if we had saved ourselves the trouble of this excessive minuteness. The principle which is here involved is well worthy of our attention, not merely in our attempts at the mensuration of the earth, or in any other mensuration whatever, but in all matters: for, whenever we labour to be excessively fine, we are either proportionally useless, or as much in error as in the ordinary way.

There are one or two more facts connected with these pendulum experiments which may in time throw a little light upon the composition of the earth, at least in so far as the mere weight of materials is concerned. When the observations are made on islands situated in the deep sea, it is found that the pendulum indicates a greater degree of local gravitation than when experiments are made on the main land in the same latitudes; and that if the islands are formed of compact volcanic matter, such as basalt,—the rock which is so remarkable for the grandeur and regularity of its natural pillars at the Giant's Causeway in Ireland, the island of Staffa on the west of Scotland, and many other places,—the local gravitation is greater than when the islands are formed of less compact materials. Now in the case of the island, it is specifically heavier than the water which surrounds it, and it is in mass the more so the deeper the water is; and thus it, as it were, concentrates the local gravitation upon itself; whereas, in an inland country, the said local gravitation is distributed all around, and there is in this distribution a tendency, though a very slight one, to retard the vibration of the pendulum.

Upon nearly the same principle we may explain those local variations which have been observed upon the land, for they have been most conspicuous where it was ascertained that there existed some heavy stone in the vicinity; as, for instance, a ridge of compact volcanic matter, a mass of granite, or something else specifically heavier than the general rock of the surrounding country.

For all popular purposes, though it is desirable to understand the principles of those nice matters, we may leave them out of the estimate, and shall not err very much if we adhere to the round or simple numbers which are easily remembered, and say that the earth is a globe 8,000 miles in diameter, or 4,000 miles radius, and about 25,000 miles in circumference. These cost no trouble in the bearing in mind; and when we require more minuteness, we can easily revert to the more complicated and fractional numbers, regarding the equator and a meridian as curves of different measures, and the first a circle but the other not.

This being understood, we may return to our map, though there are one or two points of reference in latitude which it is convenient to bear in mind. Latitude is definite measure on the earth, beginning at the circumference of the equator, and extending both ways to 90° at the poles. Thus there is something peculiar about it, inasmuch as it begins anywhere on the circumference of a great circle, and terminates at points, which are the poles of that circle. The whole measure from equator to pole is rather large for reference, and therefore the division into zones is a convenient one ; the more so that it refers also to places which have certain peculiarities in the length of the day.

From the equator to nearly $23\frac{1}{2}°$ both ways, forms what is called the torrid, the equatorial, or the inter-tropical zone, the last being its preferable appellation, as it is described by its boundaries, the tropics, or latitudes beyond which the line joining the centres of the sun and earth never declines, either northward or southward. The latitude of these tropics is rather less than $23\frac{1}{2}°$, but this is sufficiently near for the purposes of mere memory ; and it is sufficiently near also to consider the degree of latitude as containing 70 British miles, though $69\frac{1}{5}$ miles is nearer the truth.

Beyond $66\frac{1}{2}°$ of latitude of both hemispheres —that is, a patch around each pole, about $23\frac{1}{2}°$ in radius, or 47° in whole breadth measured across the pole,—is called the polar zone ; and, in order to avoid the constant repetition of the words north and south as descriptive of the two poles, the north pole and every thing relating to it is called *arctic*, and the south pole and all relating to it *antarctic*. It is of some use to remember these names, because the star which at present and must for many years be considered the north pole star, is pointed out by being in a line with two very conspicuous stars in the constellation of the great bear (*arctos*.)

The intermediate parts, extending from latitude $23\frac{1}{2}°$ to latitude $66\frac{1}{2}°$, and each measuring 43° in latitude, are called temperate zones, though it would probably be as well to give them a different name, insomuch as all parts of them are not temperate.

We mention this division into zones partly because it gives us reference to larger masses than we can obtain by means of single latitudes, and partly because, from the common names of the zones, the ignorant are in some danger of being betrayed into error. When, for instance, one portion of the earth is called *torrid*, another *temperate*, and a third *frigid*, we are very apt to suppose that those names are descriptive of the qualities of the places to which they are applied, and that there are no very hot countries except in the torrid zone, and no very cold countries except in the frigid and polar ones. Now nothing can be more erroneous than such a conclusion as this, for the boundaries of these zones are determined, not by the heat or cold of places, but by the position of the sun at certain times of the year. The heat or cold of any of them, or of any portion of it, does not therefore depend upon its being in a particular zone, or having a definite position in latitude, any further than the heat or cold of its climate is dependant on the sun ; and, under the same apparent enjoyment of solar influence, the circumstances of countries differ so much, that this position alone is not sufficient for stamping the character of any country. When therefore we refer to these zones, we are to be understood as referring only to mere position, and as leaving the characters of places to their own descriptions, though it be true that there is upon the average more solar action at the equator than on any other parallel, and that there is a gradual diminution as we recede from the equator both ways ; the average climate being somewhere about the middle of the quadrant, or 45° ; but that the poles are the points of greatest cold, instead of being demonstrated, is rendered doubtful by observations made on the north of America, where it appears that the very commencement of the polar zone, which is on a parallel with at least a habitable part of Europe, is colder than countries nearer the pole ; and if we take the middle of the quadrant, which gives us the south of France, in Europe, and trace it along to Canada, in North America, we find there the burning heat of fully a tropical summer, alternating with certainly not less than the rigour of a polar winter. We shall afterwards have occasion to examine the influence which the sun has upon the earth in different climates, as well as those local or general causes by which this action is modified ; and therefore all that is essential in the meantime is not to fall into error by supposing climate to depend wholly on the lengths of the day at different seasons, as measured by the apparent motion of the sun.

With this understanding, when we turn our attention to the map, the first thing which strikes us is the remarkable way in which the two great constituent portions of the earth's surface, the land and the sea, are distributed. It is near enough, for the common purposes of memory, to assume that the entire surface of the earth contains about 200,000,000, of square miles. Of this, about three-tenth parts, or rather less than one-third, is occupied by land, and the remainder, being about seven-tenths, or more than two-thirds of the whole, is occupied by water. It being understood that the term water is applied only to the seas and oceans, which are all connected with each other, and which consequently everywhere surround every portion of the land ; but that rivers and lakes are considered as part of the land, even though they happen to be salt water. This understanding is necessary, because a river, and even a lake, really belongs to the economy of the land through which it flows, or in which it is situated, and not to the economy of the sea into which the waters of the rivers are discharged. Besides, all those mighty movements of the ocean which connect it, not only with the general economy of the globe of the earth, but with that of the solar system, are not found in those collections of water which we are considering as adjuncts of the land. When we look at the two hemispheres as divided by the circles which form the boundaries of the map, we perceive that there is considerably more land in the eastern one than in the western, and that in both there is far more land on the north side of the equator than on the south ; that the greatest breadth of land upon any parallel is somewhere near the fiftieth degree of north latitude ; and that the parallel of about $66\frac{1}{2}^{\circ}$ falls upon the land throughout almost the whole of its length.

In the opposite hemisphere, or on the south side of the equator, the land is not only much smaller in quantity, but it has a more tropical situation, and the different parts of it are farther apart from each other. Even here, they are not equally distributed ; for the Pacific Ocean, though studded with islands in many places, will be found to occupy a full third of the circumference of every parallel in the southern hemisphere; while, on the equator, the Atlantic occupies only about a sixth part, and the Indian Ocean rather less. But at the southern extremities of these oceans, as measured from continent to continent, the distances are nearly the same. On examining the extreme points of the land in each of those situations, and they are the most remarkable points on the surface of the globe, it will be found that Africa, which occupies the central position, extends to the latitude of about 35°, or we may say in round numbers 2,400 miles to the southward of the equator. Australia, taking to the southernmost extremity, the smaller island, Van Diemen's Land, reaches to about 44°, or we may say about 3,000 miles; while America extends to at least 56°, and we shall not greatly err if we consider it as extending 4,000 miles south of the equator, which is about one-sixth part of the entire circumference of the globe.

It is true that Australia, which forms the right hand of the three great portions of land in the south, as we look upon the map of the world, does not extend to the equator, but is interrupted by Torre's Strait, in about 11° south latitude; but on the north of this continent, and all the way till we reach the main land of Asia, there are numbers of islands, which of course impede the motions of the water, and take the intermediate narrow seas out of the general laws which regulate the wide oceans. New Guinea, the largest of those islands, has not been wholly discovered, but there is reason to believe that it extends within not more than half a degree of the equator without any interruptions except at Torre's Strait. This strait is also in general so shallow that the bottom is visible, in calm and clear weather; and it is full of islands, so that though the interruption between the Pacific and the Indian Ocean produced by the land is very much broken by channels, yet the land is sufficient to form a boundary to the general motion of the waters, and cause the Pacific on the one hand, and the Indian Ocean on the other, to assume different characters at the same time that there is an intercourse between them, not merely by vessels passing from the one to the other through the different straits, but by the reciprocal action of the two oceans upon each other, and upon the insulated portions of land.

If we examine the hemisphere north of the equator, we find the state of things very different. Except the northern part of the Atlantic, the breadth of which is not very great, and Bhering's Strait, between Asia and America, which is narrow and not very deep, there is no communication northward between the oceans and the pole. It is known that for part of the year the ice of the Arctic Ocean joins land to land at both of these passages; and that it is probable that, in some seasons at least, there is no open water during any part of the year.

The different circumstances in which the two poles or polar portions of our globe are thus situated, must, it will readily be seen, impress upon them considerable differences of character; and it is necessary to attend to those differences, and to know their causes and also their effects, before we come to any conclusions respecting the countries which are situated in them.

From mere inspection of the map, it will at once be seen that there can be no great current of the waters of the oceans circulating in any way round a parallel on the north side of the equator, but that on the south side of the equator there may be such a current circulating with comparatively little interruption as near the equator as the fortieth or fiftieth degree of latitude. There is no question that most of the differences of character which we meet with between places having the same latitude, on the north side of the equator and on the south, are owing to this absence of the means of a circulating current in the one, and presence of it in the other; but we shall be better enabled to estimate the influence of this difference when we come to a future section, and are in possession of more of the elements.

Let us next examine the form of the land in respect of its mère boundary; and here we may as well mention a word which is very convenient when we attempt to describe the directions of the coasts of land, or the shores of seas. When we say that the position is in any particular direction, instead of saying that it extends, or lies, or stretches, or runs in that direction, we say it "trends;" and if we keep this meaning of the word, it gives us a clearer notion than any of the common words by which we usually express either states of rest or kinds of motion.

With this understanding we may begin our survey at the point where the western and eastern continents are nearest each other, because it is there that the distinction between them is most clearly seen. This point is Bhering's Strait, which is just about the northern polar circle, latitude $66\frac{1}{2}°$; from this point, the north coast of Asia trends north-westward, and keeps generally above 70°, reaching 76° at some points; but when we come to the coast of Europe it is less; and, so far as is known of the former, the outline is more irregular. In Lapland, again, we have the extreme of Europe, reaching beyond the seventieth degree; and if we examine the map, it is worthy of being borne in mind, that the same meridian, namely, the twentieth east of Greenwich, passes through the northernmost part of Europe, and the southernmost of Africa.

On this north coast of the eastern continent there are some islands amidst the snow and ice, the most remarkable of which is Nova Zembla, near the north-eastern angle of Europe; and Spitzbergen, remarkable alike for its barren cliffs and the vast masses of ice which fall thence into the sea during the summer season, is situated directly north of the continent, and lies nearer to the north pole than any land which has been examined; for the northern extremity of it is beyond the 80th degree of latitude, and, therefore, not much farther distant from the pole than the length of the island of Great Britain.

As we glance round the boundaries, it will be of use to bear in mind the forms of their outlines, because some part of the characters of countries depend upon these; as, for instance, if the outline is much broken, we may generally conclude that the surface of the country is rugged and unequal, and, if the outline is even, we may in general conclude that the surface of the country is flat. These are not of course invariable and unerring means of judgment, but they are worth recollecting, as the means of keeping the subject before us, and ultimately guiding us to the truth.

There is one other point which is worthy of our remembrance; and that is, the relative lengths of our measures, the degree of latitude and the degree of longitude. Except in so far as arises from the earth not being a perfect sphere, and for ordinary purposes it may be so regarded, the degrees of latitude are every where of the same length: but it is of course different with those of longitude, for the meridians which mark the degrees of longitude all meet each other at the poles, while two meridians, ten degrees different in longitude, may be reckoned about seven hundred miles apart at the equator. The law according to which they diminish is that of the cosines of the latitudes; that is, the radii of the circles forming the different quadrants; and any one who examines the bounding circle in the map, and imagines straight lines to be substituted for the circular arches which mark the parallels, will at once see that these lines shorten very slowly near the equator, but very fast near the poles; and thus will have some notion of the law of their diminution, even though not conversant with mathematics. We may mention that, at 60°, the diameter of the parallel circle, and consequently the circumference of it, and also the degree of longitude, which is the three-hundred-and-sixtieth part of the circumference of every parallel, is exactly half of what it is at the equator; that is, it is about thirty-five miles. If we call the northern boundary of Asia and Europe the parallel of 70°, and that is not very wide of the truth, we have the degree of that parallel about twenty-three miles and a half; and as the extent in the parallel is from 20° east, eastward, to 170° west, which is 170°, we may say, that in round numbers this northern shore of Europe and Asia is, on the straight line, about 4000 miles in length.

In studying the outline of a coast on the map, it is desirable to observe what rivers fall into the sea on that coast; because the lengths and directions of those rivers give us some data for ascertaining the general slope of the country, and this is at least one important fact in its natural history. Now, if we look back at this north coast of Asia and Europe, we find that there are several very large rivers which discharge themselves into the Polar Sea—as, for instance, the Lena, by a number of mouths, between 120° and 130° east longitude, the Yenissi, by one long estuary, in between 80° and 90°, and the Obe, into an inland sea, or arm of the sea, in about 70° east longitude. We observe that these rivers, together with others of considerable magnitude, though inferior to these, all flow towards the Polar Sea, and that on the average they traverse the country from about the fiftieth to the seventieth degree north latitude, that is, about 1400 miles north and south, taking them on the straight line, while the curvatures of some of them must be nearly double. Some of these rivers, as the Lena, for instance, fall into the sea in very high latitudes—the Lena as much as between 72° and 73°—so that we may infer that the whole of the country, for about 1400 miles in breadth from north to south, through which these rivers flow, not only inclines or slopes towards the north, but has its coast nearer the pole than any other country of the same extent with which we are acquainted. Hence we might, without any other means of judgment, conclude that this must be a part of the world remarkable for the intense cold of its winters. And, as the sea which lies along this dreary coast is cut off from much communication with the main body of the ocean, in consequence of the high latitude, the ice, and the narrowness of the entrance to it, we may readily suppose that whatever of compensating effect there may be in the waters as circulating over the surface of the earth, it must be in a great measure lost to this country; and we accordingly find that, while the cold is very severe during the winter, and the ice does not thaw upon the coast even in the heat of summer, yet upon the plains in the interior the heat of summer is often very great, and burns up the vegetation. The general name of this country is Siberia, as may be seen by the map; and it is a country, so to speak, which is given up to its own climate, and cut off from even natural intercourse, such intercourse as air and sea have, with the rest of the earth.

In the eastern portion of the north of Europe, as far as the White Sea, that rivers of considerable magnitude, of which the Petchora and Dvina are the chief, flow toward the Arctic Ocean; but though the winter is severe in the valleys of these rivers, especially in that of the Petchora, they are separated from Siberia by a ridge of mountains, and the mouth of the Dvina is in about latitude 65°, which is about 500 miles farther to the south than the mouth of the Lena. Still, the winter is very long and very severe in these countries, while the summer for a short time is often intolerably hot; and this part of Europe may be said to partake much of the climate of Siberia, though it does not exhibit all the gloomy features of that land of winter, of desolation, and of ruin.

In many places of this northernmost coast of the world, for in point of latitude it is the northernmost which lies nearly on a parallel, we have something approaching a realization of the *Ultima Thula* of the ancients—that fabled country, which was neither land, sea, nor air. Some of the rivers flow over beds of ice even in the heat of summer, and in other places the soil or solid part of the country, such as it is, consists of a mixture of ice and gravel, which does not deserve the name either of land or sea. On these extremes of the country there are of course no trees or shrubs; and the only land animals are polar bears, which find their subsistence by the margins of the sea, and probably extend their expeditions in winter across the pole to the most northerly parts of America. But it is not a little singular that this land, which is at present a land of desolation, appears to have been at one time the habitation of animals of the largest growth; for, even in the ice, where the rivers enter the Frozen Sea, there are the bones of elephants and other large animals in vast numbers—numbers so vast, indeed, that they form entire islands; and near the shores, there have been found the entire bodies of animals of this class, preserved in masses of solid ice. So numerous are the remains of the elephant in this part of the world, that the tusks form a considerable article of commerce, although there has not been a living elephant in the whole country within the period of history. This is a singular point in the history of the world. The fact that the entire animal has been found preserved in the ice forbids us from supposing that at any period the climate could have been much warmer than it is at present; and yet, as all the larger animals have evidently perished, it has certainly undergone some strange revolution; and that revolution appears, from the traces of plants which are left in the deposites of soil, to have been as great in the vegetable kingdom as in the animal.

After we pass the White Sea the character of the country begins to change; and we find no more large rivers, or extensive countries sloping towards the north. Immediately between the White Sea and the Arctic Ocean, estimating directly northward, there is indeed a low, swampy, cold, and inhospitable region; but as we approach North Cape we find a bolder shore and a better climate, and this continues throughout the whole range of the west coast of Norway till we come to the Naze, or south point of that country, which is nearly opposite to the north point of the island of Great Britain. The coast here is bold and mountainous, very much intersected by arms of the sea, and studded with numerous islands, some of which are covered with natural forests, and some are inaccessible rocks. There are situations at which the currents of the sea flow between these with very great violence, and produce waterfalls and whirlpools of the most splendid character. In this part of Europe there is scarcely anything which can be called a river; the waters having their sources at no very great distance from the sea, and flowing chiefly in brawling rivulets, which often dash down the rocks and through the forests with much grandeur. The number of small animals which the heat of summer calls into existence in this country is very great; and the numbers of birds, especially of those which inhabit near the waters, that resort hither in summer for the purpose of building their nests and rearing their broods, is almost incredible to those who have not actually seen them. We shall, however, be better enabled to notice these matters at a future time.

After the coast of Norway is passed we come to the entrance of the Baltic, an inland sea, which receives more than the average quantity of water from rivers, and from the entrance of which there is consequently a continual stream or current of water poured outward to the ocean. The Baltic, as may be seen by the map, divides into several arms or bays, the largest of which, the Gulf of Bothnia, extends northward in the direction of North Cape, and the second in size, the Gulf of Finland, extends eastward to St. Petersburg, the capital of Russia. The Gulf of Riga is further south than this, on the east side; and there are some smaller gulfs on the south side of the sea.

The greater part of the countries which are situated northward, or polarly, of the Baltic, have their principal slope towards this sea; and, though the climate is not so warm here as it is upon the external or Norwegian shore, toward the open ocean, it is still by no means a cold climate for the latitude. Great part of the country is covered with luxurious forests of timber, the banks of the streams are very romantic; and altogether it is a country of much interest, though decidedly polar in its character, and although for a considerable period of the year the sea is covered with ice, and the earth wrapt up in a mantle of ice and snow.

On the south side of the Baltic the character of the country is entirely different; it consists in great part of accumulations of sand, or of light gravelly soil, with some patches of richer ground in the bottoms by the banks of the rivers; and as many of these come from a considerable distance up the country, they have in the course of time brought down vast deposites of sand and gravel, which form very singularly shaped bars near the mouths of some of them. Upon examining the map it will be found that the principal rivers which empty themselves into the Baltic on this side are: the Neva, at St. Petersburg—which comes from two large lakes, Ladoga and Onega, which freeze in winter, are subject to violent storms, and send down such masses of ice that it becomes necessary to have moveable bridges at St. Petersburg; the Duna at Riga; the Niemen at Memel; the Vistula at Dantzic; and the Oder further to the west. Upon examining the last mentioned rivers it will be found that they have their sources considerably to the southward, and that there is in this part of Europe a large portion of country sloping towards the Baltic. These countries which slope toward the Baltic are not in so high a latitude as those which, in Siberia, the northern part of Asia, slope towards the Arctic Sea; and they are protected from the polar blasts by the mountainous land on the opposite side of the Baltic. Still, as this country declines to the north, and is bordered by a sea which is generally covered with ice in whole or part in winter, and as the intervention of the high land in Sweden and Norway, and also the British islands farther to the south, cut it off from the action of the Atlantic, its climate runs more upon extremes of cold in winter and dry heat in summer than might perhaps be expected from its latitude. As will be apparent from inspecting the straight outlines of this part of the Baltic, the shores are in general flat; and in many places near the banks of the rivers, especially to the south-east of this sea, the surface is covered with forests of pine timber.

From the entrance of the Baltic to the Strait of Dover, the coast is low and sandy, and the country flat, and in some places cold and barren. Some large rivers may be traced as entering the sea here, and determining the general slope of the country toward the north-west. The chief of these are the Elbe and the Rhine, the first coming from Bohemia, above the mountains in Germany, and the second from the centre of the Alps in Switzerland. Both these rivers bring down vast quantities of mud, so that the Elbe is very much interrupted by banks; and the Rhine does not enter the sea as one river. Intermediate between these two there are smaller rivers, the Weser and the Ems, which flow through countries which are well wooded and not very elevated.

From the Strait of Dover to the bottom of the Bay of Biscay, the coast will be observed opening to the English Channel and the Atlantic, and deriving full advantage from the vicinity of that ocean. The general slope of the country is also to the west here, as may be seen by the courses of the Seine, the Loire, and the Garonne, in France. On the south side of the Bay of Biscay, the mountains in the north of Spain run very near the shore, so as to leave only a narrow strip of land; and when we pass Cape Finisterre, which is about the westerly point of continental

Europe, there are valleys in succession opening to the Atlantic, as is indicated by the courses of the rivers Douro, Tagus, Guadiana, and Guadalquiver, in Portugal and Spain. The valleys of those rivers open to the Atlantic, and the southern ones especially have a more tropical character than any other part of Europe ; the rock of Gibraltar, situated on the north side of the entrance to the Mediterranean, being the only part of the European continent where apes, of any species, are found in a wild state.

The Mediterranean presents us with a singular feature in the structure of part of Europe and of Asia ; and the great valley, of which it forms the basin, extends from within ten degrees of the equator to the sixtieth degree of latitude, or nearly so : thus ranging over an extent of nearly 3500 miles, from north to south, and carrying many of the characters of an ocean-surrounded country into the very heart of the continent.

It is necessary to pay particular attention to the positions and relative magnitudes of the different parts and continuations of this important inland sea, because it has great influence upon the natural features and history of a very extensive portion of the world ; which influence may be regarded as extending in latitude on the meridian from near the equator to the confines of the polar circle, and even within it. We may also join in the same central basin the great insulated salt lake, the Caspian Sea,—which is now on a lower level than the Mediterranean or its continuation, the Black Sea, and separated from the latter by the mountains of Caucasus, which are sufficiently elevated to have their summits covered with perpetual snow. To the northward of this mountainous ridge the country is flat, however, and abounds in marshes ; and there are pretty clear indications that not only were the Caspian Sea and the Mediterranean united at some period of their history, but that the water extended to a very considerable distance over what is now land, and was in all probability connected with the Baltic.

On looking at the map, it will be seen that there is another large lake in central Asia, which may be regarded as belonging to the great system—so to call it—of Mediterranean waters : this is the lake of Aral ; and it will be observed that two large rivers, one from the south-east, the Oxus, and another from the east, the Sihon, fall into the lake of Aral, and have their sources as far to the eastward as the seventieth degree of east longitude.

As the centre of this great basin may be considered as lying on the parallel of forty, where the degree of longitude is about fifty-two and a-half miles ; and as it occupies, if we take it from the Strait of Gibraltar eastward, about 70°, on this parallel, its extreme dimensions in longitude cannot be estimated at less than 3600 miles ; or, if we average the western termination, the dimensions may be stated at 3500 miles both ways, which is a very large, as well as a very diversified portion of the earth.

It is true that we cannot consider this as one uniform and continuous country to the full extent of its extreme dimensions ; for, if we take the valleys of the rivers, it lies something in form of a crab, with one claw extending up the Nile into Africa, and another eastward into central Asia, by the lake of Aral, and the rivers Oxus and

Sihon. Great part of the valley of the Nile, too, is very narrow, and is really little more than a fertile streak seaming the desert, and wholly dependant on the river for its fertility. The eastern rivers are also separated from the Mediterranean both by mountains and by deserts ; and the northern and western rivers have, in some instances, high mountains between them. But still there is a unity of character about the whole of this district, notwithstanding the ramifications and irregularities of its parts, and the vast difference of climate which it contains ; and this unity is felt in all its natural characters, and in its productions, both vegetable and animal. It thus becomes important as a large portion of the earth, which has a common character, and a character which is more terrestrial than aquatic, that is, depends more on the land than on the sea. No doubt there is a great deal of water in the central parts of this region, but still this water is unconnected with the great oceans, or uninfluenced by their economy ; so that the influence which it produces is local, affecting only the land in its own neighbourhood, and being affected by that land and the rivers which it furnishes.

This particular portion of the world is the grand historical portion, whether we regard it as connected with the history of man, of nature generally, or of any particular department of nature. It is the world, as known to the ancients, and it has the longest and the most varied story. There is also a progress of seasons, a succession of vegetables, and a migration of birds in this district, of all of which we require to inform ourselves ; and therefore it behoves us to get well acquainted with the local situations of the most striking features, in order that we may convert them into a tablet of memory for the rest.

All that is valuable of northern Africa may be said to belong to this valley; but the mountains, beyond which the country gradually becomes dry, and passes into the great desert, are not far from the shore, and consequently the maritime country is reduced to rather a narrow slip along the coast; and though there are numerous small streams, and also very productive fields in the states of Barbary, there is no river of any consequence on that side, except the Nile in Egypt.

On the Levant, or eastern extremity of the Mediterranean, and also of its continuations, the mountains in general come near the shore, and the rivers are small. For more than the southern half of the Levant, which lies nearly on a meridian, the country is mountainous, and there is no river available for any purpose of communication; but further to the north, the Orontes, though but a small river, passes within so short a distance of the Euphrates, that it points out a very obvious and easily effected communication between the Mediterranean water and the Indian Ocean, by means of the Euphrates and the Persian Gulf; and it is worthy of remark, that at the present time there is a disposition, on the part of the rulers of that country, to suffer the establishment of a regular conveyance this way, either by means of canals or of railways, and of steam navigation upon the Euphrates. It is true, that the country is in a very unsettled state, and that the whole of the wastes are infested with predatory Arabs, who have never been honest at any period of the world's history; but in former times, when the country was in a flourishing state, they were kept in subjection ; and there is no doubt that if a trade were once established, by means of which the country could be revived and renovated, they might be kept in subjection again. The wild men of the deserts live upon the weakness of nations ; and in proportion as the settled population waxes strong, they vanish.

The peninsula of Asia Minor, which lies between the Levant on the south, the Black Sea on the north, and the Archipelago, the Dardanelles, the Sea of Marmora, and the Strait of Constantinople on the west, is a mountainous country, containing but few rivers. It is, however, one of the most delightful climates in the world, and was at one time a great nursery of the arts. There are salt lakes, deserts, and other unpromising elements in it ; but still there is enough of abundant promise to render it, in the hand of an active population, one of the most valuable countries in the world ; and it is worthy of remark, that the Armenians, who are natives of one part of this country, are the general traders over the east.

We shall merely mention the rivers and valleys on the other side of the Mediterranean, and leave the reader to trace their positions in the map ; for this purpose we shall return to the western part, and just name the principal ones in their order. The plains of Murcia and Valentia, on south-east of Spain, are remarkable for their fertility, their beauty, and the richness of some of their productions ; but the rivers in them are short, as the central elevation is here near the eastern shore of the Peninsula, and the principal rivers flow towards the Atlantic. Farther to the northward, the Ebro, which drains the southern slopes of the ridge of the Pyranees, is a noble stream, and its source lies considerably to the westward of the bottom of the Bay of Biscay.

From the south of France we have the Rhone, a river of large size, the principal stream of which comes from the very centre of the Alps, and the northern one, the Saone, from the western side of the mountains of Jura, connecting all the south-east of France with the Mediterranean. To the eastward of the Rhone, the Alps and their southern spur, the Apennines, extend near to the shore ; so that, though the country on the margin of water is very beautiful, there is no river of any considerable magnitude. The chief streams of peninsular Italy flow to the Mediterranean ; but though they are renowned for their historic fame and the beauty of their scenery, they are upon too small a scale for being admitted as features in a general view of the earth. When we come to the other side of Italy, at the head of the Gulf of Venice or Adriatic Sea, we meet with a river and valley of more imposing character—the river Po, and valley of Lombardy. This river drains the southern slopes of the Alps, rolls a vast volume of water in proportion to its length, and presents some interesting features in natural history, to which we may have afterwards occasion to revert. On the opposite side of the Gulf of Venice, and round the whole shores of Greece and by Constantinople, till we come to the western side of the Black Sea, there is no river of much importance. The country is mountainous, or at all events diversified in its surface ; and most of the streams are torrents, flowing in deep channels, often with great rapidity, and corresponding beauty.

When we come to the Danube, we may regard the district which it waters as the grand central valley of Europe; for the river extends nearly two-thirds across the country, without reckoning its windings, and its tributaries come from the Alps on the one hand, and from the mountains which divide the waters toward the Baltic and the western sea on the other. This is the largest valley which opens into the Mediterranean waters.

After we pass the mountains, or the height which may be regarded as the continuation of them, separating the valley of the Danube from the more northerly parts of Europe, we come to a country in which the distinctions of mountain and valley are not so clearly made out; and here we have some large rivers flowing southward from the centre of Russia, of which the Dneiper falling into the Black Sea, and the Don, falling into its continuation, the sea of Azof, are the chief. If, however, as the general character of the country requires, we admit the Caspian into this natural division of the earth, we have the Volga, the largest of European rivers, rising, by some of its branches as far north as about 61° latitude, and by others not far from St. Petersburg, and opening up a communication between the Baltic and the eastern seas.

We omitted to mention that the river Nile, in Egypt, may be observed as being at no great distance from the Red Sea, which is an arm of the Indian Ocean; and that thus a communication can readily be established between the Mediterranean and that ocean, by means of this channel; but the Red Sea is rather a dangerous navigation. It is at certain seasons subject to most violent tempests;

and the reefs and shoals in it are constantly changing their places. It has, however, been a line of communication between Egypt and India in most stages of the world; and perhaps it is the earliest navigation of any extent which was carried on to such a distance.

We shall afterwards have occasion to revert to the natural history of this highly interesting part of the earth; and therefore we shall only further remark in the meantime, that as this central portion of Europe and Asia is cut off by mountains, or natural boundaries of some kind or other, from the action of the great oceans, so it serves to connect very great extremities of climate both in latitude and in longitude, and its natural history becomes in consequence equally varied, interesting, and instructive. Taking it to the extent which we have mentioned, its northern boundary is swampy forests of pine, or, farther to the eastward, *steppes* or plains which are nearly destitute of vegetation, at least at certain seasons, and are at other seasons covered with pools of stagnant water, in many instances impregnated with salt. On its eastern boundary we have in succession the pine, the cedar, and the cypress, till we come to the acacia and the date palm in the southern climates; on the west we have the pine, the larch, the oak, the beech, and other deciduous trees, according to the soil and the elevation; and through them we gradually pass through the olive, the cork oak, and the orange, until we again reach the country of the date, which last may be said to be the ultimate tree on the margin of the African desert, by which the countries on the shores of the Mediterranean are cut off from the rest of Africa, farther to the south.

There are other changes which it is desirable to be acquainted with. At the western part of this great extent of country the climate and weather partake, to some extent, of that habitual variableness without extremes of seasons, which we experience in our insular situation; and as we proceed eastward, and approach nearer to Siberia, the weather is more regular to its seasons; but the characters of those seasons are more extreme.

The ridges of mountains and other interruptions, extending from east to west, break the continuity over the greater part of the longitudinal stretch; but there is one meridian which may be considered as affording an ample play to the whole northward and southward character of the region. This is nearly about longitude 32° east of London, or the situation of the Nile in the south, and between the mouths of the Dneiper and Don on the North; and here there is almost equal fertility in regions nearly 1500 miles apart in latitude, and less difference in the character of their productions than we would be apt to suppose. The country which lies immediately to the north of the Black Sea is not indeed a country of palms, like that on the banks of the Nile; but both are equally rich in grain and fruits; both are enriched by the overflow of the rivers, and many of the fruits of both are exactly the same; and, because of the rich soil deposited by the rivers, and the uninterrupted heat of the summer, they flourish better to the north of the Black Sea than in perhaps any other part of Europe.

The most remarkable distinction between the rivers of southern Russia and the Nile, as affecting the general economy of nature on their banks, and in the intermediate regions, is the different times at which their overflows or inundations take place; and as the causes of these are also of an opposite character, and tend to throw some light upon the connexion of tropical and polar influence, we shall mention them, reserving the full explanation to our notice of the *Air*, as that is the grand medium of intercourse between climate and climate on the earth's surface.

The overflowing of the Nile is occasioned by the rains which fall seasonally in central Africa; and in that part of the country whence the Nile is chiefly supplied with its water, the rains begin to fall in June, about the time when the sun is at its greatest apparent declination northward, or vertical at the northern tropic, or parallel of $23\frac{1}{2}°$. The flooding of the Russian rivers is produced by the melting of the snows which have fallen in the central part of Russia in early winter, and which, as they lie on a flat surface, and melt very quickly when the thaw does set in, leave great part of the surface flooded with stagnant water, which creeps slowly to the rivers; and, as their currents are also sluggish, they expand to the width of seas; and the inhabitants of the villages, whose houses are erected on tall posts, have no intercourse with each other for some weeks, except by boats; but no sooner is this inundation over, than the ground is covered with most luxurious vegetation, as if by magic, and the richness of the year far more than repays to the people the slight inconvenience to which they are subjected by the flood.

By the time that this flood has partially subsided, and the joint action of the sun and moisture have begun to produce those swarms of insects and other small animals which are always met with at such places, the valley of the Nile has become parched, and all the products of the overflowing of that river have been consumed. So the birds of innumerable races, wing their way to the northward, and find another Egypt on the banks of the rivers which flow into the Black Sea—the Danube, as well as the rivers farther to the north; though the Lower Danube has itself the expanse of a moderate sea, and the islands with which it is studded are so numerous, and so tangled, that the winged multitudes which annually visit it are perhaps not so conspicuous. It is not the water birds alone which partake in this great movement, for it applies equally to all birds which feed their young chiefly upon the larvæ of insects and on worms, which are the common food of most young birds. In this country we have many feathered strangers in summer, which take their departure before the winter sets in; but with us the numbers are very trifling compared with what they are in this great basin of the eastern continent. The flocks of them which are seen on their journeys are quite incredible; and that not merely of small birds, but of those of large size. An intelligent traveller mentions having stood on the top of Mount Carmel, and seen three flocks of storks passing over him, in high flight, on their journey from Egypt northwards, each flight about half a mile in breadth, and the whole requiring three hours to pass the traveller. Now, if we allow only twenty miles an hour,—which is a slow rate for any bird on migratory flight, for it is astonishing how speedily even a large bird, moving apparently slow, clears the horizon,—if we allow only this rate, it will give us a stream of storks sixty miles long and half a mile broad, which one would imagine might colonize half the rivers in the world; and yet this was but one exhibition of one species of the countless multitudes of birds which pass and repass annually between the extremities of the basin of the Mediterranean waters.

This basin, if its natural history were fully worked out, would form ample materials for not one volume merely, but as many volumes as would fill a book-case of considerable dimensions. We cannot, of course, enter upon the details of it, though we may perhaps have occasion again to revert to it, in order to show how very replete it is with instruction of the most delightful kind; and also how, when we are once in possession of a few of the general principles, we can bring those principles to bear upon the details so clearly that every fact is explained the instant it is observed; and every instance, both of perception and reflection, brings knowledge.

There is one other general point connected with this important central portion of the eastern continent which we may mention, though it is hardly necessary, in as much as it will not fail to impress itself upon every one who brings even a moderate degree of reflection to the examination of the map. Glancing back at the map, we find that in latitude it brings the regions of the equator and of the poles into natural connexion with each other by means of this tie; and that if we take the sources of the western rivers, the Po and the Danube for instance, and the sources of the eastern ones, the Oxus and the Sihon, we find that the Alps of Europe are brought into connexion with the central mountains of Asia; and the breezes of the Atlantic,—which reach the Alps, and are mainly influential in regulating the great seasonal characters of the weather there,—are thus made to unite with the Monsoons of the Indian Ocean, which seasonally pour out their rains, and fling their burden of snows upon the lofty summits of the Himalaya. We have seen of how much consequence the reciprocal actions of the north and south are to nature; and those of the east and west are not less so. But if they are thus useful to nature, because nature works in concert and without jealousy or war, is it not evident that they would be equally serviceable to man, if all the inhabitants of this wide district could be made to work in concert, without hostility and without animosity. It is thus that we derive lessons of true wisdom when we catch glimpses of great principles in nature:—but we must leave these matters to the reflection of the reader, and proceed to another subject.

SECTION IV.

GENERAL FEATURES OF THE EARTH.—EASTERN CONTINENT CONTINUED.

When we extend our survey of the eastern hemisphere beyond the strait of Gibraltar, or inlet to the Mediterranean waters, we speedily come to regions of characters entirely new. Here we must attend to the curvature of the meridians; because, as the shore lies near the margin of the map, the meridian is almost a circle, while our proper conception of it ought to be that of a straight line. The first country we come to, extending southward to about the 29th degree of latitude, has a good deal of the character of the warmer parts of Europe. This is the kingdom of Morocco, which is cut off from the rest of Africa by the mountains of Atlas. These are of sufficient height for having their summits covered with snow, and they, therefore, give rise to rivulets and streams. A spur of the same mountains, proceeding in a north-west direction, and terminating at Ceuta, on the south of the strait, cuts off Morocco from the Mediterranean, and leaves it wholly to the influence of the Atlantic on the one side, and the mountain ridge on the other. The climate of this part of Africa is therefore more the climate of an island than of part of a great continent; and though it is not quite equal to the climates of the adjacent islands, the Canaries and the Madeiras, which have, perhaps, the finest climate in the world, it is still a delightful, as well as a productive country, even in the hands of an indolent population.

But when we pass this small maritime country, we arrive at the most singular region on the surface of the globe—a region which unquestionably acts a most important part in the economy of the earth's surface; but as it acts through the medium of the air, the principle of its action cannot be perfectly understood without some knowledge of that. This region may be stated as extending, upon the average, about 2000 miles, from east to west, and not less than 1000 from north to south; so that it occupies nearly as much of the surface of the earth as the whole continent of Europe.

This vast extent of country contains neither river nor mountain; and we believe there is not on the surface, or for some depth below it, anything which can be called a rock, or even a large stone. It is true, that the surface is not perfectly flat, that there are patches where water stagnates, and that some of these are of sufficient magnitude to be inhabited, and to resemble islands, only they are far more inaccessible than if they were placed in the very centre of the largest ocean on the surface of the globe, because the surface of the surrounding sand is as oppressively hot as the surface of the sea is refreshingly cold, as nothing but animal strength can be employed in crossing them, and as, when the winds are up, the sand forms at once the billow on the surface, and the shower in the air. Generally speaking, however, the broad parts of these deserts are tranquil, and the only difficulty experienced in crossing them arises from fatigue, or the want of provisions or of water, or from the predatory bands by which they are infested; for it seems a pretty general law, that if a region which is naturally bad be at all habitable, mankind make it worse.

There is no doubt that those vast accumulations of sand, wherever we may meet with them,—whether on the shores of the sea, as in many parts, of the east coast especially, of our own country, or more inland, in places where we have no evidence that the sea has ever been,—are always to be considered as ruins, and ruins which have been produced in the slow progress of time, and not by any violence or convulsion of nature; because the powers which act in those convulsions act upon masses of matter, and not upon the smaller portions. The effect of the volcano is as often to consolidate matter into rocks and mountains as to break them to pieces; and the earthquake not only never produces accumulations of sand, but would be comparatively silent and harmless if its action were confined to such accumulations. Even the lightning, which we may regard as the most mild and feeble display of those great powers which affect the solid parts of our globe, never reduces substances to powder: it breaks rocks into fragments, and sometimes, on the mountain tops, even in our own country, it ploughs up the mossy soil in trenches, as if an army had been going about to fortify a camp; but it never reduces to powder; and when it strikes the sands, it often turns a tube several feet in length into a coarse glass; and those tubes, which are nothing more than the sand melted, have sometimes been called thunderbolts by the ignorant; whereas the real thunderbolt, that which strikes with whatever energy or effect it may strike, is merely an action, not a thing,—a phenomenon of matter, and not matter itself.

Even the sea, except on its shores, and probably only where the water, the land, and the air all meet, has no power of turning any substance into sand; and "the oozy bottom of the deep," which is the grand receptacle for all matters heavier than water, which we lose sight of upon land, is not a region of destruction. The sea assails the cliffs, but its action is too great for originally preparing the materials of a sand bank, though banks are sometimes shifted from place to place by its action; and though we find that, on the beach where the tide beats with violence, the pebbles are smoothed and rounded, they are not reduced to sand.

In fact, the only means which we are aware of whereby those sandy wastes, which we meet with in different parts of the world, and in none more than in this wide expanse of Sahara in Africa, are those which are put in operation, at the surface of the earth, by the common action of the weather. In our own country, it is highly probable that the accumulations of sand, which we meet with on some of the shores, and even those which form extensive and thick strata of rock underground, may at one time have formed rocks of what are considered a more primary structure, in combination with the beds of clay, and the strata of clay-slate which we meet with in other places. In the long continued action of the weather, the alternate operations of wetting and drying, to say nothing of freezing and thawing,—the effects of which are still more powerful,—there is energy enough for the decomposition of the hardest rocks, if those rocks are not protected by coverings of vegetable soil, which soil does not remain long if it ceases to be covered with living vegetables.

This progress of destruction is no doubt a slow one, and it must depend upon particular circumstances whether the result of the destruction of rock by this surface action shall or shall not be the production of a desert. If, as the decomposition goes on, the sand, which is chiefly the flinty or silicious matter, which, though broken into small crystals, is not so fine as to be washed down by water and form a paste, is removed, as fast as it is produced on the surface, by the washing away of the clay, then, of course, the rock is removed altogether, and either a bed of clay is left in its place, or a new rock is exposed to the weather. This removal of the sand as it forms, requires, of course, powerful action of the weather —pelting rains and sweeping winds, and it requires, also, that the surface shall be sloping, and not level. Countries, of which the surfaces are irregular, formed of hill and dale, and near the sea, are those upon which the weather is most violent and variable, and therefore most likely to remove any sand which may be produced in the manner now stated; and such countries are also those in which vegetation is most likely to resist both the decomposition of the rock and the formation of a desert. Such countries, too, are always furrowed over with watercourses; and though the streams which run in these commit devastation on their banks, and sometimes break through the natural dams of rock by which lakes are inclosed, and pour these in overwhelming floods down the watercourses, yet, in consequence of the very great havoc which they thus commit at one place, they usually make compensation at another, by forming a new deposit; and not unfrequently, the sea refuses to receive the ruin of the land, throws it back again into a bar, and a receptacle is formed for the subsequent debris and rubbish which is brought down by the stream.

There is no doubt that the fine clays in the south of England, of which porcelain and the finer kinds of pottery are made, had once formed part of granite rocks, the sandy portion of which has been removed by the action of the weather in the course of ages, and probably now forms part of the banks in the estuary of the Thames, or otherwise on the east side of the island. Nor is this mere conjecture, for we find insulated masses of granite, standing, like ruins, high above the present surface where they are situated, and bearing evident testimony that they are fragments of rocks which are now gone.

Wherever there are beds of sand, or of sandstone rock, we may always conclude that they have been formed by some such action as that which we are now describing; and that, though the waters may have carried them to the places of their deposit, and eddies of the wind, and also of the water, may have rounded them into small hills, yet their original formation must always have been at the surface of the earth, exposed to the action of the air and the weather.

And we can see the progress of this disintegration in some places of our own country. Ben Nevis, one of the highest of the Scottish mountains, if not the very highest, has the upper part composed of porphyry, a very hard rock, which we shall probably have to notice afterwards, and a considerable portion of the upper part of the mountain is destitute of vegetation; there is rarely a night, even in summer, when it does not freeze on the top; and it is never long without showers, there being very often a rain cloud investing the upper part of the mountain, while the sun shines brightly on all the country around. This is exactly such an action as is calculated to destroy rock, and which, in rocks of some structures, would separate the sand from the other ingredients; but all the component parts of porphyry are in very small particles, and, therefore, the utmost that the weather can accomplish is to break this rock into angular fragments, similar to those which are used in road-making. And, along the upper slopes of the mountain, there lie beds of such fragments, which would be quite sufficient for repairing all the roads in a county; and the number of these, the level to which they have descended, and the large masses which, having been undermined by the weather and thrown down, are scattered around the base of the mountain, clearly show that Ben Nevis is in a state of decay, and that it requires only length of time to reduce its lofty summit to the level of vegetation, or even to that of the surrounding country.

The difference between any portion of a small island near the sea, where there are rains and the means of fertility, and that of a country like Sahara, which is inland, and in a hot climate, is of course very great; but still, though the power of destruction may be more energetic in Africa than in Britain, it is a power of exactly the same nature; it is the only power by which we can suppose such a result brought about, and, therefore, the study of it is of great use when we attempt to understand the natural history of the earth; for it will not do on this subject to rest satisfied with the simple fact, that any one appearance that we meet with *is*,—our business is to ascertain *how* it is, and, if possible, *why* it is. This becomes evident when we bear in mind that every thing we meet with is, as has been said, a *production*—the result of some *secondary operation*—which secondary operation is a natural cause, and therefore not only open to our inquiry, but urging us to inquire. It is not enough for us to fold our hands in idleness, and content ourselves with saying that any one appearance, or thing, or place, is part of the creation of God; for it would be presumption in us to pretend to have the slightest knowledge of the condition of worlds, or of any portion of worlds, as they came immediately from the hand of the Almighty. All created things address themselves to us by a long line of descent; and though we can see the secondary mode of production, and can trace it backward as far as facts and philosophy will bear us out, yet we cannot, and we dare not, even speculate about the primary step, where Almighty power willed the commencement of a world, or of a race of its inhabitants.

In these more mighty changes which take place on the earth itself, we must not be disappointed though we are unable to bring the times within the brief record of our chronology; neither must we feel any disappointment though revelation does not come to the aid of our reason on these subjects. The purpose of revelation is our own welfare as immortals, and as such it neither could benefit nor be benefited by any inquiry or any information respecting the phenomena of the material creation; and it would be inconsistent with the general law which we find running through the whole of nature that there should be a spiritual discernment of material things. For the purposes of philosophy, God has given us, as men, and in our own natural endowment, all that is necessary for us : and if he had revealed the same kind of endowment, or the same result to which this endowment leads, it would have been superfluous,—which, in creation, is an impossibility, altogether inconsistent and absurd.

Take an example :—An oak, when in the full maturity of its growth, and just before it begins to decay at the heart—by how much do we ascertain by mere observation that the bole of it thickens, or the branches extend, in the course of an entire season ? But this is a large portion of the duration of the oak, for we cannot date it at much more than two hundred or three hundred years. Therefore,—in order to have a parallel case, and to bring, as near as it is possible, our observation of the oak to a proportion with human observation of the earth, in point of time,—let us suppose that a huntsman rides past the oak at the full mettle of his steed, by how much shall his passing glance ascertain that it has grown during the moment that that glance is cast upon it ? This is the proper mode of speculating on the changes which the earth has undergone : and the chief difficulty and source of error and failure which we have in this most exciting study, is getting rid of our common notions of time.

We may rest assured that the tale which Sahara has to tell is a very long one ; and that, though we have no reason to doubt that, at one period of the world's history, this extensive district was once as rich as it is now barren, and as lovely as it is now desolate, yet that time must have long gone by; and it is instructive for us to find on the surface of the earth, and evidently produced by natural causes acting at the surface, an instance, and a very striking instance, of similar antiquity to that with which we meet in so many places when we dig into the substance. We know not what change the conversion of this district into a desert may have produced upon the powers by which it was so converted, but we have evidence now that the valley of the Nile is not remarkable for the decomposition of rocks. The edifices reared by the Egyptians of old, are probably among the most ancient in the world, and yet, unless in so far as human violence has ruined them, they remain entire, while buildings of similar materials, and not one-fourth the age, have in other places crumbled into shapeless heaps. When, however, we leave the valley of Egypt, and go to the hill tops, especially those near the Red Sea, which are still exposed to violent winds, and at least occasional rains, we discover the same incipient ruin which has been mentioned as characterizing the upper slopes of Ben Nevis. The rocks are broken into fragments, and, generally speaking, the clayey part has been washed into the fissures, so that the rain, when it does fall, runs off, and so supplies no spring, and produces no fertility.

If we take the Egyptian monuments, those hills which are covered with broken stone, and the sandy deserts, we get at least three points, or epochs, in the history of the desert: the Egyptian monuments must be vastly more modern than the commencement of ruin upon the mountains, and this commencement of ruin must be vastly more modern than the similar commencement which we may presume to have once taken place in the deserts of shifting sand. That we have the shifting sand in some places alternating in the hollows with the crumbling hills, and in others with little patches of verdure, we might be prepared to expect; for so long as the country is sufficiently diversified for occasioning some surface action, we may very readily suppose that the sand and the more compact materials will continue for a long time to be removed, gradually exposing a new surface of the hill to the powers of destruction. It follows almost as a matter of course, that the finer particles, which are suspendable for a long time in water, and which may be observed always colouring the water in a clay pit, will first form a waterproof deposit in the hollow: and this may continue for a long time a pool, or even an oasis, or island in the desert, and may afterwards furnish wells by digging, after a mass of sand has been blown upon it and destroyed the surface.

When once a desert has been formed to the same extent as it exists here,—and, indeed, as it may be partially traced, and sometimes is very conspicuous, along the whole of the lower ground which separates the central basin of the eastern continent from the countries which lie to the south and the east,—when once such a desert has been formed, it tends to spread itself, as though it were an ill-conditioned sore, upon the earth; and it does this the more readily the more extensive it is, and the warmer the climate in which it is situated. We may mention, without anticipating, that one of the chief means by which the air is cooled is the converting the moisture into vapour, and that, generally speaking, this operation is nearly in proportion to the heat. This is the reason why the margin of the waters and the shade of trees are so cool and refreshing in sultry weather ; by their cooling tendency the trees, to some extent, and the water, if it is extensive, probably to more, perform a part the very opposite of that which the desert performs—they cool the air over them, and it descends and comes outwards in all directions from them, often a delightful and refreshing breeze, which tends to spread fertility.

The desert, on the other hand, when beaten upon by the heat of the sun, especially when that sun is nearly over head, as is the case on Sahara, is intensely hot ; in consequence of this heat the air over it is continually ascending, like the smoke of a furnace, and the air from all sides around moves inwards to supply its place : but the air which thus moves towards the desert becomes hotter as it approaches, and therefore, instead of letting fall in rain any part of the moisture with which it is already charged, it drains the moisture of the surrounding parts ; and, as it is not cooled when over the desert, it lets fall none of its moisture, but ascends into the upper regions of the air, and there spreads to a great distance, carrying the moisture along with it. In this way it is highly probable that the moisture which the desert thus drains from the dry and scanty vegetation on the desertward side of the mountains of Atlas may descend in snow upon the summits of those mountains, or in rain upon the countries between them and the sea.

This progress can easily be understood to be much more rapid than the original conversion of a fertile country into a desert, and hence we find that there is not a little of its progress which has taken place within the period of authentic and not very remote history. On both sides of the valley of the Nile, and on every part of the margin of the desert, which has been examined with sufficient care, there have been found the most conclusive evidence of former fertility and population, and in many instances abundant population and a high state of the arts. These evidences are traceable along the whole line of the desert, both in Africa and where it extends into Asia; and in the latter quarter of the world, we have whole provinces now entirely unproductive, and ruins of magnificent cities, well known to history, in the progress of being buried in the sand.

What may have been the cause which converted the first portion of the earth into a desert of sand we have not the means of ascertaining; but there is some reason to believe that the tropical character of the year which belongs to all the southern hemisphere, with the exception of the smaller islands, which are either of volcanic origin or the production of coral insects, has probably some connexion with the extent of desert which lies between the countries which communicate with one another by the medium of the Mediterranean waters and those which have the tropical seasons. We are not yet in possession of all the elements; but we shall afterwards be able, perhaps, to show, with at least a considerable degree of probability, that the circulation of the air and the waters freely round the southern hemisphere in not a very high latitude, and the cutting off the influence of the cold of the south pole from any connexion with the climate and economy of the middle latitudes, which is the result of this circulation, is at least one important element in determining why, in the one hemisphere, the seasons should be chiefly broken into dry and rainy, while in the other there is the regular succession of spring, summer, autumn, and winter.

In some parts of India we have at least a vague sort of evidence of the manner in which a desert might be produced. The action of nature is so powerful in that country, that if man ceases to practise his arts of culture for even a very short time, the memorials of himself and his works are speedily obliterated. If the country is so situated that the periodical rains can reach it, man and his memorials are blotted out by the power of vegetation ; and the bamboo jungle, rising to the height of sixty feet in a single year, and bristling with spines which are almost as formidable as the bayonets of armies, first conceal his dwelling, and then give up the remains of it to the leopard, the snake, and the bat. If, however, the rains do not reach the country, the change would be of a very different character : vegetation would soon cease, and in brief space large tracts of ere-while fertile ground would be turned into unproductive deserts. There are many of the higher districts of southern India upon which it would be altogether impossible to obtain crops, except by means of artificial watering, often from wells which require to be sunk to the depth of two hundred or three hundred feet ; and we have only to suppose a stop put to the labours of man in such a country in order to conceive how a desert might be begun in it, and this desert once begun would extend very rapidly. Indeed, from the violence of elemental action, probably at a time when the rains of the Monsoons extended more completely over India than they do at present, there are evidences of a very remarkable decomposition of what has once been the uppermost rock in that country.

To enter into all the details of evidence, either as to the original cause of the great desert itself, or as to the effects which it produces in the general economy of the earth, would, however, require more space than we are able to bestow upon it ; and the full understanding even of what is known would require the introduction of principles which do not, strictly speaking, come within the scope of this volume. We shall, therefore, only offer one or two further short remarks on this very singular region of the world, —a region which, though it is most extended and conspicuous in Africa, yet stretches the whole way from the extreme west of that continent to the confines of Siberia, interrupted only by mountain chains and the valleys of rivers, the last of which it is gradually invading. Indeed, it is easy to see how very soon even a large river might be obliterated by the desert ; because if the sand once reach the banks, and drift into the channel, the water will steal through underneath, and the process of obliteration will go on much more rapidly than those who have not thought of the subject are aware of. And, in those situations where the river flows in a sandy channel, and receives no addition to its waters, we have proofs in many places that the evaporation alone is sufficient to dry it up ; for in Arabia, Persia, and various other countries, the greater number of the rivers which rise in the interior mountains, and flow for some distance over the plains, are lost in the sand or dried up by the heat of the sun acting upon its surface.

There is a peculiar species of vegetation which, as we may so express it, contends with and resists the desert; this consists chiefly of saline plants, but these in time increase the evil. Though their growth is exceedingly slow, and they keep their places for long periods of time, yet they at last give way: and, as they decompose, the salts which they contain are left on the surface. In the wet season, there is generally some rain upon the desert as far as vegetation extends, and this rain washes the saline water into the hollows, where it poisons the waters, or at all events renders them bitter, whether those waters remain in pools at the surface, or sink down into the sand and are procured by digging wells.

About the seventeenth degree of north latitude, on the west coast of Africa, the desert terminates; and it is probable that there extends across the continent at that parallel a belt of country about half the breadth of the desert, consisting of an alternation of mountains and fertile valleys. The interior of this part is only imperfectly known, but it should seem that from the mouth of the river Senegal to the Bight of Benin, in the Gulf of Guinea, there extends a district which differs very much in its characters from the desert to the north of the Senegal. Upon looking at the map, it will seem that the Senegal, which rises at a considerable distance southward of its confluence with the sea, has some of its branches more in a direction from east, and that there are mountains, or at all events hills, between the upper part of this river and the desert. Also, the river Niger may be traced from nearly the same source as the Senegal, but flowing in the opposite direction, having a much longer course, and ultimately discharging its waters into the Bight of Benin by a number of mouths. The lower part of the valley of this river is but imperfectly known, but it is ascertained that the river discharges by its numerous mouths a vast quantity of water, and therefore it is probable that there are extensive branches falling into the river from mountains, and probably across plains to the eastward ; and that these continue or may be traced from the opposite sides of the same heights which give rise to the different branches of the Nile. At all events, it is certain that the country —which is nearly bounded on the north and east by the Senegal and the Niger, and on the west and south by the sea, and which is of considerable dimensions, being about 1,500 miles from east to west, and half as much on the average from north to south—is as remarkable for its fertility as the country to the northward is for its barrenness. Generally speaking, the coast of this country—which is low and swampy, wooded down to the water's edge, and rank with aquatic vegetation in many places—is very unhealthy ; and as this is the part of the world with which the slave trade was so long carried on, there is but too much reason for the natives being hostile to European visitors, or at all events suspicious of them upon very slight grounds. For these reasons, we know but little of this country, farther than that it is exceedingly rich, and might be rendered exceedingly valuable ; and we know also that the seasons in it are very extreme, that the heat is intolerable, and the rains, when they do come, come with the utmost violence. The seasonal action between the northern hemisphere and the south, and between the Atlantic on the south of this part of Africa and the land, is, as it were, cut off by the desert, and the whole concentrated upon this portion of the country. The consesequence is, that upon this portion there is exerted more than the average degree of seasonal action; and the excessive fertility, and also the unhealthiness, are results of the violence of this action.

From the bottom of the Gulf of Guinea to its southern termination, it will be observed that the west coast of Africa preserves its general unbroken character. The coast is known at points as far as the latitude 15° or 16° south, and in this part of the coast there is the mouth of at least one river of considerable magnitude; and this river leads us to some conjectures as to the interior of the country here, of which there is very little certain knowledge. This river is the Zaire, or river of Congo, in about 7° south latitude, and in one respect it resembles the Nile in Egypt,—that is, its waters rise when there is no rain in the country on the coast. It does not overflow the country as the Nile overflows Egypt, for its current is rapid, and it runs in a deep channel, as the Nile does in many parts of Upper Egypt; but there is a decided rising of the waters in the channel, and this rising is so gradual, and continues so long, that it must come from a country, either where the rains are less violent than they are on the coast near the mouth of the river, or where these accumulate in the hollows, and swell the waters of temporary or permanent lakes, from which they are of course much more gradually discharged than they are from the surface of the ground, especially when that ground is uneven.

This is a circumstance worthy of attention, because it throws considerable light on at least one of the characters of countries. If a river either passes through a lake of much extent, or collects its different branches into such a lake, it can never be so much swollen by floods, or do so much damage to the country by this means, as one which has not a regulating dam, which is the purpose that the lake answers. It is of little consequence whether the accumulation of water be in a lake which is never emptied out, or in one which is merely seasonal, if the breadth of surface upon which the water is retained is the same in both cases; and the larger that this is in proportion to the breadth of the channel, the flooding of the river must be the less violent and of the longer duration. There are instances of this in our own country which are very striking, and the effects of which on the lakeless rivers are often alarmingly destructive. The rivers on the east of Scotland, from the Tay to the Ness, pass through no lakes of any consequence, and upon the mountains in which they have their sources the autumnal rains sometimes fall with fearful violence, and the floods sweep away the crops, the houses, the very land itself, and in some instances the inhabitants. The Ness is a river of several times the size of the neighbouring Findhorn, and some of its feeders rise in grounds more elevated, and situated in climates much more rainy; but, a few years ago, when the Findhorn, and the smaller rivers to the eastward of the Ness, were sweeping their banks with a desolating flood, the Ness expanded in its ample lake, was flowing quietly along its six or seven miles to its confluence with the sea, without disturbing the place of a single pebble, any more than in the driest season of the year.

It is not known what course the Zaire takes in the interior, nor what is the character of the country there; but the continent is still sufficiently broad for preventing any reciprocating action between the Atlantic on the west, and the Indian Ocean on the east; but, from the absence of rivers of any consequence, it must have little rain, or great evaporation. From the mouth of the Niger round the African coast to the entrance of the Red Sea, indeed to the mouth of the Nile, which is a line of coast between 8,000 and 9,000 miles, there is not so much water discharged into the sea by rivers as there is into the north and west of the Black Sea from the Danube to the Don, which is not more than 500 or 600 miles.

Hence, though we do not know what may be the particular form and distribution of the land in Southern Africa, we know that its character must be dryness; and the character of the coast for about 800 miles, from latitude 16° southward, furnishes us with some means of ascertaining what must be the general cast of the heights, and this will enable us to turn them to some account in understanding the general economy of nature in this very singular quarter of the world. Along the whole of this eight hundred miles of coast there is not,—at least during the dry Monsoon, when the wind of Southern Africa is generally south-east, and this coast can be approached with safety,—any fresh water to be met with. The coast consists of dry hills of sand or indurated clay, covered with a few hard and prickly plants, and presenting an aspect as dreary as possible. It is a curious fact, that this length of desert coast in Southern Africa should be almost exactly the same as that of the desert coast of Sahara in Northern Africa. We are not to infer from this that there is the same correspondence between the deserts themselves, though there is certainly a considerable extent of desert in this part of Africa.

As the interior of the country here is more imperfectly known than it is even in the north, we must take our notion of its general characters from the position of the principal rivers, and that of the heights, which will, in some measure, prepare us for the peculiarities of seasons afterwards to be noticed. At about 29° south latitude, to the northward of the British colony of the Cape, there flows into the Atlantic a river of considerable magnitude, the Orange river, which runs westward nearly on the parallel for at least 300 miles, while its branches, which are numerous in the upper country, both from the north and the south, perhaps exceed this length. The upper valley of this river is broad, thickly wooded in many places, and in others containing rich plains; the lower valley is narrower, but it is also very thickly wooded, and contains vast numbers of the larger antelopes, of Cape buffaloes, and of various other animals. Along the south side of the valley of this river there are mountains which divide the coast or Cape country from the interior, unless by a long and laborious march; those mountains are, in some places, not less than 10,000 feet in height, and they are often covered with snow in the cold seasons, by which means they probably tend to render this valley of the Orange River more fertile than it otherwise would be, and also give it a different climate from that of the Cape. The northern side of the valley is understood to "crop out" into a desert, a certain portion of which has grass and bushes in the rainy season, and this is understood to be one of the seasonal resorts of the vast herds of swift antelopes which are migratory in Southern Africa.

The position of the central height to the northward of this is not known, but it must trend to the westward, because about 11° to the northward of Orange River there is a considerable river, the Zambezi, which falls into the Indian Ocean; and beyond this river it is probable that an elevation extends northward to the sources of the Nile. Thus, the two coasts of Southern Africa are separated from each other, and the economy of nature on the west side is regulated by the movements of the Atlantic, while that on the east side is regulated by the Indian Ocean, and may be said to extend in a connected chain by Arabia, Persia, and India, to the Himalaya Mountains and central Asia.

Before we glance at the seasonal action, it may not be amiss to examine the outline of the Indian Ocean. Those of Africa and Arabia are nearly straight, and many places of both are dry and barren. The Red Sea and the Persian Gulf are so narrow at their entrances that they hardly break the continuity of this line, though they are both interested, as offering lines of communication with Western Europe, and especially with the Mediterranean, which, if they were once fully established, might tend greatly to the improvement of the countries adjacent. We have already mentioned that the navigation of the Red Sea is difficult, and confined to certain seasons of the year, but still it opens up a ready communication with Arabia and all the east of Africa, and the commodities there are peculiar, some of them are valuable, and the country is capable of much improvement. The mountains which traverse great part of the African continent, about the tenth degree of north latitude, are understood to be very rich in gold, and before the discovery of America, a good deal of that metal was, and even now is obtained, not probably by systematic mining, though some of the native Africans can reduce iron from the ore, and therefore it is not unreasonable to conclude that they might dig gold from the mine. At all events, gold-dust forms an article of commerce on both sides of the continent, and it is probable that, in former times, most of the gold, of which large quantities were obtained by trade in India—where there are no gold mines, was got from Africa, by the Red Sea. The Persian Gulf is of still greater interest. The confluence of the Euphrates with that gulf is not above 800 miles from the Mediterranean, in a straight line, and near Aleppo the river approaches within 150 of the Mediterranean. It is true that much of the country is now desert, but it is equally true that this is owing, in many instances, to man's neglect; and if Europe and Asia, or, more strictly speaking, the Mediterranean and the Indian Ocean, could be united by this line, the advantages to all the people dwelling around both would be very great.

Persia, which lies along the north shore of the Arabian Sea, or western arm of the north part of the Indian Ocean, on the parallel of about 25°

north, presents a low and sandy shore; and though there are hills of various elevations, there are not, if we take the line as extended parallel to the coast of Africa and Arabia, any mountains till we come to the great central chain of the Hindû Kosh and Himalaya, which are in about latitude 35° at this point, or about 700 miles from the sea, though to the eastward their direction inclines to the south. Beyond the Hindû Kosh we have the south-eastern part of the central basin; and behind the Himalaya, extending in the direction of north-east, we have a vast stretch of country —at least, between 2000 and 3000 miles, and more than 1000 in average breadth, which is hemmed in by mountains on all sides for the most part; and thus may be said to have no connexion with any sea. This country is but imperfectly known, though we have every reason to believe that it is dry, and in many parts completely a desert, and destitute of all kinds of herbage. It is presumed that its general height above the level of the sea is considerable, not less, perhaps, than two miles, which is more than twice the height of our highest mountain, and in many places considerably more than this. It is called the *table land* of Asia, that name being given to districts of country, the general level of which is high above that of the sea. It is not to be understood, that when we speak of a table land we mean a land of which the surface is flat like a table; for all that we mean is, that the lowest parts of the land are at a considerable height above the mean level of the sea, without any regard to the mountains by which the surface of the table land may be broken. The borders of this portion of Asia are very mountainous, and the interior of it is, as we have said, little known; but there are no rivers of any magnitude which issue from sources far into the mountains; and though there may be on it a few streams, which terminate in lakes, it does not appear to contain an expanse of water of any consequence. No doubt the largest rivers of Asia, whether they flow to the Arctic Ocean, the Indian Ocean, or the Pacific, rise on the confines of this table land. But the ridges of mountains on its confines are generally double, with the river rising and flowing for some distance through the valley between them, parallel to the table land. These mountains sometimes have the exterior ridge not only the loftier of the two, but so lofty that it freezes continually on their summits; and thus no water in a state of vapour can reach the interior of the table land over such barriers. In consequence of this, the country must be very dry at all seasons; and as there are some parts of Persia, on the south side of the mountains, where it does not often rain,—perhaps not once in a year or two,—we may presume that on this table land it rains less frequently, and that, therefore, it is easily heated, and as easily cooled. Those two qualities always go together, in so far as the solid earth is concerned; though, in countries where the warm surface is deluged with rain, the cold is very much increased by the evaporation, as any one may feel in passing along a newly-watered road, or street, on a very warm day. It is of importance to attend to the position of this table land, and of the lofty mountains which lie between it and Persia and India, because, as we shall see afterwards, it performs a very important part in the whole economy of the Indian Ocean, and on the countries both to the west and to the east, as far as the Cape of Good Hope on the one hand, and Australia on the other. Indeed, much of the surface of both these countries bears a considerable resemblance to that of this table land, so far as all three are known. At the Cape there is a fertile plain along the sea coast; but, behind this, the ground rises in successive terraces, each more barren than the other, till it at last reaches the great Karoo, which, in the centre of the country, south of Orange River, and just at the foot of the mountains, extends about 300 miles in length, by 80 in breadth, is totally uninhabited, and consists of hard clay, the surface of which is seldom moistened by a shower, though, on the lower terraces, and the steps, or elevations between them, rains frequently fall with so much violence that the soil is swept into the sea, and the channels of the streams are worn to such a depth that, in the dry season, the water is not visible, and, in the greater number, there is none to be found. It is supposed that a good deal of the interior of the country, to the northward of Orange River, and also to the northward of the Zambezi, partakes not a little of this character, so that we have upon the line of the western coast of the Indian Ocean two elevated deserts, in some measure answering to one another, only that on the north side of the equator is larger and in a higher latitude than that on the south; still we shall afterwards see how the action of those deserts will alternate with the summer and winter, and impart that general character to the seasons in all the countries which lie between.

If we take Australia, though there are some fertile spots on it, and though the rains fall, in the south part especially, with equal violence as in Southern Africa, yet from all the evidence which has been obtained, by the examination of the greater part of the north-west coast, we may assume that much of the surface of Australia is dry and barren, though it may not be elevated above the rains, as is the case with great part of the African Karoo. This gives us, at the other corner of the Indian Ocean, on the same parallel with Southern Africa, and equalling in size the table land of Asia, another extent of country adapted for acting alternately with that table land at the different seasons; but there are local causes which interrupt this action, and take the intermediate lands from under its influence.

We must have other elements before we can explain this action in a satisfactory manner; but still it is desirable that we should take along with us all those peculiarities of the earth which affect the result; and therefore it is desirable to look back at the map, between the northern parts of the ocean and the mountains. Here we meet with India, having something of a three-cornered shape, and sending large rivers both to the Arabian Sea on the west side, and the Bay of Bengal on the east. The Indus, the principal river on the west, rises beyond the most elevated ridge of the Himalaya; but after passing through a gorge, or opening in the mountains, it receives a number of large branches from the opposite side of the ridge, though some of them also have their sources on the other side. Indeed, it is not unusual for the largest rivers, which rise in ridges of mountains, to have their sources beyond the loftiest summits. For a considerable part of its course, the Indus receives no branch, and in the lapse of years it has washed down immense quantities of sand and mud. As the country immediately east of the mouth of the Indus is very flat, there is a desert, which extends upwards nearly as far as the first ridge of the mountains. This desert, in many places, presents nothing on the surface but sand and crumbling rocks, and no water is obtained unless by digging to the depth of several hundred feet; and we need not add that on such a country it seldom rains. Further south, the west coast of India presents a bolder shore. The peninsula of Gujerat is hilly, and a little way to the south, the appearance of the coast is mountainous, while a considerable part of the interior is a table land, upon which it seldom rains; though the seasonal rains on the coast are often so violent, that the torrents which they form sweep trees, and rocks, and everything before them. In the country nearer the Indus, which we have mentioned as being desert, the very same monsoon which breaks in rain upon the western Ghauts—for such is the name of the mountains, or rather the passes on the shores of India—sweeps over without depositing a drop of water, and ultimately breaks on the mountains, the sides of which it deluges with rain, and floods the branches of the Indus, and also those of the Ganges, or main river, which traverses the great valley of Bengal, and ultimately enters the bay of the same name.

In noticing the remaining portion of the eastern continent, as it appears on the map, we may be more brief, because in it the great action which regulates the seasons and their productions is between the land and the Pacific, or those portions of it by which the shores are washed. Generally speaking, the islands to the south-eastward of Asia are remarkable for the fineness of their climates, and the richness of their vegetation; only such parts of them as are swampy are very unhealthy. They are, however, the gardens of the world, at least of the eastern hemisphere of it; and some of them are very remarkable,—the Japan Isles, for instance, which lie in nearly the same average latitude as the Strait of Gibraltar, have a tropical character in the low grounds, and many of the plants have the singular property of growing equally well in greathe at and in extreme cold. It is curious, though we are not aware that any inference can be drawn from it, that on the east coast of New Holland, a little south of Sidney, almost exactly in the same latitude as the centre of the Japan Isles, and differing only ten degrees in longitude, there is a small district, the Illawarra district, the vegetation of which is much more tropical than that of the country for a great way to the north, and also a great deal more beautiful. But we must cast a hasty glance on the general features of the western hemisphere, namely the American continent, and then proceed to other matters.

Upon examining the map, it will not fail to be observed that there is a very remarkable physical difference between Europe and the other large divisions of the eastern continent. Europe is of comparatively small size, very irregular in its figure, and much intersected by seas, so that the greater part of it may be regarded as consisting of coast country; and the only exception is perhaps a portion of the centre of Russia, and from the flatness of this part, and the quantity of snow which falls upon it, there is very little of it in a state of desert, even during the heat of the summer ; though to the northward of the Black Sea there are, on the flats between the rivers, approximations to this kind of country, there are no trees ; agriculture is not carried on, and the surface is either pastured by the cattle of wandering tribes, or by wild animals ; and this is the only part of Europe in which any species of antelope, the characteristic ruminating animal of the desert, is to be found.

Antelope desert animal.

In Asia and in Africa the case is very different, and we are perhaps within the truth when we say that a full half of the surface of Asia has the desert character for at least some part of the year, and in Africa the proportion is perhaps greater. The comparison of those divisions of the eastern continent very strongly indicates the advantages which countries derive from the vicinity of the open sea, both in respect of mildness of climate and general fertility.

Desert – Comparative between Europe & Asia & Africa.

SECTION V.

GENERAL FEATURES OF THE EARTH. AMERICA.

The relative proportions of land and water, and the position of the land with reference to the whole surface, in the western hemisphere, are very different from those in the eastern. If we lay a ruler or extend a line in any way across the hemisphere from 60° north latitude on the western boundary, to 60° south latitude on the eastern, we find that, with the exception of a very small portion of the southern extremity of the continent, a still smaller portion of Asia at the opposite extremity, and a few groups of islands spotted over the wide sea, the whole of the land lies on the north-east side of this line, and that the whole on the south-west side is sea. The land, too, has more the appearance of being one than the eastern land ; but it is still nearly intersected in the middle, so that two distinct portions offer themselves for our description ; North America, extends from the isthmus of Panama, which is in 9° north, and about 79° west, northward to the polar ice, and having the greatest breadth about the parallel of 50° north ; but it also includes Greenland,—which is only separated by straits, if separated at all, and those straits do not appear to be ever altogether clear of ice. Its greatest extent in longitude is about the parallel of 70°, where it extends from about 25° to about 78°. The western boundary lies pretty nearly on a straight line, and is washed by the North Pacific ; the most remarkable deviations are, the peninsula of California, between 23° and 33°, and the point of Alaska, from which the group of the Aleutian Islands extend in a curve toward the coast of Siberia ; and, indeed, if we follow this direction, we find a succession of islands, by Japan and the Philippines, to New Guinea, and thence north-westward into the Bay of Bengal. There are some portions of the north coast which remain still to be explored. The western half of it lies on the average at about 70° north latitude ; but farther to the eastward, where it is so irregular as hardly to admit of description, some portions, either main land or islands, are situated farther to the northward than any portion of the eastern hemisphere except Spitzbergen ; and as the southern shore of this very remote land is the part which has been seen, it may possibly extend to the pole itself ; and this may be one of the reasons why the cold is so much more severe in winter than in the corresponding latitudes of any part of the eastern continent.

The eastern side of North America is very irregular, being broken by inland seas, and sea-like estuaries and lakes. Above latitude 60° there is Hudson's Strait, which leads to Hudson's Bay, an inland sea, which is, at least, double the size of the Baltic. Between latitude about 46° and 52° there is the estuary of the St. Lawrence, which penetrates the country to a great extent ; and then there is the vast assemblage of fresh water, the American lakes, the largest of which, Lake Superior, contains probably as much water as all the fresh water lakes in the world, with the exception of those of America. To the southward, where the continent narrows, there are successively the Gulf of Mexico and the Caribbean Sea, the details of which may be seen on the map.

In order to understand the natural features of North America, we must begin with the mountain ridges, or other central elevations, or watersheds, from which the rivers flow to the opposite seas, and not with the rivers themselves ; because these are so numerous, and many of them so winding in their courses, that it is difficult to trace them. When we take these elevations as the basis, there are four natural divisions, exclusive of the narrow portion south of the Gulf of Mexico : first, that which is exposed to the Polar Ocean ; second, that which is exposed to the Pacific ; third, that which is exposed to the Atlantic ; and fourth, the great central valley lying between the two former, and being, for various reasons, the most important of the whole in reference to the natural history of the earth.

The southern boundary of the first, or polar division, may be traced from the north side of the entrance of the St. Lawrence, and the average of it is nearly the parallel of 50° ; that is, the latitude of the south side of England, and the middle of Germany. This boundary is rocky and hilly till we come near the lakes, and then it passes over swamps and flats till we arrive at the stony mountains in about longitude 114°. The circumstance of so great a breadth of Polar America passing into the southern country, without any intervening mountains to interrupt communication by means of the air, enables this portion and the central portion to alternate with each other throughout the whole of their range,—the polar influence carrying winter into the south during one part of the year, and the tropical influence carrying summer into the north during the opposite part. As the alternation of those seasons is not interrupted by any cross ridge of mountains, it is much greater at each extremity, and of course along the whole line between them, than in any other part of the world; and this being the case, there is, in spring and autumn, more variation of weather, more disturbance of the atmosphere, and consequently more rain or snow, according to circumstances, than falls upon the same parallel of the eastern continent. The surface, too, even on the borders of the valley, does not rise into so lofty mountains as we meet with in most other countries; and a very great proportion of this surface is still occupied by primeval forests, and much of the central parts by lakes and swamps. Hence there is a superabundance of moisture, and along with this a superabundance of vegetable action during the summer half of the year. Though the principle can be better explained after we have considered the properties of the air, yet we may mention that the great heat of summer, and the warm surface and abundant vegetation, are circumstances most favourable for loading the air with humidity, that is, with the elements of rain or snow.

But the atmosphere of this district does not merely abound with the elements of rain and snow, for the very action by which the atmosphere is loaded with moisture tends to precipitate that moisture to the earth upon much slighter changes than would be required for effecting the same purpose where there was less action. The precipitation of humidity either as rain or snow depends upon the contact with each other of strata of air of different temperatures moving in different directions; and of course it depends upon the general temperature, whether the moisture which is thus condensed shall descend liquid or frozen. It is always, or at least generally, out of the warmer stratum or current of air that the rain cloud or snow cloud is formed, and the spring rains are produced by the resistance of the northward portion of the air, which condenses the moisture of the warmer current from the south; while the autumnal and early winter rains are produced from an invasion, as it were, of the northern air, and the result of this is rain or snow, according to circumstances.

It is not on the plains or in the extensive valleys any where that the greatest quantity of rain falls; because, from the comparative uniformity of the surface, the state of the atmosphere, except at the times of the seasonal changes, which are to a very considerable extent brought about by the fading of vegetation from the surface of the earth in autumn, and its revival again in the spring, and which, therefore, have not the most powerful effect upon a country like the central valley of North America, clothed as many parts of it are, as we have said, with primeval forests of great luxuriance. This is, in the American valley, rendered more conspicuous, that is, the seasons, unless at the turns, are more uniform than if there were not a free circulation between the regions of the equator and those of the pole. Hence, in that country, those atmospheric changes which are the cause of those abundant rains are thrown more toward the mountains than in most places of the world. The mountains on the eastern side of the valley, which will be found generally to consist of two ridges from about latitude 35° to latitude 42° or 43°, and portions of which on reference will be found entitled the Alleghany Mountains, the Cumberland Mountains, and various other names applicable to local portions, are not only of no very great elevation, but the action of nature on both sides of them is nearly the same; and therefore they have not very much effect upon the physical and meteorological character of the central valley. On the opposite side of that valley it is different: the mountains there, though not lofty as compared with many ridges in other parts of the world, are yet sufficient, both in height and in breadth of country which they occupy, to separate from each other the natural action of the countries to the east and the west, or rather wholly to cut them off from each other, and stamp upon them very different characters. These mountains to the westward of the valley are called the Stony Mountains, and the fact of their getting this name explains to us at least some of their characters, for it shows us that at some seasons the action of the weather upon them must be so violent as to tear away much of the soil and expose the rock. Accordingly, we find that these mountains, and the plains at their base, are more abundantly supplied with rivers than any part of the world which we have hitherto examined; and those rivers are no stinted streams, but roll immense volumes of water onward to the main trunks. About 50° may be regarded as the summit level where the valley slopes, on the one hand south to the Mexican Gulf, and on the other northward to the Arctic seas. On the first of these slopes the grand central river is the Mississippi; this stream is not the longest, neither does it by any means roll along the largest volume of water, but it preserves more constantly than any others the central line of the valley; and, therefore, it serves well for fixing in one's recollection the general position of that valley. There is only one large branch from the east, or left-hand bank of the river, the Ohio, which is a beautiful winding river, with, generally speaking, a slow current, and flowing through a very fertile district; the Illinois above and the Tennessee below the Ohio, or rather forming a branch of it, are among the principal of the left bank branches. On the right, the Missouri is a river formed of an almost countless number of branches, and discharging a vast quantity of water. Both the main stream and the branches are very impetuous in some parts of their courses, and roll down great quantities of sand, gravel and mud. The Mississippi itself has not only formed an artificial channel, elevated above many parts of the surrounding country, but it is continually altering that channel, by destroying and forming portions of the banks and islands in the channel, rolling along vast numbers of uprooted trees, and often by its overflows converting large tracts of the country, beyond the elevated artificial banks, into swamps and stagnant waters, which, in the lower part of its course especially, are very redolent of all kinds of aquatic life; including among the rest, the alligator and the soft-shelled or ferocious tortoise, and which nourish a most exuberant vegetation, but which are exceedingly unhealthy to the human race.

The forests in this immense valley consist of various kinds of timber. On the north of the

Mississippi portion, toward the great lakes, the prevailing timber on the light and dry lands is pine, and on those of better quality there is a great variety of deciduous trees, oaks, walnuts, maples, and an endless variety of others, generally differing in their species from European trees of the same genera, and more rapid in their growth, and more gorgeous in their foliage, but for the most part inferior in the compactness and durability of their timber. There is one character of these deciduous forests of North America which renders them highly valuable in ornamental plantations, and that is the richness and varied successions of the autumnal tints. Some of our native trees fade into various shades of brown and russet, and others pass into the "seared and yellow leaf," preparatory to shaking off their summer attire, and taking their winter's repose; but the American trees display colours far more rich, and, along with every shade of brown and olive, there are the purest yellow, and the most intense crimson. Those beautiful colours are of longer duration also than the autumnal tints of our trees, and though the subject has not been investigated in a scientific manner, there is no doubt that these autumnal changes of colour are in proportion to the variations of temperature at that season, while the largely developed leaves and their beautiful green in the summer are owing to the then tropical character of this most extensive and highly interesting valley. As we proceed to the southward, those pyramidal and evergreen coniferous trees, which are usually called American cedars, but which are in reality junipers, form, upon the swampy grounds, forests so thick, that not a single sunbeam can reach the surface of the earth for many square miles; and when we come to the lower parts of the valley, we find that magnificent tree, the deciduous cypress (*taxodium disticha*), which, in the form of its long and pendent feathered leaves, the softness of their green, the rich cinnamon colour of the boles and branches, and the immense size to which it grows, is one of the most beautiful trees in the forest. They are also few vegetables which rival in beauty the different species of magnolias, especially those with large tulip-like flowers of the most delicate whiteness, which come out early in the season, before the leaves, and which are as grateful to the smell as they are pleasing to the eye. It would, however, require many pages to trace even the mere outline of this region of excessive fertility,—a region which, in the abundance of its productions, both animal and vegetable, is equalled by few on the surface of the globe. Yet even this is, in some respects, a ruin; and, abundant as it is in waters, exuberant in woods, and swarming with animals,—some of which, as for instance the American bison, are of great size, and found in herds to the number of many thousands, browsing together on the wide savannahs, —and astonishing as are the flocks of birds which seasonally throng to the woods, thick as locusts, and absolutely built upon the branches, bird over bird, till the whole forests creaks and crashes under their weight, and countless thousands are precipitated to the ground, so that the people resort thither to give their pigs an annual feast of pigeons;—yet, notwithstanding all this, even the great valley of the Mississippi is, in some respects, a ruin; for there are found, in various places of it, the bones and other remains of large animals of which no living specimen has been met with. Among these may be enumerated the same elephant of times long gone by of whose entire carcase a specimen was found preserved in the Siberian ice, and which clearly demonstrated that this animal had been of a polar or cold climate character, and not the same with the living elephant either of Africa or of Asia. One thing, however, is singular: that the remains of the *mastodon,*—an animal which had rivalled the elephant in size, and agreed with it in its general haunts and more general characters, though different in many of the details of its structure,—are found buried along with those of the elephant in the valley of the Ohio; and that they occur also in South America, in France, in Germany, and in Siberia. Of the subjects, which press themselves upon one's attention while looking upon the map of this land of many waters, there is, however, literally, no end.

If we take the central valley of North America from the average shore of the Polar Sea, which is here exceedingly irregular in its outline, to the Gulf of Mexico, we find that the central elevation, or summit level where the water divides, lies about midway between them, being in central America about the parallel of 50°. This northern part has not, however, that unity which belongs to the valley of the Mississippi, but may be regarded as divided into three natural parts,—the valley of the St. Lawrence, including the great lakes in the upper part, and not extending far to the westward of Lake Superior, the principal one, the division being about 94° or 95° west longitude. This valley hardly deserves the name in the upper part, or all the way above the great fall of Niagara between Lake Erie and Lake Ontario, for the summit levels, or places of water-shed, in that part of the world are marshes, and not mountains; and at those falls there is a breast work of rock, into which the river has cut a channel of more than six miles in length; and if we are to suppose that the action of the water has been uniform, namely, six or seven inches in the year, as it is at present, the time passed in the performing of this operation would amount to about two and fifty thousand years. The volume of water which works here is perfectly astonishing, being not less than six hundred thousand tons descending in the minute; and from the height through which it descends, the actual power which this falling water possesses, if it could be rendered available to the purposes of human art, would be equal to that of about a million of steam engines!

The elevation of the breast work of rock which here crosses the general valley of the St. Lawrence is about three hundred feet, though the hills which diversify it rise a good deal higher. Of this height, the fall occupies about one hundred and fifty feet, the great or Canadian fall being about one hundred and forty, and the American, eastern, or smaller fall about one hundred and sixty. The grandeur of this fall, whether we consider the immense power of the rolling water or the splendour of the scenery, is altogether beyond description; and for this reason many circumstances respecting it have been greatly exaggerated, as is always the case when men attempt to describe in words that which, in reality, is beyond the power of language. Above this stupendous cataract there is a navigation on the lakes of not much less than a thousand miles, taking the average curve of the positions; and as the form of the group will be seen to be very irregular, they contain a great deal of shore, and have much influence upon the natural economy of the surrounding country, besides the advantage which they afford in the way of communication between the different parts. The extreme length from the northernmost point to the southernmost is not less than five hundred miles on the straight line.

Below this there is still about five hundred miles of a vast river before the sea is reached, and nearly other five hundred before the wide estuary is arrived at. The mountains which bound this lower valley of the St. Lawrence, both on the north and the south, are not very elevated, but they are sufficient to cut it off from the action of the Atlantic on the south-east, and from that of the countries towards Hudson's Bay on the north. Thus, this valley, the lower extremity of which is turned in the direction of the icy sea, to the eastward of Greenland, and the upper end in the direction of the lakes, not only has a seasonal action in itself, alternating between south-west and north-east, but it in so far breaks the reciprocal action which would take place between the temperate and polar countries in those longitudes over which it extends.

The third part of the northern division of this great central portion of North America inclines toward Hudson's Bay. It is a country in which there are no mountains, but an alternation of forests and swamps, with numerous small lakes, and abundance of rivers, though none of them are of any considerable magnitude.

The third or remaining division of this part of the continent lies along the Mackenzie River, which flows from Slave Lake to the Polar Ocean, its confluence with that ocean being in about 69° in latitude. The northern part of the country here is cold in the extreme during winter, while in summer it is very hot in proportion to the latitude. As in this part of the country there is no central elevation to interrupt the action over the whole latitude of the continent, the turns of the seasons are violent in the extreme. The snows in the early part of the winter fall speedily and in great quantity, but when they are over the air is tranquil, and the country may be travelled in all directions. At the commencement of summer again the snow melts rapidly; but as the country is flat, the rivers do not very speedily discharge the accumulated water, and thus a great portion of it remains stagnant in the swamps; and the quantity and vigour of vegetation are much greater than we should be led to suppose from the extremity of the cold in winter. In the extreme north, the spring floods, or "freshes," as they are termed, often roll down immense quantities of sand and gravel, which cover great masses of ice and snow, and so cut them off from the action of the atmosphere that, even in places where there is a surface vegetation in the summer, solid ice may be found upon digging a few feet into the earth.

In all this country, both southward and northward, the annual waste of timber bears, of course, some proportion to the vast annual production; and as there may be said to be a sweeping flood once a year passing over great part of the surface, the quantity of timber borne down by the rivers is immense. All along the northern shore of the American continent the people find drift timber in far greater abundance than they require for all the purposes of their simple economy; and the surplus is borne eastward along the margin of the polar ice, so that in Iceland, and the more dreary isles still farther to the eastward, in which not a single tree fit for domestic purposes grows, the few inhabitants of the habitable isles, and the occasional resorters to those which are not habitable, are abundantly supplied with timber from the American forests, which is wafted to their shores without any labour or contrivance of man. Nor is this supply of timber a matter of the open shores only, or a matter of yesterday, for there are various places where former deposits of this drift wood have been covered with earthy matters, and upheaved above the mean level of the sea, and at the same time wholly or partially changed into coal by the action of volcanic fires.

The Atlantic portion of America, or that which extends from the mouth of the St. Lawrence southward to the Florides, and which is in some measure cut off from the central valleys throughout its whole extent, is an alternation of fertile lands and swamps, crossed by very many rivers, though none of them are of large size. In consequence of the vicinity of the Atlantic, and the general set of the current of water in this part of that ocean being from the tropical to the polar latitudes, the seasons in this coast country do not run quite so much upon extremes as they do in the central valley; but it is of comparatively small dimensions, and of course plays a correspondingly small part in the economy of the earth's surface.

North America, to the westward of the Stony Mountains, is also, generally speaking, a narrow country, though it is much broken by lateral spurs of the mountains, which in many places descend to the sea coast in very irregular chains, forming valleys of equally irregular distribution. The sea opposite this part of the shore is very broad: and from what has been said of the nearness of the mountains to the shore, the action of this great sea is confined to a comparatively narrow stripe of land. The position of the mountains also, which at their northern extremity trend north-westward, intercepts the free communication with the Polar Ocean; and, from the joint operation of this cause and that formerly mentioned, the whole influence of the eastern half of the North Pacific is concentrated upon a narrow portion of this coast. The result is, that in the rainy monsoon, or rainy season, during which, in consequence of causes hereafter to be mentioned, the ocean sends its seasonal rain clouds against this portion of America, they burst upon it with indescribable force,—fury far greater than that with which, as we have hinted, the monsoons from the Indian Ocean burst upon the elevated lands, on the western, or Malabar, coast of the Indian peninsula.

This has very marked effects upon the country itself, and also upon some parts of that which is farther to the east. To the northward of the parallel of 42° the river Columbia may be traced, falling into the Pacific, and being by much the largest river on the western side of the whole continent of America. The different branches of this river flow in passages among the mountains, which, though very crooked and irregular, admit the action of the storms of the Pacific to the very centre of the mountains; and it will be perceived that the sources of the principal rivers which flow towards the Gulf of Mexico and the Arctic Sea, lie immediately opposite to those of the principal branches of the Columbia, and that they are at no great distance from each other; here, therefore, over an extent of at least one thousand miles from south-east to north-west, the Stony Mountains consist of a single chain; and as the sources of the rivers, as is almost invariably the case, overlay each other, the action of the Pacific tends to the supply of water for the rivers of the central valley, both northward and southward, as well as for those which flow to that ocean itself.

But, to the southward of the mouth of the Columbia, the country assumes a different character, as the mountains there divide into two branches, one following nearly the line of the sea coast from about latitude 45° to latitude 23°, an extent of about fifteen hundred miles, their summits being, upon the average, about six hundred miles from those of the main chain of the Stony Mountains. The Gulf of California extends into the southern part of this country for nearly the half of its length, at which place the two ridges are nearer to each other than they are to the north, and as the gulf is about a hundred and fifty miles wide for the first third of its length from the entrance, the country here is on both sides tolerably well supplied with water during the rainy season; but to the north there is a sort of Sahara on a small scale, where the rivers almost disappear during the dry season, and some of them are lost in lakes or marshes strongly impregnated with salt.

As the current of water from the tropical regions circulates freely in the Pacific, the temperature on this side of America is higher than it is on the east coast, or in the centre; and as the rains of the Pacific are, for the greater part of the line of coast, confined to a comparatively small breadth of country, they fall with great violence, and sweep all the soil from the summits and slopes into the hollows. This constant renewal of the soil, together with the excessive humidity, gives a vast impulse to vegetation in this part of the world, and trees grow to a greater height than in any other region—two hundred and fifty feet, or even three hundred, is said to be no uncommon height for the pines of California, and they attain a diameter of fifteen or sixteen feet at the base, so that a room of considerable dimensions might be worked out of the solid. In general the climate here is very hot, and the only inconvenience which the inhabitants sustain is from the violence of the rain storms, against which some tribes are said to defend themselves, not by huts, but by thatching themselves with a roof of long leaves, reeds, or grass, tied together at the top, and put over their heads and shoulders.

There are, however, so many peculiarities in this part of the American continent, that it is impossible even to name by far the greater number of them; we must, therefore, just glance at the southern portion of America, and then proceed to the other parts of our subject. But still, the position of North America upon the globe; the complete division of the west coast country from the rest by means of the Stony Mountains; the extent of the valley of the Mississippi, the vast quantity of water which descends that river, its winding course, and the continual destroying and reproducing of portions of the land on its banks, the immense quantity of alluvial matter which is deposited in the lower valley; and the connexion which this valley has with the regions of the north, through the lakes and swamps of the middle latitudes; all these, with a number of other circumstances, tend to render North America a highly interesting portion of the world; and this interest is by no means diminished by the reflection that this, the country of so much power and capability in a natural point of view, is the one where the triumph of human industry over wild nature is at once the most recent and the most remarkable. When we look upon the eastern hemisphere, we find that many of its districts are the monuments of mighty nations which have ceased to exist; but in America, we have, as it were, the beginning of a nation in one year, and its maturity in the succeeding one.

SECTION VI.

GENERAL FEATURES OF THE EARTH.—AMERICAN CONTINENT CONTINUED.

That portion of the map of the world which now claims our attention, presents the most splendid features, and displays the workings of nature upon a more magnificent scale than any which we have yet passed over in our hasty review. In respect of the vast extent and stupendous elevation of its mountain ridges, of the depth and sublimity of the valleys and ravines by which these are cleft asunder, of the violence of the storms which rage on their summits, of the number and grandeur of the volcanoes which blaze amid their ever-enduring snows, and of the extent to which those nether fires shake the earth to pieces by their violence—to say nothing of the immense stores of the precious metals which they contain, and which, in many instances, can be procured only by men whose drink is the mountain snow, and whose dwellings are inaccessible for fully one half of the year, and then only with the extreme both of labour and of peril—there is no portion of the earth's surface which is at all comparable with South America. So, also, in no part of the world are there to be found rivers of the same sea-like magnitude which do not roll with foaming currents,—as is the case with the Mississippi, which renders the land on its banks unstable and uninhabitable,—or, as is the case in the St. Lawrence, present dangerous rapids and impracticable waterfalls, but roll placidly on, and offer, for the purposes of safe and easy navigation and intercourse, pathways of more than two thousand miles into the interior of at once the most extended and the most fertile basin on the face of the earth. Nowhere is the soil over so great a breadth of land so indescribably rich—nowhere are the forests the same depth, the same ornamental beauties, or the same numbers of inhabitants. In short, if we would see the majesty of the material creation—the giant of geography, it is to South America that our attention must be directed.

Before, however, we can throw our rapid glance over this singularly inviting continent, we must take up the connexion from North America; for the narrow part of the country which lies between, bounded on the west by the Pacific, and on the east by the Gulfs of Mexico and Honduras and the Caribbean Sea, has general characters, differing not only from the rest of continental America, but from every other part of the world. The details belong to particular geography, and, in so far as relative position is concerned, they may be learned from the map; so that we shall consider the whole of this country under the general appellation of Mexico. It may be considered as extending from about the parallel of 30° north, to about 9° north and 79° west, where, between the Bay of Mandingo on the Atlantic shore, and that of Panama on the Pacific, the isthmus is narrowest; and here, North America may be said, technically speaking, to terminate, and South America to commence.

If, however, we regard it according to its natural characters, which is the proper view,—if we are to look upon the map of the world as an instrument of instruction,—the best account which could be given of any other country would afford us no adequate notion of this one. Upon observing it on the map, it will be seen that the two great oceans here approach very closely to each other, and that, for more than half the extent of the country, the average breadth from sea to sea is not much greater than that of England, while in many parts it is less. Now we know, from direct observation, than the action of the Atlantic extends not only over England, but over the eastern sea, and to a considerable portion of continental Europe beyond; for the prevailing winds are from the west. In Europe, the action of the Atlantic is but the secondary, or returning current, and it is in latitude considerably removed from the direct action of the vertical sun, even during the height of summer; while all the narrower parts of Mexico lie within the tropic, and are in the line of the full set of the primary current, uninterrupted, not only from the coast of Africa, but from the Cape of Good Hope, and the ocean beyond. Hence we might suppose that the Atlantic and Pacific would alternate with each other upon this narrow land, and carry alternate seasons of rain, in turns, over the whole of it, thus giving it the same glades of exuberant verdure, the same spice-clad hills, and the same marshes, rank with forests of reeds, which we meet with in those oriental islands, where the Pacific and the Indian Ocean alternately answer to each other's call, and keep nature continually awake and working, by the play of shifting monsoons between the east and the west.

Such, however, is not the case: there is no communication by means of the atmosphere, even at the narrowest part of this land, between the Atlantic and the Pacific; and not only so, but the direct action of each is confined to a comparatively narrow stripe of land along its own shore. The reason of this will become abundantly apparent, from the physical structure of the country.

On the parallel of the northern part of the Gulf of Mexico, the eastern ridge of the Stony Mountains subsides; and though the country is still elevated in the centre, it can hardly be said to be mountainous. Here there is little action of either ocean; and as there are no lofty summits to treasure up humidity in snow, or even to assist in condensing and collecting it as rain, the surface is, in many places, burnt up in the dry season, and, as already said, there are portions of it permanently desert, destitute alike of water and of vegetation. As the continent begins to narrow, the elevation increases; and there are some ridges of hills, covered with pine forests and interspersed with plains, which are inhabited by numerous herds of wild horses, and men who are still more wild, for they are the renegades of all the surrounding countries. The coast in this place, for about half way south on the Gulf of Mexico, may be considered as in some respects a continuation of the central valley of North America, and under the influence of the northward and southward seasonal action which takes place there; and, after this point is passed, the interior of the country has acquired an elevation, upon the average, of not less than about 5000 feet, altogether independently of the mountains, some of which attain an altitude of more than 15,000 feet. This elevated central country forms the table land of Mexico, which extends, varying in height and breadth, along the whole of the narrow part of the continent, so as completely to cut off, not only the mutual action of the two seas, but the action of each upon the central country, which is thus thrown upon its own resources, with little or no connexion in the general action of the globe. Over this singular land, there are scattered many mountain peaks, and several considerable ridges, the summits of which are above the line of perpetual snow, and on which, even to a considerable way downward, the weather is excessively severe; but the general aspect is that of a number of valleys, or, strictly speaking, basins, or shells, which do not open to the sea, and from which, consequently, no rivers are discharged. Some of these still contain lakes, in their central or lowest parts; and near the city of Mexico there is a lake of considerable dimensions: almost all of them contain stagnant pools for a short time during the rains; and they give evidence of having been at one time the basins of lakes of considerable extent; and at that period of its history Mexico may have been a well-watered country, covered with an abundant vegetation, and, though within the tropics, having a climate as cold as that of the upper valley of the Mississippi, if not colder. The deposits of salt, and also of the remains of aquatic animals, which are found in the bottoms, are sufficient proofs that there has once been abundance of water there; and the fact of there being no outlets to the sea, forbids us to suppose that the waters of the ancient lakes of Mexico can have found their way along the surface of the earth to the general receptacle of the waters.

Hence arises the question—what has become of those waters? and wherefore is it that so much of the surface of this apparently once fertile country is now mantled in desolation and sowed with salt? There are two ways, and it may have partly gone by each of them. In the first place, the shore countries, both on the east and the west, are exceedingly hot; and though the seasonal rains fall with great violence, they last for only a small portion of the year. The table land, though more elevated, and therefore not so warm as the shore countries, is still tropical. The season of rain on it is short, and therefore, under any state of things, the evaporation produced by the heat must have drank up much of the moisture of the surface; and as we shall be better able to explain afterwards, the more that the surface of any country is covered with tall and growing vegetation, the greater is the quantity of moisture which is turned into vapour. It is another general law, that air from a colder district, although saturated even to the point of depositing its moisture in rain, becomes absolutely a drying or evaporating atmosphere when it is carried to a surface which is more heated. For instance, the east winds, in the early part of our summer, which come across the eastern sea, are really charged with a considerable quantity of moisture, but they do not rain upon the comparatively dry plains of Norfolk, Suffolk, and Essex; they pass over these in cold and withering drought, and discharge their humidity on the more midland and elevated parts of the country. Upon these principles, the hot countries on the Mexican shores must every year withdraw a portion of water from the interior; and thus the ancient Mexican lakes may be said to have been in part drained, and the modern ones in part draining, through the sky.

Secondly, this table land is full of volcanoes. The craters, or rather the chimneys of some of these, may penetrate the earth to a depth considerably beyond that of the bottom of the sea. Indeed, it is probable that all volcanoes, and all volcanic action, result from connexion with the sea; because we have no remarkable volcano at any very great distance inland; and because, where the sea appears to have evidently receded from volcanic countries, the volcanoes are all extinguished. Thus there are extinct volcanoes in the mountains towards the south of France; and we have the evidence of vast accumulations of sand, and sea shells, and even the distinct markings of successive beaches, to prove that the sea has, in the course of ages, retreated a great way in that country. Now, it is easy to understand how the chimneys of these volcanoes, and the cracks and fissures produced by earthquakes, which are general concomitants of volcanic action, and not unfrequently take place in their greatest violence between the volcanoes and the sea, thereby further proving what we have stated, may, indeed must, have acted as under-drains to the table land of Mexico, and thus accelerated the progress of drought and desolation. Farther, it is a remarkable fact, that there are in the sea between the Mexican shores and the island of Cuba, fountains of fresh water, which are discharged from the bottom with so much force that they boil over the surface so violently as to be dangerous for light boats, and so perfectly unmingled with the water of the sea, that sailors are sometimes in the habit of drawing fresh water from them with pitchers. The water of those sub-marine springs is cold; it is accompanied by no discharge of vapour; and, as was ascertained by Humboldt, there are fishes found in it which are not natives of those seas. Therefore, this water must descend through fissures in the earth somewhere: those fissures must be of sufficient size to admit the passage of the mainland; and consequently, nothing but the pressure of a head of water, in the same manner as makes an ordinary fountain to cast up its jet, can produce those sub-marine springs. This head of water must also demand a very considerable elevation, in order to clear its way to the surface, through the ocean water, unmingled with that water, and where,—as is the case between Cape Catoche in Yutacan, and Cape St. Antonio in Cuba,—the current of the ocean runs with much velocity and force. Those springs are, no doubt, nearer to Cuba than to any part of Mexico, and therefore they may be supplied from that island; but if the fact is admitted in the case of Cuba, it cannot be denied in that of the Mexican table land.

These circumstances—though in the notice of them we have been obliged to anticipate some principles, the full understanding of which requires a knowledge of the general laws of action both of the air and the sea—are yet very necessary to be borne in mind, in order that the reader may fully understand that progress of nature which has brought some very large portions of the land to that condition in which we now find them. If the reader has attended to what we have stated respecting much of central Asia, the greater part of northern Africa and of New Holland, and partially of all places which are cut off from communication with the sea, he will at once perceive that there has been by some means an abstraction of the water from those places; and that though, in such as have been volcanic and have contained much moisture on the surface, the volcanic action may have occasioned an under-drainage,—yet, after a certain stage, that drainage may be supposed to cease, and to cease the sooner the more tropical, and therefore the warmer, the climate. After vegetation is in a great measure gone, except those saline plants which are the last to quit the desert, a few weeks of periodical rain, occurring once in the year, must rather hasten then retard the final catastrophe. Those rains which, in places cut off from the sea are derived from the country itself, either in its remaining brooks and pools and vegetation, or from the mountains which enclose it or are upon it, not only wash the little soil there is from the parched surface, but afford an evaporation, and at the same time cool the air, and send it loaded with its moisture, in part at least, out of the country. The violence with which rain falls is generally in proportion to the resistance offered by the dryness and warmth of the earth; so that while we have gentle showers upon thick forests and green savannahs, we have in the very same latitudes pelting torrents, which sweep everything before them, upon the barren plains and the bare mountains. It seems, indeed, and it is in accordance with the general benevolence and beauty of the system, that the rain of heaven which falls upon the fertile land to refresh and to nourish, comes upon the sterile track to rend its mountain rocks, break its stones into sand, and sow its valleys with salt. The saline plants greatly assist at this stage of the progress; and though there is no part of the table land of Mexico which has yet become drifting sand like Sahara, there is much of it covered with saline deposits, beyond all human power to restore to any degree of fertility, and therefore given up to utter barrenness and ruin, until some of the more mighty movements of nature, the period of which does not fall within the brief span of human history, shall remodel it, reclothe it with vegetation, and repeople it with life. From the peninsula of Yutacan southward, the east coast is exposed to the direct current from the Atlantic. Yutacan itself is narrow and less elevated than the country to the westward, so that the atmospheric current sweeps across, and Yutacan is covered with luxuriant forests in all the lower parts. The same applies to the countries round the Gulf of Honduras, a little to the south; but when the most easterly point of the Musquito shore is reached, the northern part of South America both meets the current, and bends it to the north, so that for great part of the year the surface is burnt up. Along this shore, where the intensity of the Atlantic current acts with all its force upon a small breadth of land, the rains, though not of very long continuance, are unequalled in their violence; so that in the course of an hour or two the hollows are fathoms deep in water, rolling and roaring with the utmost fury, and bearing down everything save the strongest and most deeply rooted trees. The West India Islands, as may be seen from their position in the map, form a sort of guard to this coast, and they have their share of the violent action of nature to which it is subjected.

We shall now glance at America from the Isthmus of Panama southward; and here, though the rivers are majestic and well defined, the great ridge of the mountains form the most striking as well as the most general feature. As will be seen from the map, those mountains are nowhere at any considerable distance from the shore of the Pacific, and the coast country there is a mere border, in which there is no river worthy of notice in a general sketch. Generally speaking, the Andes follow the line of the coast very exactly, and they attain their greatest elevation in about the middle length of the country, that is, in about 16° south latitude. Immediately under the equator there is a sort of central point whence the mountains diverge, one branch running north-eastward in the direction of Trinidad; and we may imagine a continuation through the West India Islands till we come to Yutacan, and thus we have a basin wholly land-bound on the one-half of its circumference, and partially so on the other, and including within it the Caribbean sea; another branch keeps the line of the Pacific shore, and diminishes in height as it reaches the Isthmus of Panama. Several other ridges diverge from these, all directed northward, and separated from each other by very deep and highly romantic valleys, which are in some places so narrow, and their boundaries so steep, that the width is scarcely more than the depth. From the equator to about 6° south, the summit of the Andes, that is, the base of the individual peaks, forms a sort of table land bearing some resemblance to that of Mexico, but resembling more a very elevated valley between two ridges of mountains. We may mention that, in the Spanish language, a ridge of mountains which stretches in line, whether straight or crooked, without being broken into rugged peaks, is called a *cordillera ;* and where the chain of the Andes runs double, as it does in this part, the ridge next the Pacific is called the Cordillera of the coast, and the second the Cordillera of the interior.

In latitude about 15° south, the great chain of the Andes branches again, and the ridge of the interior, taking a sweep northward of about 70 miles, again returns parallel to the ridge of the coast, and the two enclose between them a singular upland valley, in which there is situated the lake of Titicaca, from which the river Desaguadero flows southward, and is lost by evaporation in a sandy desert in about latitude 19°, or about one hundred miles north-west of the celebrated silver mines of Potosi. The eastern or interior ridge here consists of perhaps the most lofty mountains on the face of our globe, though it is only lately that they were known, and consequently they have not been accurately measured. Those that have been measured, however, have an elevation of not less than twenty-four thousand two hundred feet, which is only one thousand five hundred less than the most elevated of the Himalaya ridge, the mountain of Dhawalaghiri ; and, as this mensuration did not extend to the snowy summits of Sorate, between 15° and 16° south latitude, which are the most elevated of the whole, there is reason to believe that these mountains are still more lofty than the highest in Asia.

The chain of the Andes varying in elevation at different places, but still retaining a height at which there is snow almost all the year round, not only on the peaks, but in passes by which the ridge can be crossed from east to west, stretches onward to the very southern extremity of the American continent, still at only a small distance from the shore of the Pacific, though, from about latitude 28° to 42°, the average breadth of the country from the summits to the sea may be estimated at about one hundred and fifty miles.

A mountain ridge of so vast an elevation, extending the whole length of South America, and being, generally speaking, not more than one hundred miles from the shore, must effectually cut off all the breadth of the country to the eastward, that is, the entire continent, except a mere border on the west, from the action of the Atlantic, and also confine that of the Pacific to the stripe of land which lies along its own shore. It so happens, too, that the sources of the principal streams lie to the westward of the most elevated summits, while the courses of the rivers, of which these streams are the feeders, are directed towards the east. This cuts the small stripe of land, consisting of Peru, some intermediate tracks which are nearly desert, and Chili, from all reciprocal action of nature, and indeed from all general intercourse of man and man, with the eastern part of the continent, which in a general view may be considered as more eminently deserving the name of South America. Thus we are to regard the country as inclining to the shores, which the map points out to us, being to the north-east, the east, and the south-east; an idea of the natural divisions of which may be readily formed by examining the courses and lengths of the principal rivers.

Leaving out the minor ones, there are three of these which indicate the centres of three remarkable portions of the country, the Orinoco, which discharges its waters into the Atlantic by a number of mouths, the principal one of which is about 60° west longitude, and 9° north latitude;

the Amazon, which discharges into the sea, immediately under the equator, and in about 50° west longitude, a larger volume of water than probably any other river on the surface of the globe; and the Plata, which pours its stream into a wide estuary in about 14° south and 59° west, nearly on the same meridian with the principal mouth of the Orinoco. Between those rivers there are ridges of mountains, some of which would be considered both extensive and elevated in many parts of the world, but they sink into nothing as compared with the gigantic Andes, and none of them can be considered as a continuation of, or as connected with, that mighty ridge. Between the Orinoco and the Amazon there are heights, the general direction of which is east and west; but at about longitude 66° they subside, so that the branches of the one river come near to, and are said to be in some instances connected with, the branches of the other; and to the eastward those heights are interrupted by swampy places, upon which the water stagnates to a great extent during the rainy season.

Between the Amazon and La Plata the mountains are much more irregular. From Paraiba, on the north coast of Brazil, in about 41° west, a ridge commences and runs nearly parallel to the east coast, and about three hundred miles distant from it, to about the 20° of south latitude, where it turns eastward and joins another ridge, which may be traced northward on the right bank of the river San Francisco to about the latitude 10° south; and from the junction of these—which forms an elevated district of sterile character, but containing the rich diamond mines of Brazil—another ridge extends southward to the estuary of La Plata.

The central elevation, where the waters of the Amazon and La Plata divide, is very irregular, as some of the branches of the Amazon rise as far to the southward as 20° latitude, and those of the Paraguay, or central stream of La Plata, at least five hundred miles farther to the north. The character of the country at which the waters divide between those great rivers is as irregular as its position in latitude; sometimes it consists of mountains, or, more strictly speaking, of hills, and sometimes of plains, which are flooded during the rainy season, and burnt up during the dry.

Of these great divisions of South America, the most interesting beyond all calculation is the valley of the Amazon,—a valley which contains more than half as much surface, and probably more fertile land, than the whole continent of Europe, and compared with which the Valley of the Nile, long and much as it has been celebrated, is a mere line, and such valleys as those of the Danube and the Ganges are only little patches. The length of this valley, on the straight line from east to west, is little short of two thousand miles, and its breadth from north to south is very little less, and this not at a few detached points only, but very nearly for the whole range of the length, and certainly for two-thirds of it. Nor is there within this vast extent of country any district of even moderate extent sterile, or incapable of being reclaimed from sterility; and the whole is so little elevated above the mean level of the sea, that the river and its principal branches are navigable for the greater part of their length, and the western ones up to the very gorges by which they issue from the Cordillera of the Andes, and in some instances beyond. Those branches, too, roll no stinted tides, and no merely seasonal waters. The western branches drain both sides of the Cordillera of the interior for an extent of at least twelve hundred and fifty miles; and the summits are every where above the line of perpetual snow, so that the waters which flow thence know little abatement at any season of the year. In Upper Peru, or Bolivia, that is, the country immediately to the east of the Andes, the large rivers which unite to form the main stream of the Amazon are almost countless; and farther to the eastward the branches on this, the right-hand bank, would be accounted rivers of the first magnitude in almost any other part of the world. The Madera, which rises about 20° south latitude, near the mountains of Potosi, has a course of not less than one thousand four hundred miles, which the windings will bring up to not less than two thousand. The Topayos and Xingu, though inferior to the Madera, are large rivers; and they are exceeded by the Tocantins, which, consisting of two large branches, drains the western parts of Brazil. On the left bank the rivers are not of such gigantic dimensions; but still the Yupura and the Rio Negro rival in magnitude the largest rivers in the European continent.

The Orinoco is a small river compared with the Amazon; but still its length and volume of water are very considerable, though, as its valley does not open so immediately upon the current of the Atlantic as that of the other, the plains in the upper part, which are also in some instances more elevated, are more liable to be burnt up during the dry season. Still the lower valley of the Orinoco, the country between that and the Amazon, and great part of the coast of Brazil, are remarkable for the luxuriance of their forests, and the vigorous growth and exquisite beauty of many of the climbing plants, and plants with bulbous roots, with which those forests are adorned.

The upper country, too, is one continuous forest, extending along the eastern slopes of the Andes from about 4° north of the equator to little less than 20° south, and reaching down the country to an extent which has only been explored at certain points, but which is everywhere very great. This is, in fact, the very home of vegetation; and as the action of the Atlantic current reaches the Andes, and is returned by the floods of the low countries during the rains, and the melting of the snows during the droughts; and farther, as the course of the rivers during the greater part of their extent is slow and placid, there are evidently fewer of the elements of wearing out in this valley of the Andes than in any region with which we are acquainted; while, from the number of its rivers, their magnitude, and the comparative flatness of the intermediate land, there is no region upon the face of the globe which could be so completely connected together by means of artificial navigations. Besides, the climate is exceedingly warm, and the soil equal to the growth of every imaginable production requiring a situation of the most favourable kind; and though the great inland chain of the Andes, in consequence of the labour of reaching it from the western sea, is comparatively little known, it is well understood that the mountains there are far more rich in the precious metals than in the countries farther to the north.

There is one remarkable point in this part of South America, and that is, the situation of the celebrated mountains and mines of Potosi. These are detached from the great chains of the Andes, and situated nearly under the twentieth degree of south latitude, and between 65° and 66° west longitude. In the maps, except those of very modern construction, these mountains are laid down considerably to the westward of the true position, and therefore an improper notion is given of the shape of this part of the country; but in as far as the division of the great waters is concerned, the summit level as between the Amazon and La Plata, and also the internal marshy desert, in which the Desaguadero is lost, may be considered as situated near Potosi; for Rio Grande, a branch of the Madera, rises immediately to the north, and the Pilcomaya, a branch of La Plata, immediately to the south; while there flow towards the west some small streams which are lost in the same desert which drinks up, or evaporates, the waters of the Desaguadero.

To the southward of this summit level we come into the plains of Paraguay, or those situated in the western half of the valley of La Plata; and these, not having the advantage of a similar current to that which plays along the valley of the Andes, are in many places sterile, or, at all events, naked of forests; and this character of country continues down the centre of the southern part of the continent till we come to the termination of the Pampas, or vast plains, which in general produce herbaceous vegetation only, the most conspicuous of which is alternate crops of clover and thistles; and this termination brings us to about 40° south latitude. On the left bank of La Plata there are mountains of some elevation between the different branches of that river; the sides of those mountains are clothed with woods, and the bottoms afford rich pastures, in which countless thousands of wild cattle, the produce of stock originally imported from Europe, find abundance of food; and, indeed, many parts of the country on the other side of the river is stocked in a similar manner, and in nearly the same abundance.

The country southward of the Pampas is sufficiently narrow for being under the influence of both oceans; and though its surface is very irregular, it abounds with vegetation of a more tropical character than the latitude would lead us to suppose. Such is a very brief outline of the characters of the principal lands which are of sufficient extent for having much influence in the general economy of the earth's surface.

But though the space to which this volume is restricted prevents the possibility of giving anything else than mere outlines of the more general features; yet, in order that the reader may fully understand and duly appreciate the general subject, it will be necessary to acquire a knowledge of the details, at once extensive and accurate. Indeed, a knowledge of the earth's surface, down to even very minute particulars, is essentially necessary for every one, both as a portion of general education, and as a means of turning that education to account in practice; and probably the hasty survey which we have attempted to take may induce many, whose geographical knowledge has hardly extended beyond the mere repetition of a few names, to acquire a knowledge of that science more consistent with its usefulness and the pleasure which it is so well calculated to furnish.

SECTION VII.

BRIEF ABSTRACT OF THE EARTH'S FEATURES.

In the preceding sections we have taken a cursory and sketchy view of the great component parts of the earth's surface, as preparatory for examining the operation of those causes upon which the different climates and productions of its several regions depend. But before we proceed to notice those causes, it may be desirable to bring to a sort of focus those elements which we have attempted to collect, as this will save some particular reference afterwards. The chief points to be attended to in the configuration of the earth's surface as affecting climate, are those which interrupt the communication between any region and the sea, and those which break the circulation, whether of sea or of air. In the latter case, the circulation may be broken either in the direction of east and west on a parallel, or north and south on a meridian; and we shall see afterwards that the interruption on a parallel is of most importance in countries situated near the poles, and that on a meridian in countries nearer the equator.

Leaving the pressure of the atmosphere—which, by being sometimes greater at one place than at another, throws the ocean out of that shape which it would naturally assume if the waters were at a state of rest—we may mention that land, as between sea and sea, always occasions an interruption to some extent or other; that if the land rises into mountainous ridges of any considerable elevation, these occasion a greater interruption than would be produced by a far greater breadth of low and flat land, and if they rise within the region of snow they offer the same obstacle as an entire quadrant from the equatorial to the polar regions; and that, independently of elevation of surface, surfaces of different characters, and clothed with different kinds of vegetation, offer different degrees of interruption. Thus, if the surface is bare, and so situated that the sun beats strongly upon it, no current of the atmosphere can sweep over it, and therefore no influence of any other region can affect it to any considerable extent; because such a surface rarefies and expands the air, gives it an upward motion, prevents it from depositing any moisture which may be in it, and at the same time draws toward itself the air on the surface of the ground all round it. If a surface of this kind is large, such as the desert of Africa, or of central Asia, or the table land of Mexico, the air which comes in from the surrounding regions is heated, rendered more dry, and thus conveyed, without producing rain, to distances more remote than those from which it fetches moisture while it is a surface current moving toward the desert.

On the other hand, if the interruption is high land, and especially land which rises above the line of perpetual snow, it resists the current towards it; or, if that current is powerful enough to reach the cold and elevated surface, it is condensed there, and parts with its humidity, and so moves back again along the surface, generally speaking, as a cooling and dry atmosphere.

When we apply these principles to what we have observed in examining the map, we find that the most extensive interruption on the meridian occurs in America, where the Andes, and their continuation in the table land of Mexico, and the Stony Mountains, completely separate the action of the seas, and thus break any circulation that there may be from 55° south latitude to 75° north, or, we may say, to the permanent ice of the Polar Sea, where of course all current and all circulation on the parallel is at an end. This interruption, in as far as the mountains are concerned, is nearly on a meridian from 55° south to 10° north, or, in round numbers, for an extent of four thousand five hundred miles; and for the rest of their length, about as much more, they interrupt it in an oblique direction from south-east to north-west, extending in this way over only 5° less in latitude than in the south, and at the same time trending westward at their northern extremity over a full quadrant, or 90° of longitude. Notwithstanding this, there are comparatively few portions of the American continent which are cut off from the influence of the sea in every direction. On the northern part of the continent, the only part which is so, except when the Polar Sea is covered with ice and snow, and consequently has the same effect as if it were land covered with the same substances, the only portion which is so cut off, and the cutting off is not total, is the western half of the great central valley toward the Stony Mountains, a portion of the country in Upper California, where there is a second ridge between the Stony Mountains and the Pacific, and the comparatively low country between the Stony Mountains and the table land of Mexico. These districts are, as we have seen, latitude for latitude, far less fertile than those which enjoy a communication with the sea. The parts of the central valley on the west, or right bank of the Mississippi, do not contain such dense forests as are found on the opposite bank, or such giant trees as we meet with on the west coast, in consequence of the trend of the mountains forming a protecting wall against the chilling blasts of the pole, the climate is, notwithstanding the violent seasonal rains, warmer than the same latitudes on the east. When rains do occur on this eastern side of the Stony Mountains it is natural to suppose that they fall with more violence than on the other bank of the river; because the rocks and naked plains are more intensely heated and more speedily cooled than a surface covered with luxuriant vegetation. We find also that, as we approach the river, the country on this right-hand side possesses naturally some advantages over that of the left. On this latter situation the forest in its natural state came down all the way from the Rhodadendron groves of the eastern mountains to the very bank of the river, and even into its current whenever that threw a bar of new land or afforded anchorage for a drifting tree; and whether it was campagne or marsh, there was found a species of wood adapted to it. No doubt the action of the river and the eddying of the winds throw up "bluffs" or sand hills, on this side as well as on the other; and upon the more arid heights, which did not afford depth of rootage for a large tree, and were not of a mossy nature enough for the mountain shrubs, were open blades, with here and there a scattered tree, forming what the Americans, adopting the French phrase, not very happily term "prairies;" but there were originally no such wide savannahs as those which afforded grazing for the innumerable herds of the American bison on the western bank of the river.

In the central part of America, namely, that from the parallel of the Gulf of Mexico to the Isthmus of Panama, the whole of the table land is cut off from connexion with the seas; and it may be regarded as a mountain interruption.

In South America, the whole continent, with the exception of a small stripe along the western shore, is cut off from the Pacific; and, though it were not, the action of the Pacific here is not toward the land, but in a line parallel to the shore. Hence, even over this long and narrow district, the action of the sea and land upon each other is very trifling; and the progress of the whole western country may be considered as one toward barrenness and drought. Wherever there is moisture, this portion of America is very fertile, and the climate is delightful; though, from the proximity of the Cordillera to the sea, and the strong volcanic action which is constantly going on at different points of that Cordillera, through great part of its length, the country on the shore of the Pacific is liable to dreadful calamities from earthquakes. From the extent of the valley of the Amazon, both in length and in breadth, there is little room for lands unaffected by the action of the sea to the eastward of the Cordillera of the Andes. The spots at which this action is not felt, and which are in consequence parched and burnt up during the season of drought, are the elevated plains on the upper part of the Orinoco. The desert, which drinks up the Desaguadero, to the southward of that singular valley between the double Cordillera of the Andes which contains the lake of Titicaca, was the cradle of Peruvian civilization, and most likely the place which sent the romancing adventurers of the earlier ages of discovery to seek, in a more northerly and easterly part of South America, an *El Dorado*—a city paved with gold, and having its buildings roofed with the same costly material; this mountain valley, and the country to the south of the summit level, between the sources of the Madera and Pilcomaya, until the Pampas is passed over, and the mountainous region of Patagonia arrived at, are the only portions of South America which are not, to some extent at least, subjected to the influence of the sea.

On the eastern continent we have, in the first place, Africa, breaking the continuity, in the direction both of the latitude and the longitude; although we know too little of the nature of Southern Africa, from 10° north and 20° south of the equator, to be able to state its specific effect. We do know, however, that the surfaces, both of Africa and New Holland, are sufficiently powerful for changing the current in the Indian Ocean into monsoons, alternating between those countries and the south of Asia.

In Europe, the obstacles presented by mountains chiefly affect the action in the direction of the latitude, and cut off communication with the cold regions at the pole; while great part of the continent is open to the action of the Atlantic on the west. In Asia the deserts and the mountain ridges cut the centre of the continent completely off from all influence of the sea on the south: and the mountains and deserts to the westward of China, though the particulars of them are imperfectly known, form a barrier equally complete between central Asia and the Pacific. It should seem that the mountains which separate

Siberia from the countries to the south form a less perfect barrier against the Siberian cold; for though China is warm in the summer, the winter at Pekin, which is nearly on the same parallel with Madrid, or rather to the south of it, and not nearly so high above the level of the sea, is much colder than it is even in France.

These recapitulations will serve as a sort of artificial memory of the features of the land, upon which the general characters of the great divisions are founded; and if these are once fully understood, the more minute particulars can be worked out by any one who attentively studies the details of geography. We have not noticed any of the smaller islands which lie scattered over the wide ocean, because these in general partake of the uniformity of the ocean itself; and, generally speaking, they are more fertile and more healthy than the broad lands, and never liable to be burnt up with drought. The reason of this last circumstance is, that in those small spots there is a sea air, sufficiently charged with humidity, always ready to blow from the shores, when the surface of the land becomes heated. Thus, there is no such great differenee between season and season in the islands as we meet with in the continents, especially those parts of the continents which are either cut off from the action of seas, or have an uninterrupted play of currents between the tropical and the polar regions constantly passing over them. When we once have obtained a knowledge of those constituent surfaces of the earth, upon which any agencies can act, as producing differences between region and region, in productiveness, in healthiness, in beauty, and in every thing which can render them desirable as the residence of man, or show man how he can improve their natural imperfections in his little way, we are next to inquire what the agencies are that act differently upon those different surfaces.

This is a far more difficult part of the subject, and one of which our knowledge may be said to be in its infancy; inasmuch as we know not all the agents which conduce to this end, and we know not how the one of them may modify the action of the other, or how, under the operation of the same agent, district may conspire with, or conspire against district, so as to produce a result different from what there would be if either of the districts were acted upon without the other.

SECTION VIII.

AGENTS AND INSTRUMENTS IN THE MORE GENERAL PHENOMENA OF THE EARTH.

In treating of these, it will be necessary, in the meantime, to limit our consideration to the present state of our abode—to the earth as it now presents itself to our view, without including any of those agencies by which the solid strata of which it is composed, have been moulded into their present forms, tempered to their present consistencies, placed in their arrangements, and disposed in those localities, which the map shows that they occupy. The knowledge of these latter questions is still in its infancy; and from the little that has happened within the period of recorded history, we may conclude that many generations of men must be gathered to the dust before there are any remarkable general changes in the general aspect of the earth.

But those who wish to write popularly, so as to afford a little instruction to all who may stand in need of it, must write for the day, and of the day; and as the world as we now live in it—and not as it was before we were born, or it shall be after we are no more for its enjoyment—is the living book of our instruction, the volume which the Almighty has spread wide defore us for our contemplation, our pleasure, and our improvement, we should make our artificial volume as much in accordance with it as possible. What is it, we would ask, that is the object of our seeking for a knowledge of the parts, productions, and phenomena of the earth? Is it not that we may the more thoroughly and the more rationally enjoy the portion of it which comes under our more immediate observation?—Is it not that every opening of the eye shall be an inlet of knowledge and pleasure, that every step which we take upon the soil shall be a step in the ways of wisdom, and that every object which we examine shall be made at once to tell its own tale, and to proclaim the wisdom and the goodness of Him whose creature it is?

And it is for the want of this capacity of reading, as we run the race of life, both over space, and during time, that there is any dreary road, or any weary hour to afflict us, and embitter our lives. Where in creation, we would ask, is the blank page? The cultivated field, the barren moor, the overshadowing forest, the naked heath, the beetling rock, the shifting sand, every thing on which the eye can alight, is full of instruction. Nay, Sahara itself, the wide and wasted desert, is a volume in which, though the characters are different, the language of the Almighty is as forcible, as in the richest spot under the canopy of heaven. It is the same with the succession of events; for Nature knows no vacant day—her operations are unceasing; and though they vary with times and with seasons, as well as with places, their variableness is an additional charm, an enticement to the study of them, which is ever new. The uncultivated mind is, in truth, the only blank; and man is the only idler in creation. And we have the proof that it is man's fault in the fact that man's punishment is as closely linked with it as the light of the morning is with the rising of the sun; and we may safely say, that nine-tenths of the vice, and more of the misery of society arises from the struggle of untutored nature to escape from the vacant hour: that hour, during which the mind, solely because it is unoccupied, becomes at once its own tempter and its own tormentor.

But if we all could acquire the power and the habit of enjoying with knowledge that which is within the range of our observation, and which costs us nothing, either in time or in money, we should have no leisure to be idle, and no desire to be vicious. Imagine that one has to cross the most extensive and the most dreary common in England, where no human habitation is in view; where there is not a trace of human art; where not a sheep nibbles the unproductive surface, and, saving a few little tuneless birds, flitting now here, now there, nothing appears to break the monotony of the scene. Need we be alone there?—or need our thoughts wander either after vice or after vanity? Assuredly not; for this also is a page of the book which is all instruction; and if we question the stunted heath, or the lichen upon the stone, we shall find that they have got a tale to tell, and are the indexes to the general character of some land, to which, in consequence of its position on the globe, or the other seas or lands to which it is exposed, the economy of Nature has been less bountiful than to our country; and, as we shift our ground, and come to the mossy stone, which stands high and sheltering, with grassy tufts around it, it shall tell us of the benefits of a sheltering elevation, and transport us to the Alps, the Himalaya, or the Andes, and show us that those lofty and untenanted elevations, with all their sterility, and cold, and snows, perform a most important function in Nature's economy, by preserving the beauty and the life of those regions which lie around their bases.

We shall not farther pursue this analogy, because it must be apparent to every one, that if we possess even a little knowledge, keep it about us ready for use, and know how to use it, we shall be enabled to turn any and every scene into an index, not only to all the physical features and phenomena of the earth, but to all which has been done by man, and for man, upon its surface. Could we all arrive at this, it is impossible for those who have not entered upon the journey toward it to know how delightful we should find the world, and how little our peace would be disturbed, and our enjoyment interrupted, by those little ills and reverses, which are, in the very nature of things, inseparable from our condition; and which, we may add, fall more heavily upon those whom we are apt to envy, than on those whom we pity.

This is by no means so difficult of accomplishment as some may be apt to suppose; for, on the contrary, it is natural to us, and we have to be schooled into refraining from it. The child breaking the rattle, in order to learn the cause of the noise which it makes, is an instance which has often been brought forward; but it is one which is fraught with the most important instruction; for in that attempt of the child, there is evinced the rudiment of that desire of knowledge which would raise the man high and honourable in acquirements, if, for the sake of a few pence, we did not break the desire of knowledge for the purpose of saving the rattle. Connexion, relation between object and object in place, and event and event in succession, is the grand matter, all which deserves the name of knowledge, indeed; and therefore it is to this our attention should be constantly directed. The individual facts may be the rods which compose the bundle, but it is their relations to each other which form the band, and give to the bundle the strength of unity. This is needful upon all subjects, and is especially needful upon a subject embracing so many particulars, and particulars so apparently different from each other, as are embraced in even a very simple general view of the earth. For this reason we have noticed them here; and, having done so, we shall briefly advert to the subjects enumerated in the title of the section.

But before we can rightly understand how any agent acts in the bringing about of any result, we must know what resistance that agent has to overcome, for it is a law of nature that there can be no action of any kind whatever unless there is some resistance to be overcome: the agent must no doubt possess energy sufficient for overcoming the resistance; but admitting this, it may be stated as a general truth, that the intensity of the action is in proportion to the strength of the resistance, and when we consider that all natural action, even though the agents of it are what we call second causes, is performed under the direction, or in strict accordance with the law of the Great First Cause, we must be convinced that the value of the natural action will always be in exact proportion to the resistance which is offered to the performance of it.

The general resistance to all action on the earth's surface, whether of agents external of that surface, or of the different parts of which it is composed, is gravitation. As the earth taken as a whole is exactly balanced by its own motion on the one hand, and its gravitation towards the sun on the other, so every piece and particle of matter of which the earth is composed is retained in its relative position by its gravitation towards the earth, and the earth is so much larger than any piece of matter which we could imagine to be moved on its surface, by any power of motion with which we are acquainted, that, if left to gravitation alone, every piece and every particle of matter must have speedily come to its balance, and so remained at rest with regard to the earth, without ever changing one way or another. This general resistance has, of course, to be overcome before there can be any change, that is, any result of action.

Again, all the inorganic parts of the earth, that is, all substances, whether solid, liquid, or air, (for the same substance may be in either of these three states, according to circumstances,) which is not part of a plant or animal, the result of vegetable or of animal growth, is held together by a species of attraction, or tendency of the parts towards each other, which is different from gravitation, but which acts on the small scale, something towards the same effect, though not in the same manner, as gravitation acts apon the great scale. The grand distinction is, that gravitation belongs equally to all matter, in proportion to its quantity, whatever may be its kind, whereas the attractions which hold together the smaller pieces of matter depend on the kind of matter, and not on the quantity. It would be foreign to our purpose to enter into the very curious question of what constitutes difference of kind in matter, and though we had room for it, it would lead us away from our general subject, and not be very instructive, because it is a subject the foundation of which is one of those mysteries which is coeval with creation itself, and therefore beyond the keenest scrutiny of man. We have to believe, however, that if all dead matter were placed in peculiar circumstances, it might, by means of powers or qualities which God has implanted in it or endowed it with, separate into parts which would, in like parts found in different compounds as now existing, arrange itself into crystals of some sort or other, every separate one obeying a definite law; and when we actually examine even the smallest grains of dust, which are the dust of the earth as dead matter, and not the remains of anything which has once grown or been alive, we find that it is composed of little crystals, and that all rocks are composed of similar materials, though in some the particles are so very minute that we cannot examine them at all by the naked eye, or perfectly by even the most powerful microscope.

All these minor attractions, as we may call them, are resistances which the agents that produce changes on the earth's surface have overcome, and there is even more than this. It is doubtful whether there is any action without liquidity, and it is certain that there can be little or no living action, either of plant or of animal, without the presence of air, not of the mere gaseous fluid of the atmosphere, which we usually mean when we speak of the air, but of other substances in a state of gas, either singly or in combination. Thus, for instance, a man could not live for many minutes, or be comfortable for more than a few seconds, if there were not a quantity of the very same matter of which diamond is composed removed from the substance of his body in the state of gas, and mixed with one of the component parts of atmospheric air. So also no plant could be healthy without giving out a portion of the same substance in the same state; and as the bodies of men and the substances of plants contain a considerable proportion of this same matter of diamond, there must be some means by which it is received into both, and received in greater quantity than is necessary. Hence, in carrying on the operations at the earth's surface there must be in the agents a power of melting solids into liquids, and of converting both solids and liquids into gases. Farther, as it is necessary that the substances so melted, or so turned into gas, should, under other circumstances, return to the solid state, either in the same combinations as before or of different ones, it becomes necessary that the agents which melt the solids or convert the substances into gas, should not destroy the tendency which the matter of those substances has, in each, to resume the more compact forms, or, if circumstances require it, to exert the attractions of the particles to their utmost extent, and form crystals.

Here we see how very simple, yet how beautiful, the foundations are upon which all those varied substances which compose and ornament the earth are maintained amid all their changes. We may remark also that there is a wonderful similarity between the means by which our sublunary system is kept up amid all its changes, and those by which the system of the heavens is sustained in all the motions and changes of position, distance, and mutual influence of the mighty volumes of matter of which that stupendous system is composed. In the system of the heavens there is one principle of gravitation which retains the whole of the circulating bodies, planet, satellite, and comet, in their orbits, and there is one power arising from motion of those bodies which keeps them outward to the circumference of the orbit with an intensity which exactly balances the force with which the attraction of the sun draws them toward that luminary; and though, in an elliptic orbit, these forces alternately get the better of each other, the one which is overcome is not in the least destroyed, but retains its elasticity and vigour, and re-acts, and overcomes the other in its turn.

Just so in what goes on upon the surface of the earth—though the subjects and the phenomena are more numerous, there is one law to them all; and here also the opposing forces alternately get the better of each other; and by this means, while all the action and all the variation of the system is kept up, the powers with which substances are endowed are never destroyed.

General gravitation, as preserving the form of the earth and retaining the aggregate of its materials in their places, and those particular tendencies to unite and solidify and crystalize, of which we have taken some notice, may be regarded as the passive powers in the economy of the earth; and we have the grand active power or agent in the sun, in the same manner as in the system of the heavens; but to whatever change any one particular matter may be subjected, or through how many compounds soever it may pass, we cannot even suppose that it for one moment loses that principle of solidifying or crystalizing which characterizes it as an individual piece of matter as perfectly as matter generally is characterized by the position of gravitation or weight; and as we cannot regard gravitation as an existence apart from matter, but merely as a phenomenon of that which gravitates, so we cannot regard the tendency to solidity or crystalize as an existence, but merely as a phenomenon of that in which, under circumstances favourable to it, it is displayed. It is a beautiful part of the system that that same sun which retains the planets in their orbits should be the grand agent in all the phenomena on their surfaces; for though we know only the earth of our own knowledge, we have no reason to suppose that our earth should be the favoured planet and an exception to the law by which all the others are regulated. In the meantime, however, we are not called upon to examine the uniformity of the system to which our earth belongs, but merely to notice the agency which keeps up growth and life upon its surface; and that agency is, without doubt, the influence of the solar beams, which at all times fall upon one half of the earth, the centre of which is the point at which the radius vector, or imaginary line joining the centre of the sun and earth, meets the earth's surface, and this point, and consequently the illuminated hemisphere of which it is the centre, shifts with the motions of the earth, both rotatory and orbital, the former producing day and night, and the latter changes of season.

When we say that the rays of the sun fall upon the earth, we must be careful that we understand what we say, because our common meaning of the word "fall" is the descent of matter by gravitation.

Now, though the emanation which we call the rays or beams of the sun does come to the earth, and also goes to every other body in the system from that luminary, and though we have the means of calculating the rate at which it moves, yet we are not warranted in saying that any *thing* comes, that the sun is in the least degree exhausted, or the matter in the bodies which it illuminates increased one single particle by this action of the sun upon them.

The beams of the sun have several different effects; they heat, they illuminate, they produce and destroy colour, and they promote various compositions and decompositions, to which it is not necessary to attend in order to understand their general effects upon the earth. But whether we regard the sun-beams as heat, as light, as affecting the colours, or as affecting the composition of bodies, we know nothing of the separate existence of a sun-beam. It produces no heat, unless in something heated; nor light, unless in something illuminated; and, in short, no effect whatever, unless there is some substance in which and in which alone that effect can become apparent. Thus when we speak of the passage or the influence of sun-beams, we must not suppose that we are speaking of anything which is in itself material, but rather of a kind of action, the power of performing which, or, which is the same thing, of making the effect of which visible in that which is acted upon, belongs to the luminous body.

Nor must we suppose that there is anything peculiarly mysterious in the fact of our having no evidence and no ground whatever for supposing that the sun-beams are substances of any kind, that is, that they are matter, however fine and delicate, which might be contained in a vessel, and, if accumulated in sufficient quantity, weighed in a scale; for whenever we advance a single step beyond the consideration of matter as existing lifeless and at rest, and mix up with it the notion of any kind of action, how simple or how small soever, we come to exactly the same perplexity. Thus that gravitation which retains the earth in its orbit, and gives stability in all its parts, cannot be considered as being matter, that is, as capable of any existence apart from that which gravitates. The motion of the planets in their orbits, by which their several gravitations toward the sun are balanced, is not, in any sense of the word, matter. Those minor attractions upon which, as we have mentioned, the forms and the qualities of any substances depend are not matter. The growth of plants, that by means of which they are evolved from seeds, rise up in stems in opposition to the gravitation of matter, put forth leaves, expand blossoms, and ripen seeds which contain the germs of new generations, but always of plants of the same species, is not matter. The life of animals, the power of motion, the will by which that motion can in many, indeed in most instances, be performed or suspended, is not matter. And attend to what we will, if we find a single atom of matter in any other state than that of absolute and unchangeable rest, there is always something in supplement to the mere matter which would tell in the scale of a balance; and therefore those causes of motion, though in the abstract not objects of our senses, and therefore not at all conceivable by us as separate existences, are as familiar to us as that matter, all the phenomena of which appear to depend upon them. Nor is it consistent with our general experience that those viewless agencies which have not in themselves matter should act without any intervening material connexion. The earth requires no chain to bind it to the central sun, the stone requires no string where it may be pulled toward the ground, the hills are not anchored to their places by cables and grappling irons, the plant does not draw its nourishment towards itself by means of material cords, and there is no matter of connexion between the prey and the predatory animal, when the hound courses the hare, or the falcon cleaves the sky in pursuit of a bird. Now, as that which really constitutes the action in all these cases is not matter itself, and acts without any material connexion, it is in perfect accordance with the unity of the system, the one law given by the one Creator to the one creation, that whatever influence the sun of a system exerts upon the other bodies of that system, in addition to the retaining of them in their orbits by superior gravitation, should, like that gravitation, be action, and not matter; and unless we admitted the original creation of the one as well as of the other, our notions of what God has made, as well as God himself, would be vain and imperfect. And when we regard this action as being as essential to what we observe in the world as the matter on which it acts, we can no more imagine the destruction of it than we can imagine the annihilation of matter, except by the same power which called it into existence to perform the purposes of His will.

Nor must we either wonder at this, or confound this action of matter with anything like mind,—like that immortal spirit in man which has the hope of immortality in it,—for there is a distinction between them which, though sometimes overlooked, is plain enough, and at the same time both necessary and desirable to be known.

The action of matter, on what scale or by what creature soever it may be exerted, performs its function without plan and without knowledge on its part; and though not a tittle of it can be lost to the whole creation, there is no identity and therefore permanence in it as relates to any one instance of an individual thing or combination of things, in which the effects of it may be displayed. When a stone falls to the earth and there remains, it renders up to the mass of the earth the motion which it had acquired during its fall, and that motion ceases to have any separate existence, nor can it be again revived as the same identical action; so also when a tree withers or an animal dies, the growth of the tree and the life of the animal are rendered up, never again to be revived as the same identical actions, in the very same manner as the substance of the tree and the body of the animal are, as matter, given up to the dust, as soon as an opposite kind of action, the action of decomposition, as belonging to dead matter, has destroyed their organic structure. And we may add, that if the purpose of the Almighty with regard to a planet, or even to a sun with all its attendant system, should be accomplished, and the period for which He had ordained it to last at an end, that planet or that sun and system would no more return in its individual identity; but yet neither its matter nor its motion would be lost to the universe, though the eye and the telescope of observation might seek for it in vain. And this holds of all matter and of all action of mere matter, including the human body among the rest; for in all that is declared of the resurrection there is allusion to "a *new* body:"—"This corruptible shall put on incorruption; this mortal shall put on immortality." "It is sown a natural body; it is raised a spiritual body."

This view of the substance and the action of matter is far more important than any detail of a single science, or any statement of individual facts, however correct and however minute, because it is of far more consequence that the mind should feel its ground firm under it than that it should struggle in quagmires; and unless we see clearly that there has been created an action of matter as well as a mere substance of matter, and that the varieties of the action impress on the substance all the varieties of its appearance, and bring about all the changes which it undergoes, we cannot have a thorough ground of hope in the immortality of our own spirits, as resting upon the judgment of reason, neither can we have a due impression of the wonderful power and still more wonderful goodness of our Maker.

Truly this action of matter is a wonderful thing; it controls suns and systems, operating athwart distances, at the very thought of which the fancy turns giddy; and not only can "not a sparrow fall to the ground" without its control, but there is not a mote that dances in the sunbeam, or a particle, it may be not the millionth part of a mote, which is not as much under its government as the mightiest mass in creation,—aye, the most apparently insignificant event that comes round—the opening of a bud, the drooping of a leaf, or the flicker of a thistle-down—but which belongs as much to the system, and is as safe in the administration of the law, as the roll of the ocean, or the career of a planet.

But mighty, and incomprehensible to us, as the action of matter is, there is the stamp of mortality upon it, in every individual case or form in which we can see it displayed. The emanation of the sun, which we are to consider the grand cause of the greater phenomena of the earth, vast as it is, and mighty as is the distance across which it can exert its varied and curious influences, falls short of the power of the immortal spirit in man. We can determine its motion only when we consider it as light; because the distance at which we can have any knowledge of it as heat, or in any other point of view, except as light, is very limited; and we may say, that we require the direct contact of the action of heat with that which is heated, and, in many instances, the continuation of that contact for a time, before the effect is perceptible. In the case of light it is different. The eye, being a material organ, of course has a limit, beyond which it cannot see; but the range is greater than any length which we can determine; and we have an easy means within that range of finding the rate at which the action of light is propagated. We can observe the planet Jupiter in two different positions of the earth's orbit; in the one of which we are the whole diameter of the orbit of the earth, or about 190,000,000 of miles, nearer to Jupiter than in the other. We can also calculate the time at which the eclipses of Jupiter's moons begin and end; and this we can do, referring them to a common centre. Now it is found, by actual observation, that when the eclipse is observed from the longer distance, it happens about $16^m\ 26^s$ later in time, than when it is observed from the shorter distance. The part of the eclipse which is chosen for this purpose is, the instant that the moon emerges from the shadow of Jupiter; and it is evident, that the above mentioned minutes and seconds are the time that the light of the satellite requires to travel across the earth's orbit; and if we divide the diameter of the orbit by the seconds, we find that the propagation of light is at the rate of about 192,000 miles per second. We cannot accurately observe a much shorter time than the fifth of a second, and during that time light advances 38,500 miles, or rather more than equal to $1\frac{1}{2}$ times round the earth.

This, it will be admitted, is a motion of most astonishing rapidity; but still it is nothing compared with the motion of thought, which is of course the propagation of the action of mind, just as that with which we are comparing it is the propagation of one display of the action of matter. But the mind does not require 16^m, or even 16^s, or a measurable fraction of 16^s, to carry its thoughts, not across the orbit of the earth merely, but round the orbit of every planet in the system, and onward to every known star. Now, if this is not a proof that mind is something higher, or something more pure and ethereal, and therefore more absolved from the possibility of destruction, than matter in its most gigantic masses, and the action of matter in its fleetest career, we know not where such a proof of it is to be found; and if in our examination of that grand agency, whose effects upon the earth we are about to examine, this philosophical establishment of the immateriality, and, by consequence, the immortality of mind, would be in itself an ample reward for the small trouble which the analysis of the subject costs us. Nor is it possible for us to approach such subjects without a feeling of the most reverential, but, at the same time, the most delightful, gratitude, that the jewel of immortality is to be found in every casket of nature, and that every casket may be opened, if we will but use the key.

We are therefore to understand that the action of the sun, to which we give the name of sunbeams, and which is altogether different from the attraction of gravitation of the sun as a mass of matter, is the great agent in terrestrial phenomena; and that this agent acts as heat, as light, and in various other ways, nor have we any means of ascertaining the exact number.

It is considered as heat that this agency performs its principal operations on the grand scale; and therefore this is the sense in which we require to understand it most fully. Now, the general effect of heat, whether we regard it as the heat of the sun or as heat from any other source, is to counteract the attractions or cohesions of matter, by means of which the small parts of which bodies are composed are held together; and though we cannot practically arrive at the bottom of the scale, or that state of bodies in which we can say there is no action of heat, yet we may presume that solidity would in all cases be the result of the withdrawal of this action to a certain extent; and that, on the other hand, if a sufficient action of heat were applied to any substance whatever, under proper circumstance, that substance would pass into a state of liquid, and afterwards into a state of gas; and also that, if we could still continue to apply an increased action of heat, this gas might be spread to an unlimited extent through space, so that no sensation and no instrument could detect its existence,—that, for instance, a solid body not bigger than a pin's head might be so operated upon by heat as to be diffused equally through the whole of the space occupied by the solar system, or through any space how large soever.

But though the action of heat thus changes the form and the volume of all bodies, and though we cannot imagine any portion of matter capable of resisting it, if made to act with sufficient intensity, yet we are not to understand that heat either deprives the matter so acted upon of its tendency to gravitate, or of that particular attraction of cohesion, when the absence of heat allows it to operate, which determines a body to be of one kind of matter rather than of another. It is true that most of the bodies which we meet with in nature, whether organized bodies or not, are compounds; and the action of heat upon them very frequently separates the compound, and dissipates some of the component parts, while the others are left behind; and as the conclusion to which we come with regard to any substance, being simple, is not the ultimate conclusion in nature, but merely the point beyond which our observation and experience cannot be carried, we cannot say positively that there is any such thing as an absolutely simple portion of matter in existence, that is, a portion which could not by possibility be resolved into two or more parts, differing from each other in their properties. When we speak of simple substances we must always be understood as speaking of them with this limitation; and thus far it is quite sufficient for us, because any speculation beyond what we know cannot be wisdom, and is very likely to be folly.

Heat acts very differently upon different substances, but these modifications of its action are matters of detail; and though the applications of them are of the greatest use both in the understanding of nature and in the practice of the arts, yet it belongs to chemistry, and not to a general view of natural action. But we may mention, that heat always acts most intensely on that which abides its action, or which has not some means of defence in the particular form, texture, or colour of its surface. A solid is the body most easily affected by the action of heat, because it cannot escape; a liquid is less so, because it can escape in vapour, though the liquid which passes the least readily into vapour can receive the strongest impression of the action of heat. It is for this reason that boiling oil burns one so much more intensely than boiling water. Gases are the most difficult to be made sensibly hot, because they get away from its action by expanding, and occupying a larger space; or if the heating cause is near the surface of the earth, the heated gas mounts up in the atmosphere, and gets out of the reach of the action of farther heat.

Substances have the power of reflecting, or turning away from their surfaces, the action of heat; and this increases in proportion as the surface is whiter and more smooth, and diminishes in proportion as it is darker in the colour, and rougher.

If the action of heat which is applied to bodies is not wholly exerted in loosening their cohesion, and increasing their volume, then they are disposed to give it out to all the surrounding bodies in proportion as these are disposed to receive it; and this giving out may be effected by direct transmission, if the bodies are in contact, or by radiation, if they are at a distance.

If the heat expands the volume of a body without effecting any decomposition, the heat may be abstracted; and when this is done the body will return to nearly its former volume. This is not always the case, but as we do not know what bodies are absolutely simple, or whether there be any such, we are of course unable to know with certainty what part may have been removed, or what new part added, in any case of the application of heat.

The few particulars which we have mentioned tend to show that, though heat may be regarded as only one agency, the effects of it are varied without end; and that, what with melting, and turning into gas, and separating compounds, it sets matter free from the trammels of its existing attractions and combinations, and thus enables it to enter into new ones; and thus the constant succession of destruction and renovation, of extinction of life in the old and commencement of life in the young, is enabled to be brought about. The doctrine of heat is indeed the most interesting doctrine in the whole study of material nature; and it cannot be otherwise, because heat is the grand agency by which results are brought about, both in the operations of nature and in the practice of the arts; and, though a result or phenomenon also follows the withdrawal of heat, we are to consider this matter as a return to the state previous to the action of the heat—just as we consider the dissolution of a body after death as the return of its material substance to dust.

Considered as light, the action of the sun is also highly interesting; and, as it is in this point of view that it displays all nature to our observation, it is, perhaps, more fascinating to us than the study of heat, though we have no reason to believe that its effects are nearly so powerful in the greater operations which are carried on upon the surface of the earth. That it does produce many effects is certain; as, for instance, it increases the quantity of charcoal in plants, and imparts to them the greater number of those properties in consequence of which they show colour; for plants which grow wholly excluded from the light are white. But, in the action of the sun upon the earth, light and heat, and all the other modifications of the agency, are so constantly united, and, indeed, in all probability, so identically *one* action, only varied by the objects acted on, that we may consider them as acting together, and as one simple energy.

The law which this energy follows is, to emanate from every point of a body which, like the sun, gives out visible light and sensible heat, and which for this reason is called a radiant body, and to emanate from every point in all directions, but always in straight lines. Whether it moves at the same rate throughout the whole of its journey, or slackens as it proceeds, we have no means of ascertaining; but as, though it is from points on the surface only that it can proceed to other bodies, yet, like gravitation, it is referable to the centre of the radiating body, and therefore its intensity at different distances must be inversely as the squares of those distances,—that is to say, at double the distance it will have only one-fourth of the intensity, at three times the distance only one-ninth, and in a similar relation for all distances whatever. And, as the emanation proceeds in the same way, whether we regard its effect as heat, as light, or anything else, we of course must consider them all as diminishing in the same ratio. But the distances of any two points on the earth's surface from the sun differ so very much from the mean distance, that it is not worth while to take this consideration into the account in our estimates of the solar influence upon different regions of the globe.

Though the general effect of the sun-beams, and indeed of heat from any other source, be to soften, and melt, and expand every substance, the parts of which are not separated from each other by this operation, yet, when the parts are saparated, the result, upon that which remains is often consolidation and hardening. Thus, when the solar heat drinks up the water with which clayey soil is impregnated, by turning that water into vapour, the clay becomes indurated, and, contracting, champs and breaks into deep fissures ; and, in like manner, when the heat of the sun turns into vapour the moisture of the vegetation on field or in forest faster than the feeders of the vegetable can supply the waste, the herbage is burnt up, and the trees languish and drop their leaves, and, if the fervour is of sufficient continuation, they wither, and, if nature has not adapted them to endure this extremity, they die. There are curious provisions in the vegetable world for guarding against this destroying action of the sun. The plants of the desert generally have their leaves thick in substance, and covered with an epidermis, or outer skin, which is smooth, to turn away the influence of the sun by reflection, and at the same time remarkably tough, and free from any pore. But there are many of the more arid regions which still have moisture enough during one part of the year for the growth of shrubs; and many of those shrubs shed their leaves, not by withering, but by heeling off, as our desiduous trees do in the autumn, and then they go into a state of repose during the excessive heat, not dissimilar to that into which our trees and shrubs pass during the winter.

On the trees which grow on the intermediate lands in warm climates, and which are not only evergreen, but, with short pauses, overgrowing, the leaves have, generally speaking, the same smooth and firm epidermis as the plants of the desert; and any one may observe that all evergreens which bear the rigour of winter with us without shedding their leaves, have those leaves much more firm in their texture and smooth in their surface than trees which shed their leaves in the winter; nay, so close is this connexion between the firmness and smoothness of the leaf, and the power of endurance in the plant, that among our deciduous trees the delicate leaf is always the first to fall, and the leaves which have smooth surfaces remain longer on the tree than those which have not. The mulberry and the beech are perhaps extreme instances in this country; the leaf of the mulberry is delicate, and its surface is not smooth, and mulberry leaves drop at the very first frost, without having previously shown any signs of decay, so that they may be gathered from the ground on the morning of one day as green and perfect as they were on the tree the day before. The leaves of the beech, on the other hand, are firm and smooth after they come to maturity, so that they are less eaten by insects than the leaves of most trees, and, instead of dropping at the first frost, they have a very gradual decay, and in many situations clothe the tree with a russet mantle, which lasts during the greater part of winter. The action of heat upon the individual productions of nature is, however, a matter of many details, and we have thrown out these hints merely in order to show that it is worthy of being studied. Having done so, we shall mention the instruments by means of which the action of the sun is distributed over the earth, and by means of which the intercourse of nature is carried on between one place and another.

The grand instruments by which the action of the sun is distributed over the earth, and in so far equalized in different regions, are the air and the water; and therefore it is necessary to have some knowledge of them before we can rightly understand the economy of the earth.

The air is the grand messenger. It everywhere invests the earth to an indefinite height, but a height far greater than the summit of the most lofty mountains, and it becomes rarer, or contains less matter in an equal bulk, as we ascend above the surface. Though we must reserve the explanation of the principles on which it acts, and also those phenomena of which it is more immediately the instrument, to our volume on THE AIR, yet it would be impossible to render the present subject intelligible without some allusion to its properties, and therefore we must state them, but we shall do it very briefly, and without going into the investigations from which the properties are deduced. In all our rational and useful inquiries into nature we labour under this difficulty,—that it is impossible to be systematic,—to begin with some one element which we can clearly define, and proceed gradually to the others. We require the whole at once, or else we tie ourselves down to the individual points, which, taken singly, have but little interest, and thus our knowledge of them is imperfect, and comparatively useless in so far as it goes, from want of the connexion. For these reasons, when we would so treat the subject as to be popularly interesting and popularly useful, we must sacrifice the regularity of system, and be contented with a little real knowledge divested of all the appearance, and deprived of all the honour, of wisdom and learning.

The air, and all other substances which are in a state of gas, may be considered as having the attraction of cohesion between their particles so perfectly subdued and neutralized, that they are instantly obedient to the operation of the slightest force that can be applied to them. On this account they have sometimes been called *elastic fluids;* that is, fluids which have a spring; but as there is perhaps no substance which has not some elasticity or springiness, and as there is no substance in which that property is absolutely perfect, the name is not a very happy one, as it is apt to mislead those who are endeavouring to understand the reality. The air is, however, a very springy substance, the most obedient spring with which we are acquainted; so much so that it may be always said, in all cases and in every situation, to be constantly at the top of its bent. It is the cohesion of the air which is neutralized much more than its gravitation, for the latter is a property which is constant to the quantity of matter, and is no farther affected by heat or any other cause than that cause alters the specific gravity, or quantity of matter, in a given space; but the cohesion of air is so far subdued that, though not destroyed, it is converted into or changed for a principle of repulsion, as between particle and particle, a tendency to occupy more space if not restrained by some cause. The gravitation or weight of the mass of air counteracts it in this way, and keeps it in its position over the surface of the land and sea, but at the same time leaves it a perfect freedom of motion in obedience to any impulse that it may receive: and the decrease of density as we ascend is the means of an upward or a downward motion, according to circumstances. If air were confined in a close vessel, and sufficient heat applied, it is probable that it could be brought to a degree of temperature much higher than any furnace with which we are acquainted; but when it is in its free state, it expands whenever heat is applied to it, and if it can expand without any opposition, it does not get sensibly warmer. Any opposition which it can meet with to expanding in the open atmosphere can be only the weight of the air around it and over it; and in proportion as this is less, the sensible effect of heat upon the air must be less. But the air is less dense as we ascend above the mean level of the earth's surface, and therefore as we ascend above that surface the air must be colder, and also more uniform in its temperature than it is lower down; farther, if the air is enclosed between lofty elevations of the ground, these must co-operate with the gravitation in rendering the expansion more difficult, and therefore the same action of heat must produce more sensible heat in confined valleys than on open expanses, and, more generally speaking, on the surface of the land than on that of the sea. But if air expands by the application of heat, and in this expansion has to work against gravitation, which is a permanent and indestructible principle ; and as the two are, as we have said, always exactly balanced ; the withdrawal of the action of heat must enable the gravitation to re-act, and produce a compression, condensation, and increase of weight proportional to the heat withdrawn. Farther, as the spring of the air extends round the whole globe, and is everywhere equally obedient to gravitation, in proportion to its density, there must be a constant tendency in the denser portions to descend to the surface, as there is in the rarer ones to ascend from it; also, when any portion has been heated for a time, and thereby expanded, if the heat is withdrawn, the surrounding portions must press in upon it, and the gravitation must bring it downward until an equal equilibrium is restored. Thus, though every particle of the air is always balanced, and we cannot call it unstable, it is the most moveable of material things, and its mobility fits it admirably for being the general messenger of nature upon the earth. These hints as to the general nature of air must suffice in the meantime, and we have endeavoured to make them such as any one can verify by actual observation.

The next point of inquiry is, "what does this general messenger of nature carry?" The answer to this is, it carries heat, and it carries moisture, but chiefly the latter; and in this respect it may be said to bring drink for all the children of nature that inhabit the land. It does even more than this, for it alters the form of surface in the seas, and causes motions or currents in the water of them. It does this by the variable pressure of its gravitation; and though the extent may not be great over surfaces of moderate extent, yet there is no doubt that it is considerable on the wide oceans. The air presses, upon an average, with the weight of about fifteen pounds upon every square inch of the surface, whether of the land or the sea; and it is subject to variations of pressure, varying sometimes as much as a fifth part of this quantity, or about three pounds on the inch. Now, if we suppose that a pressure of this kind comes upon the sea in the southern hemisphere, where the surface is so extensive, while there is no such pressure on the sea in the northern, it is easy to perceive that the ocean waters will get an impulse northwards; and, generally speaking, if there is more pressure of the air upon one part of the surface of water than upon another, the water will be depressed where there is most weight upon it, and elevated where there is least.

The air is supplied from the surface of water, and of every thing humid, with that moisture which it carries. This is taken up by the air in the very curious process of evaporation, which is much too intricate for being explained here, but which any one will readily understand, at least in its effects, who observes that, even though the sun is not shining, the surface of the ground dries on a rainless day; and that if a warm surface, such as that of a dry road or a pavement, is watered, and left to dry, it produces an agreeable coolness, and gives motion to a refreshing current of the air. Or the same thing may be personally felt; for if in a very dry day the hands are dipped in water, and then held up with the fingers expanded, they will not only become agreeably cool, but if the operation is repeated often enough, they will feel as chilly, under exposure to the summer sun, as they would do in the winter air.

This evaporation invariably produces cold, so that a portion of the action of heat is required in order to reduce the water into those small particles in which it ascends in the air, is held supported by that substance, and carried from one region to another.

The different degrees of heat to which it is exposed have also some effects upon the density of water, but trees are so small that, in a cursory view of the phenomena of the earth's surface, we need hardly take them into account.

The reader cannot have failed to remark the very different effects which the grand agent in terrestrial phenomena, the beams of the sun, considered as heat, produce on the air and on the water. They expand the air without removing any part of its substance, and thus set it in motion all over the earth, while they enable the air, as a messenger, to take up such a burden of water as is necessary for the general purposes of the earth's economy.

It is impossible to view the three subjects on which we have remarked in this section, either in their own nature or in their connexion and their adaptation with each other, without being struck with the astonishing display of wisdom which they offer to our contemplation; and when we consider the range of the scale upon which they act, the extreme vastness on the one hand, and the incomprehensible minuteness on the other, and yet that in all the countless millions of their results, whether magnificent or minute, there is equal perfection in the attainment of the intended purpose, we cannot refrain from considering this as the grand demonstration of the greatness and the goodness of the Creator, the wonder in short of the material creation. The agent, the influence of the sun, comes on the average from the distance of 95,000,000 of miles, and comes at the rate of 192,000 miles in a second, and it comes in such a way as to tell not only upon every point of the earth's surface, and every drop of the ocean, but upon every particle of the atmosphere, even at those vast elevations at which these particles are so thinly scattered as that they could not support the down of the lightest feather, no, not the thin air which we meet with on the summits of the mountains, or the more attenuated gas with which we fill balloons that carry men and their apparatus more than mountains high. This all-pervading energy, which works for good to the whole earth, notwithstanding its immense velocity, does not injure a single thing—does not bend a fibre or break a cobweb. In this there is a proof altogether irresistible, that this influence of the sun cannot be matter, in our sense of the word. The atmospheric air is, in all probability, divided, down to the ultimate particle, and therefore it contains in its substance no single piece of matter which can strike any mensurable portion of the surface of any body. But when the air is put in motion, only to the velocity of our swiftest birds, which we can easily see for considerable distances on their flight, that is, when it moves at about one hundred miles in the hour, it forms what we call a hurricane, which uproots the forests, levels the habitations of men with the ground, and sweeps the crop, and even the soil in which it is rooted, into the sea. But the velocity of the hurricane is a mere nothing compared with that of the solar action, which is 1,920 times as fast in a minute as the hurricane sweeps in an hour. At this rate the solar action moves very nearly, 7,000,000 of miles in the time that the hurricane moves one mile. But moving bodies strike against surfaces, and therefore the forces with which they strike are as the squares of velocities, and therefore if what we call the sun-beams were composed of matter as dense as the atmosphere, they would strike the earth, over the whole hemisphere on which they fall, with a force equal to that of 49,000,000,000,000 (forty-nine billions) of hurricanes, which is utterly above our comprehension, but which certainly would suffice in one moment to turn the earth into invisible vapour. But the sun-beams produce no injurious effect, and therefore it is impossible to conceive that they can consist of anything but mere action, perceptible only in its effects. It is farther astonishing that this action should be the means by which every living and growing thing is called into being, the pencil which paints Nature in all her varied hues, the odour which perfumes the flowers, the aroma which gives raciness to the fruits, and the interpreter to the human eye of all the wonders of its working. Nor is it less a marvel that this little organ can question the fleeting beam, and make it render up that knowledge which it carries onward on wings which are swift beyond all human comprehension.

It is in these views of natural action that we have the most splendid displays of the Creator; and it is somewhat singular, that those who have written expressly on what is called natural theology, should have neglected or omitted this most beautiful, most striking, and most convincing part of the subject. Lord Brougham, in the very delightful discourse which he has recently published, as introductory to a new edition, with annotations, of Paley's "Natural Theology," well remarks, that that very popular, but not very profound, author, has strangely omitted all allusion to mind in his treatise; and his lordship might have added, that not only in Paley, but in those abler authors of whom Paley is little else than the copyist, the only part of the subject which evinces Almighty power is almost or altogether neglected, and that the whole of the magnificent system of creation is brought down to the standard of common mechanics. By this means the subject is deprived of the greater part of its interest, and the Creator of the greater part of the glory which cannot fail to be ascribed to Him by every one who duly understands the working of that wonderful system of which He is the Author. Indeed, as the God of Nature is THE LIVING GOD, it follows by necessary consequence that he must be most powerfully and most clearly displayed, not merely in living nature, but in that which constitutes nature's life.

SECTION IX.

MODIFICATION OF THE SUN'S ACTION, BY THE FIGURE OF THE EARTH.

Those circumstances which occasion the differences between the several regions of the world, in respect of their vegetable productions, their animal inhabitants, and their adaptation as abodes for man, are often summed up in the general name, *climate;* but as that word was originally applied to positions in latitude, or differences of length in the longest day only, and as this is only one of the elements upon which the real climate, the average temperature, the fertility, and the characters of the seasons depend; and further, as there are great differences of climate in the same latitude of the two hemispheres, and also at different parts of the same hemisphere, it would be better to treat separately the chief causes upon which these depend, and then to see how the whole apply to the several countries.

The first to be noticed, because the simplest, is that which we have set down as the title of this section—the modification of solar action by the earth's figure; and on the consideration of this there is no necessity for any allusion either to the daily or the annual motion of the earth.

From the earth being nearly globular, the sun being a much larger globe, and the rays of light and heat coming in all directions from every point of the sun, we may assume, that the whole beam of the sun which the earth intercepts, and which is exactly equal to a section of the earth, on the plane of a great circle, the pole of which is the point of the earth's surface, met by the line joining the centres of the two bodies, comes to the earth as in lines parallel to each other; that is, that the whole of this cylindrical beam, 8000 miles in diameter, which the earth intercepts, is of equal intensity, so that if it acted upon a plane surface, instead of the convex hemisphere of the earth, it would illuminate and warm the whole of that plane surface equally. But this beam of light and heat is intercepted by the convex hemisphere, on the centre of which it falls perpendicularly, and beyond the boundaries of which it passes in tangents to the circumference, without at all acting on the surface. The first point to be ascertained is, the power which the beam itself has to produce effects on the different parts of the hemisphere on which it falls.

If the whole surface of the hemisphere were of uniform matter and texture, so that the solar action would be equal, and all points of it equally exposed to that action, then the effect upon every point would be matter of very simple geometrical investigation, upon the very simple principle, that the same power, acting in the same manner, upon surfaces exactly similar, must have exactly the same effect upon each.

In the centre of the illuminated hemispheres the effect must be the greatest possible; and what it is, is matter of observation, by means of any instrument which can be employed as a *thermŏmeter*, or measurer, of heat. We cannot, of course, get at the exact mathematical degree of heat which would be found at the maximum point, or that where the sun is vertical, in the supposed case of the surface of the hemisphere being perfectly uniform, and there being no external substance to affect the influence of the sun. The reasons why we cannot do this are very obvious: we have no hemisphere of uniform surface, and we always have the atmosphere ready to convey heat from the places which are warmer, by mounting up with it from the surface, and bearing it off to colder places.

As little can we have a thermometer which we can be sure will indicate the proportions of the solar action, in different places, with equal accuracy. Our thermometer usually consists of a quantity of some fluid, as of spirits of wine, or mercury, enclosed in a glass case, consisting of a ball and stem, or tube, with the air expelled and excluded from the vacant part. The degree of heat, whether of the sun, or of anything else, which such an instrument measures, is only the expansion of the fluid which it contains; and, therefore, it can tell us nothing further than the effect of heat in expanding that particular fluid. But even this is something; for though we do not get the absolute heat in any one case, we get its relations in different cases, which answers very nearly the same purpose. This does well enough in practice, where we have to find the joint effect of all the causes upon which the degree of heat, or, as we call it, the temperature, depends; yet we cannot apply it to the simple case of a hemisphere of uniform surface and uniform susceptibility to the action of the sun, which is the element of climate now more immediately under consideration.

The sun's action is a maximum, or the greatest possible, at the point where the sun is vertical;

that is, at the centre of the illuminated hemisphere; and it becomes less as we recede from this point, in proportion as the surface turns away from this; that is, it is in the proportion of the cosines of the angular distances from the centre of the hemisphere,—the radius of the earth, which, in the case of the earth's convex surface, is the cosine of a quadrant, or 90°, being the expression for the maximum effect, that is, for the effect when the sun is vertical. It is of little use to state what the rate of this decrease of solar action, from the centre to the circumference, upon the hypothesis of uniform surface, is; inasmuch as there is nothing answering to it in what we can observe; but as it is true in theory, and as the deviations from it in reality arise from the nature of the varied surface of the earth, from the motions of the earth, and from the effects of the atmosphere, it may not be amiss to state, in approximate terms, the proportional action for every five degrees.

If we call the whole as maximum action, at the point where the sun is vertical, 1000, we have the following proportional numbers for the other parts of the hemisphere: at 5°, or 350 miles from the centre of illumination, 996; at 10°, or 700 miles, 984; at 18°, or 1050 miles, 965; at 20°, or 1400 miles, 939; at 25°, or 1750 miles, 906; at 30°, or 2100 miles, 866; at 35°, or 2450 miles, 819; at 40°, or 2800 miles, 766; at 45°, or 3150 miles, (the middle distance,) 707; at 50°, or 3500 miles, 642; at 55°, or 3850 miles, 573; at 60°, or 4200 miles, 500, or one-half the maximum; at 65°, or 4530 miles, 422; at 70°, or 4900 miles, 342; at 75°, or 5250 miles, 258; at 80°, or 5600 miles, 173; at 85°, or 5950 miles, 87; and at 90°, or 6300 miles, (the extremity of the hemisphere,) 0.

In order to see how slowly the action decreases near the centre of the illuminated hemisphere, and how rapidly near the boundary or termination, it may not be amiss to bring these numbers together, and to state the progressive difference between every successive 5°, and the total difference between each and the maximum.

Degrees from	0°	5°	10°	15°	20°	25°
Proportions	1000	996	984	965	939	906
Progressive difference		4	12	19	26	33
Difference from max.		4	16	35	61	94
Degrees	30°	35°	40°	45°	50°	55°
Proportions	866	819	766	707	644	573
Progressive difference	40	47	53	59	65	69
Difference from max.	134	181	234	293	358	427
Degrees	60°	65°	70°	75°	80°	85°
Proportions	500	422	342	258	173	87
Progressive difference	73	78	80	84	85	86
Difference from max.	500	578	658	742	827	923

At 90° prop. = 0 ; prog. diff. = 77; diff. from max. = 1000.

These numbers are but rude approximations, but they are sufficient to show the principle ; and it is not necessary to go into the minutiæ, because, as we have said, there is nothing in actual observation to correspond with this theory. Still as this enters as one element into what we actually observe, it is necessary to understand the principle. Were it not for the atmosphere, the currents of the ocean, the motions of the earth, and the different ways in which the sun acts upon different kinds and shapes of surfaces, the theory as above stated would be found to agree with observation ; and thus we are led to inquire into the causes why the actually-observed facts are different from the results of the calculation.

At 10° from the point where the sun is vertical, the diminution of the sun's influence is less than 1-60th; at 20° it is less than 1-16th; at 30° it is less than 1-7th; at 40° it is less than 1-4th; at 50° it is more than one-third; at 60° it is exactly one-half; at 70° it is more than 6-10ths; at 80° it is 17-20ths; and at 90° it is the whole.

The half temperature is thus at 60° while the half distance is at 45°, the difference of which is 15°, or about 1050 miles all the way round; and this is the advantage in effect of solar influence upon the earth, which it derives in consequence of its spherical figure. This advantage is not lost in consequence of any of the circumstances which modify the action of the sun, because those modifications affect the whole temperature, and consequently do not affect this element of it any more or in any way different from the others.

This is another remarkable instance of advantage arising from the very simplest and most general and elementary principle in nature—the gravitation of matter. It is in consequence of this gravitation that all the heavenly bodies, which are composed of matter having any degree of density, have assumed the spherical form; and this form is indeed as inseparable from the fact of gravitation as that fact is inseparable from our original notion and definition of matter. Herein, therefore, we see wisdom, infinitely superior to man's wisdom, not in degree only, but in kind; and accomplishment, superior to anything that man can accomplish, not only in degree but in kind:—we discover in fact the living principle in the very simplest attribute of dead matter. Thus, gravitation is, as it were, a seed sown by the Almighty in a soil the best adapted for its fructification, and its fruits everywhere fill both the heavens and the earth with beauty and usefulness. It is highly instructive to catch even passing glimpses of those wonders of creation—for truly they are the wonders. We admit that the things themselves, which address themselves merely to the senses, are withal pleasing and delectable: but they are nothing in comparison with the system of working which runs through the whole, possessing attributes which to us may well seem a combination more than mortals could have dreamt of,—the perfection of simplicity, and the perfection of power, co-operating together, or rather, being one and the same. But if we find one single principle thus running through the whole of nature, and if we find that principle powerful and perfect to the utmost extent that material nature can bear, how can we, how dare we, resist the conviction that this is one work of one Being, all-wise, all-powerful, and, as the whole works for good, all-bountiful?

We shall now very briefly notice one or two of the circumstances which modify the solar action, and would modify it, although the earth were at rest, and presented always the same hemisphere to the sun; and this will simplify the case when we come to consider the modifications which are produced by the motions, whether diurnal or seasonal.

The first cause of modification is the atmosphere, which, as we have mentioned, invests the earth in every direction, and which becomes more and more rare as it is higher and higher above the surface. The absolute height to which it ascends above the earth is an inquiry which belongs to the natural history of the air itself; so that we have only at present to consider the height to which it affects the beams of the sun as they fall upon the earth; and here again we shall find that this substance, which answers so many important purposes, would tend to increase the benefit which the earth derives from the solar beams, even though it, as well as the earth itself, were in a state of rest.

It is a property of light, that when it falls obliquely, or slantingly, on the surface of a transparent substance of denser nature than that out of which it comes to this substance, it turns into the denser substance, at a certain rate which varies with the nature of the substance and the degree of obliquity; and of course it is a matter to be practically determined by observation for each particular substance. This property is called the *refrangibility* of light, and the change in any particular case is called *refraction*.

It is another property of light, that when it falls upon surfaces it is in whole or in part turned away from those surfaces, and this turning is called *reflection*, which means bending back again. If the light falls obliquely, and is reflected in whole or in the greater part, it comes away from the surface at exactly the same angle at which it fell upon it, as it does in the case of a common mirror; but if it is reflected only in part, the rest of it follows the same law as when emanating from a luminous body,—that is, it proceeds in all directions from every point of the surface. When light is thus decomposed by the surface on which it falls, it becomes, as it were, *new* light,—that is, light differently composed from the original beam, and always wanting some of the elements which it had in that beam. This decomposition may extend to the whole of the light, or only to a part of it; and as the light of the sun, when falling at the same angle, must be understood as always capable of producing exactly the same effect, the difference must depend on the nature of the substance on which it falls, and it is therefore, like the former, a matter of practical observation.

This point is only incidental to our main subject; but it is one of great interest in the study of creation, because it involves the doctrine of all those colours with which natural objects are adorned. It is possible by refraction to obtain from the light of the sun, as thrown upon white paper, any colour, and any intensity of that colour, which it is possible to imagine; and, therefore, in order that an object may show any tint whatever, we have only to suppose that it separates the portion of light capable of producing this tint, thereby making new light of it, and causing it to be seen in any direction in which the object may be viewed. But this *diffraction*, or decomposition, of light at the surfaces of bodies may be combined with reflection there. The reflection is always in proportion to the smoothness of the surface, and the obliquity at which the light falls on it; and if these are beyond a certain amount, the colour disappears, and nothing is observed but a shining surface. We have a very good instance of this in looking at a highly varnished picture, which hangs on the wall at the end of a room which is very near to a window in the side; if we stand near to that side where the window is, we see the colours of the picture, and they continue to be visible to us till we are a good way past the middle of the room in our progress to the opposite side; but when we move to such a position as that two lines drawn, the one from the window and the other from our eye, make equal angles with the picture, the picture disappears altogether, by the light being reflected; and if the varnish were smooth and bright enough on the surface, and we saw it first from this position, it would be impossible for us to tell whether we were looking at a picture or a dull mirror. It is worthy of remark, that Nature's pictures never have this imperfection. It is true, that her most lovely colours seldom have any gloss; but even in the case of those which have gloss, that gloss does not, like the varnish of a picture, present us with a blank,—it always gives us a beauty, and generally a metallic reflection, as we find in the feathers of many birds. But we shall have occasion to enter more minutely into this very beautiful department of nature when we treat generally of the *Air*, the medium through which alone colour is displayed.

From what we have said of the atmosphere and of light, it follows, that when light falls upon the hemispherical atmosphere, it must be differently affected at points which are at different distances from the centre of this hemisphere; and that, as the atmosphere becomes the denser the nearer we approach the surface of the earth, the light must be more and more affected as it gets nearer to the surface. We may mention, that the clear atmosphere does not, to any very sensible amount, diffract, or decompose, light; and that is the reason why, when seen from the summit of a very lofty mountain, the cloudless sky is very nearly black; but when there are foreign substances in the atmosphere, such as particles of vapour, or very minute dust, of which there is often a great quantity, though nothing but the light can detect it—just as nothing can detect the motes in the sun-beam but that beam itself,—and these floating substances, and the substance of the air itself, supply, by their action on the light, all the varied colours of skies and clouds which we observe, and also all the light which prevents the shadow from being absolutely dark, and forms the twilight, by means of which the light and darkness fade into each other by the most gentle and the most delightful gradation.

At the middle of the hemisphere, the light of the sun must fall perpendicularly, or right down upon the surface of the atmosphere, and therefore it will not be refracted there; and that it should not is very obvious, for this simple reason,—that if it is proceeding right into the atmosphere it cannot go "more right" into it. But everywhere else it falls obliquely; and the obliquity increases toward the boundary of the hemisphere in the rate above stated, till, at the very extremity, it passes over the surface, and has no effect whatever.

Now, up to a certain point at least, the refraction increases with the obliquity; and, in consequence of this obliquity, the light has also to travel a longer way through the same height of atmosphere than when it comes perpendicularly, or directly; and on both these accounts it is evident that, as we recede from the centre of the hemisphere, the atmosphere will have more and more tendency to refract, or bend toward the surface of the earth, the rays of the sun; and by this means again the very form of the atmosphere, which, like that of the earth, is a result of gravitation, tends to increase the action of the sun upon those parts of the earth's surface at which, on account of the form of the earth, that action is diminished.

It should seem that the upper part of the atmosphere is, so to express it, "fined away" into surrounding space, so that the commencement of it has no effect whatever upon light; for we cannot say that there is either a definite beginning or a definite end of twilight, though of course there is of our perception of it; neither can we say what might be the effect of the sun-beams in the case of an atmosphere wholly divested of moisture, or other foreign substances, for we have no experience of such an atmosphere; and though we were to imagine one, we could not imagine any use for it. We have said, that the atmosphere is the "messenger," and if there is no message the messenger is useless, and may be discharged.

To what extent, and whether to any extent, this beneficial effect of the atmosphere—in sending down an additional portion of the solar influence to those places of the earth on which the direct light of the sun falls obliquely—may be diminished by the reflection of light from the air itself, or from the particles of moisture, or other foreign substances floating in it, we have no means of judging; but though there is no doubt that when the reflecting substance acquires the density of a black cloud overshadowing the whole horison, it may be a source of cold, and certainly is a cause of darkness; yet, when the air is sufficiently clear for allowing the light of the sun to reach the earth unbroken, the reflection from these particles can have but a trifling effect; and, in the case of heat radiating from the earth to the colder atmosphere over it, we have evidence that clouds diminish this operation, and render the cold less intense than it otherwise would be. This is a subject, however, which belongs more to the doctrine of the air.

The other causes which, on the supposition that the earth is still, and the sun shines constantly on the same hemisphere, tend to modify the solar action, are the different kinds of substance and surface upon which the beams of the sun fall. This is an extensive as well as an intricate inquiry, and it is one of experiment, and as such almost requires to be treated as a distinct science; so that all which we can pretend to accomplish is, simply to point out the general principles; and we shall do this with reference to only three principal kinds or characters of surfaces: first, the surface of water; secondly, land covered with abundant vegetation; and thirdly, land which is bare of vegetation, or nearly so.

In the case of water, 18 parts in 1000 are reflected when the light falls perpendicularly; 22 parts when it falls at 40°; 200, or about one-fifth, when it falls at 75°; 501, or nearly one-half, when it falls at 85°; and 725, or rather less than three-fourths, when it falls at 89½°. From these proportions, which are the results of experiments carefully made, it will be seen, that near the middle of the hemisphere the increase of reflection from the surface of the water is comparatively small: but that it increases very rapidly toward the extremities of the hemisphere, so that at 75° there falls only half the influence,—that is, only half acts upon the surface of the water, and the other half is reflected into the air. Of the quantity so reflected, however, a considerable portion must expend its energy in heating the air; and this heating of the air by sun-beams reflected from the water is one of the principal causes why the polar seas are so much involved in fogs during the hot season; and the reflection of it by the surface is the chief reason why, when the sun becomes low, the surface of the water so speedily freezes in those parts of the world.

But we have seen that, even where the light falls perpendicularly, eighteen parts in the thousand, or about one-fifty-fifth of the whole, is returned by reflection; and therefore, even under the most powerful action of the sun, and independently altogether of the portion of that action which is consumed in evaporating, the entire effect of the sun-beams falling on the surface of the water cannot be exerted in heating that water. In this case, however, as well as in the other, the portion which the surface of the water returns by reflection must be in great part applied to the warming of the superincumbent air; so that water has always a tendency to preserve a greater uniformity of atmospheric temperature, and, consequently, a greater uniformity of climate, than can be expected upon the land.

Surfaces covered with thick vegetation reflect less of the sun-beams than any others; they bear to the surface of the water nearly the same resemblance which velvet does to a mirror, and to the bare earth a resemblance not unlike that which velvet has to plain stuff. But vegetables in a state of growth absorb the greater part of the sun-beams which fall upon them; and as they present a far greater surface camparatively humid than the portion of the earth which they occupy, and as evaporation goes on—at least under the direct action of the sun—at every part of this surface, the evaporation from a close vegetation must be not only greater than from the bare earth, (where there is, in truth, little to be evaporated,) but greater than from the same breadth of water as the surface which the vegetation occupies.

But the leaves of vegetables under other circumstances have the power of what may be called *counter evaporation*,—that is, they can take out of the air that moisture which it holds suspended in a state of invisible vapour,—and thus they may be, and are practically found to be, sources both of warmth and of dryness. It is easy to understand how this must be the case:—the leaves, young shoots, and indeed all the active and growing parts of vegetables, contain a great quantity of moisture in their substance, and very many of them contain far more than they can receive from the earth by means of the roots. This is not the case with air plants, which are not at all connected with the soil, or with plants that grow in the dry sands, only; for it applies equally to all sorts of vegetables, excepting perhaps those which actually grow in the water. It is upon this principle that plantations of timber tend so very much to improve the climate and fertility of those countries in which they are situated, by diminishing the heat of the torrid regions, and the cold of the tropical ones; and in this we see the beautiful provision which nature has made in the polar and the tropical forests,—for, under circumstances favourable to their growth, forests are more abundant there than in the middle latitudes.

Lands bare of vegetation always tend to increase the particular character of the climate in which they are situated, because the light of the sun acts more powerfully upon them than upon water, or upon surfaces covered with vegetation. They absorb the greater part of the heat, that is, they themselves become more heated than the others; and, instead of producing any mitigation under circumstances of great heat, by the evaporating of moisture, they act as so many furnaces, heating the air over them by means of radiation.

But they cool as speedily as they heat, and therefore under circumstances the reverse of those which heat them strongly they are cooled and tend to cool the air by abstracting heat from it. Thus, surfaces of bare earth, while they are the most unprofitable that the earth can present, are at the same time subject to the greatest extremes of climate; still, however, even they have their use in the general economy, because by the violence of their action, they serve to put in motion the currents of the atmosphere.

Such are a few of the principal effects which the atmosphere and the great component parts of the surface of the earth have in modifying the action of the sun, so as to produce those differences of climate and productions which we find in different regions. We have mentioned them without reference to the motions of the earth, because though those motions produce very different results from what would take place if the earth were at rest, and the shining constantly on the one-half of it, yet the motions only modify the results, without in the least destroying the principles on which they depend. This may, indeed, be said to be the case in the whole of nature; for, though we are accustomed to use the word, there is really no such thing in nature as an opposition; and when cause modifies cause, however different the joint effect may be from the single one, it is always the effect of co-operation; the one, as it were, accommodating and assisting the other, and not conspiring against it. This is an understanding which we should carry with us in all our inquiries into natural subjects; and if we could make it our own, take it into society with us, act upon it, and make every thing there consent and co-operate, the world would certainly not be less pleasant or less profitable to live in, than it is with its strifes and oppositions, whatever ability may be displayed in the conducting of these, and though, as is generally found to be the case, those who are really in the wrong are always most determinedly in the right.

Our business in the next section will be to consider the influence of the earth's rotation upon its axis in modifying the solar action; and in order to render this as simple as possible, and enable such readers as are not accustomed to inquiries of the kind to get as clear and as correct a view of the principle as possible, we shall take the very simplest case in which the subject can present itself; and then, if we succeed in making this intelligible, we shall perhaps be able to make it the means of throwing light upon the more complicated cases.

In treating of the effects of rotation, we shall have occasion to open up some views of the subject, which, we believe, are new, and to some may appear not a little startling; but they will abide the test of the keenest scrutiny; and we cannot too often repeat, that how much soever it may excite our wonder, we ought not entertain the slightest scepticism of the grandeur of anything which God has made.

SECTION X.

EFFECTS OF THE EARTH'S ROTATION.

The simplest view which we can take of this part of our subject, is that which occurs twice in the course of the year, when the sun is directly over head at the earth's equator, and the poles of the earth's rotation are in the extremities of the illuminated hemisphere. It is true that, in consequence of atmospherical refraction, the portion actually illuminated by the sun is a very little more than a hemisphere, and the twilight portion extends for some twelve degrees, or about 840 miles all the way round this; but, in the general consideration of the matter, these circumstances may be left out, only we must not forget that they actually exist.

In this position of the earth, the plane of the equator is directed to the sun, or, if it could be seen from the sun, it would be projected into, that is, it would appear to the eye as, a straight line; and as the axis of rotation is at right angles to the plane of the equator, and also to every parallel of latitude, the sun would shine upon exactly the half of each parallel, and the other half of each parallel, as well as of the equator, would be in the twilight and the dark. We need scarcely add, that as the earth turned round under those circumstances, every point on its surface would pass through the light, and the dark and twilight in equal portions of time, or that day and night would be equal at every imaginable place on the earth's surface. Farther, the height of the mid-day sun above the horizon would be, at every place, equal to the distance of that place from the pole; and the zenith distance of the sun at mid-day, or the sun's distance from the point over head, at mid-day, would be everywhere equal to the latitude.

It will, perhaps, assist in forming a clearer notion, if we suppose that a cylindrical beam of light, equal in the cross section to the section through the earth upon a meridian, comes to the earth with its centre exactly on some point of the equator, and that the end of this beam, which falls upon and acts upon the earth and its atmosphere, embraces them as a hemispherical cup would embrace the half of a spherical ball. We have only to imagine the earth to turn round in this cup of light, on two points on opposite parts of the lip, and then we shall have a very efficient view of the matter. In the course of the twenty-four hours, that is, of one rotation, every point of the equator must come in succession to the centre of the cup; and every other point, while it crosses an arch drawn across the hollow of the cup, through the two points of rotation and the centre, must cross this arch exactly as far from the centre as the place itself is from the equator on the earth. This is exactly the view which we would have if it were possible for us to get a sufficient way off and look at the earth. That, however, is impossible, and we are constrained to look from the earth, and thus both the position and the motion are reversed to our observation. But we need not perplex ourselves about this reversal, because we have instances of it in every case in which we can change looking *at* into looking *from.* Thus, when one looks at a mirror, and sees one's reflection (it is not an *image*, though so called in the books,) from the mirror, the right side is turned to the left; and if one moves to the right hand, looking at the mirror, the reflection, as shown from the mirror, will apparently move to the left hand. The same, of course, happens in every case where we have a reverse view.

The circumference of the equator is larger than that of any parallel, for its radius, or half the measure across it, is the radius of the earth; and the radii of the parallels are the co-sines of the latitudes,—half the radius of the earth at 60°, as we mentioned in last section, and 0 at the poles. But this difference of length makes no difference in the action of the sun upon the parallels, for they all travel across the hollow of the illuminated cup in exactly the same time; and as the influence of the sun is in itself invariable, the pole, which does not budge an inch, does not, on account of the rotation, receive less of that influence than the equator, which, in the same time, has travelled over 25,000 miles. But the light falls on the parallels at different angles, till, at the poles, the angle is 0, that is, the sun appears just in the horizon, therefore the influence of the sun upon the said parallels is in the proportion of the co-sines of their latitudes.

When the sun is over the equator, therefore, the change which the rotation produces on the influence of the sun upon it from what that influence would be if the earth were at rest, is merely to throw the influence which, in the case of the hemisphere at rest, is distributed into circles round the pole or centre of the surface of the hemisphere, into the equator and the parallels on the earth. The centre point of the hemisphere of light, as immoveable, is changed into the equator; the circle 10° from that point is changed into latitude 10°, both north and south; and all the other circles are changed into the corresponding parallels till we come to the boundary of the illuminated hemisphere, which is changed into the two poles.

This change is worthy of attending to, because that which is a single point, and the centre or maximum of the sun's action in the immoveable hemisphere, becomes the circumference of a great circle—namely, the equator, in consequence of the rotation; and of the other circles, from the centre of illumination to the circumference, there is also a reversal in point of magnitude, for as the circumference of the fixed hemisphere becomes two points, namely, the poles, in consequence of the rotation, the circles, which were nearest the fixed circumference, and consequently largest, are now nearest the fixed points, the poles, and are consequently smallest.

This has a considerable effect on the distribution of solar heat, for if the point at the centre, which received the maximum heat when fixed, is expanded out into the circumference of a great circle, this great circle can receive the maximum action of the sun directly vertical over it only for one moment in the twenty-four hours; and in like manner, as the smaller circles are expanded into larger ones, the quantity of solar action to which they are exposed is proportionally diminished by this expansion. It is true that the equator is still, in this position, the place of maximum action of the sun, and the poles are the places of least action; but all the actions—maximum, intermediate, and least,—as told upon any point of any parallel, are very different from what they would have been had there been no rotation.

This effect of rotation is worthy of some attention, as tending to establish the grand truth of how beautifully all the parts of creation work together. We have seen that the necessary consequence of the rotation of the earth is the turning of the heat at one point into the circumference of a circle, measuring about 25,000 miles; and that each of the smaller circles round this point in the immoveable hemisphere are changed into the larger parallel circles. The heat at the equator is, notwithstanding the seasonal and other modifications which we have not yet noticed, very great as compared with that, not at the poles merely, but 20° or 30° distant from them. But a circle of any dimensions is geometrical infinitude as compared with a point; and therefore, had the earth been at rest the sun's action upon the illuminated hemisphere would have been infinitude as compared with the present heat of the equator. It is impossible for us to estimate its intensity, or even to form any idea of it; but it would certainly have been enough to turn, not merely into ashes, but into invisible vapour, any substance upon earth of which we are acquainted. Were it not for its rotation, therefore, the earth could not be inhabited—nay, the probability, aye, the certainty is, that it could not exist. This is a fact as clearly established as the simplest which passes before our eyes; and it tends, in a manner peculiarly forcible, to impress upon us what a wonderful fabric creation is; how fraught every part of it is with instruction, and how it speaks of the wisdom, the power, and the goodness of its Maker, in a language which no tongue or pen can embody in words.

And we have a partial example of the consequences of want of rotation in the physical condition of our attendant, the moon. This body is not rotationless, for it makes one rotation every time that it revolves round the earth, and thus moves only 29½ times slower in rotation than the earth does; but notwithstanding, the moon bears evidence of the terrible effects of the sun upon a body which turns only at this rate; for the moon is all over like the scoria of a furnace, or the ruin left by some destructive volcano. Yet, as we estimate rates of motion on the surface of the earth, the motion in rotation of a point on the surface of the moon is not so very slow, being rather more than ten miles in the hour. This, however, is very small, compared with the motion in rotation of a point in the earth's equator, for that is more than 1000 miles in the hour. We believe the elements of the ratio, at which the heating of a sphere diminishes, in consequence of its being made to turn on an axis, have not been investigated; but the probability is, that the heating is inversely as the *squares* of the rates, and that the effect of the sun upon the equator of the moon is to the same on the equator of the earth as 10,000 to 1.

If all the matters which compose the aggregate of our earth as a planet,—solid matter, water, and air,—were carried along with it in its rotation, exactly in their places, or even making allowance for slow and local motions of animals, and other comparatively small substances, the general results of rotation would be as stated, and it would only remain to consider the farther modifications arising from the annual motion, and to apply to them the secondary modifications arising from the nature of the earth's surface; but there are some circumstances, connected with the moveable parts of the planet, which require to be noticed before the economy of the earth's surface can be rightly understood, though the full investigation of the principles, and the enumeration of the details, belong to the history of the Air and the Sea, the parts in which those modifying circumstances take place.

To have a clear notion of the foundation of this matter, we must refer to a very general principle in mechanics; and this reference will not be lost, inasmuch as the knowledge of this principle very frequently saves those who bear it in mind from serious, and even fatal, accidents. The principle is this: if any vehicle, or body of any kind, which can be considered as a carriage, is once fairly in motion, with all its load, at any given rate, every part of that load partakes equally of the motion of the carriage, and has no more tendency to fall while the carriage is in uniform motion, however rapid, than if the carriage were standing perfectly still; but if the motion of the carriage varies, it takes some time before this variation can be communicated to the load; and if that load is not fastened, it is liable to be thrown off, if the variation in the rate of the carriage be either sudden or considerable. If the motion of the carriage slackens, the load overruns it, and is thrown forwards; and if the motion of the carriage is quickened, it outruns the load, and that is thrown off behind. The knowledge of this principle is of great use to those who have occasion to travel on the outside of coaches,—and especially of coaches which are in the habit of making frequent stoppages. The accident to which a coach in motion is most liable, is stoppage; and, therefore, the outside traveller should hold himself ready against this accident, which is easily done by keeping the body in a position reclining a little backwards. The same precaution is of use in boats, especially small boats,—large vessels do not get under way and bring up, so suddenly as to jerk their passengers overboard; though, where a trim sailing smack is beating, and brings up through the wind, there is some danger that a landsman may measure the length of his back on the deck when the vessel first makes way on the other board. This is not our present subject, however; and we merely mention a few points, that they may serve as an artificial memory of the principle; and, having done so, we shall briefly notice how this principle applies more especially to the atmosphere.

The earth may be considered as a great carriage rolling along through the regions of space, loaded with an immense number of passengers, and having all the loose inanimate substances as luggage. When these are solid, the gravitation and friction jointly act as a sort of tie, and keep them in their places. The water is more mobile, because the parts of it move upon each other with little or no friction; and the atmosphere is, to continue the simile, a sort of light "imperial" on the top of the carriage, which can hardly be said to have any fastening at all, but which remains steady as long as the part of the earth upon which it is carried has a uniform motion; but the instant that the motion of the earth quickens, the air is left behind; and the moment that the motion of the earth under it slackens, the air moves forward, and leaves the place where it was.

With regard to its annual, or orbital, motion, considered simply, there is no perceptible variation of this kind, either in the air or the water, because the size of the orbit is so great that any small portion of it hardly differs from a straight line; and the change of the earth's rate of motion, from the slowest at the aphelion, to the quickest at the perihelion, and the reverse back again, is so gradual, that, before its change becomes at all sensible, it is communicated to the whole component parts of the planet—land, sea, and air.

So, also, in the case of any loose body, or water, or air, which retains its position in latitude,—that is, does not shift either northwards or southwards,—there is no tendency to difference of motion between it and the earth under it, and, consequently, no separation in lateral distance between the one and the other on account of the earth's diurnal motion of rotation. When, however, there is a considerable change in latitude, happening in a comparatively short period of time, this change must occasion a difference of rate between the motion in rotation of the earth, over which the moveable body has come, and that moveable body.

This explains itself, when we consider that the earth's rotation is performed on a perfect line; that the extremities of this line have no rotatory motion; that any point at the equator has a daily motion of 25,000 miles; and that the motion of a point on any other parallel must bear the same proportion to this, which the co-sine of the latitude of that parallel bears to co-sine 0°, which is the latitude of the equator. We shall not go into the particulars, and especially not into the calculation; but, as before stated, the co-sine of 60° is equal to one half of the co-sine 0°; and, therefore, any point on the earth's surface, or the air, the water, or any other substance, carried on the surface of the earth at that point, must be carried just half as fast as at the equator, that is, at the rate of 12,500 miles a day. North of this, the daily motion in rotation is less than half that at the equator, and it lessens very rapidly, as places are nearer to the pole, the point at which it ceases altogether. On the other hand, between the parallel of 60° and the equator, the rate of motion must be greater than half the equatorial rate, the variations becoming less and less for equal changes of latitude, till we approach nearly to the equator; and then, for some two or three degrees, there is very little difference, as the co-sine of the latitude there differs very little from co-sine 0°.

We are therefore to regard the earth as being, in its diurnal rotation, a carriage of many motions, —of motions increasing, from rest at the poles, in the proportion of the sines of the polar distances, or complements of the latitudes to 90°, to a rate of 25,000 miles a day at the equator; or, if we view them in the other way, as commencing at the equator, then they decrease in the same proportion the reverse way: that is, as the co-sines of the latitudes, (which are exactly the same as the sines of the polar distances,) from 25,000 miles a-day at the equator, to perfect rest at the poles. In this range there is an unbroken succession of change, though the rate of increase is a decreasing one, if we view the matter from the poles to the equator; and the rate of decrease is an increasing one, if we view it from the equator to the poles. It is exactly the same in both hemispheres; that is, on the north side of the equator, and on the south; for when we speak of the two hemispheres, without any qualifying epithet, we always mean the two portions into which the equator divides the earth's surface, and not the hemispheres, which, in our map, are represented on the plane of a meridian. In the two hemispheres the rates of daily motion, as to north and south, are of course reversed, because the poles are on opposite sides of the equator; and the hemispheres are considered simply as halves of the earth, and, without reference to their varieties of surface, the exact reverses of each other; so that whatever tells northward in the one tells southward in the other, and conversely. It is only necessary, besides this, to bear in mind, that the earth's rotation is performed eastward, in order to understand how the motions of the atmosphere are affected by the different rates of motion, in rotation, of the different parallels.

At the poles, unless affected by some external cause, there can be no tendency in the air to move either way; because the pole has no motion, except the orbital one; and this, as we have said, is so gradual in its changes, that it cannot in the least disturb even the lightest loose substance on the surface of the earth. But the equator, and every thing situated on the equator, whether air or not, is carried eastward, at the rate of 25,000 miles a day, or more than 1000 miles in the hour; and this rate of motion diminishes as we recede from the equator towards either pole.

Now, it will readily be seen, that if any loose substance, such as the air, is, by any means, carried from nearer the pole to nearer the equator, it must have less motion eastward, in rotation, than the lower latitude into which it arrives, and that, if we could suppose the air over the pole instantly transported to the equator, the difference between its motion in rotation, and that of the earth at the equator, would be the whole 25,000 miles in a day. The obvious consequence, upon the mechanical principle which we have mentioned, would be, that this air would remain at rest, in respect of rotatory motion, and that the earth would escape eastward from it at the rate of 25,000 miles in the day, or more than 1000 miles in the hour. But we estimate rest from the earth, and not from the atmosphere; and, therefore, the feeling to an observer at the equator would be, that this air, instantly transported from the pole to the equator, moved westward at the rate of more than 1000 miles an hour; or it would become an east wind, blowing with that velocity.

In reality, air cannot be instantaneously transported from the pole to the equator, because air is a material substance, although one of comparatively little specific gravity; and therefore it must take some time of the operation of any cause to move it from one place to another; and it would take a comparatively long time to move it along the quadrant of a meridian, from the pole to the equator, which is a distance of about 6250 miles. In the course of moving over this long distance, even if we were to suppose air to come all the way from the pole, it would gradually acquire a portion of the motion in rotation of the different parallels over which it passed; and it would acquire more of this in proportion as its own rate of motion toward the equator were slower. We are not practically acquainted with any motion of the air, in any direction, exceeding 100 miles in the hour, which is the velocity of those destructive hurricanes which occasionally visit some parts of the world, and are always productive of mischief. This is only about one-tenth of the rate of motion in rotation at the equator ; and therefore the natural motion of any current of the air arriving at the equator, either from the north or the south, must be far less than this ; for the hurricane is a disturbance of the air, and not a natural motion. It arises from the sudden action of some expansive force, or the sudden destruction of some resistance. Thus, for instance, if a heavy rain were to fall upon a thirsty desert, which had been long dry, and to which, in consequence, there had been a regular current of the air, or set of the wind from all sides, then the evaporation produced by the rain upon the dry and thirsty surface would bring a great degree of cold; this cold would condense, and bring down the air over the desert, and stop the current which was moving towards the desert on the surface. The consequence would be violent winds in the neighbourhood of the desert, until the current desertward were stopped, and the natural equilibrium of the atmosphere restored.

But though no natural movement of the atmosphere toward the equator could carry the air there, possessing so little rotatory motion as to occasion anything like a hurricane from the east, yet it is perfectly evident that any surface current arriving at the equator, how slowly soever it might arrive, would have some less motion than the surface of the earth at the equator; and that this difference, whatever it might be, whether ten miles in the hour, one mile, or anything else, would give the air an apparent motion westward, which would be the counterpart of a real motion of the earth's surface eastward, just as the apparent motion of the sun, the moon, and the other celestial bodies.

But air cannot arrive at the equator from either hemisphere, partaking of one motion only; because as the motion in rotation is constant, and as on the parallels near the equator it is very little less than at the equator itself, air arriving at the equator must arrive there with very nearly the same rate of motion in rotation that the surface of the earth has; and this will hold though we suppose a current of air to set the whole way from the pole to the equator, because the farther it has to travel it must be the longer on the way, and the more affected by the rotatory motion of the parallels over which it passes; and as this rotatory motion is most rapid near the equator, no current of the air can, by any force with which we are acquainted, be made to set so strongly toward the equator as to produce a permanent east wind there, though at some distance from the equator there may be such a wind, unless under circumstances where it is counteracted by the nature of the earth's surface. But, even where there is no such counteraction, and a wind of this kind is felt, it is easy to see that it cannot be a wind blowing directly from the east, because if the current of air forming the wind is on the north side of the equator, it has a motion southward, and if on the south side of the equator it has a motion northward. It is thus, whether in the one hemisphere or the other, acted on by two forces, one impelling it towards the equator, and the other, the deficiency of its motion in rotation compared with that of the parallel over which it arrives, impelling it in a direction parallel to the equator. It is therefore affected by two forces acting at right angles to each other, and therefore the resulting motions must be in the diagonal of a parallelogram, the sides of which represent those forces. Thus, if the motion toward the equator, and the deficiency of rotatory motion, compared with that on the parallel, are exactly equal to each other, this current will become a north-east wind in the northern hemisphere, and a south-east wind in the southern; if the motion toward the equator is the greater of the two, the resulting current of the air will be more nearly a wind blowing southward in the northern hemisphere, or a wind blowing northward in the southern; and if the deficiency of motion on the parallel, or tendency of the air westward, is greater than its motion toward the equator, it will produce a wind blowing more in the direction of from the east, in both hemispheres.

On the other hand, if any cause whatever shall produce a current of the atmosphere toward the poles, the circumstances of this current will be exactly the reverse of those of a current from the pole to the equator. That is to say, such a current will leave the equator with an equatorial velocity in rotation, namely, a velocity of more than 1000 miles an hour, and though this velocity will gradually diminish as this current sets farther into the hemisphere, upon the very same principle which makes the motion in rotation of the polar current toward the equator increase as it advances, yet this current from the equator, or indeed from any lower latitude to any higher latitude, must arrive at that latitude with more motion in rotation than the surface of the earth has there, and the difference, whatever it may be, must become a greater motion of the air eastward than the earth has, or, which is the same thing, a west wind, that is, a wind blowing from the west. In speaking of all winds and currents of the atmosphere, we are accustomed to speak of them in the names of those points of the compass from which they blow, though the set of the current is really in the other direction; for instance, a south wind is a northward motion of the air, a west wind is an eastward motion, and so on in all other cases.

The west wind, produced by a current from the equator toward the pole, and it would obviously be the same from the same cause in both hemispheres, must be subject to the same modifications as a current from the pole toward the equator; that is to say, as it proceeded it would lose part of its rate of motion in rotation, and be changed into a wind blowing from the south-west if in the northern hemisphere, and to a wind blowing from the north-west if in the southern hemisphere, and it would be more nearly in the direction of from the west, or from the north in the one hemisphere, and the south in the other, according as its excess of motion in rotation, or its motion from the equator were the greater of the two.

These considerations are, strictly speaking, parts of the natural history of the Air, but it is altogether impossible to form any notion of the general economy of the earth's surface without them; and thus we have no alternative but that of at least mentioning the outlines of them in this place; nor need we apprehend exhausting the doctrine of the air by such brief hints as these, because, when we come to take up that beautiful department of nature as our principal subject, we shall find no want of matter, and matter of the greatest interest.

From what has been said, the reader will perceive that, in order to put the whole atmosphere in motion, we have only to imagine some cause which shall set it in motion at the equator; and the reader must have anticipated, that exactly such a cause presents itself in the sun. The sun apparently travels westward round the equator at the times of the equinoxes (and these are the positions of the earth with regard to the sun which we are considering in the present section,) at the rate of more than 1000 miles an hour,—that is, as the earth turns eastward at this rate, the point where the sun is vertical apparently travels westward at the same rate, being in fact the counterpart of the earth's motion, as told upon the heavens in looking from the earth, upon the same principle that one's reflection is reversed when one looks from one's self at the mirror.

We stated formerly that air is perfectly obedient to the influence of heat, and that it is impossible to apply heat to any portion of it without causing that portion to expand, occupy more space, and constantly be specifically lighter:—

Consequently, as the sun apparently moves round the equator, the air at the points where, in succession, the sun appears to be vertical, must be, from what has been already said of the maximum effect of the sun-beams when they fall perpendicularly, more heated than any where else. Being heated, it must be expanded; and being expanded, and thereby becoming specifically lighter, it must ascend into the upper part of the atmosphere until it arrives at a height where the mass of the air has the same specific gravity as itself. That it must ascend is evident, for it cannot expand downwards into the earth, because every crevice which can be filled with air is always filled with it, in consequence of the remarkable thinness or rarity of that fluid, and its equal pressure in all directions. As little can it expand laterally, at least beyond very moderate limits, because the air there is colder, and therefore denser, and consequently capable of offering more resistance than the heated air, and must in fact press it upon it and force it upwards, upon the simple principle of the tendency of all fluids to maintain a perfect equilibrium or balance in all their parts.

Thus, we may assume as a general fact, and observation establishes the truth of the assumption, that, at the point where the sun is vertical, there is a constant rarefication and ascent of the air, and a constant setting in of the surface-air from all sides to supply its place, until this surface-air becomes heated in its turn, and is rarefied and replaced. It is not exactly at the point where the sun is vertical that this maximum, rarefaction, and ascent of the air take place. The heat of the sun, though a powerful cause, is still only a material and finite one, and therefore it cannot produce any effect instantaneously, but must require time, which is an indispensable element in all action of matter. Besides, there is no definite spot upon which this maximum action of the sun falls, for though it is greatest at the centre, the diminution is gradual throughout the whole illuminated hemisphere; and, unless in so far as depends upon different kinds of surface, which belongs to the earth, and not to the sun's action, there is no change perceptible from any one point, or even for several miles, in juxta-position with each other.

Taking all these circumstances together, it is easy to see that the period of maximum heat must be after the time when the sun is vertical, and, consequently, in latitudes where the sun is never vertical it must take place after the time that the sun passes the upper meridian, that is, after twelve o'clock at noon. We are not, in the meantime, to draw any conclusion from this fact, but it is necessary to have all the circumstances of the case fairly and clearly before us, and then many of the applications will suggest themselves.

We are then to understand generally that, when the sun apparently travels vertically round the equator, the solar influence extending just to both poles, and no farther, and all places in both hemispheres enjoying equal day and night, the maximum influence of the sun apparently travels westward, a little behind the place where that luminary is vertical, and there gives to the air of the atmosphere that primary motion which ultimately makes it circulate over the whole earth, and produce so many beneficial effects. From a certain space around this point of maximum effect, the air is constantly ascending, and there is as constant a replacement of it by the air from the other parts of the earth. The earth, and consequently the air over it, must, from the increasing obliquity of the sun's rays, become colder and colder as the equator is receded from, though, because there is little difference in the position at which the light falls, for several degrees on each side of the equator, there must be nearly equal heat there; and therefore the maximum effect may be regarded as not travelling round the equator merely as a line, but as passing over as a zone of some considerable breadth, say two or three hundred miles. The breadth of this zone, and the fact of its being heated sufficiently,—in order to occasion such an expansion and ascent of the atmosphere as shall produce a wind from the north-east, or some point between the north and east, in the northern hemisphere, and a wind from the south-east, or from some point between the south and east, in the southern hemisphere,—depends, in a great measure, upon the surface over which this zone passes. If that surface is susceptible of the highest degree of heat, that is, if it is bare earth, not much elevated above the mean level of the sea, it will have the maximum temperature, and extend to the greatest breadth in latitude. If it is clothed with luxuriant vegetation, the evaporation from that vegetation will consume a portion of the solar influence, and the effect upon the atmosphere will be diminished to the same extent; and if it passes over the surface of the water, the effect will be still farther diminished, though it is only over the uniform surface of water, stretching to a considerable extent on each side of the equator, that this current of the atmosphere can be distinctly perceived.

If the reader will turn to the map of the world, he will find that the equator falls upon a comparatively small portion of land, namely, about

10° in the oriental islands of Gilolo, Celebes, Borneo, and Sumatra, over about 30° of the continent of Africa, and over about the same extent in the continent of South America, making in all 70° out of 360°, or seven thirty-sixths, or not much more than one-fifth of the entire circumference of the globe. The remaining 290°, or nearly four-fifths of the circumference of the equator, fall upon water; and by looking at the map it will be perceived, that it falls upon wide seas, uninterrupted by any land, except a few small islands. Farther than this, it will be perceived that the equator, with the exception of the interior of Africa, which is but little known—though the probability is that in this latitude it is not a desert,—that the equator falls upon lands which are covered with luxuriant vegetation. In the eastern islands the places immediately under it are perfect gardens; and in America, it passes along the great valley of the Amazon, about half way up the left hand, or northern, branches, but still within the range of their fertilizing influence, and over a country which is, generally speaking, clothed with forests. Therefore, in so far as the land is concerned, the action of the sun on the equator—that is, *immediately* on the equator—may be considered as being a minimum; and as land forms so small a portion of the circumference of that great circle, the action of the sun, when over the equator, is principally resolved into action upon the water. In understanding the general effect of the sun upon the earth, it is necessary, therefore, to call to mind the effect which that luminary has upon water.

The principal effect in this way is to evaporate, and thereby to occasion cold; and this tendency may be considered as extending equally to the surfaces of rich vegetation over which the equator passes, as to those covered by the ocean. In consequence of this, the influence of the sun upon the equator may be regarded as a minimum influence, in respect of mere heating or burning up; but the same circumstances which render it a minimum in this respect, make a maximum in benefit to the other regions of the earth. The evaporative power of the atmosphere, under all circumstances, increases with the heat; and as, when the sun is vertical, the portion of the sunbeams which are reflected from the surface of the water, without affecting the temperature of that fluid, are reflected back into the atmosphere, they tend to increase the quantity of evaporation; and as, in addition to this, the surfaces over which the equator passes, have the maximum qualities for affording evaporation, it follows that there is not only a continual ascent of the atmosphere over the equator, but that the atmospheric fluid so ascending constantly carries along with it a large quantity of moisture. This moisture is borne into the upper regions of the air, and distributed, by means of the counter currents, over both hemispheres, supplying them with the matter of rain, one of the elements of fertility; which also brings along with it the other element of fertility, namely, the action of heat.

In this we see many advantages resulting to the habitable parts of our earth; and it enables us to understand the motion of the oceanal waters, taken on the mean, or when the sun is on the equator; from which it is by no means difficult to estimate what the effects must be when the sun is to the north or the south of that circle.

Immediately under the equator, or rather in a zone of indefinite breadth,—of which the equator may be regarded as the centre, but which passes off by imperceptible degrees, both northward and southward, and may be said not entirely to cease till the poles are arrived at, at least, when the sun is over the equator,—there is a continual waste of water, or draining of water from the surface of the sea, and also from that of the vegetable clod, in consequence of the action of the sun; and the consequence of this must be a constant tendency of the waters, especially of the surface waters, of the great oceans, especially of the Pacific and the Atlantic, which stretch, from polar ice to polar ice, from the polar regions towards the equatorial; and the water so brought, evaporated by the equatorial heat, and returned again through the upper air, must contribute in no small degree to mitigate the climate and increase the fertility of countries in both hemispheres remote from the equator.

But the surface water, so moved from the polar regions toward the equatorial, must partake of that modification arising from increased rotatory motion in the earth, which we have mentioned as affecting the similarly directed currents of the atmosphere; that is to say, as the surface waters of the ocean come from high latitudes, where the motion in rotation is comparatively slow, into high latitudes, where it is comparatively rapid, these surface waters must, so to speak, lag behind the bottom of the ocean, in its eastward rotation, or, in other words, there must be a current of the surface waters westward, on the same principle, though not to the same extent, that there is a current westward of the superincumbent air; and this current is attended with the same beneficial effects as the aerial current, by equalizing the temperature of the ocean waters, in the same manner that the other equalizes the temperature of the atmospheric fluid. When we say "equalizes," we do not, of course, mean to say, that the temperature either of the sea or air is, or can be, the same in all latitudes, or that it would be the same even on the supposition that the whole surface of the earth were uniform, and equally affectable, by the action of the sun; but it is true, that in consequence of both the oceanic and the atmospheric currents towards the equator, the maximum influence of the sun upon that particular circle is distributed into the two hemispheres; and, in consequence of the same, there is a general tendency westward given both to the waters of the ocean, and to the air immediately over the surface of the earth, while in the upper regions of the atmosphere there is a return current of the air, which carries water along with it, to replace the quantity which is evaporated in the equatorial regions.

This is a very beautiful part of the working of the system; and we cannot help admiring it, as showing, in the earth itself, upon the great scale, the same admirable wisdom, and the same perfect contrivance and accomplishment, which we perceive in those minor works of nature, which we can take in our hand, or place wholly before our eyes. Indeed, we cannot look upon any one production, substance, phenomenon, or circumstance, connected with nature, without perceiving how admirably each works, and how still more admirably all work together for the good of the whole. This is not, however, the whole of the case, viewing even the simplest form of it, namely, that which supposes the sun to appear constantly in the equinoxial position, or directly over head at the earth's equator; for, when we turn our attention to the poles, and especially when we take along with us the consideration between water and different degrees of heat, we see still farther what a glorious piece of workmanship the world is.

We have, of course, no practical evidence of what the effect would be at the poles if the sun were to revolve constantly round the equator, either upon the supposition that the earth's surface were perfectly uniform, or taking it varied, as it now exists; because heat is not a substance which we can either measure with the line or weigh in the balance, and, consequently, we can speak only about its observed effects. But from what has been said of the reflective power of the atmosphere, in sending down to the earth a portion of the solar influence,—which, if it were without the atmosphere, would pass effectless over it,—we may be sure that even in this state of things the poles themselves would not be left in absolute cold, but would enjoy some portion of the solar influence, however small. Now this mean position of things, or the sun over the equator, may be considered as the average of the year in both hemispheres, and, therefore, as that which we are to take as the basis of our investigation; and though we cannot state what would be the temperature at the poles, as told by the thermometer, yet we may assume, from the result of actual observation, that in that state of things there would be a considerable zone round each pole, in which water could not exist except frozen, or in the state of ice or snow. Water thus becomes a most important element in all our general inquiries respecting the economy of the earth's surface.

The icy zones could have no communication with the central, or equatorial parts of the earth, by means of currents; because, independently of other circumstances, the water there would be bound in fetters of perpetual ice. It is well worthy of our consideration to remark how beautifully the water is adapted to the degree of solar action on our globe; and that, while there is a certain equatorial portion, over which water is constantly converted into vapour, there would be, in the case of the sun constantly revolving round the equator, a portion as constantly sealed up by this congealing power, and retained at the poles, notwithstanding all the vigour of the solar influence at the equator. And it is further worthy of remark, that there are, in almost every latitude, portions of the earth's surface which rise to such a height above the mean level as that they have this degree of polar cold, or, at all events, that they have cold enough for arresting and freezing a certain portion of the atmospheric humidity, and storing it up for the purpose of watering and refreshing those portions of the land which would otherwise be burnt up.

These polar portions, with their perpetual ice, would of course be taken out of the influence of the general current, not only of the waters of the ocean, but of the atmospheric air; and if the sun were to revolve constantly round the equator, the polar zones, to a breadth which we have no means of ascertaining, but which would exist to some considerable extent, would be the regions of desolation and of death—no, not of death, they would be regions of no life.

Besides this, it is near the poles that the difference of velocity in rotation is greatest; because, if we are to take a small portion, as, for example, a single degree round the pole, the circumference of that degree does not differ very much from a circle one degree in radius; and if we take 10° from the pole, the circumference of the parallel is not much more than one-hundredth part less than the circumference of a circle having these 10° for radius, and is such that the motion in rotation there is between 180 and 200 miles in the hour, which is a very rapid rate, at the distance of only about 700 miles from the pole. This motion in rotation is far greater than any impulse towards the equator which the sun can give to the atmosphere, even in the vicinity of that circle; and therefore we can easily see that, upon the average, the atmosphere, not merely for 10° round each, but for a much greater distance, must be, as it were, chained by the polar influence, restricted to the polar region, and cut off from all connexion with the sun's action at the equator. And as the circumstance of there being a difference of seasons does not take the poles out of what would be their average condition if there were no change of seasons, but merely causes the heat and cold to alternate seasonally upon them in the summer and winter, it is evident that, independently of varieties of surface, this is the average character of the polar climates. There is a general tendency in the east wind to blow constantly over those regions of the globe whenever from any cause the atmosphere receives a motion towards the equator; and, as we have said, the tendency of the surface air towards the equator is constant, it follows, by necessary consequence, that the tendency of the polar air is to circulate in the direction of from east to west, or to be an east wind, in all cases where it is not affected by differences of surface. But it is also evident, that as these portions of the earth are very little under the governing influence of the sun, local causes must have much more effect upon them than upon places nearer to the equator. Indeed, we may state it as a general truth, that the influence of the sun diminishes all the way from the equator, or, taking the seasons into consideration, from the parallel at which the sun is vertical, to those places at which the sun appears just in the horizon. But as it is the law of nature, that when one cause ceases there is always an opposite cause to come into operation, it must appear evident that local circumstances must act much more powerfully in latitudes near the poles than they do in low latitudes near the equator; that, as there is a gradual diminution of the sun's controlling influence from the parallel where the sun is vertical till we arrive at 90° distance from that parallel, so there must be an increase of the opposite causes, and that local circumstances must gain more and more power as the influence of the sun becomes less and less.

We are therefore to consider the influence of heat as exerted by the sun, and the influence of cold, or congelation, as exerted in the absence of that luminary, as being laid against each other on the quadrant of the meridian from the equator to the pole. The sun's influence is a maximum at the equator, and (refraction excepted) 0 at the poles; and the action of congelation is a maximum at the poles, and at the mean level of the surface, 0, or a minimum at the equator.

In proportion as the solar influence predominates, which is an influence exterior and extrinsic of the earth, it is evident that every terrestrial cause, be it what it may, must be held in subjection; and it is equally evident, that in proportion as this solar influence diminishes, every species of terrestrial must come more vigorously into play; so that at the equator we have the maximum influence of the sun, at the poles we have the maximum of local causes, and over the quadrant we have the one increasing and the other diminishing, whether we estimate from equator to pole, or from pole to equator; the equality of them, or the place where the one is as influential as the other, being theoretically about the middle of the quadrant, or at latitude 45° either way, but differing in reality from the varied surfaces which the earth presents.

As there are, at opposite ends of the quadrant in latitude, two opposed and opposing actions,—a solar, or heating, action at the equatorial extremity, and a cooling, or freezing one at the poles,—it follows as matter of course that if there is, in either hemisphere, an action by which the one of these is cut off from the other, and each confined more immediately within its own region, the effect of each within its own region will be greater than if they were allowed free intercourse with each other on the confines, by means of which the one would there mitigate or compensate the other.

In our brief survey of the earth we saw that, in the northern hemisphere, both the eastern and the western continents reach northward to not only the southerly limit of the polar ice, but to that latitude beyond which this ice is not melted, even in the heat of the northern summer. Hence it is easy to see that, in the northern hemisphere there can be no circulating current round the globe in high latitudes, either of the ocean waters or of the atmosphere; and not only this, but in fact that no current can circulate, in longitude, round any part of the northern hemisphere, because in this hemisphere both continents extend from the polar ice to a considerable distance southward of the equator. Therefore, in the northern hemisphere we may state that there is a general connexion as between tropical and polar influence, except in so far as this influence is interrupted by ridges of mountains; and it follows, by necessary consequence, that as summer and winter alternate, their alternation of the play of the seasons must extend over a much greater range in latitude than if the connexion of those extremes to climate were broken by any definite natural barrier capable of retaining the solar influence more in the tropical regions, and confining the opposite influence, that of cold, more within the region of the pole.

Even in this hemisphere we find in different longitudes very remarkable differences of climate and of seasons, arising from greater or less connexion between the lands and an open sea on the north. In the central part of America, the seasonal range in the high latitudes is a maximum; for while there is a cloudless atmosphere and comparatively great heat, heat which burns up the vegetation, and leaves the rocks bare, almost to the very shores of the Polar Sea, during the summer months, the temperature there is so low for five or six months in the winter, that quicksilver becomes solid, and may be hammered on an anvil. This intensity of cold during winter extends not only across the whole northern coast of America, but also along the whole of the north of Asia and of Europe to the islands of Nova Zembla, or about 60° east of the meridian of Greenwich; and thence to about 40° west, or about 90° on the parallel of 70°, (indeed it is rather less,) is the only portion of the northern hemisphere which may be said to enjoy the advantage of an open sea on the north. Bhering's Strait, between America and Asia, is too narrow for admitting any current of the Pacific to set toward the north; and it is understood that the general run of the water there is southward, being in all probability the spent current of the Atlantic making its escape from under the polar ice.

This Atlantic current, as will be seen upon examining the map, is turned by the oblique line of the east coast of North America and the island of Newfoundland, at which latter place it, in summer, meets with the "fresh," or surface water, produced by the melting of the snows in the countries around Davis's Strait, Hudson's and Baffin's Bays, and the other land-locked seas on the north-east of America: and at the meeting there is an eddy, and a great deposit of the matters carried by both currents, which deposit has formed the great bank of Newfoundland, which is the pasture of such innumerable shoals of fish, especially of cod.

Thence the current sets eastward, against the shores of Europe, or, more strictly speaking, in the direction of the island of Spitzbergen, though the coasts of Britain and Norway, and ultimately the islands of Nova Zembla, tend to turn it northward against the margin of the polar ice. In consequence of this, the countries round the White Sea, though more southerly in latitude than Lapland, have a much colder winter, and their summer is not so much refreshed by showers.

But though this northerly current in the Atlantic tends to moderate the seasons in Europe, rendering the winter more mild, and the summer more showery, and, therefore, less intensely hot than it otherwise would be under the same latitude, yet this is not a circulating current in any beneficial sense of the word, but may be said to exhaust itself against the polar ice. In summer, when it has the greater intensity of motion, and also the greatest warmth, this current acts upon the huge masses of snow, or rather of ice, which accumulate in the dells and ravines of Spitzbergen, and the other mountainous countries of the extreme north. The bases of those great masses are in the sea; and the action of the current cuts them off, and they fall headlong with tremendous crashes, and make those regions of desolation terrific with the sound. Those icy formations are still more majestic towards the American shores, where the winter sets in with more violence, and is of longer duration than on the north of Europe, and where, also, the break of the winter is more sudden. Those icebergs are often very large, being some miles in dimensions, and often at least two thousand feet thick, of which two-thirds are usually below the surface. Those masses are, however, phenomena of a seasonal character, and do not belong to the consideration of the earth's rotation on its axis; though it is necessary to pay some attention to the difference of situation which these great bodies hold in the two hemispheres, because this enables us to see the effect of that free circulation which the air and the water have round the south pole at a comparatively low latitude.

When we examine the southern hemisphere we perceive that almost the whole parallel of 35° falls upon the sea, or, at all events, there are not above 20° or 39° of it upon land, while this land is comparatively narrow; and the only portion of it which is sufficient to interrupt the current is South America; and the general position of the coast of that country merely throws this current southward, but not so far south as that it is at any time interrupted by ice. Hence the tropical influence is confined on the south side, and the polar influence on the north side, by the current in this sea; and the heat of the one region, and the cold of the other, are both thereby augmented.

What may be the character of the surface of our globe immediately around the south pole has not been clearly ascertained, though as high a latitude as 75° has been reached in some places; but whatever may be the character of the land there, the icebergs float down into much lower latitudes than they do in the northern hemisphere, having been observed off the Cape of Good Hope, in latitude from 36° to 39°. Nor are these of very rare occurrence, or to be regarded as small fragments, for some of them have been found two or three miles in circumference, and rising from one hundred and fifty to two hundred and fifty feet above the surface of the water. The mass below water answering to this elevation above must of course depend in a great measure upon the consistency of the ice, but the average may be considered as about eight parts in the water to float one part above.

It is highly probable, that though there are mountainous shores in the southern hemisphere upon which icebergs can be formed, yet that the polar surface there is not at any time so much heated during the summer as in the northern hemisphere; and this again is a means of lessening the intercourse by the air between tropical and polar latitudes in the south. When we examine the whole hemisphere on the map, and see how little land is in it, and also that the different lands lie nearly on a parallel, and that the seas which separate them are everywhere of much greater breadth than the lands themselves, we can easily perceive that those countries will not answer to each other by any return of season or alternation of climate, as we have mentioned is the case between Africa and Australia, and the south of Asia. Each of the southern lands is thus, as it were, given up to its own climate; and though this climate is, perhaps, not so very different, upon the average, from the climate in the northern hemisphere as we might be led to expect, yet it is more uniform in the different seasons. The action of the sun on the surface of the water is altogether less than on the surface of land; and it is probable that there is even less evaporation, as least at some seasons. By this means the southern hemisphere has the air over it much more uniform than the north; and the consequence is, that the seasons, with the exception of the rains, are milder. In Van Diemen's Land, for instance, which is in about the same latitude as the north of Spain, the winter is as mild as in the very south of Europe, while the summer is not warmer than in the north of France. In other places of the south, the size of the lands, and the consequent distance of great part of them from the sea, has a considerable effect upon their character; but still greater uniformity throughout the year may be considered as the characteristic of these climates.

The currents of the ocean, and of the atmosphere over it, have very considerable effect upon the characters of countries. As the motion both of the air and of the water on the surface is toward the equator, or the parallel of greatest heat, so the surface of both—that is, the ocean water and the air over it—must move towards the parallel of greatest heat with less velocity eastward than that parallel has; and this must cause a westward current of the water, and a westward set of the wind over its surface. Of course the motion of the air must be by far the more rapid of the two, because it is more acted on by expansion of the parallel of greatest heat than the water is by evaporation; and also, because it is a great deal lighter than water. The result is, that while the current of the ocean is hardly perceived, except under particular circumstances, the current of the atmosphere produces a distinct and steady wind on both the wide seas, which is familiarly known by the name of the *trade wind*.

On the principles already explained, this trade wind blows from the north-east to the northward of the parallel of greatest heat, and from the south-east on the south side of that parallel. Thus the trade winds of the two hemispheres act obliquely upon each other; and if the one is, owing to the season, either different in temperature, or differently charged with humidity, from the other, the result will necessarily be, the depositing of a quantity of that humidity and rain; and if the two trade winds are interrupted either wholly or partially by islands, they will also deposit a considerable quantity of their humidity upon those islands, or, indeed, upon any land which opposes itself to them. When we look at the map, and take the equator as the mean parallel of the greatest heat, we find two remarkable places against which the trade winds must tell in the manner which we have attempted to explain. Those places are the north-east portion of South America, and the islands of the Eastern Archipelago, between New Holland and the south-east of Asia. This action tells singly upon America, only the form of that continent turns it to the northward. But among the oriental islands the effect is different; because of the reciprocating action which takes place across them, as it were, between New Holland and the dry countries of Southern Asia. As both New Holland and the Asiatic countries alluded to are dry for great part of the year, the heat is powerful upon them, and thus the monsoon alternating from the one to the other than the set of the trade wind from the Pacific; and therefore their seasons are much more varied than the seasons in the corresponding parts of South America, in which may be included the West India Islands. The continual meeting of the sea winds at those two places gives them, however, greater fertility and natural action of every kind than any other part of the earth's surface.

Indeed, in every part of the world where we have a sea wind setting toward the land, that wind is a cause of general fertility, as well as of mitigation of the seasons. This is especially felt in all those parts of Europe which abut upon the Atlantic, and it tells upon them in a greater uniformity of seasons. Thus, in consequence of this action of the Atlantic, the winter is much milder in the British islands, and the north-west of France, than it is on the same parallels in central Europe; but on the other hand the summer is not nearly so hot, for while the vine country on the west of France scarcely reaches the lower valley of the Loire, it inclines to the north-east in the interior part of the continent, so that grapes come to maturity in the valley of the Rhine as far to the northward as the southern part of England, and farther to the eastward they come to maturity a good deal to the north of this. Not only so, but in the countries immediately to the north of the Black Sea, to which allusion has already been made, we have the fruits of tropical climates, such as the melon, and the water melon, growing freely in the open fields as a common crop, without any of that attention which is required for the culture of even the cucumber in the warmest parts of England. From this it is easy to see that the effect of an insular situation must be greater uniformity of climate, though the weather may be more variable than takes place on extensive lands. If the island is situated in a tropical latitude the result is perpetual fertility, unless it happens to be within the range of a monsoon or shifting trade wind, and then it will have a rainy season and a dry. If, on the other hand, the island is situated far on the polar zone, and excluded from communication with the open sea, as is the case with Nova Zembla, and the numerous islands on the north of America, the climate will make an approximation to perpetual sterility, more so than an extensive land in the same situation.

SECTION XI.

MODIFICATION ARISING FROM THE EARTH'S MOTION IN ITS ORBIT.

In order to understand the effects of this cause, we must bear in mind the position which the axis of the earth's rotation maintains with regard to the motion in the orbit. In doing this, with a view to understand the effect on the earth itself, as producing seasons, it is not necessary to take into account the difference of rate at which the earth moves in different parts of its orbit, or the different distances at which it is from the sun. We have no absolute means of ascertaining the effect of these with anything like accuracy; but the probability is, that as the relation of the velocity and distance is the same throughout the whole orbit, so that the radius vector always sweeps over equal surfaces in equal times, it is probable that the two causes of variation very nearly neutralize each other.

We are therefore to consider the earth as revolving with its axis always parallel to itself— that is to say, not shifting its position sideways, but making an angle of about sixty-six and a half degrees with the plane of the orbit. This angle is always made in the same direction, in consequence of the axis continuing parallel to itself, and therefore it must be inclined as much from the orbit in the opposite direction as it is inclined to it in the one first mentioned. This greater inclination must, of course, be as many degrees more than 90°, which is a right angle, or the angle of no inclination, that is, it must be $113\frac{1}{2}°$. This, with the former, makes exactly 180°, or two right angles, the whole angles which a line can make with a plane.

The radius vector, or line joining the centre of the sun and centre of the earth, which we may regard as being the axis or central line of the beam of solar action, which always falls upon a hemisphere of the earth, and the position of the radius vector, with reference to the earth's axis, must make in the course of the year, or time of performing a revolution in the orbit, all possible angles with the earth's axis between those two inclinations, that is, between $66\frac{1}{2}°$ and $113\frac{1}{2}°$; and as we are to suppose that the radius vector meets the axis at the very centre of the earth, it will follow that the angle which the axis and radius form there will be always as much more than 90° told to the one end as it is less than 90° told the other way; $66\frac{1}{2}°$ is $23\frac{1}{2}°$ less than 90°, and $113\frac{1}{2}°$ is $23\frac{1}{2}°$ more than 90°, therefore the greatest deviation, as told either way at the earth's axis, will be from $66\frac{1}{2}°$ to $113\frac{1}{2}°$, and the deviation from a right angle both ways will be $23\frac{1}{2}°$.

We are thus to imagine that the radius vector is a line fixed at the centre of the sun, and also that of the earth, and that the earth is carried round at the extremity of it in such a manner as that the axis upon which the earth turns makes $66\frac{1}{2}°$ of an angle at the one end, and $113\frac{1}{2}°$ at the other; that these angles continue becoming more and more nearly equal to each other as the earth is carried round, but always amounting to the same sum, that is, 180°, or two right angles, and, consequently, each being a right angle when they become equal to each other. When this equality is arrived at, it is gradually lost, by the angle which was formerly the smaller now becoming the greater; and this equality continues to augment until the particular angles are just the reverse of what they were at the commencement, —namely, that which was 113½° at the commencement will now have become 66½°, and that which was 66½° will have become 113½°. This will take place after exactly half a revolution, and we may mention that these two positions of the radius vector and the axis are the perihelion or point nearest to the sun, and the aphelion or point most distant; that the maximum inclination toward the south end of the axis, that is, the nearest approach of the radius vector to the south pole, is the place of the perihelion, and the situation when the radius vector is most inclined toward the north pole is the place of aphelion. It of course follows from this, that when the radius vector is equally inclined to both poles, or when the angle each way is 90°, the earth must be at the points of mean distance, or the extremities of the shorter axis; in which case the radius vector, by making equal angles with the axis both ways, will apparently travel westward directly over the earth's equator, and the illuminated hemisphere will extend exactly to each pole, and the temporary influence of the sun upon the earth will be exactly the same, although the radius vector (the extremity of which answers to the centre of the sun) always apparently travelled along the equator, and day and night were everywhere equal.

But we must not thence infer that there will be a medium climate in the two hemispheres or even at any one place in the same hemisphere, at those times when day and night are equal. For there are many circumstances which require to be taken into account before we can even judge at what will be the action of the sun at those times ; and these modifying circumstances, which form the grand elements of our estimate of the actual climates of countries, depend partly on the motion of the illuminated hemisphere upon the earth, partly on the surface from which the radius vector has arrived, and partly also upon the progressive history of the earth itself ; so that in the solution of this, the grand problem of geography, that which determines the inhabitableness and value of the earth, we must content ourselves with approximations, derived partly from theory, but much more from direct observation.

Where the requisite data are so varied, so difficult to be understood, so many of them unknown, and when, of those which are known, some are so contradictory of each other, it is hardly possible to do more than give a slight view of the working of the system ; and in order to obtain even this view we must consider some of the elements separately. Of these, the position of the illuminated hemisphere upon the earth is the one which is simplest in theory, and therefore it is the best for being made a general index or sort of artificial memory to the rest.

We are to understand that under every position of the radius vector, with regard to that of the earth's axis, a cylindrical beam of light, that is of solar influence of every sort, equal to the section of the earth, including its atmosphere, falls upon these, and falls upon a hemisphere in the manner we have already explained, that is, with a maximum influence at the centre or point where the radius vector meets the surface, declining, or diminishing in the ratio of the co-sines of the distances from this point, and becoming 0 at the circumference of the hemisphere. This illuminated hemisphere, which expression we use as a short name for all the effects which the sun produces upon the earth, is constant in its amount, and constant to the radius vector as its centre; and therefore, in order to understand how it applies to the earth at different times, in consequence of the earth's compound motions of revolution and rotation, we have only to examine the way in which the radius vector travels over the earth's surface. This travelling is of course apparent, and not real; but it is the counterpart and measure of the influence jointly of the two real motions of the earth, and therefore when we once understand them, we need have no difficulty in understanding this, even though we speak figuratively of the radius vector travelling over the surface of the earth, instead of that surface really turning upon or through the radius vector.

As the greatest deviation from a right angle—or the *declination*, as it is called—is, both ways, $23\frac{1}{2}°$, or more correctly about $23° 28'$, it follows that the radius vector must, at the opposite extremities of the greater axis of the orbit, which answer to our mid-winter and mid-summer, be on, or appear to travel over, the parallel of latitude answering to the declination, of which $23\frac{1}{2}°$ is near enough for general purposes. We shall suppose the examination begun when the sun has its greatest declination south, or when the radius vector travels over about $23\frac{1}{2}°$ south latitude, which will be found to cross nearly the middle of New Holland, a portion of the Island of Madagascar, Southern Africa, to the northward of Orange River, where the country is understood to be dry and barren, and South America, near the parallel of Rio, where the mountains on the east coast are high, and the plains in the interior become burnt up during the hot season. We shall afterwards return to the characters of the land and sea, and their relative proportions to each other, on the different parallels over which the radius vector travels at the different seasons of the year; but it is desirable that we should notice them as we go along, and carry forward in our memories the accumulated mass of evidence. At this season of the year the radius vector travels only about 90° of land on the parallel, and 270° of sea, making in all 360°, the circumference of every parallel, and the lands passed over are wide apart from each other, and generally speaking of a dry and arid character, capable of being strongly heated, and of heating and giving a powerful ascending motion to the atmosphere over them.

When the radius vector travels over this parallel of 23½° south, to which we give the name of the southern *tropic*, because the sun apparently *turns* there, and proceeds no farther into the southern hemisphere, it is within 66½° of the south pole, and 113½° distant from the north. But the illuminated hemisphere always extends, even without taking any notice of the refraction of the atmosphere, exactly 90° in every way around the centre of its surface, that is, the point over which the radius vector appears to travel. In this state of things, therefore, the sun will, during the entire rotation of the earth, shine 23½° beyond the south pole, but not shine on a zone of the same radius round the north pole. The earth will, in fact, turn with 23½° around its north pole, elevated out of the illumination, and at equal extent round the south pole, turned wholly into the illumination. There will, consequently, be no direct action whatever of the sun upon the northern polar zone, while upon the southern one that action will revolve round, the height of the sun being 23½° above the horizon at the south pole; and in all places within the zone, the sun will be the polar distance of the place, that is, the difference between its latitude and 90°, more than 23½° above the horizon at mid-day, and the same quantity less than 23½° above the horizon at mid-night; also, in all places of the southern hemisphere down to the tropic of the sun will be on the meridian to the north of the zenith at mid-day, and within the polar zone, on the meridian south of the zenith at mid-night.

At the tropic the sun will pass the meridian exactly in the zenith at noon, but it will not appear to pass in a vertical semicircle, beginning in the east and terminating in the west, but will travel in an oblique circle, commencing to the south of east and terminating to the south of west. By this means, the sun's diurnal arc above the horizon will be a greater portion of the circumference of a circle than when the declaration from the equator is less. Consequently the most powerful action of the sun upon the earth as counted for a single day, will be when the sun, that is, the radius vector, travels over the tropic. The relative lengths of the day in the different parallels are matters of easy calculation, and can be judged of with sufficient accuracy by means of a tolerably good globe; but we may mention that, when the sun travels over the southern tropic, day and night are at exactly equal length at the equator; that at the middle of the quadrant, or 45°, the sun rises at fifteen minutes past four o'clock, and sets at forty-five minutes after seven o'clock, making the day fifteen hours and a half long, and the night eight hours and a half, and this without making any allowance for the increased length of the day, which arises from the refraction of the atmosphere, and which, as that refraction is a maximum when the sun is in the horizon, and 0 when the sun is in the zenith, the advantage resulting from it, and also the length of twilight, increases with increase of latitude.

The state of the northern hemisphere, with regard to day and night, and consequently to the direct influence of the sun, without taking into consideration any of the modifying causes, is, at this season, the exact reverse or counterpart of that on the southern; and in the other half of the year, when the sun apparently travels round the northern tropic, or $23\frac{1}{2}$° north latitude, the circumstances of the hemispheres are reversed; and in so far as the sun is concerned, whatever influence is exerted upon any parallel of the one of them in the one case, is exerted in exactly the same manner upon the corresponding parallel of the opposite hemisphere in the other. It is not therefore necessary to go over the description a second time, at least in so far as this general action is concerned, because the only difference is, that the sun is seen as looking north at mid-day in the southern hemisphere, and seen by looking southward in the northern beyond the tropic.

But when we come to examine the surface of the globe, where the northern tropic falls, we find it very different from that on which it falls in the southern. We have fully 75° of continuous land in Africa and Arabia, and the only interruption which this meets with in the Red Sea is so trifling, that it need not to be taken into the account. Then we have this northern tropic falling upon at least 45° of land eastward of the Arabian Sea, while the coast of Persia comes so near the tropic, and is at the same time so dry and warm, that we may admit it as being a tropical country. We have thus the northern tropic in the eastern hemisphere alone, stretching over an almost unbroken extent of 140° of longitude, which is about seven-eighteenths, or considerably more than a third of the whole parallel, while in the southern tropic the land occupies only a fourth of the parallel, and this fourth consists of parts far distant from each other, while Australia, the broadest of them, is not more than 40°.

In the western hemisphere, the tropic falls much more upon the sea; though, if we take the continuous range of the West India Islands, and bear in mind that local causes give a tropical character to the lower valley of the Mississippi and the country westward, we may say that there are not less than 40° of land upon which the tropic falls in the northern hemisphere. Adding this to the quantity in the eastern hemisphere, we find that the northern tropic falls upon land for 180°, or one-half of its extent, while the southern one falls only upon a quarter.

This difference in extent of land, in longitude, cannot fail of making a wonderful difference in the sun's seasonal action upon the two hemispheres; and there is no doubt that the characters of the lands themselves tend greatly to increase this difference. If we look at the map, we have the whole range of the African desert, Arabia, Persia, and India, to the foot of the Himalaya mountains, excessively dry at one season of the year, and much of them composed of rainless deserts of sand, which, from the rays of the sun reaching all sides of the grains, is much more speedily heated than even a surface of indurated earth. It is true that, to the eastward of the Himalaya mountains, or rather of the mouth of the Ganges, is, comparatively speaking, a humid country, covered with immense forests, and, in great part, converted into swamps during the rains; but the southern spurs of the Himalaya mountains, and the Bay of Bengal, cut off this eastern country from all connexion with the arid tracks to the west; and therefore, we may consider the action of those tracks as being concentrated and separate; and farther, as the African part of it is cut off from communication with the Mediterranean, and all the rest abutting upon the Mediterranean country, which receives little or no ocean influence, we can easily see how powerful an effect this vast tract of thirsty land, susceptible of the most powerful solar action, must have upon the seasons in the eastern portion of the northern hemisphere: and when we look toward the west, and bear in mind what the characters of the land are there, we can also perceive that, though different, the influence here must also be great, and much increased by the free communication which the centre of North America opens up between the intertropical regions and those of the North Pole.

On the south side of the equator we have no lands capable of affording such effect to the heat of the southern summer, or the cold of the southern winter. From all that is known of Australia, it is by no means improbable that that vast island contains within it a sort of southern Sahara; but still it cannot have either the same continued dry heat, or the same comparative tranquillity in the lateral motion of the air, as the north of Africa. Australia may be said to be placed in a sea of troubles; for, with the exception of the north, where the land-locked sea is almost as hot as the land itself during the summer, it is exposed to the general current of the Pacific Ocean on the east, and the alternating monsoons of the Indian Ocean and the Southern Ocean, as far at least as the general current of the waters which confines the action of cold to the high southern latitudes, on the south and the west. There is also no spot in this great island at the distance of more than 1000 miles from the sea on some side; and as the monsoon ranges more than this distance in India, and the trade wind of the Atlantic feels its way for more than 2000 miles up the great valley of the Amazon, there is no reason to conclude that any part of Australia is without rain. The storms of those seas are also no jokes; and they are perhaps not so regular in the discharge of rain as those which beat upon and wear the slopes of the narrow part of America: they are, certainly, as violent when they do happen.

Much of what can be said about Australia is conjectural; but all the evidence leads to the conclusion, that it is, in great part at least, a country which has been wasted by rain. In respect of latitude, New Holland ranges nearly on the same parallel with the last 25° of Southern Africa,—the last half of which is without the tropic, and the first half within, in the same manner as in Australia. Now, though Africa is the narrower country, upon the parallel, by more than one-third, yet the breadth of both is considerable; and we may infer at least some similarity in their physical characters, and draw at least some conclusions respecting what is unknown of Australia, from what we know of Southern Africa. Now, in Africa, the characters of the seasons are, violent rains with the one monsoon, and burning drought with the other. The rains fall with so much violence upon the indurated grounds, that the accumulated waters float off by the channels of the rivers, in the form of travelling lakes, which sweep every thing before them; and, since the settlement at Sidney on the east coast of Australia, there has been evidence of the same violence of rain there. The rivers, as is the case in Southern Africa, have cut deep channels through the solid rock; and, on more than one occasion, the Hawksbury has risen to such a height as to sweep away all the crops and the buildings, and to teach the people to erect their dwellings above the level to which those floods extend. In the south-west too, the rains sometimes scourge the country down to the very rock, and produce new land, and give rise to new vegetation, in the hollows by the margin of the sea.

The effect of those violent rains is the very opposite of what might, at first sight, be supposed. They break the soil in pieces, and separate the clayey particles, and also the saline ones; and they hold these in solution, after they have deposited the sand and gravel. The clayey matter is thus carried into every hollow by the water which settles there; and though it is originally dissolved in water, it effectually shuts up all the fissures and pores of the earth, so that the water cannot penetrate and form reservoirs for the supply of springs, but remains on the surface, to be disposed of either by flooding to the sea, or by the progress of evaporation. Hence, on all the shores of Australia which have been visited, there are accumulations of rubbish, in which mangroves breed, and grow very rapidly, form barriers against the action of the tide, and occasion the formation of lagunes and marshes between their vegetable barrier and the original line of the coast. Behind these there is a gradual accumulation of all those finer particles of the soil which the heavy rains wash down from the more elevated parts; and thus when rain does fall, there is more violent surface action between water and air than in places where the water can penetrate the soil and form springs. From all that we know of the country, there is no reason to suppose that there are any lofty mountains in Australia; and thus there is no interuption to the action of the sea over great part of it. So much evaporation from the surface produces a moderate degree of cold, even in the low latitude which this country occupies; and this, together with this action being as between sea and land round the whole country, renders the climate less variable than in corresponding latitudes of the northern hemisphere, or even than in Southern Africa, or the extra-tropical part of South America.

But though we can thus see that there are great differences of action between the southern tropical sun in our winter, and the northern tropical sun in our summer, yet the quantity or land across which those two parallels lie, and the different characters of the lands themselves, are so mixed up with the operations of other causes, that it is impossible to estimate their relative influences on the seasons in the two hemispheres with anything like accuracy. The inquiry also is farther embarrassed by the fact, that the polar influence and the tropical are, in the southern hemisphere, separated from each other by the circulating current of the sea. We do know, however, from observation, that the characters of those southern lands are far more tropical, that is, far more uniform, ever-green and ever-growing, in their seasons, than the same latitudes in the northern hemisphere.

We have thought best to begin by a reference to the tropics, or times of extreme solar action in the two hemispheres; because in this we most strikingly see the practical advantages which result to the earth from the simple fact of the oblique position in which its axis stands to the plane of the orbit, as taken on the line of the major axis, or line joining the points of aphelion and perihelion, in which it is at mid-summer and mid-winter, in the northern hemisphere, or with us, and at mid-winter and mid-summer in the southern hemisphere, or on the opposite side of the equator. The effect which this produces, when taken along with the consideration that it is the necessary result of the mere motions of the earth, is one of the most beautiful instances which we have of the very simple means by which results of the highest importance are brought about in nature, by means so very simple that they altogether exceed, in the wisdom of their contrivance, anything that could occur to us in the course of our art. We should hardly expect before hand that the mere fact of the axis standing always at an angle of $66\frac{1}{2}°$ to the plane of the orbit taken in the direction of the major axis, the influence of the sun would be distributed with really more than double, nay, ten times the uniformity over the surface of the earth, which it would have had, if the position of the axis had been at right angles to the plane of the orbit, taken in the position of this major axis, or line of the apsides in the orbit. Such, however, is the fact; and it is a necessary fact, the result of the mere arrangement, without any additional waste of power or contrivance. That this connexion should be with the major axis of the orbit, and not with that of any other diameter, or of any other position of the radius vector, is also a beautiful part of the system, because it places this advantage which the earth derives on the basis of greatest stability. The major axis is the immutable part of a planetary orbit,—the created part, as it were,—depending on the quantity of matter in the sun and the planet, and the velocity in motion which the planet had received at its creation; and it is more independent of the disturbances of other planets, or of any casualty whatever, than any other element of the orbit. In consequence of the attraction of other planets, the earth may move faster or slower in some parts of its orbit during one revolution than during another; and the orbit may, from the same cause, swing a little upon the major axis; but this axis remains immutable in its position with regard to the sun, or, at all events, the variation to which it is subject—the change in the obliquity of the axis is exceedingly slow, and also contains in itself the means of its own compensation.

It is impossible to reflect on those matters without being struck with the astonishing displays of wisdom and goodness which they set before us; and it is equally impossible to be so struck without feeling a higher degree of reverence for the bountiful Author of this wondrous system.

The tropics are, for various reasons, the parallels at which, when the sun becomes vertical there, the solar action is greatest; and they are so for various reasons. The circumference on the tropic is considerably shorter than on the equator; and thus the motion in rotation through the light of the sun is slower, and the solar influence is greater. The circumference of the tropic is about 22,600 miles, while that of the equator is about 25,000. Thus the length of the tropic is about one-twelfth part less than that of the equator; and consequently, the tendency of the sun to heat the tropic must be greater than it is to heat the equator, for the simple reason that it is carried more slowly through the heating cause; and we know, from experience, that the heat communicated is in proportion to the slowness with which the body passes through the radiating heat. It is true that we are unable to apply our arithmetic to this case, and state precisely by how much more the earth is heated, in consequence of the slower velocity in rotation of the tropic than of the equator; for the motion of the sun-beams is so very rapid, that we are unable to bring it within the limits of our calculation for anything but very long distances; and besides, it is combined with the two motions of the earth—in the orbit and on the axis—in producing the effect; and those three motions we are unable correctly to estimate, though we know that some increase of heat must be the result, and that it must be distributed equally on both sides of the tropic; though different causes modify its effects in these different situations.

The increase in the length of the day, when the sun is overhead at the tropic, while day and night are constantly equal at the equator, is another cause why the vertical sun should produce a greater degree of heat there than at the equator; and this cause is carried down increasingly into the higher latitudes of the hemisphere, over whose tropic the sun is, so that those polar summers, during the brief period that they are at their height, may, in the absence of evaporation, be as hot as the summers within the tropics.

There is another reason—the variableness of the daily declination of the sun. The earth's orbit tells upon the surface of the earth, as a circle crossing the equator in two opposite points, and extending to the tropics, or to the latitudes of $23\frac{1}{2}°$ nearly on the north and the south sides, though, on account of the motion of the equinoxial points, this telling of the plane of the earth's orbit upon the surface of the earth cannot be permanently represented by a fixed circle: because the equinoxes do not always happen in the same longitudes on the equator, or the solstices—that is, the mid-summer and mid-winter points—at the same longitudes on the tropics. But still we may, for general purposes, consider the equator, and this telling of the earth's orbit, which answers to the ecliptic, as two great circles of the earth considered as a globe; that they bisect each other, or divide each other, into two equal parts, which are also equal to each other in the two circles; and that their planes make an angle of about 23° on that equatorial diameter, the extremities of which, for the particular time, answer to the equinoxial point.

Now, by examining any two circles of the same size which intersect each other on a map, or otherwise, it will be observed, that just midway between the intersections they are nearly parallel to each other; and that this parallelism extends for a greater part of their lengths in proportion as the angle at which they intersect each other is less. In consequence of this intersection taking place at the equinoxial points, the sun's declination shifts very nearly one minute of latitude in the hour, though it shifts a little more at the spring equinox in March than at the autumnal one in September. At midsummer, when the sun passes vertically over the northern tropic, the change of declination is not one second of time in the hour, indeed not half a second; and it is not much greater at the winter's solstice, when the sun is vertical over the southern tropic. In the first month after the equinox, or from the 20th of March to the 20th of April, the sun's longitude changes northward in round numbers rather more than 12°, or more than the half of its entire quantity; whereas, in the last month immediately preceding the summer's solstice, it does not change above 3°. The rate of changing is very nearly the same before and after both the equinoxes and both the solstices, so that the rates which have been stated may be regarded as an average of them all.

In consequence of those differences in the change in declination the sun may be said to linger near the tropics for a considerable number of days, which days are not very perceptibly different in length; and it is because there is scarcely any change in declination on the days of the tropics themselves, that these are called the *solstices*,—that is, the times at which, in respect of declination, the sun "stands still." This lingering of the sun for several days very nearly on the same parallel of latitude, once in each hemisphere, at opposite times of the year, and at those times when the solar influence is alternately a maximum in each, enables each hemisphere to have a winter's repose, long in proportion as the latitude is high, though much modified by local causes ; and also, alternating with this, a continual period of heat, during which the temperature, up to pretty high latitudes, is certainly not less than the average of what it is, under ordinary circumstances, within the tropics.

When the sun has arrived at the equator—that is, at the end of a quarter of a year from the tropic—the rate of declination has become the greatest possible; thence to the next tropic it diminishes, in the same rate that it increased ; and it increases again during the third quarter ; is again a maximum when the sun is again over the equator; and decreases during the fourth quarter, until it arrives at the tropic at which the estimate is begun, and the revolution of the year is completed.

If we could view this annual path of the earth from the sun, we should see it told upon surrounding space as a great circle of the sphere of the heavens ; but we see it as looking from the earth at the sun ; and therefore, if there were no rotation of the earth it would be told upon the sphere of the heavens as a great circle, of which the earth is the centre. But we do not see it in this simple way, for our observation partakes, as we ourselves do, of the earth's motion in rotation ; and therefore, if we were to collect the results of a year's observations, the joint motions of the earth, annual and diurnal, would be told in an apparent motion of the sun in the sphere of the heavens in two spiral lines, the one twisting round, in between 182 and 183 coils, from the southern tropic to the northern, and the other twisting round back again, in an equal number of coils, from the northern to the southern. The sun's daily change of declination, taken at the same hour, at noon, for instance, would be the distance between every two coils; and thus these would appear to be very close to each other at the tropics, but they would gradually widen toward the equator, at which their distance would be the greatest possible. The space of the heavens upon which this double spiral would be told, would be that over head to the intertropical zone of the earth, or $23\frac{1}{2}°$ each way, or $47\frac{1}{2}°$ in all, in breadth. Thus the sun must appear directly overhead only once in the year at each tropic,—namely, on the midsummer day in the hemisphere answering to that tropic, only it would continue without being at any perceptible distance from the zenith. But within every other latitude within the tropics, the sun must pass directly over head at mid-day twice in the year, once before the midsummer day and once after it; and we shall not err much if we consider these two days as two mid-summer days. If the earth were uniform in its orbital motion, the two midsummer days at the equator would divide the year into two parts of exactly the same length of absolute time. But, in consequence of the orbit being an ellipse, with the sun in one of the foci, the motion is more rapid in the perihelion half of the orbit, which answers to the winter half-year in the northern hemisphere, than it is in the aphelion half, which answers to the summer half-year in the same. In consequence of this, the two halves of the year, as reckoned from equinox to equinox, are not of the same length. We have every reason to believe that the earth's diurnal rotation is perfectly uniform,—that is, it takes place in exactly the same duration of absolute time, whether the earth be more near to the sun or more distant from it. We infer this from the fact, that the rotatory motion belongs wholly to the earth itself, and is not in any way influenced by the sun; and consequently, distance from that luminary, however it may itself change, can have no effect upon this motion. We have, indeed, no means of verifying this fact other than that our well-regulated time-keepers keep the same rate with it, for it is in itself our primary standard of time. Still, both the agreement of the time-keeper with it, and its being a function of the quantity of matter in the earth only, which we cannot possibly imagine to be changed as a whole, we conclude, with as much certainty as we can have upon a mixed subject, that this our standard of time, in estimating seasons, as well as in the nicer divisions by which we regulate our engagements, is perfectly uniform.

If we regard the length of the day as uniform, estimate the length of the year at 365 days without the fraction, and count the time from equinox to equinox, as ascertained by actual observation, we find that the summer half-year is eight days longer in the northern hemisphere than the winter half-year; and, as the seasons in the two hemispheres are exactly the reverses of each other, it of course follows, than in the southern hemisphere the winter half-year is eight days longer than the summer.

This difference of solar action upon the two hemispheres in the alternating halves of the year, would have a considerable influence upon their relative temperatures, even though the surfaces of both were perfectly uniform, and exactly the same; and this effect would be, to throw the parallel of greatest average annual heat to the northward of the equator. But the different characters of the two hemispheres, as we have attempted to describe them, tend greatly to increase the difference of solar action upon them. The northern hemisphere contains a great breadth of land, either immediately within the tropic, or at very little distance from it; and, in the eastern hemisphere especially, this land is, to a great extent, dry and sandy, and of the very character which renders it most susceptible to solar action. Therefore, the northern hemisphere is much more heated during the northern summer than the southern one is during the opposite season.

The southern hemisphere, too, though the polar part of it is in some measure cut off from that near the tropics, by the circulating currents which we have mentioned as revolving freely round by the southern extremities of the lands, is altogether a surface less susceptible of heat than the northern hemisphere; and therefore it is more given up to the uniform action of the sun, the chief operation of which, over the wide surface of the seas, is to cause an evaporation; and the general set of the atmospheric current is northward, or, in consequence of its being affected by the two motions, north-westward, for more than half of the year. The centre towards which this current tends is the parallel over which the radius vector travels, —that is, where the sun is vertical at the particular season. From what we have already said, both as to the character of the northern hemisphere and as to the duration of the northern summer, this parallel is more in the northern hemisphere than in the southern; if we take the average of the year, the current from the south may be stated as reaching to the northward of the equator.

But this current is so much affected by the characters of the several lands, that it is different in almost every longitude, and in many instances it is turned into a direction different from what we should expect, if we did not carefully examine the different surfaces, and the variations of the sun's action upon them.

Were it not for those local causes, we might describe the state of things as being a current of the atmosphere from the southern hemisphere, and another, but a weaker current, from the northern, moving along the surface of the ground toward the parallel of greatest heat for the time, ascending there by means of that greatest heat, cooling as their mingled mass rises higher above the earth's surface, both on account of the expansion from the smaller pressure of the higher atmosphere, and from less of reflected and radiated heat from the earth.

Wherever the parallel of greatest heat is situated, we are to understand that the current from the northern hemisphere, or from that portion of the earth which is north of the parallel directly under the sun for the time, always has a higher temperature than the current from the south. This arises from the average characters of the two hemispheres, without any regard to those local causes by which the general action is modified, but we have already mentioned, that when two currents of air of different temperatures, and each saturated with as much humidity as it can carry, come together, the compound which results from their mixture is never capable of holding in solution the same quantity of moisture as was held by the two separately. Therefore, where the currents from the two hemispheres meet, there is a constant tendency to the formation of clouds, and the fall of rain; and, as the southern current passes for most of the surface over the sea, we may state that, though it is colder, and consequently has less evaporative power, than the northern current, it has the advantage of more evaporable matter, which, in all probability brings the two to an equal saturation with moisture.

When the sun is nearer the equator, and the declination is changing at the most rapid rate, the action of those currents upon each other shifts most rapidly in latitude, though at this time it affects the two hemispheres more equally than when the sun is near either of the tropics.

When the sun is near the southern tropic, the action upon the whole surface of the earth may be considered a minimum, as the sun then apparently travels round the surface which is least affected by its action. The southern summer may thus be stated as the time of greatest repose for the whole earth. Generally speaking, the effect of this season upon such of the southern lands as are of considerable breadth, and not much elevated, is to burn them up with drought; for, as their surfaces get heated, the south wind, or south-east wind, which then blows upon them, is rarefied by the increased heat of the surface, and converted into a drying wind. In the small islands this is but little felt, but it tells very strikingly upon Australia, the southern part of Africa, and the plains of South America. Over a great extent of these countries, vegetation withers during this season; and the grasses or the deciduous trees of our climates could not exist. Hence, much of the vegetation is totally different, not only in its external appearance, but also in its internal structure. The whole of our native trees perform the labour of the season external of the wood, and just between that substance and the bark, where a new layer, both to the wood and to the bark, is formed in every year of the growth of the tree, and when a tree is no longer able to perform this annual function, it dies.

Some of the southern trees, and trees of the middle latitudes, (for this influence extends as far as the northern tropic, or beyond it, according to circumstances,) have this habit; but then they are fortified against the excess of heat and drought much in the same manner as the pines of the arctic lands and the mountains generally, in the northern hemisphere, are so fortified; that is, they have the bark smooth, and either covered with an impervious epidermis, or giving out in small quantity some matter which evaporates with great rapidity, so as actually to produce a condensation of water from the air, which, though imperceptible to the eye, tends greatly to the nourishment, or at all events to the refreshing, of the tree. The leaves also partake of one or other of those qualities; and, generally speaking, the trees do not labour so hard in the production of their fruit, for though there are generally succession crops upon them, they take a full year or more to bring each of these to maturity, after the appearance of the flowers. Such trees are always in leaf, and where the earth is sufficiently rich to support them, they throw a protecting shadow over the ground, which really shelters it more from the vertical sun than our trees do from the slanting sun of our climates. It is not in the regions of extreme drought, the exposed plains which are subjected for months to the intensity of the sun's action, that we meet with trees of this description. In such places the ligneous vegetation consists in general of hard and prickly bushes, which are stript of their leaves in the intensity of the drought; and in many places indeed, such bushes, and also many of the trees, are leafless, the functions of leaves being performed by enlarged foot-stalks, which have much of the strength and power of resistance of timber, and none of those characters which we are accustomed to regard as properly belonging to, and being descriptive of, a leaf. In more favourable situations, however, we meet with evergreen trees which elaborate, in part, their own moisture out of the air, by the evaporation of peculiar matter, and it is owing to the evaporation of this matter that such forests are so richly perfumed.

We find a verification of this, by attending to the progress of our own seasons. In winter the fields and the forests are scentless, or the smell which they emit is simply that of fresh mould, of the withered blade, or the decaying leaf. When Spring comes, and touches every little bud with his pencil of emerald, calling them forth from those swaddling clothes by which they were shielded from the winter, and bidding them expand and perform their labours, and adorn the summer, there is freshness; but we cannot positively say there is fragrance, until the season advances and the blossom is put forth. In fact, by an attentive examination of the appearances of the year around us, and by comparing each effect with its cause, and remarking how perfectly all the beings, and all the agencies which we observe in nature, answer to each other, and promote the grand purpose of the whole, we should really derive more pleasure, and more instruction, not respecting our own neighbourhood merely, but respecting almost every spot on the surface of earth, than from all the volumes that have been written, or that can be written, upon the subject.

From these few hints it will be perceived, that our deciduous vegetation, such of it as attains a growth sufficient for forming a sheltering mantle for the earth, works at the surface, and as near the solar action as possible; that great part of the seasonal action is in leaves, of which the epidermis is thin, so that they suck up humidity like sponges, and, on the other hand, are soon withered away by the drought, or nipped by the frosts; but that the trees of the polar regions, and of our mountains, have leaves with a fine epidermis, which probably absorbs little or no moisture, and is just as unsusceptible to the alternations of heat and cold to which they are subject; and that, in those trees of tropical countries which grow at the outsides, there is perhaps greater firmness of epidermis; and there are other means by which they are enabled to resisit the drought, though trees of this character, although abounding in all the more favoured spots of the intertropical countries, are not the typical trees. These last are the palms, the tree-ferns, and several other races, which do not grow by an increase of substance at or near the outside; but consist of a successive production of what are commonly called leaves, but which are in reality not leaves, in the sense in which we apply that term to the annual covering of the forest trees. They are, more strictly speaking, *fronds*—" green expansions" of the tree itself, and not separate organs, to assist in the elaboration of other matter. A plant of this kind usually rises with the same thickness of stem which it is to preserve while it lasts; and this stem is elongated by growth at the top only, upon which there is a large, and often an exceedingly beautiful crown of the fronds, in the centre of which is the single bud of the tree, protected from the heat, not only by the thick investment of the more advanced portion by which it is surrounded, but generally by a great quantity of liquid sap,—a quantity so great, that the inhabitants of such countries tap it off by gallons, and prepare it either as a cooling, or as an intoxicating, liquor, according to circumstances. Those palms are often exceedingly majestic in their appearance, and attain a greater height than any other trees, excepting, perhaps, some of the pines on the west coast of North America. They are also the most durable of trees. Their leaves, or fronds, consist of long fibres, which are remarkably tough: the epidermis of many of them is not only hard and tough, but in some it is absolutely cased with an armature of flint. Their tall stems are branchless, and, considering their strength, they are exceedingly flexible and elastic; so that they bow their splendidly crowned heads to the violence of the weather, or stand armed amid the burning heat with perfect impunity, and thus live to record more revolutions of the earth in its orbit than the most ancient and stately oaks of our forests. The palm is, indeed, often used as the emblem of immortality, as well as of victory—of triumph over time, as well as triumph over enemies; and when we consider the multitudes of the human race which subsist upon the fruit, or the farinaceous substance of those stately trees, the numerous uses to which the wood and the fronds are applied, the beauty when growing, and the durability, both against decaying nature and casualty in art, we may well cease to wonder that this family of trees should have, in all ages, claimed the attention and drawn forth the admiration of mankind.

When the sun is over the southern tropic,—that is, when it is midsummer in the southern hemisphere,—the action of the sun in the northern hemisphere is necessarily the least possible, and the greatest portion possible of its polar zone is given up to the dominion of the winter's cold. The empire of this cold does not, for the reasons which have been already stated, range on a parallel of latitude, but forms an irregular line, being farthest to the north on the west of Europe, ranging more southerly as one proceeds eastward into Asia, and probably having its most southerly limit in North America as far to the south in some places as the forty-fifth degree, or middle of the quadrant; whereas, on that part of western Europe which meets the current from the Atlantic, it may be reckoned about 20°, or 1400 miles farther to the north. Within this irregular zone, where the cold may be said to hold unbroken sway during several months of the winter, there is a portion of the year which is perfectly tranquil, without cloud, without wind, or without alteration of any kind. In the early part of the season, when the snow comes, it comes with great violence ; but the frost soon gets so intense, that it congeals every particle of moisture in the atmosphere ; and as dry air is a very bad conductor of heat, there is much less inconvenience felt from the severity of the cold than from a much less intense degree of cold in lower latitudes. The snow also gives to the marshy grounds the same consistency, and the same uniformity of surface, as the rest of the land ; and therefore, as the inhabitants are largely supplied with the fur of animals, to protect them from the immediate action of the cold, the winter in those regions becomes the grand season of friendly intercourse and conviviality ; and even in places where the thermometer is to be for months below the freezing point, the people long for the winter, as the season of enjoyment. Nay, even the Esquimaux, in their oven-shaped huts, formed of masses of snow, in the same manner as we build houses of brick or of stone, feel this season not at all uncomfortable. The all-provident sea furnishes them with an abundance of oil, which they burn in their lamps, and near the heat of which they are comparatively comfortable, reposing on their thick matting of skins, though the bedstead under them is of unthawed snow ; and the walls, ceiling, and door of the hut are of the same material. Even in places much farther to the south, where there is not every year an unbroken period of winter, when such a period comes, it has its advantages ; and there is a pleasure in moving about the country, and also a healthiness, which are unknown in the more open winters.

In those latitudes which are without the dominion of the confirmed winter, and yet not so high as to be exempted from all wintry influence, this particular season is in general very variable; nor is it difficult to see why it should be so. The people of such places are not under the government of any one power. They are alike the subjects of the cold and the sun; and, as is the case with all who have to serve two masters, they are obliged to submit to the sway of the one whose turn it is to have the ascendant. In such places, it is impossible to lay down any general rules by which we can judge of what this season may be; neither can we state the latitude at which, on any longitude, this variableness of the winter shall be a maximum; for the boundary of the zone of winter's sway is so irregular, that the position of it is a matter of observation, and not of theory; and, as this is the point at which, on the average of the year, local causes have the greatest influence, we cannot, from the experience of one year, infer, with any thing like certainty, what shall be the character of the next.

We have mentioned that the sun's daily change in declination is very slow, near the tropics, compared with what it is near the equator; and in consequence of this, the tropical part of the year is the period of steady weather, whether we regard the hemisphere in which it is summer, or that in which it is winter. Thus, in the case of the sun being over the southern tropic, while the northern lands are, as has been mentioned, given up to the quiet dominion of cold, the southern lands are scorched and burnt up by an excess of heat. Under this state of things, those southern lands heat, rarefy, and send into the upper atmosphere, the air over them, and that air is replaced by the colder air from the sea, both to the northward and to the southward of the parallel of greatest heat. Thus, in Southern Africa, and the plains of South America, and, generally speaking, also in New Holland, there is a south or south-east wind, with continual burning drought. This is severely felt in Southern Africa, notwithstanding that the wind there blows from the south-east or wholly from the sea ; and it is also comparatively severe in South America, so much so as to burn up the plains. This is not confined to the regions of the equator, but extends to countries considerably to the north. In America it reaches not only to the central plains between the sources of the great rivers, but also to the narrow part of the country, to the West India islands, and also to the countries immediately to the westward of the valley of the Mississippi, all of which are burnt with drought during this the southern summer. Nor is its influence confined to the American continent ; for it is perhaps more perceptible in the eastern one, the southern parts of which are of a more arid character, and therefore more easily heated. The ease with which Central and Northern Asia are cooled, during this, their winter, tends still to augment the same effect : and the Mediterranean co-operates in carrying this effect into Africa. The air from the cooled land of Central and Northern Asia, and that from the Mediterranean, are carried southward ; and as both pass over much warmer surfaces than those which they leave, they become drying winds.

Thus in all parts of the earth which may be said to be under the direct and immediate control of the sun, the southern winter is the rainless season; and on this account also, as well as on account of its being the season of minimum effect of heat upon the earth generally, it is the season of the least action of Nature in all her kingdoms; and if we could imagine the possibility of the sun constantly revolving round the southern tropic, the economy of nature would very speedily be changed, and all the southern and intertropical parts would be burnt up, while the northern polar zone would be abandoned to extreme cold; and the only habitable zone of the earth would very soon be that which lay intermediate between the action of the sun and that of the cold, and from the nature of things, the burning desert on one hand and the polar ice on the other, would gradually encroach upon the opposite sides of this zone, till the remains of its fertility were also destroyed. Thus we see the advantages which the earth derives from its oblique motion in its orbit, by means of which seasons of productiveness are distributed over the greater part of its surface, while the two hemispheres, from the difference of their characters, are still enabled to act in opposite ways at different seasons; and thus carry both the sun's influence and the fertilizing humidity which this influence puts in motion in the direction of the meridian, or north and south; and, this being done, the difference of motion in rotation in the different latitudes turns the current into oblique directions, by means of which the beneficial effects are further increased.

We are not in possession of all the necessary information for knowing what is the specific action in the *antarctic*, or southern polar zone, during the height of this, its summer, because that zone has not been so completely examined as the corresponding zone in the north. But the formation of icebergs, their great size, and the comparatively low latitudes into which they float, lead us to conclude that there must be within this zone rocky lands of considerable elevation above the mean surface ; and the researches which have been made in recent times, especially to the southward of America, in so far corroborate this view of the case, which indeed must be the true one, wherever those antartic lands may be situated. We know of no means by which an iceberg of the dimensions of those observed off the Cape can be formed, but by the depositation of a vast quantity of ice and snow upon a high and rocky shore during stormy weather, and its detachment thence by the action of the summer heat. We know that the icebergs of the northern hemisphere are produced in this manner ; and that the largest ones come from the high lands on the shores of Baffin's Bay ; and as the southern ones are both larger in volume, and float into lower latitudes, than the northern one's, we may reasonably conclude that they are formed in the cliffs of more high and rugged lands.

We have said that in this hemisphere the polar action is, in a great measure, cut off from the tropical, by means of the current which sweeps round the entire circumference to the southward of the continents; but still this current cannot influence very much the gravitation of the whole mass of waters in the sea. Therefore we may suppose that the snows which are piled upon the antarctic lands, whatever these may be, and also those which are accumulated in hummocks upon the annual part of the ice, must, when they melt, occasion a superabundance of ocean water there, and a consequent motion of that water in the direction of the equator. Farther, as it appears, both from theory, and from all the direct information which we have, that the general accumulation of ice at the south pole is greater than that at the north, we may reasonably suppose, that the set of the sea current toward the tropical parts of the earth must be greater in the southern hemisphere than in the northern. It is this, in fact, which produces the circulating current to which we have so frequently alluded: for if there were no motion of the south polar waters into a lower latitude, which had a quicker motion in rotation than the places at which they were melted out of the ice and snow, there would be no means of putting in motion any westward current in the South Seas.

During the intensity of this southern summer, there is, generally speaking, a dry south wind upon all the three southerly lands, though it is much less felt in Van Diemen's island, from its insular situation, and in Patagonia, from the diversity of its surface and the elevation of its mountains. In those tropical countries which lie to the northward of the equator, the prevailing wind at this season is, on the other hand, from the north. From Southern Asia, this current of the air is drawn by two powerful causes, or rather by one powerful cause acting in two different regions, the one situated to the south-west of it, and the other to the south-east, both nearly equi-distant from the south of Asia, and from each other. There are Southern Africa to the westward, and Australia to the eastward; and while their parched and burnt-up surfaces are at this season sufficient to convert into a drying wind the atmosphere which moves toward them fully charged with humidity from the Great Southern Ocean, they also influence the set of the winds as far as the Himalaya mountains, and their continuation in Southern Asia. Europe is cut off from this action by the Mediterranean, the mountains of Atlas, and the Great African Desert, and the greater part of Europe is cut off from even the Mediterranean action by the Pyrenees, the mountains of central France, the Alps, and their continuation. We may also add, that Asia, to the north of the Himalaya and their continuation, which extends, with little interruption, to the narrow seas which separate it from Europe, is in like manner cut off from that action which takes place between the two hemispheres; and thus it also is, in a great measure, given up to its own local climate. In Egypt, however, which opens by the valley of the Nile as far to the southward as the mountains of Abyssinia, there is, at this season of the year, a continual set of the air, or blowing of the wind, from the north. Thus, though there is much less land in the southern hemisphere than in the northern one, and therefore much less action of the sun during the southern summer than during the northern, there is still a great tendency of the air toward all the broader lands in that hemisphere; and they are much more parched, or have drier seasons, than any of the lands in the north, excepting such as are permanently desert.

In America, to the eastward of the Stony Mountains, there is nothing material to interrupt the invasion of the polar winter during this season; and therefore we find a cold winter extending south the valley of the Mississippi to a much greater extent, that is, into a much lower latitude, than we find in Europe. At the same time, the plains of the southern and intertropical parts of America are burnt up.

But after the midsummer in the southern hemisphere has passed over, and the sun declines toward the north, bringing into the northern hemisphere that greater degree of solar action of which we have mentioned that it is susceptible, the state of things changes; and the change is accompanied by a general depositation, over the southern and tropical parts, of the moisture which the atmosphere has evaporated, and hitherto held in solution; and in this return of the season, we may say that, the more southerly the places are, the rain falls on them with the greater violence, provided that they are of sufficient breadth and uniformity of surface to be out of the operation of local causes, as between sea and land.

The times at which these rains commence in different places depend, in some sort, upon local causes; and they are sometimes brought directly by the sea winds which accompany the sun in its northerly declination, and sometimes by the returning current, as the surface of the southern land cools. In all cases, however, it is evidently the land which puts those currents originally in motion, that is, the action of the sun upon the land, either by arriving and heating, or by withdrawing and leaving to cool. Thus, in India, the south-western monsoon, which begins not long after the spring equinox, breaks first on the more northerly parts of the Malabar coast, showing that this direction is given to the air by the ascent of the atmospheric volume over the dry plains and deserts of Northern India, which have now been long subjected to burning drought; and as we advance farther and farther south along the Malabar coast, the setting in of this rainy season is later and later. At the commencement, that is, during part of April and May, this current of the atmosphere can hardly be said to amount to a steady and constant wind; but it is so during June, July, and August, about the end of which latter month it begins to fall off. When it first breaks, it is accompanied by violent thunder, lightning, and rain; but these slacken as it advances, and before its termination they cease altogether. In October the current is reversed, and an opposite wind blows strongly from the north-east, continuing till about the end of December, or the depth of the southern winter. This north-eastern monsoon is occasioned by the great cold, and consequent pressure and condensation of the air upon the Himalaya mountains and the adjacent country, at the same time that the lands to the south are again beginning to get warm.

In Southern Africa, almost the entire summer half-year is perfectly dry, with a wind from the south; and the rains do not set in till the returning current, about June and July; but their violence is generally very great. Throughout the rest of Africa there are rains nearly at the same period of the year, but perhaps a little earlier in the places which are farther to the north; and as that part of the country which lies immediately north of the Gulf of Guinea, and may be said to be bounded on two sides by the sea, and nearly on the other two by the Senegal and the Niger, is subject to a sort of oblique action of the air between Sahara and the southern deserts, there are some differences in its seasons of rains.

In America, that is, in the parts near the tropics, where the seasons consist of an alternation of rain and drought, the times do not differ much from those on the eastern continent; only, as there is no land to answer to South America, and occasion monsoons, the rains proceed more regularly over that country; but as far as seasonal rains do reach to the northward, they accompany the northward motion of the sun.

When we get without the range of this tropical influence, the equinoxes are the times of variable weather; because it is then that the surface is most exempted from the influence both of the summer sun and the winter cold, and local causes are enabled to produce the most conspicuous effects. So also in those countries which are subject to monsoons, or other alternations of rain and drought, it is always at the turn of the monsoons that the weather is most violent. It is always in situations where the monsoon, or other periodical action, is liable to the greatest interruptions, that those times of change are marked by the greatest violence and disorder of the weather. In latitudes which are comparatively high, we find that there is generally an atmospheric disturbance some time near the equinox, and every one must have heard of equinoxial gales. Those gales do not, however, happen at the times when day and night are equal; because the causes upon which they depend require some time to produce their effects, and the times so required must always be in proportion to the resistance with which the cause meets. Thus, a country which has a uniform surface of considerable extent will resist every change much longer than one of which the surface is irregular, and in consequence of which the weather is never very steady. In consequence of this resistance, we have the changeable weather at a greater or less time after the astronomical period of the equinox; and the violence, or, at all events, the rapidity, with which the change takes place, is always in proportion to the resistance with which the cause producing the change meets. Thus, in England, where the weather is not very steady at any season, those changes are not rapid or violent; and there is often a long struggle of alternate summer and winter, both after the vernal equinox and after the autumnal. In countries farther to the north, however, and of which the surface is more flat and uniform, the changes are far more rapid; and in some of the polar countries, where the snows do not dissolve till the year is considerably advanced, the transition from winter to summer is so rapid that there can hardly be said to be any intervening spring; while at the turn of the year there is an equally brief duration of what we call autumn, and winter follows closely on summer, so closely, indeed, that the standing crops are often buried in the snows. There is another peculiarity of those northern countries, and that is the uncertainty of the two great seasonal changes, which are comparatively regular in places nearer to the equator. The reason of this is the comparatively weakened action of the sun, and the consequent strength of local causes, in consequence of which the particular train into which the weather has run is not so easily broken as in places where the influence of the sun is more powerful.

Such are a few of the leading particulars by means of which some judgment may be formed of the general features and economy of our planet; but the subject is one of great extent, and at the same time involving many uncertainties and difficulties. It is impossible for us to say of how many of the elements we may be entirely ignorant; and of those of which we have some knowledge, very many are but imperfectly understood, so that they demand much more intimate observation before we can speak positively respecting them.

The hints which are given in the preceding sections will show both how the general elements of a rational knowledge of the earth may be acquired, and how we are to use them as instruments of knowledge. Had space permitted, it would now have been our business to proceed with an examination of the three classes of beings, which make up the observable part of the earth, namely, minerals, plants, and animals. But the introduction of these, even in the most imperfect manner, is inconsistent with our limits; and therefore we have considered it more useful to take a survey of the earth as a whole,—to examine the habitation with sufficient breadth of detail for comprehending its general characters, rather than to give a mere dry catalogue of its accommodations and of all the creatures by which it is tenanted. There is, however, so close a connexion between the greater movements of the earth, and of the waters and air upon its surface, and the characters of all its growing and living productions, that if we are able to excite a desire of knowing the one, a desire of knowing the others will follow of necessary consequence. In order to stimulate this desire, it requires no argument to prove that the earth itself is the first subject of our study, because it serves as a kind of artificial memory of all the rest; so that, if we once know the earth well, it will enable us to bear in mind the characters of its component parts and its inhabitants, as occasion makes us acquainted with them. And we may say, without fear of contradiction, that he who has made himself well acquainted with the general structure and economy of the earth, has laid a surer foundation for knowledge,—not only extensively and practically useful, but knowledge which has a vital principle in it, and will grow in the contemplation,—than could be laid by the study of almost any other subject.

Nor, if we enter upon this study with a right mind, in the earnest and honest desire of truth, and with a disposition to turn this truth to the greatest possible advantage, can we fail in being both morally and religiously the better for it. In this subject we find displays of wisdom and goodness which are far beyond any that we can meet with in the details of single objects upon the earth, however wonderful, or however beautiful, these may be in themselves; and when we are enabled to observe with what perfect conducement to the general good, seas and lands, mountains and valleys, deserts and fertile regions, and hemisphere with hemisphere, co-operate with each other, it is impossible for us to avoid perceiving, and feeling with no common delight, that "the earth is full of the glory of the Lord."